



# AWR-362

# Flooding Hazards: Science and Preparedness

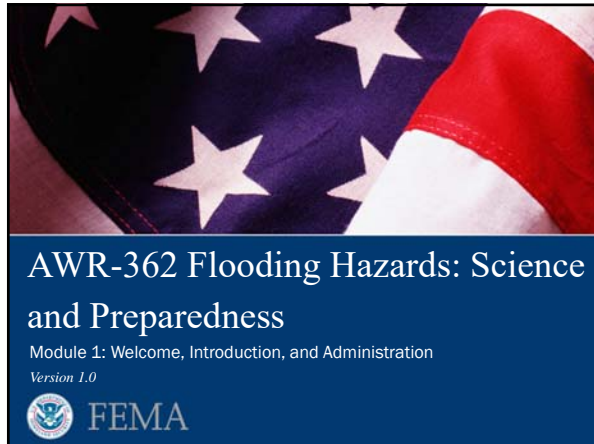
Participant Handout

*Version 1.0*



# FEMA

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AWR-362 Flooding Hazards: Science and Preparedness

## Enabling Learning Objectives

- 1-1 State the course agenda
- 1-2 State the course goal
- 1-3 Explain how performance will be evaluated

1.2

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## Welcome

- Instructor introduction
- Class structure and housekeeping:
  - Breaks
  - Restrooms
  - Emergency exits
  - Cell phones
- IACET CEUs and other professional CECs available

1.3

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## Introductions

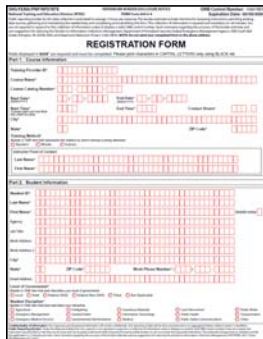
- Name
- Agency or Organization
- Title

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## Continuing Education

- International Association for Continuing Education and Training (IACET)
  - Participants who successfully complete this course will receive 0.1 CEUs for every eligible course contact hour
- This course may also be eligible to provide the other professional continuing education credits

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## Course Registration

✓ UPPERCASE letters  
No abbreviations

## Evaluation Strategy

- Pre-test to assess current knowledge of course content
- Post-test administered at conclusion of course
- Pre- and post-test scores compared to measure performance
- Need a score of 70% or better on the post-test to successfully complete the course

1.7

## Pre-test

- Self-evaluation tool to assess your current knowledge
- Answer to the best of your ability

The image shows a 'Test Answer Sheet' from the National Disaster Preparedness Training Center (NDPTC). It includes fields for 'Last Name', 'Course Identification' (with sub-fields for 'Course' and 'Test Item Identification'), and 'Pre Test'/'Post Test' checkboxes. Below these is a grid for marking answers, with columns labeled A, B, C, and D, and rows numbered 1 through 20.

1.8

## Test Answer Sheet

This image is an annotated version of the 'Test Answer Sheet' form. Three callout boxes provide instructions: 'Fill in bubbles completely' points to the answer grid; 'Black Ink and (24x36) - 1 cm x 1 cm' points to the 'Last Name' field; and 'Indicate Test Type' points to the 'Pre Test' and 'Post Test' checkboxes.

1.9



## Pre-test Answers

*Click to advance slide!*

1-10



## Course Goal

*This course will prepare participants to recognize the conditions that lead to flood events, evaluate their community's risk, and prepare appropriately.*

1-11



## Learning Objectives

Upon successful completion of this course, participants will be able to:

- *Differentiate between types of flooding hazards based on the meteorological and hydrological conditions*
- *Access and interpret FEMA flood risk maps*

1-12

## Learning Objectives (continued)

Upon successful completion of this course, participants will be able to:

- *Identify organizations involved in forecasting and monitoring flooding, and understand the products they issue*
- *Describe preparedness and mitigation actions to be taken in anticipation of flooding events*


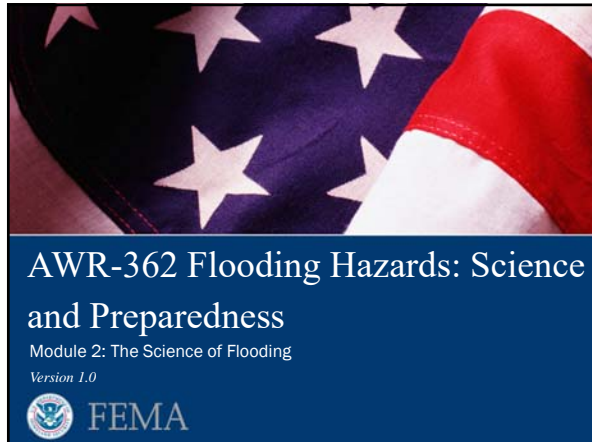
## Course Agenda

Module	Title	Time
1	Welcome, Introduction, and Administration	50 minutes
2	The Science of Flooding	80 minutes
3	Flood Risk	75 minutes
4	Flood Forecasting and Public Information	105 minutes
5	Safe Preparation and Mitigation for Floods	40 minutes
6	Course Summary and Administration	40 minutes

*(Three 10-minute breaks will take place between modules as needed with a 1-hour lunch following Module 3)*

## Summary


- Stated the course agenda
- Stated the course goal
- Explained how performance will be evaluated



## Enabling Learning Objectives

- 2-1 Outline the hydrologic cycle
- 2-2 Identify the meteorological, seismic, and other conditions that lead to flooding
- 2-3 Name hazards associated with riverine, flash, and coastal flooding

2.2



## What is a flood?

*American Meteorological Society:*

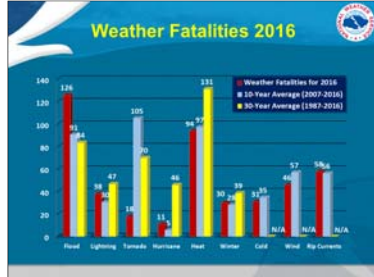
- The overflowing of the normal confines of a stream or other body of water; or
- The accumulation of water over areas that are not normally submerged

*National Weather Service:*

- Any high flow, overflow, or inundation by water which causes or threatens damage

2.3

## U.S. Weather Fatalities 2016



- Flooding killed 126 people in 2016, and 91 people and 84 people annually in 10- and 30-year averages.
- On average, flooding is second only to heat as the cause of weather-related deaths in the U.S.

## Causes of Flooding

- Excessive Rain
- Tropical Storms
- Coastal Flooding
- Frontal Systems
- Infrastructure Failure
- Thunderstorms
- Ice Jams / Ice Jam Breakup
- Tsunamis



(Source: NOAA, 2017)

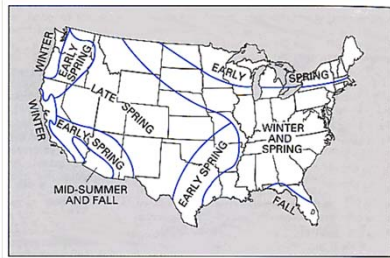
## Factors In Flooding

- Precipitation Intensity
- Storm Duration
- Terrain
- Ground Cover
  - Rural versus Urban
- Ground Saturation
  - Surface Runoff
- Infrastructure Capability



(Source: NOAA, 2017)

## Seasonal Distribution

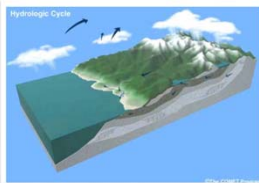


(Source: USGS, 2017)

- The peak of flood season arrives at different times of year depending on the region
- While the West Coast has peak flooding in winter, it is the spring in the Mountain West, Midwest and Atlantic and fall for the Southwest and Florida

2.7

## Hydrologic (Water) Cycle

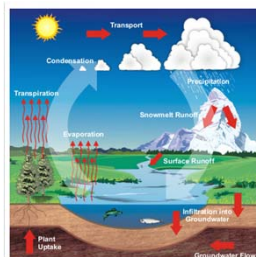


(Source: UCAR, 2017)

- Water evaporates from the surface and rises into the atmosphere
- Water vapor condenses into clouds
- Falls back to the surface (precipitation)
- Collects on land and flows back to oceans

2.8

## Water Runoff



(Source: NOAA, 2017)

- Meteorologists forecast rainfall amounts
- Hydrologists use forecast rainfall amounts and develop a forecast for runoff

$$\text{precipitation} - \text{infiltration} = \text{runoff}$$

**More critical than just rain totals!**

2.9

## Flooding Causes (Rain)

- The heaviest precipitation occurs where rainfall rate is highest for the longest time

$$\text{Total Rainfall} = \text{Average Rainfall Rate} \times \text{Duration}$$

- Flash Flooding: Very high rate in a short timeframe
- Riverine Flooding: Moderate rate over an extended period

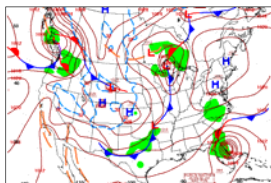


(Source: NOAA, 2017)

2.10

## Extra-tropical Cyclones

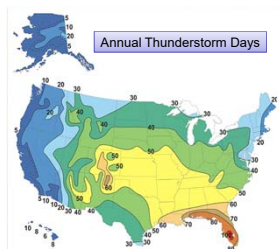
- AKA mid-latitude cyclones, frontal systems
- Low pressure systems
- Thunderstorms commonly found along the cold front
- Steady, persistent rain can be found along the warm front



(Source: NOAA, 2017)

2.11

## Thunderstorms



(Source: NOAA, 2017)

Three Ingredients Required:

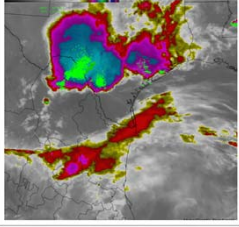
- Instability
- Moisture
- Lift

*Can result in sudden, heavy downpours*

2.12

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## Mesoscale Convective Systems (MCS)



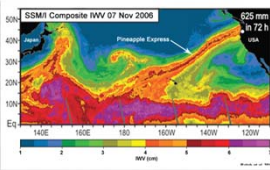
- Widespread, organized thunderstorm complex
- Can last 6-12 hours or more and cover multiple states
- Often initiates in the evening and gains strength through the night
- Can be slow moving, or “back building”

(Source: NOAA, 2017)

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## Atmospheric River (AR)

An atmospheric river (AR) is a stream of very moist air in the atmosphere responsible for producing significant levels of rain and snow, especially in the Western U.S.



- Weak ARs can bring beneficial rain
- Strong ARs can cause extreme rain, flooding and landslides
- Often originate in the tropics


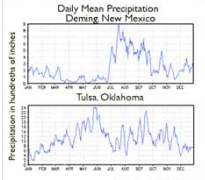
(Source: UCAR, 2017)

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## North American Monsoon

Beginning in July, moisture transported from Gulf of CA, East Pacific, and Gulf of Mexico

Concentrated rain and increased thunderstorms in Southwest U.S.





(Source: NOAA, 2017)

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## Tropical Cyclones

- Tropical cyclones hold all world records for rainfall from 24 hours to two weeks!
- Inland floods can occur days after landfall
  - Harvey (2017) dropped 50" of rain in Houston area
- Geographic conditions may intensify the flooding
  - Irene (2011) in Vermont
- Storm surge is a major hazard
  - Any coastal storm can cause a storm surge, mid-latitude too!



(Source: Brooks, 2014)

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## "More to the Story than the Category"

Category	Central Pressure	Winds (mph)	Surge	Damage	Storm (category)
5	<920	>155	>18'	Catastrophic	KATRINA (3) IKE (2)
4	944-920	131-155	13'-18'	Extreme	SANDY (1) ISAAC (1)
3	964-945	111-130	9'-12'	Extensive	
2	979-965	96-110	6'-8'	Moderate	CHARLEY (4)
1	>980	74-95	4'-5'	Minimal	


(Source: UCAR, 2017)

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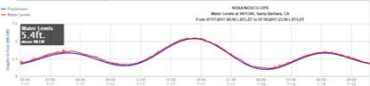
## Tides

- Driven by gravitational pulls of both the moon and sun
- High tides can enhance impact of other flooding factors
- "King Tides": Colloquial term for extreme high tides; predictable

San Francisco Embarcadero at low tide and king tide



1 February 2011: 16:51  
20 January 2011: 11:32

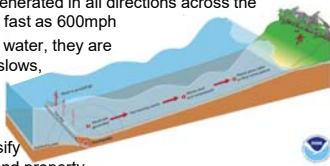


(Source: NOAA Tides and Currents, 2017)

## Tsunami

The most common cause of tsunamis are underwater landslides and earthquakes

1. An underwater earthquake occurs when a plate shifts abruptly and pushes water upward with tremendous force
2. Low and fast waves are generated in all directions across the ocean, some speeding as fast as 600mph
3. As waves enter shallower water, they are compressed, their speed slows, and they build in height
4. The wave height increases and associated currents intensify becoming a threat to life and property

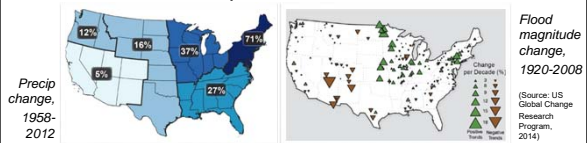


(Source: NOAA, 2017)

2-10

## Changing Climate, Changing Floods

- Sea level rise will bring flooding to formerly dry coastal areas
- Precipitation has increased across the U.S.
- Flood magnitude (extreme precipitation) has increased in some places and decreased in others



Flood magnitude change, 1920-2008  
(Source: US Global Change Research Program, 2014)

2-20

## Snowmelt Flooding



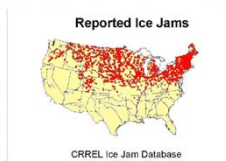
(Source: NOAA Office of Water Prediction, 2017)

- Water content measured as the Snow Water Equivalent (SWE – “swee”)
  - Depth of water if snow cover melts
- Water flows through snow at a wide range of speeds:
  - Internal snowpack structure
  - Condition of the snowpack
  - Amount of water coming through

2-21

## Ice Jams

- Ice forms on a river
- Increased discharge due to snowmelt or additional precipitation raises river stage and breaks/moves ice
- Ice stops moving (jams)
  - Higher levels upstream
  - Jam progresses upstream



(Source: U.S. Army, 2017)



(Source: NOAA, 2014)

## Dam / Levee Break

- Overtopping results in 1/3 of dam failures
- Remaining 2/3 were “sunny day” failures:
  - Deliberate sabotage
  - Structural failure of dam itself
  - Movement or failure in the support foundation
  - Inadequate maintenance and upkeep



(Source: FEMA, 2010)

## Specific Flood Hazards

- Many of the impacts of flooding are similar regardless of cause
- However, different types of flooding can come with a variety of intensities and impact



(Source: NOAA, 2011)



(Source: NOAA, 2017)



## Riverine Flooding Characteristics

- Dynamics vary with terrain:
  - Flat areas – can be slow process to flood, land may stay covered for extended period
  - Hilly areas – response can be shortly after rains fall, yet also dry out sooner
- Overbank Flooding: Volume of water exceeds the capability of the river channel to hold it



(Source: NOAA, 2017)

2-25



## Riverine Flooding Hazards



(Source: NOAA, 2008)

- Floodwaters can reach areas far from the actual river
- Often considered “slow disaster”
- Typically a property damage incident:
  - Timing and peak water levels can be predicted
  - Much of the damage caused when receding water leaves behind mold issues / rotted foundations / etc.

2-26



## Flash Flooding Characteristics

- Rapid rise (and often fall) in water levels
- Common in areas with steep slopes / valleys
- Can occur along smaller waterways in urban locations
- Harder to specifically forecast the peak water levels and timing



(Source: NOAA, 2013)

2-27

## Flash Flooding Hazards

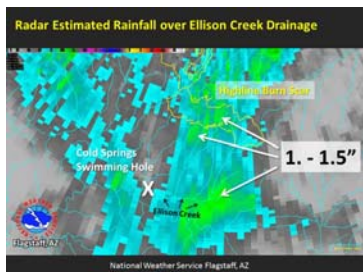
- High velocity: Water moving at 10 mph has the same pressure on a structure as 270 mph winds
- High debris load
- Water / bridge washout
- Sudden impact can result in loss of life:
  - Drivers underestimate the depth and speed of water
  - Campers / others outside are at increased risk



(Source: NOAA, 2017)

2-28

## Flash Flooding in “Dry” Areas



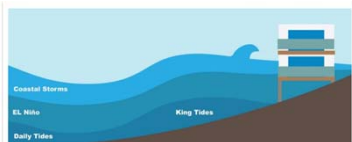
(Source: NOAA, 2017)

- Particularly dangerous in areas where flooding might not be common consideration
- Dangerous in isolated areas with no cell signal

2-29

## Coastal Flooding / Tsunami Characteristics

- Occurs on oceanic coasts and Great Lakes
- Storm surge superimposed on wave action; wind from large storms cause frequent swells which erode beach and/or extend inland causing damage




(Source: NOAA NOS, 2017)

2-30

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## Coastal Flooding / Tsunami Hazards

- Storm surge peaks in short timeframe:
  - Too late to evacuate once it begins
  - Hard to predict exact heights prior to landfall
- Wave run-up pushes past the shoreline and can impact roads, buildings, and infrastructure well away from the coast




(Source: NOAA, 2017)

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## Vehicular Flood Risk Fatalities

- Half of flood deaths occur in vehicles**
- 6 inches** of flowing water can knock an adult off their feet
- 12 inches** of water will float many vehicles
- 2 feet** of rushing water will carry away most vehicles, including SUVs and pickups



(Source: NOAA, 2017)

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## Don't Wade in There, Either

- Flood safety applies to first responders, too!
  - Infectious and Diarrheal Diseases
  - Venomous or Dangerous Animals
  - Wound Infections
- Be aware of secondary hazards
  - Chemical Contamination
  - Electrocution
  - Injuries from Obscured Objects
- Floodwaters are never safe



## Summary

- Outlined the hydrologic cycle
- Identified the meteorological, seismic, and other conditions that lead to flooding
- Named hazards associated with riverine, flash, and coastal flooding

3-34



## AWR-362 Flooding Hazards: Science and Preparedness

Module 3: Flood Risk

Version 1.0



FEMA



## Enabling Learning Objectives

- 3-1 Specify what determines flood risk in a given area
- 3-2 Describe the frequency and probability of flooding
- 3-3 Summarize the basic mechanism of the National Flood Insurance Program

3-2



## Floodplain

39 CFR 776.3: "... the lowland and relatively flat areas adjoining inland and coastal waters including flood-prone areas of offshore islands, including, at a minimum, that area subject to a one percent or greater chance of flooding in any given year (also known as a 100-year floodplain)."

3.3



## Understanding Probability

- Imagine rolling a standard, six-sided die. You roll a five.
- What was the chance, or probability, of rolling a five?
  - 1 out of 6
- You roll the die again. What is the chance of rolling a five again?
  - Still 1 out of 6



3.4



## Probability of Flood

- The climate of a particular region is the "die" and the weather is what you roll on a particular day
- This is why a "100-year" flood has a 1% chance of occurring **every year**... *even if one already occurred the previous year!*
- These probabilities are calculated using historical data, flood risk factors, and statistical modeling

3.5

## Return Period

- The average number of years between floods of a certain size is the recurrence interval or **return period**
- The actual number of years between floods of any given size varies because of the naturally changing climate

$$\text{Number of years} / \text{number of events} = \text{return period}$$

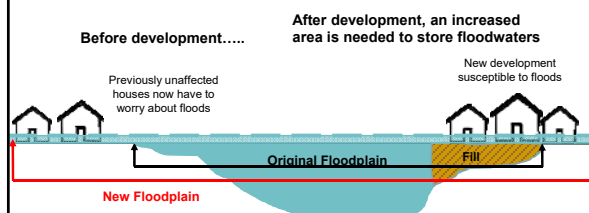
3.6

## 100-year Floods can Happen Two Years in a Row

Recurrence intervals and probabilities of occurrences		
Recurrence interval, in years	Probability of occurrence in any given year	Percent chance of occurrence in any given year
500-year flood	1 in 500	0.2%
100-year flood	1 in 100	1%
50-year flood	1 in 50	2%
25-year flood	1 in 25	4%
10-year flood	1 in 10	10%
5-year flood	1 in 5	20%
2-year flood	1 in 2	50%

3.7

## Floodplains Can Change!



(Source: B. Brown, 2017)

3.8

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## The Regulatory Floodplain

0.2% Chance Flood Zone (500-year) - X zone

1% Chance Flood Zone (100-year) - A or V zone

(Source: FEMA, 2017)

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## FEMA Flood Insurance Terms

- **Base Flood Elevation (BFE):** computed elevation to which floodwater is anticipated to rise during the base flood (100-year flood)
- **Special Flood Hazard Area (SFHA):** Land covered by floodwaters of the base flood
- **A Zone:** Subject to rising waters, usually near a lake, river, stream, or other body of water
- **V Zone:** Coastal flood zone

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## Do You Have to Be in a Floodplain to Flood?

Is this area "in" a floodplain?

Is this area "out" of a floodplain?

FIRM FLOOD INSURANCE RATE MAP  
FLOOD ZONES  
UNITED STATES  
FEDERAL EMERGENCY MANAGEMENT AGENCY

DID YOU KNOW? Flooding occurs in all 50 states with nearly 12.5 MILLION people living at risk.

DID YOU KNOW? People outside of mapped high-risk flood areas file nearly 25% of all National Flood Insurance Program (NFIP) flood insurance claims and receive one-third of Federal Disaster Assistance for flooding. Floods are the most common natural disaster in the U.S. and since standard homeowners' insurance doesn't cover flooding, it's important to have protection.


(Source: FEMA, 2017)

(Source: FEMA/NFIP, 1999)

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## Factors Influencing Flood Risk

- Location, Location, Location
  - Proximity to Water Sources
  - Proximity to Mitigation Measures
- Climate
- Topography
- Land Use / Built Environment
- Prior Events
- Community Capacity





(Source: FEMA, 2016) (Source: USGS, 2010)

3.12

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## Location: Proximity to Water, Mitigation Areas

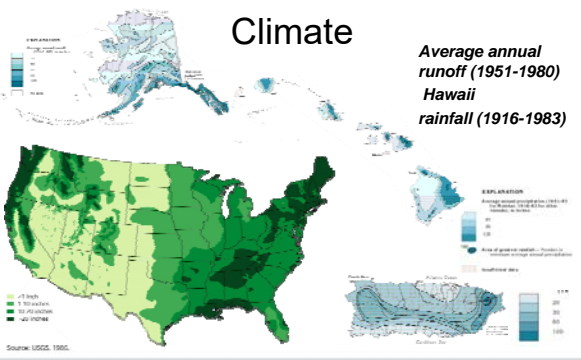
(Source: FEMA, 2014) (Source: FEMA/NFIP Community Rating System, 2017)

3.13

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## Climate

**Average annual runoff (1951-1980)**  
**Hawaii rainfall (1916-1983)**



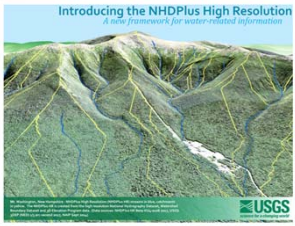

Source: USGS, 1985.

3.14

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## Topography and Elevation

Introducing the NHDPlus High Resolution  
*A new framework for water-related information*

(Source: USGS, 2017)




(Source: Google Maps, 2017)

3.15

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## Land Use / Built Environment

- Density
- Pervious / Impervious Surfaces
- Stormwater System
- Protection Measures
- Community Capacity
  - Manpower, equipment
  - Proper maintenance

(Source: Allison Hardin, undated)



(Source: FEMA, 2015)

3.16

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## Prior Events

- Wildfire burn scars
- Heavy winter snows
- Previous rainfall
- Debris blocking flow

(Source: FEMA, 2015)

(Source: Allison Hardin, undated)


3.17

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## Determining Risk

### Gather Information

FEMA, state, local, and tribal officials collect current and historic flood-related data including:



Hydrology    Infrastructure    Hydraulics    Land use    Existing maps such as:

- Floodplain
- Base map
- Flood Map, if existent

(Source: FEMA, 2017)

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## The Flood Map Service Center

FEMA Flood Map Service Center: Welcome!

Looking for a Flood Map?

Enter an address, a place, or longitude/latitude coordinates

Looking for more than just a flood hazard map?

Use Search All Products to access the full range of flood information for your community.

About Flood Map Service Center

The Flood Map Service Center (FMSC) is the official public source for flood hazard information produced in support of the National Flood Insurance Program (NFIP). Use the FMSC or the public official Flood Map, access a range of other flood maps to identify and learn about areas at risk to better understand your risk.

Flood hazard maps are continuously updated through a variety of processes. Please be informed that you may not see any from the site they change or become superseded by new maps over time. For additional information please see the [Flood Hazard Mapping Updates Section](#).


Announcements

As of August 1, 2017 all FEMA systems will require the use of the "flood" product and help links will no longer function. This is a change to the way we display flood information on our website. Please be informed that you may not see any from the site they change or become superseded by new maps over time. For additional information please see the [Flood Hazard Mapping Updates Section](#).

<https://msc.fema.gov/portal/>

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## Flood Insurance Rate Map (FIRM)




Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- Regulatory Floodway
- Special Floodway
- Area of Undetermined Flood Hazard
- 0.2% Annual Chance Flood Hazard
- Future Conditions 1% Annual Chance Flood Hazard
- Area with Reduced Risk Due to Levee

(Source: FEMA/NFIP, 2017)

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## The National Flood Insurance Program

- Voluntary *quid pro quo* program
- Agreement between FEMA and community
- Community adopts and enforces an ordinance addressing flood risk
- In return, Federal government makes flood insurance and grants available
- Ordinance is enforced locally
- Appeals go to local jurisdiction, not federal government


3.21

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## Three NFIP Directives



**Risk Identification and Mapping:** Creating maps that serve as the basis for risk evaluation



**Ensuring Availability of Flood Insurance:** Maintaining the National Flood Insurance Program capabilities to provide federally-backed flood insurance




**Community Compliance:** Ensuring communities in the National Flood Insurance Program are following base regulations found in 44 CFR Part 60

3.22

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## Federal Responsibilities



(Source: FEMA, 2017)

- Oversee national program
- Identify risks through mapping
- Establish development standards
- Provide affordable insurance coverage
- Provide assistance to states

3.23



## State Responsibilities

- Oversee state NFIP program, grants
- Provide technical assistance to local communities
- Document and evaluate floodplain management activities
- Establish or recommend development standards (if allowed by state law)

3-24



## Local Responsibilities

- Adopt and enforce local ordinances or court orders to minimum standards or higher
- Issue / deny floodplain development permits
- Oversee and inspect development
- Maintain development records
- Remedy violations



(Source: FEMA, 2017)

3-25



## Summary

- Specified what determines flood risk in a given area
- Described the frequency and probability of flooding
- Summarized the basic mechanism of the National Flood Insurance Program

3-26



## Observations

- ASOS (Automated Surface Observing System); Primary Federal weather platform
- Upper air; Instrument packages on weather balloons



(Source: NOAA, 2017)



(Source: COMET, 2017)



(Source: NOAA, 2017)

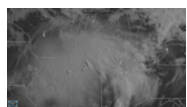
## Remote Sensing

### Satellite

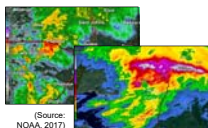
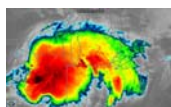
- Space based
- Visible, infrared (heat), water vapor
- Can show cloud tops, moisture content

### Radar

- Ground-based NEXRAD
- Base reflectivity (rain rate)
- Storm total precipitation
- Type of precipitation



(Source: CIMMS, 2017)

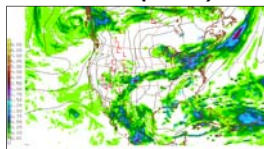


(Source: NOAA, 2017)

## Computer Models

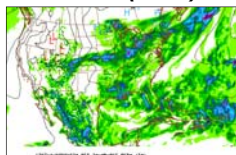
Numerical Weather Prediction (NWP)

### North American Model (NAM)

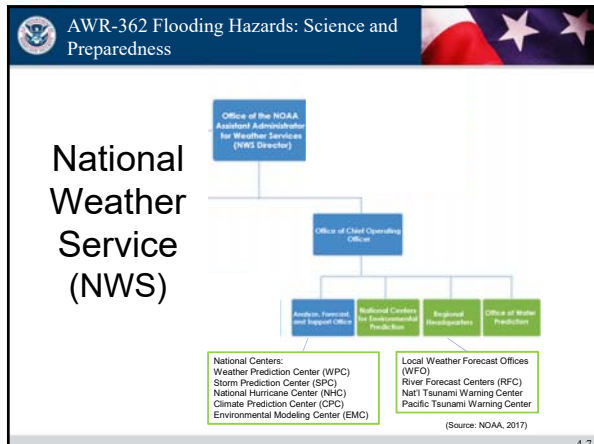


(Source: NOAA, 2017)

### Global Forecast Model (GFS)



(Source: NOAA, 2017)

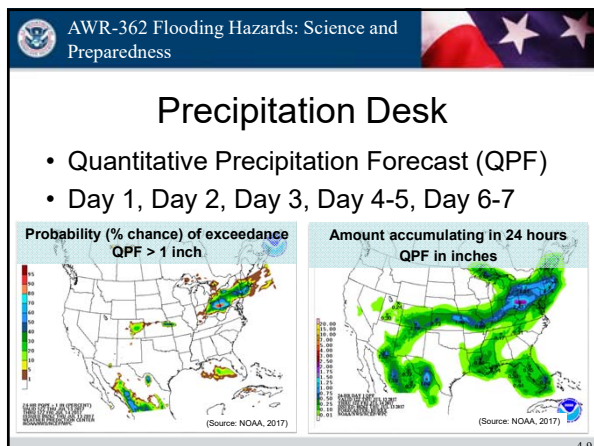


AWR-362 Flooding Hazards: Science and Preparedness

## Weather Prediction Center (WPC)

- Online at <http://www.wpc.ncep.noaa.gov>
- Starting point for local forecasts
- Provides national weather analysis and forecast products:
  - Precipitation Outlooks
  - Flash Flood Potential
  - Winter Weather Guidance
  - Surface Analysis
  - Daily Weather Map

(Source: NOAA, 2014)



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## Excessive Rainfall Outlook

Day 1 Excessive Rainfall Outlook  
Valid 11:00 PM Oct 14 2017  
Thru 11:59 PM Oct 18 2017  
Issued 11:02 AM Oct 14 2017  
Forecaster BLM/ML  
NCAA/NWS/CFMPC

Prob of exceed exceeding flash flood guidance in the next 4-5 days

Risk	Code	Color
Marginal 5-10%	MRGL	green
Slight 10-20%	SLGT	yellow
Moderate 20-50%	MDT	red
High >50%	HIGH	pink

(Source: NOAA, 2017)

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## Climate Prediction Center (CPC)

### Chances of Above Normal (“A”) / Normal (“N”) / Below Normal (“B”) Precipitation

- 6-10 day outlooks
- 8-14 day outlooks
- 3-4 week outlooks
- Monthly outlooks
- Seasonal outlooks

(Source: NOAA, 2017)

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## River Forecast Centers (RFCs)

- Data Collection
- Hydrologic Forecasts:
  - Estimate how much rain gets into the river
  - Estimate how fast runoff gets to river gage
  - Estimate how fast upstream water arrives
  - Estimate water flow into water height
- Quality Control
- Precipitation Forecasts

water.weather.gov/ahps/rfc/rfc.php

(Source: NOAA, 2017)



## Weather Forecast Office Operations



(Source: NOAA, 2017)

Operated 24 x 7 x 365:

- Meteorologist in Charge (MIC)
- Warning Coordination Meteorologist (WCM)
- Science and Operations Officer (SOO)
- Service Hydrologist
- Forecasters
- Technicians

4-13



## WFO Responsibilities

- Create local forecasts
- Provide data and insight to the RFCs
- Coordinate with public safety partners and agencies
- Offer expert guidance on weather and flooding issues
- Provide additional training on weather and hydrology issues

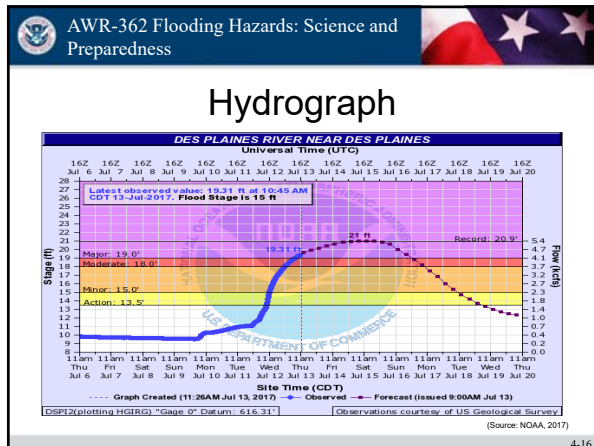
4-14



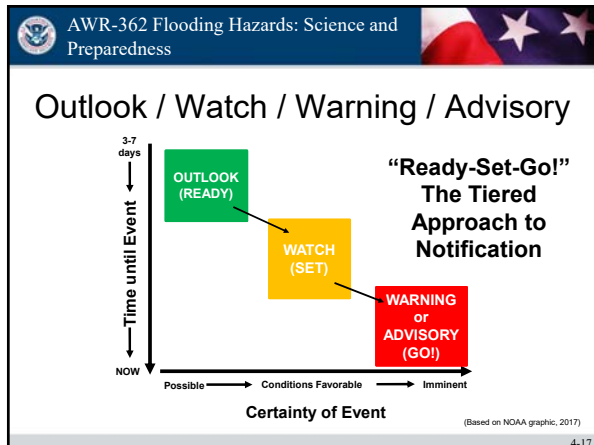
## Hydrograph Terms

- **Stage** – water surface level in a river
- **Action Stage** – some mitigation required
- **Minor Flooding** – minimal threat
- **Moderate Flooding** – some inundation of structures / roads near stream
- **Major Flooding** – extensive inundation with evacuations and life safety threat
- **Record Flooding**

4-15



4.16



4.17

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## Outlook

**Flood Threat**  
Valid from 6 AM AST Jul 13, 2017 to 6 PM AST Jul 13, 2017

This hazardous weather Outlook is for Puerto Rico and the adjacent Atlantic Coastal waters.

**Day One...Today and Tonight**

- Thunderstorms...** There is a chance of isolated thunderstorms with heavy rainfall and brief gusty winds this afternoon across the interior and west sections of Puerto Rico.
- Flooding...** Heavy rains could lead to urban and small stream flooding.
- Wind...** Sustained winds 20-24 mph are expected across the Atlantic and Caribbean near-shore waters.
- Waves...** Choppy seas 4 to 6 feet with occasional seas up to 8 feet are expected across the Atlantic waters.
- Rip Currents...** There is a moderate risk of rip currents for the north, southwest and south facing beaches of the islands.
- Heat...** Heat index between 102 and 107 F are possible across coastal areas.

**Day Two through Seven...Saturday through Thursday**

A tropical wave which is now located in the vicinity of the lesser Antilles will bring an increase in low level moisture and therefore shower and thunderstorm activity late tonight into early Saturday. Therefore there is a chance for urban and small stream flooding.

(Source: NOAA, 2017)

4.18

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## Watch

- Flash Flood Watch
  - Short duration, high intensity flooding possible
- Flood Watch
  - Slow developing, flooding possible from long duration rainfall
- River Flood Watch
  - Issued for river forecast points when flooding is possible in the next 24-48 hours
- Storm Surge Watch
  - Issued by National Hurricane Center
  - Possibility of water moving inland within 48 hours

4-10

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## Warning

- Flash Flood Warning
  - Short duration flash flooding from rainfall > 1" per hour
  - Also used when a dam failure is imminent or occurring
  - Rarely used "flash flood emergency" language
- Flood Warning
  - Long duration flooding is imminent or occurring
- River Flood Warning
  - River flooding is imminent or occurring
- Storm Surge Warning
  - Issued by NHC
  - Life-threatening inundation within 24 hours

(Source: NOAA, 2017)

4-20

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## Advisory

- Minor / nuisance flooding is imminent or occurring
  - Large and sometimes confusing array of localized flood advisory products (small stream flood advisory, arroyo flood advisory, urban flood advisory, etc.)
- *This will be changing*

(Source: NOAA, 2017)


4-21

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## Hazard Simplification

- Expected in 2022
- Remove *Flash Flood Watch*; include in Flood Watch
- Consolidate advisories to “Flood Advisory”
- Reformat flood products:
  - What
  - Where
  - When

(Source: NOAA, 2017)



4.23

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## Tsunami Messages: Alert Levels


TWC Alert Level:	<b>WARNING</b>	<b>ADVISORY</b>	<b>WATCH</b>	<b>INFORMATION STATEMENT</b>
TWC-determined Threat:	<b>EXPECTED FLOODING</b>	<b>STRONG CURRENTS LIKELY</b>	<b>DANGER LEVEL NOT KNOWN</b>	<b>NONE or MINOR WAVES AT MOST</b>
Local Authority Safety Action:	<b>EVACUATION RECOMMENDED</b>	<b>STAY AWAY FROM SHORE</b>	<b>PREPARE, STAY ALERT FOR MORE INFORMATION</b>	<b>NO ACTION SUGGESTED</b>

4.23

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## Cellular Phone Alerts

- Wireless Emergency Alerts (WEA)
  - Most smartphones
  - Not an app
  - Can be disabled
- Phone Apps
  - FEMA, Red Cross, Radar, TV stations
- Interactive NWS (iNWS)



(Source: NOAA, 2017)

4.24

## NOAA All Hazards Radio

- Typically called a “Weather Radio”
- Can be set to alert based on event type and location
- Important to have if broadcast or cell services go offline



(Source: NOAA, 2017)

4-25

## Traditional and Social Media



(Source: NOAA, 2017)



(Source: Rob Dale, 2008)

- On camera meteorologists are the “public face” of weather forecasting
  - Can add value to NWS watches and warnings by providing localized information
- Social media: Facebook and Twitter for each local WFO provide tailored info
  - National centers like WPC also have social media accounts

4-26

## Flood Exercise

- Break into small discussion groups; use the binders to get a closer look at the handouts
- This exercise will provide practical experience in reading FIRMs, NWS outlooks, watches, and warnings, and hydrographs
- Note your group’s answers on the provided question sheet for your own reference

4-27

## Handout #1



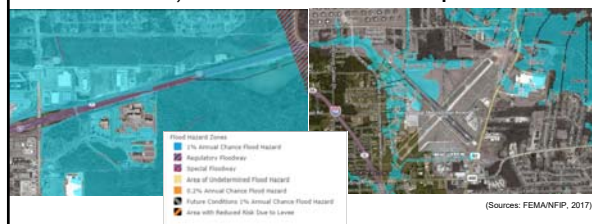
(Source: Google Maps, annotated by Rob Dale, 2017)

4-28

## Handout #2 Flood Insurance Rate Map

Medical Center, Interstate

Airport



(Sources: FEMA/NFIP, 2017)

4-29

## Group Discussion

- Where are possible sources of flooding in Baton Rouge, LA?
- According to the FIRM, what is the risk at the airport? At the medical center?
- If the area is not in the 1% floodplain, can flooding still happen?

4-30

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## Handout #3 – Wednesday PM

- What is the risk of flash flooding in Baton Rouge?
- How many days are there to plan for flooding?

Day 2 Excessive Rainfall Outlook  
 Valid 12Z Thu Aug 12 2018  
 Threat 12Z Fri Aug 13 2018  
 Forecast 12Z Wed Aug 12 2018  
 Forecast 12Z Thu Aug 13 2018  
 NWS/NM/NWS/CPC/MR/C

Risk of rainfall exceeding flash flood guidance in the next 48 hrs

HIGH > 95%	SLGT 5%-10%
MODT 10%-25%	MRGL 2%-5%

(Source: NOAA, 2016)

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## Handout #4 – Thursday AM

FLASH FLOOD WATCH FOR PORTIONS OF SOUTHEAST LOUISIANA AND SOUTHERN MISSISSIPPI... ENCLUDING THE FOLLOWING AREAS... IN SOUTHEAST LOUISIANA... ASCENSON... ASSUMPTION... EAST BATON ROUGE... EAST FELICIANA... BERWELLS... LYNDENTON... NORTHERN TANGEPAROLA... POENTE COUPEE... ST. HELENA... ST. JAMES... ST. JOHN THE BAPTIST... WASHINGTON... WEST BATON ROUGE AND WEST FELICIANA; IN SOUTHERN MISSISSIPPI... ARDE... PASKI... HALTHALL AND VELKINSON.

THROUGH SATURDAY MORNING

ABUNDANT TROPICAL MOISTURE POOLED AROUND A WEAK SURFACE LOW PRESSURE SYSTEM NEAR THE MISSISSIPPI COAST WILL ALLOW FOR FAVORABLE CONDITIONS FOR HEAVY RAINS AND THE POTENTIAL OF FLASH FLOODING IN THE CENTRAL GULF COAST REGION. STORM TOTAL RAINFALL ACCUMULATIONS THROUGH SATURDAY MORNING COULD RANGE BETWEEN 5 AND 8 INCHES WITH SOME LOCALLY HIGHER AMOUNTS CLOSE TO 10 INCHES... PARTICULARLY ALONG THE MISSISSIPPI COAST AND INTO THE METRO NEW ORLEANS AREA.

IMPACTS INCLUDE FLASH FLOODING IN LOW LYING AND POORLY DRAINED AREAS AS WELL AS ELEVATED LEVELS ON AREA RIVERS AND STREAMS.

(Source: NOAA, 2017)

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## Group Discussion

- Where is Baton Rouge, LA in relation to the Flash Flood Watch?
  - After Hazard Simplification, what type of watch would this be?
- If conditions worsen, what is the next product you could expect to be issued by the local NWS WFO?
- Given the forecast, list one or two preparations that you would recommend to the hospital and the airport

## Handout #5 – Friday AM



- Is Baton Rouge in the Flash Flood Warning?
- What are your concerns at the hospital? Airport?

(Source: NOAA, 2017)

4-34

## Handout #6 – Friday AM



(Source: NOAA, 2017)

4-35

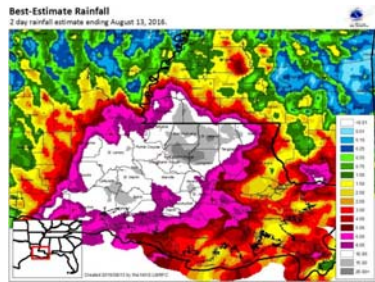
## Group Discussion

- What is the current level and stage of the Amite River?
- When is the river forecast to peak and how high will the peak be?
- What type of message would you convey to the public regarding the progress of flooding, based on the hydrograph and text of the warning? Craft a sentence or list two to three bullet points.

4-36

## Rainfall Totals

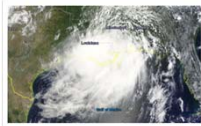
*Baton Rouge Storm Total:*  
**20.8"**



4.37

## Flood Impact

- Widespread flash flooding, record river flooding in SE Louisiana / SW Mississippi
- Amite River crested at 46.2 feet, 4 feet above forecast
- 13 people killed due to flooding
- Interstates 10 and 12 closed for days
- Over 50,000 homes and businesses flooded



(Source: NOAA, 2016)



(Source: FEMA, 2016)

4.38

## Flood Impact (continued)

Ochsner Medical Center in Baton Rouge:

- Transferred 57 critical patients elsewhere in the state over a weekend via military vehicle
- Diverted ambulances for nearly a week
- Staff members were unable to leave for three days due to flooded roadways



(Source: Google Maps, 2017)

4.39



## Summary

- Described the hydrological forecast cycle
- Distinguished between an outlook, watch, warning, and advisory issued by the National Weather Service
- Interpreted a hydrograph from the U.S. Geological Survey
- Described dissemination methods for public warnings

4-40



## AWR-362 Flooding Hazards: Science and Preparedness

Module 5: Safe Preparation and Mitigation for Floods

Version 1.0



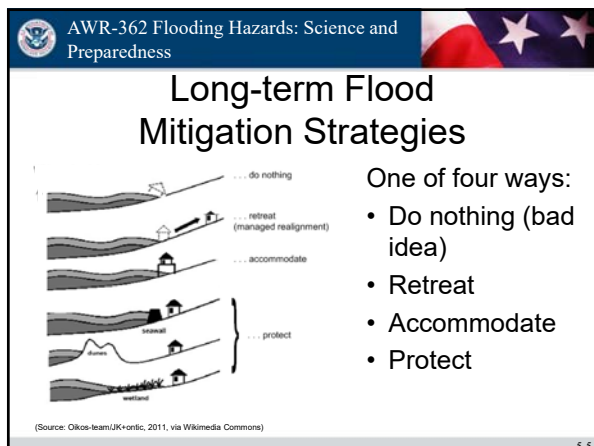
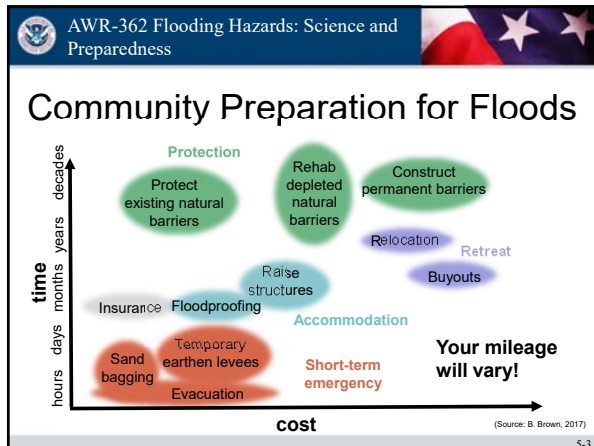
FEMA

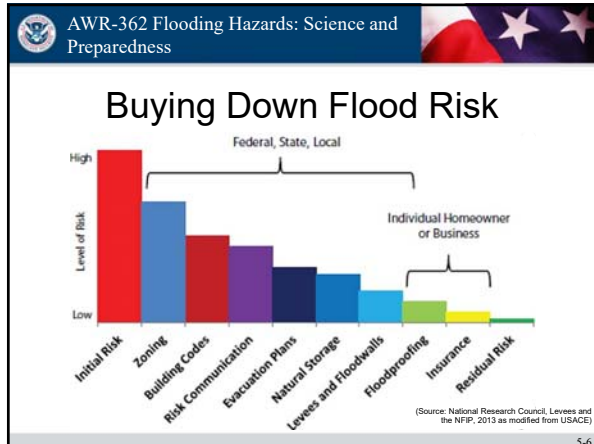


## Enabling Learning Objectives

- 5-1 Describe mitigation strategies that reduce flood risk
- 5-2 Identify partners and methods that can assist in mitigation implementation

5-2



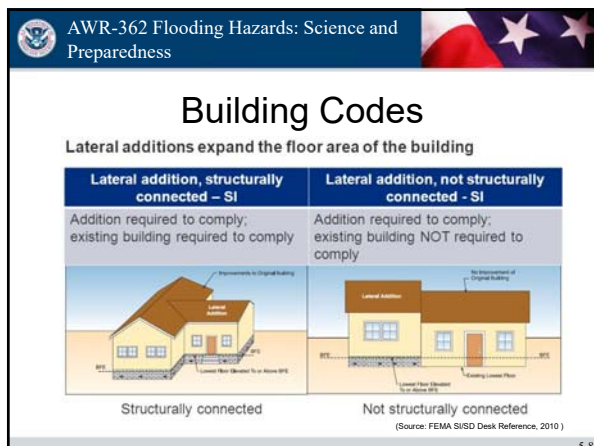


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## Zoning

- Overlay Zones
- Low Density Zones
- Conservation Zones
- Transfer of Development Rights (TDR)

(Source: FEMA, 2017)



## Risk Communication

- Be prepared to present a unified message through many channels
- Model press releases, Tweets, and Facebook posts addressing public risk factors

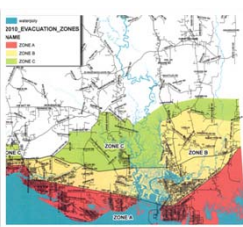


(Source: FEMA, 2015)

s. 9

## Evacuation Plans

Evacuation routes should always be clearly marked for those unfamiliar with the area



(Source: FEMA/USACE via UCAR, 2010)



(Source: FEMA, 2017)

s. 10

## Natural Storage and Buffers



(Source: NOAA Narr Marine and Fisheries Service, 2011)

- Mangrove Stands
- Coral Reefs
- Wetlands
- Estuaries

s. 11

## Levees and Floodwalls



(Source: FEMA, 2011)



(Source: FEMA, 2013)

s.12

## Floodproofing

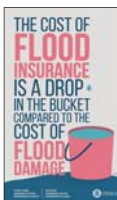
- A **wet** floodproofed structure allows floodwaters to enter the enclosed areas of a house
- A **dry** floodproofed structure is made watertight below the level that needs flood protection to prevent floodwaters from entering
  - Dry floodproofing may not be done to bring a noncompliant structure into compliance



(Source: FEMA, 2013)

s.13

## Individual Risk Management and Insurance



(Source: FEMA, 2017)

- When the individual is responsible for their own risk, the community's work is reduced
- Encourage individuals to:
  - Ensure property is elevated above flood risk
  - Invest in mitigation aids such as sand bags or personal flood control measures
  - Research alternative parking areas for cars and personal property, alternative routes
  - Buy flood insurance

s.14

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## Funding Options (Besides Taxes)

- Grants ( FEMA: mitigation grants: Flood, Pre-disaster, Hazard)
- Bonds
- Utilities
- Special districts
- Impact fees
- Tax increment financing
- Municipal Improvement Districts (MID)

(Source: FEMA, 2014)

S.15

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## Available Community Advice

(Source: FEMA, 2017)

- Via state NFIP offices
- Via professional organizations (floodplain managers associations, state stormwater managers associations, planners associations)
- Via grant coordinators

S.16



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## Partners in Preparation: U.S. Army Corps of Engineers

- USACE provides disaster preparedness, response services, and advanced planning measures under the Flood Control and Coastal Emergency Act
- Civil Works program includes dam safety, flood risk management, levee safety, regulatory permitting
- Expertise in sustainability and resilience

(Source: USACE, undated, accessed 2017)



S.17

 AWR-362 Flooding Hazards: Science and Preparedness 

## Available Individual Assistance

- Prior to an event through online guidance:
  - <https://www.ready.gov>
  - <http://www.floodsmart.gov>
  - [How to Prepare for a Flood](#) booklet via FEMA
- Following an event in the form of Individual Assistance grants (if approved)


s.18

 AWR-362 Flooding Hazards: Science and Preparedness 


## Summary

- Described mitigation strategies that reduce flood risk
- Identified partners and methods that can assist in mitigation implementation

s.19



**AWR-362 Flooding Hazards: Science and Preparedness**  
Module 6: Course Summary and Administration  
*Version 1.0*

 **FEMA**

AWR-362 Flooding Hazards: Science and Preparedness

## Enabling Learning Objectives

- 6-1 Identify additional resources and training opportunities
- 6-2 Provide feedback on a course evaluation form
- 6-3 Complete a post-test

6.3

AWR-362 Flooding Hazards: Science and Preparedness

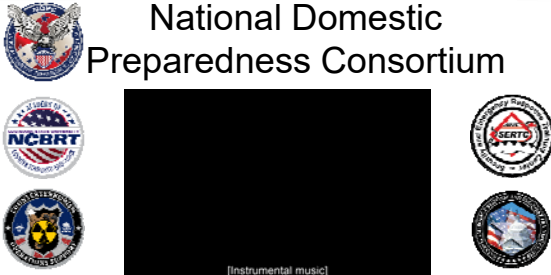
## Course Summary

*Prepare participants to recognize the conditions that lead to flood events, evaluate their community's risk, and prepare appropriately*

6.3


AWR-362 Flooding Hazards: Science and Preparedness

## National Domestic Preparedness Consortium



[instrumental music]

www.ndpc.us



6.4

## Course Evaluation

A detailed form titled "Student Assessment of Course and Instructors" with multiple sections for rating various aspects of the course and instructors. It includes a header with the NDPTC logo and a table of evaluation items.

6.5

## Post-test

A form titled "Year Answer Sheet" with a header including the NDPTC logo. It contains a grid for recording answers to multiple-choice questions, with columns labeled A, B, C, and D.

6.6

## Thank You!



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 website: ndptc.hawaii.edu

6.7