Introduction/Overview

CHAPTER 1

CONTENTS

FIGURES

TABLE

1.0 Introduction

Floodplains are home to nearly 10 million households. In an average year, floods kill 150 people and cause over $3 billion in property damage. National average annual flood losses continue to increase.

NOTE:

The overall objective of this document is to assist in the construction of buildings with building utility systems that are designed and built so that the buildings can be re-occupied and fully operational as soon as electricity and sewer and water are restored to the neighborhood.

A large proportion of flood damage is incurred by components of building utility systems such as furnaces, boilers, air conditioning compressors, air ducts, water supply pipes, septic tanks and sewer pipes, electric and gas meters, control panels, electrical wiring, and gas pipes. Flooding of building utility systems impacts people, communities and businesses in many ways, some of which are outlined below:

- Flood inundation can damage equipment leading to costly repair bills. The force of moving water and floating debris can destroy equipment leading to costly replacement bills.
- Inundation of electrical system components such as switches, fuse boxes, control panels, and receptacles causes short-circuits, corrosion, and possibilities for electrical shock hazards and fires.
- Inundation of fuel system components such as tanks, pipelines, and gas meters can cause flotation of tanks, corrosion, severance of pipe connections, and rupture of tanks. Floating fuel tanks in flood waters are a fire and debris impact hazard. Floodwater contaminated with fuel oil makes clean-up of flood damaged houses much more difficult and expensive.
- Flood induced damage to pipes, manholes, septic tanks, service connection pipes, and on-site wells can contaminate wastewater and water supply systems rendering otherwise habitable buildings uninhabitable and can cause hazardous waste to be released into floodwater.
- Flood induced disruption in business operations can generate productivity declines resulting in substantial economic losses.

Despite concentrated efforts of government and the private sector to mitigate flood hazards, many problems still remain with current practices, including methods of design and construction of building utilities. For that reason, this guide was prepared to illustrate the design and construction of building utility systems for residential and non-residential structures located in flood-prone areas in order to comply with the National Flood Insurance Program (NFIP) floodplain management requirements.

The intended users of this manual are developers, architects, engineers, builders, code officials and homeowners who are involved in designing and constructing building utility systems for residential and non-residential structures. This manual discusses flood protective design and construction of utility systems for new buildings and modifications to utility systems in existing buildings.

1.1 How to Use this Manual

1.1.1 Organization of the Manual

This manual is organized into four main chapters as follows:

CHAPTER 1 - Introduction/Overview

- Introductory discussion of the background, goal, intended users, and organization of the manual
- Effects of flood hazards on building support utility systems
- Introduction to the methods of floodproofing building support utility systems

CHAPTER 2 - Regulatory Framework

- Background of the National Flood Insurance Program (NFIP)
- Discussion of community regulations and the permitting process
- NFIP floodplain management definitions
- NFIP requirements for new and existing buildings
- Model Building Codes
- Code compatibility with the NFIP
- Discussion of health and sanitary regulations

CHAPTER 3 - New and Substantially Improved Buildings

This chapter covers both new and substantially improved buildings, as defined by the NFIP. Substantially improved buildings are those that have been improved to an amount equal to 50% of their market value. Refer to Chapter 2 and Appendix B, Glossary of Terms, for the definition of the term substantially damaged.

NOTE:

New and substantially improved structures must meet the minimum requirements of the NFIP contained in the local building code and floodplain management regulations. Substantially improved buildings include those that have been substantially damaged. See your building official or floodplain administer for more information. Chapter 3 of this manual provides guidance on how to meet the requirements for building utility systems in new and substantially improved buildings. Chapter 4 provides guidance on additional ways to protect building utility systems in existing buildings that have not been substantially improved.

- Introduction to floodproofing utility systems in new and substantially improved buildings
- Discussion of systems, hazards, methods of protection and recommended flood protection practices for:
  - Heating, Ventilating, and Air Conditioning (HVAC) Systems
  - Fuel Systems
  - Electrical Systems
  - Sewage Management Systems
  - Potable (drinking) Water Systems

CHAPTER 4 - Existing Buildings

This chapter provides guidance on floodproofing building support utility systems for existing structures that have not been substantially damaged or improved.

- Discussion of methods of retrofitting various types of systems:
  - Heating, Ventilating, and Air Conditioning (HVAC) Systems
  - Fuel Systems
  - Electrical Systems
  - Sewage Management Systems
  - Potable (drinking) Water Systems

1.1.2 Use of Icons

The following icons are used in this manual:

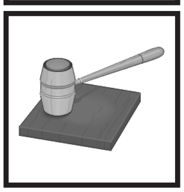
Note: Contains important information

Caution: Contains information related to compliance with the minimum NFIP requirements and other laws and ordinances

Meets minimum NFIP requirements and is also the recommended practice

For your reference, each of the chapters, sections within Chapter 3, and appendices are represented by the following icons:

Chapter 1 - Introduction/Overview

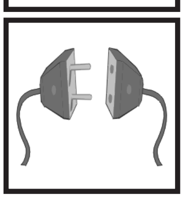


Chapter 2 - Regulatory Framework

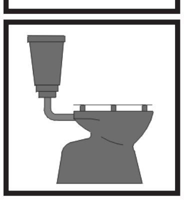
Chapter 3.0 - Introduction to Floodproofing Utility Systems in New and Substantially Improved Buildings

Section 3.1 - Heating, Ventilating, and Air Conditioning (HVAC) Systems

Section 3.2 - Fuel Systems



Section 3.3 - Electrical Systems



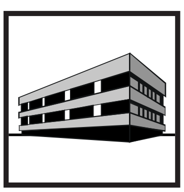
Section 3.4 - Sewage Management Systems

Section 3.5 - Potable Water Systems

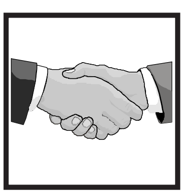
Chapter 4 - Existing Buildings

Appendix A - Bibliography and Sources of Information

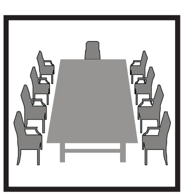
Appendix B - Glossary of Terms



Appendix C - FEMA Offices



Appendix D - NFIP State Coordinating Agencies



Appendix E - Professional Organizations

1.1.3 Metrification

The Federal Emergency Management Agency (FEMA) is committed to the federal government's transition to the metric system. However, in most cases English units remain the standard of practice for construction. Therefore, this manual has been prepared using English units.

However, it is foreseeable that the metric system may be the standard of measurement in this country in the future. With this in mind, soft metric conversions have been provided to promote familiarity with the metric system.

A critical component of unit conversion is rounding. Designers should check to ensure that rounding does not exceed allowable tolerances for design or fabrication.

Quantity	From English Units	To Metric Units	Multiply By
Length	foot inch	(m) (mm)	0.3048 25.4
Area	square foot acre	m^2 m^2	0.092 4047
Volume	gallon cubic foot	L m^3	3.7714 .283
Pressure	psf psi	Pa kPa	47.8803 6.8947
Power	horsepower	kW W	.746 746
Weight	pounds	kg	.4535
Flow	cfs	lps	28.3
Velocity	fps	mps	0.3048

Table 1.1.3: Metric conversion factors

1.2 Introduction to Hazards

> **NOTE:**
> The analysis of both flood-related hazards and non-flood-related hazards is discussed in detail in Chapter IV of FEMA Publication 259 - *Engineering Principles and Practices of Retrofitting Flood-prone Residential Structures.*

Building utility systems should be designed and constructed to avoid or resist the effects of the hazards or combinations of hazards that exist in floodplains. These hazards include:

- lateral hydrostatic and buoyant forces caused by standing or slow moving water above the surface of the ground;
- hydrodynamic forces from the moderate-velocity flow or high-velocity flow of water as well as wave action;
- impact loads caused by floating debris;
- localized ponding caused by poor drainage;
- erosion and scour caused by the removal of soil and loose material by moving water as it flows over land;
- site-specific hazards, such as alluvial fans (mudslides), closed basin lakes (no outlet), and movable bed streams (erosion);
- Non-flood-related hazards such as high winds, earthquake, snow, and land subsidence. While floods continue to be a major hazard to homes nationwide, they are not the only natural hazard that causes damage to structures located in floodplains;
- site-specific soil or geotechnical considerations, such as soil pressure, bearing capacity, scour potential, shrink-swell potential, and permeability; and
- contamination caused by dissolved chemicals, silt, suspended solids, and other contaminants contained in floodwaters.

The designer of a building must be prepared to take into consideration all possible hazards that a structure could be subjected to. When designing for multiple hazards, one must ensure that the design for one hazard does not negatively impact on a building support utility system's ability to resist damages from other hazards.

Multiple hazards can occur under two hazard scenarios, as shown below.

- **Hazards that have low risk of occurring simultaneously.** As an example, there is little risk of riverine flooding occurring simultaneously with an earthquake. Most would consider it unreasonable to design for this combined hazard scenario.
- **Hazards that have a high risk of occurring simultaneously.** As an example, hurricanes induce both high winds and flooding. In coastal areas, most would consider it reasonable to design for this combined hazard scenario.

With minor modification, protection of system components from flooding can increase the components' ability to resist other damaging forces. For example, the flood protection of fuel tanks that must be located below the Design Flood Elevation (DFE) to resist lateral and vertical (buoyancy) flood forces also improve the tank's ability to resist forces from high winds and earthquakes.

NOTE: The Design Flood Elevation (DFE) is a regulatory flood elevation adopted by a community that is the BFE, at a minimum, and may include freeboard as adopted by the community.

However, if a system is elevated above expected flood levels, it may leave the system exposed to an increased threat of damage from high winds and earthquakes. As a result, building support utility systems elevated on support structures such as platforms, pedestals, posts, and piers, may be exposed to increased forces. These increased forces may result in toppling of components of building support utility systems or collapse of their support structures if the protection measures are not properly designed.

There are often simple solutions to address different design concerns. For example, structures used to elevate building support systems can be properly strengthened to resist increased wind and seismic loads through the simple addition of cross-bracing.

Some building codes address the structural loads from natural hazards in detail. The multi-hazard design of a building's utility system is not addressed in as much detail. In those cases where significant threats from multiple hazards are known to exist, professional engineers and/or architects as well as local building officials and floodplain administrators should be consulted.

1.2.1 Examples of Flood Damage to Building Support Utility Systems

Flood water often contains dissolved chemicals, silt, suspended solids, and floating debris. Moving flood water exerts pressure on everything in its path, and causes erosion of soil and scour around solid objects. In coastal areas, breaking waves with floating debris can cause extensive physical damage. With such destructive characteristics, flood waters present many hazards to the often fragile components of building support utility systems.

The photographs presented on the following pages show examples of flood damage to building support utility systems.

HVAC: Improperly designed and installed furnaces, boilers, water heaters, air ducts and other indoor equipment, as well as compressors, heat pumps and other outdoor equipment are often inundated by flood waters. Flood waters can cause corrosion and contamination by silt deposits, short-circuit of electronic and electrical equipment, and other physical damage.

Figure 1.2.1A: Electric heat pump dislocated from its shattered wooden stand by velocity flow in a coastal area

Fuel Systems: Inundation of improperly designed and installed fuel system components such as tanks, pipelines, valves, regulators and gas meters can cause flotation and rupture of tanks, corrosion and short-circuit of electronic components, and severance of pipe connections. In extreme cases, damage to fuel systems can lead to fires.

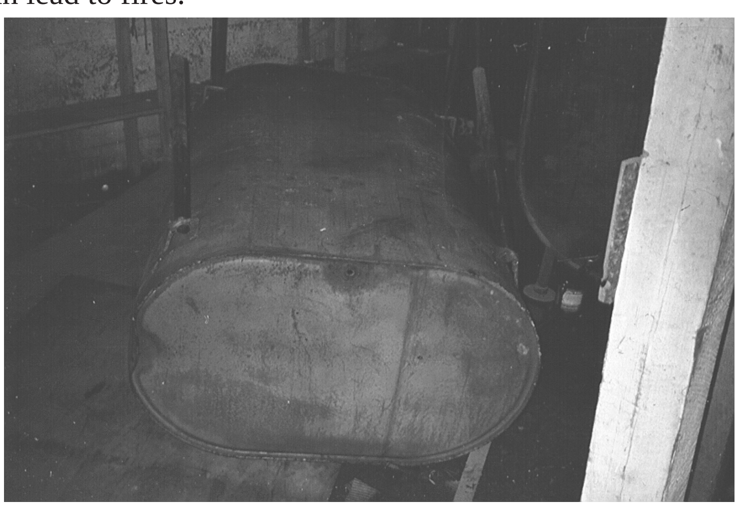


Figure 1.2.1B: Interior fuel oil tank dislocated by buoyancy forces

Electrical Systems: Inundation of improperly designed and installed electrical system components such as switches, electric panel board, and receptacles causes short-circuit, corrosion, and possibilities for electrical shock hazards. In velocity flow areas, electrical panels can be torn off their attachments by the force of breaking waves or floating debris impact.

Figure 1.2.1C: Electrical panel board damaged by velocity flow in a coastal area

Wastewater and Water Supply Systems: Improperly designed and installed pipes, manholes, septic tanks, service connection pipes, and on-site water wells can be exposed by erosion and scour caused by floodwaters with velocity flow. Inundation can also cause tanks to float. Sewage backup can occur even without the structure flooding.

Figure 1.2.1D: The result of sewage back-up through a toilet during a riverine flooding event

1.3 Basic Protection Methods

Building utility systems can be protected from flood damage. The minimum requirements of the NFIP are as follows:

The community must "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." [44CFR60.3(a)(3)]

The primary protection methods that apply to residential and non-residential building utilities in order to meet the minimum requirements of the NFIP include elevation or component protection in place.

The developer, architect, engineer, builder, or code official must recognize that designing a new or existing building support utility system to eliminate or minimize flood damage also influences how that utility system will react to hazards other than those associated with floodwaters.

1.3.1 Elevation

Elevation refers to the location of a component and/or utility system above the DFE.

Elevation is highly recommended for all utility system components in new and substantially improved structures except where the component needs to extend below the DFE for service connection or code compliance. Specific NFIP criteria for utilities will be discussed in detail in the subsequent chapters.

For new and substantially improved structures located in A Zones, the NFIP requires that the lowest floor be above the DFE. In new and substantially improved structures located in V Zones, the NFIP requires that the lowest horizontal structural member of the lowest floor be above the DFE. Non-residential buildings may also be dry floodproofed to the DFE. When the

NOTE:

Substantial Improvement:
Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the value of the structure before the "start of construction" of the improvement. This term includes structures which have incurred "substantial damage," regardless of the actual repair work performed. The term does not, however, include either:
1.) Any project for improvement of a structure to correct existing violations of state or local health, sanitary, or safety code specifications which have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions, or
2.) Any alteration of a "historic structure" provided that the alteration will not preclude the structure's continued designation as a "historic structure."

lowest floor or horizontal structural member of the lowest floor in a structure is located above the DFE, utility system components can be protected from flood damage by locating them anywhere on, or above, the lowest floor of the structure.

If the lowest floor is above the DFE, it is also possible to achieve elevation by hanging utility system components, such as pipes and ducts, from the bottom of the lowest floor as long as the bottom of every component is above the DFE.

In existing structures, elevation can be achieved by relocating utility system components to locations above the DFE such as utility sheds and closets as well as in the attic space.

1.3.2 Component Protection

Component protection refers to the implementation of design techniques that protect a component or group of components from flood damage when they are located below the DFE. Component protection is sometimes referred to as *floodproofing*, especially in retrofitting existing structures. Floodproofing is further broken down into wet and dry floodproofing.

Wet floodproofing refers to the elimination or minimization of the potential of flood damage by implementing waterproofing techniques designed to keep floodwaters away from utility equipment within areas that are generally expected to be inundated with floodwaters. Wet floodproofing is covered within this manual.

Dry floodproofing refers to the elimination or minimization of the potential for flood damage by implementing a combination of waterproofing features designed to keep floodwaters completely outside of a structure. Dry floodproofing within SFHAs is prohibited by the NFIP for all new and substantially improved structures, except for non-residential structures located in A Zones.

Utility system components within a dry floodproofed structure are protected since they are not likely to come in contact with floodwaters. Since dry floodproofing applies to building protection, it will not be considered further in this publication. The specific design techniques for dry floodproofing existing residential structures are described in detail in FEMA Publication 259 - *Engineering Principles and Practices for Retrofitting Flood-prone Residential Buildings*, and for non-residential building in FEMA Publication 102 - *Floodproofing non-Residential Structures.*