What is Floodproofing?

Managing Flood Risk is Your Responsibility

Many existing buildings located near rivers, streams, and lakes (and some located a surprising distance away) have a risk of flooding. As the owner and/or occupant of such a structure, you can put your head in the sand and hope for the best. Or you can take an active role in understanding the risks and taking measures to reduce the chances and severity of future flood damage to the structure and its contents.

**Floodproofing** can be defined as any combination of structural or non-structural additions, changes, or adjustments to a building that reduces or prevents flood damage to the structure and/or its contents. Simply stated, floodproofing includes any effort a property owner may take to reduce flood damage.

Options for Protecting Flood-Prone Property

There are a number of ways to protect your property from flood damage (and yourself from the associated heartache). The options include:

- **Demolition**: Removing flood-prone development and relocating to a safer location is a permanent solution to a flooding problem. This is most often done after a major flood as an alternative to costly repairs. Grant funding for a “buyout” may be available to cover some of the costs.

- **Relocation**: Relocating an existing structure is also a dependable way to remove both the structure and the people using that structure from harm’s way. The building is raised, placed on wheels, transported to a new location (away from the flood hazard), and placed on a new foundation.

- **Elevation**: Almost any structurally-sound building can be elevated so that the finished living space is located above the anticipated height of flood waters. The building is separated from its foundation, lifted with hydraulic jacks, and placed on a new or extended foundation. The building can be elevated on solid perimeter foundation walls, fill, or an open foundation system (piers, posts, columns, or piles).

- **Levees and floodwalls**: A structure can be surrounded by a barrier to prevent the encroachment of floodwaters. This can be a levee constructed of compacted fill or a floodwall of concrete or other material. If openings are left for the driveway and/or sidewalk, closures must be installed to close these access points prior to a flood.

- **Dry floodproofing**: Dry floodproofing involves sealing building walls with waterproof compounds, so that the structure is watertight. This technique can only be used when the walls are strong enough to withstand the hydrostatic force of the water. Shields may be installed to seal off doors, windows, and other openings.

- **Wet floodproofing**: There are a variety of techniques that can reduce the damage to a building and its contents, while allowing the structure to flood. The building must be anchored to prevent flotation and must have flood vents, or permanent openings, that allow water to flow in and out of the structure without damaging the foundation. Vulnerable items, such as utilities, appliances, and contents are relocated (permanently or temporarily) to higher parts of the building (above the anticipated flood height) or protected in place. Flood-damage resistant building materials are used for those parts of the building that will be flooded. Automatic shut-off valves are installed on sewer and fuel lines.
Floodproofing Info #1

- Flood insurance: Insurance will do nothing to prevent flood damage, but can protect your financial investment. Although the annual premiums for flood insurance may be high (depending on the location, age, and elevation of the structure), the investment may significantly lower the financial burden when flood damage occurs. Flood insurance coverage is available from the National Flood Insurance Program (NFIP) for any building and/or its contents if the municipality participates in the NFIP (by regulating floodplain development).

**Developing a Floodproofing Strategy**

Developing an appropriate strategy for protecting your property (and yourself) from flood hazards requires evaluation of the risks, technical considerations, costs, and personal preferences:

- **Regulations:** Consult with the municipal building official about regulations that relate to floodproofing options. If an existing building in the regulated floodplain has been substantially damaged or is substantially improved, regulations require that the entire structure be brought into compliance with current floodplain development standards, which precludes the use of some floodproofing techniques. Other building code requirements will also apply to the project.

- **Assess the hazards:** The desired depth of flood protection is a central consideration, since both the technical challenges and the costs for floodproofing measures may increase with water depth. The potential for high water velocities, scouring, ice, and debris flows should also be taken into account. The amount of warning time must also be considered – protective measures that require time to implement aren’t appropriate if the area is prone to flash flooding.

- **Identify feasible floodproofing options:** The applicability of any floodproofing technique depends on the nature of the flood hazard (depth, velocity, debris potential, warning time), site characteristics (size, location, slope, soil type), and building characteristics (structural condition, type of foundation, type of building construction).

- **Assess the costs and benefits:** Some floodproofing options may be too costly and others may not provide the desired amount of risk reduction.

- **Develop a strategy for managing flood risks:** The decision regarding a floodproofing project must also be based on the personal preferences and concerns of the people who will be living with the results on a day-to-day basis. Are there aesthetic preferences? Concerns about the accessibility of the building? Special considerations related to historic structures? Would someone be available and able to implement protective measures prior to a flood? How much risk are you willing to live with? These considerations must be integrated with technical and financial considerations to develop the most appropriate strategy for managing the flood risks in a particular situation.

*Floodproofing does not eliminate all flood risks – but it can “buy down” the risk to an acceptable level.*

**Additional information about floodproofing techniques is provided in other information sheets (available at [www.stcplanning.org](http://www.stcplanning.org]):**

- Floodproofing Info #2: Elevating a Structure
- Floodproofing Info #3: Relocating a Structure
- Floodproofing Info #4: Dry Floodproofing
- Floodproofing Info #5: Wet Floodproofing
- Floodproofing Info #6: Levees and Floodwalls
- Floodproofing Info #7: Selecting Floodproofing Techniques – Regulatory Considerations
- Floodproofing Info #8: Selecting Floodproofing Techniques – Assessing Flood Risk
- Floodproofing Info #9: Selecting Floodproofing Techniques – Technical Considerations
- Floodproofing Info #10: Selecting Floodproofing Techniques – Financial Considerations
- Floodproofing Resources
Elevating a Structure

**Elevation** involves raising a building in place so that the finished living space is located above the anticipated height of flood waters. The building is separated from its foundation, lifted with hydraulic jacks, and placed on a new or extended foundation. The building can be elevated on solid perimeter foundation walls, fill, or an open foundation system that supports the structure at key points.

**Applicability**

Almost any structurally-sound building can be elevated.

**Flood hazard**: Building elevation is practical for almost any flood situation. The flooding conditions must be taken into account to select an elevation technique that will withstand the expected water depths, velocities, debris impacts, and scour (as well as other hazards).

**Building condition**: A building must be in sound structural condition in order to be elevated. Lighter wood-frame structures are easier and often cheaper to raise than masonry. In addition to being more expensive to elevate, masonry structures are also susceptible to cracks. Multistory houses are more difficult to stabilize during the lifting process. It may be necessary to lift attached garages, porches, wings, or additions separately, especially if they are built on separate foundations.

**Substantial damage/improvement**: If the cost of repairs or improvements to a floodplain structure exceeds 50% of the market value of the building before the damage or improvement, then the entire structure must be brought up to current floodplain development standards. Elevation is generally the most feasible technique for achieving compliance.

**Access**: New staircases, elevators, or ramps are generally required to provide access. Functional and attractive solutions can usually be developed. When an attached garage is elevated, an elevated driveway is needed for access. When the amount of elevation reaches 4 or more feet, consider elevating the building a full story so that the lower level can be used for parking.

**Costs**

The cost to lift the building on steel beams and extend or replace the foundation will depend on the size of the structure, type of construction, and amount of elevation. Additional project costs include: disconnection/reconnection of utility lines, elevation of service equipment, temporary housing during construction, and removing/storing belongings. Additional expenditures may be required to bring the building into compliance with building codes. If the structure has been substantially damaged by flooding, part of the cost may be eligible for Increased Cost of Compliance flood insurance coverage.

**Elevation Techniques**

A key decision is the type of foundation on which the building will be elevated.

- **Extended foundation walls**: In areas of low to moderate water depth and velocity, the current foundation can be extended vertically and the structure set down on the extended walls. Flood vents must be installed in the foundation walls to allow water to enter and exit the structure, which protects the walls from collapse. New and larger footings may be needed. It may also be necessary to reinforce both the footings and the walls using steel reinforcing bars to provide structural stability.
Abandoning the lower enclosed area: An alternative for a masonry building on a slab-on-grade foundation is to abandon the existing lower enclosed area and convert it to a flood-prone area below the first floor that is used only for parking, storage, and building access. An existing upper floor can be used for living space. For a one-story building, the roof and roof framing can be removed to build a new second story living area.

Fill: In order to elevate an existing building on fill, the structure must be temporarily relocated while fill is brought in and compacted.

Open foundation: Elevating a building on an open foundation involves raising it onto piers, posts (columns), or piles and allowing water to flow beneath the building. The foundation type depends on the flood and site characteristics. Piers are designed primarily for vertical loading and are thus most appropriate for shallow depth and low velocity flood conditions where they will not be subjected to significant horizontal forces. Posts and columns are generally cross braced for added stability and can be used when the anticipated flood conditions involve moderate depths and velocities. Piles (which are driven or jetted deep into the ground) are less susceptible to the effects of high-velocity floodwaters, scouring, and debris impact and are often used to elevate coastal buildings.

<table>
<thead>
<tr>
<th>Advantages and Disadvantages of Elevation</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Elevation to the required flood protection level allows a substantially damaged or improved structure to be brought into compliance with floodplain development standards.</td>
<td>• Elevation can significantly reduce flood risks to the structure and its contents.</td>
<td>• Cost may be prohibitive.</td>
</tr>
<tr>
<td>• Elevation to the required flood protection level allows a substantially damaged or improved structure to be brought into compliance with floodplain development standards.</td>
<td>• Elevation can significantly reduce flood risks to the structure and its contents.</td>
<td>• Elevation may significantly alter the appearance of the structure.</td>
</tr>
<tr>
<td>• Elevation can significantly reduce flood risks to the structure and its contents.</td>
<td>• Except where the area below the structure is used for storage, elevation does not require active intervention during a flood (such as relocation of vulnerable items to higher levels).</td>
<td>• The structure should not be occupied during a flood.</td>
</tr>
<tr>
<td>• Except where the area below the structure is used for storage, elevation does not require active intervention during a flood (such as relocation of vulnerable items to higher levels).</td>
<td>• Often reduces flood insurance premiums. (In the regulated floodplain, actuarial insurance costs are based on the height of the first floor relative to the Base Flood Elevation.)</td>
<td>• Additional stairs and/or an elevator may be required to access the structure.</td>
</tr>
<tr>
<td>• Often reduces flood insurance premiums. (In the regulated floodplain, actuarial insurance costs are based on the height of the first floor relative to the Base Flood Elevation.)</td>
<td>• Techniques are well-known and qualified contractors are often readily available.</td>
<td>• Special measures must be taken if the structure will be subject to high-velocity water flow, fast-moving ice or debris flow, or erosion.</td>
</tr>
<tr>
<td>• Techniques are well-known and qualified contractors are often readily available.</td>
<td>• Does not require that additional land beyond the original footprint of the structure.</td>
<td>• Additional costs may be incurred to bring the structure into compliance with current building codes for plumbing, electrical, and energy systems.</td>
</tr>
<tr>
<td>• Does not require that additional land beyond the original footprint of the structure.</td>
<td></td>
<td>• Forces due to wind and seismic hazards must be considered.</td>
</tr>
</tbody>
</table>

Additional Information

Relocating a Structure

Relocating an existing structure away from a flood-prone location prevents future flood damage to the structure and removes the people who use the building from harm’s way. The procedure normally involves removing the building from its foundation, placing the structure on a wheeled vehicle, transporting it to a new location, and setting it on a new foundation.

Applicability
Removing a structure from the flood hazard area is the most reliable technique for protecting a structure from future flood damage.

Flood hazards: Because the cost of relocating a building can be high, this technique is most appropriate for high hazard areas where continued occupancy is unsafe. Relocation should be considered if the site is susceptible to deep water, high velocities, ice or debris flow, flash flooding, or undercutting by erosion.

Building condition: A building must be in sound structural condition in order to be moved. Most types and sizes of structures can be relocated either as a unit or in segments. One-story wood-frame houses are usually the easiest to move, particularly if they are located over a crawl space or a basement. Houses constructed of brick, concrete, or masonry are also moveable, but usually with more difficulty and increased costs.

Type of facility: In addition to high hazard locations, from which relocation is desirable, there are also uses that are inappropriate for flood-prone areas and should be relocated to low risk sites. These include critical facilities that should remain operational during a flood, operations that store or use significant amounts of hazardous substances, and facilities that are difficult to evacuate (such as medical or nursing facilities).

Costs
Cost is a major concern associated with building relocation. In addition to the cost of moving the structure are the expenses associated with purchase and preparation of the new site, installation of utilities, construction of a new foundation, and restoration of the old site. Arrangements must also be made for temporary housing and storage of belongings. If electrical, plumbing, heating, or other systems do not meet current building code requirements, they will need to be brought into compliance. If the structure has been substantially damaged by flooding, part of the costs may be eligible for Increased Cost of Compliance flood insurance coverage.

The Relocation Process
- Selecting the new site: Selection of a new site for relocating a structure requires consideration of: natural hazards, utility connections, accessibility for site preparation, and the moving route between the old and new sites. Narrow roads, restrictive load capacities (of roads or bridges), low clearances (under bridges or power lines), or other restrictions along the route to the new site can complicate a relocation project. If an alternate route is not available, it may be necessary to move the structure in sections.
- Permitting: All permits required for construction at the new site, for moving the building, and for restoring the old site should be obtained before the relocation project begins.
Lifting the building: If the building has a basement or crawlspace foundation, it is separated from the foundation 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. Buildings with slab-on-grade foundations are lifted with the concrete floor slab attached, so the I-beams are inserted below the slab.

Preparing the new site: Preparation of the new site includes: erosion control, grading/clearing (as needed), driveway construction, construction of a new foundation, and installation of utilities ( electrical, gas, water, sewer, telephone, and cable).

Moving the building: Trailer wheel sets are placed beneath the building and attached. The building is towed to the new site, positioned over the partially completed foundation, and supported on cribbing while the foundation is completed below it. The building is lowered onto the new foundation and construction completed (utility connections, backfilling, landscaping, etc.)

Restoring the old site: Restoration of the abandoned site usually involves removal of the foundation and utilities, backfilling the basement, grading, and vegetative stabilization.

### Advantages and Disadvantages of Relocation

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Removing a building from a flood-prone location is the most reliable means of preventing future flood damage to the structure and contents and reducing personal risk to the occupants.</td>
<td>• Relocation is only possible if the building is structurally sound.</td>
</tr>
<tr>
<td>• Allows for a substantially damaged or improved structure to be brought into compliance with floodplain development standards.</td>
<td>• Cost may be prohibitive.</td>
</tr>
<tr>
<td>• Relocation techniques are well-known and qualified contractors are often readily available.</td>
<td>• A new site must be located and purchased.</td>
</tr>
<tr>
<td>• If the structure is removed from the regulated floodplain, the cost of flood insurance is reduced significantly and mandatory flood insurance requirements are eliminated.</td>
<td>• Disposition of the flood-prone lot must be addressed.</td>
</tr>
<tr>
<td>• Additional costs may be incurred to bring the structure into compliance with current building codes for plumbing, electrical, and energy systems.</td>
<td></td>
</tr>
</tbody>
</table>
Dry Floodproofing

Dry floodproofing involves sealing the exterior of a building to prevent the entry of flood waters. This technique can only be used when the walls are strong enough to withstand the hydrostatic force of the water. Shields may be installed to seal off doors, windows, and other openings.

Applicability
A dry floodproofed building must withstand both the lateral pressure of floodwater and buoyancy forces. This technique is only applicable to structurally sound buildings in areas of shallow, low-velocity flooding.

Flood hazard: Dry floodproofing is infeasible when flood depths exceed 3 feet due to the risk of structural damage. Dry floodproofing should also be avoided in areas subject to high velocity flows, erosion, debris impact, or waves, which can damage the structure or puncture waterproof sealants. An additional consideration is the expected duration of flooding, because waterproofing compounds, sheeting, or sheathing may fail or deteriorate if exposed to floodwaters for extended periods. Most dry floodproofing systems require human intervention, which can only be implemented if there is adequate warning time.

Building characteristics: Dry floodproofing is appropriate primarily for slab-on-grade buildings with concrete or solid masonry walls. It should not be attempted if there is a basement. When dry floodproofing a wood-frame structure, only buildings constructed of block or faced with brick veneer should be considered. Weaker construction materials, such as wood-frame with siding, will often fail at much lower water depths. Even brick or concrete block walls should not be floodproofed above a height of three feet (without extensive engineering analysis) due to the danger of structural failure from excessive flood-related forces.

Regulations: Dry floodproofing is not allowed for new, substantially damaged, or substantially improved residential structures in the regulated floodplain. However, it can be used to bring a substantially damaged or substantially improved non-residential structure into compliance with floodplain development standards.

Emergency operation: If the design requires manual installation of flood shields or other activities, a physically capable person must be aware of the flood threat and able to implement all necessary interventions before flood waters arrive.

Costs
Dry floodproofing may be less costly than other methods of protecting flood-prone structures. Project costs depend largely on the building size, depth of protection, types of material used, and number of openings.

Techniques
Dry floodproofing is a sophisticated technique that requires an understanding of the hydrostatic forces that can damage walls and floors, as well as the protective measures used to withstand those forces. The project design should be certified by a licensed professional. FEMA’s Floodproofing Certificate is available at [http://www.fema.gov/plan/prevent/fhm/dl_fpc.shtm](http://www.fema.gov/plan/prevent/fhm/dl_fpc.shtm) and is required if a non-residential structure is dry floodproofed for compliance with floodplain development requirements or insurance rating purposes. Professional certification is recommended for all dry floodproofing projects due to the technical challenges of such projects.
Sealing building walls: Since most wall materials will leak, it is generally necessary to apply waterproof sealants to the building walls, all structural joints (such as where walls meet foundations), and openings for utility lines. Cement- and asphalt-based coatings are often the most effective sealant. However, if applied to outside walls, these coatings can drastically change the appearance and may be susceptible to puncturing. Addition of a new masonry veneer over the coating can provide additional protection and aesthetic appeal. Clear coatings, such as epoxies and polyurethanes, can be applied to exterior walls without changing the appearance, but tend to be less effective than cement- and asphalt-based materials.

Permanently seal openings: It may be possible to permanently seal the lower portions of some window or door openings. For example, all or part of a low window can be replaced with brick or glass block.

Flood shields for openings: Windows or doors that extend below the flood protection level require temporary installation of watertight shields over the openings. The material used and installation methods depend on the width of the opening, flood depth, and other considerations. A plan must be developed and implemented to ensure that flood shields are properly installed prior to a flood.

Interiors drainage: A good interior drainage system must be provided to collect water that leaks through the sealant or sheeting and around the shields. This system typically requires a sump pump and an emergency power source, such as a portable generator, to enable operation during a power outage.

Other: It may also be necessary to strengthen the walls, anchor the building, install backflow valves in sanitary and storm sewer lines, elevate utility systems, anchor fuel tanks, or implement other measures.

### Advantages and Disadvantages of Dry Floodproofing

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Dry floodproofing reduces risk to the structure and contents if the design flood level is not exceeded.</td>
<td>• Dry floodproofing is generally not technically feasible for flood depths exceeding 3 feet or for a structure with a basement.</td>
</tr>
<tr>
<td>• May be less costly than other retrofitting measures.</td>
<td>• This technique cannot be used to bring a substantially damaged or improved residential structure into compliance with floodplain development standards.</td>
</tr>
<tr>
<td>• For non-residential buildings, dry floodproofing can satisfy the requirement for bringing substantially damaged or improved structures into compliance with floodplain development standards.</td>
<td>• Usually requires human intervention and adequate warning time for installation of protective measures. Practices requiring human intervention should not be used when there is a risk of flash flooding or if warning times are short.</td>
</tr>
<tr>
<td>• May reduce flood insurance premiums for a non-residential building.</td>
<td>• Requires on-going maintenance.</td>
</tr>
<tr>
<td>• Does not require additional land beyond the original footprint of the structure.</td>
<td>• Flood insurance premiums are not reduced for residential structures.</td>
</tr>
<tr>
<td>• Retains the structure in its present environment and may avoid significant changes in appearance.</td>
<td>• Measures can fail or be exceeded by large floods, in which case the effect will be as if there was no protection.</td>
</tr>
<tr>
<td></td>
<td>• If design loads are exceeded, walls may collapse, floors may buckle, and the structure may even float, potentially resulting in more damage than if the building were allowed to flood.</td>
</tr>
<tr>
<td></td>
<td>• The structure should not be occupied during a flood.</td>
</tr>
<tr>
<td></td>
<td>• Shields and sealants may not be aesthetically pleasing.</td>
</tr>
<tr>
<td></td>
<td>• The damage to the exterior of the structure and other property may not be reduced.</td>
</tr>
<tr>
<td></td>
<td>• May be subject to leakage, which could cause damage to the structure and its contents.</td>
</tr>
<tr>
<td></td>
<td>• Dry floodproofing does nothing to minimize the potential damage from high-velocity flood flow, wave action, erosion, or debris impact.</td>
</tr>
</tbody>
</table>
Wet Floodproofing

Wet floodproofing includes a variety of techniques that allow a structure to flood inside, but reduce the resulting damage to the building and its contents.

Wet floodproofing is generally the least expensive floodproofing technique, but it may also be the least effective. Although damages are reduced, significant cleanup and some repairs are usually required after a flood. Wet floodproofing is often used to reduce damage to existing flood-prone structures when other floodproofing techniques are not technically feasible or are too costly.

Building characteristics: Because wet floodproofing allows flood waters to enter the building, it is most practical for unfinished portions of a building, such as the basement, crawl space, or garage. It may be the desired technique for structures with basements that cannot be protected technically or cost-effectively by other techniques. The structure should have space above the flood protection level to relocate and/or temporarily store vulnerable items.

Flood hazard: Wet floodproofing is most suitable for areas with shallow flooding that only inundates unfinished space. In areas prone to flash flooding, temporary relocation of vulnerable items is not feasible. Wet floodproofing does nothing to alleviate the threat of damage from flowing water, erosion, debris impacts, or floodborne contaminants.

Regulations: In most circumstances wet floodproofing cannot be used to bring a substantially damaged or substantially improved structure into compliance with current floodplain development standards. However, if there is no basement (below grade on all sides) and finished living space is located above the flood protection level, compliance can be achieved by wet floodproofing a crawl space or other enclosed area below the lowest floor and using that area solely for parking, storage, or building access.

Costs
The major costs of this measure involve rearranging utility systems, installing flood vents, replacing materials that are not flood-resistant, acquiring labor and equipment to move items, and cleanup when floodwaters recede. Major disruptions to structure occupancy may occur during and after floods.

Techniques
Flood vents: The purpose of allowing water into the structure is to enable equalization of the interior and exterior hydrostatic pressures, which greatly reduces the likelihood of wall failures and structural damage. To accomplish this, the structure must have flood vents, or permanent openings, that allow water to flow in and out of the building without damaging the foundation. The size and number of openings must be sufficient to allow the water level inside the building to rise and fall at roughly the same rate as the water level outside. If the floodproofed area is above grade, the flood vent openings should meet or exceed the standards for floodplain development (see FEMA Technical Bulletin 1, referenced below). If the building has a basement, additional openings may be required so an engineer or architect should determine the number and size of flood vents.

Protect service equipment: Vulnerable items, such as utilities and appliances may be moved to a place in the building higher than the flood protection level. This could be existing space, such as an attic or a small addition that would serve as a utility room. Service equipment can be protected from shallow flooding with low floodwalls and shields or elevated on a platform. Ductwork and specially designed furnaces can be suspended from the ceiling. Electrical system components can be elevated. Keep in mind that most service equipment must remain accessible for maintenance. Automatic shut-off valves are installed on sewer and fuel lines.
Anchoring: Foundations, fuel tanks, equipment, and other components located below the flood protection level should be firmly anchored to resist flotation, collapse, and lateral movement.

Flood resistant materials: Building materials in flood-prone parts of the structure can be replaced with flood-damage resistant materials. Carpeting, paneling, and gypsum wallboard can be replaced with materials that will require cleaning rather than replacement after a flood (see FEMA Technical Bulletin 1, referenced below)

Protect building contents: To the extent possible, use of the floodproofed area should be limited and the contents permanently relocated to higher areas. If there is sufficient warning time, other items vulnerable to flood damage can be temporarily relocated to higher parts of the building prior to a flood.

<table>
<thead>
<tr>
<th>Advantages and Disadvantages of Wet Floodproofing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
</tr>
<tr>
<td>• No matter how small the effort, wet floodproofing can, in many instances, reduce flood damage to a building and its contents.</td>
</tr>
<tr>
<td>• Installing flood vents to equalize hydrostatic pressure protects the building from structural damage that could result from flood loads on the walls and floors.</td>
</tr>
<tr>
<td>• Costs for relocating or storing contents (except basement contents) after a flood warning is issued are normally covered by flood insurance.</td>
</tr>
<tr>
<td>• Wet floodproofing measures are often less costly than other measures.</td>
</tr>
<tr>
<td>• The appearance of the building is usually not adversely affected.</td>
</tr>
<tr>
<td>• Does not require that additional land beyond the original footprint of the structure.</td>
</tr>
</tbody>
</table>

Additional Information

Levees and Floodwalls

Levees and floodwalls are barriers that hold back floodwaters. A levee is constructed of compacted soil and requires more land area. Floodwalls are built of manmade materials, such as concrete and masonry. These structures may completely surround the building or may tie into high ground at each end. If openings are left for the driveway and/or sidewalk, closures must be installed to seal these access points prior to a flood.

Applicability

Because levees and floodwalls are located away from the structure or area to be protected, they provide flood protection without altering the building.

Flood hazard: Although levees and floodwalls can be built to any height, they are usually limited to four feet for floodwalls and six feet for levees (due to cost, aesthetics, access, water pressure, and space). The structure should be built at least one foot higher than the anticipated flood depth (freeboard protection). No matter how high the barrier is, it can always be overtopped by a larger flood, which would cause as much damage as if no protection were provided (or more). In areas with high velocity flow, erosion protection may be necessary to protect an earthen levee or prevent undermining of a floodwall. Flash flooding precludes the use of closures that require human intervention to install. If flooding lasts more than 3 to 4 days, seepage is more likely to pose problems.

Site requirements: A levee or floodwall is not feasible if it would impede flow or block natural drainage in a manner that results in damage to surrounding property. Considerable horizontal space is required for levees; floodwalls are generally more appropriate for small sites. The underlying soil must support the levee or floodwall and resist seepage of water under the structure.

Building characteristics: A house with a basement can still experience flood damage even if a levee or floodwater protects the structure from surface water. Saturated soil can exert hydrostatic pressure on basement walls, causing them to crack, buckle, or even collapse.

Access: Access to the structure can be enabled by providing a means of crossing over a levee or floodwall, such as a ramp or stairway. If this is not feasible, it may be necessary to design openings at driveways, sidewalks, or other entrances and a mechanism for closing all such openings. Designs that do not require human intervention are preferable. If a closure requires manual installation, the effectiveness of the flood protection system depends on the availability of a capable person who is aware of the flood threat and has sufficient time to install closures and make certain they are properly sealed.

Aesthetics: The rounded outlines of an earthen levee can be shaped to blend into the natural landscape. Floodwalls can be designed as attractive features by incorporating them into the landscape design and utilizing decorative bricks or blocks (although this will generally increase the cost).

Regulations: A levee or floodwall cannot be used to bring a substantially damaged or substantially improved structure into compliance with current floodplain development standards.
**Costs**
Depending on the availability of suitable local soil, levees may be less expensive than other floodproofing options. However, if suitable fill material is not locally available, the expense of transporting proper material to the site can be significant. The cost of floodwalls is usually greater than that of levees.

**Techniques**
- **Levees**: To be effective, a levee must be constructed with compacted, impervious soils. The practice of piling stream sediment on the bank does not provide flood protection. The embankment slopes must be gentle (usually a ratio of one vertical to two or three horizontal) to provide adequate stability and minimize erosion. The levee’s width will thus be several times its height.
- **Floodwalls**: Floodwalls are generally constructed of solid concrete (alone or in combination with masonry). They must be designed to withstand water pressure without overturning or displacement.
- **Closures**: Mechanisms for closing access openings in a levee or floodwall include automated systems (usually expensive) or manually operated flood gates, stop logs, or panels. There are often hinges or sliding mechanisms for installation. If the closure is not permanently attached, it must be stored in a readily accessible location. Any sewers or drain pipes passing through or under a floodwall or levee require closure valves to prevent backup and flooding inside the building and protected area.
- **Interior drainage**: Rain, snow melt, and seepage water must be removed from the protected side of a levee or floodwall using drains (with flap valves to prevent backflow during a flood) and a sump pump. An emergency power source for the electric sump pump enables operation during a power outage.
- **Maintenance**: Routine inspection enables identification and repair of problems while they are still minor. Levees should be checked for signs of erosion, settlement, loss of vegetation, animal burrows, and trees. Inspect floodwalls for cracking, spalling, or scour. Routine maintenance is needed to make sure that sump pumps, valves, drain pipes, and closures operate properly.

<table>
<thead>
<tr>
<th>Advantages and Disadvantages of Levees and Floodwalls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
</tr>
<tr>
<td>• Levees and floodwalls can protect a building and the surrounding area from inundation without significant changes to the structure if the design flood level is not exceeded.</td>
</tr>
<tr>
<td>• There is no pressure from floodwater to cause structural damage to the building.</td>
</tr>
<tr>
<td>• These barriers are usually less expensive than elevating or relocating the structure.</td>
</tr>
<tr>
<td>• Occupants do not have to leave the structure during construction.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Selecting Floodproofing Techniques – Regulatory Considerations

Regulated Floodplain
If a building is located within the area shown on the Flood Insurance Rate Map as 100-year floodplain, a floodproofing project is considered floodplain development and requires a Floodplain Development Permit from the municipality. The requirements depend on the magnitude of the project and whether it is in a regulatory floodway.

| “Substantial Improvement” | Any repair or improvement of an existing floodplain building, the cost of which equals or exceeds 50% of the market value of the structure (excluding the land) before the improvement. If the structure has sustained “substantial damage,” any repairs are considered substantial improvement regardless of the actual repair work performed. (There are exceptions for improvements required to assure safe living conditions and for historic structures.) |
| “Substantial Damage” | Damage to a building, regardless of the cause, for which the cost of restoring the structure to its before-damaged condition would equal or exceed 50% of the market value of the structure before the damage occurred. |

Substantial Improvement Rule
If a building is substantially improved then the entire structure must be brought into compliance with current floodplain development standards. This rule applies to any building in the regulated floodplain that is not already in compliance with current standards. This may occur because the building predates enactment of floodplain development standards or if the flood hazard map or development requirements were revised after construction of the building.

Current Floodplain Development Standards
In New York, current standards for floodplain development require that buildings be protected to a level two or more feet above the Base Flood Elevation (BFE; calculated 100-year flood level) or three feet above the highest adjacent grade if no BFE is available. For residential buildings, this protection must be provided by elevating the lowest floor to or above the flood protection level and utilizing flood-resistant design below that level. Non-residential buildings can be protected either by elevation or by dry floodproofing to the flood protection. (Additional information about floodplain development requirements is provided in floodplain fact sheets, available at [www.stcplanning.org](http://www.stcplanning.org).)
Floodproofing Options for Substantially Improved Buildings
A floodproofing project may constitute a substantial improvement or may be necessitated because a building is being substantially improved. The requirement to bring a structure into compliance with current floodplain development standards limits the floodproofing techniques that can be utilized:

- **Elevation**: The technique that is most commonly used to bring a non-compliant structure up to floodplain development standards is to elevate it so that the first floor is at or above the flood protection level. If the main floor is appropriately elevated, but the structure has a basement or non-compliant enclosed area (such as a crawl space without flood vents), compliance may be achieved by filling the basement and wet floodproofing any enclosed area that remains below the main floor (so that the basement or crawl space is no longer considered the “lowest floor”).

- **Relocation**: Relocating a building to a site outside of the floodplain is an effective, though generally expensive, way to comply with floodplain development standards.

- **Dry floodproofing**: Floodplain development standards allow dry floodproofing of non-residential structures, but cannot be used to bring residential structures into compliance. Use of this technique for residential structures is limited to buildings that do not trigger the substantial improvement rule or to situations in which the owner desires additional protection above the required flood protection level.

- **Wet floodproofing**: The use of wet floodproofing techniques is required for those portions of the building located below the flood protection level. However, if finished living space is not elevated to the required level (or dry floodproofed for non-residential buildings), then wet floodproofing cannot be used to bring the structure into compliance with current standards. In some cases, the main floor may be properly elevated, but the building has inadequate flood vents, non-elevated utilities, or other violations. In these cases, wet floodproofing measures can be used to bring the structure up to floodplain development standards, provided that any remaining enclosed areas below the flood protection level are used solely for parking, storage, or building access.

- **Levees and floodwalls**: Levees and floodwalls may not be used to bring a substantially damaged or substantially improved building into compliance with floodplain management standards.

---

The floodway is the channel of a river or stream and the overbank areas that must remain open to carry the deeper, faster moving water during a flood.

---

Regulatory Floodway
If any portion of a project constitutes an encroachment in the floodway (delineated on the Flood Insurance Rate Map or Flood Boundary and Floodway Map), the project can only be permitted if a licensed professional engineer demonstrates that the proposed encroachment shall not result in any rise in the 100-year flood elevation. This generally precludes the use of levees or floodwalls in the floodway.

Existing Building Code
A floodproofing project, like any other repairs to an existing building, must utilize materials and practices that comply with standards in the NYS building codes and must not make the building less conforming to those codes. **In some cases, the project might require upgrades to bring the building into compliance with current building codes** (for plumbing, electrical, energy systems, or other existing violations). This depends on the scope of the improvements and is most likely to be necessary for elevation and relocation projects.
Selecting Floodproofing Techniques – Assessing Flood Risk

A realistic floodproofing strategy must be based on an understanding of the current flood risks and reasonable objectives for reducing those risks. The flood risk for an existing building depends on both the local flood hazard (how often the water will get how deep) and the impact that those flood conditions will have on the structure, its contents, and the occupants.

Flood Hazards

Because we can’t predict future floods, floodproofing decisions need to be based on available information about probability of particular flood conditions. The flood characteristics that should be evaluated include:

- Frequency with which floodwaters will reach various depths.
- Amount of warning time prior to flooding of the structure (or loss of access due to flooding of roads).
- Flow velocity, including the potential for erosion or scour.
- Duration of flooding.
- Debris load, such as trees or ice, which can cause impact damage.

The following sources can be used to assemble as much information as possible about the flood hazards at a particular location:

- **Flood Insurance Rate Map and Flood Insurance Study**: The flood hazard map (available at municipal offices, County Planning Departments, or online at [http://msc.fema.gov](http://msc.fema.gov)) indicates if the property is in the so-called “100-year floodplain.” This is the area calculated to have a 1% or greater probability of flooding in any given year. If the map provides an elevation for this 1% probability flood, additional information can be found in the accompanying Flood Insurance Study (FIS). Locating the site on a Flood Profile (in the back of the FIS) will enable determination of the calculated elevation for the 10-year, 50-year, 100-year, and 500-year flood at that location. If a flood elevation is not provided on the map (Approximate A Zone), simplified methods can be used to estimate an elevation for the 1% probability flood. Note that flood hazards change over time (usually increasing as a result of development), so if the calculations for the maps are old or of the floodplain is an Approximate A Zone, the actual flood elevations may be higher. If the flood hazard maps indicate that the site is in the “floodway” portion of the floodplain, it is likely to be subject to high velocity flood flows.

- **Other flood studies**: A study of flood characteristics may have been conducted for a highway project or other purpose. If reliable flood height and frequency information are not currently available, it may be beneficial to conduct an engineering study, particularly if you plan to implement an expensive floodproofing project.

- **Historic information**: The characteristics of past flood events can provide valuable information about the potential for high flow velocities, short warning times, flood-borne debris, and long inundation periods. In flood-prone areas that are not indicated on flood hazard maps, historic flood heights may be the best information you have for anticipating future flood depths. However, weather patterns and land use changes are increasing the flood hazards in many areas. So if you are using the past as a key to the future, be sure to include an extra margin of safety. Consult with neighbors, municipal officials, County Soil and Water Conservation Districts, the local Fire Department, and County Emergency Management personnel about previous flood conditions and the potential for more severe floods in the future.

- **Site characteristics**: If the property is located near a small, high gradient stream, you should be prepared for flash flooding. In these areas, there may be little or no warning time, high water velocities, significant debris loads, and the potential for streambank erosion. A larger watershed generally allows greater warning time. A wide floodplain enables the water to spread out and slow down, particularly if flow is hindered by dense vegetation. Flooding from lakes or large rivers may take longer to recede.

---

**Flood Impacts**
The appropriate floodproofing technique and the desired level of protection depend on the impact that flooding will have on the building.

**Elevation Certificate:** It may be necessary to get a survey to determine how flood elevations (from the Flood Insurance Study) relate to the depth of water at your building. If a surveyor does this, request an Elevation Certificate, which will document the elevation of the bottom floor, next highest floor, equipment servicing the building, lowest adjacent grade, and highest adjacent grade.

**Flood Probability:** The 100-year flood has a 1% probability of occurring during any given year and a 26% probability of occurring during a 30-year period (the length of a standard mortgage). The chart at the right can help with evaluating the benefit of protecting to a particular magnitude flood event. Regardless of the flood protection level you choose, keep in mind that a larger flood is always possible.

**Floodproofing Objectives**
It may be difficult to determine the flood level to which the building should be protected. Regulatory and flood insurance considerations generally favor protection to the 100-year flood elevation with additional freeboard (factor of safety provided by protecting to a higher level). However, if lower portions of a building sustain repeated damage from more frequent flood events, significant benefits can be achieved with a lower level of protection, even though the first floor remains susceptible to the 100-year flood. If you are elevating a building, the incremental cost of raising it a few feet higher may be worthwhile to provide additional protection and to reduce the cost of flood insurance.

The following considerations may be helpful in evaluating floodproofing options
- Compliance with current floodplain development standards requires protection from the 1% probability flood event (Base Flood Elevation for the 100-year flood) with two feet of freeboard. See Floodproofing Info #7: Regulatory Considerations for Floodproofing.
- The cost of flood insurance is generally significantly lower if the elevation of the first floor and the lowest service equipment are above the elevation of the 1% probability flood. (Non-residential structures can be dry floodproofed to this level rather than elevated.)
- If an enclosed area below the finished living space is below grade on all sides or does not have adequate flood vents, it is considered the lowest floor for insurance purposes. Filling a basement or installing flood vents in a crawl space may thus enable significantly lower flood insurance costs.
- Do not rely on a floodproofing technique that requires human intervention if you are not certain that someone will be available and able to implement the needed actions.
- If someone using the building has difficulty with stairs, building accessibility may be a concern.
- Are aesthetics an important consideration?
- How much risk can you tolerate?
- How much money can you invest in “buying down” your risk to a lower level?

---

Selecting Floodproofing Techniques – Technical Considerations

The effectiveness and cost of a floodproofing technique depends on the particular circumstances of the location and the building. Once you have identified those options that are consistent with regulatory requirements, evaluated the flood risks, and considered your floodproofing objectives, the attached floodproofing matrix can be used to evaluate the technical feasibility of the remaining options.  

Instructions

Step 1: Complete the “Regulatory Considerations” row by placing an X in the box for any floodproofing measure that is prohibited or infeasible based on regulatory considerations.

Step 2: In the left column, check the applicable flooding, site, and building characteristics.

Step 3: Place an X in the “Not Advisable” boxes that apply to the characteristics checked (unless there is a plan to engineer a solution to address the specific characteristic). These measures are infeasible.

Step 4: For the remaining measures, review the Special Considerations (below) that correspond to numbers in the rows with checked characteristics. These issues must be accounted for to make the measure applicable. If the consideration cannot be addressed, place an X in the box and eliminate that measure from consideration.

Step 5: The remaining floodproofing measures warrant additional evaluation of technical considerations, preferences, costs, and benefits. A preferred measure should evolve from the evaluation.

Special Considerations

1 – May be prohibited if the project constitutes a substantial improvement in a regulated floodplain.
2 – Technical constraints (and costs) for levees and floodwalls increase for higher flood protection levels.
3 – Fast flood velocity is conducive to erosion; special protective measures may be required.
4 – Flash flooding does not allow time for human intervention. These measures are only feasible if they perform without human intervention. Openings in foundation walls must be large enough to equalize water forces and should not have removable covers. Closures and shields must be permanently in place. Wet floodproofing cannot include last-minute modifications.
5 – A technique that requires human intervention is only feasible if there will be sufficient warning time to implement the emergency plan. Someone must: (1) be aware of the flood threat, (2) get to the site, and (3) implement all required protective measures.
6 – Ice and debris loads should be accounted for in the design of foundations and floodwall/levee closures.
7 – If the floodproofing technique will constitute a new encroachment (obstruction) in the regulatory floodway, a licensed professional engineer must demonstrate that it will not result in any rise in the height of the 100-year flood.
8 – All development in the regulated floodplain must comply with local requirements concerning substantial improvements, use of flood resistant materials, protection against flood damage, etc.
9 – Permeable soils allow seepage under floodwalls and levees; therefore, some type of subsurface cutoff feature would be needed beneath structures. Saturation of permeable soils can also increase soil pressures against a structure, necessitating additional precautions for dry floodproofed structures.
10 – Concrete and masonry buildings and those with slab-on-grade foundations present special difficulties for lifting and moving.
11 – Basement walls are subject to hydrostatic pressure and buoyancy forces, which may make levees, floodwalls, and dry floodproofing inappropriate.
12 – Not advisable unless engineering solution is developed to address the specific constraint.

5 Soil survey information (maps, soil descriptions, and tables) is available at county Soil and Water Conservation Districts and online at http://websoilsurvey.nrcs.usda.gov.
<table>
<thead>
<tr>
<th>Floodproofing Measures</th>
<th>Elevation</th>
<th>On Foundation Walls</th>
<th>On Fill</th>
<th>On Piers, Posts, or Columns</th>
<th>Relocation</th>
<th>Dry Floodproofing</th>
<th>Wet Floodproofing</th>
<th>Levees and Floodwalls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulatory Considerations</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Flood Depth</strong></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>□ Shallow (&lt;3 feet)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>□ Moderate (3-6 feet)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>□ Deep (&gt;6 feet)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Flood Velocity</strong></td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>□ Slow/Mod. (&lt;5 feet per second)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>□ Fast (&gt;5 feet per second)</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>Flash Flooding</strong></td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>□ Yes (&lt; 1 hr warning)</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>□ No</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td><strong>Ice and Debris</strong></td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>□ Yes</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>□ No</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td><strong>Site Location</strong></td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>□ Floodway</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>□ Regulated Floodplain</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td><strong>Soil Type</strong></td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>□ Permeable</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>□ Impermeable</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td><strong>Building Foundation</strong></td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>□ Slab on Grade</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>□ Piers, Posts, Columns, or Crawl Space</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>□ Basement/Split Level</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td><strong>Building Construction</strong></td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>□ Concrete or Masonry</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>□ Wood or Other</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td><strong>Building Condition</strong></td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>□ Good</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>□ Fair</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>□ Poor</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>
Selecting Floodproofing Techniques – Financial Considerations

Floodproofing costs money. Generally, a higher level of flood protection costs more. Prior to selecting a floodproofing method, it is necessary to evaluate the benefits of a proposed project and the anticipated cost of achieving those benefits. The following information can be used as general guidance for evaluating floodproofing options.⁶

Benefits
Floodproofing is principally a means for reducing damages from future floods. This includes the cost of repairing the building and its utility systems, repair or replacement of damaged contents, the time and expense for cleanup, the cost of housing during periods when the structure cannot be occupied, and loss of income if flood cleanup and repairs require time off from work. The tables on the following page can be used to estimate potential damages to buildings and contents based on the depth of flooding. The history of previous damages can also help with this assessment. Keep in mind that the damages from frequent events may be prevented numerous times over the life of the building. Because no floodproofing project can prevent all potential flood damages, the expected project benefit is the difference between the expected damages without the project and the expected damages if the project is implemented.

Additional benefits of floodproofing include:
- **Increased safety:** Floodproofing reduces health and safety impacts associated with reentry into a flooded structure. Relocation away from the flood hazard area precludes the need to evacuate and is thus even safer.
- **Reduced flood insurance premiums:** The cost of flood insurance for buildings that do not comply with floodplain development standards (at the time of construction) is generally quite high. Actuarial rates are based on the height of the first floor (or dry floodproofing of non-residential buildings) relative to the height of the 100-year flood. A project that brings a building into compliance and/or increases the level of protection can significantly reduce the annual cost of flood insurance.
- **Increased resale value.**
- **Intangible benefits** result from reducing the annoyance, inconvenience, and stress associated with preparation for and recovery from flood events.

Project Costs
General information about construction costs for retrofitting projects is provided on the following pages. These values are only appropriate for preliminary planning purposes. Once a floodproofing method has been selected and the project is designed, a more accurate cost estimate can be developed. Make sure that the detailed cost estimate includes all of the project elements, such as temporary housing during construction, landscaping, and annual maintenance expenses.

---

Depth-Damage Tables
The following tables can be used to estimate the damage that may be sustained each time a building is flooded, based on the depth of flooding relative to the top of the first floor (excluding the basement, which is defined as any portion of the building with its floor below grade on all sides).

### Contents Damage Percent by Building Type
(based on total value of contents)

<table>
<thead>
<tr>
<th>Flood Depth</th>
<th>1 Story without Basement</th>
<th>2 Story without Basement</th>
<th>Split Level without Basement</th>
<th>1 or 2 Story with Basement</th>
<th>Split Level with Basement</th>
<th>Mobile Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>14</td>
<td>8</td>
<td>5</td>
<td>17</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>1</td>
<td>21</td>
<td>14</td>
<td>14</td>
<td>23</td>
<td>24</td>
<td>66</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>20</td>
<td>20</td>
<td>30</td>
<td>29</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>41</td>
<td>27</td>
<td>38</td>
<td>35</td>
<td>33</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>44</td>
<td>30</td>
<td>41</td>
<td>42</td>
<td>41</td>
<td>90</td>
</tr>
<tr>
<td>5</td>
<td>45</td>
<td>33</td>
<td>42</td>
<td>50</td>
<td>48</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>60</td>
<td>36</td>
<td>50</td>
<td>57</td>
<td>53</td>
<td>90</td>
</tr>
<tr>
<td>7</td>
<td>65</td>
<td>39</td>
<td>51</td>
<td>66</td>
<td>54</td>
<td>90</td>
</tr>
<tr>
<td>8</td>
<td>66</td>
<td>44</td>
<td>62</td>
<td>74</td>
<td>66</td>
<td>90</td>
</tr>
<tr>
<td>&gt;8</td>
<td>68</td>
<td>50</td>
<td>65</td>
<td>77</td>
<td>72</td>
<td>90</td>
</tr>
</tbody>
</table>

Floodproofing Cost Estimates
The following cost estimates are for preliminary planning purposes only. They are based on nationwide averages and published in 2001.\(^7\)

Elevation:
2-foot raise:  Wood frame building with basement or crawlspace – $18 per square foot
               Wood frame building with slab-on-grade foundation – $50 per square foot
               Masonry building with basement or crawlspace – $37 per square foot
               Masonry building with slab-on-grade foundation – $50 per square foot
3- to 8-foot raise – add $0.80 per square foot for each additional foot of elevation
Above 8 feet – add $1.05 per square foot
Wood frame with brick veneer on walls – add 10 percent

These costs include foundation, existing utilities, and miscellaneous items. Large buildings (3 or more stories and those with footprints more than 2,500 square feet) and those with complex shapes are technically more difficult to elevate and may thus be more costly.

Displacement costs – Additional expenses will be incurred to remove and store contents and for temporary living quarters during construction, which may last 2 to 3 weeks.

Relocation:
Relocation costs:  Wood frame building with basement – $34 per square foot
                  Wood frame building with crawlspace – $29 per square foot
                  Wood frame building with slab-on-grade foundation – $54 per square foot
                  Masonry building with basement – $52 per square foot
                  Masonry building with crawlspace – $34 per square foot
                  Masonry building with slab-on-grade foundation – $65 per square foot
Wood frame with brick veneer on walls – add 10 percent
Restoration of old site:  $12 per square foot of building footprint

These costs include off-site relocation (less than 5 miles) and new site development for a 1,000 square foot building. Extrapolation of this unit cost to larger buildings may result in artificially high estimates because the costs of relocation do not increase proportionally with building size. However, if the building has 3 or more stories, a footprint greater than 2,500 square feet, or a complex shape, technical challenges may result in increased costs.

Displacement costs – Additional expenses will be incurred to remove and store contents and for temporary living quarters during construction, which may last 3 to 4 weeks.

Dry Floodproofing
Sprayed-on cement (above grade) – $3.50 per square foot
Waterproof membrane (above grade) – $1.17 per square foot
Asphalt (2 coats below grade; not including cost of excavation) – $1.17 per square foot
Perimeter drainage – $33 per linear foot
Plumbing check valve – $660 lump sum
Sump pump (with backup battery) – $1,060 lump sum
Metal flood shield – $77 per square foot
Wood flood shield – $24 per square foot
Sprayed-on cement (above grade) – $3.50 per square foot

Wet Floodproofing
Unfinished basement: 2 feet height (above basement floor) – $1.80 per square foot of house footprint
   4 feet height (above basement floor) – $3.70 per square foot of house footprint
   8 feet height (above basement floor) – $10.60 per square foot of house footprint
Crawlspace: 2 feet height (above lowest adjacent grade) – $1.40 per square foot of house footprint
   4 feet height (above lowest adjacent grade) – $3.45 per square foot of house footprint

Floodwalls and Levees
Floodwalls: 2 feet above ground level – $90 per linear foot
   4 feet above ground level – $132 per linear foot
Levees: 2 feet above ground level – $39 per linear foot
   4 feet above ground level – $73 per linear foot
   6 feet above ground level – $122 per linear foot
Interior drainage – $4,500 lump sum
Closures – $77 per square foot
Riprap – $33 per cubic yard
Seeding of disturbed areas – $0.05 per square foot

Floodwall costs are based upon typical foundation depth of 30 inches. Levee costs are based upon typical foundation depth of one foot, 5-foot top width, and 1:3 side slopes. Levee costs include seeding and stabilization.

Additional Costs
- Compliance with building codes – These estimates do not include additional expenditures that may be required to bring the building into compliance with building codes.
- Professional or architectural design – 10% of estimated costs
- Contractors’ profit – 10% of estimated costs
- Contingency to account for unknown or unusual conditions
- Annual maintenance expenses – Levees, floodwalls, dry floodproofing, and wet floodproofing projects all require ongoing maintenance.

Additional Information
- FEMA’s Benefit-Cost Analysis methodology and tools can be used to evaluate the cost effectiveness of proposed retrofitting projects ([http://www.fema.gov/government/grant/bca.shtm](http://www.fema.gov/government/grant/bca.shtm)).
Floodproofing Resources

Information about Multiple Floodproofing Techniques

- Homeowner’s guide to Retrofitting: Six Ways to Protect Your House from Flooding, FEMA 312 (1998), [http://www.fema.gov/library/viewRecord.do?id=1420](http://www.fema.gov/library/viewRecord.do?id=1420) – information about floodproofing options and guidance to help in decision making; designed for readers who have little or no knowledge about flood protection methods or building construction techniques

- Repairing Your Flooded Home, FEMA 234 (1992), [http://www.fema.gov/library/viewRecord.do?id=1418](http://www.fema.gov/library/viewRecord.do?id=1418) – advice on post-flood cleanup and repair; includes recommendations for rebuilding using techniques that reduce future damage

- Flood Proofing: How to Evaluate Your Options, U.S. Army Corps of Engineers (1993), [https://www.nwo.usace.army.mil/nfpc/fphow/ace8.htm](https://www.nwo.usace.army.mil/nfpc/fphow/ace8.htm) – information to assist with determining whether or not floodproofing is appropriate and which technique is the best measure to consider; includes a benefit/cost analysis technique


Flood Resistant Materials and Construction

- Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas, Technical Bulletin 2, FEMA FIA-TB-2 (2008), [http://www.fema.gov/library/viewRecord.do?id=1580](http://www.fema.gov/library/viewRecord.do?id=1580) – information about requirements for flood-damage resistant materials and a table describing five classes of building materials ranging from those that are highly resistant to floodwater damage to those that have no resistance to flooding

- Flood-Resistant Design and Construction, American Society of Civil Engineers (ASCE) 24-05, purchase at [www.asce.org](http://www.asce.org), highlights available at [http://www.fema.gov/library/viewRecord.do?id=3515](http://www.fema.gov/library/viewRecord.do?id=3515) – ASCE 24 is a referenced standard in the NYS Residential and Building Codes. It includes standards for resisting flood loads and flood damage and for dry floodproofing of nonresidential buildings
Elevation and Relocation of Buildings
- **Above the Flood: Elevating Your Floodprone House**, FEMA 347 (2000), [http://www.fema.gov/rebuild/recover/fema347.shtm](http://www.fema.gov/rebuild/recover/fema347.shtm) – description of alternative techniques that can be used to elevate existing floodprone buildings and case studies of homes in south Florida that were elevated above the 100-year flood level following Hurricane Andrew
- **Raising and Moving the Slab-on-Grade House with Slab Attached**, U.S. Army Corps of Engineers (1990), [https://www.nwo.usace.army.mil/nfpc/fpslab/ace2.htm](https://www.nwo.usace.army.mil/nfpc/fpslab/ace2.htm) – description of the steps taken to raise and relocate a slab-on-grade structure

Dry Floodproofing
  - Add Waterproof Veneer to Exterior Walls
  - Dry Floodproof Your Building

Wet Floodproofing

Protecting Utilities and Equipment
  - Protect Wells from Contamination by Flooding
  - Install Sewer Backflow Valves
  - Raise or Floodproof HVAC Equipment
  - Anchor Fuel Tanks
  - Raise Electrical System Components
  - Build with Flood Damage Resistant Materials
Floodproofing Resources


Flood Vents


Floodplain Management

- **Southern Tier Central Regional Planning and Development Board** has developed fact sheets and forms to assist with regulation of floodplain development. These and other flood risk information are available at [http://www.stcplanning.org/index.asp?pageId=108](http://www.stcplanning.org/index.asp?pageId=108). Fact sheets are:
  - Floodplain Facts #1: Floodplain Development
  - Floodplain Facts #2: Non-Building Floodplain Development
  - Floodplain Facts #3: Modifications to Existing Floodplain Structures
  - Floodplain Facts #4: Residential Structures in the Floodplain
  - Floodplain Facts #5: Non-Residential Structures in the Floodplain
  - Floodplain Facts #6: Manufactured Homes, Recreational Vehicles, and Trailers in the Floodplain
  - Floodplain Facts #7: Accessory Structures and Garages in the Floodplain
  - Floodplain Facts #8: Enclosed Areas Below the Flood Protection Level
  - Floodplain Facts #9: Flood Resistant Design
  - Floodplain Facts #10: Floodplain Development in Approximate A Zones
  - Floodplain Facts #11: Development in Areas of Shallow Flooding
  - Floodplain Facts #12: Floodway Encroachments
  - Floodplain Facts #13: Floodplain Variances

Certificates


Additional Resources

- **FEMA’s Benefit-Cost Analysis** methodology and tools are used to evaluate cost effectiveness for grant applications ([http://www.fema.gov/government/grant/bca.shtm](http://www.fema.gov/government/grant/bca.shtm)).
- **National Nonstructural / Flood Proofing Committee** supervises research and provides technology transfer on floodproofing techniques ([https://www.nwo.usace.army.mil/nfpc](https://www.nwo.usace.army.mil/nfpc)).