



# Mitigation Ideas

A Resource for Reducing Risk to Natural Hazards

January 2013



**FEMA**

## Acknowledgements

FEMA's Risk Analysis Division funded the development of this document, which updates *Mitigation Ideas: Possible Mitigation Measures by Hazards Type* created by FEMA Region V in 2002. The primary authors and project managers were Julie Baxter and Karen Helbrecht from FEMA and Stacy Franklin Robinson, Sara Reynolds, Adam Reeder, and Hilary Kendro from the Strategic Alliance for Risk Reduction (STARR). Laura Coventry (STARR) provided layout and design support. Special thanks to the following FEMA program areas for their contributions to this project: Hazard Mitigation Planning, Building Sciences, Environmental and Historic Preservation, Flood Mitigation and Insurance, and Hazard Mitigation Assistance.

# Table of Contents

Introduction .....	4
Drought.....	5
Earthquake.....	9
Erosion .....	15
Extreme Temperatures .....	19
Flood .....	21
Hail .....	33
Landslide .....	35
Lightning .....	39
Sea Level Rise.....	41
Severe Wind .....	45
Severe Winter Weather.....	51
Storm Surge.....	55
Subsidence.....	59
Tornado.....	63
Tsunami .....	65
Wildfire .....	69
Multiple Hazards .....	75
FEMA Resources/Publications .....	83
FEMA Contacts .....	88



# Introduction

The purpose of this document is to provide a resource that communities can use to identify and evaluate a range of potential mitigation actions for reducing risk to natural hazards and disasters.

The focus of this document is mitigation, which is action taken to reduce or eliminate long-term risk to hazards. Mitigation is different from preparedness, which is action taken to improve emergency response or operational preparedness.

Ideas for mitigation actions are presented for the following natural hazards:

- Drought
- Earthquake
- Erosion
- Extreme temperatures
- Flood
- Hail
- Landslide
- Lightning
- Sea level rise
- Severe wind
- Severe winter weather
- Storm surge
- Subsidence
- Tornado
- Tsunami
- Wildfire

*Examples of mitigation actions are planning and zoning, floodplain protection, property acquisition and relocation, or public outreach projects.*

*Examples of preparedness actions are installing disaster warning systems, purchasing radio communications equipment, or conducting emergency response training.*

Actions that may mitigate multiple hazards are presented in the last section, entitled “Multiple Hazards.”

The suggested mitigation actions are summarized into four types: (1) Local Planning and Regulations, (2) Structure and Infrastructure Projects, (3) Natural Systems Protection, and (4) Education and Awareness Programs. Examples of activities that can be used to accomplish each mitigation goal are identified, as well as the relevant FEMA publications or resources, if applicable.

This document is intended to be a starting point for gathering ideas and should not be used as the only source for identifying actions. Communities should seek innovative and different ideas for reducing risk that meet their unique needs. The actions listed are not necessarily eligible for Federal assistance programs. Users should review specific program guidance and contact their State Hazard Mitigation Officer (SHMO) or regional FEMA office for more information.





# Flood

A flood is the partial or complete inundation of normally dry land. The various types of flooding include riverine flooding, coastal flooding, and shallow flooding. Common impacts of flooding include damage to personal property, buildings, and infrastructure; bridge and road closures; service disruptions; and injuries or even fatalities.

## Local Planning and Regulations

### F-1 Incorporate Flood Mitigation in Local Planning

*FEMA Resources/Publications*  
*FEMA 100, 268, 473*

**Comprehensive planning and floodplain management can mitigate flooding by influencing development. Strategies include:**

- Determining and enforcing acceptable land uses to alleviate the risk of damage by limiting exposure in flood hazard areas. Floodplain and coastal zone management can be included in comprehensive planning.
- Developing a floodplain management plan and updating it regularly.
- Mitigating hazards during infrastructure planning. For example, decisions to extend roads or utilities to an area may increase exposure to flood hazards.
- Adopting a post-disaster recovery ordinance based on a plan to regulate repair activity, generally depending on property location.
- Passing and enforcing an ordinance that regulates dumping in streams and ditches.
- Establishing a "green infrastructure" program to link, manage, and expand existing parks, preserves, greenways, etc.
- Obtaining easements for planned and regulated public use of privately-owned land for temporary water retention and drainage.

### F-2 Form Partnerships to Support Floodplain Management

**Partnerships between local, state, and regional entities help expand resources and improve coordination. Consider the following actions:**

- Developing a stormwater committee that meets regularly to discuss issues and recommend projects.
- Forming a regional watershed council to help bring together resources for comprehensive analysis, planning, decision-making, and cooperation.
- Establishing watershed-based planning initiatives to address the flood hazard with neighboring jurisdictions.
- Forming a citizen plan implementation steering committee to monitor progress on local mitigation actions. Include a mix of representatives from neighborhoods, local businesses, and local government.



## F-3 Limit or Restrict Development in Floodplain Areas

*FEMA Resources/Publications*  
*FEMA 100, 268, 473*

**Flooding can be mitigated by limiting or restricting how development occurs in floodplain areas through actions such as:**

- Prohibiting or limiting floodplain development through regulatory and/or incentive-based measures.
- Limiting the density of developments in the floodplain.
- Requiring that floodplains be kept as open space.
- Limiting the percentage of allowable impervious surface within developed parcels.
- Developing a stream buffer ordinance to protect water resources and limit flood impacts.
- Prohibiting any fill in floodplain areas.

## F-4 Adopt and Enforce Building Codes and Development Standards

*FEMA Resources/Publications*  
*FEMA 100, 268, P-762*

**The use of building codes and development standards can ensure structures are able to withstand flooding. Potential actions include:**

- Adopting the International Building Code (IBC) and International Residential Code (IRC).
- Adopting ASCE 24-05 *Flood Resistant Design and Construction*. ASCE 24 is a referenced standard in the IBC that specifies minimum requirements and expected performance for the design and construction of buildings and structures in the flood hazard areas to make them more resistant to flood loads and flood damage.
- Adding or increasing “freeboard” requirements (feet above base flood elevation) in the flood damage ordinance.
- Prohibiting all first floor enclosures below base flood elevation for all structures in flood hazard areas.
- Considering orientation of new development during design (e.g., subdivisions, buildings, infrastructure, etc.).
- Setting the design flood elevation at or above the historical high water mark if it is above the mapped base flood elevation.
- Using subdivision design standards to require elevation data collection during platting and to have buildable space on lots above the base flood elevation.
- Requiring standard tie-downs of propane tanks.

## F-5 Improve Stormwater Management Planning

**Rainwater and snowmelt can cause flooding and erosion in developed areas. Stormwater management practices to prevent this include:**

- Completing a stormwater drainage study for known problem areas.
- Preparing and adopting a stormwater drainage plan and ordinance.
- Preparing and adopting a community-wide stormwater management master plan.
- Regulating development in upland areas in order to reduce stormwater run-off through a stormwater ordinance.
- Linking flood hazard mitigation objectives with EPA Stormwater Phase II initiatives.
- Developing engineering guidelines for drainage from new development.
- Requiring a drainage study with new development.
- Encouraging the use of Low Impact Development techniques

## F-6 Adopt Polices to Reduce Stormwater Runoff

**In addition to stormwater management, techniques to reduce rain runoff can prevent flooding and erosion, such as:**

- Designing a “natural runoff” or “zero discharge” policy for stormwater in subdivision design.
- Requiring more trees be preserved and planted in landscape designs to reduce the amount of stormwater runoff.
- Requiring developers to plan for on-site sediment retention.
- Requiring developers to construct on-site retention basins for excessive stormwater and as a firefighting water source.
- Encouraging the use of porous pavement, vegetative buffers, and islands in large parking areas.
- Conforming pavement to land contours so as not to provide easier avenues for stormwater.
- Encouraging the use of permeable driveways and surfaces to reduce runoff and increase groundwater recharge.
- Adopting erosion and sedimentation control regulations for construction and farming.



## F-7 Improve Flood Risk Assessment

*FEMA Resources/Publications*  
*FEMA 416, 467-1, B-797*

### Heighten awareness of flood risk with the following:

- Incorporating the procedures for tracking high water marks following a flood into emergency response plans.
- Conducting cumulative impact analyses for multiple development projects within the same watershed.
- Conducting a verification study of FEMA’s repetitive loss inventory and developing an associated tracking database.
- Regularly calculating and documenting the amount of flood-prone property preserved as open space.
- Requiring a thorough watershed analysis for all proposed dam or reservoir projects.
- Developing a dam failure study and emergency action plan.
- Using GIS to map areas that are at risk of flooding.
- Obtaining depth grid data and using it to illustrate flood risk to citizens.
- Incorporating digital floodplain and topographic data into GIS systems, in conjunction with Hazus, to assess risk.
- Developing and maintaining a database to track community exposure to flood risk.
- Revising and updating regulatory floodplain maps.

## F-8 Join or Improve Compliance with NFIP

*FEMA Resources/Publications*  
*FEMA 100, 209, FIA-15A,*  
*NFIP Technical Bulletins*

**The National Flood Insurance Program (NFIP) enables property owners in participating communities to purchase insurance protection against flood losses. Actions to achieve eligibility and maintain compliance include:**

- Participating in NFIP.
- Adopting ordinances that meet minimum Federal and state requirements to comply with NFIP.
- Conducting NFIP community workshops to provide information and incentives for property owners to acquire flood insurance.
- Designating a local floodplain manager and/or CRS coordinator who achieves CFM certification.
- Completing and maintaining FEMA elevation certificates for pre-FIRM and/or post-FIRM buildings.
- Requiring and maintaining FEMA elevation certificates for all new and improved buildings located in floodplains.

## F-9 Manage the Floodplain Beyond Minimum Requirements

*FEMA Resources/Publications*  
*FEMA 100, 209, 213, 268, 480;*  
*FIA-15A*

**In addition to participation in NFIP, implementing good floodplain management techniques that exceed minimum requirements can help minimize flood losses. Examples include:**

- Incorporating the ASFPM’s “No Adverse Impact” policy into local floodplain management programs.
- Revising the floodplain ordinance to incorporate cumulative substantial damage requirements.
- Adopting a “no-rise” in base flood elevation clause for the flood damage prevention ordinance.
- Extending the freeboard requirement past the mapped floodplain to include an equivalent land elevation.
- Including requirements in the local floodplain ordinance for homeowners to sign non-conversion agreements for areas below base flood elevation.
- Establishing and publicizing a user-friendly, publicly-accessible repository for inquirers to obtain Flood Insurance Rate Maps.
- Developing an educational flyer targeting NFIP policyholders on increased cost of compliance during post-flood damage assessments.
- Annually notifying the owners of repetitive loss properties of Flood Mitigation Assistance funding.
- Offering incentives for building above the required freeboard minimum (code plus).

## F-10 Participate in the CRS

*FEMA Resources/Publications*  
*FEMA 100, 209, 213, 268, 480;*  
*FIA-15A*

**The Community Rating System (CRS) rewards communities that exceed the minimum NFIP requirements. Depending upon the level of participation, flood insurance premium rates are discounted for policyholders. Potential activities that are eligible to receive credit include:**

- Advising the public about the local flood hazard, flood insurance, and flood protection measures.
- Enacting and enforcing regulations that exceed NFIP minimum standards so that more flood protection is provided for new development.
- Implementing damage reduction measures for existing buildings such as acquisition, relocation, retrofitting, and maintenance of drainageways and retention basins.
- Taking action to minimize the effects of flooding on people, property, and building contents through measures including flood warning, emergency response, and evacuation planning.

## F-11 Establish Local Funding Mechanisms for Flood Mitigation

**Potential methods to develop local funding sources for flood mitigation include:**

- Using taxes to support a regulatory system.
- Using impact fees to help fund public projects to mitigate impacts of land development (e.g., increased runoff).
- Levying taxes to finance maintenance of drainage systems and capital improvements.

## Structure and Infrastructure Projects

### F-12 Remove Existing Structures from Flood Hazard Areas

Communities may remove structures from flood-prone areas to minimize future flood losses by acquiring and demolishing or relocating structures from voluntary property owners and preserving lands subject to repetitive flooding.

### F-13 Improve Stormwater Drainage System Capacity

Rainwater and snowmelt can cause flooding and erosion in developed areas. Structural stormwater management projects that prevent this include:

- Installing, re-routing, or increasing the capacity of a storm drainage system.
- Increasing drainage or absorption capacities with detention and retention basins, relief drains, spillways, drain widening/dredging or rerouting, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, or channel redirection.
- Increasing capacity of stormwater detention and retention basins.
- Increasing dimensions of drainage culverts in flood-prone areas.
- Using stream restoration to ensure adequate drainage and diversion of stormwater.
- Requiring developers to construct on-site retention basins for excessive stormwater and as a firefighting water source.
- Providing grassy swales along roadsides.

### F-14 Conduct Regular Maintenance for Drainage Systems and Flood Control Structures

Regular maintenance will help drainage systems and flood control structures continue to function properly. Potential activities include:

- Performing regular drainage system maintenance, such as sediment and debris clearance, as well as detection and prevention of discharges into stormwater and sewer systems from home footing drains, downspouts, or sewer pumps.
- Implementing an inspection, maintenance, and enforcement program to help ensure continued structural integrity of dams and levees.
- Routinely cleaning debris from support bracing underneath low-lying bridges.
- Routinely cleaning and repairing stormwater drains.
- Regularly clearing sediment build-up on riverbanks near aerial lines.
- Inspecting bridges and identifying if any repairs or retrofits are needed to prevent scour.
- Incorporating ice jam prevention techniques as appropriate.

## F-15 Elevate or Retrofit Structures and Utilities

*FEMA Resources/Publications*

*FEMA 54, P-85, 114, P-259, 347, P-348, P-499*

**Structures and utilities can be elevated to reduce flood damage, including:**

- Elevating structures so that the lowest floor, including the basement, is raised above the base flood elevation.
- Raising utilities or other mechanical devices above expected flood levels.
- Elevating and anchoring manufactured homes or, preferably, keeping manufactured homes out of the floodplain.
- Relocating utilities and water heaters above base flood elevation and using tankless water heaters in limited spaces.

## F-16 Floodproof Residential and Non-Residential Structures

*FEMA Resources/Publications*

*FEMA P-55, 114, P-259*

**Floodproofing techniques may protect certain structures from flood damage, including:**

- Wet floodproofing in a basement, which may be preferable to attempting to keep water out completely because it allows for controlled flooding to balance exterior and interior wall forces and discourages structural collapse.
- Encouraging wet floodproofing of areas above base flood elevation.
- Using water resistant paints or other materials to allow for easy cleanup after floodwater exposure in accessory structures or in a garage area below an elevated residential structure.
- Dry floodproofing non-residential structures by strengthening walls, sealing openings, or using waterproof compounds or plastic sheeting on walls to keep water out.





## F-17 Protect Infrastructure

*FEMA Resources/Publications*

*FEMA P-259, 345, 543, B-797*

**Mitigation techniques can be implemented to help minimize losses to infrastructure from flood events, such as:**

- Elevating roads and bridges above the base flood elevation to maintain dry access. In situations where flood waters tend to wash roads out, construction, reconstruction, or repair can include not only attention to drainage, but also stabilization or armoring of vulnerable shoulders or embankments.
- Raising low-lying bridges.
- Floodproofing wastewater treatment facilities located in flood hazard areas.
- Floodproofing water treatment facilities located in flood hazard areas.
- Depending on its infrastructure capabilities, using check valves, sump pumps, and backflow prevention devices in homes and buildings.
- Using bioengineered bank stabilization techniques.

## F-18 Protect Critical Facilities

*FEMA Resources/Publications*

*FEMA P-259, 345, 543, B-797*

**Techniques to protect critical facilities from flood events include:**

- Requiring that all critical facilities including emergency operations centers (EOC), police stations, and fire department facilities be located outside of flood-prone areas.
- Requiring all critical facilities to meet requirements of Executive Order 11988 and be built 1 foot above the 500-year flood elevation.
- Installing/upgrading stormwater pumping stations.
- Raising electrical components of sewage lift stations above base flood elevation.
- Raising manhole openings using concrete pillars.
- Installing watertight covers or inflow guards on sewer manholes.
- Installing flood telemetry systems in sewage lift stations.
- Installing back-up generators for pumping and lift stations in sanitary sewer systems along with other measures (e.g., alarms, meters, remote controls, and switchgear upgrades).
- Building earthen dikes around flood-threatened critical facilities.
- Using bioengineered bank stabilization techniques.

## F-19 Construct Flood Control Measures

**Small flood control structures can be built to prevent flood damage. Examples include:**

- Using minor structural projects that are smaller and more localized (e.g., floodwalls or small berms) in areas that cannot be mitigated through non-structural activities or where structural activities are not feasible due to low densities.
- Using revetments (hardened materials placed atop existing riverbanks or slopes) to protect against floods.
- Using bioengineered bank stabilization techniques.



## Natural Systems Protection

### F-20 Protect and Restore Natural Flood Mitigation Features

*FEMA Resources/Publications*  
*FEMA 100, 268*

**Natural resources provide floodplain protection, riparian buffers, and other ecosystem services that mitigate flooding. It is important to preserve such functionality with the following:**

- Protecting and enhancing landforms that serve as natural mitigation features (i.e., riverbanks, wetlands, dunes, etc.).
- Using vegetative management, such as vegetative buffers, around streams and water sources.
- Protecting and preserving wetlands to help prevent flooding in other areas.
- Establishing and managing riparian buffers along rivers and streams.
- Retaining natural vegetative beds in stormwater channels.
- Retaining thick vegetative cover on public lands flanking rivers.

### F-21 Preserve Floodplains as Open Space

*FEMA Resources/Publications*  
*FEMA 100, 268*

**Preserving natural areas and vegetation benefits natural resources while also mitigating potential flood losses. Techniques include:**

- Developing an open space acquisition, reuse, and preservation plan targeting hazard areas.
- Developing a land banking program for the preservation of the natural and beneficial functions of flood hazard areas.
- Using transfer of development rights to allow a developer to increase densities on another parcel that is not at risk in return for keeping floodplain areas vacant.
- Compensating an owner for partial rights, such as easement or development rights, to prevent a property from being developed.

### F-22 Increase Awareness of Flood Risk and Safety

**Ideas for increasing flood risk awareness include the following:**

- Encouraging homeowners to purchase flood insurance.
- Annually distributing flood protection safety pamphlets or brochures to the owners of flood-prone property.
- Educating citizens about safety during flood conditions, including the dangers of driving on flooded roads.
- Using outreach programs to advise homeowners of risks to life, health, and safety.
- Offering GIS hazard mapping online for residents and design professionals.
- Establishing a Program for Public Information (PPI) with a PPI committee (as suggested by Activity 332 of the CRS Coordinator's Manual).

## Education and Awareness Programs

### F-23 Educate Property Owners about Flood Mitigation Techniques

*FEMA Resources/Publications*  
*FEMA Building Code Tool Kit (FEMA CD)*

Educate property owners regarding options for mitigating their properties from flooding through outreach activities such as:

- Using outreach activities to facilitate technical assistance programs that address measures that citizens can take or facilitate funding for mitigation measures.
- Encouraging homeowners to install backflow valves to prevent reverse-flow flood damages.
- Encouraging residents in flood-prone areas to elevate homes.
- Educating the public about securing debris, propane tanks, yard items, or stored objects that may otherwise be swept away, damaged, or pose a hazard if picked up and washed away by floodwaters.
- Asking residents to help keep storm drains clear of debris during storms (not to rely solely on Public Works).

*Other flooding-related mitigation actions may also apply to other hazards. See the sections entitled "Storm Surge," "Erosion," and "Multiple Hazards" for other possible ideas.*



# FEMA Contacts

## Federal Emergency Management Agency (FEMA)

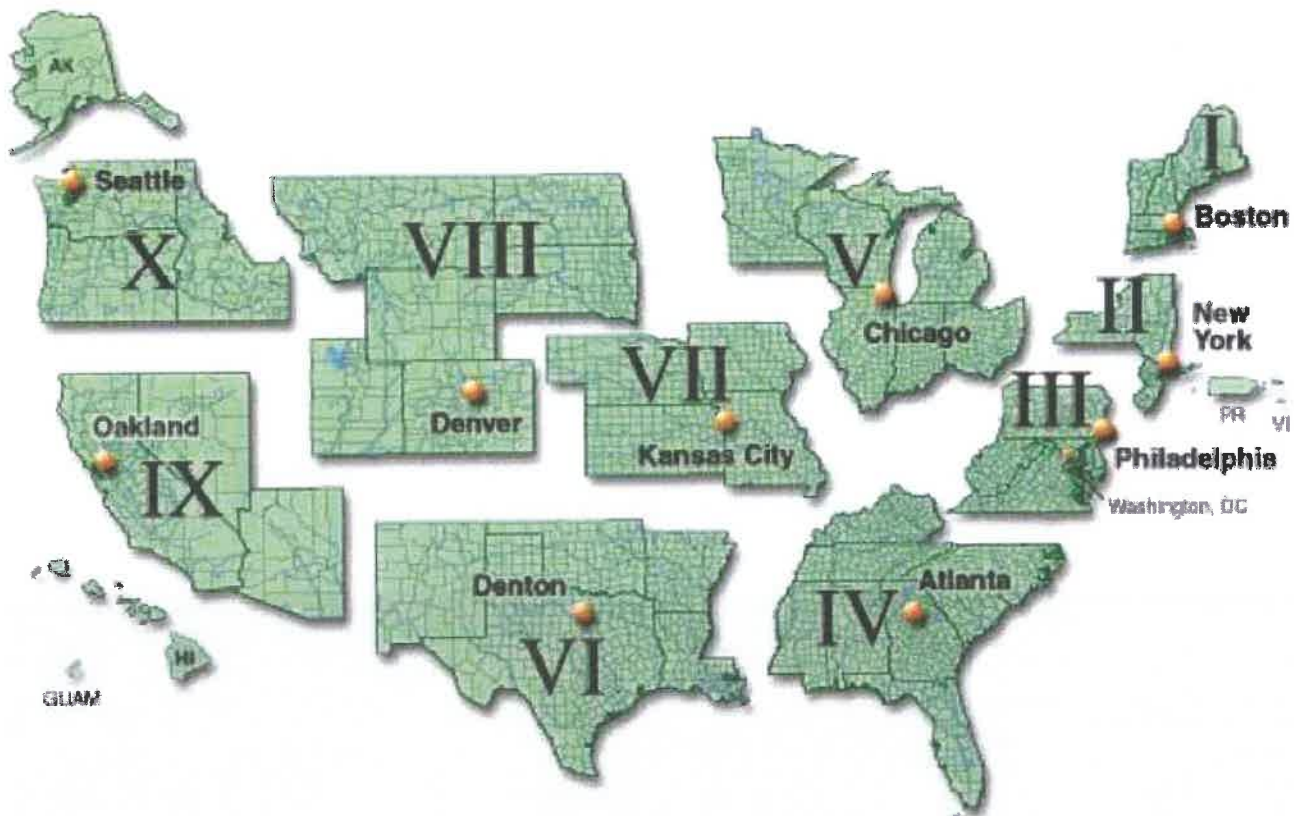
U.S. Department of Homeland Security

500 C Street SW

Washington, DC 20472

General Operator: (202) 646-2500

Website: <http://www.fema.gov/>



### FEMA Region I

99 High Street  
6th Floor  
Boston, MA 02110  
Phone: (617) 223-9540

### FEMA Region IV

3003 Chamblee-Tucker Road  
Atlanta, GA 30341  
Phone: (770) 220-5200

### FEMA Region VII

2323 Grand Boulevard  
Suite 900  
Kansas City, MO 64108  
Phone: (816) 283-7061

### FEMA Region IX

1111 Broadway  
Suite 1200  
Oakland, CA 94607  
Phone: (510) 627-7100

### FEMA Region II

26 Federal Plaza  
Suite 1337  
New York, NY 10278  
Phone: (212) 225-7209

### FEMA Region V

536 South Clark Street  
Chicago, IL 60605  
Phone: (312) 408-5500

### FEMA Region VIII

Building 710  
Box 25267  
Denver, CO 80225  
Phone: (303) 235-4800

### FEMA Region X

130 228th Street SW  
Bothell, WA 98021  
Phone: (425) 487-4600

### FEMA Region III

615 Chestnut Street  
Philadelphia, PA 19106  
Phone: (215) 931-5608

### FEMA Region VI

Federal Regional Center  
800 North Loop 288  
Denton, TX 76209  
Phone: (940) 898-5399