Hazardous Weather and Flooding Preparedness
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A Cooperative Effort
Administrative Information

- Emergency exits and procedures
- Location of restrooms
- Mobile devices
- Procedure for questions
- Course materials
- Evaluation & Certificates
Unit 1: Introduction and Course Overview
Importance of Hazardous Weather Training

• Allows you to perform more effectively
• Enables you to make better emergency management decisions

✓ Preparedness ✓ Mitigation
✓ Protection ✓ Response
✓ Prevention ✓ Recovery
Hazardous weather and flooding preparedness requires a team approach
Course Goals

To enable you to:

• Recognize potentially hazardous weather and flooding situations

• Plan appropriately

• Coordinate warnings and responses
Units of Instruction

<table>
<thead>
<tr>
<th>Unit 1</th>
<th>Introduction and Course Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 2</td>
<td>Weather Overview</td>
</tr>
<tr>
<td>Unit 3</td>
<td>Introduction to Hazardous Weather</td>
</tr>
<tr>
<td>Unit 4</td>
<td>Role of the Emergency Manager</td>
</tr>
<tr>
<td>Unit 5</td>
<td>NWS Hazardous Weather Products</td>
</tr>
<tr>
<td>Unit 6</td>
<td>Projecting the Impacts of Hazardous Weather and Flooding</td>
</tr>
<tr>
<td>Unit 7</td>
<td>Activity</td>
</tr>
<tr>
<td>Unit 8</td>
<td>Course Summary</td>
</tr>
</tbody>
</table>
Course Objectives (1 of 2)

• Analyze how the components of weather interact to create hazardous weather

• Anticipate the impact of hazardous weather events to enhance preparedness

• Evaluate actions taken by Emergency Managers to prepare for and respond to, actual hazardous weather events
Course Objectives (2 of 2)

• Interpret information contained in National Weather Service forecast and warning products, as well as in other weather resources

• Assess your community’s state of readiness for hazardous weather and flooding events

• Evaluate the effectiveness of emergency response actions for a given scenario
Course Schedule

• Day 1: Units 1–4
• Day 2: Units 5–8
Participant Introductions

• Name
• Location
• Job description
  – Primary responsibilities
  – Hazardous weather and flooding preparedness expertise/experience
• Training goals/expectations
Hazardous Weather in the U.S.

Annual averages:
- 100,000 thunderstorms
- 5,000 floods
- 1,300 tornadoes
- 6 Atlantic hurricanes
- 600 fatalities
- $14B in losses
Tornadoes

• 10 times more tornadoes in the U.S.
• 70-75 deaths per year on average
• People at greatest risk in mobile homes or outdoors
• Safest place is underground or in properly built safe room
Flash Floods

• Over 90 deaths each year
• Nearly half due to driving through flood waters
• Many flash floods occur at night
Severe Thunderstorms

- Damaging hail
- Destructive winds
- Potential tornadoes
- Frequent lightning
Extreme Temperatures

• Cause approximately 1,100 deaths in the U.S. each year
• Most at risk:
  – Elderly
  – Children
  – People with chronic medical conditions
  – People outdoors
Winter Storms

• Transportation interruptions impact:
  – Goods and services
  – Emergency vehicles
  – Local transportation

• Extended power outages can lead to:
  – Hypothermia
  – Carbon monoxide poisoning
Tropical Cyclones

- Nearly 50 deaths per year
- Over $5 billion in damages per year
- Include:
  - Hurricanes
  - Typhoons
  - Tropical storms
  - Tropical depressions
Tsunamis

• Series of ocean waves
• Caused by:
  – volcanic eruptions
  – undersea earthquakes
  – landslides
• High hazard in the Pacific and Caribbean
• Low hazard but high impact for Atlantic and Gulf of Mexico
Space Weather

• Solar storms that impact the Earth and our technological systems

• NWS’ Space Weather Prediction Center warns for space weather hazards

• Impacts can include:
  – Radio communications outages
  – Power disruptions
  – Significant GPS errors
Case Study:

Palm Sunday Tornado Event
Unit Summary

• What to expect from the course
• The importance of planning for hazardous weather events
Unit 2: Weather Overview
(Northern Hemisphere and the U.S.)
Objectives

• Define basic components of weather
• Distinguish between high and low pressure areas on a map
• Calculate the dew point using a conversion chart, when given the relative humidity and temperature
• Describe weather patterns
Basic Components of Weather

- Temperature
- Moisture
- Air Pressure
- Wind
Temperature

• Degree of heat in the atmosphere
• Measures heat energy and expresses molecular activity
• Hot air is less dense and rises
• Cold air is more dense and sinks
• Molecules move to equalize temperature variations
• Temperature variations influence atmospheric circulation
Moisture

• Enters atmosphere as water vapor
• Condensation creates:
  – Clouds
  – Rain
  – Dew
  – Frost
  – Fog
Air Pressure

• Amount of force exerted on the Earth by the air mass above a given location
• Measured by one-square-inch columns of air extending through atmosphere
• Molecules in atmosphere move to equalize pressure
Isobars

Lines that connect points of equal air pressure on the Earth’s surface

Image Credit: National Oceanic and Atmospheric Administration
Wind

- Movement of air due to pressure differences
- Flow determined by:
  - Pressure gradient force
  - Coriolis Effect
  - Friction

Image Credit: National Oceanic and Atmospheric Administration
Pressure Patterns

- Low
- High
- Trough
- Ridge

Image credit: National Oceanic and Atmospheric Administration
Walkthrough: Reading a Surface Pressure Map

Activity/Image Source: National Weather Service
JetStream Online School for Weather
Reading a Surface Pressure Map
Isobars

[Diagram of isobars with numerical values]
Areas of High and Low Pressure
Areas of Expected Precipitation
Wind Direction
Moisture: Fuel for Severe Weather

<table>
<thead>
<tr>
<th>Dew Point</th>
<th>Relative Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature to which air must be cooled to be saturated</td>
<td>Percentage of water vapor in air compared to what the air is capable of holding</td>
</tr>
</tbody>
</table>
Converting Relative Humidity to Dew Point

Example:

• Relative humidity = 50%
• Temperature = 50°F
• Dew point = ?
Converting Relative Humidity to Dew Point

Practice #1:
- Relative humidity = 85%
- Temperature = 80°F
- Dew point = ?
Converting Relative Humidity to Dew Point

Practice #2:

• Relative humidity = 60%
• Temperature = 80°F
• Dew point = ?

<table>
<thead>
<tr>
<th>RH (%)</th>
<th>DP (°F)</th>
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<tbody>
<tr>
<td>97</td>
<td>T – 1</td>
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<tr>
<td>94</td>
<td>T – 2</td>
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<td>91</td>
<td>T – 3</td>
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<td>88</td>
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<td>85</td>
<td>T – 5</td>
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<td>82</td>
<td>T – 6</td>
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<td>79</td>
<td>T – 7</td>
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<td>76</td>
<td>T – 8</td>
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<td>73</td>
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<td>70</td>
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<td>T – 12</td>
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<td>62</td>
<td>T – 14</td>
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<td>60</td>
<td>T – 15</td>
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<td>58</td>
<td>T – 16</td>
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<td>56</td>
<td>T – 17</td>
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<td>54</td>
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<td>52</td>
<td>T – 19</td>
</tr>
<tr>
<td>50</td>
<td>T – 20</td>
</tr>
</tbody>
</table>
Precipitation

Occurs when the atmosphere can no longer hold moisture

<table>
<thead>
<tr>
<th>Frozen Precipitation</th>
<th>Unfrozen Precipitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow</td>
<td>Drizzle</td>
</tr>
<tr>
<td>Sleet</td>
<td>Rain</td>
</tr>
<tr>
<td>Hail</td>
<td></td>
</tr>
</tbody>
</table>
Winter Precipitation: Snow

- Surface temperature increases with height then decreases
- Temperature remains below freezing and precipitation falls as snow

Image credit: National Oceanic and Atmospheric Administration
Winter Precipitation: Sleet

- Temperature increases to above freezing before decreasing
- Snowflakes partially melt and then refreeze into ice pellets

Image credit: National Oceanic and Atmospheric Administration
Winter Precipitation: Freezing Rain

- Precipitation becomes rain in warm layer
- Falls back into below freezing air temperature
- No time to refreeze into sleet but freezes on contact

Image credit: National Oceanic and Atmospheric Administration
How do the Great Lakes affect weather in warm conditions?
Air Masses

Moisture:
- m-Maritime (moist)
- c-continental (dry)

Temperature:
- A- Arctic latitudes
- P- Polar latitudes
- T- Tropical latitudes

Image credit: National Oceanic and Atmospheric Administration
Fronts

- Cold fronts
- Warm fronts
- Stationary fronts
- Occluded fronts
- Drylines

Image credit: National Oceanic and Atmospheric Administration
Cold Front

- Leading edge of an advancing cold air mass
- Creates thunderstorms and severe weather conditions
- Shown on weather maps as a straight line with triangles hanging below it

Image credit: National Oceanic and Atmospheric Administration
Warm Front

• Edge of an advancing warm air mass
• Usually moves slowly
• Brings precipitation
• Shown on weather maps as a straight line with half circles on top of it

Image credit: National Oceanic and Atmospheric Administration
Stationary Fronts

- Creates the potential for long-term precipitation
- Shown on weather maps as a straight line with blue triangles below and red semicircles on top
Fronts on a Weather Map

Image credit: National Oceanic and Atmospheric Administration
What are the four basic components of weather that contrast sharply in the area of a front?
Low Pressure Development

COLD

WARM
Low Pressure Development

COLD

WARM
Low Pressure Development
Low Pressure Development

Diagram showing the movement of low pressure areas with indications of Warm and Cool regions.
Low Pressure Development
Low Pressure Development

[Map showing weather patterns with labels COLD and WARM]
Prevailing Westerlies
Jet Streams
Prevailing Westerlies Affected by Jet Stream
Shift in Jet Stream
Unit Summary

• Define basic components of weather
• Distinguish between high and low pressure areas on a map
• Calculate the dew point using a conversion chart, when given the relative humidity and temperature
• Describe weather patterns
Unit 3: Introduction to Hazardous Weather
Unit Objectives

• Describe various types of hazardous weather
• Summarize potential dangers caused by hazardous weather
• Explain how community and environmental factors can worsen the impact of hazardous weather
Hazardous Weather Events
Choose a Natural Hazard

- Thunderstorms
- Tornadoes
- Flash Floods
- River Floods
- Coastal or Lakeshore Floods
- Extratropical Cyclones
- Tropical Cyclones
- Tsunamis
- Winter Storms
- Excessive Cold
- Fog
- Excessive Heat
- Dust Storms
- Wind Storms
- Fire Weather
- Space Weather
- Volcanic Ash
- Go to Activity
Thunderstorms

• Local storm produced by a cumulonimbus cloud
• Accompanied by lightning, thunder, gusty winds, heavy rain, and hail
• May be violent
Thunderstorm Hazards

- Lightning
- Hail
- Damaging winds
- Flash flooding
- Tornadoes
- Wildfires
# Thunderstorm Classifications

<table>
<thead>
<tr>
<th>Category</th>
<th>Wind Speed</th>
<th>Precipitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary</td>
<td>&lt; 35 knots (40 mph)</td>
<td>Variable</td>
</tr>
<tr>
<td>Approaching</td>
<td>≥ 35 knots (40 mph)</td>
<td>Hail &gt; ¾ inch</td>
</tr>
<tr>
<td>Severe</td>
<td>≥ 50 knots (58 mph)</td>
<td>Hail ≥ 1 inch</td>
</tr>
</tbody>
</table>
Thunderstorm Ingredients

- Moisture
- Instability
- Lift
Stages of Thunderstorms

- **Developing Stage**: 0°C, 5-8 km
- **Mature Stage**: 0°C, 8-16 km
- **Dissipating Stage**: 0°C, 8-11 km
Types of Thunderstorms

- Single Cell
- Multicell
- Squall Line
- Supercell
Severity of Thunderstorms

Lifted Index (LI)

Convective Available Potential Energy (CAPE)
Surface Weather Map

LI = -12

CAPE = >4500 J/kg
Thunderstorms: Damaging Winds

- Straight-line winds
- Downbursts
- Micro bursts
- Gust fronts
Pennsylvania Severe Wind Reports

Data Source: NWS Storm Prediction Center
All times are Eastern Daylight Time (EDT)
Pennsylvania Severe Wind Reports

Pennsylvania Severe Wind Reports

PENNSYLVANIA SEVERE WIND REPORTS
BY MONTH (1955-2015)

Data Source: NWS Storm Prediction Center
Thunderstorms: Hail

- Updrafts carry water droplets to a freezing altitude
- Ice chunks become too large to be sustained by updrafts
- Ice falls to earth as hail
- Can reach speeds of 100+ mph
- Largest hailstone measured was 8 inches wide!
Thunderstorms: Hail

Falling raindrops...

Hail Size Comparison Chart

- CD/DVD: Approximately 4 1/2 inches
- Golf Ball: 1 1/8 inches
- Pool Ball: 2 1/8 inches
- Baseball: 1 1/2 inches

Produced by Michael F. Lema, NWS, National Weather Service, Yankton, South Dakota
Pennsylvania Severe Hail Reports

Data Source: NWS Storm Prediction Center
Thunderstorms: Lightning

- Powerful discharge between cloud and ground
- No safe place outdoors!
Thunderstorms: Lightning
Thunderstorms: Lightning
May 4, 2003 Thunderstorms
Tornadoes

- Most violent storms on earth
- Typically develop along a dryline
- Often occur in early spring

F3 tornado, Le Sueur County, Minnesota, 08/24/2006
Credit: Wikimedia/Joshua Jans
Tornado Alley

Map showing the region of Tornado Alley in the United States, with areas labeled as Cold Dry Air, Warm Dry Air, Warm Moist Air, and Tornado Alley itself.

FEMA
Hazardous Weather and Flooding Preparedness
Tornado Characteristics

- Destructive wind
- Movement
- Rain/hail
Pennsylvania Tornadoes

**Pennsylvania Tornadoes**

*By Intensity (1950-2017)*

- **EF-0**: 208
- **EF-1**: 393 95%
- **EF-2**: 154
- **EF-3**: 27
- **EF-4**: 10
- **EF-5**: 1

*Data Source: NWS Storm Prediction Center, NWS Public Information Statements*

*Note: Note Fujita (F) Scale upgraded to Enhanced Fujita (EF) Scale in 2007*

*2015-2017 Data are Preliminary*
Pennsylvania Tornadoes

![Bar chart showing Pennsylvania tornado occurrences by hour (1950-2017).]

Data Source: NWS Storm Prediction Center, NWS Public Information Statements
All times are Eastern Daylight Time (EDT)
*2015-2017 Data are Preliminary
Pennsylvania Tornadoes

PENNSYLVANIA TORNADOES
BY MONTH (1950-2017*)

Data Source: NWS Storm Prediction Center, NWS Public Information Statements
*2015-2017 Data are Preliminary
Pennsylvania Tornadoes

Data Source: NWS Storm Prediction Center, NWS Public Information Statements
Note: Prior to radar usage in the 1970s, many tornadoes were unreported
*2015-2017 Data are Preliminary
1985 Wheatland PA Tornado
Funnel Clouds and Waterspouts
The Enhanced Fujita Scale

<table>
<thead>
<tr>
<th>FUJITA SCALE</th>
<th>DERIVED EF-SCALE</th>
<th>OPERATIONAL EF-SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F Number</td>
<td>Fastest 1/4-mile (mph)</td>
<td>3 Second Gust (mph)</td>
</tr>
<tr>
<td>0</td>
<td>40-72</td>
<td>45-78</td>
</tr>
<tr>
<td>1</td>
<td>73-112</td>
<td>79-117</td>
</tr>
<tr>
<td>2</td>
<td>113-157</td>
<td>118-161</td>
</tr>
<tr>
<td>3</td>
<td>158-207</td>
<td>162-209</td>
</tr>
<tr>
<td>4</td>
<td>208-260</td>
<td>210-261</td>
</tr>
<tr>
<td>5</td>
<td>261-318</td>
<td>262-317</td>
</tr>
<tr>
<td>#</td>
<td>Damage Indicator</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Small barns, farm outbuilding</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>One- or two-family residence</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Single-wide mobile home</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Double-wide mobile home</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Apt, condo, townhouse</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Motel</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Masonry apt. or motel</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Small retail bldg</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Small professional bldg</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Strip mall</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Large shopping mall</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Large, isolated retail bldg</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Automobile showroom</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Automotive service bldg</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>School, elementary</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>School, junior or senior high</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Low-rise bldg</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Mid-rise bldg</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>High-rise bldg</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Institutional bldg</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Metal bldg system</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Service station canopy</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Warehouse</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Transmission line tower</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Free-standing tower</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Free-standing pole</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Tree – hardwood</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Tree - softwood</td>
<td></td>
</tr>
</tbody>
</table>
Example
## Degree of Damage (DI = 2)

<table>
<thead>
<tr>
<th>DOD</th>
<th>Damage Description</th>
<th>EXP</th>
<th>LB</th>
<th>UB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Threshold of visible damage</td>
<td>65</td>
<td>53</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>Some loss of roof covering material, gutters, awning, or siding</td>
<td>79</td>
<td>63</td>
<td>97</td>
</tr>
<tr>
<td>3</td>
<td>Broken glass in doors and windows</td>
<td>96</td>
<td>79</td>
<td>114</td>
</tr>
<tr>
<td>4</td>
<td>Uplift of roof deck, significant loss of material</td>
<td>97</td>
<td>81</td>
<td>116</td>
</tr>
<tr>
<td>5</td>
<td>Entire house shifts off foundation</td>
<td>121</td>
<td>103</td>
<td>141</td>
</tr>
<tr>
<td>6</td>
<td>Large sections of roof removed</td>
<td>122</td>
<td>104</td>
<td>142</td>
</tr>
<tr>
<td>7</td>
<td>Exterior walls collapsed</td>
<td>132</td>
<td>113</td>
<td>153</td>
</tr>
<tr>
<td>8</td>
<td>Most walls collapsed</td>
<td>152</td>
<td>127</td>
<td>178</td>
</tr>
<tr>
<td>9</td>
<td>All walls</td>
<td>170</td>
<td>142</td>
<td>198</td>
</tr>
<tr>
<td>10</td>
<td>Slab swept clean</td>
<td>200</td>
<td>165</td>
<td>220</td>
</tr>
</tbody>
</table>
## The Enhanced Fujita Scale

<table>
<thead>
<tr>
<th>F Number</th>
<th>Fastest 1/4-mile (mph)</th>
<th>3 Second Gust (mph)</th>
<th>EF Number</th>
<th>3 Second Gust (mph)</th>
<th>EF Number</th>
<th>3 Second Gust (mph)</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>40-72</td>
<td>45-78</td>
<td>0</td>
<td>65-85</td>
<td>0</td>
<td>65-85</td>
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<tr>
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<td>73-112</td>
<td>79-117</td>
<td>1</td>
<td>86-109</td>
<td>1</td>
<td>86-110</td>
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<tr>
<td>2</td>
<td>113-157</td>
<td>118-161</td>
<td>2</td>
<td>110-137</td>
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<td>111-135</td>
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<tr>
<td>3</td>
<td>158-207</td>
<td>162-209</td>
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<td>138-167</td>
<td>3</td>
<td>136-165</td>
</tr>
<tr>
<td>4</td>
<td>208-260</td>
<td>210-261</td>
<td>4</td>
<td>168-199</td>
<td>4</td>
<td>166-200</td>
</tr>
<tr>
<td>5</td>
<td>261-318</td>
<td>262-317</td>
<td>5</td>
<td>200-234</td>
<td>5</td>
<td>Over 200</td>
</tr>
</tbody>
</table>
May 22, 2011 Tornado, Joplin MO

Photo credit (both images): NOAA
May 3, 1999 Tornado Event, OK-KS
Flash Floods

- Heavy rains
- Dam or levee failure
- Water from breakup of ice
- Intense rainfall on impervious areas
Flash Flood Factors

- Rainfall intensity and duration
- Topography
- Soil composition
- Ground cover
Flash Flood Hazards

- Force of water
- Debris flows
- Mud slides
Historical Examples

1990 Ohio Flood

1985 Wyoming Flood

2010 Campgrounds Flood
River Floods

- Long-term event
- Along rivers and streams
- Natural and inevitable
River Flood Factors

- Heavy rainfall from large-scale storms
- Stationary or slow-moving thunderstorms
- Land-falling tropical storms / hurricanes
- Saturated soil from previous rainfall
- High existing river flows
- River ice jams
- Rapid snowmelt
- Aggradation
- Large watersheds
- Watershed development
River Flood Hazards

- Damaged buildings and vehicles
- Uprooted trees
- Drowning
- Drinking water contamination
- Hazardous material release
- Sewer overflows
- Debris with sharp objects
- Communications and/or transportation interruptions
- Fires
Tennessee Flood of 2010

Opryland area photo copyright Metropolitan Government of Nashville and Davidson County, Gary Layda, Photographer. Nashville skyline photo courtesy of USGS.
Great Flood of 1993
Coastal and Lakeshore Flooding Terms

- Surf
- MSL
- Tidal Cycle
- Datum Plane

- Seiche
- Storm Surge
- Swell
Storm Surge Characteristics

- Caused by storm winds across water
- Worsened by above normal tide levels
- Development factors include:
  - Low barometric pressure
  - Wind
Coastal Floods

- Inundation of land along the oceanic coast by sea waters
- Originates from ocean front, back bays, and sounds
- Affects public and maritime interests
Coastal Flood Ingredients

Results from:

• Storm surge and/or seiche reaching land
• Heavy surf
• Tidal piling
Coastal Flood Factors

- Tidal cycles
- Persistence and behavior of the storm
- Topography, shoreline orientation, and bathymetry of the area
- River stage or stream run-off
- Presence or absence of offshore reefs
Coastal Flooding Hazards

- High winds
- Quickly rising water levels
- Fierce wave action
- Shore erosion, seawall destruction
- Debris from destroyed property
- Destruction of protective dunes and barrier islands
Lakeshore Flooding

- Affects general public and marine interests
- Causes are variable
- Extent of the flooding is dependent on the shore terrain
Lakeshore Flooding Hazards

- High winds
- Quickly rising water levels
- Fierce wave action
- Shore erosion
- Debris carried by water
Lakeshore Flooding Examples

• Ottawa, Erie, Lucas, and Sandusky Counties, Ohio: November 11, 1998
• New York Shore of Lake Erie: November 6, 2005
Extratropical Cyclones

- Low-pressure storms
- Form off the Pacific coast, in Gulf of Mexico, over the Atlantic, or in Great Lakes
Extratropical Cyclone Characteristics

• Form outside the tropics
• Cover area 700-1000 miles across
• Center is colder than surrounding air
• Winds are strongest in upper atmosphere
Extratropical Cyclone Hazards

• Swells, storm surges, and huge waves
• High winds
• Heavy rains, flooding, and flash flooding

• Heavy snow
• Mud slides
• Downbursts
• Tornadoes
• Ice Storms
1993 Superstorm
Tropical Cyclones

- Coastal storms that form within the tropics
- Storm center is warmer than the surrounding air
- Winds are strongest at 10,000 feet
# Tropical Cyclone Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical Depression</td>
<td>Maximum sustained winds near the surface less than 39 mph</td>
</tr>
<tr>
<td>Tropical Storm</td>
<td>Winds of 39–73 mph</td>
</tr>
<tr>
<td>Hurricanes or Typhoons</td>
<td>Winds of 74 mph or more</td>
</tr>
</tbody>
</table>
Hurricane Ingredients

- Water over 80°F and 200 feet deep
- Winds converging near water surface
- Unstable air and humidity
- Winds moving in one direction
- Upper atmosphere high pressure
## Hurricane Classifications

<table>
<thead>
<tr>
<th>Category</th>
<th>Central Pressure (Millibars)</th>
<th>Central Pressure (Inches)</th>
<th>Winds (MPH)</th>
<th>Wind (KTS)</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>≥ 980</td>
<td>28.94</td>
<td>74 – 95</td>
<td>64 – 82</td>
<td>Minimal</td>
</tr>
<tr>
<td>2</td>
<td>965 – 979</td>
<td>28.50 – 28.93</td>
<td>96 – 110</td>
<td>83 – 95</td>
<td>Moderate</td>
</tr>
<tr>
<td>3</td>
<td>945 – 964</td>
<td>27.91 – 28.49</td>
<td>111 – 129</td>
<td>96 – 112</td>
<td>Extensive</td>
</tr>
<tr>
<td>4</td>
<td>920 – 944</td>
<td>27.17 – 27.90</td>
<td>130 – 156</td>
<td>113 – 136</td>
<td>Extreme</td>
</tr>
<tr>
<td>5</td>
<td>&lt; 920</td>
<td>&lt; 27.17</td>
<td>&gt; 156</td>
<td>&gt; 136</td>
<td>Catastrophic</td>
</tr>
</tbody>
</table>
Hurricane Hazards

- Coastal flooding
- Wind storms
- Riverine/flash flooding
- Tornadoes
Hurricane Katrina
Tsunamis

• Series of ocean waves of extremely long length
• Generated by:
  – Earthquakes (primarily)
  – Volcanic eruptions
  – Landslides
  – Asteroid impacts

NOAA News Photo
Tsunami Characteristics

• Can be 100 miles or more from crest to crest
• 2-3 inches high in deep ocean
• 30-100 feet high near land
• Wave speed of up to 500 mph
Tsunami Types

Local/Regional
- Source generally within 1,000 km
- Response time = minutes
- Automatic public evacuation required

Distant (Teletsunami)
- Source generally more than 1,000 km away
- Response time = a few hours
- Organized evacuation possible
Tsunami Hazards

• Coastal tsunami inundation
• Damage from debris
Tsunami Information

NWS tsunami warning centers:

• Alaska Tsunami Warning Center (ATWC)
• Pacific Tsunami Warning Center (PTWC)
2009 Tsunami in American Samoa
Winter Storms

Extratropical storms that bring:

• Cold temperatures
• Precipitation
• High winds
Winter Storm Ingredients

- Cold air
- Moisture
- Lift
Winter Storm Conditions
Winter Storm Hazards

- Strong winds
- Extreme cold
- Precipitation
- Blizzard conditions
1993 Superstorm
January 2016 Snowtorm
Pennsylvania Average Snowfall
Excessive Cold

- Varies according to the normal climate of a region
- May accompany or follow winter storms
- Can occur without storm activity
# Excessive Cold: Wind Chill

<table>
<thead>
<tr>
<th>Wind</th>
<th>30°</th>
<th>25°</th>
<th>20°</th>
<th>15°</th>
<th>10°</th>
<th>5°</th>
<th>0°</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 mph</td>
<td>19°</td>
<td>13°</td>
<td>6°</td>
<td>0°</td>
<td>-7°</td>
<td>-13°</td>
<td>-19°</td>
</tr>
<tr>
<td>20 mph</td>
<td>17°</td>
<td>11°</td>
<td>4°</td>
<td>-2°</td>
<td>-9°</td>
<td>-15°</td>
<td>-22°</td>
</tr>
<tr>
<td>25 mph</td>
<td>16°</td>
<td>9°</td>
<td>3°</td>
<td>-4°</td>
<td>-11°</td>
<td>-17°</td>
<td>-24°</td>
</tr>
<tr>
<td>30 mph</td>
<td>15°</td>
<td>8°</td>
<td>1°</td>
<td>-5°</td>
<td>-12°</td>
<td>-19°</td>
<td>-26°</td>
</tr>
</tbody>
</table>
Extreme Cold Hazards

- Frostbite
- Hypothermia
- Death
December 1992 Blizzard
Fog

• Water droplets suspended in the air
• Hazardous when visibility is reduced to 1/4 mile or less
Fog Characteristics and Hazards

- Intensity and duration varies with location and type
- Reduces visibility for motorists and air traffic
2007 California Multi-vehicle Accident
Excessive Heat

Occurs from a combination of high temperatures and high humidity
Excessive Heat Characteristics

• Definition varies according to normal climate
• Death rates affected by:
  – Sudden rise in temperature
  – Prolonged heat waves
Heat Index

NOAA's National Weather Service

Heat Index

Temperature (°F)

Relative Humidity (%)

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

- Caution
- Extreme Caution
- Danger
- Extreme Danger
Extreme Heat Hazards

- Mechanical and electrical failures
- Heat cramps
- Fainting
- Heat exhaustion
- Heatstroke
July 1995 Heat Wave
Dust Storms

Particles of dust or sand lifted into the air by strong winds
Dust Storm Hazards

- Injury, especially respiratory issues
- Reduced visibility
- Damage to crops, buildings, and vehicles
- Abrasive effect on machinery
- Power outages
Types of Dust Storms

• Non-convective
  – Caused by sustained high wind at the surface
  – May last several hours or days

• Convective
  – Caused by thunderstorm or microburst
  – Usually sudden and short-lived
## Dust Storm Characteristics

<table>
<thead>
<tr>
<th>Factor</th>
<th>Nonconvective Events</th>
<th>Convective Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of onset</td>
<td>• Recognizable weather patterns</td>
<td>• Predictable over an area of jurisdiction within 0-3 hours</td>
</tr>
<tr>
<td></td>
<td>• Easily identified 24 to 36 hours in advance</td>
<td>• Locations identifiable minutes in advance</td>
</tr>
<tr>
<td>Duration</td>
<td>Ranges 3-4 hours to 2-3 days</td>
<td>• Microbursts – a few seconds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Macrobursts – a few minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Wake depression – up to two hours</td>
</tr>
<tr>
<td>Timing</td>
<td>• Occur mainly during the late winter and early spring</td>
<td>• Usually occur during the spring and summer</td>
</tr>
<tr>
<td></td>
<td>• Conditions worsen during late morning</td>
<td>• Occur in association with late afternoon or evening thunderstorms</td>
</tr>
<tr>
<td></td>
<td>• Most intense during late afternoon</td>
<td></td>
</tr>
</tbody>
</table>
April 1995 Arizona Dust Storm
Wind Storms

Require a warning when:

- Sustained winds of 40+ mph last 1 hour or longer
- Winds of 58+ mph occur
Types of Nonconvective Wind

- Gradient High Winds
- Mesoscale High Winds
- Channeled High Winds
- Tropical Cyclone Associated High Winds
- Chinook or Foehn Winds
Wind Storm Ingredients

Extreme pressure gradient caused by:

- Terrain effect
- Temperature differences, as with downslope winds
- Mesoscale systems or convective complexes
Wind Storm Hazards

• Impaired visibility
• Crop damage
• Destruction to buildings and vehicles
• Power outages and other infrastructure damage
• Broken trees
November 1991
California Wind Storm
# Beaufort Wind Scale

<table>
<thead>
<tr>
<th>Beaufort number</th>
<th>Wind Speed (mph)</th>
<th>Seaman’s term</th>
<th>Effects on Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Under 1</td>
<td>Calm</td>
<td>Calm; smoke rises vertically.</td>
</tr>
<tr>
<td>1</td>
<td>1-3</td>
<td>Light Air</td>
<td>Smoke drift indicates wind direction; vanes do not move.</td>
</tr>
<tr>
<td>2</td>
<td>4-7</td>
<td>Light Breeze</td>
<td>Wind felt on face; leaves rustle; vanes begin to move.</td>
</tr>
<tr>
<td>3</td>
<td>8-12</td>
<td>Gentle Breeze</td>
<td>Leaves, small twigs in constant motion; light flags extended.</td>
</tr>
<tr>
<td>4</td>
<td>13-18</td>
<td>Moderate Breeze</td>
<td>Dust, leaves and loose paper raised up; small branches move.</td>
</tr>
<tr>
<td>5</td>
<td>19-24</td>
<td>Fresh Breeze</td>
<td>Small trees begin to sway.</td>
</tr>
<tr>
<td>6</td>
<td>25-31</td>
<td>Strong Breeze</td>
<td>Large branches of trees in motion; whistling heard in wires.</td>
</tr>
<tr>
<td>7</td>
<td>32-38</td>
<td>Moderate Gale</td>
<td>Whole trees in motion; resistance felt in walking against the wind.</td>
</tr>
<tr>
<td>8</td>
<td>39-46</td>
<td>Fresh Gale</td>
<td>Twigs and small branches broken off trees.</td>
</tr>
<tr>
<td>9</td>
<td>47-54</td>
<td>Strong Gale</td>
<td>Slight structural damage occurs; slate blown from roofs.</td>
</tr>
<tr>
<td>10</td>
<td>55-63</td>
<td>Whole Gale</td>
<td>Seldom experienced on land; trees broken; structural damage occurs.</td>
</tr>
<tr>
<td>11</td>
<td>64-72</td>
<td>Storm</td>
<td>Very rarely experienced on land; usually with widespread damage.</td>
</tr>
<tr>
<td>12</td>
<td>73 or higher</td>
<td>Hurricane Force</td>
<td>Violence and destruction.</td>
</tr>
</tbody>
</table>
Fire Weather

Meteorological conditions that promote the spread of wildfire
Fire Weather Terms

• Fire Danger
• Prescribed Burn
• Wildfire
• Wildlands
• Red Flag Warning
  – Sustained wind of 20mph for ≥2hrs
  – ≤30% Relative Humidity
  – ≤10% 10-hour Fuel Moisture
Fire Weather Hazards

- Destruction of property
- Injury
- Death
- Secondary effects:
  - Erosion
  - Landslides
  - Water quality problems
Fire Weather Ingredients

- Low humidity
- High winds
- Dry thunderstorms
- Unstable air
Other Factors

- Dry conditions
- Urban-wildland interface
- Available fuel
- Hilly terrain

Large wildfires 1980-2003
## Wildfire Categories

<table>
<thead>
<tr>
<th>Haines Index</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 or 3</td>
<td>Very Low</td>
</tr>
<tr>
<td>4</td>
<td>Low</td>
</tr>
<tr>
<td>5</td>
<td>Moderate</td>
</tr>
<tr>
<td>6</td>
<td>High</td>
</tr>
</tbody>
</table>
2002 Colorado “Hayman” Wildfire

Image credit (both photos): NOAA
October 1991 California Brush Fire
Space Weather

- Solar storms impacting Earth and technological systems
- Solar cycle maximum forecast to occur in 2013 and again in 2022 = more active space weather
- NWS’ Space Weather Prediction Center warns for space weather hazards
Space Weather Impacts

- Radio communications outages
- Power disruptions
- Significant GPS errors

Image credit: NOAA/SWPC
Source of Space Weather: The Sun

- Sunspots
- Coronal Mass Ejection (CME)
- Solar Flares
Solar Wind

- Outward flow of solar particles and magnetic fields from the Sun
- Solar flares and CMEs increase the density and velocity of the solar wind
- When directed at the earth’s magnetic field it can be compressed to the altitude of our satellites
- The increased energy from the solar wind result in geomagnetic storms
Space Weather Storm Types

- Radio Blackouts
- Solar Radiation Storms
-Geomagnetic Storms
Impacts on the Electric Power Grid

- CME impacts Earth's magnetic field
- Fluctuations generate electric fields on Earth
- Geomagnetically induced currents (GIC) can flow into power lines and transformers, leading to:
  - Transformer saturation
  - Overheating
  - Voltage drops
  - Transformer damage
  - Potential grid collapse
Volcanic Ash

- Small jagged pieces the size of sand and silt (less than 1/12 inch in diameter) of:
  - rocks
  - minerals
  - volcanic glass
Volcanic Ash Impacts

- Four inches leads to collapse of weaker roofs
- Twelve inches leads to death of most:
  - vegetation
  - livestock
  - aquatic life
- Can scratch the skin and eyes
- Can lead to respiratory failure
Volcanic Ash Services

- NOAA operates 2 Volcanic Ash Advisory Centers
- NWS Forecast Offices use this information to issue local Ashfall Advisories
- Advisories mean that airborne ash plume is resulting in deposition at the surface – it is snowing ash
Image credit:
NOAA/NGDC U.S. Geological Survey
Above: T.P. Miller
Left: R.G. McGimsey
May 1980 Mount Saint Helens, WA
Activity: Identifying Potentially Hazardous Situations
Unit Summary

• Describe various types of hazardous weather
• Summarize potential dangers that can be caused by hazardous weather events
• Explain how community and environmental factors can worsen the impact of hazardous weather
Unit 4: Role of the Emergency Manager
Objectives

• Describe the role of the Emergency Manager in planning and responding to hazardous weather events

• Identify actions Emergency Managers should take to prepare for, and respond to, hazardous weather events

• Develop strategies for improving coordination among State and local communities in the days or hours leading to a hazardous event
What is your role in planning for and responding to hazardous weather?
The Role of the Emergency Manager

- Identifies and coordinates resources
- Facilitates emergency management activities
- Ensures participation and cooperation among all key players
What mitigation actions has your community taken for hazardous weather events?
What action does your Emergency Operations Plan (EOP) require the emergency manager to take when a NWS warning is issued?
Do you wait for the NWS to issue it or might you issue a warning prior to the NWS?
Large Scale Events

Lead time usually allows time to:

• Track the event’s evolution and progress
• Provide detailed warning
• Prepare an adequate response
1993 Superstorm

- 197 fatalities
- $2 billion damage
What steps should the Emergency Managers have taken?
If a similar event happened in your area, what warning and coordination procedures would be used, according to your EOP?
1993 Midwest Flood

- 48 fatalities
- Evacuations displaced 54,000
- 50,000 homes damaged or destroyed
- Losses of $15–20 billion
Small Scale Events

• Localized
• May develop without, or with minimal, advance notice
The Big Thompson Canyon Flood 1976

- Flash flood killed 139 people
- $35.5 million in damage
What advanced planning activities should the Emergency Manager have completed to help prepare for the event?
During and immediately following the event, how should the Emergency Manager have responded?
Does anyone have any questions about the Emergency Manager’s role during small-scale events?
StormReady Program

• Proactive approach to show your community is prepared for storms.

• Meet basic criteria:
  – Establish a 24-hour warning point and EOC
  – Have more than one way to receive severe weather warnings and forecasts and to alert the public
  – Create a system that monitors weather conditions locally
  – Promote the importance of public readiness through community seminars
  – Develop a formal hazardous weather plan, which includes training severe weather spotters and holding emergency exercises.
StormReady Pennsylvania
(As of July 2017)

89 StormReady Sites:
58 Counties, 16 Communities, 1 Government/Military Site
5 University Sites, 9 Commercial Sites
19 Supporters

Back to StormReady Communities
StormReady Home
Weather-Ready Nation Ambassador

• Partnership between NWS, public, and private sector to build community resilience.

• Free program where you commit to:
  – Setting an example by becoming “Weather-Ready” yourself (e.g., making employee preparedness a priority & having a disaster plan)
  – Promoting Weather-Ready Nation messages in outreach activities
  – Providing incentives to your constituents and stakeholders to become more resilient
  – Sharing success stories with NOAA
Weather-Ready Nation Ambassador

- NWS will provide:
  - Provide outreach content to create a Weather-Ready Nation
  - Work with WRN Ambassadors to explore innovative collaborations to promote disaster preparedness and incorporate weather, water, and climate information in decision-making
  - Assist with StormReady opportunities for communities
  - Recognize your organization as a WRN Ambassador
  - Use of WRN Ambassador logo
Small Group Activity: The Dallas Hailstorm
6:44 p.m.
7:25 p.m.
Unit Summary

• Describe the role of the Emergency Manager in planning and responding to hazardous weather events

• Identify actions Emergency Managers should take to prepare for and respond to hazardous weather events

• Develop strategies for improving coordination among State and local communities in the days or hours leading to a potentially hazardous event
Unit 5: NWS Hazardous Weather Products
Objectives

• Describe the mission of the NWS
• Describe the basic organizational structure of the NWS
• Explain the purpose of various NWS products
• Explain how Probability of Precipitation is determined
• Select the NWS forecast products and other local resources that are most appropriate for the hazards affecting your community
NWS Overview

• Gathers and disseminates weather and flooding information
• Provides weather, hydrologic and climate forecasts and warnings
• Focused on protection of life and property
Group Activity: NWS Offices Knowledge Bowl

• Review the activity sheet (5 minutes)
• First team captain to raise a hand answers
• Provide answer within 15 seconds
• Turn ends when:
  – An incorrect answer is given,
  – Time runs out, OR
  – The team answers 3 questions correctly
Which NWS office type is responsible for working with water resource managers?
Which office is responsible for training observers and storm spotters?
Which two office types have 21 locations?
Which office type has 122 locations?
Which office type works exclusively with the FAA?
Which office type develops and improves numerical weather, climate, hydrological, and oceanic predictions?
Which office is made up of nine centers?
Which office executes the operational suite of the numerical analysis and forecast models?
Which office provides tornado and severe thunderstorm weather watches?
Which office provides space weather alerts and warnings?
Which office monitors and forecasts short-term climate fluctuations including issuing seasonal outlooks for hurricane season?
Which office issues weather predictions for the Atlantic and Pacific Oceans?
Which office provides real-time weather model diagnostics and national precipitation predictions?
Which office provides national aviation warnings and forecasts?
Which offices oversee policy, service, and operational issues for the NWS offices in their Regional areas of responsibility?
Which offices work with FEMA, NEMA, and IAEM on national policy, service, and operational issues?
Which offices provide tsunami warnings?
Which office provides forecasts of tropical weather systems in both the Atlantic and Eastern Pacific?
Which office type would most likely provide routine operational decision support to your EOC?
NWS Information Dissemination

- NOAA Weather Wire Service (NWWS)
- NOAA Weather Radio All Hazards (NWR)
- National Warning System (NAWAS)
- Emergency Managers Weather Information Network (EMWIN)

- Family of Service (FOS)
- NOAAPort
- Interactive NWS (iNWS)
- NWSChat
- Social Media
- Integrated Public Alert and Warning System (IPAWS)
NWWS

- Most reliable and timely warning delivery system
- NWS forecasts, warnings, and other products
NWR

• Provides voice broadcasts of weather information
• Is available to most of U.S. population
• Can activate alarms to alert users to imminent threats
• Used by NWS as primary means to activate EAS
NAWAS

• Network connecting Federal, State, area, county, and city warning points
• Warns public of potential loss of life and/or property
• Provides free exchange between law enforcement, EM agencies, and NWS
EMWIN

• Supplement to other services
• Live stream of critical emergency information at no recurring cost
• Uses radio, internet, and satellite methods to disseminate the basic datastream
FOS

Subscription services available to media, EM agencies, and private companies

• Server Access Service (SAS)
• Radar Product Services (RPS)
NOAAPort

Data is...

• Collected by GOES satellite environmental sensors and NWS observing systems
• Processed to create NWS operational data stream
• Routed to the appropriate NOAAAPort channel for uplink and broadcast
• Provided in near-real-time to NOAA and external users
• Mobile alert service
  – Text messages
  – Email alerts
  – Doppler radar data
• For NWS core partners only
  – Emergency managers
  – Public safety officials
  – SKYWARN amateur radio operators
  – Government partners
NWS Chat

• Situational awareness tool tailored for:
  – Emergency managers
  – Other public safety officials
  – News media
  – Skywarn Net Control Operators

• Provides a direct, operational communication link for information exchange during hazardous weather events
Social Media

U.S. National Weather Service

Write something...

Attach...

U.S. National Weather Service + Others U.S. National Weather Service Just Others

U.S. National Weather Service Kids are off from school but the learning doesn’t have to stop. Want to do some experiments with weather? Here are a few...

Weather Experiments

What to learn hands-on about the weather? Need a science project for school? Try some of these educational experiments. Experiments with this content will require adult help. Please use caution handling thermometers, hot plates, matchbox or dry ice. Please read the DRY ICE SAFETY PAGE before using it.

23 hours ago - Comment Like Share

1. 6 people like this.
2. View all 82 comments.

U.S. National Weather Service: Do your children ever ask you what makes rainbows? Do you wonder yourself? NWS Western Region explains how rainbows form...


Twitter: @NC_Wx

Time/Date: 2010-07-19 13:47

 مصدر الحريق يلي: في 39017, OH 43017, OH 45972. VERTW

Share the forecast experience with some of your friends. Use our simple share tools to start connecting.

More Ads

FEMA
Hazardous Weather and Flooding Preparedness
IPAWS

• Next-generation infrastructure of alert and warning networks
  – Commercial Mobile Alert System (CMAS)
  – Wireless Emergency Alerts (WEA)

• Automatic alerts with unique ring tone and vibration
Alerting Authorities

- Local
- State
- Territorial
- Tribal
- Federal

IPAWS, continued

Part 1 of 3 - part graphic, titled Alerting Authorities. The validated Alerting Authorities can be Federal, State, territorial, tribal, or local officials designated within their level of government as an authority responsible for communicating emergency alerts and information to the public. After completing FEMA sponsored training, IPAWS recognized Alerting Authorities will be given a Collaborative Operations Group and access to the IPAWS capabilities. IPAWS CAP alert messages will be generated and sent to an IPAWS CAP Alert Origination Tool, such as Framework or other compatible emergency and incident management tools.

Part 2 of 3 - part graphic, titled Alerting Disseminators. The Alert Disseminators include: the Emergency Alert System (EAS), Commercial Mobile Alert System (CMAS), Internet Services, National Oceanic and Atmospheric Administration (NOAA), and various state/local unique alerting systems.

Part 3 of 3 - part graphic, titled American People. EAS provides alerts via the traditional broadcast means of radio (AM, FM, and Satellite) and television (digital and analog over the air, cable, and satellite). CMAS provides alerts via participating cellular phones, pagers, and other commercial mobile network devices. Likewise, Internet Services allow the American public to retrieve alert messages via independent web services and sites or applications that may be offered. Internet services also allow for growth and integration with future consumer technologies accessible via internet connected devices. NOAA provides alert information via the All Hazards Weather Radio system and other National Weather System alert and information services. Individual state and local governments may also choose to integrate local alerting systems such as emergency telephone networks, sirens, and digital signs on roadways with IPAWS to receive and be activated by CAP alerts.
What other location dissemination systems are in use?
Other Dissemination Systems

- Law Enforcement Telecommunications Systems (LETS)
- State Warning Point (SWP)
- Area Warning Points (AWPs)
- County Warning Points (CWPs)
- NWS WFO and National Center websites
- Emergency Alert System
- Outdoor Warning Siren Systems
Interpreting Probability

Probability of Precipitation (PoP):

The chance or likelihood of an event occurring at some point in the forecast area, over a certain period of time.
PoP

- **PoP = P_a \times a_c**
- **P_a = probability that precipitation will occur somewhere in the forecast area during the forecast period**
- **a_c = percent of the area that will receive measurable precipitation**
## PoP Examples

<table>
<thead>
<tr>
<th>No precipitation, but scattered storms</th>
<th>Precipitation occurring, scattered storms to continue</th>
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<tbody>
<tr>
<td>$P_a = 80%$</td>
<td>$P_a = 100%$</td>
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<tr>
<td>$a_c = 30%$</td>
<td>$a_c = 30%$</td>
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<tr>
<td>PoP $= 0.80 \times 0.30 = 24% = 20%$</td>
<td>PoP $= 1.0 \times 0.30 = 30%$</td>
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</table>
PoP Example

- A line of thunderstorms is forecast to cover the northern 80% of the forecast area
- The forecaster is confident of the likelihood of the occurrence (100% probability)
- PoP for the forecast area would be 80%
- 100% x 80% = 80%
What is the PoP for a city in the southernmost part in the forecast area if the thunderstorms are NOT expected to move through the city?
Pre-Impact Information

- Typical life-cycle for the event
- Upstream conditions
- Impact in other areas
- Current conditions
What factors tend to increase the reliability of forecasts?
NWS Forecast Products

Goals:

• Increase public awareness of potential impact

• Promote appropriate public response
Activity: NWS Products

• Work with your table group
• Review information for your assigned NWS product
• Prepare a 5-minute presentation
• Address the questions on the activity instructions
### Non-routine NWS Products

<table>
<thead>
<tr>
<th>Outlooks or Statements</th>
<th>Advisories</th>
<th>Watches</th>
<th>Warnings</th>
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<tbody>
<tr>
<td>• HW event may develop</td>
<td>• HW event is imminent or occurring</td>
<td>• Risk of HW event has increased but still uncertain</td>
<td>• HW event is imminent or occurring</td>
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<tr>
<td>• Forecaster confidence &gt; 30%</td>
<td>• Forecaster confidence &gt; 80%</td>
<td>• Forecaster confidence &gt; 50%</td>
<td>• Forecaster confidence &gt; 80%</td>
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<tr>
<td>• Provides considerable lead time</td>
<td>• Used for less serious conditions</td>
<td></td>
<td>• Used for conditions that threaten life and property</td>
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</table>
How is the information provided by NWS different from the information given by TV news stations?
Emergency Manager’s Decision Support Page

- Local website maintained by many Local NWS Offices
- Provides Emergency Managers with information on:
  - Weather hazards facing the area
  - Preparedness
  - Upcoming workshops
Forecasts

Outlooks, Advisories, and Warnings

• Short-term
• Zone
• Extended
• Long range
Statements and Discussions

Statements

• Issued during weather events to advise of changing conditions
• Can amplify or cancel previously issued advisories and warnings

Discussions provide rationale for the forecasts
Other Sources

• Automated Local Evaluation in Real Time (ALERT)
• Local spotter groups/SKYWARN
• Amateur Radio Relay League (ARRL) and Amateur Radio Emergency Services (ARES)
• America’s Weather and Climate Industry
• Online resources
ALERT

• Computerized local flood-warning system
• Integrates self-reporting, field sensors, base station microcomputer, and specialized software
• Includes real-time streamflow simulation model
Spotters/SKYWARN

National network of trained volunteers who provide:

• Weather observations
• Valuable local data
ARRL and ARES

Amateur radio operators can provide:

- Emergency communications
- Their own equipment
- Service as weather spotters
America’s Weather and Climate Industry

• Various private vendors for weather and climate information
• Services available by subscription
• Cost and quality varies among vendors
Online Resources

Forecasting and historical weather data from:

- NWS
- Many universities
- Other online resources
Individual Activity: Selecting a Forecast Product

• Work individually
• List appropriate products and resources for your community
• Refer to information from the earlier Group Activity
• Be prepared to share your responses
Unit Summary

- Describe the mission of the NWS
- Describe the basic organizational structure of the NWS
- Explain the purpose of various NWS forecast products
- Explain how Probability of Precipitation is determined
- Select the NWS forecast products and other local resources that are most appropriate for the hazards affecting your community
Unit 6: Projecting the Impacts of Hazardous Weather and Flooding
Objectives

• List sources of information needed to determine a community’s vulnerability to hazardous weather events
• Identify climatological and community factors that contribute to your community’s vulnerability to hazardous weather and flooding
• Complete a hazard analysis for a hydrometeorological event to which your jurisdiction is vulnerable
• Propose mitigation measures for a hazardous weather or flooding event
What is your community’s state of readiness for responding to hazardous weather and flooding events?
In light of what you now know, what are your concerns about your community’s response capabilities?
Local Vulnerability

Based on climatological and community factors
Climatological Factors

• How bad can it get?
• How often has it occurred?
• How likely is it to happen?
• When are we most vulnerable?
Pennsylvania Tornado Risk
(Through June 2017)

Pennsylvania Tornadoes
1950-2017*

*2015-17 data are preliminary. Sources include NWS WFOs and SPC, Tornado History Project
Pennsylvania Tornado Risk
(Through June 2017)

Strongest Tornadoes*
by county since 1950

*2015-17 data are preliminary. Sources include NWS WFOs and SPC, Tornado History Project
Pennsylvania Tornado Risk
(Through June 2017)

Most Recent Tornadoes*
by county

*2015-17 data are preliminary. Sources include NWS WFOs and SPC, Tornado History Project
Largest Hail on Record

Pennsylvania: 5.5”
June 26, 1950

A DVD is 4.75”
## Pennsylvania Snow Records

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# Pennsylvania Snow Records

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<td>DONEGAL 2 NW</td>
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<tr>
<td>Wyoming County</td>
<td>20.5</td>
<td>TUNKHANNOCK</td>
<td>25.0</td>
<td>DIXON</td>
<td>25.0</td>
<td>DIXON</td>
</tr>
<tr>
<td>York County</td>
<td>32.0</td>
<td>YORK 3 SSW PUMP STN</td>
<td>33.0</td>
<td>NEW PARK</td>
<td>36.0</td>
<td>SPRING GROVE</td>
</tr>
</tbody>
</table>
What are the sources of information you would use to relate each of these factors to your community’s vulnerability?
Community Factors

- People at risk
- Property at risk
- Local building codes
- Locations of critical facilities
- Locations of key resources
- Condition of infrastructure
- Local geography and topography
Activity: Analyzing Threats
Debrief: Mitigation Measures

What mitigation measures can your community implement to reduce the impacts of the event you just analyzed?
Mitigation Funding Resources

Local

State

Federal
Potential Local Mitigation Funding Resources

- Nonprofit organizations
- Taxes
- Private sector funding
Potential State Mitigation Funding Resources

• Emergency funds
• Conservation and historical preservation initiatives
• Earmarked funds from lottery, taxes, and other sources
Federal Mitigation Funding Resources

- Hazard Mitigation Grant Program (HMGP)
- Pre-Disaster Mitigation (PDM) Program
- Public Assistance (PA) Grant Program
- Flood Mitigation Assistance (FMA) Program
- Repetitive Flood Claims (RFC) Program
- Severe Repetitive Loss (SRL) Program
- HUD’s Community Development Block Grants (CSBG)
- National Tsunami Hazard Mitigation Program (NTHMP)
Unit Summary

• List sources of information needed to determine a community’s vulnerability to hazardous weather events

• Identify climatological and community factors that contribute to your community’s vulnerability to hazardous weather and flooding

• Complete a threat analysis for a hydrometeorological event to which your jurisdiction is vulnerable

• Propose mitigation measures for a hazardous weather or flooding event
Unit 7: Activity
Unit Objectives

• Describe factors that influence the selection of emergency response options
• Determine response priorities
• Propose appropriate emergency responses
Activity:
Severe Summer Storms
Activity Notes

• Work in your table group
• Role-play as the affected emergency management agency
• Consider your own EOP
• Use NWS forecasts and graphics
Activity Scenario

• After a period of heavy rain from a recent tropical system, local waterways are running high.
• Several days of very warm and muggy weather have surged into the Commonwealth which is about to be interrupted by a potent storm system.
• Very warm and moist air is streaming in against a stalled front over New York and the Great Lakes region.
• The stage is set for some storm development along a cold front draped through Ohio.
Weather Brief #1
Wednesday, July 12
11:00 AM
Weather Brief #1

• Severe storms are likely in the afternoon hours on, **Thursday, July 13**
• There is a potential for a severe wind driven event known as a derecho to move across the state
• SPC has the region under a moderate risk for severe weather
  • Risk for widespread winds 60-75mph
  • Risk for 2” diameter hail
  • Risk for a few tornadoes
• Local streams and creeks running high and ground is very saturated = flash flood risk
Day 2 Convective Outlook
### Risk Categories for Convective Outlooks

**Understanding Severe Thunderstorm Risk Categories**

<table>
<thead>
<tr>
<th>THUNDERSTORMS (no label)</th>
<th>1 - MARGINAL (MRGL)</th>
<th>2 - SLIGHT (SLGT)</th>
<th>3 - ENHANCED (ENH)</th>
<th>4 - MODERATE (MDT)</th>
<th>5 - HIGH (HIGH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No severe* thunderstorms expected</td>
<td>Isolated severe thunderstorms possible</td>
<td>Scattered severe storms possible</td>
<td>Numerous severe storms possible</td>
<td>Widespread severe storms likely</td>
<td>Widespread severe storms expected</td>
</tr>
<tr>
<td>Lightning/flooding threats exist with all thunderstorms</td>
<td>Limited in duration and/or coverage and/or intensity</td>
<td>Short-lived and/or not widespread, isolated intense storms possible</td>
<td>More persistent and/or widespread, a few intense</td>
<td>Long-lived, widespread and intense</td>
<td>Long-lived, very widespread and particularly intense</td>
</tr>
</tbody>
</table>

* NWS defines a severe thunderstorm as measured wind gusts to at least 58 mph, and/or hail to at least one inch in diameter, and/or a tornado. All thunderstorm categories imply lightning and the potential for flooding. Categories are also tied to the probability of a severe weather event within 25 miles of your location.
Day 2 Severe Probability

ISSUED: 0800z
VALID: 13/1200Z-14/1200Z

Total Severe Probability Legend (in %):
5 15 30 45 60 Sig
Day 2 Probability to Categorical Outlook Conversion

<table>
<thead>
<tr>
<th>Day 2 Outlook Probability</th>
<th>Combined TOR, WIND, HAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>MRGL</td>
</tr>
<tr>
<td>15%</td>
<td>SLGT</td>
</tr>
<tr>
<td>15% with Significant Severe</td>
<td>SLGT</td>
</tr>
<tr>
<td>30%</td>
<td>ENH</td>
</tr>
<tr>
<td>30% with Significant Severe</td>
<td>ENH</td>
</tr>
<tr>
<td>45%</td>
<td>ENH</td>
</tr>
<tr>
<td>45% with Significant Severe</td>
<td>MDT</td>
</tr>
<tr>
<td>60%</td>
<td>MDT</td>
</tr>
<tr>
<td>60% with Significant Severe</td>
<td>HIGH</td>
</tr>
</tbody>
</table>
This Hazardous Weather Outlook is for Pennsylvania.

.DAY ONE...Today and Tonight.

The probability for widespread hazardous weather is low.

.DAYS TWO THROUGH SEVEN...Thursday through Sunday.

Severe thunderstorms...including the threat of dangerous tornadoes...are expected across Pennsylvania between 12 pm and 8 pm Thursday.

All modes of severe weather are possible...tornadoes...damaging winds...large hail...and locally heavy rain which may produce flash flooding and small stream and creek flooding.

Based on the latest data...it appears the severe thunderstorm threat may evolve into a large squall line known as a derecho. Beginning in the west as early as 12 pm Thursday and lasting until 6-8 pm in the east. Atmospheric parameters appear favorable for the development of a squall line with embedded areas of winds in excess of 70 mph. Thunderstorms may produce strong tornadoes or large hail.

Although the greatest threat for severe weather will progress from west to east, do not focus on any particular hour...be prepared for activity at any time. Review your preparedness action plans and be ready to take action when watches and warnings are issued. Stay tuned to further updates on this potential hazardous weather outbreak.

.SOTTER INFORMATION STATEMENT...

Activation of storm spotters...emergency management personnel...and ham radio operators is expected Tuesday.
Instructions

• Work in your table group
• Consider:
  – Community information
  – Maps
  – NWS products provided
• Discuss questions and record responses
• Be prepared to share
Weather Brief #2
Thursday, July 13
11:00 AM
Weather Brief #2

• Severe storms have fired in eastern Ohio.
• A severe wind driven event known as a derecho is likely and will move across the state after 2PM.
• SPC has the region under a moderate risk for severe weather:
  • Risk for widespread winds 60-75mph
  • Risk for 1.5” diameter hail
  • Risk for a few tornadoes
• Local streams and creeks running high and ground is very saturated = flash flood risk with heavy rain 2-3” per hour.
Day 1 Convective Outlook

Severe Weather Outlook
Thursday, July 13, 2017

ISSUED: 1200z
VALID: 13/1200Z-14/1200Z
## Day 1 Probability to Categorical Outlook Conversion

<table>
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<th>WIND</th>
<th>HAIL</th>
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</thead>
<tbody>
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<td>Not Used</td>
<td>Not Used</td>
</tr>
<tr>
<td>5%</td>
<td>SLGT</td>
<td>MRGL</td>
<td>MRGL</td>
</tr>
<tr>
<td>10%</td>
<td>ENH</td>
<td>Not Used</td>
<td>Not Used</td>
</tr>
<tr>
<td>10% with Significant Severe</td>
<td>ENH</td>
<td>Not Used</td>
<td>Not Used</td>
</tr>
<tr>
<td>15%</td>
<td>ENH</td>
<td>SLGT</td>
<td>SLGT</td>
</tr>
<tr>
<td>15% with Significant Severe</td>
<td>MDT</td>
<td>SLGT</td>
<td>SLGT</td>
</tr>
<tr>
<td>30%</td>
<td>MDT</td>
<td>ENH</td>
<td>ENH</td>
</tr>
<tr>
<td>30% with Significant Severe</td>
<td>HIGH</td>
<td>ENH</td>
<td>ENH</td>
</tr>
<tr>
<td>45%</td>
<td>HIGH</td>
<td>ENH</td>
<td>ENH</td>
</tr>
<tr>
<td>45% with Significant Severe</td>
<td>HIGH</td>
<td>MDT</td>
<td>MDT</td>
</tr>
<tr>
<td>60%</td>
<td>HIGH</td>
<td>HIGH</td>
<td>MDT</td>
</tr>
<tr>
<td>60% with Significant Severe</td>
<td>HIGH</td>
<td>HIGH</td>
<td>MDT</td>
</tr>
</tbody>
</table>
Flash Flood Guidance

How much rain can fall within 3hrs before flash flooding can occur...
11 A.M. Radar Image
Weather Brief #3
Thursday, July 13
12:30 PM
URGENT - IMMEDIATE BROADCAST REQUESTED
Severe Thunderstorm Watch Number 105
NWS Storm Prediction Center Norman OK
1230 PM EDT THU JUL 13 2017

The NWS Storm Prediction Center has issued a
Severe Thunderstorm Watch for portions of
EXTREME EASTERN OHIO
ALL OF PENNSYLVANIA
NORTHERN WEST VIRGINIA
NORTHERN MARYLAND

Effective this Thursday afternoon and evening from 12:30 pm until 800 pm EDT.

...THIS IS A PARTICULARLY DANGEROUS SITUATION...

Widespread damaging winds
Thunderstorm wind gusts to 80mph
Isolated hail to 2 inches in diameter
Isolated tornadoes
Dangerous lightning

The severe thunderstorm watch area is approximately 300 statute miles west to east
along a north and south line from Ashtabula Ohio to 35 miles east of Parkersburg
West Virginia. For a complete depiction of the watch see the associated watch
outline update (wous64 kwns wou6).

Remember...a severe thunderstorm watch means conditions are favorable for severe
thunderstorms in and close to the watch area. Persons in these areas should be
on the lookout for threatening weather conditions and listen for later statements
and possible warnings. Severe thunderstorms can and occasionally do produce
tornadoes.

Discussion...Intense MCS has developed n/s across eastern Ohio and continues to
develop as it moves ewd. The storm environment downstream features strong instability
and sufficient deep-layer flow/shear to maintain an organized MCS...and there will be
the potential for widespread very damaging winds with this bowing system through this
afternoon. In addition brief tornadoes are still possible but widespread damaging
winds and isolated large hail are the dominant threats.

Aviation...A few severe thunderstorms with hail surface and aloft to 2 inches.
Extreme turbulence and surface wind gusts to 80 knots. A few cumulonimbi with
maximum tops to 550. Mean storm motion vector 24540.
Estimated Storm Arrival Time

- 2-4PM
- 4-6PM
- 6-8PM
Weather Event
Thursday, July 13
2:00-7:00PM
Severe Event Timeline

- Storms fire in Ohio in the morning hours of July 13.
- The storms merge into a line and push eastward reaching western Pennsylvania **by 2PM**.
- The line of severe storms expands from north to south and travels across the state between **2-7PM**.
- The storm line moves east at 60mph.
- Storm winds reach **60-75mph**.
- Rainfall rates reach **2-3”/hr**.
## Severe Event Timeline

<table>
<thead>
<tr>
<th>2:00PM</th>
<th>3:00PM</th>
<th>4:00PM</th>
<th>5:00PM</th>
<th>6:00PM</th>
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<tbody>
<tr>
<td>Allegheny</td>
<td>Bedford</td>
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<td>Adams</td>
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<tr>
<td>Armstrong</td>
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<td>Franklin</td>
<td>Dauphin</td>
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<td>Union</td>
<td>Wyoming</td>
<td>Wayne</td>
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<td>York</td>
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</tr>
<tr>
<td>Washington</td>
<td>Westmoreland</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Activity Debrief
Group Reporting

• What actions did you take?
• What worked well?
• What didn’t work well?
• How did you address communication and coordination with NWS and others?
Storm Summary

- The line leaves a widespread path of wind damage from west to east across the state.
- Damage includes extensive power outages, downed trees and limbs, and sporadic structural damage.
- Some areas experience hail damage with 1.5”-2.0” hail stones.
- 2.0-3.5” of rain over 45 minutes to 1 hour results in extensive flash flooding in hundreds of local municipalities.
Simulated Derecho Timeline
Preliminary Damage Reports

PA
Total Reports = 772
- Tornadoes = 7
- Hail Reports = 219
- Wind Reports = 546
Estimated Total Rainfall

- 2.5-3.0" in some areas
- 3.0-3.5" in a larger region
- 2.0-2.5" in a different region
Images from the Event
Destruction
Unit Summary

• How has this activity made you think differently about your emergency management responsibilities during hazardous weather events?

• How can you improve coordination with NWS and others during hazardous weather events?
You should now be able to...

- Describe factors that influence the selection of emergency response options during a hazardous weather event
- Determine response priorities for a hazardous weather event
- Propose appropriate emergency responses for a hazardous weather event in a given scenario
Unit 8: Course Summary
Unit Objectives Review

For each unit objective, consider:

• Did we cover it?
• Can you do it?
• Do you have any questions?
Unit 1: Introduction and Course Overview

This unit focused on preparing you to:

Recognize the importance of planning for hazardous weather and flooding events
Unit 2: Weather Overview

This unit focused on preparing you to:

Analyze how the components of weather interact to create hazardous weather
Unit 2 Review Question #1

What is the significance of a dew point greater than 60°F?
Unit 2 Review Question #2

With what type of pressure system are cloudy skies associated?
Unit 3: Introduction to Hazardous Weather

This unit focused on preparing you to:

Anticipate the impact of hazardous weather events to enhance preparedness
Unit 3 Review Question #1

What are some hazards associated with a winter storm? What effects might they have on the community?
What are three basic factors that contribute to thunderstorm development?
Unit 3 Review Question #3

What are some community factors that contribute to the risk level of hazardous weather events?
Unit 4: Role of the Emergency Manager

This unit focused on preparing you to:

Evaluate actions taken by Emergency Managers to prepare for, and respond to, actual hazardous weather events
Unit 4 Review Question #1

What are the five primary responsibilities of the emergency manager related to hazardous weather events?
Unit 4 Review Question #2

What are some ways that emergency managers can prepare for hazardous weather in advance?
Unit 5: NWS Hazardous Weather Products

This unit focused on preparing you to:

Interpret information contained in National Weather Service forecast and warning products, as well as in other weather resources
Unit 5 Review Question #1

What is the difference between a Watch and a Warning?
Unit 5 Review Question #2

What two values are multiplied to figure the Probability of Precipitation?
Unit 5 Review Question #3

Which type of NWS office directly supports local/state emergency management response to hazardous weather?
Unit 6: Project the Impacts of Hazardous Weather and Flooding

This unit focused on preparing you to:

Assess your community’s state of readiness for hazardous weather and flooding events
Unit 6 Review Question #1

How can you help your community be ready for hazardous weather events?
Unit 6 Review Question #2

What potential resources may be used to help fund mitigation measures?
Unit 7: Activity

This unit focused on preparing you to:

Evaluate the effectiveness of emergency response actions for a given scenario
Unit 7 Review Question #1

In the Unit 7 activity, what did you learn about your community’s ability to respond to real events?
Thank you for attending!

• Final Exam
• Closing Remarks
• Course Evaluation
  – Must complete on TrainPA to release course certificate
• Certificate
  – Visit TrainPA to save