# Chapter 4
# Flood Risk Management

## Contents

# Tables



# Figures

# 1.0 Introduction

This chapter addresses programs and policies adopted by the Urban Drainage and Flood Control District (UDFCD) to manage flood risks and reduce potential losses from flood events. This chapter also provides guidance for specific physical measures that can be implemented to help protect individual structures from flood damage.

Flood risk management includes all of the activities that the public and private sector can employ to reduce risk to individuals, structures, and communities from flooding. It includes master planning; floodplain management; design, construction and maintenance of flood management facilities; acquisition and relocation of structures at risk; floodplain preservation (including natural and beneficial functions); flood insurance; floodproofing; public information and awareness; flood warnings and preparedness; self-help; best management practices (BMPs); and green infrastructure. UDFCD pursues all of these activities to varying degrees. The theme of flood risk management is integrated throughout the Urban Storm Drainage Criteria Manual (USDCM), from key principles and policies in the *Drainage Policy* Chapter to guidance on master planning in the *Planning Chapter*, to criteria for designs in the *Open Channel* Chapter and others. The purpose of this chapter is to provide guidance on flood risk management topics not addressed in other portions of the USDCM. This chapter should be used in conjunction with the flood risk management policies, guidance and criteria in other portions of the USDCM.

**UDFCD's Approach to Floodplain Management**

Historically, development has encroached into floodplains, constricted floodways, impacted ecological integrity, and removed the natural character of riparian corridors. In recent years, enlightened developers have recognized the value of preserving floodplain, wetland, and riparian areas in general. This offers the opportunity to establish the character of the new development and offer amenities that are components of livable communities and healthy economies. UDFCD therefore advocates the following approach:

- Preserve floodplain and riparian systems to the greatest extent possible,
- Mitigate the effects of watershed urbanization with stream stability techniques, and
- Restore degraded and damaged stream systems.

A key component of flood risk management is the National Flood Insurance Program (NFIP), which was created in 1968 when Congress passed the National Flood Insurance Act. The NFIP is administered at the federal level by the Federal Emergency Management Agency (FEMA). UDFCD works closely with FEMA through its Cooperating Technical Partners (CTP) program.

Local, state, and federal governments and private insurance companies all have important roles related to the goals and objectives of the NFIP. The role of participating communities is especially important and is given special attention in this chapter. Communities (i.e., city, county, or other local governments) are eligible for federally-backed flood insurance if they have the statutory authority to adopt and enforce floodplain regulations and participate in the NFIP, and if they adopt the NFIP's minimum requirements, which include regulating development in mapped floodplains. Only when a community carries out its floodplain ordinance responsibilities can residents and property owners obtain flood insurance. UDFCD encourages all communities to participate in the NFIP and, currently, all of the communities within the UDFCD boundary that have mapped floodplains are participants.

This chapter provides a general overview of both preventive and corrective measures for mitigating flood risks. Topics addressed include:

- Floodplain management fundamentals, including definitions, key policies, and key strategies,
- Flood Hazard Area Delineation (FHAD) studies by UDFCD,
- Flood Insurance Rate Maps (FIRMs) and revision methods, such as Conditional Letters of Map Revision (CLOMRs), Letters of Map Revision (LOMRs), and others,
- The relationship between FHADs and FIRMs,
- Flood insurance,
- Floodplain regulations, and
- Floodproofing guidance.

A glossary of flood risk management terms is provided at the end of the chapter.

**Ribbons of Green**

Stream corridors and adjacent riparian zones are not geographically large; however, their environmental importance is immense. "Riparian areas comprise less than one percent of the land area in most western states, yet up to 80 percent of all wildlife species in this region of the country are dependent upon riparian areas for at least part of their life cycles." (Congressional Testimony of Robert Wayland, EPA, June 26, 1997). Riparian areas are often called "ribbons of green", reflecting the contrast with the otherwise dry landscape of the arid west. Agricultural and land development activities have resulted in loss or significant degradation of 75 to 95 percent of this invaluable habitat. Development projects have the opportunity to preserve, protect, and utilize stream corridors and adjacent riparian areas. In fact, increased urban runoff often results in sustained base flows in streams that were ephemeral in the pre-development condition.

**Natural and Beneficial Functions of Floodplains**

The low banks adjacent to streams are infrequently occupied by floodwaters. During a flood event, these overbank areas serve an important function in moderating peak discharges and velocities, and filtering out sediment and debris. The natural and beneficial functions of floodplains can be summarized as follows:

Flow conveyance - Floodplains have the capacity to store and convey floodwaters, thus diminishing floodwater velocities and reducing flood damages and erosion.

Soil fertility - Soil fertility is increased as periodic floodplain inundation replenishes nutrients in the surrounding soils.

Biodiversity - Floodplains enhance biodiversity, providing breeding and feeding grounds for fish and a wide variety of wildlife including endangered species.

Water quality - Floodplains improve water quality and quantity by providing areas of groundwater recharge, while also filtering impurities and nutrients.

# 2.0 Floodplain Management Fundamentals

## 2.1 Basic Definitions

In order to understand floodplain management, some of the key terms defined by and used throughout the NFIP are provided below. Additional terms are defined in a glossary at the end of this chapter. Much of the information provided here can also be found on the websites for FEMA (http://www.fema.gov) and the United States Army Corps of Engineers' (USACE) National Flood Risk Management Program (http://www.nfrmp.us/).

### 2.1.1 Floodplain

A floodplain is any land area susceptible to being inundated by flood waters from any sources. Most floods fall into one of three

categories: 1) riverine flooding, 2) shallow flooding, and 3) coastal flooding (not relevant within UDFCD). Riverine flooding is the most common along the Front Range of Colorado, and includes flash floods, which can occur in urban areas where impervious surfaces, gutters and storm sewers generate and convey runoff at a rate that exceeds the capacity of the receiving stream. Floodplain boundaries (i.e., the area inundated during a flood) typically are determined based on the peak runoff rate generated during a specific, design-storm event (see below).

### 2.1.2 100-year Flood/Base Flood

The 100-year flood has a 1 percent chance of occurring in any given year (Annual Exceedance Probability [AEP] = 0.01) and is referred to as the base flood by FEMA. The base flood is used by the NFIP for the purpose of requiring the purchase of flood insurance and regulating development. It should also be noted that the 100-year floodplain is an estimation of flood limits produced from a model that includes a large number of variables. At the same time, there are also variables that are not typically considered in this determination such as debris and mud flow, changes in vegetation, potential embankment failures (where present), and other "what if" scenarios. Determining the limits of flooding during this event draws a line which can be regulated. Those within "the line" and who don't own their home are required to buy flood insurance. Those who do own their home or who may be just beyond "the line" are not required to buy flood insurance. In reality, limits of flooding associated with this event frequently include homes beyond the mapped floodplain which means that structures close to a stream, even those outside the mapped area of flooding are still at risk. UDFCD recommends providing 18 inches or more of freeboard for new development projects to account for debris flow, aggradation, and changes in vegetation, as these cannot be considered when determining the regulatory floodplain.

**Photograph 4-1**. Colorado flooding in September of 2013 forced hundreds, many of them outside of mapped floodplains, out of their homes.

**Properties Outside of the Mapped Floodplain are still at Risk**

"More than 17 percent of homes destroyed or damaged in four of the counties hardest-hit by the September Floods in Colorado–Weld, Larimer, Boulder, and Logan, were NOT in the floodplain" (Brown and Crummy). Flood insurance outside of the floodplain can be purchased at a relatively low cost.

### 2.1.3 Base Flood Elevation

The base flood is used by the NFIP as the basis for mapping, insurance rating, and regulating new construction. The base flood elevation (BFE) is the computed elevation of the water surface during the base flood. BFEs are published in Flood Insurance Studies (FISs) and on FIRMs for Special Flood Hazard Areas (SFHAs) that have been identified as high-risk flooding zones and have consequently been studied in detail. BFEs are used by governmental agencies, insurance agencies, engineers, and others to manage development and determine property owners' risk to flooding.

### 2.1.4 Special Flood Hazard Area and Floodplain Zones

The base floodplain (1 percent chance of flood) is referred to as the SFHA on NFIP maps, otherwise known as FIRMs. The SFHA can have any of several designations (e.g., Zone A, AE, A1-30, AO, AH, V, VE or V1-30), depending on the flood data available, the severity of the flood hazard, and/or the age of the flood map (see Table 4-1 for definitions of different flood zones). In addition to the SFHA, Shaded Zone X areas also exist, which are generally areas that are outside of the 100-year floodplain, areas inundated with less than one foot of water during the 100-year flood, or areas that are within the 500-year floodplain. Unshaded Zone X areas are typically areas outside of the 500-year floodplain. The SFHA is the area, at a minimum, where NFIP floodplain regulations must be enforced by a community if it is a participant in the NFIP. The SFHA is also the area where mandatory flood insurance purchase requirements apply. Detailed definitions for flood zones can also be found on FEMA's website.

**Table 4-1. FEMA Flood Zone Definitions**

| **MODERATE TO LOW RISK AREAS** | |
|---|---|
| **Zone** | **Description** |
| **B and X (shaded)** | Area of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods. Are also used to designate base floodplains of lesser hazards, such as areas protected by levees from 100-year flood, or shallow flooding areas with average depths of less than 1 foot or drainage areas less than 1 square mile. |
| **C and X (unshaded)** | Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level. |
| **HIGH RISK AREAS** | |
| **Zone** | **Description** |
| **A** | Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas, no depths or base flood elevations are shown within these zones. |
| **AE** | The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones. |
| **A1-30** | These are known as numbered A Zones (e.g., A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format). |
| **AH** | Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones. |
| **AO** | River or stream flood hazard areas, and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones. |
| **AR** | Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam). Mandatory flood insurance purchase requirements will apply, but rates will not exceed the rates for unnumbered A zones if the structure is built or restored in compliance with Zone AR floodplain management regulations. |
| **A99** | Areas with a 1% annual chance of flooding that will be protected by a federal flood control system where construction has reached specified legal requirements. No depths or base flood elevations are shown within these zones. |
| **UNDETERMINED RISK AREAS** | |
| **Zone** | **Description** |
| **D** | Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk. |

**Notes:** Definitions for high risk coastal zones are not provided here because they are not relevant to areas within the UDFCD boundary.

Flood Insurance Rate Maps relevant to areas within the UDFCD boundary have all been updated with the new flood zone nomenclature, so Zones A1-30 no longer exist on these FIRMs.

### 2.1.5 Floodway and Flood Fringe

Where a detailed study has been conducted, the floodplain includes two main components: 1) the regulatory floodway and 2) the flood fringe. In most waterways, the floodway is where the water flow is deepest and most rapid; within Colorado, it is the area that must be reserved (kept free of obstructions) in order to discharge the base flood without increasing 100-year water surface elevations more than 0.5-foot. In addition to the 0.5-foot surcharge, provide a minimum of one foot of freeboard above 100-year water surface elevations as shown on Figure 4-1.

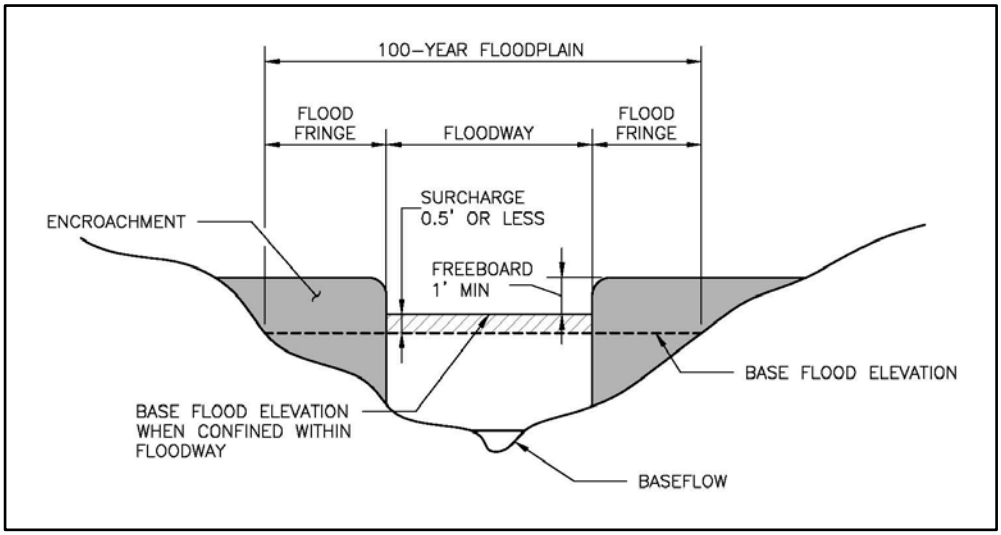


**Figure 4-1. Floodway and flood fringe**

Floodway boundaries are determined through the use of computer modeling. The flood fringe is the area located outside of the designated floodway but within the floodplain boundary. In contrast to the floodway, where no development is allowed, minimum NFIP regulations allow development within the flood fringe, though some communities adopt stricter regulations and restrict development within the flood fringe. The local floodplain administrator within a particular community can provide details about specific regulations pertaining to whether any development is allowed within the 100-year flood fringe.

### 2.1.6 Community Rating System (CRS)

The CRS program provides reductions in flood insurance premium rates based on a community's floodplain management activities. Communities that implement activities above and beyond the minimum requirements of the NFIP are eligible to receive reductions of up to 45 percent for flood insurance premiums. The reduction in rates is a reflection of reduced flood risks within the community. The voluntary program helps to reduce flood risks to insurable properties, strengthens insurance aspects of the NFIP, and encourages a comprehensive approach to floodplain management. UDFCD encourages communities to participate in the CRS program, and by doing so, citizens have an opportunity to benefit from the perspectives of both reduced flood risk and economics. Credits are provided for a variety of community flood protection activities.

### 2.1.7 CRS Credits

As a community accrues more points for implementing floodplain management activities, its CRS Class rating improves, corresponding to increasingly higher insurance discounts for its citizens. Points are awarded for engaging in any of 18 creditable activities, which fall under one of the following categories: 1) Public information; 2) Mapping and regulations; 3) Flood damage reduction; and, 4) Flood preparation.

In addition to lower flood insurance rates, there are several benefits of the CRS program:

- Increased opportunities for citizens and owners to learn about flood risk relative to their properties and businesses and how to better protect themselves,
- Enhanced public safety,
- Reduced damage to property,
- Decreased economic loss,
- Technical floodplain management activities are made available to community officials at no charge in some cases, and
- Incentives to maintain flood programs.

### 2.1.8 CRS Application Process

For a community to apply for CRS participation, their first step is to inform FEMA of their interest in applying. A CRS application must then be submitted, with documentation showing the activities the community is seeking credit for. The application, along with the floodplain activities for which the community is seeking credit, will be reviewed and verified. Once verified, the community, the State, insurance companies, and others will be notified by FEMA of the new credit to be granted.

To learn more about the CRS program, visit http://www.fema.gov/nfip/crs.shtm or contact UDFCD.

### 2.1.9 Flood Insurance Study (FIS)

The FIS is a report published by FEMA by county and issued along with the county FIRM. A FIS is a compilation and presentation of flood risk data for specific watercourses, lakes and coastal flood hazard areas within a community. The FIS contains background information such as the base flood discharges and water surface elevations used to develop the FIRM. The FIS and FIRM together serve as the basis for flood insurance ratings and regulating floodplain development.

## 2.2 Floodplain Management Strategies

In 1972 UDFCD adopted a two-pronged approach consisting of a comprehensive floodplain management program to prevent new problems from being created by new development, while "fixing" existing problems. UDFCD dedicates many resources to the planning, design, construction, and maintenance of projects aimed to fix past mistakes of development and works with FEMA, the Colorado Water Conservation Board (CWCB), and local governments to utilize and enforce floodplain regulations effectively. The two–pronged approach can be described as follows:

- **Floodplain Preservation.** Identify areas of significant natural and beneficial functions relevant to floodplains and manage future development in these areas in a way that preserves these floodplains. Natural and beneficial functions of floodplains include the following:

    1. Floodplains diminish floodwater velocities and reduce flood damages and erosion through their natural characteristics of conveyance and storage.

2. Soil fertility is increased as floodplains naturally replenish nutrients during times of flood inundation.

3. Floodplains improve water quality and quantity by filtering impurities and recharging groundwater.

4. Floodplains provide breeding and feeding grounds for fish and wildlife.

- **Mitigation of Effects of Urbanization.** Work with local governments and developers to manage future development in or near hazardous areas to minimize future flood risks and identify areas potentially subject to flood hazards by mapping the 1% (100-year) floodplain and 0.2% (500-year) floodplain in undeveloped areas. UDFCD encourages the implementation of stream stability and improvement techniques to mitigate the effects of urbanization, such as increases in flood flows, velocities, shear forces and other hydraulic parameters, which can cause erosion and stream decay.

FEMA also identifies key floodplain management strategies for reducing economic losses and reducing losses of beneficial floodplain resources as a result of flooding. Figure 4-2 illustrates how these strategies are applied to reduce flood risk through federal, state, local, and individual efforts. FEMA's four strategies are:

- **Strategy 1**. **Modify human susceptibility to flood damage:** Replace disruption by avoiding hazardous, uneconomic or unwise use of floodplains. This strategy includes policies such as using zoning codes to direct development out of the floodplain; acquiring land in floodplains to preserve open space; and restoring and preserving the natural resources and functions of floodplains.

- **Strategy 2. Modify the impact of flooding:** Assist individuals and communities to prepare for, respond to, and recover from a flood. Actions to implement this strategy include providing information and education to assist communities with flood protection following flood emergency measures during a flood; reducing financial impacts through disaster assistance, flood insurance, and taxes; and preparing recovery plans and programs to help people rebuild.

**Advantages of Sustainable Floodplain Management for Communities**

There are tremendous advantages to communities that encourage a thoughtful approach to development adjacent to natural streams:

- UDFCD assistance in meeting NFIP maintenance responsibilities.
- CRS credits for floodplain preservation.
- Linear recreation corridors.
- Community identification and sense of community that encourages volunteerism.

**Advantages of Sustainable Floodplain Management for Developers**

UDFCD recognizes that development is essential to community building. Good environmental stewardship cannot exist in the absence of a good business process. When the approach to stream corridors turns from overcoming a problem to embracing a resource, the following positive outcomes emerge:

- Lower capital costs,
- Lower operation and maintenance costs,
- Open space credits,
- Multi-use opportunities, including parks and recreation,
- Increased marketing potential,
- Lot premiums adjacent to stream corridors,
- Community character and identification, and
- Neighborhood ownership of the stream corridor.

- **Strategy 3**. **Modify flooding itself:** Develop projects that control floodwater. Projects include dams and reservoirs that store excess runoff from developed areas upstream; creating dikes, levees, and floodwalls around developed areas; altering channels to increase flow capacity; diverting high flows around development; increasing pervious ground covers in developed areas; and developing on-site detention.

- **Strategy 4**. **Preserve and restore natural resources:** Renew the purpose of floodplains by reestablishing and maintaining floodplain environments in their natural state. Policies to implement this strategy include developing land use regulations such as zoning; acquiring land for open space; permanently relocating buildings; restoring floodplains, wetlands, and habitats; educating people on the importance of floodplains as natural resources and how to protect them; and providing financial initiatives for preserving and/or restoring land.

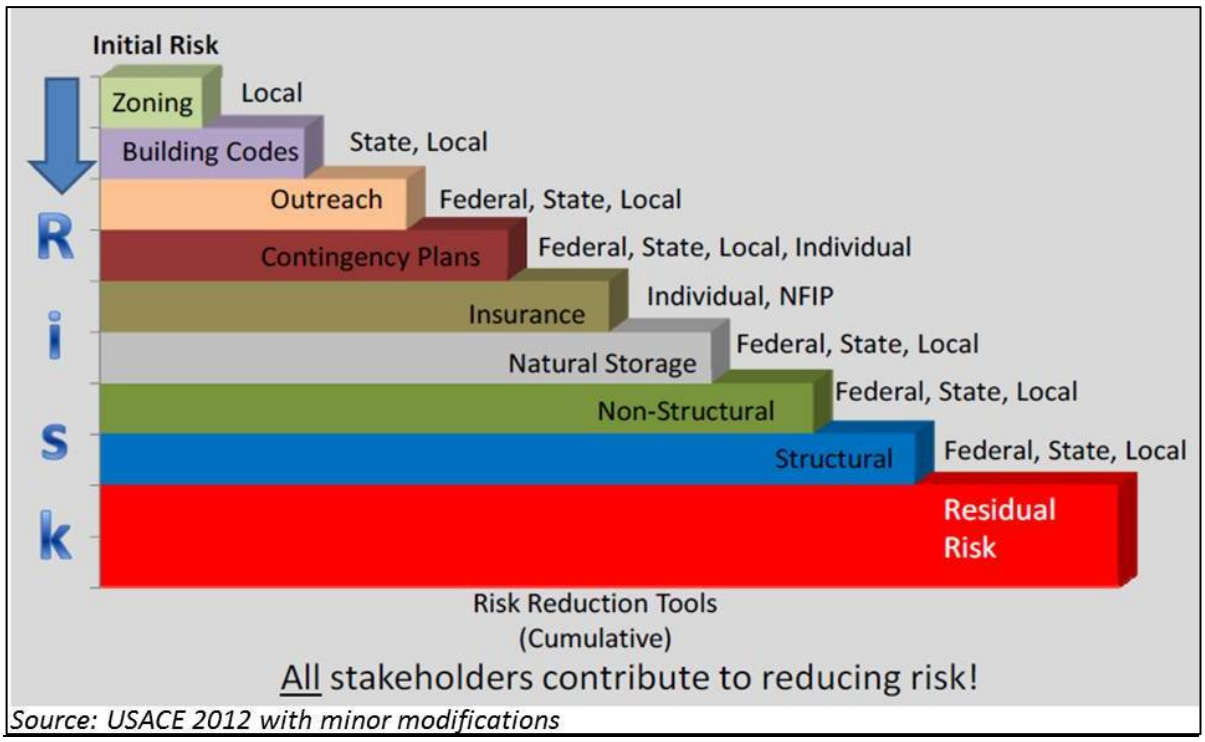


**Figure 4-2. Shared strategies to "buy down" flood risk**

# 3.0 Floodplain Mapping Changes and Administration

## 3.1 Background Information

FHADs and FIRMs are important tools that allow communities to manage floodplains and help to reduce flood risk by regulating development within mapped floodplains. FHADs delineate floodplain areas inundated by the 100-year flood and publish flood profiles for the 100-year flood and other flood frequencies. Hydrologic and hydraulic studies are performed to evaluate changes in watersheds and flood hazard areas. These changes are evaluated, including Master Planning changes which have been implemented, to predict the potential extent of flooding in flood-prone areas. UDFCD offers FHADs to communities within the UDFCD boundary as a tool to help preserve floodplains and reduce the risks of flooding to existing and future development. UDFCD currently does not regulate floodplains based on

FHAD studies, but instead relies on local governments to utilize FHAD mapping in conjunction with other resources to manage and administer floodplain regulations. FHADs often serve as the basis for FEMA FIRMs.

FIRMs show information such as the locations of properties relative to the 100-year floodplain, the type of SFHA zone for a property, the relative 100-year water surface elevations (BFEs), the vertical datum used for the BFEs and more. FIRMs are also used for flood insurance ratings and for making reasonable determinations of required flood insurance. By contrast, FHADs are typically based on contour intervals of two-foot or less (i.e., more precise resolution). For this reason, FHADs should be referenced when conducting localized planning and design.

FHADs are available through the Electronic Data Management (EDM) Map available at www.udfcd.org. The EDM is a user-friendly database that provides access to many resources including FHADs, as-built drawings, design reports, major drainageway planning studies, monument information, outfall systems planning studies, and other special reports. Flood hazard information included on the EDM is based on the best available data although floodplain maps included with the actual FHAD report will provide the most detail with regard to the delineation. While information on the EDM may be more current, it may differ from the official, effective Federal flood hazard information used in the NFIP. The official Federal flood hazard information for a given location needs to be obtained from FEMA. FEMA has a National Flood Hazard Layer (NFHL) that shows all digital flood hazard information for a given location. FEMA updates the NFHL with all approved PMRs and LOMRs.

Effective FIRMs may need to be updated or corrected by FEMA, communities, UDFCD, or individuals. Reasons for revising a floodplain map include:

- Non-flood-related map features (e.g., corporate boundaries) need correction.
- Current, more accurate topography is available and needs to be incorporated.
- Existing flood data, such as base flood elevations or new hydrology, need to be incorporated.
- A flood control project needs to be reflected in the mapping.

It is important to note that many small projects, such as clearing of overgrown vegetation along channels, minor bank stabilization work, and small-scale maintenance activities and projects do not have a measurable effect on the base flood and do not warrant a map change. Requests for map changes should be prepared by an engineer familiar with the FEMA guidelines.

**Cooperating Technical Partner**

The UDFCD Floodplain Management Program is a Cooperating Technical Partner (CTP) with FEMA and was the first CTP in the country. The Floodplain Management Program reviews Letter of Map Change (LOMC) submittals within UDFCD's service area in addition to completing flood insurance map modernization and maintenance projects.

When new map information becomes available to a community, the community is obligated by its agreement with FEMA to submit it as soon as practicable, but not later than six months after the date that the information became available (NFIP Section 65.3). Within the UDFCD boundary, CLOMRs and LOMRs, described in Section 3.3, are currently reviewed by UDFCD, which is a CTP with FEMA.

## 3.2 Types of Regulatory Floodplain Map Changes

Four types of map changes exist related to regulatory floodplains, including:

1. Restudies,
2. Physical Map Revisions (PMRs),
3. Revisions, and
4. Amendments.

Of the four types of map changes, UDFCD typically only administers the third category, map revisions (i.e., CLOMRs and LOMRs), for communities within their boundary. Brief descriptions of the different types of map changes include the following:

**National Flood Hazard Layer (NFHL)**

The NFHL is a computer database that contains the flood hazard map information from Digital Flood Insurance Rate Map (DFIRM) databases and LOMRs. The NFHL provides DFIRM and LOMR data as one integrated dataset. Letters of Map Amendment (LOMAs) and Letters of Map Revision Based on Fill (LOMR-Fs), which are based on property descriptions, are notated with a case number but not shown graphically. An NFHL dataset includes all the digital flood hazard data that are effective and available as of the dataset release date.

NFHL coverage is available in the UDFCD region. The NFHL is available on FEMA's website and can be used with GIS, as well as Google Earth.

**Restudy:** A restudy is a new Flood Insurance Study for a part or all of a community. A restudy may occur in cases where the hydrology (peak flow rates) has changed, perhaps due to increased development, new information, or changed topography. Another example of a restudy is when a community is interested in establishing BFEs along a watercourse located in an approximate or unnumbered Zone A (where BFEs have not previously been defined). UDFCD typically does not conduct restudies unless provided a grant to do so.

**PMR:** A PMR is an action whereby one or more map panels are physically revised and republished. A PMR is used to change flood risk zones, floodplain and/or floodway delineations, flood elevations, and/or planimetric features. A PMR requires the same detailed analysis as a LOMR but typically covers a greater area.

**Revision:** A map revision may be necessary for the following cases:

- A scientifically-based challenge to a published BFE has been confirmed.
- New flood data is available because of a flood control project.
- A physical change has occurred in the floodplain or floodway boundaries.
- New flood data are available.
- Fill has been placed in the floodplain that would change the effective floodplain.

**Amendment:** A map amendment is used to remove a specific property that was inadvertently or incorrectly mapped in the SFHA from the requirement to purchase flood insurance. For example, this can occur because of high ground that is not reflected on the map which delineates the SFHA. Map amendments do not change the SFHA on the FIRM.

## 3.3 Requests for Letter of Map Change

In order to officially revise a FIRM (or DFIRM), a LOMC must be issued by FEMA. A LOMC is a letter which reflects an official revision to an effective NFIP map. There are several types of requests for LOMC that can be submitted to FEMA, two of which are submitted to and reviewed by UDFCD. These are described below:

**CLOMR:** A CLOMR is FEMA's comment on a proposed project that would affect the hydrologic and/or hydraulic characteristics of a flooding source and, consequently, result in the modification of the existing regulatory floodway or effective BFEs. A CLOMR does not revise an effective NFIP map, but rather it indicates whether the project, if built as proposed, would or would not be removed from the SFHA by FEMA if later submitted as a request for a LOMR. A CLOMR becomes effective on the date sent and there is no appeal period. UDFCD reviews CLOMR applications for all areas within its boundary.

**CLOMR-F:** A Conditional Letter of Map Revision Based on Fill (CLOMR-F) is FEMA's comment on whether a proposed project involving the placement of fill would result in an area being removed from the SFHA on the NFIP map. This letter does not revise an effective NFIP map, but indicates whether the project, if built as proposed, would or would not be removed from the SFHA by FEMA if later submitted as a request for a Letter of Map Revision Based on Fill (LOMR-F). The CLOMR-F becomes effective on the date sent. CLOMR-F applications are not reviewed by UDFCD. For a project within the UDFCD boundary, a CLOMR-F application can be sent directly to FEMA for review.

**LOMA:** A LOMA is an official amendment, by letter, to an effective NFIP map. A LOMA establishes a property's location in relation to the SFHA. LOMAs typically remove areas that are inadvertently mapped in the 100-year floodplain. While a LOMA can be used to establish that a specific structure or parcel is not included in the SFHA, LOMAs do not change the delineation of the SFHA on the FIRM. UDFCD does not review LOMA requests; such requests must be submitted directly to FEMA. The map amendment becomes effective on the date of the approval letter sent by FEMA.

**LOMR:** A LOMR is an official revision, by letter, to an effective NFIP map. A LOMR may change flood insurance risk zones, floodplain and/or floodway boundary delineations, planimetric features, and/or BFEs. The letter becomes effective after a 90-day appeal period in addition to the time required to advertise the appeal. UDFCD reviews LOMR applications for all areas within its boundary.

**LOMR-F:** A LOMR-F is an official revision, by letter, to an effective NFIP map. A LOMR-F provides FEMA's determination concerning whether a structure or parcel has been elevated on fill above the BFE and excluded from the SFHA. LOMR-F applications are not reviewed by UDFCD; they must be submitted directly to FEMA. The map amendment becomes effective on the date of the approval letter sent by FEMA. A LOMR-F does not change the SFHA on the FIRM, and is therefore discouraged by UDFCD.

If physical changes to the floodplain have changed the flood hazard information shown on the effective FIRM, a revision must be requested. As soon as practicable, but not later than six months after the date such information becomes available, a community must notify FEMA of the changes by submitting technical or scientific data in accordance with Code of Federal Regulation 44 CFR 65.3. The request must be accompanied by the appropriate portions of the MT-2 application forms package, titled *Revisions to National Flood Insurance Program Maps* (FEMA Form 81-89 Series), along with the required supporting information. Within the UDFCD boundary, UDFCD will review the request on FEMA's behalf. See FEMA's website for all map change forms.

# 4.0 Flood Insurance

The Flood Disaster Protection Act of 1973 added a key requirement to the NFIP. If a community participates in the NFIP, flood insurance is a prerequisite for receiving grants or loans for the purchase of buildings located in a designated floodplain, if the grant or loan is from a federal agency or through a federally-related loan program.

The mandatory flood insurance requirement applies to all forms of federal or federally-related financial assistance for buildings located in SFHAs. The requirement applies to secured mortgage loans from all financial institutions such as lenders, savings and loan institutions, banks, etc., as well as all mortgage loans purchased by Fannie Mae or Freddie Mac.

**Population Growth and Floodplain Management**

Since 1969 the population living within the boundaries of the UDFCD has tripled; however, UDFCD estimates that there are 5,000 fewer structures in mapped 100-year floodplains than there were in 1969. This is due to UDFCD's two-pronged approach to floodplain management of preserving floodplains in areas that have not yet developed and implementing remedial measures where there are existing flood hazards.

## 4.1 Purchasing Flood Insurance

NFIP coverage is available to all owners of eligible property (a building and/or its contents) located in a community participating in the NFIP. Either property owners or renters may insure their property against flood loss. As long as a property is located in a community that participates in the NFIP, it is eligible to have flood insurance, even if the property is not located in a designated floodplain, provided that the building has two or more outside rigid walls, a fully secured roof affixed to a permanent site, and the building is not: 1) located entirely over water, or 2) located principally below ground. Owners of buildings under construction, condominium associations, and owners of residential condominium units in participating communities all may purchase flood insurance. Condominium associations may purchase insurance coverage on a residential building, including all units, and the building's commonly owned contents under the Residential Condominium Building Association Policy (RCBAP). The unit owner may separately insure personal contents as well as obtain additional building coverage under the Dwelling Form as long as the unit owner's share of the RCBAP and the added coverage do not exceed the statutory limits for a single-family dwelling. The owner of any condominium unit in a non-residential condominium building may purchase only contents coverage for that unit.

# 5.0 UDFCD, Local, and State Floodplain Management Programs

As noted in Section 1, a primary component of flood risk management is the NFIP, which is administered at the federal level by FEMA (within the UDFCD boundaries, UDFCD acts as an agent of FEMA). At the state level, floodplain rules and regulations are promulgated by the CWCB, and at the local level, the requirements of the NFIP, at a minimum, are adopted and enforced by communities that participate in the NFIP. Pertinent regulations at the different levels of government are summarized in the following sections.

## 5.1 UDFCD Programs

UDFCD operates four programs, all of which play a role in flood risk management. These programs include:

- The Master Planning Program identifies areas of existing problems, areas that will require

improvements as development occurs in the future and addresses the preparation of conceptual plans for drainage and flood control infrastructure.

- The Floodplain Management Program serves to keep new land development out of floodplains, while emphasizing their natural and beneficial functions.
- The Design, Construction and Maintenance Program corrects existing problems, emphasizing multiple-use opportunities, and maintains structural and non-structural solutions.
- The Information Services and Flood Warning Program provides valuable support to the preceding programs.

This approach to floodplain management has been effective, with the Floodplain Management Program leading preventive efforts and the Design, Construction, and Maintenance Program focusing on remedial efforts. Both of these are supported by the Master Planning and Information Services and Flood Warning Programs.

Descriptions of these programs as they pertain to floodplain management are provided below:

### 5.1.1 Master Planning Program

The Master Planning Program partners with communities within the UDFCD boundary in the development of master plans–Major Drainageway Plans and Outlet System Plans. Master plans are an important tool to help identify remedial flood risk management projects for construction and to guide new land development projects to be consistent with regional drainage and flood control needs. Master plans also provide valuable input to UDFCD's Five Year Capital Improvement Program, and help with the identification and acquisition of rights-of-way for future capital improvements and areas for preservation. The master planning program at UDFCD also promulgates design criteria for use by consultants working on UDFCD projects and those working for a developer.

### 5.1.2 Floodplain Management Program

One of the primary functions of the Floodplain Management Program is to prevent new flood damage potential from being introduced into the 100-year floodplains. This program assists local governments to assure they remain in the NFIP and keep flood insurance available for their citizens. UDFCD also works with FEMA and, since 2001 has received annual grants from FEMA to review requests for Letters of Map Change to FIRMs at the local level. UDFCD also has received several grants from FEMA for map modernization and maintenance.

**"Good Neighbor Policy"**

The UDFCD "Good Neighbor Policy" was passed by the UDFCD Board of Directors in 2011 in recognition of the importance of natural and beneficial functions of streams and floodplains, including trail corridors, parks, recreation, wildlife habitat, flood storage and groundwater recharge. The policy states UDFCD's commitment to preserving and enhancing natural and beneficial functions in all UDFCD programs. The policy includes partnering with local governments and others such as Great Outdoors Colorado and the Trust for Public Land to acquire and preserve areas of significant natural beneficial functions and/or flood hazards. The "Good Neighbor Policy" formalizes approaches that have been developed for many years by UDFCD to sustainably manage streams and floodplains.

In lieu of using its authority to regulate floodplains, UDFCD provides an incentive program, called the Maintenance Eligibility Program (see inset), and works with local governments to implement their own regulations.

The Floodplain Management Program reviews and comments on proposed developments in or near floodplains at the request of local governments. Through this process, developers and local governments are strongly encouraged to follow or implement the appropriate portions of UDFCD master plans. This also provides an opportunity for UDFCD to guide development away from the floodplains and to encourage communities to utilize the natural and beneficial functions of the floodplains as assets to their developments and their communities.

**UDFCD Maintenance Eligibility Programs**

In 1980, UDFCD adopted a Maintenance Eligibility Policy, which states: "Facilities constructed by, or approved for construction by, a local public body as of March 1, 1980, must be approved by the UDFCD in order for these facilities to be eligible for UDFCD maintenance assistance." The Maintenance Eligibility Program is run by the Floodplain Management Program and provides a mechanism for UDFCD to ensure that facilities are built to criteria that both allow for maintenance and provide multi-use benefits and preservation of beneficial natural functions.

With a preference for preservation over channelization or fill, the determination of maintenance eligibility rests with the Floodplain Management Program. The less disruption of the floodplain, the easier it is for the project to be eligible. In many cases, grade control and a maintenance access trail are all that is required to be eligible for maintenance.

### 5.1.3 Design, Construction, and Maintenance Program

The design and construction of master-planned projects are carried out through the Five Year Capital Improvement Plan (CIP). Each year the UDFCD Board adopts a Five Year Capital Improvement Plan which lists projects and UDFCD participation for the next five years. This plan forms the basis for UDFCD participation in design and construction projects. The emphasis of the Design, Construction and Maintenance Program is to provide flood management projects that serve multiple purposes, and to the extent possible, preserve, enhance, or recreate the natural and beneficial functions of the floodplain.

The Design, Construction, and Maintenance Program also provides long term maintenance for projects built by UDFCD, as well as those approved as part of the Maintenance Eligibility Program. This maintenance includes routine efforts such as debris removal and management of the vegetation, as well as long term structural repairs as needed for drainage facilities.

### 5.1.4 Information Services and Flood Warning Program

The Information Services and Flood Warning Program was established to enhance flood warning capabilities within the UDFCD region and consolidate and make available pertinent information. The Flood Warning Program assists local governments in developing flood warning plans and installing and maintaining automated flood detection networks. In addition, UDFCD contracts with a meteorological service to provide local governments with early predictions of flood potential and to warn them as flood threats become more imminent. Daily forecasts and real-time data are available from UDFCD's website. This UDFCD Program includes a number of vital multi-program support functions such as: developing, operating and maintaining UDFCD's Geographic Information System (GIS). GIS is used extensively for DFIRM production and maintenance, tracking projects for maintenance eligibility, design and

construction projects, routine and restorative maintenance projects, flood threat recognition and warning decision support, data sharing, regional mapping initiatives, and other applications.

## 5.2 Local Floodplain Regulations

For the purposes of the NFIP, a community is a political entity that has the authority to adopt and enforce a floodplain ordinance for the area under its jurisdiction. The participating communities in the NFIP carry out floodplain administration at the local level. Communities can benefit from both FEMA programs and UDFCD programs, as described below.

### 5.2.1 FEMA Programs for Participating Communities

There are two key FEMA programs for participating communities:

**Community Rating System (CRS):** The CRS is a voluntary program established by the NFIP to assist communities that want to reduce flood insurance premium rates based on a community's floodplain management activities. Communities that implement activities above and beyond the minimum requirements of the NFIP are eligible to receive reductions in rates of up to 45 percent for flood insurance premiums for properties within the community. Credits are provided for a variety of community flood protection activities (ASFPM 2009).

**Community Assistance Program (CAP):** (FEMA 480) CAP is a FEMA program that funds state activities which help communities that participate in the NFIP. States participating in the NFIP are eligible for CAP federal funding assistance. CAP is intended to help states identify, prevent and resolve floodplain management issues in participating communities prior to a flood occurring (ASFPM 2009).

## 5.3 State Floodplain Rules and Regulations

Rules and regulations for regulatory floodplains in the State of Colorado are designated and approved by the CWCB, which is part of the Department of Natural Resources (DNR). In general, the purpose of the Colorado rules are to provide uniform standards for regulatory floodplains in Colorado and to provide standards for activities that may impact regulatory floodplains.

The Colorado rules also assist the CWCB and communities with the development of floodplain management practices that are sound and that facilitate implementation of the NFIP. The Colorado rules apply throughout the state, regardless of whether a community participates in the NFIP. The rules also apply to activities conducted by state agencies and to federal activities that are fully or partially financed

**Useful Links for Federal Floodplain Regulations**

Code of Federal Regulations
44 CFR, Parts 59, 60, 65 and 70 http://ecfr.gpoaccess.gov

NFIP
Information and links on multiple aspects of the NFIP http://www.fema.gov/business/nfip

FEMA Map Service Center
Flood Insurance Rate Map information http://www.fema.gov/national-flood-insurance-program/map-service-center

by state funds, or for projects or studies for which the CWCB has made a loan or grant (DNR 2010).

The most recent version of the rules and regulations for Colorado was adopted on November 17, 2010 and became effective on January 1, 2011. The revised Colorado floodplain rules and regulations include 20 rules. Obtaining the complete version of these rules from CWCB website (http://cwcb.state.co.us/legal/Pages/Rules.aspx) is recommended. A few key aspects of these rules include the following:

**Critical Facilities:** The revised Colorado rules have special requirements for Critical Facilities regarding development in floodplains (see inset).

**Standards for Regulatory Floodways:** In cases where floodways are to be delineated through physical map revisions involving local government participation, communities shall delineate floodways for the revised reaches based on a 0.5-foot rise criterion. (Note: This is a change from the previous rules, which based floodways on a 1-foot rise criterion. For the definition of "floodway," see the Glossary at the end of this chapter.)

**Criteria for Determining the Effects of Flood Control Structures on Regulatory Floodplains:** If a publicly operated and maintained structure is specifically designed and operated either in whole or in part for flood control purposes, its effects shall be taken into consideration when delineating the floodplain below such structure. If a structure is not specifically designed and operated for flood control purposes (e.g., such as a roadway embankment), then its effects shall not be taken into account, even if it provides inadvertent flood routing capabilities that reduce the 100-year flood downstream. In addition, the CWCB recommends that irrigation facilities (including, but not limited to, ditches and canals) not be used as stormwater or flood conveyance facilities, unless specifically approved and designated by local governing jurisdictions and approved by the irrigation facility owners.

**Critical Facilities – Floodplain Regulation**

Critical Facilities in Colorado are subject to special requirements regarding their location within regulatory floodplains. Critical Facilities generally consist of the following categories (refer to the state regulations for detailed descriptions):

**Essential Services:** These include police and fire stations, hospitals, emergency shelters, communication hubs (e.g., telephone, broadcasting, etc.), public utility plants, and air transportation lifelines (airports, helicopter pads, air traffic control centers). Wastewater treatment plants, water treatment plants and hydroelectric facilities are specifically exempt from this category.

**Hazardous Materials:** Facilities that produce or store highly volatile, flammable, explosive, toxic and/or water-reactive materials are in this category. Examples include chemical plants, pharmaceutical manufacturing facilities, certain laboratories, refineries, hazardous waste and disposal sites, and above-ground gasoline storage or sales centers.

**At-Risk Populations:** Examples of facilities with at-risk populations include nursing homes, day care and assisted living for 12 or more individuals, pre-schools, and K-12 schools.

**Vital to Restoring Normal Service:** Facilities in this category include government operation (such as courts, jails, building permitting, and maintenance facilities) and essential structures for public colleges and universities (dormitories, office and classrooms).

The local jurisdiction having land use authority has the responsibility of identifying Critical Facilities in a community. Key components of the Critical Facility regulations include: 1) communities are encouraged to limit development of Critical Facilities within the 500-year floodplain, where possible, 2) all new and substantially changed critical facilities located within the 100-year floodplain shall have 2 feet of freeboard (instead of 1 foot), and 3) ingress and egress for new critical facilities shall have continuous non-inundated access for evacuation and emergency services.

**Criteria for Determining the Effects of Levees on Regulatory Floodplains:** Both UDFCD and CWCB discourage the use of levees for property protection, flood control, and flood hazard mitigation, unless other mitigation alternatives are not viable. Levees should not be constructed for the primary purpose of removing undeveloped lands from mapped floodplain areas for the purposes of developing those lands because of the potential impairment of the health, safety, welfare and property of the people. Design and construction of levees identified for this purpose are not eligible for UDFCD maintenance or for CWCB grants or loans. The Rule also provides requirements for mapping areas protected by levees, levee maintenance, ownership, freeboard, interior drainage, human intervention and operation, and analysis.

**Recommended Activities for Regulatory Floodplains:** The CWCB lists numerous floodplain management activities and actions to increase a community's overall level of flood protection. These suggestions include, but are not limited to, the following practices:

- Adopting local standards above and beyond the FEMA and CWCB minimum requirements,
- Enrolling in the NFIP and the Community Rating System programs,
- Developing early warning flood detection systems,
- Educating real estate and lending professionals about state and federal requirements,
- Advising the public that floods greater than the 100- and 500-year events do occur, and
- Prohibiting the construction of new levees that are intended to remove land from a regulatory floodplain for the purpose of allowing new development to occur.

# 6.0 Floodproofing

## 6.1 Definition of Floodproofing

Floodproofing is any combination of structural or nonstructural changes or adjustments incorporated in the design, construction, or alteration of individual buildings or properties that will reduce damage from flooding.

## 6.2 Scope of Floodproofing Guidance Provided

The primary focus of this section is on floodproofing commercial, institutional and critical facilities (public works projects). This section is not intended to address residential floodproofing.

For general guidance on residential floodproofing measures, FEMA has prepared the "Homeowner's Guide to Retrofitting," available online at: http://www.fema.gov/library/viewRecord.do?id=1420. Avoidance of development in floodplains is the preferred approach for flood risk management for residential development.

## 6.3 Typical Causes of Flooding

Flooding in the UDFCD region typically results from heavy rains during the spring and summer months. Intense rainfall can lead to flooding and, in general terms, is exacerbated by increased impervious cover associated with urban development. Typical causes of flooding are described in the following sections.

### 6.3.1 Inadequate Street Conveyance

As discussed in the *Street, Inlets, and Storm Drains* chapter, the minor drainage system should be designed to convey flows generated by storms ranging between the 2-year and 10-year event. Over time, the street conveyance capacity can be diminished by pavement overlays that reduce the gutter depth and alter the design slopes. As a result, even during minor storms, water can pond or exceed the gutter capacity and result in localized flooding.

### 6.3.2 Inadequate Storm Drain Conveyance

Older sections of the metropolitan area have storm drain systems that were constructed prior to the development of current drainage criteria. In many cases, capacity is limited to the 2-year, or more frequent, design storm. A less frequent storm event, such as the 5-year event, has larger flows and could cause surcharging in the storm drains and the occurrence of localized flooding.

### 6.3.3 Inadequate Channel Conveyance

Prior to the development of current floodplain and drainage criteria, development often encroached on natural streams which resulted in reduced conveyance capacity. Overbank flooding is the most dangerous type because of the combination of velocity and depth of floodwaters. Adherence to a community's floodplain requirements is important. The goals of these requirements include limiting development within the floodplain and restricting development within the floodway.

### 6.3.4 Sewage Backup

Flooding can inundate and overload sanitary sewer systems. As a result, water can flow backward through sewer lines and out through toilets or floor drains. Protection against sewage backup is typically addressed with the installation of a backflow valve in the sanitary service line running from the house.

## 6.4 Factors That Affect Flooding Damage

Damage to structures from flooding is primarily determined by a combination of the following six factors:

- Depth/elevation,
- Velocity of flow,
- Frequency of occurrence,
- Rates of rise and fall,
- Duration, and
- Debris impact.

Each of these factors is described further below.

### 6.4.1 Depth/Elevation of Flooding

The depth and elevation of flooding are closely related and are viewed as a single characteristic for the purpose of this discussion. Flood depth is the height of the floodwater above the surface of the ground or other feature at a specific point. Flood elevation is the height of the floodwater above an established reference datum. The standard datums used by most federal agencies and many state and local agencies are the National Geodetic Vertical Datum (NGVD) and the North American Vertical Datum (NAVD), though other datums are also used.

Whereas ground elevations are established by surveys, flood elevations may be calculated or surveyed from watermarks left by floods. Elevations of the ground, floodwaters, and other features cannot be meaningfully compared with one another unless they are based on the same datum. The flood depth at any point is equal to the flood elevation minus the elevation of the reference point (such as the ground or the lowest floor of the building), assuming that all elevations are based on the same datum. Figure 4-3 illustrates this relationship.

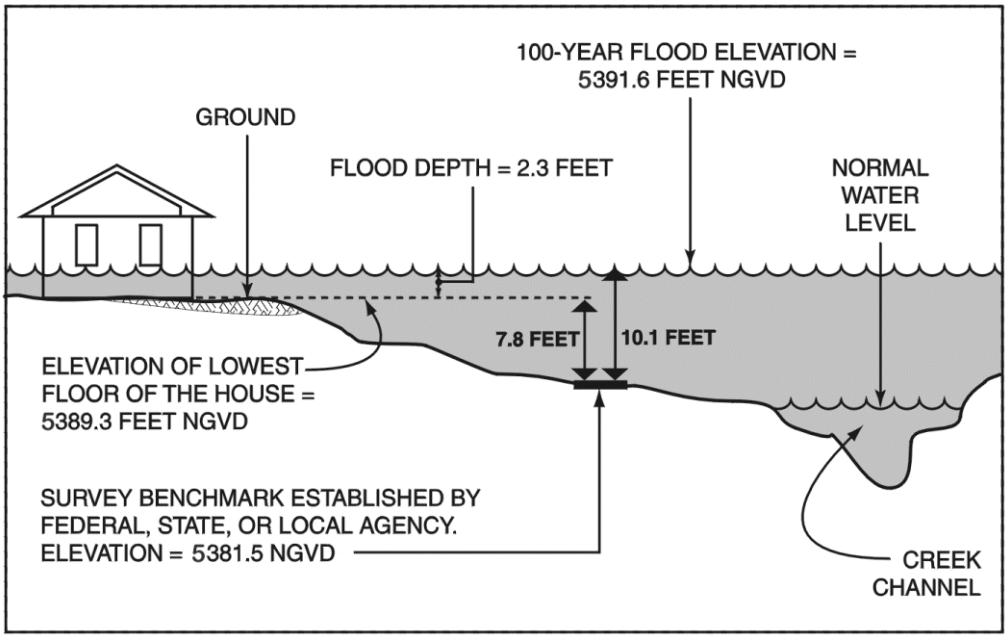


**Figure 4-3. Schematic representation of flood depth and flood elevation**

The depth of water during a flood directly affects the forces exerted on the building, including buoyant forces and hydrostatics pressure, as illustrated below.

**Buoyant Force:** Water surrounding and underneath a building, such as situations where soils are saturated around a basement or crawl space, creates a buoyant force upward on the floor slab, as shown in Figure 4-4. The buoyant force is directly related to the depth of water above the elevation of the floor slab.

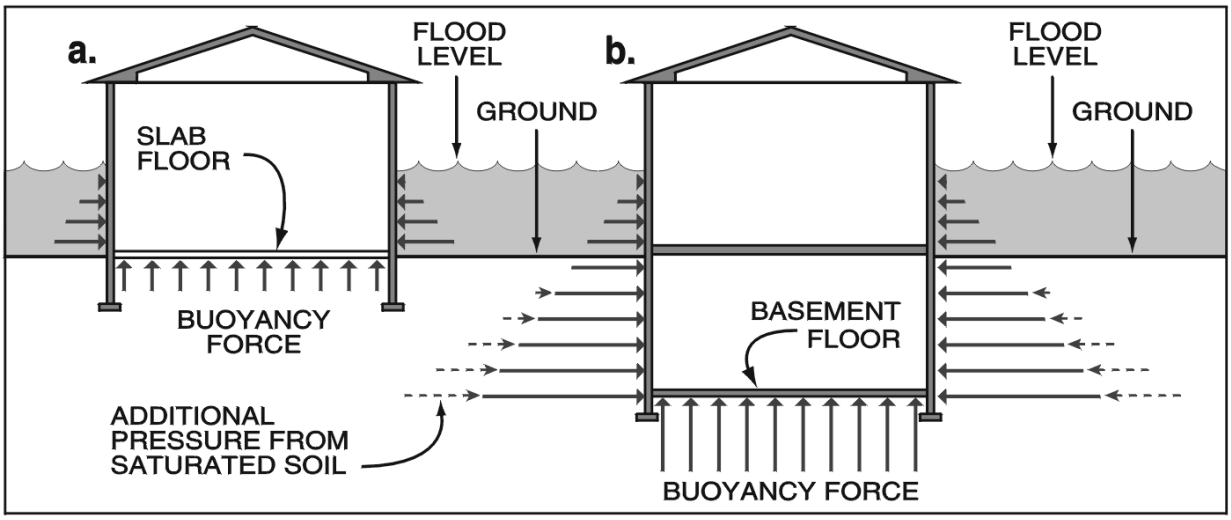


**Figure 4-4. Buoyant force and hydrostatic pressure diagram**

**Hydrostatic Pressure:** Hydrostatic pressure is applied horizontally to walls that are submerged below the water surface, as shown in Figure 4-4. The amount of hydrostatic pressure increases with the water depth, and therefore the pressure on basement walls is greater than the pressure on the walls of the upper

floor, as represented by the arrows in the figure. The horizontal pressure on basement walls is made even greater by the weight of the saturated soil that surrounds the basement. Extensive structural damage can occur, and possible collapse of the building, if the horizontal pressure exceeds the strength of the walls.

Note that in Figure 4-4, no water is shown inside the building. If water is allowed to enter, as shown in Figure 4-5, the hydrostatic pressures on both sides of the walls and floor are equalized, and the walls are much less likely to collapse and fail.

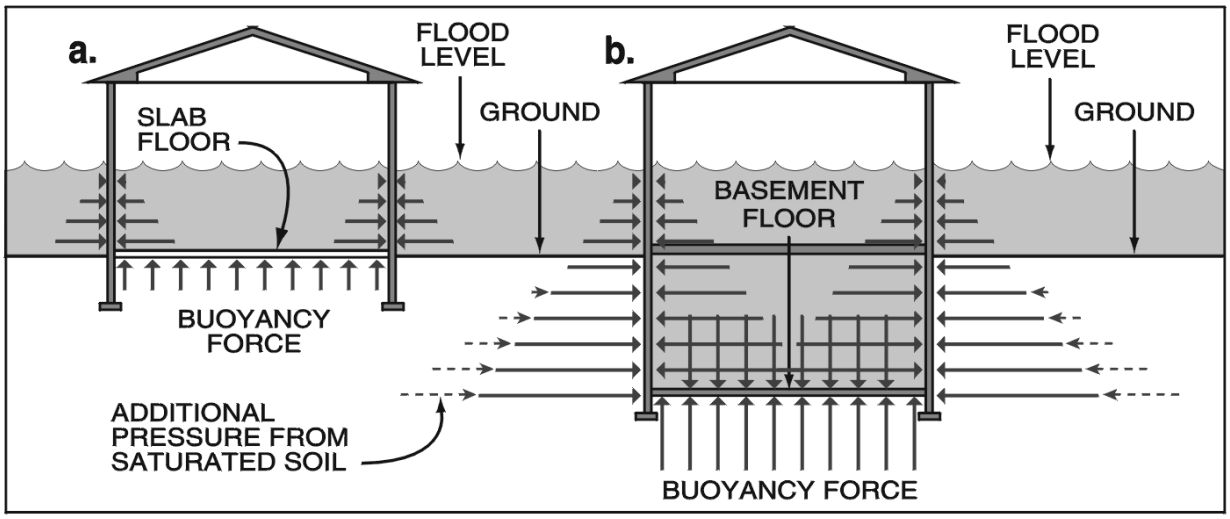


**Figure 4-5. Hydrostatic pressure with wet floodproofing**
(allowing flood waters to enter building)

### 6.4.2 Flow Velocity

Flow velocities during riverine floods can reach 5 to 10 feet per second (ft/sec), and may be greater in some situations. For reference, 10 ft/sec is roughly equivalent to 7 miles per hour.

The velocity of riverine floodwaters depends primarily on two factors: 1) the longitudinal slope of the channel/floodplain, and 2) the roughness of the channel/floodplain. As expected, flow rates are more rapid in steep floodplains and in floodplains that are relatively smooth (e.g., over parking lots) rather than rough (i.e., covered with large rocks, trees, dense vegetation, or other obstacles). Also, flow velocities in the floodplain are typically higher near the center of the main channel than at the outermost fringes, where velocities are slower.

If a structure is located where floodwaters are moving, the flow velocity influences the potential amount of structural damage incurred, particularly if the velocity exceeds approximately 5 ft/sec. The force exerted by flowing water, referred to as hydrodynamic pressure, is added to the hydrostatic pressure from the floodwater against the walls of the building. In addition to the hydrodynamic and hydrostatic forces, flow along the sides of a building creates friction that can damage wall coverings, such as siding. On the downstream side of the building, away from the flow, the water creates a suction force that pulls on walls (see Figure 4-6). In some situations, the combination of these forces can destroy one or more walls and cause the building to shift on its foundation or even be swept away.

Flowing water can also cause erosion and scour around objects that obstruct flow, such as foundation walls. Both erosion and scour can weaken the structure by removing supporting soil and undermining the foundation. In general, the greater the flow velocity and larger the building, the greater the extent and depth of erosion and scour. Also, any objects carried by floodwaters will be moving at roughly the same speed as the water.

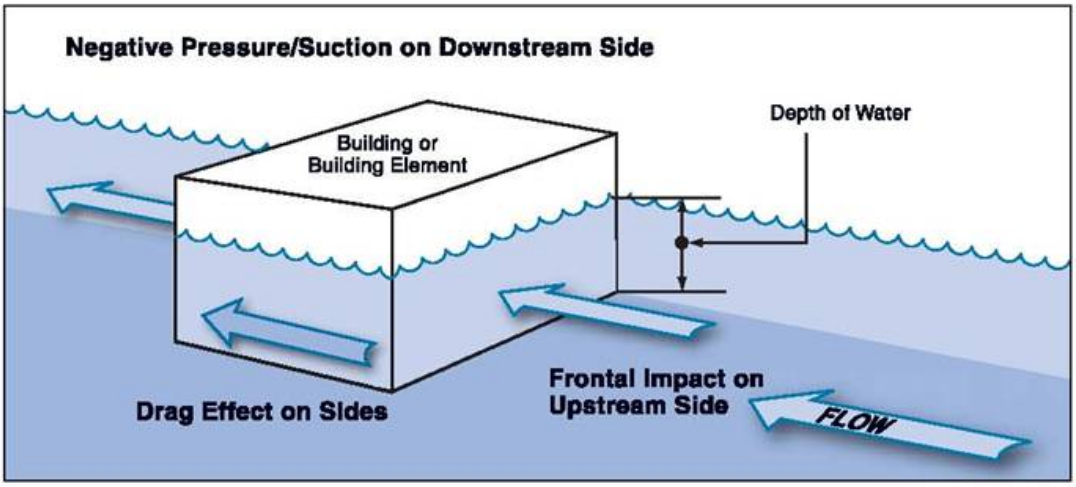


**Figure 4-6. Effects of moving water on a structure**

### 6.4.3 Flood Frequency

Flood frequencies are usually determined through statistical analyses performed by engineers, floodplain management agencies and other organizations as a basis for engineering designs and flood insurance rates. Those analyses define the probability, expressed as a percentage, that a flood of a specific magnitude will be equaled or exceeded in any year.

As previously noted, the 100-year flood is particularly important because it serves as the basis of the NFIP flood insurance rates and regulatory floodplain management. The 100-year flood is also referred to as the 1% annual exceedance probability flood (i.e., it has a 1% chance of being exceeded in a single year).

### 6.4.4 Rates of Rise and Fall

The rates of rise and fall refer to how rapidly the depth of floodwaters increase and decrease during a flood. Floodwaters with high flow velocities, such as those associated with steep terrain or caused by the failure of a dam or levee, usually rise and fall more rapidly than slower-moving floodwaters, as in gently sloping floodplains. The rate of rise is important because it affects the amount of warning prior to an impending flood. In floodplains of streams with high rates of rise, homeowners may have little notice of a coming flood, perhaps only hours, or none at all in some cases. If the flood protection method for a property involves contingent measures that a property owner must implement prior to the floodwaters arriving, the amount of warning time is especially important.

The rate of rise and rate of fall are also important because of their effect on hydrostatic pressure. As discussed previously, hydrostatic pressure is greatest when the water level outside the building is significantly different than the water level inside the building and, hence, the internal and external pressures are not equalized. When floodwaters rise rapidly, water may not flow into a building quickly enough for the level inside the building to rise at the same rate as the level outside. Conversely, when floodwaters fall rapidly, water that has filled a building may not flow out quickly enough, resulting in higher pressure inside the building than outside. In either situation, the unequal hydrostatic pressures can cause structural damage.

### 6.4.5 Duration

Duration is related to the rates of rise and fall. Relative to a flood, duration is the amount of time it takes for the source of the flood (i.e., river, creek) to return to its normal level. Generally, water that rises rapidly will recede more rapidly, and water that rises slowly will recede more slowly. Duration is important because it determines how long the structural members (e.g., foundation, floor joists, wall studs), interior finishes (e.g., drywall and paneling), service equipment (e.g., furnaces and hot water heaters), and building contents will be affected by floodwaters. Long periods of inundation are more likely to cause damage than short periods. In addition, long-duration flooding can saturate soils as shown on Figure 4-4, resulting in increased pressure on the foundation. Duration also affects how long a building remains uninhabitable.

### 6.4.6 Impact of Debris and Contaminants in Floodwaters

Floodwaters can carry debris of all types, including trees, automobiles, boats, storage tanks, mobile homes, and even entire buildings. All of these add to the dangers of flooding. Even when flow velocity is relatively low, large objects carried by floodwaters can easily damage windows, doors, walls, and, more importantly, critical structural components of a building. As velocity increases, so does the danger of greater damage from debris.

Contaminants in floodwaters, in addition to sediment, frequently include substances such as oil, gasoline, sewage, and various chemicals. If floodwaters carrying large amounts of dirt or hazardous substances enter a building, cleanup costs are likely to be higher and cleanup time greater.

## 6.5 Classes of Floodproofing Techniques

Floodproofing techniques are classified based on the type of protection provided:

- **Permanent measures:** Always in place and require no action if flooding occurs.
- **Contingent measures:** Require installation prior to the occurrence of a flood.
- **Emergency measures:** Improvised at the site when flooding occurs.

In the Denver metropolitan area, floodproofing efforts should focus on permanent measures because most of the stream systems respond rapidly to intense rainfall events. Contingent measures are more effective when combined with an early flood warning system or in areas not immediately adjacent to a stream channel.

Most floodproofing methods are more appropriate only where floodwaters are less than 3 feet deep. At depths greater than 3 feet, walls and floors are more likely to collapse because of the higher water pressure.

## 6.6 Floodproofing Methods

For new development, the first option for flood risk management should always be to construct outside of the floodplain. If building outside the floodplain is impractical for a site, then the structure should be constructed in compliance with local floodplain regulations. The remaining floodproofing methods discussed in this chapter are primarily for retrofitting existing structures.

### 6.6.1 Overview of FEMA Methods

Most regulations for floodproofing are based on the minimum NFIP standards for constructing, modifying, or repairing buildings located in the floodplain. FEMA has published numerous references on the subject of floodproofing methods (FEMA 1984, 1986a, 1986b, 1991, 1993a, 1993b, 1993c, 1993d, 1993e, 1994, 1995, 1996, 1998, 2000, 2001, 2008, 2009), several of which list six specific methods. Three of the methods can be used to meet NFIP residential floodproofing requirements. The other three do not meet the minimum NFIP requirements, but can be used to minimize damages, as listed below:

Methods that <u>can</u> be used to meet NFIP residential floodproofing requirements:

**Elevation:** Raise the structure so the lowest floor is above the flood level.

**Relocation:** Move the structure out of the floodplain to higher ground where it will not be exposed to flooding.

**Demolition:** Tear down the damaged structure and either: a) properly rebuild the structure on the same property, or b) buy or build a structure outside the floodplain.

Methods that <u>cannot</u> be used to meet NFIP residential floodproofing requirements:

**Dry floodproofing:** Seal the structure to prevent floodwaters from entering.

**Levees and floodwalls:** Build a physical barrier around the structure to hold back floodwater.[1]

**Wet floodproofing:** Make uninhabited portions of the structure resistant to flood damage and allow water to enter during flooding (cannot be used to meet NFIP requirements for residential floodproofing).

Sections 6.6.2 through 6.6.7 provide descriptions of each of the six floodproofing methods identified by FEMA, their respective advantages and disadvantages, and where they are appropriate to apply.

### 6.6.2 Elevation

Elevating a building to prevent floodwaters from reaching living areas is an effective retrofitting method. The goal of the elevation process is to raise the lowest floor to a level at or above the flood protection elevation (FPE). This can be achieved by elevating the entire building, including the floor, or by leaving the building in its existing position and constructing a new, elevated floor within the building. See figure 4-7. The method used depends largely on the construction type, foundation type, and flooding conditions.

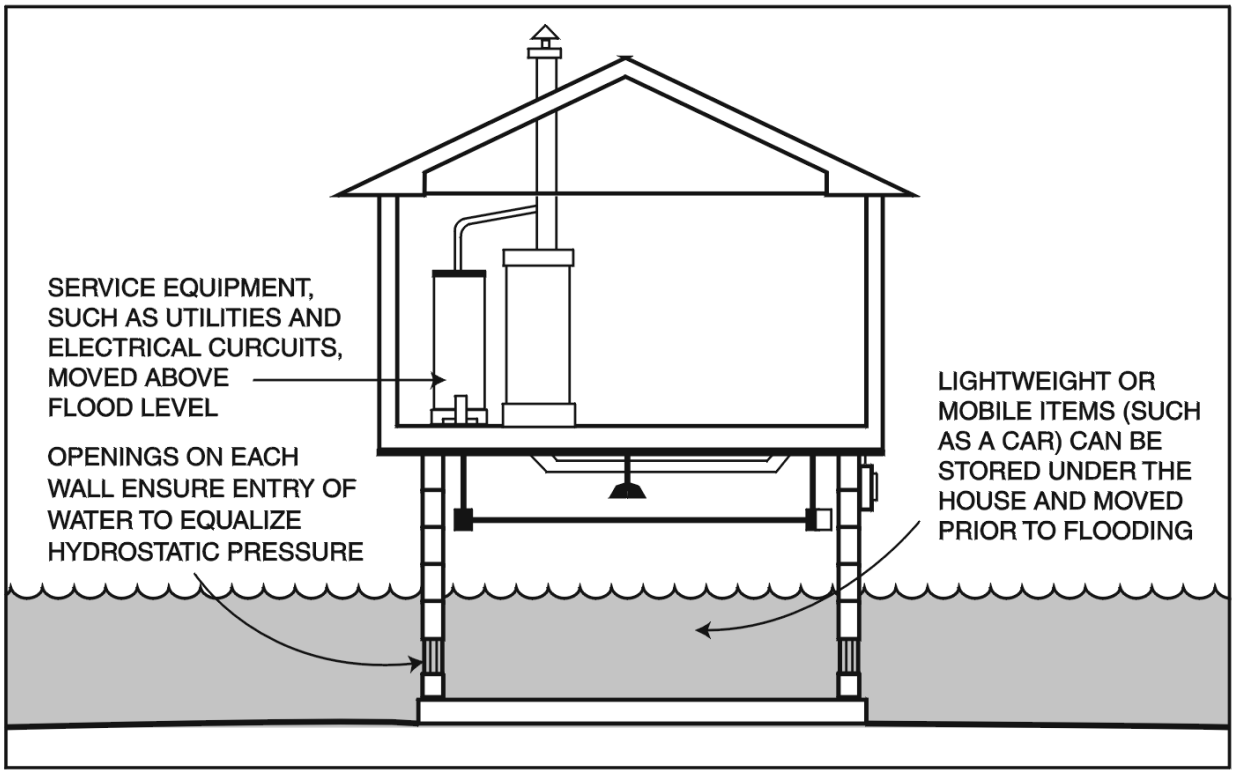


**Figure 4-7. Example of a structure elevated on continuous foundation walls**

[1] In February 2007, the UDFCD Board of Directors adopted a levee policy which discourages local governments from authorizing or permitting levees for new development and states that such levees would not be eligible for UDFCD maintenance assistance. The policy will allow the use of levees as a last resort to protect existing structures.

During the elevation process, most buildings are separated from their foundations, raised on hydraulic jacks, and held by temporary supports while a new or extended foundation is constructed below. This method works well for buildings originally built on basements, crawl spaces, or open foundations. The new or extended foundation can consist of continuous walls or separate piers, posts, columns, or pilings.

A variation of this method is used for buildings with slab-on-grade foundations, where the slab forms both the foundation and the floor of the building. Elevating that type of structure is easier if the building is left attached to the slab foundation and both are lifted together. After the building and slab are lifted, a new foundation is constructed below the slab.

In cases where the building is on an open foundation, it can be elevated with piers, columns, or piles. Piers should be properly anchored to footings. Columns are typically braced members but also need to be properly anchored.

Alternative techniques are available for masonry buildings on slab-on-grade foundations. These techniques do not require the lifting of the building. Instead, they involve raising the floor within the building or moving the living space to an upper story.

Although elevating a building can help protect it from floodwaters, other factors need to be considered before choosing this method. For example, the walls and roof of an elevated building may be more susceptible to wind forces because they are higher and more exposed. In addition, continuous wall foundations and open foundations both can fail as a result of damage caused by erosion and the impact of debris carried by floodwaters. If portions of the original foundation, such as the footings, are used to support new walls or other foundation members or a new second story, they must be capable of safely carrying the additional loads imposed by the new construction as well as any additional loads generated by wind or flood waters.

Advantages and disadvantages of the elevation method of floodproofing are summarized in Table 4-2.

**Table 4-2. Advantages and disadvantages of the elevation method**

| Advantages | Disadvantages |
|---|---|
| Raising the floor elevation to or above the FPE allows a substantially damaged or substantially improved building to be brought into compliance with the community's floodplain management ordinance or law[1].<br><br>The elevation method does not require the additional land that may be needed for construction of floodwalls or levees.<br><br>Except where a lower floor is used for storage, the elevation method eliminates the need to move vulnerable contents to areas above the water level during flooding.<br><br>The elevation method often reduces flood insurance premiums.<br><br>Elevation techniques are well known, and qualified contractors are often readily available. | Cost may be prohibitive.<br><br>The appearance of the building may be adversely affected.<br><br>Access to the building may be adversely affected.<br><br>The building must not be occupied during a flood.<br><br>Unless special measures are taken, elevation is not appropriate in areas with high-velocity flows, waves, fast-moving ice or debris flow, or erosion.<br><br>Additional costs are likely if the building must be brought into compliance with current code requirements for plumbing, electrical, and energy systems.<br><br>Potential wind and earthquake loads must be considered. |

1 Verify all requirements when applying for the floodplain permit.

### 6.6.3 Wet Floodproofing

Wet floodproofing a building is accomplished by modifying the uninhabited portions of the structure (such as the crawl space or unfinished basement) to enable floodwaters to enter without causing significant damage to either the building or its contents. The purpose of allowing water to enter portions of the building is to equalize the interior and exterior hydrostatic pressures, thereby reducing the likelihood of wall failures and structural damage (see Figure 4-8). Wet floodproofing is practical in only a limited number of situations and is typically used when all other retrofitting methods are either too costly or are not feasible.

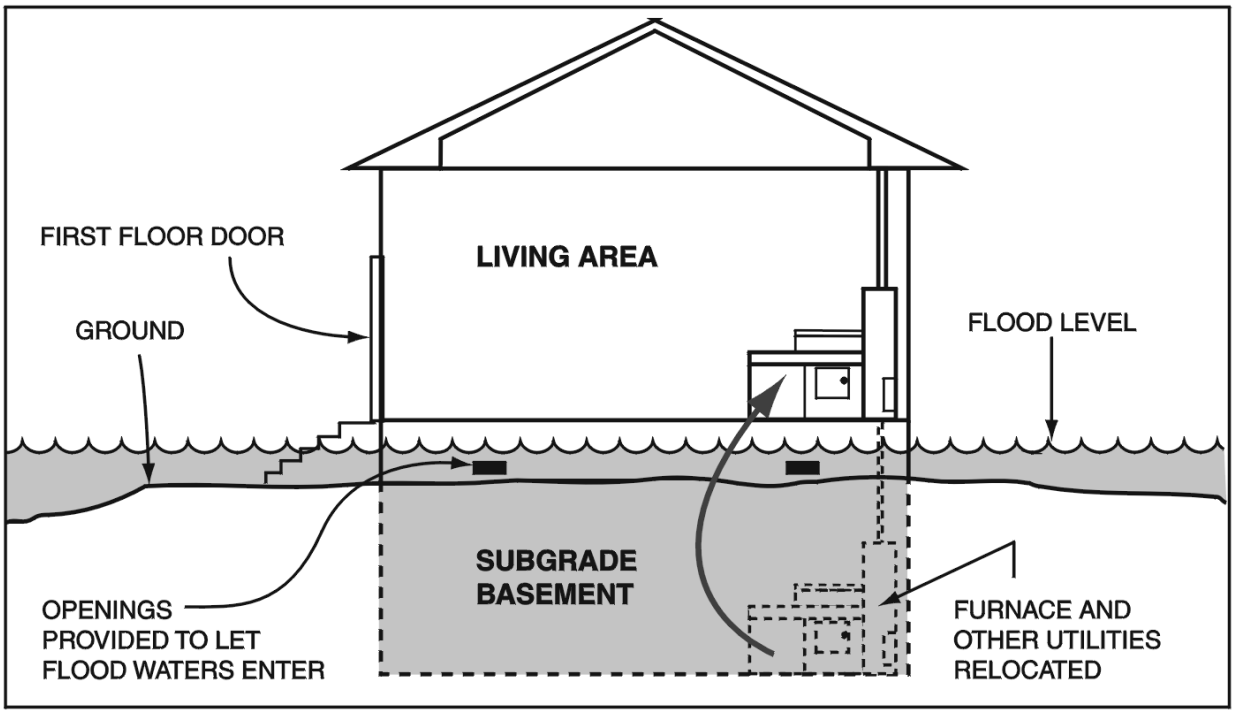


**Figure 4-8. Example of building with wet floodproofed subgrade basement**

Because wet floodproofing allows floodwaters to enter the building, all construction and finishing materials below the FPE must be resistant to flood damage. For this reason, wet floodproofing is practical only for portions of a building that are not used for living space, such as a basement as defined by the NFIP regulations, a walkout-on-grade basement, crawl space, or attached garage. It would not be practical for most slab-on-grade buildings, in which the living space is at or very near the ground level. Whether or not wet floodproofing is appropriate for a building will depend on the flood conditions, the FPE selected, the design and construction of a building, and whether the building has been substantially damaged or is being substantially improved.

Advantages and disadvantages of wet floodproofing are summarized inTable 4-3.

**Table 4-3. Advantages and disadvantages of wet floodproofing**

| Advantages | Disadvantages |
|---|---|
| Wet floodproofing can, in many instances, reduce structural damage to a building.<br><br>Because wet floodproofing allows internal and external hydrostatic pressures to equalize, the loads on walls and floors will be less than in a dry floodproofed building.<br><br>Flood insurance will cover the costs in some instances for moving or storing contents (except basement contents) after a flood warning is issued.<br><br>Wet floodproofing measures are often less costly than other types of retrofitting.<br><br>Wet floodproofing does not require the additional land that may be needed for floodwalls and levees.<br><br>The appearance of the building is usually not adversely affected. | Wet floodproofing may be used to bring a substantially damaged or substantially improved building into compliance with a community's floodplain management ordinance or law only if the areas of the building below the FPE are used solely for parking, storage, or building access.<br><br>Preparing the building and its contents for an impending flood requires adequate warning time and human intervention.<br><br>A building with wet floodproofing will get wet inside and possibly contaminated by sewage, chemicals, and other materials conveyed in floodwaters. Extensive cleanup may be necessary.<br><br>Periodic maintenance of wet floodproofing measures is likely necessary.<br><br>The building must not be occupied during a flood, and it may be uninhabitable for some time afterward.<br><br>Uses in the floodable area of the building must be limited.<br><br>Pumping floodwaters out of a wet floodproofed basement too soon after a flood may lead to structural damage.[1]<br><br>Wet floodproofing does not minimize the potential damage from high-velocity flood flow and wave action. |

[1]**WARNING.** After floodwaters recede from the area around a building with a wet floodproofed basement, the owner will usually want to pump out the water that filled the basement during the flood. If the soil surrounding the basement walls and below the basement floor is still saturated with water, however, removing the water in the basement too quickly can be dangerous. As the water level in the basement drops, the outside pressure on the basement walls becomes greater than the inside pressure and damage can result (e.g., the walls can collapse and/or the floor can be pushed up or cracked).

### 6.6.4 Dry Floodproofing

In some situations, a building can be made watertight below the FPE, so that floodwaters cannot enter. This method is called dry floodproofing. Making a building watertight requires sealing the walls with waterproof coatings, impermeable membranes, or supplemental layers of masonry or concrete. Also, doors, windows, and other openings below the FPE must be equipped with permanent or removable shields, and backflow valves must be installed in sewer lines and drains (see Figure 4-9). Flood characteristics that affect the success of dry floodproofing are flood depth, flood duration, flow velocity, and the potential for wave action and flood-borne debris.

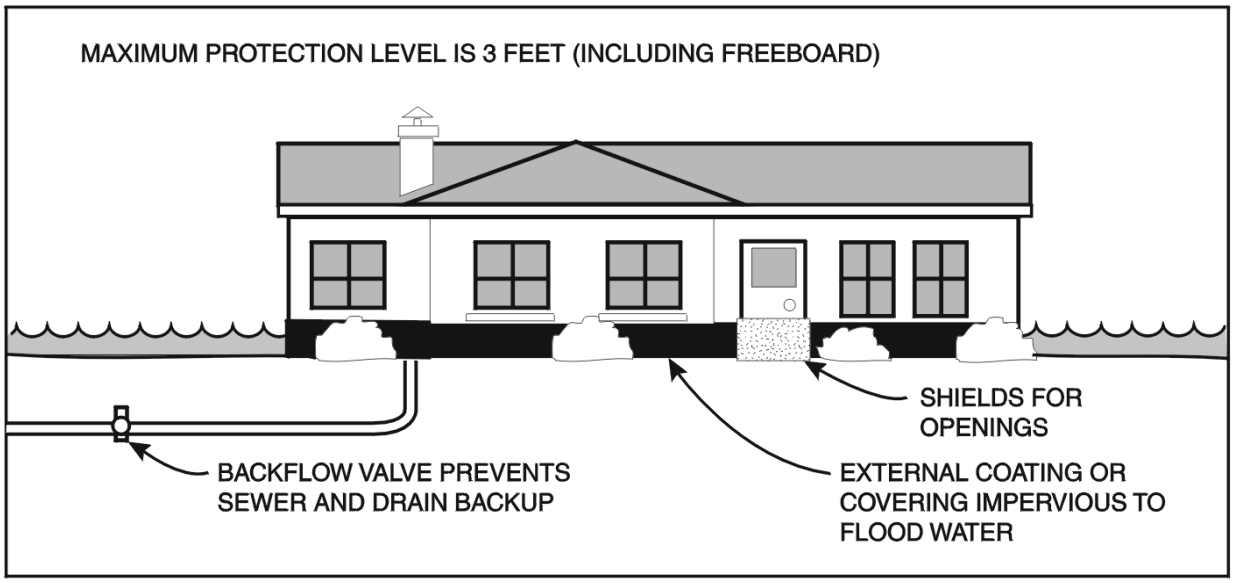


**Figure 4-9. Example of a dry floodproofed structure**

Flood depth is important because of the hydrostatic pressure that floodwaters exert on walls and floors. Since water is prevented from entering a dry floodproofed building, the exterior pressure on walls and floors is not counteracted as it is in a wet floodproofed building. The ability of building walls to withstand the pressure exerted by floodwaters depends in large part on their construction. Typical masonry and masonry veneer walls, without reinforcement, can usually withstand the pressure exerted by water up to about 3 feet deep. When flood depths exceed 3 feet, unreinforced masonry and masonry veneer walls are much more likely to crack or collapse. In addition, in most cases, the buoyancy force exerted by water with a depth greater than 3 feet is enough to crack a slab or push it up.

An advantage of masonry and masonry veneer walls is that their exterior surfaces are resistant to damage by moisture and can be made watertight relatively easily with sealants. In contrast, typical frame walls are likely to fail at lower flood depths, are more difficult to make watertight, and are more vulnerable to damage from moisture. As a result, it is not recommended to rely upon dry floodproofing for buildings with frame walls that will be damaged by moisture. Dry floodproofing is not an appropriate method to protect a residential structure from flood depths greater than 3 feet.

Dry floodproofing may not be used to bring a substantially damaged or substantially improved building into compliance with a community's floodplain management ordinance or law. Advantages and disadvantages of dry floodproofing are summarized in Table 4-4.

**Table 4-4. Advantages and disadvantages of dry floodproofing**

| Advantages | Disadvantages |
|---|---|
| Dry floodproofing prevents damage to the building interior, unlike some other methods (e.g., wet floodproofing, which does not protect the interior contents of the building from damage).<br><br>Dry floodproofing may be less costly than other retrofitting methods.<br><br>Dry floodproofing does not require the additional land that may be needed for levees and floodwalls. | Dry floodproofing may not be used to bring a substantially damaged or substantially improved building into compliance with a community's floodplain management ordinance or law.<br><br>Ongoing maintenance of the dry floodproofing measures is required.<br><br>Flood insurance premiums are not reduced for residential structures.<br><br>Installing temporary protective measures, such as flood shields, requires adequate warning time and human intervention.[1]<br><br>If the protective measures fail or the FPE is exceeded, the effect on the building will be the same as if there were no protection at all.<br><br>If design loads are exceeded, walls may collapse, floors may buckle, and the building may even float, potentially resulting in more damage than if the building was allowed to flood.<br><br>The building must not be occupied during a flood.<br><br>Flood shields may not be aesthetically pleasing.<br><br>Damage to the exterior of the building and other property may not be reduced.<br><br>Shields and sealants may leak, which could result in damage to the building and its contents.<br><br>Dry floodproofing does not minimize the potential damage from high-velocity flood flow and wave action. |

[1]**WARNING.** Because dry floodproofing requires human intervention, one must be willing and able to install all flood shields and carry out all other activities required for the successful operation of the dry floodproofing system. As a result, not only must one be physically capable of carrying out these activities, one must be in the building or able to go there in time to do so before floodwaters arrive.

### 6.6.5 Relocation

Relocation, or moving a building to ground located outside the flood hazard area, is the most effective floodproofing method described in the USDCM. If space permits, it may be possible to move a building to another location on the same piece of property.

Relocating a building typically involves jacking the building up and placing it on a wheeled vehicle for transport to the new site. Since the original foundation cannot be moved, it is demolished and a new foundation is built at the new site. The building is installed on the new foundation and utility lines are connected.

Relocation is particularly appropriate in areas where the flood hazard is severe. Severe flood hazards are often characterized by deep water, rapid rates of rise and fall, short warning times, wave action, high flow velocities, high debris flow, and long durations. Relocation is also appropriate for those who want less worry about damage from future floods that may exceed a specific FPE.

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

Advantages and disadvantages of relocation are summarized in Table 4-5.

**Table 4-5. Advantages and disadvantages of relocation**

| Advantages | Disadvantages |
|---|---|
| Relocation allows a substantially damaged or substantially improved building to be brought into compliance with a community's floodplain management ordinance or law.<br><br>Relocation significantly reduces flood risk to the building and its contents.<br><br>Relocation can either eliminate the need to purchase flood insurance or reduce the amount of the premium.<br><br>Relocation techniques are well known, and qualified contractors are often readily available. | Relocation costs may be prohibitive.<br><br>A new site (preferably outside the flood hazard area) must be located and purchased.<br><br>The flood-prone lot on which the building was formerly located must be sold or otherwise disposed of.<br><br>Many types of buildings are not suitable for being relocated.<br><br>Additional costs are likely if the building must be brought into compliance with current code requirements for plumbing, electrical, and energy systems. |

### 6.6.6 Levees and Floodwalls

Levees and floodwalls are both types of flood protection barriers. However, it is important to recognize that both CWCB and UDFCD discourage the use of levees. In 2007, UDFCD formally adopted a levee policy which discourages local governments from authorizing or permitting levees for new development and states that these levees will not be eligible for UDFCD maintenance assistance. The policy will allow the use of levees as a last resort to protect existing structures.

A levee is typically a compacted earthen structure; a floodwall is an engineered structure typically constructed of concrete, masonry, or a combination of both (see Figure 4-10). When these barriers are built to protect a building, they are usually referred to as residential, individual, or on-site levees and floodwalls. The practical heights of levees and floodwalls are usually limited to 6 feet and 4 feet, respectively. These limits are the result of the following considerations:

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

Since taller levees and floodwalls must be stronger, they occupy more space and typically require more space than is likely to be available on an individual residential lot. This is especially true of levees.

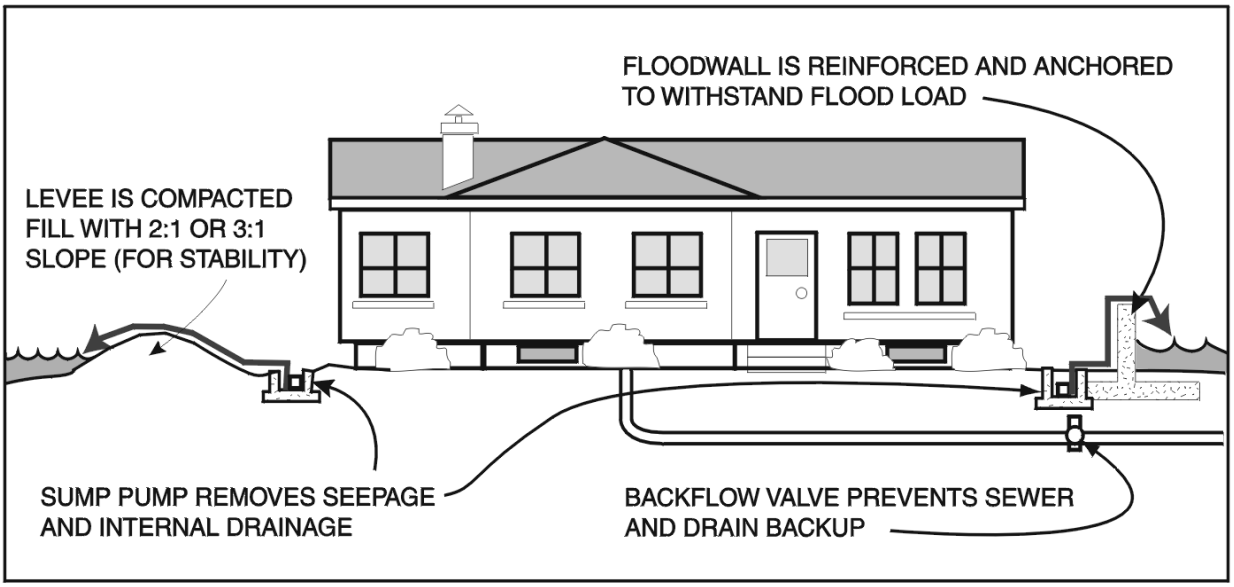


**Figure 4-10. Example of levee and floodwall protection**

Both levees and floodwalls should be constructed to provide at least 3 feet of freeboard above the BFE. Levees do not meet federal requirements for flood protection if they do not extend 3 feet above the BFE.

**Levees:** For a levee to be effective over time, it must be constructed of soils that cannot be easily penetrated by floodwaters. Furthermore, it must have proper side slopes for stability and it must be periodically inspected and maintained. In areas where flow velocities are sufficient to cause erosion, the side of the levee exposed to floodwater is usually protected with riprap or other erosion-resistant material. Levees can surround a building, or they may be built only across low areas and tied into existing high ground.

**Floodwalls:** A floodwall can surround a building, or depending on flood depths, site topography, and design preferences, it can protect isolated openings such as doors, windows, and basement entrances, including entry doors and garage doors in walkout-on-grade basements. Per unit length, floodwalls are typically more expensive than levees. Consequently, floodwalls are normally considered only for sites where there is not enough room for a levee or where high flow velocities may erode a levee.

As discussed previously, levees and floodwalls are discouraged by both the CWCB and the UDFCD. They are considered to be floodproofing measures of last resort. Recognizing this, their relative advantages and disadvantages are listed in Table 4-6.

**Table 4-6. Advantages and disadvantages of levees and floodwalls**

(Note: Levees and floodwalls are both considered to be floodproofing measures of last resort.)

| Advantages | Disadvantages |
|---|---|
| Levees and floodwalls provide protection from inundation to the building and area around it (provided that the design flood is not exceeded). No significant changes to the building are required.<br><br>Floodwaters are prevented from reaching the building or other structures in the protected area and therefore prevent damage from inundation, hydrodynamic pressure, erosion, scour, or debris impact.<br><br>The building can be occupied during construction of levees and floodwalls. | The use of levees for property protection, flood control, and flood hazard mitigation is discouraged by the CWCB. Levees should be considered only if other mitigation alternatives are not viable.<br><br>The UDFCD Board of Directors adopted a levee policy in February 2007 which discourages local governments from authorizing or permitting levees for new development. The policy states that new levees will not be eligible for UDFCD maintenance assistance. The policy will allow the use of levees as a last resort to protect existing structures.<br><br>Levees and floodwalls may not be used to bring a substantially damaged or substantially improved building into compliance with a community's floodplain management ordinance or law.<br><br>Costs may be prohibitive.<br><br>Periodic maintenance is required.<br><br>Adequate warning time and human intervention are required to close any openings in a levee or floodwall.<br><br>If a levee or floodwall fails or is overtopped by floodwaters, the effect on the building will be the same as if there were no protection at all.<br><br>An interior drainage system must be provided.<br><br>Local drainage can be affected, possibly creating or worsening flood problems for others.<br><br>The building must not be occupied during a flood.<br><br>A levee or floodwall may restrict access to the building.<br><br>Levees and floodwalls do not reduce flood insurance rates.<br><br>Floodplain management requirements may make levees and floodwalls violations of codes and/or regulations.<br><br>A large area may be required for construction, especially for levees.<br><br>Hydrostatic pressure on below-ground portions of a building may still be a problem, making levees and floodwalls an undesirable option for buildings with basements. |

### 6.6.7 Demolition

Demolition, as a floodproofing method, involves tearing down a damaged building and either rebuilding properly (i.e., compliant with floodplain regulations) somewhere on the same property or moving to a building on other property outside the regulatory floodplain. This retrofitting method may be the most practical of all those described in the USDCM when a building has sustained extensive damage, especially if severe structural damage has occurred.

Whether rebuilding or moving, the damaged building must be torn down and the site restored. Site restoration generally involves filling in the basement or foundation, grading the site, and landscaping. The services of demolition and grading contractors will likely be required. All demolition, construction, and site restoration work must be done according to the regulatory requirements of the community. Permits may be required for all or part of this work.

The advantages and disadvantages of demolition depend on the decision regarding where to rebuild the structure.

## 6.7 Engineering Considerations for Floodproofing Methods

Engineering considerations for a proposed floodproofing method include evaluating the site and building characteristics, determining the flooding characteristics, and analyzing the potential loads on the structure during a flood event. These topics are addressed in Sections 6.7.1 through 6.7.3.

### 6.7.1 Flood Hazard Analysis

Determining the potential depth of flooding is the first and most logical step in assessing flood hazards, since it is often the primary factor in evaluating the potential for flood damage. The depth of flooding is also critical in determining the extent of retrofitting that will be needed and which method(s) will be the most appropriate for a given site. Detailed flood information is provided in the FIS and FIRM where such studies are available and can be obtained from the FHAD.

The second step in assessing flood hazards is to calculate the forces acting upon a structure during a flood. These forces include hydrostatic, hydrodynamic, and impact loads. Hydrostatic forces include lateral water pressure, saturated soil pressures, combined water and soil pressures, equivalent hydrostatic pressures due to low velocity flows (< 10 ft/sec), and buoyancy pressures. Hydrodynamic forces consist of frontal impact by the mass of moving water against the projected width and height of the obstruction represented by the structure, drag effect along the sides of the structure, and eddies or negative pressures on the downstream side of the structure. Impact loads are imposed on the structure by objects carried by moving water.

### 6.7.2 Site Characteristics

Important site characteristics to evaluate include the location of the structure relative to sources of potential flooding and geotechnical considerations. The site location should be evaluated with respect to mapped floodplains and floodways and the potential for local flooding from stormwater conveyance elements.

Soil properties during conditions of flooding are important factors in the design of any surface intended to resist flood loads. These properties include saturated soil pressures, allowable bearing capacity, potential for scour, frost zone location, permeability, and shrink-swell potential.

### 6.7.3 Building Characteristics

The building should be evaluated with respect to the type of construction and the condition of the structure. The type of foundation, foundation materials, wall materials, and the method of connection all play a role in deciding which retrofitting method is most applicable. Operations involving a building in poor condition may further damage the building and result in costs that exceed its original value.

## 6.8 Selection of Floodproofing Method

In addition to engineering considerations described above, selection of the floodproofing method depends on several factors described below:

### 6.8.1 Regulatory Considerations

Federal, state, and local regulations may restrict the choice of retrofitting measures. Such regulations may include state and local building codes, floodplain management ordinances or laws, zoning ordinances, federal regulations concerning the alteration of buildings classified as historic structures, deed restrictions, and the covenants of homeowners associations.

**Federal Regulations:** The NFIP limits certain types of floodproofing. For example, the NFIP prohibits obstructions, such as berms and floodwalls, in floodways. The NFIP also requires floodproofing for buildings that are substantially improved or substantially damaged. "Substantially damaged" is defined as "damage of any origin sustained by a structure whereby the cost of restoring the structure to its prior condition would equal or exceed 50 percent of the market value of the structure before the damage occurred." Buildings that have been substantially damaged or are being substantially improved (renovated) must be elevated to a level at or above the 100-year flood level. Nonresidential buildings must be elevated or dry floodproofed.

Other federal agencies, such as the U. S. Army Corps of Engineers (USACE), U. S. Geological Survey, and Natural Resources Conservation Service, also publish floodproofing information, as do some state and local agencies. The USACE provides engineering and construction standards in the publication *Floodproofing Regulations (*1995b). Additional USACE publications (1984, 1988, 1990, 1993, 1994, 1995a, 1996, 1998) provide information on case studies and detailed engineering applications of floodproofing methods.

**State and Local Regulations:** State and local regulations may require a retrofitted building to be upgraded to meet current code requirements, unrelated to the floodproofing measures. Examples of potentially required upgrades include the electrical, plumbing, and/or the heating/ventilation/air conditioning systems (e.g., an electrical panel might require an upgrade from fuses to circuit breakers). These changes are required for the safety of the homeowner. Other code-required upgrades include those

necessary for increased energy efficiency. Any required upgrade can add to the scope and cost of the retrofitting project.

Every community that is a member of the NFIP must adopt minimum NFIP requirements. Many communities choose to adopt ordinances which are stricter than the minimum requirements of the NFIP. The local government floodplain administrator can identify the ordinances that apply to a specific project.

### 6.8.2 Appearance

Following retrofitting, the final appearance of a building and property will depend largely on the retrofitting method used and the FPE. For example, elevating a building several feet will change its appearance much more than elevating it only 1 or 2 feet. Also, a building elevated on an open foundation will appear much different than one elevated on extended foundation walls.

### 6.8.3 Accessibility

Accessibility refers to the ease with which a building can be accessed after a retrofitting project is completed. The retrofitting methods described in the USDCM affect accessibility in different ways. For example, elevating a building will usually require the addition of stairs, which may be unacceptable to some. Wet floodproofing will have little, if any, effect on accessibility. The effect of relocation on accessibility will depend on the location and configuration of the new site.

### 6.8.4 Requirement for Human Intervention

Retrofitting methods that require human intervention make it necessary for owners to be willing, able, and prepared to take the necessary action, such as placing flood barriers across the doors of a dry floodproofed building or operating a closure mechanism in a floodwall. These actions require that the owner have adequate warning of a coming flood and be able to reach the building and take action before floodwaters arrive. If these conditions cannot be met, retrofitting methods that require human intervention should be eliminated from consideration.

### 6.8.5 Benefit/Cost Analysis

The cost of retrofitting will depend largely on the retrofitting method used and the FPE. For some methods, the construction type (frame, masonry, etc.) and foundation type (crawl space, slab, etc.) will also affect the cost. In general, costs will increase as the FPE increases, but there may be tradeoffs between alternative methods. For example, elevating may be less expensive than relocating when a building is raised only 1 or 2 feet but may become more expensive at greater heights. The benefits considered in a floodproofing measure are the future damages and losses that are expected to be avoided as a result of the measure.

### 6.8.6 Other Considerations

Building owners may need to consider other factors, such as the availability of federal, state, and local financial assistance; the current value of the building versus the inconvenience and cost of retrofitting; the amount of time required to complete the retrofitting project; and the need to move out of the building during construction (including the availability and cost of alternative housing).

### 6.9 Cases Where Floodproofing is Not Appropriate

Except for demolition and relocation, floodproofing methods should not be considered in certain situations. For example, structures located within a regulatory floodway cannot be retrofitted with any substantial improvements that would result in an increase in flood levels during the base flood discharge. Under these conditions, the structure should be relocated out of the floodway and, preferably, out of the floodplain.

## 7.0 Assistance for Property Owners

### 7.1 Decision-Making Process for Property Owners

The decision regarding which floodproofing method to use will be based mainly on a combination of legal requirements, the technical limitations of the methods, and cost. Other considerations include the appearance of the building after retrofitting and any inconvenience resulting from retrofitting.

#### 7.1.1 Identification of Flood Hazards

Information about flood hazards in a specific area is available from UDFCD and local community officials. Community officials, design professionals, and contractors can use this information, along with the flood hazard information developed by FEMA and other agencies, to provide advice about retrofitting options.

#### 7.1.2 Structure Inspection

Structures being considered for floodproofing should be inspected to determine the construction method and type of foundation. Four characteristics of a building that are particularly important in retrofitting are: 1) construction type, 2) foundation type, 3) lowest floor elevation, and 4) condition. A key requirement of the inspection is performing a "Low Point of Entry" determination (see Figure 4-11).

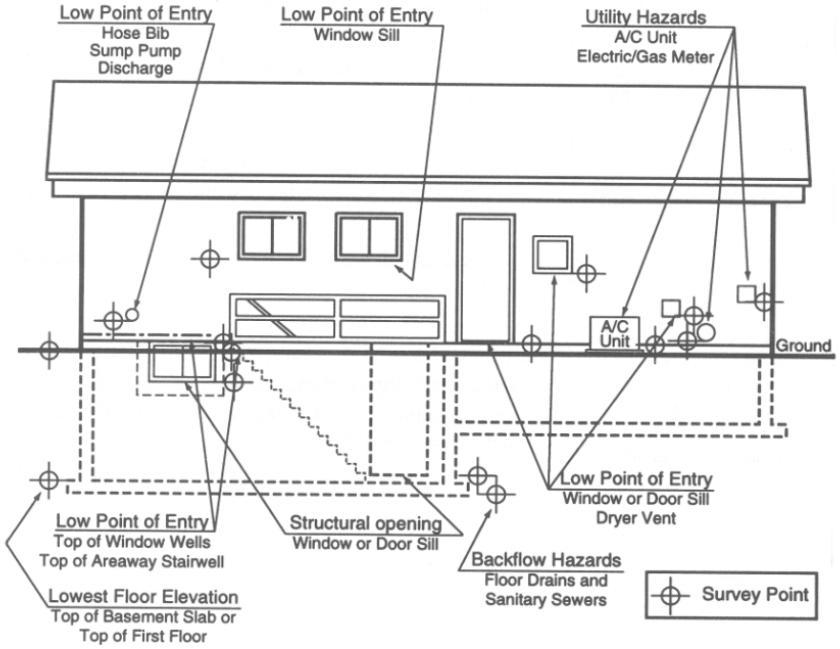


**Figure 4-11. Example of a low point of entry survey**

### 7.1.3 Consultation with Local Officials

UDFCD and local officials have copies of the FIS and FIRM published for the community by FEMA. UDFCD or community officials can determine whether a building is in the regulatory floodplain and, if so, the FPE/BFE at the location of the building.

Local officials will provide federal, state, and local regulations, codes, and other requirements that determine what retrofitting methods will be allowed. Officials can also provide information about federal, state, and local programs that provide financial assistance for homeowner retrofitting projects. If the property is 50 or more years old and federal financial assistance is being received for a retrofitting project, then the State Historic Preservation Office should also be contacted.

### 7.1.4 Consultation with Design Professional

The owner of a structure that needs floodproofing will need to consult with a design professional and a contractor in order to choose the appropriate floodproofing method and ensure that the method is properly constructed. Table 4-7 shows the types of contractors and design professionals that may be required for each of the retrofitting methods.

## 7.2 Potential Sources of Financial Assistance at Federal, State, and Local Levels

FEMA and other federal agencies have a wide array of financial assistance programs that help states, communities, and individual property owners mitigate the negative effects of flood hazards. Property owners may be eligible to receive financial assistance for a retrofitting project through one or more of these programs. If a presidential declaration of a major disaster has been issued for the area, property owners should seek information from FEMA and the state and local government representatives supporting the post-disaster recovery of the community.

The community's floodplain management ordinance or law includes requirements concerning construction in the community's regulatory floodplain. These requirements apply not only to new buildings but also to existing buildings that have been substantially damaged or that are being substantially improved. If the structure falls into one of the latter two categories, one of the following will be required:

- Elevate the building so that its lowest floor is at or above the FPE (Elevation Method).
- Move the building out of the regulatory floodplain (Relocation Method).
- Wet-floodproof the part of the building that is below the FPE (Wet Floodproofing Method). (This alternative is allowed only if the part of the building that is below the FPE is used solely for parking, storage, and building access and is not a basement as defined by the NFIP).
- Communities with more restrictive floodplain management ordinances or laws may require a greater level of protection.

Although the substantial damage/substantial improvement requirement helps protect lives and property, it has at times placed an additional burden on property owners who were trying to repair their damaged buildings. Under the original terms and conditions of the NFIP Standard Flood Insurance Policy (SFIP), the owner of a substantially damaged building was reimbursed for the costs of repairing the damage but not for the costs of complying with state and local requirements concerning substantially damaged structures. For example, the homeowner would not have been reimbursed for the cost of elevating the building, even though state or local ordinances or laws required elevating.

**Table 4-7. Requirements for contractor and design professional services**

| Method | Need for Contractor and/or Design Professional | Primary Services |
|---|---|---|
| Elevation | Design Professional | Evaluating the condition, stability, and strength of the existing foundation to determine whether it can support the increased load of the elevated building, including any wind and seismic loads. |
| | Contractor: Building Elevation Contractor | Disconnecting utilities, jacking up the building, increasing the height of the foundation, and connecting utilities. |
| Wet Floodproofing | Design Professional | Designing any necessary replacements of vulnerable structural materials and relocated utility systems. |
| | Contractor: General Construction Contractor | Replacing vulnerable structural and finishing materials below the FPE with flood-resistant materials, raising utilities and appliances to a location above the FPE, and installing openings required to allow the entry of floodwaters. |
| Relocation | Design Professional | Designing any new building, foundation, and site improvements that may be required, such as new utility systems. |
| | Contractor: Building Moving Contractor | Jacking up the building, moving it to the new site, and installing it on the new foundation. |
| | Contractor: General Construction Contractor | Preparing the new site (including grading, foundation construction, and utilities) and cleaning up the old site (including demolition). |
| Dry Floodproofing | Design Professional | For masonry walls to be dry floodproofed higher than 3 feet and for masonry veneer or frame walls to be dry floodproofed higher than 2 feet, evaluating the condition, stability, and strength of the existing walls to determine whether they can withstand the pressure from floodwaters at the FPE; designing or selecting flood shields for openings. |
| | Contractor: General Construction Contractor | Applying waterproof sealants and membranes, installing flood shields over openings below the FPE, installing backflow valves in sewer and water lines, and, if necessary, bracing or modifying walls so that they can withstand the pressure from floodwaters at the FPE. |
| Levees and Floodwalls | Design Professional | Assessing the adequacy of soils at the site and preparing the engineering design to ensure that the levee or floodwall, including any closures required, will be structurally stable under the expected flood loads and will be able to resist erosion, scour, and seepage. |
| | Contractor: General Construction Contractor | Constructing the levee or floodwall. |
| Demolition | Design Professional | Designing any new building, foundation, and site improvements that may be required, such as new utility systems. |
| | Contractor: Demolition Contractor | Disconnecting and capping utility lines, tearing down the damaged building, hauling away debris, and cleaning up the old site. |
| | Contractor: General Construction Contractor | Building the new building on the new site (May also be able to do all demolition work). |

In 1997, to provide relief for the owners of houses substantially damaged by flooding, Congress authorized the inclusion of Increased Cost of Compliance (ICC) coverage in the SFIP. With this change in effect, the SFIP reimburses homeowners not only for the cost of repairing flood damage but also for the additional cost, up to a maximum amount stated in the SFIP, of meeting certain state and local floodplain management requirements concerning substantial damage and repetitive losses. Other sources of assistance include:

**Small Business Administration (SBA):** In areas declared a major disaster area by the President, the SBA provides low-interest disaster assistance loans to individuals for both businesses and private residences. These loans cover the cost of rebuilding a damaged building, including the cost of bringing the building into compliance with applicable ordinances and laws. The loans can pay for retrofitting of substantially damaged buildings required by ordinances or laws (including elevating flood-prone buildings and rebuilding badly damaged flood-prone buildings at an alternative location), as well as some mitigation projects that are not required by ordinances or laws. At the applicant's request, the amount of the loan may be increased by up to 20 percent for hazard mitigation measures not required by the community's ordinances or laws.

**Department of Housing and Urban Development (HUD):** In an area declared a major disaster area by the President, HUD may provide additional, or allow for the reprogramming of existing, community development block grants. If a community wishes, these grants may be used for retrofitting substantially damaged or substandard buildings (including elevating flood-prone buildings and acquiring badly damaged flood-prone buildings).

**U.S. Army Corps of Engineers (USACE):** The USACE has the statutory authority to participate in flood protection projects that may include residential retrofitting (including elevating flood-prone buildings and acquiring badly damaged flood-prone buildings).

**Natural Resources Conservation Service (NRCS):** The NRCS has the statutory authority to participate in small watershed flood protection projects that may include residential retrofitting.

# 8.0 Glossary

**A Zone**: See Zone A.

**Alluvial fan**: An area at the base of a valley where the slope flattens out, allowing the floodwater to decrease in speed and spread out, dropping sediment and rock over a fan-shaped area.

**Amendment**: A change to a FEMA floodplain map that removes an area that was inadvertently included in the Special Flood Hazard Area.

**Approximate studies**: Flood hazard mapping done using approximate study methods that show the approximate outline of the base floodplain. An approximate study does not produce a base flood elevation.

**B Zone**: See Zone B.

**Base flood depth**: A measurement of the base flood in feet above ground, used for shallow flooding.

**Base flood**: The flood having a 1% chance of being equaled or exceeded in any given year. Also referred as the 100-year flood. The base flood is used by the NFIP as the basis for mapping, insurance rating, and regulating new construction.

**Basement**: Any area of the building having its floor subgrade (below ground level) on all sides.

**Base floodplain**: The area of water and land inundated by the base flood.

**Basin**: See watershed.

**Bathymetry**: The measurement of depths of water in the ocean or lakes.

**Bench marks**: Monuments on the ground that show the elevation of the spot above sea level.

**Building**: A walled and roofed structure including a gas or liquid storage tank that is principally above ground as well as a manufactured home. This is equivalent to the term “structure” in the federal regulations (44 CFR 59.1).

**Building condition survey**: A windshield survey conducted to obtain a preliminary evaluation of the extent and severity of damage to buildings after a disaster.

**C Zone**: See Zone C.

**CAP**: Community Assistance Program.

**Catchment area**: See watershed.

**cfs**: Cubic feet per second, the unit by which discharges are measured (a cubic foot of water is about 7.5 gallons).

**CLOMA**: Conditional Letter of Map Amendment.

**CLOMR**: Conditional Letter of Map Revision.

**Closed basin lake**: A lake that has either no outlet or a relatively small one, where rainfall or groundwater can cause the lake's level to rise faster than it can drain.

**Community Assistance Program**: A FEMA program that funds state activities that help communities in the NFIP.

**Community Rating System**: A program that provides a flood insurance premium rate reduction based on a community's floodplain management activities.

**Community**: A city, county, township, Indian tribe or authorized tribal organization, Alaska Native village or authorized native organization, or other local government with the statutory authority to adopt and enforce floodplain regulations and participate in the National Flood Insurance Program.

**Conditional Letter of Map Amendment**: A statement from FEMA that if a project is constructed as planned, a Letter of Map Amendment can be issued later.

**Conditional Letter of Map Revision**: A statement from FEMA that if a project is constructed as planned, a Letter of Map Revision can be issued later.

**Contour map**: A topographic map that shows points with the same elevation as connected by a contour line.

**Contour**: A line of equal elevation on a topographic (contour) map.

**Conveyance shadow**: An area upstream or downstream of an existing obstruction to flood flows.

**Cross section**: Surveyed information that describes the stream and the floodplain at a particular point along the stream.

**CRS**: Community Rating System.

**Dam breach inundation area**: The area flooded by a dam failure.

**Damage Survey Report**: A form completed by disaster assistance staff to determine the repair and reconstruction needs of public and private nonprofit facilities.

**Datum**: A common vertical elevation reference point, usually in relation to sea level.

**Detailed studies**: Flood hazard mapping studies that are done using hydrologic and hydraulic methods that produce base flood elevations, floodways, and other pertinent flood data.

**Development**: Any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations or storage of equipment and materials.

**DFIRM**: Digital Flood Insurance Rate Map. An official map of a community on which FEMA has delineated both the Special Flood Hazard Areas and the risk premium zones applicable to the community.

**Discharge**: The amount of water that passes a point in a given period of time. Rate of discharge is usually measured in cubic feet per second (cfs).

**DSR**: Damage survey report.

**Elevation reference marks**: See bench marks.

**Emergency Operations Center**: A facility that houses communications equipment that is used to coordinate the response to a disaster or emergency.

**Eminent domain**: Governmental power to acquire a property without the owner's consent.

**Encroachment review**: An analysis to determine if a project will increase flood heights or cause increased flooding downstream.

**EOC**: Emergency Operations Center.

**FBFM**: Flood Boundary Floodway Map. An official map of a community on which FEMA has delineated the regulatory floodway. Recent Flood Insurance Studies show the floodway on the FIRM and do not include an FBFM.

**FEMA**: Federal Emergency Management Agency.

**FHBM**: Flood Hazard Boundary Map. An official map of a community published by FEMA that delineates the approximate boundary of the floodplain. An FHBM is generally the initial map provided the community and is eventually superseded by a FIRM.

**FIA**: Federal Insurance Administration. FIA was the part of FEMA, which administered the National Flood Insurance Program. This is now the responsibility of FEMA's Mitigation Division.

**FIRM**: Flood Insurance Rate Map. An official map of a community on which FEMA has delineated both the Special Flood Hazard Areas and the risk premium zones applicable to the community.

**Flash flood**: A flood in hilly and mountainous areas that may come minutes after a heavy rain. One can also occur in urban areas where pavements and drainage improvements speed runoff to a stream.

**Flood**: A general and temporary condition of partial or complete inundation of normally dry land areas.

**Flood fringe**: The portion of the floodplain lying outside of the floodway.

**Flood hazard mitigation**: All actions that can be taken to reduce property damage and the threat to life and public health from flooding.

**Flood Insurance Study**: A report published by FEMA for a community issued along with the community's Flood Insurance Rate Map (FIRM). The study contains such background data as the base flood discharges and water surface elevations that were used to prepare the FIRM.

**Flood Mitigation Assistance**: A grant program that supports plans and projects for mitigating losses to insured buildings funded by the National Flood Insurance Program.

**Flood of record**: The highest known flood level for the area, as recorded in historical documents.

**Floodplain**: Any land area susceptible to being inundated by flood waters from any source.

**Floodproofing**: Protective measures added to or incorporated in a building that is not elevated above the base flood elevation to prevent or minimize flood damage. "Dry floodproofing" measures are designed to

keep water from entering a building. “Wet floodproofing” measures minimize damage to a structure and its contents from water that is allowed into a building.

**Floodway**: The channel of a river or other watercourse and that portion of the adjacent floodplain that must remain open to permit passage of the base flood without cumulatively increasing the water surface elevation more than a designated height (historically this was 1 foot, but it is now 0.5 foot in Colorado, per the CWCB Rules and Regulations for Regulatory Floodplains that became effective in 2011).

**FMA**: Flood Mitigation Assistance.

**Freeboard**: A margin of safety added to the base flood elevation to account for waves, debris, variability, and/or lack of data.

**Geographic information system**: Computer based map systems that allow the user to keep a map updated easily and to correlate geographic information with other data, such as tax records on properties.

**GIS**: Geographic Information System.

**Hazard Mitigation Grant Program**: A FEMA disaster-assistance grant that funds mitigation projects.

**HEC-2**: A computer model used to conduct a hydraulic study, which produces flood elevations, velocities and floodplain widths.

**HEC-RAS**: A computer model used to conduct a hydraulic study, which produces flood elevations, velocities and floodplain widths.

**Home rule**: A community authorized to do anything that is not prohibited by statute.

**Human intervention**: Actions that must be taken by one or more persons before floodwaters arrive in order for a building to be floodproofed.

**Hydrodynamic force**: The force of moving water, including the impact of debris and high velocities.

**Hydrologic cycle**: The natural cycle that circulates water throughout the environment to maintain an overall balance between water in the air, on the surface and in the ground.

**Hydrology**: The science dealing with the waters of the earth. A flood discharge is developed by a hydrologic study.

**Hydrostatic pressure**: The pressure put on a structure by the weight of standing water. The deeper the water, the more it weighs and the greater the hydrostatic pressure.

**Ice floe**: Large chunks of ice that can cause a great deal of damage when a frozen river or lake begins to melt and break up.

**Ice jam**: Flooding that occurs when warm weather and rain break up frozen rivers and the broken ice floats downriver until it is blocked by an obstruction, creating an ice dam that blocks the channel and causes flooding upstream.

**Increased Cost of Compliance**: An additional claim payment made to a flood insurance policy holder to help cover the cost of bringing a substantially damaged or repetitively damaged building into compliance with the community’s floodplain management ordinance.

**Individual and Family Grants**: A disaster assistance grant that helps people with their unmet needs (i.e., needs not helped by other disaster assistance programs).

**Inverse condemnation**: See "taking."

**ISO**: The Insurance Services Office, Inc., an insurance organization that provides support to FEMA on implementation of the Community Rating System.

**Lateral pressure**: The amount of pressure imposed sideways by standing water. Deeper water exerts more lateral pressure than shallower water.

**Letter of Map Amendment** (**LOMA**): An official revision to a FEMA map done by describing the property affected. LOMAs are generally issued when properties have been inadvertently included in the floodplain.

**Letter of Map Change** (**LOMC**): A Letter of Map Amendment or a Letter of Map Revision.

**Letter of Map Revision** (**LOMR**): An official revision to a FEMA map done by describing the property affected.

**Limited Map Maintenance Project**: A small-scale restudy of a Flood Insurance Study.

**LOMA**: Letter of Map Amendment.

**LOMR**: Letter of Map Revision.

**Lowest Floor**: The lowest floor of the lowest enclosed area (including basement) of a building.

**Market value**: The price a willing buyer and seller agree upon.

**Meander**: A curve in a river.

**Mitigation Division**: The FEMA office that sets national policy for the NFIP and administers the mapping program.

**M-O-M**: Multi-objective management.

**Movable bed streams**: A type of flooding that features uncertain flow paths.

**Mudslide** (i.e., mudflow): A condition where there is a river, flow or inundation of liquid mud down a hillside.

**Mudflow**: See mudslide.

**Multi-objective management**: An approach to planning and funding local programs that involves a variety of local interests and concerns.

**NEPA**: The National Environmental Policy Act, a federal law that requires agencies to evaluate the environmental impact of a proposed project.

**NGVD**: National Geodetic Vertical Datum of 1929, the national datum used by the National Flood Insurance Program. NGVD is based on mean sea level. It was known formerly as the "Mean Sea Level Datum of 1929 (MSL)."

**No-rise Certification**: A certification by an engineer that a project will not cause a set increase in flood heights.

**Non-structural flood protection measures**: Administrative tools for controlling flooding and flood damage, including regulations on development, building codes, property acquisition and structure relocation, and modification of existing buildings.

**Ordinance**: The generic term for a law passed by a local government.

**Overbank flooding**: Flooding that occurs when downstream channels receive more rain or snowmelt from their watershed than normal, or a channel is blocked by an ice jam or debris. Excess water overloads the channels and flows out onto the floodplain.

**Planned unit development (PUD)**: A regulatory approach that allows a developer to design the entire area while individual requirements may be relaxed to allow for open space, mixed land uses, and other variances to traditional zoning rules.

**Post-FIRM building**: For insurance rating purposes, a post-FIRM building was constructed or substantially improved after December 31, 1974, or after the effective date of the initial Flood Insurance Rate Map of a community, whichever is later. For a community that participated in the NFIP when its initial FIRM was issued, post-FIRM buildings are the same as new construction and must meet the National Flood Insurance Program's minimum floodplain management standards.

**Pre-FIRM building**: For insurance rating purposes, a pre-FIRM building was constructed or substantially improved on or before December 31, 1974, or before the effective date of the initial Flood Insurance Rate Map of the community, whichever is later. Most pre-FIRM buildings were constructed without taking the flood hazard into account.

**Probability**: A statistical term having to do with the size of a flood and the odds of that size of flood occurring in any year.

**Profile**: A graph that shows elevations of various flood events.

**Public/Infrastructure Assistance**: A disaster assistance grant that helps public agencies and nonprofit organizations finance repairs and reconstruction of public infrastructure.

**Q3 Flood Data Product**: A graphical representation of certain features of a FIRM in digital format.

**Reconstruction**: Building a new structure on the old foundation or slab of a structure that was destroyed, damaged, purposefully demolished or razed. The term also applies when an existing structure is moved to a new site.

**Regular Program**: Also called the Regular Phase. The phase of community participation in the National Flood Insurance Program that begins on the date of the Flood Insurance Rate Map or when the community adopts an ordinance that meets the minimum requirements of the NFIP and adopts the technical data provided with the FIRM, whichever is later. Nearly all communities participating in the NFIP are in the Regular Program.

**Rehabilitation**: An improvement made to an existing structure which does not affect its external dimensions.

**Restudy**: A new Flood Insurance Study for all or part of a community that has already had a Flood

Insurance Study.

**Retrofitting**: Retrofitting techniques include floodproofing, elevation, construction of small levees, and other modifications made to an existing building or its yard to protect it from flood damage.

**Revision**: A change to a floodplain map based on new data submitted to FEMA.

**Riverine**: Of or produced by a river. Riverine floodplains have readily identifiable channels. Floodway maps can only be prepared for riverine floodplains.

**Roughness**: A measure related to ground surface conditions that reflects changes in floodwater velocity due to ground friction.

**Runoff**: Rainfall and snowmelt that reaches a stream.

**SFHA**: Special Flood Hazard Area.

**Sheet flow**: Floodwater that spreads out over a large area that does not have defined channels at a somewhat uniform depth.

**Special Flood Hazard Area**: The base floodplain displayed on FEMA maps. It includes the A and V Zones.

**Stafford Act**: The Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988, as amended, which authorizes FEMA's current disaster assistance programs and the Hazard Mitigation Grant Program. The Disaster Mitigation Act of 2000 made extensive changes to the Stafford Act.

**Stationing**: Determining the distance along a stream.

**Statutory authority**: The powers granted to a local government by state law.

**Stillwater flood elevations:** Show the elevations of various coastal floods, not counting waves.

**Storm surge**: Water that is pushed toward shore by persistent high wind and changes in air pressure. Storm surges can result from hurricanes and other coastal storms.

**Stormwater management**: Efforts to reduce the impact of increased runoff that results from new development.

**Stormwater detention**: Storing stormwater runoff for release at a restricted rate after the storm subsides.

**Stormwater retention**: Storing stormwater runoff for later use in irrigation or groundwater recharge, or to reduce pollution.

**Structural flood control**: Measures that control floodwaters by construction of barriers or storage areas or by modifying or redirecting channels.

**Submit to rate**: A process used when an insurance agent cannot complete the rate calculation for a flood insurance policy. The application is sent to the WYO Company or FEMA to be individually rated.

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

structure before the damage occurred.

**Substantial improvement**: Any reconstruction, rehabilitation, addition or other improvement to a structure, the total cost of which equals or exceeds 50 percent of the market value of the structure before the start of construction of the improvement. The definition of "substantial improvement" includes buildings that have incurred "substantial damage" regardless of the actual repair work performed.

**Taking**: Obtaining private property with or without compensating the owner. The term also includes reducing the value of private property to such an extent that the owner is deprived of all economic interest.

**Thalweg**: The bottom of a river channel.

**Topographic map**: See contour map.

**Transect**: A survey of topographic conditions used in coastal flood studies.

**Tsunami**: A large wave caused by an underwater earthquake or volcano which can raise water levels as much as 15 feet.

**V Zone**: See "Zone V."

**Variance**: A grant of relief by a community from the terms of a land use, zoning, or building code regulation.

**Velocity**: The speed of moving water; a force that is measured in feet per second.

**Watershed**: An area that drains into a lake, stream, or other body of water.

**X Zone**: See "Zone X."

**Zone A**: The Special Flood Hazard Area (except coastal V Zones) shown on a community's Flood Insurance Rate Map. There are five types of A Zones:

**A**: SFHA where no base flood elevation is provided.

**A1-30**: Numbered A Zones (e.g., A7 or A14), SFHA where the FIRM shows a base flood elevation in relation to NGVD.

**AE**: SFHA where base flood elevations are provided. AE Zone delineations are now used on new FIRMs instead of Numbered A Zones.

**AO**: SFHA with sheet flow, ponding, or shallow flooding. Base flood depths (feet above grade) are provided.

**AH**: Shallow flooding SFHA. Base flood elevations in relation to NGVD are provided.

**Zone B**: Area of moderate flood hazard, usually depicted on Flood Insurance Rate Maps as between the limits of the base and 500-year floods. B Zones are also used to designate base floodplains of little hazard, such as those with average depths of less than 1 foot.

**Zone C**: Area of minimal flood hazard, usually depicted on Flood Insurance Rate Maps as above the

500-year flood level. B and C Zones may have flooding that does not meet the criteria to be mapped as a Special Flood Hazard Area, especially ponding and local drainage problems.

**Zone D**: Area of undetermined but possible flood hazard.

**Zone V**: The Special Flood Hazard Area subject to coastal high hazard flooding. There are three types of V Zones: V, V1-30, and VE, and they correspond to the A Zone designations.

**Zone X**: Newer Flood Insurance Rate Maps show Zones B and C (see above) as Zone X.

# 9.0 References

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