

Nonstructural (Flood Proofing) Flood Risk Adaptive Measures

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US Army Corps of Engineers
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Agenda

- Flood Risk Adaptive Measures (i.e., Nonstructural Measures)
- Nonstructural Considerations and Data
- Resources



USACE Nonstructural Flood Proofing Committee

Committee Members and Advisors

The USACE National Nonstructural Flood Proofing Committee (NFPC) was established during 1985. The NFPC functions under the general direction of the Chief, Planning Community of Practice, Directorate of Civil Works, HQUSACE. Currently the NFPC consists of five active multidisciplinary members and four advisors.

Members

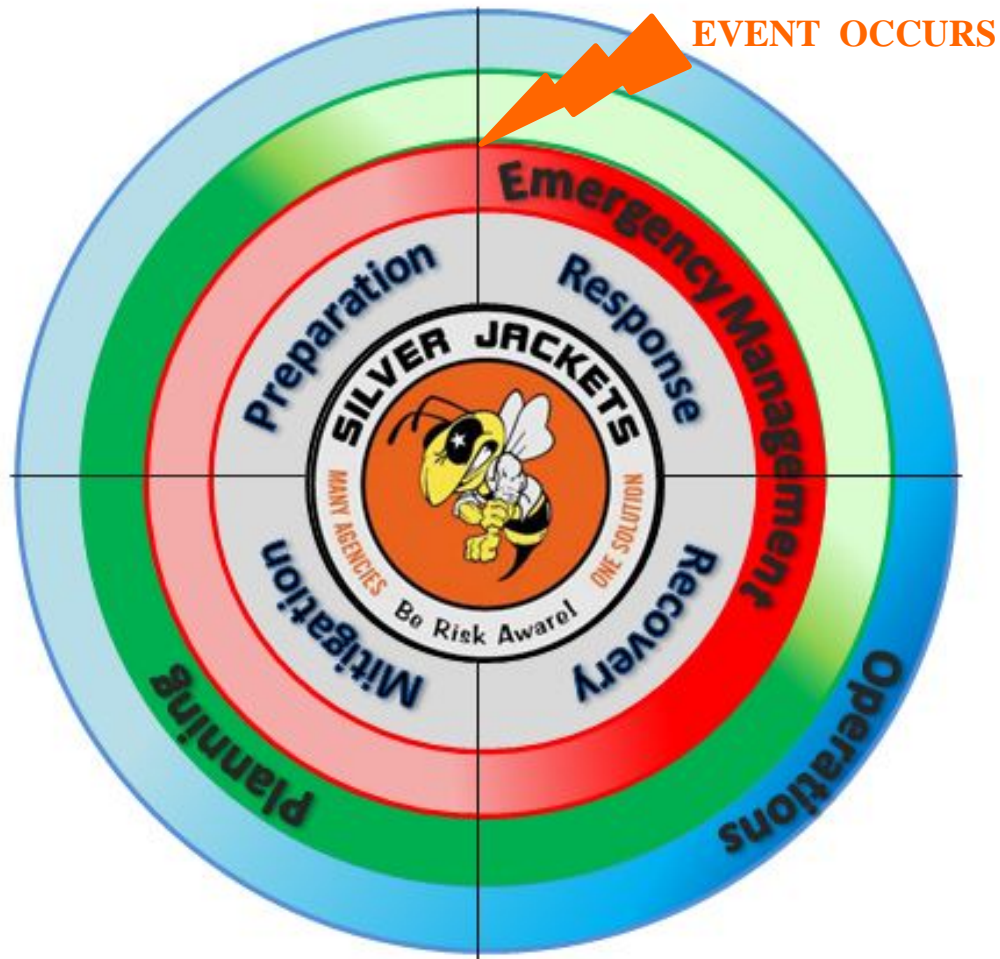
- **Chair: Randall Behm, Omaha District**
- **Secretary: Kim Gavigan, Los Angeles District**
- **Steve O’Leary, Huntington District**
- **Keven Lovetro, New Orleans District**

Advisors

- **Mary Weidel, Detroit District**
- **Lea Adams, Hydrologic Engineering Center**
- **Brian Rast, Kansas City District**



Disaster Merry-Go-Round



The Cycle will always exist, but to what extent.

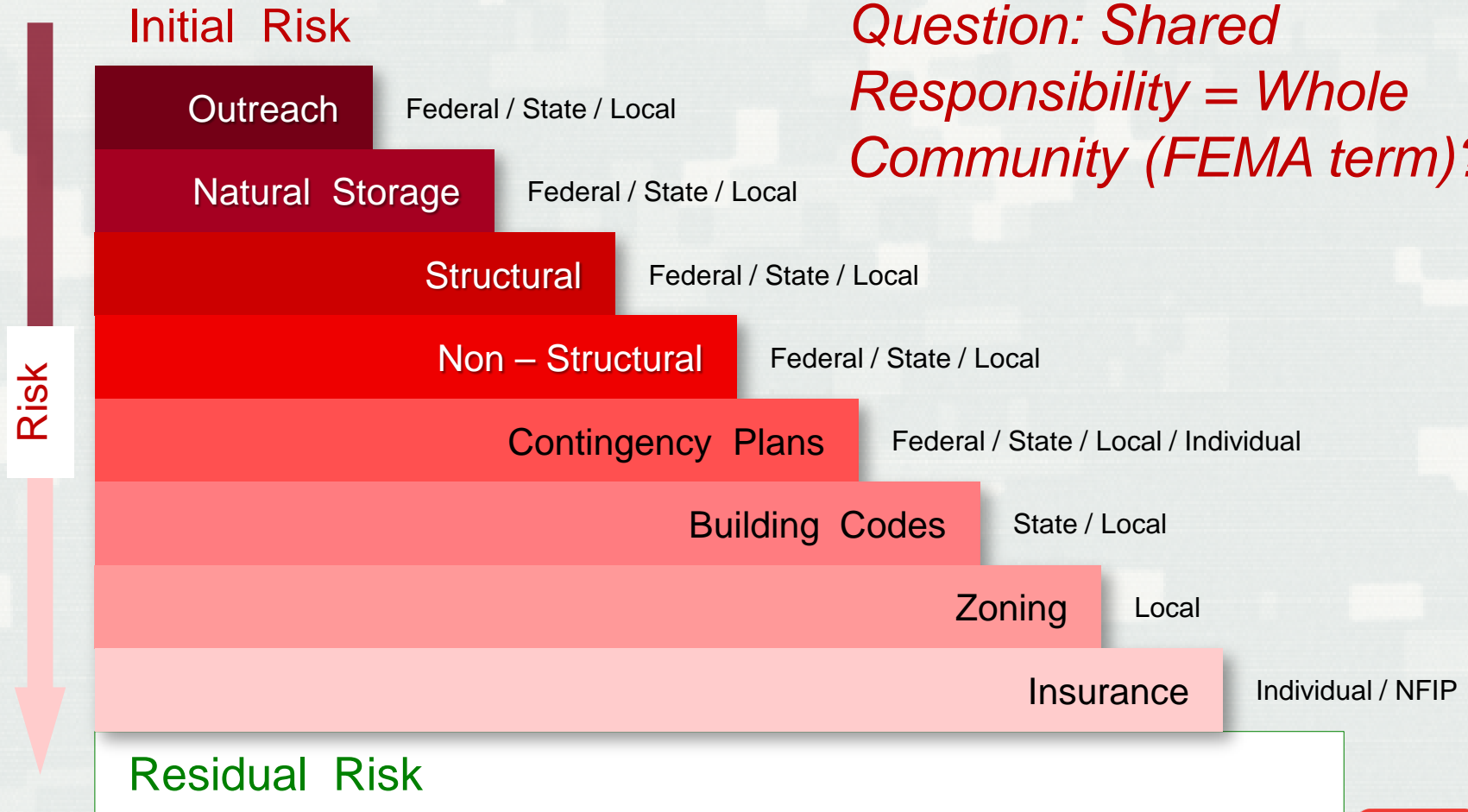


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Shared Risk Management

“ Driving Down the Risks with an Informed and Engaged Public “

Question: Shared Responsibility = Whole Community (FEMA term)?



All Stakeholders Contribute to Reducing Risk !



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Floodplain Management

The Most Cost Effective Flood Risk Reduction Measure.....

**.....Don't Build in an Area
That Floods**



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Nonstructural Flood Risk Management Definition

Nonstructural flood risk management can be categorized as a set of **physical** or **nonphysical** measures utilized for mitigating loss of life as well as existing and future flood damages.

The physical measures adapt to the natural characteristics of the floodplain without adversely affecting or changing those natural flood characteristics. These measures are generally compliant with the NFIP and cause no adverse affects to the floodplain, flood stages, velocities, or the environment.

Because of their ability to adapt to flood risk, these measures may also be referred to as **Flood Risk Adaptive Measures** and can be incorporated into existing or new structures to mitigate for potential future flood damages and life loss.



Flood Risk Adaptive Measures

- Risk = Probability X **Consequences**
- Physical or Nonphysical measures
- Adapt to the natural characteristics of the floodplain.
- Do not adversely affect or change natural flood characteristics.
- Cause no adverse affects to the floodplain, flood stages, velocities, or the environment.
- (i.e., Nonstructural measures)



Common Nonstructural Measures



Acquisition (buyout / demolition)



Relocation

- Individual Structures
- Multiple Structures / Community



Elevation



Dry Flood Proofing



Wet Flood Proofing



Berms and Walls (*are these nonstructural?*)



Flood Warning & Emergency Evacuation Plans / Systems



Other

- *National Flood Insurance Program (NFIP)*
- *Floodplain Management*
- *Land Use Regulation (Zoning) / Building Codes*



Emergency Evacuation Plans & Flood Warnings

- Prepare emergency plans
- Determine affected areas
- Identify affected parties
- Prepare warning message
- Distribute warning message
 - ▶ Weather radios
 - ▶ Media
 - ▶ Sirens
 - ▶ Public education
 - ▶ Schools
 - ▶ Reverse 911



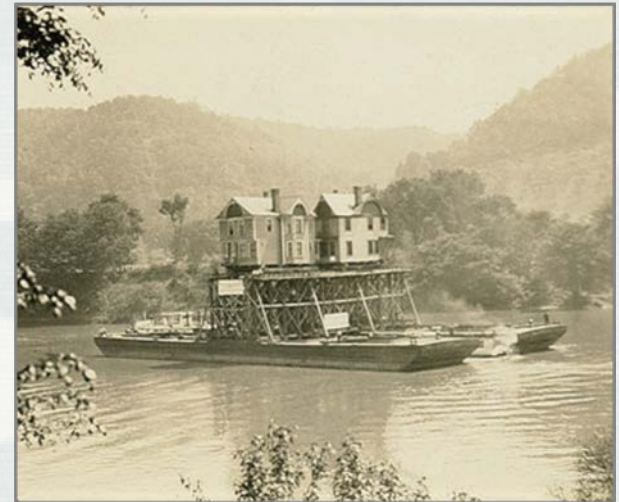


Nonstructural – Examples Acquisition





Nonstructural – Examples Relocation (Single Structure)





Nonstructural – Examples

Elevation on Extended Foundation Walls



...is one of the most common and effective methods used to prevent flooding of living space...

.....recommend design and construction by reputable/qualified professionals and contractors...

.....**Not** permitted in V Zones...**Not** recommended in Coastal A Zones...**Not** permitted in regulatory floodway...

.....**Acceptable** in A Zones.





Nonstructural – Examples Elevation Utilizing Piers / Posts / Columns





Nonstructural – Examples

Concrete Slab Utilizing Segmented Piles



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Nonstructural – Examples

Berms / Walls / Barriers



Not FEMA Accredited

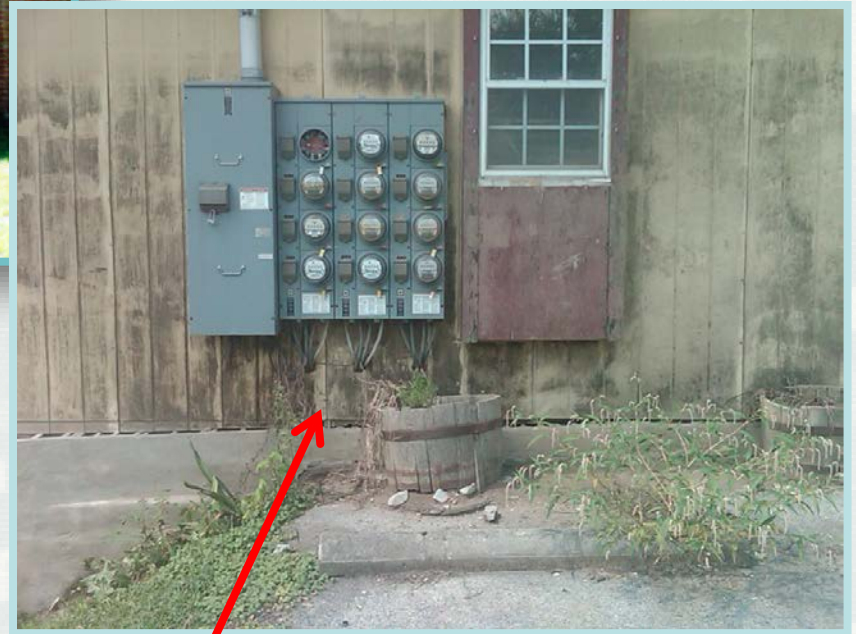


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Elevate Utilities



Successful



Unsuccessful

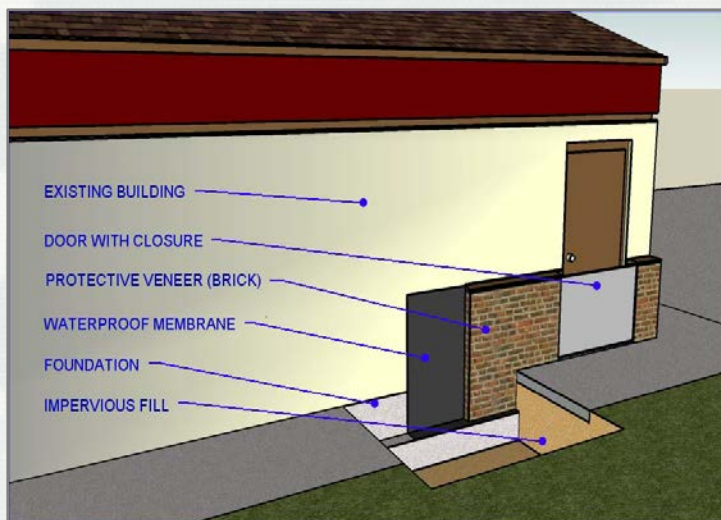




Nonstructural – Examples

Dry Flood Proofing

- Flood depths 3 feet or less
- Structurally sound buildings
- New construction
- Retrofitting existing buildings
- No basement or crawl space





Nonstructural – Examples

Wet Flood Proofing



City of Sacramento Fire Station 43 (Natomas, CA)



Church (Grundy, VA)



Town Hall (Prestonsburg, KY)

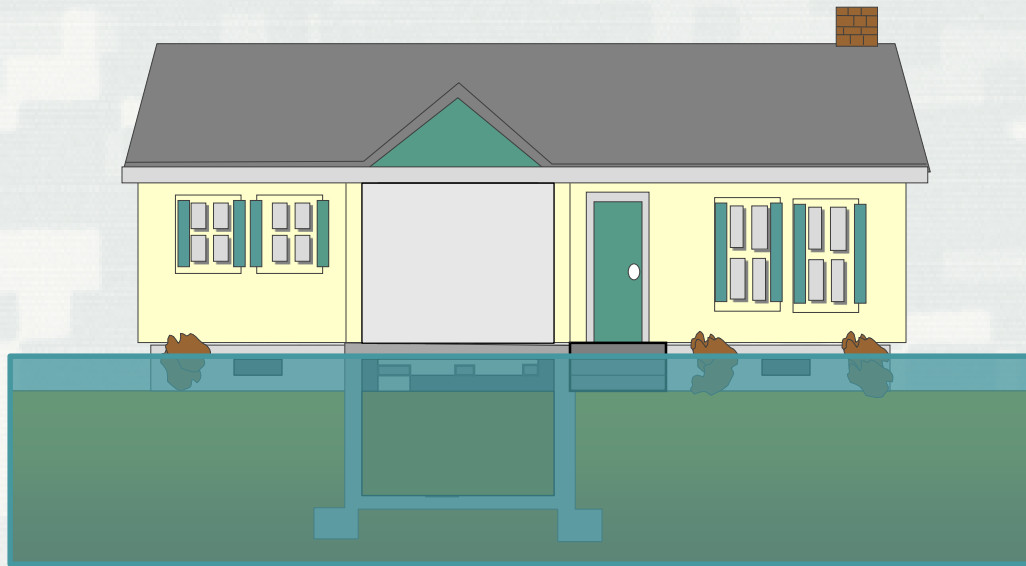


Nonstructural – Examples Elevated Floor



Nonstructural – Examples

Elevated Equipment / Utilities / Appliances



Low Impact Development

- Rain Garden
- Planter Box
- Green Space
- Porous Pavement
- Other.....



*** Caution Caution Caution ***

While nonstructural flood risk reduction measures may result in lower property damages, there could be potential restrictions which the property owner needs to investigate prior to implementation:

- **Local Ordinances**
- **State Regulations**
- **National Flood Insurance Program (NFIP)**

Work with your local Floodplain Administrator

Flood insurance is highly recommended, even for structures which may have been retrofitted with nonstructural measures, because not all floods are the same frequency.



Nonstructural Considerations and Data Collection



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Flood Risk Adaptive Measures Considerations

Elevation

- Generally no higher than 12-feet (relocate/acquire if depth greater than 12-feet)
- Elevation on extended foundation requires flood vents to equalize flood waters
- Elevate exterior utilities (central air, electric meter, etc.)

Dry Flood Proofing

- Generally no higher than 3- or 4-feet for residential and commercial construction
- Greater than 4-feet requires assessment of wall integrity

Basement Modifications

- Considered lowest habitable floor elevation for flood insurance purposes
- Elevate utilities (furnace, water heater, softener) internally or externally via addition

Berms and Ring Levees

- USACE design/implementation requires levee design specifications
- Requires Operation and Maintenance manual when implemented by USACE



Assessing The Situation

Flood Characteristics

Flood depth, Flood velocity, Flood duration, Rate of rise, Debris/Ice flows, Wave action, Floodway, Other(?)

Site Characteristics

Location, Soil type, Topography, Site size, Urban/Rural, Other(?)

Building/Structure Characteristics

Type of construction, Foundation, Condition of the building, Lower levels (Basement), Historical Significance, Other(?)

Other Considerations

Building Occupancy, Building Codes, Zoning Ordinances and Local Restrictions, Other Agencies (Local / State / Federal), Aesthetics, Public Health/Safety/Welfare, Other(?)





Flood Damage Reduction

US Army Corps of Engineers

National Nonstructural / Flood Proofing Committee

FLOOD DAMAGE REDUCTION MATRIX		FLOOD DAMAGE REDUCTION MEASURES												
		NONSTRUCTURAL MITIGATION MEASURES												
		Elevation on Foundation Walls	Elevation on Piers	Elevation on Posts or Columns	Elevation on Piles	Elevation on Fill	Relocation	Buyout/Acquisition	Dry Flood Proofing	Wet Flood Proofing	Flood Warning Procedures	Flood Plain Regulation	Flood Insurance	Flood Mitigation 1
Flood Characteristics	Flood Depth													
	Shallow (<3 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 ft)	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
	Deep (greater than 6 ft)	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
	Flood Velocity													
	Slow (less than 3 fps)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 5 fps)	N	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y
	Fast (greater than 5 fps)	N	N	N	Y	N	Y	N	N	Y	Y	Y	Y	Y
	Flash Flooding													
	Yes (less than 1 hour)	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y
No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Ice and Debris Flow														
Yes	N	N	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	
No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Site Characteristics	Site Location													
	Coastal Flood Plain													
	Beach Front	N	N	N	Y	N	Y	N	N	Y	Y	Y	Y	
	Interior (Low Velocity)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Riverside Flood Plain	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Soil Type													
	Permeable	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	
	Impermeable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Structure Foundation													
	Slab on Grade	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Crawl Space	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y		
Basement	Y	N	N	N	N	Y	N	Y	Y	Y	Y	Y		
Structure Construction														
Concrete or Masonry	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
Metal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
Wood	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
Structure Condition														
Excellent to Good	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
Fair to Poor	N	N	N	N	N	N	Y	N	N	Y	Y	Y		
MED/NEE/Recreation/Social Characteristics	Economic													
	Structure Protected	Y	Y	Y	Y	Y	Y	Y	Y	N	4	N	Y	
	Cost to Implement	M	M	M	M	M	H	H	L	L	L	L	H/M	
	Potential Flood Insurance Cost Reduction (Residential)	Y	Y	Y	Y	Y	Y	N	N	N	Y	-	Y	
	Potential Flood Insurance Cost Reduction (Commercial)	Y	Y	Y	Y	Y	Y	Y	N	Y	-	-	Y	
	Potential Adverse Flooding Impact on Other Property	N	N	N	N	Y	N	N	N	N	Y	N	N	
	Reduction in Admin Costs of NFIP	N	N	N	N	Y	Y	N	N	N	5	-	2	
	Reduction in Costs of Disaster Relief	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Reduction in Emergency Costs	N	N	N	N	N	Y	N	N	N	N	N	2	
	Reduction in Damage to Public Infrastructure	N	N	N	N	N	Y	Y	N	N	N	N	2	
	Potential for Catastrophic Damages if Design Elevation Exceeded	N	N	N	N	N	N	Y	N	N	N	N	N	
	Promotes Flood Plain Development	N	N	N	N	N	N	N	N	N	N	6	N	
	Environmental													
	Ecosystem Restoration Possible	N	N	N	N	N	Y	Y	N	N	N	N	N	
	Potential Adverse Environmental Impact	N	N	N	N	N	N	N	N	N	N	N	N	
	Recreation													
	Recreation Potential	N	N	N	N	N	Y	Y	N	N	N	N	2	
	Social													
	Community Remains Intact	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	3	
	Population Protected	N	N	N	N	N	Y	Y	N	N	Y	N	2	
Potential Structure Marketability Increase	Y	Y	Y	Y	Y	N	Y	Y	N	4	N	Y		

1. NFIP Flood Mitigation may vary by structure
 2. Buyout/acquisition only
 3. Elevation only
 4. Post FIRM construction only
 5. Post FIRM structures elevation on fill
 6. Yes, if in floodplains less frequent than the 100-year
 Y-Yes L-Low
 N-No M-Med
 H-High

The US Army Corps of Engineers National Nonstructural/Flood Proofing Committee (NFFPC) is available to assist in any aspect of formulating and implementing nonstructural flood damage reduction measures and realizing the opportunities that exist with nonstructural.

For more information, please contact the NFPC Chairman and committee members at: dl-cenwo-nfpc@usace.army.mil or visit the NFPC website at: <http://www.usace.army.mil/missions/CivilWorks/ProjectPlanning/nfpc.aspx>



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Field Data Collection

Search Existing Datasets:

County/City Assessors Database

Existing Flood Risk Management Studies

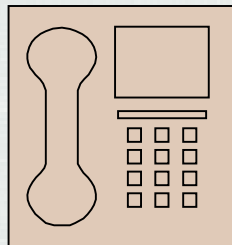
Flood Insurance Studies

Light Detection And Ranging (LiDAR)

Obtain New Data:

Surveys (first floor / lowest adjacent ground)

Homeowner / Business owner interview



Structure Inventory Data Requirements
 (Note: bold/shaded cells represent most pertinent data requirements)

Structure Data	Data Definition
Building Identification Number	Specific to Structure (geo referenced, coordinates, etc.)
Structure Address	Specific Postal Location of Structure
Critical Facility	Yes / No
Lowest Adjacent Ground Elevation	Elevation of Lowest Ground at Structure
First Floor Elevation	Elevation of Finished First Floor
Structure Category	Residential, Commercial, Industrial, Public
Structure Use	What is the Specific Use of Structure
Total Stories	Total Number of Floors Above Grade
Structure Footprint	Total Square Foot Area of At-Grade Floor
Number of Structural Corners	Total Number of Corners in Perimeter
Structure Foundation Type	Slab, Reinforced Slab, CMU, Piers, Columns, Posts, Stone
Structure Perimeter Distance	Total Length of All Exterior Sides of Structure
Exterior Wall Construction	Wood, Masonry, Brick, Metal, Stone, Concrete, Other
Structure Visual Condition	Good / Fair / Poor
Garage	Attached, Detached, None
Doorways	Number of Pedestrian Doorways
Basement	Full Basement, Half, Crawl Space, None
Structure Photos	Photograph of Four Sides of Structure
Utilities Location	Electrical, Gas, Water, Sewer, Oil, Propane, Coal, Other
Structure Value	Assessed Value of Structure
Fireplace	Yes / No
Structure Owner	Who Owns the Structure
Year Structure Built	Year Structure was Constructed (Any Historic Significance)
Water Surface Elevation	Elevation or Depth of Water at Structure (H&H activity)
Water Velocity	Erosive Potential of Flood Waters (H&H activity)



Sample Structure Inventory Sheet

Structure Address		1121 W. Huron St.		
Structure ID		10		
HEC ID		415		
				
Front View		Right Side View		
				
Back View		Left Side View		
Ground Elev. (NAVD)	1003.58	Depth of Flooding (ft)		
1st Floor Elev. (NAVD)	1005.61	Flood Event	Ground	1st Floor
		100-yr	3.96	1.93
Field Notes				
Date	12/1/2009			
Time	8:53			
Field Team	Lowell Blankers, William Williams, Larry Morong			
Foundation Type	Block			
Building Frame type	Siding			
Design Style	1 Story Frame			
Basement	Yes			
Basement Fin/Unfin	No			
Garage Attached	No			
Egress Windows	Windows in basement			
Additional Comments				



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Homeowner's Guide to Retrofitting

Six Ways to Protect Your Home From Flooding

FEMA P-312, 3rd Edition / June 2014



FEMA



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FEMA TECHNICAL BULLETIN 259

APPENDIX D

Alluvial Fan Flooding

Alluvial fan flooding is a hazard to communities in the mountainous regions of the western United States. Alluvial fan flooding is characterized by a sudden torrent of water capable of carrying rocks, mud, and debris that debouches from the steep valleys and canyons and spreads over the fan surface. The type of detailed flood damage mitigation information available for other flood-prone areas is limited for alluvial fan situations. Fan flood flows are characterized by surging, erosion, scour, channel avulsion, mud and debris flows, and sheet flows on the lower portions of the fan surface. Each fan flood event as well as each fan can exhibit different flood characteristics.

Development over the last several decades has proceeded with little cognizance of the potential for flood hazards. Many fan communities are now preparing flood management and mitigation plans, but existing structures may have to rely on floodproofing measures to reduce flood damage. Fan-wide master plans for zoning and fan-wide mitigation measures are crucial for successful protection of the community as a whole. Where master plans or mitigation schemes are inadequate or nonexistent, floodproofing and retrofitting of residences may provide the only reasonable methods for flood loss reduction.

This appendix includes a description of alluvial fan flooding and associated hazards; an overview of the regulatory framework and building code issues unique to fan areas; and design considerations for retrofitting in alluvial fan flooding areas.

D.1 Alluvial Fan Flooding Basics

Most alluvial fan floods are caused by high-intensity, short-duration summer thunderstorms. Longer duration rainstorms and spring snowpack melt, volcanically-induced flooding, and failure of water storage facilities can also cause alluvial fan floods. Alluvial fan floods can occur without warning. Both the hydraulic and hydrologic flood characteristics of alluvial fans are highly variable from fan to fan, which may be in different



NOTE

For more information regarding alluvial fans, see:

FEMA's webpage: http://www.fema.gov/plan/prevent/floodplain/nfipkeywords/alluvial_fan_flooding.shtml

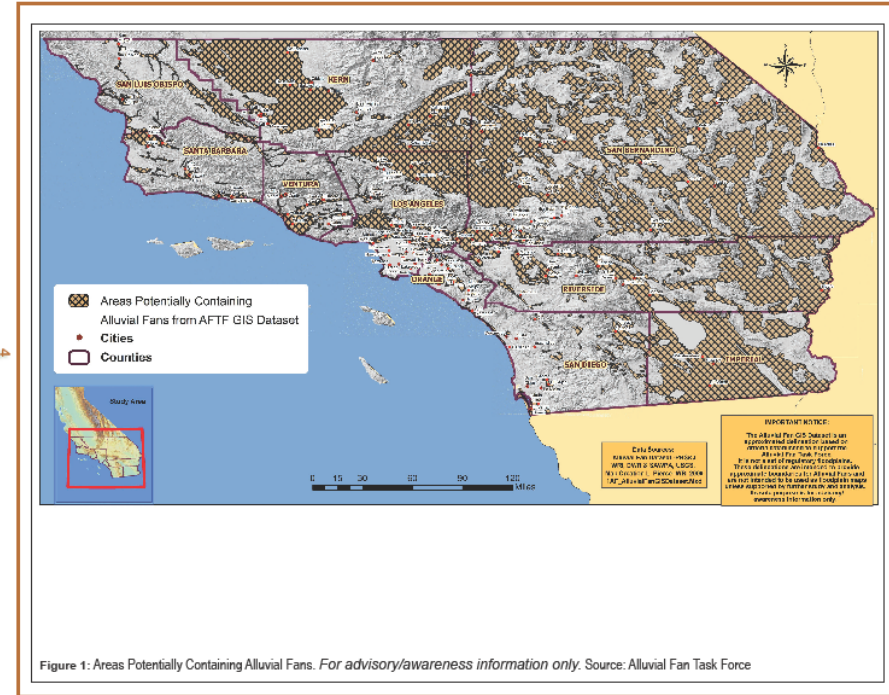
Living with the River (Washington State Department of Ecology, 2007).

FEMA 165, *Alluvial Fans: Hazards and Management* (FEMA, 1989). FEMA 165 provides an overview of alluvial fans and related management issues, and briefly discusses retrofitting of individual residential structures

Findings and Recommendations Report



JULY 2010



STATE OF ARIZONA
DEPARTMENT OF WATER RESOURCES
ENGINEERING DIVISION



Identification of and Development
within
Sheet Flow Areas

500 North 3rd Street
Phoenix, Arizona 85004

(602) 417-2445



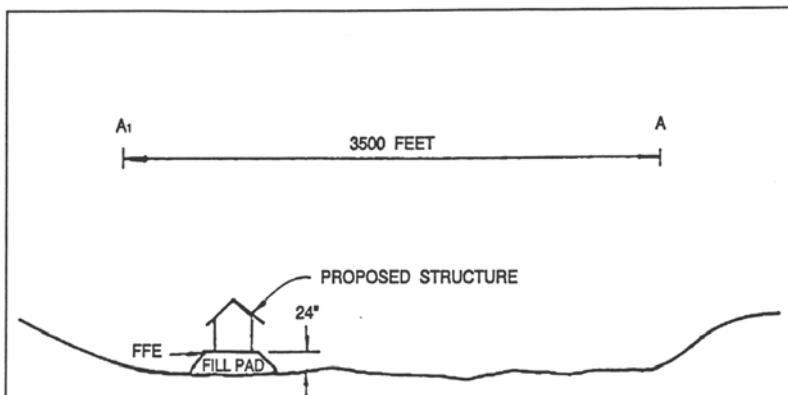


FIGURE E1-b

LEVEL I ANALYSIS OF EXAMPLE 1
(FFE = NATURAL GRADE + 2 FEET)

ILLUSTRATION NOT TO SCALE

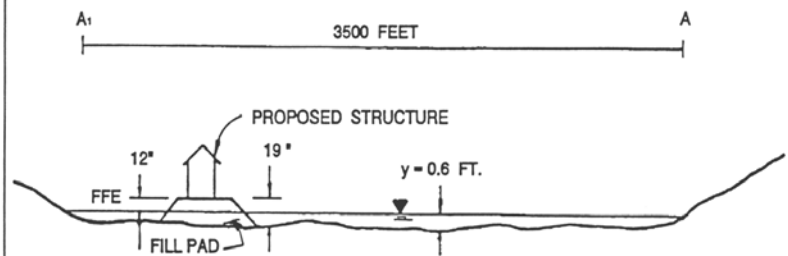


FIGURE E1-c

LEVEL II ANALYSIS OF EXAMPLE 1

ILLUSTRATION NOT TO SCALE



Figure 2

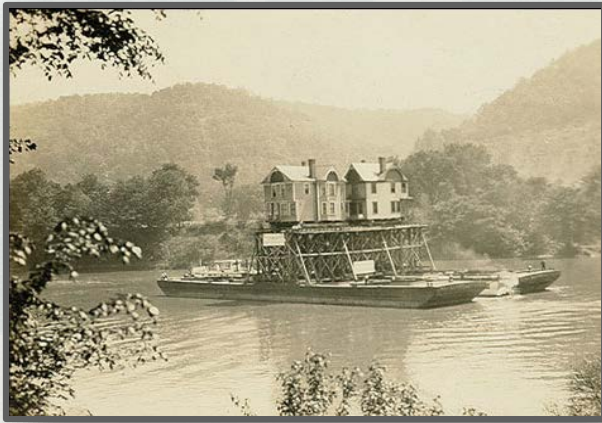
**Urban Sheet Flow Area With
Moderate Development Density**

Note Flow patterns in adjacent
natural areas

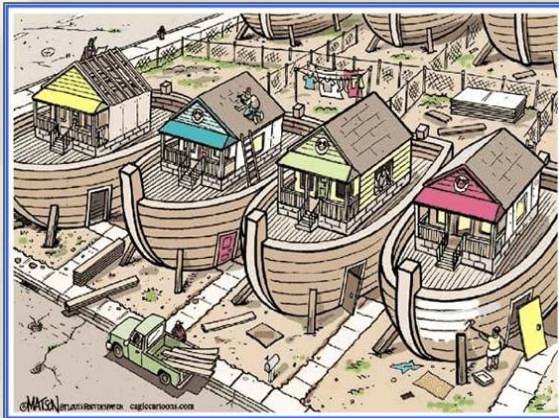
Maricopa County Recommendations

- maintain existing natural washes,
- washes 5ft wide or greater should not be disturbed,
- minimize (<40%) disturbance of lots,
- elevate structures a min. of 18" above natural grade and armor side slopes, and
- discourage (or prohibit) perimeter walls and fencing (block walls and mesh fencing should not be used).





QUESTIONS?



<http://www.usace.army.mil/Missions/Civil-Works/Project-Planning/nfpc/>



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Structural Measures



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MUD FLOW IN SANTEQUIN, UT



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WALL TO DIVERT MUD FLOW



DEBRIS BASIN AT GLENWOOD SPRINGS, CO



DEBRIS FENCE AT OREM CITY, UTAH



MUD FLOW DIVERSION AT PROVO, UT



Devore in San Bernardino County



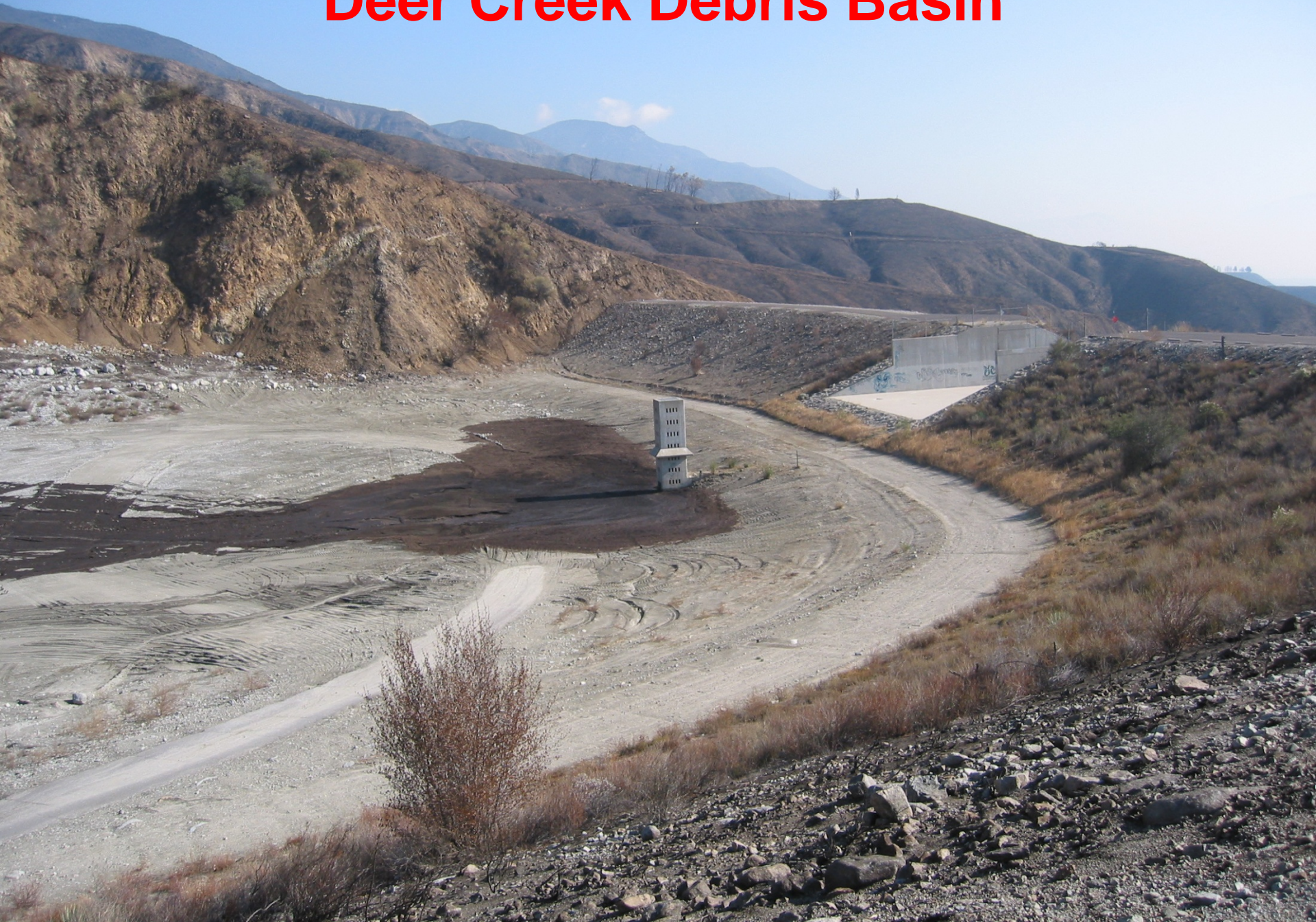






685

Deer Creek Debris Basin







665

64

63

