



Wet Floodproofing Requirements and Limitations

For Buildings and Structures Located in Special Flood Hazard
Areas in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 7 / May 2022



FEMA

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Acronyms

ASCE	American Society of Civil Engineers
BFE	base flood elevation
CFR	Code of Federal Regulations
CRS	Community Rating System
DFE	design flood elevation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
HVAC	heating, ventilation, and air conditioning
IBC®	International Building Code®
ICC®	International Code Council®
I-Codes®	International Codes®
IEBC®	International Existing Building Code®
IRC®	International Residential Code®
NFIP	National Flood Insurance Program
SEI	Structural Engineers Institute
SFHA	Special Flood Hazard Area

1. Introduction

This Technical Bulletin provides guidance on the National Flood Insurance Program (NFIP) floodplain management requirements for the design and construction of wet floodproofed buildings and structures in Special Flood Hazard Areas (SFHAs). The SFHA is identified as Zone A (A, AE, A1-30, AH, AO, A99, and AR) and Zone V (V, VE, V1-30, and VO) on a community's Flood Insurance Rate Map (FIRM) prepared by the Federal Emergency Management Agency (FEMA).

This Technical Bulletin also describes limitations on the use of wet floodproofing and how to evaluate the feasibility of using wet floodproofing measures for historic structures, agricultural structures, and functionally dependent uses.

1.1. Definition of Floodproofing

The NFIP regulations define floodproofing as “any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents” (Title 44 Code of Federal Regulations [CFR] § 59.1). Measures taken to make a building and attendant utilities and equipment watertight and substantially impermeable to floodwater, with structural components having the capacity to resist flood loads are dry floodproofing measures. “Floodproofing” in the NFIP regulations is understood to refer to “dry floodproofing.”

The term “wet floodproofing” is used in FEMA guidance publications and by floodplain management professionals to mean the use of flood damage-resistant materials and construction techniques to minimize flood damage to structures by intentionally allowing floodwater to enter and exit automatically, which means without human intervention.

Dry floodproofing measures are not covered in this Technical Bulletin. For more information on dry floodproofing, see FEMA P-936, *Floodproofing Non-Residential Buildings* (FEMA, 2013); NFIP Technical Bulletin 3, *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings*; and NFIP Technical Bulletin 6, *Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings*.

NFIP Technical Bulletin 0

NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins*, should be used as a reference with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins. It includes common concepts and terms, lists useful resources, and includes a crosswalk of the sections of the NFIP regulations identifying the Technical Bulletin that addresses each section of the regulations and a subject index.

Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

Terms Used in This Technical Bulletin

Accessory structure: A structure on the same parcel of property as a principal structure, the use of which is incidental to the use of the principal structure. For floodplain management purposes, accessory structures must be used for parking or storage, be small, represent minimal investment by owners, and have low damage potential. Under the NFIP regulations, accessory structures are non-residential structures.

Agricultural structure: For floodplain management purposes, agricultural structures are structures that are used exclusively for agricultural purposes or uses in connection with the production, harvesting, storage, raising, or drying of agricultural commodities and livestock. Structures that house tools or equipment used in connection with these purposes or uses are also considered to have agricultural purposes or uses. Some structures used for aquaculture are considered agricultural structures. Under the NFIP regulations, agricultural structures are non-residential structures.

Basement: “Any area of the building having its floor subgrade (below ground level) on all sides” (44 CFR § 59.1). The NFIP regulations do not allow basements to extend below the base flood elevation (BFE) except in dry-floodproofed, non-residential buildings.

Enclosed area (enclosure): An area below an elevated building that is enclosed by walls on all sides.

Existing building (existing structure): Buildings and structures that were constructed before a community joined the NFIP.

Flood damage-resistant materials: Any building product (material, component, or system) capable of withstanding direct and prolonged contact with floodwater without sustaining significant damage, in which “prolonged contact” means at least 72 hours and “significant damage” means any damage requiring more than cosmetic repair. “Cosmetic repair” includes cleaning, sanitizing, and resurfacing the material (e.g., sanding, repair of joints, repainting).

Human intervention: “Required presence and active involvement of people to implement a floodproofing measure prior to the onset of flooding” (ASCE 24).

Legal non-conforming building (legal non-conforming structure): Buildings and structures that were built after a community joined the NFIP but do not conform to a community’s current floodplain management requirements.

Lowest floor: Lowest floor of the lowest enclosed area of a building, including basement. An unfinished or flood-resistant enclosure that is used solely for parking of vehicles, building access, or storage in an area other than a basement area is not considered a building’s lowest floor, provided the enclosure is built in compliance with applicable requirements (44 CFR § 59.1).

Special Flood Hazard Area (SFHA): Area subject to flooding by the base flood (1-percent-annual-chance flood) and shown on Flood Insurance Rate Maps (FIRMs) as Zone A or Zone V.

Variance: Grant of relief by a community from the terms of a floodplain management regulation (44 CFR § 59.1).

Wet floodproofing: Use of flood damage-resistant materials and construction techniques to minimize flood damage to structures by intentionally allowing floodwater to enter and exit automatically (without human intervention) to minimize unequal pressure of water on walls (called hydrostatic load or pressure).

Zone A: Flood zones shown on FIRMs as Zone A, AE, A1-30, AH, AO, A99, and AR.

Zone V: Flood zones shown on FIRMs as Zone V, VE, V1-30, and VO; also known as the Coastal High Hazard Area.

Other terms used in this Technical Bulletin are defined in the glossary in Technical Bulletin O.

1.2. Limitations on the Use of Wet Floodproofing

The use of wet floodproofing measures for flood protection is limited to:

- Enclosures below elevated buildings when the enclosures are used solely for parking of vehicles, building access, or storage
- Attached garages
- Certain accessory structures used for parking of vehicles or storage
- Certain agricultural structures when communities authorize the structures in accordance with FEMA P-2140, *Floodplain Management Bulletin: Floodplain Management Requirements for Agricultural Structures and Accessory Structures*, (Version 1.1, 2021a)
- Historic structures when authorized by variances
- Functionally dependent uses when authorized by variances

The authority to allow the use of wet floodproofing measures in specific circumstances is established in FEMA Policy #104-008-03, *Floodplain Management Requirements for Agricultural Structures and Accessory Structures* (2020). The situations and conditions in which communities may authorize wet floodproofing are detailed in Section 5 of this Technical Bulletin.

Section 8 of this Technical Bulletin describes additional measures that may be used to retrofit buildings and structures when NFIP compliance is not required but owners want to reduce damage to at-risk existing and legal non-conforming buildings and structures in SFHAs.

1.3. Construction Requirements for Wet Floodproofing

Figure 1 illustrates the following typical wet floodproofing measures:

- Anchoring to resist flotation, collapse, and lateral movement
- Using flood damage-resistant materials below the base flood elevation (BFE)
- Installing flood openings to automatically equalize hydrostatic forces (loads or pressure caused by standing or slow-moving water) on exterior walls
- Protecting mechanical and utility equipment by elevating or by installing and configuring the equipment components to minimize damage (e.g., elevated water heater, elevated outlet)
- Anchoring fuel tanks to resist flotation and lateral movement

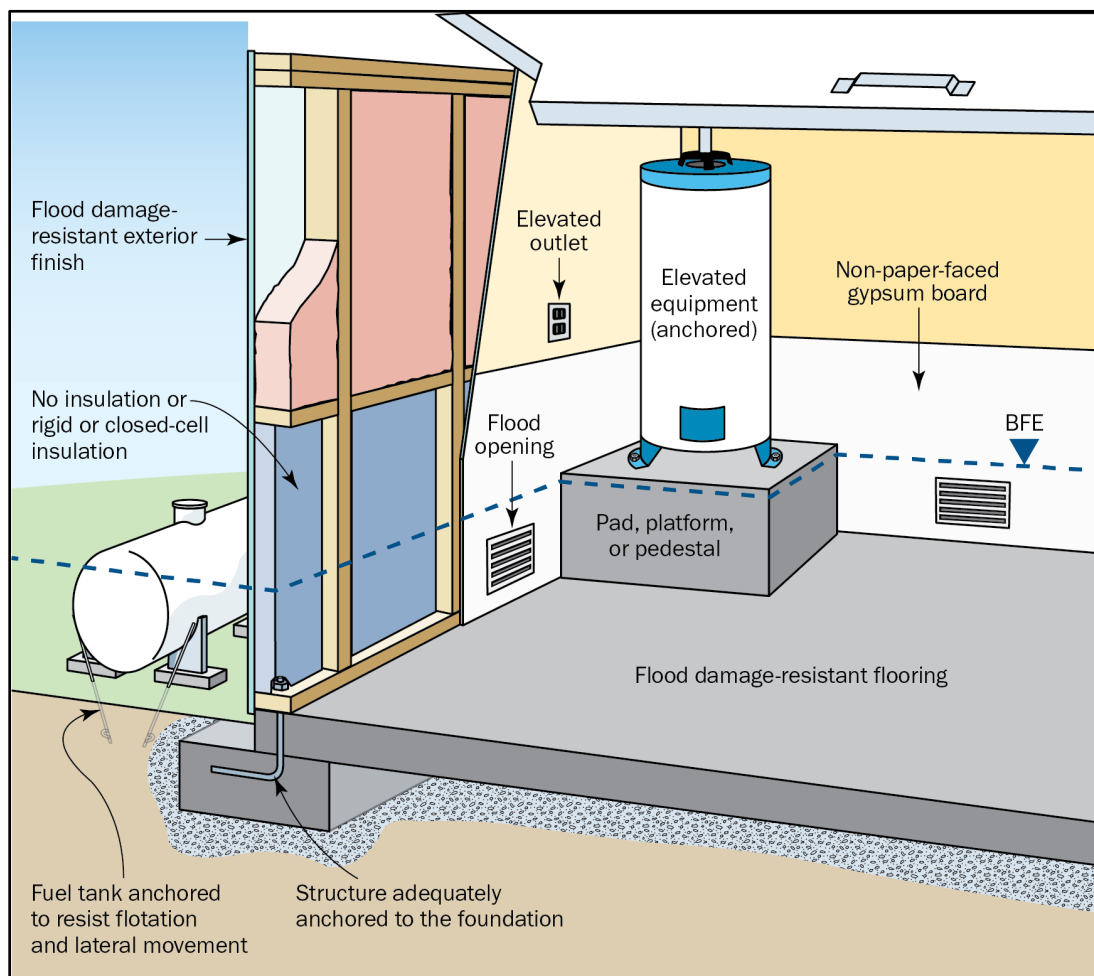


Figure 1: Typical wet floodproofing measures

Other measures that reduce the potential for flood damage may be considered wet floodproofing but should be used only when NFIP compliance is not required or when communities grant variances to the elevation or dry floodproofing requirements.

See Section 8 of this Technical Bulletin for more information on retrofit measures when NFIP compliance is not required. Those measures should also be considered when communities grant variances to the elevation or dry floodproofing requirements. Section 9 of this Technical Bulletin describes best practices to consider when evaluating the use of wet floodproofing measures.

Questions about wet floodproofing should be directed to the appropriate local official, NFIP State Coordinating Office, or FEMA Regional Office.

2. NFIP Regulations and FEMA Policy

An important NFIP objective is protecting buildings constructed in SFHAs from damage caused by flooding. The SFHA is the land area subject to flooding by the base flood. SFHAs are shown on FIRMs prepared by FEMA as Zones A and V. The base flood is the flood that has a 1 percent chance of being equaled or exceeded in any given year (commonly called the “100-year” flood). The NFIP floodplain management regulations include minimum building design criteria that apply to:

- New construction
- Work determined to be substantial improvements, including improvements, alterations, and additions
- Repair of buildings determined to have incurred substantial damage

A defining characteristic of the NFIP regulations applicable in Zone A is the requirement for the lowest floor (including basement) of residential buildings to be elevated to or above the BFE. Non-residential buildings in Zone A must be elevated or dry floodproofed to or above the BFE. The NFIP requirements in Zone V also specify building elevation, foundation, and enclosure requirements. Dry floodproofing is not permitted in Zone V.

2.1. NFIP Regulations

The NFIP regulations are codified in 44 CFR Part 60, Criteria for Land Management and Use. Specific to this Technical Bulletin, 44 CFR § 60.3(a)(3) requires that a community:

Review all permit applications to determine whether proposed building sites will be reasonably safe from flooding. If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall (i) be designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy, (ii) be constructed with materials resistant to flood damage, (iii) be constructed by methods and practices that minimize flood damages, and (iv) be

constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding.

The NFIP regulations for enclosures below the lowest floor of buildings in Zone A are in 44 CFR § 60.3(c)(5), which requires that a community shall:

Require, for all new construction and substantial improvements, that fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria: A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one foot above grade. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of floodwaters.

2.2. FEMA Policy

The NFIP regulations do not provide explicit requirements for agricultural structures or accessory structures. Therefore, these structures are regulated as non-residential structures, and the elevation and dry floodproofing requirements for non-residential structures apply to them.

In 2020, FEMA issued FEMA Policy #104-008-03 to provide clarification and technical guidance on the implementation of NFIP design and performance standards for agricultural structures and accessory structures. FEMA recognizes that the inherent design and function of certain agricultural structures and accessory structures may mean that the structures have low damage potential, which allows the use of flood protection methods other than elevation and dry floodproofing. These methods are the wet floodproofing measures that are described in this Technical Bulletin.

In 2021, FEMA issued FEMA P-2140, *Floodplain Management Bulletin: Floodplain Management Requirements for Agricultural Structures and Accessory Structures*, to clarify and refine the wet floodproofing measures that are applicable to certain agricultural structures and accessory structures described in FEMA Policy #104-008-03. FEMA P-2140 and Section 5 of this Technical Bulletin describe the circumstances under which communities may authorize wet floodproofed accessory structures by permit (based on size) and when communities must use variances to authorize wet floodproofing measures for larger accessory structures and agricultural structures. FEMA P-2140 includes decision charts that can be used to determine whether proposed projects qualify as agricultural structures or accessory structures and whether those structures may be wet floodproofed.

NFIP Requirements and Higher Regulatory Standards

Federal, State, and Local Requirements. Federal, state, or local requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of state or local building codes must also be met for buildings in flood hazard areas.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing and legal non-conforming buildings to determine whether the work constitutes substantial improvement or repair of substantial damage. If the work is determined to constitute substantial improvement or repair of substantial damage, the buildings must be brought into compliance with NFIP requirements for new construction. Some communities modify the definitions of substantial improvement and/or substantial damage to be more restrictive than the NFIP minimum requirements. For more information on substantial improvement and substantial damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010) and FEMA 213, *Answers to Questions About Substantially Improved/Substantially Damaged Buildings* (2018).

Elevation Above Minimum NFIP Requirements. Some states and communities require that buildings be elevated above the NFIP minimum requirement. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a community has freeboard requirements. References to building elevations in this Technical Bulletin should be construed as references to the community's elevation requirement where freeboard is required.

3. Building Codes and Standards

In addition to complying with NFIP requirements, all new construction, substantial improvements, and repair of substantial damage must comply with the applicable building codes and standards that are adopted and enforced by states and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®), are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes generally meet or exceed NFIP requirements for buildings and structures. Excerpts of the flood provisions of the I-Codes are available on the FEMA Building Science webpage at <https://www.fema.gov/emergency-managers/risk-management/building-science/building-codes>.

3.1. International Residential Code

The International Residential Code (IRC) applies to one- and two-family dwellings and townhomes not more than three stories above grade plane.

International Residential Code Commentary

The ICC publishes companion commentary for the IRC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

Table 1 summarizes the 2021 IRC requirements related to wet floodproofing; notes changes from the 2018, 2015, and 2012 editions; and compares the IRC provisions to the NFIP requirements. Subsequent editions of the IRC should include comparable requirements.

Table 1: Comparison of Selected 2021 IRC Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IRC Requirement and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Variance/ modification	<p>Section R104.10.1 [Modifications] Flood hazard areas. Limits granting modifications to the flood hazard area requirements unless a determination is made that certain conditions are satisfied.</p> <p><u>Change from 2018 to 2021:</u> No change.</p> <p><u>Change from 2015 to 2018:</u> No change.</p> <p><u>Change from 2012 to 2015:</u> Provisions moved from Board of Appeals to duties and powers of the building official.</p>	Equivalent to NFIP 44 CFR § 60.6 requirements for variances.
Garages and carports	<p>Section R309.3 [Garages and carports] Flood hazard areas.</p> <p>Requires garages and carports in flood hazard areas to meet requirements of R322.</p> <p><u>Change from 2018 to 2021:</u> Details of requirements for garages and carports moved from R309 to R322.</p> <p><u>Change from 2015 to 2018:</u> No change.</p> <p><u>Change from 2012 to 2015:</u> No change.</p>	Exceeds NFIP 44 CFR § 60.3 by specifying requirements for garages and carports.

Topic	Summary of Selected 2021 IRC Requirement and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Elevation (garages and carports)	<p>Section R322.2.1 (Zone A) and R322.3.2 (Zone V and Coastal A Zone) Elevation requirements.</p> <p>Requires garages and carport floors to (1) be elevated to the BFE plus 1 foot or the design flood elevation (DFE), whichever is higher or (2) be at or above grade on at least one side and meet the same requirements for enclosures below elevated dwellings.</p> <p><u>Change from 2018 to 2021:</u> Details of requirements for garages and carports moved from R309 to R322.</p> <p><u>Change from 2015 to 2018:</u> No change.</p> <p><u>Change from 2012 to 2015:</u> One foot of freeboard added. Modified to require dwellings in Coastal A Zones to comply with R322.3.</p>	Exceeds NFIP 44 CFR § 60.3 by specifying requirements for garages and carports and by requiring a minimum elevation higher than the BFE.
Enclosed areas (walls)	<p>Sections R322.2.2 (Zone A) and R322.3.6 (Zone V and Coastal A Zone) Enclosed area below required elevation and Section R322.3.5 (Zone V and Coastal A Zone) Walls below required elevation.</p> <p>Provides requirements for enclosed areas below the required elevation, including flood openings in Zone A and breakaway walls with flood openings in Zone V and the Coastal A Zone. The required elevation is the BFE plus 1 foot or DFE, whichever is higher.</p> <p><u>Change from 2018 to 2021:</u> Modified to apply requirements below the elevation required by R322, rather than the DFE.</p> <p><u>Change from 2015 to 2018:</u> Section numbers changed from R322.3.4 and R322.3.5 to R322.3.5 and R322.3.6, respectively.</p> <p><u>Change from 2012 to 2015:</u> Flood opening installation requirements moved to a new section. Requirement for flood openings in all breakaway walls added.</p>	Exceeds NFIP 44 CFR § 60.3(c)(5) and (e)(5) by requiring (1) flood openings in walls of each enclosed area, (2) flood openings on different sides of each enclosed area, (3) breakaway walls for enclosures in Coastal A Zones, and (4) flood openings in breakaway walls (Zone V and Coastal A Zone).

Topic	Summary of Selected 2021 IRC Requirement and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Enclosed areas (use limitations)	<p>Sections R322.2.2 (Zone A) and R322.3.6 (Zone V and Coastal A Zone) Enclosed areas below required elevation.</p> <p>Requires enclosed areas below the required elevation to be used solely for parking of vehicles, building access, or storage.</p> <p><u>Change from 2018 to 2021 IRC:</u> Applies requirements below the elevation required in Section R322 rather than the DFE.</p> <p><u>Change from 2015 to 2018 IRC:</u> No change.</p> <p><u>Change from 2012 to 2015 IRC:</u> No change.</p>	Equivalent to NFIP 44 CFR § 60.3(c)(5) and (e)(5) regarding the use of enclosed areas.
Equipment (electrical, plumbing, and mechanical systems)	<p>Section R322.1.6 Protection of mechanical, plumbing, and electrical systems.</p> <p>Requires that systems, equipment, and components be located at or above the required elevation, which is the BFE plus 1 foot or DFE, whichever is higher. Alternatively, those elements may be permitted below the required elevation if designed and installed to meet certain performance requirements.</p> <p><u>Change from 2018 to 2021:</u> Modified to apply flood load requirements during the occurrence of flooding to the elevation required by R322, rather than the DFE.</p> <p><u>Change from 2015 to 2018:</u> No change.</p> <p><u>Change from 2012 to 2015:</u> No change.</p>	Exceeds NFIP 44 CFR § 60.3(a)(3) by requiring a minimum elevation higher than the BFE.
Flood damage-resistant materials	<p>Section R322.1.8 Flood-resistant materials.</p> <p>Requires flood damage-resistant materials below the required elevation to conform to the requirements of NFIP Technical Bulletin 2, <i>Flood Damage-Resistant Materials Requirements</i>. The required elevation is BFE plus 1 foot or DFE, whichever is higher.</p> <p><u>Change from 2018 to 2021:</u> No change.</p> <p><u>Change from 2015 to 2018:</u> No change.</p> <p><u>Change from 2012 to 2015:</u> Modified to refer only to Technical Bulletin 2 instead of listing pressure-preservative-treated wood requirements.</p>	Exceeds NFIP 44 CFR § 60.3(a)(3) by requiring that flood damage-resistant materials extend higher than the BFE.

3.2. International Building Code and ASCE 24

The International Building Code (IBC) applies to all applicable buildings and structures. While used primarily for buildings and structures other than dwellings within the scope of the IRC, the IBC may also be used to design dwellings.

The flood provisions of the latest published editions of the IBC generally meet or exceed NFIP requirements for buildings through reference to the standard ASCE 24, *Flood Resistant Design and Construction*. ASCE 24 is developed by the American Society of Civil Engineers (ASCE). ASCE 24 applies to structures that are subject to building code requirements. ASCE 24 requirements for wet floodproofing are similar to the NFIP requirements for enclosures below elevated buildings.

International Building Code and ASCE 24 Commentaries

The ICC publishes companion commentary for the IBC, and ASCE publishes companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that are useful for complying with, interpreting, and enforcing requirements.

Table 2 summarizes the 2021 IBC and ASCE 24-14 requirements related to wet floodproofing; notes changes from 2018, 2015, and 2012 IBC editions and ASCE 24-05; and compares those provisions to the NFIP requirements. Subsequent editions of the IBC and ASCE 24 should include comparable requirements.

Table 2: Comparison of Selected 2021 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2018, 2015, and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Variance/ Modification	<p>IBC Section 104.10.1 [Modifications] Flood hazard areas.</p> <p>Limits granting modifications to the flood hazard area requirements unless a determination is made that certain conditions are satisfied. IBC Appendix G, Flood-Resistant Construction, which is not applicable unless specifically adopted, allows variances for historic structures and functionally dependent facilities.</p> <p><u>Change from 2018 to 2021 IBC:</u> No change.</p> <p><u>Change from 2015 to 2018 IBC:</u> No change.</p> <p><u>Change from 2012 to 2015 IBC:</u> No change.</p>	Equivalent to NFIP 44 CFR § 60.6 requirements for variances.

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2018, 2015, and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Enclosed areas	<p>ASCE 24-14 Section 2.7 Enclosures Below the Design Flood Elevation (Zone A) and Section 4.6 Enclosed Areas Below Design Flood Elevation (Zone V and Coastal A Zone)</p> <p>Specify requirements for enclosed areas below the DFE, including flood openings in Zone A and breakaway walls with flood openings in Coastal High Hazard Areas (Zone V) and Coastal A Zone.</p> <p><u>Change from ASCE 24-05:</u> New requirement for openings in breakaway walls in Coastal High Hazard Areas and Coastal A Zones. Specifies measurement of enclosed areas to determine square footage. Consolidates installation requirements, which apply to both non-engineered and engineered openings, and clarifies that the position is relative to the higher of the interior and exterior grade or floor.</p>	<p>Exceeds NFIP 44 CFR § 60.3(c)(5) and (e)(5) by requiring (1) flood openings in each enclosed area, (2) flood openings on different sides of each enclosed area, (3) breakaway walls for enclosures in Coastal A Zones, and (4) flood openings in breakaway walls (Zone V and Coastal A Zone).</p>
Flood damage-resistant materials	<p>ASCE 24-14 Chapter 5 Materials</p> <p>Requires use of flood damage-resistant materials below the required elevation and includes additional detailed requirements for specific materials. The required elevation depends on the Flood Design Class assigned to buildings.</p> <p><u>Change from ASCE 24-05:</u> Modified requirements for wood; preservative-treated wood required only when specified, instead of for all wood.</p>	<p>Exceeds NFIP 44 CFR § 60.3(a)(3) by requiring that flood damage-resistant materials extend higher than the BFE.</p>
Wet floodproofing limitations on use	<p>ASCE 24-14 Section 6.3 Wet Floodproofing</p> <p>Limits the use of wet floodproofing to Flood Design Class 1 structures; enclosures used solely for parking of vehicles, building access, or storage; structures that are functionally dependent on their close proximity to water; and certain agricultural structures.</p> <p><u>Change from ASCE 24-05:</u> No change. However, small parking structures were added to the Flood Design Class 1 category and specificity was added to the description of temporary structures in Flood Design Class 1.</p>	<p>Equivalent to NFIP 44 CFR § 60.3(c)(5) for enclosures and § 60.6 for functionally dependent use. Flood Design Class 1 is more specific than the NFIP by specifying temporary structures, storage buildings, small garages, and certain agricultural structures.</p>

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2018, 2015, and 2012 IBC / ASCE 24-05	Comparison with NFIP Requirements
Wet floodproofing requirements	<p>ASCE 24-14 Section 6.3 Wet Floodproofing</p> <p>Requires that wet floodproofing be accomplished by use of flood damage-resistant materials and techniques that minimize damage to the structure associated with flood loads by meeting the requirements for enclosures in Section 2.7 or Section 4.6, and by installing utilities in conformance with Chapter 7. The elevation requirement for Flood Design Class 1 structures is BFE + 1 foot or DFE, whichever is higher.</p> <p><u>Change from ASCE 24-05:</u> No change.</p>	Exceeds NFIP 44 CFR § 60.3(a)(3) by requiring that flood damage-resistant materials extend higher than the BFE.
Utility systems and equipment	<p>ASCE 24-14 Chapter 7 Attendant Utilities and Equipment</p> <p>Specifies utility elevation requirements and also requirements for equipment and utility systems that are below the required elevations, including elevators. The required elevation depends on Flood Design Class and is the BFE or higher.</p> <p><u>Change from ASCE 24-05:</u> Requirements for tanks moved to Section 9.7.</p>	Exceeds NFIP 44 CFR § 60.3(a)(3) by having specific requirements for system elements and by requiring a minimum elevation higher than the BFE.
Garages, carports, and accessory storage structures	<p>ASCE 24-14 Section 9.4 Garages, Carports, and Accessory Storage Structures</p> <p>Includes requirements and allows the use of wet floodproofing in conformance with Section 6.3 in flood hazard areas other than Coastal High Hazard Areas and the Coastal A Zone.</p> <p><u>Change from ASCE 24-05:</u> Added accessory storage structures, defined as used only for storage that is incidental to dwellings.</p>	Equivalent to NFIP 44 CFR § 60.3(a)(3).

3.3. International Existing Building Code

The International Existing Building Code (IEBC) applies to the repair, alteration, change of occupancy, addition to, or relocation of existing buildings and structures. The I-Codes define an existing building as “a building [or structure] erected prior to the date of adoption of the appropriate code, or one for which a legal building permit has been issued.” The NFIP regulations allow communities to issue variances for the repair or rehabilitation of historic structures provided the variance is the minimum necessary and the structures retain their designation as historic structures (44 CFR § 60.6(a)).

International Existing Building Code Commentary

The ICC publishes companion commentary for the IEBC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

Table 3 summarizes the 2021 IEBC requirements related to historic structures; notes changes from the 2018, 2015, and 2012 editions; and compares those provision to the NFIP requirements. Subsequent editions of the IEBC should include comparable requirements.

Table 3: Comparison of Selected 2021 IEBC Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IEBC Requirements and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Definition	<p>Section 202 Definitions; Historic Buildings. Defines buildings as historic buildings if they meet at least one of three criteria. <u>Change from 2018 to 2021 IEBC:</u> No change. <u>Change from 2015 to 2018 IEBC:</u> No change. <u>Change from 2012 to 2015 IEBC:</u> Definition of historic building added.</p>	Differs from the definition in NFIP 44 CFR § 59.1 by including local community historic registers.
Repairs	<p>Section 507.3 [Prescriptive Compliance Historic Buildings] Flood hazard areas. Provides an exception to bringing historic buildings that are substantially improved into compliance with the flood requirements of the IBC provided the buildings retain their historic designation. <u>Change from 2018 to 2021 IEBC:</u> No change. <u>Change from 2015 to 2018 IEBC:</u> No change. <u>Change from 2012 to 2015 IEBC:</u> Section 507.3 added.</p>	Equivalent to the exclusion in the definition of Substantial Improvement in NFIP 44 CFR § 59.1.

Topic	Summary of Selected 2021 IEBC Requirements and Changes from 2018, 2015, and 2012 Editions	Comparison with NFIP Requirements
Preservation of historic structures	<p>Section 1201.4 [Historic Buildings] Flood hazard areas.</p> <p>Provides an exception to bringing historic buildings that are substantially improved into compliance with the flood requirements of the IBC provided the buildings meet specific criteria and retain their historic designation.</p> <p><u>Change from 2018 to 2021 IEBC:</u> No change.</p> <p><u>Change from 2015 to 2018 IEBC:</u> No change.</p> <p><u>Change from 2012 to 2015 IEBC:</u> Compliance requirements with flood provisions in Section 1612 of the IBC and Section R322 of the IRC added.</p>	Equivalent to the exclusion in the definition of Substantial Improvement in NFIP 44 CFR § 59.1.

4. NFIP Flood Insurance Implications

NFIP flood insurance premiums for new construction and buildings that are substantially improved or repaired after incurring substantial damage are based on a number of factors such as flood risk, distance to flooding sources, elevation relative to flooding sources, type of building and foundation, number of floors, and whether a basement or enclosure is below elevated buildings. Designers, builders, and owners may wish to contact a qualified insurance agent with NFIP experience for more information on policy coverage, coverage limits, and premium costs.

The NFIP regulations for variances require communities to provide a written notice to applicants when a variance to allow a structure below the BFE is requested (44 CFR § 60.6(a)(5)). The notice requirement applies even when wet floodproofing measures are included in the building design. The notice must state that issuance of the variance will result in increased premium rates for NFIP flood insurance and that construction below the BFE increases risks to life and property.

5. Options for Communities to Authorize Wet Floodproofing

Communities have the following options to authorize wet floodproofing depending in part on the type of structure:

- Issue permits for the following:
 - Elevated buildings with enclosures below the lowest floor (see Section 5.1.1 of this Technical Bulletin)

- Buildings with attached garages (see Section 5.1.2 of this Technical Bulletin)
- Accessory structures that are not elevated or dry floodproofed, provided the structures are not larger than specific sizes (see Section 5.1.3 of this Technical Bulletin)
- Agricultural structures or accessory structures, but only when FEMA approves a community's request for a community-wide exception (see Section 5.3 of this Technical Bulletin)
- Consider issuing variances for the following:
 - Historic structures (see Section 5.2.1 of this Technical Bulletin)
 - Functionally dependent uses (see Section 5.2.1 of this Technical Bulletin)
 - Accessory structures that are larger than the specified size limits established for authorization by permit (see Section 5.2.2 of this Technical Bulletin)
 - Certain agricultural structures (see Section 5.2.2 of this Technical Bulletin)

Section 5.4 of this Technical Bulletin covers the implications for NFIP Community Rating System (CRS) communities that approve wet floodproofing.

Modifying Community Floodplain Management Regulations

FEMA P-2140 has model ordinance language for some authorization options for wet floodproofing of agricultural structures and accessory structures.

Communities considering making any modifications to floodplain management regulations should check with NFIP State Coordinating Offices or FEMA Regional Offices to ensure consistency with the NFIP and state requirements.

5.1. When Wet Floodproofing May Be Authorized by Permit

Wet floodproofing may be authorized by permit for enclosures below elevated buildings, attached garages, and non-elevated accessory structures.

5.1.1. ENCLOSURES BELOW ELEVATED BUILDINGS

The NFIP regulations provide criteria that must be satisfied when communities issue permits for elevated buildings with enclosures below the lowest floor. Enclosures below elevated buildings must be used solely for parking of vehicles, building access, or storage.

The criteria for enclosures below elevated buildings in Zone A are equivalent to wet floodproofing measures that do not require human intervention (e.g., flood openings, flood damage-resistant materials, elevated mechanical and utility equipment). Enclosures below elevated buildings in

Zone V must have breakaway walls, but breakaway walls are not considered wet floodproofing measures.

5.1.2. ATTACHED GARAGES

Attached garages without a story above are allowed to have the garage floors below the BFE provided the garages are designed and constructed to meet the same requirements as enclosures below elevated buildings. Attached garages with floors below the BFE must have flood openings and use flood damage-resistant materials, and mechanical and utility equipment must be elevated.

5.1.3. NON-ELEVATED ACCESSORY STRUCTURES

FEMA P-2140 describes the requirements that communities should adopt in order to issue permits for non-elevated accessory structures that may be wet floodproofed. FEMA P-2140 includes model ordinance language.

Before issuing permits for wet floodproofed accessory structures, communities must verify:

- Use is limited to parking of vehicles or storage.
- Size is less than or equal to the limits based on flood zone:
 - Zone A: Not larger than a one-story, two-car garage (600 square feet)
 - Zone V: Not larger than 100 square feet (breakaway walls are not required)
- The structures have low damage potential (see FEMA P-2140, Section 2.1.5).
- The structures comply with wet floodproofing requirements.

5.2. When Wet Floodproofing Must Be Authorized by Variance

The NFIP regulations and FEMA guidance address when communities may issue variances to the strict application of the floodplain management requirements, including the elevation and dry floodproofing requirements. To properly issue variances, communities should have a designated reviewing body and procedures for hearings and evaluating variance requests. FEMA P-993, *Floodplain Management Bulletin: Variances and the National Flood Insurance Program* (2014), provides guidance on variance procedures in accordance with 44 CFR § 60.6.

When considering requests for variances, communities must determine whether variances meet the NFIP criteria for issuance. To do so, the community must, at a minimum, apply the variance criteria in 44 CFR § 60.6, including determining that variances are the minimum necessary to afford relief, considering the flood conditions at a site. This means that when a community considers a variance from elevation or dry floodproofing requirements, consideration must be given to whether wet floodproofing is an appropriate alternative that minimizes potential damage.

“Minimum Necessary” and “Mixed Mitigation”

The NFIP regulations state that variances must be issued only after a determination that variances are the “minimum necessary, considering the flood hazard, to afford relief” (44 CFR § 60.6(a)(4)).

“Mixed mitigation” refers to combining partial elevation with wet or dry floodproofing. FEMA P-2140 describes and illustrates mixed mitigation measures.

5.2.1. ALLOWABLE VARIANCES IDENTIFIED IN 44 CFR § 60.6

The NFIP regulations in 44 CFR § 60.6 state that variances from the minimum requirements for buildings in SFHAs may be issued for the repair and rehabilitation of historic structures and for functionally dependent uses.

Historic Structures

The NFIP regulation in 44 CFR § 60.6(a) states that variances may be issued for the repair and rehabilitation of historic structures. The term “historic structure” is defined in 44 CFR § 59.1 and in local floodplain management regulations. FEMA P-467-2, *Floodplain Management Bulletin: Historic Structures* (2008), provides guidance on how the NFIP treats historic structures and identifies mitigation measures that can be taken to minimize the effects of flooding.

“Historic Structure” Defined in NFIP Regulations

Historic structure is defined in 44 CFR § 59.1 as any structure that is:

- (a) Listed individually in the National Register of Historic Places (a listing maintained by the Department of Interior) or preliminarily determined by the Secretary of the Interior as meeting the requirements for individual listing on the National Register;
- (b) Certified or preliminarily determined by the Secretary of the Interior as contributing to the historical significance of a registered historic district or a district preliminarily determined by the Secretary to qualify as a registered historic district;
- (c) Individually listed on a state inventory of historic places in states with historic preservation programs which have been approved by the Secretary of the Interior; or
- (d) Individually listed on a local inventory of historic places in communities with historic preservation programs that have been certified either:
 - (1) By an approved state program as determined by the Secretary of the Interior or
 - (2) Directly by the Secretary of the Interior in states without approved programs.

Communities may issue a variance for repairs to or rehabilitation of historic structures that would otherwise constitute substantial improvement or repair of substantial damage as long as the work is determined not to preclude the structure's continued designation as a historic structure.

Communities must also determine that the variance is the minimum necessary to preserve the historic character and design of the structure. Consideration of wet floodproofing measures should be part of determining whether a variance is the minimum necessary because wet floodproofing may reduce the potential for damage.

Functionally Dependent Uses

For floodplain management purposes, "functionally dependent uses" are uses that cannot perform their intended purposes unless located or carried out in close proximity to water. The NFIP definition includes only docking facilities, port facilities that are necessary for the loading and unloading of cargo or passengers, and ship building and ship repair facilities and does not include long-term storage or related manufacturing facilities (44 CFR § 59.1). Other structures and uses may be commonly located near water, but that does not qualify them as functionally dependent uses.

Communities may grant variances to allow new construction or substantial improvement of functionally dependent uses without requiring compliance with elevation or dry floodproofing requirements. Variances should be issued only after determining whether inclusion of wet floodproofed measures satisfies the requirement that variances be the minimum necessary.

In addition to general criteria for variances, the NFIP regulations at 44 CFR § 60.6(a)(7) provide that functionally dependent uses must be protected by methods that minimize flood damage during the base flood and must create no additional threat to public safety. Wet floodproofing measures may reduce the potential for damage.

5.2.2. ALLOWABLE VARIANCES NOT IDENTIFIED IN 44 CFR § 60.6

Communities may consider requests for variances to floodplain management regulations even when those variances are not explicitly identified in the NFIP regulations for variances. FEMA policy and guidance explicitly state that communities must use variances to approve accessory structures that are larger than the size limits established in FEMA P-2140 and for certain agricultural structures defined in FEMA P-2140.

Accessory Structures Larger than Specified Size Limits

Accessory structures that are larger than the size limits established in FEMA P-2140 and Section 5.1.3 of this Technical Bulletin must be elevated or dry floodproofed. Alternatively, communities may consider variances for wet floodproofed accessory structures that are larger than those size limits when the structures represent minimum investment and have low damage potential. Communities should also consider implementing the suggested best practices described in Section 9 of this Technical Bulletin, especially limiting what can be stored and requiring nonconversion agreements. Some communities require that owners execute and record a nonconversion agreement to stipulate

that they will not modify wet floodproofing measures and will not convert at-grade accessory structures to uses other than approved uses.

Communities that choose to issue variances for accessory structures larger than the specified size limits should adopt specific provisions in the variance section of their floodplain management regulations. FEMA P-2140 includes model ordinance language.

Certain Agricultural Structures

FEMA recognizes that wet floodproofing may be appropriate for certain types of agricultural structures. Variances may be issued for wet floodproofed agricultural structures only if the structures are used solely for agricultural purposes and the use is exclusively connected to the production, harvesting, storage, raising, or drying of agricultural commodities and livestock. Communities should grant variances only when it can be demonstrated that structures have low damage potential and can be designed using methods that minimize flood damage during the base flood and that no additional threats to public safety are created. Wet floodproofing measures may reduce the potential for damage.

Because wet floodproofing a new agricultural structure with the lowest floor below the BFE is not in compliance with NFIP requirements, variances must address both the non-conforming flood protection measures and the restriction of use to the designated agricultural purposes. Refer to FEMA P-2140 for requirements and procedures related to variances for agricultural structures. FEMA P-2140 includes model ordinance language.

When variances to allow wet floodproofing are considered, a best practice is to require flood emergency operations plans and inspection and maintenance plans to ensure that wet floodproofing measures remain functional (see Section 6.5 of this Technical Bulletin).

State Agricultural Structure Exemptions

Some states exempt agricultural structures or structures on farms from state and local building and zoning codes. State exemptions do not exempt those structures from floodplain management regulations administered by communities that participate in the NFIP.

5.3. Community-Wide Exception

Consistent with FEMA Policy #104-008-03, FEMA P-2140 notes that FEMA recognizes that complying with the NFIP requirements for the elevation or dry floodproofing of agricultural structures or accessory structures could cause hardship due to extraordinary circumstances or local conditions. In these cases, and in accordance with 44 CFR § 60.6(b) and FEMA Policy #104-008-03, communities may apply to FEMA for approval of a community-wide exception to issue permits for wet floodproofed agricultural structures or accessory structures. Approved community-wide exceptions allow communities to deviate from the NFIP requirements under specified conditions without having to process individual variance requests. FEMA P-2140 provides guidance on submitting a

community-wide exception request for agricultural structures and accessory structures. Communities should contact FEMA Regional Offices for assistance.

5.4. Implications for NFIP Community Rating System Communities That Approve Wet Floodproofing

Communities that participate in the NFIP Community Rating System (CRS) must maintain all required floodplain-related construction certificates listed in Section 301.b of the *Addendum to the 2017 CRS Coordinator's Manual* (FEMA, 2021b) that are applicable to the community's situation, including Elevation Certificates, V Zone design certificates, and Floodproofing Certificates. These certificates must be collected and maintained for all buildings that are constructed, substantially improved, and/or repaired after incurring substantial damage in SFHAs. Elevation Certificates are not required for accessory structures.

CRS communities periodically submit construction certificates to FEMA for review. Communities should be aware of how the CRS will respond when reviewing construction certifications for wet floodproofed structures. CRS participation and credits are not affected when CRS communities adopt ordinance language in accordance with FEMA P-2140 to allow wet floodproofed accessory structures and agricultural structures.

CRS credits for freeboard or other higher standards could be reduced if CRS communities opt to no longer require freeboard (or other higher standards) for wet floodproofed agricultural structures, historic structures, or functionally dependent uses, all of which require construction certificates.

6. Planning Considerations

This section describes the planning considerations that may influence owners and designers when they evaluate the feasibility of using wet floodproofing measures for historic structures, agricultural structures, and functionally dependent uses. Some of the considerations should be evaluated as part of deciding whether to wet floodproof accessory structures and whether to enclose areas under elevated buildings.

When identifying sites and developing plans for buildings, owners and developers should have design professionals assess building sites to determine the site-specific flood hazards and conditions that are described in this section. The hazards and conditions may influence the feasibility and selection of wet floodproofing measures. The assessment should include not only flood hazards and site conditions but also available flood warning time prior to the onset of flooding, functional use requirements, safety and access before and during flooding, and the possible need for flood emergency operations plans and inspection and maintenance plans. Designers should review the assessment findings with building owners to determine whether wet floodproofing is appropriate and whether the assessment results indicate any constraints on designs.

6.1. Flood Hazards and Site Conditions

Site assessments should determine whether sites are located in a mapped floodway, the depth of flooding, rate of floodwater rise and fall, frequency of flooding, duration of flooding, presence of ice, and likelihood of flood-borne contaminants.

6.1.1. LOCATION IN MAPPED FLOODWAY

The NFIP regulations place restrictions on construction in floodways. The floodway is the “channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the base flood without cumulatively increasing the water surface elevation by more than a designated height” (44 CFR § 59.1).

Communities must prohibit floodway encroachments unless engineering analyses demonstrate that the encroachments would not result in any increase in flood levels during base flood events (44 CFR § 60.3(d)(3)). The floodway encroachment restriction applies whether communities authorize proposed development by permit or variance.

6.1.2. DEPTH OF FLOODING

In general, the amount of physical damage that a structure incurs increases as the depth of flooding increases. Establishing a reasonable range of flood depths for wet floodproofing measures is difficult in part because of how wet floodproofed structures or parts of structures may be used. For example, wet floodproofing may involve permanent or contingent elevation of contents, equipment, and machinery. Based on local conditions and to address safety concerns, communities could establish a maximum depth of water under base flood conditions (BFE minus ground elevation) as a depth that would preclude approving the use of wet floodproofing by variance. The depth limit would not constrain the use of wet floodproofing when allowed by permit, including when used for enclosures below elevated buildings and accessory structures.

6.1.3. RATE OF FLOODWATER RISE AND FALL

A primary requirement when wet floodproofing is specified is the installation of flood openings in exterior walls to allow the automatic entry and exit of floodwater. Automatic entry and exit allow the exterior and interior flood levels to be approximately the same as floodwater rises and falls, which balances hydrostatic pressure. See Section 7.2 of this Technical Bulletin for more information on flood openings.

6.1.4. FREQUENCY OF FLOODING

Frequent flooding may render wet floodproofing impractical, depending on how structures are used. Factors that should be assessed to determine whether wet floodproofing is a viable option in areas that experience frequent flooding include the cumulative wear and tear of recurring inundation and the costs associated with repeated interruption of use, frequent removal (or inundation) of contents, and frequent cleanup activities.

6.1.5. DURATION OF FLOODING

Duration of flooding is the amount of time floodwater is expected to affect a site, starting with the onset of flooding and ending when floodwater recedes. The following two impacts associated with duration of flooding should be considered when structures are wet floodproofed:

- The longer the duration, the more likely structural components, interior materials and finishes, equipment and machinery, and contents will deteriorate because of saturation.
- Because use and occupancy are disrupted during flooding, disruption combined with the time necessary to clean up and repair may result in significant economic losses for long duration times.

6.1.6. PRESENCE OF ICE

In colder regions, the impact of large, water-borne chunks of ice can damage or destroy portions of structures that are not elevated, including wet floodproofed enclosures and structures. Water that freezes inside wet floodproofed structures can exert expansive forces that may damage both structural and non-structural components of the buildings.

6.1.7. FLOOD-BORNE CONTAMINANTS

Floodwater may contain numerous contaminants that are caustic, toxic, or putrid. Floodwater in urbanized and industrialized areas may contain salts, alkalis, oils, wastes, chemicals, and debris in higher amounts than in other areas. In agricultural areas, floodwater often contains herbicides, pesticides, fertilizers, animal waste, and dead and decaying animals. Some flooding sources contain higher concentrates of suspended sediment than others. Inundated construction materials and contents of wet floodproofed areas may be coated with sediment, debris, and contaminants.

6.2. Flood Warning Time

Flood warning time is important to consider when owners plan to relocate contents and machinery or when wet floodproofing measures that require human intervention are allowed by variance. In both cases, advance notice and time are necessary to perform the appropriate actions before the onset of flooding. When wet floodproofing measures that require human intervention are proposed as part of requests for variances, designers should determine whether warnings issued by credible sources would provide enough time to implement those measures. Determining whether the flood warning time is adequate requires estimating the total time needed to:

- Recognize the threat, including whether anticipated storm conditions will have high winds that could hamper installation
- Notify persons or contractors responsible for activation or deployment
- Travel to the site if key personnel are not located on site

- Relocate contents and machinery
- Implement the measures
- Evacuate the personnel implementing the measures using predetermined evacuation routes, taking into account whether roads or bridges may be closed by state or local officials (e.g., when high winds or overtopping by floodwater are anticipated)
- Allow for unanticipated factors that may require additional time

Additional information about flood warning time may be available from state and local emergency management agencies, local floodplain managers, river basin authorities and drainage districts, state water resources agencies, National Weather Service, U.S. Geological Survey, and the U.S. Army Corps of Engineers District Offices.

6.3. Functional Use of Wet Floodproofed Areas

Owners should evaluate the use of buildings and portions of buildings proposed to be wet floodproofed when considering the feasibility of intentionally allowing these areas to flood. Daily operations and use of these areas may need to be modified to reduce vulnerability when flooding occurs. If extended interruption of function would be detrimental, building owners should consider whether wet floodproofing is a viable option compared to elevation or dry floodproofing.

6.4. Safety and Access as Flooding Threatens

For safety, wet floodproofed buildings should not be occupied during flood conditions because floodwater may rise quickly or rise to a higher level than anticipated. In addition, muddy floodwater can obscure scour holes, washed-out paved surfaces, and tripping hazards. Safe access should be considered if an owner expects to need access to a wet floodproofed structure as flooding begins to affect a site or during flooding. See Section 6.2 of this Technical Bulletin for guidance on flood warning time.

In general, fast flowing floodwater is more dangerous than slow moving or standing water. Even shallow floodwater less than a few feet deep can be dangerous if the velocities are high. Rather than locate a new structure with wet floodproofing in an area where safe access is not assured, owners should consider sites where water depths will be shallower and velocities are not high. Some information about water depth and velocities may be available in Flood Insurance Studies or other studies by government agencies.

6.5. Recommended Plans

Flood emergency operations plans and inspection and maintenance plans should be prepared when wet floodproofing is proposed for historic structures and functionally dependent uses and when wet floodproofing is authorized by variance for other buildings.

6.5.1. FLOOD EMERGENCY OPERATIONS PLANS

Flood emergency operations plans should be required when wet floodproofing measures or a combination of wet and dry floodproofing measures that require human intervention are authorized by variance. Building owners, operators, and responsible personnel must be able to implement the plan and then safely leave the area in advance of the onset of flooding (see Section 6.2 of this Technical Bulletin). In addition, there must be sufficient time to notify and evacuate occupants when flood conditions are anticipated.

Annual review of flood emergency operations plans, with exercises for personnel, is critical to the success of the measures when flooding occurs. At a minimum, plans should:

- Identify the personnel, equipment, tools, and supplies needed to implement the measures
- Detail procedures for notifying persons responsible for implementing the measures, including chain of command
- Lay out in detail the sequence, timeline, and personnel responsible for implementing the measures
- Describe and illustrate the storage locations of equipment and deployable components
- Provide step-by-step instructions for implementing the measures
- Specify the requirements for regular review, deployment drills and training, and updating the plan

6.5.2. INSPECTION AND MAINTENANCE PLANS

Floodproofing measures require periodic inspection and maintenance plans to ensure that the measures are kept in working order so all components will function properly under flood conditions. An inspection and maintenance plan should be prepared to ensure that the components are inspected and properly maintained on a regular basis. Inspections and maintenance should be performed annually in accordance with the plans. At a minimum, plans should:

- Identify the personnel or service contractors responsible for conducting the inspections and any required maintenance
- Describe and illustrate the floodproofing measures
- Specify the requirements for regular inspections, routine maintenance, and corrective actions
- Verify that flood openings are not blocked or modified
- Verify that flood damage-resistant materials have not been replaced with materials that would be damaged by contact with floodwater

- List contact information for the manufacturer of any product, such as flood damage-resistant materials and flood openings

7. Design Requirements

Understanding the design considerations and requirements associated with wet floodproofing measures will help owners, builders, and design professionals develop strategies to meet the requirements when buildings are allowed to be wet floodproofed. Owners and designers should also consider the measures described in Section 8 of this Technical Bulletin and the suggested best practices described in Section 9 of this Technical Bulletin.

7.1. Foundations

The failure of foundations inundated by floodwater can cause structural damage. Foundation design is a site-specific process and must account for combined building loads, flood loads, and the flood hazard and site conditions described in Section 6.1 of this Technical Bulletin. Foundation design should also consider the effects of moving water, which may erode supporting soil, scour foundation material, or undermine footings.

The NFIP regulations require buildings to be anchored to foundations to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy. During flood events, uplift forces are often great enough to separate an improperly anchored building from its foundation. Structures that become dislodged can cause damage to other buildings or block downstream drainageways, culverts, and bridges.

7.2. Flood Openings

A primary requirement for wet floodproofing is to intentionally allow floodwater to enter and exit automatically (without human intervention). Allowing floodwater to enter and exit automatically minimizes unequal hydrostatic loads on walls. Hydrostatic loads are forces that are associated with standing or slow-moving floodwater. Unequal hydrostatic loads can cause foundation or wall collapse and flood-induced uplift.

Equalizing hydrostatic loads is achieved by installing flood openings in walls to allow water to automatically enter and exit (see Figure 2). In addition, provisions should be made to prevent air from becoming trapped during periods of inundation, which can pressurize the interior of wet floodproofed buildings and damage walls and roofs. The NFIP requirements and guidance for flood openings are discussed in NFIP Technical Bulletin 1, *Requirements for Flood Openings in Foundation Walls and Walls of Enclosures*.

Measures not Acceptable as Flood Openings

Doors, panels, and covers that must be opened before the onset of flooding do not satisfy the automatic entry and exit requirement because human intervention is required.

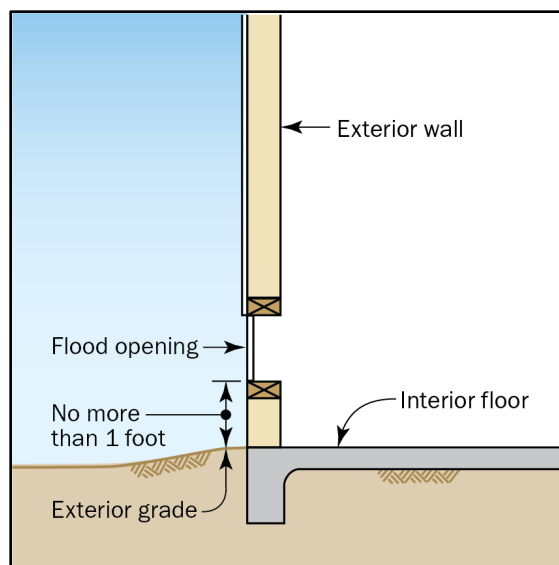


Figure 2: Typical flood opening configuration

7.3. Wall Construction

Walls of wet floodproofed buildings are subject to damage by floodwater if the walls are not properly constructed. Measures should be taken to reduce the absorption of floodwater into walls and finishes.

7.3.1. SOLID WALLS

Solid walls are walls without internal spaces that could retain floodwater. Typical solid walls are made with cast-in-place concrete or fully grouted concrete masonry units. Because the surfaces of walls made of these materials are somewhat porous, they can absorb moisture and to a limited degree, flood-borne contaminants. The intrusion of moisture can lead to damage, particularly in colder climates with freeze-thaw cycles. Sealants and waterproof paints can reduce the absorption of moisture and contaminants and facilitate cleanup.

7.3.2. CAVITY WALLS

Cavity walls are walls with internal spaces that could retain floodwater. Typical cavity walls are wood-framed walls with interior sheathing and walls made with ungrouted concrete masonry units.

Using unfinished wood-framed walls without interior sheathing and solid masonry or grouted concrete masonry units avoids difficulties with draining and cleaning cavity walls. When cavity walls are used, the walls should be constructed to enable the cavities to adequately drain as floodwaters recede. Wall cavities inundated by floodwater will be exposed to contaminants and should have clean-out access panels or other means to allow the internal air spaces to be flushed with water or cleaning agents and to allow fresh air to circulate in the cavities to facilitate drying. If the walls are insulated, foam and closed cell types of insulation should be used because they have flood damage-resistant characteristics.

7.4. Flood Damage-Resistant Materials

The NFIP regulations require that construction materials below the BFE be resistant to flood damage. Materials that are not flood damage-resistant materials may be used when necessary to address life safety and fire code requirements.

NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements*, describes five classes of materials ranging from highly resistant to flood damage to no resistance. Materials are broadly described as structural materials and finish materials based on how the materials are used in normal construction practices:

- **Structural materials** include all elements necessary to provide structural support, rigidity, and integrity to a building or building component. Structural materials include floor slabs, beams, subfloors, framing, and structural components, such as trusses, wall panels, I-joists and headers, and interior/exterior sheathing.
- **Finish materials** include all coverings, finishes, and elements that do not provide structural support or rigidity to a building or building component. Finish materials include floor coverings, wall and ceiling surface treatments, insulation, cabinets, and materials used to fabricate doors, partitions, and windows.

Technical Bulletin 2 includes guidance on fasteners and connectors used below the BFE. “Fastener” refers to nails, screws, bolts, and anchors. “Connector” refers to manufactured devices used to connect two or more building components. The performance of buildings can be compromised when fasteners and connectors are rusted or otherwise weakened by inundation. Fasteners and connectors must be made of flood damage-resistant materials.

Metal Buildings

Metal cladding and metal buildings used for agricultural structures and accessory structures must be made of corrosion-resistant materials, such as galvanized steel.

7.5. Protection of Mechanical, Plumbing, and Electrical Systems

The NFIP regulations require mechanical, plumbing, and electrical systems to be “designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding” (44 CFR § 60.3(a)(3)(iv)). The preferred method of meeting this requirement is elevating the system components above the BFE because most mechanical, plumbing, and electrical equipment is not specifically designed to prevent water from entering or accumulating within the components during flooding and thus must not be installed below the BFE. Systems that serve non-residential buildings may use techniques called “component protection” or “in-place protection” to protect non-elevated equipment and systems (see Section 8.2 of this Technical Bulletin).

Guidance for Mechanical, Plumbing, Electrical, and Other Building Utilities and Systems

FEMA P-348, *Protecting Building Utilities From Flood Damage* (2017), provides guidance on mitigation measures to protect mechanical, plumbing, electrical, and other building utilities and systems, including new installations, replacement systems, and retrofit measures for existing systems.

7.5.1. HEATING, VENTILATION, AND AIR CONDITIONING

In general, heating, ventilation, and air conditioning (HVAC) equipment is not designed to withstand inundation and will be damaged when flooded. When structures are allowed to be wet floodproofed, HVAC equipment should be elevated or have component protection measures to minimize inundation of system components and to be serviceable after floodwater recedes.

As part of proposals for wet floodproofing, especially retrofit wet floodproofing, an option may be considered when permit applicants demonstrate that elevating, using component protection, or permanently relocating HVAC equipment is not practical. The option allows the use of quick-release or disconnect mechanisms so equipment can be easily moved prior to the onset of flooding. When this option is considered, the available flood warning time should be determined (see Section 6.2 of this Technical Bulletin), and the flood emergency operations plan should include this action (see Section 6.5.1 of this Technical Bulletin).

7.5.2. ELECTRICAL SYSTEMS

Electrical systems that serve wet floodproofed buildings must be designed to minimize exposure to flooding as follows:

- Electrical service provided from poles or other overhead sources should enter buildings at a point above the BFE.
- Underground service cables may be feasible provided they are waterproofed, located where not exposed to direct contact with floodwater, and able to resist flood loads.
- Elevation of all electrical system components is required, including transformers, switchboards, and branch panels.
- An alternative to elevating components and equipment may be to enclose them in watertight panels, conduits, or chases that are insulated, rigid, and designed to withstand flood and debris impact forces.
- A minimum number of light switches and receptacles necessary to meet life safety requirements may be located below the BFE, provided they are intended for use in wet locations.
- Ground-fault circuit interrupters should be used for all electrical circuits that serve areas below the BFE.

Post-Flood Safety Inspections

Electrical system components that have been flooded must have a safety inspection before power is restored to ensure that the electrical components are completely dry and clean.

7.6. Fuel, Gas, and Liquid Storage Tanks

Fuel, gas, and liquid storage tanks are subject to hydrostatic loads (buoyancy) during inundation. When allowed above ground in Zone A, tanks can be installed and anchored on grade or elevated on platforms or fill. In Zone V, above-ground tanks must be elevated on platforms to satisfy the requirement that buildings be free of obstructions. Underground tanks must be installed and adequately anchored to account for buoyancy loads and reduced soil capacity when surrounding soils become saturated and to account for scour and erosion during flooding. Fill openings, outlets, vents, and cleanouts must be elevated above the BFE or designed to prevent the entry of floodwater and loss of contents during flooding. FEMA P-348 and FEMA P-2140 provide illustrations and descriptions of designs and options for installation of tanks.

Tanks should have labels that identify the contents. Labeling enables emergency personnel to identify the contents if a tank breaks loose and floats away. Empty tanks, whether above ground and anchored or underground, should be “topped off” (filled) when feasible prior to the onset of flooding to help resist buoyancy loads. After flooding, tank contents must be disposed of in accordance with all applicable federal, state, and local requirements.

8. Retrofit Measures When NFIP Compliance Is Not Required

The retrofit measures described in this section can be used to reduce damage to at-risk, existing and legal non-conforming buildings and structures in SFHAs when compliance with the NFIP requirements for new construction and substantial improvement is not required. These measures should also be considered when communities grant variances to the elevation or dry floodproofing requirements to satisfy the expectation that variances are the minimum necessary to afford relief.

For floodplain management purposes, existing buildings and structures are those constructed before a community joined the NFIP. Legal non-conforming buildings and structures are structures built after a community joined the NFIP but do not conform to a community’s current floodplain management requirements. Non-conformance may result from changes in requirements for buildings or changes in FIRMs that alter SFHAs, flood zones, and BFEs. In general, work on an existing or non-conforming building should not be allowed to increase the building’s non-conformity. Specifically, proposed work on legal non-conforming buildings must not be allowed if the work does not conform to the floodplain management requirements in effect at the time the building was constructed, even if the proposed work does not constitute substantial improvement.

8.1. Relocation or Elevation of Machinery and Equipment

When existing and legal non-conforming buildings and structures are not required to be brought into compliance with the NFIP minimum requirements, a degree of protection can be achieved by permanently relocating or elevating machinery and equipment. Depending on the function of the machinery and equipment, it may be able to continue service if relocated to a higher floor, or the machinery and equipment can be elevated in place. Relocated or elevated equipment will be functional when flooding does not rise higher than the height of the bottom of the equipment. This method of protection can be used for HVAC equipment that, when functional after flooding, will facilitate drying and recovery. See FEMA P-348 for guidance.

Machinery and equipment inside buildings can be elevated by permanently mounting on pads, platforms, or pedestals (see Figure 3) or by using hoists or some type of overhead suspension system when flooding is predicted. A wide range of objects can be elevated such as machinery, utility system components (particularly electrical equipment), fuel and storage containers, and building contents. Pads, platforms, and pedestals should be anchored to the floor system or slab, and the equipment should be anchored to the supporting structure.

Machinery and equipment installed outside buildings can usually be elevated on pedestals, pads, or platforms.

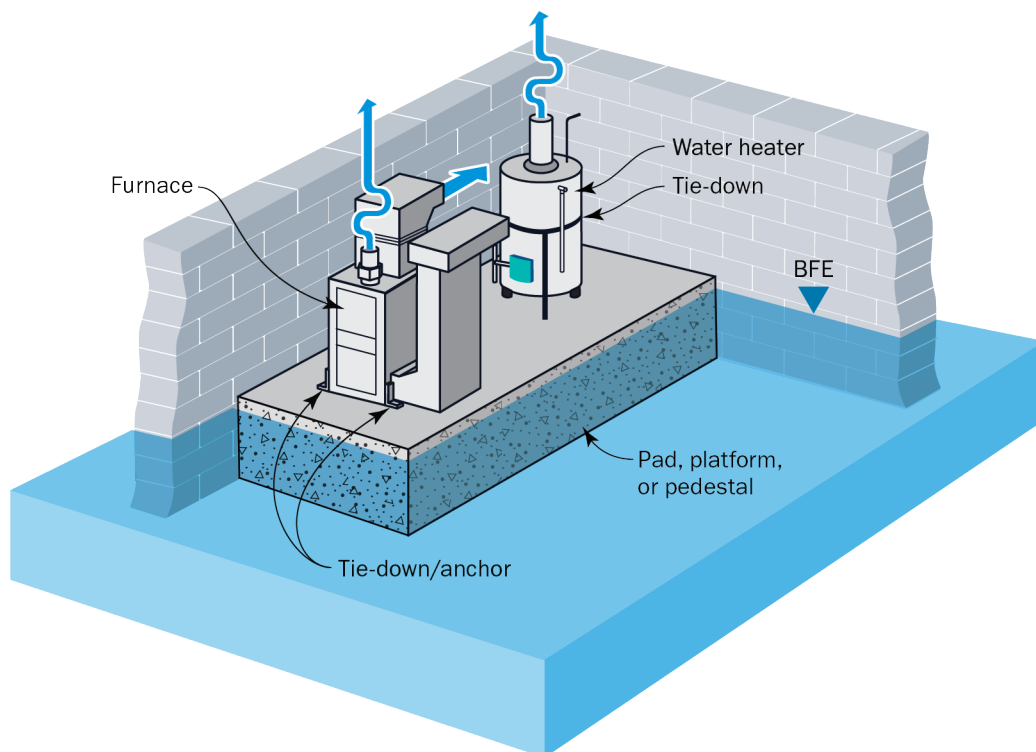


Figure 3: Elevation of equipment on a pad, platform, or pedestal in an area in which the floor slab is below the BFE

8.2. Component Protection of Machinery and Equipment

When existing and legal non-conforming buildings and structures are not required to be brought into compliance with the NFIP minimum requirements, a degree of protection can be achieved by using component protection measures (also called “in-place protection”) to protect machinery and equipment. When protected, the equipment will be functional when flooding does not rise higher than the height of the protection measure. This method of protection can be used for HVAC equipment that, when functional, will facilitate drying and recovery. See FEMA P-348 for guidance.

Component protection involves protective permanent or temporary waterproof barriers (see Figure 4), especially when components are difficult to elevate or move. Access doors in permanent barriers should be watertight when closed or protected with mountable flood shields. Tanks and storage containers can be retrofitted with anchors and tie-downs to resist flotation and movement during flooding.

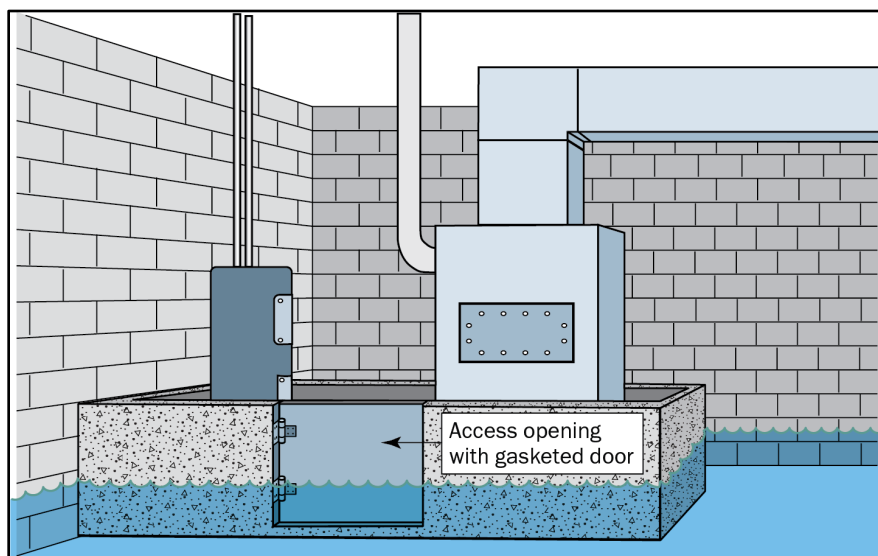


Figure 4: Water heater and furnace protected by a concrete floodwall with access protected by gasketed door or shield

8.3. Interior Drain Systems

Existing and legal non-conforming buildings and structures may have below-grade areas that are subject to flooding. If interior drain systems are not already present, retrofitting below-grade areas with measures to facilitate drainage after floodwaters recede may reduce damage. Interior drain systems also keep seepage from accumulating in interior areas of buildings but are not intended to prevent water from entering buildings during flooding. Sump pumps are commonly used for dewatering below-grade areas and facilitating recovery after floodwaters recede. Gradual dewatering is necessary to avoid creating unequal saturated soil loads on basement walls that can lead to wall failure. Sump pits generally are constructed with the bottom well below the base of the floor slab, and the floor is sloped to drain water to the sump (see Figure 5). See FEMA P-348 for guidance.

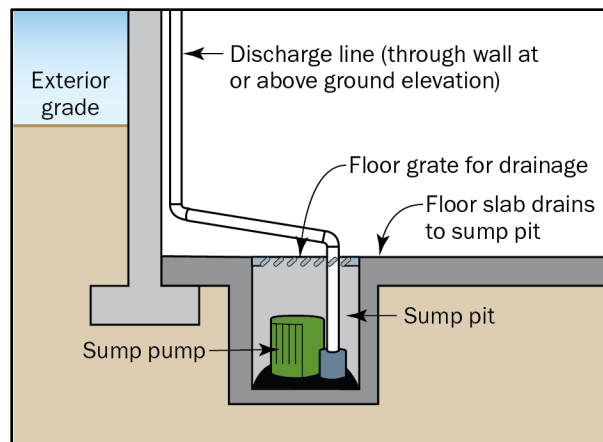


Figure 5: Typical interior drain system

8.4. Dry Floodproofing

Retrofitting some existing and legal non-conforming buildings and structures with dry floodproofing measures by sealing the perimeter walls and creating watertight structures may be technically feasible but not advisable. For guidance on dry floodproofing, refer to FEMA P-936 and Technical Bulletin 3. The likelihood that retrofit floodproofing measures will fail can be high for buildings that were not originally designed to be substantially impermeable and resistant to flood loads. In these cases, and when compliance is not required, it may be technically and economically feasible to consider wet floodproofing to minimize the potential for structural damage.

8.5. Other Considerations

When considering work on existing and legal non-conforming buildings and structures when NFIP compliance is not required, owners and designers should consider the following flood damage reduction retrofit measures:

- Walls, insulation, wall coverings, and finishes can be replaced with flood damage-resistant materials to facilitate cleanup and recovery.
- Quick-disconnect type plugs and receptacles can be used for standard electrical motors and other electrical connections to enable rapid shutdown, reinstallation and restart.
- Equipment and inventory can be mounted on skids or pallets to facilitate relocation, elevation, or removal.
- Large machinery that can be lifted from overhead can be permanently fitted with lifting bars or lugs.
- Buildings should be organized for easy access and to facilitate temporary relocation of contents.

- Contents can be moved to other areas of the building above the anticipated flood level or offsite.
- Vehicles can be moved to locations outside the flood hazard area.

9. Suggested Best Practices

Owners and designers should consider the following best practices when evaluating the use of wet floodproofing measures:

- Consider combining partial elevation or partial dry floodproofing with wet floodproofing (sometimes called “mixed mitigation”). Although written specifically for agricultural structures and accessory structures, the mixed mitigation measures described and illustrated in FEMA P-2140 are applicable to other types of structures for which wet floodproofing is authorized.
- Consider damage reduction practices such as wet floodproofing for areas known to experience flooding that are outside the mapped SFHA.
- Install and configure electrical and mechanical systems to minimize disruptions and facilitate repairs:
 - Elevate the electrical system by running wiring along the top of the walls, down to each outlet.
 - Locate outlets well above the anticipated flood level.
 - Fit appliances with quick disconnections.
- For retrofitting existing floodprone buildings with below-grade areas, install pumps to gradually remove floodwater. Gradual removal is necessary to avoid creating unequal saturated soil loads on basement walls that can lead to wall failure.
- When windows are located below the BFE, use glass block or impact-resistant plastic, wire-reinforced glass, or heavy screens to minimize damage by flood-borne debris impacts.
- Develop flood emergency operations and inspection and maintenance plans.
- Locate furniture and equipment so they can be moved quickly.
- Limit what is stored in wet floodproofed areas, including hazardous materials and pollutants.
- Require applicants and owners to sign nonconversion agreements that stipulate that wet floodproofing measures will not be modified and that wet floodproofed areas will not be converted to uses other than approved uses. Some communities require nonconversion agreements to be recorded in land records.

10. References

This section lists references cited in the Technical Bulletin. Additional resources related to NFIP requirements are provided in Technical Bulletin 0.

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- Technical Bulletin 2, Flood Damage-Resistant Materials Requirements
- Technical Bulletin 3, Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings
- Technical Bulletin 6, Requirements for Dry Floodproofed Below-Grade Parking Areas Under Non-Residential and Mixed-Use Buildings

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