Dry Floodproofing Technical Review

This job aid supplement covers the requirements associated with the technical reviews for dry floodproofing projects funded by Hazard Mitigation Assistance. FEMA will also conduct an Environmental Planning and Historic Preservation review of each project. Refer to the Dry Floodproofing: Information Required for Environmental Review Job Aid.

This Technical Review Supplement provides additional information, examples and potential sources of documentation for items listed in the job aid to help communities applying for Hazard Mitigation Assistance grants comply with application requirements.

- All Hazard Mitigation Assistance (HMA) applications must comply with the requirements outlined in the HMA Guidance.
- According to the guidance, in addition to a general programmatic review, an EHP review and a technical review will be performed by FEMA for each proposed project.
- The technical review will verify that a project demonstrates feasibility, effectiveness and cost-effectiveness. This document is intended for technical reviews of applications only.
- For assistance completing EHP compliance reviews, see the EHP Supplement Job Aids.

Introduction

The following provides a review of the information that should be provided with the grant application, including recommended documentation and a list of supplementary information, to assist FEMA when conducting technical reviews of the project application. Technical resources are identified throughout this supplement to provide clarifying information on specific project application components. The final section provides a comprehensive list of resources identified throughout this supplement.

It is recommended that the grant applicant consult a professional engineer to assist in preparing the application, as many of the documentation requirements are technical in nature. An engineer will be required for the building assessment, design and implementation. For complex dry floodproofing projects, applicants may want to consider Advanced Assistance or a phased project approach. Initial funds may be obtained to produce detailed designs of the project (Phase 1 or Advanced Assistance) for further FEMA review and approval prior to construction (Phase 2). Refer to HMA Guidance Part, VIII, A.12 and A.13 for additional guidance.

The project-specific guidance in this supplement does not provide all the information necessary to apply for funding through an HMA Program and must be read in conjunction with all other relevant guidance documents.

Additional Resources

- Hazard Mitigation Assistance Guidance (HMA Guidance)

- Hazard Mitigation Assistance Guidance Addendum
- Benefit-Cost Analysis Reference Guide and Supplement to the Benefit-Cost Analysis Reference Guide
- Hazard Mitigation Assistance Application Development

A list of all resources referenced is provided at the end of the supplement.

Summary of Steps

- ☐ STEP 1: Provide a Scope of Work
- ☐ STEP 2: Provide Structure-Specific Details
- ☐ STEP 3: Provide Available Technical Data
- ☐ STEP 4: Provide a Project Schedule
- ☐ STEP 5: Provide a Project Cost Estimate
- ☐ STEP 6: Provide a Project Site Map
- ☐ STEP 7: Provide Property Location Information
- ☐ STEP 8: Provide Structure Photographs
- ☐ STEP 9: Document the Before Mitigation Flood Risk
- ☐ STEP 10: Cost-Effectiveness Analysis
- ☐ STEP 11: Environmental and Historic Preservation Considerations

Important Terms

ASCE/SEI 7-22 (American Society of Civil Engineers/Structural Engineering Institute – Minimum Design Standards and Other Structures, 2022 Edition): This standard is used by engineers and architects to determine design loads for buildings, including seismic loads on buildings.

ASCE/SEI 24-14 (American Society of Civil Engineers/Structural Engineering Institute – Minimum Design Standards and Other Structures, 2016 Edition): This standard provides minimum requirements for design and construction of structures located in flood hazard areas and subject to building code requirements.

Base Flood Elevation (BFE): The elevation as shown on the Flood Insurance Rate Map (FIRM) for Zones AE, AH, A1–A30, AR, AR/A, AR/AE, AR/A1–A30, AR/AH, AR/AO, V1–30 and VE that indicates the water surface elevation resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year.

Design Flood: The flood associated with the greater of the following two areas:

1. Area within a floodplain subject to a 1% or greater chance of flooding in any year
2. Area designated as a flood hazard area on a community's flood hazard map or otherwise legally designated

Design Flood Elevation (DFE): Elevation of the design flood, including wave height, relative to the datum specified on the community's flood hazard map.

Dry Floodproofing: The American Society of Civil Engineers (ASCE) 24-14 defines dry floodproofing as "A combination of measures which results in a structure, including the attendant utilities and equipment, being watertight with all elements substantially impermeable and with structural components having the capacity to resist flood loads."

Federal Flood Risk Management Standards (FFRMS): A federal policy (FEMA Interim Policy FP-206-21-003) that sets forth the elevation requirements for the dry floodproofing projects in the special flood hazard area.

Flood Insurance Rate Map (FIRM): An official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community.

Lowest Floor: The lowest floor of the lowest enclosed area (including a basement). An unfinished or flood-resistant enclosure, usable 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 that such enclosure is not built to render the structure in violation of the applicable non-elevation design requirements of 44 CFR Part 60.3.

Lowest Floor Elevation (LFE): The elevation of the top of the lowest finished floor in a building.

Special Flood Hazard Area (SFHA): The land in the floodplain within a community subject to a 1% or greater chance of flooding in any given year. An area having special flood, mudflow or flood-related erosion hazards and shown on a Flood Hazard Boundary Map or a FIRM as Zone A, AO, A1-A30, AE, A99, AH, AR, AR/A, AR/AE, AR/AH, AR/AO, AR/A1–A30, V1–V30, VE or V.

Technical Review Components

To complete a successful project application, a minimum amount of technical information is required for review. The following is a step-by-step approach to addressing the major components of dry floodproofing project application. Data collected in these steps will provide reviewers with the necessary information to determine whether a project is feasible, effective and cost-effective.

The data requirements in the following steps should be compiled in an attachment to the project application. If the project impacts multiple structures, this information must be provided for each structure.

STEP 1: Provide a Scope of Work

Description: Provide a project narrative clearly identifying the proposed mitigation action and structure(s) or portions of the structure(s) to be mitigated and explaining how the project will mitigate risk. The SOW should include key milestones and coincide with the design information, project schedule and cost estimate. Prior to developing the scoping narrative and application, it is recommended that a building assessment, utilizing the methodology outlined in FEMA P-936, Floodproofing Non-Residential Buildings, Appendix C, be performed to verify if the structure is a good candidate for dry floodproofing.

References: When preparing a SOW, refer to the following:

- HMA Guidance Part IV, Section H: Scoping Narrative: Scope of Work, Schedule, and Cost Estimate
- HMA Application Development

Approach: A licensed engineer should be consulted when developing the SOW for the mitigation project. The following items are recommended for inclusion in the SOW; specific details and documentation required to support the narrative will be documented in the subsequent steps:

- Provide a detailed narrative of the flood risk being mitigated, including flood event history in the project area, if available.
- Describe the existing conditions of the structure, equipment and systems being dry floodproofed. Specific details and documentation to support the narrative are described in **Step 2**.
- Define the level of protection (i.e., the elevation to which the building or building components will be dry floodproofed, specifying the height above the base flood elevation [BFE]).
- Verify that the project will be constructed to the latest edition of codes and standards by including a description of the building code and standards that are to be followed. The latest edition of the codes and standards that should be considered include the following:
  - A statement that the proposed project will be designed and constructed to meet the requirements of ASCE 24 required for the level of protection provided.
  - A statement that the proposed project will be designed in compliance with the Federal Flood Risk Management Standard (FFRMS). Requires the elevation of the lowest floor or floodproofing level to be a minimum of BFE + 2 feet.
  - A statement that the project will be designed in compliance with National Flood Insurance Program (NFIP) standards in 44 CFR Part 60.3.
  - A description of any additional building codes and standards that will be followed.
- Describe the dry floodproofing method and the steps required to implement the mitigation activity.
- Mitigation project alternatives are required as part of the application development. Document at least two alternatives that were considered during the planning or design phase. Clearly indicate which alternative is the preferred mitigation project and discuss why it is the most practical, effective and environmentally sound alternative. One alternative is often considered the “no-action alternative” and reflects conditions expected to exist if a mitigation project is not completed. This is a key step to verify an efficient EHP review process. For additional guidance, see the Elevation EHP Review and Structural Retrofit EHP Review.
- Clearly explain the proposed mitigation activity, indicating if the entire building is to be dry floodproofed or if dry floodproofing is going to be applied to protect sections of the building or building components. Specify the deliverables and identify the tasks required to complete the proposed activity in clear, concise and meaningful terms. All cost elements must match tasks and provide sufficient detail for FEMA to determine whether the application is eligible. The scoping narrative will become part of the conditions of the award.
- Clearly identify the before-mitigation, after-mitigation, and residual risks.
  - Before-mitigation risks – Identify the before-mitigation physical damages and resulting loss of function. Damages should be correlated to the severity of flooding.
  - After-mitigation risks – Identify the after-mitigation physical damages and resulting loss of function. Damages should be correlated to severity of flooding.

- Residual risks – Identify the residual risks from the failure of the dry floodproofing such as the risk from seepage and the risk from failure of dry floodproofing barriers or pumps or loss of power.

STEP 2: Provide Structure-Specific Details

Description: It is necessary to demonstrate that a project is feasible and effective at reducing risk. As part of this demonstration, provide detailed information about each structure in the project.

References: For some details, such as capacity parameters, a professional engineer should be consulted. Documentation for most of the required details can be found in as-built drawings, design drawings, tax assessor records, aerial photo assessments, parcel databases or building permit information.

Approach: Provide the following information about the existing structure. If there are multiple structures, this information must be provided and documented for each.

- Date structure was built
- Date(s) of any upgrades or additions
- Structure type (e.g., steel frame, concrete frame, wood frame, masonry) and existing condition
- Building use (e.g., agriculture, hospital, grade school, college/university, emergency response, industrial, general services)
- Structure size in square feet of the total enclosed area
- Provide the lowest floor elevation (LFE) and/or the elevation of any critical equipment/services that are proposed to be protected.
- Describe the architectural finishes (e.g., floors, walls, and ceilings).
- Describe the major equipment needed for the facility to function (e.g., elevators, medical equipment) and the location within the building.
- Describe the building systems, such as heating, air conditioning, electrical, water supply or sanitary sewage, that will be protected by the proposed mitigation.
- Describe the foundation (see **Figure 1**).

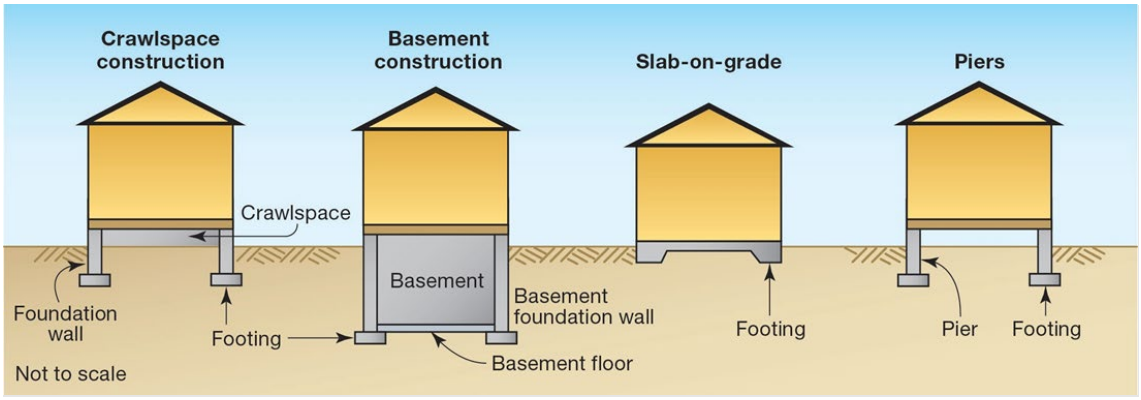


Figure 1. The four foundation types represented in this figure are crawlspace construction, basement construction, slab-on-grade and piers.

Potential Sources: Structure information may be verified through city or county property records or from building permit information. This information can often be found from publicly available websites such as tax assessor website. Some cities and counties have parcel databases with this information. Alternatively, online mapping programs with measuring features and high-quality aerial photographs may be used to estimate the size of the building. The building construction type can be verified from as-built design drawings, if available. Refer to Supplement to the Benefit-Cost Analysis Reference Guide, Section 2.2 for more information regarding LFEs.

Example: Two-story, concrete-framed, 7,500-square-foot municipal building, slab-on-grade, without a basement, no outbuildings, built in 1976. The HVAC equipment and boiler are located on the roof of the building. The electrical panel is located on the east wall, 5'-0" above the lowest floor elevation. Potable water supply enters from the north wall, 2'-6" above the lowest floor elevation. Sanitary sewage pipes join a common effluent pipe beneath the slab-on-grade and leave the building below the north wall. There is an elevator located in the northeast corner of the building; the elevator is hydraulically powered, with the equipment in a room adjacent to the elevator.

STEP 3: Provide Available Technical Data

Description: It is necessary to demonstrate that a project is feasible and effective at reducing risk. Provide engineering or design plans of the proposed dry floodproofing mitigation; these may be conceptual (e.g., sketches or schematics) with the project application. This information can be further developed following the grant award and should be accounted for in the scoping narrative, schedule, and cost estimate if not available during application development.

It must be shown that a proposed structural retrofit project will meet the requirements of the most current, enforced version of the International Exercising Building Code (IEBC), International Building Code (IBC), International Residential Code (IRC), ASCE 7, and ASCE 24. Additionally, it must be demonstrated that the proposed retrofits will improve the structure to the desired performance level, as described in **Step 1**. For multiple buildings, the information must be provided and documented for each.

References: When preparing technical data, refer to the following resources, as appropriate:

- ASCE 7-16 (or most recent version) – Minimum Design Loads for Buildings and Other Structures
- ASCE 24-14 (or most recent version) – Flood Resistant Design and Construction
- Building Codes for Mitigation: Using ASCE 24
- Highlights of ASCE 24 Flood Resistant Design and Construction
- FEMA P-348 – Protecting Building Utilities from Flood Damage
- FEMA P-936 – Floodproofing Non-Residential Buildings
- FEMA Technical Bulletin (TB)-3 – Non-Residential Floodproofing Requirements and Certification
- Texas Recovery Advisory 1 – Dry Floodproofing: Planning and Design Considerations
- Florida Recovery Advisory 1 – Dry Floodproofing: Operational Considerations

Approach: In addition to verifying that the project will meet the required codes and standards identified in the narrative (**Step 1**), provide any available information to support the following:

- Demonstrate that dry floodproofing will feasibly meet the required standards including the IEBC, IBC, IRC, ASCE 7, ASCE 24 and FFRMS.
  - Confirm that the proposed mitigation can be constructed (i.e., there is no physical limitations that will prevent its completion).
  - Provide information that verifies that the dry floodproofing will comply with the latest editions of the IEBC, IRB, IRC, ASCE 7 and ASCE 24.

> ***ASCE 24 – Flood Resistant Design and Construction*** limits the use of dry floodproofing to non-residential structures and non-residential areas of mixed-use structures located outside of High-Risk Flood Hazard Areas, Coastal High Hazard Areas and Coastal A Zones. Additionally, dry floodproofing velocities adjacent to the structure are less than or equal to 5 feet per second during the design flood. See ***ASCE 24 Section 6.2*** for a complete list of limitations and requirements.

- Provide design plans (as-builts) and specifications for the construction of the existing structure.
- Provide a description of the proposed solution to the identified risk/retrofits of the structure. The description should be accompanied by:
  - Plans, design drawings or sketches of the proposed dry floodproofing
  - Engineering calculations and/or analysis for the proposed dry floodproofing
- Demonstrate that the project will be effective at reducing physical damages and, if claimed, at reducing loss of function.
  - Information that verifies the ability of the floodproofing project to resist flood forces specified by ASCE 24 and ASCE 7 (e.g., statement from a licensed engineer that the design is compliant with ASCE 24 and ASCE 7, signed and sealed engineering calculations, product data sheets of dry floodproofing materials indicating their performance to resist water seepage and forces).
  - Documentation should indicate that prior to beginning construction, the final design drawings and specifications will be signed and sealed by an engineer licensed in the state where the project is located.
- Since elevation is critical in quantifying flood risks, the elevation of equipment or building functions that are proposed to be protected should be provided.

STEP 4: Provide a Project Schedule

Description: Include a detailed project schedule for all tasks in the project cost estimate and SOW. The schedule identifies major milestones with start and end dates for each activity. Project schedules must show completion of all activities (including construction period) within the period of performance (POP) allowed by the relevant HMA program. Sufficient detail must be provided so FEMA can determine whether the proposed activities can be accomplished within the POP.

References: HMA Guidance Part VI, Section D.4: Program Period of Performance and Part IV, Section H: Scoping Narrative: Scope of Work, Schedule, and Cost Estimate

Approach: Verify that the information in the schedule supports the scope of work and aligns with the project cost estimate.

STEP 5: Provide a Project Cost Estimate

Description: Include a detailed cost estimate for all tasks identified in the project schedule and SOW. Allowable costs are costs that are necessary and reasonable for the proper and efficient performance and administration of the federal award. All costs included in the application should be reviewed to verify they are necessary, reasonable and allocable consistent with the provisions of 2 Code of Federal Regulations Part 200. Include sufficient detail so that FEMA can determine whether costs are reasonable based on proposed activities and level of effort. Costs incurred prior to award may be considered pre-award costs and may be eligible for reimbursement. Eligibility may depend on the date they occurred and the grant program. Refer to HMA guidance and the Notice of Funding Opportunity for specifics.

References: HMA Guidance Part IV, Section H: Scoping Narrative: Scope of Work, Schedule, and Cost Estimate

Approach: Verify that the information in the cost estimate supports the SOW and aligns with the schedule. Source materials used to support the cost estimate should be referenced. Allowable costs are costs that are necessary and reasonable for the proper and efficient performance and administration of the federal award. They may include, but are not limited to:

- Engineering services for design, structural feasibility analysis, and cost estimate preparation
- Project administration and construction management
- Surveying and inspection
- Soil sampling
- Line-item construction costs of dry floodproofing components
- Completion of a title search and deed recording fees
- Dry floodproofing protection of equipment and building systems
- Permitting and/or legal fees

It is also important to verify that an annual maintenance cost has been determined using appropriate methods. The annual maintenance cost is necessary to address those costs associated with maintaining the effectiveness of the mitigation measures. Although the costs will not be funded by FEMA, they are required to be included in the BCA.

STEP 6: Provide a Project Site Map

Description: Provide a map showing the project location. If the project includes multiple structures, show the overall project boundary.

Reference: Supplement to the Benefit-Cost Analysis Reference Guide

Approach: Provide a map showing the project location, including structures, flooding source, map scale and location information. For any maps provided, ensure that a scale bar is shown, and the map is clearly labeled to identify the project boundaries, including staging area. **Figure 2** provides an example of a project site map.

Potential Sources: Official site survey, assessor maps, and topographic maps obtained from the project engineer or planner and maps created using a web-based service such as Google Maps

Figure 2. Example of a project site map. Map clearly shows the project site boundary, structure(s) to be mitigated and staging area.

STEP 7: Provide Property Location Information: Address and Latitude and Longitude

Description: Provide both the physical address(es) and the latitude and longitude of each structure being protected in the project application. For projects with multiple properties, tables containing all relevant information by property can be helpful.

PROPERTY ADDRESS

Approach: Provide property address(es) of each structure involved in the mitigation project. This includes street name and number; city, county or parish; state; and zip code. A post office box number is not an acceptable address. If the address provided does not clearly match up with the structure(s) to be acquired, provide photos or a site map with the structure(s) footprint(s) clearly identified.

Potential Sources: Property owner, local building inspector, tax assessor records, deed to the property, engineering plans

Example: 456 River Road NE, Martinsburg, Berkeley County, WV 25409

LATITUDE AND LONGITUDE

Approach: Provide the latitude and longitude of each structure involved in the mitigation project. The latitude and longitude should be taken at the center of each property. The latitude and longitude can be provided in either decimal degrees (e.g., 27.9807, -82.5340) or degrees, minutes, and seconds (27° 58’ 50.5’’ N, 82° 32’ 2.4’’ W).

Potential Sources:

- GPS device
- Free online map tools or search engines that generate latitude and longitude when an address is supplied

Example: 27.9807, -82.5340 or 27° 58’ 50.5’’ N, 82° 32’ 2.4’’ W

STEP 8: Provide Structure Photographs

Description: Provide photographs of the property, or properties, and structure(s) that are proposed to be retrofitted from all sides of the structure and photographs looking outward from each side of the building (for example see **Figure 3**).

Approach: Provide photographs of all sides of the structure.

- For each photograph, provide a descriptive caption explaining what the photo shows, the direction it was taken (e.g., "looking east" or "east side of building, looking west"), side of the structure shown (e.g., front, back) and other relevant details.
- For structures that are raised (or partially raised) due to surrounding ground level changes or other circumstances, it is important to provide photographs of different sides and angles of the foundation.
- Photographs should show foundation, walls, entrances, openings and roof, as appropriate.

Potential Sources: Use a cell phone, tablet, or camera to take clear, good quality photos for inclusion in the application.

Figure 3. Photos showing the structure to be retrofitted. Photos include all sides of the building from different cardinal directions.

STEP 9: Document the Before-Mitigation Flood Risk

Description: Provide information on the risk of flooding and the effects of that flooding both in physical damages and, when appropriate, loss of function.

There are two ways to demonstrate the risk of flooding to a hazard-prone structure: using engineering analysis to estimate the risk or using historical information to demonstrate the risk. In many flood-prone areas, FEMA has performed an engineering analysis of the risk that can be found in the published Flood Insurance Study (FIS) and accompanying FIRM (an example is provided in **Figure 4**). Include a description of the flood zone where the existing structure is located and whether the site is in a regulatory floodway. In some areas, an engineering professional may have performed an independent study of the flood risk and prepared an engineering report documenting the results. If the area has not been studied in detail, flood risk can be demonstrated by documenting a flood event history.

References: FEMA's Flood Map Service Center and FEMA's How to Find Your FIRM and Make a FIRMette

Approach: The flood risk should be documented by one of the following three approaches:

1. If an FIS and FIRM are available for the project area, provide a copy of the map, with the project location and impacted structure(s) footprint(s) outlined on the map and a copy of the associated information in the FIS. Verify that the flood zone in which the structure is located is clearly noted. Note whether the structure is in the Special Flood Hazard Area (SFHA) (the 100-year floodplain) and if located in a regulatory floodway.

   If an FIS and FIRM exist for the project area, this documentation should be provided whether an independent flood analysis or historical flood information was used to assess the project.

2. If an independent engineering study exists and is being used to assess the flood risk for the project, provide a copy of the professionally certified report. The report should include hydrologic and hydraulic (H&H) calculations used to determine flood elevations for four events with varying flood recurrence intervals such as the 10-year, 50-year, 100-year or other interval. If these calculations were completed using modeling software, the engineering report should document all model inputs and outputs. Inundation maps also are recommended to support the analysis and document which structures are at risk.

3. If detailed flood analysis is not available, provide a list of historical flood events along with the following information:

   - Specific date of each flood event
   - Measured or estimated high water marks from the event in the vicinity of the project area, if available
   - Size of the event (flood recurrence interval such as the 10-year, 50-year or other interval), if known. See Supplement to the Benefit-Cost Analysis Reference Guide.
   - A list of physical damages to the structures included in the project application and the associated repair costs. Actual insurance claims may be available through the homeowner or BureauNet if the buildings are flood insured. See Supplement to the Benefit-Cost Analysis Reference Guide.

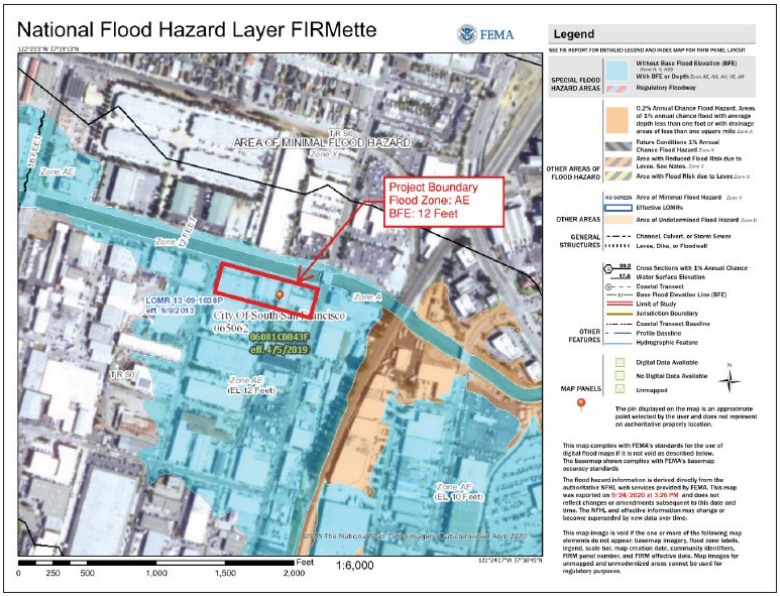


Figure 4. FEMA FIRMette with dry floodproofing project boundary identified.

STEP 10: Cost-Effectiveness Analysis

Description: Cost-effectiveness of a dry floodproofing project must be demonstrated to obtain FEMA funding. Cost-effectiveness is determined through a benefit-cost analysis (BCA). A BCA is a quantitative procedure that assesses the cost-effectiveness of a hazard mitigation measure over the useful life of the project by comparing potential avoided damages (benefits) associated with the mitigation measure to the cost of a project in current dollars. **Figure 5** helps to illustrate this concept.

This section provides guidance on the following:

- **Step 10A:** Benefit-Cost Analysis – Modeled Damages
- **Step 10B:** Benefit-Cost Analysis – Historical or Professional Expected Damages
- **Step 10C:** Additional Benefits for a Benefit-Cost Analysis

All BCA inputs must be justified and documented. When appropriate FEMA default/standard values are used, it should be clearly stated.

FEMA will only consider applications that use a FEMA-approved methodology to demonstrate cost-effectiveness. FEMA provides a BCA Tool that allows applicants to calculate a project's Benefit-Cost Ratio (BCR). The BCR is a calculation of the project benefits divided by the project costs. Projects for which the benefits exceed costs (a BCR of 1.0 or greater) are considered cost-effective. FEMA requires the use of the BCA Tool to ensure calculations are consistent with OMB Circular A-94 Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs. Benefits may include avoided damage, loss of function and displacement. In the case of dry floodproofing projects, these include:

- Avoided physical damage to the structure(s) and contents

- Avoided displacement costs – the costs required to move and reside in a temporary location while repairs are performed on the structure
- Avoided emergency response costs – the costs incurred after the event that would be avoided by the project. For example, costs to rent a temporary generator when the building's generator was flooded would be avoided if the generator would be protected by the dry floodproofing.
- Avoided loss of rental income
- Avoided volunteer labor time that typically support cleanup and repair work
- Avoided loss of business income or net revenue (for commercial properties)
- Avoided loss of public services (for public properties)
- If reductions in the loss of function are claimed:
  - Provide substantiation as to how the reduction in physical damages will reduce loss of function. Since benefits from reducing loss of function depend on the duration of functional loss, provide substantiation to support the reduction in the duration of the loss of function.
  - When substantiating loss of function benefits, it is important to consider system interconnectivity and interdependence and that all systems required for functionality need to operate to reduce loss of function.

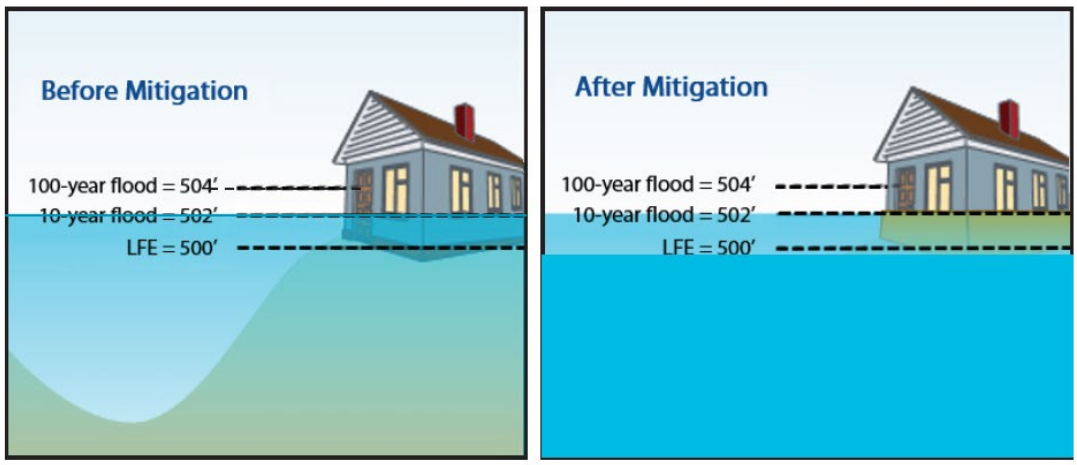


Figure 5. Before and after mitigation dry floodproofing.

Table 1. Comparison of mitigation benefits.

Recurrence Interval	Expected Damages Before-Mitigation	Expected Annual Damages After-Mitigation – Dry Floodproofing	Estimated Annual Damages Avoided
10-year flood	$1,981	$0	$1,981
100-year interval	$17,121	$1,000	$16,121

Before-mitigation, the structure's lowest floor elevation is at 500 feet. At this location, the 10-year flood event is estimated to be 502 feet, causing an estimated $1,981 in damages to the structure, and the 100-year flood event is estimated to be 504 feet, causing an estimated $17,121 damages to the structure. After-mitigation,

the structure is floodproofed up to 4 feet. The 10-year flood event now causes $0 in expected damages and the 100-year flood event causes $1,000 in expected damages to the structure.

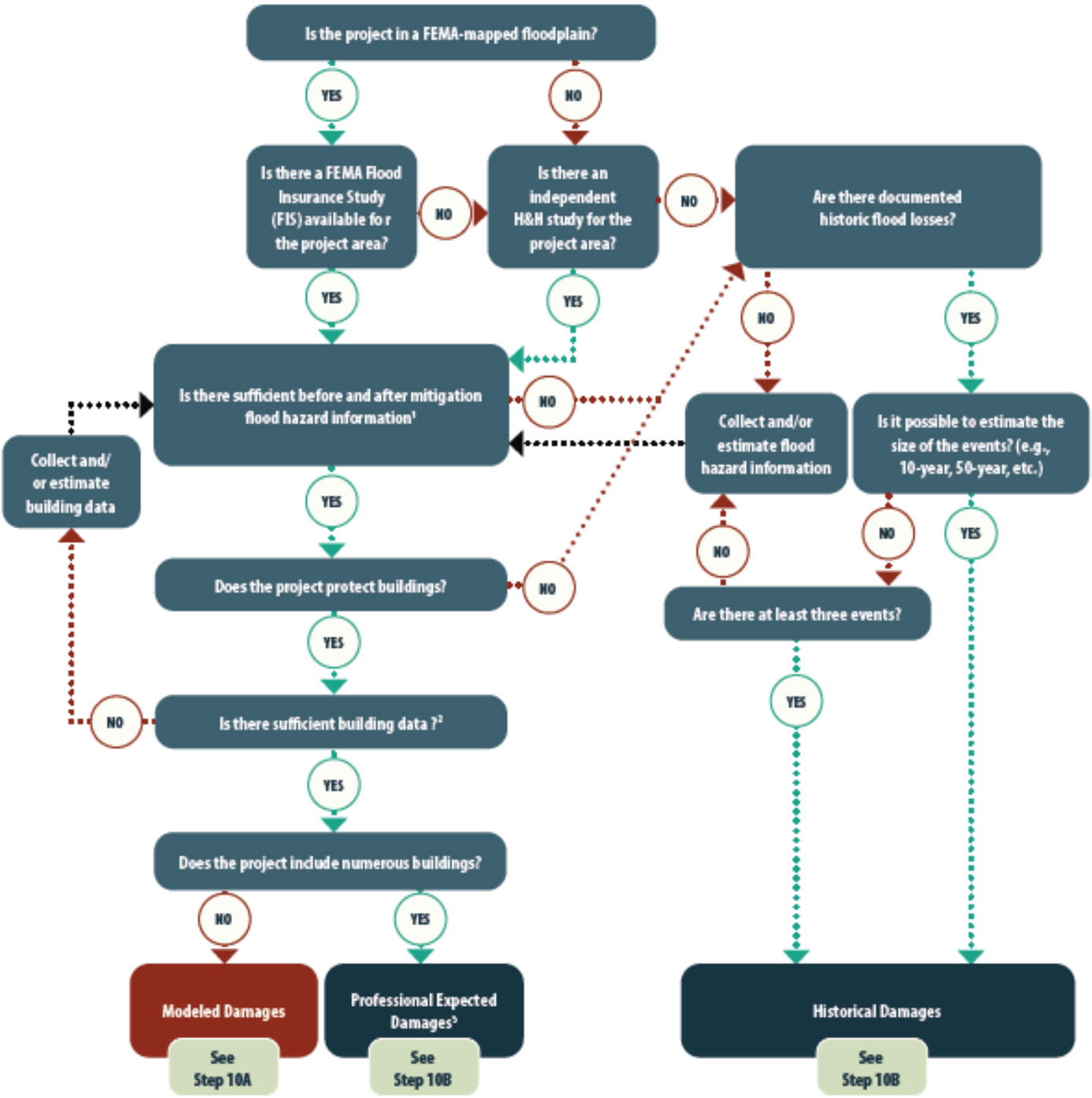
It is important to note that there are several benefits that could be counted for a project, and any or all benefits can be included in a BCA when analyzing cost-effectiveness. The approaches outlined in **Step 10A** and **Step 10B** of this supplement are focused primarily on avoided physical damage (structure and contents), loss of service/function and displacement costs. It is recommended that the applicant start on a BCA using these types of benefits as they are typically the largest benefits for dry floodproofing projects.

If the BCR does not exceed 1.0, or is slightly over 1.0, after following **Step 10A** or **Step 10B**, move to **Step 10C** to find additional methods for calculating potential benefits for the project.

This supplement only provides a recommended approach to documenting cost-effectiveness. For detailed guidance on using the FEMA BCA Tool, please refer to the FEMA BCA Reference Guide and FEMA Supplement to the BCA Reference Guide. For additional questions, please contact the BC Helpline at ***bchelpline@fema.dhs.gov*** or at ***1-855-540-6744***. Provide a .pdf of the BCA report and an export of the BCA .zip file.

Approach: There are several methods to evaluate cost-effectiveness. The method used will depend on the data collected in the previous steps of this supplement. Use the flowchart in **Figure 6** to analyze the data available for the project site and determine the recommended approach.

The FEMA BCA Tool includes embedded Help Content. Click on the information button within the tool to access the Help Content.



NOTES

1. Building information must include LFE.
2. Described in **Step 9**, the project must have information on 4 events. (e.g., 10-year, 50-year, 100-year, 500-year) for before- and after-mitigation.
3. Modeled damages may be used for multiple structures; however, each structure must be included in the BCA project as its own mitigation action.

Figure 6. Flowchart for Determining the Appropriate BCA Frequency and Damage Relationship in the FEMA BCA Tool

STEP 10A: Benefit-Cost Analysis Tool – Modeled Damages

Description: Using modeled damages is suitable when the project is primarily protecting structures, as it only calculates damages to structures. The BCA Tool can utilize modeled damages to analyze proposed mitigation projects by comparing estimated flood elevations for various flood events to the structure's LFE. The BCA Tool then uses established depth-damage curves to estimate losses based on a percentage of the building replacement value (BRV). Additionally, it uses the same depth-damage curves to estimate damage to building contents, displacement from the building, and loss of use of the building. Using modeled damages is recommended for BCAs when users have detailed flood hazard information and structural data (using **Step 9**, Approach 1 and 2).

References: FEMA's Benefit-Cost Analysis Reference Guide, Supplement to the Benefit-Cost Analysis Reference Guide, FEMA BCA Tool (including Help Content within the Tool)

Approach: The following describes the essential flood hazard data required to estimate avoided physical damages using Modeled Damages in the BCA Tool. If **Step 1** through **Step 9** of this supplement are followed and all data gathered, there should be minimal additional data collection needed to complete the Modeled Damages BCA. To verify the information entered in the BCA software, the following supporting information must be provided:

- Project useful life (PUL) – FEMA-approved values can be found in the BCA Reference Guide or within the BCA Help Content Project Cost – refer to **Step 5**.
- Provide the location of the structure to be retrofitted (address or latitude/longitude).
- Provide the annual maintenance cost associated with maintaining the effectiveness of the components installed as part of the mitigation project.
- Flood hazard information for before-mitigation scenarios – Refer to **Step 9** and **Table 2**.

Table 2. Flood Hazard Information used in the BCA Tool – Modeled Damages.

Coastal Projects	Riverine Projects
Ground surface elevation	Stream bed elevation
BFE or 100-year elevation with wave action	Flood elevations for the 10-, 50-, 100-, and 500-year recurrence intervals (RIs) (alternative recurrence intervals are acceptable when using H&H study)
Still water elevation (for the 10-, 50-, 100-, 500-year RI). Alternative RIs are acceptable when using a non-FEMA H&H study	Flood discharge rates for the 10-, 50-, 100-, and 500-year RIs (riverine flood hazard analysis only, alternative RIs are acceptable when using an H&H study)

- Structural information – Refer to **Step 2**.
  - Provide the total building replacement value (BRV).
  - Specify the structure use (e.g., hospital, college/university, single-family dwelling).
  - Lowest floor elevation (LFE), in feet
- After-mitigation building parameters for each of the following – Refer to **Step 2**.

- Elevation for the top flood barrier or dry floodproofing, in feet

Although the information listed above is required to calculate avoided building damages, the BCA Tool will use FEMA standard values to automatically calculate some avoided losses using Depth-Damage Functions (DDF). If different values are used, supporting documentation should be provided.

STEP 10B: Benefit-Cost Analysis Tool – Historical or Professional Expected Damages

Description: The FEMA BCA Tool Damage Frequency Assessment (DFA) module calculates project benefits and costs for proposed mitigation projects for any hazard. The DFA module compares user-entered damages/losses and the frequency that they occur in the before-mitigation scenario versus the after-mitigation scenario to calculate benefits based on avoided damages. The DFA module is used when the user has hazard data for professional expected damages (**Step 9**, Approach 2) or historical damages (**Step 9**, Approach 3).

For a dry floodproofing project, DFA module is most typically utilized when there is no detailed H&H analysis for the project area and the risk to the project site is demonstrated through past flood damages to the structure. Information regarding each of the scenario events was described in **Step 9** of this supplement. For each damage event, the corresponding recurrence interval information is needed. If recurrence intervals are not available, the BCA Tool will calculate a recurrence interval when historical damage data from at least three events are provided.

References: FEMA's Benefit-Cost Analysis Reference Guide, Supplement to the Benefit-Cost Analysis Reference Guide, and FEMA BCA Tool (including Help Content within the Tool)

Approach: The DFA module calculates project benefits for proposed hazard mitigation projects based on either documented historic damages (such as physical damages or loss of function) or professional expected damages (estimated damages that have not yet occurred or occurred but not to the extent possible) from at least one known-frequency event. If recurrence intervals are not known and there are historical damage data from at least three events, the DFA module can estimate a recurrence interval; otherwise, additional data collection or analysis will be needed. The calculation compares before- and after-mitigation conditions and an example calculation is shown in **Table 3**.

- **Before-mitigation:** Based on existing conditions at the site. To demonstrate the current risk, actual historical damages or estimated damages for certain severity events (e.g., the 10-year flood, the 50-year flood or other interval) can be entered in the DFA module to perform a BCA.
- **After-mitigation:** The same scenario flood events should result in reduced damages due to the mitigation project. The after-mitigation damages should be estimated based on the level of protection provided by the project. For example, for a project that dry floodproofs a building above the 100-year flood elevation, it could be assumed there would no longer be damages to the structure below the 100-year level of protection. However, there may be some residual risk from floods greater than the 100-year flood resulting in damages.

Table 3. Before- and after-mitigation estimated damages.

Recurrence Interval	Before-Mitigation Damages			After-Mitigation Damages		
	Building (Structural)	Contents (Nonstructural)	Loss of Function	Building (Structural)	Contents (Nonstructural)	Loss of Function
10-year	$5,000	$2,500	$10,000	$0	$0	$0
100-year	$7,500	$3,450	$25,000	$750	$350	$1,000
1,000-year	$25,000	$12,500	$30,000	$1,250	$1,500	$5,000

Potential Sources:

- Insurance claims, receipts from repair of flood damages, FEMA Public Assistance projects, BureauNet data, documentation of loss of service from a utility provider, Public Works Department
- Results of structural models developed and certified by a professional engineer

STEP 10C: Additional Benefits for a Benefit-Cost Analysis

Description: There are several benefits that could be counted for a project. Any or all the benefits can be used to demonstrate that a project is cost-effective, or, in other words, has a BCR greater than 1.0. Once the initial BCA information is collected and a preliminary analysis is performed, additional benefits may be analyzed, if needed. Corresponding documentation must be included with the application to support any additional benefits.

Approach:

Answer the following questions:

1. Do the services that the structure provides have to be temporarily relocated? Displacement costs are based on the length of time the building is out of service, a one-time cost for setting up and moving a temporary facility to continue operations, and monthly costs for occupying the temporary facility (rent). The BCA Tool will use FEMA standard values to automatically calculate the avoided losses to contents and avoided displacement costs. If different values are used, supporting documentation must be provided.
2. Is there a business run out of the building or home? Provide an estimate of net business income that would be lost is each scenario event.
3. Does the building have any rental property for which the owner receives income? What is the cost of rent income per month?
4. Is there a business run out of the building? How much income does the business bring in per month?
5. Does the project prevent loss of service to a utility?
6. Are there any non-critical government services provided from the building such as a permit office or library?
7. Are there any critical services provided from the building such as police, fire, or medical services?

8. Is the building residential? If yes, how many residents reside in each building? If this information is not readily available, use averages from Census data related to the municipality or county. These values can be used to estimate avoided mental stress and loss of productivity (if the BCR is already over 0.75) and displacement costs.

STEP 10D: Loss of Service to Critical Facilities

Description: The BCA Tool will account for the loss of service for critical facilities such as fire stations, hospitals, police stations, and other facilities. Under each facility type, specific information is required to determine the monetary damages incurred if the facility is closed because of flooding. The following is a list of information that will allow the loss of service to be calculated.

References: Supporting documentation for loss of service calculations can include Census data, local maps, mapping programs or GIS programs, facility operations management reports, emergency plans for the facility, documents such as annual reports

Approach: To calculate loss of service, provide the following information for each facility type:

- Fire Stations
  - Type of service area served by the fire station (e.g., urban, suburban, rural, wilderness)
  - Number of people served by the fire station
  - Distance to the nearest closest fire station that would provide fire protection to the jurisdiction normally served by this fire station (in miles)
  - Distance in miles to the next closest fire station that would provide emergency medical services for the jurisdiction normally served by this fire station (in miles), if applicable
- Hospitals
  - Number of people served by the hospital
  - Distance to the nearest closest hospital (alternate hospital) that would treat the population served in the event this hospital was inoperative (in miles)
  - Number of people served by the alternate hospital
- Police Stations
  - Type of area served by this police station (e.g., metropolitan, city, rural)
  - Number of people served by this police station
  - Number of police officers working at the police station
  - Number of police officers that would serve the same area if the station were shut down due to a disaster
- Other Facilities
  - Service name (type of service)
  - Total annual budget, operating costs or revenue (must be provided with supporting documentation)

STEP 11: Environmental and Historic Preservation Considerations

Description: Environmental and, particularly, historical preservation compliance will need to be considered as part of the application process for dry floodproofing. The assistance of a licensed professional engineer, architect, or contractor may be required to help obtain the necessary information about environmental and historic preservation compliance. Refer to the EHP Supplement Job Aids.

Resources

Below is a comprehensive list of resources identified throughout this supplement. Not all these resources are necessary for every dry floodproofing project but are provided to ease in identification of source material.

PROGRAM AUTHORITIES

- The National Flood Insurance Act of 1968, As Amended, 42 U.S.C. 4001 et seq.
- The Robert T. Stafford Disaster Relief and Emergency Assistance Act, As Amended, 42 U.S.C. 4001 et seq.
- 44 Code of Federal Regulations, Part 206, Subpart N
- 2 Code of Federal Regulations, Part 200

PROGRAM GUIDANCE

- FEMA Hazard Mitigation Assistance Guidance and Addendum to the Hazard Mitigation Assistance Guidance
- Benefit-Cost Analysis Reference Guide and Supplement to the Benefit-Cost Analysis Reference Guide

TECHNICAL GUIDANCE AND STANDARDS

- ASCE/SEI 7-16, Minimum Design Loads for Buildings and Other Structures (or latest version)
- ASCE/SEI 24-14, Flood Resistant Design and Construction (or latest version)
- Building Codes for Mitigation: Using ASCE 24
- NFIP Technical Bulletin 3, Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings
- Federal Flood Risk Management Standard
- FEMA P-348, Protecting Building Utility Systems from Flood Damage
- FEMA P-424, Design Guide for School Safety Against Earthquakes, Floods, and High Winds
- FEMA P-543, Design Guide for Improving Critical Facility Safety from Flooding and High Winds
- FEMA P-577, Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds
- FEMA P-787, Catalog of FEMA Building Science Branch
- FEMA P-936, Floodproofing Non-Residential Buildings
- Florida Recovery Advisory 1 – Successfully Retrofitting Buildings for Wind Resistance

- Highlights of ASCE 24 Flood Resistant Design and Construction
- International Building Code (IBC) 2018 (or most recent version)
- International Existing Building Code (IEBC) 2018 (or most recent version)
- International Residential Code (IRC) 2018 (or most recent version)
- Texas Recovery Advisory 1 – Dry Floodproofing: Planning and Design Considerations

ADDITIONAL TOOLS AND RESOURCES

- FEMA's How to Find Your FIRM and Make a FIRMette
- FEMA's Map Service Center
- FEMA Benefit-Cost Analysis (BCA) Tool
- Cost Estimating Principles for Hazard Mitigation Assistance Applications
- FEMA's National Flood Hazard Layer
- Hazard Mitigation Assistance Application Development
- EHP Review Supplements
- FEMA Hazard Mitigation Assistance Job Aids