Planning for the Threat
Hurricane Evacuation Decision Making

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Hurricane History of New England

The map shows only Cat 2 and above hurricanes!
Hold on! What about TS, Cat 1, Cat 2...

Saffir-Simpson Hurricane Wind Scale

Surge, rainfall, and pressure fit the scale like a square peg in a round hole

<table>
<thead>
<tr>
<th>Category</th>
<th>Central Pressure</th>
<th>Winds (mph)</th>
<th>Surge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Millibars</td>
<td>Inches</td>
<td>Damage</td>
</tr>
<tr>
<td>5</td>
<td>&lt; 920</td>
<td>&lt; 27.17</td>
<td>&gt;155</td>
</tr>
<tr>
<td>4</td>
<td>944-920</td>
<td>27.17-27.88</td>
<td>131-155</td>
</tr>
<tr>
<td>3</td>
<td>964-945</td>
<td>27.91-28.47</td>
<td>111-130</td>
</tr>
<tr>
<td>2</td>
<td>979-965</td>
<td>28.50-27.91</td>
<td>96-110</td>
</tr>
<tr>
<td>1</td>
<td>≤ 980</td>
<td>≤ 28.94</td>
<td>74-95</td>
</tr>
</tbody>
</table>

KATRINA (3)
IKE (2)
SANDY (ET)
CHARLEY (4)
Decision Making in the Face of Uncertainty

Key Questions:

Will we be impacted by the storm, and if so when? For how long?

How much coastal flooding and where?

What about wind and inland flooding from rain?

Who do we need to evacuate?

When does the evacuation need to start and how long will it take?

HES and NHC/NWS products assist/support you with evacuation decision making
Hurricane Evacuation Studies (HES)

- Hazards Analysis
  - SLOSH Model Development
  - Surge MOMS

- Vulnerability Analysis
  - Identify at Risk:
    - Populations
    - Infrastructure
    - Critical Facilities

- Behavioral Analysis
  - Public Survey
  - Analysis of Survey Responses
  - Results for Input

- Shelter Analysis
  - Determining the Shelter Need
  - Estimate Number of Shelter Spaces
  - Potential

- Transportation Analysis
  - Analysis of Traffic Volumes, Evac. Routes, and Destinations
  - Traffic

Critical Information for Planning and Response...
Hazards Analysis

Understanding Storm Surge Potential

- Storm surge has the highest potential for death and damage
- Storm surge is the main reason we evacuate the coast
- Worst Case Scenario Surge Maps used to assess risk in your community

Analysis: Hazard Vulnerability Behavioral Shelter Transportation
Products: Surge Maps Evacuation Zones Planning Data Clearance times
What are the zones based on?

Storm surge vulnerable areas created using the SLOSH model

Maximum of Maximum Storm Surge Potential “MOM”

- Consist of thousands of runs
- Different intensities, pressure, angles of approach, forward speed, wind radii
- One per category – Worst case scenarios
Evacuation Zones

“Know Your Zone”

- Communicate risk to the public
- Communicate evacuation orders by zone
Vulnerability Analysis

Who may need to evacuate and What is at risk

- Citizens residing in surge prone areas
- Critical facilities
- Mobile/Manufactured home communities
- Vulnerable shelters
- Colleges/Universities
Vulnerability Analysis

Critical Facility Maps
Hurricane Behavioral Analysis

- Attitudes about risk from hurricane hazards – Primarily storm surge
- Evacuation intentions and past experiences
- Evacuation destinations
- Evacuation routes
- Sources of forecast information

<p>| Table 4-2: Perceived Vulnerability of Home – Believe Home would Flood Dangerously |
|-----------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Category 2</th>
<th>Category 3</th>
<th>Category 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A / 1-2</td>
<td>B / 3-4</td>
<td>Non-Surge</td>
</tr>
<tr>
<td>42%</td>
<td>22%</td>
<td>13%</td>
</tr>
</tbody>
</table>

<p>| Table 4-3: Perceived Vulnerability – Believe Home would not be Safe |
|-----------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Category 2</th>
<th>Category 3</th>
<th>Category 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A / 1-2</td>
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</tr>
<tr>
<td>42%</td>
<td>32%</td>
<td>28%</td>
</tr>
</tbody>
</table>
Hurricane Behavioral Analysis

- **600 total surveys in state**
  - 300 in Surge Inundation Zones 1 and 2 (Combined)
  - 200 in Surge Inundation Zones 3 and 4 (Combined)
  - 100 in non-surge areas of adjacent coastal communities
Some Key Findings

- Serious under-concern about surge
- Evacuation intent over-stated
- Evacuation intent highest (and better predictor of actual behavior)
  - For major storms
  - For mandatory or ordered evacuations
  - For households with children
  - With recent real hurricane experience
- Often get “False Experience” effect
  - Earl/Irene/Sandy?
Shelter Analysis
Understanding Shelter Need

Key Sheltering Information:

- Location/Identification
- Potential Shelter Demand
- Flood Risk
- Capacity
- ARC vs. Local Shelter
- Pet Friendly

Table 5-3: Public Sheltering Demand and Sheltering Capacity – New Haven County

<table>
<thead>
<tr>
<th>Community</th>
<th>Scenario A Low Occ</th>
<th>Scenario A High Occ</th>
<th>Scenario B Low Occ</th>
<th>Scenario B High Occ</th>
<th>Shelter Capacities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branford</td>
<td>806</td>
<td>832</td>
<td>992</td>
<td>1,023</td>
<td>70</td>
</tr>
<tr>
<td>East Haven</td>
<td>750</td>
<td>761</td>
<td>968</td>
<td>978</td>
<td>175</td>
</tr>
<tr>
<td>Guilford</td>
<td>395</td>
<td>413</td>
<td>574</td>
<td>594</td>
<td>35</td>
</tr>
<tr>
<td>Hamden</td>
<td>613</td>
<td>618</td>
<td>1,202</td>
<td>1,209</td>
<td>5,145</td>
</tr>
<tr>
<td>Madison</td>
<td>344</td>
<td>385</td>
<td>487</td>
<td>530</td>
<td>105</td>
</tr>
<tr>
<td>Milford</td>
<td>1,224</td>
<td>1,255</td>
<td>1,652</td>
<td>1,689</td>
<td>4,962</td>
</tr>
<tr>
<td>New Haven</td>
<td>1,892</td>
<td>1,914</td>
<td>3,254</td>
<td>3,282</td>
<td>400</td>
</tr>
<tr>
<td>North Haven</td>
<td>266</td>
<td>271</td>
<td>511</td>
<td>517</td>
<td>50</td>
</tr>
<tr>
<td>West Haven</td>
<td>1,026</td>
<td>1,032</td>
<td>1,567</td>
<td>1,576</td>
<td>105</td>
</tr>
<tr>
<td>Totals</td>
<td>7,316</td>
<td>7,481</td>
<td>11,207</td>
<td>11,398</td>
<td>11,047</td>
</tr>
</tbody>
</table>
Shelter Analysis

Shelter Capacity/Demand Maps

Figure 5-3: Estimated Evacuating Population Using Shelters for Scenario B High Tourist Occupancy – Middlesex County
Transportation Analysis

Understand traffic congestion potential based upon evacuation decisions

• Traffic Patterns (bottle necks)
• Evacuating Vehicles

Clearance Time tables

Variables of:
  • Response
  • Population
  • Evacuation Scenarios (one way, Multi state)
  • Storm Category
Evacuation Clearance Times - Example

Timeline

<table>
<thead>
<tr>
<th>H = -48</th>
<th>H = -36</th>
<th>H = -24</th>
<th>H = -18</th>
<th>H = -12</th>
<th>H = -6</th>
<th>H = 0</th>
<th>H = +6</th>
<th>H = +12</th>
<th>H = +18</th>
<th>H = +26</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
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</table>

- **Evacuation Start Time**
- **Forecasted Onset of TS winds or surge**

**Clearance Time = 48hrs**

Begins when the first evacuating vehicle enters the road network, ends when the last vehicle reaches an assumed point of safety.
Evacuation Decision Calculation

- NHC Forecast Advisories
- HES Data: Pre-determined Evacuation Zones
- Arrival Time of TS Winds
- Clearance Time

Evacuation Start Time
HES in HURREVAC

Evacuation Timing Reports
Wind Timing Reports
Wind Speed Probability Reports
The Hurricane Evacuation Study:

**Informs** your **plans** with data from the 5 analysis

**Supports** your **response** operations by providing:

- Information on which populations and facilities to evacuate
- Information on shelter risk, capacity and demand
- **Timing guidance in HURREVAC**
- Clearance Times for specific storm scenarios
- Information on critical traffic bottlenecks and suggested traffic control points
Technical Data Reports

Detailed reports of the following analyses:

- Hazards Analysis
- Vulnerability Analysis
- Behavioral Surveys
- Shelter Analysis
- Transportation Analysis

New England Hurricane Evacuation Study
Technical Data Report
June 2016

Analysis: Hazard Vulnerability Behavioral Shelter Transportation
Products: Surge Maps Evacuation Zones Planning Data Clearance times
Hurricane Scenario

Advisory 40
Issued at 11AM
Saturday August 31st
Cat 3
Moving 13mph
Center located off the coast of GA/SC
Assume an 17 hour CT (worst case)
Ex. Stamford

Mobilize response assets? Call for an evacuation? **When** do you take action?
This was Hurricane Edouard 1996

In this scenario, given a 17 hour Clearance Time, evacuations would have to begin Sunday PM in order to be complete before the onset of TS force winds.

This would leave 27 hours from the issuance of this advisory to make an evacuation decision, notify the public, and mobilize response assets.
Key forecast products, clearance times and local planning factors guide Evacuation Decision Making and other Response Actions

### Product Timelines

**When is key information available?**

<table>
<thead>
<tr>
<th>Tropical Cyclone Products – Distribution Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Normal Operations</strong></td>
</tr>
<tr>
<td>Hurricane Watch</td>
</tr>
</tbody>
</table>

### National Weather Service

**Tropical Cyclone Products**

- **> 5 Days**
  - 5 Day Forecast
  - Public Advisory
  - Wind Speed %
  - Forecast Discussion
- **3-5 Days**
  - TS/Hurricane Watches
- **2-3 Days**
  - TS/Hurricane Warnings
  - TS/Hurricane Local Statements
  - Operational Storm Surge Products
- **1-2 Days**
  - TS/Hurricane Warnings
  - TS/Hurricane Local Statements
  - Operational Storm Surge Products

- Few products
- Large uncertainty
- More products
- Forecast hazards
- Detailed products
- Warnings
NHC Forecast Cone

- Represents the probable track of the center of the tropical cyclone
- Formed by connecting circles centered on each forecast point (at 12, 24, 36 h, etc.)
- Size of the circles determined so that, say, the actual storm position at 48 h will be within the 48-h circle 67% of the time
• Intended for general public to enhance the response to instructions from local officials.

• Highlights areas that have a significant risk of life-threatening inundation by storm surge.

• Introduces the concept of a storm surge watch/warning.

• Issued 48 hours before the arrival of life-threatening surge (or other hazards that would impede evacuation).

• Issued in collaboration with local NWS Offices.
Factors the map takes into account:

» Flooding due to storm surge from the ocean, including adjoining tidal rivers, sounds, and bays
» Tides
» Land elevation
» Uncertainties in the track, landfall location, intensity, and size of the cyclone

Factors the map does not take into account:

» Wave action
» Freshwater flooding from rainfall
» Flooding inside levees and overtopping
Questions?

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