CHAPTER 8 – ELEVATION

8.1 Introduction

Elevating a structure to prevent floodwaters from reaching living areas is an effective and one of the most common mitigation methods. The goal of the elevation process is to raise the lowest floor to or above the required level of protection. This can be done by elevating the entire structure, including the floor (Figures 8-1 and 8-2), or by leaving the structure in its existing position and constructing a new, elevated floor within it.

Figure 8-1. Residence before elevation

Figure 8-2. Residence shown in Figure 8-1 now elevated 5 feet

Table 8-1 includes a summary of advantages and disadvantages for using elevation as a mitigation measure.

Table 8-1. Considerations for Using Elevation

Advantages	Disadvantages
▪ Elevating to or above the BFE allows a substantially damaged or substantially improved house to be brought into compliance with the community's floodplain management ordinance or law. ▪ Often reduces flood insurance premiums. ▪ Techniques are well-known, and qualified contractors are often readily available. ▪ May be fundable under FEMA mitigation grant programs.	▪ Cost may be prohibitive. Additional costs are likely if the structure must be brought into compliance with current code requirements for plumbing, electrical, and energy systems. ▪ The appearance of the structure and access to it may be adversely affected.

For a detailed discussion of the techniques to elevate a structure, see FEMA 312, *Homeowner's Guide to Retrofitting: Six Ways to Protect Your House From Flooding*, Chapter 5 or FEMA 259, *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures*, Chapter VI-E. Additional references are included in Section 8.5, Available Resources. The three most common elevation techniques are:

- Elevating on open foundations
- Elevating on continuous foundation walls
- Elevating by extending the walls or by moving the living space to an upper floor

8.2 Technical Considerations

8.2.1 Structure Type

Concrete, masonry, or brick faced structures require special attention to ensure that the structure is not damaged during the elevation process. For a structure with wood-frame construction, with a brick veneer, the brick could be removed and then reapplied once the elevation process is complete.

8.2.2 Foundation Type

There are four main types of structure foundations. In order of increasing difficulty to elevate, they are:

- Crawlspaces
- Piers, Posts, Piles, Columns, and Shear Walls
- Basements
- Slabs-on-Grade

8.2.2.1 Crawlspaces. A building on this type of foundation is the easiest to work with on an elevation project. There is usually room for the contractor to move lifting beams under the building and to deploy the lifting jacks. The building is lifted to the desired height, the new foundation is constructed up to the correct elevation to bring the lowest floor to the flood protection level, and the building is then lowered onto the new foundation and connected. Once the utilities are reconnected, the residents may reoccupy the home or business.

8.2.2.2 Piers, Posts, Piles, Columns, and Shear Walls. This type of construction is often found in buildings within a coastal floodplain, allowing floodwater to pass under the building and around the piles or posts. To elevate this type of construction, the building is often raised and moved to one side while new piles or posts are either poured or driven into the ground. The building is then moved back onto the site and lowered onto the new foundation supports.

8.2.2.3 Basements. This type of construction can be difficult to work with on an elevation project because anytime NFIP regulations are employed to bring a residence into compliance, the existing basement will need to be abandoned and filled. The NFIP requires the lowest floor to be above the BFE: a pre-existing basement is considered the lowest floor, therefore the basement must be filled and new foundation footings and walls constructed to the proper flood protection elevation. The physical elevation of the building is also more difficult because the support structures for the lifting beams must be constructed outside of the basement's footprint in order to begin the lifting process.

8.2.2.4 Slabs-on-Grade. This type of construction is very difficult to elevate. Depending upon the slab construction (with or without stiffeners), support beams must be placed close together to ensure the slab is not broken. The area underneath the slab must be excavated to insert the lifting equipment and disconnect utilities. If the slab is not adquately reinforced with reinforcing steel, the slab may crack when lifted. This approach is discussed in detail in USACE's *Raising and Moving the Slab-on-Grade House with Slab Attached.*

The alternatives to excavating under the slab (e.g., cut openings in the walls for the lifting beams, detach the walls from the slab, and lift the building without the slab) require that a new floor is constructed on the elevated foundation, the building is placed upon the new floor, and the holes through the walls are repaired.

8.2.3 Structure Size

Large rambling structures, buildings constructed of extremely heavy materials, and multi-story structures require special attention before they are elevated.

8.2.4 Utility Modifications

All utilities must be disconnected before the structure is elevated and reconnected on its new foundation. Underground utilities need to be protected from the lifting equipment and site excavations. Some utilities that service a structure may need modification once the elevation project is complete. For instance, the electrical service mast may need to be relocated or raised after a structure is elevated to keep the wires off the roof of the structure or away from other hazards. FEMA 348, *Protecting Building Utilities from Flood Damage,* provides additional information on utility modifications.

8.2.5 Other Hazards

Although elevating a structure can help protect it from floodwaters, other natural hazards need to be considered before choosing this method; in particular, earthquake, wind, and hydrostatic and hydrodynamic forces. For example, elevation causes a structure to become “top heavy” and, therefore, more susceptible to the overturning forces of earthquakes. Because the walls and roof of this structure are higher and more exposed, it can be more susceptible to wind forces. Likewise, both closed and open elevated foundations can fail as a result of damage caused by erosion and the impact of debris carried by floodwaters. If portions of the original foundation are used to support new walls, other foundation members, or a new second story, they must be capable of safely carrying the additional loads imposed by the new construction along with the expected flood, wind, and earthquake forces. Constructing or elevating a structure in accordance with applicable building codes will address most if not all of these issues.

8.2.6 Vents

For all elevation projects, vents in the enclosed areas below the BFE are required. Most building codes will require vents for air circulation; additionally, vents are needed to relieve hydrostatic pressure. FEMA’s Technical Bulletin 1-93 details the NFIP criteria for the placement of vents in the foundation walls. Although some building codes may be more stringent, the most common requirement is to provide 1 square inch of vent opening for every square foot of enclosed space. The bottom of the vents must be no higher than 1 foot above the outside grade (Figures 8-3 and 8-4). Inside and outside ground elevations should be essentially equal and the vents must be installed in two or more walls. If the openings in the vents are covered with bars or screening to keep pests from entering the crawlspace, the cross-sectional area of the bars or screening must be deducted from the vent opening area.

Figure 8-3. New foundation with vents

(Source: W. A. Wilson Consulting Services)

Figure 8-4. New foundation with vents

(Source: W. A. Wilson Consulting Services)

8.3 Relative Costs

The relative cost ranking is based on the combination of the estimated costs for the elevation project and a determination of cost-effectiveness.

8.3.1 Estimated Cost

The cost of elevating a structure is generally in the middle range compared to the costs of implementing other mitigation measures. Basic costs for elevating structures on open and closed foundations include constructing a foundation, elevating utilities, and adding or extending staircases.

> **ICC Coverage.** The cost of elevating a substantially damaged structure may be an eligible flood insurance claim under Increased Cost of Compliance (ICC) coverage (see FEMA 301, *NFIP's Increased Cost of Compliance Coverage Guidance for State and Local Officials,* for additional information).

In some instances, slab-on-grade structures are raised without the slab attached. Although this method of elevation may be less expensive than raising the structure with the slab, it involves detaching the structure from the slab and requires alterations to the interior and exterior walls. Therefore, raising the structure without the slab is most often done when the structure has experienced substantial damage, yet remains structurally sound.

The cost of elevating by extending walls and abandoning an existing lower level depends on whether the structure has an existing upper level that can be used for living space. If an upper level is available, abandoning the lower floor would involve primarily elevating or relocating utilities, adding openings in the lower-level walls, and ensuring that all construction materials are flood-resistant.

Examples of cost estimating items that may need to be considered include the following:

- Preparation of the structure for elevation
- Elevation of the structure, including cost of steel beams, jacks, etc.
- Construction of the new, elevated foundation
- Secure the structure to the new foundation
- Replacement or reconstruction of items removed from the structure prior to elevation

To estimate the relative cost of a elevation project, examples of general cost estimates have been provided below and are included in FEMA 312, *Homeowner's Guide to Retrofitting: Six Ways To Protect Your House From Flooding* and FEMA 259, *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures*.

The figures in Table 8-2 are example cost estimate numbers used in a study for the St. Louis Metropolitan Sewer District. These numbers were generated using the U.S. Army Corps of Engineers' publication, *Flood Proofing - How to Evaluate Your Options,* and updated to 2002 and adjusted for the St. Louis area. It is important to note that the cost estimate numbers are location and time dependent.

Table 8-2. General Estimates of the Unit Costs for Typical Elevation Projects

Elevation	
Wood-frame building on piles, posts, or columns	$36/square foot
Wood frame on concrete or block foundation walls	$32/square foot
Brick walls	$43/square foot
Slab-on-grade	$45/square foot

Appendix C, Cost Estimating, provides guidance and references for conducting a more detailed cost estimate. Additional cost estimates can be obtained from R.S. Means' *Contractor's Pricing Guide*. A blank preliminary cost estimating worksheet (Worksheet D) is provided in Appendix B.

8.3.2 Determination of Cost-Effectiveness

A component of the relative cost scoring is to include a determination of cost-effectiveness. Table D-1 in Appendix D, Determining Cost-Effectiveness, provides a quick screening for the cost-effectiveness of a project. The attributes included in the table are frequency of flood, level of damage, project cost, project benefits, and criticality (impact or loss of function). For example, if the frequency is the 10-year flood, the project will have a very high likelihood of cost-effectiveness.

Based on the combination of the estimated cost of the project and the likelihood of cost-effectiveness, a relative cost ranking will be assigned on Worksheet B, Appropriate Mitigation Measures. If the likelihood of cost-effectiveness is low, the ranking of relative cost will be either moderate or high, based on the estimated cost of the project. However, if the estimated cost is low and the likelihood of cost-effectiveness is very high or high, the relative cost ranking will be low.

8.4 Additional Considerations

8.4.1 Substantial Damage/Improvement

If the structure being elevated has been substantially damaged or is being substantially improved, the local floodplain management ordinance or law will generally restrict the structure from having a basement (as defined under the NFIP) if the structure is located within the mapped 100-year floodplain. For areas removed from the SFHA by the placement of fill, see FEMA Technical Bulletin 10-01, *Ensuring That Structures Built on Fill In or Near Special Flood Hazard Areas are Reasonably Safe from Flooding*.

The NFIP regulations define a basement as "any area of the building having its floor sub-grade on all sides." If the structure has a basement, it must be filled in as part of any elevation project. The NFIP definition of basement does not include what is typically referred to as a "walkout-on-grade" basement, whose floor would be at or above grade on at least one side. Additional information on substantial damage requirements is included in FEMA 213, *Answers to Questions About Substantially Damaged Buildings.*

FEMA Technical Bulletin 11-01, *Crawlspace Construction for Buildings Located in Special Flood Hazard Areas,* provides guidance on crawlspace construction and supports a policy decision to permit crawlspaces to be built up to 2 feet below the lowest adjacent exterior grade (LAG), provided that other considerations are met. Previously, these below grade crawlspaces were considered basements under NFIP regulations.

8.4.2 Access to the Structure by the Lifting Crew

Elevating a structure requires specialized heavy equipment and materials, ranging from large front-end loaders to long steel beams. Therefore, there must be enough room on the site from obstructions such as trees, adjacent structures, and utilities. The proximity of adjacent neighbors may also require obtaining agreements or temporary easements from them. Any repairs from damage to their property must be covered in a pre-construction agreement and completed promptly. The *Flood Risk and Mitigation Possibilities* tab in NT provides a check box to indicate whether adequate clearance exists at the site (Figure 8-5).

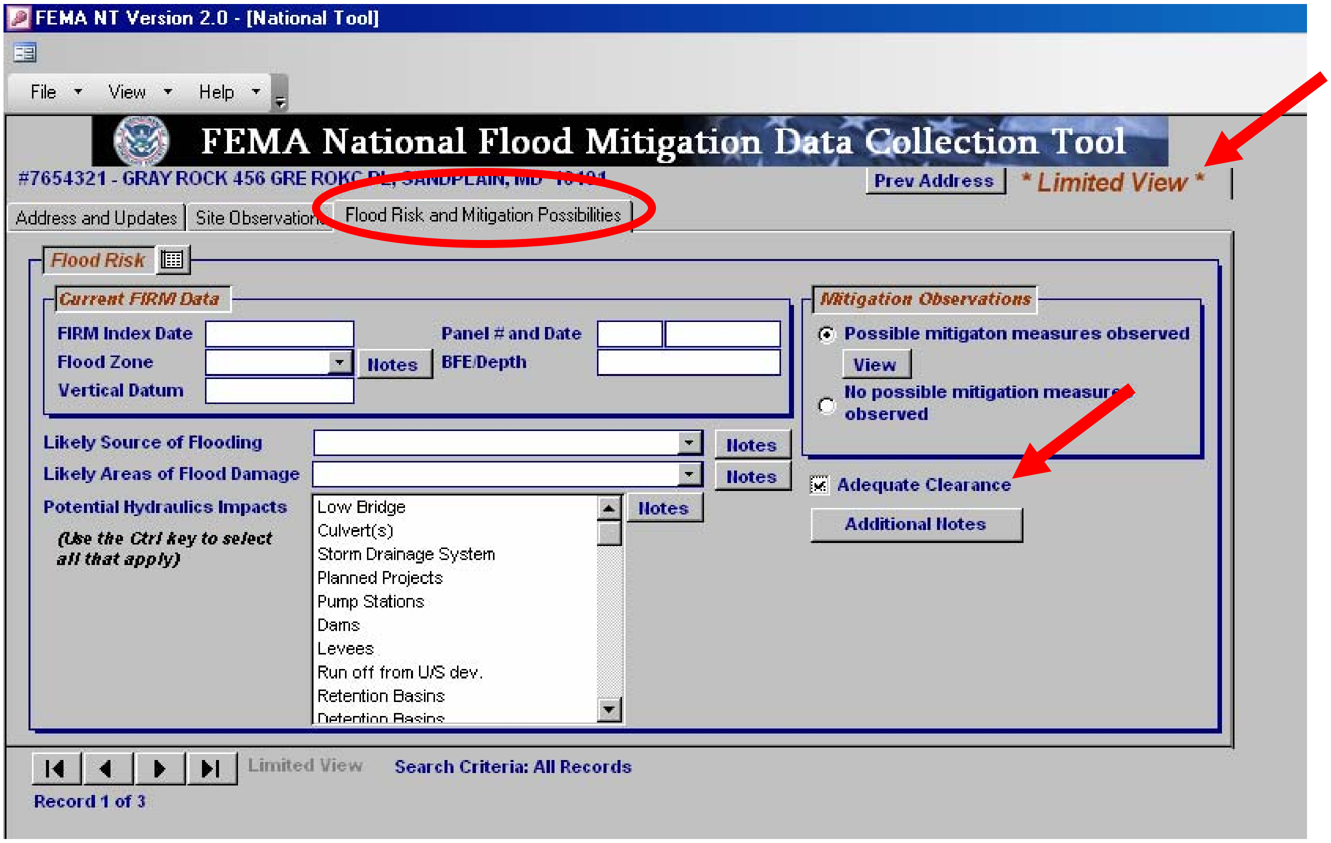

Figure 8-5. ***Flood Risk and Mitigation Possibilities*** **tab - Adequate Clearance**

8.4.3 Access to the Structure Following Elevation

An elevated structure is harder to access due to the height. If the structure is a residence, the age and physical condition of the occupants must be taken into consideration. Ramps, stairs and elevators can been used for entryways on many elevated residences (Figure 8-6). Refer to the Americans with Disabilities Act (ADA) and FEMA Technical Bulletin 4-93, *Elevator Installation for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program*, for additional information.

Figure 8-6. Elevator provides access to elevated structure

8.4.4 Codes and Ordinances

The local building code and the community's floodplain ordinance must be followed. The *Additional Site Information* tab should list any pertinent regulatory requirements or standards (Figure 8-7):

- Floodplain location requirements
- Local and state permits
- Design wind speeds and seismic loadings
- Snow loads
- Frost depths
- Height restrictions
- Restrictions on size or types of foundations
- Lowest floor requirements
- Heat duct elevation requirements
- Foundation venting requirements
- ADA requirements

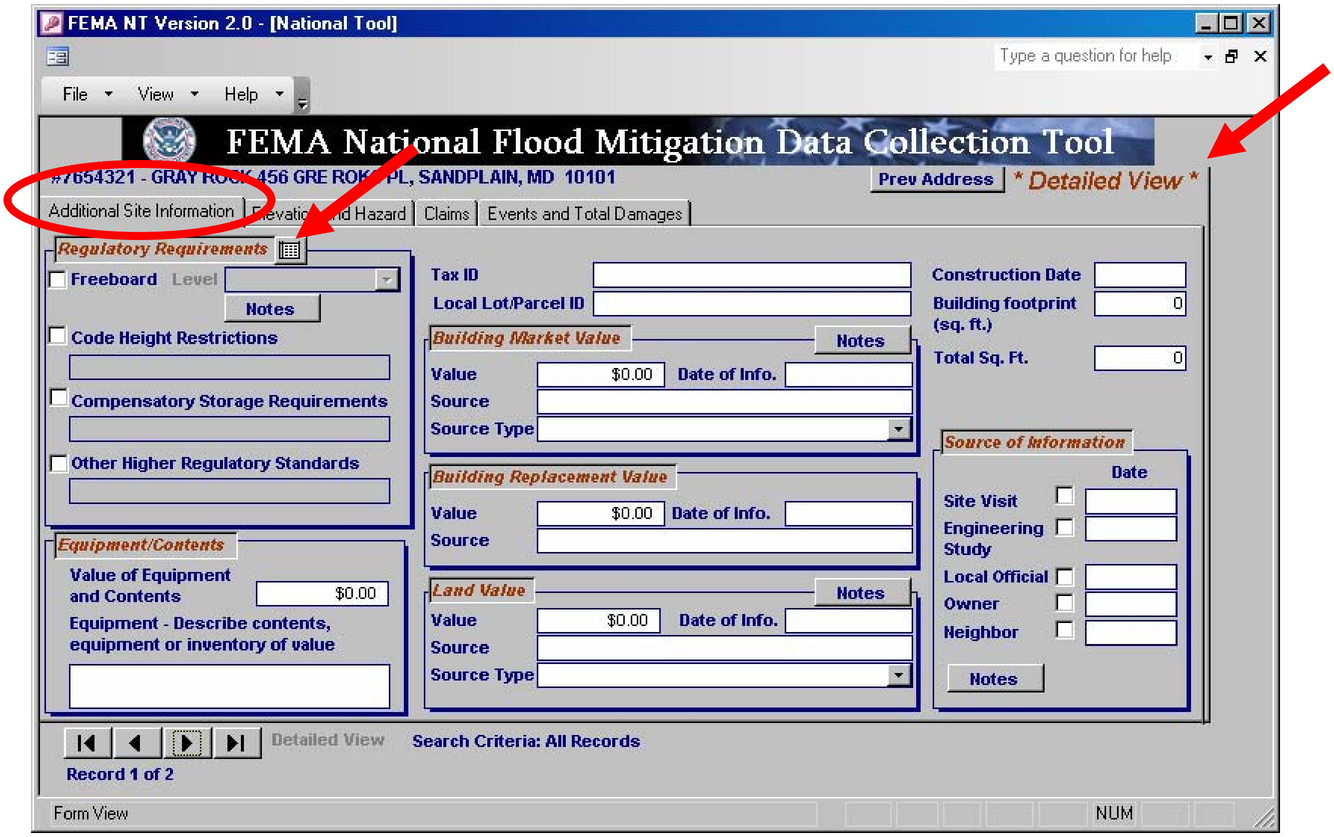

Figure 8-7. *Additional Site Information* tab - Regulatory Requirements

8.4.5 Historic Preservation

Structures placed on or designated as eligible for the National Register of Historic Buildings have historic value to the nation and are protected by legislation. As such, structural modifications to them, even for the purpose of protecting them from flooding, may be limted or not allowed. This is particularly true for changes that affect the exterior of the structure. Many communities have local historic preservation commissions and State Historic Preservation Officers (SHPOs) that can identify historic buildings and historic districts or neighborhoods (see Appendix G for a list of SHPOs).

8.4.6 Housing of Occupants

During the elevation process, the occupants of a residential structure will need to be temporarily relocated. Most elevation projects will result in the residents being relocated for 1 to 3 months.

8.4.7 Aesthetics

The visual aspect of an elevated structure is vitally important to both the property owner and the neighborhood, especially for residential structures. If the proposed project is perceived to be an "eyesore," it can be difficult to convince the property owners to proceed with the project, despite being protected from flooding. Additionally, a neighborhood eyesore can lead to criticism of the project itself and possible non-participation in future mitigation initiatives. Small cosmetic changes can greatly improve the looks of an elevated structure, such as:

- Landscaping and shrubbery
- Fill placed along the foundation wall, giving the appearance of the structure being located on a small knoll
- Extending siding down over the foundation walls

Figures 8-8 and 8-9 illustrate the contrast between a structure without cosmetic improvements and a structure with improvements.

Figure 8-8. House elevated 8 feet, but lacking landscaping, producing a stark look

Figure 8-9. House elevated over 5 feet with retaining wall, porch, and landscaping

8.5 Available Resources

FEMA 85. *Manufactured Homes in Flood Hazard Areas: A Multi-Hazard Foundation and Installation Guide*. See Chapter 8, Methods for Mitigating Flood Hazards 8.1 Elevation

FEMA 213. *Answers to Questions About Substantially Damaged Buildings*.

FEMA 259. Engineering Principles and Practices of Retrofitting Floodprone Residential Structures. See Chapter VI-E, Elevation.

FEMA 301, *NFIP's Increased Cost of Compliance Coverage Guidance for State and Local Officials.*

FEMA 312. *Homeowner's Guide to Retrofitting: Six Ways to Protect Your House from Flooding.* See Chapter 3, An Overview of the Retrofitting Methods and Chapter 5, Elevating Your House.

FEMA 347. *Above the Flood: Elevating Your Floodprone House*.

FEMA 348. *Protecting Building Utilities from Flood Damage*. See Chapter 4, Existing Buildings.

FEMA 511. *Reducing Damage from Localized Flooding*. See Chapter 10, Retrofitting.

FEMA Technical Bulletin 1-93. *Openings in Foundation Walls for Buildings Located in Special Flood Hazard Areas*.

FEMA Technical Bulletin 4-93. *Elevator Installation for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program.*

FEMA Technical Bulletin 10-01 *Ensuring that Structures Built on Fill In or Near Special Flood Hazard Areas are Reasonably Safe from Flooding.*

FEMA Technical Bulletin 11-01. *Crawlspace Construction for Buildings Located in Special Flood Hazard Areas: National Flood Insurance Program Interim Guidance*.

The Louisiana State University (LSU) Extension Center website (http://www.louisianafloods.org) lists many retrofitting publications, provides advice on floodproofing methods and flood insurance, and links to online shopping for retrofitting products and contractors.

USACE. *Flood Proofing - How to Evaluate Your Options.*

USACE. *Raising and Moving the Slab-on-Grade House with Slab Attached.*

R.S. Means'. *Contractor's Pricing Guide*.