Homeowner's Guide to Retrofitting

Six Ways to Protect Your Home From Flooding

FEMA P-312, 3rd Edition / June 2014

FEMA




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Preface

The Federal Emergency Management Agency (FEMA) has prepared this guide specifically for homeowners who want to know how to help protect their homes from flooding. As a homeowner, you need clear information about the options available to you and straightforward guidance that will help you make decisions. This guide gives you both, in a form designed for readers who have little or no experience with flood protection methods or building construction techniques.




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Acronyms

ASCE	American Society of Civil Engineers
ASFPM	Association of State Floodplain Managers
AST	aboveground storage tank
BFE	base flood elevation
CDC	Centers for Disease Control
CMU	concrete masonry unit
CRS	Community Rating System
DFE	design flood elevation
DHS	U.S. Department of Homeland Security
DRC	Disaster Recovery Center
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
fps	feet per second
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
HUD	U.S. Department of Housing and Urban Development
HVAC	heating, ventilation, and air conditioning
IBC	International Building Code
ICC	Increased Cost of Compliance
IEBC	International Existing Building Code
IRC	International Residential Code

ACRONYMS

LAG	lowest adjacent grade
LiMWA	limit of moderate wave action
LOMA	Letter of Map Amendment
MEP	mechanical, electrical, and plumbing
MiWA	Minimal Wave Action
MoWA	Moderate Wave Action
mph	miles per hour
MSC	Map Service Center
msl	mean sea level
NAVD	North American Vertical Datum
NFIA	National Flood Insurance Act
NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum
NRCS	National Resources Conservation Service
OSHA	Occupational Safety and Health Administration
OSB	oriented-strand board
PDM	Pre-Disaster Mitigation
PNP	private non-profit
RFC	Repetitive Flood Claims
SBA	Small Business Administration
SFHA	Special Flood Hazard Area
SFIP	Standard Flood Insurance Policy
SHMO	State Hazard Mitigation Officer
SHPO	State Historic Preservation Office
SRL	Severe Repetitive Loss
UL	Underwriters Laboratories
USACE	U. S. Army Corps of Engineers
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
UST	underground storage tank

1.0 About This Guide

The Third Edition of FEMA P-312, *Homeowner's Guide to Retrofitting*, has been prepared to update the state of art in residential flood protection methods and reflect changes made to the National Flood Insurance Program (NFIP).

1.1 Who This Guide Is For

The Federal Emergency Management Agency (FEMA) has prepared this guide specifically for homeowners who want to protect their homes from flooding. It provides clear information about the options available to you and straightforward guidance that will help you make decisions. This guide is designed for readers who have little or no experience with flood protection methods or building construction techniques.

> **DEFINITION**
>
> FEMA is an agency within the Department of Homeland Security (DHS) that administers the NFIP. The NFIP is a Federal program, created by Congress in 1968. The NFIP makes flood insurance available to communities that adopt and enforce floodplain management ordinance, regulation, or provisions of the building code that meet the minimum requirements of the NFIP regulations.

If you are an engineer, an architect, a construction contractor, or someone with skills in those fields, you may want to ask FEMA for copies of technical manuals that cover design and construction in greater detail. For example, all flood protection methods described in this guide are discussed in depth in FEMA P-259, *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures*, Third Edition (FEMA. 2012a). If you work in a coastal area, FEMA P-55, *Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas*, Fourth Edition (FEMA. 2011b), may also be useful. If you would like to obtain copies of these documents or other FEMA documents referred to in this guide free of charge, you can download them from the FEMA Web site (http://www.fema.gov/resource-document-library) or call the FEMA Publications Service Center at 1-800-480-2520. See Appendix A for a list of documents concerning flood protection prepared by FEMA and other agencies and organizations.

In addition to FEMA publications, architects and engineers may want to obtain literature from the American Society of Civil Engineers (ASCE). ASCE 24, *Flood Resistant Design and Construction* provides minimum requirements for flood-resistant design and construction of structures located in flood hazard areas. ASCE 7, *Minimum Design Loads for Buildings and Other Structures*, may also be useful since formulas for flood loads are described in this document.

1.2 How This Guide Can Help You

You should take steps to protect your home if it has been damaged by flooding or is in an area where flooding is likely to occur. But first, you need to know what methods are available, how they work, how much they may cost, and whether they will meet *your* specific needs. This guide covers all of those issues. It also explains flood hazards and how they can damage your home.

> **DEFINITION**
>
> In this guide, the term **local officials** refers to the employees of your community who are responsible for floodplain management, zoning, permitting, building code enforcement, and building inspection. The responsibilities of local officials vary from one community to the next. In your community, you may need to work with one or more of the following: floodplain administrator, building official, city engineer, and planning and zoning administrator.

Flooding is only one of several natural hazards that may threaten your home. This guide includes maps that will help you determine whether your home is in an area where earthquakes or high winds occur, and it also explains when your retrofitting project should include protection against these hazards.

Your state and local governments probably have adopted building codes and other rules and regulations that you will need to know about. This guide explains how your **local officials** can advise you on those codes, rules, and regulations. Regardless of the flood protection method you choose, you may wish to consult with a licensed architect, engineer, or contractor for assistance with some of the retrofitting measures described in this guide. This guide describes the types of services you can expect design professionals and contractors to provide.

1.3 How To Use This Guide

To get the most from this guide, you should first read Chapters 2, 3, and 4. Chapter 2 explains retrofitting and, by describing how flood, wind, and earthquake forces can damage your home, helps you understand how retrofitting works. Chapter 2 also provides a discussion of Federal, State, and local financial assistance programs that may help pay for your retrofitting project. Chapter 3 provides short descriptions of the six flood protection methods covered by this guide. It gives you the information you will need as you begin to think about how to protect your home, including the approximate costs, advantages, and disadvantages of each method. Chapter 4 leads you through four steps that will help you decide which method or methods will best meet your needs. Chapter 4 also explains how to work with local officials, design professionals, and contractors.

When you finish Chapter 4, you will be ready to focus on a specific retrofitting strategy. In some cases, a single method may adequately address your needs. In other cases, a combination of methods may be best. Then you can move to Chapter 5, 6, 7, 8, or 9, depending on the method or methods you've chosen. Those chapters describe the methods in greater detail and include photographs and illustrations that show how the methods are applied. Chapter 9 explains how you can protect service equipment (utility systems; heating, ventilating, and air conditioning [HVAC] systems; and large appliances) in conjunction with the retrofitting method you have chosen.

As you read this guide, you will often find information in the margins of pages—definitions (such as the one on the previous page), notes, and warnings. Each is identified by a special symbol:

DEFINITION – The meaning of a technical or other special term. Where a term is first used in the text, it is shown in bold type and the definition is provided in the margin. You can also find these and other definitions in Appendix B.

NOTE – Supplemental information you may find helpful, including things to consider as you plan your retrofitting project, suggestions that can make the retrofitting process easier, and the titles and sources of other publications related to flood protection and retrofitting.

CROSS REFERENCE – Reference to another relevant part of the text or another source of information.

WARNING – *Critical* information that will help you avoid mistakes that could result in dangerous conditions, violations of your community's ordinances or regulations, and possibly delays and higher costs in your retrofitting project. Be sure to read these warnings. If you are unsure about what a specific warning means or what to do to avoid the problem it describes, consult your local officials. Chapter 4 provides information about working with local officials.

A final note before you begin Chapter 2: No guide or other document of this type can anticipate every retrofitting situation or every concern a homeowner may have about undertaking a retrofitting project. If you have questions that this guide does not answer, consult your local officials. Other resources include:

FEMA's Building Science Helpline, a technical assistance hotline, can be reached at 1-866-927-2104 (phone) or FEMA-Buildingsciencehelp@dhs.gov (email).

If FEMA has set up a Disaster Recovery Center (DRC) in your area in response to a Presidential Declaration of a Major Disaster, members of the DRC Mitigation staff can answer questions and advise you on recovery strategies. Call the FEMA Helpline at 1-800-621-3362 for the location of a DRC in your area.

NOTE

Many government agencies, including FEMA and non-profit organizations, maintain sites on the Internet where you can find information about flooding, high winds, earthquakes, and other hazards. Appendix A includes a partial list of available sites at the time this guide was prepared.

Appendix A of this guide lists helpful publications from FEMA and other organizations. The FEMA Web site, http://www.fema.gov, has information about all of these resources and more.

Appendix C lists the staff members of the FEMA Regional Office for your State.

Appendix D identifies your State NFIP Coordinator and State Hazard Mitigation Officer (SHMO).




2.0 Introduction to Retrofitting

Every year, flooding causes an average of over 90 percent of the disaster-related property damage in the United States and accounts for an average of over 75 percent of all Presidential Disaster Declarations. In fact, between 2003 and 2013, the NFIP paid an average of over $3.5 billion a year in flood claims. In 2012, the year of Hurricane Sandy, the NFIP paid over $8 billion in flood claims.

Although recent improvements in construction practices and regulations have made new homes less prone to flood damage, many existing homes continue to be repetitively damaged by flooding. In fact, repetitive loss records account for approximately 30 percent of all claim payments made in the history of the NFIP. Between 1978 and 2014, over 186,000 homes were flooded more than once. These homes alone accounted for approximately $15 billion in flood damages, subjecting the owners to a cycle of flooding and repairing.

The good news is that this cycle of repetitive flood damage can be broken. Homeowners across the country have protected their homes from flooding using the techniques described in this guide. One example can be found in New Orleans, where many residential neighborhoods were inundated by Hurricane Katrina in 2005 (Figures 2-1 and 2-2).

Figure 2-1. This home in New Orleans was inundated by 4 feet of water during Hurricane Katrina.

Figure 2-2. This home, from Figure 2-1, was elevated in a manner that added to both its appearance and its value. As a result of its elevation, the home avoided major damage from Hurricane Isaac in 2012.

One family decided to take action after their home flooded during Hurricane Katrina. They hired a contractor to elevate their home on concrete piers so that it would be above the level of future, similar floods (Figure 2-2).

At the outset of the project, the homeowners were concerned about how the home would look after it was elevated. But once construction was complete, their concerns were alleviated. Access to the front door is now provided by a well-designed double staircase that also serves as an architectural focal point. In addition to providing protection from future floods, elevating the home created a space below that could be used for parking and storage.

In other areas where flooding has caused repeated damage, entire homes have been relocated outside the flood hazard area or protected by floodwalls and levees designed as attractive landscaping features. As you read this guide, you will see that it is possible to protect your home from flooding while preserving or even enhancing its attractiveness and value.

NOTE

Any retrofitting project you undertake must meet the legal requirements of your community, including the floodplain management ordinances your community adopted to participate in the NFIP. By enforcing these ordinances, your community helps reduce future flood damages. As explained later in this chapter, the ordinances are based on the 1-percent-annual-chance flood, also referred to as the "base flood." Remember this term; you will encounter it many times as you read this guide. For more information, see Section 2.3.3.

2.1 What Is Retrofitting?

You may be wondering, "What is retrofitting and why is it necessary?" Retrofitting is making changes to an existing building to protect it from flooding or other hazards, such as high winds and earthquakes. You have already seen one example of retrofitting, and you'll learn about more in the following chapters.

Construction technologies, including both methods and materials, continue to improve, as does our knowledge of hazards and their effects on buildings. Many existing homes were built when little was known about where and how often floods and other hazardous events would occur or how buildings should be protected. As a result, retrofitting has become a necessary and important tool in **hazard mitigation**.

DEFINITION

Hazard mitigation is sustained action taken to reduce or eliminate long-term risk to people and property from hazards such as floods, hurricanes, earthquakes, and fires.

In addition to any retrofit completed on your home, updated Flood Insurance Rate Maps (FIRMs) and new legislation may have implications for your insurance premiums. Before making any changes to your home, FEMA strongly recommends that you discuss retrofit options with your insurance agent and work closely with design professionals and State and local officials.

2.2 Types of Flooding

This guide focuses primarily on retrofitting for flood protection. If you decide to retrofit your home, you'll need to be aware of other potential hazards as well, such as high winds and earthquakes. They are discussed later, but first you must understand flooding—where and how it occurs, the nature of the threat it poses, and how it can affect your home.

Most of the flooding that occurs in the United States is either riverine or coastal flooding, although flooding also occurs around lakes and ponds, and in areas where storm drainage systems are not adequate. Riverine flooding, as its name implies, occurs when rivers and streams overflow their banks (Figure 2-3). Riverine floodwaters can move quite rapidly, as in a **flash flood**, or very slowly, as they often do where the land is gently sloping or flat. The primary causes of riverine flooding are rainfall and rapidly melting snow (and sometimes a combination of both). Water from rain and rapidly melting snow eventually finds its way into stream channels. When the amount of water being carried by a stream exceeds the capacity of the stream channel, it spreads out into the area along the stream, commonly referred to as the floodplain. Usually, the homes and other buildings at greatest risk from riverine flooding are those near the stream channel, where the depths and speed of floodwaters are often greatest.

DEFINITION

Flash flood: A flood caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours. A flash flood rises and falls very quickly and is usually characterized by high flow velocities.

Figure 2-3. These homes in Gays Mills, WI, were inundated by riverine flooding during the Midwest floods of 2008.

Figure 2-4. The extreme impact of large, fast-moving waves, combined with the removal of supporting soil by erosion and scour, can have devastating effects on buildings exposed to coastal flooding. Hurricane Floyd destroyed this home along the coast of North Carolina in 1999.

Coastal flooding, which is caused by **storm surge** and **wave action**, primarily affects coastal areas, especially those along the beachfront, but it can also affect areas around bays and can back up along rivers and streams that empty into bays. Coastal flooding is most dangerous, and causes the most severe damage, where large waves are driven inland by the wind (Figure 2-4). These wind-driven waves occur primarily along the open coast, where they can destroy homes, wash away protective dunes, and erode the soil, often to the extent that the ground surface is lowered several feet. But they can also move inland where the land is flat and there are no large dunes or other obstacles to break them. In these areas, the level of damage can rival that along the open coast.

DEFINITION

Storm surge is the rise in the level of the ocean that results primarily from strong winds associated with hurricanes and other storms. Decreased atmospheric pressure from these storms also makes a small contribution to storm surge.

Coastal flooding can also move inland into low-lying areas beyond the limit of wave action. The danger in these areas is primarily from inundation due to storm surge but, even here, fast-moving floodwaters can result in **scour** and **erosion** around building foundations.

Another cause of flooding, which can affect homes outside identified floodplains, is the limited capacity of local drainage systems, including storm sewers, culverts, and drainage ditches. These systems are usually designed to carry a specific amount of water, which is referred to as the "design capacity" of the system. When heavy rainfall over an area causes the design capacity of the system to be exceeded, water will begin to back up and fill low-lying areas near system inlets and along open ditches. Depending on the amount and **intensity of rainfall**, the floodwater may continue to rise and may eventually affect homes.

A similar problem occurs when drainage system inlets are plugged or obstructed by mud or other debris and when drainage system outlets are submerged by water during riverine or coastal floods. In the latter situation, water can flow backwards in the system and reach areas that otherwise might not have flooded.

DEFINITION

Wave action refers to the characteristics and effects of waves that move inland from an ocean, bay, or other large body of water. Large, fast-moving waves can cause extreme erosion and scour, and their impact on buildings can cause severe damage. During hurricanes and other high-wind events, storm surge and wind increase the destructiveness of waves and cause them to reach higher elevations and penetrate further inland.

Scour refers to a localized loss of soil, often around a foundation element.

Erosion refers to a general lowering of the ground surface over a wide area.

Intensity of rainfall refers to the amount of rain that falls during a given amount of time. It is usually expressed in inches of rainfall per hour. The higher the number of inches per hour, the greater the intensity.

2.3 How Flooding Can Damage Your Home

To understand how flooding can damage your home, you need to know about six important flood characteristics: depth/elevation, flow velocity, frequency, rates of rise and fall, duration, and debris impact. Most of these characteristics apply to both riverine and coastal flooding, and they can vary—sometimes greatly—from one place to another. The flood conditions at a particular site, such as the location of your home, are determined largely by the combination of these characteristics. The following paragraphs explain these characteristics. Section 2.3 and Chapter 4 explain how you can determine the flood conditions at your home.

2.3.1 Depth/Elevation of Flooding

The depth and elevation of flooding are so closely related that, for the purposes of this discussion, they can be viewed as a single characteristic. Flood depth is the height of the floodwater above the surface of the ground or other feature at a specific point. Flood elevation is the height of the floodwater above an established reference **datum**. The standard datums used by

DEFINITION

An elevation **datum** is an arbitrary surface that serves as a common reference for the elevations of points above or below it. Elevations are expressed in terms of feet, meters, or other units of measure and are identified as negative or positive, depending on whether they are above or below the datum. Three common elevation datums are mean sea level (msl), NGVD, and NAVD.

most Federal agencies and many State and local agencies are the National Geodetic Vertical Datum (NGVD) and the North American Vertical Datum (NAVD); however, other datums are also in use. The use of other datums is important because elevations of the ground, floodwaters, and other features cannot be meaningfully compared with one another unless they reference the same datum. If a survey has established a **benchmark**, this point can be used to determine the flood depth and elevation. When the elevation of the ground (or another surface such as the **lowest floor** of your home) and the elevation of the floodwaters both use the same datum or benchmark, the flood depth at any point is equal to the flood elevation at that point minus the elevation of the ground (or other surface) at that point. Figure 2-5 illustrates this relationship. Ground elevations are established by surveys; flood elevations may be calculated or they may be known from water marks left by past floods.

The depth of flooding at your home is important primarily because floodwaters, even when they are not moving, exert pressure on structural components such as walls and concrete floor slabs. The pressure exerted by still water is called "hydrostatic pressure." It is caused by the weight of the water, so it increases as the depth of the water increases. As shown in Figure 2-6, floodwater, including water that has saturated the soil under the home, pushes in on walls and up on floors. The upward force on floors is called "**buoyancy.**"

DEFINITION

A **benchmark** is a reference point established by a survey with a precisely known relationship to a datum.

Under the NFIP, the **lowest floor** of a building is the floor of the lowest enclosed area within the building, *including the basement*. The only exception is an enclosed area below an elevated building, but only when the enclosed area is used solely for parking, building access, or storage and is compliant with relevant regulations. The elevation of the lowest floor can be very important in retrofitting, as you will see in later chapters.

Buoyancy refers to the upward hydrostatic force that floodwater exerts on the floors of homes with enclosed spaces below the flood level.

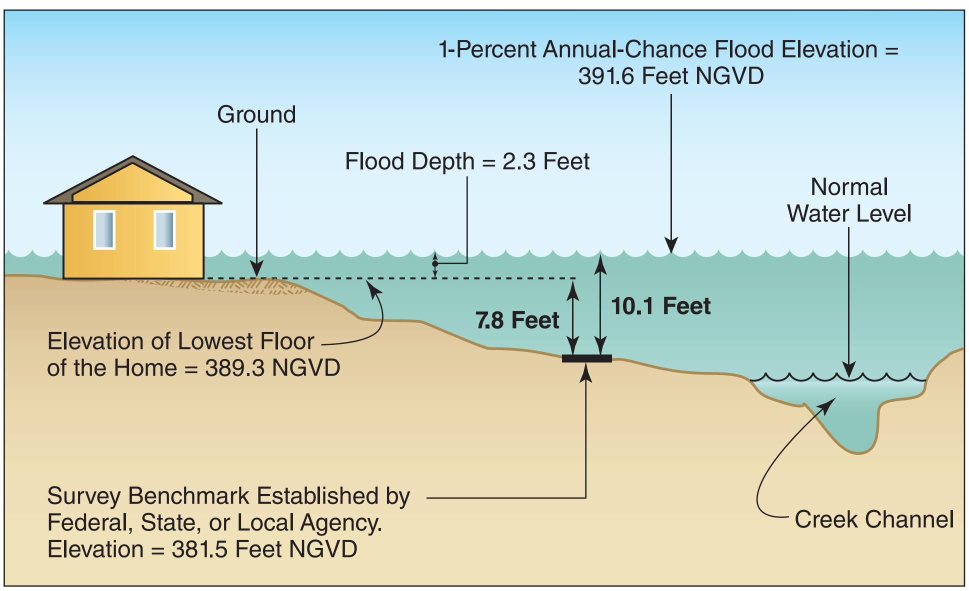


Figure 2-5. In this example, the 1-percent-annual-chance flood elevation is 391.6 feet (10.1 feet above the benchmark elevation of 381.5 feet), and the elevation of the lowest floor of the home is 389.3 feet (7.8 feet above the same benchmark). The flood depth above the lowest floor is therefore equal to 391.6 feet – 389.3 feet, or 2.3 feet during the 1-percent-annual-chance flood.

As shown in Figure 2-6b, water that has saturated the soil poses a special hazard for basement walls. Because hydrostatic pressure increases with the depth of the water, the pressure on **basement** walls is greater than the pressure on the walls of the upper floor, as indicated by the arrows in the figure. This pressure is made even greater by the weight of the saturated soil that surrounds the basement.

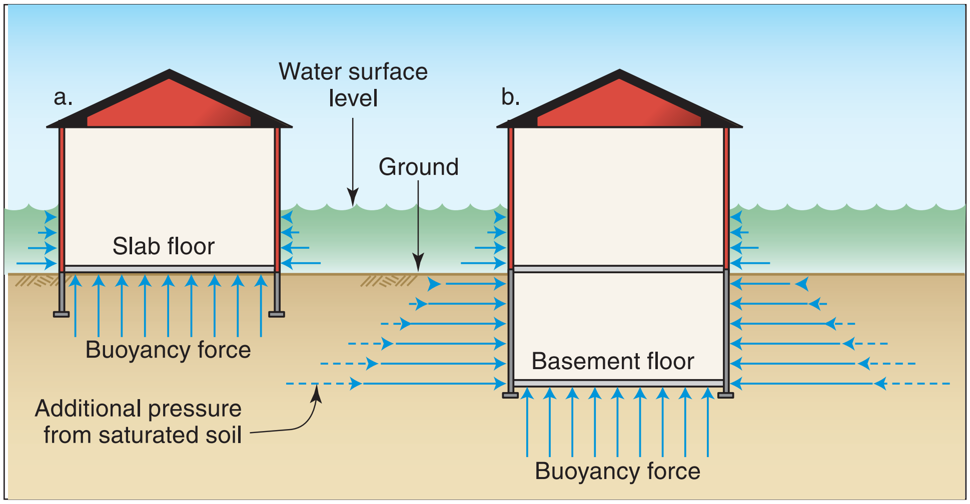


Figure 2-6. Hydrostatic pressure acts on walls and concrete slab floors. The weight of saturated soils adds to the pressure on basement walls. Figure 2-6a shows a home with a concrete slab floor. Figure 2-6b shows a home with a basement.

The walls of homes built using standard wood-frame or masonry construction are not designed to resist this pressure. If the pressure exceeds the strength of the walls (including basement walls), it can push them in or out (Figure 2-7), cause extensive structural damage, and possibly cause the home to collapse. In some areas, the buoyant force of hydrostatic pressure on basement floors has pushed homes entirely out of the ground.

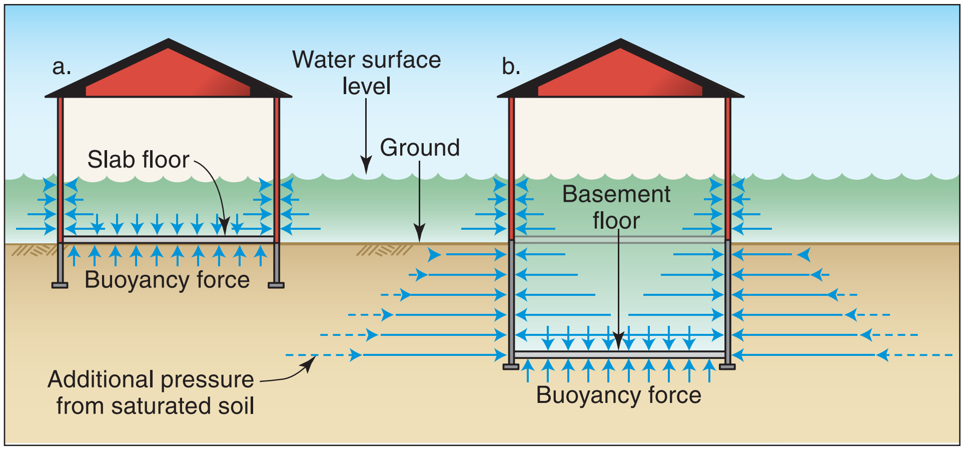
If water is allowed to enter, the hydrostatic pressures on both sides of the walls and floor become the same, or equalized (Figure 2-8), and the walls are much less likely to fail. As discussed in Chapters 3, 5, 7, and 8, this is an important consideration in some types of retrofitting methods.

DEFINITION

The NFIP regulations define a **basement** as "any area of the building having its floor subgrade on all sides." Note that the NFIP definition of basement does not include what is typically referred to as a "walkout-on-grade" basement, whose floor would be at or above the surface of the ground that touches the outside walls of the building on at least one side (see Section 3.1.2). This ground surface is referred to as the "adjacent grade."

Figure 2-7. The walls of this basement in Wisconsin failed because of the pressure exerted by water and saturated soil.

Figure 2-8. Once water enters the home, hydrostatic pressure is equalized. Figure 2-8a shows a home with a concrete slab floor. Figure 2-8b shows a home with a basement.



2.3.2 Flow Velocity

Flow velocity is the speed at which floodwaters move. It is usually measured in feet per second (fps). Flow velocities during riverine floods can easily reach 5 to 10 fps and, in some situations, may be even greater. Expressing velocities in fps is common in floodplain studies and engineering analyses. It may be helpful to relate fps to a more familiar unit of measure. For example, 10 fps is roughly equal to 7 miles per hour (mph).

The velocity of riverine floodwaters depends on a number of factors; one of the most important is the slope of the stream channel and floodplain. As you might expect, floodwaters will generally move much faster along streams in steep mountainous areas than streams in flatter areas. However, even within the same floodplain, flow velocity can still vary. As water flows over the ground, its velocity depends largely on the roughness of the ground surface. For example, water will flow more swiftly over parking lots, roads, and other paved surfaces, and will flow more slowly over ground covered with large rocks, trees, dense vegetation, or other obstacles. Also, flow velocities in the floodplain will usually be higher nearer the stream channel than at the outermost fringes of the floodplain, where water may flow very slowly or not at all. In areas subject to coastal flooding, velocities depend largely on the speed of the wind and, like riverine flow velocities, on the slope and roughness of the ground surface.

If your home is in an area where floodwaters are flowing, especially if they are moving more than about 5 fps, the flow velocity is important for several reasons. Flowing water pushes harder on the walls of a building than still water. So instead of just the hydrostatic pressure caused by the weight of the floodwater resting against the walls of your home, you have the additional pressure of moving water, referred to as "hydrodynamic pressure" (Figure 2-9). As water flows around your home, it pushes against the side of the home that faces the flow (the upstream side). As it flows past the sides of the home, it creates friction that can tear at wall coverings, such as siding. On the side of the home that faces away from the flow (the downstream side), the water creates a suction that pulls on walls. In some situations, the combination of these forces can destroy one or more walls (Figure 2-10), cause the home to shift on its foundation, or even sweep the home away.

Flowing water can also cause erosion and scour. As previously discussed, erosion refers to a general lowering of the ground surface over a wide area. Scour refers to a localized loss of soil, often around a foundation element. Both erosion and scour can weaken the structure of a home by removing supporting soil and undermining the foundation. In general, the extent and depth of erosion and scour increase as the flow velocity and size of the home increase. Also, keep in mind that any objects being carried by floodwaters will be moving at roughly the same speed as the water. The dangers associated with these objects are discussed in Section 2.3.6.

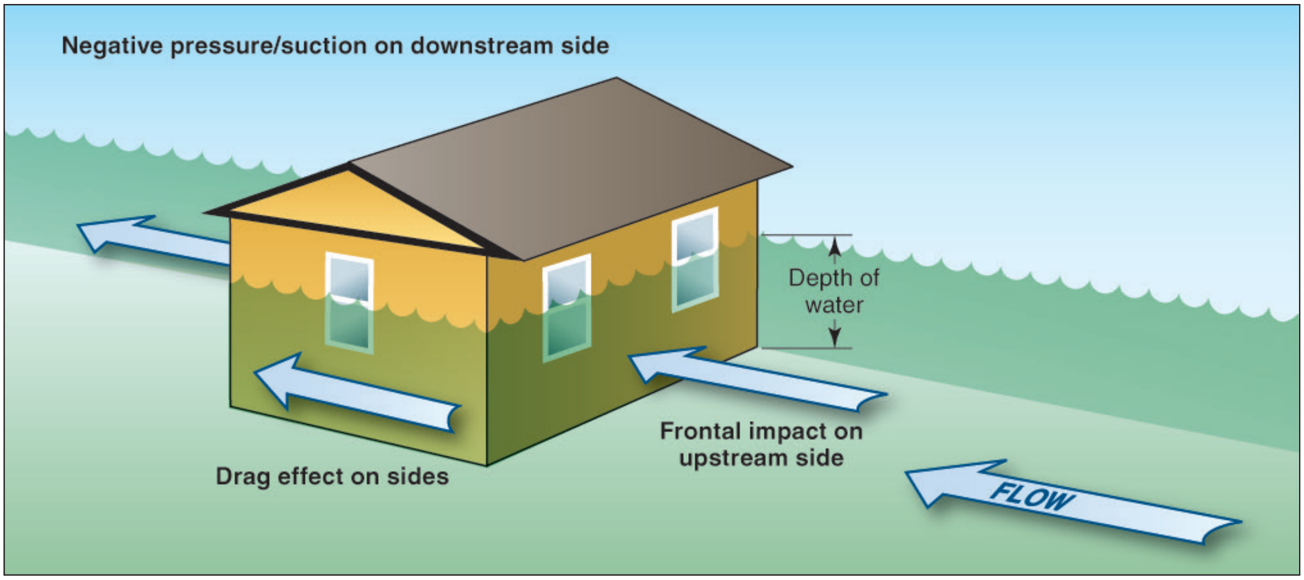


Figure 2-9. Moving water acts on the front, sides, and back of a home.

Figure 2-10. Water moving at high velocity destroyed the wall of this home and caused the building to shift on its foundation.

2.3.3 Flood Frequency

You may have been told that your home is in "the 100-year" floodplain, or you may have heard that term used to describe a specific flood. You may also have heard similar terms used, such as "50-year flood" or "500-year flood." These terms can be misleading. Flood frequencies are usually determined through statistics and engineering analyses performed by floodplain management agencies and other organizations responsible for implementation of flood control programs and floodplain regulation. The results of those analyses define the probability, expressed as a percentage, that a flood of a specific size on a specific stream will be *equaled or exceeded* in any year.

For example, the flood that has a 1 percent probability (1 in 100) of being equaled or exceeded in any year is sometimes referred to as the 100-year flood. This term is simply a convenient way to express probability. It should not be interpreted to mean a flood that happens exactly once every 100 years. Nor does it imply that once a

100-year flood occurs there is little risk of another 100-year flood occurring in the near future. To the contrary, changes in climatic conditions, such as those caused by El Niño, often result in clusters of floods that occur over relatively short times at the same location. In this publication, the term 1-percent-annual-chance flood is used to describe the 100-year flood.

For most homeowners, the value of these terms is that they indicate relative frequencies and sizes. Over time, a 1-percent-annual-chance (100-year) flood is expected to occur less often than a 2-percent-annual-chance (50-year) flood and more often than a 0.2-percent-annual-chance (500-year) flood. In addition, a 1-percent-annual-chance flood will be more severe than a 2-percent-annual-chance flood and less severe than a 0.2-percent-annual-chance flood. For example, if your home is in the 1-percent-annual-chance floodplain of a nearby stream or river, the 1-percent-annual-chance flood elevation at your home will be lower than the 0.2-percent-annual-chance flood elevation, and the water from a 2-percent-annual-chance flood might not even reach your home.

The 1-percent-annual-chance flood is particularly important for homeowners because it is the basis of NFIP flood insurance rates and regulatory floodplain management requirements. These requirements are discussed in detail in Section 2.5. In the NFIP, the 1-percent-annual-chance flood is referred to as the "base flood." The elevation associated with the base flood is referred to as the "base flood elevation" (BFE), and the floodplain associated with the base flood is referred to as the "special flood hazard area" (SFHA). Other Federal agencies, such as the U.S. Army Corps of Engineers (USACE), use the 1-percent-annual-chance flood for planning and engineering design, as do many State and local agencies. These agencies often have their own names for the 1-percent-annual-chance flood.

2.3.4 Rates of Rise and Fall

You may not have heard these terms before, but they describe important characteristics of flooding: how rapidly the elevation (and therefore the depth) of water increases and decreases during a flood. These rates are usually expressed in terms of feet or inches per hour. Floodwaters with high flow velocities, such as those in areas of steep terrain, and water released by the failure of a dam or levee, usually rise and fall more rapidly than slower-moving floodwaters, such as those in more gently sloping floodplains.

Rate of rise is important because it affects how much warning you will have of an impending flood. For example, homeowners in the floodplains of large rivers like the Mississippi and Missouri may know days in advance that flooding is occurring upstream and will eventually reach their homes. But in the floodplains of streams with rapid rates of rise, homeowners may have only a few hours' notice of a coming flood or perhaps none at all. With adequate warning, you will be better prepared to take steps to protect yourself and your property. Warning time is particularly important for flood protection methods that depend on action you must take. Chapters 3, 4, 7, and 8 further discuss this issue.

Rates of rise and fall are important also because of their effect on hydrostatic pressure. As explained in the discussion of flood depth/elevation, hydrostatic pressure is most dangerous for a home when the internal and external pressures are not equalized. This situation occurs when the level of water inside the home is significantly higher or lower than the level outside. When floodwaters rise rapidly, water may not be able to flow into a home quickly enough for the level inside the home to rise as rapidly as the level outside. Conversely, when floodwaters fall rapidly, water that has filled a home may not be able to flow out quickly enough, and the level inside will be higher than the level outside. In either situation, the unequalized hydrostatic pressures can cause serious structural damage, possibly to the extent that the home collapses.

2.3.5 Duration

Duration is how long a flood lasts, or how long it takes for the creek, river, bay, or ocean to return to its normal level. As a homeowner, you may be more interested in how long floodwaters remain in or around your home or perhaps how long they block nearby streets. In many floodplains, duration is related to rates of rise and fall. Generally, water that rises and falls rapidly will recede more rapidly, and water that rises and falls slowly will recede more slowly. An example of this relationship is the extensive flooding that occurred in the broad, flat floodplains of the Midwest in 2008. In those areas, floodwaters rose slowly and remained high for many weeks or longer.

If your home is flooded, duration is important because it determines how long the structural members (such as the foundation, floor joists, and wall studs), interior finishes (such as drywall and paneling), service equipment (such as furnaces and hot water heaters), and building contents will be affected by floodwaters. Long periods of inundation are more likely to cause greater damage than short periods. Duration can also determine how long your home remains uninhabitable.

2.3.6 Debris Impact

Floodwaters can pick up and carry objects of all types—from small to large, from light to heavy—including trees, portions of flood-damaged buildings, automobiles, boats, storage tanks, mobile homes, and even entire homes. In cold climates, wintertime floods can also carry large pieces of ice. Dirt and other substances, such as oil, gasoline, sewage, and various chemicals, can also be carried by floodwaters. All of these types of debris add to the dangers of flooding. Even when flow velocity is relatively low, large objects carried by floodwaters can easily damage windows, doors, walls, and, more importantly, critical structural components of your home. As velocity increases, so does the danger of damage from debris. If floodwaters carrying large amounts of dirt or hazardous substances enter your home, damages may be greater. In addition, your cleanup costs are likely to be higher and your cleanup time longer.

As you read the remaining sections of this guide, keep these flood characteristics and their effects in mind. Section 2.3 and Chapter 4 explain how you can find out more about flooding in your area, including flood elevations near your home.

2.4 Other Hazards

Two more hazards you should be aware of are high winds (including hurricanes) and earthquakes. For homes in areas subject to these hazards, some retrofitting methods are more appropriate than others. Chapters 3 and 4 further discuss this issue. But, regardless of the method you choose, if your home is in a high-wind or earthquake hazard area, your design professional or contractor must ensure that all structural changes made can withstand not only the expected flood forces, but the expected forces of winds or earthquakes as well.

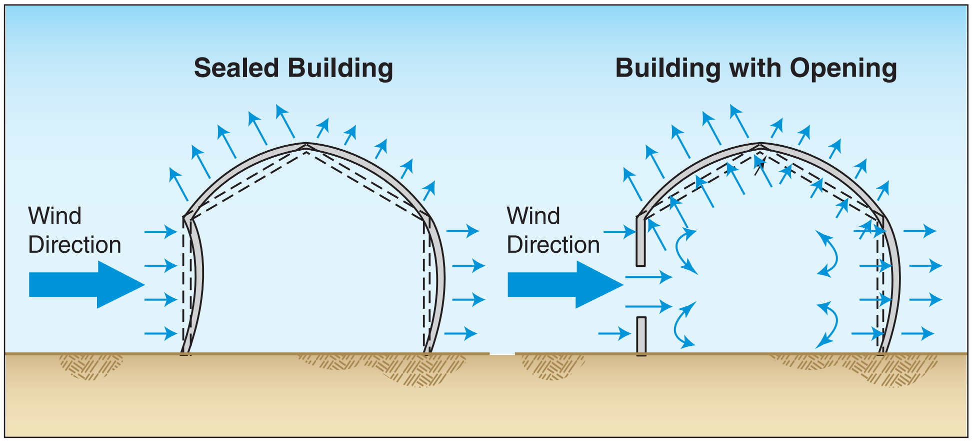
Wind is similar to flowing water in that it pushes against the side of the home that faces the wind and pulls on the side that faces away (Figure 2-11). Wind passing over a home can exert a lifting force on the home. The combination of push, pull, and lift acts on the home, including the foundation, and can result in extensive damage if the structural system and **building envelope** are not adequately designed and constructed.

DEFINITION

The **building envelope** is the entire exterior surface of a building (including walls, doors, and windows) that encloses or envelopes the space within.

The ability of the wind to damage a building is increased if the wind or windborne debris breaches the building envelope by breaking windows, collapsing doors, or puncturing walls. Once the envelope is breached, wind will enter the building and the pressure on the walls and roof will increase, as shown in Figure 2-11. Wind and flood forces can combine in different ways, depending on the directions of the wind and flood flow. When the wind and flood flow direction are the same, the load on the home is greater than the load from either wind or flood alone.

Figure 2-11. Wind forces on a sealed building are less than wind forces on a building with an opening.



The movement of the ground during an earthquake can place large horizontal and vertical loads on a home (Figure 2-12). Like the loads that result from flood flow and wind, earthquake loads can cause extensive damage to a home if they have not been accounted for in the structural design.

High-wind and earthquake hazards vary throughout the United States. In Chapter 4, you will find maps that show the areas where these hazards are greatest. For more information on retrofitting for wind refer to FEMA P-804, *Wind Retrofit Guide for Residential Buildings* (FEMA.2010c), and for more information on retrofitting for earthquakes refer to FEMA 232, *Homebuilders' Guide to Earthquake-Resistant Design and Construction* (FEMA. 2006).

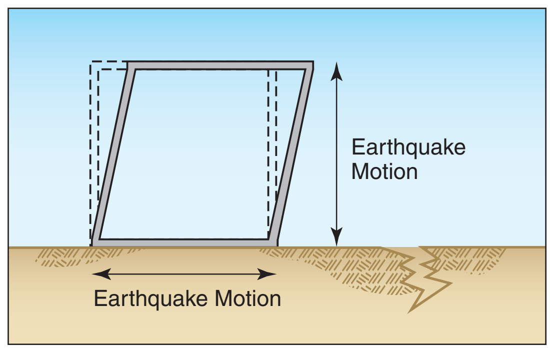


Figure 2-12. Earthquake forces act in both horizontal and vertical directions.

2.5 Federal, State, and Local Regulations

In most communities throughout the United States, construction in floodplains is governed by combinations of Federal, State, and local regulations; however, floodplain development can also be regulated wholly, or in part, by the International Codes (I-Codes). The I-Codes are a comprehensive, consensus-based set of model building codes that are often adopted at the State or local level. At the Federal level, FEMA administers the NFIP. Congress created the NFIP in 1968 when it passed the National Flood Insurance Act (NFIA). The NFIP is a voluntary program for communities. Its goal is to reduce the loss of life and the damage caused by flooding, to help the victims of floods, and to lower the costs of flood damage borne by the taxpayer. Communities participate in the NFIP in several ways:

- Guiding future development away from flood hazard areas
- Requiring that new buildings, **Substantially Improved** existing buildings, and repair of **Substantially Damaged** existing buildings in the SFHA be constructed in compliance with floodplain management ordinance, regulation, or provisions of the building code intended to reduce flood damage

- Providing floodplain residents with financial assistance after floods
- Transferring the cost of flood losses from the taxpayer to the owners of flood-prone buildings by requiring the purchase of flood insurance for buildings in the SFHA

The NFIP operates through a partnership between the Federal Government, the States, and individual communities such as counties and incorporated cities, towns, and villages.

A participating community adopts and enforces a floodplain management ordinance, regulation, or provisions of the building code to regulate development within that floodplain, including new construction, Substantial Improvement of existing buildings, and repair of Substantially Damaged buildings. In return, federally backed flood insurance is made available to property owners and renters who live in the community.

A participating community's floodplain management ordinance, regulation, or provisions of the building code must, at a minimum, meet the requirements of the NFIP regulations, but each community is free to establish additional or more stringent requirements to provide additional protection. For example, the regulatory floodplain defined by a community must include the entire SFHA, but it may also include other flood hazard areas within the community. Additionally, some States require communities to adopt and enforce floodplain management requirements that exceed the minimum requirements of the NFIP.

DEFINITION

Under the NFIP, an improvement of a building (such as reconstruction, rehabilitation, or an addition) is considered a **Substantial Improvement** if its cost equals or exceeds 50 percent of the market value of the building before the start of construction of the improvement.

Similarly, damage to a building, regardless of the cause, is considered **Substantial Damage** if the cost of restoring the building to its before-damage condition would equal or exceed 50 percent of the market value of the building before the damage occurred. Consult your local officials about determining the value of your home.

For more information, consult your local officials, or refer to FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010).

These points are particularly important because of their potential effect on your retrofitting project. In this guide, you will find many references to requirements included within your community's floodplain management ordinance, regulation, or provisions of the building code. These are the *minimum* requirements that all communities must adopt and enforce in their floodplain management ordinance, regulation, or provisions of the building code to be compliant with the NFIP regulations. Remember that you must comply with *your community's* requirements, which may be more stringent.

Usually, communities enforce other requirements that affect construction, both inside and outside of the regulatory floodplain. These requirements include those associated with building codes and land use regulations, such as zoning and subdivision ordinances.

2.5.1 The Community Rating System

The NFIP Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management actions that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reward community actions that meet the three goals of the CRS. The three goals of the CRS are to:

- Reduce flood damage to insurable property
- Strengthen and support the insurance aspects of the NFIP
- Encourage a comprehensive approach to floodplain management

When communities participate in the CRS, flood insurance rates for insured property owners and renters are discounted in increments of 5 percent to a maximum discount of 45 percent, based on 18 creditable activities. The activities are organized under four categories:

- Public information (e.g., offering references on flood insurance and flood protection at the public library)
- Mapping and regulations (e.g., guaranteeing that a portion of currently vacant floodplain will be kept free from development)
- Flood damage reduction (e.g., acquiring, elevating, and/or relocating flood-prone buildings so that they are out of the floodplain)
- Flood preparedness (e.g., providing early flood warnings to the public)

To apply for CRS participation, a community submits documentation of its floodplain management activities to the Insurance Services Office, which works on behalf of FEMA and the insurance companies. Specific information about CRS and the application process can be found at the CRS online resource center at http://training.fema.gov/EMIWeb/CRS/.

2.5.2 Flood Insurance Rate Maps

To provide communities with the information they need to enact and enforce floodplain management ordinance, regulation, or provisions of the building code, FEMA conducts floodplain studies for communities throughout the United States and publishes the results in Flood Insurance Studies (FISs) and FIRMs (Figure 2-13). The FIS for your community provides information about the names and locations of flood sources; historical flood data; flood elevations of varying frequency, including BFEs; areas inundated by the various magnitudes of flooding; and boundaries of the SFHA and **floodway**. This information is presented on FIRMs, which are used by FEMA and local communities to establish flood insurance rates.

DEFINITION

The regulatory **floodway** is the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height (44 CFR §59.1).

More simply put, the floodway is the portion of the SFHA where new development is strictly regulated to prevent flood elevations from increasing. The flood hazard is usually greater in the floodway than in the surrounding areas of the SFHA, referred to as the “floodway fringe.” Floodwaters in the floodway fringe are typically shallower and have less velocity.

NFIP regulations do not prohibit development in all portions of the SFHA. Instead, the regulations require that residential buildings in the SFHA be elevated to or above the community’s BFE. But floodplain development can reduce the amount of space available to pass floodwaters, which can increase flood elevations. For this reason, the NFIP and local communities prohibit Substantial Improvement and new construction in the floodway.

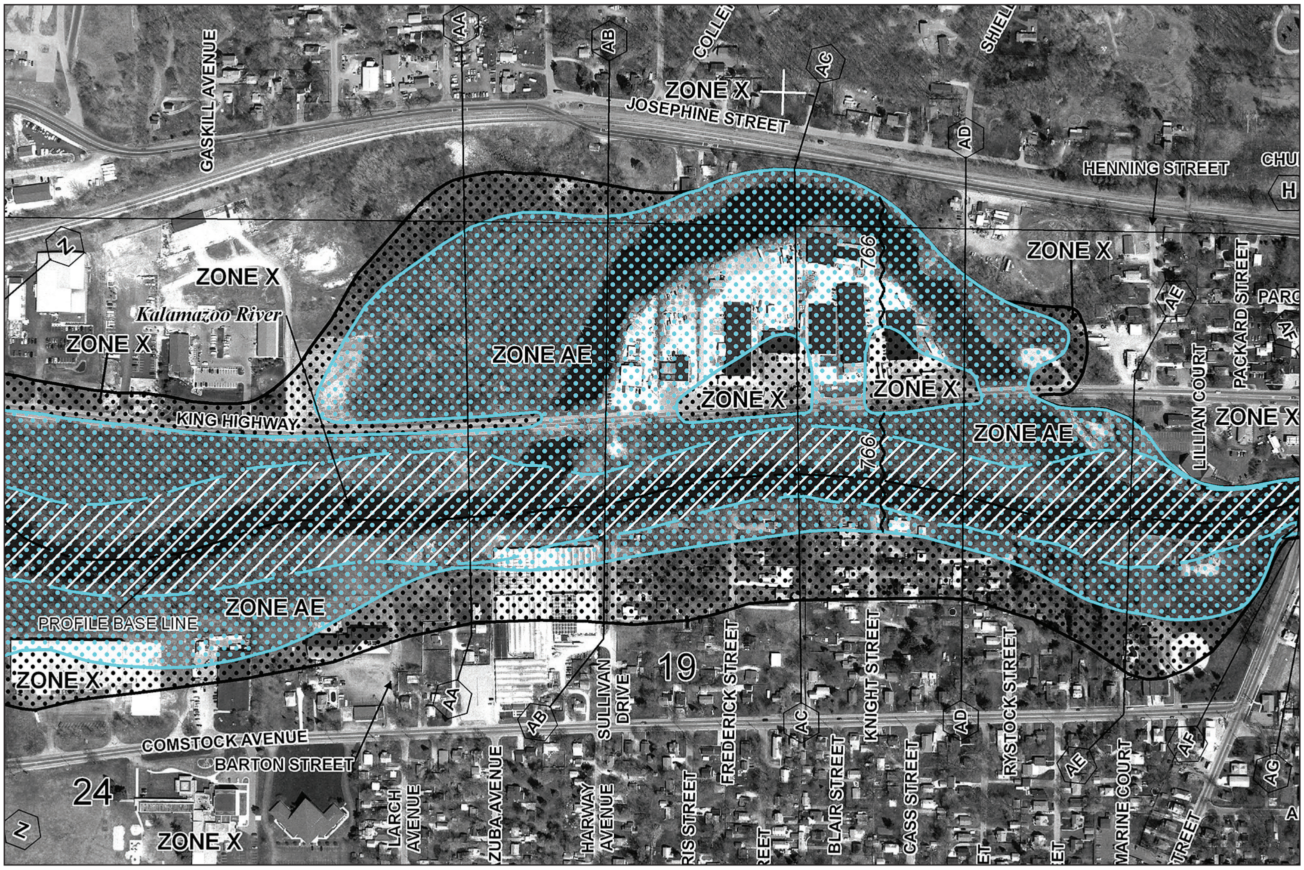


Figure 2-13. This FIRM for riverine flooding shows the SFHA (Zone AE), floodway (hatch-marked Zone AE along centerline of river channel), and areas outside the SFHA (Zone X). The area between the limits of the base flood and 0.2-percent-annual-chance flood are delineated by shaded Zone X. Areas above the 0.2-percent-annual-chance flood are delineated by unshaded Zone X.

FIRMs are available online at FEMA's Map Service Center (MSC): http://www.msc.fema.gov. The site allows you to search for your flood map in one of four ways:

- Searching for your address
- Using the catalog, which allows you to select your State, county, community, and flood map from a list
- Using a map search, which allows you to zoom into your community from a map of the United States
- Searching for a map panel by ID Number

Once you find your FIRM, you can create a printable FIRMette using the MSC Viewer. A FIRMette is a full-scale section of a FEMA FIRM that you create for yourself online. There is no cost for making a FIRMette. FIRMettes are used by many different parties such as community officials, mortgage lenders, real estate agents, design professionals, insurers, land developers, engineers, and surveyors.

The MSC Viewer allows you to zoom to the area you want to be included in your FIRMette and format your printable map. You can save your FIRMette either as an Adobe PDF file or as a TIFF file. The Map Service Center offers a step-by-step tutorial on creating FIRMettes.

Other Federal agencies, such as the USACE, U.S. Geological Survey, and Natural Resources Conservation Service (formerly U.S. Soil Conservation Service), also publish flood information, as do some State and local agencies. This information is often useful as a supplement to FISs and FIRMs. But, because it is developed to meet other needs, it is not used for the NFIP unless it has been reviewed and approved by FEMA.

If you have questions about flood hazards in your community, including the limits of the regulatory floodplain, flood elevations, or sizes and frequencies of past floods, check with your local officials. Usually, they will have copies of the FIS and FIRM for your community. They can also help you determine whether your home is in the regulatory floodplain and advise you about flood protection methods, including those described in this guide. Local officials can also advise you about floodplain management requirements, building codes, and other requirements that may determine the types of changes you can make to your home. See Chapter 4 for more information about working with local officials. You can also get help from your FEMA Regional Office (Appendix C) and the office of your NFIP State Coordinator (Appendix D).

2.6 Financial Assistance for Retrofitting

2.6.1 Federal Programs

FEMA and other Federal agencies have an array of financial assistance programs that assist States, communities, and individual property owners mitigate the negative effects of flood hazards. You may be eligible to receive financial assistance through one or more of these programs that will help pay for some of the retrofitting projects documented in this guide. Check with your local officials, the FEMA Regional Office for your State (Appendix C), your NFIP State Coordinator (Appendix D), or your State Historic Preservation Office (SHPO) (Appendix E).

If a Presidential Major Disaster Declaration has been issued for your area, you may want to seek information from FEMA and the State and local government representatives supporting the post-disaster recovery of your community. Keep in mind that funding for assistance programs is limited; often not everyone's needs can be met. Many Federal assistance programs provide grants to State and local governments, who must then set priorities for the use of the grant funds, including any potential use by individual property owners. Additionally, not all methods of retrofitting are eligible for funding.

NOTE

This section is not meant to be an all-inclusive description of Federal assistance. Following a Presidential Major Disaster Declaration, State and local officials will be briefed on the available types of post-disaster assistance.

Help from FEMA

Increased Cost of Compliance

One of the benefits provided by the NFIP is Increased Cost of Compliance (ICC) coverage. If your home is covered by a Standard Flood Insurance Policy (SFIP), is in an SFHA, and has been declared by your community to be Substantially Damaged or repetitively damaged by flood, ICC will help pay for certain types of retrofitting. ICC coverage is available for most SFIPs.

NOTE

If a flood in your area is a federally declared disaster, you must register with FEMA to obtain assistance. The directions at http://www.fema.gov will walk you through the application process.

If your home sustains a flood loss and the community has declared it Substantially Damaged or repetitively damaged, ICC will help pay the cost (up to $30,000 effective May, 2011) for the following retrofitting methods:

- Elevation: This raises your home to or above your community's adopted design flood elevation (DFE) (see Chapters 3 and 5).
- Relocation: This includes moving your home to another floodplain location on your lot and elevating it or moving it completely out of the regulatory floodplain (see Chapters 3 and 6).
- Demolition: This razes your home and restores the original property (see Chapters 3 and 6).

As noted earlier, your community's floodplain management ordinance, regulation, or provisions of the building code must include a requirement for Substantial Damage. Substantial Damage as defined in Section 2.5.

Some communities may have adopted a cumulative Substantial Damage or repetitive loss provision so that repetitively damaged buildings can qualify for an ICC claim payment. In order for buildings to qualify for a claim payment under ICC coverage as a "repetitive loss structure" the building must be covered by a contract for flood insurance and incur flood-related damages on two occasions during a 10-year period ending on the date of the event for which the second claim is made, in which the costs of repairing the flood damage, on the average, equaled or exceeded 25 percent of the market value of the building at the time of each such event. Note that ICC availability under this provision applies only if the community has adopted a cumulative Substantial Damage or repetitive loss provision in the floodplain management ordinance, regulation, or provisions of the building code. Also, note that under the NFIP, communities are not required to adopt a repetitive loss provision in their floodplain management ordinance, regulation, or provisions of the building code.

Remember, communities with a more restrictive floodplain management ordinance, regulation, or provisions of the building code may require a greater level of protection. If for example, your community requires new and Substantially Improved or Substantially Damaged buildings to be elevated 1 or more feet above the BFE, ICC allows for an ICC claim payment up to the $30,000 limit of coverage.

An ICC claim may also be paid for a combination of retrofitting actions. For example, ICC coverage allows for a claim payment for the cost of demolition and elevation at the same or another site within the SFHA. The ICC payment to demolish and elevate your home is limited to $30,000.

To learn more about ICC coverage, review your SFIP and contact your insurance agent, your community floodplain management official, the FEMA Regional Office that serves your community (Appendix C), or the office of your NFIP State Coordinator (Appendix D). If a Presidential Declaration of Major Disaster has been issued for your area, you can get help from the Mitigation and Insurance Desk at the local DRCs. In many cases, the ICC payments are used to offset the non-Federal cost-share to participate in a disaster assistance program.

Unified Hazard Mitigation Assistance Program

FEMA's Hazard Mitigation Assistance (HMA) grant programs present a critical opportunity to reduce the risk to individuals and property from natural hazards while simultaneously reducing reliance on Federal disaster funds. Hazard mitigation is the only phase of emergency management specifically dedicated to breaking the cycle of damage, reconstruction, and repeated damage. HMA programs provide pre- and post-disaster funding to States, Territories, Indian Tribal governments, local governments, and eligible private non-profits (PNPs) for activities that are consistent with the National Mitigation Framework's Long-term Vulnerability Reduction capability. Qualified private non-profits (PNPs) and *individual homeowners* are also eligible to receive HMA grant funds, but they must apply through a State agency or local government.

The statutory origins of each HMA program differ, but their goals are the same: reduce community vulnerability to disasters, promote individual and community safety and resilience, promote community vitality after an incident, and reduce response and recovery resource requirements in the wake of a disaster. Three grant programs are currently included in the Unified HMA program:

The **Hazard Mitigation Grant Program (HMGP)** is authorized by Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended (the Stafford Act), Title 42, United States Code (U.S.C.) 5170c. The key purpose of HMGP is to ensure that the opportunity to take critical mitigation measures to reduce the risk of loss of life and property from future disasters is not lost during the reconstruction process following a disaster. HMGP is authorized by a Presidential Declaration of Major Disaster. A Governor may request HMGP funding be available throughout the State or only in specific jurisdictions. The amount of HMGP funding available to the Applicant is based upon the estimated total Federal assistance to be provided by FEMA for disaster recovery under the Presidential Declaration of Major Disaster.

The **Pre-Disaster Mitigation (PDM)** program is authorized by Section 203 of the Stafford Act, 42 U.S.C. 5133. The PDM program is designed to assist States, Territories, Indian Tribal governments, and local communities to implement a sustained pre-disaster natural hazard mitigation program to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on Federal funding from future disasters. PDM provides funds on an annual basis.

The **Flood Mitigation Assistance (FMA)** program is authorized by Section 1366 of the NFIA, 42 U.S.C. 4104c, with the goal of reducing or eliminating claims under the NFIP. FMA provides funds on an annual basis.

The National Flood Insurance Fund provides the funding for the FMA program. The PDM and FMA programs are subject to the availability of appropriation funding, as well as any program-specific directive or restriction made with respect to such funds.

Table 2-1 provides a summary of eligible retrofit activities for each of the three programs in the Unified HMA Program. More information about each program can be found on the FEMA HMA Web site at https://www.fema.gov/hazard-mitigation-assistance.

CROSS REFERENCE

The Repetitive Flood Claims (RFC) program and the Severe Repetitive Loss (SRL) program have been eliminated and significant changes have been made to the FMA program. For more information, refer to the *Unified Hazard Mitigation Assistance Guidance*.

Table 2 1. Eligible Retrofit Activities by Program

Elibigle Activities	HMGP	FMA
Acquisition/Demolition (for purposes of open space)	✔	✔
Relocation	✔	✔
Elevation	✔	✔
Dry Floodproofing (historic residential structures)	✔	✔
Mitigation Reconstruction		✔

Help from Other Federal Agencies

Several Federal agencies offer disaster assistance to communities and citizens. For a complete list of Federal assistance programs for which you are eligible, visit http://www.disasterassistance.gov.

Small Business Administration (SBA)

SBA provides low interest disaster loans to homeowners, renters, businesses of all sizes, and PNP organizations to repair or replace real estate, personal property, machinery and equipment, inventory, and business assets that have been damaged or destroyed in a declared disaster. Visit http://www.sba.gov/services/disasterassistance/ for more information.

U.S. Department of Housing and Urban Development (HUD)

HUD provides flexible grants to help cities, counties, and States recover from Presidentially Declared Major Disasters, especially in low-income areas, subject to availability of supplemental appropriations. Visit http://www.hud.gov/ for more information.

U.S. Army Corps of Engineers (USACE)

The USACE has the statutory authority to participate in flood protection projects that may include residential retrofitting (including elevating flood-prone homes and acquiring badly damaged flood-prone homes). Contact the appropriate USACE Division office for further information. You can find more information and contact information for your USACE Division office at http://www.usace.army.mil.

Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture (USDA)

The NRCS has the statutory authority to participate in small watershed flood protection projects that may include residential retrofitting. Contact your local Conservationist for further information. More information is available at http://www.nrcs.usda.gov.

Other Assistance Programs

Other Federal programs intended to protect and improve the environmental quality of floodplains may offer financial assistance.

2.6.2 Non-Federal Help

Programs Sponsored by State and Local Governments

States, local governments, and flood control and drainage districts sometimes develop financial assistance programs to promote flood hazard retrofitting projects. Ask your local officials whether such a program exists in your community.

Voluntary Organizations

After floods and other major disasters, voluntary organizations often offer their services to support the rebuilding of homes. Occasionally, materials are donated and volunteers offer to provide labor that could be used to reduce the cost of a retrofitting project. Check with local officials, local service organizations, and homes of worship for information about such services. Note that you must obtain building permits and comply with all relevant regulations (including Substantial Damage requirements, if they apply), even if you receive assistance from voluntary organizations.

Environmental Interest Organizations, Including Land Trusts and Nature Conservancies

Numerous non-government, non-profit, and quasi-public organizations are dedicated to enhancing the environmental benefits of floodplains. Sometimes these organizations provide funds that can be used in the restoration or protection of the natural beneficial value of the floodplain.




3.0 An Overview of the Retrofitting Methods

This guide describes six retrofitting methods for you to consider as you think about how to protect your home from flooding:


Elevation – Raising your home so that the lowest floor or lowest horizontal member is at or above the regulated flood level. You can accomplish this in several ways. (Chapter 5)


Relocation – Moving your home to higher ground where it will reduce the exposure to flooding. (Chapter 6)


Demolition – Tearing down your damaged home and either rebuilding on the same property or buying or building a home elsewhere. (Chapter 6)


Wet Floodproofing – Making portions of your home resistant to flood damage and allowing water to enter during flooding. (Chapter 7)


Dry Floodproofing – Sealing your home to prevent floodwaters from entering. (Chapter 7)


Barrier Systems – Building a floodwall or levee around your home to restrain floodwaters. (Chapter 8)

This chapter describes the six methods in detail. Keep in mind that only elevation, relocation, allowable wet floodproofing, and demolition can be used to meet the minimum requirements of the NFIP. Barrier systems, dry floodproofing, and some wet floodproofing may be used to minimize damages, but are not recognized as meeting the minimum requirements of the NFIP. Remember that purchasing flood insurance for your home is important, even if you mitigate using one of these methods.

While the aforementioned mitigation methods protect the actual structure, this guide also describes retrofitting options for equipment and utilities to consider as you think about how to protect your home from flooding:

Equipment/Utilities – Equipment/Utilities – Retrofitting existing building equipment and utility systems may involve a combination of elevating and/or protecting in place. (Chapter 9)

For each method, you will find a section that explains how the method works and where it should and should not be used, lists its advantages and disadvantages, and provides a relative cost estimate. But first, you should be aware of some general cautions about retrofitting.

WARNING

In the areas listed below, the risks to lives and property are usually greater than in other flood-prone areas:

- Coastal High Hazard Areas (insurance Zone V, VE, and V1–V30) shown on a FIRM (Figure 2-13)
- Coastal A zones (portion of Zone A seaward of the limit of moderate wave action (LiMWA))
- Floodways shown on a FIRM (see Figure 2-13)
- Alluvial fan flood hazard areas (certain Zone AO with depths and velocities) shown on a FIRM
- Areas subject to flash floods
- Areas subject to ice jams
- Areas subject to extremely high-velocity flood flows

Modifying a home to protect it from flood damage in these areas requires extreme care and may also require complex, engineered designs. If your home is in one of these areas, relocation or demolition (as described later in this chapter and in Chapter 6) may be a more conservative option rather than any of the other retrofitting methods discussed in this guide. If you have any doubt about whether your home is in an area of unusually severe hazard, consult your local officials.

3.1 Cautions

3.1.1 Substantial Improvement/Substantial Damage

NOTE

Substantial Improvement and **Substantial Damage** are defined in Section 2.5 and Appendix B.

As noted in Chapter 2, your community's floodplain management ordinance, regulation, or provisions of the building code includes restrictions on the types of changes that may be made to a home that is being **Substantially Improved** or that has sustained **Substantial Damage**. These restrictions prohibit or limit the use of some retrofitting measures. Two of the six methods described in this guide—dry floodproofing and levees/floodwalls—can reduce future damage but may not be used to bring a Substantially Improved or Substantially Damaged home into compliance with your community'sfloodplain management ordinance, regulation, or provisions of the building code. Instead, in accordance with your community's requirements, you must do one of the following:

- Move the home out of the regulatory floodplain
- Elevate the home so that its lowest floor is at or above the BFE
- In conjunction with elevation, wet floodproof the areas of the home below the BFE and use them only for parking, building access, or storage

- Demolish the home and either rebuild or buy a home elsewhere

Additional requirements apply to the use of wet floodproofing. These are described later in this chapter and in Chapter 7.

3.1.2 Basements

Another important floodplain management requirement concerns basements. If your home has a basement below the BFE and your local officials determine that it is being Substantially Improved or is Substantially Damaged, *the basement must be eliminated*. You can usually do this by backfilling it with compacted soil or other suitable material. For floodplain management purposes, the NFIP regulations define a basement as "any area of the building having its floor subgrade on all sides." Your community's floodplain management ordinance, regulation, or provisions of the building code may include a more restrictive definition of basement.

Note that the NFIP definition of "basement" does not include what is typically referred to as a "**walkout-on-grade**" basement, whose floor would be at or above adjacent grade on at least one side of the building. Depending on your community's floodplain management ordinance, regulation, or provisions of the building code, the requirement to eliminate the basement in a Substantially Improved or Substantially Damaged home *may not* apply to a walkout-on-grade basement. Instead, you may be able to wet floodproof the area. However, a wet floodproofed walkout-on-grade basement may be used only for parking, building access, or storage.

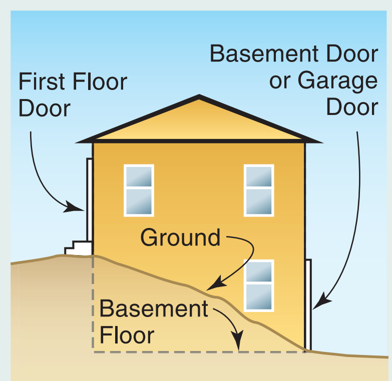
Your local officials can tell you more about these requirements and others that may be specified by local building codes and ordinances (see Chapter 4).

3.1.3 Flood Protection Elevation and Risk

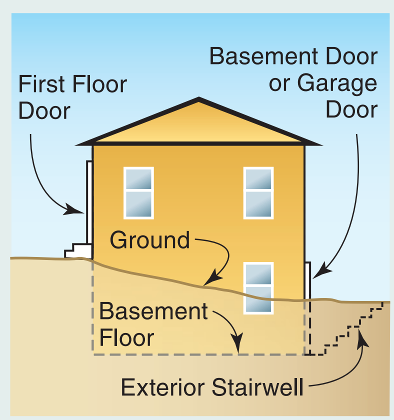
When you retrofit your home, one of the most important things you will do is choose a level of flood protection. In other words, will you protect your home from the base flood, the 0.2-percent-annual-chance flood, or some other flood? In some instances, this decision will be entirely yours; in others, it will depend largely on the regulatory requirements of your community, your State, or both. If your retrofit project is being funded through a Federal, State, or local agency, you may also be subject to different regulatory requirements. For the purpose of this publication, the **flood protection elevation** is considered the flood protection level you choose for your home.

DEFINITION

Walkout-on-grade is a term commonly used to describe a basement whose floor is at ground level on at least one side of a home. The term "walkout" is used because most basements of this type have an outside door or doors (entry door, garage door, or both) at ground level (see figure below). Note that if a basement floor is below grade on all sides (a basement as defined by the NFIP regulations) the basement may still have an outside door, but the door will be below ground level and stairs will be required for access.



Walkout-on-Grade Basement



SubGrade Basement

DEFINITION

Flood protection elevation – The elevation you choose to protect your home against the flood hazard. Although it is feasible for you to have a flood protection elevation less than the DFE, protecting your home to at least the DFE is recommended.

Design flood elevation (DFE) – The elevation of the design flood relative to the datum specified on the community's FIRM or flood hazard map. The design flood is the greater of the following two flood events: (1) the base flood, affecting those areas identified as special flood hazard areas on the community's FIRM; or (2) the flood corresponding to the area designated as a flood hazard area on a community's flood hazard map or otherwise legally designated. The I-Codes, ASCE 7, and ASCE 24 use the term DFE. In many communities, the DFE is identical to the BFE. Communities may designate a design flood (or DFE) in order to regulate based on a flood of record, to account for future increases in flood levels based on upland development, or to incorporate freeboard.

Base flood elevation (BFE) – The elevation of the base flood relative to the datum specified on a community's FIRM. The base flood has a 1 percent chance of being equaled or exceeded in any given year. BFEs are shown on FIRMs for many SFHAs. Relative to NFIP requirements, the BFE is the minimum elevation to which the lowest floor of a building must be elevated or floodproofed (Zone A). In Zone V, the bottom of the lowest horizontal structural member must be elevated to or above the BFE; floodproofing is not permitted in Zone V. Many SFHAs are shown on FIRMs without BFEs; in these areas, community officials and permit applicants are required to obtain and use information from other sources, or must estimate or develop BFEs at specific locations.

Freeboard – An added margin of safety, expressed in feet above a specific flood elevation, usually the BFE. In States and communities that require freeboard, buildings are required to be elevated or floodproofed to the higher elevation. For example, if a community adopts a 2-foot freeboard, buildings are required to be elevated or floodproofed to 2 feet above the BFE.

As you will see in this chapter, different retrofitting methods protect your home in different ways. For example, when you elevate your home, you protect it by raising its lowest floor to a specified elevation. When you dry floodproof your home, you use sealants, shields and other measures to protect the part of your home below a specified elevation by preventing water from entering the building. Because some seepage is anticipated, sump pumps are used to control the seepage and flood-damage-resistant materials are used to prevent damage where seepage is likely to occur. The home's structural components must have the capacity to resist increased flood loads resulting from dry floodproofing. To wet floodproof, you allow floodwaters to enter your home, but prevent damage below a specified elevation by using flood-damage-resistant materials and construction techniques. When you protect your home with a levee or floodwall, the top of the levee or floodwall is constructed to a specified elevation. To meet the requirements of the NFIP and potentially reduce your flood insurance premium, FEMA recommends protecting your home to the DFE.

If your home is being Substantially Improved or has been Substantially Damaged, your community's floodplain management ordinance, regulation, or provisions of the building code will specify a DFE that is at least equal to the BFE (the elevation of the 1-percent-annual-chance flood). Communities may require a higher DFE if they wish, or they may be required to do so by State law. Some States and communities require a higher DFE by establishing freeboard requirements, as discussed in Section 3.1.4. Your local officials can advise you about this.

On the other hand, if NFIP compliance is not required (the building does not have to meet the requirements of Substantial Improvement/Damage), then you may choose to have a flood protection level less than the DFE.

Although you cannot use a flood protection elevation lower than that required by your community, you are probably free to use a higher elevation if you wish to provide a greater level of flood protection. Depending on your situation, your choice of flood protection method and optimal elevation will be based largely on the cost to elevate to different elevations, the risk reduction provided by different elevations, and the annual cost of insurance premiums at different elevations.

In general, you will find that the cost of retrofitting increases as your flood protection elevation increases. For example, protecting your home to the elevation of the 2-percent-annual-chance flood with one of the methods described in this guide will probably cost you less than protecting it to the BFE with the same method (although the additional cost to protect to the BFE may be small). Although using a lower flood protection elevation may result in a less expensive retrofitting project, it exposes your home to a greater risk of flood damage and higher insurance rates. So in choosing a flood protection elevation, you must consider not only how much you are willing to pay, but also the level of risk you are willing to accept, including the potential for damage, financial loss, and emotional distress. For example, recent studies have shown that adding 1 to 3 feet of freeboard above the BFE to an elevation project can pay for itself within a few years through a 25 to 60 percent annual reduction in flood insurance premiums.

NOTE

A single-story home that is valued at $150,000 and located in Zone AE can have differing insurance premiums based on the level of protection. If the home is elevated to the BFE and does not have an enclosure, the annual premium would be approximately $1,294. If the same home is elevated to 2 feet above the BFE, the annual premium would be approximately $389. The increase in the flood protection level would result in a 70 percent savings in annual insurance premiums that would be passed onto the homeowner.

One way to see the relationship between your flood protection level and risk is to look at the probabilities associated with floods of various magnitudes during a period of 30 years, which is also the same length of a standard mortgage (Figure 3-1). The percentages shown along the vertical axis of the graph in Figure 3-1 are the probabilities that a flood will be equaled or exceeded during a 30-year period. This probability decreases as the magnitude of the flood increases. So the probability of a flood with an elevation equal to or greater than the flood protection elevation you choose decreases as your flood protection elevation increases. For example, compare the risks associated with the 2-percent-annual-chance (50-year) flood and the base flood. If you choose a flood protection elevation equal to the elevation of the 2-percent-annual-chance (50-year) flood, the probability that a flood as high as or higher than your flood protection elevation will occur during a 30-year period is 45 percent. But if you choose a flood protection elevation equal to the 1-percent-annual-chance flood (100-year flood or base flood), the probability drops to 26 percent. Although the base flood serves as the basis for NFIP insurance rates and regulatory floodplain management requirements, the relative frequency of any given flood (e.g., 2- year or 10-year) serves as a useful reference point when selecting a retrofitting option, evaluating cost effectiveness, and comparing relative risk.

Regardless of the flood protection elevation you choose or are required to use, you must realize that a larger flood is always possible and that there will always be some risk of damage. If you don't have flood insurance, you should purchase a policy; if you have flood insurance, you should maintain your policy, even if you have protected your home to or above the BFE. Once a home has been retrofitted to meet the NFIP requirements for Substantially Improved structures, it will probably be eligible for a lower flood insurance rate depending on the level of protection of your flood retrofit. Note that dry floodproofing of residential structures is not permitted to meet NFIP requirements, and is not recognized for flood insurance premium reduction purposes. Also, unless a floodwall or levee is accredited, it is not recognized for flood insurance premium reduction purposes.

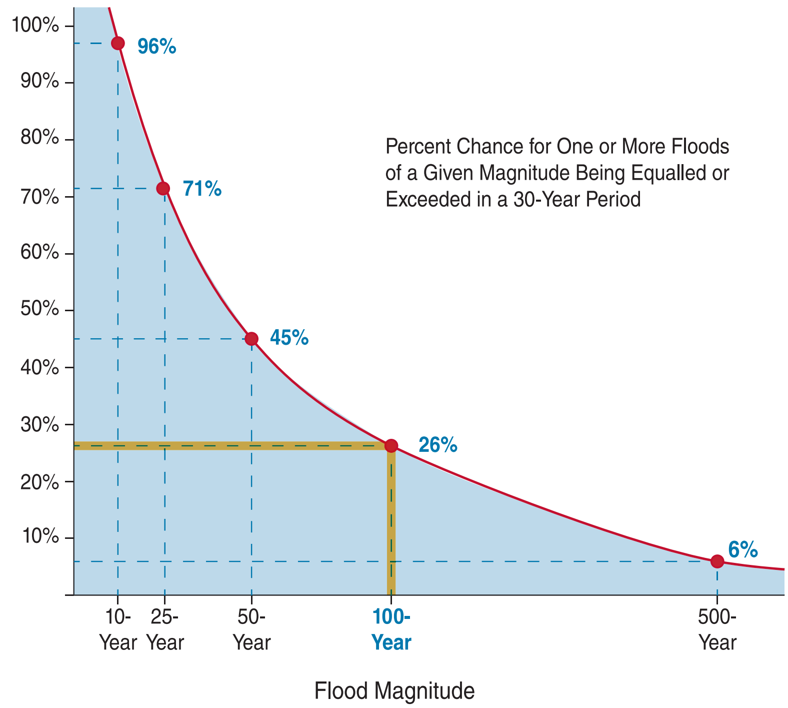


Figure 3-1. This graph shows the relationship between flood recurrence intervals and the probability of an event occurring within a 30-year period.

3.1.4 Freeboard and Flood Mapping Uncertainties

If you are protecting your home by elevating it, dry floodproofing it, or building a levee or floodwall, you should include a minimum of 1 foot of freeboard in your flood protection elevation, even if your community does not require you to do so. For example, if you are elevating your home to protect it from the base flood, your flood protection elevation should be equal to the BFE plus 1 foot.

Freeboard is recommended because of uncertainties regarding expected flood elevations. These uncertainties exist for several reasons, but the two primary reasons are limitations of the analytical methods used in floodplain studies and potential effects of future **watershed** development, such as the construction of buildings and roads.

> **DEFINITION**
>
> The **watershed** of a stream is the geographic area that contributes surface water, from rain or melting snow, to that stream.

FEMA and other agencies that perform floodplain studies use a variety of standard engineering methodologies to determine flood frequencies and flood elevations. These methods involve the use of historical data, field measurements, and assumptions and judgments, all of which can affect the accuracy of the results. Some amount of uncertainty regarding the results is, therefore, unavoidable, and the potential for flood elevations higher than those expected should always be accounted for in retrofitting. For example, FEMA's FIRMs include areas subject to the 0.2-percent-annual-chance flood (designated on FIRMs as Zone B or shaded Zone X) and areas outside of the 0.2-percent-annual-chance flood (designated on FIRMs as Zone C or unshaded Zone X). Homes constructed in Zones B, C, or X are not considered to have a high risk of flooding by the NFIP, but that does not mean that they are not subject to flooding. In fact, 25 to 30 percent of all flood insurance claims are for flood damages that occur in one of these zones.

Another example of uncertainties in mapping exists in coastal areas. Coastal FIRMs show Coastal High Hazard Areas (designated on FIRMs as Zones V, VE, and V1–V30), which are subject to waves of 3 feet or higher. However, historic observations have shown that many coastal homes located outside of Zone V areas still experience significant damage from moderate wave heights of 1.5 to 3 feet. For this reason, FEMA is working to update many coastal FIRMs to include SFHAs seaward of the LiMWA, also known as Coastal A Zones. Zone A in coastal areas is divided by the LiMWA. The LiMWA represents the landward limit of the 1.5-foot wave. The area between the LiMWA and the Zone V limit is known as the Coastal A Zone for building code and standard purposes and as the Moderate Wave Action (MoWA) area by FEMA flood maps. Again, this area is subject to wave heights between 1.5 and 3 feet during the base flood. The area between the LiMWA and the landward limit of Zone A due to coastal flooding is known as the Minimal Wave Action (MiWA) area and is subject to wave heights less than 1.5 feet during the base flood. Although not an NFIP requirement, FEMA recommends that homes located in Coastal A Zones meet the same requirements as homes constructed in Zone V areas. Figure 3-2 is a typical paper FIRM showing the delineations between Zone V, the MoWA area, the LiMWA, Zone A, and the MiWA area. Figure 3-3 is an example of a transect perpendicular to the shoreline showing the delineations between Zone V, the MoWA area, the LiMWA, Zone A, and the MiWA area.

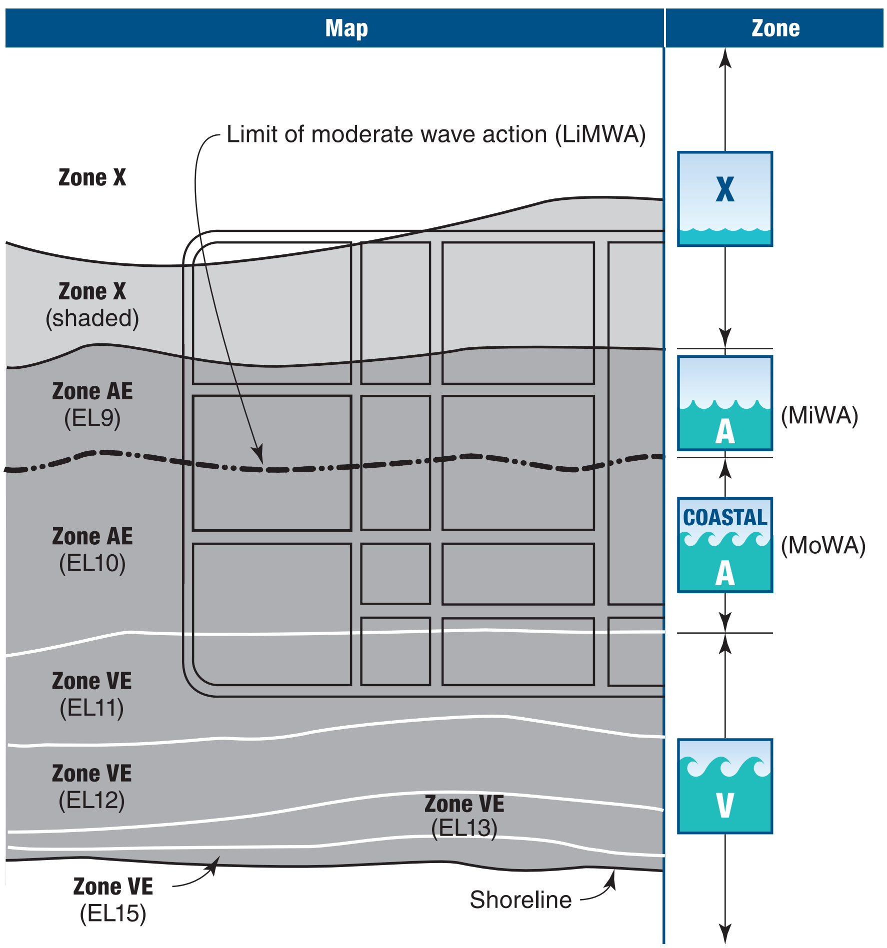


Figure 3-2. Portion of a paper FIRM showing coastal flood insurance rate zones. The icons on the right indicate the associated flood hazard zones for design and construction purposes. The LiMWA is not shown on older FIRMs, but is shown on newer FIRMs.

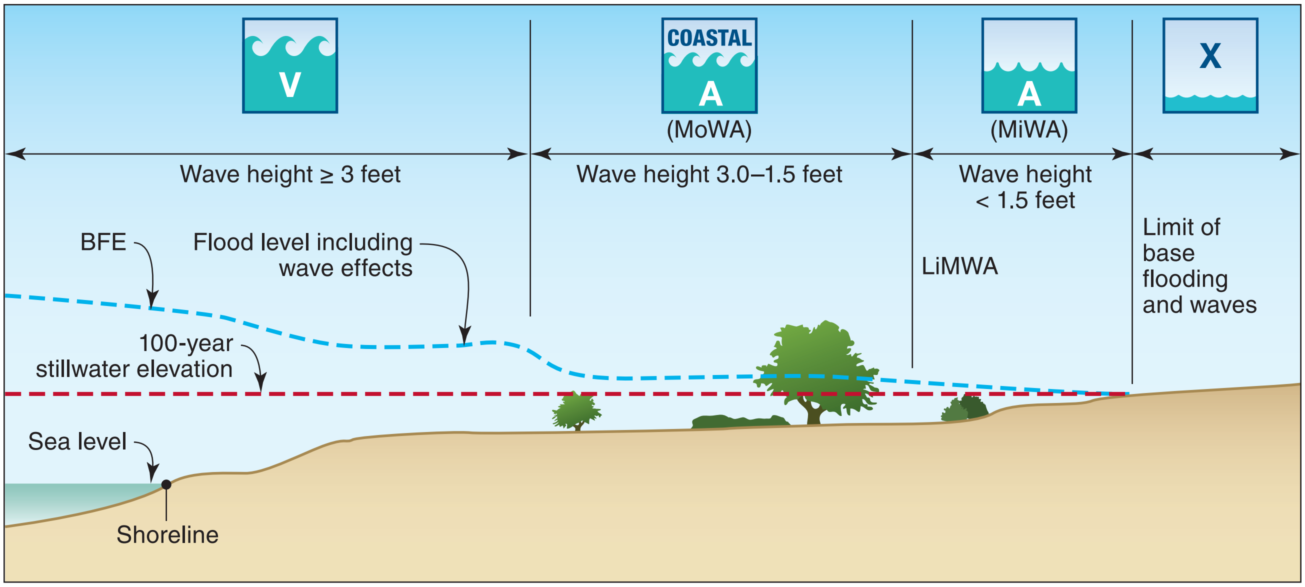


Figure 3-3. Typical transect perpendicular to the shoreline showing the delineations between Zone V, the MoWA area, the LiMWA, Zone A, and the MiWA area.

Development in a watershed can increase the size and frequency of floods in that watershed. In general, watershed development reduces the amount of open ground available to absorb water from rain and melting snow and, therefore, increases the amount of water that makes its way into streams. As a result, in a developing watershed, an amount of rainfall that might have caused minor floods in the past may cause larger floods and higher elevations in the future.

FEMA's floodplain studies are based on the watershed conditions existing at the time the studies are performed. They do not account for potential increases in watershed development or any other changes that might affect the sizes of future floods. The reason for this approach is that one of the primary purposes of FISs and FIRMs is to provide the technical basis for establishing flood insurance rates. Therefore, the flood hazards must be shown as they are, not as they might be. Also, attempting to predict the level of future watershed development in every study and determine the effects not only would be extremely difficult but also would require additional assumptions and judgments that could increase uncertainty. However, in many watersheds, some amount of development is inevitable. So, providing freeboard is a prudent means of protecting against the increased flood elevations that may result.

3.1.5 Human Intervention

Retrofitting methods fall into two general categories: those that depend on **human intervention**, which are referred to as "active" methods, and those that do not, which are referred to as "passive" methods. For example, elevating your home does not require human intervention to be effective. But what if you have a floodwall with an opening for your car? In addition to requiring interior drainage, a floodwall with an opening will protect your home only if you can close the opening before flooding occurs. So your floodwall will have to be fitted with a gate (or some other type of closure mechanism), and every time flooding threatens, you will have to be warned far enough in advance so that you can close the gate in time.

> **DEFINITION**
>
> **Human intervention** is any action that a person must take to enable a flood protection measure to function as intended. This action must be taken every time flooding threatens.

The need for adequate warning time and human intervention makes active methods less reliable than passive methods. You should try to avoid active methods when you choose a retrofitting method for your home, keeping in mind that active methods cannot be used to bring a home into compliance with the NFIP. If your retrofitting project includes active methods, you must have a plan that describes what actions you will take to make the measures work and when you will take those actions.

WARNING

Some communities may restrict or prohibit the use of active retrofitting methods for flood protection.

3.1.6 Other Considerations

The retrofitting measures discussed in this guide may be the best means of protection for a home in an area where a large flood control project or major waterway improvement, is not feasible, warranted, or appropriate. You should keep the following in mind whenever you consider a retrofitting project:

- Communities participating in the NFIP require permits for all development within the regulatory floodplain. Under your community's floodplain ordinance or law, any changes to buildings and other structures are considered "development." These changes include improvements and repairs of existing buildings and other structures. Also, communities usually require building permits for many of the activities associated with the retrofitting methods described in this guide. In communities that have adopted a floodplain ordinance or law, health code, and building code, the permits required by these ordinances, laws, and codes may be issued separately or as one combined permit. You may need a permit for the following:
  - Modifying your existing home or building a new home on a flood-prone site. A floodplain permit and possibly a building permit will be required.
  - Moving a home on public rights-of-way. If you relocate your home, you will probably need a permit, not only from your community but also from your State, as well as from any other communities through which the home will pass on its way to the new site. A relocation project may also require a permit for the foundation at the new site.
  - Demolishing a damaged home and restoring the site after demolition, including grading, planting vegetative cover, capping and abandoning utilities, and removing or securing underground septic and fuel storage tanks.

  You may wish to obtain the permits necessary for your retrofitting project yourself or arrange for your retrofitting contractor or design professional to obtain them. But remember, you must have the necessary permits in hand before you begin your project. As discussed in Chapter 4, your local officials are the best source of information about State and local permit requirements.

CROSS REFERENCE

Your design professional or contractor should review some or all of the applicable versions of the following nationally recognized codes and standards:

- International Code Council, *International Building Code* (IBC)
- International Code Council, International Existing Building Code (IEBC)
- International Code Council, *International Residential Code* (IRC)
- ASCE, *Minimum Design Loads for Buildings and Other Structures* (ASCE 7)
- ASCE, *Flood Resistant Design and Construction* (ASCE 24)
- See Appendix A for more information.

- In addition to meeting the requirements of the floodplain management ordinance and building codes, you may need to comply with the requirements of *other Federal, State, and local laws and ordinances, such as those dealing with zoning setbacks and wetlands*. Again, your local officials are the best source of information about these requirements.
- If your retrofitting project will involve financial assistance from a Federal agency and your property is 50 years old or older, you must work with that agency to *ensure that your project complies with the National Historic Preservation Act* (16 U.S.C. 470). The act requires that, before releasing any Federal assistance, the agency determine whether the property is eligible for inclusion in the National Register of Historic Places and if so, whether your project will have any effect on the historic character of the property. This requirement may not apply in some emergency situations or if the agency has made prior arrangements with historic preservation officials. For more information, contact your SHPO (Appendix E).
- Most retrofitting measures should be *designed and constructed by experienced professionals*, such as contractors, engineers, and architects. Using professionals helps you make sure that the work is done properly, that code and regulatory requirements are met, and that, once completed, the retrofitting measures will work.
- Most retrofitting measures cannot be simply installed and forgotten. You will need to *periodically inspect and maintain them* to be sure that they will continue to work over time, especially if they require human intervention or depend on certain materials.
- Even though retrofitting will help protect your home from flooding, *you should never remain in your home during flooding*. Stay informed about flooding conditions by monitoring local radio and television stations. Be prepared to evacuate when necessary.
- Elevating your home may reduce the cost of your NFIP flood insurance policy. Relocating a home to a site outside the regulatory floodplain eliminates the mandatory flood insurance purchase requirement and significantly reduces the cost of flood insurance for an owner who wishes to purchase a policy.

3.2 Construction Terminology

In the remainder of this guide, you will find many references to common types of home construction, such as frame or masonry, and common types of home foundations, such as slab-on-grade or crawlspace. Even if you are already familiar with these and other home construction terms, take a minute to review the following information before you move to the descriptions of the retrofitting methods.

3.2.1 Construction Type

The most common home construction types are (Figure 3-4):

Frame – walls constructed of wood or light-gauge metal studs, with wood, vinyl, or aluminum siding

Masonry veneer – frame walls with a non-structural, decorative, exterior layer of brick, stone, or concrete block instead of siding

Masonry – walls constructed of brick, stone, or concrete block

Modular home – frame home assembled on site on a permanent foundation from separate sections manufactured elsewhere (subject to local building codes)

Manufactured home – prefabricated frame home constructed on a transportable frame that can be placed on a permanent or temporary foundation (subject to Federal and State standards)

Some homes consist of combinations of two or more of these construction types.

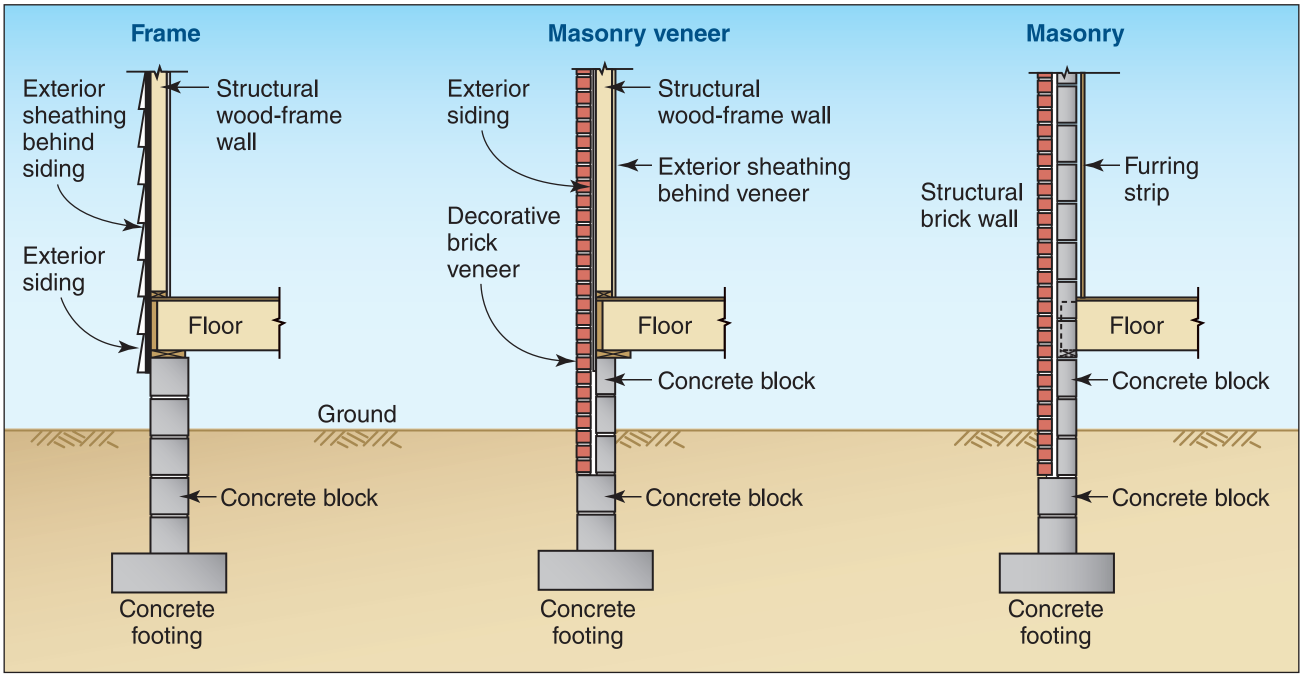


Figure 3-4. Typical cross-sections of three common construction types: frame, masonry veneer, and masonry. The foundation shown here for all three construction types consists of concrete blocks and a concrete footing. The same construction types are also found on basement and slab-on-grade foundations.

3.2.2 Foundation Type

Most homes of the construction types listed above are built on the following types of foundations (Figure 3-5):

Basement – with masonry or **cast-in-place** concrete walls

Crawlspace – with masonry or cast-in-place concrete walls

Slab-on-grade – either a slab with a masonry or concrete foundation or a thickened slab (see Figure 5-5 in Chapter 5)

Open foundation – usually concrete or masonry piers, but sometimes wood, concrete, or metal posts, columns, or piles

Some homes are built on more than one type of foundation. Various combinations of basement, crawlspace, and slab-on-grade foundations are common. Manufactured homes are occasionally installed on basement or crawlspace foundations but are more often supported either by stacks of concrete blocks or by foundation systems designed specifically for manufactured homes.

DEFINITION

Concrete poured into forms at the construction site is referred to as **cast-in-place** concrete.

WARNING

The relative costs in this chapter are provided only as examples of what to expect when choosing a retrofitting method. Be sure to get a complete, written cost estimate from your contractor and design professional before you begin any retrofitting project (see Chapter 4).

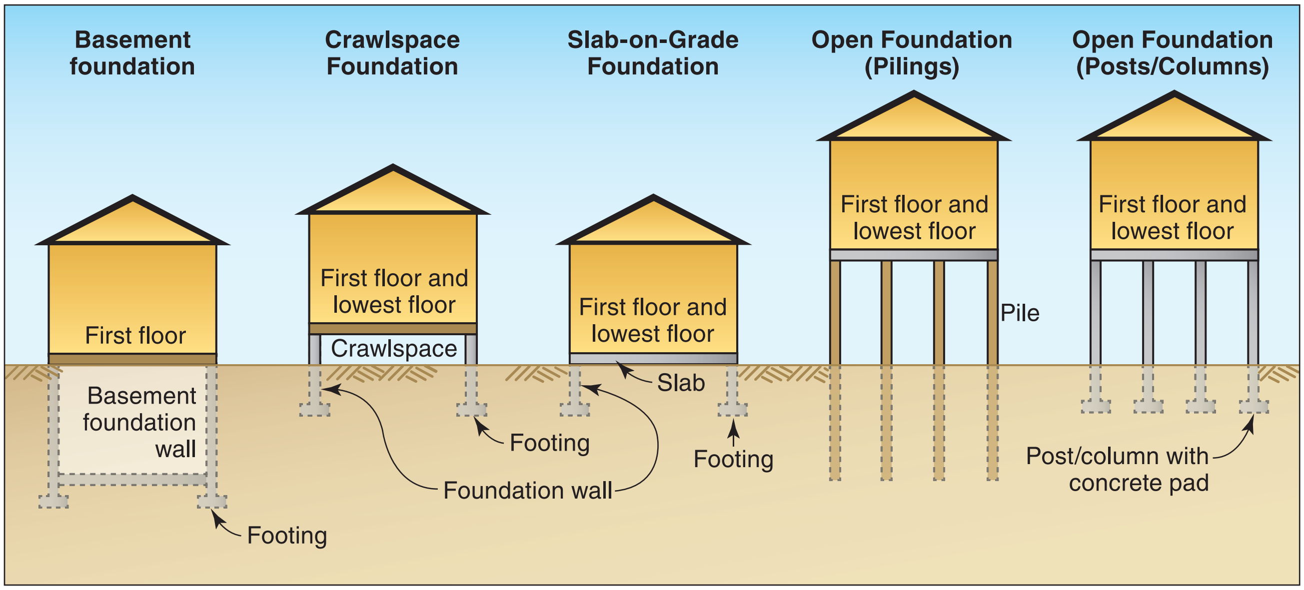


Figure 3-5. Home foundation types.

3.3 Retrofitting Methods and Costs

The following sections give an overview of the six retrofitting methods, explain how they work and where they are appropriate, and list their advantages and disadvantages. With this information, you will be ready for Chapter 4, *Deciding Which Method Is Right for Your Home*.

NOTE

When you elevate your home, the existing foundation will need to be extended or demolished and rebuilt. This decision will depend on the condition of the existing foundation and its ability to carry additional loads.

3.3.1 Elevation

Elevating a home to prevent floodwaters from reaching living areas is an effective retrofitting method. The goal of the elevation process is to raise the lowest floor to or above the DFE. You can do this by elevating the entire home, including the floor, or by leaving the home in its existing position and constructing a new raised floor within the home. The method used depends largely on construction type, foundation type, and flooding conditions. Chapter 5 presents more detailed information on elevation.

During the elevation process, most homes (including manufactured homes) are separated from their foundations, raised on hydraulic jacks, and held by temporary supports while a new or extended foundation is constructed below. This method works well for homes originally built on basement, crawlspace, and open foundations. As explained later in this section, the new or extended foundation can consist of continuous walls or separate piers, posts, columns, or piles.

CROSS REFERENCE

FEMA P-550, *Recommended Residential Construction for Coastal Areas: Building on Strong and Safe Foundations* (FEMA. 2009), offers more detail about these foundation types and elevation.

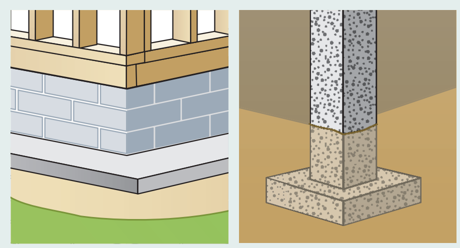
For homes with slab-on-grade foundations, elevation can be done in one of two ways. One approach is to leave the home attached to the slab foundation and lift both together. After the home and slab are lifted, a new foundation is constructed below the slab. The other approach is to detach the home from the slab and elevate the home, leaving the slab foundation in place. After the home is lifted, a new, elevated floor is constructed.

CROSS REFERENCE

FEMA has produced a videotape titled *Best Build 3: Protecting a Flood-Prone Home*, which illustrates the retrofitting methods described in this guide (see Appendix A).

DEFINITION

A **footing** is the base of a foundation. Footings are usually made of concrete and may be reinforced with steel bars. Foundation walls are supported on continuous footings; separate foundation members, such as piers, are supported on individual footings.



Continous footing   Individual footing

NOTE

Elevation on open foundations is required by the NFIP in Zone V areas (even when the ground elevation lies above the BFE) and is strongly recommended for Coastal A Zones. Some States and communities have formally adopted open foundation requirements for Coastal A Zone construction.

Unlike other types of construction in which elevation can be relatively straightforward, elevating slab-on-grade homes with the slab intact is technically challenging and often not feasible. When a slab-on-grade home is elevated with the slab intact, the slab, which was previously continuously supported by the soils beneath it, must function as a structural element. It must span the distance between the portions of the foundation that support the elevated home. Typically, these slabs often are either unreinforced or only lightly reinforced with welded wire fabric and are essentially non-structural. These slabs may not be able to support the loads of an elevated home. Consequently, the slab foundation should be thoroughly evaluated by a registered design professional before choosing this mitigation option.

Alternative techniques are available for masonry homes on slab-on-grade foundations. As described later in this section, these techniques do not require the lifting of the home. Instead, they involve raising the floor within the home or moving the living space to an upper story. Guidance for elevating slab-on-grade masonry homes can be found in FEMA P-347, *Above the Flood: Elevating Your Floodprone House* (FEMA. 2000).

Although elevating a home can help protect it from floodwaters, you need to consider other hazards before choosing this method. Elevating the home can make it more susceptible to damage from earthquakes. In addition, both continuous wall foundations and open foundations can fail as a result of damage caused by erosion and the impact of debris carried by floodwaters. If portions of the original foundation, such as the **footings**, are used to support new walls or other foundation members, or a new second story, they must be capable of safely carrying the additional loads imposed by the new construction and the expected flood, wind, and earthquake forces.

Method #1: Elevating on Continuous Foundation Walls

Although this method is usually used in flood hazard areas where the risks of wave action and high-velocity flow are low (Figures 3-6 and 3-7), continuous foundation walls in low-velocity flow areas with wave action can also be susceptible to structural damage. Open foundations should be considered as a reasonable mitigation option. After the home is detached from its foundation and raised on jacks, the existing foundation is often saved and the foundation walls are extended. The new portions of the walls are usually made of masonry block or cast-in-place concrete. Although this method may be the easiest way to elevate a home, it can involve some additional construction modifications or reinforcements.

Figure 3-6. Typical cross-section of home elevated on continuous foundation walls.

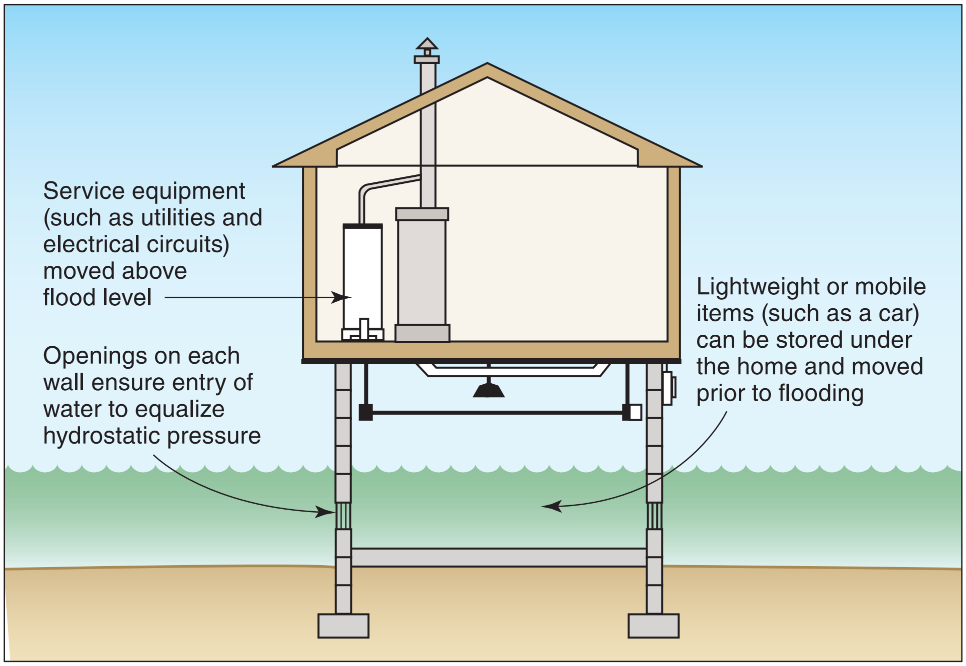


Figure 3-7. Before (left) and after (right) photos of a retrofitted home elevated on extended continuous foundation walls.

Depending on the size of your home, the amount of elevation, and the magnitude of the potential environmental loads (such as those from floods, wind, earthquakes, and snow), your contractor may have to modify or reinforce the footings and foundation walls to ensure the structural stability of the home. The original footings may have to be replaced with ones that have a higher capacity for environmental loads. Both the footings and the foundation walls may need to be reinforced with steel bars.

This type of foundation creates what is referred to under the NFIP as an "enclosure." The enclosure must be constructed of flood damage-resistant materials, have all service equipment elevated above the DFE, and be used only for parking, access, or storage. NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* (FEMA. 2008), defines a "flood [damage]-resistant material" as "any building product [material, component, or system] capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage."

"Prolonged contact" means at least 72 hours, and "significant damage" means any damage requiring more than cosmetic repair. Technical Bulletin 2 provides a detailed list of appropriate flood damage-resistant materials and also classifies flood damage-resistance of materials as acceptable or unacceptable based on water resistance and ability to be cleaned.

The enclosure must also be constructed with openings to allow equalization of hydrostatic pressure to comply with NFIP and building code requirements. As explained in Chapter 2, unequalized hydrostatic pressure exerted by floodwaters can collapse walls, regardless of the construction materials used. The NFIP may require that openings be installed in the foundation walls so that water can flow into and out of any enclosed area below the newly elevated home. NFIP Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures* (FEMA. 2008), provides guidance on the NFIP regulations concerning openings in foundation walls. When the water levels on both sides of the foundation walls are the same, the hydrostatic pressure is equalized. If you are elevating your home as part of a Substantial Improvement or in connection with repairs of Substantial Damage, your community's floodplain management ordinance, regulation, or provisions of the building code will require that you install openings in all areas below the BFE. Consult your local officials about local requirements for openings.

Method #2: Elevating on Open Foundations

Unlike continuous foundations, open foundations consist of individual vertical structural members that support the home only at key points. Because they present less of an obstacle to flood flows than continuous walls, open foundations can be used in areas where there are risks of wave action and high-velocity flood. Most open foundations consist of piers, posts, columns, or piles.

Piers. Piers (or columns) are commonly built with masonry block or are made of cast-in-place concrete (Figure 3-8). Piers can be made from wood and steel as well. The bottom of each pier sits on a concrete footing. Pier foundations are used in conventional construction; they are not just a means of elevating a flood-prone home. In conventional use, they are designed primarily for vertical loading—to hold the weight of the home. They are not normally designed to resist large horizontal forces, such as those associated with moving floodwaters, waves, impacts from floodborne debris, wind, and earthquakes. As a result, pier foundations are generally used where the risks of wave action and high-velocity flow are low to moderate and the potential for earthquakes is low.

If you decide to elevate your home on a pier foundation, you should expect your contractor to reinforce the piers and footings with steel reinforcing bars and to connect the piers to the footings so they will not separate under flood or other forces. Adequate connections between the piers and the home are also necessary so that the home and foundation will resist lateral loads from floods, winds, and earthquakes, and uplift from buoyancy.

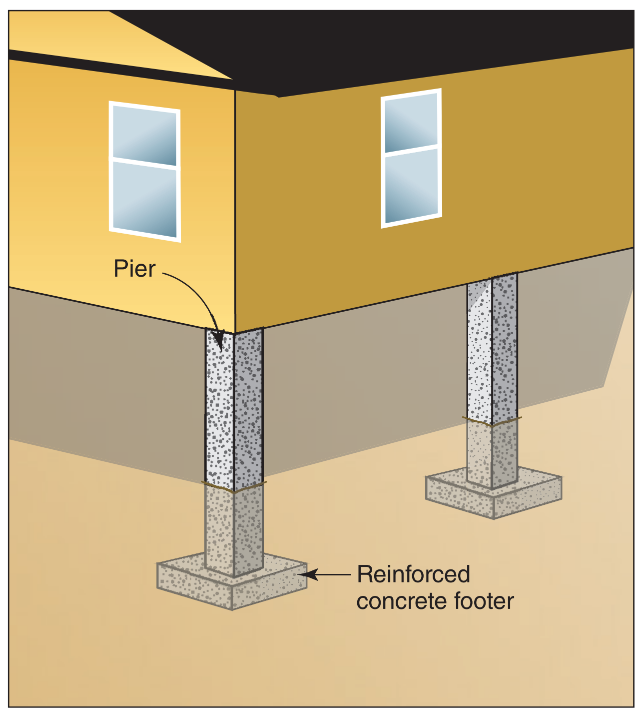


Figure 3-8. Home elevated on reinforced concrete piers.

Posts. Posts are usually made of wood or steel (Figure 3-9). They are generally square but may also be round. Posts are set in holes, and their ends are encased in concrete, or supported on concrete pads (as in the figure). After posts are set, the holes are filled with concrete, dirt, gravel, or crushed stone.

Posts can be connected to each other with bracing made of wood, steel rods, or guy wires. The type is usually determined by cost, flood conditions, expected loads, the availability of materials, and local construction practice. Like piers, posts are generally used where the risks of wave action and high-velocity flow are low to moderate.

One primary difference between piers, and posts is the dimension of the element – piers are larger in cross section because they usually are CMU (concrete masonry unit) or concrete block and are usually shorter than posts. Posts are braced together because they are usually taller and more slender with less stability than piers.

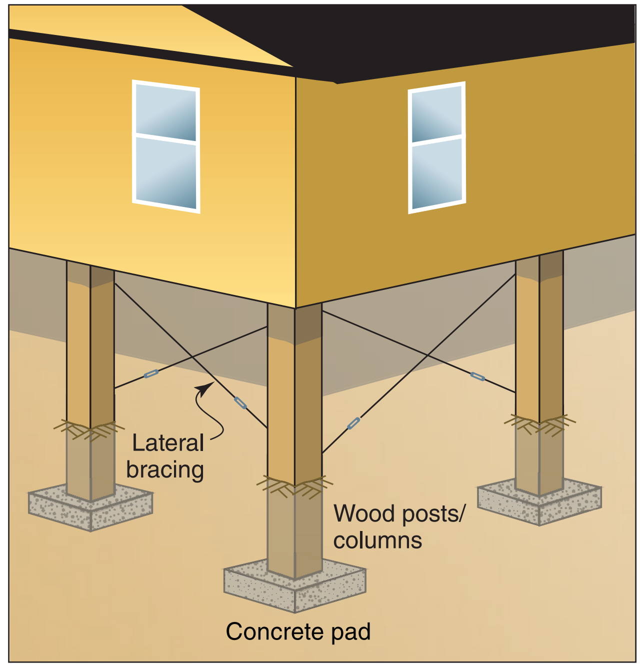


Figure 3-9. Home elevated on posts

Piles. Piles are usually made of wood, but fiber-reinforced polymer, steel, or **precast** concrete piles are also common in some areas (Figure 3-10). Piles are similar to posts but, instead of being set in holes, they are driven into the ground or jetted in with streams of water. Also, piles are embedded deeper in the ground than either piers or posts. As a result, pile foundations are less susceptible to the effects of high-velocity flow, waves, debris impact, erosion, and scour than the other types of open foundations. Piles differ from piers and posts also in that they do not rest on footings. Instead they are driven until they rest on a solid support layer, such as bedrock, or until they are embedded deep enough that the friction between the ground and the piles will enable them to resist the loads that are expected to act on them.

DEFINITION

Concrete materials such as posts, beams, and blocks that are brought to the construction site in finished form are referred to as **precast**.

Jetting is a process in which the hole for the installation of a pile is made by a high-pressure stream of water from a nozzle attached to the bottom of the pile.

Cribbing usually consists of a framework of crisscrossed timbers that provides temporary structural support.

Because driving and **jetting** piles requires bulky, heavy construction machinery, an existing home must normally be moved off its existing foundation and set on **cribbing** until the operation is complete. As a result, elevating a home by placing it on a pile foundation will usually require more space and cost more than elevating with another type of foundation. Pile foundations are used primarily in areas where other elevation methods are not feasible, such as where floodwaters are deep and the risks of wave action and high-velocity flow are great. For example, pile foundations are used extensively in oceanfront areas exposed to high-velocity flow, waves, and high winds (Figure 3-11).

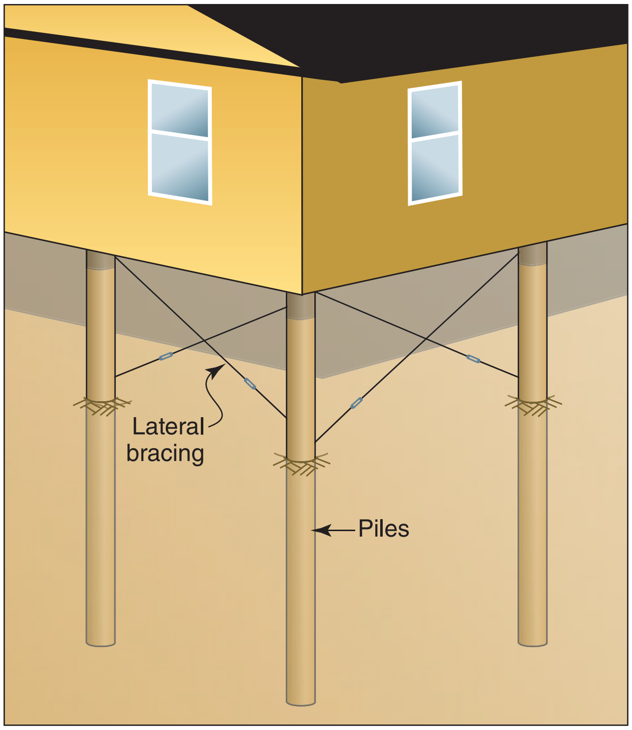


Figure 3-10. Home elevated on piles.

Figure 3-11. Example of well-elevated and embedded pile foundation tested by Hurricane Katrina. Note adjacent building failures (Dauphin Island, AL, 2005).

Methods #3 and #4: Elevating by Extending the Walls of the Home or Moving the Living Space to an Upper Floor

For masonry homes on slab-on-grade foundations, two alternative elevation methods are available. One is to remove the roof, extend the walls of the home upward, replace the roof, and build a new, raised floor at the DFE (Figure 3-12). This technique works best where the floor needs to be raised less than 4 feet to reach the DFE. The floor can be either a new slab or a new wood-framed floor. For a new slab, fill dirt is placed on top of the old slab and the new slab is built on top. If a new wood-framed floor is built, the space between it and the old slab is left open and becomes a crawlspace (and must be retrofitted with openings to allow floodwaters in the crawlspace).

CROSS REFERENCE

As discussed in Section 2.6, the cost of elevating a Substantially Damaged home may be eligible for a flood insurance claim under ICC coverage.

Figure 3-12. The owner of this flood-prone home in south Florida decided to build a new wood-framed second story on top of the masonry first story. The new second story is well above the BFE.

The second technique is to abandon the entire lower floor, or lower enclosed area, of the home and move the living space to an existing or newly constructed upper story. This technique works best for multi-story homes where the DFE is more than 4 feet above the level of the lower floor. The abandoned lower floor or enclosed area is then used only for parking, building access, or storage.

These techniques, like the others, have their limitations. The portions of the home below the DFE will be exposed to flooding and must, therefore, be made of flood damage-resistant materials. That is why this method is applicable to masonry homes rather than frame homes, which would be much more easily damaged by flooding. The area below the DFE cannot be used for living space; it may be used only for parking, building access, or storage. In addition, all appliances and utilities must be moved to the upper floor. Also, openings must be cut into the walls of the lower floor to allow water to enter during flooding so that the hydrostatic pressure on the walls will be equalized. In essence, the lower floor is wet floodproofed (see Section 3.4.1).

Adding a new second story to a single-story home may require that the foundation be strengthened so that it can support the additional load. You must consult an engineer if you plan to use this method. The second story can be frame or masonry (to match the lower floor). The method you choose will depend on the advice of your engineer, cost, appearance, the availability of materials and experienced contractors, and the risks of other natural hazards such as hurricanes and earthquakes.

Table 3-1 presents the advantages and disadvantages of elevation.

The relative costs shown in Table 3-2 are for elevating frame, masonry veneer, and masonry homes of various foundation types. The costs for extending utilities and adding or extending staircases are included. The costs shown for elevating frame, masonry veneer, and masonry homes on existing slab-on-grade foundations are based on the assumption that the home is raised with the existing slab attached.

Table 3-1. Advantages and Disadvantages of Elevation

Advantages	Disadvantages
• Brings a Substantially Damaged or Improved building into compliance with the NFIP if the lowest horizontal structural member of the lowest floor is elevated to the BFE • Reduces flood risk to the structure and its contents • Eliminates the need to relocate vulnerable items above the flood level during flooding • Often reduces flood insurance premiums • Uses established techniques • Can be initiated quickly because qualified contractors are often readily available (unless project is implemented immediately after a disaster) • Reduces the physical, financial, and emotional strains that accompany flood events • Does not require the additional land that may be needed for floodwalls or levees	• May be cost-prohibitive • May adversely affect the structure's appearance • May adversely affect access to the structure • Cannot be used in areas with high-velocity water flow, fast-moving ice or debris flow, or erosion, unless special measures are taken • May require additional costs to bring the structure up to current building codes for plumbing, electrical, and energy systems • Requires consideration of forces from wind and seismic hazards and possible changes to building design

NFIP = National Flood Insurance Program; BFE = base flood elevation

Table 3-2. Relative Costs of Elevating a Home

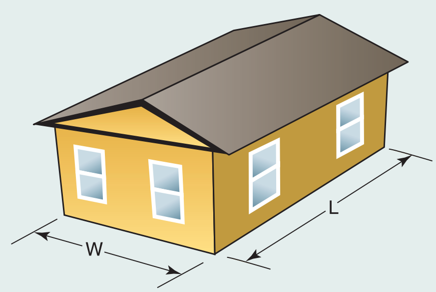
Construction Type	Existing Foundation	Retrofit	Relative Cost
Frame	Basement, crawlspace, or open foundation	Elevate on continuous foundation walls or open foundation	Lowest
Frame with masonry veneer		Elevate on continuous foundation walls or open foundation	
Load bearing masonry		Extend existing walls and create new elevated living area	
Frame	Slab-on-grade	Elevate on continuous foundation walls or open foundation	
Frame with masonry veneer		Elevate on continuous foundation walls or open foundation	
Load bearing masonry		Elevate on continuous foundation walls or open foundation	Highest

Occasionally, slab-on-grade homes are raised without the slab. Although this method can be less expensive than raising the home with the slab, it involves detaching the home from the slab and requires extensive alterations to interior and exterior walls.

The cost of abandoning an existing lower level will depend on whether the home already has an upper level that can be used for living space. If an upper level is available, abandoning the lower floor would involve primarily elevating or relocating utilities, adding openings in the lower-level walls, and ensuring that all construction materials below the BFE are flood damage resistant. This method is well-suited to a home with a walkout-on-grade basement, which can be wet floodproofed and used for parking, building access, or storage. The cost of adding a new frame upper level and raising the roof to accommodate the new level would vary, depending upon the amount of interior finishing and other factors.

DEFINITION

The footprint of a house is the land area it covers (see figure). This area is equal to the length of the house multiplied by its width. Note that the footprint is not necessarily equal to the total square footage of the house.



Footprint = L x W

3.3.2 Relocation and Demolition

Relocation is the retrofitting measure that can offer the greatest security from future flooding. It involves moving an entire structure to another location, usually outside the floodplain. Relocation as a retrofitting measure not only relieves anxiety about future flooding, but also offers the opportunity to reduce future flood insurance premiums. Demolition is tearing down a damaged home. A new compliant home can be rebuilt on site, rebuilt on another property, or the owner can simply move in to another structure elsewhere. These retrofitting methods are discussed below.

Relocation

Moving your home to high ground, outside the flood hazard area, is the most effective of the retrofitting methods described in this guide. Retrofitting literature commonly refers to this method as relocation. Chapter 6 presents more detailed information on relocation. When there is enough space and the ground is high enough, you may even be able to move your home to another location on the same piece of property.

Relocating a home involves detaching it from the foundation, raising it with jacks, and placing it on a wheeled vehicle that delivers it to the new site. The original foundation is demolished and a new foundation is built at the new site. The home is installed on the new foundation and all utility lines are connected. Relocation is particularly appropriate in areas where the flood hazard is severe, such as where flood conditions are characterized by one or more of the following:

- Deep water
- Rapid rates of rise and fall
- Short warning time
- Wave action
- High-velocity flow
- High debris potential
- Long duration
- Erosion

Relocation is also appropriate for homeowners who want to be free of worries about damage from future floods that may exceed a selected flood protection elevation.

Although similar to elevation, relocation requires additional steps that usually make it more expensive. These include moving the home, buying and preparing a new site (including building the new foundation and providing the necessary utilities), and restoring the old site (including demolishing the old foundation and capping and abandoning old utility lines).

Homes of all sizes and types can be relocated, either as a unit or in segments. One-story frame homes are usually the easiest to move, particularly if they are built on a crawlspace or basement foundation that provides easy access to the floor framing. Masonry homes can also be moved, but usually with more difficulty and at a higher cost.

Professional home movers can advise you about the things you need to consider when deciding whether to relocate. The structural integrity of your home will have to be checked. Also, you may need to find a place where you can store furniture and other belongings temporarily. However, in most instances, the contents of your home may remain in the home while it is being moved. Keep in mind that there must be a clear route to the new site. Narrow roads, restrictive overpasses, and bridges with low weight limits may make it impossible for your home to be moved to the new site. Also, many States and communities have requirements that govern the transport of homes and other buildings on public rights-of-way. For information about structural movers in your area, visit http://www.iasm.org. Table 3-3 presents the advantages and disadvantages of relocation.

Table 3-3. Advantages and Disadvantages of Relocation

Advantages	Disadvantages
• Allows Substantially Damaged or Improved structure to be brought into compliance with the NFIP • Significantly reduces flood risk to the structure and its contents • Uses established techniques • Can be initiated quickly because qualified contractors are often readily available (unless project is implemented immediately after a disaster) • Can eliminate the need to purchase flood insurance or reduce the premium because the home is no longer in the floodplain • Reduces the physical, financial, and emotional strains that accompany flood events	• May be cost-prohibitive • Requires locating a new site • Requires addressing disposition of the flood-prone site • May require additional costs to bring the structure up to current building codes for plumbing, electrical, and energy systems • May take a long time, depending on time required to find desired property, purchase it, and develop it with desired utilities • May be cost-prohibitive to relocate, as well as to develop the site with desired utilities (water, sewage, electrical, natural gas, cable, telephone etc.)

NFIP = National Flood Insurance Program

Table 3-4 shows the relative costs of relocating homes of different construction and foundation types. In addition to moving and construction costs, it is important to account for the additional relocation project costs of any new property that must be purchased.

WARNING

The relative relocation costs shown here are based on a small home. Because relocation costs do not increase proportionally with the size of a home, the cost per square foot of moving a larger home may be less than that shown here.

Table 3-4. Relative Costs of Relocation

<table>
<tr><th>Construction Type</th><th>Existing Foundation</th><th>Retrofit</th><th>Relative Cost</th></tr>
<tr><td>Frame</td><td rowspan="3">Crawlspace, or open foundation</td><td rowspan="9">Relocate existing home and install the home on a new foundation at the new site, hook up utilities, and restore the old site</td><td rowspan="9">Lowest
↓
Highest</td></tr>
<tr><td>Frame with masonry veneer</td></tr>
<tr><td>Load bearing masonry</td></tr>
<tr><td>Frame</td><td rowspan="3">Basement</td></tr>
<tr><td>Frame with masonry veneer</td></tr>
<tr><td>Load bearing masonry</td></tr>
<tr><td>Frame</td><td rowspan="3">Slab-on-grade</td></tr>
<tr><td>Frame with masonry veneer</td></tr>
<tr><td>Load bearing masonry</td></tr>
</table>

Demolition

Demolition is tearing down a damaged home. A new compliant home can be rebuilt on site, rebuilt on another property, or the owner can simply move in to another structure elsewhere. This retrofitting method may be the most practical of all those described in this guide when a home has sustained extensive damage, especially severe structural damage. Chapter 6 presents more detailed information on demolition.

Whether you intend to rebuild or move, you must tear down your damaged home and then restore the site. Site restoration usually involves filling in a basement, grading, and landscaping. As a result, you will need the services of a demolition contractor. The contractor will disconnect and cap all utility lines at the site and then raze the home with a bulldozer or other heavy equipment. If you decide to rebuild on the old site or somewhere else on the same property, your construction contractor may be able to do the demolition and site restoration work as part of the home construction.

CROSS REFERENCE

As discussed in Section 2.6, the cost of demolishing a Substantially Damaged home may be an eligible flood insurance claim under ICC coverage.

Remember, all demolition, construction, and site restoration work must be done according to the regulatory requirements of your community. Permits may be required for all or part of this work. If you decide to rebuild on the site of your old home, you must rebuild in compliance with your community's floodplain management ordinance or law and other ordinances and codes, which means ensuring that the lowest floor of your new home is at or above the DFE. You can do this by elevating your new home on an extended foundation as described in Section 3.3.1 or on compacted fill dirt if your property is located in Zone A. If your property is located in Zone V area, you must elevate your home on piles or columns. A better approach is to build your home on an alternative building site outside the regulatory floodplain, where you can use standard construction practices, including the construction of a basement. Remember, if you rebuild on the same site, within the regulatory floodplain, your community's floodplain management ordinance, regulation, or provisions of the building code will not allow your new home to have a basement (as defined by the NFIP regulations) if it is located below the DFE. Figure 3-13 shows a home damaged by Hurricane Irene that is slated for demolition.

Figure 3 13. Many homes in the Town of Prattsville, NY, were slated for demolition during the recovery effort following Hurricane Irene.

The advantages and disadvantages of demolition vary depending on which of the following three options you choose:

1. Rebuilding on the existing site
2. Rebuilding on an alternative site on a different part of your property, which may be outside the regulatory floodplain
3. Moving to a home on another property, which may be outside the regulatory floodplain

CROSS REFERENCE

See Section 7.1.7 for a discussion of flood damage-resistant materials.

The advantages and disadvantages of option 1 are similar to those listed in Table 3-1 for the elevation method. The advantages and disadvantages of options 2 and 3 are the same as those listed in Table 3-3 for the relocation method, with the following exceptions: If you choose option 2, you will avoid the need to buy another lot and dispose of your existing property.

If you decide to demolish your damaged home and rebuild somewhere on your existing property (option 1 or 2 above), your costs will include tearing down the damaged home, building the new home to the community's specified elevation, reconnecting utility lines, and restoring the site around the new home. If you decide to move to a home outside the regulatory floodplain (option 3), your costs will include tearing down the damaged home, buying or building a home elsewhere, capping and abandoning the old utility lines, and restoring the old site.

The cost of tearing a home down, which is not a complex or difficult job, will be almost entirely for the disposal of the resulting debris. This cost can vary widely, depending on the amount of debris and whether a dumping fee is required at the disposal site. The major costs associated with the demolition method will be for building or buying a home and will, therefore, depend on how and where you build or on the type of home you buy. Be sure to get a complete cost estimate before you begin a demolition project. Table 3-5 shows approximate costs for tearing down your home and rebuilding on the same site.

Table 3-5. Relative Costs of Demolition and Rebuilding

Construction Type	Proposed Foundation Type	Relative Cost
Frame	Closed Foundation	Lowest
	Open Foundation	↓
Frame with Masonry Veneer	Closed Foundation	
	Open Foundation	
Load bearing masonry	Closed Foundation	
	Open Foundation	Highest

3.4 Floodproofing

Wet floodproofing allows floodwaters to enter your home while using various techniques to minimize flood damage and protect critical systems and contents. Wet floodproofing techniques include raising utilities and important contents to or above the flood protection level, installing and configuring electrical and mechanical systems to minimize disruptions and facilitate repairs, installing flood openings or other methods to equalize the hydrostatic pressure exerted by floodwaters, and installing pumps to gradually remove floodwater from basement areas after the flood.

The purpose of dry floodproofing your home is to make it watertight (substantially impermeable) to floods of limited duration (a few hours) and depth (typically less than 2-3 feet). Dry floodproofing reduces the potential for flood damage by reducing the probability that your home's interior will be inundated. It can be an appropriate alternative for flood mitigation when relocating or elevating buildings is not cost effective or technically feasible.

3.4.1 Wet Floodproofing

Wet floodproofing a home is modifying the uninhabited portions of the home (such as a crawlspace, basement, or other enclosure) so that floodwaters will enter but not cause significant damage to either the home or its contents. The purpose of allowing water into portions of the home is to ensure that the interior and exterior hydrostatic pressures will be equal. Allowing these pressures to equalize greatly reduces the likelihood of wall failures and structural damage. Wet floodproofing may be used when other retrofitting methods are either too costly or are not feasible. If you intend to wet floodproof your basement, a licensed engineer or design professional is needed to determine the structural integrity of the walls. Wet floodproofing is practical in only a limited number of situations. Chapter 7 presents more detailed information on wet floodproofing.

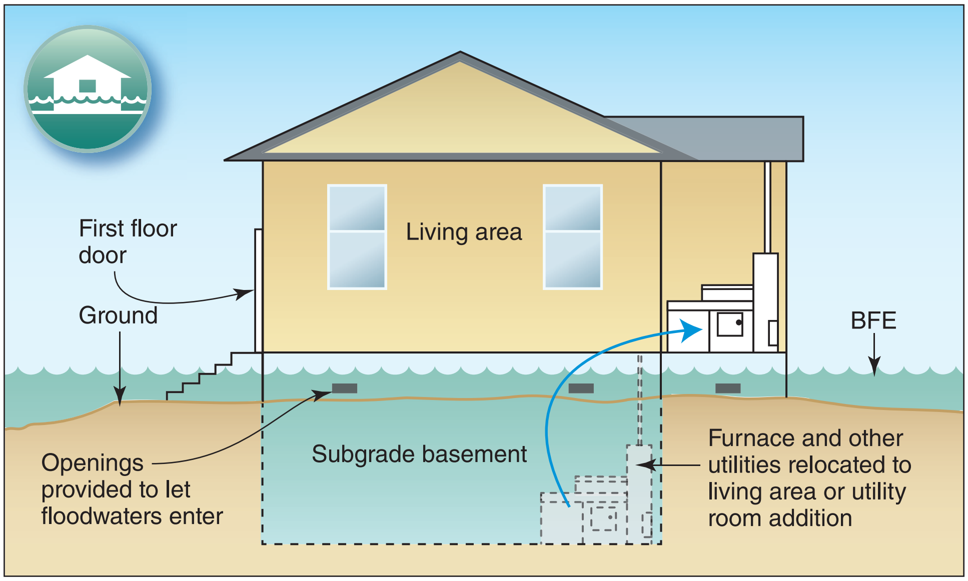
Because wet floodproofing allows floodwaters to enter the home, all construction and finishing materials below the DFE should be resistant to flood damage. For this reason, wet floodproofing is practical only for portions of a home that are not used for living space, such as a basement as defined by the NFIP regulations, an enclosure such as a walkout-on-grade basement or a crawlspace, or an attached garage. Figure 3-14 illustrates a home with a wet floodproofed subgrade basement. Wet floodproofing this home protects it from hydrostatic pressure, but not hydrodynamic pressure and floodborne debris. To minimize damages, service equipment must be elevated above the flood level and the walls of the basement must be built with flood damage-resistant materials.

Figure 3-15 illustrates a home in which the lower level was modified to create an enclosure that is built with flood damage-resistant materials, service equipment was elevated above the flood level, and the lower level is used solely for parking, access, and storage. As illustrated in Figure 3-15, openings must be placed in the walls to relieve hydrostatic pressure. If the lowest elevated floor is above the community's DFE and the enclosure is protected as described above, the home would meet the minimum requirements of the NFIP.

> **WARNING**
>
> Wet floodproofing mitigation methods can lead to NFIP compliance only if the area is limited to parking, access, or storage; designed to allow for automatic entry and exit of flood waters; and uses only flood damage-resistant materials below the DFE. If your home is being Substantially Improved or has been Substantially Damaged, your community's floodplain management ordinance or law will restrict your use of wet floodproofing to attached garages and enclosed areas below the BFE that are used solely for parking, building access, or storage. For more information, consult your local officials. Note that basements (any area of the building having its floor subgrade on all sides) cannot be wet floodproofed to meet NFIP requirements.

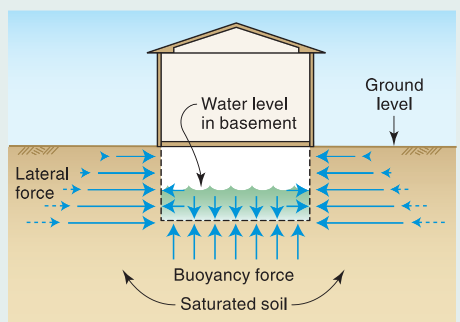
Wet floodproofing would not be practical for most slab-on-grade homes in which the living space is at or very near the ground level. Whether or not wet floodproofing is appropriate for your home will depend on the flood conditions, the flood protection elevation you have selected, the design and construction of your home, and whether you are required to bring your home into compliance because it is being Substantially Improved or has been Substantially Damaged.

Figure 3-14. A home with a wet floodproofed subgrade basement. Note: Wet floodproofing a basement is not permitted to achieve NFIP compliance. If Substantial Improvement or Substantial Damage requirements are triggered, the basement would need to be filled.



WARNING

After floodwaters recede from around a home with a wet flood-proofed basement, you will need to pump out the water that filled the basement during the flood. However, you must take certain precautions before you pump out the water. If the soil surrounding the basement walls and below the basement floor is still saturated with water, removing the water in the basement too quickly can be dangerous. As the water level in the basement drops, the outside pressure on the basement walls and floor becomes greater than the inside pressure (see figure). As a result, the walls can collapse and the floor can be pushed up or cracked (see Section 2.3.1). If you are unsure whether pumping out your basement is safe, contact a licensed dewatering contractor. Note that basements (any area of the building having its floor subgrade on all sides) cannot be wet floodproofed to meet NFIP requirements.



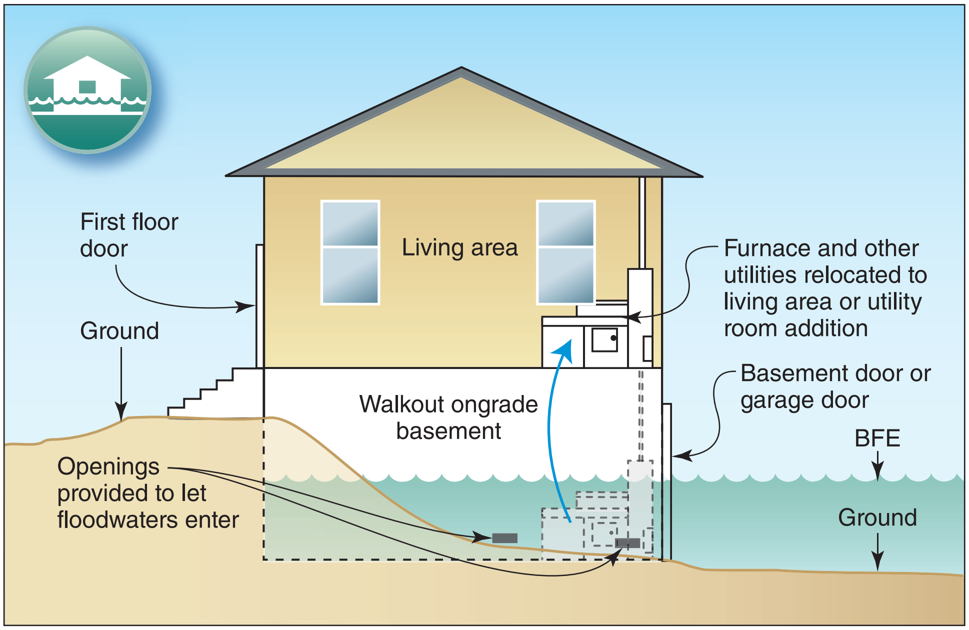


Figure 3-15. A home with a wet floodproofed enclosure. Note: Interior grade must be at or above the exterior grade along the entire length of the lowest side to prevent being a basement.

If you are considering wet floodproofing, keep the following in mind:

- Your home should have space above the DFE in which you can temporarily or permanently store items that could be damaged by floodwaters.
- If your furnace, water heater, or other service equipment is below the DFE, it should be protected as well. You may be able to move the equipment to another floor, elevate it, or protect it in place (see Chapter 9).
- Any construction and finishing materials below the DFE that are not flood damage-resistant should be removed or replaced with materials that are flood damage-resistant.
- If a flood occurs, you will not be able to live in your home as long as floodwaters remain.
- Wet floodproofing does not alleviate the threat of damage from high-velocity flood flow and wave action.
- Your community's floodplain management ordinance, regulation, or provisions of the building code will not allow you to wet floodproof your basement as defined under the NFIP if your home has been Substantially Damaged or is being Substantially Improved.

Table 3-6. Advantages and Disadvantages of Wet Floodproofing

Advantages	Disadvantages
• Reduces the risk of flood damage to a building and its contents, even with minor mitigation • Greatly reduces loads on walls and floors due to equalized hydrostatic pressure • May be eligible for flood insurance coverage of cost of relocating or storing contents, except basement contents, after a flood warning is issued • Costs less than other measures • Does not require extra land • Reduces the physical, financial, and emotional strains that accompany flood events	• Does not satisfy the NFIP requirement for bringing Substantially Damaged or Improved structures into compliance • Usually requires a flood warning to prepare the building and contents for flooding • Requires human intervention to evacuate contents from the flood-prone area • Results in a structure that is wet on the inside and possibly contaminated by sewage, chemicals, and other materials borne by floodwaters and may require extensive cleanup • Does not eliminate the need to evacuate during floods • May make the structure uninhabitable for some period after flooding • Limits the use of the floodable area • May require ongoing maintenance • May require additional costs to bring the structure up to current building codes for plumbing, electrical, and energy systems • Requires care when pumping out basements to avoid foundation wall collapse

NFIP = National Flood Insurance Program

> **DEFINITION**
>
> The **lowest adjacent grade** is the lowest ground surface that touches any of the exterior walls of your home.

Wet floodproofing is generally less expensive than the other flood protection methods described in this guide. Table 3-7 shows the relative approximate costs of wet floodproofing homes on basement and crawlspace foundations to heights between 2 feet and 8 feet. In a home with a basement, this height is measured from the basement floor. In a home with a crawlspace, this height is measured from the **lowest adjacent grade** to the home. The relative costs include those for adding wall openings for the entry and exit of floodwaters, installing pumps, rearranging or relocating utility systems, moving large appliances, and making it easier to clean up after floodwaters recede. The relative costs shown for basements in Table 3-7 are valid only for unfinished basements. Wet floodproofing a finished basement would involve the removal of all non-flood damage-resistant materials and replacing finish materials with flood damage-resistant materials. As a result, wet floodproofing costs for finished basements would be higher and would vary, depending on the amount of finish material to be removed or replaced.

Table 3-7. Relative Costs of Wet Floodproofing

Construction Type	Existing Foundation	Retrofit	Relative Cost
Frame, frame with masonry veneer, or load bearing masonry	Crawlspace	Wet floodproof crawlspace to a height of 2 ft to 4 ft above LAG*	Lowest
	Basement	Wet floodproof unfinished basement to a height of 2 ft to 4 ft above the basement floor	↓
	Basement	Wet floodproof unfinished basement to a height of 8 ft above the basement floor	Highest

* LAG – Lowest Adjacent Grade

3.4.2 Dry Floodproofing

In some situations, a home can be made watertight below the DFE, so that floodwaters cannot enter. This method is called "dry floodproofing." Section 7.2 presents more detailed information on dry floodproofing. Making the home watertight requires sealing the walls with waterproof coatings, impermeable membranes, or supplemental layers of masonry or concrete. Also, doors, windows, and other openings below the DFE must be equipped with permanent or removable shields, and backflow valves must be installed in sewer lines and drains.

The flood characteristics that determine whether dry floodproofing is effective are flood duration, flow velocity, and the potential for wave action and floodborne debris. You should consult a design professional before undertaking a dry floodproofing project. Figure 3-16 shows a typical dry floodproofed home and Table 3-8 presents the advantages and disadvantages of dry floodproofing.

Flood protection elevation is important to know because of the hydrostatic pressure that floodwaters exert on walls and floors. Because water is prevented from entering a dry floodproofed home, the exterior pressure on walls and floors is not counteracted as it is in a wet floodproofed home (see the discussion on pages 3-26 and 3-27). The ability of a home's walls to withstand the pressure exerted by floodwaters depends partly on how the walls are constructed. Typical frame and masonry veneer walls are likely to fail at lower flood depths, are more difficult to make

WARNING

Dry floodproofing may not be used to bring a Substantially Improved or Substantially Damaged home into compliance with your community's floodplain management ordinance or law unless the home is located in a community granted with a floodproofing exception.[1] Dry floodproofing residential buildings will not reduce flood insurance premiums.

WARNING

Even concrete block and brick walls should not be dry floodproofed above a height of 3 feet, unless an engineering analysis has been performed that shows that the walls will withstand the expected hydrostatic and hydrodynamic loads and debris impact forces. The effects of buoyancy on slab floors must also be considered.

[1] Use FEMA Form 086-0-24, Residential Basement Floodproofing Certificate: This is a form that is provided to communities participating in the National Flood Insurance Program that have been granted an exception by FEMA to allow the construction of floodproofed residential basements in Special Flood Hazard Areas.

watertight, and are more vulnerable to damage from moisture. As a result, dry floodproofing is not recommended for homes with frame and masonry veneer walls.

Even if frame and masonry veneer walls are reinforced to withstand the pressure of deeper water, the effects of buoyancy must be considered. The buoyancy force exerted by water may be enough to crack a slab floor or push it up.

WARNING

Because dry floodproofing requires human intervention, you must be willing and able to install all flood shields and carry out all other activities required for the successful operation of the dry floodproofing system. As a result, not only must you be physically capable of carrying out these activities, you must be home or able to get home in time to do so before floodwaters arrive.

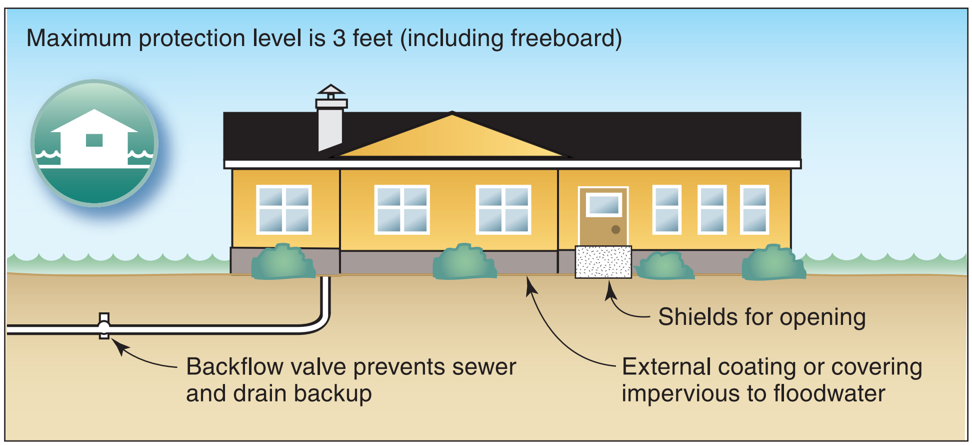


Figure 3-16. A typical dry floodproofed home.

Table 3-8. Advantages and Disadvantages of Dry Floodproofing

Advantages	Disadvantages
• Reduces the flood risk to the structure and contents if the design flood level is not exceeded • May be less costly than other retrofitting measures • Does not require the extra land that may be needed for floodwalls or reduced levees • Reduces the physical, financial, and emotional strains that accompany flood events • Retains the structure in its present environment and may avoid significant changes in appearance	• Does not satisfy the NFIP requirement for bringing Substantially Damaged or Improved residential structures into compliance • Requires ongoing maintenance • Does not reduce flood insurance premiums for residential structures • Usually requires human intervention and adequate warning time for installation of protective measures • May not provide protection if measures fail or the flood event exceeds the design parameters of the measure • May result in more damage than flooding if design loads are exceeded, walls collapse, floors buckle, or the building floats • Does not eliminate the need to evacuate during floods • May adversely affect the appearance of the building if shields are not aesthetically pleasing • May not reduce damage to the exterior of the building and other property • May lead to damage of the building and its contents if the sealant system leaks • Involves increased costs for a design professional • At times, may require invasive retrofits • Does not minimize the potential for damage from high-velocity flood flow and wave action

NFIP = National Flood Insurance Program

Duration of flooding is critical because most sealing systems will begin to allow some seepage after prolonged periods of exposure to water. If your home is in an area where floodwaters remain high for 24 hours or longer, you should use a different retrofitting method. Dry floodproofing is not appropriate in areas with a risk of high-velocity flood flow, wave action, or both. Either condition may render dry floodproofing totally ineffective and cause severe damage.

Floodproofed homes are not meant to be occupied during a flood. Flood warning time should be adequate and evacuation plans should be developed to ensure that occupants are not stranded in the home during a flood. Dry floodproofing actually increases the risk to occupants if floodwaters rise higher than the floodproofing design level because severe structural damage can occur. Further, the interior of the home will likely be subject to inundation, which may occur rapidly.

Dry floodproofing is not recommended for homes with basements. Saturated soils pressing against basement walls can damage them or cause them to fail. The buoyancy force exerted by saturated soils below the basement can cause the basement floor to fail or even push the entire home up.

Sealant systems, especially those that rely on membranes and coatings, can be punctured by ice and other types of debris. If your home is in an area where floodwaters are known to carry debris, you should select a different retrofitting method.

The total cost for dry floodproofing a home will depend largely on the size of the home, the type and condition of the wall system, the flood protection elevation, types of sealant and shield materials used, number of plumbing lines that have to be protected by check valves, and number of openings that have to be covered by shields. Table 3-9 shows approximate costs for elements of a dry floodproofing project.

Table 3-9. Relative Costs of Dry Floodproofing

Component	Height of Dry Floodproofing	Relative Cost
Waterproof Membrane (above grade)[1]	3 Feet	Lowest
Asphalt (two coats on foundation up to 2 feet below grade)[1]	3 Feet	
Sprayed-on Cement (above grade)[1]	3 Feet	Highest
Wood Flood Shield	3 Feet	Lowest
Metal Flood Shield	3 Feet	Highest

[1] Cement, asphalt, and membrane are alternative sealant methods.

3.4.3 Barrier Systems

Levees and floodwalls are types of flood protection barriers. A levee is a compacted earthen structure; a floodwall is an engineered structure usually built of concrete, masonry, or a combination of both (concrete masonry unit [CMU]). When these barriers are built to protect a home, they are usually referred to as "residential," "individual," or "onsite" levees and floodwalls. The practical heights of these levees and floodwalls are usually limited to 6 feet and 4 feet, respectively. These limits are the result of the following considerations:

- As the height of a levee or floodwall increases, so does the depth of water that can build up behind it. Greater depths result in greater water pressures, so taller levees and floodwalls must be designed and constructed to withstand the increased pressures. Meeting this need for additional strength greatly increases the cost of the levee or floodwall, usually beyond what an individual homeowner can afford.

WARNING

Levees and floodwalls may not be used to bring a Substantially Improved or Substantially Damaged home into compliance with your community's floodplain management ordinance or law and do not eliminate the insurance requirement on the home for federally backed mortgages.

- Because taller levees and floodwalls must be stronger, they usually require more space than is likely to be available on an individual lot. This is especially true of levees.
- Levees require a large land area for construction. For example, the levee in Figure 3-20 is 4 feet tall and about 27 feet wide.

Chapter 8 presents more detailed information on levees and floodwalls. Figure 3-17 shows a home protected by a levee and floodwall; Figure 3-18 shows a home protected by a levee. Remember that levees and floodwalls should be designed by a licensed engineer.

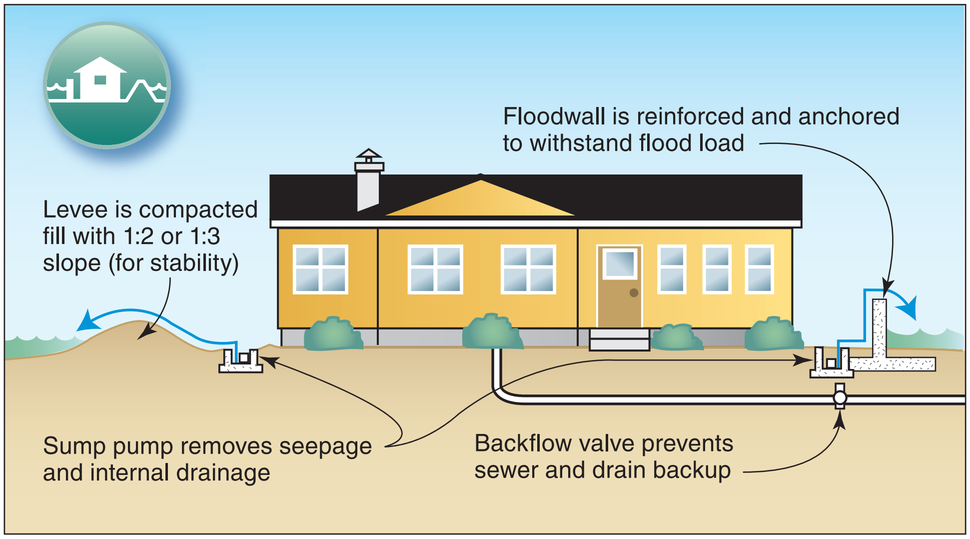


Figure 3-17. A home protected by a levee (left) and a floodwall (right).

Figure 3-18. A home protected by a levee.

Both levees and floodwalls should provide at least 1 foot of freeboard. For example, if you are building a levee to protect your home from the base flood, the top of the levee should be at least 1 foot above the BFE.

For a levee to be effective over time, it must be constructed of soils that cannot be easily penetrated by floodwaters, it must have proper side slopes for stability, and it must be periodically inspected and maintained. In areas where high-velocity flows could erode the surface of a levee, the side of the levee exposed to floodwater is usually protected with a covering of rock, referred to as **riprap**, or with other erosion-resistant material. Levees can surround a home, or they may be built only across low areas and tied into existing high ground.

DEFINITION

Riprap refers to pieces of rock or crushed stone added to the surface of a fill slope, such as the side of a levee, to prevent erosion.

A floodwall can surround a home or it can protect isolated openings, such as doors, windows, and walkout-on-grade basements, depending on flood depths, site topography, and design preferences. When built with decorative bricks or blocks or as part of garden areas, floodwalls can become attractive architectural or landscaping features. But they can also be built solely for utility, usually at a lower cost.

WARNING

Special design considerations are necessary when levees or floodwalls are built to protect a home with a basement. Even though the surface water is kept from coming into contact with the home, the soil below the levee or floodwall and around the home can become saturated, especially during floods of long duration. The resulting pressure on basement walls and floors can cause them to crack buckle, or collapse.

Because a floodwall is made of concrete or masonry rather than compacted earth, it is more resistant to erosion than a levee and generally requires less space than a levee to provide the same level of protection. But floodwalls are usually more expensive. As a result, floodwalls are normally considered only for sites where there is not enough room for a levee or where high-velocity flows may erode a levee. Also, some homeowners prefer floodwalls because they can be more aesthetically pleasing and allow for the preservation of existing site features, such as trees.

As shown in Figure 3-17, an interior drainage system, including a sump pump, must be installed in the area protected by a levee or floodwall. The purpose of the system is to remove rainwater trapped inside the protected area and, during flooding, to remove water that enters through seepage or infiltration.

Including an opening in a levee or floodwall may also be necessary to provide access for a car or other vehicle. All openings must be equipped with closures similar to those used in dry floodproofing. Installing closures over openings in levees and floodwalls requires advance warning of flooding in most cases—in other words, levees and floodwalls generally require human intervention. One exception is a low, earthen levee that can be sloped to allow vehicle access.

Table 3-10 presents the advantages and disadvantages of levees and floodwalls. Figure 3-19 shows a home protected by a floodwall.

Table 3-10. Advantages and Disadvantages of Levees and Floodwalls

Advantages	Disadvantages
• Protects the area around the structure from inundation without significant changes to the structure • Eliminates pressure from floodwaters that would cause structural damage to the home or other structures in the protected area • Costs less to build than elevating or relocating the structure • Allows the structure to be occupied during construction • Reduces flood risk to the structure and its contents • Reduces the physical, financial, and emotional strains that accompany flood events	• Does not satisfy the NFIP requirements for bringing Substantially Damaged or Improved structures into compliance • May fail or be overtopped by large floods or floods of long duration • May be expensive • Requires periodic maintenance • Requires interior drainage • May affect local drainage, possibly resulting in water problems for others • Does not reduce flood insurance premiums • May restrict access to structure • Requires considerable land (levees only) • Does not eliminate the need to evacuate during floods • May require warning and human intervention for closures • May violate applicable codes or regulations • Individual residential levees or floodwalls cannot be used to bring a home with a first floor elevation below the BFE into compliance with the NFIP • May not be ideal for homes with basements because hydrostatic pressure on below-ground portions of the home can lead to structural failures • May require a professional determination that the BFE did not increase in the project area, which could make levees and floodwalls difficult and expensive to design

NFIP = National Flood Insurance Program

NOTE

The costs for levee construction can vary greatly, depending on the distance between the construction site and the source of the fill dirt used to build the levee. The greater the distance that fill dirt must be hauled, the greater the cost.

Figure 3 19. A home protected by a floodwall designed as a landscaping feature.

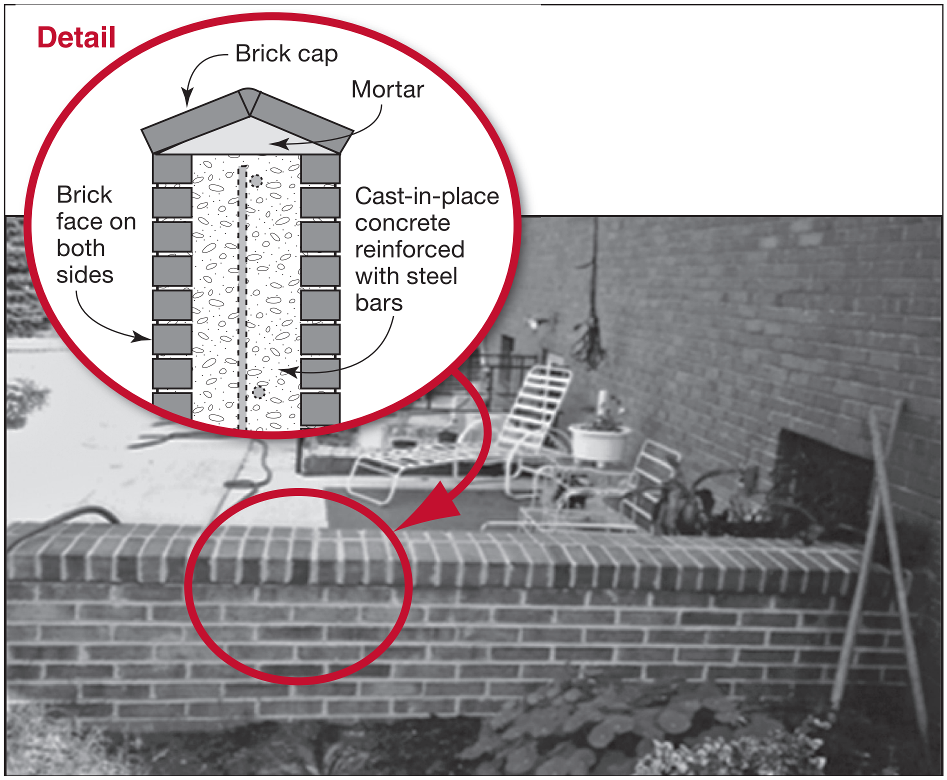


Table 3-11 shows the relative costs for levees and floodwalls of various heights. Additional costs for erosion protection using seeding or riprap, interior drainage, and installation of closures may be required for levees and floodwalls. Figure 3-20 illustrates the dimensions of these structures.

Table 3-11. Relative Costs of Levees and Floodwalls

Construction Type	Existing Foundation	Retrofit	Relative Cost
Frame, Masonry Veneer, or Masonry	Basement, Crawlspace, Open Foundation, or Slab-on-Grade	Levee constructed 2 feet above grade	Lowest
		Levee constructed 4 feet above grade	
		Floodwall constructed 2 feet above grade	
		Levee constructed 6 feet above grade	
		Floodwall constructed 4 feet above grade	Highest

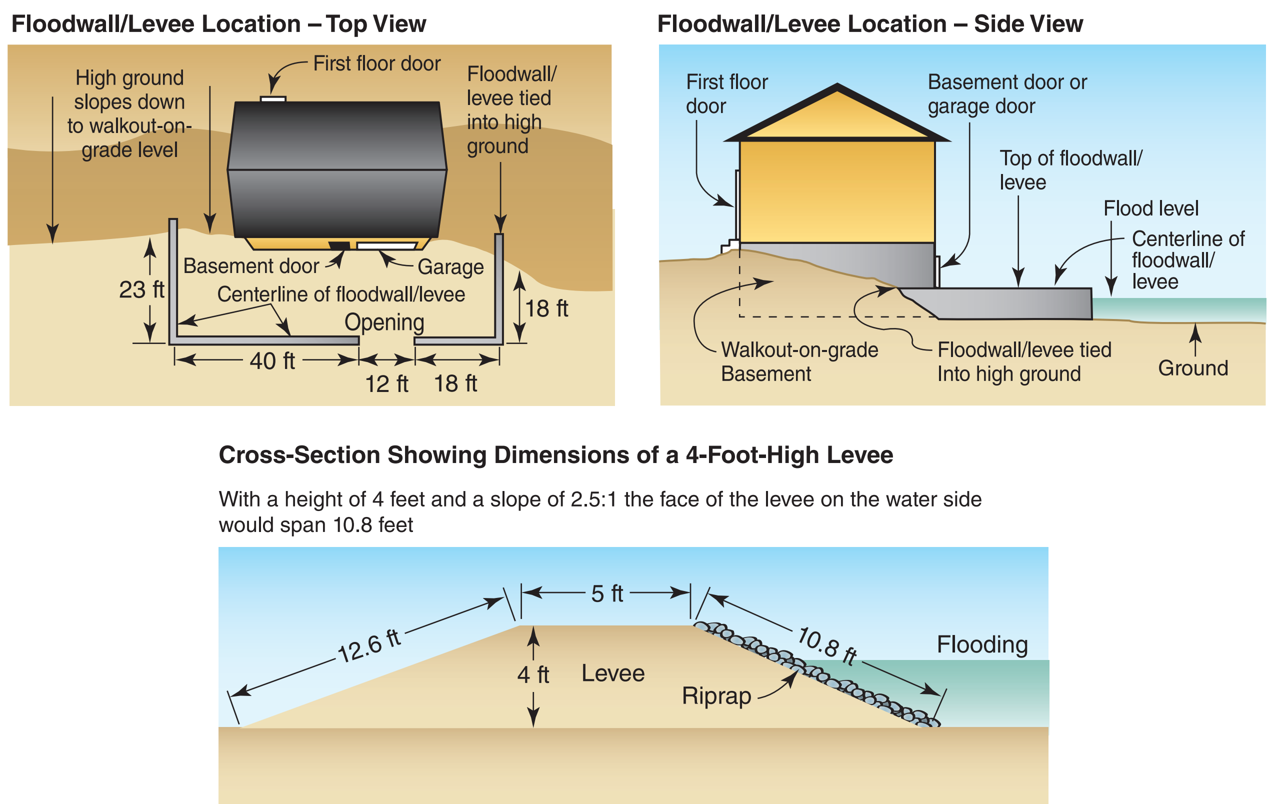


Figure 3-20. Example of floodwall and levee dimensions.

3.5 Summary

To protect your home from flooding, you may be able to use one or more of the retrofitting methods described in this chapter. However, some retrofitting methods are probably inappropriate for your home and some may not be allowed by your State or community. Also, if the Substantial Improvement and Substantial Damage requirements do not apply to your home, you may be faced with decisions about the level of protection you are willing to pay for and the level of risk you are willing to accept. Table 3-12 provides a comparison of the relative costs of each of the retrofitting methods listed in this chapter based on home construction type and foundation type.

Chapter 4 will help you decide on a method. Note that cost is not the only consideration when evaluating mitigation measures. Depending on your decision, you can move on to Chapter 5, 6, or 7 for a detailed look at your preferred method.

Table 3-12. Relative Costs of Various Retrofit Measures

Construction Type	Existing Foundation	Measure	Retrofit	Relative Cost
Frame, Masonry Veneer, or Masonry	Crawlspace or Basement	Wet Floodproofing	Wet floodproof crawlspace to a height of 4 feet above lowest adjacent grade or wet floodproof unfinished basement to a height of 8 feet above basement floor	Lowest
Masonry Veneer or Masonry	Slab-on-Grade or Crawlspace	Dry Floodproofing	Dry floodproof to a maximum height of 3 feet above lowest adjacent grade	
Frame, Masonry Veneer, or Masonry	Basement, Crawlspace, or Open Foundation	Barrier Systems	Levee constructed to 6 feet above grade or floodwall constructed to 4 feet above grade	
Frame, Masonry Veneer, or Masonry	Basement, Crawlspace, or Open Foundation	Elevation	Elevate on continuous foundation walls or open foundation	
Frame, Masonry Veneer, or Masonry	Basement, Crawlspace, or Open Foundation	Relocation	Elevate on continuous foundation walls or open foundation	
Frame, Masonry Veneer, or Masonry	Slab-on-Grade	Elevation	Elevate on continuous foundation walls or open foundation	
Frame, Masonry Veneer, or Masonry	Slab-on-Grade	Relocation	Elevate on continuous foundation walls or open foundation	Highest
Frame, Masonry Veneer, or Masonry	Slab-on-Grade, Crawlspace, Base-ment, or Open Foundation	Demolition	Demolish existing building and buy or build a home elsewhere	Varies




4.0 Deciding Which Method is Right for Your Home

With the information from Chapters 2 and 3, you are ready to decide which retrofitting method is right for your home. Your decision will be based primarily on hazards to your home, permit requirements, the technical limitations of the methods, and cost. Other considerations might include such things as the appearance of the home after retrofitting and any inconvenience resulting from retrofitting. Making a decision involves four steps:

STEP 1 — Determine the Hazards to Your Home
- Flood
- Wind
- Earthquake
- Others

STEP 2 — Inspect Your Home
- Construction Type
- Foundation Type
- Lowest Floor Elevation
- Condition
- Others

STEP 3 — Check with Your Local Officials
- Hazards
- Regulations/ Codes
- Technical Guidance
- Financial Assistance

STEP 4 — Consult a Design Professional and a Contractor
- Qualifications
- Site Inspection
- Cost Estimate
- Permits
- Design
- Schedule

The four steps are described in the next section. In Appendix G, you will find a retrofitting checklist that will help you work with local officials, design professionals, and retrofitting contractors. The checklist includes spaces where you can record the results of Steps 1 and 2, important questions you should ask, and decision-making matrices that will help you choose a retrofitting method. Before you go any further, you may want to make a copy of the checklist (see Appendix G) so that you can begin filling it out.

4.1 Making Your Decision

4.1.1 Step 1 – Determine the Hazards to Your Home

If you are using this guide, your home has probably been damaged by flooding or you know that it is in a flood hazard area. Refer to Section 2.3 for descriptions of each of the hazards in the checklist. Information about flooding and other hazards in your area is available from local officials, as discussed later in Step 3. But if your home has been flooded, review what you already know. Look at the Step 1 section of the checklist. Answer as many of the questions as you can. Local officials, design professionals, and contractors can use the information you provide, along with the flood hazard information developed by FEMA and other agencies and organizations, to advise you about your retrofitting options.

You also need to be aware of other hazards, such as high winds (Figure 4-1), earthquakes (Figure 4-2), fires, landslides, and **tsunamis**. If your home is in an area subject to one or more of these hazards, your retrofitting project should take the additional hazards into account. The foundation may need to be reinforced and the connections between the foundation, walls, and roof may need to be strengthened as part of the retrofitting project. Depending on the nature of the hazards and your choice of retrofitting methods, State and local regulations may require that additional changes be made to your home, beyond those necessary for flood protection. Your local officials can tell you if such requirements apply and can give you more information. General information for different hazards can be obtained as follows:

- Wildland fire: Wildland fire risk information is available from the U.S. Forest Service at http://www.fs.fed.us/fire/
- Tsunami: Tsunami hazard maps are available from the NOAA Center for Tsunami Research at http://nctr.pmel.noaa.gov/time/resources/

NOTE

The results of Steps 1 and 2 will help your local official to advise you and will also be useful when you consult a design professional or retrofitting contractor.

DEFINITION

A **tsunami** is a large, rapidly moving sea wave or series of waves produced by an undersea earth movement (earthquakes, crustal displacements, or landslides) or volcanic eruption.

NOTE

The retrofitting checklist provided in Appendix G references Figure 4-1 and Figure 4-2. If you are unable to interpret these maps, local officials and design professionals will be able to help you. Exposure to hazards quantified in Figure 4-1 and Figure 4-2 may limit the options available to safely retrofit your home.

WARNING

If you are retrofitting a home that is being Substantially Improved or has been Substantially Damaged, your community's floodplain management ordinance, regulation, or provisions of the building code will *not* allow you to have a basement, as defined by the NFIP, below the BFE. The NFIP regulations define a basement as "any area of the building having its floor subgrade on all sides." If your home has such a basement, you will be required to fill it in as part of any elevation project. See Section 2.3.1 for the NFIP definition of a basement.

- Landslide: Landslide risk information is available from the U.S. Geologic Survey at http://landslides.usgs.gov/

4.1.2 Step 2 – Inspect Your Home

The discussion in Chapter 3 may have prompted you to begin thinking about your home, specifically how it is constructed and the type of foundation it has. Before you check with your local officials or consult a design professional and contractor, you should inspect your home and fill out the section of the checklist for Step 2. Four characteristics of your home that are particularly important in retrofitting are construction type, foundation type, lowest floor elevation, and condition. (When you fill out the portion of the checklist concerning construction and foundation type, you may want to refer to the descriptions in Chapter 3.)

Construction Type

As explained in Chapter 3, the construction type for most homes will be frame, masonry veneer, masonry, modular, manufactured, or a combination of two or more of these types. The following generalizations can be made about the effect of construction type on retrofitting:

- The most appropriate elevation technique for frame homes and manufactured homes usually is to elevate on extended foundation walls or open foundations.
- Masonry homes are frequently elevated by extending the walls of the home upward and raising the lowest floor or by abandoning the lowest floor and moving the living area to an existing or new upper floor.
- Frame homes, masonry veneer homes, and manufactured homes are easier to relocate than masonry homes.
- Masonry and masonry veneer homes are usually easier to dry floodproof than other types of homes, because masonry is a more flood damage-resistant material than the materials used in frame homes.

Foundation Type

As explained in Chapter 3, most homes of the construction types listed above are built on a basement, crawlspace, slab-on-grade, or open foundation or on a combination of two or more of these types. The following generalizations can be made about the effect of foundation type on retrofitting:

- Homes on basement or crawlspace foundations are easier to elevate than slab-on-grade homes.
- Elevating homes on basement foundations normally involves elevating or relocating utility system components typically found in basements, such as furnaces and hot water heaters.
- Homes on basement foundations should not be dry floodproofed or protected by levees or floodwalls unless an engineering evaluation conducted by a design professional shows that it is safe to do so. This precaution is necessary because neither dry floodproofing nor the construction of levees or floodwalls prevents saturated soils from pressing on basement walls. This pressure, which is unequalized because water is not allowed to enter the basement, can damage basement walls or even cause them to fail.
- For some homes on basement foundations, an engineering evaluation is a necessary part of a wet floodproofing project. If the home is in an area where saturated soils begin to press on basement walls before water enters the basement, the unequalized pressure may damage walls or cause them to fail. If wet floodproofing is to be used in this situation, the engineering evaluation must show that the basement walls can resist the expected pressure.

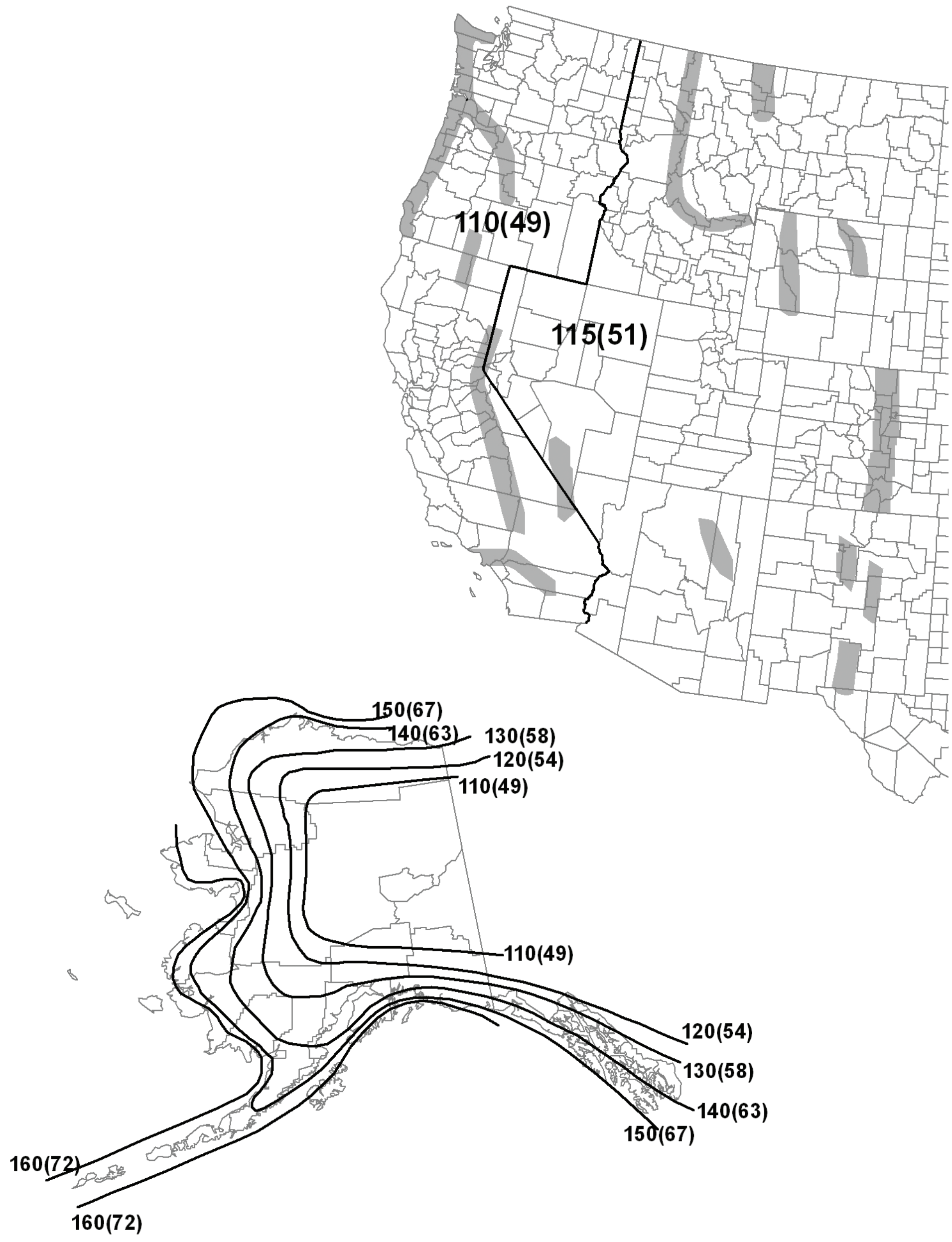
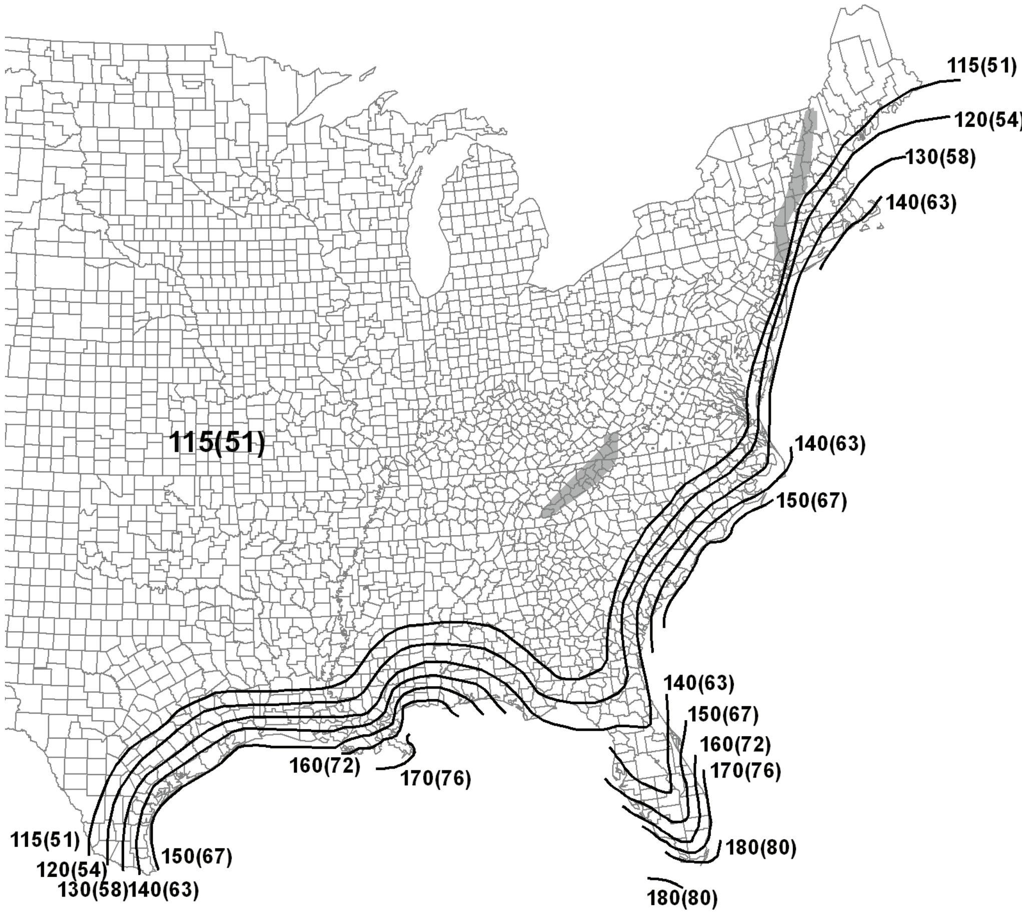
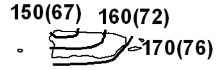


Figure 4-1. Peak gust wind speeds in the United States. Source: *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-10. Used with permission from ASCE.



Special Wind Region

Location	Vmph	(m/s)
Guam	195	(87)
Virgin Islands	165	(74)
American Samoa	160	(72)
Hawaii – Special Wind Region Statewide	130	(58)



Puerto Rico

Notes:

1. **Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.**
2. **Linear interpolation between contours is permitted.**
3. **Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.**
4. **Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.**
5. **Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 Years).**

Figure 4-1 continued. Peak gust wind speeds in the United States. Source: *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-10. Used with permission from ASCE.

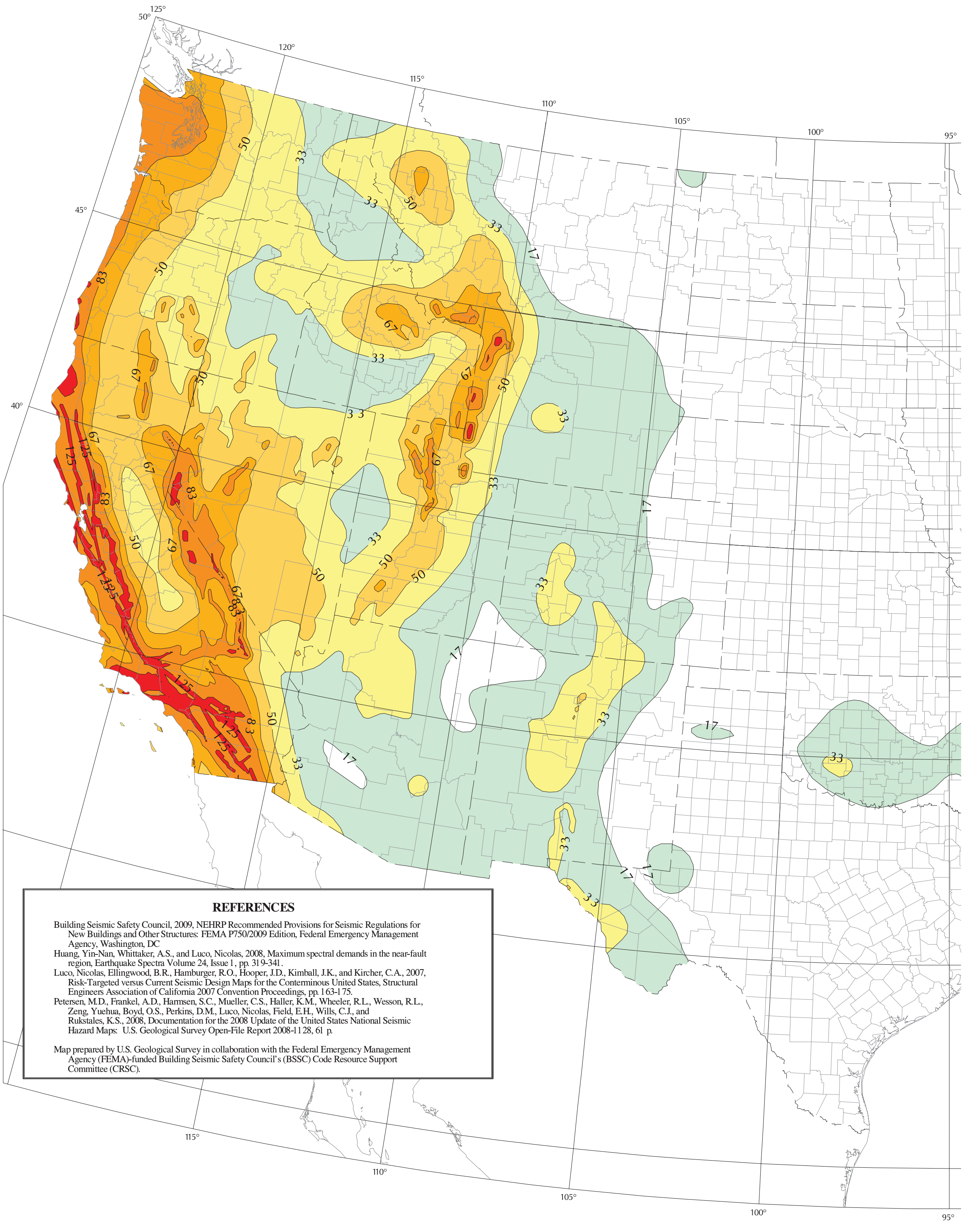


Figure 4-2. Seismic Design Categories Map of the United States for low-rise Occupancy Category I and II structures located on sites with average alluvial soil conditions. Map prepared by U.S. Geological Survey in collaboration with the Federal Emergency Management Agency (FEMA)-funded Building Seismic Safety Council's (BSSC) Code Resource Support Committee (CRSC).

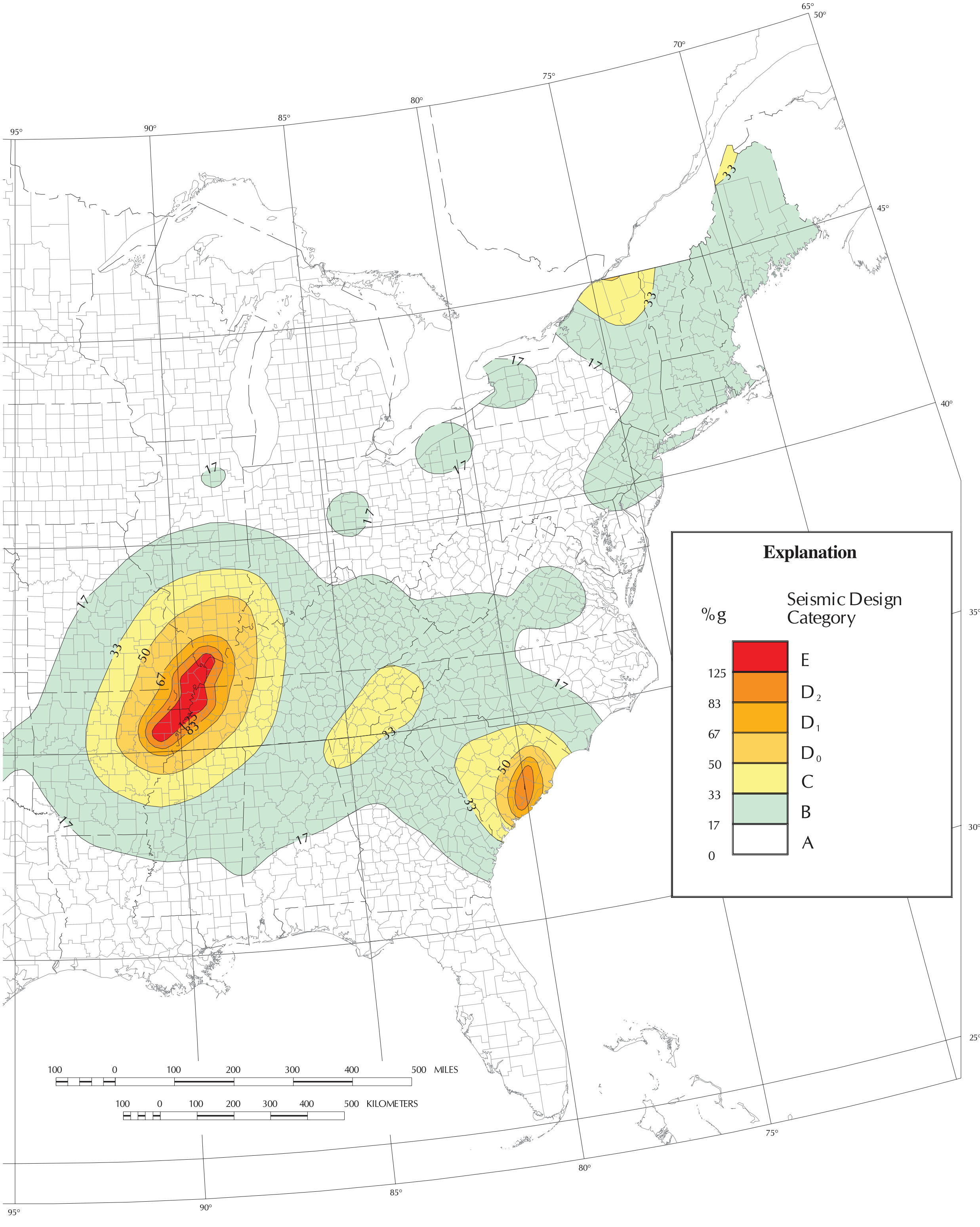
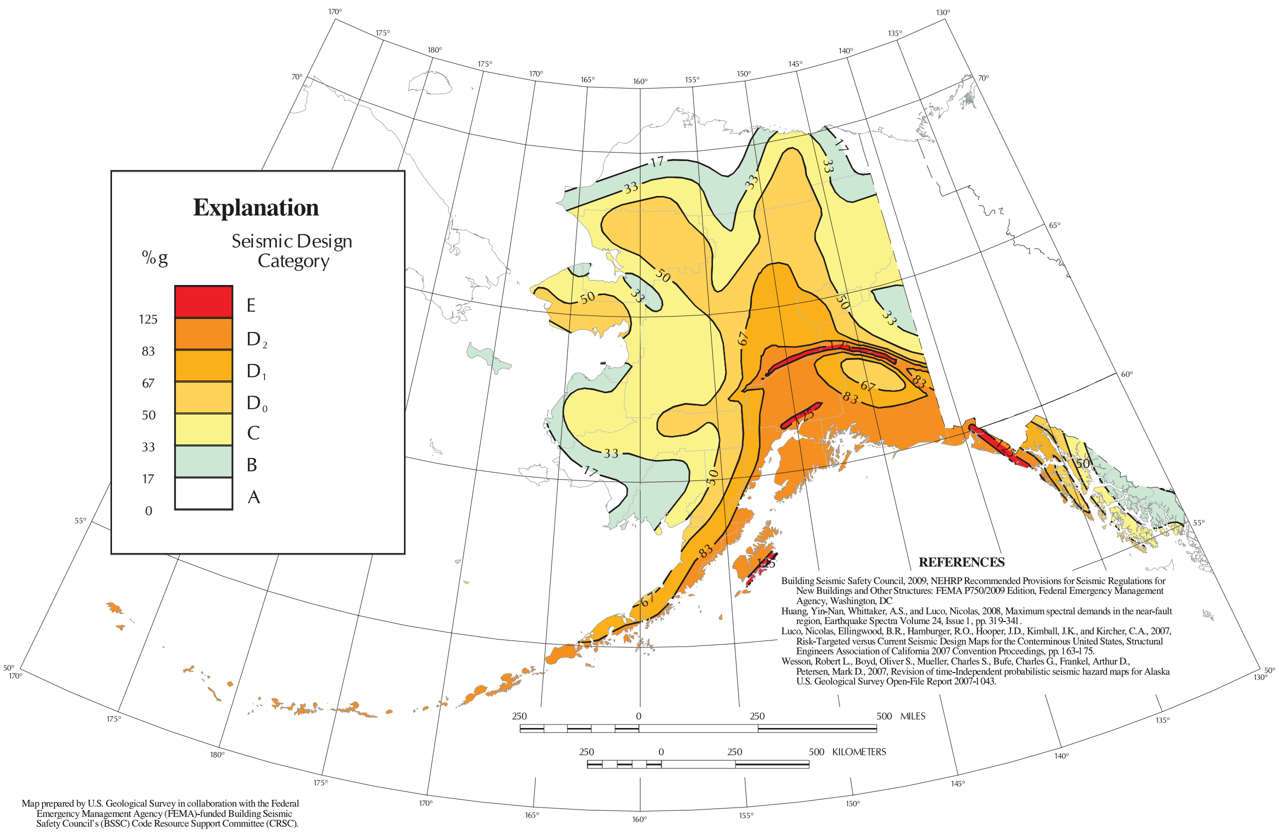


Figure 4-2 continued. Seismic Design Categories Map of the United States for low-rise Occupancy Category I and II structures located on sites with average alluvial soil conditions. Map prepared by U.S. Geological Survey in collaboration with the Federal Emergency Management Agency (FEMA)-funded Building Seismic Safety Council's (BSSC) Code Resource Support Committee (CRSC).



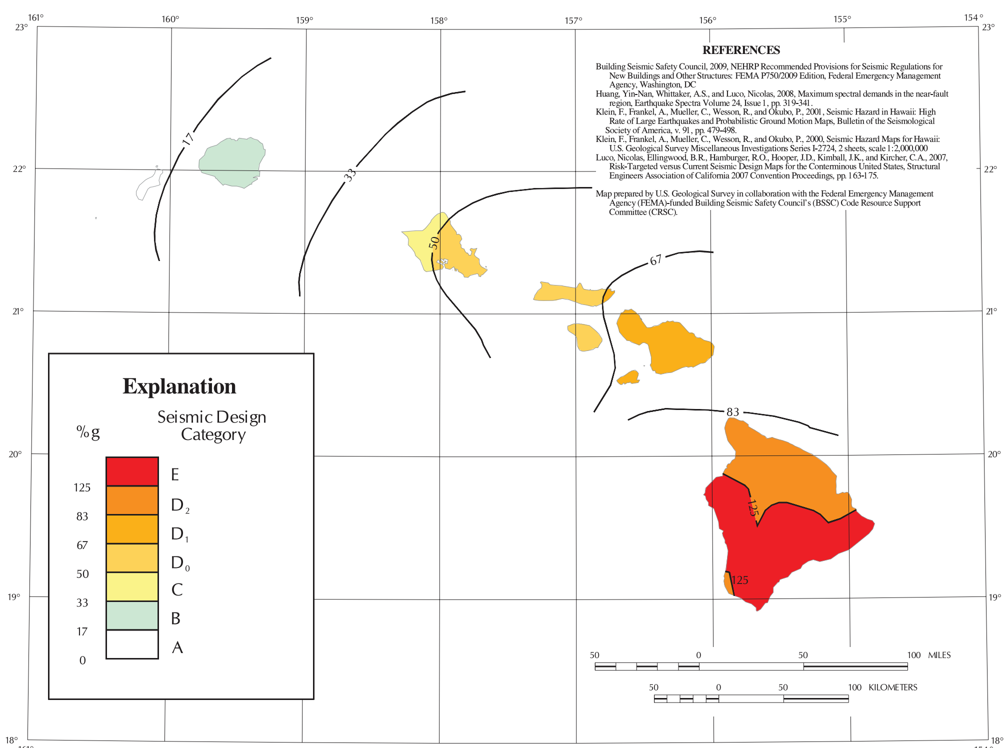


Figure 4-2 continued. Seismic Design Categories Map of the United States for low-rise Occupancy Category I and II structures located on sites with average alluvial soil conditions. Map prepared by U.S. Geological Survey in collaboration with the Federal Emergency Management Agency (FEMA)-funded Building Seismic Safety Council's (BSSC) Code Resource Support Committee (CRSC).

Lowest Floor Elevation

As noted in Chapter 3, the "lowest floor" of your home, as defined by your community's floodplain management ordinance, regulation, or provisions of the building code, is not necessarily the first or finished floor. For example, the lowest floor could be the floor of a basement or the floor of an attached garage. As shown in Figure 4-3, the location of your lowest floor can vary with foundation type. For homes that are to be elevated, wet floodproofed, or dry floodproofed, the difference between the elevation of the lowest floor and the DFE determines how high the home must be elevated or how high the wet or dry floodproofing protection must reach. In general, as the difference between the lowest floor elevation and the DFE increases, so does the cost of elevating, wet floodproofing, or dry floodproofing. This difference is particularly significant for dry floodproofing. As noted in Chapter 3, even masonry walls should not be dry floodproofed higher than 3 feet unless a structural evaluation by a design professional shows that it is safe to do so.

The elevation of your lowest floor can be established by a survey, which may be necessary as part of your retrofitting project. But even if you do not know your lowest floor elevation, you can estimate the difference between it and the flood protection elevation. Your conversations with your local officials, design professionals, and contractors will help you determine the level of flood protection you should provide. *Remember, if your home is being Substantially Improved or has been Substantially Damaged according to your community's floodplain management ordinance, regulation, or provisions of the building code, your flood protection elevation must be at least equal to the DFE.* As explained in Step 3, your local officials can tell you about this requirement.

Elevation certificates are used to determine insurance premium rates under the NFIP. If your community participates in the NFIP, it must obtain the as-built elevation of the lowest floor for all new or Substantially Improved structures in SFHAs. Your community may use FEMA's elevation certificates to keep track of lowest floor elevations for all of the new and Substantially Improved structures in flood zones. Communities that participate in the NFIP CRS are required to obtain and maintain elevation certificates.

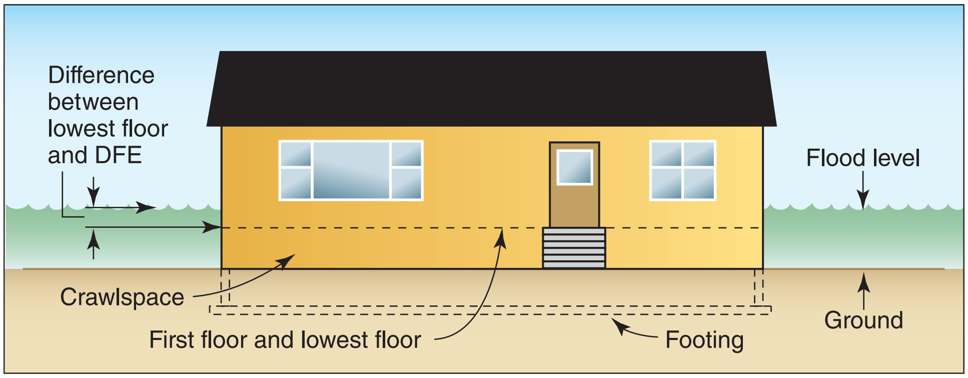
> **NOTE**
>
> Occasionally, a small area is inadvertently shown to be within the SFHA on a FIRM, even though the ground is at or above the BFE. If this occurs, an individual property owner may submit survey information to FEMA and request that FEMA issue a document that officially removes a property from the SFHA, called a Letter of Map Amendment (LOMA).

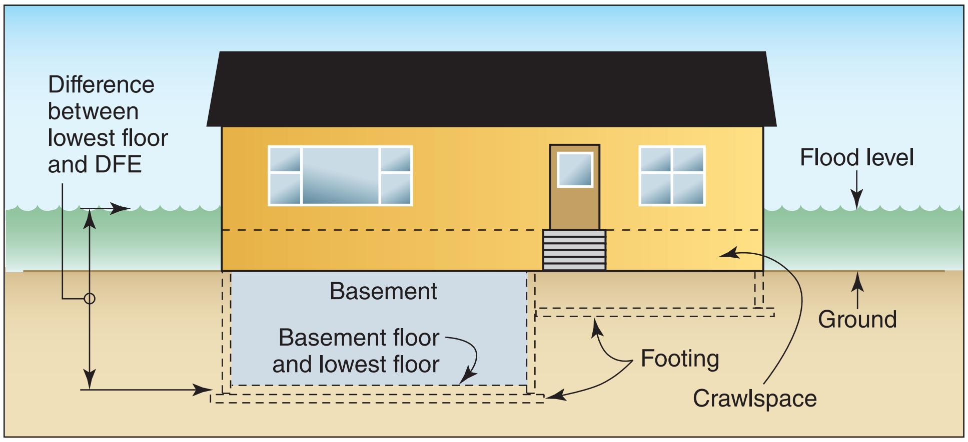
If an elevation certificate already exists for your home, it will provide information about your specific property, including:

- Property information, including address, building use, and foundation information
- FIRM information, including panel number and BFE
- Building elevation information determined by a survey
- Certification by an engineer, architect, or surveyor
- Photographs of the building

Elevation certificates must be completed by a land surveyor, engineer, or architect who is licensed in your State to perform surveys. Instructions on completing the elevation certificate and the form itself may be found on the FEMA Web site at http://www.fema.gov/media-library/assets/documents/160.

Figure 4-3. Difference between flood level and lowest floor in homes on crawlspace and basement foundations.





Condition

Your design professional or contractor should conduct a detailed inspection of your home before beginning any retrofitting work. You can help by first conducting your own assessment of the condition of your home and recording any information you have about past or current damage. This information may also be helpful to community officials who advise you about floodplain management and building code requirements and appropriate retrofitting methods.

If your home has been damaged by a flood, hurricane or other high-wind event, earthquake, fire, or other disaster, make a note of the extent of the damage, when it occurred, and whether it was repaired (the checklist provided in Appendix G can be used to list these damages). If repairs were made, make a note of who made them and describe what was done. Any structural damage and repairs to walls, floors, foundations, and roofs is particularly important. You should also describe any damage resulting from other causes, such as foundation settlement, dry rot, and termite damage. Your goal is to give your design professional and contractor as much information as possible so that they can determine how the condition of your home will affect your choice of a retrofitting method.

NOTE

A historic property is a resource (i.e., building, structure, site, object, or district) that is listed in or eligible for listing in the National Register of Historic Places or listed in a State or local inventory of historic places. For more information, visit your State's SHPO Web site (see Appendix E).

Other Considerations

In addition to construction type, foundation type, lowest floor elevation, and condition, you should make note of interior and exterior service equipment that must be protected as part of your retrofitting project. Interior service equipment must be protected if you elevate or wet floodproof your home. This equipment includes furnaces, heating and air conditioning ductwork, hot water heaters, large appliances, and electrical system components, such as service panels, outlets, and switches. Exterior service equipment must be protected if you elevate, wet floodproof, or dry floodproof and, in some situations, if you build a levee or floodwall. This equipment includes air conditioning and heat pump compressors and electric and gas meters.

> **NOTE**
>
> Elevation of electric and gas meters is typically controlled by the utility company.

In a home that is dry floodproofed, all openings below the DFE should be sealed. These openings may include doors and windows as well as openings for water pipes, gas and electric lines, dryer vents, and sump pump discharge pipes. In a home that is wet floodproofed, dry floodproofed, or protected by a levee or floodwall, backflow valves must be installed on all water and sewer lines with openings below the DFE. These valves prevent floodwaters and wastewaters from backing up into your home. Chapter 9 describes how to protect interior and exterior service equipment.

4.1.3 Step 3 – Check with Your Local Officials

This is a particularly important step. While you can obtain information from your FIS and your FIRM online (Chapter 2 discusses how to obtain FIRMs online), your local officials can help you to interpret that information. They will have hard copies of the FIS and FIRM published for your community by FEMA. Your officials will be able to tell you whether your home is in your community's regulatory floodplain and, if so, the BFE at the location of your home. They may also have information about flood conditions near your home, including flow velocity, the potential for wave action and debris flow, rates of rise and fall, warning time, and duration of inundation.

> **NOTE**
>
> Be sure to ask local officials about State or local freeboard requirements that may apply to your retrofitting project.

Local officials will inform you of Federal, State, and local regulations, codes, and other requirements that can determine what retrofitting methods you will be allowed to use and how changes can be made to your home. They can also tell you about Federal, State, and local programs that provide financial assistance for homeowner retrofitting projects, and they can help you determine whether you are eligible for such assistance. With the information you recorded in Steps 1 and 2, local officials may also be able to advise you about the most appropriate retrofitting method for your home. The officials you need to talk to will depend on how your community has assigned responsibilities for floodplain management and construction permitting. If you do not know who has these responsibilities in your community, you should begin with an official such as a city clerk, mayor, or county administrator.

> **NOTE**
>
> In addition to meeting the minimum requirements laid out in your local floodplain ordinance, any retrofit activities should comply with the current building code. Talk to your design professional about applicable codes and standards.

Remember that if your property is individually historic, potentially historic, or within the boundaries of a historic district and you are receiving Federal financial assistance for your retrofitting project, the Federal agency providing the assistance must first satisfy Federal historic preservation compliance requirements. Your local officials may not be aware of these requirements if they do not normally deal with federally assisted projects. Should historic preservation compliance be triggered, the Federal agency will need to consult with your SHPO. Remember that any compliance review must be completed before retrofitting work is initiated or the Federal assistance could be jeopardized.

When you talk to your local officials, be sure to do the following:

- Bring this guide with you.
- Bring your completed retrofitting checklist.
- Discuss what you already know about your home and the hazards that affect it.
- Work through the points listed in the section of the checklist for Step 3.
- Ask any other questions you may have.
- Work through the decision-making matrix provided in Section 4.2 with the official. Use the matrix that applies to your situation: Substantial Improvement / Substantial Damage or NOT Substantial Improvement / NOT Substantial Damage.
- Take notes about everything you discuss.

Remember that your goal is to find out what you can legally do to retrofit your home, identify the requirements you must comply with throughout the retrofitting process, and eliminate retrofitting methods that cannot be applied to your home or do not meet your needs. You may find that the restrictions and requirements of Federal, State, and local regulations will eliminate some retrofitting methods from consideration. Ultimately, your decision will be based on technical limitations of the methods, cost, and other considerations, such as the effect that retrofitting will have on the appearance of your home. The decision-making matrices will help guide you through this process.

Your next step, whether you have chosen one method or are considering two or more, is to consult a properly licensed, bonded, and insured design professional and retrofitting contractor.

4.1.4 Step 4 – Consult a Design Professional and Retrofitting Contractor

To complete this step, you will need to know what types of services are required for your retrofitting project and how to evaluate and select design professionals and contractors.

You will probably need the services of a contractor regardless of the retrofitting method you select. The type of contractor you hire will depend on the method. You will likely also need to consult a design professional, such as an architect or a structural engineer. Alternatively, you can hire a general contractor who will arrange for all the necessary services, including those of a design professional. Table 4-1 shows the types of design professionals and contractors that may be required for each of the retrofitting methods.

Knowing the types of services required for your retrofitting project is important, but so is hiring a reputable and competent design professional and contractor.

Table 4-1. Requirements for Design Professional and Contractor Services

Method	Need for Design Professional and/or Contractor	Primary Services
Elevation	**Design Professional**	Evaluating the condition, stability, and strength of the existing foundation to determine whether it can support the increased load of the elevated home, including any wind and seismic loads, or designing a new foundation
	Contractor: Home Elevation Contractor	Disconnecting utilities, jacking the home up, increasing the height of the foundation or building a new foundation, and connecting utilities
Wet Floodproofing	**Design Professional**	Designing any necessary replacements of vulnerable structural materials and relocated utility systems
	Contractor: General Construction Contractor	Replacing vulnerable structural and finish materials below the DFE with flood damage-resistant materials, raising utilities and appliances to a location above the DFE, and installing openings required to allow the entry of floodwaters
Relocation	**Design Professional**	Designing any new building, foundation, and site improvements that may be required, such as new utility systems
	Contractor: Home Moving Contractor	Jacking the home up, moving it to the new site, and installing it on the new foundation
	Contractor: General Construction Contractor	Preparing the new site (including grading, foundation construction, and utilities) and restoration of the old site (including demolition)
Dry Floodproofing	**Design Professional**	For masonry walls to be dry floodproofed, evaluating the condition, stability, and strength of the existing walls to verify whether they can withstand the pressure from floodwaters at the DFE; designing or selecting flood shields for doors or other openings
	Contractor: General Construction Contractor	Applying waterproof sealants and membranes, installing flood shields over openings below the DFE, installing backflow valves in sewer and water lines, and, if necessary, bracing or modifying walls so that they can withstand the pressure from floodwaters at the DFE
Levees and Floodwalls	**Design Professional**	Assessing the adequacy of soils at the site, preparing the engineering design to ensure that the levee or floodwall, including any closures required, will be structurally stable under the expected flood loads and will be able to resist erosion, scour, and seepage
	Contractor: General Construction Contractor	Constructing the levee or floodwall
Mitigation Reconstruction	**Design Professional**	Designing any new building, foundation, and site improvements that may be required, such as new utility systems
	Contractor: Demolition Contractor	Disconnecting and capping utility lines, tearing down the damaged home, hauling away debris, and restoration of the site
	Contractor: General Construction Contractor	Building the new home on the restored site or new site; this contractor may also be able to do all demolition work

DFE = design flood elevation

If you have used a licensed design professional and a licensed contractor in the past and were satisfied with the work, you might consider using them again. Even if they do not provide the types of services you now need, they may be able to recommend someone who can. Otherwise, you can search online or contact the professional association that represents the types of specialists you are looking for. Appendix F contains a list of the addresses and telephone numbers of several of these associations. They can usually give you a list of members in your area who specialize in the type of work you need. Before you hire a design professional or a contractor, check with your local Better Business Bureau, consumer protection agency, or licensing authorities. These organizations can tell you whether there have been any complaints about the quality of the design professional's or contractor's past work, including whether the work was completed on time.

Next, you will need to meet with the design professional and contractor to discuss your project. At the meeting, be sure you do the following:

- Provide the information you collected in Steps 1, 2, and 3.
- Ask the questions listed on the retrofitting checklist located in Appendix G, as well as any others you may have.
- Verify that the design professional is licensed and registered in the State in which the work will be done.
- Verify that the contractor is licensed, bonded, and insured as required by State and local laws.
- Ask for proof of insurance. If the design professional or contractor does not have disability and worker's compensation insurance, you may be liable for accidents that occur on your property.
- Ask for references. Reputable design professionals and contractors should be willing to give you the names of previous customers. Call some of them and ask how satisfied they were with the work. Ask if they would hire the design professional or contractor again.
- If you are trying to decide between two or more retrofitting methods, discuss your preferences and ask for more information.

> **WARNING**
>
> Areas recovering from floods are often prime targets for less-than-honest business activities. Here are some pointers that can help you avoid problems:
>
> *Check* with your local Better Business Bureau, consumer protection agency, or licensing authorities before you hire a contractor.
>
> *Beware* of "special deals" offered after a disaster by contractors you don't know.
>
> *Beware* of unknown contractors who offer to use your home as a "model home" for their work.
>
> *Do not* sign any contract under pressure by a salesperson. Federal law requires a 3-day cooling-off period for unsolicited door-to-door sales of more than $25.
>
> *Beware* if you are asked to pay cash on the spot instead of with a check made out to the name of a business.
>
> *Ask contractors for references.* A reputable contractor should be able to give you a list of past clients in your area who can comment on the quality of the contractor's work.

Any design professional or contractor you hire will need to conduct a site visit to inspect your home and determine how the work should be carried out. During the site visit, you should expect your design professional or contractor to assess the structural condition of your home and determine what changes will be required by the retrofitting method you choose. If you agree on a method and decide to proceed with the project, be sure to do the following:

- Get a written, signed, and dated estimate. It should cover everything you expect to be done. (Some design professionals and contractors will charge a fee to prepare the estimate.)
- Get signed and stamped building plans that show details of the proposed retrofitting measure.
- Decide whether you, the design professional or contractor will obtain the necessary permits.
- Ask for a warranty or guarantee. Any warranty or guarantee from the design professional or contractor should be written into the contract. The contract should clearly state the terms of the warranty or guarantee, who is responsible for honoring it (such as a manufacturer or the contractor), and how long it will remain valid.
- Get a written contract. It should be complete and clearly state all work to be done, the estimated cost, the payment schedule, and the expected start and completion dates for the work.

Note that, if a project is funded by a FEMA HMA grant, starting construction prior to FEMA's approval or award of the grant can jeopardize grant funding.

4.2 Decision-Making Matrices

This section provides two matrices that can help you decide which retrofitting method will best meet your needs. If your home is either being Substantially Improved or has been Substantially Damaged, the NFIP regulations limit your choice of retrofitting methods to elevation, relocation, or demolition (Table 4-2). If your home is **NOT** being Substantially Improved or has **NOT** been Substantially Damaged, additional retrofitting methods may be considered, such as dry floodproofing, wet floodproofing, and construction of levees or floodwalls (Table 4-3).

You may require guidance while using the matrix. Local officials, design professionals, and contractors can help you evaluate factors you are unsure about, so take the matrix with you when meeting with them. This will be helpful to determine which methods are cost prohibitive or are not technically feasible.

After you have identified the appropriate matrix to use, identify any methods eliminated by regulations, ordinances, or laws established by State or other agencies and organizations. Also, you may have already decided that one or more methods will not meet your needs. Mark each eliminated method by placing an "X" in the box directly below the name of the method (on the line labeled "Prohibited by Federal, State, or Local Regulations or Eliminated by Homeowner"). An "X" in this row means that the method is eliminated and will not be considered further.

The next step is to evaluate the remaining methods. Your evaluation will be based on the factors listed on the left hand side of the matrix. The factors are explained below. For each evaluation factor under each method, discuss your concerns with your local official, design professional, and contractor. If your concerns cannot be resolved, place an "X" in the appropriate box. After you have worked through the entire matrix, add the number of "Xs" under each method and show the sum on the Total "Xs" line. Remember, each "X" is based on your preferences and the input of local officials, design professionals, and contractors. So, although not all factors are equally critical, the method with the lowest total "Xs" will probably best meet your needs.

4.2.1 Evaluation Factors

Federal, State, and Local Restrictions – Federal, State, and local regulations may restrict the homeowner's choice of retrofitting measures. Such regulations may include State and local building codes, floodplain management ordinance, regulation, or provisions of the building code, zoning ordinances, Federal regulations concerning the alteration of buildings classified as historic structures, deed restrictions, and the covenants of homeowners' associations. The homeowner and the homeowner's design professional or contractor should check with community officials to determine whether any such restrictions apply.

Appearance – The final appearance of a home and property after retrofitting will depend largely on the retrofitting method used and the DFE. For example, elevating a home several feet will change its appearance much more than elevating only 1 or 2 feet, and wet floodproofing will change its appearance very little. However, a change in appearance will not necessarily be a change for the worse (see photographs in Chapter 3). The homeowner should discuss the potential effects of each method with local officials and with the design professional or contractor.

Cost – The cost of retrofitting will depend largely on the retrofitting method used and the flood protection elevation. For some methods, the construction type (frame, masonry, etc.) and foundation type (crawlspace, slab, etc.) will also affect the cost. In general, costs will increase as the flood protection elevation increases, but there may be tradeoffs between alternative methods. For example, elevating may be less expensive than relocating when a home is raised only 1 or 2 feet, but may become more expensive at greater heights. Other costs include those for both routine and long-term maintenance and insurance premiums. Adding additional freeboard to an elevation project will generally increase the project's cost; however, the additional freeboard may produce significant savings on insurance premiums. The annual savings on insurance premiums may quickly return the investment required to add freeboard.

Accessibility – Accessibility refers to how easy or difficult it is to routinely reach and enter the home after the retrofitting project is completed. The retrofitting methods described in this guide affect accessibility in different ways. For example, elevating a home will usually require the addition of stairs, which may be unacceptable to some homeowners. In these cases, homeowners may have to consider installing small elevators or using an entirely different retrofit method. Levees and floodwalls can make access more difficult unless they are equipped with openings, which require human intervention (see below). Wet floodproofing will have little if any effect on accessibility. Dry floodproofing openings can be very expensive; often points of access are sealed off to control project costs. The effect of relocation on accessibility will depend on the location and configuration of the new site.

Code-Required Upgrades – State and local regulations may require that a retrofitted home be upgraded to meet current code requirements that were not in effect when the home was built. Portions of the electrical, plumbing, and HVAC systems could be affected. For example, the electrical panel might have to be upgraded from fuses to circuit breakers. These changes are required for the safety of the homeowner. Other code-required upgrades include those for increased energy efficiency. Any required upgrade can add to the scope and cost of the retrofitting project. The homeowner and the homeowner's design professional or contractor should check with community officials to determine whether such regulations apply.

Human Intervention – For retrofitting methods that require human intervention, homeowners must be willing, able, and prepared to take the necessary action, such as operating a closure mechanism in a floodwall or placing flood barriers across the doors of a dry floodproofed home. Also, the homeowner must always have adequate warning of a coming flood and must be at home or near enough to be able to reach the home and take the necessary action before floodwaters arrive. If these conditions cannot be met, retrofitting methods that require human intervention should be eliminated from consideration.

4.2.2 Substantial Improvement / Substantial Damage Matrix

Table 4-2. Retrofitting Methods for Substantially Improved or Substantially Damaged Homes

Retrofitting Methods Substantially Improved or Substantially Damaged Homes					
	Elevation[1]				
Evaluation Factors	**Elevation on Extended Foundation Walls** 	**Elevation on Open Foundation** 	**New Living Area over Abandoned First Floor** 	**Relocation** 	**Demolition** 
Prohibited by Federal, State, or Local Regulations or Eliminated by Homeowner					
Appearance					
Cost					
Accessibility					
Code-Required Upgrades					
Human Intervention					
Other					
Total "Xs"					

[1] Note that if you elevate a Substantially Improved or Substantially Damaged home, you can still wet floodproof an enclosed area under the home below the BFE, provided that: (1) the area is only used for parking, building access, and storage, (2) the area is designed to allow for automatic entry and exit of flood waters through the use of openings, and (3) the area is constructed with flood damage-resistant materials.

4.2.3 NOT Substantial Improvement / NOT Substantial Damage Matrix

Table 4-3. Retrofitting Methods for Homes That are NOT Substantially Improved or Damaged

Retrofitting Methods for Homes NOT Substantially Improved or Substantially Damaged								
	Elevation							
Evaluation Factors	Elevation on Extended Foundation Walls	Elevation on Open Foundation	New Living Area over Abandoned First Floor	Relocation	Dry Floodproofing	Wet Floodproofing	Levees or Floodwalls	Demolition
Prohibited by Federal, State, or Local Regulations or Eliminated by Homeowner								
Appearance								
Cost								
Accessibility								
Code-Required Upgrades								
Human Intervention								
Other								
Total “Xs”								




5.0 Elevating Your Home

One of the most common retrofitting methods for homes is elevation. When a home is properly elevated, the living area should be above most flood levels. Several elevation techniques are available. In general, they involve lifting the home and building a new foundation or extending the existing foundation below it, or leaving the home in place and either building a new elevated floor system within the home or adding a new upper story and converting the ground level to a compliant enclosure.

During the elevation process, most frame, masonry veneer, and masonry homes are separated from their foundations, raised on hydraulic jacks, and held by temporary supports while a new or extended foundation is constructed below. The living area is raised so that only the foundation remains exposed to flooding. This technique works well for homes originally built on basement, crawlspace, and open foundations. When homes are lifted with this technique, the new or extended foundation can consist of continuous walls or separate piers, posts, columns, or piles. Masonry homes are more difficult to lift, primarily because of their design, construction, and weight, but lifting these homes is possible. In fact, numerous contractors throughout the United States regularly perform this work.

A variation of this technique is used for frame, masonry veneer, and masonry homes built on slab-on-grade foundations. In these homes, the slab forms both the floor of the home and either all or a major part of the foundation. Although elevating these homes with the walls and slab attached and lifting them together may appear easier, this may not be a viable option. A slab-on-grade home should be inspected by a structural engineer to determine whether the slab is sufficient to support the house without being continuously supported by the soil it was designed to sit on top of. If the slab isn't strong enough to be lifted, the walls can be elevated and a new wood floor system constructed.

NOTE

Always use a licensed, bonded, and insured contractor for elevation projects. Be sure that your contractor has experience with elevation projects and understands the considerations discussed in Section 5.1. Prior to hiring a contractor, be sure to check references.

For masonry homes on slab-on-grade foundations, an alternative mitigation technique in which the home is left on its original foundation may be easier. This technique involves removing the roof and raising the living space, either by extending the walls of the home and raising the floor or by abandoning the lower level and moving the living space to an existing or newly constructed upper floor. Another alternative for homes with high ceilings may be to shift the floor system on the upper floors reducing the ceiling height, but creating space above the BFE to construct a new first floor. The abandoned lower enclosed area is then converted to a compliant enclosure that is used only for parking, building access, or storage. See Section 5.2.2 for more information.

In both of these techniques, portions of the original walls will be below the DFE. This approach is appropriate for masonry construction, but not for frame construction, because of potential code compliance issues and flood insurance implications for wood-frame foundations.

This chapter describes and illustrates various elevation methods and discusses the most important considerations regarding elevation. Remember, you should never attempt an elevation project without the help of experienced design and construction professionals.

5.1 Considerations

Prior to elevating a home, a number of factors, such as how high to elevate, whether to incorporate the existing foundation, other hazards (wind, earthquake, etc.), how access to the house will be accomplished, and which elevation technique is appropriate, should all be considered. Some common factors to consider in elevating your home are described in the sections that follow.

5.1.1 Amount of Elevation

The amount of elevation required is determined by the flood protection elevation you have chosen. The minimum elevation should be determined based on various sources of information. Decisions need to be made based on the effective date of the FIRM and whether any additional data, such as changes to the flood source around the building site or flooding events since the FIRM, may make is necessary to elevate higher. Homeowners should also consider that potential future changes to the factors that influence floods may result in higher flood events. Resources such as Hurricane Sandy Recovery Advisory No. 5, *Designing for Flood Levels Above the BFE After Hurricane Sandy* (FEMA.2013b), may provide some helpful guidance on how to determine your flood protection elevation. Consider whether the locally enforced elevation requirements are sufficient or whether you should consider elevating even higher. For example, if your house is located in Zone A, you may only be required to elevate your home to the BFE so that the top of the lowest floor is at or above that elevation (see Figure 5-1). However, elevating 1 or 2 feet higher will provide increased protection and result in lower annual flood insurance premiums.

NOTE

FEMA HMA grants will only support elevation projects to the flood protection elevation stipulated by the engineering standard ASCE 24, *Flood Resistant Design and Construction*, or higher. In most instances, the minimum elevation will be the BFE plus at least 1 foot of freeboard.

As explained previously, if your home is being Substantially Improved or has been Substantially Damaged, your community's floodplain management ordinance, regulation, or provisions of the building code will require that your lowest floor be elevated to or above the BFE. If Substantial Improvement and Substantial Damage requirements do not apply, you may be able to elevate to any height you wish. Keep in mind that raising your home to an elevation below the BFE not only provides less protection, but will not provide the lower insurance premiums that come with elevation to or above the BFE. If you decide to raise your home to an elevation below the BFE, the community is required to evaluate the cost of all improvements, including the cost to elevate your home to determine whether your proposed project is a Substantial Improvement. Regardless of whether your home is being Substantially Improved or has been Substantially Damaged, you should consider incorporating at least 1 foot of freeboard into your flood protection elevation (as shown in Figure 5-1). Often this will ensure that at a minimum, the floor framing will be elevated above the floodwaters.

Elevating a home to 3 or 4 feet above the existing ground level usually will not have a great effect on its appearance and will require only minimal landscaping and regrading. If you plan to elevate more than 4 feet above the existing grade, you should consider elevating your home a full story. Not only will your home be protected against deeper floods, but you can use the space below for parking, building access, or storage (Figure 5-2). If you decide to incorporate parking under a living area, verify that any necessary code requirements have been addressed in the retrofit. This could include providing a fire-rated floor assembly between the parking area and the living area above. Hurricane Isaac Recovery Advisory 1, *Minimizing Wind and Water Intrusion by Covering the Underside of Elevated Buildings* (FEMA. 2012c), provides some guidance on such assemblies.

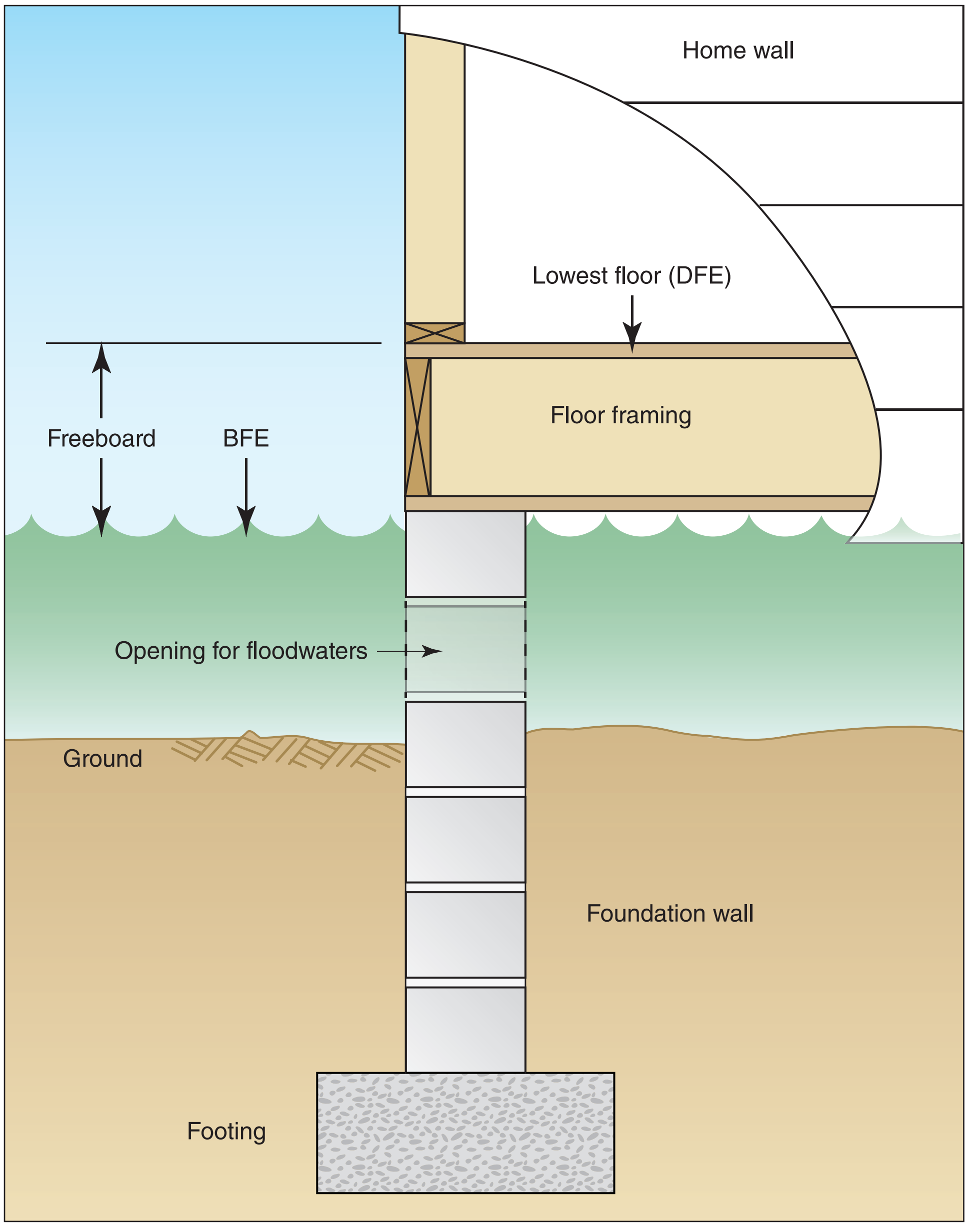


Figure 5-1. As shown in the cutaway view, the lowest floor is above the flood level. When at least 1 foot of freeboard is provided, only the foundation is exposed to flooding.

WARNING

If your home is being Substantially Improved or has been Substantially Damaged and is in a Coastal High Hazard Area (Zone V, VE, or V1–V30 on the FIRM for your community), your community's floodplain management ordinance, regulation, or provisions of the building code requires that the bottom of the lowest horizontal structural member (rather than the lowest floor) be elevated to or above the BFE. In many homes, the lowest horizontal structural member is a beam that supports the framing of the lowest floor. With the exception of Elevating on an Open Foundation (Section 5.2.3), the elevation techniques presented in this guide are not appropriate for homes in Coastal High Hazard Areas. If you have any doubt about the type of flood hazards that may affect your home, check with your local officials.

Figure 5-2. This home in Cedar Falls, IA, was elevated one full story. The garage and storage area are at the home's original elevation.

5.1.2 Existing Foundation

In general, the most economical approach to elevating a home is to use as much of the existing foundation as possible. Although some elevation methods do not allow this approach, most do. If you choose one of the latter, a design professional must evaluate the capacity of your existing foundation to support the loads that will be imposed by the elevated home and, as discussed in the next section, the loads expected to result from flooding and other hazards at the site. If changes must be made to the foundation to increase its strength and stability, they can be made as part of your retrofitting project. A design professional may determine that an older foundation constructed of mortared rock, masonry, or even poured concrete needs to be completely replaced or the local building code may require that it be replaced.

CROSS REFERENCE

Fill used for structural support and elevation is prohibited in Coastal High Hazard Areas. Check with your local officials about State and local requirements considering the use of fill. NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements* (2008), offers further guidance about using fill in Zone V.

The type of foundation on which your home was originally built (basement, crawlspace, slab-on-grade, piers, posts, piles) also can affect the elevation process. This issue is discussed in Section 5.2.3.

5.1.3 Hazards

Because so many elevation techniques are available, elevation is practical for most flood situations, but the flooding conditions and other hazards at the home site must be examined so that the most suitable technique can be determined. Regardless of the elevation technique used, the foundation of the elevated home must be able to withstand all the necessary loads (wind, seismic, snow, etc.) on the house, which also should include the expected flood loads from buoyancy, hydrostatic pressure, hydrodynamic pressure, and debris impact. It must also be able to resist undermining by any expected erosion and scour.

If you are elevating a home in an area subject to high winds, earthquakes, or other hazards, a design professional should determine whether the elevated home, including its foundation, will be able to withstand all of the horizontal and vertical forces expected to act on it. In making this determination, the design professional must consider a number of factors, including the structure and condition of the home, the soil conditions at the site, the proposed elevation technique, and the hazards at the site. The conclusion may be that additional modifications must be made during the retrofitting project. In some flooding conditions, another alternative, such as relocation, may be a better option. High wave loads, swift currents, or unstable soil may make relocation necessary. Sometimes the condition of the house and the necessary retrofits may also indicate that reconstruction of the entire house is a more cost-effective option.

5.1.4 Access

Elevating a home usually requires that new means of access be provided. For example, if your entry doors were originally at ground level, new staircases, elevators, or ramps will have to be built. When an attached garage is elevated, providing access for vehicles may require changes to portions of your lot, such as building a new, elevated driveway that ties into high ground elsewhere. This solution can be practical when the amount of elevation required is no more than 2 or 3 feet. As noted earlier, when the amount of elevation reaches 4 or more feet, you should consider elevating your home a full story so that you can use the lower level for parking and avoid the need for an elevated driveway. Constructing a means of access can be a considerable cost and should be included in the price for the elevation.

Figure 5-3. With attention to detail and planning, homeowners have created attractive retrofitted homes.

The need to provide a new means of access is often the main objection that homeowners have to elevating. But functional and attractive solutions to this problem can usually be developed, as shown in Figures 2-2 and 5-3.

5.1.5 Home Size, Design, and Shape

In general, the larger the home and the more complex its design and shape, the more difficult it will be to lift on jacks. Multistory homes are more difficult to stabilize during the lifting process and, as the dimensions and weight of a home increase, so do the required numbers of jacks and other pieces of lifting equipment. Exterior wall coverings such as stucco and brick veneer complicate the lifting process because they must either be removed or braced so that they will stay in place when the home is lifted. Homes with simple square or rectangular shapes are easier to lift than those with attached garages, porches, wings, or additions, which often must be detached and lifted separately, especially if they are built on separate foundations. Features such as chimneys can also add to the cost of lifting a house because they must be either braced or removed during the lifting process. Older properties may also include features such as cisterns, which may create access issues and result in higher lifting costs.

Before a home is lifted, a design professional should inspect it to verify its structural soundness. All the structural members and their connections must be able to withstand the stresses imposed by the lifting process. Lifting an unsound home can lead to potentially expensive damage.

5.1.6 Service Equipment

> **DEFINITION**
>
> **Service equipment** includes utility systems, heating and cooling systems, and large appliances in a retrofitted home.

Before your home is elevated, all utility lines (water, sewer, gas, electric, telephone, etc.) must be disconnected. At the end of the project, the lines will be reconnected and any landscaping that may be necessary will be completed. Adjustments may be required for any overhead electrical service lines to ensure they maintain all appropriate vertical and horizontal clearances. If you elevate your home on an open foundation, utility lines that enter the home from below may be exposed to damage from flooding and below-freezing temperatures. Protecting utility lines in these situations usually involves anchoring them securely to vertical foundation members and, if necessary, insulating them. All **service equipment** outside the home, such as air conditioning and heat pump compressors, and gas and electric meters, must be elevated to or above the flood protection elevation. In homes with basements, any service equipment originally installed in the basement must be raised above the flood protection elevation, which may require relocation to an upper floor or a small addition to house the equipment. Chapter 9 discusses the protection of service equipment. Moving or relocating utility meters, such as natural gas or electric meters, may be at the discretion of the utility service provider. Providers may require meters to stay at elevations below the BFE.

5.2 The Elevation Techniques

The elevation techniques and their applications to different types of homes are discussed in the following sections.

5.2.1 Elevating on Extended Foundation Walls

Frame, masonry veneer, and masonry homes can all be elevated on extended foundation walls. As discussed in the following sections, the technique used for homes on basements, crawlspaces, and open foundations differs from that used for homes on slab-on-grade foundations. The potential for an elevated slab-on-grade foundation to fail either during the lifting process, or even worse once the house is occupied, makes this elevation technique one that should be carefully scrutinized by a design professional familiar with the calculation of building loads and the design of concrete slabs.

Homes on Basement Foundations and Crawlspace Foundations

The elevation process is the same for frame, masonry veneer, and masonry homes on basement and crawlspace foundations. Figures 5-4a through 5-4d illustrate the process.

First, holes are made at intervals in the foundation wall so that a series of steel I-beams can be installed at critical points under the floor framing (Figure 5-4a). If the foundation walls are made of concrete blocks, the lifting contractor can remove individual blocks to create the required holes. If the walls are made of poured concrete, the holes will be cut out. The I-beams are placed so that they run perpendicular to the floor joists. A second set of beams is then placed below and perpendicular to the first set (Figure 5-4a). The two sets of beams extend the width and length of the home and form a cradle that supports the home as it is being raised.

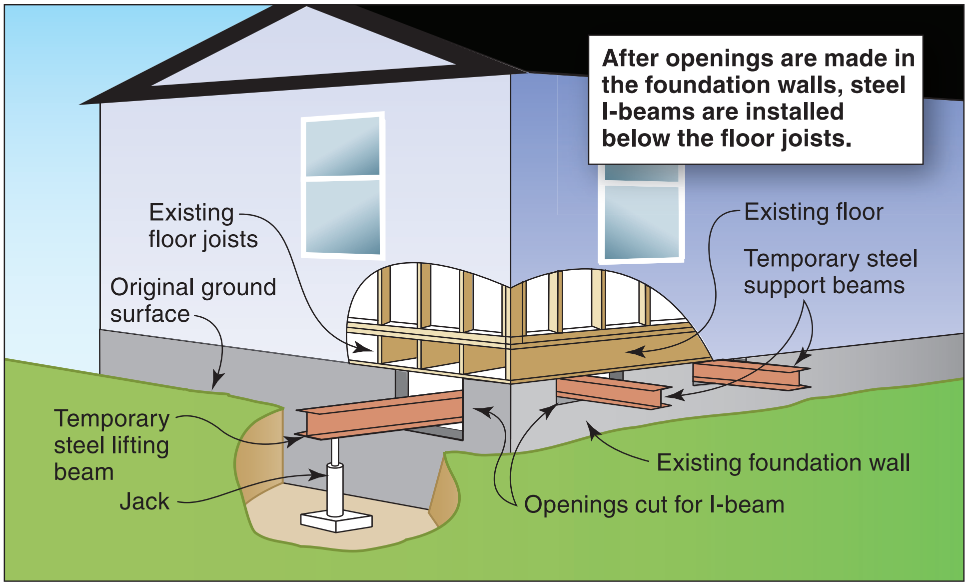
In Figure 5-4a, the foundation walls are shown extending far enough above the ground surface to provide easy access to the area below the floor framing. However, in some homes, the foundation walls will not be this high. To lift such a home, the contractor must first dig trenches at intervals around the foundation. The I-beams are then lowered into the trenches and inserted below the floor framing. The contractor may also have to dig holes for the lifting jacks, as shown in the figure. The number of jacks needed will depend on the size, shape, and type of home being lifted.

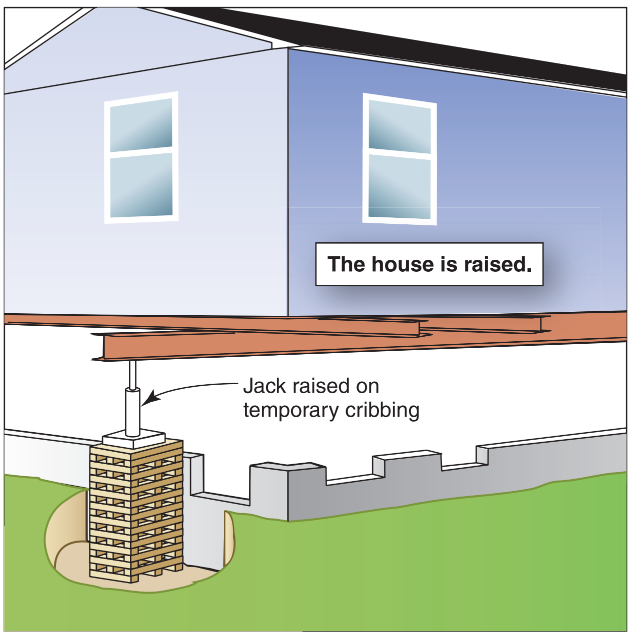
CROSS REFERENCE

For more information about openings requirements, refer to FEMA Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures* (2008), and FEMA P-259, *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* (FEMA. 2012a).

Once the beams and jacks are in place, the elevation process begins. The jacks will extend only so high; so at intervals during the process, the home and jacks are supported temporarily on cribbing while the jacks are raised (Figure 5-4b). After the home is elevated high enough, it is again supported on cribbing while the foundation walls are extended to the desired height with concrete blocks or poured concrete (Figure 5-4c). The home is then lowered onto the extended foundation walls, the I-beams are removed, and the holes where the beams passed through are filled. An important part of the project is installing flood openings in the foundation walls (your building permit should specify the size and location of these openings), no higher than 1 foot above the ground, so that floodwaters can enter and equalize the internal and external hydrostatic pressures. As shown in Figure 5-4c, the contractor may be able to create these openings by only partially filling the I-beam holes.

Figure 5-4a through 5-4d. Elevating a basement or crawlspace foundation home on extended foundation walls.





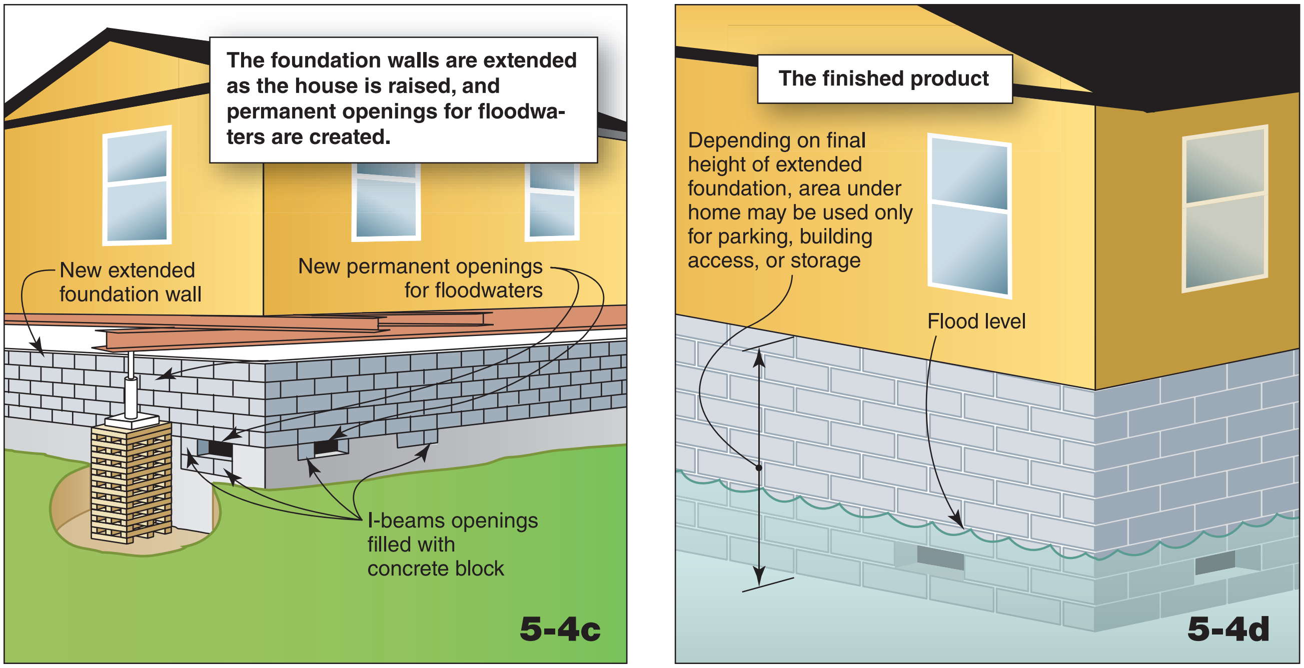


Figure 5-4a through 5-4d continued. Elevating a basement or crawlspace foundation home on extended foundation walls.

Homes on Slab-on-Grade Foundations

Frame, masonry veneer, and masonry homes on slab-on-grade foundations are also lifted with hydraulic jacks and a network of steel I-beams. However, slab-on-grade homes present special difficulties and require a different lifting technique. An alternative is to leave the existing slab and extend the walls (see Section 5.2.2), or convert the ground level of the home and build a new upper floor (see Figures 5-12a through 5-12c). See Hurricane Sandy Recovery Advisory No. 7, *Reducing Flood Risk and Flood Insurance Premiums for Existing Residential Buildings in Zone A* (FEMA. 2013e) for more information on doing such conversions.

The importance of evaluating the slab

To determine the best approach, the slab must be evaluated by a structural engineer. The engineer can determine which elevation method is suitable for the house. Often the slab will not be of sufficient strength to span the distances necessary to use the standard interior pier spacings associated with wood-framed floor systems.

The floor of a home on a slab-on-grade foundation is formed by the slab rather than the wood joist and beam framing found in homes on crawlspace and basement foundations. The slab is usually 3½ to 6 inches thick and is often reinforced only with wire mesh. As shown in the cross-section view in Figure 5-5, the slab can be supported by foundation walls and footings or by a thickened edge created when the slab is poured. Slabs are almost never designed to be lifted and supported on a wall and pier system but rather to rest on the ground. If the slab is not designed to be supported it could fail during elevation as a result of the loads. The wire mesh is often insufficient to provide adequate reinforcing in the slab and is only intended to prevent the slab from cracking.

Because the slab forms the floor of the home, and occasionally the foundation as well, elevating a slab-on-grade home is more difficult than elevating a house with a wood-framed floor system regardless of the lifting method used. Because this process is more difficult than that used for homes on basement and crawlspace foundations, it should be performed only by a highly skilled contractor with extensive experience in lifting slab-on-grade homes. In lifting the slab, the contractor must take extreme care during the lifting process to avoid breaking the slab and compromising the structural integrity of the home.

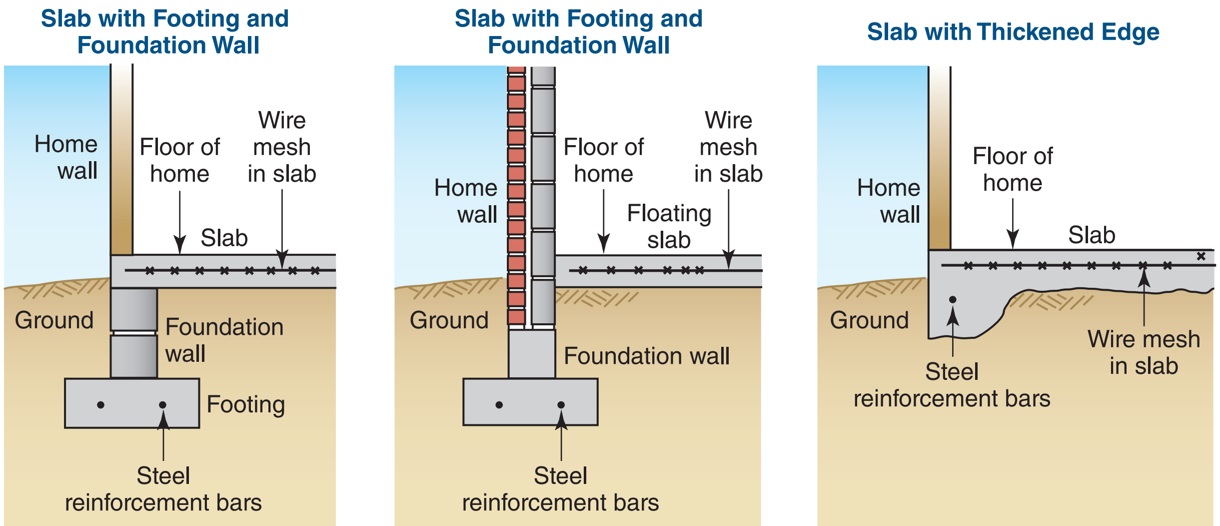


Figure 5-5. Cross-section view of slab-on-grade foundation variations.

Although the slab can be lifted while still attached to the walls, the slab may be dangerously weak once the house is occupied. A more practical method may be to separate the walls from the slab and lift the house leaving the slab in place. A new wood-framed floor can be constructed and the existing slab can remain in place.

Elevating with the slab remaining in place

If a design professional determines that the original slab is strong enough to support the elevated home under the expected flood, wind, earthquake, and other loads, the slab may be left in place and the new foundation walls built on top of it. Otherwise, the slab must be cut back and a completely new foundation constructed, as shown in Figure 5-6. The lift is accomplished by cutting openings into the walls and inserting I-beams through the openings. To enable the beams to lift the home, the contractor attaches horizontal wood bracing to the interior and exterior walls at the tops of the openings (Figure 5-7). Figure 5-8 shows an example of a retrofitted slab-on-grade house where the house was detached from the slab and a new floor system was constructed.

When the beams are jacked up, they push against the bracing, which distributes the lifting force equally across the walls. The bracing also supports the walls, which lack the structural stability that would otherwise be provided when the walls and floor are left attached. Without bracing, the walls could twist, bend, or collapse when the home is lifted.

Another option for elevations that do not exceed more than a few feet may be to construct a new elevated concrete slab. Building a new slab floor involves placing fill dirt on top of the old slab and pouring a new slab on top of the fill. Although the old slab is left in place, it is usually broken up so that it will not be forced up by the buoyant effect of floodwaters or saturated soil.

The primary advantage of lifting the home without the slab is that the home is lighter and, therefore, easier to lift. This benefit applies mainly to frame and masonry veneer homes. However, this method has several disadvantages:

- Cutting holes in the interior and exterior walls of the home and attaching wood bracing is invasive and must be repaired before the elevated home is habitable.

- Because of the invasive lifting techniques, the habitable parts of the first floor may not be available for use for an extended period of time during the project.
- The contents of the first floor must be removed before the elevation process can begin.

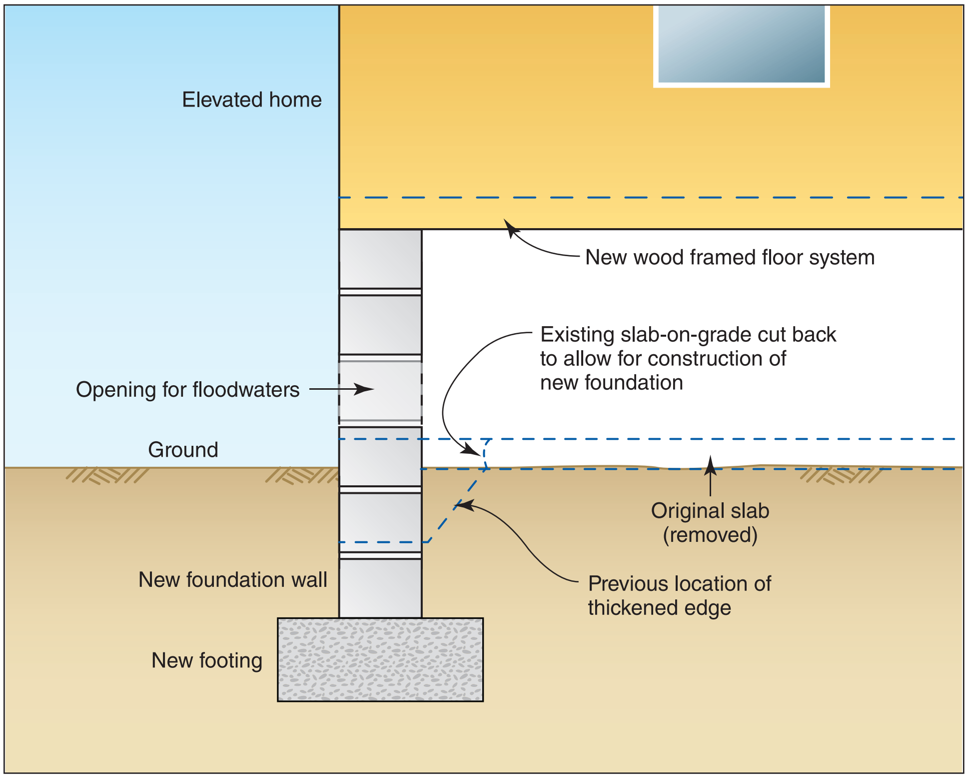


Figure 5-6. Building a new foundation for a slab-on-grade home.

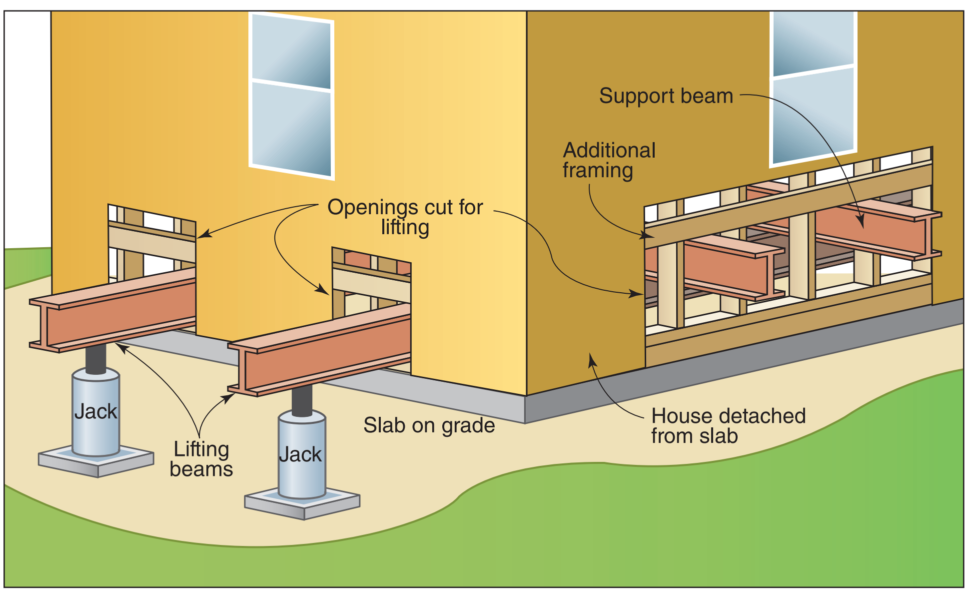


Figure 5-7. Elevating a slab-on-grade home without the slab.

Figure 5-8. House in Zone A was detached from its slab foundation (which remains) and elevated on masonry piers. The floor system is supported by new wood joists (Mandeville, LA).

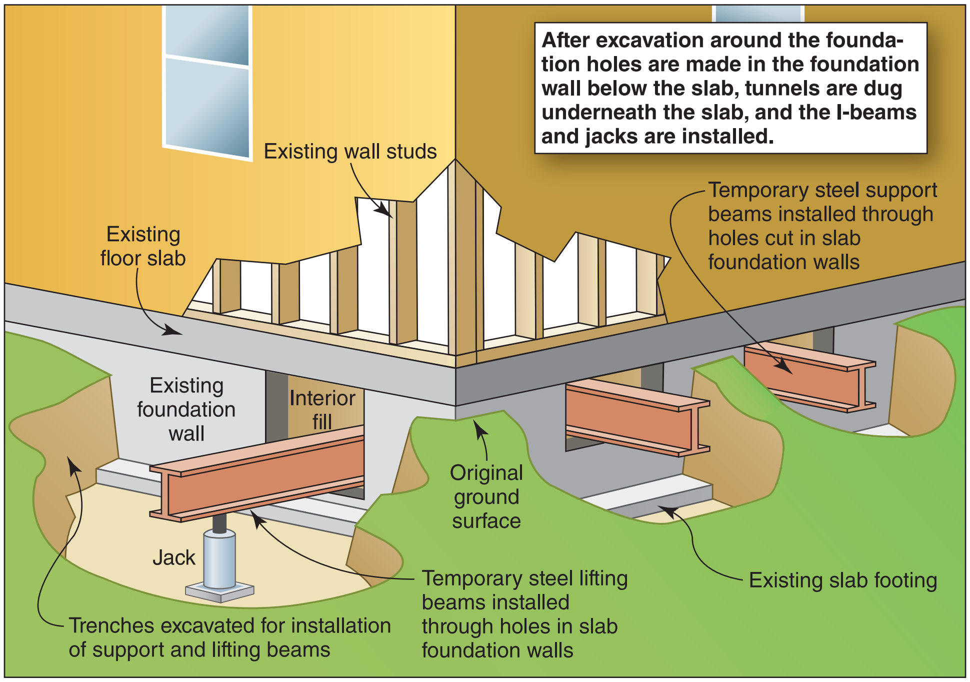
Elevating with the slab attached

When the slab is determined to be of sufficient thickness and reinforced such that it can be supported on piers, the slab can be lifted while still attached to the walls. The elevation process (Figures 5-9a through 5-9d) is similar to that used for homes on basement and crawlspace foundations, except that the I-beams must be placed below the slab, which is at ground level. Therefore, the contractor must dig trenches at intervals around the foundation, and tunnel under the slab. The I-beams are lowered into the trenches and moved into place beneath the slab through the tunnels (Figure 5-9a).

The contractor must also dig holes for the lifting jacks because they have to be placed below the beams. Once the beams and jacks are in place, the lifting process begins. As shown in Figures 5-9b and 5-9c, the home is lifted and a new foundation is constructed beneath it.

Some slab-on-grade houses are constructed on what are called stemwalls. These systems consist of a concrete footing with a short perimeter wall made of poured concrete or masonry block. If the slab was originally supported by foundation walls and footings (see left and middle illustrations in Figure 5-5), the contractor may be able to leave them in place and extend the existing walls upward. This approach is possible only when a design professional determines that the original foundation walls and footings are strong enough to support the elevated home and slab under the expected flood, wind, earthquake, and other loads. If the slab was originally supported on the ground by its own thickened edge (see right illustration in Figure 5-5), a completely new foundation must be constructed.

In both situations, the contractor must construct not only foundation walls under the perimeter of the slab, but also additional vertical foundation members, such as piers, at several locations under the slab. These additional foundation members are necessary because slabs are designed to rest directly on the ground, not to support the weight of the home.



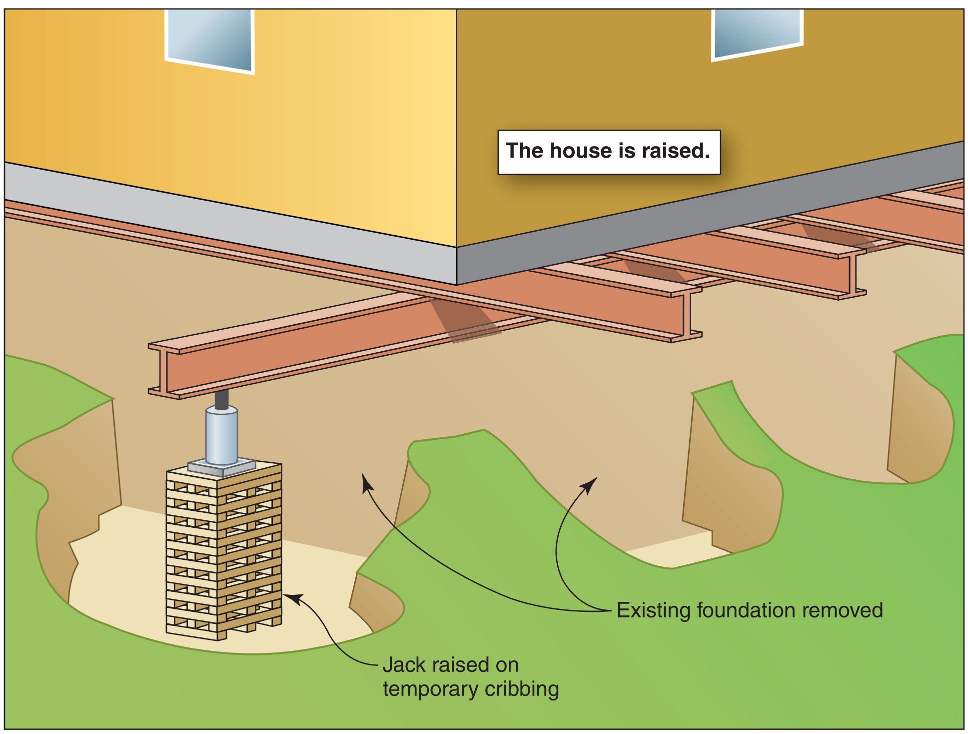
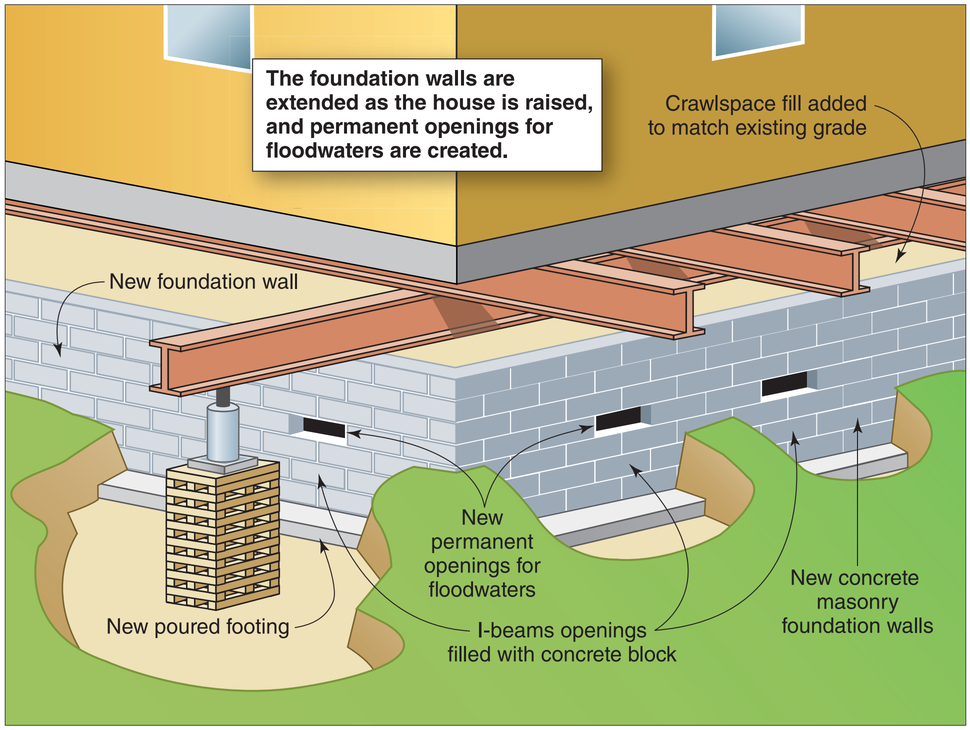
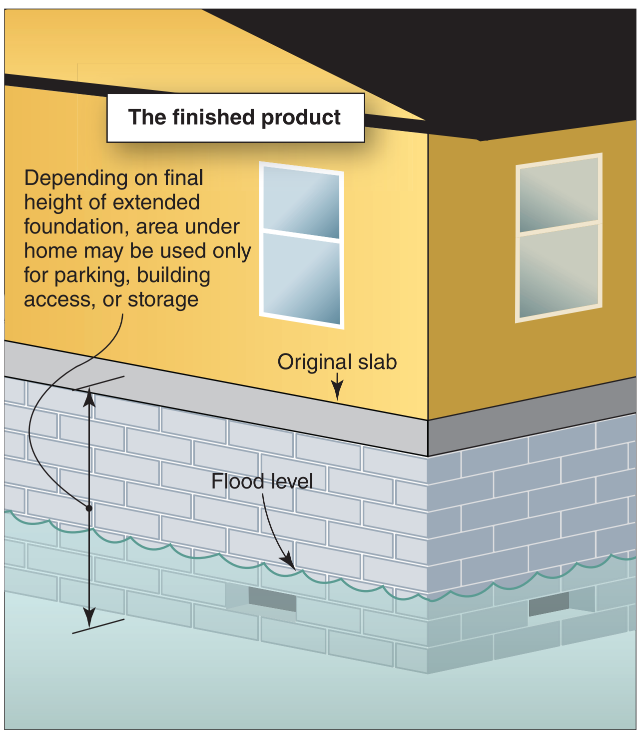


Figure 5-9a through 5-9d. Elevating a slab-on-grade home with the slab attached.

Figure 5-9a through 5-9d continued. Elevating a slab-on-grade home with the slab attached.





The primary advantage of lifting the home with the slab still attached to the walls is that the home can remain intact and many of the contents can remain inside during the lifting process. However, this method has several disadvantages:

- Most slabs were constructed to be continuously supported by the ground underneath them and are minimally reinforced. Insufficiently supporting such a slab can result in cracking or catastrophic failures that could potentially injure the occupants.
- Retrofitting slabs with insufficient thickness or reinforcement can be expensive.
- If the house is not lifted evenly, the slab could crack during the elevation process.
- If uneven settlement occurs, the weight of the elevated slab may exceed the capacity of the masonry piers commonly used for elevation projects.

Do not consider elevating a slab-on-grade house without seeking the help of a structural engineer. Although many elevation contractors have experience elevating slab-on-grade houses, concrete has the potential to catastrophically fail and appropriately assessing the strength of the slab may be difficult for most contractors. Slabs cast on the ground can have wide variations in thickness and the pier spacing may need to be adjusted once the bottom of the slab becomes visible. Structural engineers familiar with the design requirements for slabs can properly address the risk of a slab failure.

5.2.2 Alternative Elevation Techniques for Masonry Homes on Slab-on-Grade Foundations

Elevating by Extending the Walls of the Home

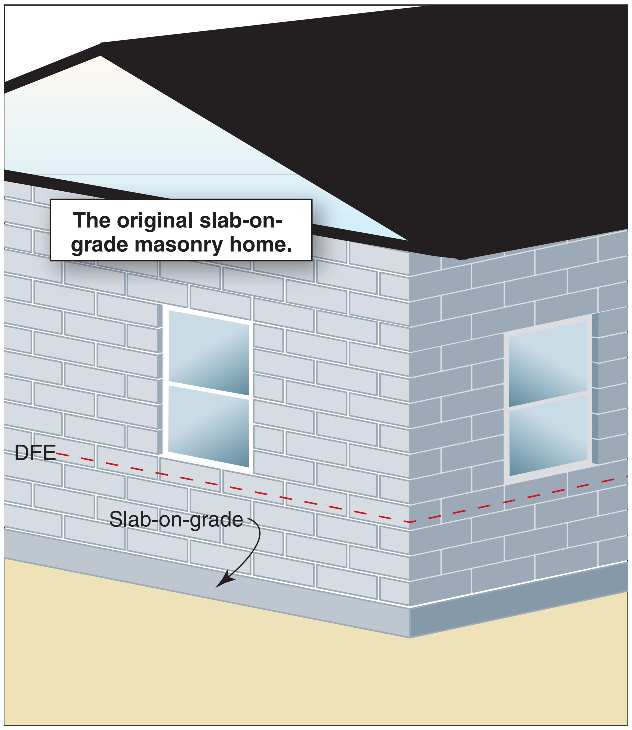
An alternative technique for elevating a masonry home on a slab-on-grade foundation is to extend the existing walls of the home upward and then build a new raised floor above the old slab. This technique is illustrated in Figures 5-10a through 5-10c.

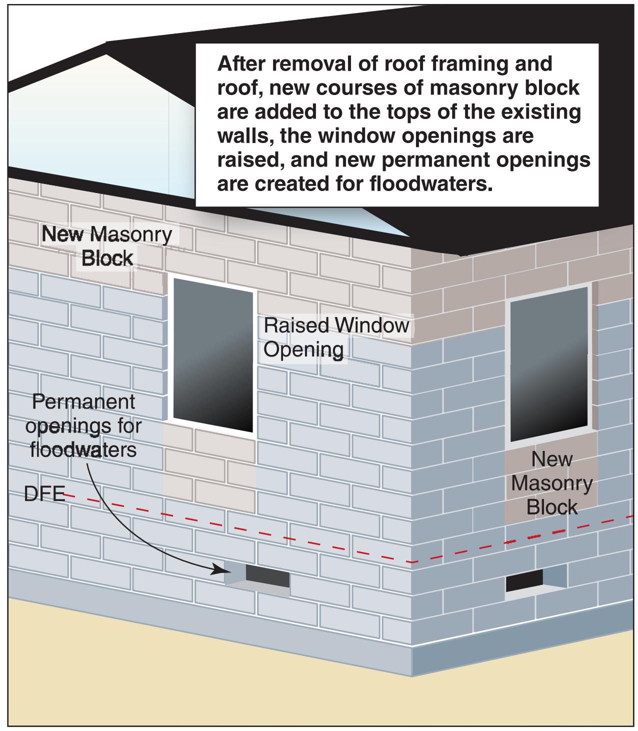
First the roof framing and roof are removed so that the tops of the walls will be accessible. The contractor can then extend the walls upward with additional courses of either concrete block (as shown in Figure 5-10b) or brick or with wood or metal framing. The choice of materials is based on several considerations, including cost, the final appearance of the home, the strength of the existing foundation, and the design requirements associated with the identified hazards, including high winds and earthquakes.

The final height of the extended walls will depend on how high the lowest floor must be elevated. For example, if the lowest floor must be elevated 3 feet to reach the flood protection elevation, the height of the walls must be increased by the same amount if the original ceiling heights in the home are to be maintained.

The new raised floor can be either a wood-framed floor system or an elevated concrete slab similar to the original slab (referred to as a stemwall). When a new wood-framed floor system is installed, the area below the floor becomes a crawlspace (as in Figure 5-10c) or other enclosed area that may be used for parking, building access, or storage. Flood openings must be installed in the foundation walls to allow external and internal water pressures to equalize. Additional openings may be needed for ventilation.

For a new elevated slab floor, fill dirt is placed on top of the old slab and compacted as required. Then a new slab is poured on top of the fill. When this method is used, openings in the foundation walls are not required because the entire area under the new slab is completely filled with dirt and is therefore protected from the pressure of floodwaters.





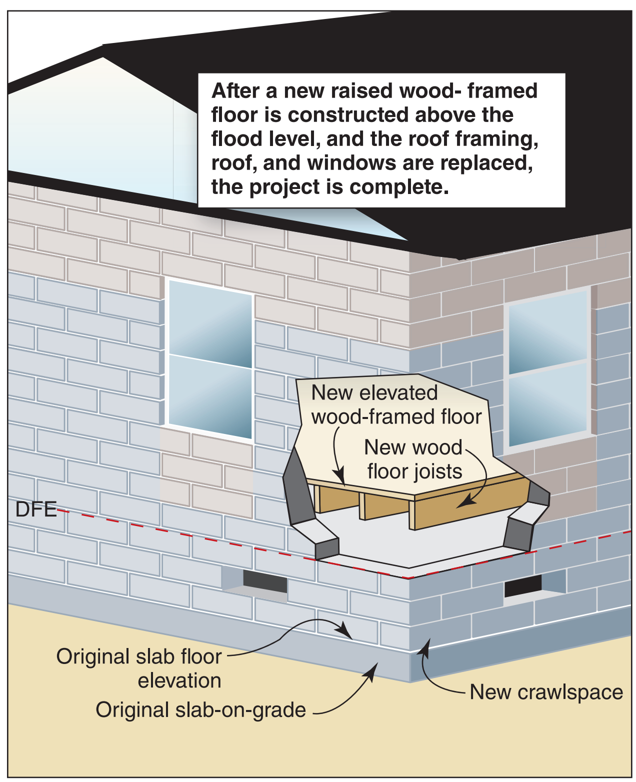


Figure 5-10a through 5-10c. Elevating by extending the walls of a solid masonry home.

Elevating by Abandoning the Lower Enclosed Area

Another alternative for a masonry home on a slab-on-grade foundation is to abandon the existing lower enclosed area of the home (the area with the slab floor) and allow it to remain below the flood protection elevation. This technique requires that the living area be restricted to upper floors of the home and that the lower enclosed area be used only for parking, building access, or storage. Because this technique leaves the original floor and walls below the flood protection elevation exposed to flooding, it is best suited to masonry homes on slab-on-grade foundations. In these homes, both the walls and floor are made of concrete or masonry, which are not easily damaged by contact with floodwaters. Only materials resistant to flood damage should be used on portions of the building below the flood protection elevation.

CROSS REFERENCE

For more information about flood openings, refer to FEMA Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures* (2008), and FEMA P-259, *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* (FEMA. 2012a).

The amount of work required for this technique depends largely on whether the home already has an upper floor that can be used for living space. When an upper floor exists, abandoning the lower enclosed area involves removing any interior finishing materials below the flood protection elevation (including interior wall sheathing and insulation unless required by code) and elevating or relocating vulnerable appliances (such as furnaces, washing machines, and freezers) and utility system components (such as electrical wiring and service boxes). These modifications are the same as those required for wet floodproofing, as described in Chapter 7.

This elevation measure may be the most practical for town houses or row houses. In an attached dwelling at least one wall and usually two are common or "party" walls. These walls make lifting the actual walls impossible. Shifting the elevation of the floor joists may be the only practical solution in these situations. This technique requires significant alterations to the front and back walls of the unit or any walls that are not common to the other units. These walls typically have the windows and exterior doors, which must be relocated (shifted up) as the floor framing is shifted. Interior walls also must be removed and replaced with these projects. Although this is an invasive method, the flood risk and potential financial implications of flood insurance premiums may make it a palatable mitigation option. Figure 5-11 illustrates how this could be done for a row house with high ceilings. This method also makes it possible to convert the ground floor to an NFIP-compliant enclosure and make adjustments to the upper floors, such as moving utilities and mechanical equipment to higher floors. Uses appropriate for areas below the BFE are described in Chapter 7.

For one-story homes, abandoning the lower enclosed area requires the construction of a new second story as shown in Figures 5-12a through 5-12c. The required steps are similar to those described in Section 5.2.1. The roof and roof framing are removed, a new second story is built on top of the existing walls, the roof and roof framing are replaced, and openings are added for floodwaters. The construction options are the same: frame or masonry. Again, the choice is based primarily on the considerations of cost, final appearance, the strength of the existing foundation, and the need to address other natural hazards, such as high winds and earthquakes.

Figure 5-11. Elevation of the floor levels in a row house to maximize living area above the BFE in Zone A (Source: Hurricane Sandy Recovery Advisory 3 (FEMA. 2013f)).

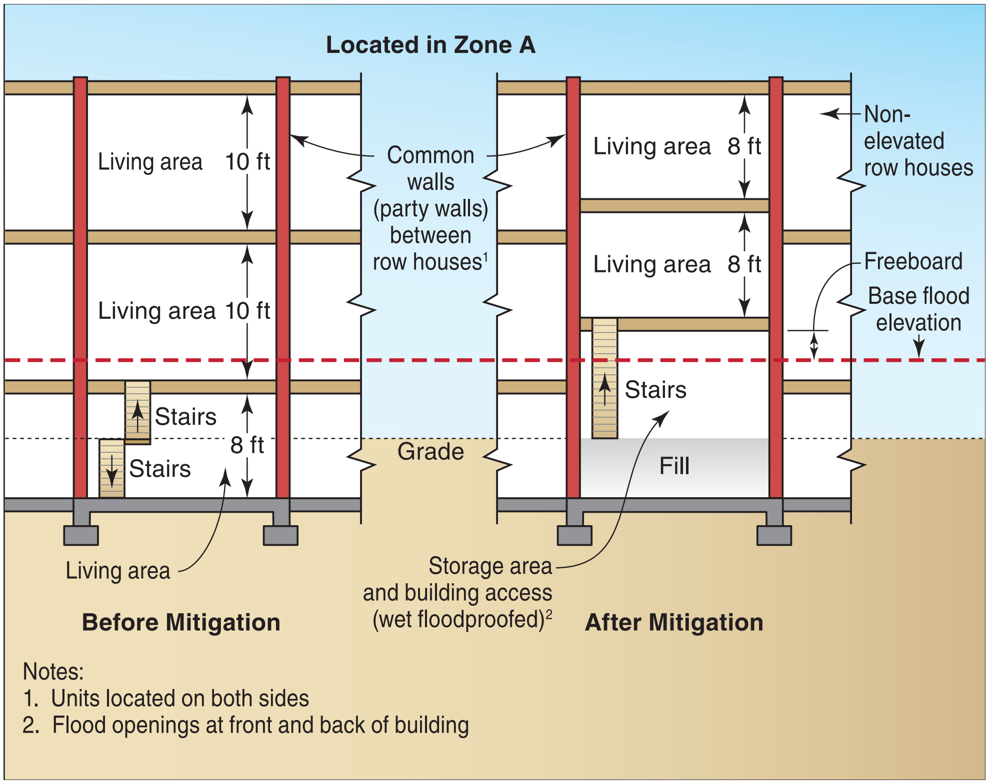
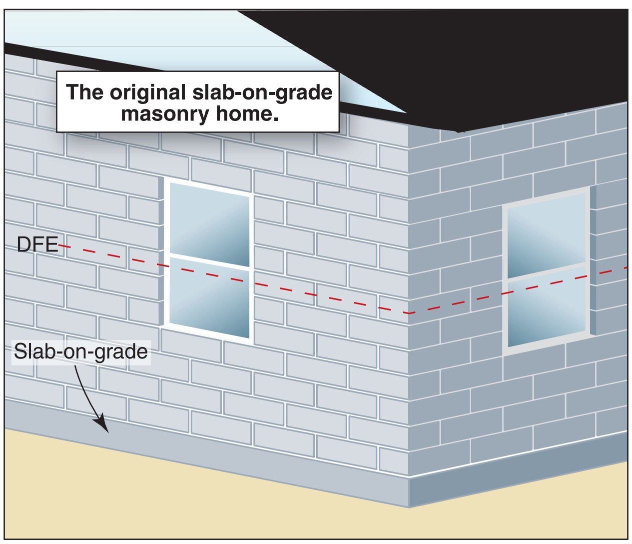
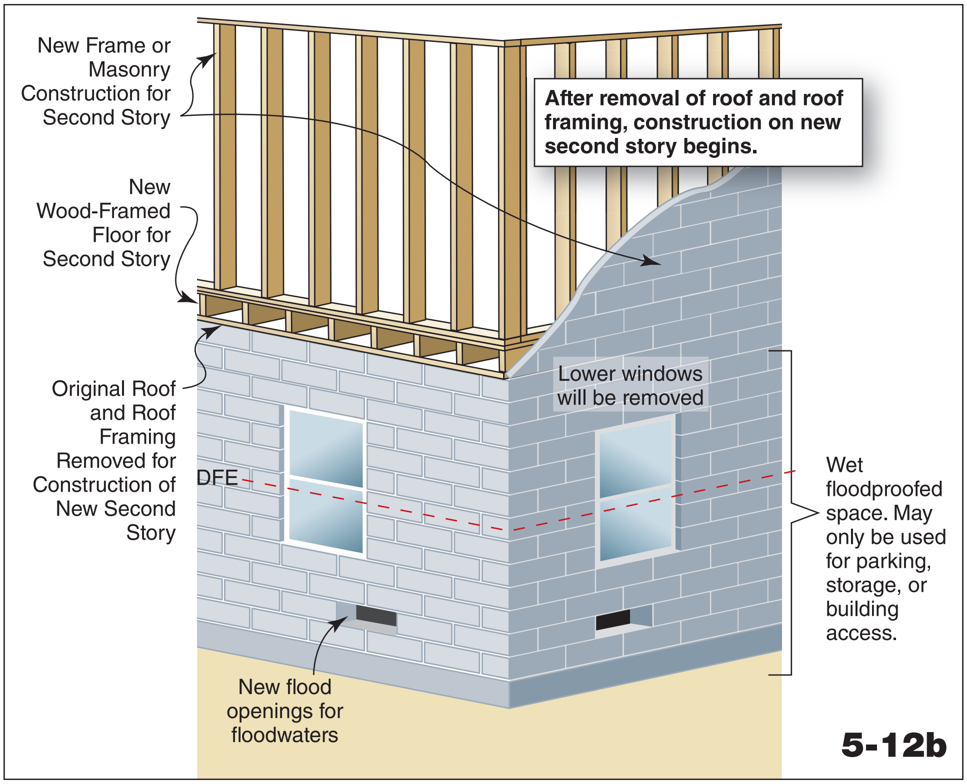


Figure 5-12a through 5-12c. Home elevated by adding a new second story over an abandoned lowest floor.





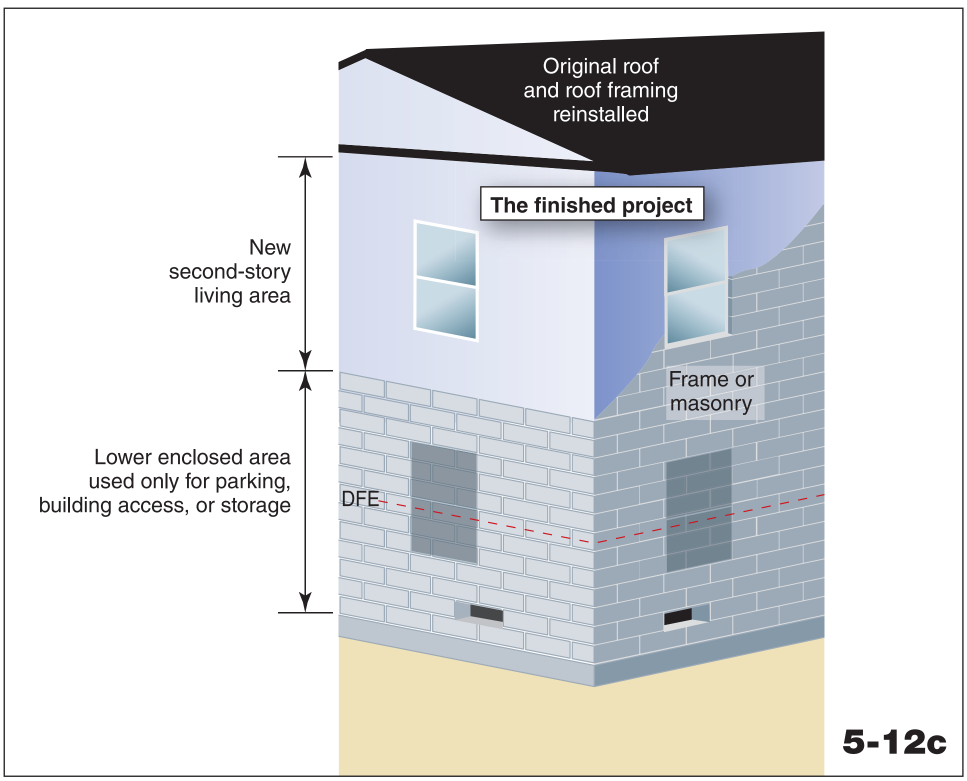


Figure 5-12a through 5-12c continued. Home elevated by adding a new second story over an abandoned lowest floor.

Mitigation Reconstruction

Mitigation reconstruction is the construction of an improved, elevated building on the same site where an existing building and/or foundation has been demolished. There may be reasons why elevating your home may not be feasible. If physical or economic obstacles are too great, you may want to consider demolishing your home and rebuilding a code-compliant home that is elevated above the flood level (see Chapter 6).

For FEMA HMA grants, mitigation reconstruction is only permitted if traditional structure elevation cannot be implemented. Activities that result in the construction of new living space at or above the BFE will only be considered when consistent with the mitigation reconstruction requirements.

5.2.3 Elevating on an Open Foundation

Frame, masonry veneer, and masonry homes on basement, crawlspace, and slab-on-grade foundations can also be elevated on open foundations consisting of piers, posts, columns, or piles. Homes originally constructed on open foundations can also be elevated this way.

NOTE

Open foundations are required for elevations in Coastal High Hazard Areas (Zones V, VE, and V1–V30) and are recommended for elevations in riverine floodplains where flow velocities are greater than 5 fps.

Piers

Figures 5-13a through 5-13d show how a home on a basement or crawlspace foundation can be elevated on masonry piers. The lifting process is the same as that shown in Figure 5-4 for elevating on extended foundation walls. Once the home is lifted high enough, new masonry piers may be built on the existing foundation, if it is adequate. If the existing foundation is not adequate to support the elevated home, it will have to be either modified or removed and replaced by separate footings for the individual piers.

An existing basement must be filled in with dirt and graded. An old basement slab can be left in place and covered with fill dirt. A basement slab does not need to be removed, but it should be broken up in place so that it will allow water to seep through it and reduce buoyancy forces before being covered with fill dirt. The home in Figure 5-13d has been elevated approximately one full story, and a new concrete slab has been poured at ground level below it. The open area below the home can be used for parking, building access, or storage.

Piers can be constructed of cast-in-place concrete as well as fully grouted masonry blocks. However, regardless of the construction materials used, piers are designed primarily for vertical loading imposed by the weight of the home, including its contents and any exterior loads, such as those imposed by snow. Because the forces associated with flooding, wind, and earthquakes can impose horizontal loads, piers used in retrofitting must be adequately reinforced with properly sized and placed steel bars. The connections between the piers and the original foundation and elevated home also must be able to resist the expected horizontal and vertical loads on the home so the home does not shift off the foundation.

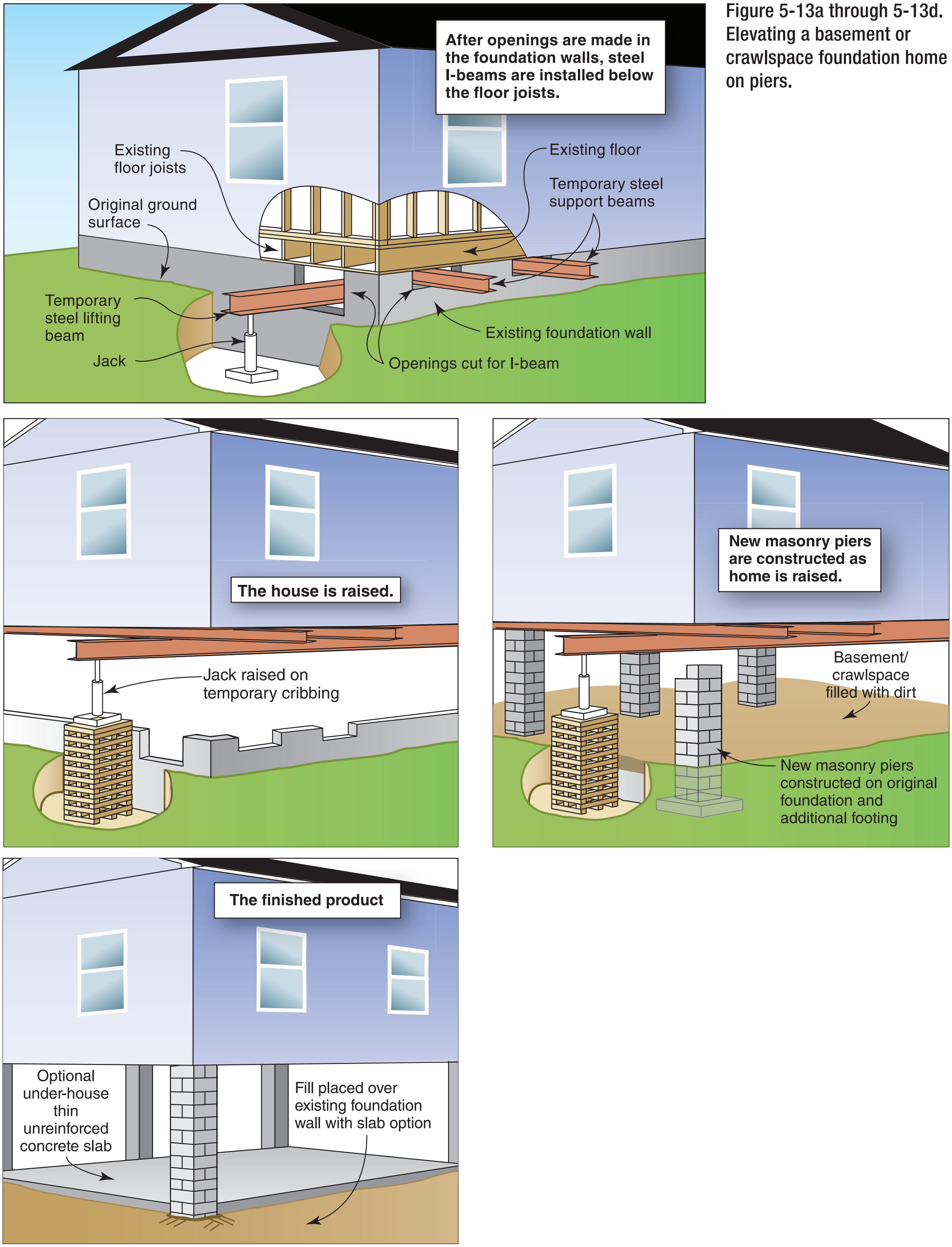


Figure 5-13a through 5-13d. Elevating a basement or crawlspace foundation home on piers.

Posts or Columns

For posts or columns, the home elevation process is the same as that described for piers; however, the existing foundation usually must be removed so that the posts or columns and their concrete encasements or pads can be installed. Posts are usually placed in drilled or excavated holes. Each post or column is either encased in concrete or anchored to a concrete footing.

Figure 5-14 shows a home elevated on two types of post or column foundations. Because an elevated house sits higher off the ground on a slender foundation, the lateral (sideways) loading on the house becomes a more important factor than a house sitting only a few feet off the ground on a continuous foundation. Large lateral loads can be exerted on the house by forces such as wind, earthquakes, or floodwaters. Simple wooden posts will not likely be able to resist these lateral loads and would require a formal design by a structural engineer. Lateral bracing can be used to prevent movement of the building for occupant comfort, but it should not be used to provide lateral support to prevent foundation failure. Additionally, bracing in two directions is only recommended in areas of low velocity flooding—areas with high-velocity flooding should only be braced in one direction (as shown in Figure 5-14). Depending on the potential lateral loads that the house must resist, a metal framing system may be a more practical approach than simple wooden posts. This system may also require an extensive concrete footing system so that the loads can be transferred down the posts or columns and into the ground. Although this elevation technique may appear simple, you should retain the services of a structural engineer who understands how loads are transferred.

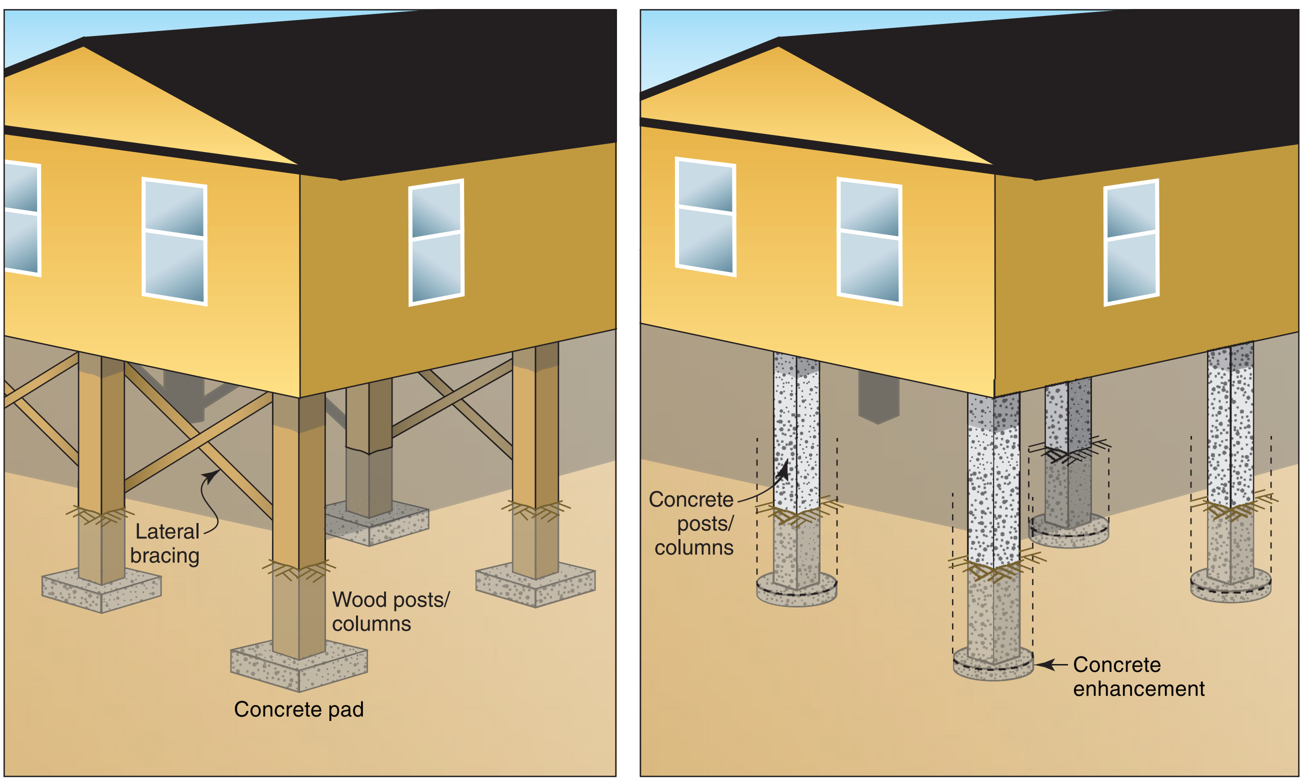


Figure 5-14. Home elevated on post or column foundations.

Piles

Elevating on piles is a more involved process than elevating on piers, posts, and columns. Piles are usually driven or vibrated into the ground or jetted in with a high-pressure stream of water. They are not supported by concrete footings or pads. Unlike the construction of wall, pier, or post or column foundations, the pile-driving operation, which requires bulky, heavy construction machinery, cannot be carried out under a home that has been lifted on jacks. Instead, the home is usually lifted and moved aside until the piles have been installed. Because the existing foundation is not used, it must be removed. Figure 5-15 shows a home elevated on a pile foundation.

More information on elevating homes on open foundations can be found in Hurricane Sandy Fact Sheet No. 2, *Foundation Requirements and Recommendations for Elevated Homes* (FEMA. 2013c). This fact sheet addresses many of the common issues associated with elevating homes on open foundations, and also addresses elevating a home on an open foundation that is confined by narrow lot lines.

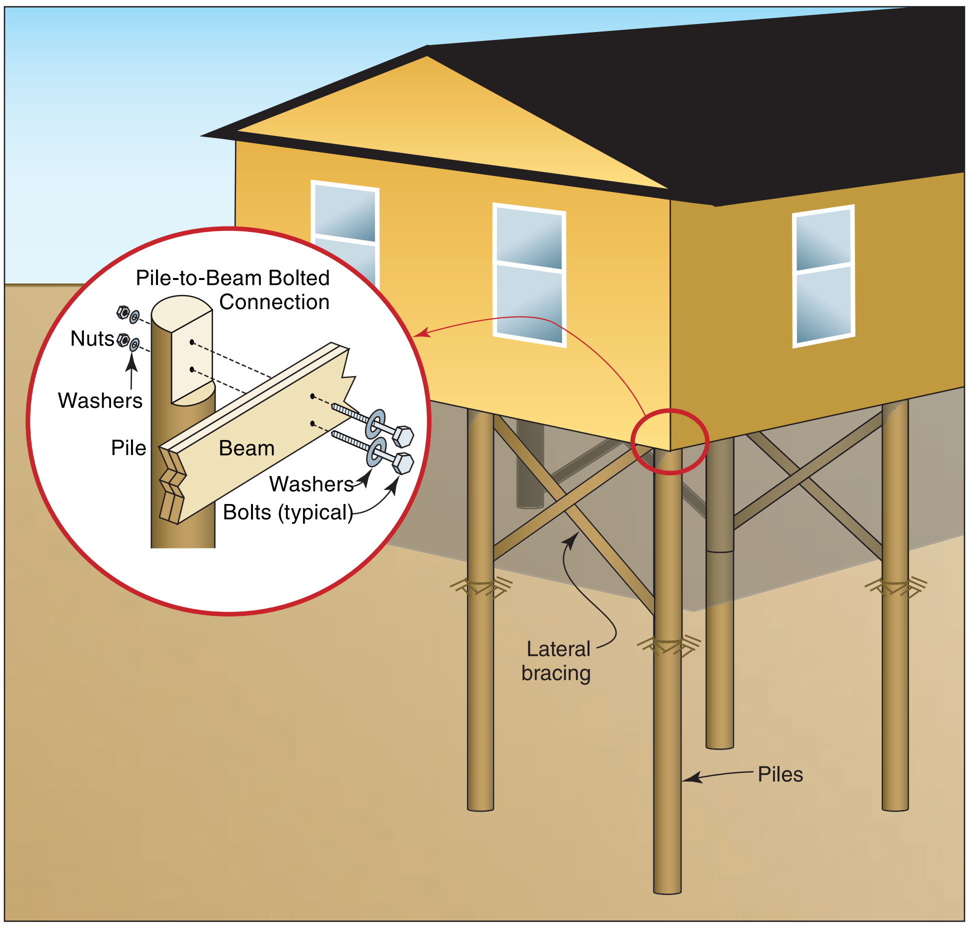


Figure 5-15. Home elevated on piles.




6.0 Relocation and Demolition

This chapter describes two mitigation alternatives: relocation and demolition.

Relocation

Demolition

These mitigation options can be more effective than other mitigation methods because they provide the opportunity to relocate or rebuild in an area outside of the floodplain. If rebuilding outside the floodplain is not possible, then moving to less vulnerable locations (i.e., from Zone V to a Zone A) on the same property or on a new property is also an option. If neither rebuilding outside the floodplain or in a less vulnerable location is feasible, elevation may be your best option. Elevation is described in detail in Chapter 5. This chapter addresses relocation outside of the floodplain.

Because relocation and demolition are both complex, you should consult design and/or construction professionals to help with your mitigation project.

6.1 Relocation

Relocation, or moving your home out of the flood hazard area, offers the best protection from flooding. It also can free you from anxiety about future floods and lower your flood insurance premiums. However, relocation usually is the most expensive of the retrofitting methods.

The relocation process involves lifting a home off its foundation, placing it on a heavy-duty flatbed trailer, hauling it to a new site outside the flood hazard area, and lowering it onto a new conventional foundation. The process sounds straightforward, but a number of considerations require careful planning.

NOTE

Always use a licensed, bonded, and insured contractor for relocation projects. Be sure that your contractor has experience with relocation projects and understands the considerations discussed in Section 6.1.1. Checking the contractor's references is very important.

For information about home relocation companies, contact the International Association of Structural Movers at P.O. Box 2104, Neenah, WI 54956-2104 (803) 951-9304, http://www.iasm.org/.

6.1.1 Considerations

Condition of Home

For a home to be picked up and moved successfully, it must be structurally sound. All the structural members and their connections must be able to withstand the stresses imposed when the home is lifted and moved. Before the home is lifted, the home moving contractor must inspect it to verify its structural soundness. A home that is in poor condition, especially one that has been damaged by flooding, may need so much structural repair and bracing that relocation is not be practical (see Section 6.2 for demolition).

Home Size, Design, and Shape

In general, the types of homes that are the easiest to elevate (as discussed in Section 5.1.5) are also the easiest to relocate: single-story, wood-frame homes over a crawlspace or basement foundation, especially those with a simple rectangular shape. These homes are relatively light, and their foundation design allows the home moving contractor to install lifting equipment with relative ease. Multistory homes and solid masonry homes are more difficult to relocate because their greater size and weight requires additional lifting equipment and makes them more difficult to stabilize during the move. Slab-on-grade foundations complicate the relocation process because they make the installation of lifting more difficult.

The relocation process is also more complicated for homes with brick or stone veneer, which can crack and peel off when disturbed. Removing the veneer before the home is moved and replacing it once the home is on the new foundation at the new site may be less expensive. For the same reason, chimneys may need to be removed before the move and rebuilt afterwards. If they are to be moved with the home, they must be braced extensively.

NOTE

Relocation is sometimes used as an alternative to demolition (as described in Section 6.2) when a home has been damaged. Instead of demolishing the home, the owner may be able to sell it for salvage to a contractor, who will then move the home to another site, renovate it, and sell it. Relocation is also used after a community acquires a flood-prone property from the owner. Instead of leaving the home to be demolished, the owner may decide to keep the home and move it to property outside the flood hazard area.

Moving Route Between Old and New Sites

Restrictions along the route to the new site can complicate a relocation project, especially for large homes. Narrow roads, restrictive load capacities on roads and bridges, and low clearances under bridges and power lines can make finding an alternative route necessary. When no practical alternatives are available, the home moving contractor may have to cut the home into sections, move them separately, and reassemble the home at the new site. Experienced home movers can make the cuts and reassemble the home in such a way that it will not appear to have ever been apart.

CROSS REFERENCE

See Section 4.1.3 for information about working with local officials regarding flood hazards and permitting requirements in your community.

Disruption of Occupants

Among all the retrofitting methods, relocation is the most disruptive for the occupants of the home. Before the home can be lifted, all utility systems must be disconnected, and the home becomes uninhabitable. You cannot move back into the home until it has been installed at the new site and all utility systems reconnected. In the interim, you will need temporary lodgings and a place to store your furniture and other belongings.

6.1.2 The Relocation Process

The relocation process consists of more than lifting and moving the home. You must work with your contractor to select a new site for the home, and the contractor must plan the moving route, obtain the necessary permits, prepare the new site, and restore the old site.

Selecting the New Site

Selecting a new site for your relocated home is similar to selecting a site on which to build a new home. You need to consider the following:

Natural Hazards – Remember that the goal of relocating is to move your home to a site that will be safe from flooding and other natural hazards. Before buying new property, check with local officials about the flood, wind, and earthquake hazards at any new site you may be considering (see Section 4.1.3).

Utilities – Determine what steps you need to take to install new utility systems and to have utility lines extended to your new site. Consider electrical, gas, water and sewer, telephone, and cable TV services. Your community will probably require that your new utility systems meet current code requirements. Regardless of these requirements, you should consider upgrading one or more of your utility systems to provide more energy-efficient service.

> **WARNING**
>
> Regardless of the age of your home, you may be required by local regulations to bring it up to current code when you move it to a new site. This requirement could affect not only the home but also its utility systems. You should check with your local officials about such requirements before you decide to relocate.

Accessibility – Your new site must be accessible to the home movers and to the construction crews that will prepare the site and build the new foundation for your home. The more difficult it is for contractors to reach and work at your new site, the more expensive your relocation project is likely to be. If extensive grading and clearing are necessary for adequate access, some of the characteristics that made the site attractive to you may be diminished. Your existing site may also present some accessibility issues if your home has a cistern or septic tank system installed on the property. If these need to be detached from your home and installed at the new project site, additional time and cost may be involved.

Another important consideration regarding accessibility is the difficulty of moving the home to the new site. In determining the best route between the old and new sites, the moving contractor must anticipate potential problems. For example, the routing of the home may be impeded by narrow bridges and road cuts, bridges with low weight limits, low-hanging utility lines and traffic signals, low underpasses, tight turns, road signs, and fire hydrants.

The moving contractor should also coordinate any special services that may be required to deal with obstacles, such as raising traffic lights, relocating signs, and constructing temporary bridges. Utility lines can usually be raised temporarily during the move, but utility companies often charge for this service. In some cases, it may be possible to avoid some obstacles by choosing an overland (non-road) travel route.

Permitting

You or your moving contractor must obtain permits to move the home on public roads or other rights-of-way. These permits may be required by local governments, highway departments, and utility companies, not only in the jurisdiction from which your home is being moved, but also any jurisdiction through which the home will pass. If the moving route crosses or affects private land, you may need to obtain the approval of the landowner.

Obtaining the necessary permits and approvals may be a lengthy and complex process, and you may find that the requirements vary from jurisdiction to jurisdiction and agency to agency. So it is extremely important that you, your design professional, and your moving contractor investigate the need for permits and approvals before you make a final decision to relocate.

You or your design professional should check with local officials to make sure that, when your home is moved to the new site, it will conform to all zoning requirements and building codes in effect at the time of the relocation. The design professional should also determine the local design standards and permitting requirements that govern the development of your new site. All permits required for construction at the new site, moving your home, and restoring the old site after the home is moved should be obtained *before* the relocation project begins.

Preparing the New Site

Before the home is moved, the new foundation must be designed and is usually partially constructed. The foundation will be completed after the home is brought to the site. Clearing, excavation, and grading are necessary to allow construction to begin and to ensure that the home can be maneuvered on the site. Also, unless already available, utility service must be brought into the site so that there will be no delay in connecting them to the home and making it habitable. Figure 6-1 shows a new slab-on-grade foundation that is being constructed for a relocation project.

CROSS REFERENCE

Refer to Section 5.2 for a description of how homes on various types of foundations are lifted off their foundations.

Figure 6-1. New foundation is being prepared (photo courtesy of Wolfe House Movers).

Lifting the Home

In general, the steps required to lift a home off its foundation are the same as those described in Section 5.2.1 for elevating a home on extended foundation walls. As described in Section 5.2.2, the steps to lift homes on basement and crawlspace foundations differ from those for homes on slab-on-grade foundations.

Homes on basement and crawlspace foundations are separated from their foundations and lifted on steel I-beams that pass through the foundation walls directly below the floor framing. The lifting is done with hydraulic jacks placed directly under the I-beams. The process for homes on slab-on-grade foundations is similar. However, because these homes are lifted with the concrete floor slab attached, the I-beams are inserted below the slab. Figures 6-2 through 6-5 show the basic steps for lifting a home.

Figure 6-2. Clearing pathways beneath the structure for lifting supports (photo courtesy of Wolfe House Movers).

Figure 6-3. Pathways for lifting beams (photo courtesy of Wolfe House Movers).

Figure 6-4. Beams supported by cribbing are placed at critical lift points (photo courtesy of Wolfe House Movers).

Figure 6-5. Hydraulic jacks lift the structure, and the home is separated from existing foundation (photo courtesy of Wolfe House Movers).

Moving the Home

After the home is lifted, the moving contractor performs the grading and excavation necessary to create a temporary roadway that will allow the home to be moved to the street. The area beneath the home must be leveled and compacted so that trailer wheel sets can be placed under the home (Figure 6-6). The wheel sets and lifting beams form the trailer on which the home will be moved.

Figure 6-6. Trailer wheel sets are placed beneath the lifting beams (photo courtesy of Wolfe House Movers).

After the wheels are attached, a tractor or bulldozer tows the home to the street. As the home is being moved, workers continually block the wheels to prevent sudden movement. At the street, the home is stabilized, the trailer is attached to a truck, and the move to the new site begins (Figure 6-7).

Figure 6-7. The move to the new site begins (photo courtesy of Wolfe House Movers).

At the new site, the moving contractor positions the home over the partially completed foundation and supports the home on cribbing so the trailer wheels can be removed. As in the home elevation process described in Chapter 5, the home is lifted on hydraulic jacks to the desired height and the foundation is completed below it. The home is then lowered onto the foundation, all utilities are connected, and any necessary backfilling and landscaping is completed (Figure 6-8).

Figure 6-8. House is lowered and connected to the foundation after the foundation is fully constructed (photo courtesy of Wolfe House Movers).

Restoring the Old Site

After the home is moved, the old site must be restored according to the local regulations. Restoring the site usually involves demolishing and removing the old foundation and any pavement, such as a driveway or patio; backfilling an old basement; removing all abandoned utility systems; grading to restore areas disturbed by demolition; and stabilizing the site with new vegetation. Permits are normally required for demolition, grading, and vegetative stabilization.

If your old site included a septic tank or fuel storage tank, you may have to meet the requirements of environmental regulations aimed at preventing contamination of groundwater. Depending on the age and condition of the tank, you may be required to drain and remove it. If it is an underground tank, you may have to drain it and anchor it to prevent flotation. You may also be required to test the soil around an underground fuel tank to determine whether leakage has occurred. As the homeowner, you will usually be responsible for cleaning contaminated soil if there has been any leakage from the tank. In this situation, you will need the services of a qualified geotechnical or environmental engineer.

Local utility companies or regulatory officials can inform you about requirements concerning capping, abandoning, or removing various utility system components.

NOTE

Always use a licensed, bonded, and insured contractor for demolition projects and for reconstruction projects. Be sure that your contractor has experience with demolition (and construction for mitigation reconstruction) and understands the considerations discussed in Section 6.2.1.

NOTE

Many homeowners have sold or deeded vacated flood-prone properties to local municipalities for use as parkland or open space.

6.2 Demolition

Demolition is tearing down a damaged home and either rebuilding a compliant home on the same property, rebuilding a compliant home on new property, or moving into another structure. This retrofitting method may be the most practical of all those described in this guide when a home has sustained extensive damage, especially severe structural damage.

If a flood-prone home has been severely damaged, because of flooding or any other cause, demolition can be practical and effective. Demolition may also be practical for an undamaged home that, because of deterioration over time or for other reasons, is not worth retrofitting with any of the other methods described in this guide. If you choose demolition, you will tear down your damaged home and either rebuild a compliant home on the same property or elsewhere outside the floodplain. If you decide not to rebuild, your State or local government may buy or **acquire** your property. Depending on your choice of a site for your new home, this method can lower or even eliminate your flood insurance premiums. If you decide to rebuild, your

DEFINITION

Acquisition is the process by which your State or local government purchases your flood-prone property, demolishes the building, and maintains the land as an open space.

mitigation reconstruction project may be eligible for FEMA grant money (see Section 2.6.1).

The demolition process involves disconnecting and capping utility lines at the damaged home, tearing the home down, removing debris and otherwise restoring the old site, and building or buying a new home. The most important considerations relate to how badly your home has been damaged and your options of building or buying a new home.

> **DEFINITION**
>
> **Mitigation reconstruction** is the construction of an improved, elevated building on the same site where an existing building and/or foundation has been demolished.

6.2.1 Considerations

Amount of Damage

Demolition is more practical for severely damaged homes than for those with little or no damage. If a flood, fire, earthquake, hurricane, or other disaster has caused extensive damage to the interior and exterior of your home or left it structurally unsound, you will probably find that demolishing the home and rebuilding it is easier than making all of the necessary repairs. Also, remember that a severely damaged home in the regulatory floodplain will almost surely be considered Substantially Damaged under your community's floodplain management ordinance, regulation, or provisions of the building code. Salvaging such a home would require repairing the damage and elevating the home (including backfilling a basement); wet floodproofing areas used only for parking, building access, or storage; or relocating the home as described in Section 6.1.

Rebuilding or Buying Another Home

After demolishing your home, you may buy or build a home elsewhere or, in some cases, rebuild on your existing property at an elevation above the BFE. Regardless of your decision, your goal is to greatly reduce or eliminate the potential for damage from floods, earthquakes, high winds, and other hazards. If you buy or build a home elsewhere, you'll want to find a site that is outside the regulatory floodplain, ideally one that is well above the BFE. You should also check with your local officials about other hazards before you make your final decision.

If you demolish your existing house and plan to relocate elsewhere, you will need to think about what to do with the existing property (land). Property that is entirely within the regulatory floodplain may be difficult to sell because of restrictions on its use. Your community may be interested in acquiring your property and then converting it to a public use, open space area. If you receive a FEMA grant to buy out your property then the land will most likely be deeded to the community and its use will be restricted to open space. As explained in Section 2.6, some Federal programs provide grants to States and communities that they can use to buy flood-prone homes and properties. State and local programs may also provide financial assistance. Check with your local officials about these programs.

When buying or building a home elsewhere is too expensive, you may be able to rebuild on your existing property, either on the site of your old home or, preferably, on a portion of your property that is outside the regulatory floodplain. If you rebuild on the site of your old home, your community's floodplain management ordinance, regulation, or provisions of the building code will require that the lowest floor be at or above the BFE. How you meet this requirement depends on the flood zone and code requirements of your community. An important disadvantage of this approach is that you may not have access to your home during floods.

If your existing property includes a large enough area outside the regulatory floodplain, a better choice is to rebuild there. Building outside the floodplain gives you greater freedom to build the type of home you want. Also, because both the home and property are outside the floodplain, restricted access during flooding is less likely to be a problem. Remember that floods do not follow the lines on FIRMs, so although building outside of the floodplain may not involve insurance implications, building high is safer and smarter. Property owners outside of high-risk flood areas file over 20 percent of NFIP claims and receive one-third of disaster assistance for flooding.

Disruption of Occupants

Like relocation, demolition can be disruptive for the occupants of the home. Unless you decide to buy an existing home elsewhere, you must find a place to live and to store your furniture and belongings while your new home is being built.

Permitting

You or your design professional or contractor must check with local officials regarding permitting requirements for the necessary work. All permits for demolition should be obtained before the demolition process begins, including disconnecting and capping utilities, disposing of debris, new construction, and restoration of the old site.

6.2.2 The Demolition Process

Tearing Down the Old Home

Your utility companies must first turn off all services to the home. Your demolition contractor will then disconnect the utility lines. If you do not plan to rebuild on the same site, the contractor will cap the lines permanently or remove them according to the requirements of the utility companies. Before demolition begins, environmental hazards, such as asbestos, must be abated in accordance with Federal, State, and local requirements. Typically, the demolition contractor will bulldoze the home and then dispose of the resulting debris as required by Federal, State, and local regulations.

Restoring the Old Site

If you are not rebuilding on the old site, it must be restored according to the requirements of local regulations. Site restoration usually involves demolishing and removing not only the home, but also any pavement, such as a driveway or patio; grading to restore areas disturbed by the demolition; and stabilizing the site with grass.

If your old site included a septic tank or fuel storage tank, you may have to meet the requirements of environmental regulations aimed at preventing contamination of groundwater. You may be required to drain and remove aboveground and underground storage tanks, or you may have to anchor them to resist flotation. You may also be required to test the soil around an underground tank to determine whether leakage has occurred. As the homeowner, you will usually be responsible for cleaning contaminated soil if there has been any leakage from the tank. In this situation, you will need the services of a qualified geotechnical or environmental engineering firm.

Local utility companies or regulatory officials can inform you about requirements concerning capping, abandoning, or removing various utility system components.

Rebuilding – Mitigation Reconstruction

Your construction contractor will prepare the site and build your new home according to the local building code, floodplain management, and zoning requirements. The lowest floor of your new home must be at or above the BFE, so your new home cannot include a basement. Figure 6-9 shows a mitigation reconstruction project that was recently completed in Louisiana following Hurricane Katrina.

WARNING

If you rebuild on the site of your old home, your community's floodplain management ordinance, regulation, or provisions of the building code will not allow you to have a basement below the BFE.

Depending on where you decide to rebuild, local utility companies may have to extend new lines onto the site of your new home. This is usually done before construction is completed and your contractor will hook up the utility lines as part of construction. You may need the services of a design professional if specialized utility systems are required because of the location of your site, the type of home you decide to build, or the nature of the hazards at the site.

Figure 6-9. Typical mitigation reconstruction project.




7.0 Floodproofing

This guide describes two types of floodproofing: wet and dry. As its name implies, wet floodproofing allows floodwaters to enter the enclosed areas of a home. In contrast, dry floodproofing prevents the entry of floodwaters. Because both approaches rely on varying philosophies of managing flood waters, this chapter separates the approaches and mitigation methods.

7.1 Wet Floodproofing

The benefit of wet floodproofing is that, if floodwaters are allowed to enter the enclosed areas of the home and to quickly reach the same level as the floodwaters outside, the effects of hydrostatic pressure, including buoyancy, are greatly reduced. As a result, there are equalized loads imposed on the home during a flood and the likelihood of structural damage may be greatly reduced. Wet floodproofing is generally used to limit damages to enclosures below elevated buildings, walkout-on-grade basements, below-grade basements, crawlspaces, or attached garages. It is not practical for these areas to be used as living space, and, if the home is being Substantially Improved or has been Substantially Damaged, wet floodproofing can lead to NFIP compliance only if (1) the area is limited to parking, access, or storage, (2) designed to allow for automatic entry and exit of flood waters through the use of flood openings, and (3) uses only flood damage-resistant materials below the DFE.

Successful wet floodproofing involves the following:

- Ensuring that floodwaters enter and exit the home's enclosed area (for NFIP compliance, floodwaters must exit the enclosed area automatically, without the use of pumps)

WARNING

If your home is being Substantially Improved or has been Substantially Damaged, your community's floodplain management ordinance or regulations will restrict the use of wet floodproofing to attached garages and enclosed areas below the BFE that are used solely for parking, building access, or storage. For more information, refer to NFIP Technical Bulletin 7, *Wet Floodproofing Requirements* (1993).

WARNING

Non-compliant wet floodproofing a residence will *not* reduce the flood insurance premium.

NOTE

Flood damage-resistant materials are discussed later in this chapter.

- Ensuring that floodwaters inside the home rise and fall at the same rate as floodwaters outside the home
- Reducing damage caused by contact with floodwaters to areas of the home that are below the flood level
- Protecting service equipment inside and outside the home
- Relocating high-value contents stored below the DFE

This chapter describes the modifications that must be made to a home as part of a wet floodproofing project and the most important considerations for this retrofitting method. Protection of service equipment is discussed in Chapter 9.

7.1.1 Design Flood Elevation

All construction and finish materials in the areas of the home that will be allowed to flood should be resistant to damage caused by direct, and possibly prolonged, contact with flood-water. Areas used for living space typically contain floor and wall coverings and other finishing materials, furniture, appliances, and items that could be easily damaged by floodwater and expensive to clean, repair, or replace. Therefore, wet floodproofing is practical only for portions of a home that are not used for living space, such as a basement, walkout-on-grade basement, crawlspace, non-air-conditioned porch, or attached garage. As shown in Figure 7-1, the lowest floor should be at or above the DFE (including freeboard) for wet floodproofing.

> **NOTE**
>
> Always consult a licensed, bonded, and insured contractor before initiating a wet floodproofing project. Be sure that your contractor has experience with wet floodproofing and understands the considerations discussed in Section 7.1.

If your DFE is above the elevation of your lowest finished floor, you should consider one or more of the other retrofitting methods described in this guide, such as elevation (Chapter 5). As you review Chapter 5, note that most of the elevation methods incorporate the principles of wet floodproofing. Elevation raises the living space above the flood level and allows floodwaters to enter the enclosed areas of the home below the living space if those areas have been retrofitted for compliance.

7.1.2 Hazards

Wet floodproofing protects a home from the effects of hydrostatic pressure but not from other flood hazards, such as the hydrodynamic force of flowing water, erosion and scour, saturation of building elements, damage to contents, the impact of ice and other floodborne debris, and damage from floodborne contaminants. If you have seen evidence of these hazards in past floods in your area, or if your community officials confirm that your home may be affected by these hazards, you should consider an alternative retrofitting method, such as relocation (Chapter 6) or elevation on an open foundation (Chapter 5). Wet floodproofing a home does not change its vulnerability to damage from high winds or earthquakes.

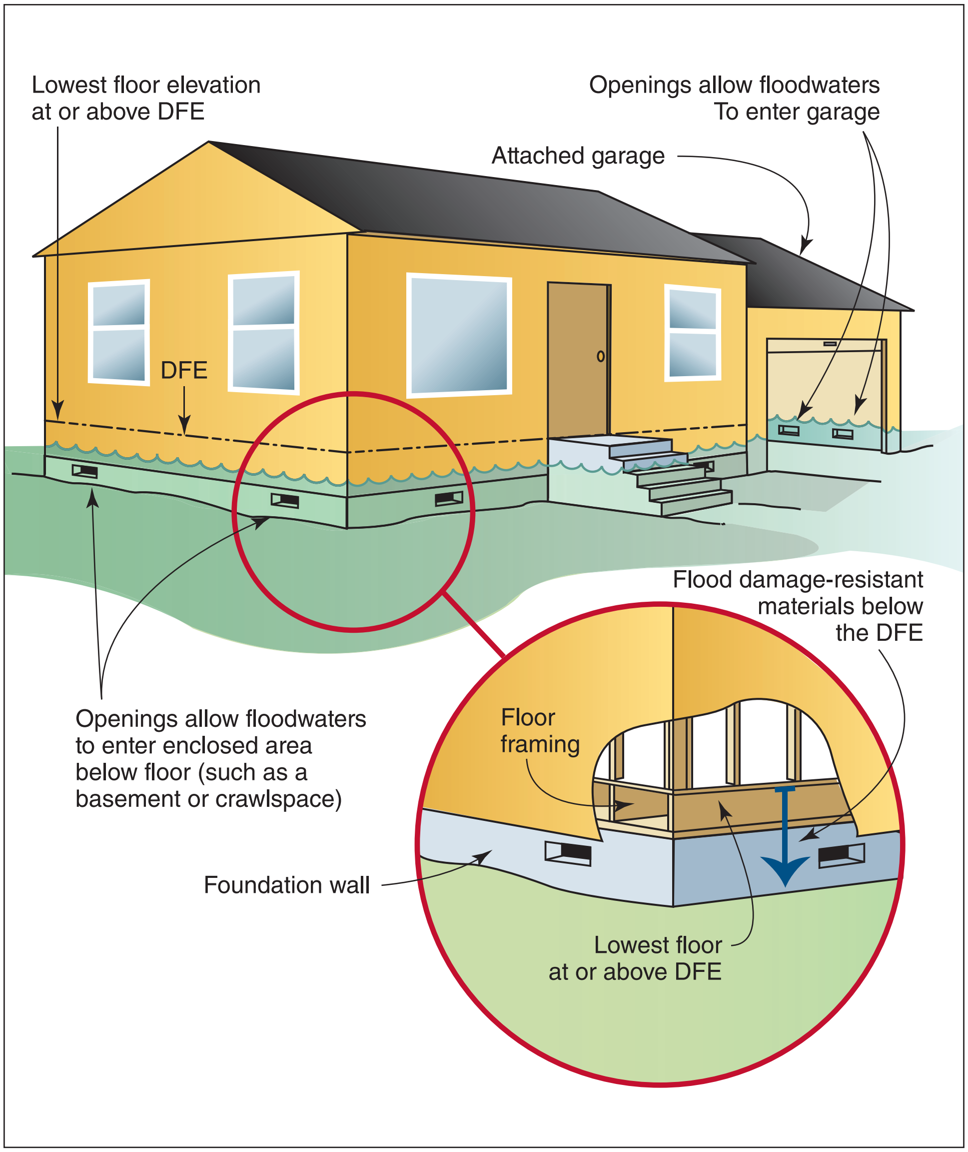


Figure 7-1. Typical wet floodproofing.

7.1.3 Post-Flood Cleanup

Remember that floodwater is rarely clean and may pose other safety hazards to occupants and contractors. Use caution when entering a recently flooded home; watch for structural instability or shifted contents as well as displaced animals. There are three important principles to follow when you first return to a flooded home before beginning repairs:

1. Personal Safety

Flooded buildings pose a number of health and safety risks, for both individuals who wish to maintain occupancy and those who work to repair the buildings. Eliminating hazards is the best way to protect occupants and workers; until conditions can

NOTE

If more than 10 square feet are affected by mold, you should contact a mold cleanup professional. For more information about mold prevention and remediation, visit the Center for Disease Control's (CDC's) mold Web site at http://www.cdc.gov/mold.

be returned to normal, anyone working in a flooded building should use appropriate personal safety equipment and take appropriate safety precautions.

Mold: The Occupational Safety and Health Administration (OSHA) Fact Sheet, *Hurricane Sandy Cleanup PPE Matrix* (OSHA-FS-3612, 2012), provides information on personal protective equipment. Anyone entering a house with visible mold growth should wear a disposable suit, rubber gloves or other hand protection, and respiratory protection. The OSHA Fact Sheet, *Mold Hazards During Hurricane Sandy Cleanup* (OSHA-FS-3619, 2012), provides information on mold.

Asbestos and Lead Paint: Asbestos in floor tile, pipe and boiler installation, and electrical wiring is common in many homes built before 1980. Breathing asbestos fibers released from building products can increase the risk of cancer and cause a number of serious lung diseases. Paint in homes constructed prior to 1978 may contain lead. If asbestos or lead paint is suspected, obtain the services of a specialist to perform material testing, and do not disturb the material until testing has been completed. If testing confirms the presence of lead, remediation should be conducted by a licensed professional in accordance with State and Federal regulations.

2. Cleaning Flood Damaged Homes to Prepare for Repair and Reconstruction

All objects that came into contact with the floodwater should be cleaned and sanitized. Water-damaged porous materials are difficult to properly clean and should be discarded.

Move out: Remove salvageable contents that were not affected by the water; dispose of all saturated porous materials, such as mattresses or upholstery.

Tear out: Remove all water-damaged interior finishes, including wet carpet and padding, curled vinyl tiles and linoleum, saturated drywall and plaster, saturated wall insulation, flooded electrical receptacles, and swollen wall paneling.

Barriers: Place plastic barriers between affected and unaffected areas of the building (typically between the first and second floors at the base of the stairs) to reduce the potential of mold spores spreading to unaffected areas.

WARNING

Although bleach is an inexpensive and convenient cleaning agent, it has many serious drawbacks when used to clean flood-impacted materials. It is not effective on porous materials, such as gypsum wall board or as a disinfectant on surfaces with residual dirt and can corrode electrical and metal components of mechanical systems. Do NOT combine chlorine bleach and ammonia, as the combination of chemicals will release vapors that can be extremely toxic or even fatal.

Application of Cleaners: Cleaners are most efficiently applied using a combination of foam cleaning processes and brush cleaning, followed by pressure washing. Foam cleaning processes allow the product to stay on the surface long enough for the chemicals to kill the mold or bacteria and makes drying easier. Brushes improve decontamination of wooden studs and other surfaces by scrubbing the foam into affected surfaces. Water-damaged porous materials should be removed. Care should be taken to inspect both the front and back side of the non-flooded gypsum wall board and plaster walls for remaining dirt and mold to ensure all affected areas are cleaned.

Pressure Washing: The fastest and most efficient rinse tool, which minimizes the amount of water used to remove residual foam from wall studs, floor joists, and other surfaces, is a residential-type pressure washer set at low pressure so that the spray is a light mist.

Cleaning Crawlspaces: Removing the flooring is the simplest way to enter crawlspaces to decontaminate these areas. Solid contaminants should be removed from under the building, along with any remaining water. All exposed sides of floor joists, foundation walls, and remaining structural elements should be cleaned with cleaning foam and brushing.

Cleaning in Weather Extremes: Although cold weather poses challenges for restoring flooded buildings, it also has some advantages. Cooler weather slows down the spread of mold. However, buildings need to be warmed to 50° to 75°F to provide for worker comfort, improve the effectiveness of cleaning and sanitizing agents, and allow commercial drying equipment to operate efficiently. Mold and bacteria spread more quickly in hot and humid weather, slowing natural drying of flooded and contaminated building elements; in such circumstances, the use of drying equipment is critical to lower the moisture content of structural materials prior to rebuilding or repair.

CROSS REFERENCE

For more information about openings requirements for wet floodproofing, refer to NFIP Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures* (2008), and FEMA P-259, *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* (FEMA. 2012a).

3. Proper Drying Prior to Rebuilding

After the cleaning process has been completed, the building and any salvageable contents need to dry. Failure to allow adequate drying prior to reconstruction can trap moisture in the building, which can cause fungal growth and potential health problems. Once the electrical and HVAC systems have been restored and sanitized, the moisture content of wetted salvageable building materials should be checked to determine whether drying equipment, such as fans and dehumidifiers, is necessary.

WARNING

Failure to allow adequate drying prior to reconstruction can trap moisture in the building, which can cause future fungal growth and potential health problems.

For more information about restoring flooded buildings or initial precautions to be taken when entering flooded buildings, refer to the Hurricane Sandy Recovery Fact Sheet Number 1, *Cleaning Flooded Buildings* (FEMA. 2013a)[1].

FEMA P-942, *Hurricane Sandy in New Jersey and New York* (FEMA. 2013d) provides a comprehensive assessment of building material performance and mitigation actions appropriate to flooded homes, other structures, and infrastructure.

7.1.4 Modifications Required for Wet Floodproofing

Wet floodproofing requires a variety of modifications to your home, including its walls, construction and finishing materials, and service equipment. Consult with a design professional or licensed contractor before you make any modifications.

7.1.5 Installing Openings

The most important part of a wet floodproofing project is installing wall openings that allow the entry and exit of floodwaters. The openings must be installed in foundation walls and in garage walls as appropriate, below the expected flood level (Figure 7-2). The goal is not simply to allow the entry and exit of floodwaters, but also to ensure

1 The fact sheet is part of FEMA's Hurricane Sandy Recovery Advisory and Fact Sheet technical series and can be downloaded at http://www.fema.gov/hurricane-sandy-building-science-activities-resources

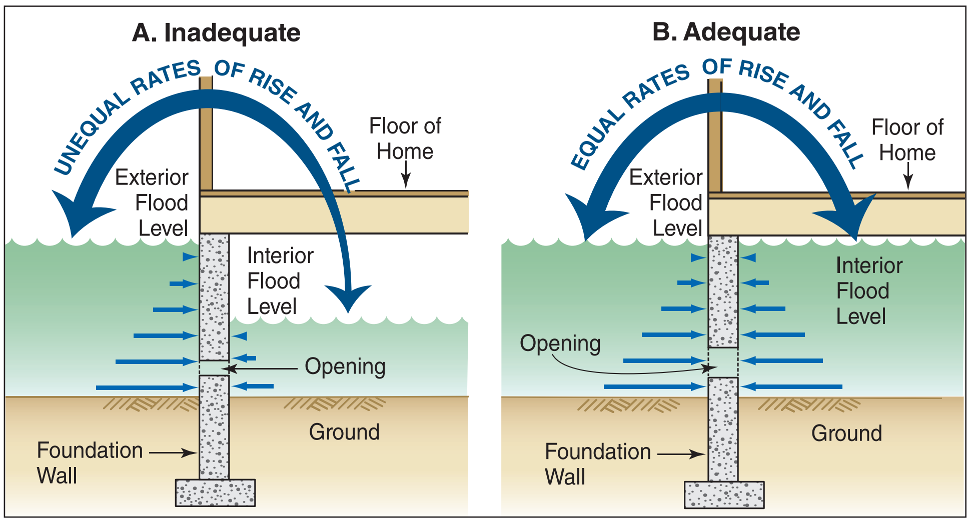
that the water level inside the home rises and falls at roughly the same rate as the water level outside so that hydrostatic pressures inside and outside are continuously equalized. As shown in Figure 7-2, large differences in the interior and exterior water levels allow unequalized hydrostatic pressures and, therefore, defeat the purpose of wet floodproofing. Figure 7-3 illustrates typical enclosures with flood openings.

For equal water levels to be maintained, both the size and number of openings must be adequate. Otherwise, when floodwaters are rising and falling, water will not be able to flow into or out of the home fast enough. The number of openings required and their size will depend on the rate of rise and the rate of fall of the floodwaters (see Chapter 2) and on the size of the area that is being allowed to flood. In general, the faster the rates of rise and fall and the larger the flooded area within the home, the greater the number and size of openings required.

NOTE

If you cover wall openings with louvers or screens, keep in mind that, the more restrictive they are, the more likely they are to become clogged with debris during floods and prevent the flow of floodwaters. Make sure that any screens or louvers allow the passage of water that contains suspended sediment and other small debris. After floodwaters have receded, screens and louvers must be cleaned of any debris that may have accumulated.

Figure 7-2. Wall openings must allow floodwaters not only to enter the home, but also to rise and fall at the same rate as floodwaters outside the home.



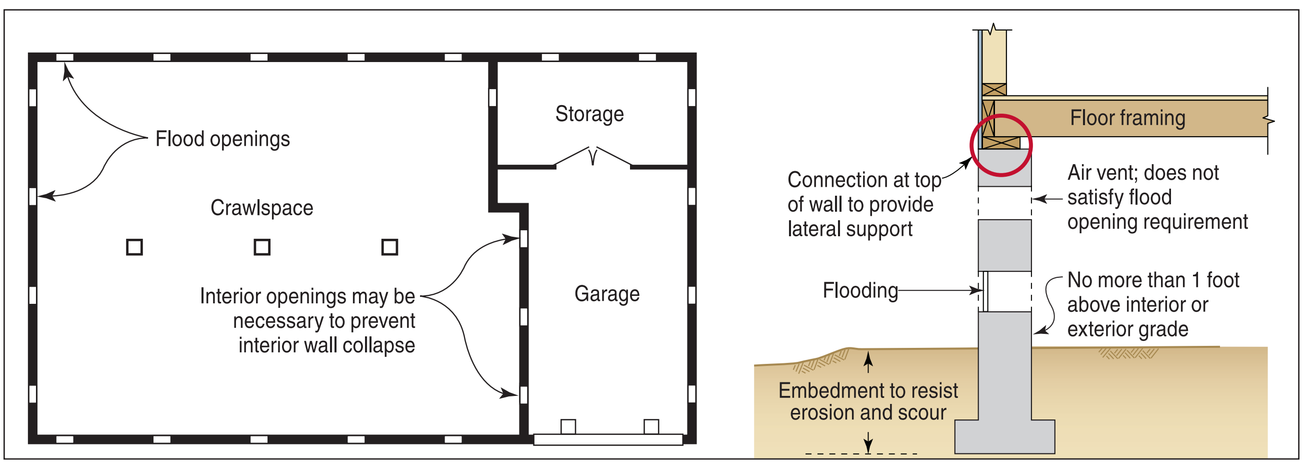


Figure 7-3. Sketch of foundation plan of home with multiple enclosed areas, each with flood openings. Typical enclosures with flood openings (Left). Flood opening in typical crawlspace foundation (Right).

If you are wet floodproofing areas below the BFE in a Substantially Improved or Substantially Damaged home, your community's floodplain management ordinance or regulation will require you to install openings in the exterior walls of all enclosed areas below the BFE (see Section 3.1.1). The minimum requirements are:

- You must provide at least two wall openings for each enclosed area—one in each of two different walls. In other words, you cannot put both openings in the same wall.
- If your home has more than one enclosed area, you must install openings in the *exterior walls of each enclosed area* so that floodwaters can enter directly from the outside.
- The total area (size) of all openings for each enclosed area must equal at least 1 square inch for every square foot of floor space in the enclosed area. For example, if the enclosed area is 25 feet by 40 feet (1,000 square feet), the total net area of the openings must be at least 1,000 square inches, or roughly 7 square feet. In this example, you could meet the size requirement by providing two 3½-square-foot openings or several smaller openings whose total net area equals 7 square feet.
- The bottom of each opening must be no higher than 1 foot above the higher of the exterior grade or interior grade directly below the opening.
- Floodwaters must be able to flow in and out of enclosed areas automatically. If you place louvers, screens, or other types of covers over the openings (which many homeowners do to prevent animals from entering the enclosed areas), they must not block the flow of water. Note that the area of any screens or louvers covering the openings must be subtracted from the gross opening area. Because the need for human intervention reduces the reliability of wet floodproofing, you may not install any type of electrical-, mechanical-, or manual-operated cover.
- Flood openings must be entirely below the BFE.

FEMA developed these requirements to provide homeowners with a straightforward means of determining where and how to install wall openings without the aid of an engineer or design professional. The requirements provide a margin of safety for wet floodproofed homes subject to flooding with rates of rise and fall as high as 5 feet per hour. If you wish to install openings that do not meet one or more of the requirements listed above, your design must be certified by a registered engineer or other licensed design professional and approved by your local officials. See FEMA's NFIP Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures* (2008), for more information about openings requirements.

7.1.6 Protecting the Underside of Elevated Buildings

The undersides of elevated coastal buildings are typically covered with vinyl or aluminum soffits or plywood sheathing to protect insulation and metal floor system connectors. The undersides of these buildings are often damaged by high hurricane force winds, allowing water to be driven into the building. Lost paneling or sheathing can become wind-borne debris, increasing the risk of damage. How the space below the building is designed and built is determined by local floodplain regulations and building codes, which may include fire resistant-rated building materials, depending on the use of the underneath space (parking, storage areas).

Underside materials should meet flood damage-resistant requirements outlined in NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* (2008), and local code requirements, including fire resistance requirements where applicable. In coastal areas, make sure to use corrosion-resistant fasteners to secure the underside materials. Wind loads based on wind speed maps for the area where the building is located must be included in the under-building wind protection assembly design. To ensure the assembly is effective, a licensed engineer or architect should prepare the design in accordance with Hurricane Isaac Recovery Advisory 1 (see Cross Reference).

7.1.7 Using Flood Damage-Resistant Materials

In the areas below the anticipated flood level, any construction and finishing materials that could be damaged by floodwaters must be either removed or replaced with flood damage-resistant materials as required by your community's floodplain management ordinance or regulations. Vulnerable materials include gypsum wall board (also called dry wall), blown-in and fiberglass batt insulation, carpeting, and non-pressure-treated wood and plywood. Flood damage-resistant materials are those that can be inundated by floodwaters with little or no damage. They include such materials as concrete, stone, masonry block, ceramic and clay tile, pressure-treated and naturally decay-resistant lumber, epoxy-based paints, and metal. In addition to resisting damage from floodwaters and their contaminants, these materials are relatively easy to clean after floodwaters recede.

Table 7-1 lists materials that are acceptable and unacceptable for use in wet floodproofing projects. NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* (2008), offers more complete guidance on materials that can and cannot be used to wet floodproof an area below the DFE. Consult a design professional before selecting materials to wet floodproof any areas in your home.

CROSS REFERENCE

For more information about flood damage-resistant materials, refer to NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* (2008). This bulletin includes a detailed list of common floor, wall, and ceiling materials categorized according to their applicability for use in areas subject to inundation by floodwaters.

CROSS REFERENCE

For more information about openings protecting the underside of elevated buildings, refer to Hurricane Isaac Recovery Advisory 1, *Minimizing Wind and Water Intrusion by Covering the Underside of Buildings* (FEMA. 2012c).

Table 7-1. Flood Damage-Resistant Materials

Material Type	Acceptable	Unacceptable
Structural Flooring Materials	• Concrete • Naturally decay-resistant lumber • Pressure-treated plywood	• Engineered wood or laminate flooring • Oriented-strand board (OSB)
Finish Flooring Materials	• Clay tile • Ceramic or porcelain tile • Terrazzo tile • Vinyl tile or sheets	• Engineered wood or laminate flooring • Carpeting • Wood flooring
Structural Wall and Ceiling Materials	• Brick face, concrete, or concrete block • Cement board / fiber-cement board • Pressure-treated plywood • Solid, standard structural lumber (2x4) • Non-paper-faced gypsum board	• Fiberglass insulation • Paper-faced gypsum board • OSB
Finish Wall and Ceiling Materials	• Glass blocks • Metal cabinets or doors • Latex paint	• Wood cabinets and doors • Non-latex paint • Particleboard cabinets and doors • Wallpaper

7.1.8 Protecting Service Equipment

When you wet floodproof a home, you should also protect the service equipment below the anticipated flood level, both inside and outside the home in accordance with NFIP requirements. Service equipment includes utility lines, heating ventilation and air conditioning (HVAC) equipment, ductwork, hot water heaters, and large appliances. Chapter 9 describes a variety of methods you can use to protect interior and exterior service equipment.

7.2 Dry Floodproofing

Dry floodproofing involves completely sealing the exterior of a building to prevent the entry of floodwaters. Unlike wet floodproofing (Section 7.1), which allows water to enter the building through wall openings, dry floodproofing seals all openings below the flood level and relies on the walls of the building to keep water out. Even if your home is dry floodproofed, water can still seep through small openings in the sealant system or through the gaskets of shields that are protecting openings (doors and windows). Internal drainage systems, utilizing sump pumps, are required to remove any water that has seeped through and to remove water collected from any necessary underdrain systems in the below-grade walls and floor of the home.

Because the walls are exposed to floodwaters and the pressures they exert, dry floodproofing is practical only for homes with walls constructed of masonry or poured concrete and only where flood depths are low (typically no more than 2 to 3 feet). Successful dry floodproofing involves the following:

- Sealing the exterior walls of the home
- Covering openings below the flood level
- Protecting the interior of the home from seepage
- Protecting service equipment outside the home

The following sections discuss the most important considerations regarding dry floodproofing and describe the modifications that must be made to a home as part of a dry floodproofing project. Protection of service equipment is discussed in Chapter 9.

WARNING

Dry floodproofing cannot be used to bring a Substantially Improved or Substantially Damaged home into compliance with the requirements of your community's floodplain management ordinance or regulation. In addition, dry floodproofing measures can fail during larger flood events.

7.2.1 Considerations

Flood Depth

The primary consideration in dry floodproofing, and the one that imposes the greatest limitations on the application of this method, is the effect of hydrostatic pressure. Because dry floodproofing prevents water from entering the home, the external hydrostatic pressure exerted by floodwaters is not countered by an equal force from water inside the home (see Chapter 2). This external pressure results in two significant problems: heavy unequalized loads on the walls of the home and buoyancy, or uplift force, which acts on the entire home.

When water rises against a wall, it pushes laterally against the wall. As the depth of water increases, so does this force, as indicated by the arrows in Figure 7-4. Tests performed by the USACE[2] indicated that, on a test subject, the maximum allowable flood depth for masonry and masonry veneer walls was approximately 3 feet. In these tests, walls exposed to greater depths of water either collapsed or suffered serious structural damage. These tests only addressed flood loads on the house and did not expose the house to wind loads. Additionally, the tests represented one flood event and the test procedures did not address the impact of similar flood loads on the longevity of the house or its ability to resist future flood events. Masonry veneer is not allowed by design standards to be considered as a material to resist lateral loads, such as flood loads. Houses should not be considered resistant to increased or high loads (such as lateral loads from floodwaters) because of the presence of a masonry veneer alone.

WARNING

The flood depth limits discussed here are provided as general guidelines only. Before you attempt to dry floodproof your home, a design professional, such as a structural engineer, must inspect it to determine whether it is structurally sound and able to resist increased flood loads expected as a result of dry floodproofing. Design professionals familiar with dry floodproofing techniques and technologies should design the dry floodproofing system so that the building's load capacities can be properly addressed.

2 The test results are documented in the following reports published by the USACE National Flood Proofing Committee: *Flood Proofing Tests – Tests of Materials and Systems for Flood Proofing Structures*, August 1988; *Systems and Materials to Prevent Floodwaters from Entering Buildings*, May 1985; *Structural Integrity of Brick-Veneer Buildings*, 1978; *Tests of Brick-Veneer Walls and Closures for Resistance to Floodwaters*, May 1978.

Hydrostatic pressure is exerted not only by floodwater, but also by soils saturated by floodwaters. As a result, basement walls can be subjected to pressures much greater than that from 3 feet of water alone (Figure 7-4). These pressures can easily cause basement walls to buckle inward or collapse (Figure 2-8). *For this reason, dry floodproofing in basements is strongly discouraged. In fact, your community's floodplain management ordinance or regulation does not allow basements in Substantially Improved or Substantially Damaged homes to be dry floodproofed.*

As shown in Figure 7-4, water and saturated soils also push up from below the home. The buoyancy force resulting from flood depths of over 3 feet can separate a dry floodproofed home from its foundation and buckle concrete slab floors in dry floodproofed slab-on-grade homes.

CROSS REFERENCE

For additional information about dry floodproofing techniques, refer to NFIP Technical Bulletin 3, Non-Residential Floodproofing – Requirements and Certification (1993), and FEMA P-259, Principles and Practices for Retrofitting Flood-Prone Residential Structures (2012).

The degree of danger posed by buoyancy depends on the flood depth, the type of soil at the home site, how saturated the soil is, the duration of the flood, whether the home has a drainage collection and disposal system, and how well that system works. Only an experienced engineer can evaluate these factors.

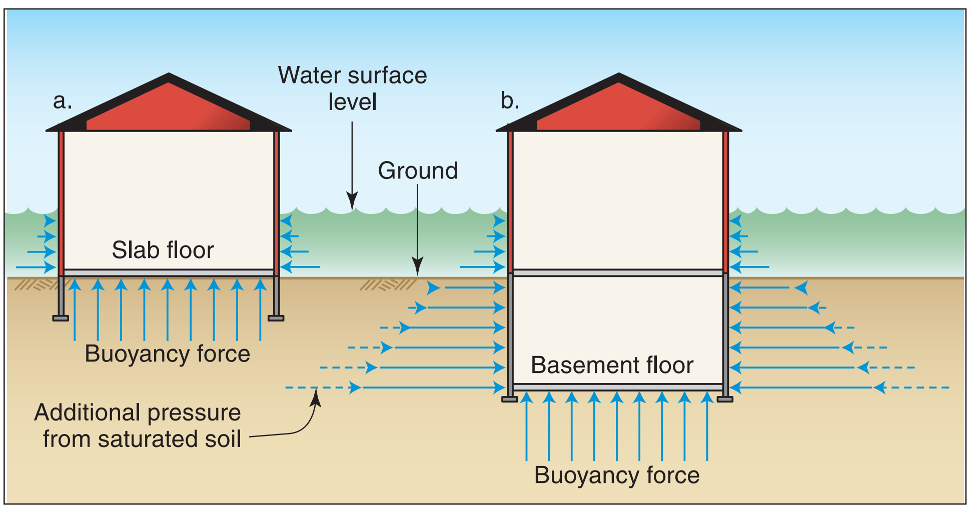


Figure 7-4. The lateral and buoyancy force resulting from the same depth of flooding is much less on a home without a basement (a) than on a home with a basement (b). The pressure on basement walls is caused by water and saturated soils.

Flow Velocity, Erosion and Scour, Debris Impact, and Wave Action

Dry floodproofing does not protect a home from the hydrodynamic force of flowing water, erosion and scour, the impact of ice and other floodborne debris, or wave action. If your home is located in an area subject to any of these hazards, consider an alternative retrofitting method, such as elevation on an open foundation (Section 5.2.3) or relocation (Section 6.1). Dry floodproofing a home does not change its vulnerability to damage from high winds or earthquakes.

Flood Duration

Flood duration is an important consideration because the potential for seepage through and deterioration of the materials used to seal the home increase with the length of time that the home is exposed to flooding. Also, the longer the duration, the greater the likelihood that the soil beneath and adjacent to the home will become fully saturated and add to the loads on the walls and floor (Figure 7-4). Additionally, most dry floodproofing methods depend on sump pumps to address water that has leaked into the house, and those pumps require electricity to run. Although some sump pumps have battery backups, these backups typically only last a few hours, so a generator system may also be required for long-duration flooding. If your home is in an area where floodwaters remain high for days, weeks, or even months at a time, consider an alternative retrofitting method, such as elevation or relocation.

Human Intervention

Dry floodproofing systems almost always include components that have to be installed or activated each time flooding threatens. One example is a flood shield placed across a doorway. For this reason, dry floodproofing is not an appropriate retrofitting method in areas where there is little or no flood warning or where, for any other reason, the homeowner will not be able or willing to install shields or other components before floodwaters arrive.

Post-Flood Cleanup

Remember that floodwaters are rarely clean. They usually carry sediment, debris, and even corrosive or hazardous materials, such as solvents, oil, sewage, pesticides, fertilizers, and other chemicals. The walls of a dry floodproofed home will be exposed to whatever is in the floodwaters. Cleaning up a dry floodproofed home after a flood may, therefore, involve not only removing mud and debris from around the home, but also decontaminating or disinfecting walls and other exterior surfaces. Hurricane Sandy Fact Sheet 1, Cleaning Flooded Buildings (FEMA. 2013a), provides some guidance on cleaning up following a flood.

7.2.2 Modifications Required for Dry Floodproofing

Dry floodproofing involves the use of sealants and shields, the installation of a drainage system, and the protection of service equipment.

Sealants

Except for some types of high-quality concrete, most wall materials are not impervious to water. Therefore, sealants must be applied to the walls of a dry floodproofed home to prevent leakage. Prior to applying a sealant, a structural engineer must determine whether the walls can resist the loads. Flexible sealants are compounds (such as asphalt coatings) or materials (such as polyethylene film) that are applied directly to the outside surface of the home walls. Sealants must also be applied to all structural joints, such as the joint between the walls and a slab floor, and to any other openings below the flood level, such as those where utility lines enter the home through the walls or floor. Some of these sealants are designed to be applied to the outside of the wall, while others can be applied to the inside of the walls. Which sealant is appropriate will depend on the manufacturer's recommendations and the access to the wall surfaces or structural joints.

Sealants that can be applied to outside walls include cement- and asphalt-based coatings and clear coatings, such as epoxies and polyurethanes. Cement- and asphalt-based coatings are often the most effective, but they can change the appearance of the wall (Figure 7-5). The aesthetic advantage of many exterior treatments is lost when these coatings are applied over them. Clear coatings do not change the appearance of the wall, but are less effective

Figure 7-6 shows one method of sealing masonry walls with an asphalt-based coating that does not detract from their appearance. In this method, a new masonry veneer is added to the existing veneer after the coating is applied.

An alternative to using coatings is to temporarily wrap the entire lower part of the home in polyethylene film when flood conditions threaten. This alternative is sometimes referred to as the "wrapped home" technique. The cross-section view in Figure 7-7 shows how this technique works. There must be at least several hours of warning time in order to properly deploy this method. The use of a flood wrapping system should be considered temporary and largely an emergency solution to a flooding problem.

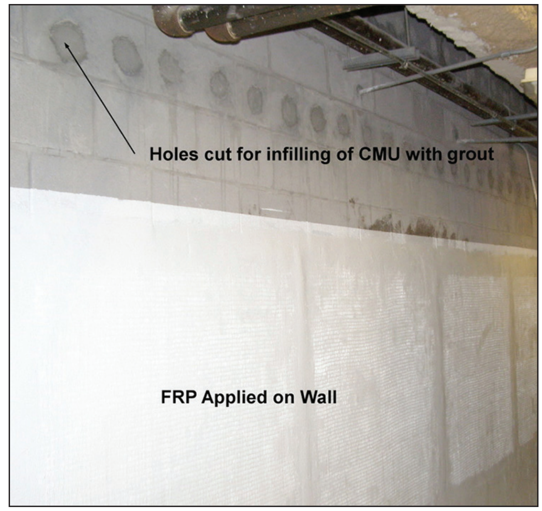


Figure 7-5. Example of an exterior application of a spray-applied asphalt membrane (left – courtesy of GMX, inc.) and an interior application of a fiber reinforced polymer wrap (right).

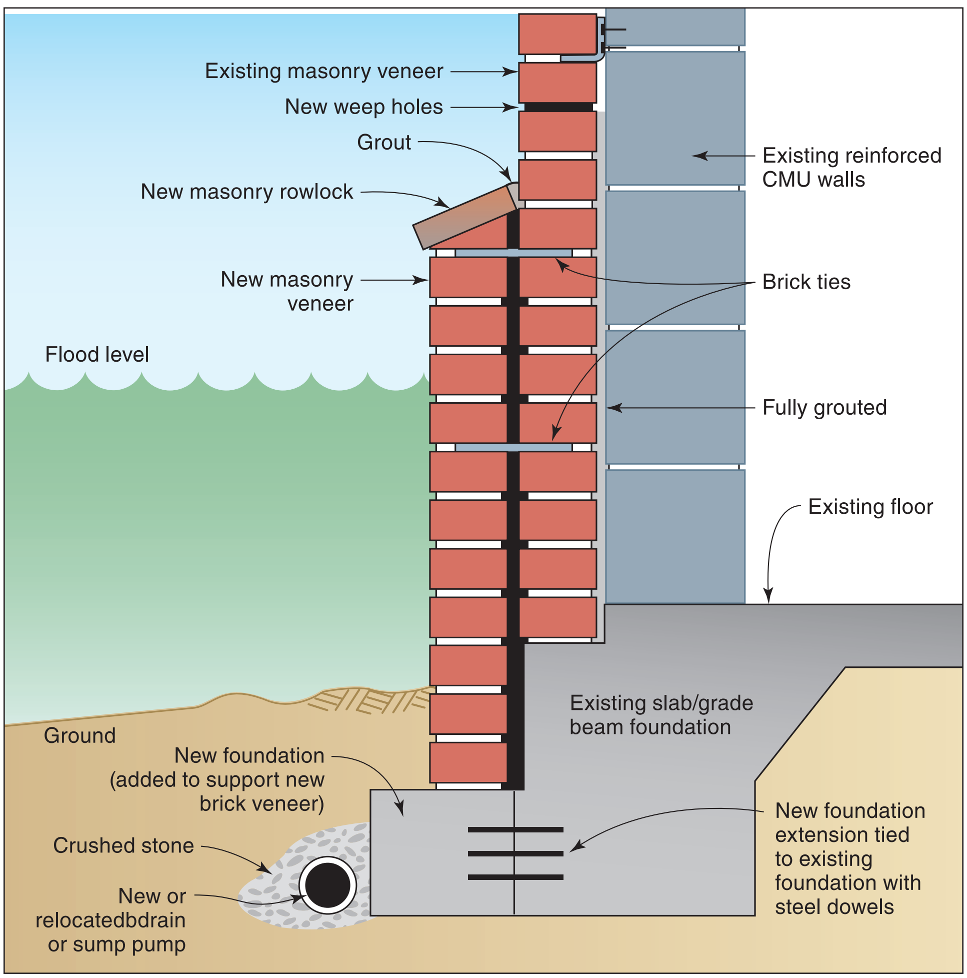


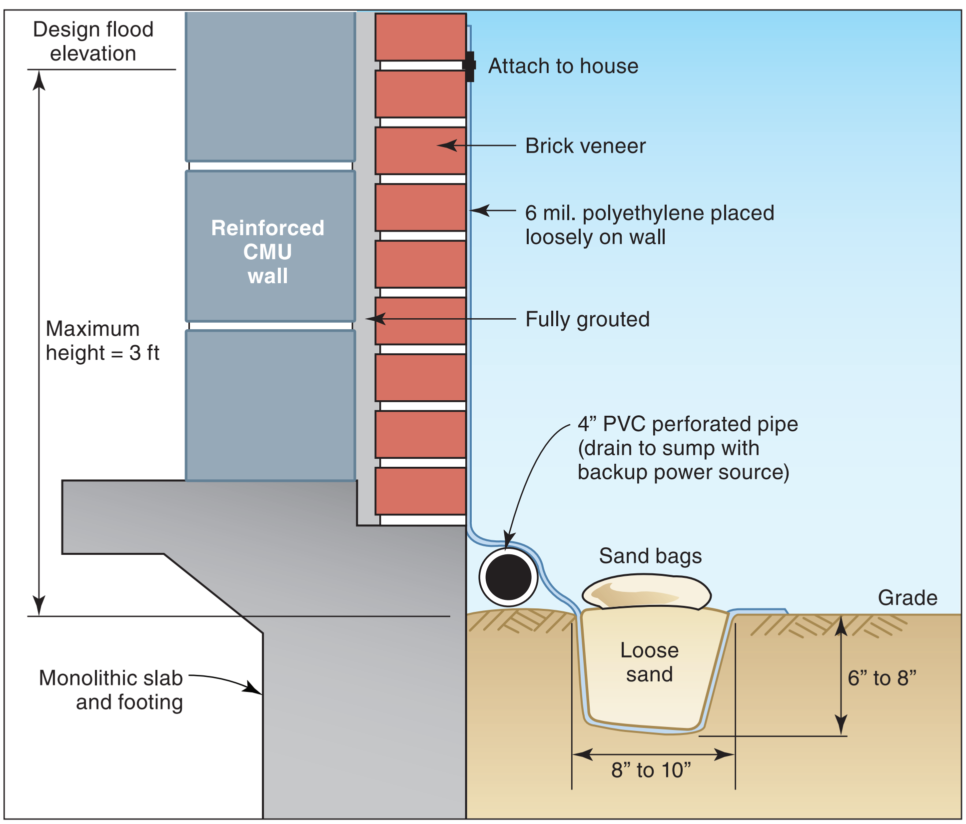
Figure 7-6. A way to seal an existing brick-faced wall is to add an additional layer of brick with a seal in between. Please note that weep holes (drainage) and wick drains are moved up to prevent moisture from getting inside the walls.

Polyethylene film is not a strong material; it cannot withstand water pressure on its own and can be punctured fairly easily. As a result, the following requirements must be met when the wrapped home technique is used:

- The manufacturer's literature must demonstrate applicability of the film to the home's building materials. Rely on actual test results, if available.
- The installation must be carried out very carefully. Even a small hole in the film will leak under the pressure of floodwaters.
- The film must be applied directly against the walls of the home so that the walls, rather than the film, provide the resistance to water pressures. This may require strengthening the walls of the home and openings, such as doors.
- Where the film covers doorways and other openings, it must be backed by framed plywood panels that are braced to resist water pressures.
- A temporary drainage system must be provided to collect and dispose of any water that leaks through holes in the film. (Drainage systems are discussed later in this section.)
- The duration of flooding should be less than 12 hours and the flood depth adjacent to the home should not exceed 1 foot.

Home wrap systems require secure connections at both the top and bottom of the wrap. The actual loads imposed vertically on the wrap are difficult to determine because they can vary depending on the quality of the installation. Voids or weak spots left from poor construction may force the wrap to carry the weight of the water and should be avoided.

Figure 7-7. In the "wrapped home" method, the lower portion of the home is protected with a temporary layer of polyethylene film. As shown, a temporary drainage line is also required.



The following should be considered in the selection of a top-of-wall connection system:

- A clamping system that uniformly supports the wrap. A small spacing on the connections and a connection system with some rigidity on the outside of the wrap can provide this needed support.
- The existing wall construction can vary widely. Part of the connection may need to be a permanent part of the wall.

WARNING

Wrap systems may be affected by freeze-thaw cycles. Careful installation in accordance with manufacturer instructions and evaluation of performance in frozen climates is advisable.

Anchoring a wrap into the ground at the base of a wall is the most important link in the wrap system (see Figure 7-7). The following recommendations should be followed during selection of a system:

- A drain line between the wrap and the building is usually required to remove any water that leaks through the wrap or seeps through the soil under the anchor.
- As with the top-of-wall connection, wrap forces are difficult to determine. Details that have worked in the past and that are compatible with the building and the selected wrapping system should be followed.
- The end of the wrap should be buried at least below the topsoil layer. Additional ballast may be needed (e.g., sandbags, stone) to prevent wrap movement in a saturated and/or frozen soil condition.
- The product literature for the wrap material and applicable codes and standards should be reviewed and followed.

Before selecting a wrapping system, make sure that the manufacturer's literature addresses the following issues.

- Are any chemicals used or stored around the home or onsite that could damage the wrapping system? Evaluate adjacent properties to identify any potential chemicals that could damage a wrap system.
- How should the wrapping system be repaired and approximately how much additional wrapping material is required for each repair? Understanding whether the wrapping material can be repaired under flood conditions or if it must be dry for a proper repair to be made is important.

Shields

Shields are flood barriers placed over openings in walls such as doorways and windows. Shields can be made of several materials, depending on the size of the opening to be covered, and should include gaskets along their edges. When flood depths are expected to reach the maximum allowable 2 to 3 feet, shields for openings wider than approximately 3 feet must be made of strong materials such as heavy-gauge aluminum or steel plates (Figure 7-8); shields for lesser depths and smaller openings can be made of lighter materials. Because of the potential risk of a shield failing, a structural engineer must assist with the design of the shields and evaluate the entire dry floodproofing system. The engineer may also determine that the walls to which the shield is attached need to be strengthened to carry the flood loads associated with the shield.

Because permanently blocking all doors and other openings would be impractical, shields are usually placed temporarily, after flood warnings are issued. Most residential shields are light enough that they can be stored in the home and, when needed, brought out and bolted in place or secured in permanently installed brackets or tracks (Figure 7-9). Although rare for residential applications, some larger, heavier shields may have to be permanently installed on hinges or rollers so that they can be opened and closed easily.

Figure 7-8. Heavy-gauge metal shield over sliding glass door opening.

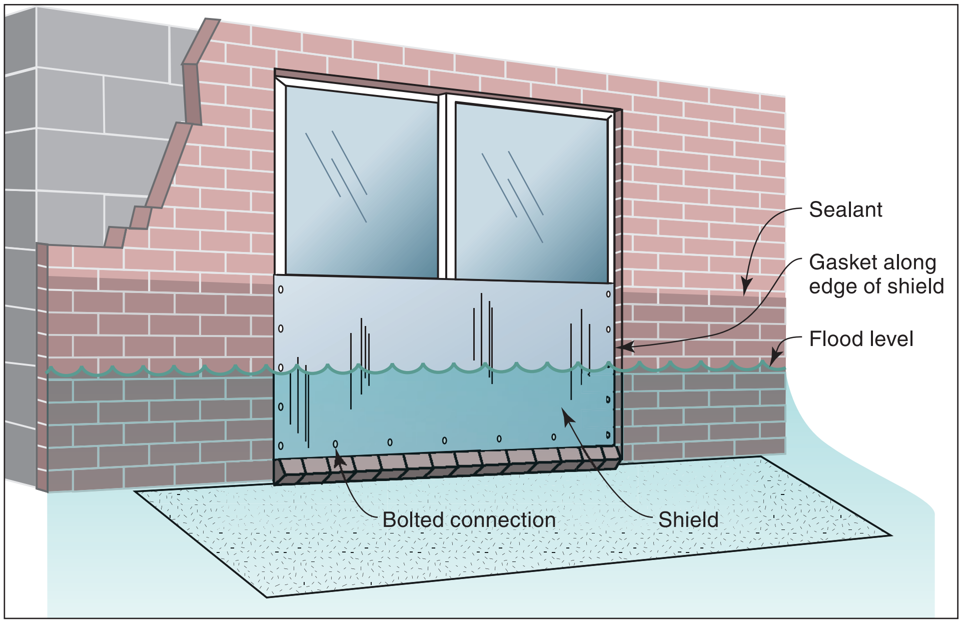
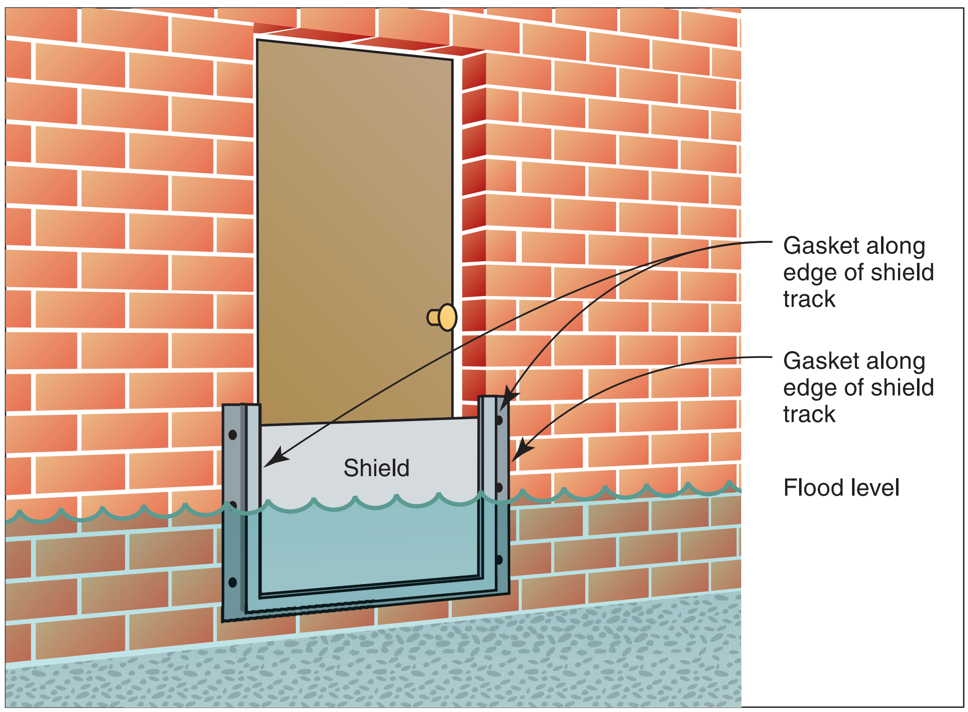


Figure 7-9. Light-gauge metal shield held in place by permanently installed tracks.



Companies that specialize in flood protection devices can provide custom-fitted flood shields. Usually, these commercial shields are made of heavy-duty materials, and some are equipped with inflatable or other types of gaskets that help eliminate leaks. Gaskets left exposed to the elements can rapidly decay. Gasket materials should be stored indoors and checked periodically for tears or decay. A faulty gasket can allow floodwaters to get past the gasket, nullifying any of the other floodproofing techniques.

An alternative to using shields is to permanently seal openings. For example, a low-level window can be removed or raised and the opening bricked up or filled with glass block (Figure 7-10).

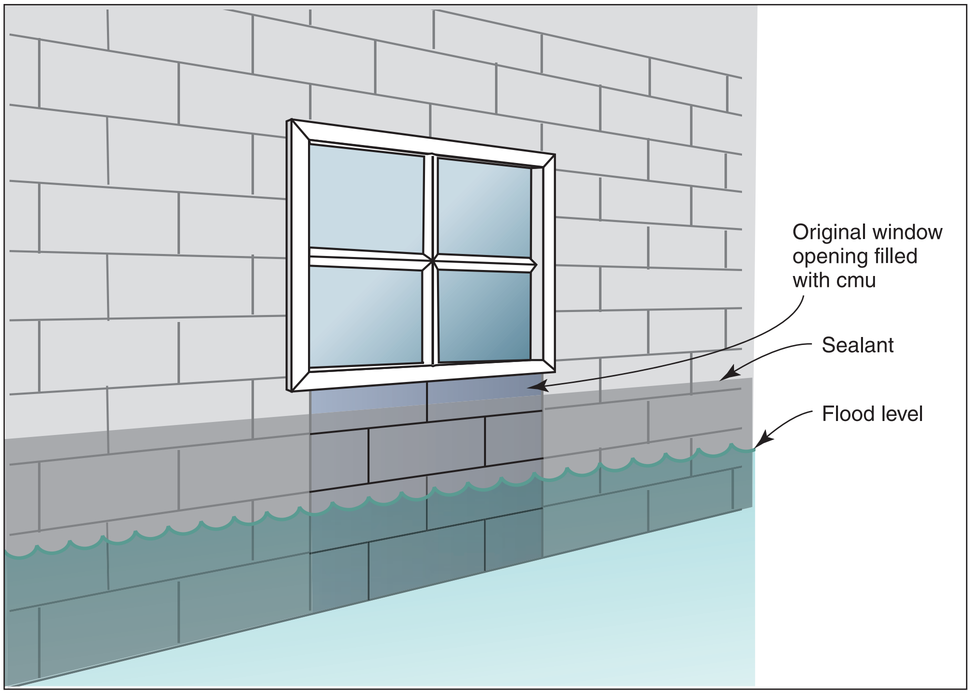


Figure 7-10. Low window raised approximately 2 feet and original opening filled with brick.

Drainage Systems

Sealants and shields provide the bulk of the protection in dry floodproofing, but they may permit some leakage, especially during floods of longer duration and when damaged by debris. They also do not protect against "**underseepage**," water that migrates downward along the sealed wall and then under the foundation. For these reasons, a dry floodproofed home must have a drainage system that will remove any water that enters the home through leaks in sealants and shields and any water that accumulates at the base of the foundation. Depending on the permeability of the soils around and under the home, the drainage system may also have to be designed to reduce buoyancy forces.

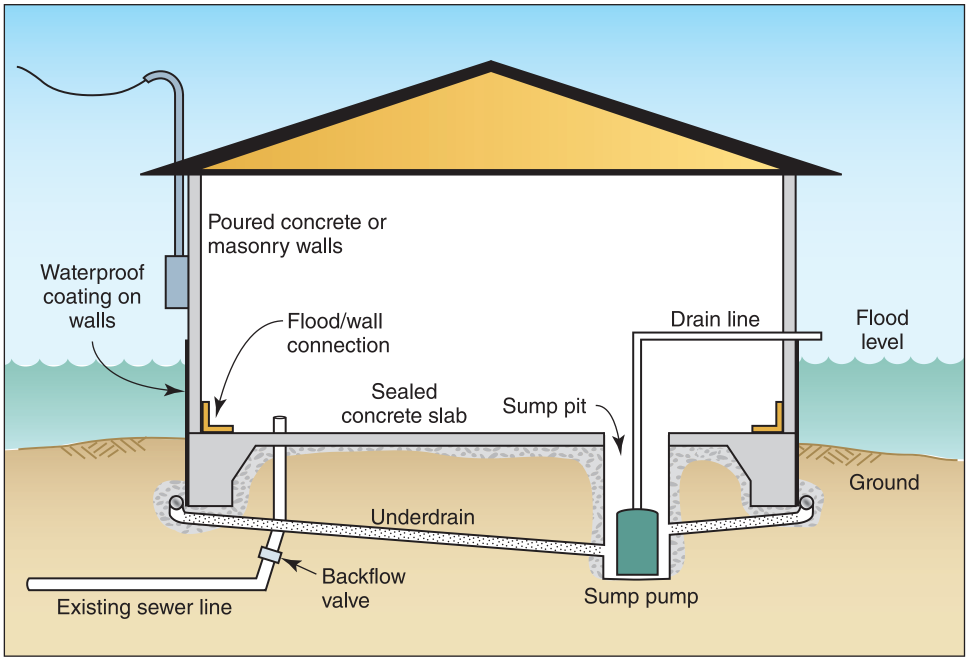
DEFINITION

Underseepage is water that migrates downward along the sealed walls of a home and then under the foundation.

An adequate drainage system includes drains along the base of the foundation and under the floor. The drains consist of perforated pipe surrounded by crushed stone. The pipes collect water that seeps through the ground and channel it to a central collection point equipped with a sump pump. This system is shown in Figure 7-11. The sump pump must have sufficient capacity to handle the inflow of water and must have an emergency power source, such as a portable generator, so that it will continue to operate if conventional electric service is disrupted. Depending on soil conditions, seepage rates may exceed the maximum discharge rates of standard sump pumps.

Drainage systems should be designed and laid out based upon several factors, such as the design flood depth, soil conditions, and the construction methods and materials of the area to be protected. These factors will also affect the size of the sump pump and the requirements for a backup power source. Because of the complexity of these designs and the potential consequences of a system failure, seek the input of a design professional familiar with dry floodproofing systems.

Figure 7-11. Drainage system for a dry floodproofed home.



Protecting Service Equipment

Dry floodproofing a home will not protect service equipment outside the home. Examples of service equipment typically found outside the home are utility lines, air conditioning compressors, heat pumps, and fuel storage tanks. Chapter 9 discusses the protection of service equipment.

8.0 Barriers

Levees and floodwalls are types of flood protection barriers. A levee is typically a compacted earthen structure; a floodwall is an engineered structure usually built of concrete, masonry, or a combination of both (Figure 8-1). Barriers can be built to protect a single structure or multiple structures. Types of barriers include levees, floodwalls, and temporary barriers.

Table 8-1 includes a summary of advantages and disadvantages for using barriers as a mitigation measure.

WARNING

Floodwalls and levees are not permitted to address Substantial Improvement/Damage and do not bring new buildings into compliance with NFIP regulations unless they are accredited per 44 CFR § 65.10.

Furthermore, the floodwalls and levees described in this chapter will not lower your flood insurance premium cost.

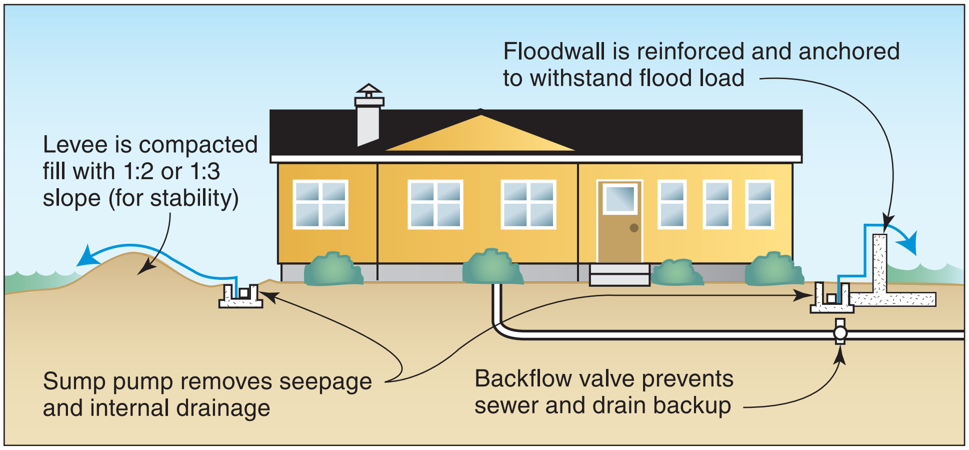


Figure 8-1. Structure protected by levee (on left) and floodwall (on right).

NOTE

For more information about barriers refer to FEMA 511, *Reducing Damage from Localized Flooding. USACE's Floodproofing – How to Evaluate your Options (FEMA.2005)* document is also a good source for barrier options.

Table 8-1. Considerations for Using Barriers

Advantages	Disadvantages
• Floodwaters cannot reach the structure(s) in the protected area and, therefore, will not cause damage through inundation, hydrodynamic pressure, erosion, scour, or debris impact. • The structure and the area around it will be protected from inundation, and no significant changes to the structure will be required.	• Barriers may not be used to bring a Substantially Damaged or Substantially Improved structure into compliance with the community's floodplain management ordinance or regulation. • Cost may be prohibitive, as a large area may be required for construction. • Periodic maintenance is required. • Local drainage can be affected, possibly creating or worsening flood problems for others.

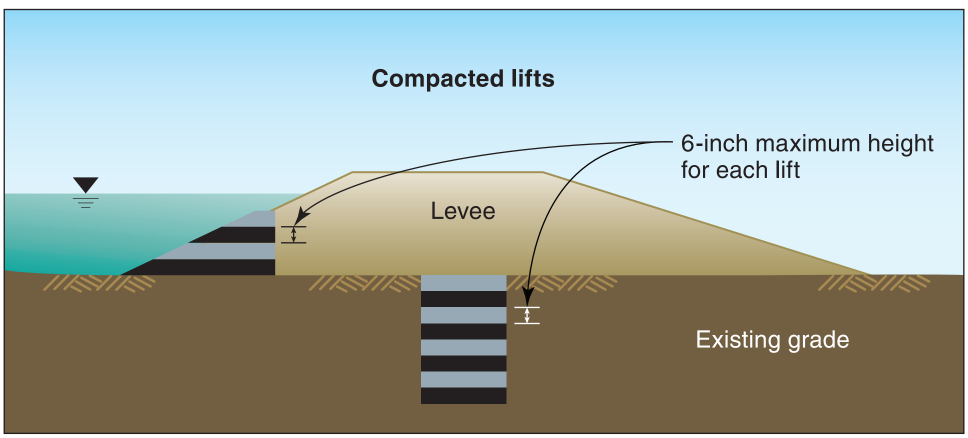
8.1 Levees

Levees are embankments or structures constructed of compacted earthen materials. Construction of a levee begins with excavating and inspecting the **cutoff trench**. This gives the designer a better look at the subsurface soil conditions, so that the presence of roots, utility lines, and animal burrows, or changes in soil conditions can be considered during the design process. The interior of the levee is composed of an impermeable core, usually clay. The lifts of impervious clay fill are placed in 6-inch layers, with each lift compacted to the density specified by the designer (Figure 8-2). As with large floodwalls, a licensed Professional Engineer should perform the levee design and certification.

DEFINITION

A **cutoff trench** is a core located below the base of a dam or levee structure. The trench is filled with an impervious material, such as clay, to form a watertight barrier to prevent under-levee seepage.

Figure 8-2. Levee construction.



Levees can be used to completely circle a building. However, they require a lot of space and a large quantity of earthen fill. Unless the fill is readily available nearby, hauling it to the site may prove to be cost-prohibitive. Integrating parts of the new levee into existing ground that is close to or above the levee's design elevation can help reduce construction costs.

8.2 Floodwalls

A floodwall is an engineered structure made of reinforced concrete or reinforced concrete block. A typical residential floodwall usually varies from 1 foot to 4 feet in height and can surround a structure or, depending on flood depths, site topography, and design preferences, protect building openings, such as doors, windows, and basement entrances, including entry doors and garage doors. When built with decorative bricks or blocks or as part of garden areas, floodwalls can be attractive architectural or landscaping features. They can also be built solely for utility, usually at a much lower cost.

Because a floodwall is made of concrete or masonry rather than compacted earth, it is more resistant to erosion than a levee and requires less space than a levee that provides the same level of protection. However, floodwalls are often more expensive. As a result, floodwalls are normally considered only for sites where there is not enough space for a levee or where high-velocity flows may erode a levee. Also, some property owners prefer floodwalls because they can be more aesthetically pleasing and allow for the preservation of existing site features, such as landscaping and trees, or covered with a decorative stone finish (Figure 8-3).

Figure 8-3. Structure protected by a floodwall with decorative stone finish.

8.3 Temporary Barriers

Several types of temporary barriers are available to address typical flooding problems. They work with the same principles as permanent barriers, such as floodwalls or levees, but can be removed, stored, and reused in subsequent flood events. Most of these barriers are meant to take the place of sandbag floodwalls and may also be used to reinforce existing permanent barriers such as levees (Figure 8-4).

Temporary barrier products are designed so that they can be used numerous times. The Association of State Floodplain Managers (ASFPM) worked with the USACE and Underwriters Laboratories (UL) to establish a testing/certification program for temporary flood barriers. ASFPM, UL, and USACE initiated program development, and FM Approvals (a division of FM Global) developed an approval system for recognizing temporary barriers as flood abatement equipment for their policyholders. In 2006, FM Approvals published FM Standard 2510, *Approval Standard for Flood Abatement Equipment* (2006). The current FM Approvals test protocols are for self-supporting, temporary barriers designed to protect against riverine flood depths up to 3 feet. These barriers are not tested for coastal flooding applications, where the presence of saltwater may hinder their performance. Because saltwater is denser than freshwater, a barrier filled with freshwater in a coastal location may float instead of providing protection against flooding.

Figure 8-4. Two-foot-high water-filled temporary barrier protecting a residence from flooding (2010 – Courtesy of Hydrological Solutions, Inc.).

8.4 Technical Considerations

The factors discussed in the following sections affect the type of a barrier best suited for your home and should be considered before making a barrier selection.

8.4.1 Height of Barrier

When barriers are built to protect a single structure, they are referred to as "residential," "individual," "on-site," or "local" levees and floodwalls. Levees and floodwalls should be built to protect the residence from predicted flood heights as depicted on FEMA FIRMs, in FISs, or local flood vulnerability analyses. If the height of the levee or floodwall would make the project cost-prohibitive, then elevation or relocation of the residence should be considered. The practical, cost-effective heights of these levees and floodwalls are usually limited to 6 feet and 4 feet, respectively. These limits are the result of the following considerations:

- The higher the levee or floodwall, the greater the depth of water that builds behind it and the greater the water pressure exerted on the barrier. Taller levees and floodwalls must be designed and constructed to withstand the increased pressures. Meeting this need for additional strength greatly increases the cost of the levee or floodwall, usually beyond what an individual property owner can afford.
- Because taller levees and floodwalls must be stronger, they must also be more massive, so they usually require more space than is likely to be available on an individual lot. This is especially true of levees.
- Local zoning and building codes may also restrict the use, size, and location.

Local floodplain management ordinances and regulations may require a "no-rise" study to prove that the barrier system will not increase flood heights downstream of the barrier structure.

If the flood depth at the project site is above the practical height limits of available barriers, an alternative mitigation method, such as elevation, should be considered. The levee or floodwall can always be overtopped by a higher-than-expected flood regardless of the height of the barrier. Overtopping is a greater concern for a levee than a floodwall because a small amount of overtopping can cause erosion at the top of the levee and cause it to fail.

8.4.2 Basement Foundations

Special design considerations are necessary when levees or floodwalls are built to protect a structure with a basement. Even though the surface water is kept from coming into contact with the structure, the soil below the levee or floodwall and around the structure can become saturated, especially during floods of long duration. The resulting pressure on basement walls and floors can cause them to crack, buckle, or even collapse. An analysis by a qualified soils engineer can help to determine a sufficient distance for the floodwall or barrier from the structure to lessen or alleviate this pressure.

8.4.3 Soil Conditions

The type of soils encountered may have a significant impact on the choice of barriers as a flood protection option. This is true regardless of the choice of a permanent barrier or a temporary barrier. The following soil characteristics must be considered:

- **Bearing capacity.** This is the capacity of a soil to support applied loads. Permanent barriers such as levees and floodwalls, as well as many temporary barriers, are very heavy. If the soil type has low bearing capacity, the barrier may either fail structurally or begin to sink, losing its design protection height and capability. In this instance, alternative mitigation, such as elevation, relocation, or floodproofing should be considered.
- **Permeability.** Barriers should be deployed on tight, impermeable soils. If the soils are permeable, such as sand or sandy loam, steps need to be taken to counteract the seepage of water under or through the barriers. These steps include installing an impervious core for a levee and a cutoff trench filled with impermeable bentonite clay soil. Bentonite clay should also line the levee surface. A cutoff trench is a below-grade core of bentonite clay that prevents movement of pervious materials, such as loose sand and gravel, which can compromise the levee's performance.

8.4.4 Duration of Flooding

All barriers exposed to floodwaters for an extended period of time will be subject to seepage or leakage. If the duration of flooding is relatively short (less than 1 day) and the depth of flooding is relatively low (less than 1 foot), many barriers will at least slow down the effects of inundation. Longer exposures require barriers that are better engineered and more carefully constructed or deployed. Likewise, deeper flood depths also need to be considered as a result of the extremely high forces exerted on the barriers by the weight of the floodwaters.

8.5 Additional Considerations

The factors discussed in the following sections involve practical considerations affecting barrier selection.

8.5.1 Annual Maintenance

A barrier requires periodic inspections and maintenance to address any necessary repairs. Otherwise, small problems, such as cracks, loss of surface vegetation, erosion and scour, animal tunnels, and trees and shrubs can quickly become large problems during a flood event. The barrier should be inspected at a minimum each spring and fall, before each impending flood, and after each flood event. To facilitate slope stability as well as maintenance and safe grass mowing, the side slopes of most levees should not be steeper than 1 foot vertically to 2.5 feet horizontally (1:2.5) on the floodwater side and 1 foot vertically to 3 feet horizontally (1:3) on the land side. In general, driveways positioned to provide access over a protective levee that circles a residence should not be steeper than 1:3. Trees and large shrubs should not be located on barriers as they can be overturned during high-wind events and compromise the structural integrity of the levee. When trees and shrubs die, their roots decay, leaving cavities for water to pass through, which can cause the barrier to fail.

Homeowners interested in additional information on inspection of levees can refer to the following technical manuals available for download from the FEMA Website at http://www.fema.gov/technical-manuals-and-guides: *Technical Manual for Dam Owners: Impacts of Animals on Earthen Dams* (FEMA 473) and *Technical Manual for Dam Owners: Impact of Plants on Earthen Dams* (FEMA 534). Although these manuals were developed for dam owners, they contain many principles that are applicable to levees.

8.5.2 Housing of Occupants

Although a residence can be used during construction of a barrier, the residence should not be occupied during a flood event. Levees and floodwalls may give the homeowner a false sense of security. Every flood is different and one that exceeds the height of the barrier could occur at any time. If water overtops the barrier, the protected area will fill rapidly. Homeowners should evacuate when a flood warning is first issued.

8.5.3 Access to Structure

Barriers can make access to the structure difficult. Openings must be created or provided for driveways, sidewalks, and other entrances. These openings must be closed prior to the flood event, as floodwaters can rise rapidly enough to prevent an opening from being closed. Examples of these closure mechanisms for floodwalls include shields similar to the ones used in dry floodproofing or prefabricated panels and permanently mounted, hinged, or sliding flood gates and prefabricated stop logs or panels for levee openings. Unless the gates remain in the closed position at all times, human intervention is required to close an entry point to prevent rising floodwaters from entering the structure (Figure 8-5).

8.5.4 Human Intervention

As described in Section 8.5.3, openings in the barrier must be closed prior to a flood event. Putting the closure mechanisms in place requires human intervention. The barrier will not protect the structure from flooding unless the property owner is willing and able to operate all closures before the flooding begins.

Figure 8-5. The City of Boulder, CO, installed a “pop up” closure to this floodwall at a City office building subject to flash floods. The closure floats up into place automatically when the site is flooded.

8.5.5 Interior Drainage

A barrier that keeps floodwater out of the protected area also will keep water in. Drains and sump pumps should be installed to remove water collected inside the barrier. In addition, caution must be taken to ensure that local drainage patterns in the area are not disrupted. An interior drainage system, including a sump pump (Figure 8-6), must be installed in an area protected by a levee or floodwall.

Figure 8-6. Small patio floodwall with sump pump.




9.0 Protecting Service Equipment

Homes are typically provided with a variety of building support service equipment. Five major services make up the mechanical, electrical, and plumbing (MEP) systems found in most homes:

- HVAC systems, including air conditioning compressors, heat pumps, furnaces, ductwork, and
- Fuel systems, including natural gas lines and fuel storage tanks
- Electrical systems, including wiring, switches, outlets, fixtures, and fuse and circuit breaker panels
- Sewage management systems, including sewer lines, drains, septic tanks, and drainage fields
- Potable water systems, including water lines, private wells, storage tanks, and water heaters

Most homes also have communications systems, including telephone, internet, and cable television lines.

CROSS REFERENCE

For more information about elevating electrical and HVAC systems, refer to FEMA 348, *Protecting Building Utilities from Flood Damage* (1999), Hurricane Sandy Recovery Advisory No. 3, *Restoring Mechanical, Electrical, and Plumbing Systems* (2013), and FEMA 499, Fact Sheet No. 8.3: *Protecting Utilities* (2010).

Some MEP equipment is typically located inside a home (e.g., furnaces, ductwork, water heaters, appliances) and some is located outside (e.g., propane tanks, air conditioning and heat pump condensers, septic tanks). Other MEP equipment includes components found both inside and outside a home (e.g., electrical systems; plumbing, gas, telephone, internet, and cable television lines; oil storage tanks).

The original placement of service equipment in and around your home was probably based on standard construction practices and the builder's preferences. As a result, service equipment is often installed in areas where it will be exposed to floodwaters, such as in a basements or crawlspaces or at ground level outside the home.

Elevation, wet floodproofing, and dry floodproofing protect the structure of your home from damage by floodwaters. But these methods, unlike relocation and the construction of levees or floodwalls, do not prevent floodwaters from reaching the home. For this reason, protecting service equipment located below the expected flood level is an essential part of a retrofitting project.

When relocating or elevating MEP systems, consider horizontal and vertical clearances; venting; and unions, fittings, and valves. The replacement of MEP systems also presents an opportunity to improve the energy efficiency of your house by selecting high-efficiency equipment that may not have been available when the damaged equipment was installed.

If your house has been damaged by a flood, the repair and restoration work must not violate any floodplain management requirements in effect when the house was originally built. Always check with your local building department, as locally enforced codes may differ from what is described in this chapter. For example, some communities may require all MEP system restoration or alteration work to comply with the applicable sections of the current code, even in houses that are not Substantially Damaged. When considering relocating or elevating MEP systems, follow all applicable codes, regulations, and manufacturers' installation requirements.

Flood Insurance Implications

Houses built after communities joined the NFIP were required to be elevated to or above the BFE to minimize flood damage. These houses should already have elevated MEP systems and components. However, if some equipment was not elevated (such as a furnace or ductwork located in a crawlspace), owners may be paying much higher NFIP flood insurance premiums than necessary. Replacing damaged equipment and elevating it on platforms not only minimizes future damage, but may lower flood insurance premiums. Check with insurance agents to find out whether taking this action will affect your flood insurance premiums.

You can protect interior and exterior service equipment in three ways: elevating it, relocating it, or protecting it in place. More information on these methods can be found in FEMA 348, *Protecting Building Utilities from Flood Damage* (1999).

9.1 Elevation

Service equipment installed outside your home can usually be elevated above the flood level. Equipment mounted on an exterior wall (e.g., an electric meter, incoming electric, telephone, and cable television lines) usually can be mounted higher up on the same wall. Equipment typically placed on the ground (e.g., air conditioning compressors, heat pumps) can be raised above the flood elevation on pedestals or platforms (Figures 9-1 and 9-2).

When you elevate service equipment, you should always consider raising it at least 1 foot above the BFE, just as when you protect your home with one of the methods described in this guide. Elevating service equipment an additional 1 or 2 feet often will not increase your retrofitting costs significantly but will provide an extra measure of flood protection. Since gas and electric meters are typically owned by a utility company, you may not be allowed to move or elevate them without the utility company's permission.

NOTE

Some utility companies have requirements for ensuring their meter readers can access the meters, such as providing stairs to a platform under the reader. Check with your service provider before elevating service equipment. Refer to the Hurricane Isaac Recovery Advisory No. 2, *Minimizing Damage to Electrical Service Components* (2012).

Figure 9-1. Air conditioning / heat pump compressor mounted on a brick pedestal outside an elevated home.

Figure 9-2. Air conditioning/ heat pump compressor mounted on a cantilevered platform attached to a home elevated on an open foundation. (Source: FEMA P-55 Figure 12-2)

The feasibility of elevating equipment inside a basement or garage depends largely on the flood level. Simply raising the equipment above the floor using a solid pad (such as masonry or concrete) or a framed platform (wood or steel) may be possible. Outdoor equipment can be elevated on a platform attached to the side of the house. The materials selected to construct elevated platforms should meet the requirements described in NFIP Technical Bulletin 2, *Resistant Materials Requirements* (2008), and should be non-combustible when required by the code. A pad should be properly anchored to the floor system or slab, and the equipment should be properly anchored to the pad.

NOTE

When elevating HVAC and other equipment, be sure to leave sufficient space around the unit to allow access for maintenance work.

As the height of the flood level increases above the floor, the amount of space available above the flood level diminishes and elevation is feasible only for smaller pieces of equipment (e.g., electrical system components, ventilation ductwork, or specialized equipment such as furnaces designed to be suspended from the ceiling). If the flood level is at or near the ceiling, elevation may not be possible. Instead, equipment must be relocated or protected in place as described in Section 9.3.

Keep in mind that most service equipment must remain accessible for routine maintenance. For example, your fuel company must be able to reach your fuel tank to fill or empty it. Before elevating any service equipment, check with the utility company to find out whether it has any requirements that would prohibit elevation or restrict elevation height.

Also, remember that any large equipment elevated on platforms or pedestals, both inside and outside your home, may be more vulnerable to wind and earthquake damage and may require additional bracing or anchorage. A design professional must determine the expected wind and earth¬quake forces at the site and account for them in the elevated platform design.

This precaution is especially important for elevated fuel storage tanks, which could rupture if they are dislodged or toppled by wind and earthquake forces. In earthquake-prone areas, fuel storage tanks are sometimes equipped with cutoff valves that can help prevent leaks when supply lines are ruptured. Your utility service provider can give you more information about cutoff valves and other ways to protect fuel storage tanks from natural hazards.

9.1.1 Maintaining Horizontal and Vertical Clearances

When moving equipment, either to another floor or elevated on a platform, maintain the recommended horizontal and vertical clearance around it as required by building codes and the National Electrical Code or as recommended by manufacturers. Minimum clearances required for equipment, conduits, piping, and duct work should be considered before relocating or elevating equipment. Designing for the minimum clearance is important to maintain air circulation, meet insurance or code requirements related to distance from combustible building materials, and provide space for maintenance. Most codes dictate that clearance requirements should follow those specified on the equipment label or installation instructions. Required clearance typically ranges from 6 to 36 inches, and can sometimes be reduced by installing heat shields if allowed by the building code. The use of a heat shield or other method to reduce clearance should be verified in codes and manufacturers' installation requirements. Failure to maintain proper clearance can result in safety issues, including fire, and can void equipment warranties.

9.1.2 Venting Considerations

Oil- or gas-fueled boilers, furnaces, and water heaters require adequate combustion air and venting of exhaust gases. Although some units may vent exhaust directly out of the unit through an exterior wall, other units may need to vent exhaust through a chimney. The type of venting system and the clearances necessary for the venting system may affect how high the equipment can be elevated.

The venting system should be tested to ensure it draws adequate air and backdrafting does not occur. If relocating equipment, consider the required venting system, as it may affect the final placement of the unit.

9.1.3 Unions, Fittings, and Valves

When relocating or elevating equipment is not feasible, consider replacing unions, fittings, or valves to allow faster replacement of equipment when damaged, or disconnecting equipment prior to a flood event and relocating it to a higher floor. Although this approach will not bring a non-conforming building into compliance with NFIP requirements, it may reduce potential flood damage to utility systems.

9.2 Relocation

When space permits, you can move service equipment from a basement or other area below the flood level to an upper floor of the home or even an attic. Relocation usually requires more extensive changes to both your home and the equipment being moved, but it often provides a greater level of flood protection because the relocated equipment is farther above the flood level. In some situations, you may also be able to relocate outside equipment to higher ground, but only when the slope of your lot and other site conditions permit.

CROSS REFERENCE

Chapters 3 and 4 of FEMA 348, *Protecting Building Utilities from Flood Damage* (1999), discuss relocation of service equipment in detail.

Another relocation option is to build a new, elevated utility room as an addition to your home. The addition could be built on an open foundation or extended foundation walls.

Relocating and elevating equipment and systems can be a simple process, such as elevating a water heater on a small platform, or a complex process involving relocating equipment to a higher floor or to a new addition built specifically as a utility room. Each type of system has specific vulnerabilities, characteristics, and restrictions on placement that can affect a homeowner's ability to relocate it.

9.2.1 Electrical Panels

Power outages after a flood event often last much longer if a house's electrical panel is located below the flood elevation because the panel must be replaced before power can be restored. To address this problem, the electrical panel should be relocated to an elevation above the lowest floor (into the living space). When moving electrical panels to an elevation above the lowest floor, additional components, such as a service disconnect, may need to be incorporated into the system to meet the requirements of the National Electrical Code. Also, when relocating electrical panels, codes or local requirements may require replacing significant portions of the house wiring. For additional information on relocating electrical systems, consult Hurricane Isaac Recovery Advisory No. 2, *Minimizing Damage to Electrical Service Components* (2012).

9.2.2 Electric Meters

Damage to electrical meters is common during flood events. Relocating meters can often result in reduced outage times following flood events. Although some electric utility companies allow meters to be relocated, they often have specific requirements and specifications. Most electric utility companies do not want their employees to be put at risk climbing ladders or stairs. You may be able to work with your electric utility company to find an appropriate spot to relocate your meter to reduce the risk of it being damaged by floodwaters.

9.2.3 Electrical Wiring

In many houses, some wiring is located below the BFE, especially where the utility service is routed underground. If wiring is located below the BFE and the wiring is not rated for wet locations, the wiring should be encased in a non-corrosive metal or plastic pipe (conduit) when allowed by code. The conduits should be installed vertically to promote thorough drainage when floodwaters recede. Damaged wiring is easier to replace if it is installed in a conduit.

9.2.4 Mechanical Systems

Mechanical systems include the HVAC system, duct work, and the air handler that delivers the conditioned air throughout the house. Elements of the heating and cooling system below the BFE are subject to flooding. Ductwork beneath a house's floor system is susceptible to flooding and should be removed and replaced if it is inundated by floodwaters. The ductwork connected to the furnace and air handler is often the most prone to flood damage because the furnace is often located in the basement or the building's lowest floor.

In many instances, elevating mechanical systems above the BFE may not be possible. They should still be elevated as high as possible. Relocating mechanical equipment may require replacing ductwork and moving electrical supplies and refrigerant lines. Physical obstructions, such as walls or framing, may restrict the relocation of ductwork and the final location of the system components.

Condensing units. Protecting the condensing unit for an air conditioning system can often be achieved by elevating it on a platform or attaching a platform to the side of the house. A cantilevered platform is preferred over a platform on posts. Posts can obstruct floodborne debris and are more vulnerable to damage and failure, including floodborne debris impacts and undermining by scour and erosion.

Heating systems. Boiler systems, which are typically oil- or gas-fired, heat water and either force hot water or steam through radiators or baseboards throughout the home. A hot water boiler system consists of the main boiler, heat exchanger and burner, circulation pumps or control valves, and an expansion tank. Many components of a boiler system can be damaged by contact with floodwaters. Protecting a boiler system from flooding usually requires raising the system in its entirety. Although most boiler systems in residential use are hot water systems, the protection of a steam boiler is similar. Relocating a boiler system to an upper level is ideal, but can present some significant challenges, such as needing to reroute the plumbing associated with the system. Elevating the boiler as high as possible on its current floor may be more practical. The main concerns when elevating a boiler are clearances, venting the exhaust, and protecting the supply tank from contamination. Systems using heating oil rely on either an above- or below-ground storage tank. The storage tank should be properly anchored and sufficiently sealed to prevent floodwater from contaminating the heating oil or allowing the oil to be released.

A furnace or forced air heating system uses oil or natural gas (and sometimes electricity) to heat air blown across heating coils in the system. Relocating these systems to upper floors or attic areas may be possible. If elevating the furnace to an upper floor is not possible and elevating the furnace in its existing location below the living area is the only practical mitigation measure, the required clearances and venting of the unit must be accommodated.

9.2.5 Water Heaters

Water heaters, which are oil- or gas-fired, are powered from an electric coil. Conventional residential water heaters that use storage tanks typically range in capacity from 40 to 80 gallons. When exposed to floodwater, the internal components of the water heater can be damaged.

Electric water heaters. In some buildings, electric water heaters can be relocated to a higher floor or the attic. Relocating the unit requires plumbing and electrical work, as well as a method to drain the tank and prevent water damage from leakage. Although relocating a water heater to the attic effectively protects it from flood damage, the heater must be equipped with a drain pan and drain to avoid costly water damage in the event of leakage. If a water heater is placed in an attic, it should be routinely maintained and inspected for leaks or other problems.

Oil or gas-fired water heaters. Oil- or gas-fired water heaters must be vented and may, therefore, be difficult to move into a main living space. If an appropriate location for the water heater is not available on a higher floor, it can potentially be elevated in its current location. Elevating the tank usually requires a small pad or platform, an appropriate location to vent the exhaust, and extending or shortening water supply lines and distribution lines.

Other water heaters. Although more expensive than conventional water heater systems, tankless systems, which heat water instantaneously, require significantly less space and may present a flood mitigation opportunity because of their smaller size. Converting a conventional water heater unit fueled by natural gas to a tankless system requires minimal additional work. Electric tankless water heaters, by comparison, may not be practical because of the electrical system upgrades needed in some houses to provide the additional electrical power for the water heater.

Although moving equipment into the attic area may appear to be an effective use of space, equipment such as water heaters can cause problems if they are not properly installed. Drain pans and piping to address a water heater leak must be carefully considered to make sure water will not overflow and damage rooms below. In areas subject to freezing temperatures, drain lines could freeze and prevent water from draining, causing significant interior water damage.

9.2.6 Washer/Dryer Units

Many washing machines and clothes dryers are located in basements, where they are vulnerable to flooding. Relocating this equipment to a higher floor may not be practical if space is limited in the living area. Even minimal elevation may prevent the units from being damaged in low-level flooding situations. A permanent pad or platform should be constructed to elevate these units; stacked bricks or blocks should not be used because they can shift and result in injuries to users or damage to the equipment. Elevating washing machines and clothes dryers may require altering the water and drain piping, electrical connections, and gas connections.

9.3 Protection in Place

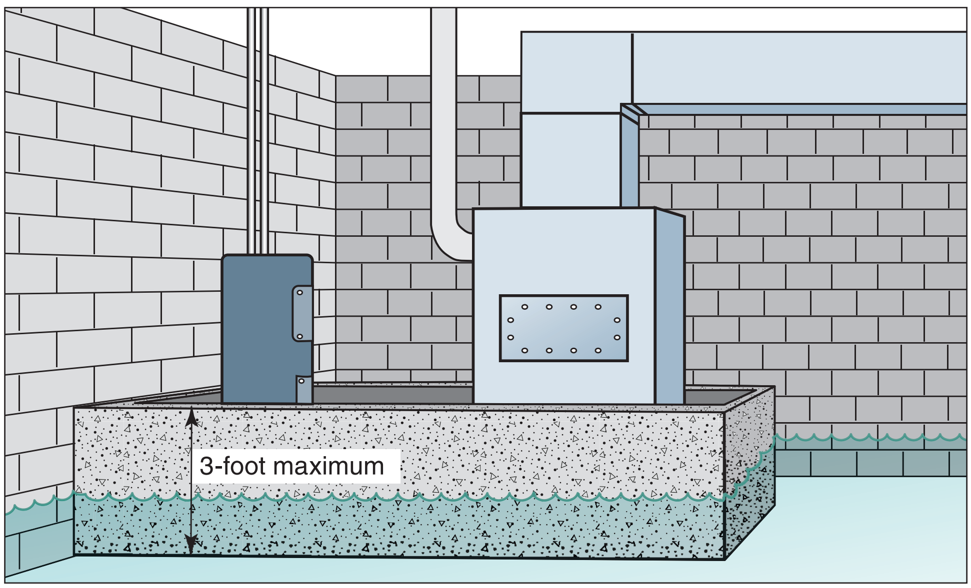
When elevation and relocation are infeasible or impractical, you may be able to protect service equipment in place with low floodwalls and shields and with anchors and tie downs that prevent flotation. Plumbing systems can be protected with valves that prevent wastewater from backing up into the home.

9.3.1 Floodwalls and Shields

Floodwalls and shields are typically components of dry floodproofing systems (Chapter 7) that are used to protect entire buildings. However, if a building is wet floodproofed, these components can be used for the protection of small areas within a building that contain service equipment that cannot be elevated or relocated. For example, you can build a concrete floodwall that surrounds one or more pieces of service equipment, such as a furnace and water heater (Figure 9-3).

If the expected flood depth is less than about 12 inches, the floodwall could be low enough that you could step over it to reach the protected equipment. A higher floodwall can include an opening equipped with a removable shield, as shown in Figure 9-3, to permit easy access to the protected equipment. In this example, the shield does not interfere with the normal operation of the equipment, so it should be left in place and removed only when necessary to service the equipment. Leaving the shield in place allows the barrier to function without human intervention.

Figure 9-3. Water heater and furnace protected by a concrete floodwall with opening and gasketed shield.



In general, barriers and shields of the type shown in Figure 9-3 are practical only when flood depths are less than about 3 feet. The greater hydrostatic pressure exerted by deeper water requires barriers and shields that are more substantial, have more complex designs, and are, therefore, more expensive. As discussed in Chapter 8, all floodwalls should provide at least 1 foot of freeboard above the expected flood elevation.

Regardless of the height of the barrier, the area it protects should be equipped with a sump pump that will remove any water that accumulates through seepage.

CROSS REFERENCE

For more information about anchoring fuel storage tanks, refer to FEMA 348, Protecting Building Utilities from Flood Damage (1999), and the FEMA Fact Sheet series *Protect Your Property from Flooding, Anchor Fuel Tanks* (2011).

9.3.2 Anchors and Tiedowns

Anchors and tiedowns are used primarily for aboveground storage tanks (ASTs) that are not el-evated above the flood level and for underground storage tanks (USTs). Both types of tanks are extremely vulnerable to flotation. Floodwaters and debris impact forces act directly on ASTs, and USTs can be forced out of the ground by the buoyancy force of saturated soils. When either type of tank is displaced, its connections can be severed and the escaping fuel can cause hazardous conditions.

ASTs can be anchored with metal straps or cables that cross over the tank and connect to ground anchors. The length and type of ground anchor you need depends largely on the type of soil at the site. A design professional can advise you about anchors. Another way to anchor an AST is to embed its legs in a concrete slab (Figure 9-4).

Ground anchors can also be used for USTs. The anchoring method involves excavating the soil above the tank, placing steel I-beams across it, and connecting them to ground anchors. Again, check with a design professional concerning the required size and type of anchor. USTs can also be anchored with a concrete slab similar to the one shown in Figure 9-4. Installing the slab involves excavating around the tank and removing it temporarily while the slab is poured. Another alternative is to excavate down to the tank and pour a concrete slab on top, ensuring not to cover access openings.

NOTE

Be especially careful when anchoring storage tanks or other service equipment in floodways, Zone V areas, and other high-risk areas. Consider the effects of high-velocity flows, wave action, fast moving floodborne debris, and extensive erosion and scour wherever these hazards are likely to occur.

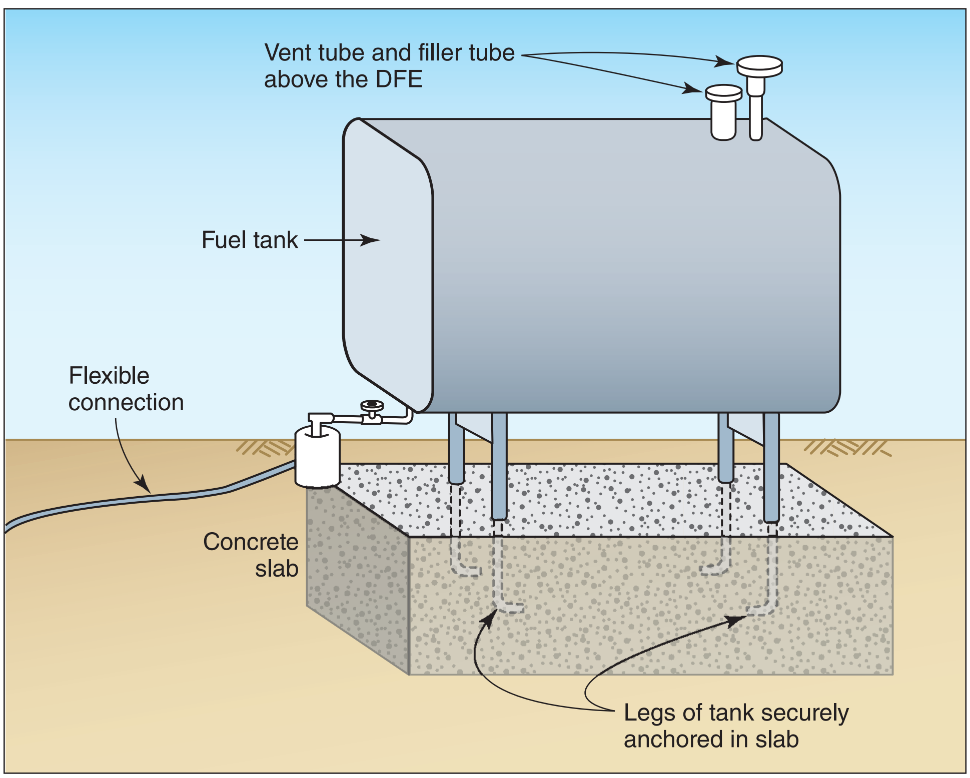


Figure 9-4. Anchoring a fuel storage tank with a concrete slab.

On all tanks below the flood level, both aboveground and underground, flexible connections must be used between the tank and the supply line. Also, the vent and filler tubes must extend above the flood protection elevation (Figure 9-4). If you have adequate warning of an impending flood, top off the tank. A full tank will be less susceptible to corrosion from accumulated moisture and will be heavier and better able to resist buoyancy.

Although anchoring is particularly important for storage tanks, remember that the levels of future floods can rise higher than expected and inundate service equipment that you have elevated, relocated, or protected in place. For this reason, service equipment should be anchored whenever possible so that it will remain in place when acted on by flood forces. Anchorage systems should be designed assuming a worst-case scenario of an empty tank.

9.3.3 Backflow Valves

Flooding can inundate and overload sanitary sewer systems and combined sanitary/storm sewer systems. As a result, water can flow backward through sewer lines and out through toilets or drains. The best solution to this problem is usually to install a backflow valve. These valves include check valves, gate valves, and dual backflow valves.

WARNING

The installation of backflow valves and other plumbing modifications is usually regulated by State and local building codes. Some municipalities may prohibit the use of backflow valves. A plumber or contractor licensed to work in your area will know about the code requirements that apply to your retrofitting project.

Check valves operate without human intervention. Under normal conditions, they allow wastewater to flow from the home to the main sewer line. When flooding causes the flow to reverse, a flap or other check mechanism in the valve prevents water from flowing back into the home. A disadvantage of check valves is that they can become blocked open by debris and fail to operate. For this reason, check valves must be inspected regularly and cleaned as necessary.

Gate valves are manually operated, provide a better seal, and are unlikely to be blocked open. However, they are more expensive than check valves and require human intervention.

The third alternative is dual backflow valves, which combine the benefits of the check valve and the gate valve. As the most expensive of the three valve types, the dual backflow valve should be considered primarily for use in homes subject to repeated backflow flooding. Gate valves and dual backflow valves are usually installed outside the home in a valve pit (Figure 9-5). A licensed plumber should install any check valve system in compliance with local codes. Some current community codes only allow use of dual check valve systems.

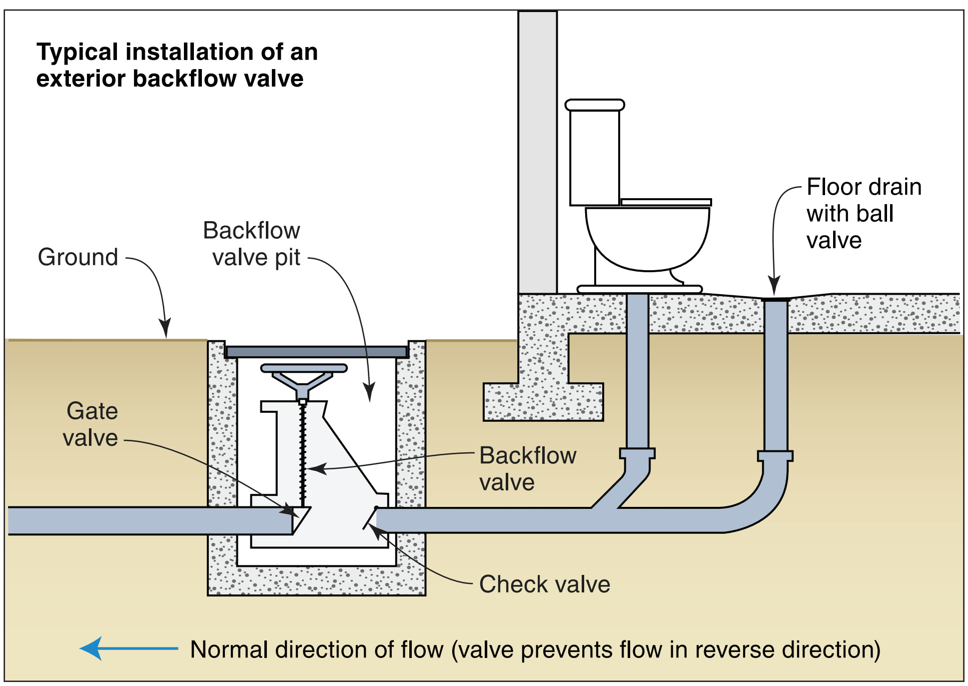


Figure 9-5. Example of an exterior backflow valve installed in a valve pit.




Appendix A

Bibliography and Sources of Information

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Federal Emergency Management Agency – Technical Bulletin Links

Openings in Foundation Walls and Walls of Enclosures, Technical Bulletin 1, August 2008, http://www.fema.gov/media-library/assets/documents/2644.

Flood Damage-Resistant Materials Requirements, Technical Bulletin 2, August 2008, http://www.fema.gov/media-library/assets/documents/2655.

Non-Residential Floodproofing – Requirements and Certification. Technical Bulletin 3, April 1993, https://www.fema.gov/media-library/assets/documents/3473.

Free-of-Obstruction Requirements, Technical Bulletin 5, August 2008, http://www.fema.gov/media-library/assets/documents/3490.

Wet Floodproofing Requirements, FIA-TB-7, December 1993,
http://www.fema.gov/media-library/assets/documents/3503.

U.S. Army Corps of Engineers

Tests of Brick-Veneer Walls and Closures for Resistance to Floodwaters, May 1978.
http://www.dtic.mil/docs/citations/ADA064860.

Structural Integrity of Brick-Veneer Buildings, 1978. http://www.dtic.mil/docs/citations/ADA055972.

Systems and Materials to Prevent Floodwaters from Entering Buildings, May 1985.
http://www.dtic.mil/dtic/tr/fulltext/u2/a156050.pdf.

USACE National Flood Proofing Committee: *Flood Proofing Tests – Tests of Materials and Systems for Flood Proofing Structures*, August 1988. http://cdm16021.contentdm.oclc.org/cdm/ref/collection/p16021coll11/id/6.

Flood Proofing – How to Evaluate Your Options, July 1993. http://www.usace.army.mil/Library/Pages/default.aspx.

For additional information about natural hazards and hazard mitigation, visit the Internet sites listed below:

American Red Cross
http://www.redcross.org

Applied Technology Council
http://www.atcouncil.org

Association of State Floodplain Managers
http://www.floods.org

Disaster Research Center, University of Delaware
http://www.udel.edu/DRC/

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

Federal Emergency Management Agency
http://www.fema.gov

Hazard Reduction and Recovery Center (HRRC), Texas A&M
http://archone.tamu.edu/hrrc/

Insurance Institute for Business & Home Safety (IBHS)
http://www.disastersafety.org/

National Association of Home Builders
http://www.nahb.org/

National Flood Insurance Program (NFIP)
http://www.floodsmart.gov/floodsmart/

National Geophysical Data Center
http://www.ngdc.noaa.gov

National Information Service for Earthquake Engineering, University of California at Berkeley
http://nisee.berkeley.edu

Natural Hazards Center at the University of Colorado, Boulder, Colorado
http://www.colorado.edu/hazards

StromStruck – A Tale of Two Homes
http://www.stormstruck.com/

U. S. Army Corps of Engineers – National Nonstructural Flood Proofing Committee
http://www.usace.army.mil/Missions/CivilWorks/ProjectPlanning/nfpc.aspx

U.S. Department of Housing and Urban Development (HUD) – Office of Policy Development and Research (PDNR)
http://www.huduser.org/portal/index.php

U. S. Geological Survey – Earthquake Hazards Program
http://quake.wr.usgs.gov

U. S. Natural Resources Conservation Service
http://www.nrcs.usda.gov

Wind Engineering Research Center, Texas Tech University
http://www.depts.ttu.edu/weweb/




Appendix B

Glossary

Many of the terms defined here are also defined in the margins of pages on which they first appear or explained in the body of the text.

Acquisition and demolition – The voluntary process by which your State or local government purchases an existing at-risk building, and, typically, the underlying land; demolishes the building; and converts the land to open space. The land is then maintained as open space and used to restore and/or conserve the natural floodplain functions.

Active retrofitting method – Method that will not function as intended without human intervention. See "passive retrofitting method."

Adjacent grade – See "lowest adjacent grade (LAG)."

Alluvial fan flooding – Flooding that occurs on the surface of an alluvial fan (or similar landform) that originates at the apex of the fan and is characterized by high-velocity flows; active processes of erosion, sediment transport, and deposition; and unpredictable flow paths.

Armor – To protect fill slopes, such as the sides of a levee, by covering them with erosion-resistant materials such as rock or concrete.

Backfill – To fill in a hole with the soil removed from it or with other material, such as soil, gravel, or stone.

Backflow valve – See "check valve."

Barrier systems – See "floodwall" or "levees."

Base flood – Flood that has a 1 percent probability of being equaled or exceeded in any given year (formerly known as the 100-year flood).

Base flood elevation (BFE) – The elevation of the base flood relative to the datum specified on a community's Flood Insurance Rate Map (FIRM). The elevation is shown on the FIRM for Zones AE, AH, A1–A30, AR, AR/A, AR/AE, AR/A1–A30, AR/AH, AR/AO, V1–V30, and VE and indicates the water surface elevation resulting from a flood that has a 1 percent chance of equaling or exceeding that level in any given year. The BFE is the National Flood Insurance Program's (NFIP's) minimum elevation to which the lowest floor of a building must be elevated or floodproofed (Zone A). In Zone V, the bottom of the lowest horizontal structural member must be elevated to or above the BFE; floodproofing is not permitted in Zone V. Many SFHAs are shown on FIRMs without BFEs; in these areas, community officials and permit applicants are required to obtain and use information from other sources, or must estimate or develop BFEs at specific locations.

Basement – Any area of the building having its floor subgrade (below ground level) on all sides.

Benchmark – A reference point established by a survey with a precisely known relationship to a datum.

Building envelope – The entire exterior surface of a building (including cladding, roofing, exterior walls, doors, and windows) that encloses or envelopes the space within.

Buoyancy – The upward hydrostatic force that floodwater exerts on the underside of submerged members (such as floor slabs, walls and footings) of homes that have enclosed spaces below the flood level.

Cast-in-place concrete – Concrete poured and formed at the construction site.

Check valve – Valve that allows water to flow in one direction, but automatically closes when the direction of flow is reversed.

Closure – Shield made of strong material, such as metal or wood, used to temporarily close openings in levees, floodwalls, and dry floodproofed buildings.

Coastal A Zone – The portion of the coastal SFHA referenced by building codes and standards, where base flood wave heights are between 1.5 and 3 feet, and where wave characteristics are deemed sufficient to damage many NFIP-compliant structures on shallow or solid wall foundations.

Coastal High Hazard Areas – SFHAs along the coasts that have additional hazards due to wind and wave action. These areas are identified on FIRMs as Zones V, V1–V30, and VE.

Compaction – In construction, the process by which the density of earth fill is increased so that it will provide a sound base for a building or other structure.

Crawlspace – Type of foundation in which the lowest floor of a home is suspended above the ground on continuous foundation walls.

Cribbing – A temporary framework that usually consists of criss-crossed timbers that provide temporary structural support. Cribbing usually consists of layers of heavy timber.

Cutoff trench – A core located below the base of a dam or levee structure. The trench is filled with an impervious material, such as clay, to form a watertight barrier to prevent under-levee seepage.

Datum – An elevation datum is an arbitrary surface that serves as a common reference for the elevations of points above or below it. Elevations are expressed in terms of feet, meters, or other units of measure and are identified as negative or positive, depending on whether they are above or below the datum. Three common elevation datums are mean sea level (msl), NGVD, and NAVD.

Debris – Materials carried by floodwaters, including objects of various sizes and suspended soils.

Demolition – The act or process of reducing a structure, as defined by State or local code, to a collapsed state.

Design capacity – For drainage systems, the volume of water that a channel, pipe, or other drainage line is designed to convey.

Design flood elevation (DFE) – The elevation of the design flood relative to the datum specified on the community's FIRM. The design flood is associated with the greater of the area subject to the base flood or the area designated as a flood hazard area on a community flood hazard map. The I-Codes, ASCE 7, and ASCE 24 use the term DFE. In most communities, the DFE is identical to the BFE. Communities may designate a design flood (or DFE) in order to regulate based on a flood of record, to account for future increases in flood levels based on upland development, or to incorporate freeboard.

Dry floodproofing – Protecting a building through a combination of measures in order to prevent the entrance of floodwaters. Structural components of the building must have the capacity to resist the resulting flood loads.

Duration – The measure of how long a flood lasts. Duration can also refer to how long it takes for a creek, river, bay, or ocean to return to its normal level.

Elevation – In retrofitting, the process of physically raising an existing building so that it is above the height of a given flood.

Elevation datum – Arbitrary surface that serves as a common reference for the elevations of points above or below it. Elevations are expressed in terms of feet, meters, or other units of measure and are identified as negative or positive, depending on whether they are above or below the datum. Three common datums are mean sea level (msl), National Geodetic Vertical Datum (NGVD), and North American Vertical Datum (NAVD).

Enclosure – That portion of an elevated building below the lowest elevated floor that is either partially or fully shut in by rigid walls.

Erosion – A general lowering of the ground surface over a wide area.

Federal Emergency Management Agency (FEMA) – Agency within the Department of Homeland Security (DHS) that administers the NFIP. The NFIP is the Federal program, created by Congress in 1968, that makes flood insurance available in communities that adopt and enforce floodplain management ordinances or laws that meet the minimum requirements of the NFIP regulations.

Federal Insurance and Mitigation Administration (FIMA) – Component of FEMA directly responsible for administering the flood insurance aspects of the NFIP.

Fill – Material such as soil, gravel, or stone that is dumped in an area to increase the ground elevation. Fill is usually placed in layers and each layer compacted (see "compaction").

Flap valve – See "check valve."

Flash Flood – A flood caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours. A flash flood rises and falls very quickly and is usually characterized by high flow velocities.

Flood – Under the NFIP, "a general and temporary condition of partial or complete inundation of normally dry land areas" from: 1) the overland flow of a lake, river, stream, ditch, etc.; 2) the unusual and rapid accumulation or runoff of surface waters; and 3) mudflows or the sudden collapse of shoreline land.

Flood damage-resistant material – Any building product (material, component, or system) capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage.

Flood depth – Height of floodwaters above the surface of the ground at a given point.

Flood elevation – Water surface elevation of floodwaters based on a given elevation datum.

Flood frequency – Probability, expressed as a percentage, that a flood of a given size will be equaled or exceeded in any given year. For example, the 1 percent annual chance flood has a 1 percent chance (1 in 100) of being equaled or exceeded in any given year.

Flood protection elevation – The elevation to which you choose to protect your home. Although a flood protection elevation less than the DFE is feasible, FEMA recommends protecting your home to at least the DFE.

Floodplain – Any area susceptible to inundation by water from any source. See "regulatory floodplain."

Floodplain management – Program of corrective and preventive measures for reducing flood damage, including flood control projects, floodplain management regulations, floodproofing or retrofitting of buildings, and emergency preparedness plans.

Floodproofing – Any combination of structural or nonstructural changes or adjustments included in the design, construction, or alteration of a building that reduce or eliminate flood damage to the building and its contents. See "dry floodproofing" and "wet floodproofing."

Floodwall – Flood barrier constructed of manmade materials, such as concrete or masonry, to keep water away from or out of a specified area.

Floodway – Portion of the SHFA that must be reserved to prevent significant increases in flood elevations. The flood hazard is usually greater in the floodway (higher flood depths and velocities) than in the surrounding areas of the SFHA, referred to as the "flood fringe."

Flow velocity – Speed at which water moves during a flood. Velocities usually vary across the floodplain and are generally greatest near the channel and lowest near the edges of the floodplain.

Footing – The base of a foundation, usually made of concrete and sometimes reinforced with steel bars. Foundation walls are supported on continuous footings; separate foundation members, such as piers, are supported on individual footings.

Footprint – The land area a house covers. This area is equal to the length of the home multiplied by its width. The footprint is not necessarily equal to the total square footage of the home.

Frame Construction – A type of construction in which a supportive framework forms the primary structural element of a building. In residential construction, the framework typically consists of wood or steel members.

Freeboard – An added margin of safety, expressed in feet above a specific flood elevation, usually the BFE. In States and communities that require freeboard, buildings are required to be elevated or floodproofed to the higher elevation. For example, if a community adopts a 2-foot freeboard, buildings are required to be elevated or floodproofed to 2 feet above the BFE.

Frequency – See "flood frequency."

Grade beam – In a slab foundation, a support member cast as an integral part of the slab, as opposed to a separate footing.

Hazard mitigation – Sustained action taken to reduce or eliminate long-term risk to people and property from hazards such as floods, hurricanes, earthquakes, and fires.

Human intervention – Any action that a person must take to enable a flood protection measure to function as intended. This action must be taken every time flooding threatens.

High-velocity flow – During a design flood or lesser conditions, water movement adjacent to structures and/or foundations with flow velocities greater than 10 feet per second.

Hydrodynamic force – Force exerted by moving water.

Hydrostatic force – Force exerted by water at rest, including lateral pressure on walls and uplift (buoyancy) on floors.

Ice Jam – Accumulation of floating ice fragments that causes the bridging or damming of a channel or stream.

Impervious soils – Soils that resist penetration by water.

Intensity of rainfall – The amount of rain that falls during a given amount of time. It is usually expressed in inches of rainfall per hour. The greater the number of inches per hour, the greater the intensity.

Jetting – A process in which the hole for the installation of a pile is made by a high-pressure stream of water from a nozzle attached to the bottom of the pile.

Letter of Map Amendment (LOMA) – Occasionally, a small area is inadvertently shown to be within the SFHA on a FIRM, even though the ground is at or above the BFE. If this occurs, an individual property owner may submit survey information to FEMA and request that FEMA issue a document that officially removes a property from the SFHA, called a Letter of Map Amendment.

Levee – Manmade barrier, usually constructed of compacted soil, designed to contain, control, or divert the flow of flood water from a specified area.

Local officials – Community employees who are responsible for floodplain management, zoning, permitting, building code enforcement, and building inspection.

Lowest adjacent grade (LAG) – The lowest ground surface that touches any of the exterior walls of a home. The LAG is determined at the pier or post of an attached deck or porch if the elevation is lower than the point where soil touches the foundation of the building.

Lowest floor – Floor of the lowest enclosed area within a building, including a basement. The only exception is an enclosed area below an elevated building, but only when the enclosed area is used solely for parking, building access, or storage and is compliant with relevant regulations

Limit of Moderate Wave Action (LiMWA) – A line indicating the limit of the 1.5-foot wave height during the base flood. FEMA requires new flood studies in coastal areas to delineate the LiMWA.

Minimal Wave Action (MiWA) area – The portion of the coastal Special Flood Hazard Area where base flood wave heights are less than 1.5 feet.

Moderate Wave Action (MoWA) area – see Coastal A Zone.

Manufactured home – A prefabricated frame home constructed on a transportable frame that can be placed on a permanent or temporary foundation (subject to Federal and State standards).

Masonry – Walls constructed of brick, stone, or concrete block.

Masonry veneer – Nonstructural, decorative, exterior layer of brick, stone, or concrete block added to the walls of a building.

Mean sea level (msl) – A tidal elevation datum based on data collected over a 19-year tide cycle.

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.

Modular home – A frame home assembled on site on a permanent foundation from separate sections manufactured elsewhere (subject to local building codes).

National Geodetic Vertical Datum (NGVD) – A geodetic elevation datum previously used by FEMA for the determination of flood elevations. While NGVD has been updated to the NAVD datum on many FIRMs, it is still the datum referenced on many of the older FIRMs.

North American Vertical Datum (NAVD) – A geodetic elevation datum currently used by FEMA for the determination of flood elevations.

Passive retrofitting method – Method that operates automatically, without human intervention. See "active retrofitting method."

Permeable soils – Soils through which water can easily penetrate and flow.

Pier – Vertical support member of masonry or cast-in-place concrete that is designed and constructed to function as an independent structural element in supporting and transmitting both building loads and environmental loads to the ground.

Piling – Vertical support member of wood, steel, or precast concrete that is driven or jetted into the ground and supported primarily by friction between the pilings and the surrounding earth. Pilings often cannot act as independent support units and therefore are often braced with connections to other pilings.

Post – Long vertical support member of wood or steel set in holes that are backfilled with compacted material. Posts often cannot act as independent support units and, therefore, are often braced with connections to other posts.

Precast concrete – Concrete materials such as posts, beams, and blocks that are brought to the construction site in finished form.

Prolonged contact – At least 72 hours of contact with floodwaters.

Rates of rise and fall – How rapidly the elevation of the water rises and falls during a flood.

Regulatory floodplain – Flood hazard area within which a community regulates development, including new construction, the repair of Substantially Damaged buildings, and Substantial Improvements to existing buildings. In communities participating in the NFIP, the regulatory floodplain must include at least the area inundated by the base flood, also referred to as the SFHA.

Reinforcement – Inclusion of steel bars in concrete members and structures to increase their strength.

Relocation – In retrofitting, the process of moving a home or other building to a new location outside the flood hazard area.

Retrofitting – Making changes to an existing home or other building to protect it from flooding or other hazards.

Riprap – Pieces of rock or crushed stone added to the surface of a fill slope, such as the side of a levee, to prevent erosion.

Saturated soils – Soils that have absorbed, to the maximum extent possible, water from rainfall or snowmelt.

Scour – A localized loss of soil, often around a foundation element.

Sealant – In retrofitting, a waterproofing material or substance used to prevent the infiltration of floodwater.

Service equipment – The utility systems, heating and cooling systems, and large appliances in a retrofitted home.

Significant damage – As it relates to flood-damage resistant materials, any damage requiring more than cosmetic repair.

Slab-on-grade – Type of foundation in which the lowest floor of the home is formed by a concrete slab that sits directly on the ground. The slab may be supported by independent footings or integral grade beams.

Special Flood Hazard Area (SFHA) – An area delineated on a FIRM as being subject to inundation by the base flood, designated Zone A, AE, A1–A30, AR, AO, AH, A99, V, VE, or V1–V30.

Storm surge – Water pushed toward the shore by the force of the winds swirling around a storm. It is the greatest cause of loss of life due to hurricanes..

Subgrade – Below the level of the ground surface.

Substantial Damage – Damage to a building, regardless of the cause, is considered Substantial damage if the cost of restoring the building to its before-damage condition would equal or exceed 50 percent of the market value of the building before the damage occurred

Substantial Improvement – Under the NFIP, an improvement of a building (such as reconstruction, rehabilitation, or an addition) is considered a Substantial Improvement if its cost equals or exceeds 50 percent of the market value of the building before the start of construction of the improvement.

Substantially impermeable – A wall is considered substantially impermeable if it limits water accumulation to 4 inches in a 24 hour period. In addition, sump pumps are required to control any seepage and flood-resistant materials must be used in all areas where seepage is likely to occur. This standard is the minimum requirement; lower seepage rates are possible and strongly encouraged by FEMA, particularly in new construction.

Sump pump – Device used to remove water from seepage or rainfall that collects in areas protected by a levee, floodwall, or dry floodproofing. In addition, a sump pump is often part of a standard home drainage system that removes water that collects below a basement slab floor.

Tsunami – Large, rapidly moving sea waves produced by an undersea earth movement (earthquakes, crustal displacements or landslides) or volcanic eruption.

Underseepage – Water that migrates downward along the sealed walls of a home and then under the foundation.

Veneer – See "masonry veneer."

Walkout-on-grade basement – Basement whose floor is at ground level on at least one side of a home. The term "walkout" is used because most basements of this type have an outside door or doors (entry door, garage door, or both) at ground level. A walkout-on-grade basement is not considered a basement under the NFIP. See "basement."

Watershed – The land area that drains water to a particular stream, river, or lake. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge.

Wave action – The characteristics and effects of waves that move inland from an ocean, bay, or other large body of water. Large, fast-moving waves can cause extreme erosion and scour, and their impact on buildings can cause severe damage.

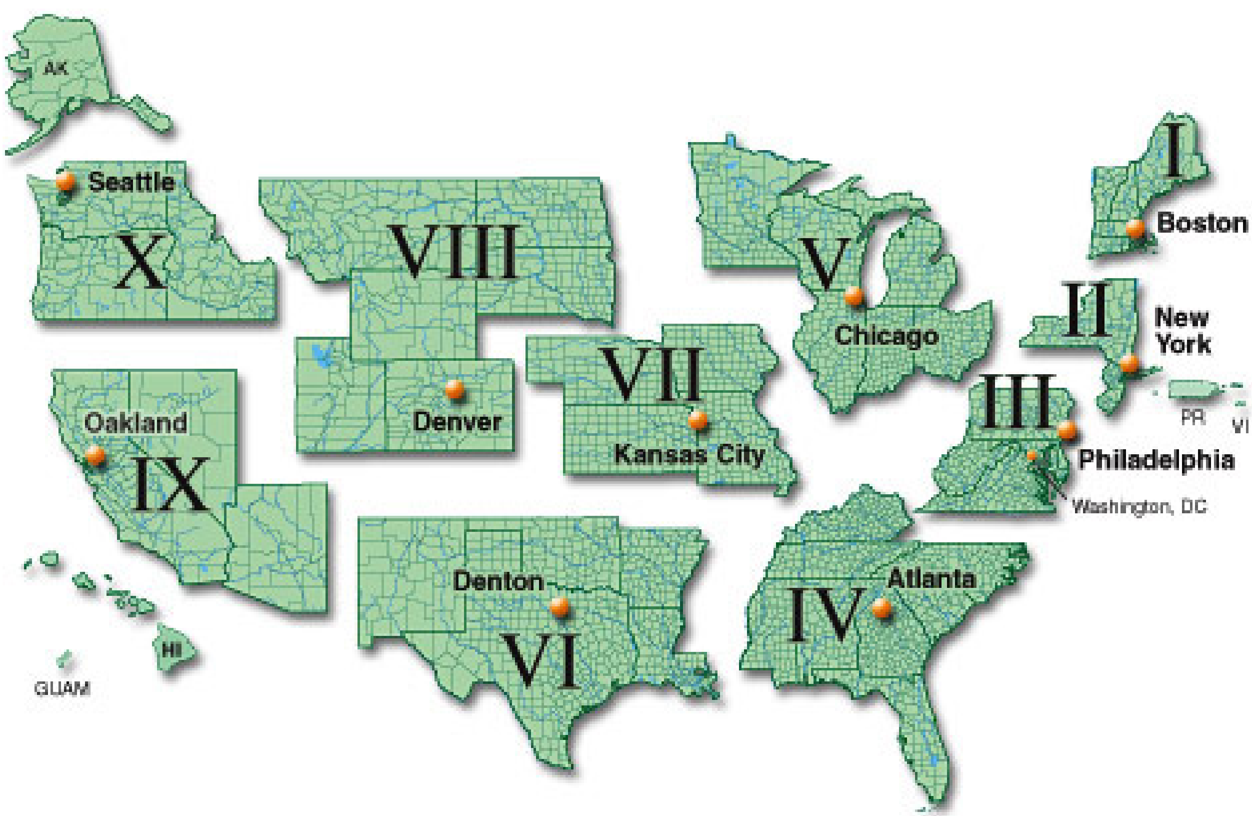
Wet floodproofing – The use of flood-damage-resistant materials and construction techniques to minimize flood damage to areas below the flood protection level of a building, which is intentionally allowed to flood. Usually, only enclosed areas used for parking, building access, or storage are wet floodproofed.




Appendix C

FEMA Offices

The addresses and telephone numbers of FEMA Headquarters and the 10 FEMA Regional Offices are listed below. Staff members of the Regional Office for your area can give you more information about retrofitting, hazard mitigation, and the National Flood Insurance Program.



FEMA HEADQUARTERS500 C Street, SW
Washington, DC 20472
(202) 646-2500, (800) 621-FEMA (3362)
TTY: (800) 462-7585

REGION I – CT, MA, ME, NH, RI, VT
99 High Street, Sixth Floor
Boston, MA 02110
(877) 336-2734

REGION II – NJ, NY, PR, VI
26 Federal Plaza, Suite 1337
New York, NY 10278-0002
(212) 680-3600

REGION III – DC, DE, MD, PA, VA, WV
615 Chestnut Street
One Independence Mall, Sixth Floor
Philadelphia, PA 19106-4404
(215) 931-5500

REGION IV – AL, FL, GA, KY, MS, NC, SC, TN
3003 Chamblee Tucker Road
Atlanta, GA 30341-4112
(770) 220-5200

REGION V – IL, IN, MI, MN, OH, WI
536 South Clark Street, Sixth Floor
Chicago, IL 60605-1521
(312) 408-5500

REGION VI – AR, LA, NM, OK, TX
Federal Regional Center
800 North Loop 288
Denton, TX 76209-3698
(940) 898-5399

REGION VII – IA, KS, MO, NE
9221 Ward Parkway, Suite 300
Kansas City, MO 64114-3372
(816) 283-7061

REGION VIII – CO, MT, ND, SD, UT, WY
Denver Federal Center
Building 710, Box 25267
Denver, CO 80255-0267
(303) 235-4800

REGION IX – AZ, CA, HI, NV, American Samoa, Guam, Commonwealth of the Northern Mariana Islands, Republic of the Marshall Islands, Federated States of Micronesia
1111 Broadway, Suite 1200
Oakland, CA 94607-4052
(510) 627-7100

REGION X – AK, ID, OR, WA
Federal Regional Center
130 228th Street, SW
Bothell, WA 98021-8627
(425) 487-4600




Appendix D

NFIP State Coordinating Agencies

Alabama

Alabama Department of Community and Economic Development
Office of Water Resources
401 Adams Avenue, Suite 434
P.O. Box 5690
Montgomery, AL 36103-5690
Phone: (334) 353-0853
http://www.adeca.alabama.gov/water/

Alaska

Alaska Department of Commerce, Community, and Economic Development
550 West 7th Avenue, Suite 1770
Anchorage, AK 99501-3510
Phone: (907) 269-4583
Fax: (907) 269-4539
http://www.commerce.state.ak.us/

Arizona

Arizona Department of Water Resources
3550 North Central Avenue
Phoenix, AZ 85012-2105
Phone: (602) 771-8657
Fax: (602) 771-8686
http://www.azwater.gov/

Arkansas

Arkansas Natural Resources Commission
101 East Capitol, Suite 350
Little Rock, AR 72201-3823
Phone: (501) 682-3969
Fax: (501) 682-3991
http://www.anrc.arkansas.gov/

California

California Department of Water Resources
3464 El Camino Avenue, Suite 200
Sacramento, CA 95821
Phone: (916) 574-1409
http://www.water.ca.gov/

Colorado

Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, CO 80203
Phone: (303) 866-3441
Fax: (303) 861-4272
http://cwcb.state.co.us/

Connecticut

Department of Energy and Environmental Protection
79 Elm Street
Hartford, CT 06106
Phone: (860) 424-3537
Fax: (860) 424-4075
http://www.ct.gov/dep/

Delaware

Department of Natural Resources and Environmental Control
89 Kings Highway
Dover, DE 19901
Phone: (302) 739-9921
Fax: (302) 739-6724
http://www.dnrec.delaware.gov

District of Columbia

District Department of the Environment Watershed Protection Division
1200 First Street, 5th Floor
Washington, DC 20002
Phone: (202) 535-2248
Fax: (202) 535-1364
http://green.dc.gov/watershed

Florida

Division of Emergency Management
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100
Phone: (850) 922-4518
http://www.floridadisaster.org/

Georgia

Georgia Department of Natural Resources
4220 International Parkway, Suite 101
Atlanta, GA 30354
Phone: (404) 656-6382
Fax: (404) 675-1607
http://www.gadnr.org/

Guam

Guam Department of Public Works
542 North Marine Corps Drive
Upper Tumon, Guam 96913
Phone: (671) 646-3131
Fax: (671) 649-6178
http://www.dpw.guam.gov

Hawaii

Hawaii Department of Land and Natural Resources
1151 Punchbowl Street
P.O. Box 221
Honolulu, HI 96809
Phone: (808) 587-0267
Fax: (808) 587-0283
http://www.state.hi.us/dlnr/docare/

Idaho

Idaho Department of Water Resources
322 East Front Street
Boise, ID 83720
Phone: (208) 287-4928
http://www.idwr.idaho.gov/

Illinois

Illinois Department of Natural Resources Office of Water Resources
One Natural Resources Way
Springfield, IL 62702-1271
Phone: (217) 782-4428
Fax: (217) 785-5014
http://dnr.state.il.us/OWR/

Indiana

Indiana Department of Natural Resources
402 West Washington Street, Room W264
Indianapolis, IN 46204-2748
Phone: (317) 234-1107
Fax: (317) 233-4579
http://www.state.in.us/dnr/

Iowa

Iowa Department of Natural Resources
502 East 9th Street
Des Moines, IA 50319
Phone: (515) 281-8942
Fax: (515) 281-8895
http://www.iowadnr.com/

Kansas

Kansas Department of Agriculture
109 SW 9th Street, 2nd Floor
Topeka, KS 66612-1283
Phone: (785) 296-5440
Fax: (785) 296-4835
http://www.ksda.gov/

Kentucky

Kentucky Division of Water
200 Fair Oaks Lane, 4th Floor
Frankfort, KY 40601
Phone: (502) 564-3410
Fax: (502) 564-9899
http://www.water.ky.gov/

Louisiana

Louisiana Department of Transportation and Development
Public Works and Water Resources Division
Floodplain Management Section
1201 Capitol Access Road
P.O. Box 94245
Baton Rouge, LA 70804-9245
Phone: (225) 274-4354
Fax: (225) 274-4351
http://www.dotd.state.la.us/

Maine

Maine Department of Agriculture, Conservation and Forestry
Floodplain Management Program
93 State House Station, 17 Elkins Lane
Augusta, ME 04333-0038
Phone: (207) 287-8063
Fax: (207) 287-2353
http://www.state.me.us/spo/

Maryland

Maryland Department of the Environment Water Management Administration
1800 Washington Boulevard, Suite 430
Baltimore, MD 21230
Phone: (410) 537-3775
Fax: (410) 537-3751
http://www.mde.state.md.us/

Massachusetts

Massachusetts Department of Conservation and Recreation
Flood Hazard Management
251 Causeway Street, Suite 800
Boston, MA 02114
Phone: (617) 626-1406
Fax: (617) 626-1349
http://www.mass.gov/dcr/

Michagan

Michigan Department of Environmental Quality
525 West Allegan Street
P.O. Box 30458
Lansing, MI 48909-7958
Phone: (517) 335-3448
http://www.michigan.gov/deq

Minnesota

Minnesota Department of Natural Resources
500 LaFayette Road, Box 32
St. Paul, MN 55515-4032
Phone: (651) 259-5713
Fax: (651) 296-0445
http://www.dnr.state.mn.us/

Mississippi

Mississippi Emergency Management Agency
Office of Mitigation
1 Mema Drive
P.O. Box 5644
Pearl, MS 39208
Phone: (601) 933-6610
Fax: (601) 933-6805
http://www.msema.org/

Missouri

Missouri State Emergency Management Agency
2303 Militia Drive
P.O. Box 116
Jefferson City, MO 65101
Phone: (573) 526-9135
http://sema.dps.mo.gov/

Montana

Montana Department of Natural Resources and Conservation
Floodplain Management Program
1424 9th Avenue
Helena, MT 59620-1601
Phone: (406) 444-6654
Fax: (406) 444-0533
http://dnrc.mt.gov/wrd/water_op/floodplain/default.asp

Nebraska

Nebraska Department of Natural Resources
301 Centennial Mall South
Lincoln, NE 68509-4876
Phone: (402) 471-3932
Fax: (402) 471-2900
http://www.dnr.ne.gov/

Nevada

Nevada Division of Water Resources
901 South Stewart Street, Suite 2002
Carson City, NV 89701
Phone: (775) 684-2847
http://water.nv.gov/

New Hampshire

New Hampshire Office of Energy and Planning
4 Chenell Drive, 2nd Floor
Concord, NH 03301
Phone: (603) 271-1762
Fax: (603) 271-2615
http://www.nh.gov/oep/

New Jersey

Department of Environmental Protection
401 East State Street
P.O. Box 420
Trenton, NJ 08625
Phone: (609) 292-2296
http://www.state.nj.us/dep/

New Mexico

New Mexico Department of Homeland Security and Emergency Management
13 Bataan Boulevard
P.O. Box 27111
Santa Fe, NM 87508
Phone: (505) 476-9617
Fax: (505) 471-9695
http://www.nmdhsem.org/

New York

New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-3507
Phone: (518) 402-8146
Fax: (518) 402-9029
http://www.dec.ny.gov/

North Carolina

North Carolina Department of Public Safety
Division of Emergency Management
4218 Mail Service Center
Raleigh, NC 27699-4218
Phone: (919) 825-2317
http://www.ncem.org/

North Dakota

North Dakota State Water Commission
900 East Boulevard Avenue
Bismark, ND 58505-0850
Phone: (701) 328-4898
Fax: (701) 328-3747
http://www.swc.state.nd.us/

Ohio

Ohio Department of Natural Resources
2045 Morse Road, Building B-2
Columbus, OH 43229
Phone: (614) 265-6752
Fax: (614) 265-6767
http://www.dnr.state.oh.us/

Oklahoma

Oklahoma Water Resources Board
3800 North Classen Boulevard
Oklahoma City, OK 73118
Phone: (918) 581-2924
Fax: (981) 581-2754
http://www.owrb.ok.gov/

Oregon

Department of Land Conservation Development
635 Capitol Street, NE, Suite 150
Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 375-5518
http://www.lcd.state.or.us/

Pennsylvania

Pennsylvania Department of Community and Economic Development
Commonwealth Keystone Building
400 North Street, 4th Floor
Harrisburg, PA 17120-0225
Phone: (717) 720-7445
Fax: (717) 783-1402
http://www.newpa.com/

Puerto Rico

Puerto Rico Planning Board
Centro Gubernamental Roberto Sanchez Vilella
P.O. Box 41119, Minillas Station
Santurce, PR 00940-90985
Phone: (787) 723-6200
http://www.jp.gobierno.pr/

Rhode Island

Rhode Island Emergency Management Agency
645 New London Avenue
Cranston, RI 02920
Phone: (401) 462-7048
Fax: (401) 944-1891
http://www.riema.ri.gov/

South Carolina

South Carolina Department of Natural Resources
Flood Mitigation Program
2762 Wildlife Lane
West Columbia, SC 29172
Phone: (803) 755-9335
Fax: (803) 755-0152
http://www.dnr.sc.gov/

South Dakota

South Dakota Division of Emergency Management
118 West Capitol Avenue
Pierre, SD 57501
Phone: (605) 773-3231
Fax: (605) 773-3580
http://www.oem.sd.gov/

Tennessee

Tennessee Department of Economic and Community Development
Tennessee Tower Building
3211 North Roan Street
Johnson City, TN 37601
Phone: (423) 434-0158
Fax: (423) 434-0037
http://www.tn.gov/ecd/

Texas

Texas Water Development Board
1700 North Congress Avenue
P.O. Box 13231
Austin, TX 78711-3231
Phone: (512) 463-3509
Fax: (512) 475-2053
http://www.twdb.state.tx.us/

Utah

Utah Department of Public Safety
Division of Emergency Management
1110 State Office Building
Salt Lake City, UT 84114
Phone: (801) 538-3332
Fax: (801) 538-1676
http://www.cem.utah.gov/

Vermont

Vermont Department of Environmental Conservation
Water Quality Division, River Management
1 National Life Drive, Main 2
Montpelier, VT 05620
Phone: (802) 490-6152
http://www.anr.state.vt.us/dec/dec.htm

Virgin Islands

Virgin Islands Department of Planning and Natural Resources
Cyril E. King Airport, Terminal Building 2nd Floor
St. Thomas, VI 00802
Phone: (340) 774-3320
http://www.dpnr.gov.vi/view-divisions

Virginia

Virginia Department of Conservation and Recreation
Division of Dam Safety and Floodplain Management
600 East Main Street, 24th Floor
Richmond, VA 23219
Phone: (804) 371-6135
Fax: (804) 371-2630
http://www.dcr.virginia.gov/

Washington

Washington State Department of Ecology
P.O. Box 47600
300 Desmond Drive, SE
Olympia WA, 98504
Phone: (360) 407-6131
http://www.ecy.wa.gov/

West Virginia

West Virginia Division of Homeland Security and Emergency Management
Capitol Building 1, Room EB-80
1900 Kanawha Boulevard
Charleston, WV 25305-0360
Phone: (304) 957-2571
Fax: (304) 965-3216
http://www.dhsem.wv.gov/

Wisconsin

Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707
Phone: (608) 266-3093
http://dnr.wi.gov/

Wyoming

Wyoming Office of Homeland Security
5500 Bishop Boulevard
Cheyenne, WY 82002
Phone: (307) 777-4907
Fax: (307) 635-6017
http://wyohomelandsecurity.state.wy.us/main.aspx




Appendix E

State Historic Preservation Offices

Alabama

Alabama Historical Commission
468 South Perry Street
P.O. Box 300900
Montgomery, AL 36130-0900
Phone: (334) 230-2690
http://www.preserveala.org

Alaska

Alaska Department of Natural Resources
Office of History and Archeology
550 West 7th Avenue, Suite 1310
Anchorage, AK 99501-3565
Phone: (907) 269-8721
Fax: (907) 269-8908
http://www.dnr.state.ak.us/parks/oha/index.htm

Arizona

Arizona State Parks
1300 West Washington
Phoenix, AZ 85007
Phone: (602) 542-4009
http://azstateparks.com/SHPO/index.html

Arkansas

Arkansas Historic Preservation Program
1500 Tower Building
323 Center Street
Little Rock, AR 72201
Phone: (501) 324-9880
Fax: (501) 324-9184
http://www.arkansaspreservation.org/

California

Office of Historic Preservation
Department of Parks and Recreation
1416 9th Street, Room 1442
P.O. Box 942896
Sacramento, CA 94296-0001
Phone: (916) 653-6624
Fax: (916) 653-9824
http://ohp.parks.ca.gov/

Colorado

Colorado Historical Society
Office of Archaeology and Historic Preservation
1300 Broadway
Denver, CO 80203
Phone: (303) 866-2136
Fax: (303) 866-2711
http://www.coloradohistory-oahp.org

Connecticut

Connecticut Commission on Culture and Tourism
Historic Preservation and Museum Division
One Constitution Plaza, 2nd Floor
Hartford, CT 06103
Phone: (860) 256-2800
Fax: (860) 256-2811
http://www.cultureandtourism.org/cct/site/default.asp

Delaware

Division of Historical and Cultural Affairs
21 The Green
Dover, DE 19901
Phone: (302) 736-7400
Fax: (302) 739-5660
http://www.state.de.us/shpo/index.htm

District of Columbia

Office of Planning
801 North Capitol Street, NE, Suite 4000
Washington, DC 20002
Phone: (202) 442-7600
http://planning.dc.gov/planning/site/default.asp

Florida

Division of Historical Resources
R. A. Gray Building
500 South Bronough Street
Tallahassee, FL 32399-0250
Phone: (850) 245-6333
http://www.flheritage.com/

Georgia

Department of Natural Resources
Historic Preservation Division
34 Peachtree Street, NW, Suite 1600
Atlanta, GA 30303
Phone: (404) 656-2840
Fax: (404) 657-1046
http://www.gashpo.org/

Hawaii

Department of Land and Natural Resources
State Historic Preservation Division
Kakuhihewa Building
601 Kamokila Boulevard, Suite 555
Kapolei, HI 96707
Phone: (808) 692-8015
Fax: (808) 692-8020
http://www.hawaii.gov/dlnr/hpd/hpgreeting.htm

Idaho

Idaho State Historical Society
2205 Old Penitentiary Road
Boise, ID 83712
Phone: (208) 334-2682
Fax: (208) 334-2774
http://www.idahohistory.net/shpo.html

Illinois

Illinois Historic Preservation Agency
1 Old State Capitol Plaza
Springfield, IL 62701-1507
Phone: (217) 782-4836
http://www.state.il.us/hpa/ps/

Indiana

Department of Natural Resources
Division of Historic Preservation and Archaeology
402 West Washington Street, Room W274
Indianapolis, IN 46204-2739
Phone: (317) 232-1646
http://www.state.in.us/dnr/historic/

Iowa

State Historical Society of Iowa
600 East Locust
Des Moines, IA 50319
Phone: (515) 281-6200
http://www.iowahistory.org

Kansas

Kansas State Historical Society
6425 SW 6th Avenue
Topeka, KS 66615
Phone: (785) 272-8681
Fax: (785) 272-8682
http://www.kshs.org/resource/buildings.htm

Kentucky

Kentucky Heritage Council
300 Washington Street
Frankfort, KY 40601
Phone: (502) 564-7005
Fax: (502) 564-5820
http://heritage.ky.gov/

Louisiana

Division of Historic Preservation
Office of Cultural Development
Department of Culture, Recreation and Tourism
1051 North Third Street
P.O. Box 44247
Baton Rouge, LA 70804
Phone: (225) 342-8160
Fax: (225) 219-9772
http://www.crt.state.la.us/hp/

Maine

Maine Historic Preservation Commission
55 Capitol Street
65 State House Station
Augusta, ME 04333-0065
Phone: (207) 289-2132
http://www.state.me.us/mhpc/

Maryland

Maryland Historical Trust
100 Community Place
Crownsville, MD 21032-2023
Phone: (410) 514-7600
Fax: (410) 514-7678
http://mht.maryland.gov/

Massachusetts

Massachusetts Historical Commission
Department of the Commonwealth
220 Morrissey Boulevard
Boston, MA 02125-3314
Phone: (617) 727-8470
Fax: (617) 727-5128
http://www.sec.state.ma.us/mhc/mhcidx.htm

Michigan

Department of History, Arts, and Libraries
702 West Kalamazoo Street
P.O. Box 30738
Lansing, Michigan 48909-8238
Phone: (517) 241-2236
Fax: (517) 241-2930
http://www.michigan.gov/mshda/

Minnesota

Minnesota Historical Society
345 West Kellogg Boulevard
St. Paul, MN 55102-1906
Phone: (651) 259-3000
http://www.mnhs.org/

Mississippi

Department of Archives and History
200 North Street
P.O. Box 571
Jackson, MS 39205-0571
Phone: (601) 576-6850
Fax: (601) 576-6876
http://mdah.state.ms.us/

Missouri

Department of Natural Resources
205 Jefferson
P.O. Box 176
Jefferson City, MO 65102
Phone: (573) 751-7858
http://www.dnr.mo.gov/shpo/

Montana

State Historic Preservation Office
Montana Historical Society
1410 Eighth Avenue
Helena, MT 59620
Phone: (406) 444-7715
http://www.montanahistoricalsociety.com/shpo/default.asp

Nebraska

Nebraska State Historical Society
P.O. Box 82554
1500 R Street
Lincoln, NE 68501
Phone: (402) 471-3270
http://www.nebraskahistory.org/

Nevada

Nevada State Historic Preservation Office
901 S. Stewart Street Suite 5004
Carson City, NV 89701
Phone: (775) 684-3448
http://nvshpo.org/

New Hampshire

Division of Historical Resources
19 Pillsbury Street, 2nd Floor
Concord, NH 03301-3570
Phone: (603) 271-3483
Fax: (603) 271-3433
http://www.nh.gov/nhdhr/

New Jersey

Historic Preservation Office
Department of Environmental Protection
401 E. State Street
P.O. Box 404
Trenton, NJ 08625-0404
Phone: (609) 984-0176
Fax: (609) 984-0578
http://www.state.nj.us/dep/hpo/

New Mexico

Historic Preservation Division
Department of Cultural Affairs
Bataan Memorial Building
407 Galisteo Street, Suite 236
Santa Fe, NM 87501
Phone: (505) 827-6320
Fax: (505) 827-6338
http://www.nmhistoricpreservation.org/

New York

State Historic Preservation Office
Peebles Island
P.O. Box 189
Waterford, NY 12188-0189
Phone: (518) 237-8643
http://nysparks.state.ny.us/shpo/

North Carolina

State Historic Preservation Office
Office of Archives and History
Department of Cultural Resources
109 East Jones Street
Raleigh, NC 27699
Phone: (919) 807-6570
Fax: (919) 807-6599
http://www.hpo.ncdcr.gov/

North Dakota

State Historical Society of North Dakota
Heritage Center
612 East Boulevard Avenue
Bismarck, ND 58505-0830
Phone: (701) 328-2672
Fax: (701) 328-3710
http://www.history.nd.gov/

Ohio

Ohio Historical Society
Historic Preservation Office
567 East Hudson Street
Columbus, OH 43211-1030
Phone: (614) 298-2000
Fax: (614) 298-2037
http://www.ohiohistory.org/resource/histpres/

Oklahoma

State Historic Preservation Office
Oklahoma Historical Society
2401 North Laird Avenue
Oklahoma City, OK 73105
Phone: (405) 521-6249
Fax: (405) 522-0816
http://www.okhistory.org/shpo/shpom.htm

Oregon

Parks and Recreation Department
Heritage Programs
725 Summer Street NE, Suite C
Salem, OR 97301
Phone: (503) 986-0671
Fax: (503) 986-0793
http://egov.oregon.gov/OPRD/HCD/

Pennsylvania

Pennsylvania Historical and Museum Commission
300 North Street
Harrisburg, PA 17120
Phone: (717) 787-3362
Fax: (717) 783-9924
http://www.portal.state.pa.us/portal/server.pt?open=512&mode=2&objID=1426

Puerto Rico

Calle Norzagaray Final Cuartel de Ballaja, 3er Piso
San Juan, PR 00906-6581
Phone: (787) 721-3737
Fax: (787) 721-3773
http://www.gobierno.pr/OECH/index.htm

Rhode Island

Rhode Island Historical Preservation and Heritage Commission
Old State House
150 Benefit Street
Providence, RI 02903
Phone: (401) 222-2678
Fax: (401) 222-2968
http://www.preservation.ri.gov/

South Carolina

State Historic Preservation Office
Department of Archives and History
8301 Parklane Road
Columbia, SC 29223
Phone; (803) 896-6178
Fax: (803) 896-6167
http://shpo.sc.gov/

South Dakota

State Historic Preservation Office
State Historical Society
900 Governors Drive
Pierre, SD 57501-2217
Phone: (605) 773-3458
Fax: (605) 773-6041
http://www.sdhistory.org/HP/histpres.htm

Tennessee

Tennessee Historical Commission
Department of Environment and Conservation
2941 Lebanon Road
Nashville, TN 37243-0442
Phone: (615) 532-1550
http://www.tn.gov/environment/history/

Texas

Texas Historical Commission
1511 Colorado
P.O. Box 12276
Austin, TX 78711-2276
Phone: (512) 463-6100
Fax: (512) 463-8222
http://www.thc.state.tx.us

Utah

Utah Division of State History
300 South Rio Grande Street
Salt Lake City, UT 84101
Phone: (801) 533-3500
Fax: (801) 533-3567
http://history.utah.gov/

Vermont

Division for Historic Preservation
National Life Building, 2nd Floor
Montpelier, VT 05620-1201
Phone: (802) 828-3213
Fax: (803) 828-3206
http://www.historicvermont.org/

Virginia

Department of Historic Resources
2801 Kensington Avenue
Richmond, VA 23221
Phone: (804) 367-2323
http://www.dhr.virginia.gov/

Washington

Department of Archeology and Historic Preservation
1063 South Capitol Way, Suite 106
Olympia, WA 98501
Phone: (360) 586-3065
http://www.dahp.wa.gov/

West Virginia

West Virginia Division of Culture and History
Historic Preservation Office
Cultural Center
1900 Kanawha Boulevard East
Charleston, WV 25305-0300
Phone: (304) 558-0220
Fax: (304) 558-2779
http://www.wvculture.org/

Wisconsin

Historic Preservation Division
State Historical Society of Wisconsin
816 State Street
Madison, WI 53706-1417
Phone: (608) 264-6493
http://www.wisconsinhistory.org/hp/

Wyoming

Wyoming State Historic Preservation Office
Barrett Building
2301 Central Avenue
3rd Floor
Cheyenne, WY 82002
Phone: (307) 777-7697
Fax: (307) 777-6421
http://wyoshpo.state.wy.us/

American Samoa

c/o Executive Offices of the Governor American Samoa
Historic Preservation Office American Samoa Government
Pago Pago, American Samoa 96799
Phone: (684) 699-2316
Fax: (684) 699-2276
http://ashpo.org/

Virgin Islands

State Historic Preservation Office
Nisky Center
17 Kongens Gade
St. Thomas, VI 00802
Phone: (340) 776-8605
Fax: (340) 776-7236
http://www.dpnr.gov.vi/historic.htm




Appendix F

Professional Organizations

The organizations listed below can provide information about registered design professionals and licensed contractors in or near the area where you live.

American Institute of Architects (AIA)
1735 New York Avenue, NW
Washington, DC 20006-5292
Phone: (202) 626-7300 or (800) 242-3837
Fax: (202) 626-7547
http://www.aia.org

American Society of Civil Engineers (ASCE)
International Headquarters
1801 Alexander Bell Drive
Reston, VA 20191-4400
Phone: (703) 295-6300 or (800) 548-2723
Fax: (703) 295-6319
http://www.asce.org

Association of State Floodplain Managers (ASFPM)
2809 Fish Hatchery Road
Madison, WI 53713
Phone: (608) 274-0123
Fax: (608) 274-0696
http://www.floods.org

International Association of Structural Movers (IASM)
1223 Morning Shore Drive, Suite 200
P.O. Box 2637
Lexington, SC 29071
Phone: (803) 951-9304
Fax: (803) 951-9314
http://www.iasm.org

Insurance Institute for Business and Home Safety (IBHS)
4775 E. Fowler Avenue
Tampa, FL 33617
Phone: (813) 286-3400
Fax: (813) 286-9960
http://www.disastersafety.org

International Code Council (ICC)
Headquarters
500 New Jersey Avenue, NW, 6th Floor
Washington, DC 20001-2070
Phone: (888) 422-7233
Fax: (202) 599-9871
http://www.iccsafe.org

National Association of Home Builders (NAHB)
1201 15th Street, NW
Washington, DC 20005
Phone: (202) 266-8200 or (800) 368-5242
Fax: (202) 266-8400
http://www.nahb.org




Appendix G

Retrofitting Checklist

Use this checklist when you follow the four steps described in this chapter. The information you record here will help you work with local officials, design professionals, and contractors. Use the decision-making matrices that follow this checklist to decide which retrofitting method is right for your home.

Step 1 – Determine the Hazards to Your Home

1. How long have you lived in your home?

___ years

2. Was your home ever flooded during that time?

___ yes ___ no

(If your answer is yes, go to question 3; if your answer is no, go to question 14.)

3. How many times has your home been flooded? ________

4. What were the dates of flooding?

Flood #1 _______________ Flood #4 _______________

Flood #2 _______________ Flood #5 _______________

Flood #3 _______________

For each flood, answer questions 5 through 13 as best you can.

5. To your knowledge, were frequencies assigned to any of the floods (e.g., 2-percent-annual-chance flood, 1-percent-annual-chance flood)? If so, what were they?

Flood #1 ______________________________

Flood #2 ______________________________

Flood #3 ______________________________

Flood #4 ______________________________

Flood #5 ______________________________

6. How high did the floodwaters rise in your home?
(If you can, state the height of the water above the lowest floor, including the basement floor.)

Flood #1 _______________ Flood #4 _______________

Flood #2 _______________ Flood #5 _______________

Flood #3 _______________

7. About how long did your home remain flooded?
(You can give your answer in days, weeks, or months, as appropriate.)

Flood #1 _______________ Flood #4 _______________

Flood #2 _______________ Flood #5 _______________

Flood #3 _______________

8. Did you have any warning before your home was flooded? If so, how much warning?
(You can give your answer in days or hours as appropriate.)

Flood #1 ___ No Warning ___ Warning ________ Days/Hours

Source of warning (news report, local officials, firsthand observation): ____________________

Flood #2 ___ No Warning ___ Warning ________ Days/Hours

Source of warning (news report, local officials, firsthand observation): ____________________

Flood #31 ___ No Warning ___ Warning ________ Days/Hours

Source of warning (news report, local officials, firsthand observation): ____________________

Flood #4 ___ No Warning ___ Warning ________ Days/Hours

Source of warning (news report, local officials, firsthand observation): ____________________

Flood #5 ___ No Warning ___ Warning ________ Days/Hours

Source of warning (news report, local officials, firsthand observation): ____________________________

9. **Did the floodwaters cause scour and/or erosion around your home or elsewhere on your lot? If so, describe the effects.**

Flood #1 ___ No Erosion/Scour Occurred ___ Erosion/Scour Occurred

Description ____

____

Flood #2 ___ No Erosion/Scour Occurred ___ Erosion/Scour Occurred

Description ____

____

Flood #3 ___ No Erosion/Scour Occurred ___ Erosion/Scour Occurred

Description ____

____

Flood #4 ___ No Erosion/Scour Occurred ___ Erosion/Scour Occurred

Description ____

____

Flood #5 ___ No Erosion/Scour Occurred ___ Erosion/Scour Occurred

Description ____

____

10. **Was your home damaged by wave action or the impact of ice or other floodborne debris? If so, describe the damage.**

Flood #1 ___ No Waves or Debris ___ Waves ___ Debris

Description of Damage ____

____

Flood #2 ___ No Waves or Debris ___ Waves ___ Debris

Description of Damage ____

____

Flood #3 ____ No Waves or Debris ____ Waves ____ Debris

Description of Damage ____

____

Flood #4 ____ No Waves or Debris ____ Waves ____ Debris

Description of Damage ____

____

Flood #5 ____ No Waves or Debris ____ Waves ____ Debris

Description of Damage ____

____

11. How difficult and/or expensive was cleaning up after the floodwaters receded?
(If you can, describe what you had to do to clean up both inside your home and around your lot, how long the cleanup took, and how much you spent on cleanup.)

Flood #1 Cleanup Description ____

____

Cost $ ________________ Time ________________

Flood #2 Cleanup Description ____

____

Cost $ ________________ Time ________________

Flood #3 Cleanup Description ____

____

Cost $ ________________ Time ________________

Flood #4 Cleanup Description ____

____

Cost $ ________________ Time ________________

Flood #5 Cleanup Description ____

____

Cost $ ________________ Time ________________

12. What was the total cost to repair all flood damage, not including the cleanup costs listed above?

Flood #1 $_______________ Flood #4 $_______________

Flood #2 $_______________ Flood #5 $_______________

Flood #3 $_______________

13. What was the total value of all home contents (furnishings, belongings, etc.) damaged by flooding?

Flood #1 $_______________ Flood #4 $_______________

Flood #2 $_______________ Flood #5 $_______________

Flood #3 $_______________

14. Is your home either in or near one of the shaded areas on the wind hazard map in Figure 4-1? If you are not sure how to interpret Figure 4-1, your local officials and design professional can help you.

___ yes _____ no

15. Has your home ever been damaged by a hurricane or other high-wind event?

___ yes ___ no.

If your answer is yes, note how many times and describe both the damage and the repairs made.

____

____

____

____

____

16. **Is your home either in or near one of the shaded areas on the earthquake hazard map in Figure 4-2?** If you are not sure how to interpret Figure 4-2, your local officials and design professional can help you.

___ yes ___ no

17. **Has your home ever been damaged by an earthquake?**

___ yes ___ no.

If your answer is yes, note how many times and describe both the damage and the repairs made.

____

____

____

____

____

18. Has your home ever been damaged by other hazard events, such as fires or landslides?

___ yes ___ no.

If your answer is yes, note how many times and describe both the damage and the repairs made.

____

____

____

____

____

Step 2 – Inspect Your Home

Provide as much of the following information as you can about your home.

1. **When was your home built?** _____

2. **Construction type (see Section 3.2.1; check all that apply):**
   ___ frame ___ masonry veneer ___ masonry ___ manufactured home

3. **Foundation type (see Section 3.2.2; check all that apply):**

   ___ basement (subgrade on all sides) ___ walkout-on-grade basement ___ crawlspace

   ___ slab-on-grade ___ piers ___ posts/columns ___ piles

4. **Describe any other damage and repairs or other additions to your home other than those you described in Step 1. Other damages would include foundation settlement, dry rot, and termite damage.**

   ____

   ____

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   ____

To answer questions 5 through 9, you will need to have at least a rough idea of the DFE for your retrofitting project. If you don't have enough information to answer these questions now, go to Step 3 and determine your DFE when you talk with your local official(s).

5. **Approximate difference between elevation of lowest floor (including basement) and design flood elevation (DFE) (see Figure 4-3):**

   ___ feet

6. **Interior utilities below the DFE (check all that apply):**

   ___ furnace ___ ductwork ___ hot water heate ___ electrical panel ___ electrical outlets

   ___ electrical switches ___ baseboard heaters ___ sump pumps ___ fuel tanks

   other ____

7.	**Exterior utilities below the DFE (check all that apply):** ___ air conditioning / heat pump compressor ___ electric meter ___ fuel tank ___ septic tank ___ well ___ gas meter other____
8.	**Major appliances below the DFE (check all that apply):** ___ washer ___ dryer ___ refrigerator ___ freezer other ____
9.	**How many drains (such as sink, tub, and floor drains) and toilets are below the DFE? _______**

Step 3 – Check with Your Local Officials

When you meet with your local official(s), be sure to discuss the issues below. Also, make note of the information you receive from the local officials. (You may find that you will need to talk with more than one person to get all the information you need.)

1. Explain your retrofitting needs, go over the information you recorded in Steps 1 and 2, and discuss any preferences you may have regarding the retrofitting methods described in Chapter 3.
2. Provide the official with photographs of your home and a copy of a plat map that shows the dimensions of your lot and the location of your home. If you do not have a plat map, ask how you can get one.
3. Ask whether your home is in the regulatory floodplain. If the answer is yes, ask what the BFE is at your home and whether your home is in the floodway or Coastal High Hazard Area (Zone V). Ask whether any restudies or revisions are underway that might provide updated flood hazard information for the area where your home is located. Also, ask for additional flood hazard information concerning characteristics such as flow velocity, the potential for wave action and debris flow, rates of rise and fall, warning time, and duration of inundation. This additional information may be useful to your design professional.
4. Ask whether your home is subject to your community's regulatory requirements concerning Substantially Damaged structures or whether the retrofitting measure you are considering would subject your home to Substantial Improvement requirements. (See the definitions of Substantial Improvement and Substantial Damage in Section 2.5 and Section 3.1.1)
5. Ask whether your home is subject to high winds, earthquakes, and other hazards, such as wildfires. Refer to the maps in Figures 4-1 and 4-2.
6. Ask whether your State and/or community enforces building codes or other regulations that could affect your retrofitting decision, including any floodplain management regulations more stringent than those required by the NFIP. For example, ask whether the State or community requires freeboard for flood protection measures.
7. In your discussion of building codes, ask whether retrofitting will require that you upgrade other components of your home (such as electrical and plumbing systems) to meet current code requirements.
8. Ask about the types of permits and fees that may be required in connection with the retrofitting methods you are considering.
9. Ask whether the official is aware of any Federal, State, or local historic preservation regulations that may affect your property. If necessary, have the official follow up with the SHPO (see Appendix E) to be sure that your retrofitting project is in compliance with all preservation laws.
10. Ask about Federal, State, and local programs that provide financial assistance for certain types of homeowner flood protection retrofitting projects. Ask whether you are eligible for assistance.
11. Go through the appropriate decision-making matrix (see Section 4.2) with the official and discuss any questions you may have about the advantages and disadvantages of the alternative retrofitting methods.
12. Ask for any guidance that local officials can provide to help you find a good contractor or design professional.

Step 4 – Consult a Design Professional and Retrofitting Contractor

Initial Meeting

1. Explain your retrofitting needs; go over the information you recorded in Steps 1 and 2; discuss the results of your meeting with your local official(s), including the decision-making matrix; and discuss any preferences you may have regarding retrofitting methods you selected in Step 3.
2. Verify that the design professional is licensed and registered in the State where the work will be done.
3. Verify that the contractor is licensed, bonded, and insured as required by State and local laws.
4. Ask for references and proof of proper bonds and insurance, including disability and workers' compensation.
5. Decide whether you, the design professional, or the contractor will be responsible for obtaining and managing the work of subcontractors and for obtaining all permits required by State and local agencies.
6. Schedule a site visit.

Site Visit

1. Ask the design professional or contractor to tell you about any characteristics of your home or lot that would affect your selection of a retrofitting method.
2. Once you decide on a retrofitting method, ask for a written estimate of the project cost and schedule.

Contract

1. If you are satisfied with the cost estimate and schedule, get a written, signed, and dated contract that describes the work to be done and that states the estimated cost, the payment schedule, and the start and completion dates of the work.
2. Ask whether the contractor will provide a warranty or guarantee for the work performed. Any warranty or guarantee should be written into the contract. The contract should state the terms of the warranty or guarantee, who is responsible for honoring it, and how long it will remain valid.

Notes

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