HAZUS MH
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How Can the Current Model be Used to Assess Tsunami Risk?

- Earthquake, flood, and hurricane wind loss estimates are currently produced.
- Inundation maps used with HAZUS-MH inventory data may be used to show what is at risk.
- HAZUS-MH damage functions may be edited.

Northern California Case Study

- Profiling the tsunami hazard
- Modeling the inundated area
- Calculating the exposure
- Using the Flood Wizard software
- Editing the HAZUS-MH Software

Tsunami Profile

- 82 tsunamis have been observed or recorded in California since 1855.
  - 11 caused damage to the infrastructure
  - 4 caused casualties
- Area at risk from both distant and local tsunamis (Cascadia Subduction Zone).
- Experts estimate a 35% probability of a large (8+ magnitude) Cascadia earthquake occurring from 1995 to 2045.

Modeling the Tsunami

- Tsunami model developed by Humboldt State University


Cascadia.mov

HUMBOLDT STATE UNIVERSITY

- Tsunami caused by Cascadia earthquake (little to no evacuation time)


Tsunami simulation-So Cascadia event.mov

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Exposure

- Determining which site specific buildings are in the inundated areas
- Calculating the general building stock within the inundated areas

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Inundation Results

- 100-year tsunami exposure – general building stock

Building	Content	Total
$224,822,274	$170,524,126	$393,284,400

Total inundated value represents 4.1% of the total value in the study area

- 100-year tsunami exposure – critical facilities

Medical and Health Services	Government Function	Hazardous Materials	Schools	Other	Total
0	1	13	0	28	42

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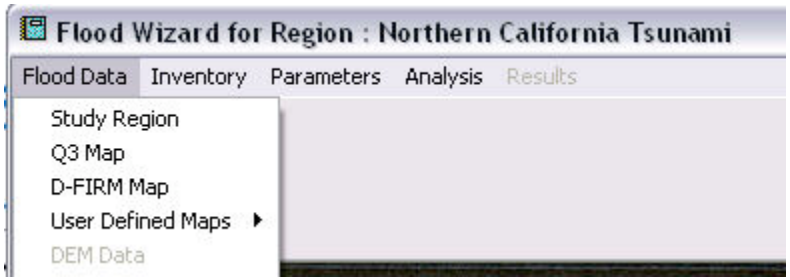
Using the Flood Wizard

- Create flood region in HAZUS-MH
- Download Digital Elevation Model (DEM)
- Convert inundation area to shape file with a field named “Zone” and containing an “A” in each record



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Editing the Damage Functions

Tsunami Sources

- FEMA Coastal Construction Manual, 3rd Edition
- ASCE 7-02 Minimum design loads for buildings and other structures, 2003
- City and County of Honolulu Building Code, 2000
- Matsutomi, Tsunami Engineering, 1999
- Harry Yeh, Oregon State University

Damage Function Components

- Breaking wave forces
- Hydrostatic forces
- Buoyant forces
- Hydrodynamic forces
- Surge forces
- Impact forces

Breaking Wave Forces

- Wave breaking typically takes place offshore.
- Exception occurs with a steep slope beach.
- Beach elevation data was analyzed and these forces were removed from consideration.

Hydrostatic Forces

- Important for 2-D structures such as seawalls.
- $F_{hs} = p_c A_w = \rho g(h - h_w/2)bh_w$
  - p_c is the hydrostatic pressure at the centroid of the wetted portion of the wall
  - A_w is the wetted area of the wall
  - h_w is the height of the wall panel
  - h is the height of the water

Buoyant Forces

- Buoyant forces act vertically through the center of mass of the displaced volume.
- A concern for wood frame buildings.
- $F_b = \rho g V$

Hydrodynamic Forces

- Occurs when steady water flows around a building.
- $F_{hd} = 1/2 C_d \rho A_f u^2 \alpha bhu^2$, where u is velocity and b is breadth

Width to Depth Ratio (w/ds or w/h)	Drag Coefficient Cd
From 1 - 12	1.25
13 - 20	1.3
21 - 32	1.4
33 - 40	1.5
41 - 80	1.75
81 - 120	1.8
> 120	2

(FEMA CCM)

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Surge Forces

- Caused by the leading edge of a surge of water.
- $F_s = 4.5\rho g h^2 b$

Impact Forces

- Caused by debris impacting the structures.
- Used HAZUS inventory to help determine debris type.

$$F_I = m\frac{du}{dt} = m\frac{u_I}{\Delta t}$$

Type of construction	Duration (t) of Impact (sec)	
	Wall	**Pile**
Wood	0.7 - 1.1	0.5 - 1.0
Steel	NA	0.2 - 0.4
Reinforced Concrete	0.2 - 0.4	0.3 - 0.6
Concrete Masonry	0.3 - 0.6	0.3 - 0.6

(FEMA CCM)

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Flood Wizard Results

- 100-year tsunami losses – general building stock

Building	Contents	Total
$80,729,519	**$68,178,240**	**$148,912,759**

The loss estimate represents 1.5% of the total inventory of the study region.

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Editing the HAZUS-MH Software

- Create a coastal flood region
- Enter the tsunami inundation elevations as the 100-year still water elevations (SWEL).
- Replace the default damage functions with the tsunami damage functions.
- Run the 100-year coastal flood.

Conclusions and Next Steps

- Although HAZUS-MH does not produce loss estimates for tsunamis, the model may be used to help evaluate the risk.
- Next steps:
  - Run the HAZUS-MH model with the new damage functions.
  - Validate the results.

Questions?

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