

Reducing Flood Risk to Residential Buildings That Cannot Be Elevated

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FEMA

The dwelling depicted here and on the cover of this publication sustained flood damage during Hurricane Sandy in 2012. The homeowner undertook measures to make the dwelling more flood resistant in the future. The structure was retrofitted using some of the techniques featured in this publication. These techniques include elevating utilities, basement infill, and installation of flood openings. These combined measures will serve to make the dwelling much more flood resistant and have the added benefit of reducing flood insurance premiums.

Reducing Flood Risk to Residential Buildings That Cannot Be Elevated

Floods can happen anywhere at any time, which is why it is important to be prepared and to take steps before a flood event to protect your property from costly damage. Taking action to reduce the impact of a disaster is known as mitigation. There are a variety of flood mitigation options for homeowners—both for newly built homes as well as existing homes located in floodprone areas. You may be familiar with mitigation measures such as elevating a home above the Base Flood Elevation (BFE) or relocating a home to high ground outside of a high risk flood area. Oftentimes it is not feasible to elevate residential structures, therefore, this publication focuses on mitigation measures other than elevating a home that can be used to protect properties from flooding, save money over time, and potentially **reduce flood insurance premiums**.

Base Flood Elevation: The height to which floodwater is expected to rise during the base flood—the flood having a one percent chance of being equaled or exceeded in any given year. Areas affected by the base flood are shown as **Special Flood Hazard Areas** (SFHAs) on FEMA flood maps.

In 2014, Congress passed the Homeowner Flood Insurance Affordability Act (HFIAA). In fulfilment of Section 26 of that act, the Federal Emergency Management Agency (FEMA) has established guidelines for property owners that:

- Provide alternative mitigation methods, other than building elevation, to reduce flood risk to residential buildings that cannot be elevated due to their structural characteristics.
- Inform property owners about how these alternative mitigation methods may affect flood insurance premium rates under the National Flood Insurance Program (NFIP).

NFIP flood insurance premiums are based on a number of factors, including flood risk zone, elevation of the lowest floor relative to the BFE, the type of building and foundation, the number of floors, and whether there is a basement or enclosure below an elevated building. This publication provides information about measures to reduce flood risks to residential buildings where elevating the home is not a viable option.

Lowest floor: The lowest floor of the lowest enclosed area (including a basement). An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access, or storage in an area other than a basement area, and having proper openings, is not considered a building's lowest floor. Note that in V Zones if the area under an elevated building is enclosed, the bottom of the enclosure would be considered the lowest floor.

Alternative Options for Reducing Your Flood Risk

Structural elevation is a well-recognized measure for reducing flood risk and often the most effective measure to reduce both flood damage and insurance premiums. Buildings that are situated at or above the level of the BFE have lower flood risk than buildings below BFE and tend to have lower insurance premiums than buildings situated below the BFE. Oftentimes, however, elevation may not be an option if your home has certain structural characteristics. These characteristics may include: attached dwelling units; connected row houses, townhomes, or brownstones; mid-rise multi-family buildings; older dwellings; and homes with construction types and/or building materials that are not suitable for elevation.

This publication describes alternative mitigation measures intended for a variety of housing types that cannot feasibly be elevated. The guidance applies to a variety of residential structures, including single family homes, and many mid-rise multi-family residential buildings. While the focus is on 1- to 4-family residential buildings that are one to three stories tall, the mitigation measures are applicable to other multi-family and even high-rise residential buildings.

1-4 family home: The NFIP classifies insured buildings into several building types. This publication addresses 1-4 family homes which include single family detached homes, row houses, townhomes, brownstones and mid-rise multi-family buildings.

Summary

This publication presents a range of flood protection measures available as alternatives to traditional structural elevation for homeowners whose residences meet both of the following conditions:

1) The residences are existing buildings. This publication is not intended to address construction of new buildings in floodprone areas as these structures should be sufficiently elevated and built in conformance with NFIP and local floodplain management regulations.

2) The residences are not Substantially Damaged or Substantially Improved, meaning that the buildings have not sustained damage or undergone improvement (i.e., reconstruction, rehabilitation, addition) where the cost of the damage or improvement exceeds 50 percent of the market value of the building before the damage occurred or improvement began. As with new construction, Substantially Damaged or Substantially Improved structures must be re-built in conformance with NFIP and local floodplain management regulations.

While all of the measures included in this publication can be effective at reducing flood damage, the current flood insurance rating framework does not provide premium reductions for all of the featured measures at the present time. Even if flood insurance premium reductions are not available, there should still be consideration given to implementing flood mitigation measures in order to reduce damages and financial losses.

The following flood protection measures can be rated under the existing NFIP framework such that implementation of these measures may result in flood insurance premium reductions. The amount of the premium reduction will vary on a case by case basis.

All Interior Modification/Retrofit Measures (Basement Infill, Abandon Lowest Floor, and Elevate Lowest Interior Floor) and Wet Floodproofing using Flood Openings: These measures can moderately to significantly reduce flood risk, and the flood insurance rating framework is presently in place to allow homeowners to receive flood insurance premiums that reflect any flood damage reduction protection provided by these measures. Use of these measures may result in buildings that meet current NFIP minimum requirements and the local floodplain ordinance, if the lowest floor is elevated to or above the BFE or locally adopted regulatory flood elevation.

The following flood mitigation measures can be used to decrease flood losses and damages. However, FEMA will need to undertake further analysis to determine whether it is appropriate to offer flood insurance premium discounts for undertaking such measures, and if so, what level of discount is appropriate for each measure.

All other Wet Floodproofing Measures (Elevate Building Utilities, Floodproof Building Utilities, and use of Flood Damage-Resistant Materials): These measures can moderately reduce flood risk and damage to utilities, floors, walls, and other areas subject to flooding.

All Dry Floodproofing Measures (Passive Dry Floodproofing System) and Barrier Measures (Floodwall with Gates and Floodwall without Gates, Levee with Gates and Levee without Gates): These measures can moderately to significantly reduce flood risk in areas subject to shallow flooding.

A more detailed discussion of each of these alternative mitigation measures and how they reduce flood damages follows in subsequent sections of this document.

Riverine flooding: Flooding that occurs along a channel, such as a river, creek, stream, or ditch, when it receives too much water and the excess flows over its banks and into surrounding areas.

V Zones: Special Flood Hazard Areas subject to high velocity wave action.

Coastal A Zones: Inland coastal areas subject to 1.5 to 3 foot waves.

Floodway: The channel of a river and the adjacent land areas that must be reserved in order to carry the base flood without increasing flood levels by more than a designated height, usually 1 foot.

The measures outlined in this publication are designed to address slow moving riverine flooding with minimal debris—the objects floodwaters pick up, such as rocks, dirt, sewage, ice, and tree branches. Most techniques presented are not appropriate for high-risk flood hazard areas subject to wave action (V zones and coastal A zones) or high velocity flow areas (floodways, areas subject to alluvial fan flooding, flash flood, mudslide, erosion, or ice jam).

Selection of Mitigation Measures

The ultimate goal of any mitigation measure is to reduce or eliminate the potential of flood damage in a way that is cost effective, complies with all applicable floodplain regulations, and is acceptable to the homeowner in terms of appearance and livability. The sections that follow include descriptions of ten flood protection methods. Each description provides information needed when considering how to protect your home, including design considerations, costs, effectiveness, limitations, and potential effect on flood insurance premiums (additional detail on premium discounts is provided on page 2 of this publication). Illustrations that show how the methods are applied are also included. In some cases, a single method may adequately address your needs. In other cases, a combination of methods may be best. Keep in mind, the flood protection method chosen must meet the floodplain management requirements and/or building codes of your local community. The methods included in this publication may not be substituted for bringing a building into compliance with local floodplain regulations following a Substantial Damage or Substantial Improvement determination by local community officials except where noted.

As you will see in the sections that follow, different flood protection methods protect your home in different ways. For example, when you 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 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. When you protect your home with a levee or floodwall, the top of the levee or floodwall is constructed to a specified elevation. Other approaches include filling in a basement or abandoning the bottom floor. For all of these flood protection methods, the greatest flood damage and flood insurance premium reductions will be achieved by floodproofing to/or elevating to or above the BFE.

About the NFIP

In most communities throughout the United States, construction in floodplains is governed by combinations of Federal, State, and local regulation. At the Federal level, FEMA administers the NFIP. 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 that participate in the NFIP take action in several ways:

- Guide future development away from flood hazard areas.
- Require 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.

Dry floodproofing: Sealing your home to prevent floodwaters from entering.

Wet floodproofing: Making portions of your home resistant to flood damage and allowing water to enter during flooding.

Flood damage-resistant material: Any building product (material, component, or system) capable of withstanding direct and *prolonged contact* with floodwaters without sustaining *significant damage*. Examples may include flood damage-resistant building finish materials such as non-paper-faced gypsum board and terrazzo tile flooring versus traditional drywall and carpeted flooring.

Substantial Damage: Damage of any origin sustained by a building whereby the cost of restoring the building to its before-damaged condition would equal or exceed 50 percent of the market value of the building before the damage occurred.

Substantial Improvement: Any reconstruction, rehabilitation, addition, or other improvement of a building, the cost of which equals or exceeds 50 percent of the market value of the building before the start of construction of the improvement.

Modifying a home to protect it from flood damage requires extreme care, will require permits, and may also require complex, engineered designs. Therefore:

- Engage a "design professional" meaning an architect or an engineer who is qualified to deal with the specifics of a flood mitigation project,
- Check your community's floodplain management ordinances,
- Check whether government grants are available,
- Hire a qualified contractor,
- Obtain a building permit,
- Determine whether the mitigation project will trigger a Substantial Improvement declaration,
- See the project through to completion, and
- Obtain an elevation certificate and an engineering certificate (if necessary).

Interior Modification/Retrofit Measures

Interior modification and retrofitting involves making changes to an existing building to protect it from flood damage. When the mitigation is properly completed in accordance with NFIP floodplain management requirements, interior modification/retrofit measures could achieve the somewhat similar results as elevating a home above the BFE.

Keep in mind, in areas where expected base flood depths are high, the flood protection techniques below alone may not provide protection to the BFE or, where applicable, the locally required freeboard elevation.

Basement Infill

These measures involve filling a basement located below the BFE to grade (ground level) (Figure 1). Sections of the basement walls that remain above ground must be retrofitted with flood openings that allow automatic entry and/or exit of floodwaters (refer to the **Flood Openings** section for details). Any basement utility systems and associated equipment must be elevated to protect utilities from damage or loss of function from flooding (refer to the **Elevate Building Utilities** section for details).

Effectiveness: Basement infill has been proven to be effective at reducing damages to building elements and contents located below the BFE since the lowest floor can potentially be re-located above the BFE (see Figure 1).

Considerations: Homeowners must be careful to install and maintain flood openings that open automatically during a flood event when needed.

Infill of basements and, if required, relocation of basement utilities will lead to a loss of square footage and the possible loss of livable or rentable space within the existing building, which may not be economically feasible for some owners.

To compensate for the loss of livable or rentable space within the existing building, additional living space above the BFE may be added in the form of an added floor or lateral addition to make up for the loss of the basement. Unfortunately, adding the cost of the additional living space may not be economically feasible for some homeowners and may also trigger a Substantial Improvement declaration.

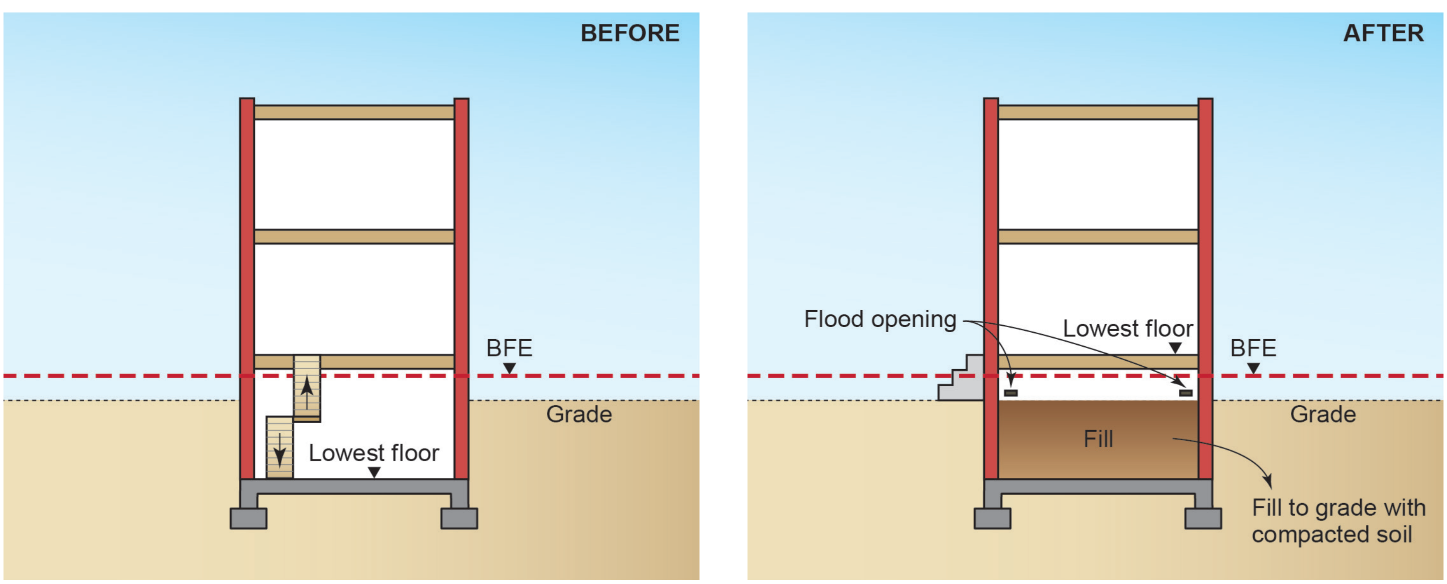
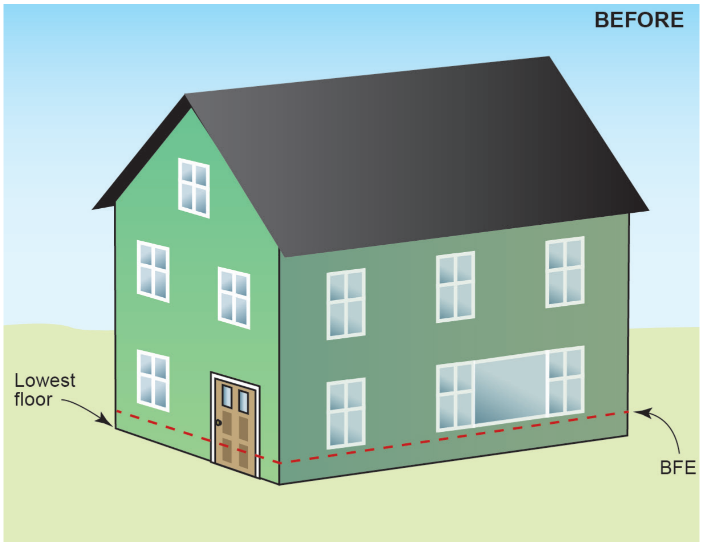


Figure 1: Basement infill before and after mitigation



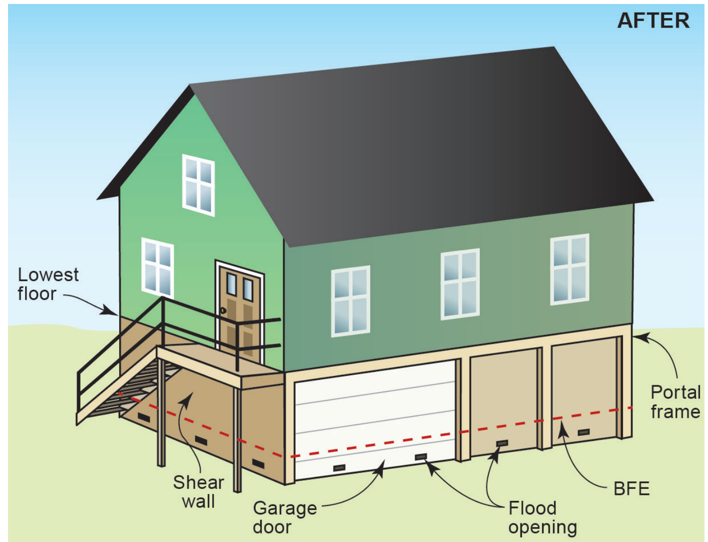


Figure 2: Abandoning the lowest floor

Cost and useful life: Basement infill is considered a relatively high-cost measure with an expected useful life of 30 to 50 years and little or no additional annual maintenance costs beyond maintaining flood openings.

Potential impact on flood insurance premiums: When the mitigation is properly completed, a flood insurance policy will be rated based on the new lowest floor living level. The higher the reference level of the lowest floor, the more significant the premium rate decreases will be. Actual premium reductions will vary on a case by case basis as individual structures are rated.

Abandon Lowest Floor

This measure involves abandoning the lowest floor of a two or more story slab-on-grade residential building (Figure 2). The lowest floor walls must be retrofitted with flood openings that allow automatic entry and exit of floodwaters (refer to the **Flood Openings** section for details). Additionally, any utility systems and associated equipment on the lowest floor must be elevated to protect utilities from damage or loss of function from flooding (refer to the **Elevate Building Utilities** section for details).

Effectiveness: Abandoning the lowest floor of a building has been proven to be effective at reducing damages to building elements and contents located below the BFE (see Figure 2).

Considerations: Homeowners must be careful to install and maintain openings that open automatically during a flood event when needed.

Abandoning the lowest floor and, if required, relocation of utilities will lead to a loss of square footage and the probable loss of livable or rentable space within the existing building, which may not be economically feasible for some homeowners.

To compensate for the loss of livable or rentable space within the existing building, additional living space above the BFE may be added in the form of an added floor or lateral addition to make up for the loss of the lowest floor. Unfortunately, adding the cost of the additional living space may not be economically feasible for some homeowners and may also trigger a Substantial Improvement declaration.

Cost and useful life: Abandoning the lowest floor of a building is considered a relatively high-cost measure with an expected useful life of 30 to 50 years and little or no additional annual maintenance costs beyond maintaining flood openings.

Potential impact on flood insurance premiums: When the mitigation is properly completed, a flood insurance policy will be rated based on the new lowest floor living level. The higher the reference level of the lowest floor is elevated, the more significant the premium rate decreases will be. Actual premium reductions will vary on a case by case basis as individual structures are rated.

Elevate Lowest Interior Floor

This measure involves elevating the lowest interior floor within a residential building with high ceilings (Figure 3). The space below the lowest elevated interior floor walls must be either filled to create a stem wall or retrofitted with flood openings that allow automatic entry and/or exit of floodwaters (refer to the **Flood Openings** section for details). Additionally, any utility systems and associated equipment located below the lowest interior floor must be elevated to protect utilities from damage or loss of function from flooding (refer to the **Elevate Building Utilities** section for details). To reduce flood damage and flood insurance premiums to the greatest extent possible, elevate the lowest floor and utilities to the BFE or above.

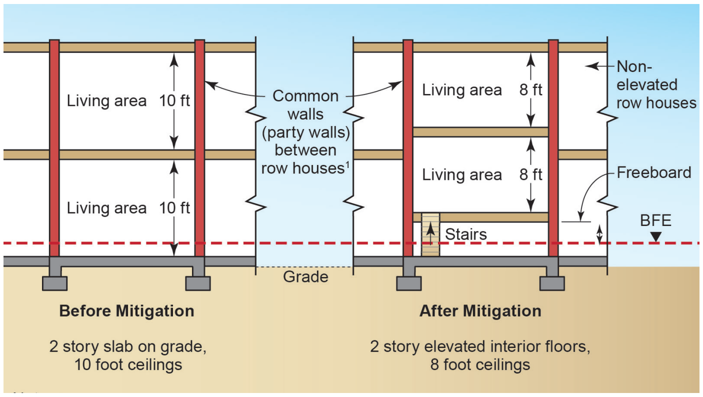


Figure 3: Elevating the lowest interior floor before and after mitigation

Effectiveness: Elevating the lowest floor of buildings has been proven to be effective at reducing damages to building elements and contents located below the BFE (see Figure 3).

Considerations: Homeowners must be careful to install and maintain openings that open automatically during a flood event when needed.

Elevating the lowest interior floor and, if required, elevating or floodproofing utilities will lead to a loss of square footage and the possible loss of livable or rentable space within the existing building, which may not be economically feasible for some homeowners. Further, this flood protection measure could trigger a Substantial Improvement declaration.

Cost and useful life: Elevating the lowest interior floor of buildings is considered a relatively high-cost measure with an expected useful life of 30 to 50 years and little or no additional annual maintenance costs beyond maintaining flood openings.

Potential impact on flood insurance premiums: When the mitigation is properly completed, a flood insurance policy will be rated based on the new lowest floor living level. The higher the lowest floor is elevated, the more significant the premium rate decreases will be. Actual premium reductions will vary on a case by case basis as individual structures are rated.

Wet Floodproofing Measures

Wet floodproofing involves making changes to a home to allow floodwaters to enter and exit without causing major damage to the home or its contents (Figure 4). Wet floodproofing is used in parts of a home that are not used as living space, such as a crawlspace, basement, garage, or other enclosure. Allowing water into parts of the home helps keep the water level inside and outside the home equal and prevents pressure from the water (known as hydrostatic pressure) from causing walls to cave in.

Hydrostatic pressure: The pressure exerted by standing water against walls and concrete slab floors.

Flood Openings

This measure involves installing openings in foundation and enclosure walls located below the BFE that allow automatic entry and exit of floodwaters to prevent collapse from the pressures of standing water.

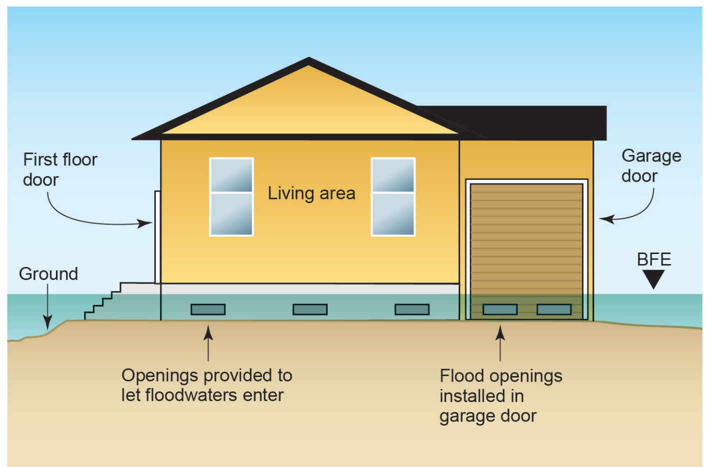


Figure 4: Flood openings and their placement

Effectiveness: Flood openings have been proven to be effective at reducing structural damage to residential buildings caused by unequal hydrostatic pressures.

Considerations: Homeowners must be careful to install and maintain openings that open automatically during a flood event and do not require human assistance.

Cost and useful life: Installing flood openings is considered a relatively low-cost measure with an expected useful life ranging from 15 to 20 years with some limited annual maintenance costs.

Potential impact on flood insurance premiums: Similar to changing the lowest level in a structure, installation of flood openings has the potential to increase the elevation at which the lowest floor is rated and may therefore lower insurance premiums (see Figure 4). Actual premium reductions will vary on a case by case basis as individual structures are rated.

Elevate Building Utilities

This measure involves elevating all building utility systems and associated equipment (e.g., furnaces, septic tanks, and electric and gas meters) to protect utilities from damage or loss of function from flooding (Figure 5). Homeowners may elevate building utility systems using a variety of techniques, including using elevated pedestals or platforms for outdoor equipment, moving equipment to higher floors or attic spaces, and building an elevated utility room. To reduce flood damage to the greatest extent possible, elevate utilities to the BFE or above.

Freeboard: A factor of safety usually expressed in feet above a flood level for purposes of floodplain management. Freeboard accounts for unknown factors, future development, and floods higher than the base flood.

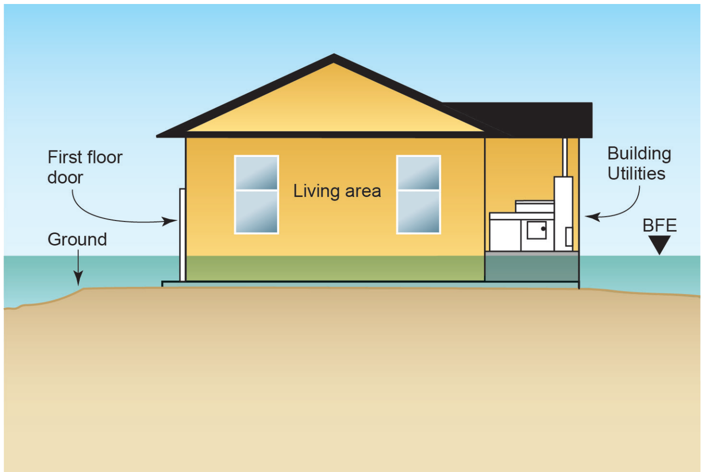


Figure 5: Elevate building utilities

Effectiveness: Elevation of all residential building utility systems has been proven to be effective at reducing or eliminating utility damage during flood events. Unlike other alternative mitigation measures, elevating building utilities is effective against coastal floods or high velocity riverine flood forces, provided that indoor utilities are elevated to a higher floor or inside an elevated utility room supported on piles. Outdoor utilities should be elevated and anchored to a platform that is attached at one end to the main building.

Considerations: Elevation of residential building utility systems above expected flood levels may expose the systems to damage from other types of hazards, such high winds and earthquakes. However, there are often simple solutions to address these design concerns.

Cost and useful life: Elevation of all residential building utility systems is generally considered a relatively moderate-cost measure with an expected useful life of ranging from 15 to 20 years with limited annual maintenance costs. However, the overall cost of the measure can vary depending on the type of building, the location of utilities, and the availability of space within the existing building.

Potential impact on flood insurance premiums: Discounts are currently available under the NFIP for elevating building utilities in the V Zone. There are also discounts available for this activity in the A Zone when utilizing the NFIP's Submit for Rate Guide.

Floodproof Building Utilities

This measure involves floodproofing all building utility systems and associated equipment to protect it from damage or loss of function from flooding (Figure 6). Homeowners may floodproof building utility systems using a variety of techniques, including placing outdoor equipment behind floodwalls or placing indoor equipment behind a wall or watertight, passive utility enclosure. In order to reduce flood damage to the greatest extent possible, floodproof to the BFE or above.

Passive system: Works automatically and does not require human assistance.

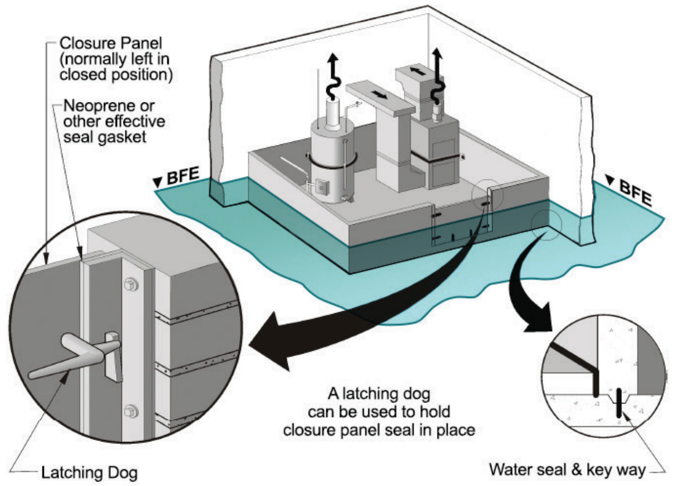


Figure 6: Detail of floodproofed building utility

Effectiveness: Floodproofing residential building utility systems can be effective at reducing or preventing utility damage during flood events. This measure is subject to other restrictions related to flood conditions (3 foot maximum flood depth, low velocity, short duration) and building conditions. Floodproofing building utilities will work best when all utility meters are elevated as well, and flap valves or passive backflow prevention devices are installed on building water and sewer lines.

Flood depth: the height of the floodwater above the surface of the ground or other feature at a specific point.

Considerations: Homeowners must be careful to choose floodproofing systems with openings that close automatically during a flood event and do not require human assistance.

Cost and useful life: Floodproofing residential building utility systems is generally considered a relatively moderate- to high-cost measure with an expected useful life ranging from 15 to 20 years with significant annual maintenance costs needed to maintain various elements of the floodproofing system. However, the overall cost can vary depending on the type of building, condition of the building, and location of the utilities.

Potential impact on flood insurance premiums: N/A (No premium rate discounts available under the current program)

Flood Damage-Resistant Materials

This measure involves the use of flood damage-resistant materials such as non-paper-faced gypsum board and terrazzo tile flooring for building materials and furnishings located below the BFE to reduce structural and non-structural damage and post-flood event cleanup (Figure 7).

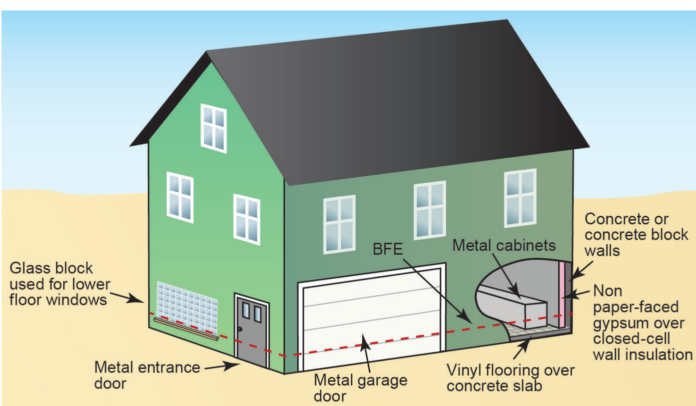


Figure 7: Flood damage-resistant materials

Effectiveness: Flood damage-resistant materials have been proven to be effective at reducing non-structural damage to residential buildings in low-velocity riverine flood events.

Considerations: Homeowners must be careful to use materials and assemblies that meet the requirements noted in FEMA Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements,* which is listed in the Resources section.

Cost and useful life: Use of flood damage-resistant materials is considered a relatively moderate-cost measure with an expected useful life ranging from 10 to 20 years and limited annual maintenance costs depending on the type of material.

Potential impact on flood insurance premiums: N/A (No premium rate discounts available under the current program)

Dry Floodproofing Measures

Dry Floodproofing involves sealing your home to prevent floodwaters from entering. Homeowners can dry floodproof their homes using waterproof coatings or coverings to prevent floodwater from passing through the walls, install waterproof shields, and install devices that prevent sewer and drain backup.

Passive Dry Floodproofing System

This measure involves installing a passive (works automatically without human assistance) dry floodproofing system around a home to protect the building from flood damage (Figure 8). The coating or covering must be impervious to floodwater and certified and constructed to a maximum of 3 feet above grade (ground level). To reduce flood damage to the greatest extent possible, floodproof to the BFE or above.

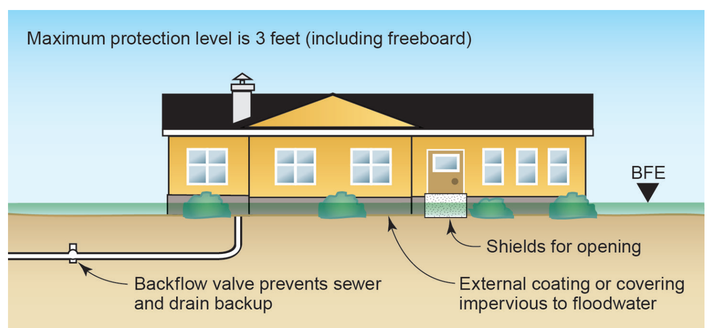


Figure 8: Dry floodproofed building

Effectiveness: Dry floodproofing of a residential building can be effective at reducing or eliminating building and contents damage during flood events. A dry floodproofing system will work best when all utility meters are elevated as well, and flap valves or passive backflow prevention devices are installed on building water and sewer lines.

Considerations: Buildings that are dry floodproofed may be subject to pressures from standing water and other sources against the foundation and exterior walls and floor surfaces. Homeowners may need to make additional changes to their home, such as reinforcing walls and floor slabs, to resist these pressures. This measure also requires the installation of a drainage system and a back-up emergency power system.

Dry floodproofing of building utilities is subject to other restrictions related to flood conditions. This measure is most appropriate where flood depths do not exceed 3 feet, flood velocities are low, and the duration of flooding is relatively short. Additionally, the measure is most appropriate for structures with concrete or masonry walls and a slab-on-grade foundation.

Cost and useful life: Design and construction of a passive dry floodproofing system is generally considered a relatively high-cost measure with an expected useful life ranging from 15 to 30 years and extensive annual maintenance costs needed to maintain the various elements of a floodproofing system. 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 that need to operate automatically.

Potential impact on flood insurance premiums: N/A (No premium rate discounts available under the current program)

Barrier Measures

Barriers, such as floodwalls and levees, can be built around a home to contain or control floodwaters. A levee is a manmade structure usually made of compacted soil. A floodwall is a structure typically made of concrete and/or masonry and varies anywhere from 1 foot to 6 feet.

Floodwall with Gates and Floodwall without Gates

These two measures involve installing a reinforced concrete floodwall, which works automatically without human assistance, constructed to a maximum of 4 feet above grade (ground level) (Figure 9). The only difference between the two options is related to openings in the floodwall for entry and exit. The floodwall with gates is built with passive flood gates that are designed to open or close automatically due to the hydrostatic pressure caused by the floodwater. The floodwall without gates is built using vehicle ramps or pedestrian stairs to avoid the need for passive flood gates. Note that sump pumps or an internal storage system along with a back-up emergency power supply are required to collect and remove floodwater that collects behind floodwalls during a flood event. To reduce flood damage to the greatest extent possible, ensure the top of the floodwall is at BFE or above.

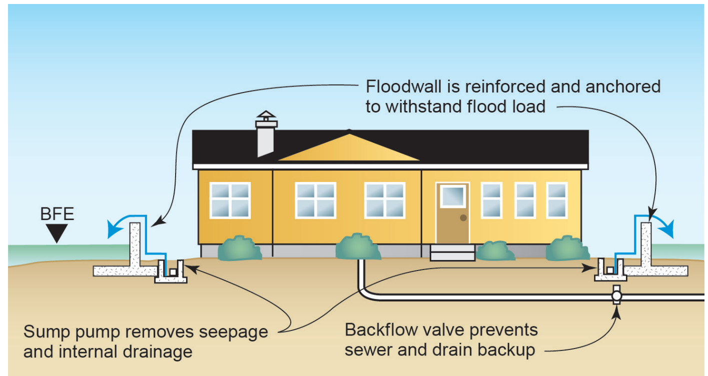


Figure 9: Residential floodwall

Effectiveness: Construction of floodwalls around a residential building can be effective at reducing or eliminating building and contents damage during flood events. The measures will work best when used along with a pump system to remove rain that falls within the floodwall as well as water that seeps through the floodwall.

Considerations: Residential floodwalls are subject to potential community restrictions and design restrictions related to flood conditions including low velocity, low debris, and short duration flood events. They are typically only cost effective where flood depths do not exceed approximately 4 feet. Site conditions may also limit the feasibility of a residential floodwall due to property limitations for constructing a vehicle ramp or building entry and exit. Additionally, this measure requires the installation of a drainage system and a back-up emergency power system is recommended.

Cost and useful life: Design and construction of floodwalls is generally considered a relatively high-cost measure with an expected useful life of 50 years and extensive annual maintenance costs needed to maintain and inspect the floodwall. However, the overall cost of the measure can vary depending on the size of the building, site features, the size and number of openings, and type of soils surrounding the building.

Other cost considerations include the need for professionally designed plans that meet floodplain management requirements, ensure that the floodwall will not divert floodwaters or adversely impact neighboring properties, and that the floodwall and its supporting drainage system will meet the intended flood protection design standards.

Potential impact on flood insurance premiums: N/A (No premium rate discounts available under the current program)

Levee with Gates and Levee without Gates

These two measures involve installing an earthen levee around a home, which works automatically without human assistance, with a clay or concrete core constructed to a maximum of 6 feet above grade (ground level) (Figure 10). The only difference between the two options is related to openings in the levee to enter and exit the property. The levee with gates is built with passive flood gates that are designed to open or close automatically due to hydrostatic pressure caused by the floodwater. The levee without gates is built using vehicle access ramps to avoid the need for passive flood gates. Note that sump pumps or internal storage systems are required to collect and remove rainwater that collects behind levees during a flood event. To reduce flood damage and flood insurance premiums to the greatest extent possible, ensure the top of the levee is at BFE or above.

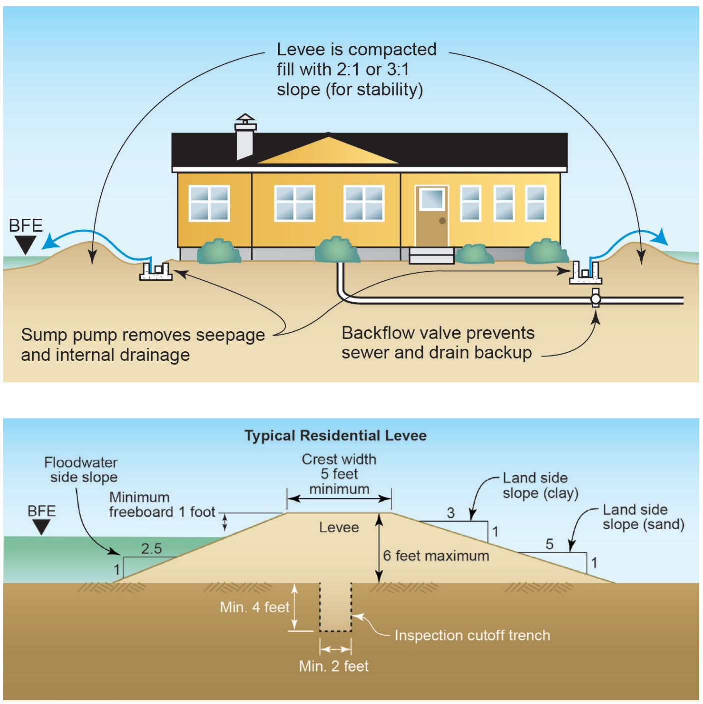


Figure 10: Residential levee and typical levee cross section

Effectiveness: Construction of levees around a residential building can be effective at reducing or eliminating building and contents damage during flood events. The measures will work best when used along with a pump system or interior storage system to address rain that falls within the levee.

Considerations: Residential levees are subject to design restrictions related to flood conditions including low velocity, low debris, and short duration flood events. They are also only cost feasible to approximately 6 feet maximum flood depth. Site conditions may also limit the feasibility of a residential floodwall due to property or building entry and exit. Additionally, this measure requires the installation of a drainage system and a back-up emergency power system is recommended.

Cost and useful life: Design and construction of levees is generally considered a relatively high-cost measure with an expected useful life of ranging from 50 to 100 years and significant annual maintenance costs needed to maintain and inspect the levee. However, the overall cost of the measure can vary depending on the size of the property to accommodate the levee and any vehicle ramps, site features, availability of suitable materials, size and number of openings, and type of soils surrounding the building.

Other cost considerations include the need for professionally designed plans that meet floodplain management requirements, ensure that the levee will not divert floodwaters or adversely impact neighboring properties, and that the levee and its supporting drainage system will meet the intended flood protection design standards.

Potential impact on flood insurance premiums: N/A (No premium rate discounts available under the current program)

Comparison of Alternative Mitigation Measures

The alternative mitigation measures presented here are suitable for use in reducing or eliminating the potential of future flood damage to existing residential buildings. Suitability was evaluated based on a number of factors, including:

- *Passive Measures:* The mitigation measure must be passive, meaning that it works automatically and does not require human assistance. Passive measures, which do not require human assistance, tend to be more effective than active measures, which require human intervention.
- *Level of Protection:* The degree to which the measure allows protection to or above the BFE. Measures that provide protection to or above the BFE are preferable to those that provide less protection.
- *Flood Hazard Conditions:* The extent to which the measure is effective as floodwater velocities increase. Only flood protection methods suitable for low velocity, low debris, and short duration flooding conditions were considered.
- *Effectiveness as a Stand-Alone Measure:* The effectiveness of the measure on its own at reducing flood damages without the need for any additional measures or techniques.

Table 1

Mitigation Measure	Life Cycle Cost	Expected Useful Life	Design Complexity	Potential for Reducing Flood Damage
Wet Floodproofing Measures				
Flood Openings	Low	15–20 years	Low	High
Elevate building utilities	Low to Moderate	15–20 years	Low	Moderate
Floodproof building utilities	Low to Moderate	15–20 years	Moderate	Limited
Flood damage-resistant materials	Moderate	10–20 years	Moderate	Limited
Dry Floodproofing Measures				
Dry floodproofing system	High	15–30 years	High	Moderate
Barrier Measures				
Floodwall with or without gates	High	50 years	High	Moderate
Levee with and without gates	High	50–100 years	High	Moderate
Interior Modification/Retrofit Measures				
Basement infill	Moderate to High	30–50 years	High	High
Abandon lowest floor	Moderate to High	30–50 years	High	High
Elevate lowest interior floor	Moderate to High	30–50 years	High	High

- *Life Cycle Cost:* Initial cost plus annual costs needed to install, operate, and maintain the effectiveness of the measure over the expected project useful life.
- *Design Level of Effectiveness:* The extent to which the measure provides protection (e.g., protection to or above BFE) and the expected damages once that level is reached.
- *NFIP Compliance:* The extent to which the measure either meets or fails to meet NFIP requirements for new and Substantially Damaged/Substantially Improved residential buildings. Structures that are Substantially Damaged following a hazard event must be brought into compliance with NFIP regulations. Similarly, any measure that triggers the Substantial Improvement threshold will require that the structure is brought into compliance with the NFIP regulations.
- *Role of Design Professionals and Building Officials in the Permitting Process:* Many alternative mitigation measures presented here will require design and construction oversight by a licensed design professional (Registered Architect/Professional Engineer). In addition they will likely need review, approval, and permits from the local jurisdiction.
- *Potential for Reducing Insurance Premiums:* The likelihood of the measure to produce measurable annualized project benefits that justify a reduction in NFIP flood insurance premiums.

Table 1 compares the mitigation methods and summarizes the life cycle cost, expected useful life, design complexity, and potential risk reduction for each of the mitigation measures. If your home is being **Substantially Improved** or has been **Substantially Damaged**, the NFIP regulations limit your choice of methods to those shown in the Interior Modification/Retrofit Measures section of the table. If your home is **not** being Substantially Improved or has **not** been Substantially Damaged, any of the methods presented may be considered as long as the cost of the mitigation project does **not** result in your home being considered Substantially Improved.

Case Studies

The final consideration in choosing a mitigation technique is deciding if its benefits outweigh its costs. Two case studies are provided here to show the flood insurance rate reductions and the time needed to recover the cost of the mitigation project based on the flood insurance discount. Individual results will vary based on building characteristics, site conditions, and BFE in relation to the lowest floor of the building.

Case Study 1 - Flood Openings

This measure involves installing openings in foundation and enclosure walls located below the BFE that allow automatic entry and exit of floodwaters. Installing flood openings is considered a relatively low-cost measure. Refer to Figure 4 for an example of this technique.

The example below shows the flood insurance premium before and after the flood mitigation project on a single family one-story home without a basement on a crawlspace foundation located in an AE Zone where the first floor elevation above the crawlspace is 4 feet above the BFE.

Estimated cost range: $6,300 to $9,500 including annual maintenance

Useful life: 15 to 20 years with limited annual maintenance costs

Current annual flood premium: $1,147 for maximum coverage ($250,000 building and $100,000 contents)

Estimated annual flood insurance premium post mitigation: $610 for maximum coverage

Estimated annual reduction in premium: $537

Estimated time to recover mitigation cost: 12 to 18 years

AE Zone: Areas within FEMA's mapped 1% annual chance floodplain where base flood elevations are provided.

Case Study 2 - Basement Infill

This measure involves filling a basement located below the BFE to grade (ground level) Basement infill is considered a high-cost measure. Refer to Figure 1 for an example of this technique.

The example below shows the flood insurance premium before and after the flood mitigation project on a concrete/masonry wall single family two-story home with a basement located in an AE Zone where the first floor elevation above the basement is at the BFE. To compensate for the loss of square footage and living space, a second story has been added.

Estimated cost range: $72,000 to $108,000 including annual maintenance

Useful life: 30 to 50 years and little or no additional annual maintenance costs beyond maintaining flood openings

Current annual flood premium: $6,537 for maximum coverage ($250,000 building and $100,000 contents)

Estimated annual flood insurance premium post mitigation: $1,631 for maximum coverage

Estimated annual reduction in premium: $4,906

Estimated time to recover mitigation cost: 15 to 22 years

Financial Assistance

FEMA and other Federal agencies have an array of grant programs to assist States, communities, and individual property owners in mitigating the negative effects of flooding. You may be eligible to receive financial assistance through one or more of these programs that will help pay for some of the mitigation measures presented here. More information can be found on the FEMA Hazard Mitigation Assistance Web site at http://www.fema.gov/hazard-mitigation-assistance or by contacting the FEMA Regional Office for your State, your NFIP State Coordinator, or your State Hazard Mitigation Officer.

Summary

Before applying any of the alternative mitigation measures described in this publication,

- contact your local building department to learn about development and permit requirements in your area;
- consult a registered design professional (architect or engineer) to determine which options may be best for your home;
- contact your insurance agent to find out how your flood insurance premium may be affected;
- learn about what financial assistance might be available to help pay for the measures.

Resources

The FEMA resources in this section offer more information about the alternative mitigation measures in this publication. For technical assistance on any of these FEMA resources, you may contact FEMA's Building Science Helpline, a technical assistance hotline, at 1-866-927-2104 (phone) or FEMA-Buildingsciencehelp@dhs.gov (email).

Above the Flood: Elevating Your Floodprone House (FEMA P-347)
http://www.fema.gov/media-library/assets/documents/725

Engineering Principles and Practices for Retrofitting Flood-Prone Residential Buildings (FEMA P-259)
http://www.fema.gov/media-library/assets/documents/3001

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

Homeowner's Guide to Retrofitting (FEMA P-312)
http://www.fema.gov/media-library/assets/documents/480

Hurricane Sandy Recovery Advisory: Reducing Flood Risk Flood Insurance Premiums for Existing Residential Buildings in Zone A (RA7)
http://www.fema.gov/media-library-data/1385402350525-0854e30dc59e2567554b87bc3cc94e36/SandyRA7ReducingFloodRisk_111913-508.pdf

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

Protecting Building Utilities from Flood Damage (FEMA P-348)
http://www.fema.gov/media-library/assets/documents/3729

Wet Floodproofing Requirements (Technical Bulletin 7)
http://www.fema.gov/media-library/assets/documents/3503

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FEMA P-1037
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