

# Colorado Flood Proofing and Flood Recovery Workshop

## Flood Proofing Data Requirements and Planning Matrix

**Randall L. Behm P.E., CFM**  
**USACE – Omaha District**  
**Chair – National Nonstructural Flood Proofing Committee**  
**September 2014**



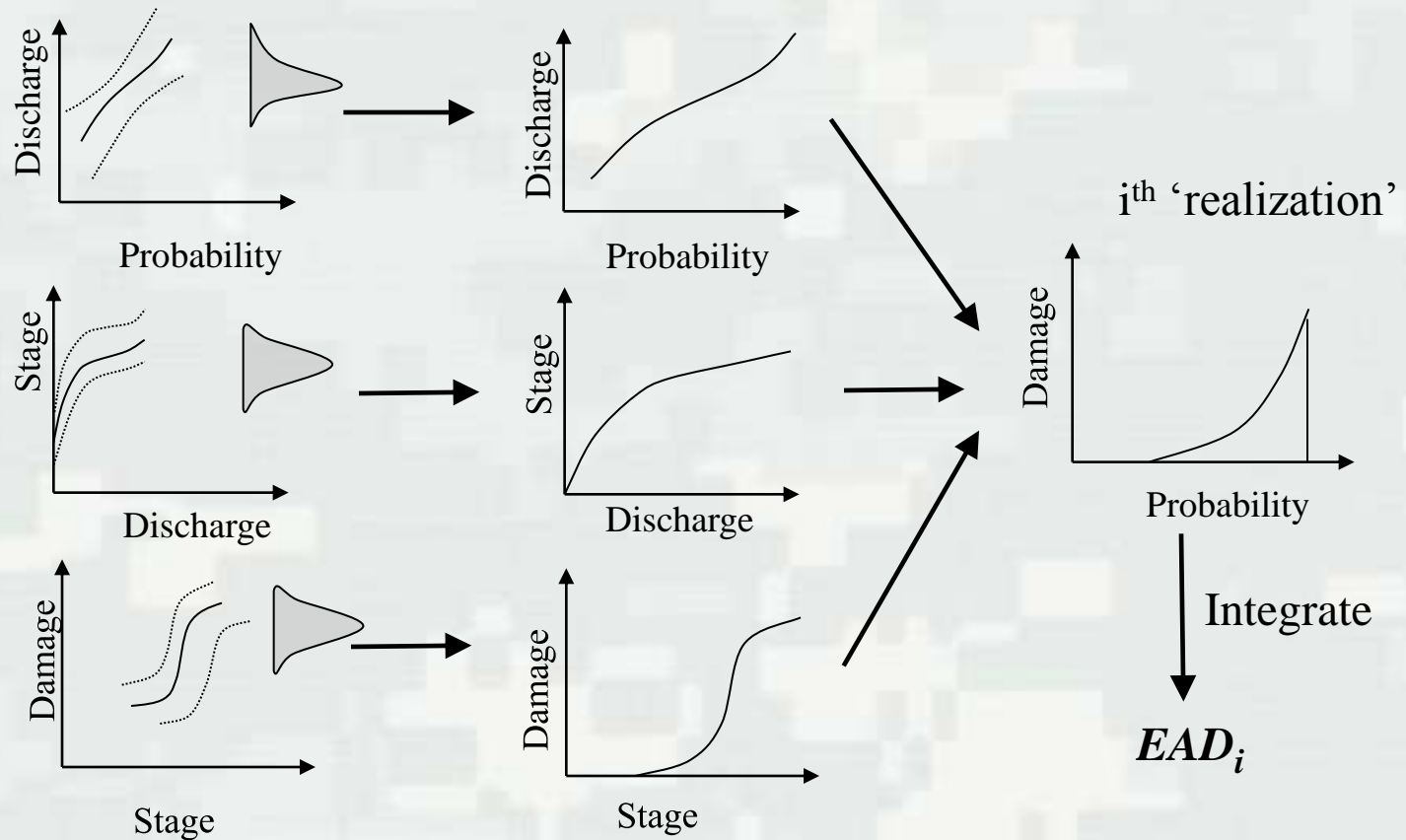
# What Analyses are Required for Engineering of Flood Risk Adaptive (Nonstructural) Measures

- **Hydrology**
- **Hydraulics**
- **Inventory of Structures**
- **Identify Potential Nonstructural Measures**
- **Cost Estimating**
- **Economic Analyses**
- **Implementation Plan**

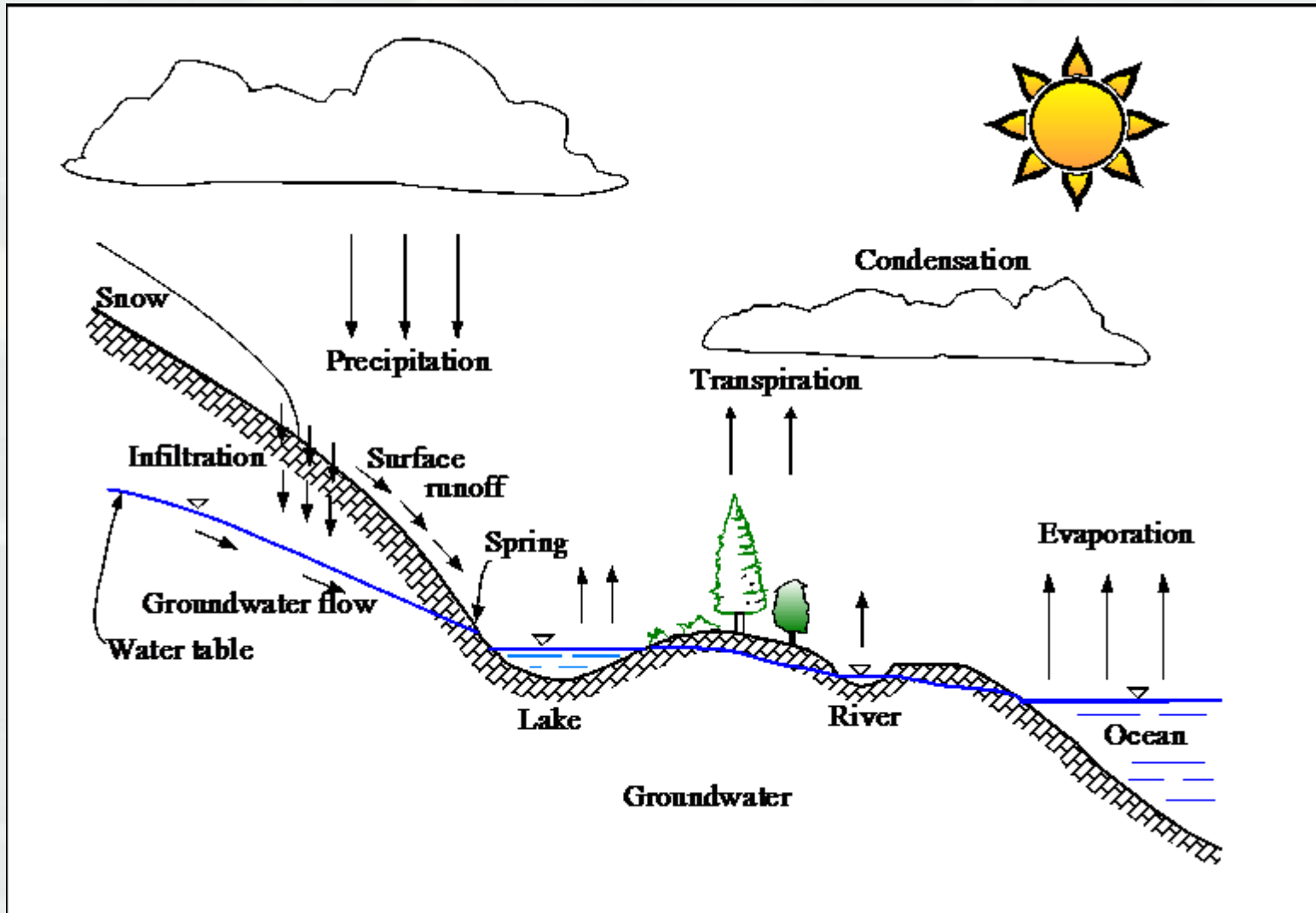
**Similar process for FRAM (nonstructural) analysis as it is for structural analysis**



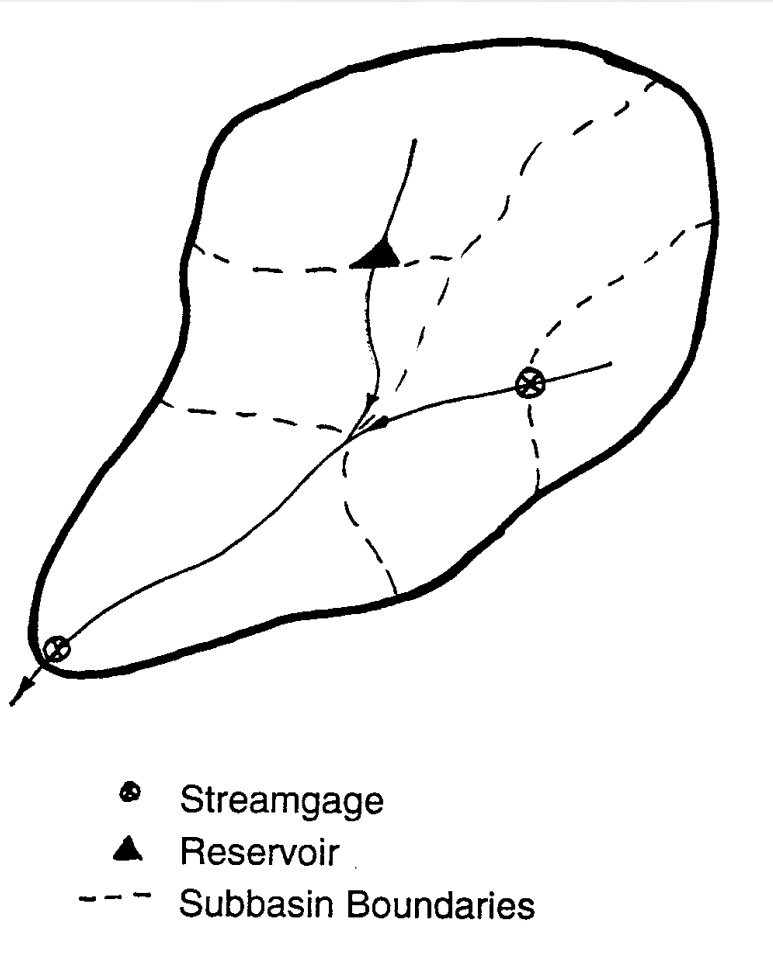
# Flow-Frequency; Stage-Discharge; Damage-Frequency Relationships



# Hydrologic Cycle

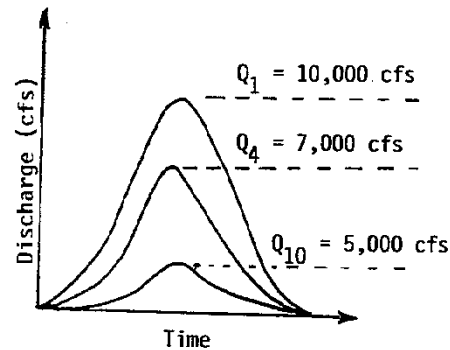


# Hydrologic Studies

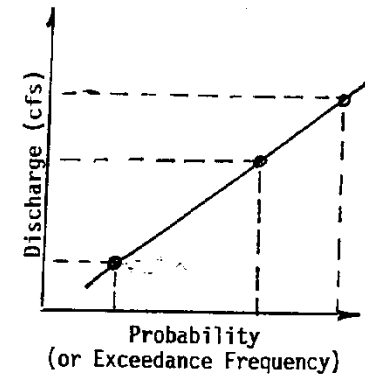


## Sub-basin Delineations

- Stream Topology
- Streamgauge Locations
- Project Locations

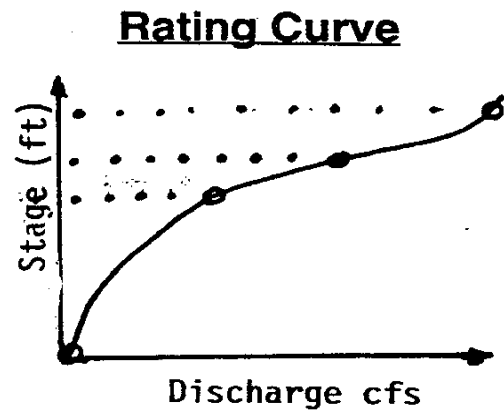
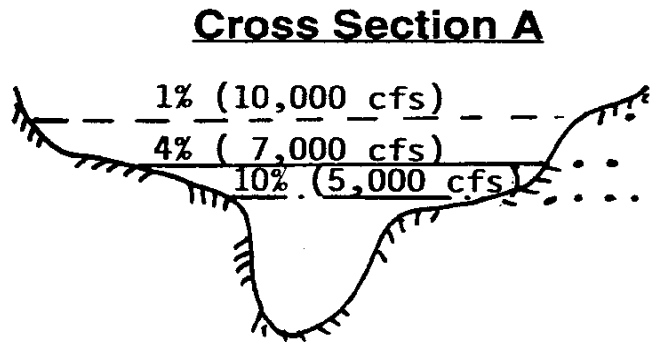
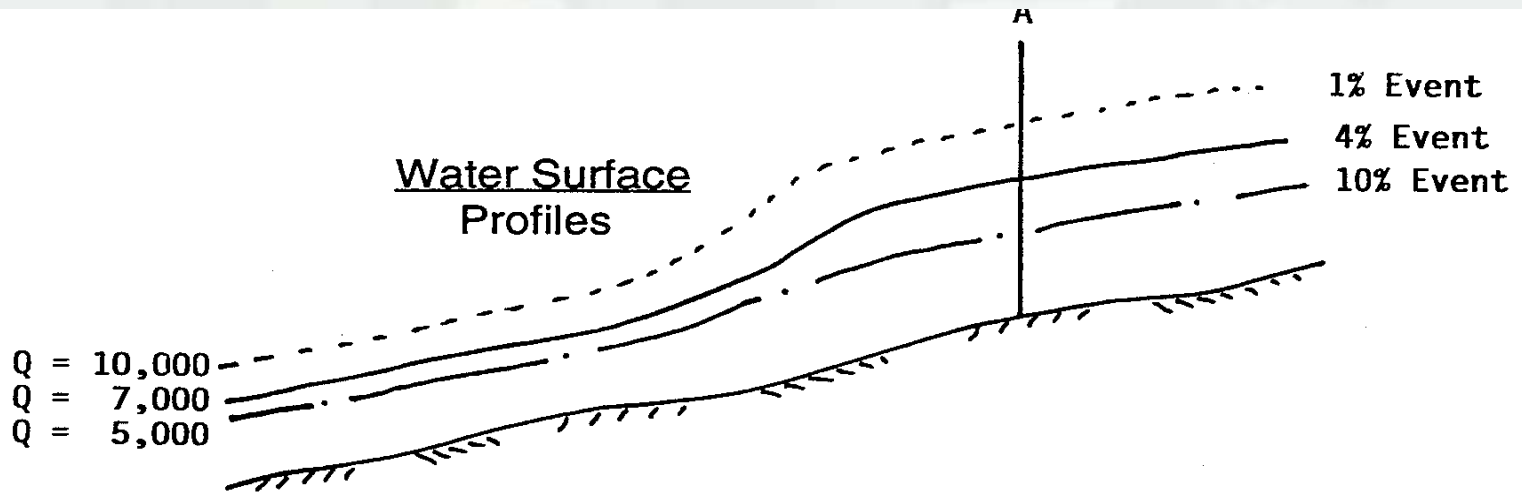


Discharge Hydrograph  
At Outlet



Frequency Curve

# Hydraulic Assessment



# Manning's "n" values of Roughness (friction factors)

$n = 0.032$



$n = 0.055$



$n = 0.075$



$n = 0.097$

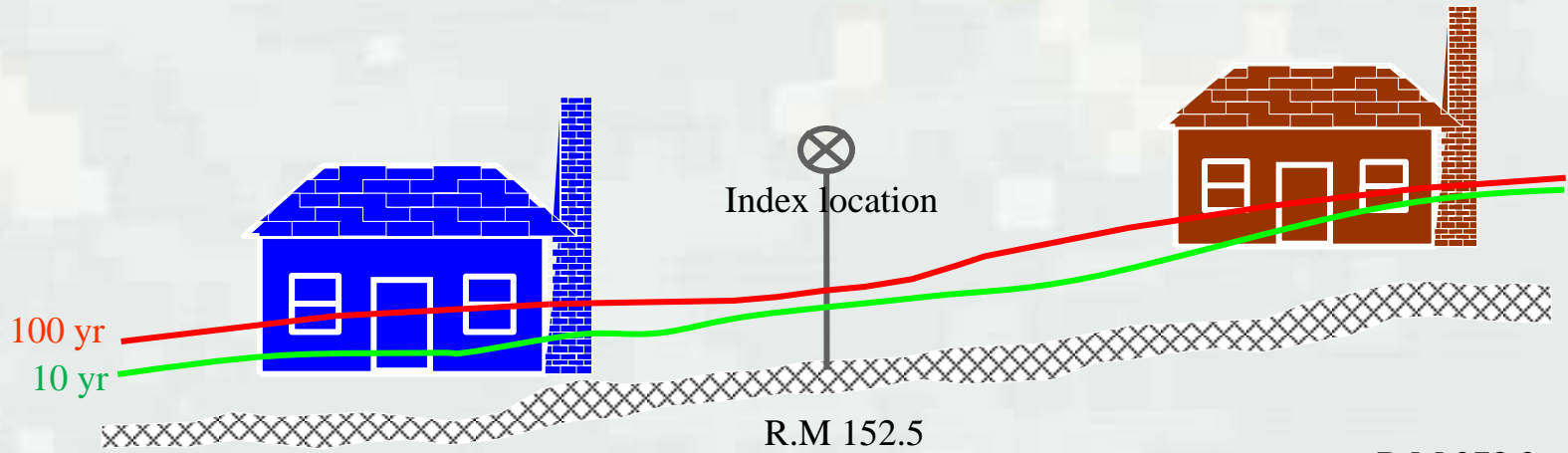
# Calibration and Sensitivity Analysis

**Calibrate to known elevations (adjust the computer model).  
Perform sensitivity analysis of key parameters.**





# Culmination of Structure Damage to Index Location



R.M. 50.0

Stage	Damage
0	0
4.5	\$15000
8	\$85000

Stage	Damage
0	0
4	\$20000
6	\$130000

R.M 278.2

Stage	Damage
0	0
5	\$5000
7	\$45000

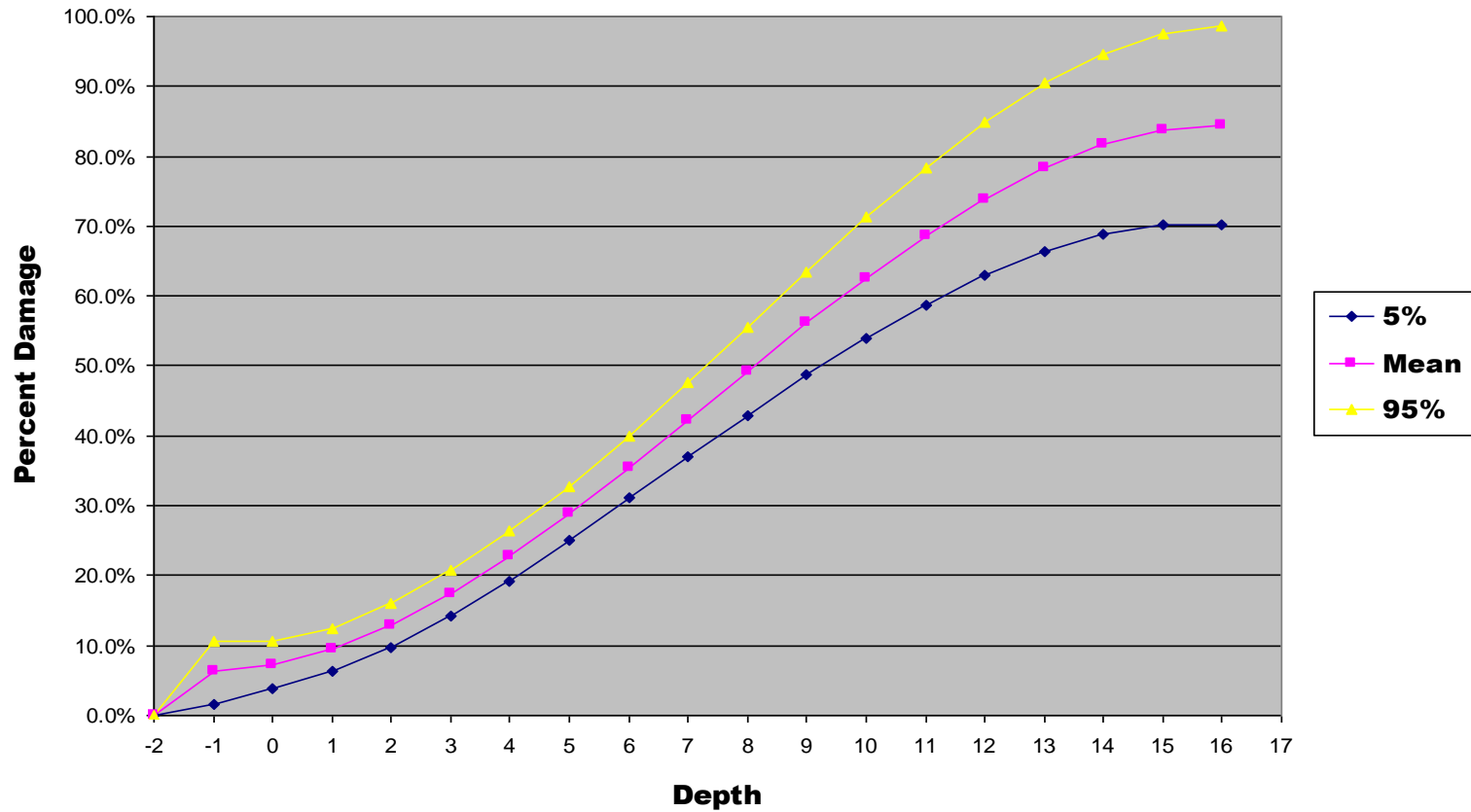
# Residential and Commercial Damage Estimates

## Land Use for some Structures Combine Information on:

- **Number of structures by building and construction types**
- **Structure values by building type and usage**
- **Content values by building type and usage**
- **Content-to-Structure ratio**
- **First floor elevation of structure**
- **Damage as a percent of value for structure and contents for various flood depths**
- **Flood depth at damage location corresponding to river stages at a reference location**
- **Flood fighting**

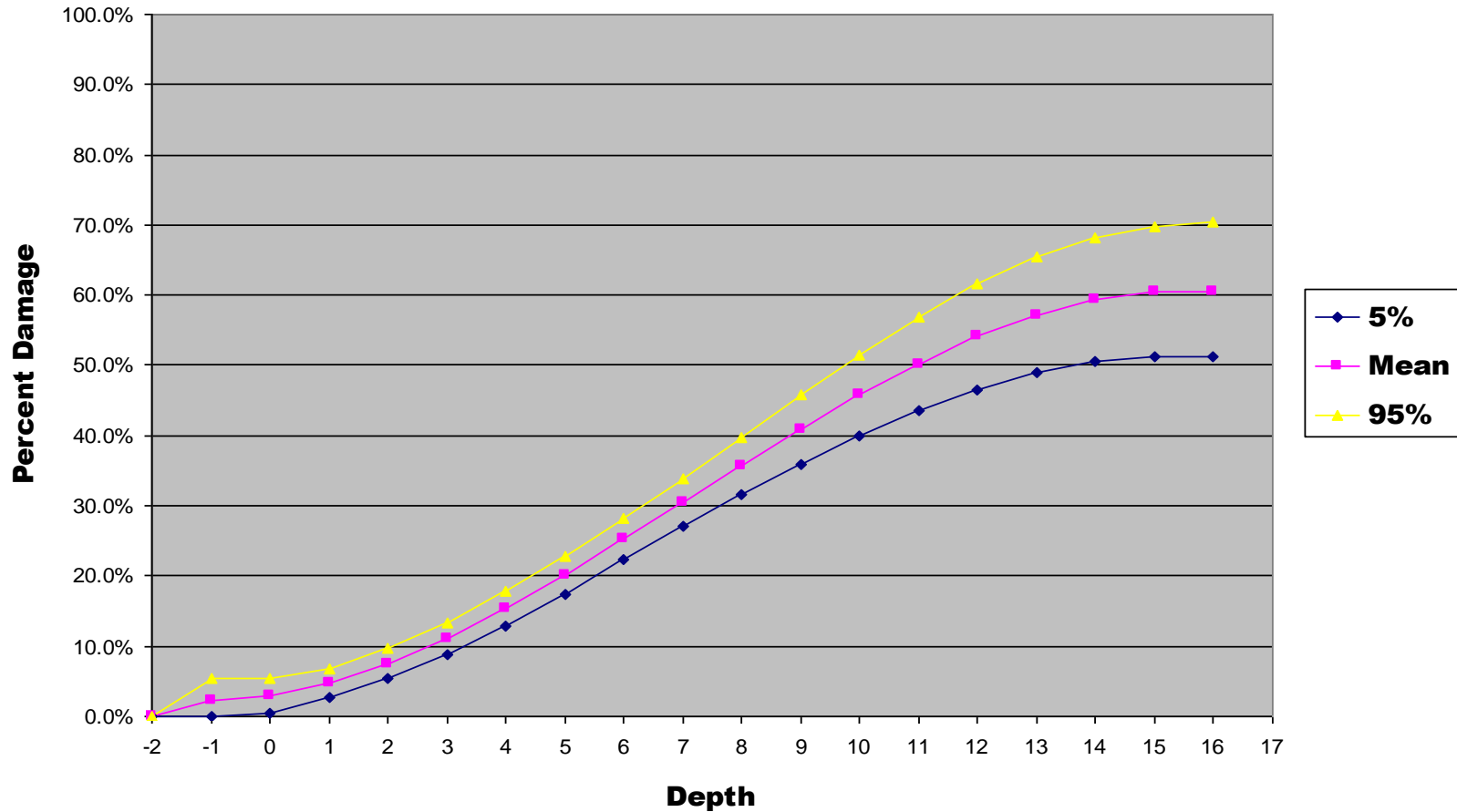
# Depth-Percent Damage with Uncertainty (structure)

Split Level Residential - No Basement (Structure Only)



# Depth-Percent Damage with Uncertainty (contents)

**Split Level Residential - No Basement (Content Only)**

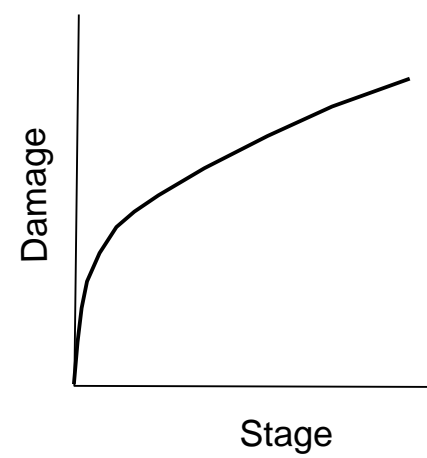
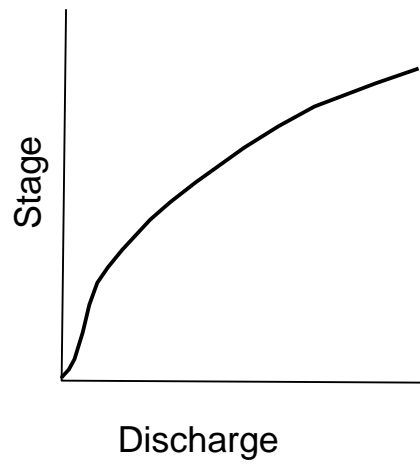
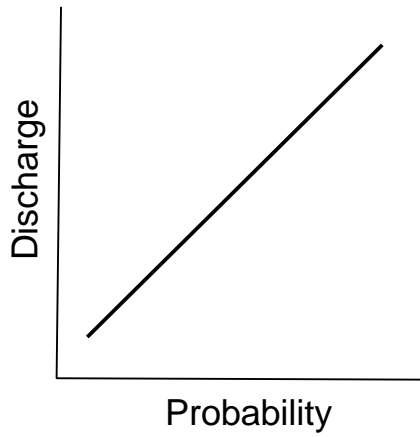
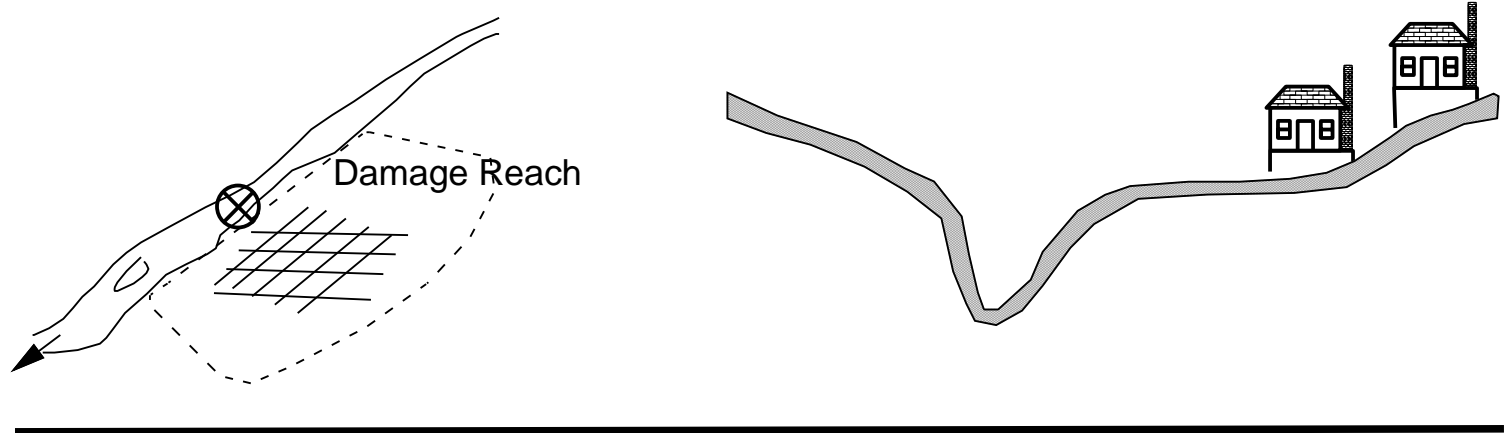


# Project Plans

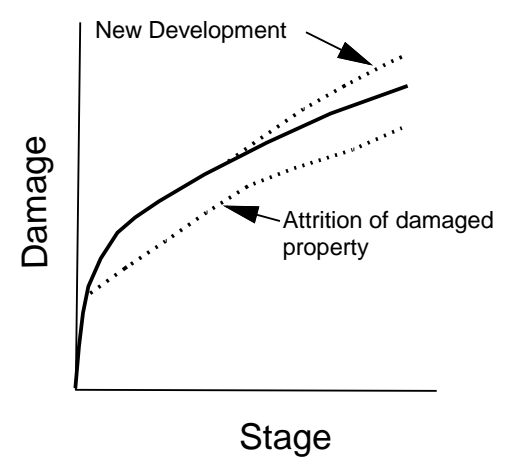
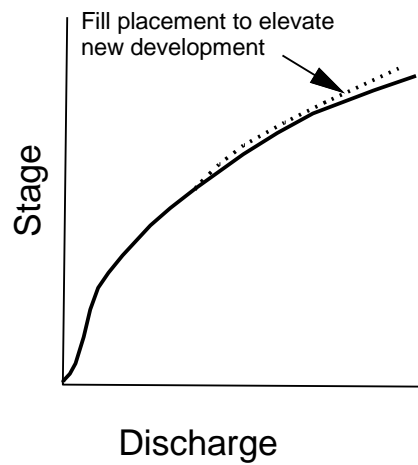
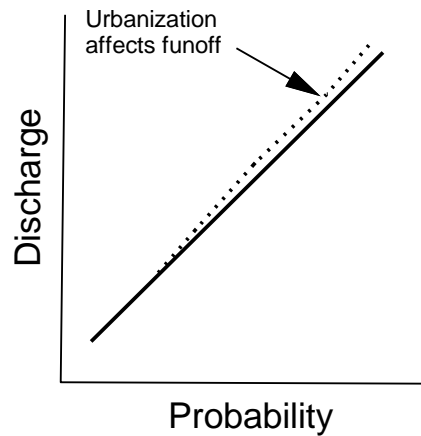
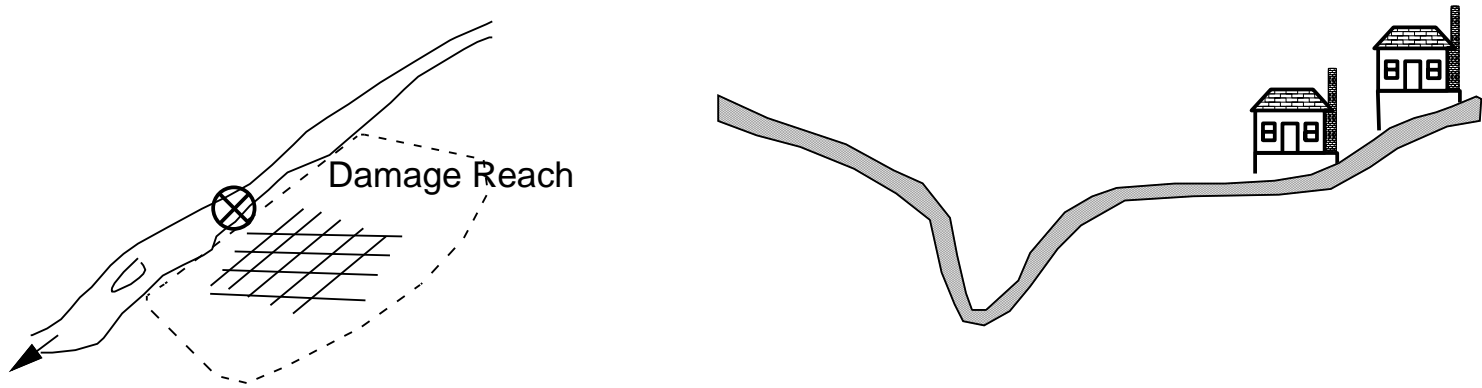
## (Without-Project Conditions)

- ▶ Represents the condition of the study area in terms of hydrology, hydraulics, and flood damage over the project life (normally 50-years) if flood damage reduction projects are not implemented.
- ▶ **Baseline condition** from which all flood damage reduction plans are measured.

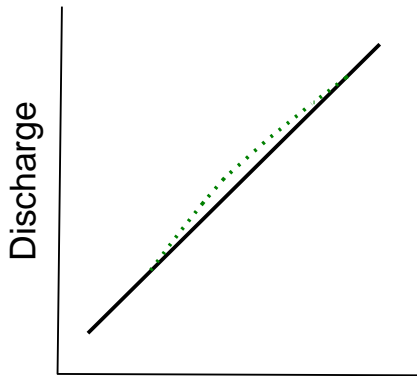
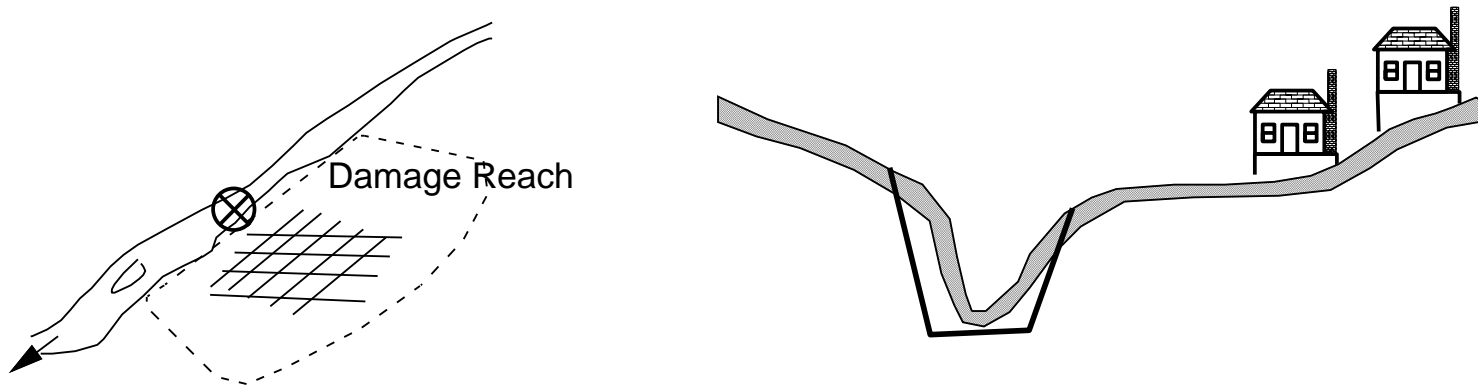
# Evaluation of Existing Conditions



# Future Without Project Conditions

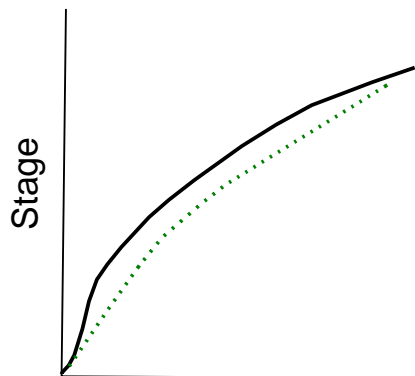


# With Channel Modification Conditions

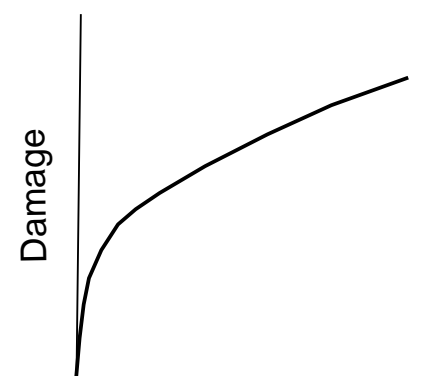


Probability

May induce higher flow rates  
downstream if storage eliminated



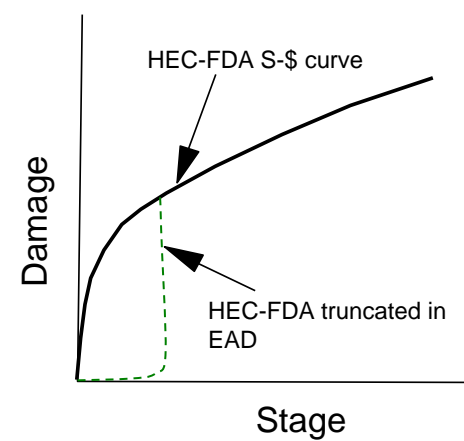
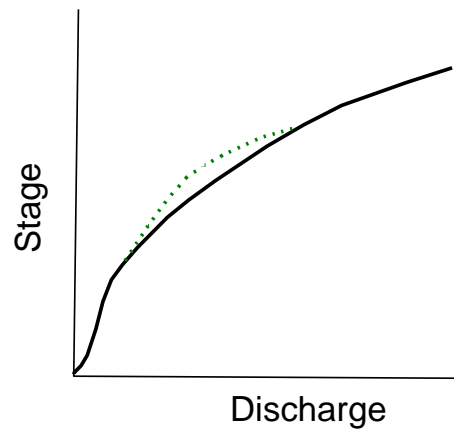
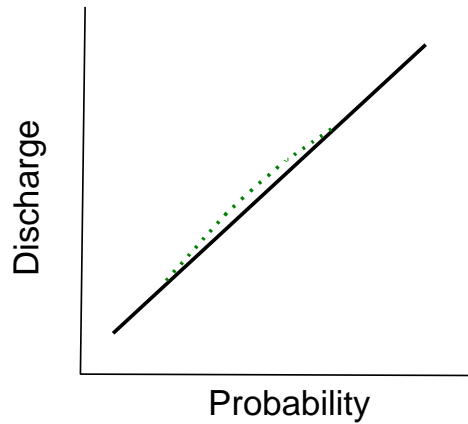
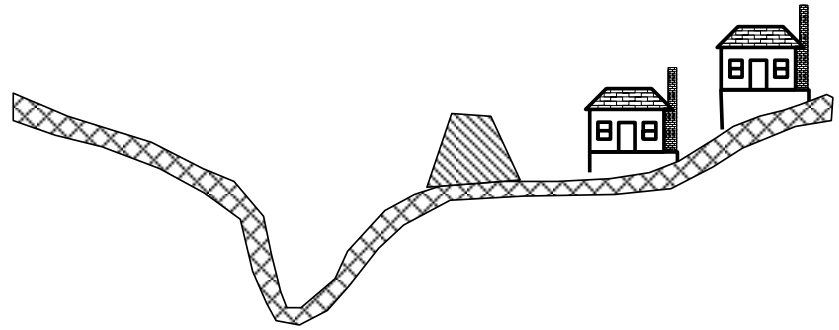
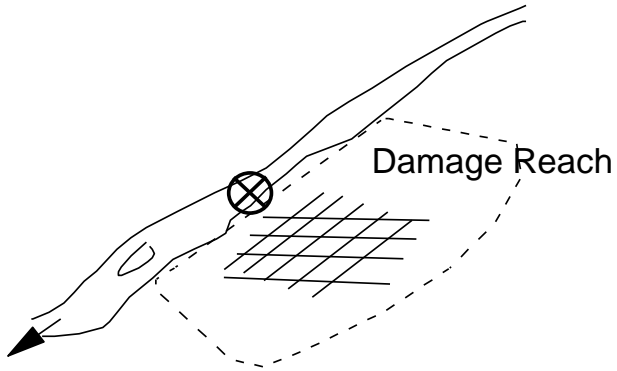
Discharge



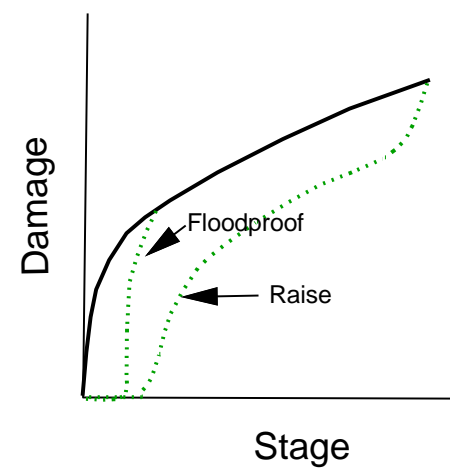
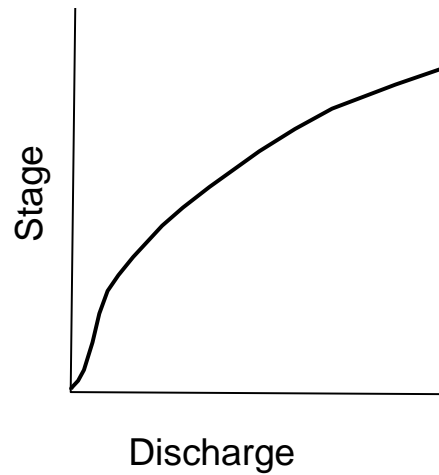
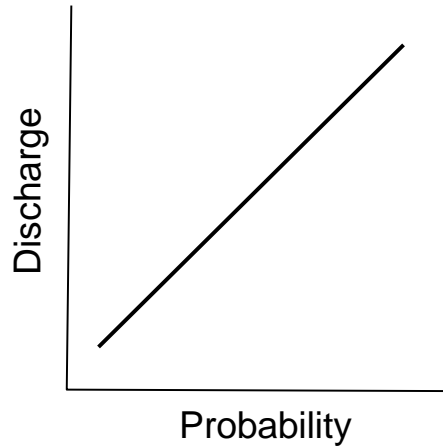
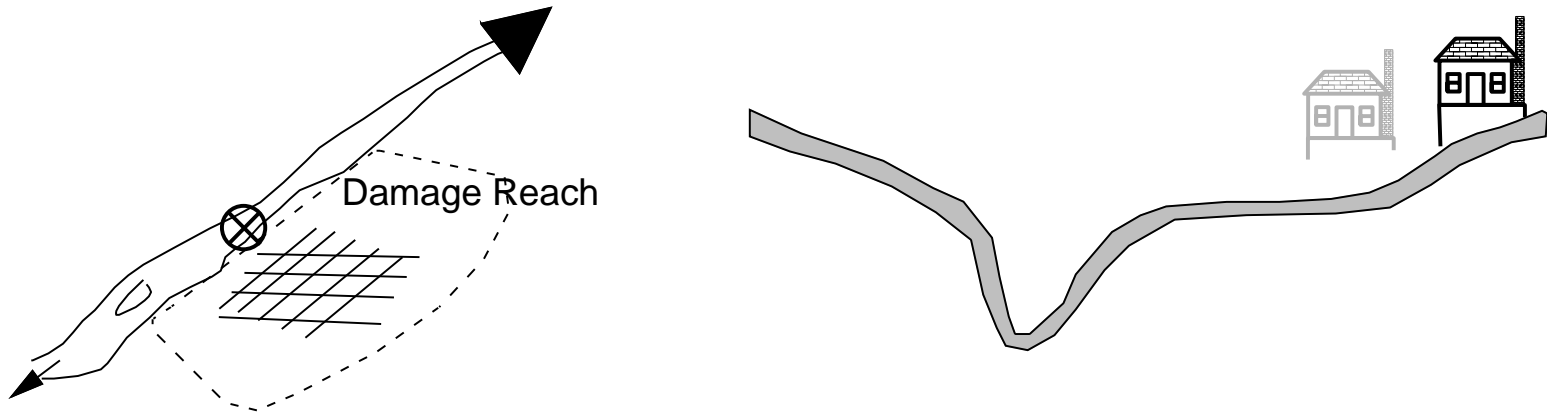
Stage



# With Levee Conditions



# With Nonstructural Measures



# EAD and the NED Plan

Plan Name	Expected Annual Damage			Annual Project Cost	Net Annual Benefits
	Total W/O Project	Total With Project	Damages Reduced (Benefits)		
Without Project Conditions	780.48	780.48	0.00	0.00	0.00
Plan 1 (Detention & Chan Improvement)	780.48	582.67	197.82	189.19	8.63
Plan 2 (Floodwall)	780.48	446.02	334.46	311.12	23.34
Plan 3 (Detention, Chan Imp, Floodwall)	780.48	360.65	419.83	448.16	-28.33

Net Annual Benefit = EAD Reduced – Annualized Project Cost

NED Plan provides the greatest Net Annual Benefit



# Field Data Collection Preparation

## Search for available datasets:

### County/City Assessors Database

Parcel ID

Address

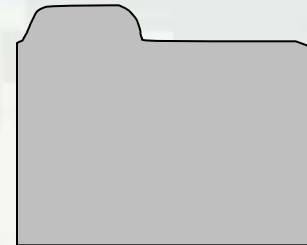
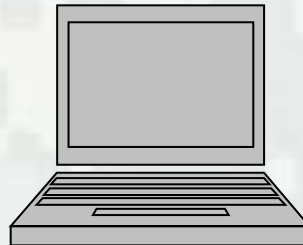
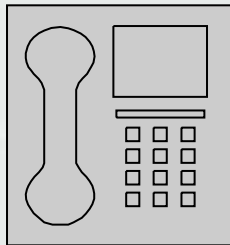
Style

Year Built

Assessed Value

Living Area

### Previous Studies



# Nonstructural Assessment Data Collection

## Recommended Data:

- **Identifier for the Structure (ID Number)**
- **Structure Location Address**
- **1<sup>st</sup> Floor Elevation (Stage)**
- **Lowest Adjacent Grade or Ground Elevation (Stage)**
- **Building Style (ranch, split-entry, etc)**
- **Foundation Type (block, poured concrete, wood)**
- **Building Materials (brick, wood, steel)**
- **Perimeter dimensions (important for quantities)**
- **Land Value/Structure Value**
- **Water Surface Profiles (generally 8 for FDA)**
- **Finished or Unfinished Basement**
- **Crawl Space or Slab on Grade**
- **Parcel Suitability for incorporating an addition**
- **Photos of Front, Left, Right, and Back (Recommended)**
- **Garage Type (Attached or Detached)**



# Sample Structure



**Front View**



**Left Side View**

# Sample Structure Field Data Collection

- **1 Story with Basement**
- **Block Foundation**
- **Basement Windows**
- **Wood Frame**
- **Detached Garage**



# Sample Structure Elevations (Stages)



First Floor  
Elevation

Begin Damage  
Depth





**Damages begin as water enters through the basement window**



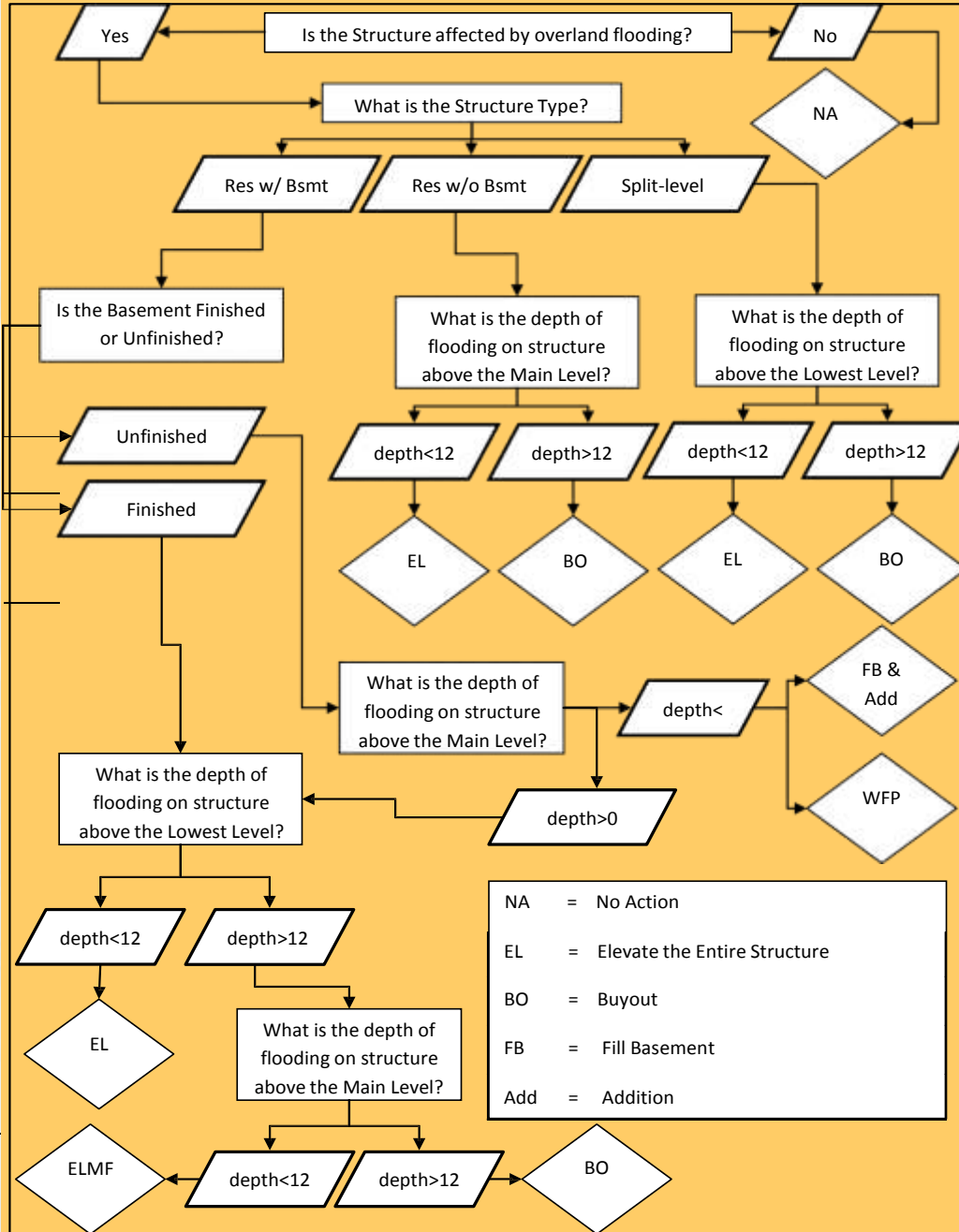
# Sample Structure Inventory Sheet

Appendix A

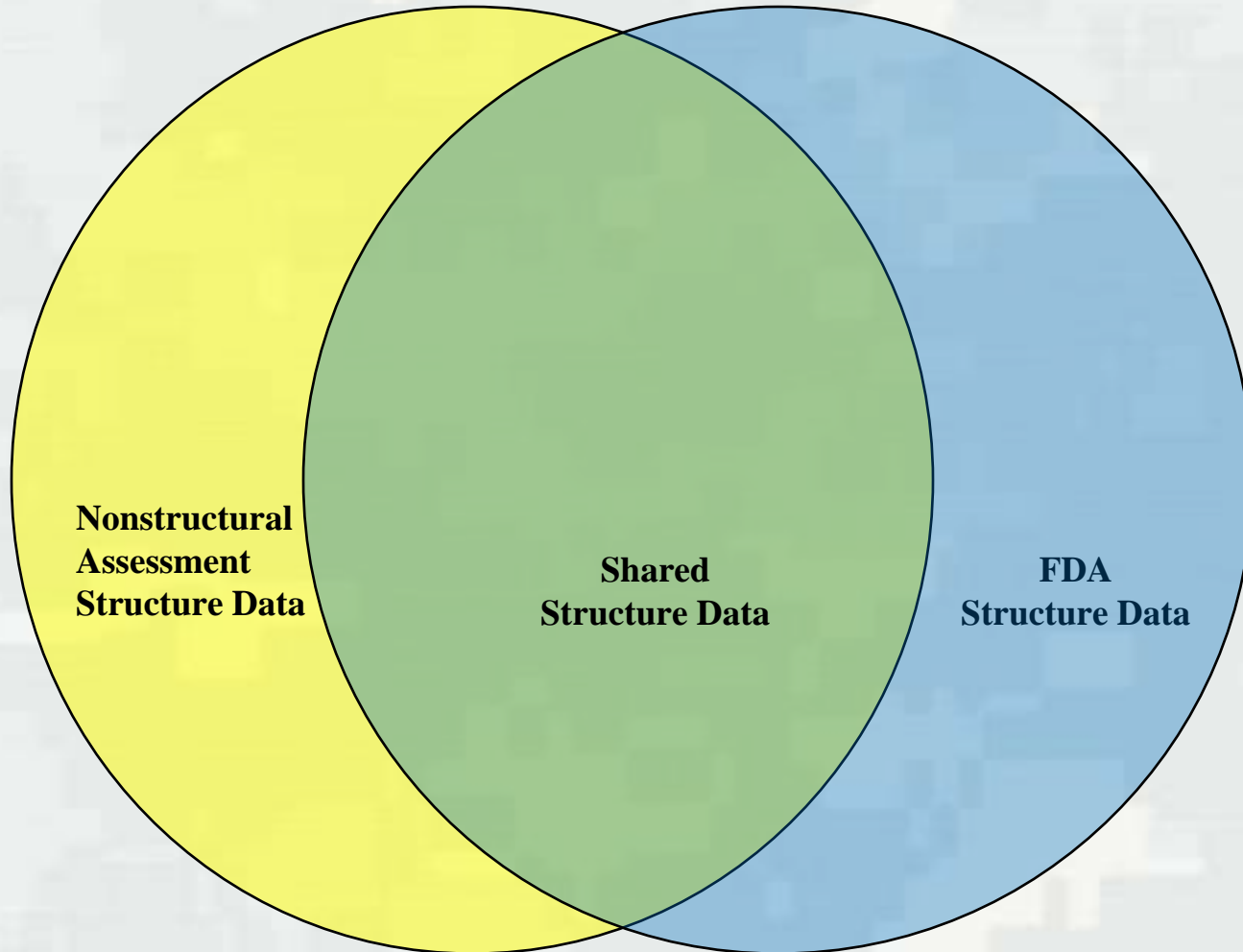
Willow Park, Missouri Valley, Iowa

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)
1 <sup>st</sup> Floor Elev. (NAVD)		1005.61	Flood Event	Ground
		100-yr	3.96	1.93
<b>Field Notes</b>				
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				

# Assessing Structures for Nonstructural Mitigation Measures



# Data Collection with HEC-FDA

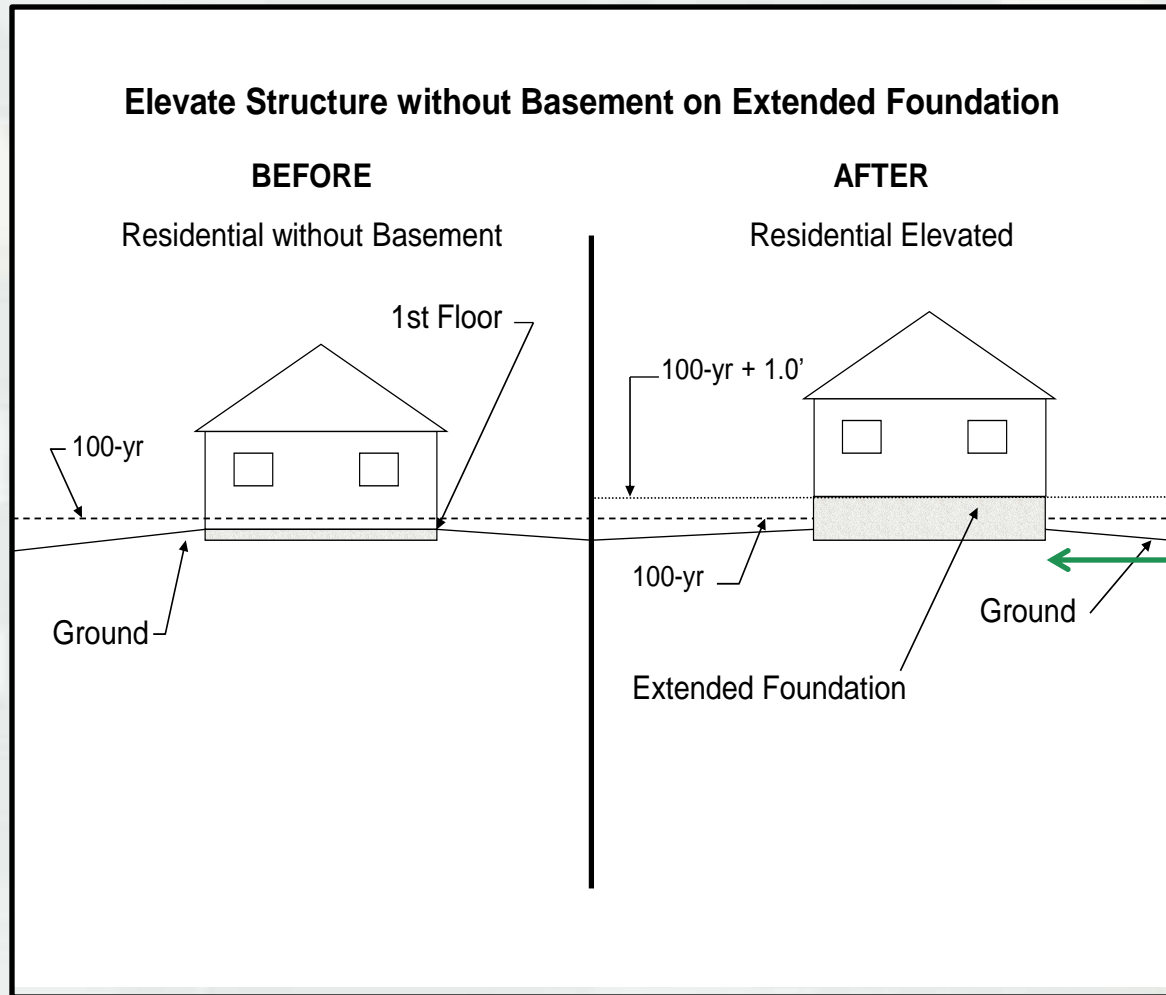


**Nonstructural  
Assessment  
Structure Data**

**Shared  
Structure Data**

**FDA  
Structure Data**

# Elevation Height



Elevation Height

=

100-yr Elevation + 1.0 Ft

-

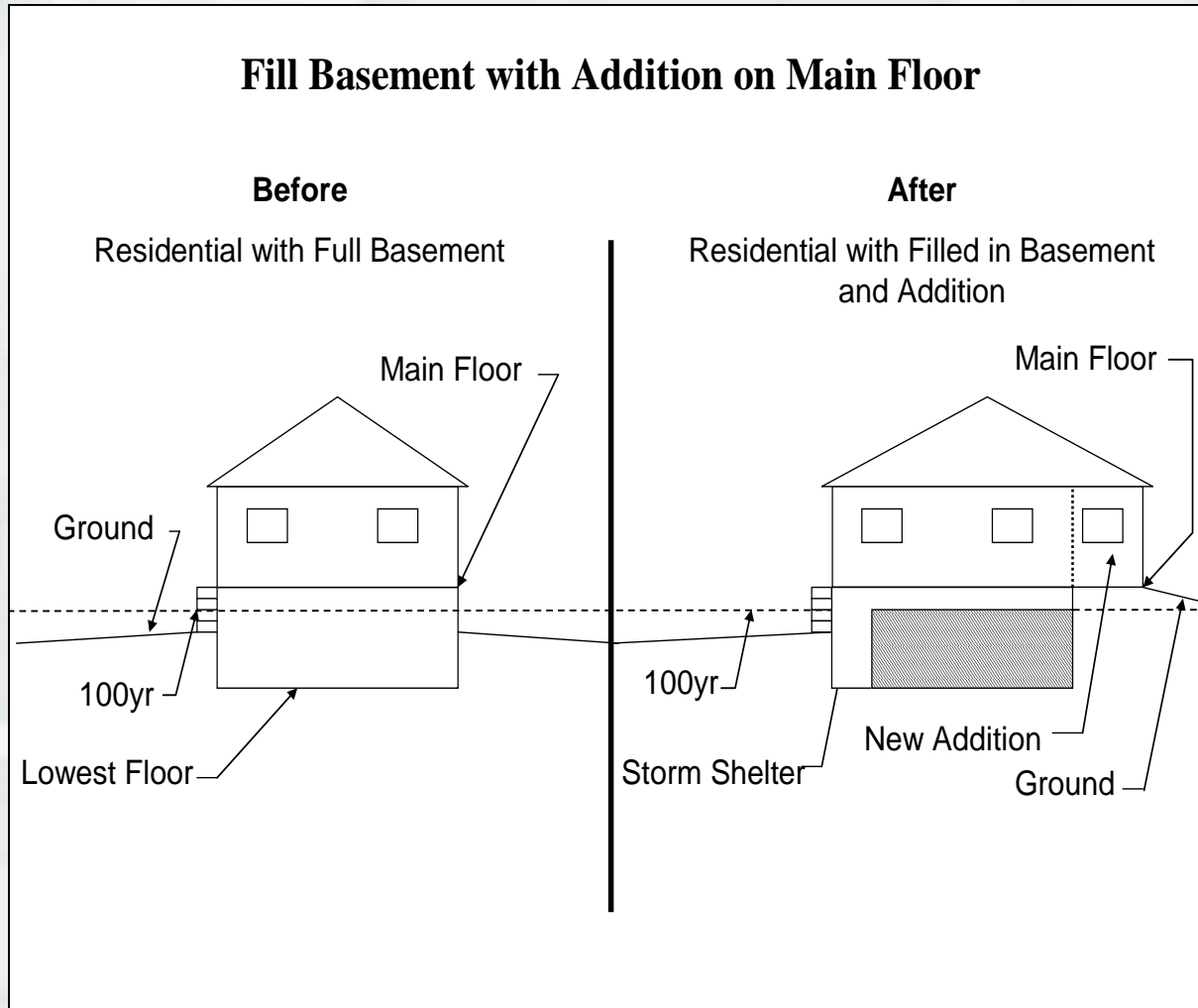
1<sup>st</sup> Floor Elevation

# Elevation on Extended Foundation

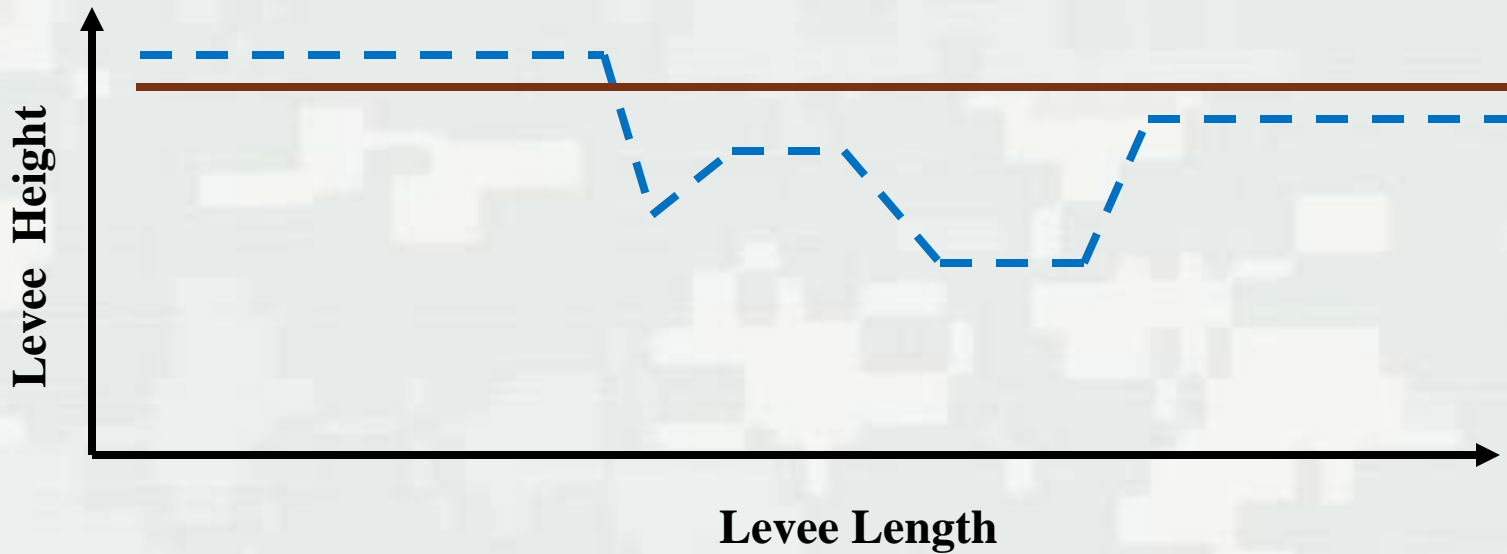


1<sup>st</sup> Floor Shifted with Elevation

# Nonstructural Measure Assessed



# Our "At-Risk" City



# Nonstructural Economic Results

ID	STREET	CITY	Nonstructural Technique	100yr Cost	Annualized Cost	Benefits (x1000)	BCR	Net Benefit
400802	110 FREEDLAND DR	Harwood	Flood Wall	348,000	19,245	10.761	0.56	-8,484
400667	438 LIND BLVD	Harwood	Elevate Structure	123,330	6,820	10.181	1.49	3,360
400707	106 RIVERSHORE DR	Harwood	Elevate Structure	112,176	6,203	2.100	0.34	-4,103
400754	324 RIVERTREE BLVD	Harwood	Elevate Structure	118,513	6,554	10.363	1.58	3,809
400007	17373 25 ST SE	Harwood Twp	Buy Out	129,564	7,165	12.832	1.79	5,667
400008	2551 173 AVE SE	Harwood Twp	Buy Out	113,870	6,297	10.018	1.59	3,721
400009	2623 173 AVE SE	Harwood Twp	Buy Out	147,854	8,177	10.397	1.27	2,220
400025	2769 173 AVE SE	Harwood Twp	Buy Out	123,074	6,806	4.205	0.62	-2,601
400009	2623 173 AVE SE	Harwood Twp	Buy Out	147,854	8,177	10.397	1.27	2,220
400001	17369 25 ST SE	Harwood Twp	Elevate Main Floor	112,176	6,203	14.768	2.38	8,565
400002	17135 25 ST SE	Harwood Twp	Elevate Main Floor	113,114	6,255	13.632	2.18	7,377
400004	17201 27 ST SE	Harwood Twp	Elevate Main Floor	112,661	6,230	21.166	3.40	14,936
400005	2569 172 AVE SE	Harwood Twp	Elevate Main Floor	113,566	6,280	12.193	1.94	5,913
400006	17283 26 ST SE	Harwood Twp	Elevate Main Floor	111,885	6,187	12.316	1.99	6,129
400010	2675 173 AVE SE	Harwood Twp	Elevate Main Floor	109,137	6,035	19.609	3.25	13,574
400011	2651 173 AVE SE	Harwood Twp	Elevate Main Floor	110,236	6,096	20.908	3.43	14,812
400012	17321 27 ST SE	Harwood Twp	Elevate Main Floor	108,070	5,976	16.894	2.83	10,918

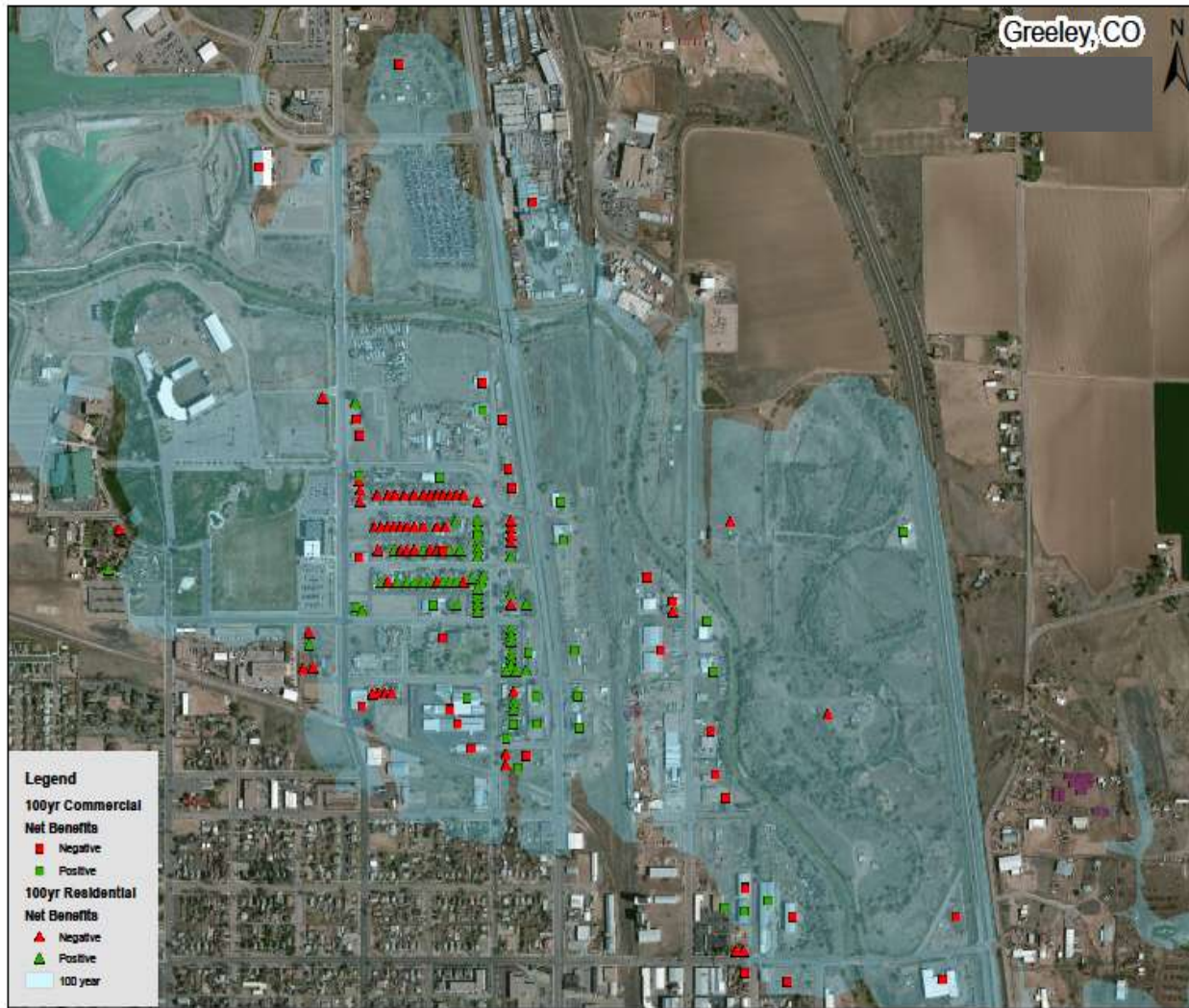
**Remember to use all of the benefits for the entire damage area,  
not just the buildings with a positive BCR**

Costs	Benefits	
124,706	212,740	BCR = 1.71





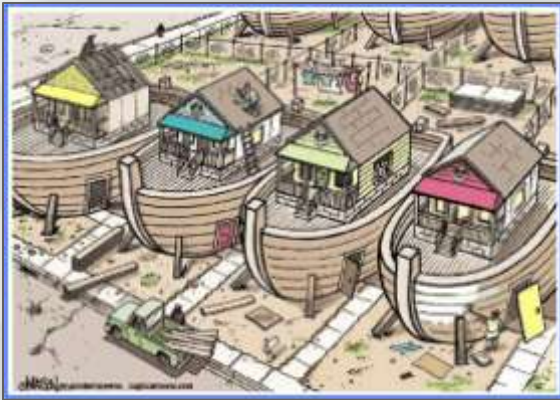
# Nonstructural Investigations with GIS



**Detailed Structure Inventory**  
**Geo-referenced Structures**  
**Residential Assessment**  
**Commercial Assessment**  
**Net Benefit Based**  
**Benefit to Cost Ratios**



# QUESTIONS?



**Randall L. Behm P.E., CFM**  
**Randall.l.behm@usace.army.mil**  
**(402) 995-2322**

