E0313: Basic Hazus

Student Manual

Date Released: 04/2019

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Lesson 1: Introduction and Overview

Visual 1: Lesson 1: Introductions and Overview

Visual 2: Let's Get Acquainted!

Participant introductions

- Name
- Organization
- Role in organization
- GIS and hazard analysis experience
- Goals and expectations for this class

Instructor introduction

Visual 3: Course Agenda

Day 1: Overview of Hazus, Hazus Inventory Data and CDMS, Introduction to Hazus Flood

Day 2: Hazus Flood

Day 3: Hazus Earthquake and Tsunami

Day 4: Hazus Hurricane and Course Wrap-up

Visual 4: Course Prerequisites

- Completed the E0190 ArcGIS for Emergency Managers course
- Advanced working knowledge of ArcGIS

Visual 5: Hints for Success

Ask LOTS of questions! There are NO "silly" questions.

Share your experiences with the rest of the class - they will learn from you and you from them.

Try to apply the concepts presented in class to your own needs. If you don't see applicability, ask for an example.

Practice the skills that you learn in class right away.

- In class (exercises and "experiments")
- After class (use it or lose it)

Visual 6: Goal and Objectives

Goal

- This lesson will introduce the purpose for which Hazus was created, the basic capabilities that it offers, and how to install and begin work in Hazus.

After completing this lesson, you will be able to:

- Identify the hazards that Hazus supports
- Describe the basic components of a Hazus loss estimation study
- Explain how Hazus supports emergency management
- Install Hazus and create a study region

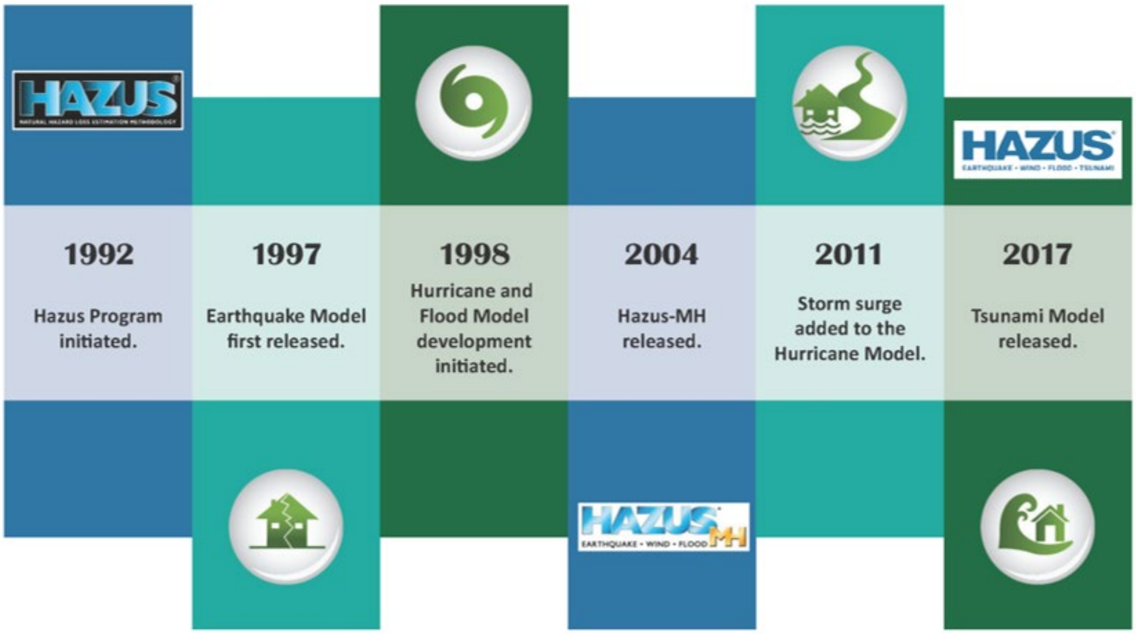
Visual 7: What is Hazus?

- Software tools and support system designed by FEMA for the purpose of providing communities with the means to identify and reduce risk from natural hazards
- Used by a variety of communities and organizations
- Available from FEMA free of charge (requires ArcGIS license with Spatial Analyst extension)

Visual 8: Supported Hazards

- Hurricane Wind and Storm Surge
- Riverine and Coastal Flooding
- Earthquake
- Tsunami

Visual 9: History



Visual 10: Supporting Emergency Management

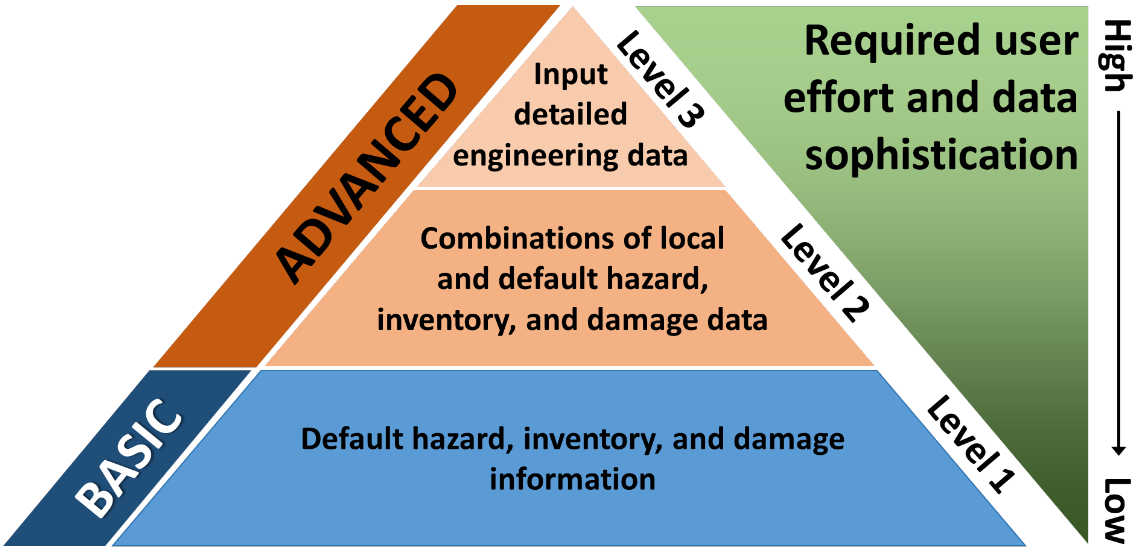
- Identify vulnerable areas
- Estimate potential impacts of hazards
- Assess level of readiness and preparedness
- Inform resource allocation
- Prioritize mitigation measures
- Inform response and post-disaster recovery efforts

Visual 11: Loss Estimation Process

- Produce maps, tables, and reports
- Analyze social and economic impacts
- Consider what is at risk
- Identify hazard
- Identify physical landscape

Direct Damages

Visual 12: User Levels



Visual 13: Inventory (Exposure)

General building types and occupancies

- Lifelines
- Replacement costs
- Demographics

Hazard-specific

- Specific building types
- First floor elevations
- Building configurations

Visual 14: Integrating User-Provided Data

Non-Hazard Data Integration Tools

- Comprehensive Data Management System (CDMS) enables integration of locally developed non-hazard data
- CDMS validates that user data are compliant with Hazus requirements

Hazard Data Integration

- ShakeMap and Hurrevac hazard data integration
- Each model includes tools for integrating user-provided hazard data

Techniques for integrating user-provided data are covered in other courses

Visual 15: Hazus 4.2 Capabilities

Hazus 4.2 Capabilities: Inputs	Earthquake	Flood	Hurricane	Tsunami
	Ground Shaking **Ground Failure**	**Frequency | Depth** **Riverine | Coastal Surge**	**Wind** **Surge**	**Depth | Momentum Flux** **Runup | Velocity**
Historic	✓	□	✓	
Deterministic	✓	✓	✓	✓
Probabilistic	✓	✓	✓	
User-supplied	✓	✓	✓	✓
Other supported inputs	Real-time & scenario USGS ShakeMaps	Risk MAP, User-supplied depth grids (ArcGRID, GeoTIFF, IMAGINE), HEC-RAS (.FLT)	Hurrevac, User-supplied wind files (.dat)	NOAA PMEL SIFT, State models

Visual 16: Introduction and Overview: Output - Direct Damage

Hazus 4.2 Capabilities: Direct Damage	Earthquake	Flood	Hurricane	Tsunami
	Ground Shaking **Ground Failure**	**Frequency | Depth** **Riverine | Coastal Surge**	**Wind** **Surge**	**Depth | Momentum Flux** **Runup | Velocity**
Direct Damage				
General Building Stock	✓	✓	✓	✓
Essential Facilities	✓	✓	✓	
Transportation Systems	✓	✓		
Utility Systems	✓	✓		
User-Defined Facilities	✓	✓	✓	✓

Visual 17: Introduction and Overview: Output - Induced Damage

Hazus 4.2 Capabilities: Induced Damage	Earthquake	Flood	Hurricane	Tsunami
	Ground Shaking **Ground Failure**	**Frequency | Depth** **Riverine | Coastal Surge**	**Wind** **Surge**	**Depth | Momentum Flux** **Runup | Velocity**
Induced Damage				
Fire Following	✓			
Debris Generation	✓	✓	✓	✓

Visual 18: Introduction and Overview: Output - Direct Losses

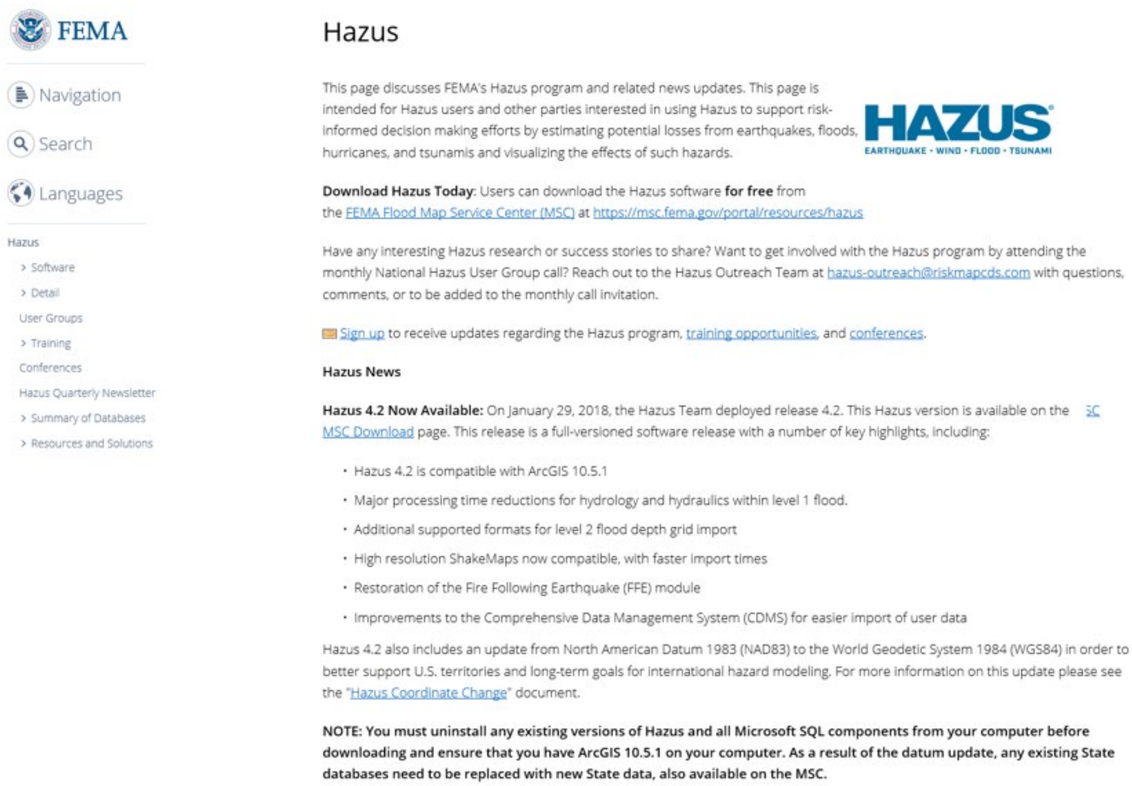
Hazus 4.2 Capabilities: Direct Losses	Earthquake	Flood	Hurricane	Tsunami
	Ground Shaking **Ground Failure**	**Frequency | Depth** **Riverine | Coastal Surge**	**Wind** **Surge**	**Depth | Momentum Flux** **Runup | Velocity**
Direct Losses				
Cost of Repair	✓	✓	✓	✓
Income Loss	✓	✓	✓	✓
Agricultural		✓		
Casualties	✓			✓
Shelter and/or Evacuation Needs	✓	✓	✓	✓
Average Annualized Loss (AAL)	✓	✓	✓	

Visual 19: Hardware and Software Requirements

- Memory: 4 GB or higher
- Disk space: 10GB for one multi-hazard large urban study region, plus inventory data size (varies by state), or 70 GB to store entire U.S. inventory data
- Graphics Adaptor: 24-bit capable video card with at least 128 MB of video memory, resolution of 1078 x 768 or higher
- Operating Systems: 64-bit versions of Windows 10 Professional and Enterprise, Windows 8.1, and Windows 7 Professional
- Supporting Software: Appropriate version of Esri ArcGIS and the Spatial Analyst extension for the flood model

Visual 20: FEMA Hazus Website

Primary FEMA resource for updated information related to Hazus:
FEMA Hazus Website (www.fema.gov/hazus)



FEMA

Navigation

Search

Languages

Hazus

> Software

> Detail

User Groups

> Training

Conferences

Hazus Quarterly Newsletter

> Summary of Databases

> Resources and Solutions

Hazus

This page discusses FEMA's Hazus program and related news updates. This page is intended for Hazus users and other parties interested in using Hazus to support risk-informed decision making efforts by estimating potential losses from earthquakes, floods, hurricanes, and tsunamis and visualizing the effects of such hazards.

Download Hazus Today: Users can download the Hazus software **for free** from the FEMA Flood Map Service Center (MSC) at https://msc.fema.gov/portal/resources/hazus

Have any interesting Hazus research or success stories to share? Want to get involved with the Hazus program by attending the monthly National Hazus User Group call? Reach out to the Hazus Outreach Team at hazus-outreach@riskmapcds.com with questions, comments, or to be added to the monthly call invitation.

Sign up to receive updates regarding the Hazus program, training opportunities, and conferences.

Hazus News

Hazus 4.2 Now Available: On January 29, 2018, the Hazus Team deployed release 4.2. This Hazus version is available on the SC MSC Download page. This release is a full-versioned software release with a number of key highlights, including:

- Hazus 4.2 is compatible with ArcGIS 10.5.1
- Major processing time reductions for hydrology and hydraulics within level 1 flood.
- Additional supported formats for level 2 flood depth grid import
- High resolution ShakeMaps now compatible, with faster import times
- Restoration of the Fire Following Earthquake (FFE) module
- Improvements to the Comprehensive Data Management System (CDMS) for easier import of user data

Hazus 4.2 also includes an update from North American Datum 1983 (NAD83) to the World Geodetic System 1984 (WGS84) in order to better support U.S. territories and long-term goals for international hazard modeling. For more information on this update please see the "Hazus Coordinate Change" document.

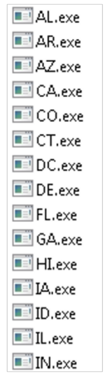
NOTE: You must uninstall any existing versions of Hazus and all Microsoft SQL components from your computer before downloading and ensure that you have ArcGIS 10.5.1 on your computer. As a result of the datum update, any existing State databases need to be replaced with new State data, also available on the MSC.

Visual 21: Installation

- Log in with a full Administrator account
- Download Hazus from the Map Service Center's website. (msc.fema.gov/portal/resources/hazus)
- Unzip the downloaded file
- Right-click on setup.exe file and select "Run as Administrator" option
- "Administrator Rights" can vary - consult the "Getting Started.pdf" document to ensure a proper installation

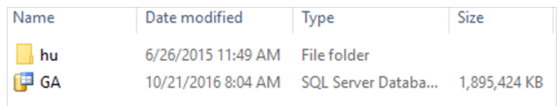
Visual 22: State Inventory Data

- Download Hazus provided data (aggregated by each state) at the FEMA Hazus Download site: msc.fema.gov/portal/resources/hazus
- Each State dataset is wrapped into a .exe file
- Extract state(s) files of interest to Data Path folder by double-clicking the .exe file and selecting the data path folder
- C:\HazusData\Inventory



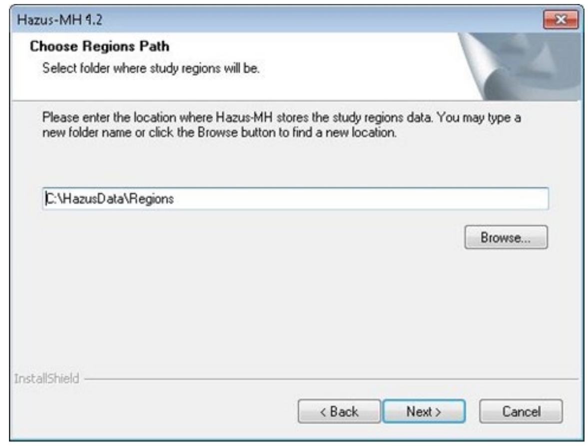
Download each State's .exe file through the Map Service Center website

Each State's .exe will extract the State databases



Visual 23: Study Region Location

- All study regions will be created in the folder specified in this window
- All data related to the Study Region will be stored in this location
- Default location is C:\HazusData\Regions



Visual 24: What is a Study Region?

The area for which you are conducting a loss estimation study.

Can be defined by state, county, or census tract. Flood only or flood-tsunami regions can also be defined by census block, community, or watershed.

Questions to consider:

- What type of hazard(s) are you studying?
- What area(s) is the hazard likely to impact?
- Do you need to understand impacts outside your immediate jurisdiction?

No damage is assessed outside the study region - even if it exists!

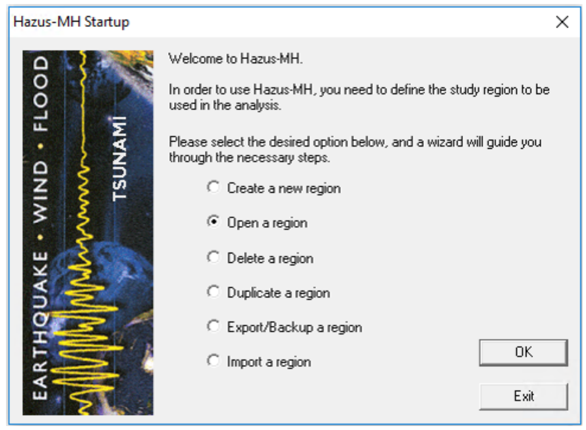
Visual 25: Study Region Size

- Size limit of 10 GB per database for SQL Server 2014 Express
- The success of a Hazus analysis will depend on the available system resources of the PC
- Large flood (riverine or coastal) and combined flood/wind analyses require large amounts of system resources even for small geographic areas (e.g., a single county)

Visual 26: Study Region Options

Hazus Startup Window

- Create a new region
- Open a region
- Delete a region
- Duplicate a region
- Export/Backup a region
- Import a region



Visual 27: Activity 1.1

The Instructor will

- Demonstrate each of the Hazus startup options
- Lead students through the creation of a new study region for Salt Lake County, Utah

Visual 28: Review

What are the four hazards that Hazus supports?

How does Hazus support emergency management?

What is the purpose of a study region?

What questions should be considered when creating a study region?

Visual 29: Questions?

Lesson 2: Hazus Inventory

Visual 1: Lesson 2: Hazus Inventory

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Visual 2: Goal and Objectives

Goal

This lesson will explore the features of the Hazus inventory.

After completing this lesson, you will be able to:

- Explain the difference between site-specific and aggregate inventory
- List examples of inventory that are common across all hazard models
- Navigate the Inventory menu

Visual 3: Hazus Inventory Types

Aggregate

Information about demographics and the general building stock (GBS) in census tracts or census blocks represented by polygons

Site-specific

Information about the built-environment, such as essential facilities, transportation and utilities represented by points and lines

Visual 4: Aggregate Inventory

General Occupancy Types

- Residential
- Commercial
- Industrial
- Religion/Non-profit
- Government
- Education
- Agriculture

Visual 5: Aggregate Inventory

33 Specific Occupancy Categories

- Residential (11)
- Commercial (10)
- Industrial (6)
- Religion/Non-profit (1)
- Government (2)
- Education (2)
- Agriculture (1)

View the categories from the Inventory menu

Visual 6: Aggregate Inventory

Specific Occupancy Types - Residential

- RES1 Single Family Dwelling
- RES2 Mobile Home
- RES3 Multi-Family Dwellings
    - RES3A Duplex
    - RES3B 3-4 Units
    - RES3C 5-9 Units
    - RES3D 10-19 Units
    - RES3E 20-49 Units
    - RES3F 50+ Units
- RES4 Temporary Lodging
- RES5 Institutional Dormitory
- RES6 Nursing Home

Specific Occupancy Types - Commercial

- COM1 Retail Trade
- COM2 Wholesale Trade
- COM3 Personal and Repair Services
- COM4 Professional/Technical Service
- COM5 Banks
- COM6 Hospitals
- COM7 Medical Office/Clinic
- COM8 Entertainment and Recreation
- COM9 Theaters COM10 Parking

Visual 7: Examples - Occupancy Type

Visual 8: Aggregate Inventory

Building Types:

General Building Types (All Models)

- Concrete
- Steel
- Manufactured Housing
- Wood
- Masonry

Specific Building Types

- Unique to each model

Visual 9: Aggregate Inventory

Example of Specific Building Type for Earthquake Inventory

Specific Building Type	General Description	Specific Description
W1	Wood	Wood, Light Frame, All heights
W2	Wood	Wood, Commercial and Industrial, All heights
S1L	Steel	Steel Moment Frame, Low-rise, 1-3 stories
S1M	Steel	Steel Moment Frame, Mid-rise, 4-7 stories
S1H	Steel	Steel Moment Frame, High-rise, 8+ stories

Visual 10: Mapping Schemes

Mapping schemes describe characteristics of buildings within a census tract or block

Examples:

- Foundation type
- First-floor elevation
- Construction materials

Generally expressed as a percentage

The default mapping schemes of your study area may be updated to better represent the accurate distribution of buildings using local data

Visual 11: Activity 2.1

The Instructor will

- Explore the aggregate inventory and mapping schemes
- Lead students to answer the following questions:
    - Where might you find information to update the Hazus-provided building inventory?
    - Why does Hazus collect information about how a building is used as well as information about the materials from which it is constructed?

Visual 12: Hazus Inventory: Site-Specific Inventory by Model

Inventory	Earthquake	Flood	Hurricane	Tsunami
Essential facilities	X	X	X	O
Transportation Systems	X	/	O	O
Utility Systems	X	X	O	O
High Potential Loss Facilities	/	O	O	O
User Defined Facilities	X	X	X	X
Hazardous Materials Facilities	O	O	O	O
Advanced Engineering Building Module	X			

O = Mapping Only / = Some Analysis X= Analysis

Visual 13: User-Defined Facilities

- User-Defined Facilities (UDFs) are any individual buildings that you may wish to add to the study region
- UDFs are not designed to replace engineering models or knowledge
- UDF results are best used by summing all the UDF results for an area rather than using individual structure results

Visual 14: GBS Results

Earthquake	Flood	Hurricane	Tsunami
Damage by Building Type	Damage by Occupancy	Damage Probabilities by Occupancy	Damage by Count
Damage by Building Count	Damage by Building Type	Damage Probabilities by Building Type	Damage by Square Footage
Damage by Square Footage	Damage by Building Count	Cost of Building Repair or Replacement	Building Economic Loss
Direct Economic Loss	Economic Loss by Full Replacement	Loss of Contents	
Building Loss by Damage State	Economic Loss by Depreciated Replacement	Business Inventory Loss, Business Income Loss, Employee Wage Loss	
		Loss of Rental Income, Relocation Costs	

Visual 15: Activity 2.2

The Instructor will

- Explore the site-specific inventory
- Lead students to answer the following questions:
    - How many fire stations are in your county?
    - Based on the values in the EfClass field, how many types of schools are in your study region?
    - How many different classes of bridges does Hazus support?
    - What unit of measurement is used for the length field in the highway bridge table?

Visual 16: Review

What are examples of Hazus site-specific inventory?

What are examples of Hazus aggregate inventory?

What is the difference between building occupancies and building types? Give examples of each.

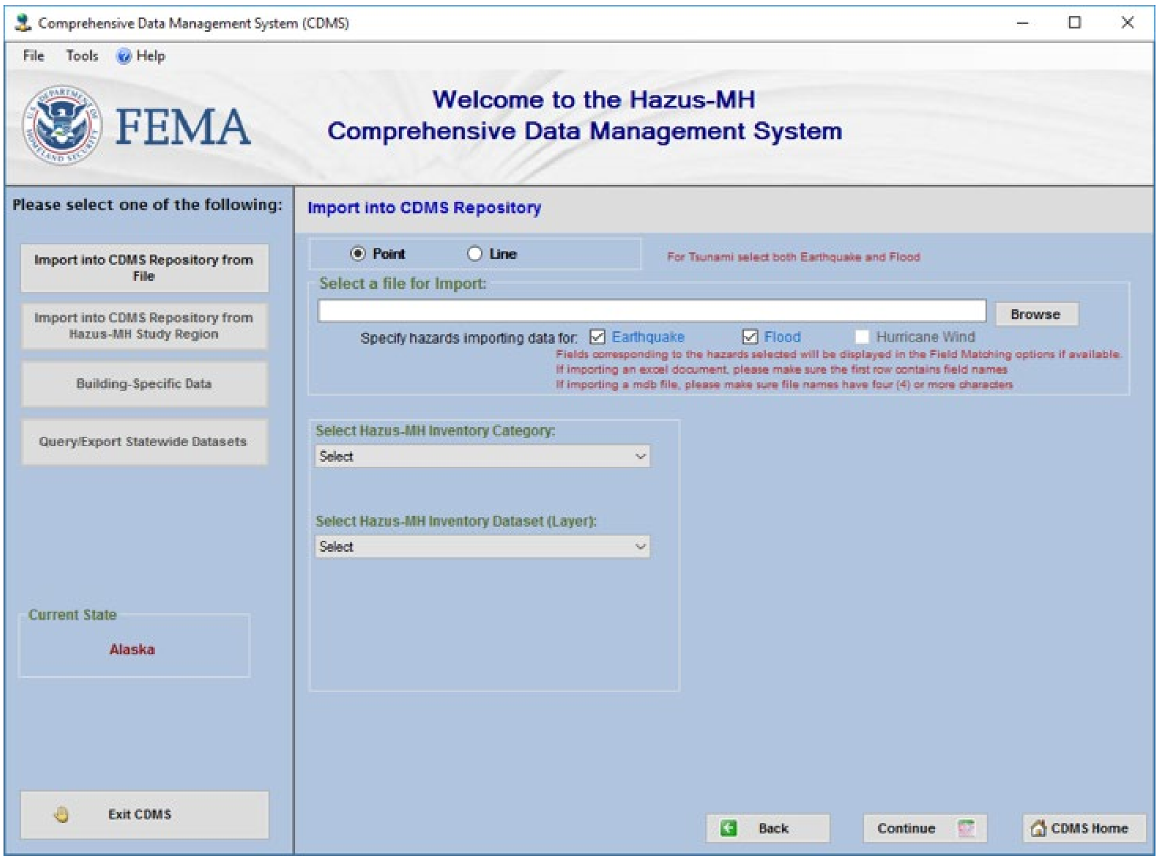
Where would you look in Hazus for a definition of a RES2 occupancy?

Visual 17: Updating the Default Hazus Data

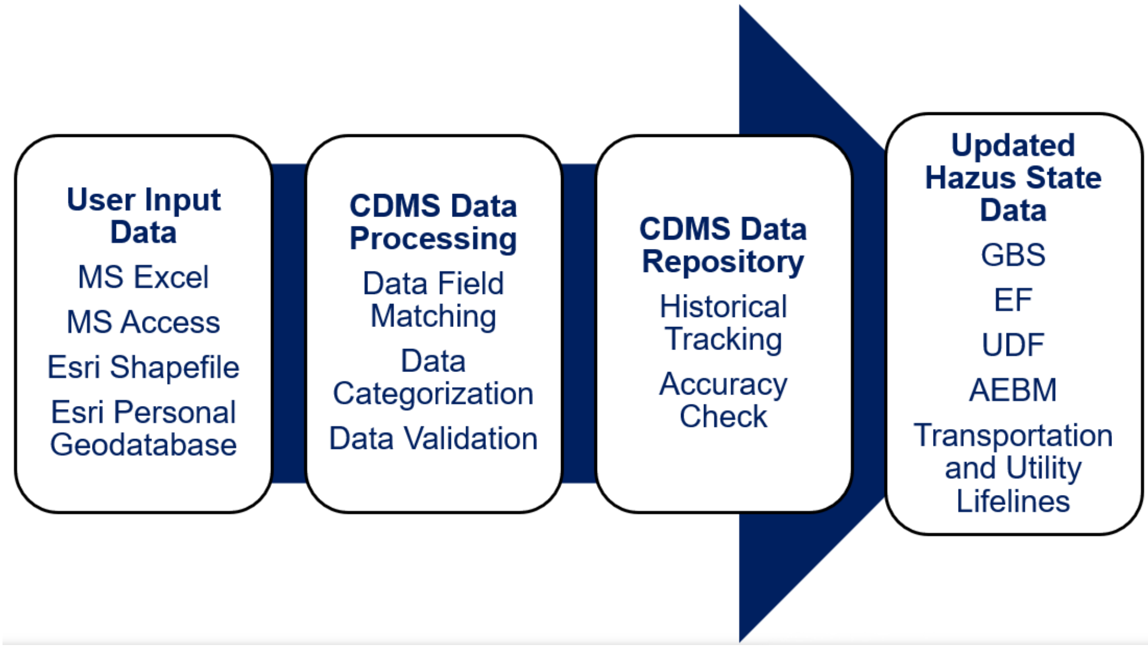
Comprehensive Data Management System (CDMS)

A Hazus support tool providing the ability to move data to and from Hazus state datasets

Enables users to assess the impacts of mitigation strategies used to help address issues generated by hazards



Visual 18: CDMS Workflow



CDMS Workflow

Visual 19: CDMS Usage Example

Example: Update Essential Facilities

- **Export** the default data from Hazus using CDMS
- **Update** the default data using local data
- **Import** the updated data into the CDMS Repository
- Use the updated data in a **new Hazus analysis**
- Package and **distribute data**, if necessary

Visual 20: Activity 2.3

Use CDMS to update the Charleston County Fire Station inventory:

- Setup the CDMS state data location
- Review the Hazus-MH default Fire Stations
- Export the Hazus-MH Fire Stations to an Excel file
- Review a 'Hazus-ready' user-provided Fire Stations inventory created in Excel
- Import the user provided Fire Stations into CDMS
- Transfer the updated Fire Station inventory to the state database

HINT: If the Excel sheet is larger than the data extents, you will import empty fields and/or records

Visual 21: Questions?

Lesson 3: Flood Hazard

Visual 1: Lesson 3: Flood Hazard

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Visual 2: Goal and Objectives

Goal

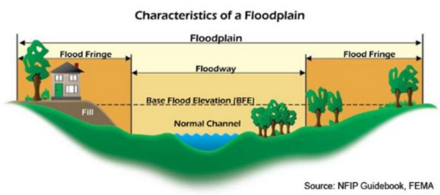
This lesson will provide an overview of the flood hazard.

After completing this lesson, you will be able to:

- Understand how Hazus creates a flood depth grid based on a return period or discharge analysis
- List the user-defined hazard options
- Provide examples of the What-If features
- Describe the key inputs for defining a coastal flood hazard

Visual 3: Basic Concept of Hazard Determination

Subtract ground surface from flood surface to determine flood depth throughout the study area.



Visual 4: Riverine Hazard Delineation Options

- **Return Period**
- **Discharge**
- **User-Defined Depth Grid**

Covered in this class

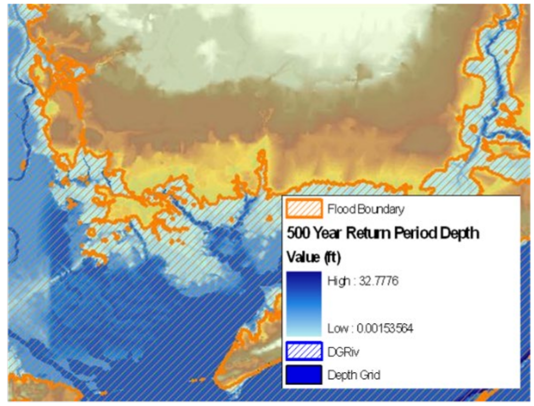
- **Flood Information Tool**
- **Quick Look**
- **Enhanced Quick Look**
- **HEC-RAS**

Covered in the "Hazus for Flood" class

Visual 5: User-Defined Hazard Options

User-Defined Hazard Options

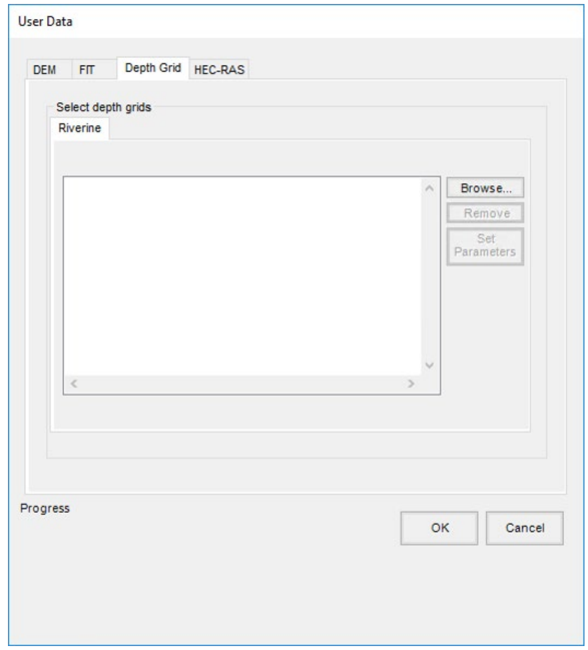
- Quick Analysis
- Quick Look
- Enhanced Quick Look
- Flood Information Tool
- User-Defined Depth Grid
- HEC-RAS



User-defined hazard options are covered in E0172: Hazus for Floods Course

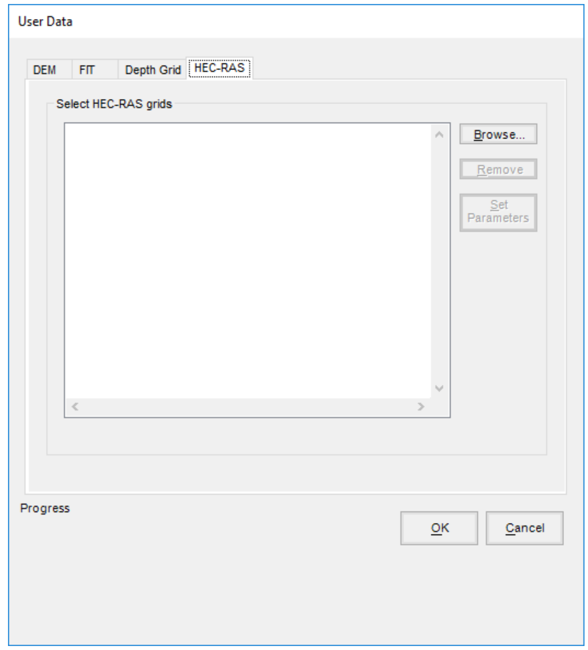
Visual 6: User-Defined Hazard Options

Users can import custom depth grids into Hazus to replace USGS DEMs and using Hazus to model the floodplain



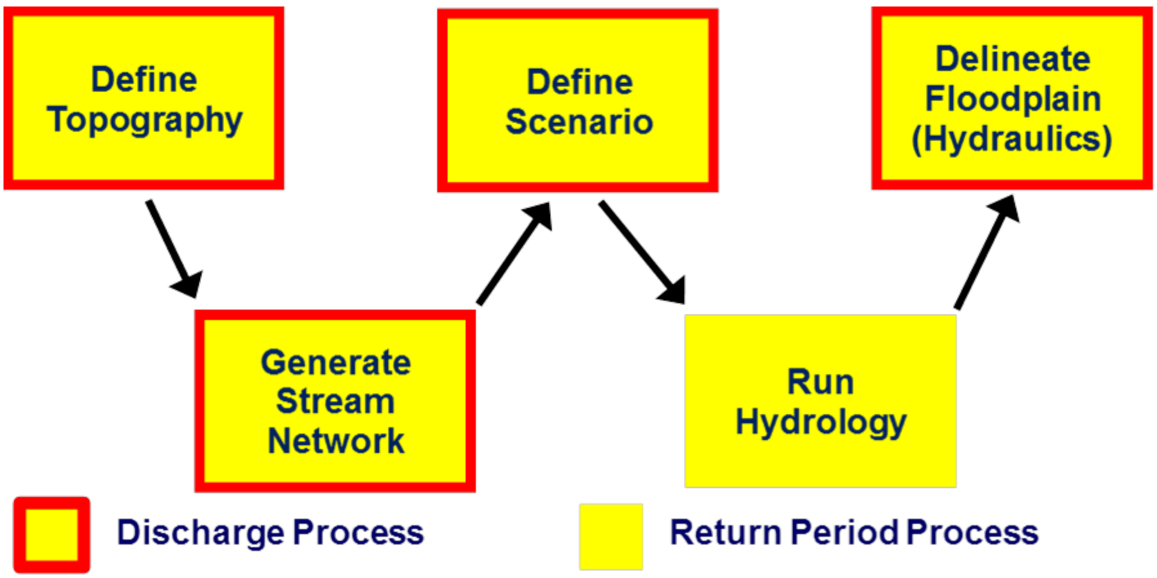
Visual 7: HEC-RAS

Users can import HEC-RAS models into Hazus to replace USGS DEMs



Visual 8: Riverine Flood Hazard Process - Return Period and Discharge

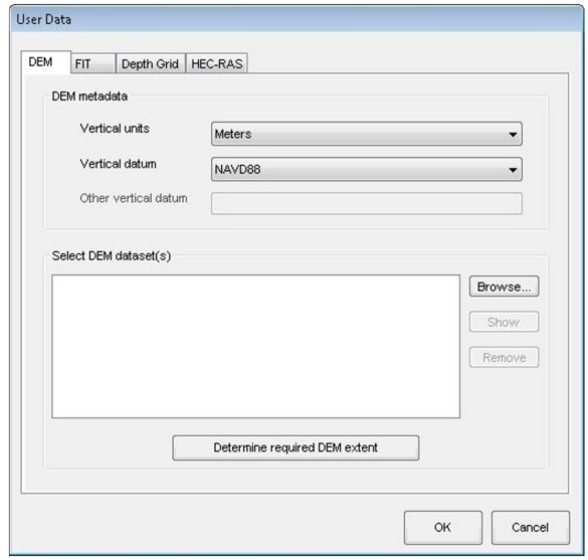
Riverine Flood Hazard Process



Visual 9: Return Period and Discharge

Defining Topography

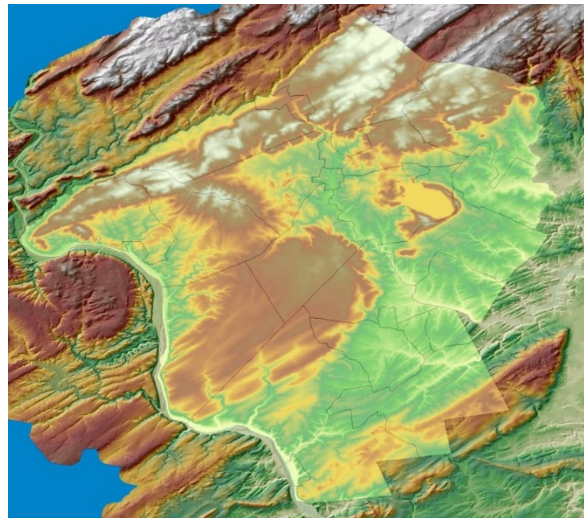
- Required DEM extents are automatically determined by Hazus.
- Hazus downloads and unzips files to be used.



Visual 10: Return Period and Discharge Process

Defining Topography (Cont'd.)

- Hazus “clips” the portion of the DEM that is needed to perform flood modeling
- DEM is shaded to show elevation changes

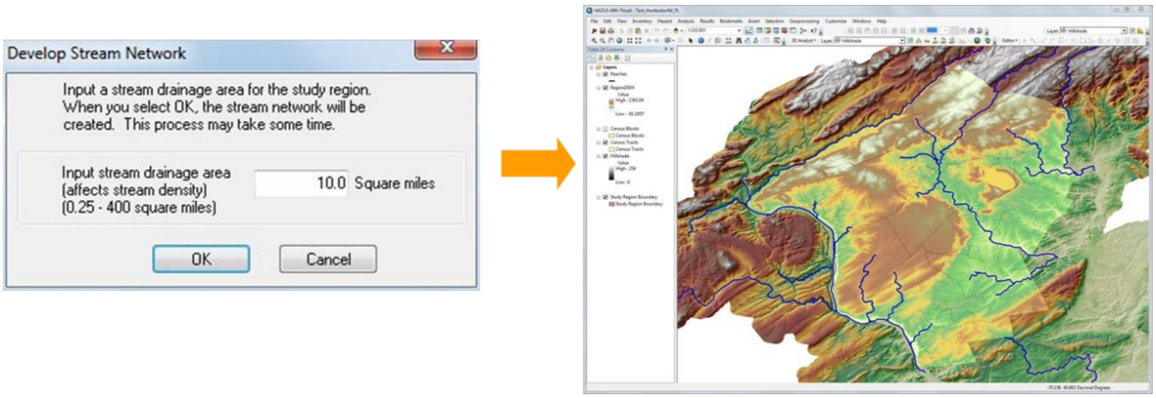


Visual 11: Return Period and Discharge Process

User defines drainage area

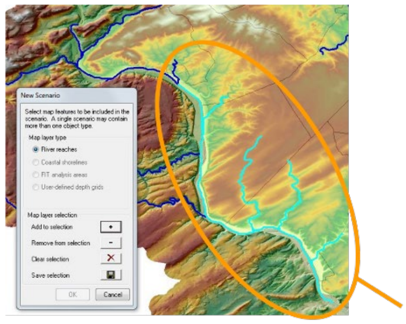
- Larger drainage area generates fewer, larger streams (faster)
- Smaller drainage area generates more, smaller streams (slower)

Hazus uses topography to identify stream locations



Visual 12: Return Period and Discharge Process

Define a Scenario

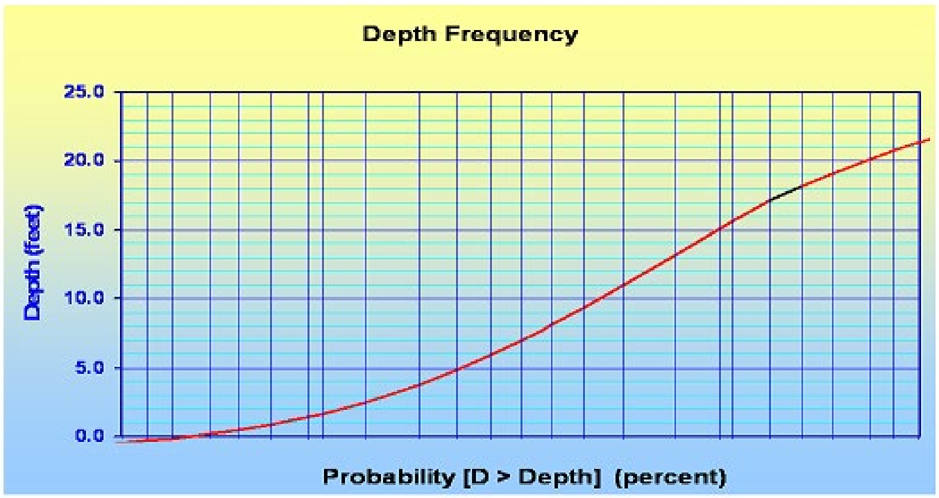


- Identify the reaches to be analyzed
- Study regions can contain multiple scenarios
- Reaches can be assigned to one or more scenarios

Example of selected reaches

Visual 13: Hydrologic Analysis

Determines discharge-frequency relationship for each reach in study region

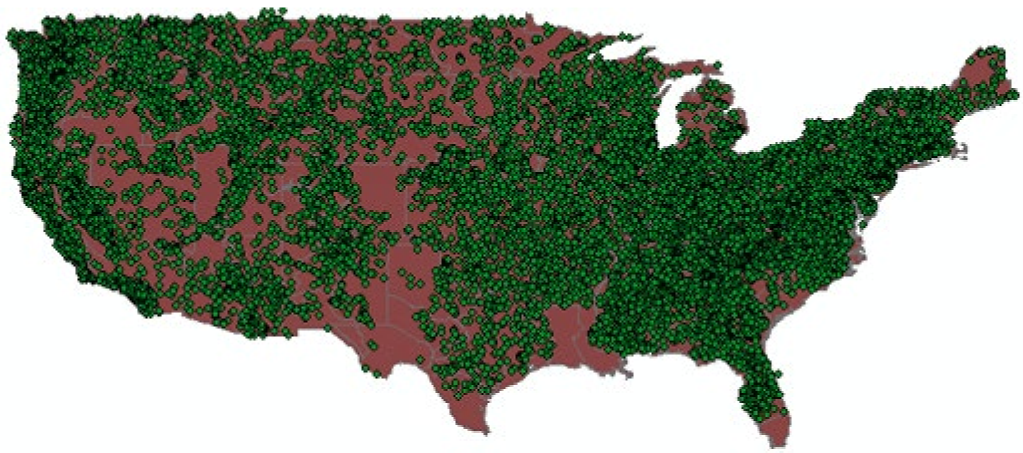


Example discharge-frequency curve from stream gage

Visual 14: Hydrologic Analysis

Hazus Approach:

- Gaged reaches: Derive curves from the USGS Streamflow Basin Characteristics File
- Hazus provided database includes approximately 11,000 gage locations and associated statistics

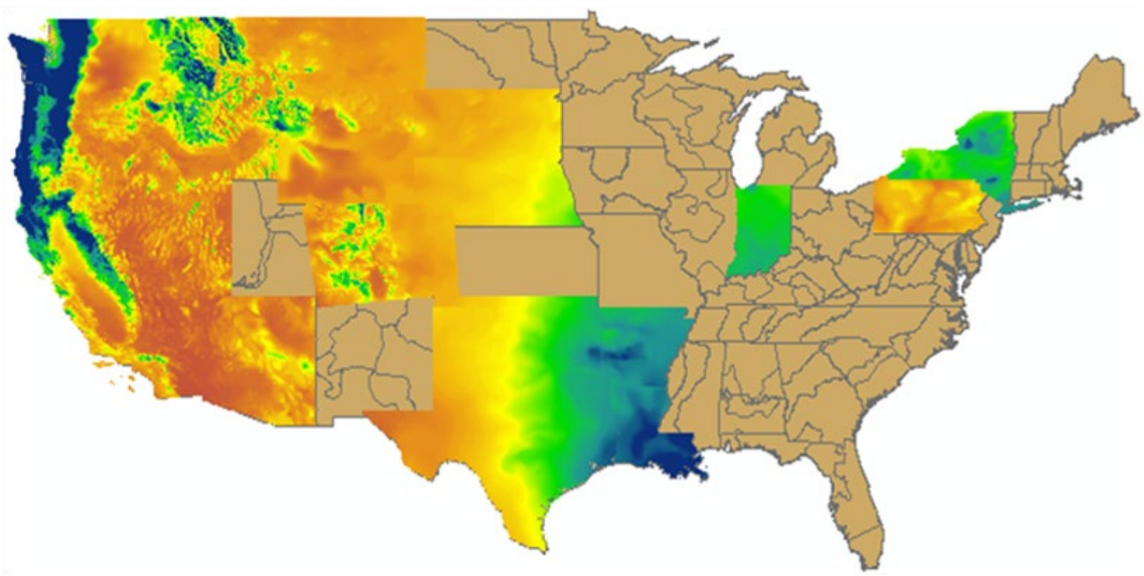


USGS Gage Location

Visual 15: Hydrologic Analysis

Hazus Approach:

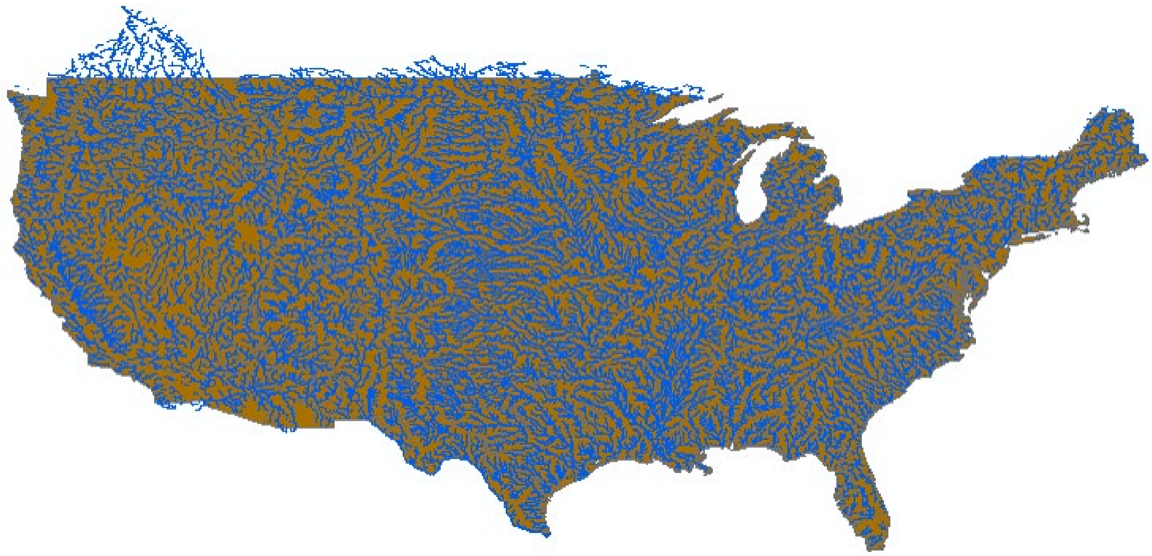
- Ungaged reaches: Apply USGS regression equations
- Input to equations comes from DEM as well as a number of Hazus-MH provided datasets such as temperature, snowfall, and others



Visual 16: Hydrologic Analysis

Hazus Approach:

- Includes a database of reaches - based on 100-square mile drainage areas - used to identify the selected reaches that are on major streams
- Discharge values are interpolated from the corresponding values in the default flood frequency database



Reach Network

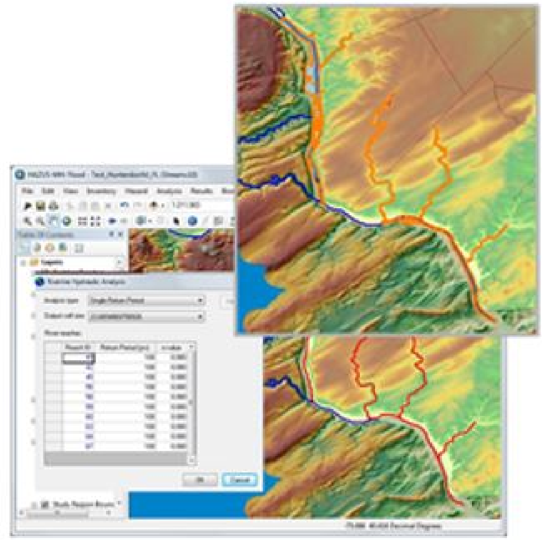
Visual 17: Hydraulic Analysis

Hazus Approach:

- Given discharge and stream channel morphology, compute flood elevations

Hazus Output:

- Flood elevations
- Flood depth grid for each user-defined frequency or discharge



Visual 18: Hydraulic Analysis

Select type of flood analysis for each reach in the scenario

Analysis Types:

- Full suite of return periods
- Single return period *
- Single discharge *

* Each reach can have a different return period or discharge

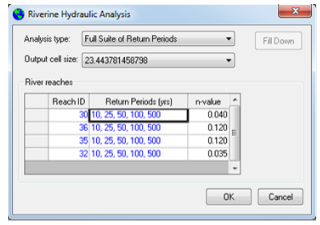
Numbered stream reaches

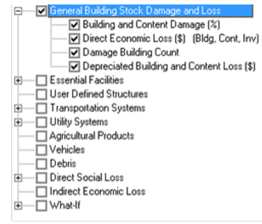
Visual 19: Annualized Loss

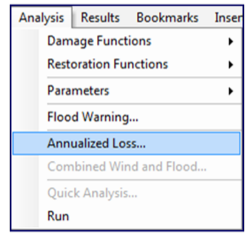
- The average annualized loss (AAL) is the estimated direct economic losses averaged on an annual basis using estimated direct economic losses
- AAL provides a community with a common economic frame of reference they can use to compare flood losses against other hazards
- AAL can be used in determining the financial feasibility of mitigation projects

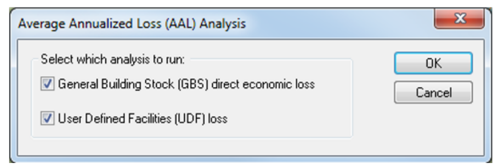
Visual 20: Annualized Loss - Steps

1. Select to run the Full Suite of Return Periods during the Hydraulic Analysis (Produces 5 sets of depth grids for each reach that was selected in the scenario)
2. Run the General Building Stock analysis and/or the User Defined Facility Analysis
3. Run the Annualized Loss Analysis



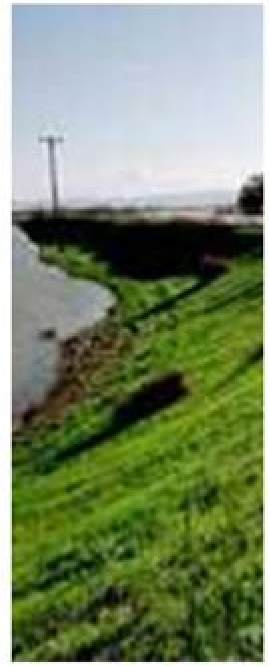






Visual 21: Riverine What-Ifs: Levees

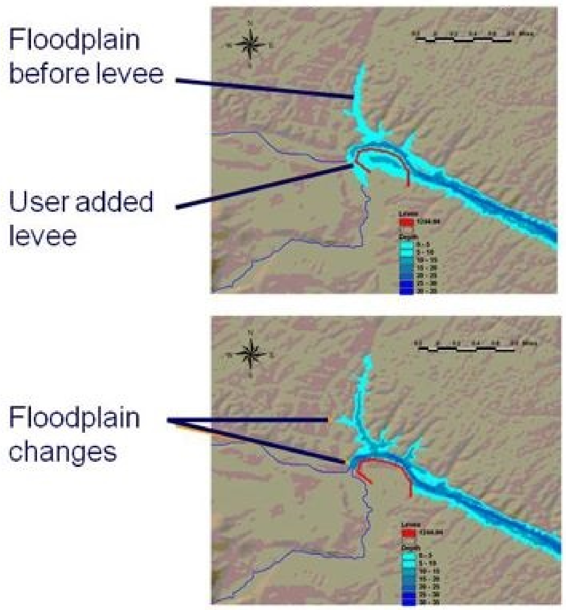
DEMs generally do not capture levees because of their narrow width



Hazus Benefits:

- Determine inundation area with and without levee
- Assess impact with and without levee

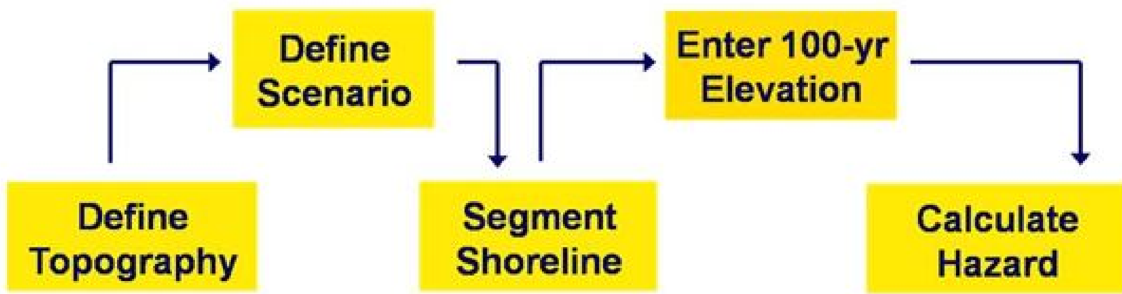
Visual 22: Riverine What-Ifs: Levees (Cont'd.)



- Draw levee so that it crosses the floodplain twice
- Enter flood recurrence interval levee protects against (e.g., 200-year)

Visual 23: Coastal Model Overview

Level 1

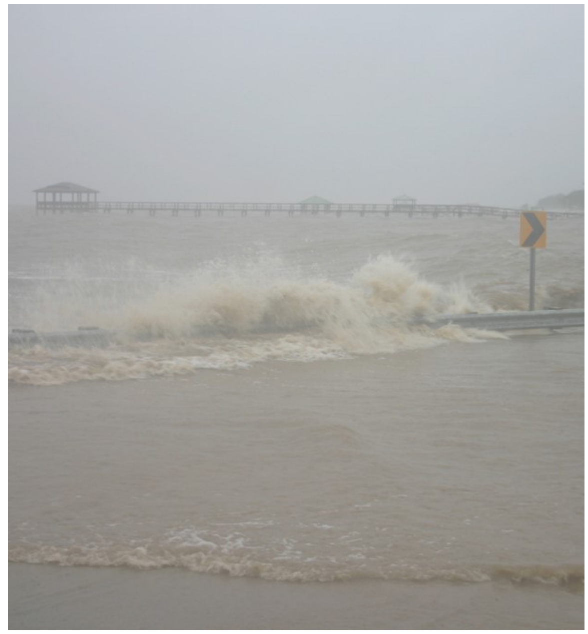


Visual 24: Coastal Hazard Data

National shoreline

- Includes a smoothed shoreline for transect development

Attribution of census blocks as coastal or great lakes



Visual 25: Modeled Wave Effects

Wave setup:

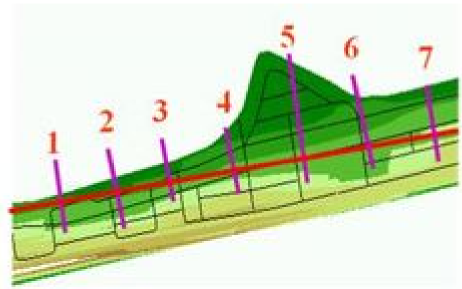
- Increase in the Stillwater level caused by waves breaking near the shoreline

Simplified overland waves:

- Affected by water depth
- Results from wave height analyses combined to develop a single water surface

Visual 26: Coastal Transect Analysis

- Analyses performed along shore-normal transects, affected by an increased inference line
- Transect spacing is uniform based on shoreline characteristics that are closer in complex terrain



Visual 27: Coastal Hazard Setup - FIS

FEMA Flood Insurance Study (FIS)

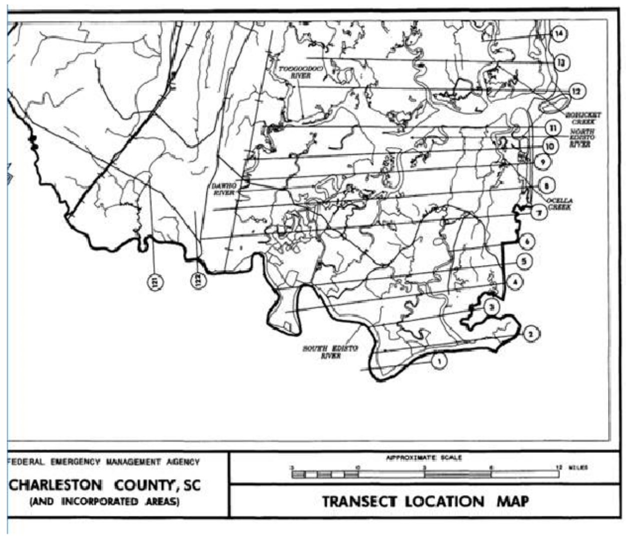
- 100-year still water elevations can be found in the FIS
- Other return periods are sometimes provided too
- Vertical datum is provided at the top of the table
- Each record in the table is associated with a transect location provided in a FIS map

TABLE 6 - TRANSECT DESCRIPTIONS

Transect	Location	Elevation (feet NGVD 29) 100-Year Stillwater	Elevation (feet NGVD 29) Maximum 100-Year Wave Crest[1]
1	Approximately 2,000 feet southwest of mouth of South Edisto River (in Colleton County)	13.0	20.1
2	Across the western portion of Edisto Island, approximately 1.4 miles southeast of the mouth of Big Bay Creek (in Colleton County)	13.0	20.1
3	Across the western portion of Edisto Island, approximately 1.6 miles southeast of the mouth of Big Bay Creek (in Colleton County)	13.0	20.1
4	Across Edisto Island, approximately 2.3 miles east of the mouth of Big Bay Creek (in Colleton County)	13.0	20.1
5	Across Edisto Island, approximately 1.0 mile southwest of Jeremy Inlet (in Colleton County)	13.0	20.1
6	Across Edisto Island, just northeast of Jeremy Inlet	13.0	20.1
7	Across Edisto Island, approximately 2.0 miles northeast of Jeremy Inlet	13.0	20.1
8	Across Edisto Island, approximately 2.1 miles northeast of Jeremy Inlet	13.0	20.1
9	Across Edisto Island, approximately 3.0 miles southwest of the mouth of North Edisto River	13.0	20.1

[1]Because of map scale limitations, the 100-year stillwater may not be shown on the FIRM.

30

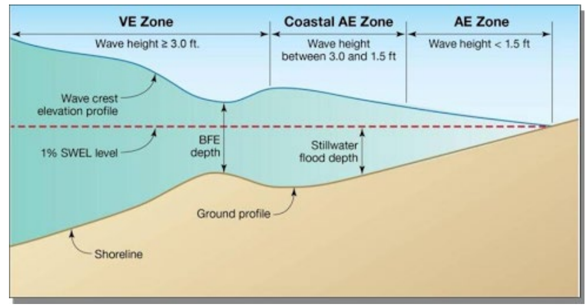


Visual 28: Coastal Hazard Output

Model calculates

- Flood surface, considering wave height
- Flood depth

Flood model develops A, Coastal A, and V zones.



Visual 29: Review

What are the steps for defining a riverine flood hazard based on a return period?

When defining the drainage area, which would create a denser stream network: 2 or 5 square miles?

If you define a flood hazard that is based on a stream discharge, do you need to run the hydrology?

What are the two required parameters for defining a coastal flood hazard?

Visual 30: Questions?

Lesson 4: Flood Analysis

Visual 1: Lesson 4: Flood Analysis

Visual 2: Goal and Objectives

Goal

This lesson will provide an overview of the methodologies used for food analysis.

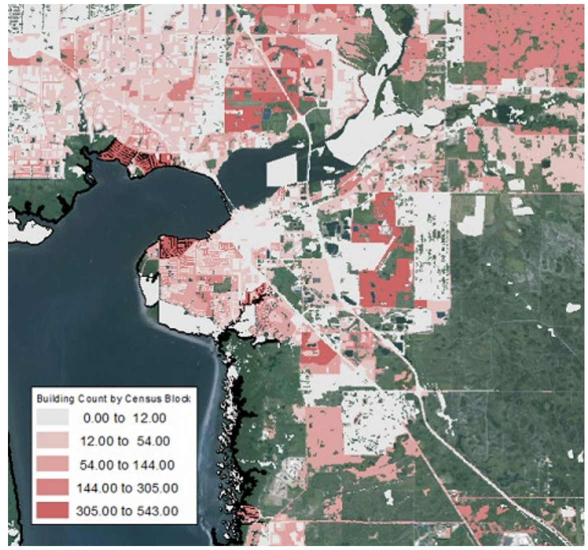
After completing this lesson, you will be able to:

- Understand flood-specific inventory
- Explain the process by which Hazus calculates flood-related losses
- Summarize analyses that can be completed in the flood model
- Provide examples of flood analysis parameters that the user can define

Visual 3: Flood-Specific Inventory

Dasymetric Inventory:

- Flood Model only
- Assumes building exposure only exists within areas which satellite and land-use data confirm there exists a built environment
- Based upon the 2011 National Land Cover Dataset (NLCD)



Visual 4: Flood-Specific Inventory

General Building Stock:

- Depreciated Replacement Costs
  - Estimates depreciated value of structures (used for insurance purposes)
- Distribution of foundation types and first-floor heights
- Estimates the first floor height based upon the foundation type

Models differ for riverine, coastal, and Great Lakes census blocks, as well as for Pre-FIRM and Post-FIRM structures

Visual 5: Flood-Specific Inventory

Agriculture:

Data are provided by National Agriculture Statistical Survey (NASS) and National Resources Inventory (NRI)

- Sub-County Polygons with average crop production, cost, and value
- Top 20 crops for each NRI Region
- Does not include livestock

Visual 6: Flood-Specific Inventory

Vehicles:

Data developed, using standard traffic models for planning

- Based on census block floor area by specific occupancy (e.g., RES1, COM1)
- Valuation based on average new and used vehicles
- Three “occupancy” classifications: Car, LtTrk (light truck), and HvyTrk (heavy truck)

Includes day and night estimates

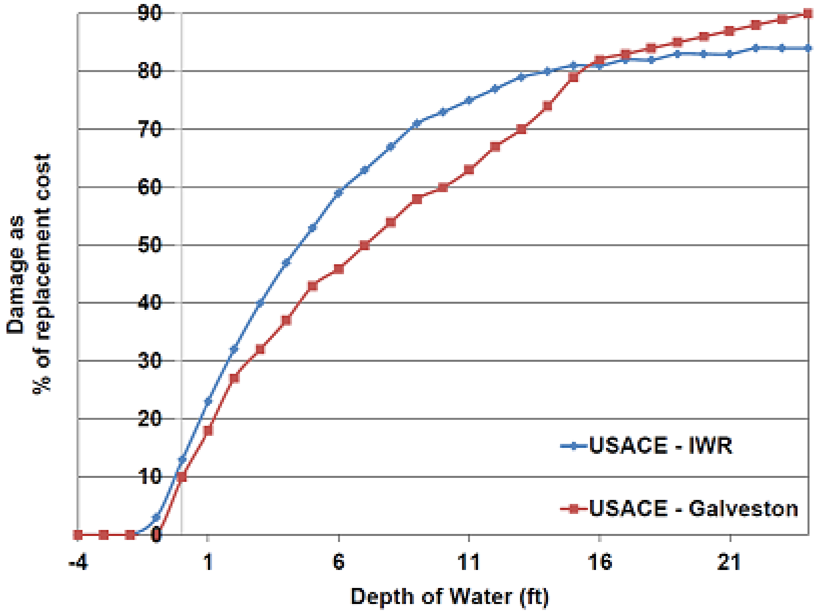
Visual 7: Damage Estimates

Damage estimated for:

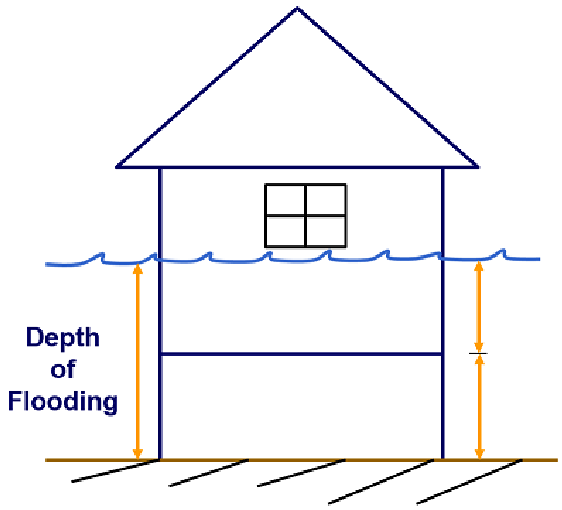
- General Building Stock
- Essential Facilities
- Bridges
- Selected utility facilities
- Vehicles
- Agriculture products

Visual 8: Depth-Damage Functions

Default depth-damage functions are assigned based on building characteristics



Visual 9: Depth-Damage Functions (Cont'd.)



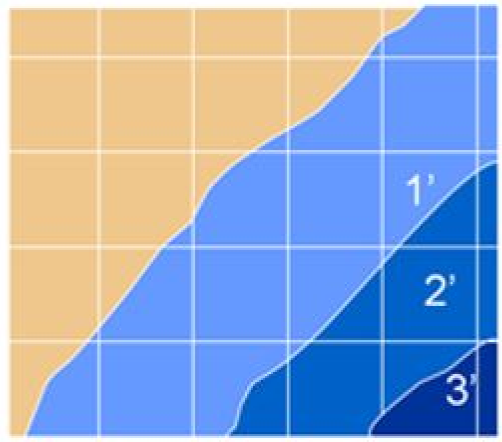
Depth-damage functions are applied to relevant depth, e.g.,

- For buildings, first-floor height (bottom of first finished floor for coastal)
- For equipment, height above first floor

Visual 10: GBS Loss Estimation Methodology

Hazus performs an area weighted assessment of damage for aggregate inventory

- Number of grid cells at a given depth is counted and then divided by total number of cells within census block
- Result is used to “weight” damage at that flood depth for each occupancy



DEM Grid points

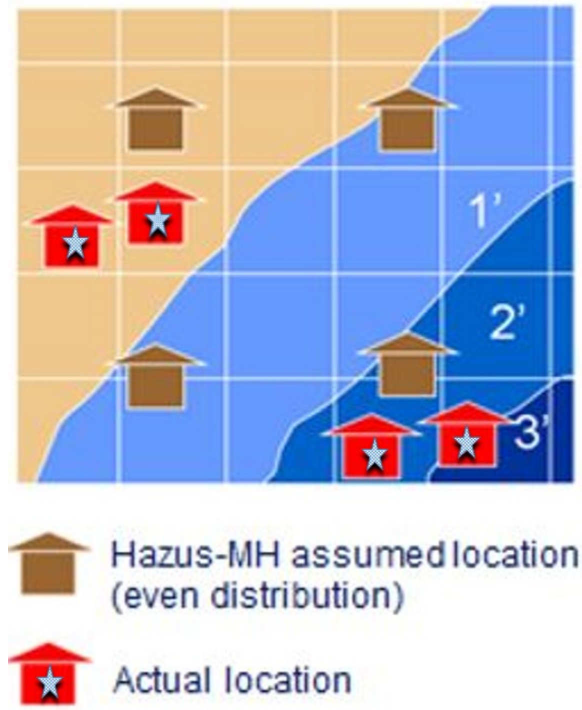
This approach is most appropriate for large areas.

Visual 11: GBS Loss Estimation Methodology (Cont'd.)

Assumes that inventory is evenly distributed across each census block.

Example: If 25% of the block has 2 ft. of water, it is assumed that 25% of the four single-family dwellings in the block are in 2 ft. of water.

Losses are reported as totals for each occupancy and building type rather than for each building.



Visual 12: Activity - GBS Advantages and Disadvantages

Answer the following questions:

- What are some of the advantages of using General Building Stock?
- What are some of the disadvantages of using General Building Stock?

Visual 13: GBS Related Analysis

The following analysis options are driven by the General Building Stock:

- Debris
- Direct Social Loss (Shelters)
- Direct Economic Loss

Why are these outputs important to communities?

Visual 14: User-Defined Facilities

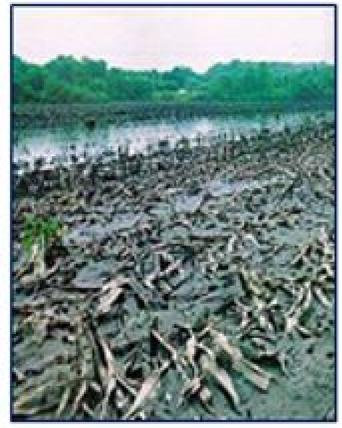
- Damages are determined by the depth of water at the location of the point representing a facility.
- Building and content damages and losses are reported on a structure-by-structure basis.
- Losses do not include business interruption, only direct loss
- UDFs are not designed to replace engineering models or knowledge.
- UDF results are best used by summing all the UDF results for an area rather than using individual structure results.

Visual 15: Viewing Depth-Damage Functions

Instructor Demonstration

- Open the Depth-Damage Functions viewer for buildings
- Change default damage functions
- View the library
- Demonstrate creating a new damage function

Visual 16: Agriculture Products



User must input a calendar date (e.g., May 25 that is converted to Julian Calendar (1 to 365) to define relation to crop cycle.

Damage is not flood-depth dependent.

- Area of impacted crop is determined.

No duration estimate is calculated.

- Flood Model estimates flood damage if duration is 0 days, 3 days, 7 days, or 14 days.

Based on USACE's AGDAM method.

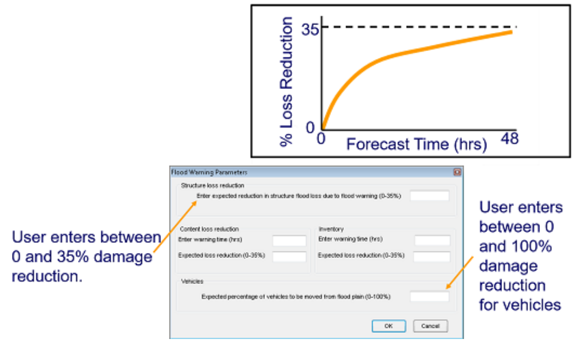
Visual 17: Vehicles

- Damages are based on type of vehicle and depth of water relative to critical vehicle components
- Hazus developed damage functions are based on expert opinion and historical damage data

Vehicle Type	VehicleID	Description	Vehicle Height	0 ft	0.5 ft	1 ft	1.5 ft	2 ft	2.5 ft
Car	Passenger Car	Damage to car from Inundation only	1.5	0	7.5	15	20	40	60
LtTrk	Light Truck	Damage to light truck from Inundation only	2.7	0	3	6	9	12	15
HvTrk	Heavy Truck	Damage to Heavy truck from Inundation only	5	0	1.9	3	5	7	8.3

Visual 18: Flood Warning

- Warning of imminent flooding can reduce damage up to 35% (The Day Curve)
- Hazus will reduce losses by user-defined percentage



Visual 19: Debris Parameters

Debris analysis can be modified to account for

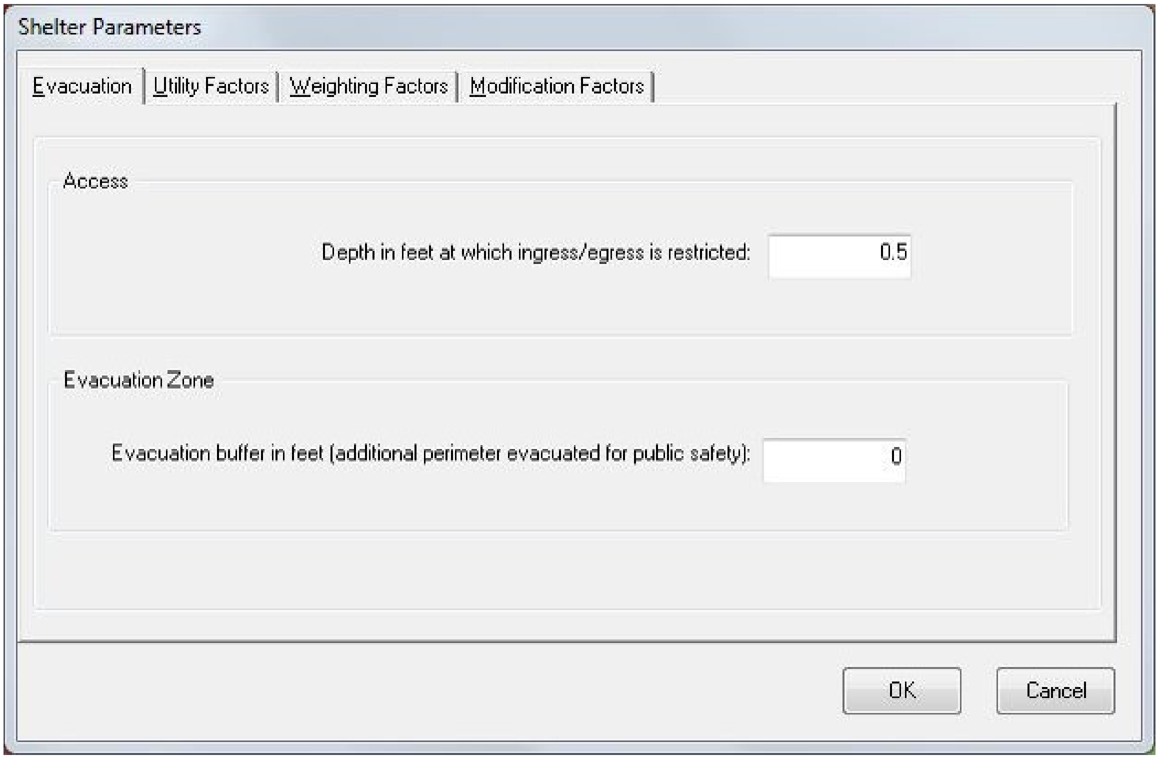
- Occupancy and Foundation Type
- Finish, Structure, and Foundation Weight

Specific Occupancy	Foundation Type	Minimum Depth	Maximum Depth	Finish Weight Per Thous Sq Ft	Structure Weight Per Thous Sq Ft	Foundation Weight Per Thous Sq Ft
RES1	Slab	0	4	4.1	0	0
RES1	Slab	4	8	6.8	0	0
RES1	Slab	8	25	6.8	6.5	25

Visual 20: Shelter

Parameters

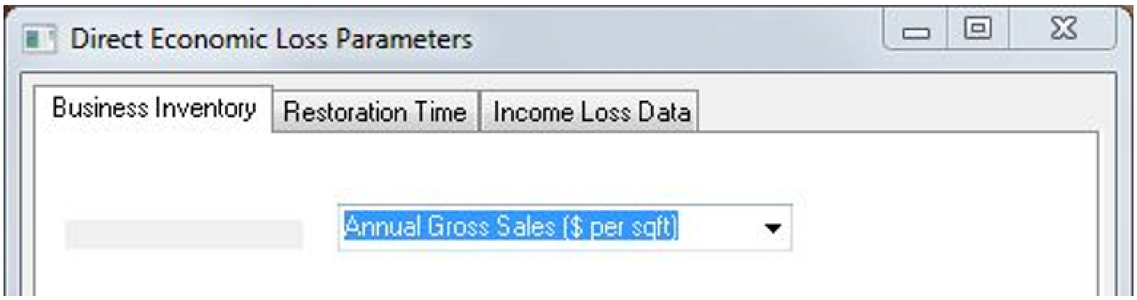
- Evacuation buffer
- Income
- Age



Visual 21: Direct Economic Losses

Parameters:

- Annual Gross Sales
- Restoration Time
- Income and Wage Losses
- Inventory Value



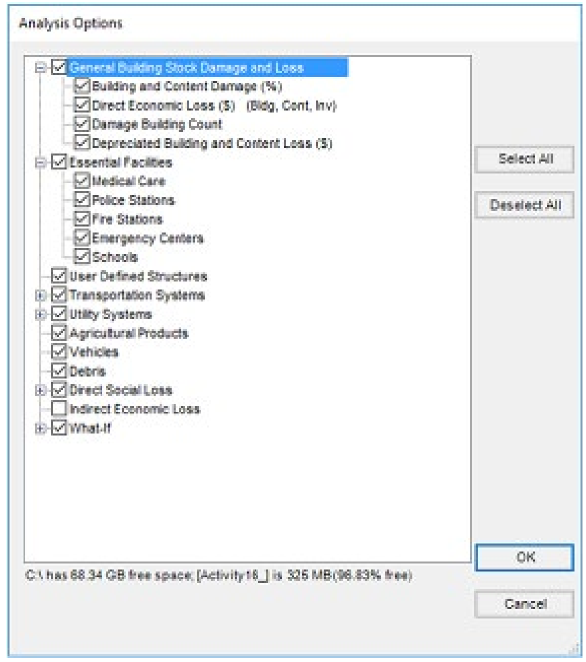
Specific Occupancy	Annual Gross Sales Per SqFt
COM1	53
COM2	77
IND1	713
IND2	226
IND3	697
IND4	656
IND5	437
IND6	768
AGR1	148

Example values for Annual Gross Sales ($ per sqft)

***Many locations nationally have the same default values.

Visual 22: Running the Analysis

- User selects desired analysis lessons to run
- Lessons can be re-run as needed
- Hint: Select only the analysis you need (speeds up processing time)



Visual 23: Activity 4.1

Explore the flood model analysis parameters and run the analysis for a 100-year return period scenario.

- Select a census block to explore during the exercise.
- Explore the flood occupancy mapping scheme.
- Explore the damage curves.
- Run the flood analysis.

Activity

See separate activity information for details.

Visual 24: Review

What process is used to estimate damages for the general building stock?

When viewing a Building depth-damage function, why does -1 foot of water produce more damage than -3 feet of water?

What type of flood analysis do you have to run to obtain bridge damages?

What are utility damages based on in the flood model?

What Hazus inventory components are analyzed for damages only in the flood model?

Name a weighted factor for shelter that the user can alter.

Visual 25: Questions?

Lesson 5: Flood Results

Visual 1: Lesson 5: Flood Results

HAZUS®

EARTHQUAKE • WIND • FLOOD • TSUNAMI

Visual 2: Goal and Objectives

Goal

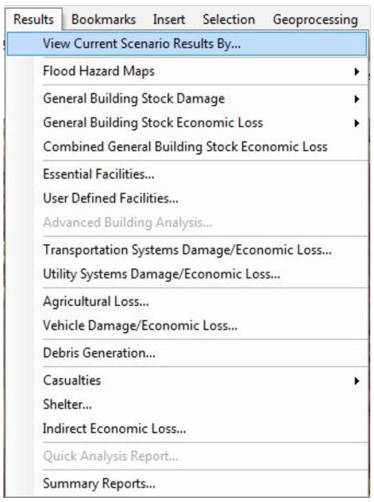
This lesson will provide an overview of the outputs of a flood analysis.

After completing this lesson, you will be able to:

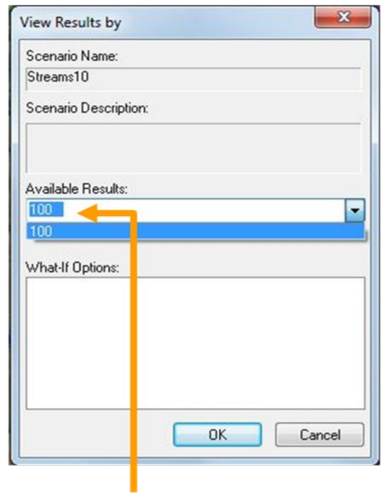
- List the key outputs of the aggregate inventory analysis
- List the key outputs of the site-specific inventory analysis
- Identify the key guidelines for properly interpreting and applying the outputs of the flood model

Visual 3: Results Menu

Loss estimations are found under the Results menu

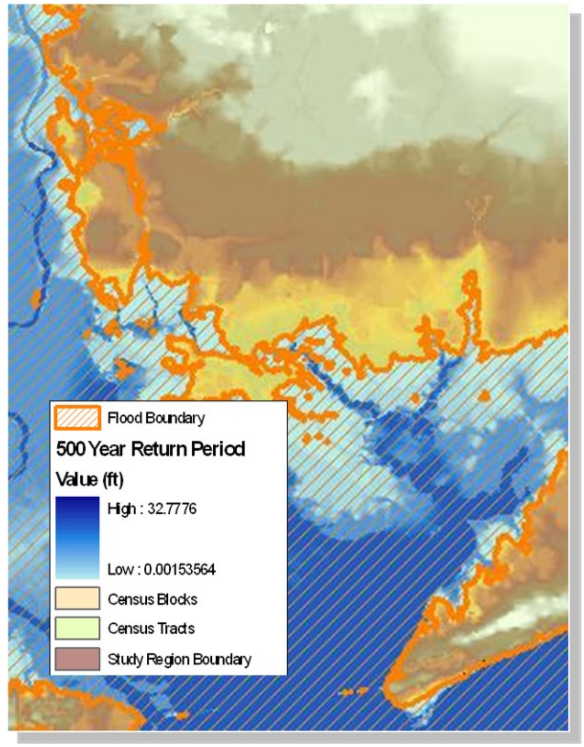


Hint: If the 'View Current Scenario Results By' menu is grayed out, just re-open your scenario.



You must select the scenario that you want to explore before the results become available

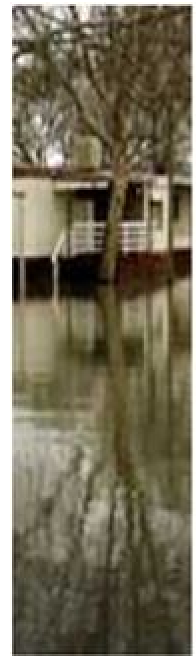
Visual 4: Flood Results: Results (1 of 4)



00 Year Flood Map Explained:

- Dark border lines (here in orange) designates the flood boundaries.
- The shaded areas adjacent to the flood boundary line, which tends to be packed closer together in terms of their hidden contour lines, are unflooded areas at a higher elevation such as slopes, hills, mountains, and ideal population settlements.
- For example, the northern and central areas of the map and the southeast area of the map.
- The shaded areas (here in light to dark blue), which tends to be spread out or flatter in terms of their hidden contour lines, are flooded areas of the map.
- For example, the southern and central areas of the map.
- The lighter blue (shaded) areas that are closer to the flood boundary and higher ground depicts less than 1 foot of flooding. In contrast are the darker blue (shaded) areas further away from the flood boundary representing a decreasing slope in elevation resulting in a high of 32.776 feet of flooding above the ground elevation.

Visual 5: Results



General Building Stock Results:

- By Amount of Damage categorized by general occupancy, specific occupancy, or building type
  - by square footage
  - by building count
- By Dollar Losses:
  - full and depreciated replacement value
  - building, content, and inventory losses
  - costs of relocation, wage, income, and rental losses
  - direct employee output losses and employment loss (days)

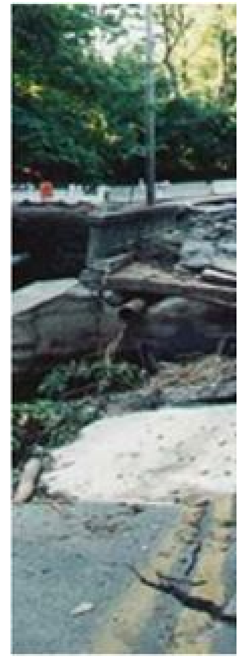
Visual 6: Results

Essential facilities:

- Building and content losses
- Functionality assessment (yes/no)
- Restoration time to 100% functionality

Lifeline losses (for selected components):

- Losses to structures and equipment
- Functionality assessment (yes/no)



Visual 7: Results

Vehicle Losses

- Daytime and Nighttime Estimates
- Car, Light Truck, Heavy Truck

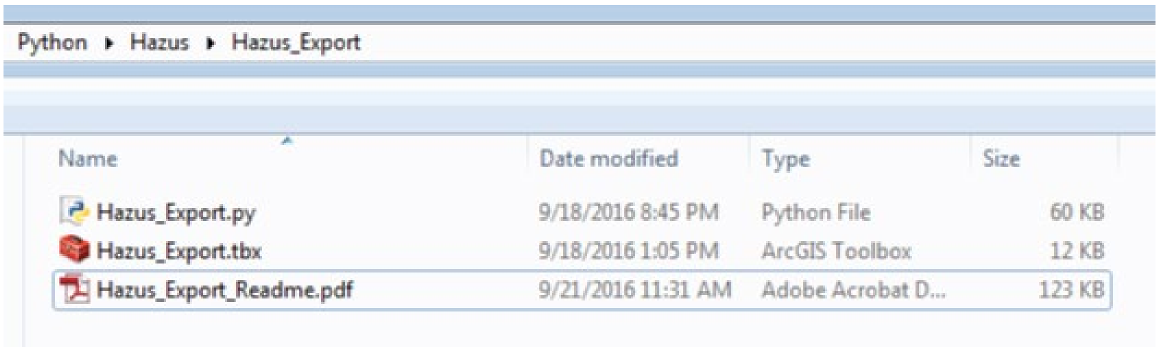
Agriculture Losses

Shelter Requirements

- Displaced Population
- Short-term sheltering needs

Visual 8: Hazus Export Tool

- Script that exports results from Hazus study regions
- C:\Program Files (x86)\Hazus-MH\BIN\Tools
- Tool does not support tsunami or multi-hazard regions



Visual 9: Activity 5.1

The Instructor will demonstrate the Results Menu for the Flood Model

- Aggregate
- Site-Specific
- Agriculture and Vehicles
- Hazus Export Tool

Visual 10: Review

What are the three types of formats that Hazus uses for results?

What are some of the file type options for exporting results?

What geographic level are the General Building Stock results reported for the flood model?

Provide examples of the General Building Stock results.

What results can you get for Essential Facilities?

In the flood model, what do utility losses include?

What losses are unique to the flood model?

Visual 11: Questions?

Lesson 6: Earthquake Hazard

Visual 1: Lesson 6: Earthquake Hazard

Visual 2: Goal and Objectives

Goal

This lesson will provide an overview of the earthquake hazard.

After completing this lesson, you will be able to:

- Identify at least two hazards associated with an earthquake
- List the process for completing a Level 1 Basic deterministic analysis in Hazus
- List the process for completing a Level 1 Basic probabilistic analysis in Hazus

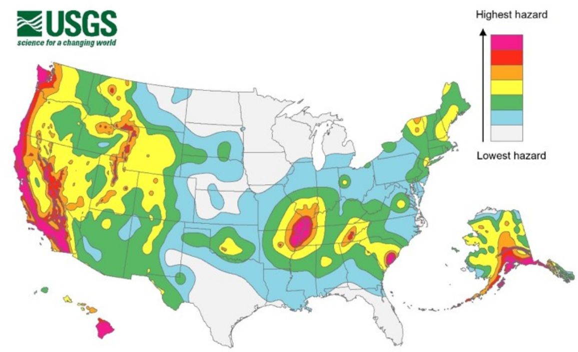
Visual 3: Where Do Earthquakes Happen?

Most of world's active faults are located along or near boundaries between shifting plates

- Plate Boundary earthquakes

Other active faults are not associated with plate boundaries and are inside plates

- Intra-plate earthquakes



Visual 4: Faults

What is a fault?

- Thin zone of crushed rock between two blocks of rock

Fault lines are intersection of two planes

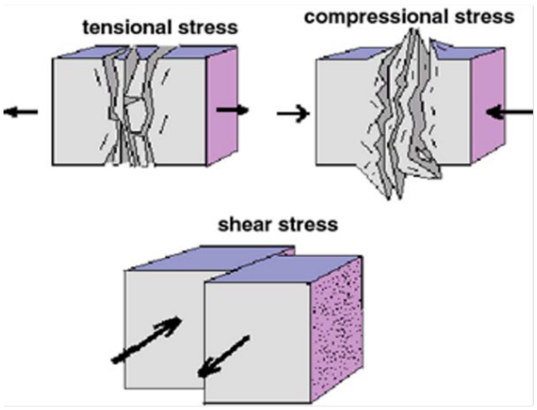
- Plane of fault with plane of earth’s surface

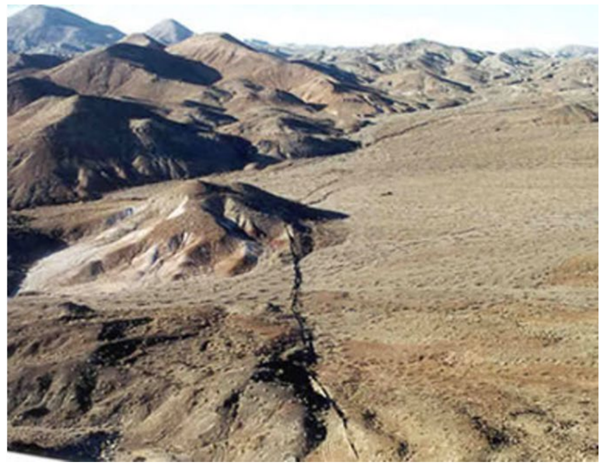
When earthquakes occur along these faults, rock on one side of the fault slips with respect to the other.

http://www.geology.wisc.edu/courses/g112/rock_deformation.html

Visual 5: Types of Stress

Stresses are related to the amount of energy release, which defines the strength of an earthquake (measured in moment magnitude)





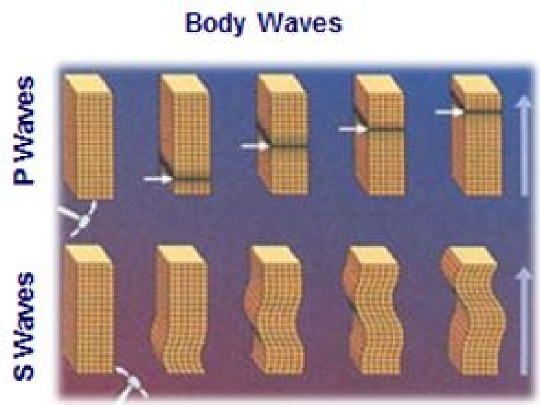
Visual 6: Ground Shaking: Seismic Waves

Ground shaking

- Caused by four main types of body and surface seismic waves

Body waves

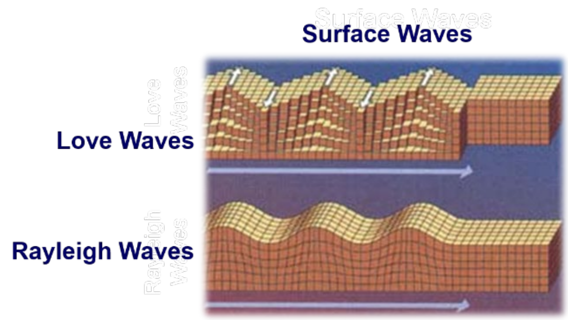
- Propagate through Earth's interior
    - Primary/Compressional, or P waves
    - Shear, or S waves



Visual 7: Ground Shaking: Seismic Waves

Surface waves

- Arrive last, mainly cause low-frequency vibrations
  - Rayleigh waves
  - Love waves



Visual 8: Ground Shaking Intensity Parameters

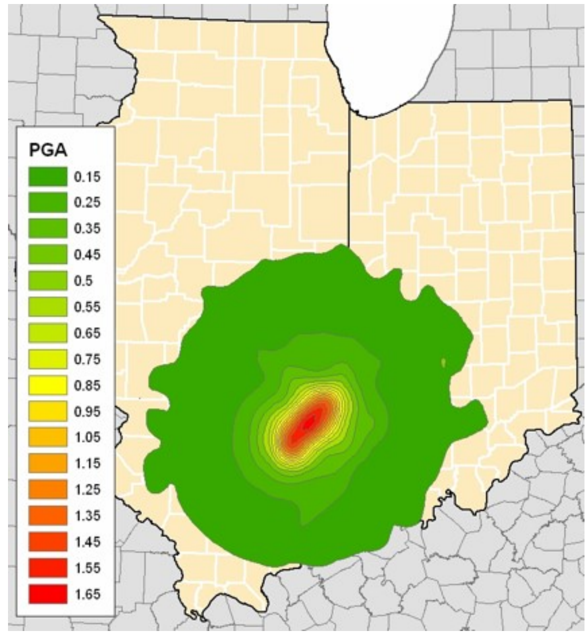
Magnitude

- Measure of earthquake's size
- Several scales have been defined, but the most commonly used are (1) local magnitude, commonly referred to as "Richter magnitude," (2) surface-wave magnitude, (3) body-wave magnitude, and (4) moment magnitude
- The moment magnitude (Mw) scale is uniformly applicable to all sizes of earthquakes
- Hazus uses moment magnitude

Visual 9: Ground Shaking Intensity Parameters

Ground Motion Parameters

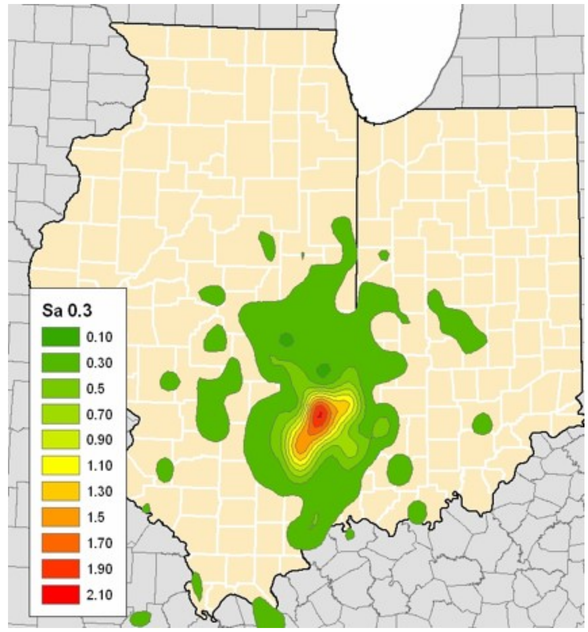
- PGD - Peak Ground Displacement
- PGA - Peak Ground Acceleration
  - Highest amount of ground motion at the base of the structure
  - Measured in g's
- PGV - Peak Ground Velocity
  - Measured in inches per second



Visual 10: Ground Shaking Intensity Parameters

Ground Motion Parameters

- Acceleration
  - Accounts for the structure filtering the input ground motion
  - Sa1.0 - more applicable to tall buildings
  - Sa0.3 - more applicable to short buildings, shorter period of shaking



Visual 11: Ground Shaking Intensity Parameters

Attenuation:

- Earthquake waves die off as they travel through Earth, so shaking becomes less intense farther from the fault

Local soil conditions:

- Certain soils greatly amplify shaking in earthquakes
- Passing from rock to soil, waves slow down but get bigger
- Soft and loose soil will shake more intensely than hard rock at the same distance from the source

Visual 12: Ground Shaking Intensity Parameters

Hazus soil types A-E are based on the shear wave velocities in the first 30 m of the soil profile

Site Class	Site Class Description	Vs Min (m/s)	Vs Max
A	Hard Rock	1500	
B	Rock	760	1500
C	Very Dense Soil and Soft Rock	360	760
D	Stiff Soils	180	360
E	Soft Soils		180

Visual 13: Ground Failure

Liquefaction:

- Saturated soils (usually loose sands) lose their bearing capacity and become fluid like "quick sand" during severe ground shaking.
- Structures built on liquefiable soils "sink" in and may even topple over.
- Dependent in part on water table depth.

Landslide - Ground Failure on uneven surfaces resulting in an avalanche of soil

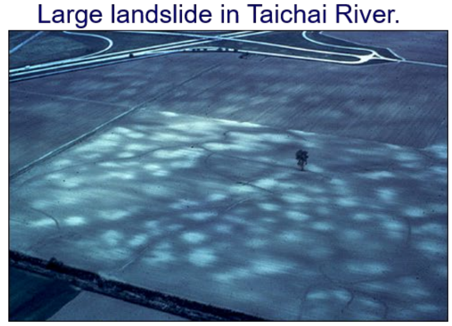
Surface Fault Rupture - Permanent Ground Displacements due to ground shaking

Visual 14: Ground Failure

The fault surface rupture sheared a levee.

Large landslide in Taichai River.

1964 Niigata earthquake.



Historical liquefaction evidence in Indiana.

Visual 15: Activity 6.1

Student activity

- Create a new study region for Salt Lake County, Utah

Visual 16: Hazus Approach

Evaluates ground motion parameters

- At the location for site-specific inventory
- At the centroid of the census tract for aggregate inventory

Ground shaking characterized in terms of

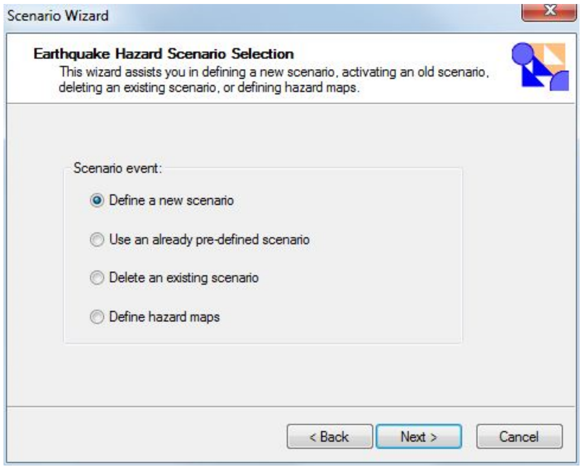
- Location-specific shaking
- Spectral response
- Peak ground values
- Regional attenuation functions
- Site-soil effects

Visual 17: Hazus Approach (Cont'd.)

Ground Failure shaking is characterized in terms of amount of ground failure due to liquefaction and landslide.

Visual 18: Earthquake Scenario Wizard

- Under Hazard > Scenario... Next... Define New Scenario



Visual 19: Defining a New Earthquake Scenario

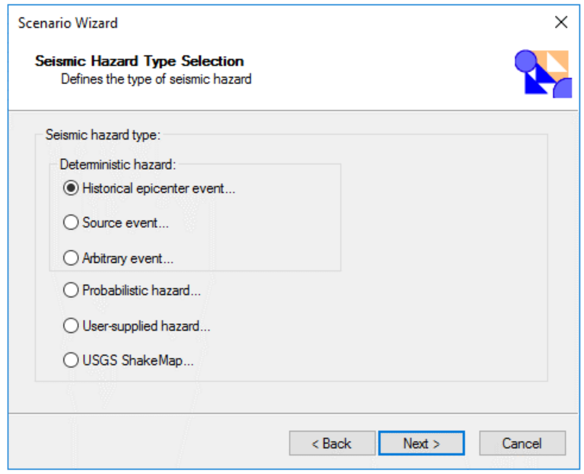
Deterministic

- USGS ShakeMap*
- Historical epicenter event
- Source event
- Arbitrary event

Probabilistic

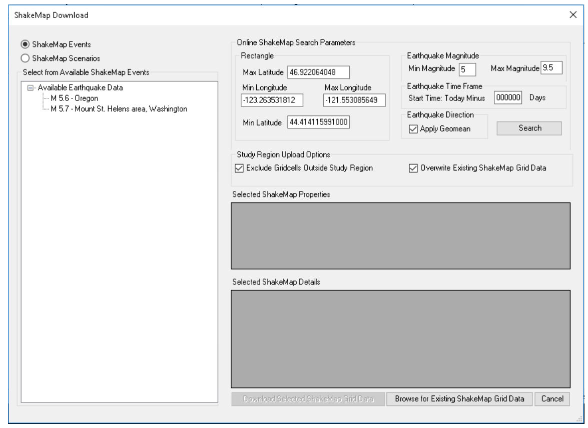
User-Supplied

*Preferred method



Visual 20: USGS ShakeMap

- ShakeMaps provide near-real-time maps of ground motion and shaking intensity following significant earthquakes
- ShakeMaps also contain archives of previous earthquakes
- Will show earthquakes in the last 90 days by default - to add historic or scenario events, make selection and expand search parameters.



Visual 21: Deterministic Events

ShakeMap - Preferred (already discussed)

- Import official USGS earthquake ground motions for credible scenarios

Historical epicenter event

- Select the desired event from the Hazus database of 3,500 historical events

Fault source event

- For the Western U.S., select the desired fault source from the Hazus database of faults

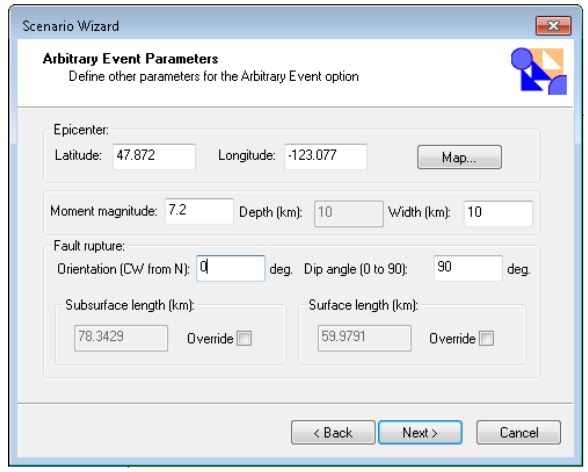
Arbitrary event

- Defined by the location of its epicenter and by its magnitude
- Epicenter is defined either by entry of latitude and longitude or graphically on a map

Visual 22: Deterministic: Arbitrary Event

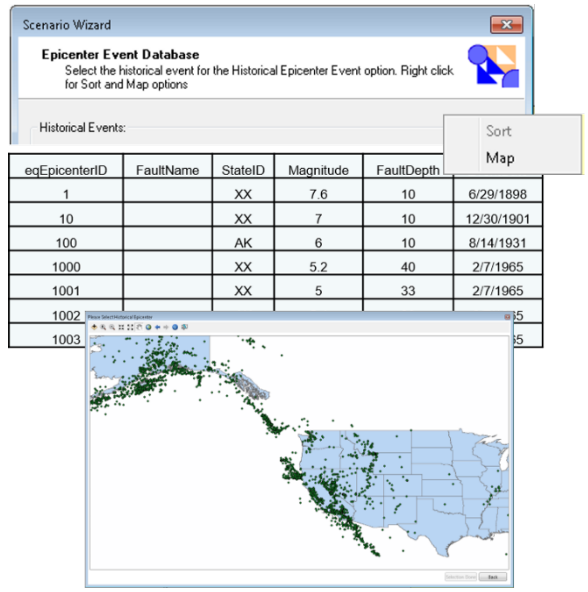
This method should only be used if ShakeMaps are not available.

- Manually enter the location of the event or define a point on a map
- Enter the Moment Magnitude and the depth of the event
- Note: Width and Fault Rupture parameters are grayed out for CEUS events



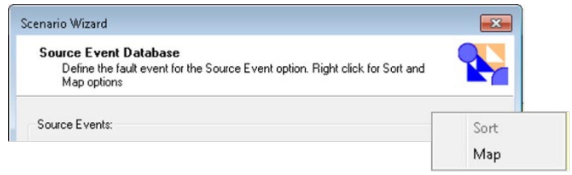
Visual 23: Deterministic: Historical Epicenter

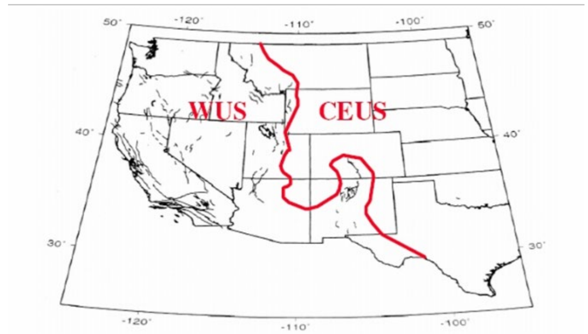
- View Historical Earthquakes 1755 – 2009 (6,200+ events)
- Sort Fields
- Map the Epicenters
- Use ArcGIS tools
    - Zoom In/Out
    - Add layers
    - Select
    - Organize Layer Visibility
    - Information Tool



Visual 24: Deterministic: Source Event

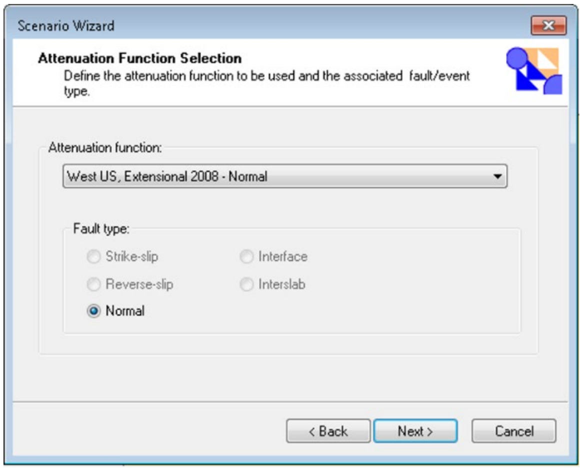
- View Known Earthquake Faults (Western US)
- Source events are only possible for the WUS areas
- Allows user to indicate location on a specific fault at which an earthquake originates





Visual 25: Finalizing Deterministic Scenarios

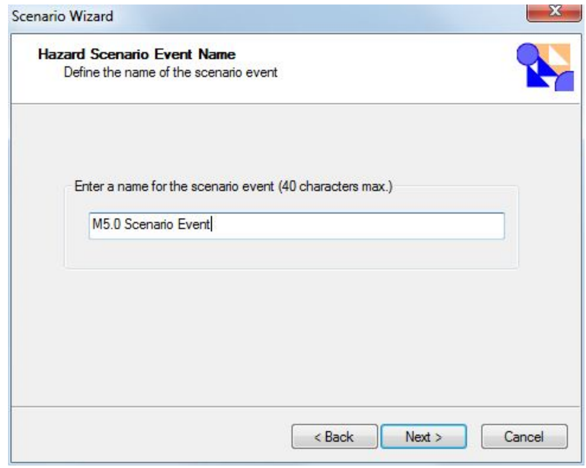
- Choose which Attenuation Function to use
- Must do this for all deterministic scenarios
- Guidance is found in TM for filtering attenuation functions at the time of scenario definition



Depending on the Attenuation Function, these choices may be grayed out.

Visual 26: Finalizing Deterministic Scenarios

Name the scenario, review the parameters, and then click Finish.



Hazus screenshot from scenario wizard where user can enter the name for the scenario event (40 characters max)

Visual 27: Activity 6.2

Student Activity

- Complete a scenario using an arbitrary event
- Complete a scenario using ShakeMap
- Compare the results

Activity

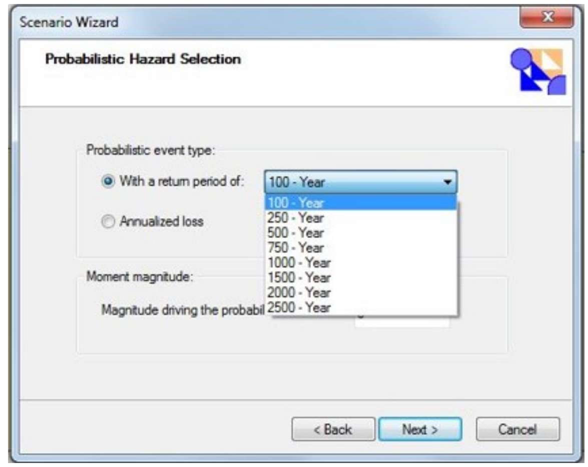
See separate activity information for details.

Visual 28: Probabilistic Scenarios

Probabilistic

- Specific Return Period
- Annualized Loss

Probabilistic seismic hazard contour maps developed by the USGS for the National Seismic Hazard Mapping Project.



Visual 29: FEMA P366

- FEMA P366 - Hazus Annualized Earthquake Losses
- FEMA P366 highlights the impacts of both high hazard and high exposure on losses caused by earthquakes
- The FEMA P366 report can be downloaded by clicking here
- The FEMA P366 data can be viewed in an ArcGIS online web map here

Cover of FEMA publication P-366 Hazus Estimated Annualized Earthquake Losses for the United States, April 2017.

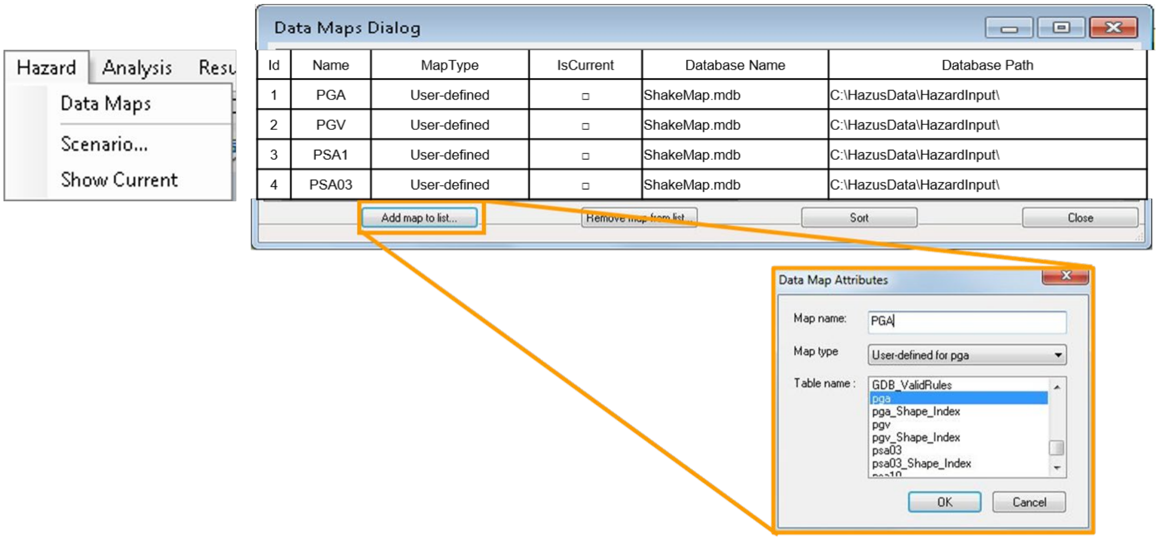
Visual 30: Using Hazard Maps

Simplified hazard maps are automatically generated during the creation of the study region. These approximate hazard maps are based on default soil maps and the census tract boundaries.

Users can modify and enhance soils, liquefaction, landslide and water depth if spatial data is available from experts or other agencies.

If available, these expert-generated maps should be used to replace the simplified maps.

Visual 31: Importing Hazard Maps

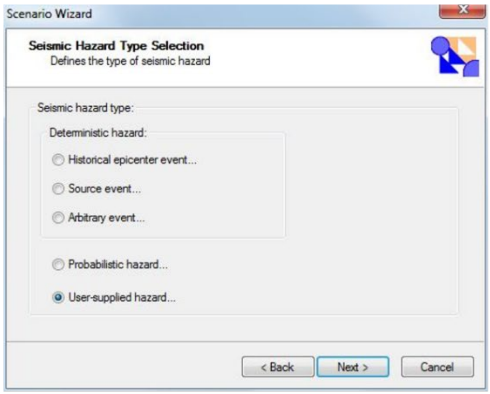


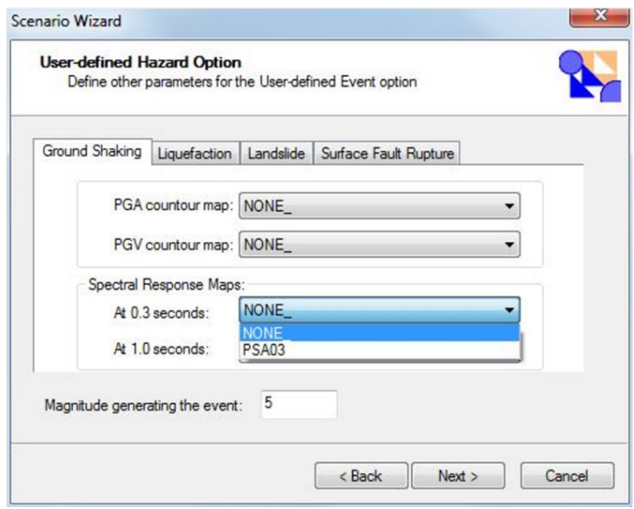
- Import user-defined maps to create more detailed analysis
- Expertly generated ground motion and soils maps can enhance the quality of your results.

Visual 32: Define Hazard Maps Option

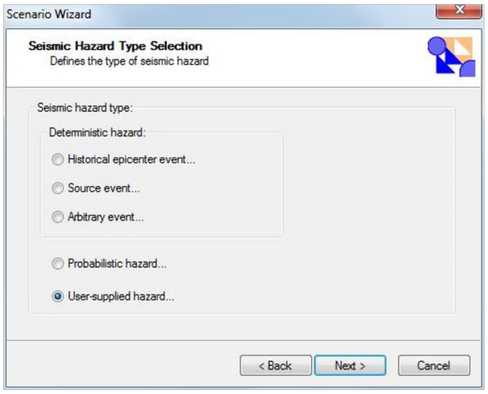
Hazard map options:

- Apply same value to the entire region
- Import hazard maps so that Hazus can generate more accurate ground motion data

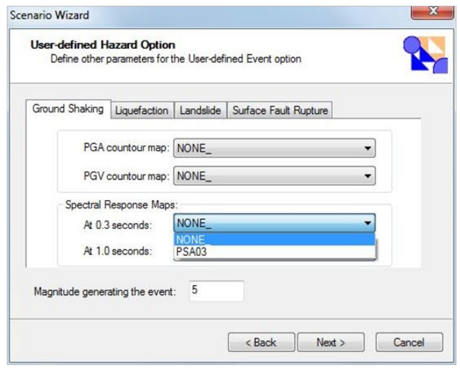




Visual 33: User-Defined Hazard Option



Allows you to import hazard maps created outside of Hazus that are related to a specific event

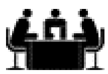


These data can be brought into Hazus in order to generate more accurate loss estimations

Visual 34: Activity 6.3

Student Activity

- Explore the impact of modifying hazard parameters
  - Soil impacts
  - Magnitude impacts
- For each case
  - Set the hazard parameters
  - Run the analysis
  - Explore the results



Activity

See separate activity information for details.

Visual 35: Review

List at least two hazards associated with an earthquake.

What type of soils map can you bring into Hazus to increase the quality of the hazard definition?

What scale does Hazus use to describe the severity of an earthquake?

What is the minimum magnitude represented in the Hazus historic earthquake database?

What is the preferred Hazus earthquake data source?

What is the source event option? Why might it be grayed out?

For more advanced study, E0174 Hazus for Earthquake and Tsunami

Visual 36: Questions?

Lesson 7: Earthquake Analysis

Visual 1: Lesson 7: Earthquake Analysis

HAZUS®

EARTHQUAKE • WIND • FLOOD • TSUNAMI

Visual 2: Goal and Objectives

Goal

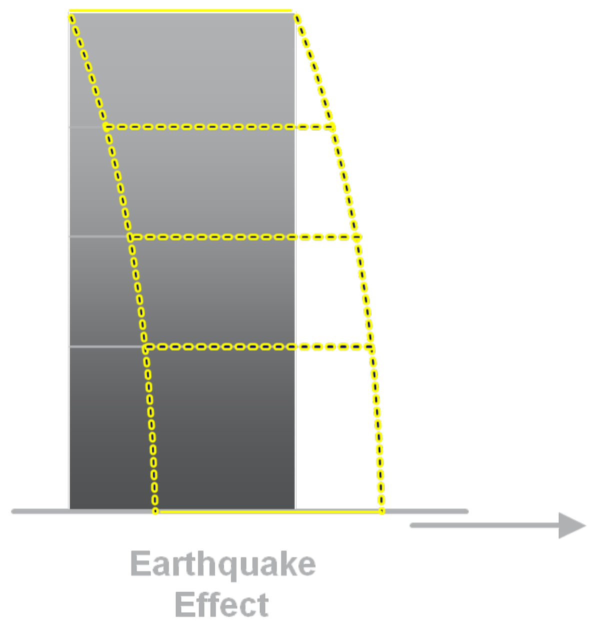
This lesson will provide an overview of the methodologies used for earthquake analysis.

After completing this lesson, you will be able to:

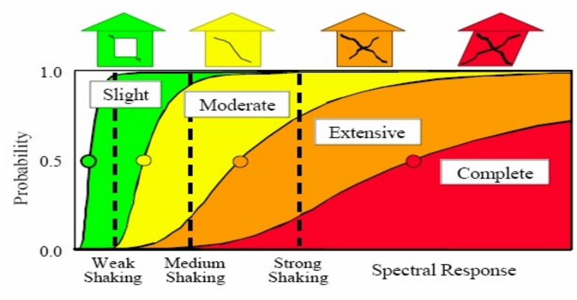
- Explain the basic process by which Hazus calculates earthquake related losses
- Summarize analyses that can be completed in the earthquake model
- Provide examples of earthquake hazard parameters that the user can define

Visual 3: Earthquake Forces on Buildings

- Earthquakes only shake ground; they do NOT exert forces to buildings
- Earthquake force is generated when super- and sub-structures ‘fight’
- Substructures comply with shaking; superstructures do not



Visual 4: Direct Physical Damage



Hazus assesses the maximum displacement that a building will undergo and the damages that would result

Damages vary according to

- Uncertainty of damage state threshold
- Variations in building capacity
- Geographic variations of ground motion

Analyzes both structural and non-structural elements

Visual 5: Examples of Damage to Buildings

Parking ramp – Northridge, 1994

Residential Damage – Northridge, 1994 (FEMA)

Visual 6: Examples of Damage to Buildings (Cont'd.)

Absence of adequate shear walls on the garage level exacerbated damage to this structure at the corner of Beach and Divisadero Streets, Marina District, San Francisco, Loma Prieta, 1989 (USGS)

Ground levels are no longer visible because of structural failure and sinking due to liquefaction. San Francisco, Loma Prieta, 1989 (USGS)

Visual 7: Examples of Damage to Buildings

Un-reinforced masonry collapse, Los Gatos, Loma Prieta, 1989 (USGS)

Structure moving off an unsecured foundation

Visual 8: Examples of Non-Structural Components

Typical nonstructural components and building contents have limited anchorage/bracing

- Drift sensitive components include veneer and finishes, nonbearing walls and partitions, and HVAC systems
- Acceleration sensitive components include racks and cabinets, computers, office equipment, and furnishings

Losses to these components are calculated

Non-structural damages, Menlo Park, Loma Prieta 1989 (USGS).

Visual 9: Direct Physical Damage

- Essential Facilities
    - Fire Stations, Police Stations, Hospitals and Clinics, Schools, Emergency Operations Centers

What can Hazus provide the community/State decision-makers?

- Parameters
    - Facility Damage
    - Restoration Time
    - Based on ground shaking and ground failure

Why is this data critical for emergency planning?

Visual 10: Direct Physical Damage

Transportation:

- Highway, Railway, Light Rail, Bus, Port, Ferry, Airport

Parameters

- Facility Damage
- Time to Restore Facility
- Economic Loss Estimations

When and in what form should this be provided to leadership?

Cypress viaduct of Interstate Highway 880, Loma Prieta, 1989 (USGS)

Oakland Bay Bridge, Loma Prieta, 1989 (USGS)

Visual 11: Direct Physical Damage

Utilities:

- Potable Water, Waste Water, Oil Systems, Natural Gas, Electric Power and Communication

Parameters

- Facility Damage
- Time to Restore Facility
- Economic Loss Estimations

Following an earthquake, how can Hazus facilitate recovery operations?

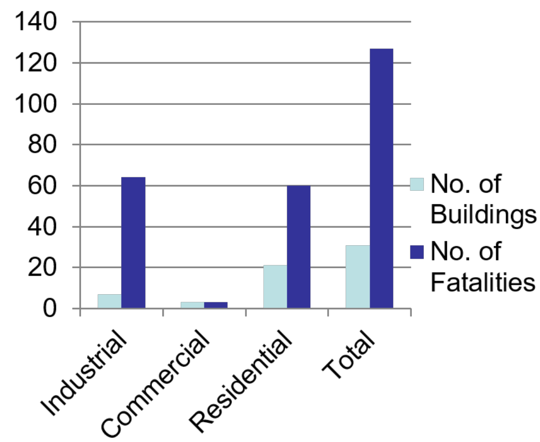
Broken utilities, Watsonville Area, Loma Prieta, 1989 (USGS)

Visual 12: Social Losses - Casualties

Calculates multiple levels of casualties based on severity and time of day

Parameters

- Damage to various Building Types
- Bridge Damage Contribution
- Time Dependent



Spence and So. 2009. “Estimating Shaking-Induced Casualties and Building Damage for Global Earthquake Events"

Visual 13: Social Losses - Shelter

Calculates need for public shelters

Parameters

- Age
- Ethnicity
- Income
- Home Ownership
- Damage states of different types of buildings

What information and recommendations can Hazus provide leadership?

Red Cross shelter; Minot, ND; June 24, 2011

Visual 14: Debris

Parameters

- Weight of structural and nonstructural model building types
- Probabilities of damage states for structural and nonstructural elements by census tract

Why is this information critical for recovery operations?

Damage in the Old Town historical district, City of Salinas, Loma Prieta, 1989 (USGS).

Visual 15: Direct Economic Loss

Parameters

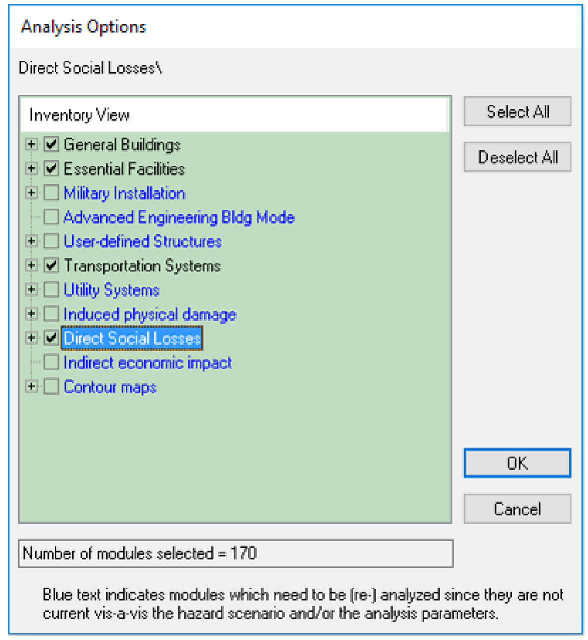
- Annual Gross Sales
- Restoration Time
- Income and Wage Losses

Visual 16: Running the Analysis

User picks modules they wish to run

Modules can be re-run as needed

Only select the analysis you need (speeds up processing time)



Visual 17: Activity 7.1

The Instructor and students will

- Estimate casualties from a M7.0 earthquake with default settings using ShakeMap
- Adjust analysis parameters for collapse rates for unreinforced masonry to 0%
- Rerun casualty analysis and compare results
- Answer the following questions:
  - What are the total number of estimated fatalities for each scenario at 2am, 2pm, and 5pm?
  - What does this imply about the influence of URM structures?

Activity

Visual 18: Review

What does the physical damage model consider?

What types of parameters can you alter for transportation and utilities?

Provide examples of non-structural components of a building.

Provide examples of building contents.

What are some of the hazard parameters that you can alter that will affect your analyses?

For what times of day does the model generate casualty estimates? Why are these times important?

Visual 19: Questions?

Lesson 8: Earthquake Results

Visual 1: Lesson 8: Earthquake Results

Visual 2: Goal and Objectives

Goal

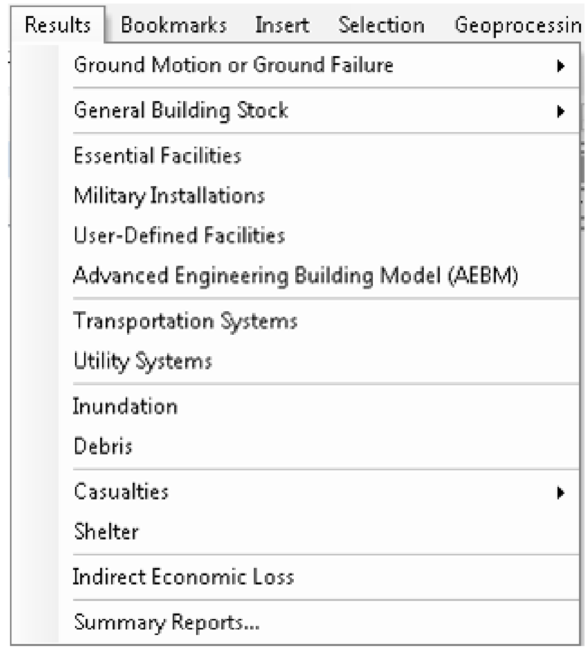
This lesson will provide an overview of the earthquake model results.

After completing this lesson, you will be able to:

- List the key outputs of the aggregate inventory analysis.
- List the key outputs of the site-specific inventory analysis.
- Identify the key guidelines for properly interpreting and applying the outputs of the earthquake model.

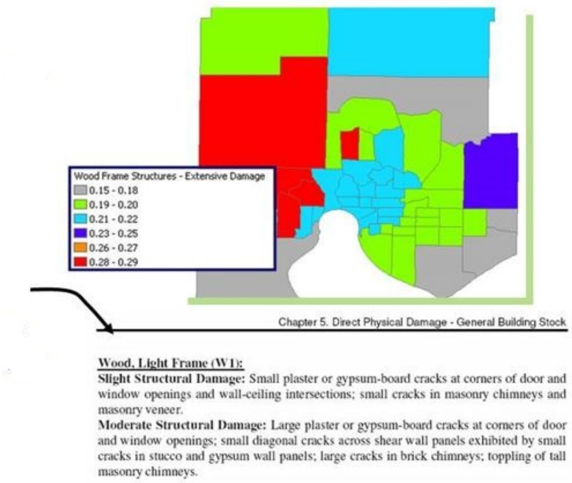
Visual 3: Results Menu

All earthquake analysis results can be found under the Results menu



Visual 4: Direct Physical Damage

- Structural and nonstructural damage estimates for buildings
- Damage state probability counts and losses
- Technical Manual describes the conditions that exist at each damage state by building type

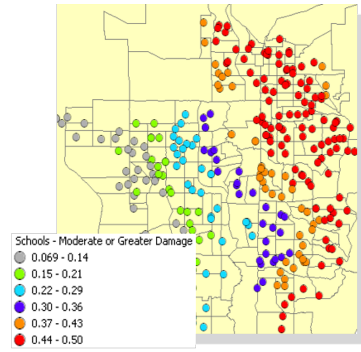


Visual 5: Direct Physical Damage

Essential Facilities

- Restoration Time to 100% Functionality
- Damage State Probability
- Damage states are described in the Technical Manual

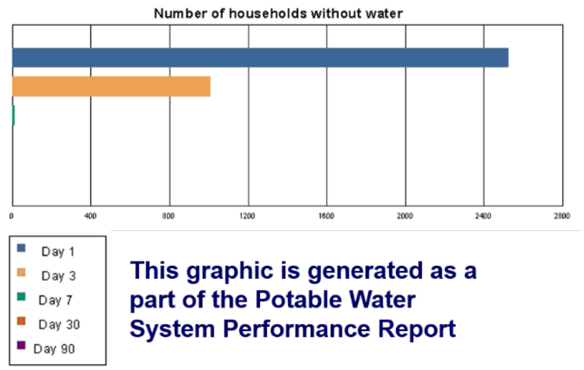
Table 6 from Global Summary Report.
"Expected Damage to Essential Facilities"



Classification	Total	At least moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	1	1	1	0
Schools	51	51	51	0
EOCs	1	1	1	0
Police Stations	22	22	22	0
Fire Stations	10	10	10	0

Visual 6: Utility Damage

- Pipeline and Facility Damages, Losses, and Functionality for Potable Water, Waste Water, Oil Systems and Natural Gas
- Functionality at 1, 3, 7, 14, 30 and 90 days
- Number of households without Potable Water and Electricity



This graphic is generated as a part of the Potable Water System Performance Report

Visual 7: Transportation Damage

Highway, Railway, Light Rail

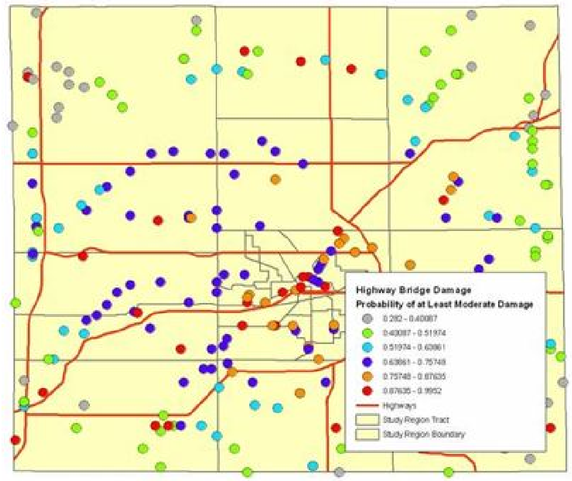
- Bridge, Segment and Tunnel Losses, Damages and Functionality

Bus, Port, and Ferry

- Facility Damage, Loss, and Functionality

Airport

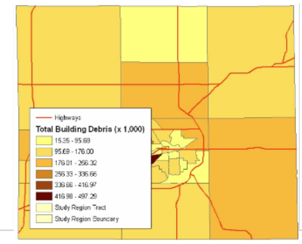
- Runway and Facility Damage, Loss and Functionality



Visual 8: Induced Physical Damage

Debris Estimates

- Tons of Wood and Brick
- Tons of Reinforced Steel and Concrete
- Number of Truckloads

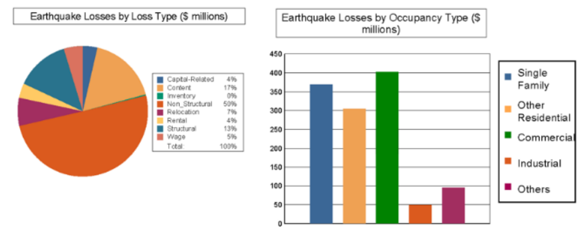


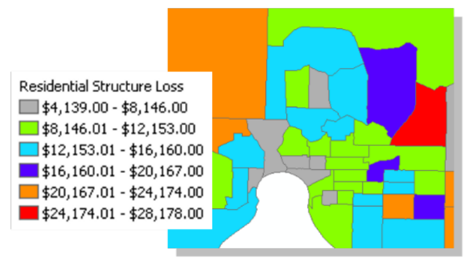
Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 8.24 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 37.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 329,400 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Visual 9: Direct Economic Losses





Building Losses (GBS)

- Structural
- Non-structural
- Content
- Business Inventory

Business Interruption

- Wage
- Income
- Rental & Relocation
- Proprietor

Lifelines

- Direct Cost of Repair

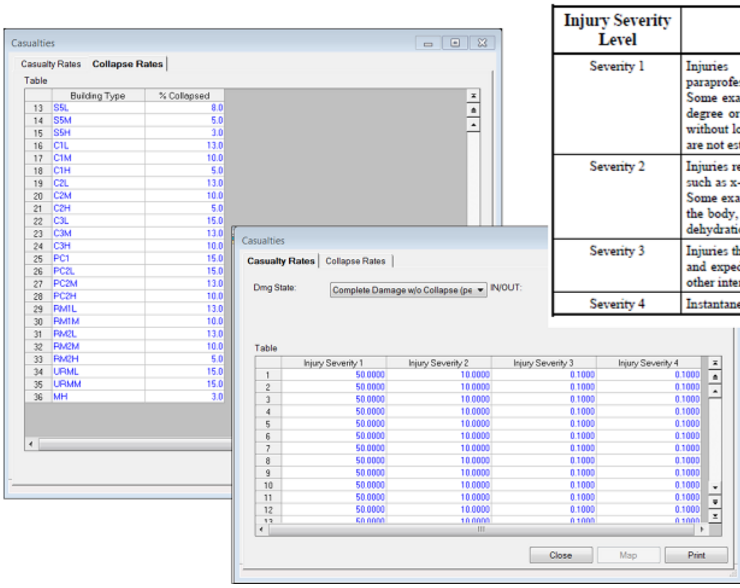
Visual 10: Social Losses - Casualties

- By severity level
- By time of day (2 am, 2 pm, 5 pm)

- **Severity 1 – No Hospitalizations**
- **Severity 2 – Hospitalization**
- **Severity 3 – Life Threatening**
- **Severity 4 – Fatality**

Occupancy	Severity 1	Severity 2	Severity 3	Severity 4	Total
Single Family	49	5	0	1	56
Educational	0	0	0	0	0
Commuting	0	0	0	0	0
Hotels	0	0	0	0	0
Industrial	10	3	0	1	14
Other-Residential	160	35	4	7	205
Commercial	6	2	0	0	8

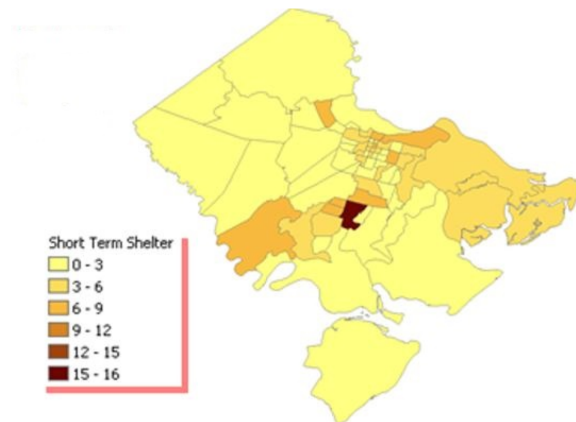
Visual 11: Probability Estimation of Casualty Levels



Injury Severity Level	Injury Description
Severity 1	Injuries requiring basic medical aid that could be administered by paraprofessionals. These types of injuries would require bandages or observation. Some examples are: a sprain, a severe cut requiring stitches, a minor burn (first degree or second degree on a small part of the body), or a bump on the head without loss of consciousness. Injuries of lesser severity that could be self treated are not estimated by Hazus.
Severity 2	Injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life threatening status. Some examples are third degree burns or second degree burns over large parts of the body, a bump on the head that causes loss of consciousness, fractured bone, dehydration or exposure.
Severity 3	Injuries that pose an immediate life threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.
Severity 4	Instantaneously killed or mortally injured

Visual 12: Social Losses - Shelter

- Number of Displaced Households
- Temporary Housing Requirements



Visual 13: Activity 8.1

The Instructor will lead the class to explore the Earthquake Results Menu

- Aggregate
- Site-Specific

Visual 14: Interpreting Outputs

All outputs are estimates - very important to convey this to others, especially decision-makers.

- Provide results as rounded numbers
- Provide results as ranges (consider bracketing)
- Include a disclaimer
- Do NOT provide exact numbers

Can you verify your results

- Using field reports or local data?
- Are the results logical based on local knowledge?

Accuracy of results will depend on the accuracy of the model inputs - the hazard, inventory, and damage functions.

Visual 15: Interpreting Outputs

Results tables provide more detail about losses than do reports.

Results may differ slightly in tables and reports due to how the output is rounded.

A result table may be blank because:

- The option was not selected in the Analysis Options window.
- Computer ran out of disk space.
- There is no damage.

Pay attention to the units of measurement used.

- Thousands versus Millions of dollars

Visual 16: Communicating Results

- Describe results in non-technical language that is easily understood by the intended audience
- Format will depend on the use of the results and the intended audience (tables, maps, talking points, etc.)
- The users of the results should be involved from the beginning in determining the types and formats of the results that best suit their needs

Visual 17: Activity 8.2

Student Activity

Explore earthquake model output:

- Explore dollar losses to pipelines.
- Explore power outage issues.
- Explore the number of major injuries for an afternoon earthquake.
- Determine the total economic impact.
- Determine the economic loss to residential structures.
- Explore debris impact.
- Explore anticipated need for hospital beds. Calculate the loss ratio

Activity

See separate activity information for details.

Visual 18: Review

What are the three types of formats that Hazus-MH uses for results?

What geographic level are the General Building Stock results reported for the earthquake model?

What results are unique to the earthquake model?

What are the four categories for casualties results?

What are the two categories of debris for which the earthquake model provides results?

Visual 19: Questions?

Lesson 9: Tsunami Hazard

Visual 1: Lesson 9: Tsunami Hazard

HAZUS®

EARTHQUAKE • WIND • FLOOD • TSUNAMI

Visual 2: Goal and Objectives

Goal

This lesson will discuss the tsunami hazard and tsunami-specific inventory in Hazus.

After completing this lesson, you will be able to:

- Define tsunami
- Describe near and distant source tsunamis
- Understand tsunami-specific inventory

Visual 3: <u>Hazus Tsunami Model</u>

- Loss estimation model that provides state-of-the-art decision support software for estimating potential losses from tsunamis.
- Available for 5 Very High-risk states (AK, WA, OR, CA, HI) and the 5 High Risk U.S. territories
- Combined Earthquake/Tsunami analysis functionality available for the 5 states and PR

Visual 4: Tsunami Overview

A series of long-period waves that are usually generated by an impulsive disturbance that displaces massive amounts of water

- Travels at speeds of > 450 mph across the ocean, slowing as it approaches shallower water
- A series of waves with minutes to hours between – the first wave may not be the largest
- Encompass the entire water column in open ocean, with an average surface height of 0.5 m

Visual 5: Tsunami Overview

Tsunamis can be triggered by

- earthquakes
- volcanic activity
- submarine landslides
- onshore landslides in which large volumes of debris fall into the water

All of these triggers can occur in the United States

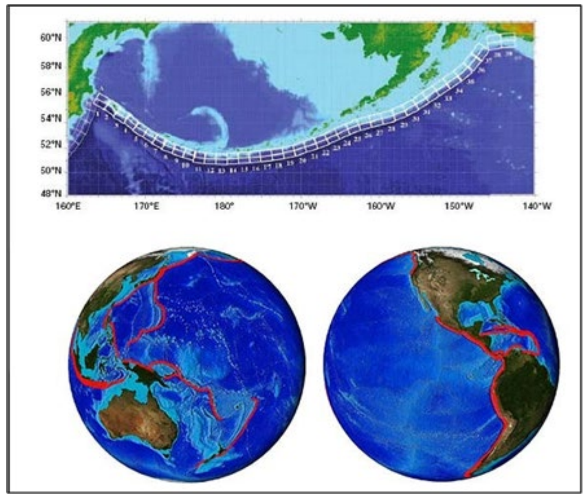
Most of the tsunamis (88%) in the Global Historical Tsunami Database were generated by earthquakes or landslides caused by earthquakes

Visual 6: Tsunami Overview

Mega Tsunamis

- Rare but induce high impacts
- Caused by major slipping along the subduction zones
    - 2011 Tohoku Tsunami
    - 2004 Indian Ocean Tsunami
    - 1960 Chilean Tsunami
    - Cascadia Subduction Zone

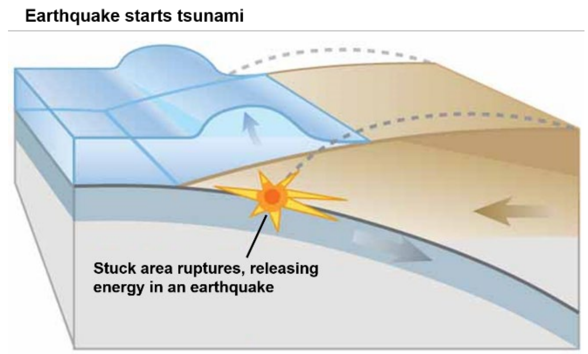
Credit: NOAA PMEL



Visual 7: Tsunami - Near vs Distant Source

Near Source (local source)

- Those generated within 100 km of a locality of interest
- Earthquake ground shaking precedes the tsunami
- Earthquake damage possible
- Subsidence (lowering) of coastal area possible
- Lead time – a few minutes to an hour

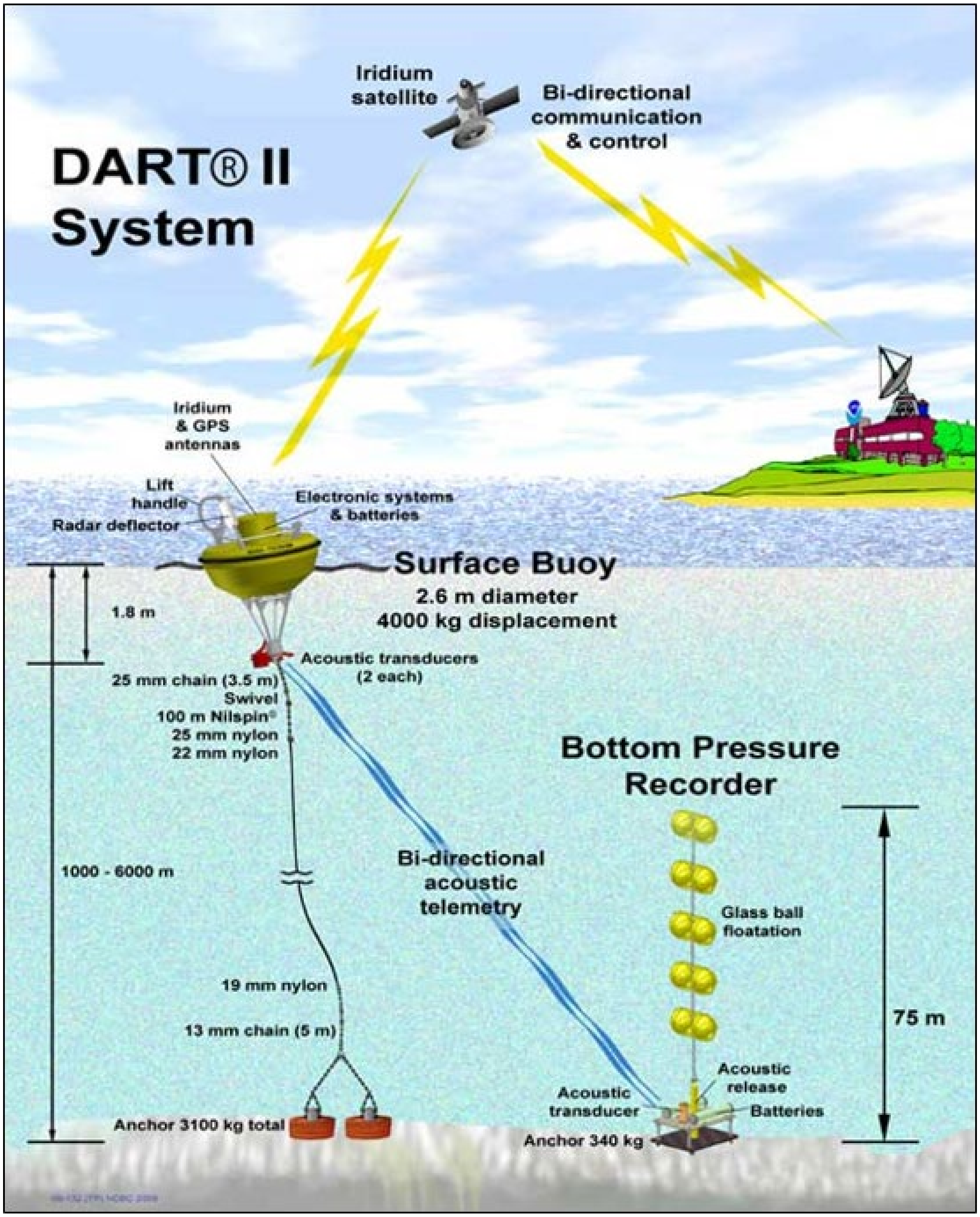


Credit: USGS

Visual 8: Tsunami - Near vs Distant Source

Distant Source

- Those generated far away (>1,000 km from a locality)
- No ground shaking precedes the tsunami
- Lead time – few to several hours

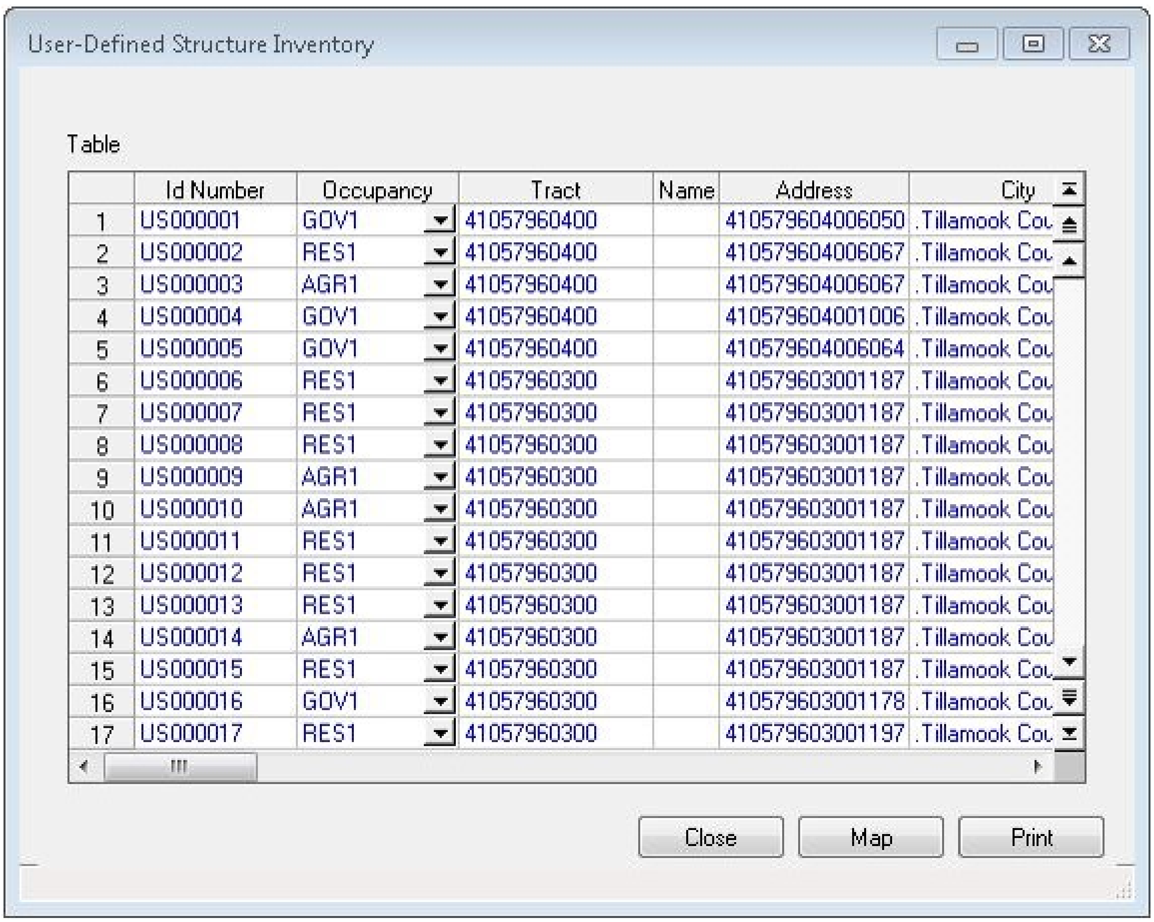


Visual 9: National Structure Inventory (NSI)

- U.S. Army Corp of Engineers' National Structural Inventory point data. Developed with FEMA.
- Creates notional structures, or 'points,' in the developed portion of each census block to represent the numbers and types of buildings that occur based on size, occupancy type, construction materials, etc.

Visual 10: User Defined Facilities

- Enables user specific datasets to be analyzed through the Hazus methodologies providing more accurate results
- User populated table using Hazus CDMS
- Attributes include:
  - Occupancy type
  - Earthquake building type
  - Design level
  - First floor height
  - Building replacement cost
  - Content replacement cost
  - Location of structure



	Id Number	Occupancy	Tract	Name	Address	City
1	US000001	GOV1	41057960400		410579604006050	Tillamook Cou
2	US000002	RES1	41057960400		410579604006067	Tillamook Cou
3	US000003	AGR1	41057960400		410579604006067	Tillamook Cou
4	US000004	GOV1	41057960400		410579604001006	Tillamook Cou
5	US000005	GOV1	41057960400		410579604006064	Tillamook Cou
6	US000006	RES1	41057960300		410579603001187	Tillamook Cou
7	US000007	RES1	41057960300		410579603001187	Tillamook Cou
8	US000008	RES1	41057960300		410579603001187	Tillamook Cou
9	US000009	AGR1	41057960300		410579603001187	Tillamook Cou
10	US000010	AGR1	41057960300		410579603001187	Tillamook Cou
11	US000011	RES1	41057960300		410579603001187	Tillamook Cou
12	US000012	RES1	41057960300		410579603001187	Tillamook Cou
13	US000013	RES1	41057960300		410579603001187	Tillamook Cou
14	US000014	AGR1	41057960300		410579603001187	Tillamook Cou
15	US000015	RES1	41057960300		410579603001187	Tillamook Cou
16	US000016	GOV1	41057960300		410579603001178	Tillamook Cou
17	US000017	RES1	41057960300		410579603001197	Tillamook Cou

Visual 11: Review

- How might a tsunami be triggered?
- What is the difference between a near and distant source tsunami?
- Which type of tsunami offers the most warning time?
- Describe the tsunami-specific inventory in Hazus.
- What states/territories are included in the Hazus tsunami model?

Visual 12: Questions?

Lesson 10: Tsunami Analysis

Visual 1: Lesson 10: Tsunami Analysis

Visual 2: Goal and Objectives

Goal

This lesson will describe how to conduct a basic tsunami analysis for losses and casualties.

After completing this lesson, you will be able to:

- List the steps for estimating tsunami losses
- Describe the steps for estimating tsunami casualties

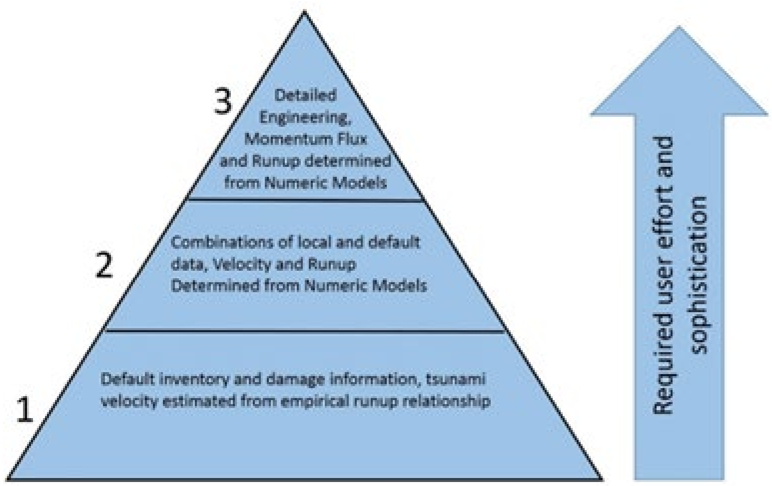
Visual 3: Levels of Tsunami Analysis

Basic (Level 1)

- Out-of-the-box default infrastructure
- Basic user input

Advanced (Level 2/3)

- User-provided data - more accurate to the region
- Data provided by third-party studies/hazard models



Levels of Analysis

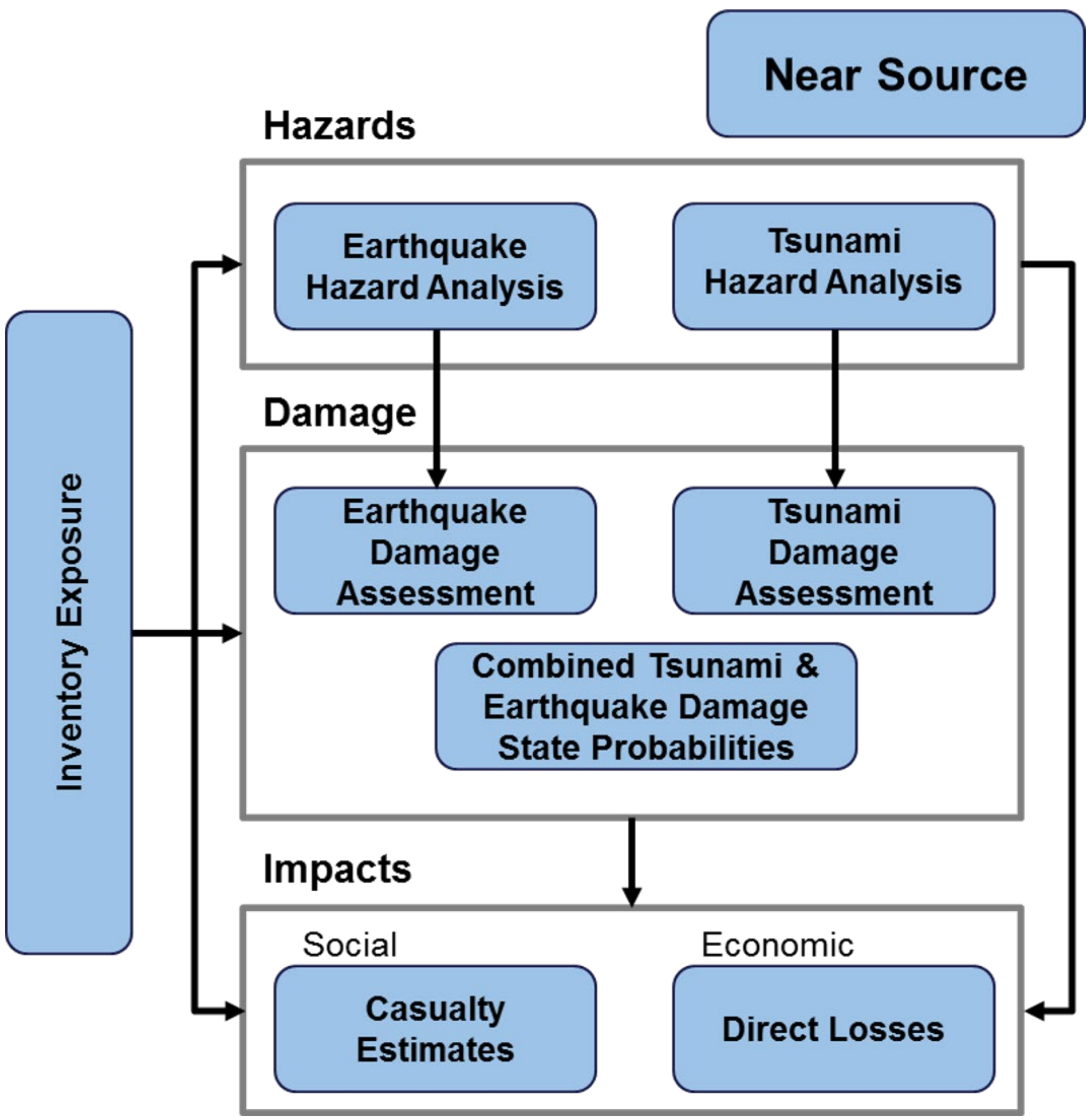
Visual 4: Hazus Analysis Components

Hazard Input

- Tsunami inundation depth
- Velocity or momentum flux
- Topography
- Run-up Height

Infrastructure

- NSI data (point location – aggregated)
- User defined structures



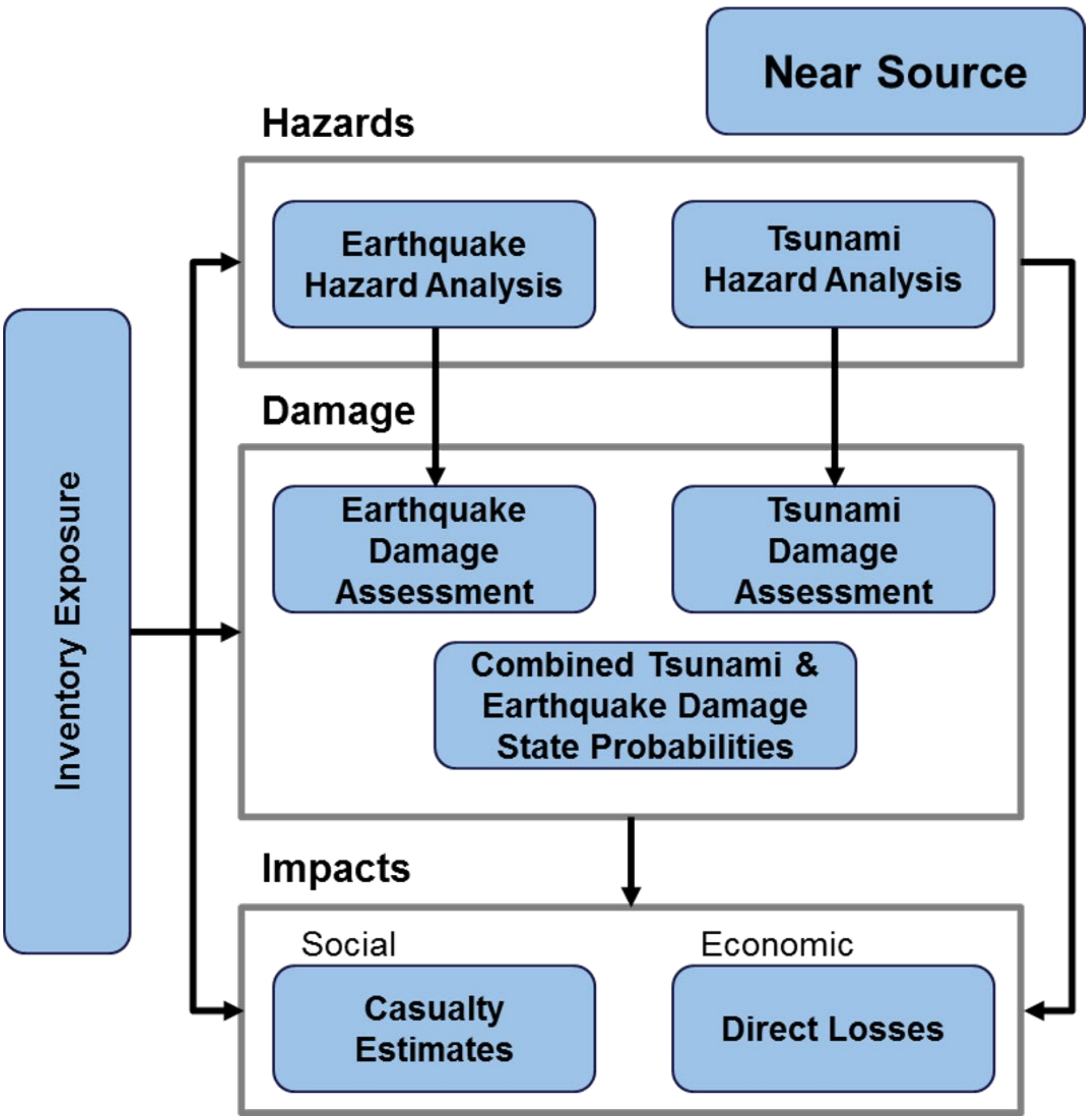
Visual 5: Hazus Analysis Components

Damage and Losses

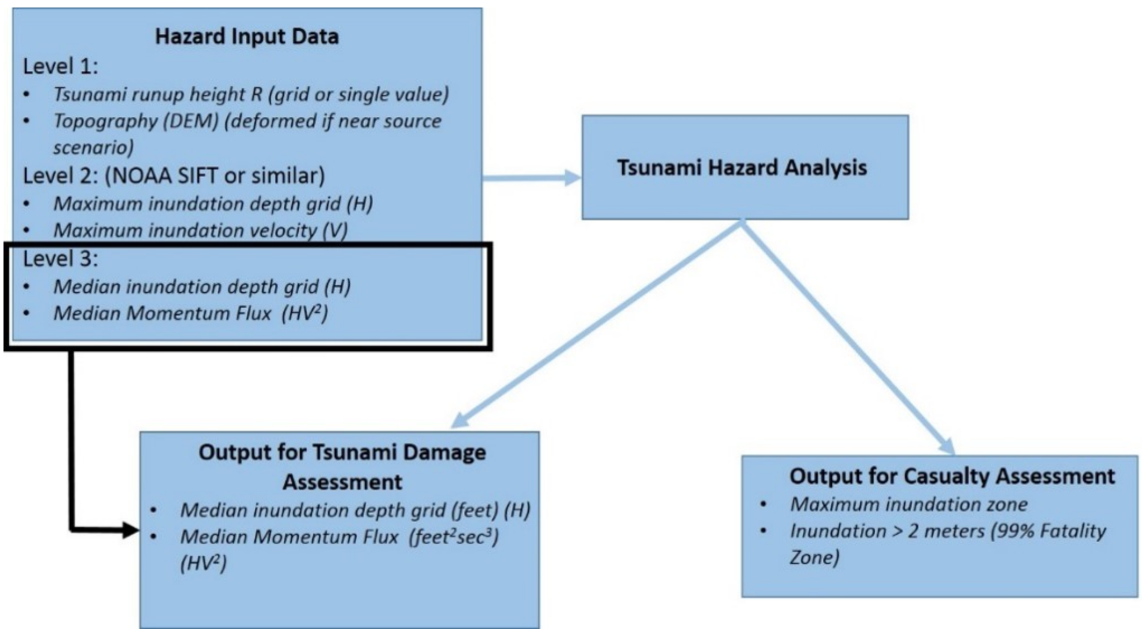
- Direct damage to structures, contents and nonstructural elements
- Direct economic losses

Casualties

- Evacuation times
- Injury/Fatality estimates
    - Age, time of day, community preparedness

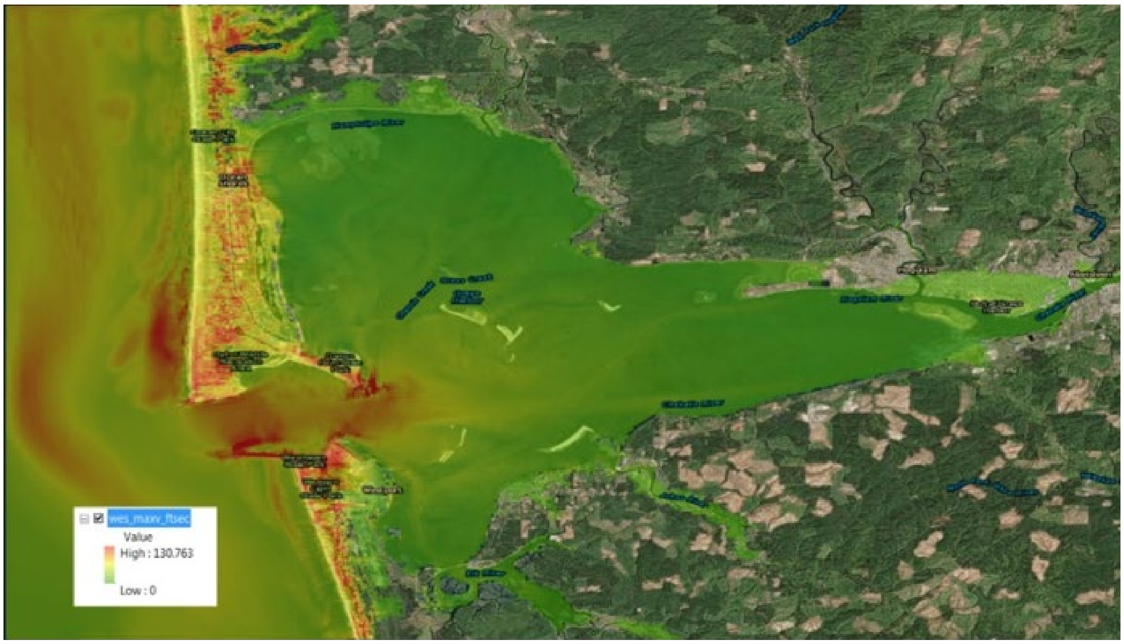


Visual 6: Hazard Analysis - User Input



Visual 7: Momentum Flux

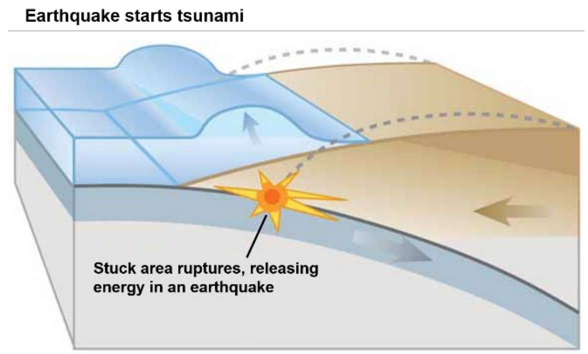
- Rate of transfer of momentum across a unit area
- Used to determine structural damage to buildings
- Calculated by Hazus (Basic Analysis) using the maximum runup height and topography (DEM)
- Provided by user for Advanced Analysis – Level 2 and 3



SIFT model velocity grid for Westport, WA

Visual 8: Near Source – Deformed DEM

- Post-earthquake event deformed topography should be used in the case of a near source scenario
- Earthquake could result in several meters of ground deformation, which may substantially change the inundation area and affect potential losses resulting from a tsunami



Visual 9: Basic Tsunami Scenario

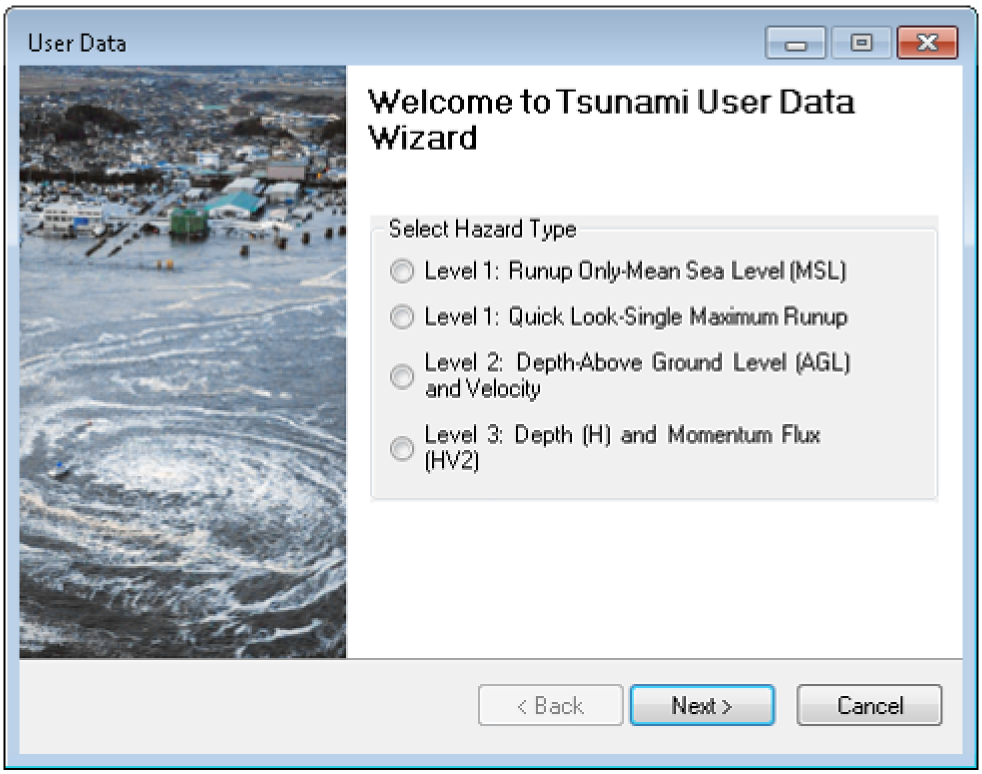
Two Options:

Level 1: Runup Only-Mean Sea Level (MSL)

- User provided Tsunami runup height raster

Level 1: Quick Look-Single Maximum Runup

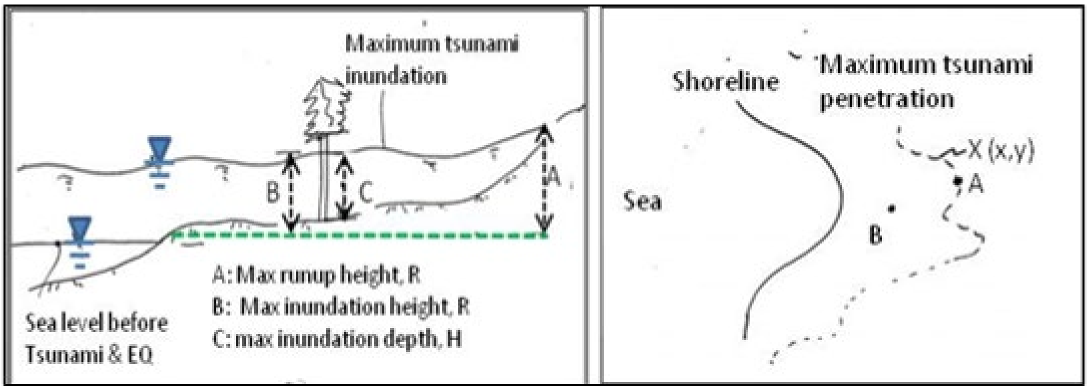
- User entered single runup value



Visual 10: Runup Only - Mean Sea Level (MSL)

Tsunami runup height (R)

- The vertical elevation of the most landward penetration of the tsunami with respect to initial sea level
- Used in combination with the topography raster (DEM) to estimate velocity and for determining content and nonstructural losses – based on depth only
- Can be used to create inundation/evacuation map boundaries

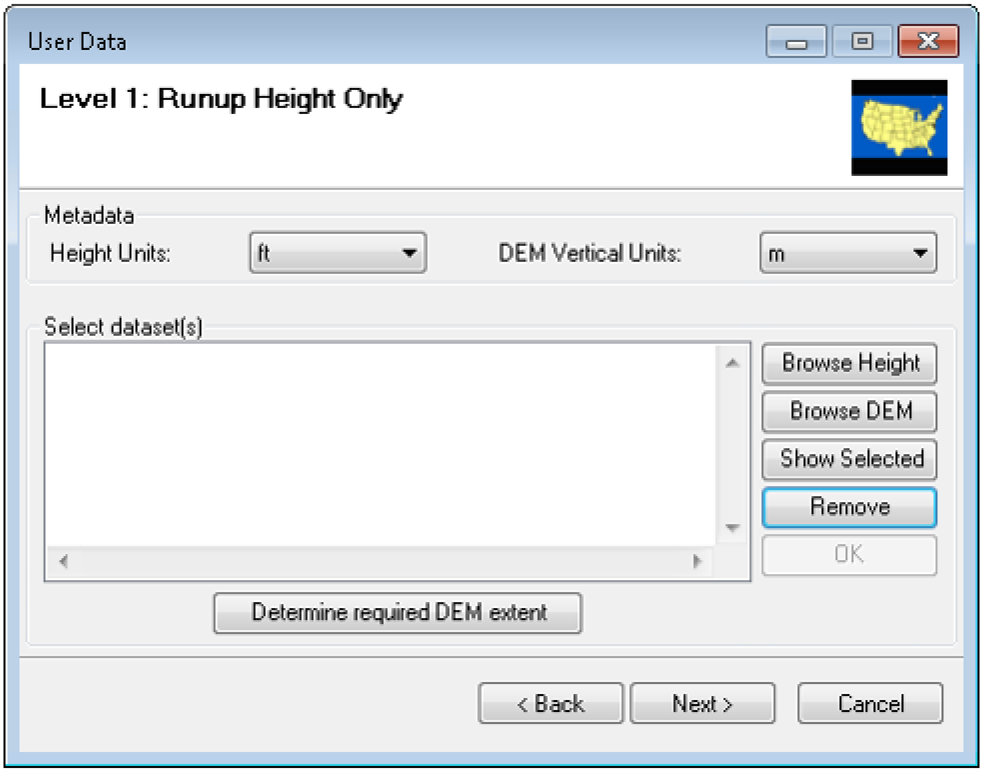


Visual 11: Runup Only-Mean Sea Level (MSL)

Input:

- User provided Tsunami runup height in raster format
- Digital Elevation Map (DEM)

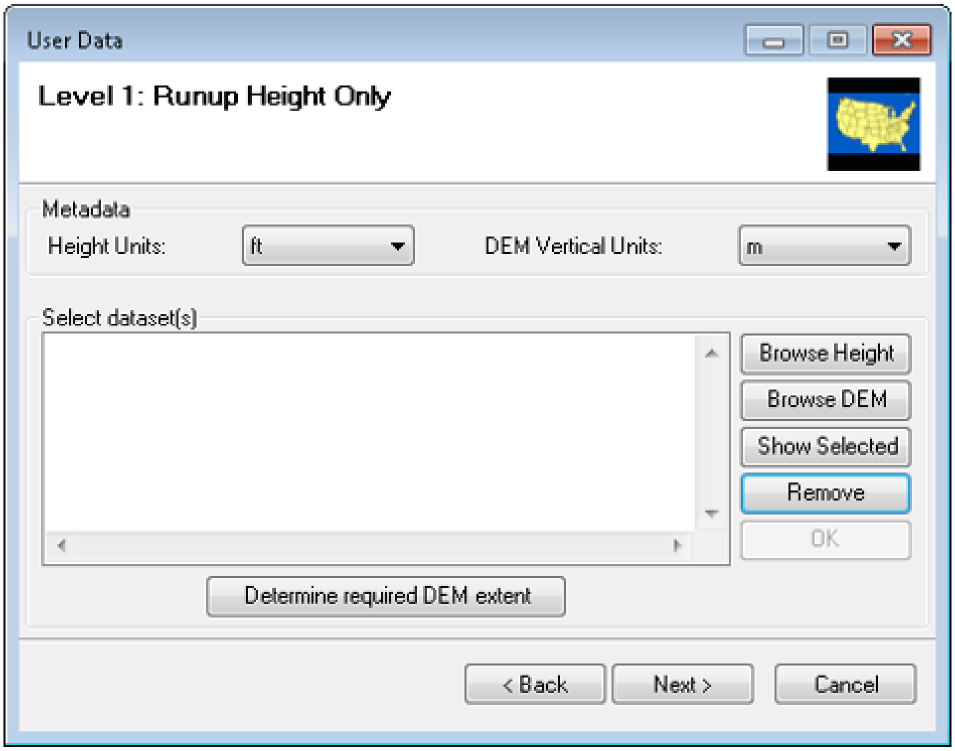
Raster units are defined using the drop down tabs under Metadata

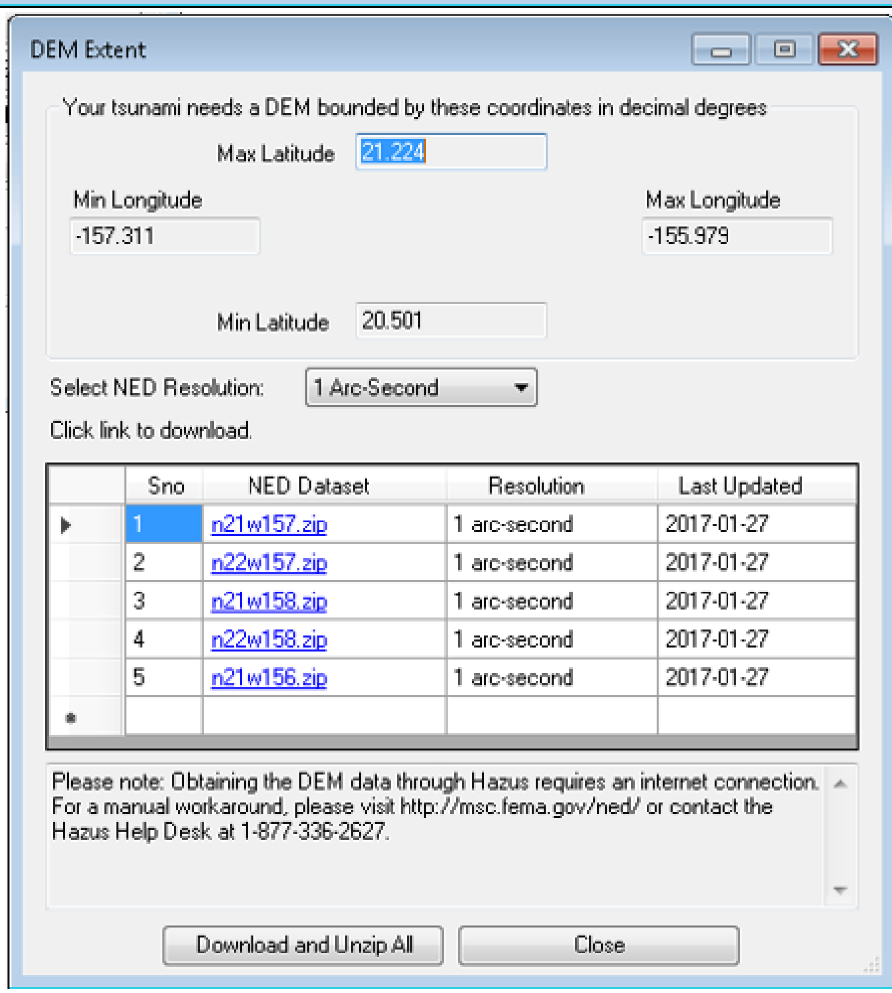


Visual 12: Digital Elevation Model (DEM)

Determine Required DEM extent

- Model will determine the required DEM extent and extract the rasters from the NED database
- Model will also Download and Unzip the NED data to a working directory under the C://HazardInput/TS/(study region) folder on the user's computer


User Data
Level 1: Runup Height Only
Metadata
Height Units:
ft
DEM Vertical Units:
m
Select dataset(s)
Browse Height
Browse DEM
Show Selected
Remove
OK
Determine required DEM extent
< Back
Next >
Cancel


DEM Extent
Your tsunami needs a DEM bounded by these coordinates in decimal degrees
Max Latitude
21.224
Min Longitude
-157.311
Max Longitude
-155.979
Min Latitude
20.501
Select NED Resolution:
1 Arc-Second
Click link to download.
Sno
NED Dataset
Resolution
Last Updated
1 n21w157.zip 1 arc-second 2017-01-27
2 n22w157.zip 1 arc-second 2017-01-27
3 n21w158.zip 1 arc-second 2017-01-27
4 n22w158.zip 1 arc-second 2017-01-27
5 n21w156.zip 1 arc-second 2017-01-27
Please note: Obtaining the DEM data through Hazus requires an internet connection.
For a manual workaround, please visit http://msc.fema.gov/ned/ or contact the
Hazus Help Desk at 1-877-336-2627.
Download and Unzip All
Close

Visual 13: Digital Elevation Model (DEM)

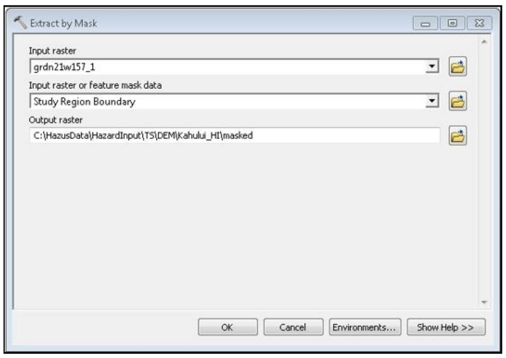
Determine Required DEM extent

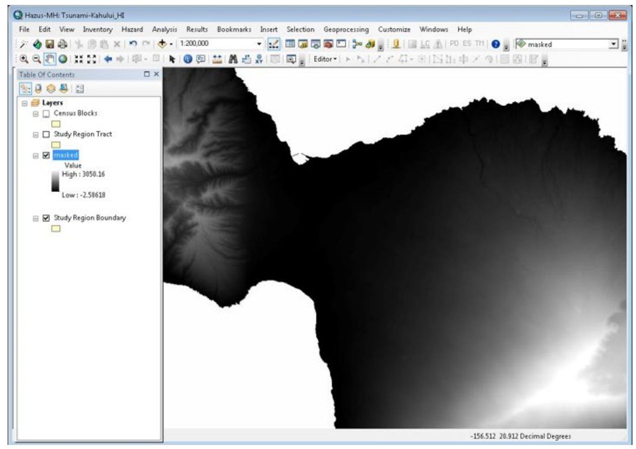
- Merge the DEMs if there is more than one for the area of interest
- Mask the DEM to the study region, which is a time saving technique especially useful for island regions

Visual 14: Masking DEM

ESRI ArcMap Extract by Mask tool

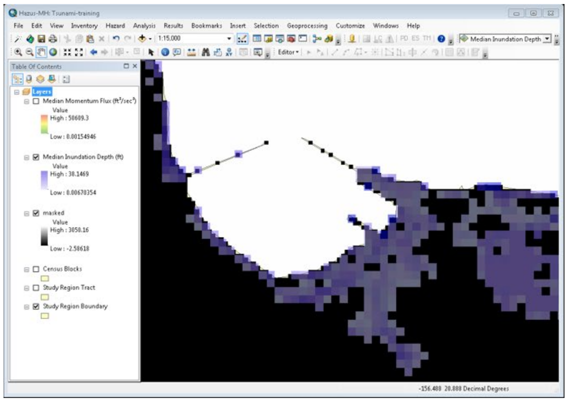
- Clips the DEM to the Study Region Boundary
- Removes all off shore sections
- Reduces processing time

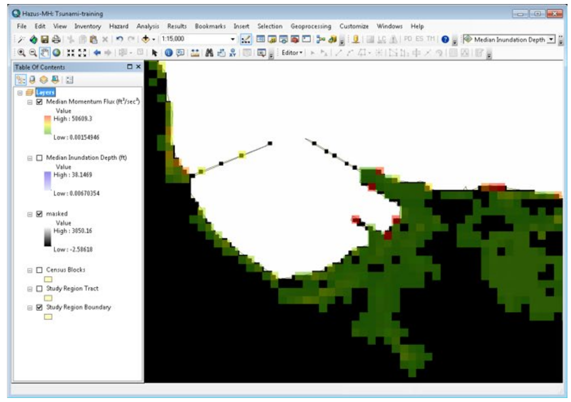




Visual 15: Runup Only-Mean Sea Level (MSL)

- Median Inundation Depth (ft)
- Median Momentum Flux (ft3/sec2)





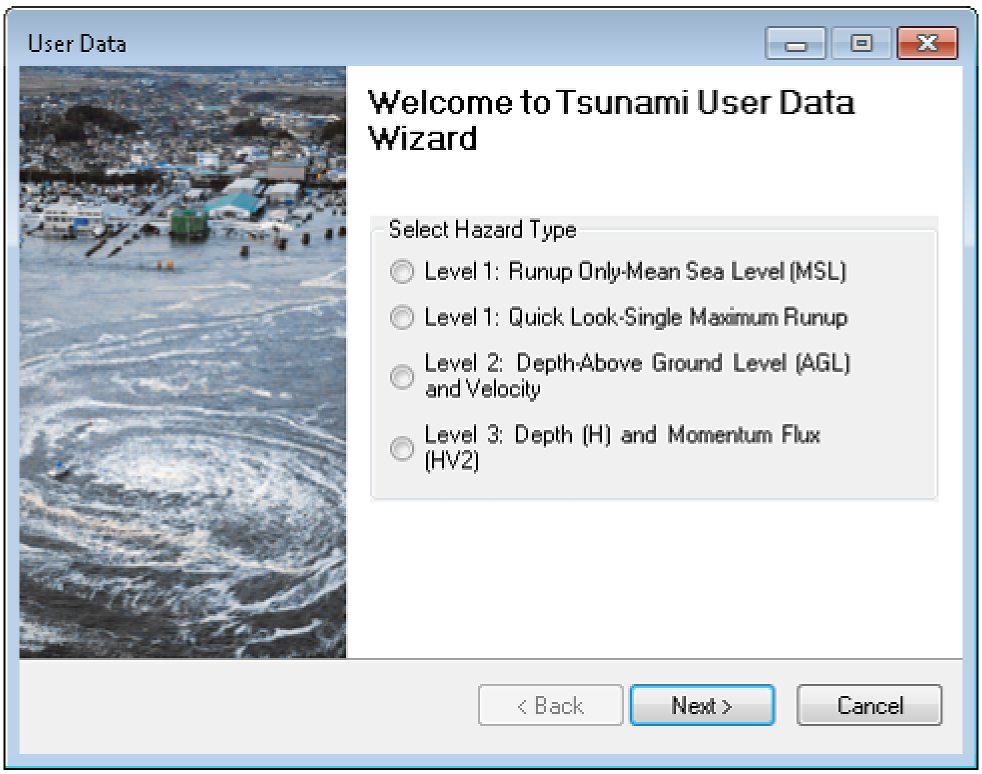
Visual 16: Quick Look - Single Maximum Runup

Input:

- Maximum Runup Height Value
  - Units defined in drop down menu
- Topography Raster (DEM)

Used in combination with the topography raster (DEM) to estimate velocity

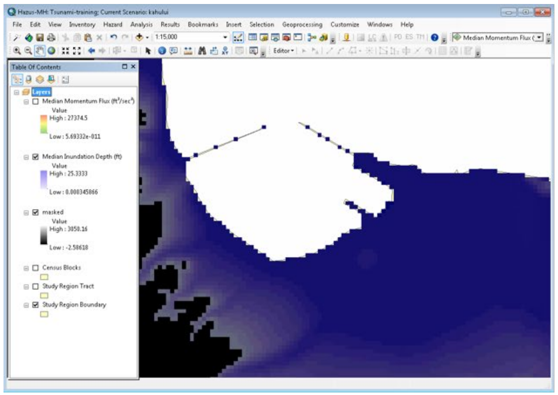
**Note: User must merge all DEMs to successfully execute this option.*

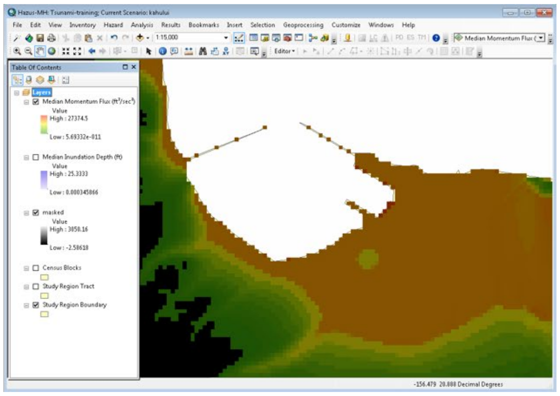


Visual 17: Quick Look Single Maximum Runup

Outputs from the process:

- Median Inundation Depth (ft)
- Median Momentum Flux (ft3/sec2)

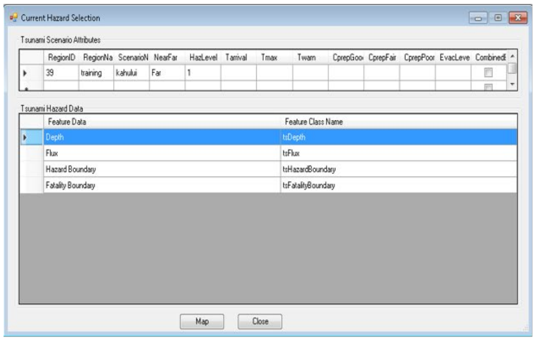


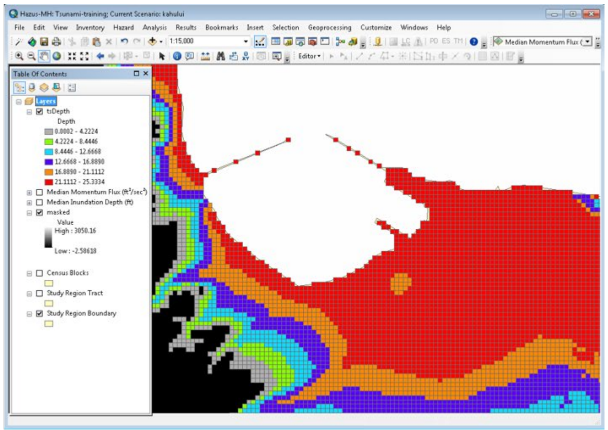


Visual 18: Current Hazard Selection

Output data from the User Defined Hazard

- Depth
- Flux
- Hazard Boundary
- Fatality Boundary





Visual 19: Analysis Options - Tsunami

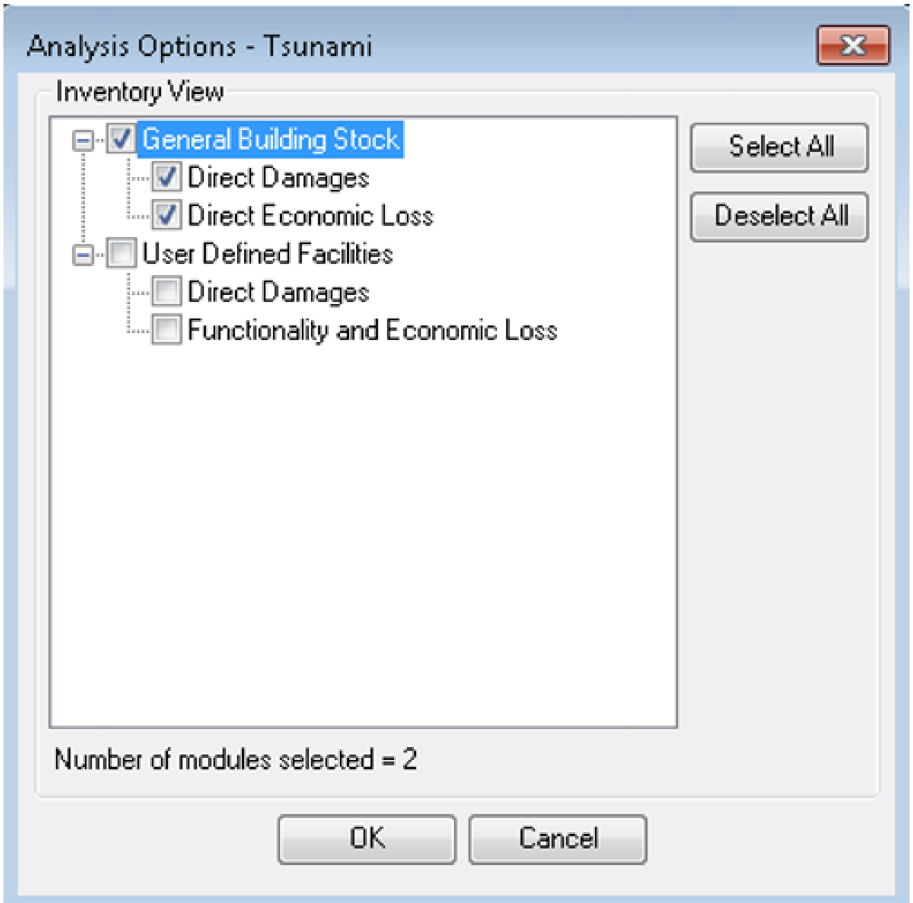
Options:

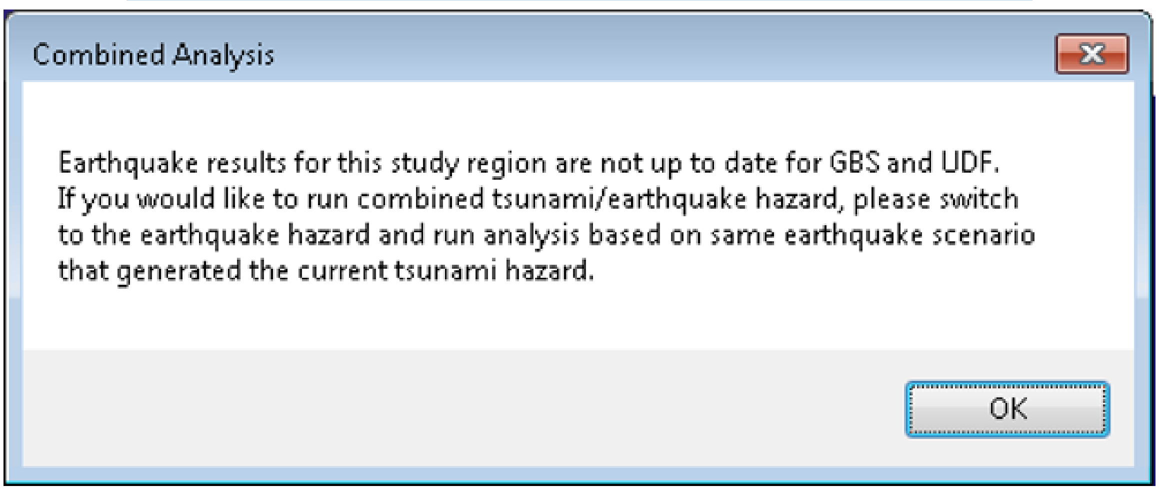
General Building Stock

- Direct Damages
- Direct Economic Loss

User Defined Facilities

- Direct Damages
- Functionality and Economic Loss


Analysis Options - Tsunami
Inventory View
General Building Stock
Direct Damages
Direct Economic Loss
User Defined Facilities
Direct Damages
Functionality and Economic Loss
Select All
Deselect All
Number of modules selected = 2
OK
Cancel


Combined Analysis
Earthquake results for this study region are not up to date for GBS and UDF.
If you would like to run combined tsunami/earthquake hazard, please switch
to the earthquake hazard and run analysis based on same earthquake scenario
that generated the current tsunami hazard.
OK

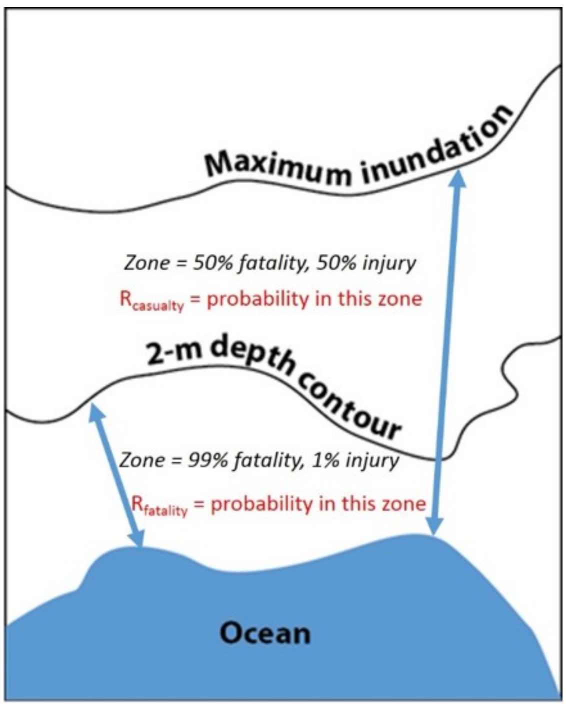
Visual 20: Casualty Scenario

Level 1 - Input:

- Fatality Boundary (depth > 2m)
- Hazard Boundary (depth > 0)
- Road Network Data
- Topography (DEM)
- Estimated time of tsunami arrival and maximum runup

Level 2 - Input:

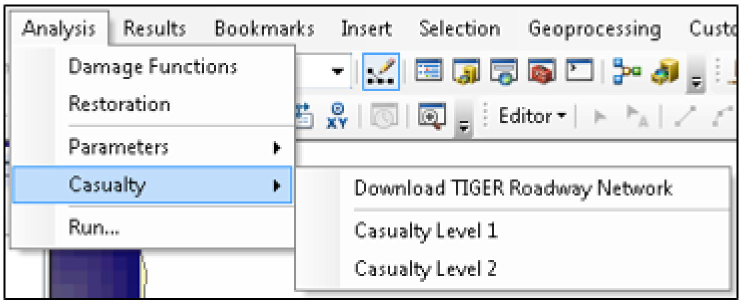
- Output travel time results provided by the USGS Pedestrian Evacuation Analyst Tool



Visual 21: Road Network Data

Casualty Level 1 assumes a ‘roads only’ analysis, in that the population will follow the road network to safety

- The Census TIGER road networks data may be downloaded through the Hazus Tsunami model from the Analysis Menu, under Casualty
- Or directly from the Census website at: 2016 TIGER/Line Shapefiles: Roads (https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2016&layergroup=Roads)



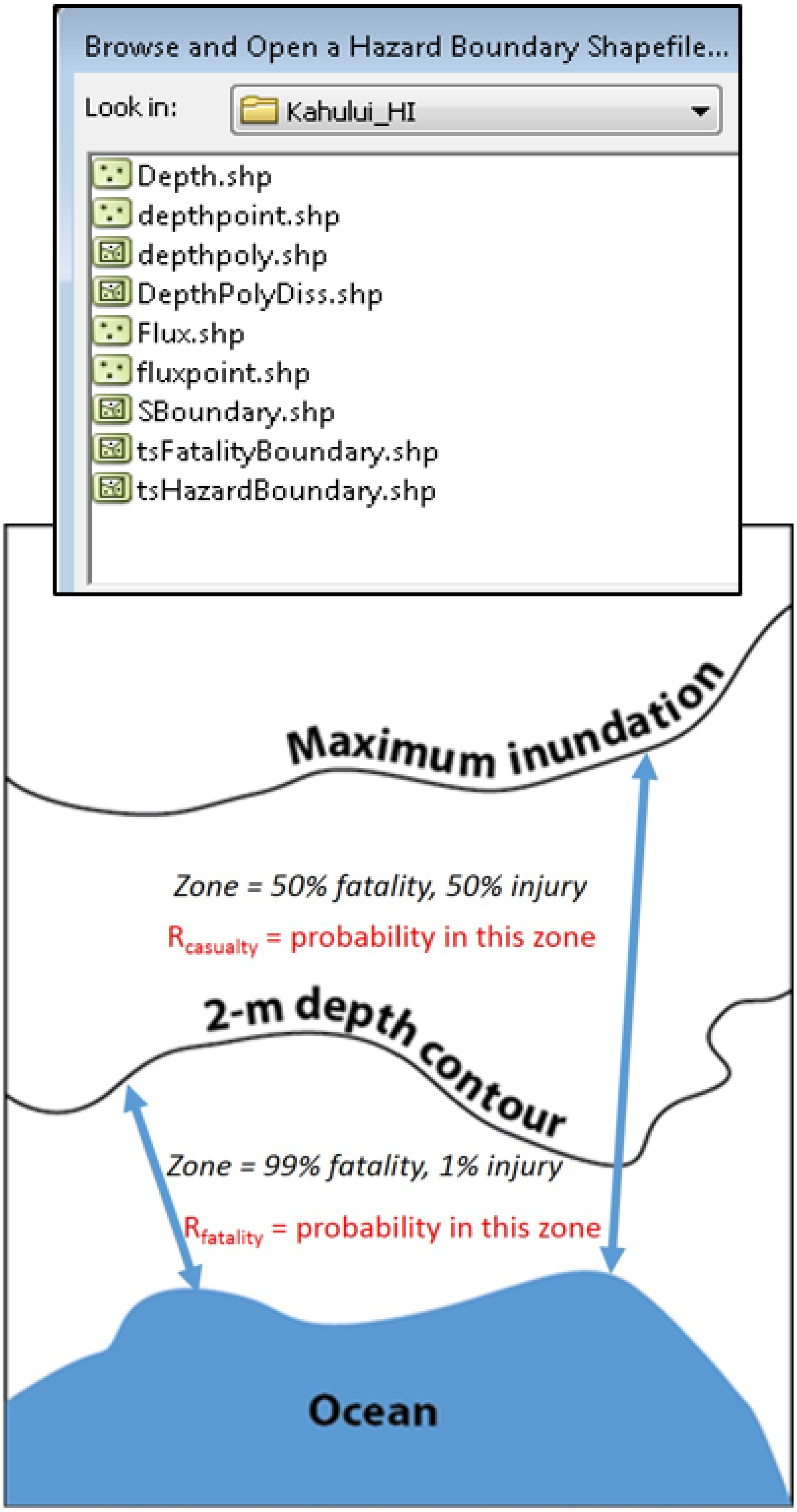
Visual 22: Hazard/Fatality Boundary Layers

Hazard Boundary

- Entire Inundation area
- Where depth > 0
- Zone with 50% fatality and 50% injury

Fatality Boundary

- Where depth > 2m
- Zone with 99% fatality and 1% injury


Browse and Open a Hazard Boundary Shapefile...
Look in:
Kahului_HI
Depth.shp
depthpoint.shp
depthpoly.shp
DepthPolyDiss.shp
Flux.shp
fluxpoint.shp
SBoundary.shp
tsFatalityBoundary.shp
tsHazardBoundary.shp
Maximum inundation
Zone = 50% fatality, 50% injury
$R_{casualty}$ = probability in this zone
2-m depth contour
Zone = 99% fatality, 1% injury
$R_{fatality}$ = probability in this zone
Ocean

Visual 23: Beware of Boundary Slivers

- Review the Hazard Boundaries to determine if slivers along the coast or other small pockets intersect with the roads, and remove them
- The model could interpret these areas as safe zones

Visual 24: Casualty Time Parameters

Arrival Time

- Estimated arrival of first tsunami wave

Time to Maximum Runup

- Time to the estimated maximum inundation

Warning Time

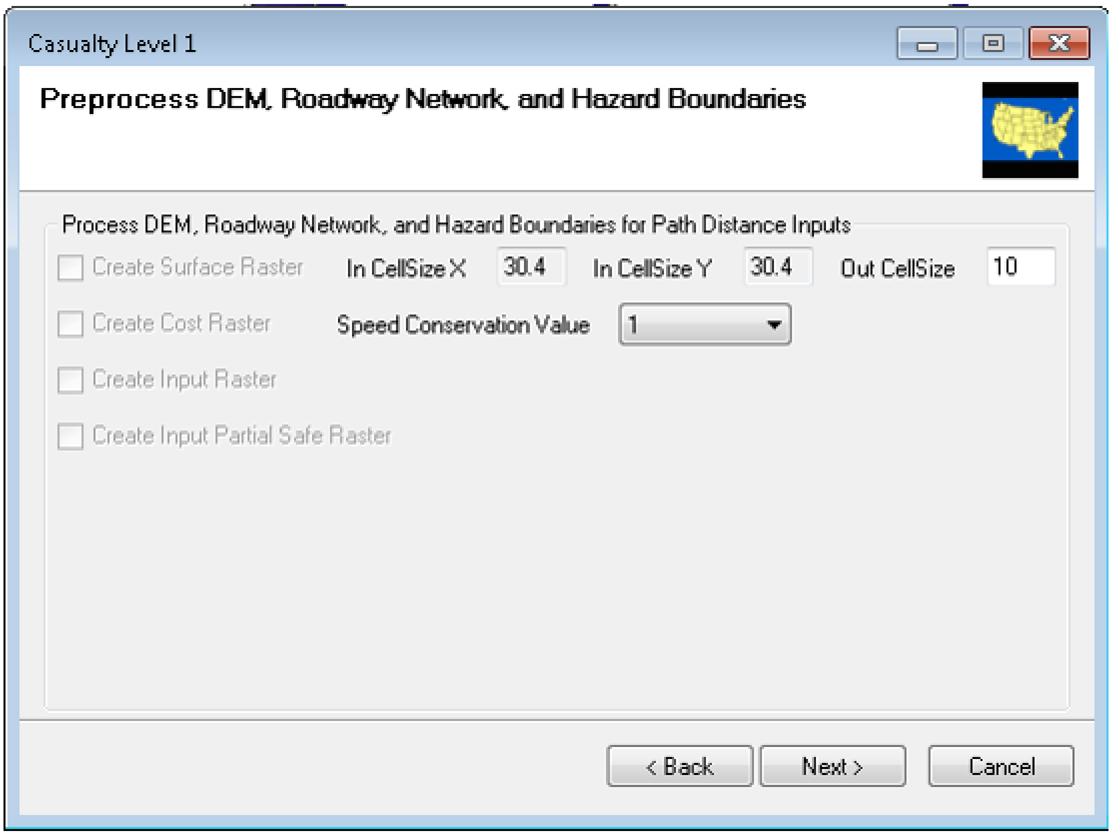
- Estimated time to warn the population (this may be 0 in the case where ground shaking provides the warning)

Visual 25: Speed Conservation Value

Speed Conservation Value

- Resistance factor

Default value is 1 – which assumes that all of the roads are clear and open



Visual 26: Travel Speed

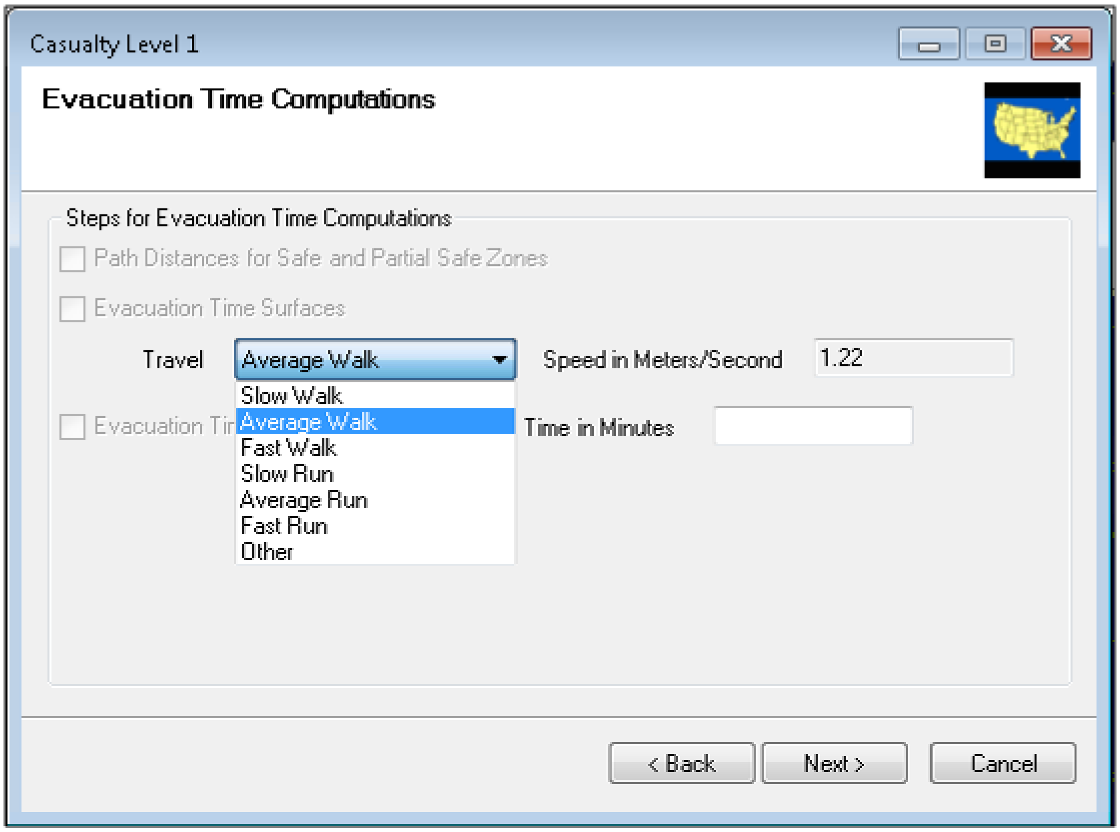
Travel Speed of evacuation population

- Based on the USGS Pedestrian Evacuation Model Parameters

Default value is Average Walk

- Assumes average speed is 1.22 m/s

Option to set the maximum travel time in minutes required to reach safety



Visual 27: Activity 10.1

- Defining a Basic Level Analysis
- Defining a Casualty Level 1 Analysis

Activity	See separate activity information for details.

Visual 28: Review

- What inputs are required for a Level 1 analysis?
- Why is it important to check the Fatality and Hazard boundaries prior to running the Casualty Analysis?
- What does the current version of the Tsunami Model NOT estimate?

Visual 29: Questions?

Lesson 11: Tsunami Results

Visual 1: Lesson 11: Tsunami Results

Visual 2: Goal and Objectives

Goal

This lesson will discuss the tsunami hazard and describe how to conduct a basic tsunami analysis.

After completing this lesson, you will be able to:

- List the key outputs of the damage analysis
- List the key outputs of the casualty analysis
- Identify the key guidelines for properly interpreting and applying the outputs of the tsunami model

Visual 3: Results

Tsunami Inundation layers

- Inundation/Hazard Boundary polygon (depth > 0)
- Fatality Boundary (depth $\geq$ 2m)

General Building Stock

- Direct Damages
- Direct and Indirect Economic Losses

User Defined Facilities

- Infrastructure damage probabilities
- Direct and Indirect Economic Losses

Visual 4: Damage Assessment Results

General Building Stock/User Defined Facilities

- Direct Damage
  - Damage probabilities by occupancy
  - Damage probabilities by building type
- Direct Economic Losses
  - Cost of building repair or replacement
  - Loss of contents
  - Business inventory loss and income loss
  - Loss of rental income
  - Relocation costs
  - Employee wage loss

Visual 5: Casualty Assessment Results

- Estimates pedestrian evacuation, and warning times to evaluate potential loss of life and injuries
- Two levels of analysis: Basic and Advanced
- Results:
    - Evacuation Travel Time (Age – Under/Over 65)
    - Day/Night population exposure
    - Day/Night probability of casualties
    - Casualties based on Community Preparedness Level (good, fair, poor)

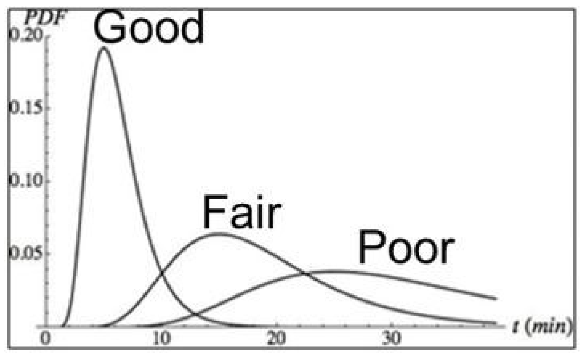
Visual 6: Community Preparedness Level

3 ratings:

- Good
- Poor
- Fair

Determined by factors such as:

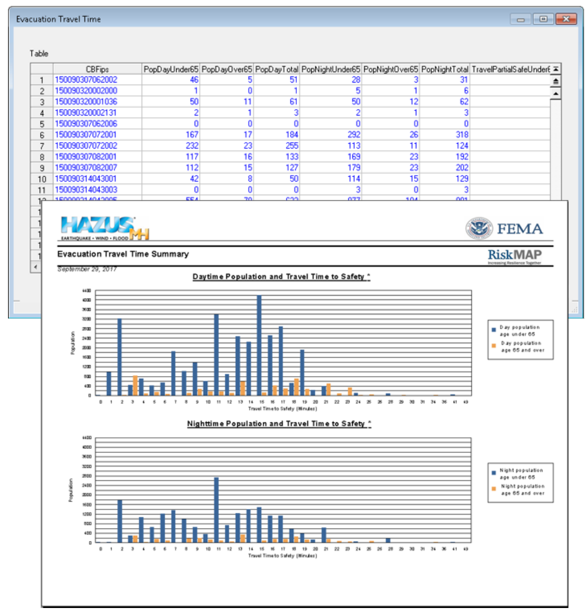
- Condition of shore-protection structures
- Emergency loud speakers
- Preparation of evacuation routes and signs
- Community's risk management level
- Education level for tsunami awareness
- TsunamiReady designated community



Visual 7: Evacuation Travel Time

Results:

- Population under 65
- Population 65+
- Day/Night
- Travel time to Partial Safety (out of Fatality zone)/Total Safety (out of Hazard zone)



Visual 8: Probability of Casualties

Day/Night

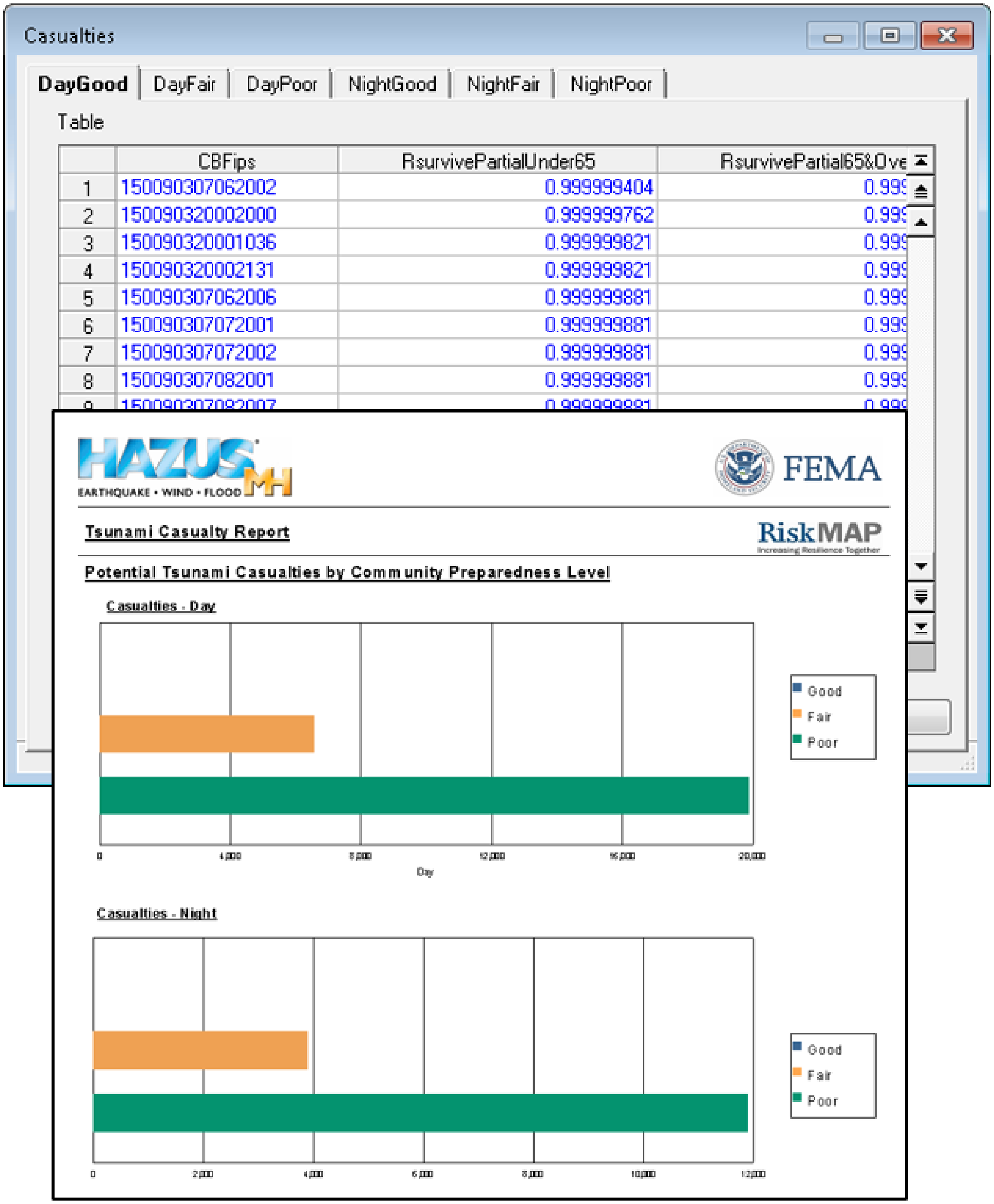
Community Preparedness Level

- Good, Fair, Poor

Injuries/Fatalities

- Under 65
- 65 and over

Partial Safety/Total Safety


Casualties
DayGood
DayFair
DayPoor
NightGood
NightFair
NightPoor
Table
CBFips
RsurvivePartialUnder65
RsurvivePartial65&Ove
1 150090307062002 0.999999404 0.999
2 150090320002000 0.999999762 0.999
3 150090320001036 0.999999821 0.999
4 150090320002131 0.999999821 0.999
5 150090307062006 0.999999881 0.999
6 150090307072001 0.999999881 0.999
7 150090307072002 0.999999881 0.999
8 150090307082001 0.999999881 0.999
HAZUS MH
EARTHQUAKE • WIND • FLOOD
FEMA
Tsunami Casualty Report
RiskMAP
Potential Tsunami Casualties by Community Preparedness Level
Casualties - Day
Good
Fair
Poor
0
4,000
8,000
12,000
16,000
20,000
Day
Casualties - Night
Good
Fair
Poor
0
2,000
4,000
6,000
8,000
10,000
12,000

Visual 9: Activity 11.1

- Explore the Results Menu

Visual 10: Available Case Studies

- NOAA PMEL Sample Data Available

Available for download:
https://tools.hazards.fema.gov/hazus/maps/data/HazardSampleData.zip

Community	County	Scenario	Level 1	Level 2	Level 3
Homer, AK	Kenai	M 9.2 1964 Alaska	hom_dem_ft hom_maxR_ft	hom_maxdg_ft hom_maxv_ftsec	hom_dg_ft_median hom_flux_ft3sec2_median
Crescent City, CA	Del Norte	M 9.0 Cascadia	crc_dem_ft crc_maxR_ft	crc_maxdg_ft crc_maxv_ftsec	crc_dg_ft_median crc_flux_ft3sec2_median
Kahului, HI	Maui	M 9.0 Cascadia	kah_dem_ft kah_maxR_ft	kah_maxdg_ft kah_maxv_ftsec	kah_dg_ft_median kah_flux_ft3sec2_median
Garibaldi, OR	Tillamook	M 9.0 Cascadia	gar_dem_ft gar_maxR_ft	gar_maxdg_ft gar_maxv_ftsec	gar_dg_ft_median gar_flux_ft3sec2_median
Westport, WA	Grays Harbor	M 9.0 Cascadia	wes_dem_ft wes_maxR_ft	wes_maxdg_ft wes_maxv_ftsec	wes_dg_ft_median wes_flux_ft3sec2_median

Visual 11: Additional Resources

https://www.fema.gov/hazus

- Hazus Tsunami Manuals
  - Hazus Tsunami Model User Guidance
  - Hazus Tsunami Technical Guidance
- Hazus Support (hazus-support@riskmapcds.com)
  - FAQs
  - Help Desk
- Additional Training Coming Soon!
  - E0174 Hazus for Earthquake and Tsunami

Visual 12: Where To Find Level 1 & 2 Data

A sample of level 2 data are available here:
https://tools.hazards.fema.gov/hazus/maps/data/HazardSampleData.zip

- Other data sources, FEMA, NOAA PMEL, Tsunami Warning Center, and State and Local Evacuation Plans

Visual 13: Review

- What outputs are created for tsunami inundation?
- In what formats are analysis results available?
- What outputs are created for casualties?

Visual 14: Questions?

Lesson 12: Hurricane Hazard

Visual 1: Lesson 12: Hurricane Hazard

Visual 2: Goal and Objectives

Goal

This lesson will provide an overview of the hurricane wind hazard.

After completing this lesson, you will be able to:

- List the steps and purpose for completing a historic storm analysis.
- List the steps and purpose for completing a User-Defined scenario.
- Explain the steps and purpose for completing a probabilistic hurricane analysis.

Visual 3: Hurricane Hazard Model

Storms initiated in:

- Atlantic
- Caribbean
- Gulf of Mexico
- Eastern Pacific
- Central Pacific

The Wind Model allows for the following hurricane behaviors:

- Storm curvature
- Multiple land falls
- Changes in intensity
- Updated version of model used for design wind speeds in ASCE-7-98

Only available in Hurricane States in the Atlantic and Hawaii. Puerto Rico and USVI are in the process of being built out.

Visual 4: Hurricane Wind Hazard Model - 3 Parts

Wind field model

- Upper level mean flow field
- Boundary layer model that relates upper level winds to surface level winds

Track model

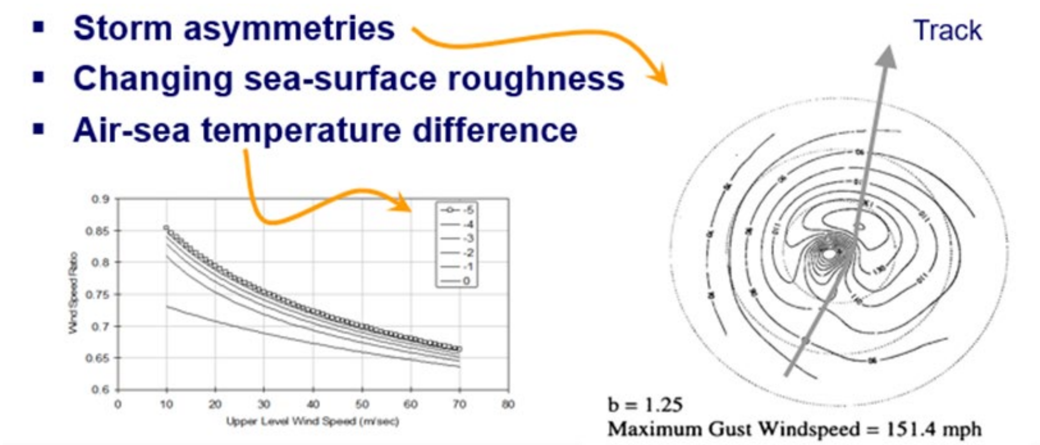
- Determines starting point, path, translation speed

Rainfall model

- Estimates amount of precipitation associated over duration of event

Visual 5: Wind Field Model

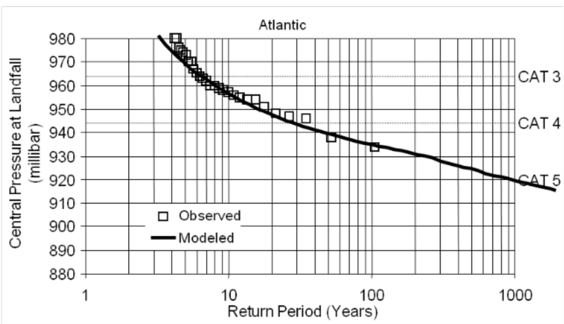
Solves full non-linear equations of motion for translating hurricane; then establishes parameters for fast running simulation



Visual 6: Hurricane Hazard: Hurricane Track Model

Models entire track of tropical storm:

- Allows storms to curve and change speed and intensity as they move
- Models hurricane wind risk over large regions
- Based on HURDAT database from National Hurricane Center (NHC)



Comparison of Modeled and Observed Storm Central Pressure at Landfall vs. Return Period for Various Geographic Regions

Visual 7: Hurricane Hazard: Rainfall Model

One of most difficult items to simulate

- Non-linear interactions of weather fronts and topography

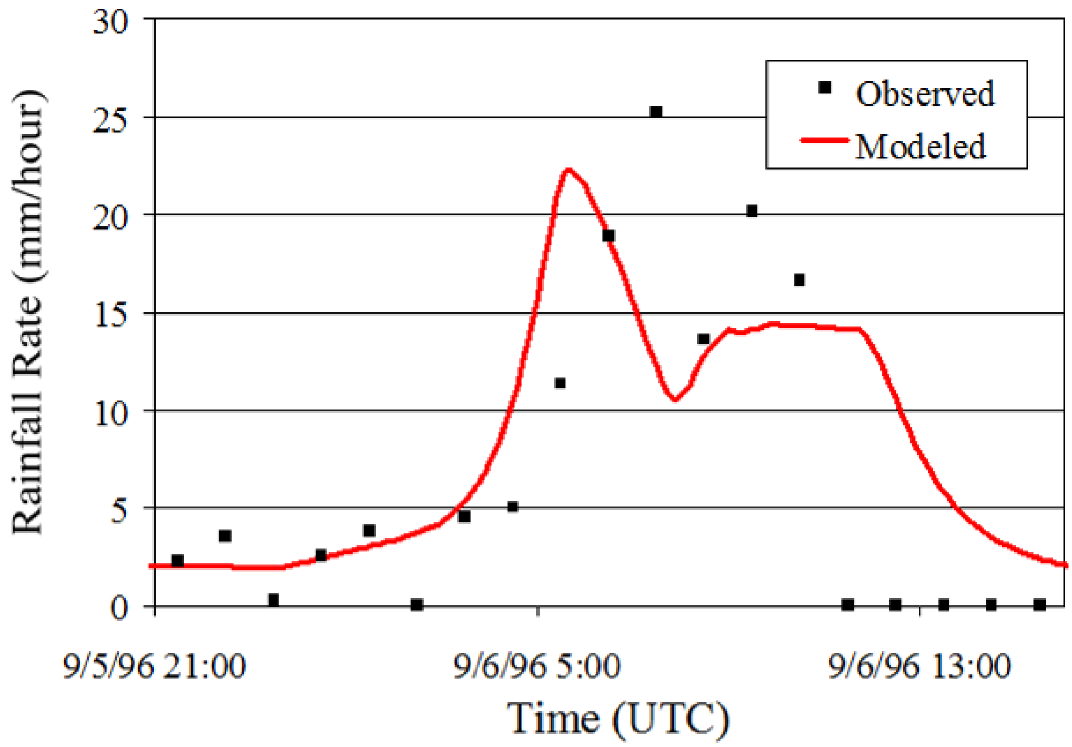
Model uses following parameters:

- Central pressure deficit
- Storm category
- Storm translation speed

Validation done with rainfall measurements from Hurricane Hugo (1989), Bertha (1996), Fran (1996), and Bonnie (1998)

Current model produces *reasonable* estimates of rainfall.

Expect significant variation with actual events due to un-modeled effects.



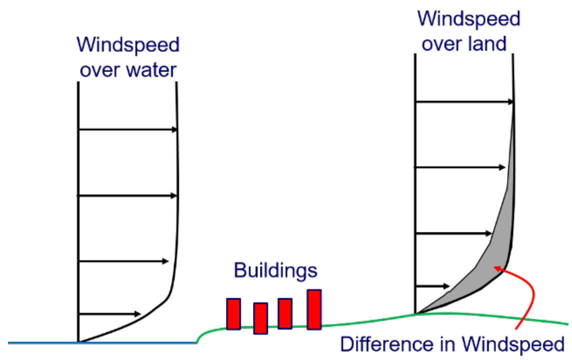
Raleigh/Durham Airport, Fran (1996)

Visual 8: Terrain Model

Surface roughness slows wind down due to friction

Roughness elements:

- Buildings
- Trees
- Vegetation
- Hills



Visual 9: Tree Blow Down Model

Tree effects during wind storms

- Positive
  - Provide shelter to structures, reducing wind pressure
- Negative
  - Falling trees produce a strike hazard to structure
  - Fallen trees add to amount of debris to dispose of after storm

Visual 10: Tree Database in Hazus

Three tree types

- Deciduous
- Coniferous
- Mixed

Tree Density (stems per acre)

3 broad height categories

- 30 - 40 ft
- 40 - 60 ft
- 60+ ft

Access to tree data through Analysis | Parameters | Trees

Census Block	Predominate Tree Type	Stems Per Acre	Tree Height <40ft	Tree Height 40ft-60ft	Tree Height 60ft+	Tree Collection Factor
130259601001000	Mixed	62	9	64	27	0.16
130259601001001	Mixed	114	9	64	27	0.15
130259601001002	Mixed	101	9	64	27	0.25
130259601001003	Mixed	121	9	64	27	1
130259601001004	Mixed	26	9	64	27	1
130259601001005	Mixed	89	9	64	27	0.33
130259601001006	Mixed	77	9	64	27	0.38
130259601001007	Mixed	115	9	64	27	0.02
130259601001008	Coniferous	39	9	64	27	0.06
130259601001009	Mixed	102	9	64	27	0.07

Visual 11: Historic Storm Scenario

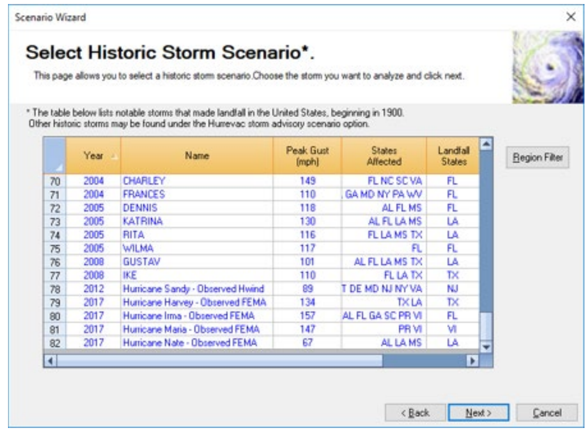
Pre-computed wind fields and storm tracks for many US landfalling hurricanes

Region Filter button

- Only those storms that affect study region state

Peak Gust

- Largest modeled gust speed over land anywhere in US
- Hurricanes Sandy, Harvey, Irma, Maria, and Nate are based on observed winds



Visual 12: Exercise 12.1

Student Activity

- Run Historic Scenario Hurricane

Activity

See separate activity information for details.

Visual 13: Review

Historic Storm Scenarios:

- Describe the software's storm database
- Define peak gusts
- What are the major steps for defining a historic storm scenario?
- In what type of situation would you want to use a historic scenario?

Answer the following questions using your activity study region:

- Which storm that affected North Carolina had the highest peak gust winds?
- Which census tract had the highest maximum sustained winds?

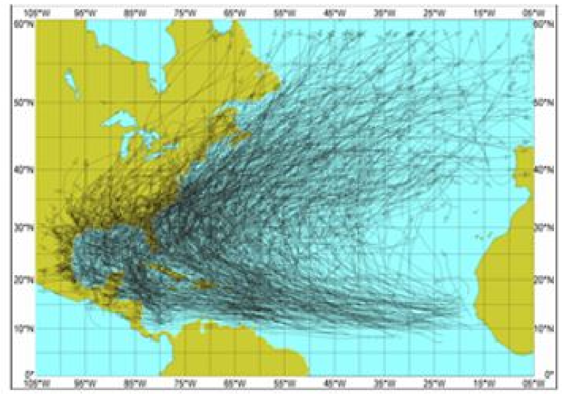
Visual 14: Probabilistic Storm Set

What if we ran every possible scenario?

Probabilistic storm set

- 100,000 years worth of storms
- Vary in size, strength, speed, direction

Provides objective way to compare risk of different areas



Visual 15: Probabilistic Results

Return Period Event

7 Return Period Events

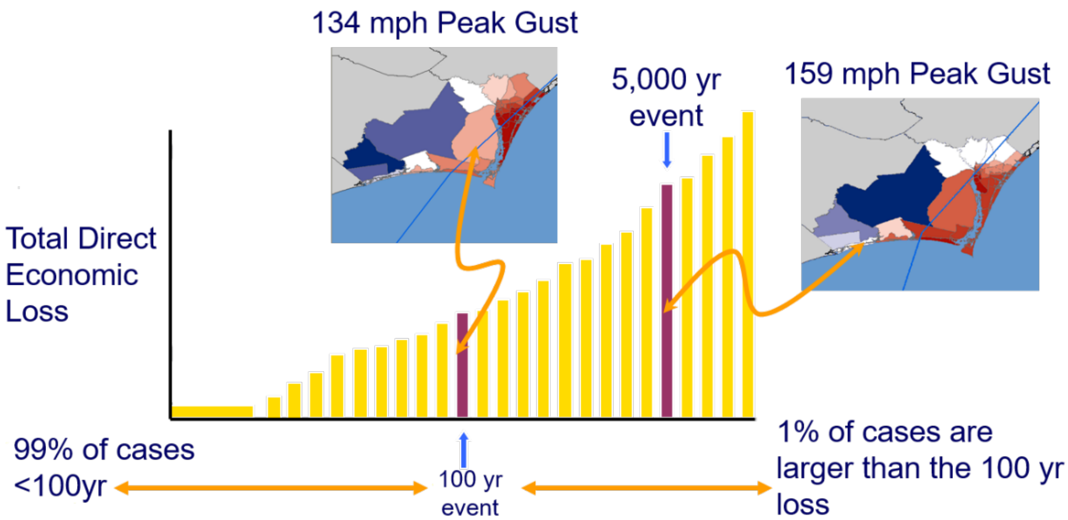
- 7 single storm scenarios from 100,000 year storm database
- “Representation” of the return period losses for study region
  - 10, 20, 50, 100, 200, 500, 1000 years
- Return periods are based on total direct economic loss for entire study region

Full set of results provided

- Damage, debris, shelter, etc.
- Dollar losses

Visual 16: 7 Return Period Events

Events Sorted by Total Loss

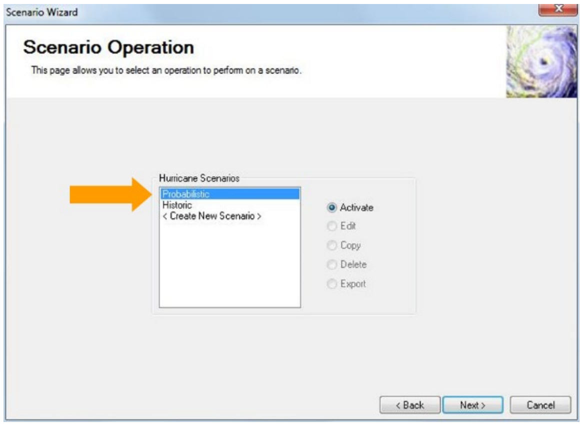


Visual 17: Selecting Probabilistic Analysis

Click Hazard | Scenario | Activate

Select

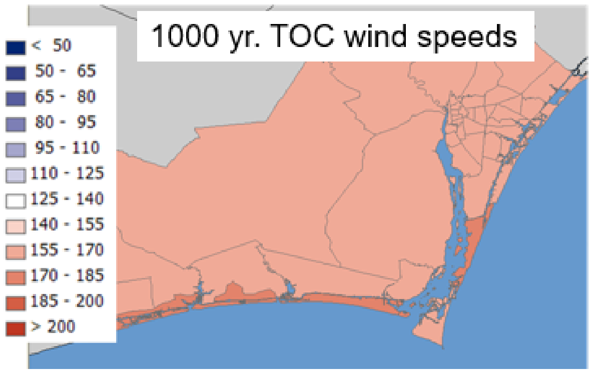
Probabilistic

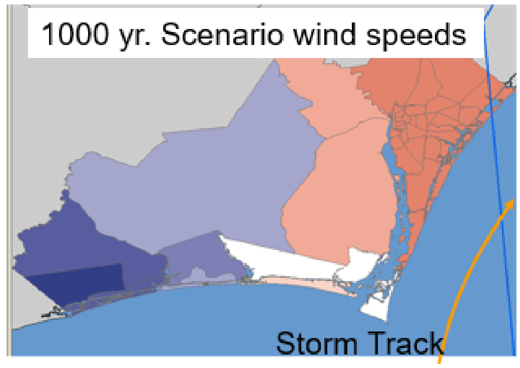


Visual 18: Probabilistic TOC versus Scenarios

TOC Return period maps: When open, any HU study region is static based on wind speeds and all national events in the 100,000 year simulated database.

Probabilistic analysis: Looks at simulated storms that *intersect study region,* and *total losses* ar ranked from those. The storm that caused that loss is used to make a wind speed map.

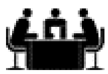




Visual 19: Activity 12.2

Student Activity

- Run Probabilistic Scenario Hurricane
- Compare Historic and Probabilistic Hurricane Scenario Results



Activity

See separate activity information for details.

Visual 20: Review

Probabilistic Storm Scenarios

- What are the seven return period events that are represented in a probabilistic scenario?
- In what type of situation would you want to use a probabilistic scenario?
- Explain the difference between the TOC and results menu return period peak gust maps and data?

Answer the following questions using your activity study region:

- What are the total direct economic losses for a 1000 year event?
- What is the 1000 year return period peak wind gust?
- Which Census Tract has the highest peak wind gust?

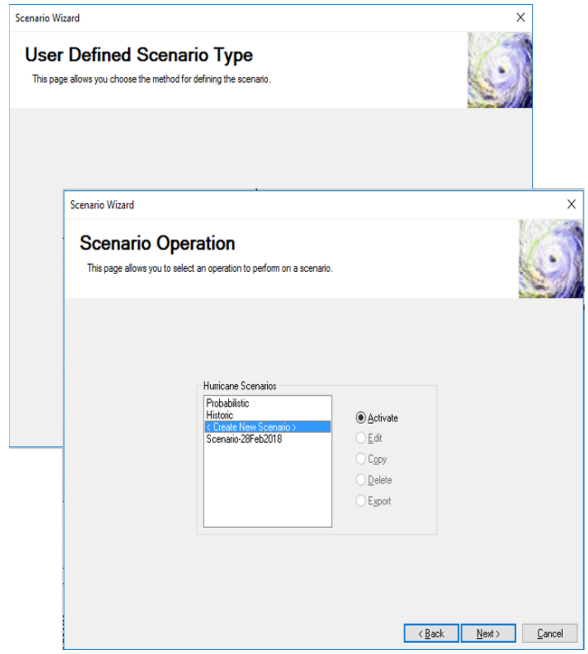
Visual 21: User Defined Scenario

4 options

- Define manually.
- Import from exported file (other Hazus users)
-
- Import from Hurrevac*

Select Define *Storm Track Manually* and click the Next button

*Preferred Method



Visual 22: Define Storm Track Manually

How fast is the storm moving?

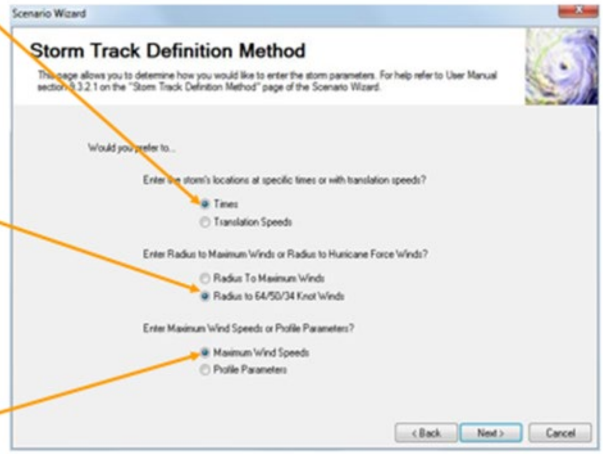
- **Elapsed time for each point along the storm track**
- **Forward translation speed of the storm at each point**

What is the size of the storm?

- **Radius to maximum winds**
- **Radius to hurricane force (64kt), 50Kt or 34Kt winds**

What is the intensity of the storm?

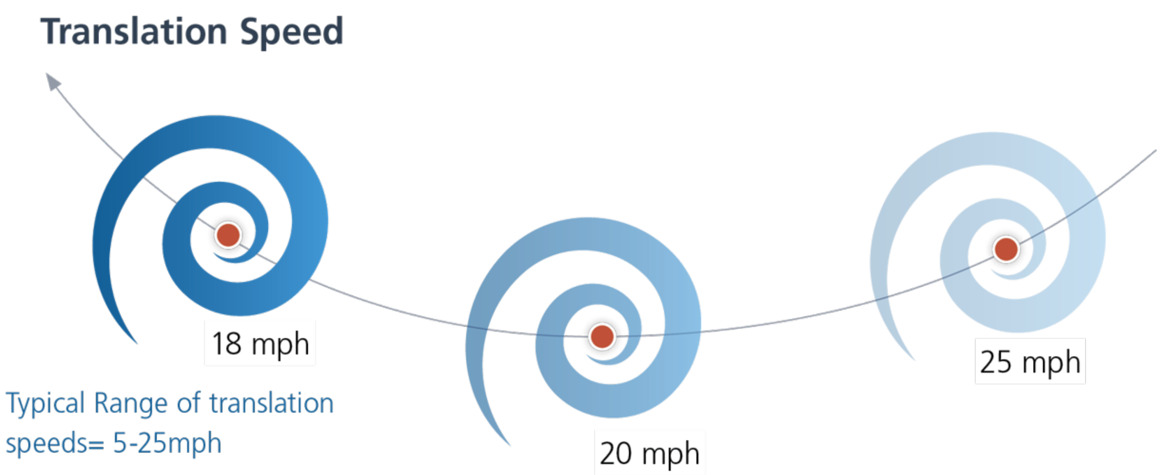
- **Maximum wind speed**
- **A Holland profile parameter**



Answers to these questions will depend on the format of the information you have.

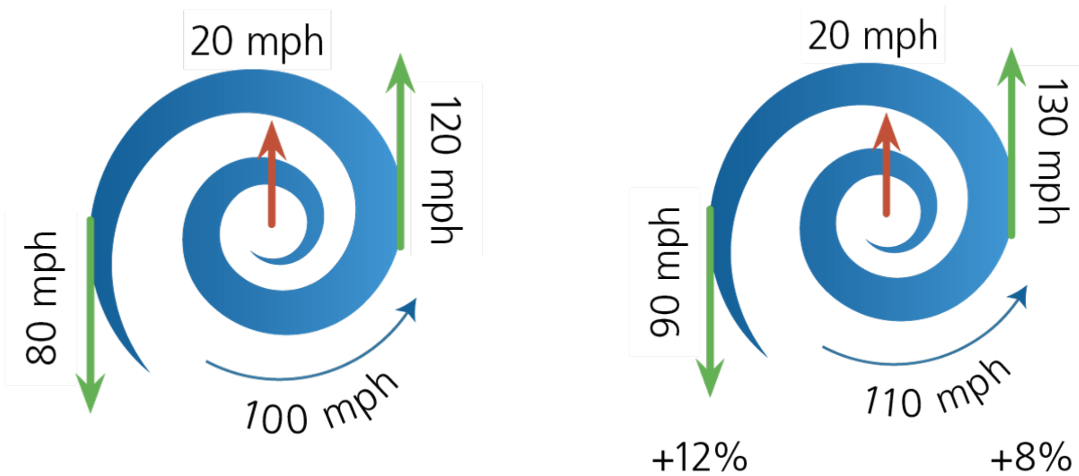
Visual 23: Parameters - Translation Speed

How fast is the storm moving?



Visual 24: Interaction of Translation and Rotation Speeds

Increase in rotation speed means different % increase on right and left side of storms



Visual 25: Parameters – Storm Size

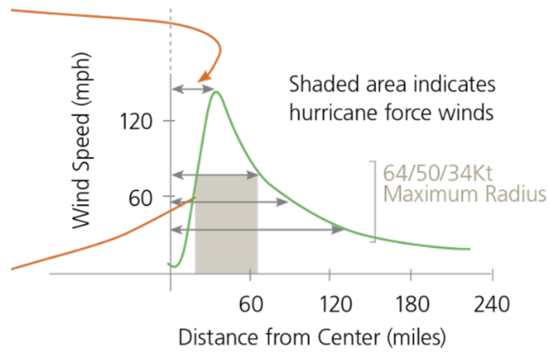
Radius to Max Winds:

- Radius to maximum wind speed indicates the size of the storm
- Range of 6-60 miles

Radius to 64kt/50kt/34kt

Force Winds:

- Maximum radius from center of storm to 64Kt (74 mph) wind speeds (1 min mean)
- Range of 10-200 miles

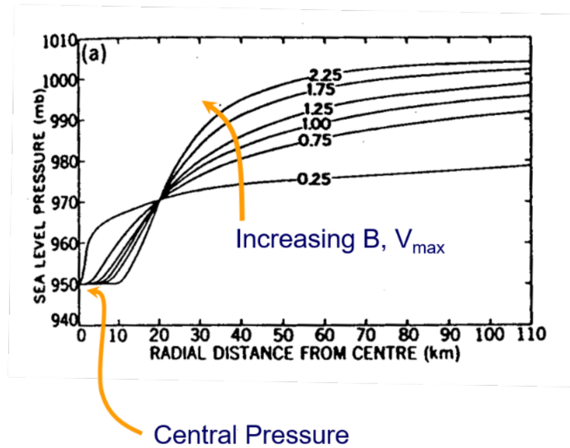


Visual 26: Parameters - Storm Intensity

Maximum Wind Speed

Profile Parameter (B)

- Parameter that describes the rate of pressure drop in the storm
- Pressure drop determines the maximum wind speed



Visual 27: Converted Wind Speeds

Typical Storm Parameters

Hazus Input Wind Speeds = 1 Min Mean

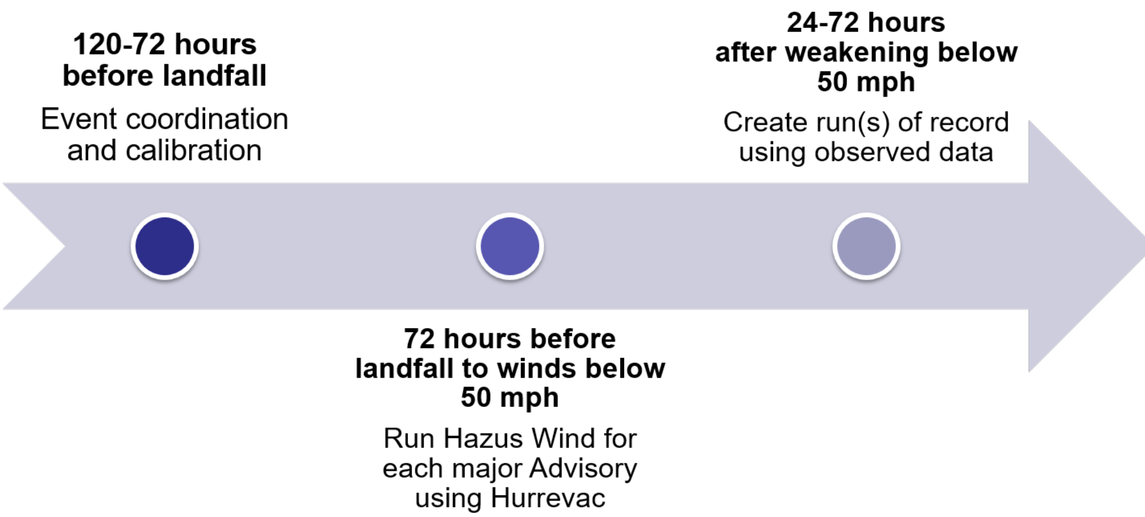
Hazus Output Wind Speeds = 3 Sec Gust

Saffir-Simpson Scale	1 Min Mean (mph)	3 Sec Gust (mph)	Min Central Pressure (mb)
1	74-95	90-116	980 and up
2	96-110	117-134	965-979
3	111-129	135-159	945-964
4	130-156	160-189	921-944
5	157+	189+	920 and below

Visual 28: Hurricane Advisories

- Current and past forecast advisory information is available from the National Hurricane Center (NHC)
- Forecast advisories can be entered into Hazus for analysis
- Forecast points will generate a range of potential losses in the Rapid Loss Assessment Report

Visual 29: When to Start Running Hazus

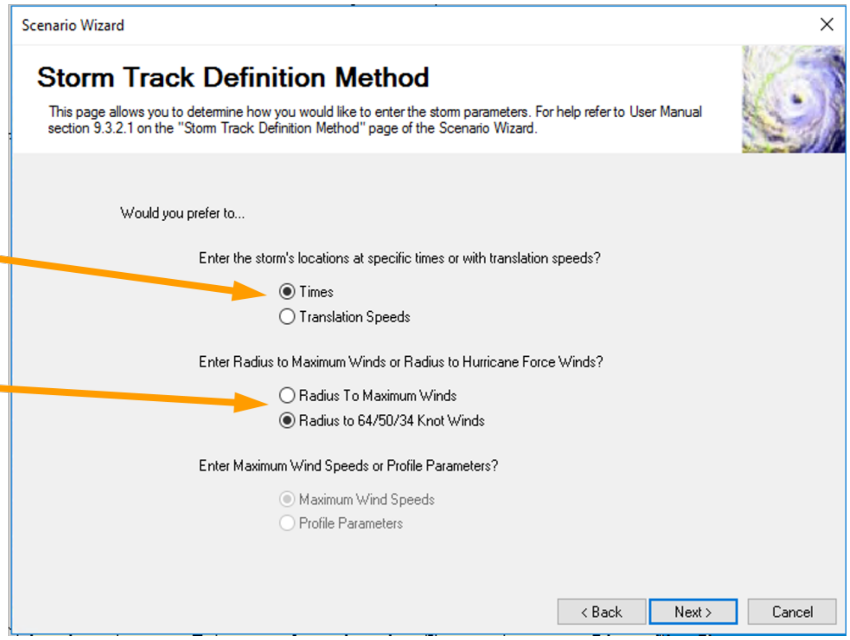


Visual 30: Storm Track Definition

For NHC Forecast Advisory:

Select **Times**

Select **Radius to 64/50/34 Knot Winds**



Visual 31: Activity 12.3

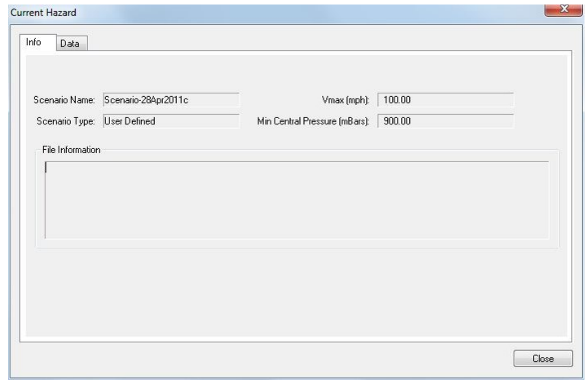
The Instructor will

- Walk through the scenario definition wizard where a user can enter their own user defined scenario
- Discuss the differences between a HURREVAC Import, import from exported file, and a user defined scenario

Visual 32: Show Current Scenario

Select Hazard | Show Current

Brings up window with your current active scenario.



Visual 33: Review

User Defined Storm Scenarios

- What are the four primary options for user defined scenarios?
- To use a NHC Advisory, which Storm Track Definitions would you pick?
- What does the storm's location at specific times or translation speeds tell the model?
- What do the radius inputs tell the model?
- What do the Maximum Wind Speeds or Profile Parameters tell the model?

Visual 34: Questions?

Lesson 13: Hurricane Analysis

Visual 1: Lesson 13: Hurricane Analysis

Visual 2: Goal and Objectives

Goal

This lesson will provide an overview of the methodologies used for hurricane wind analysis.

After completing this lesson, you will be able to:

- Understand hurricane-specific inventory
- Explain the basic process by which Hazus calculates hurricane-related losses
- Provide examples of hurricane analysis parameters that the user can define

Visual 3: Hurricane-Specific Inventory

4 regions in Florida and 4 Regions in Hawaii have Hurricane-Specific Inventory and 4 regions for other states

Based on:

- Review of building codes
- Census data
- Aerial photos review
- MLS and tax data samples

Florida/Hawaii building stock regions:

- Different building codes
- Different building practices

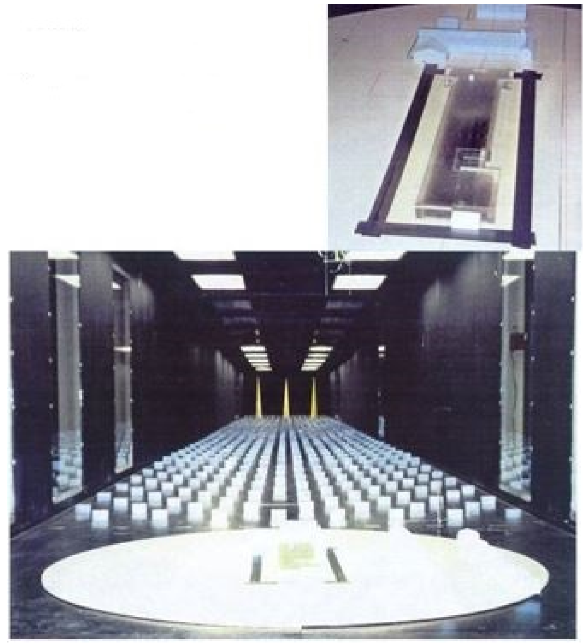
Visual 4: Wind Loads (Pressure)

In practice, design wind loads on buildings are determined, using:

- Wind tunnel data, or...
- Building code provisions based on wind tunnel data

Wind pressure is a function of:

- Wind speed
- Wind direction
- Location on building



Visual 5: Wind-Borne Debris

Two wind-borne missile models used in Hazus

- Residential
  - Shingles, wood, sheathing type missiles
- Commercial
  - Grave missiles from built-up roofing

Visual 6: Building Resistance

- Water Resistance
- Masonry Reinforcements
- Shuttering
- Roof - Wall Connections
- Roof - Deck Attachments
- Tie Downs
- Manufactured Housing Roof Covers

Example of self-adhering waterproof underlayment used to tape plywood joints, ridges and eaves. Photo depicts use around fenestrations.

Visual 7: Loss Model

Physically based damage-to-loss model

Computes direct economic losses, using

- Explicit cost
  - Windows, doors, sheathing, roof cover, etc.
- Implicit cost
  - Estimates of volume of water entering through failed windows, doors, etc.

Details of loss models found in the Hurricane Technical Manual

Visual 8: Activity 13.1

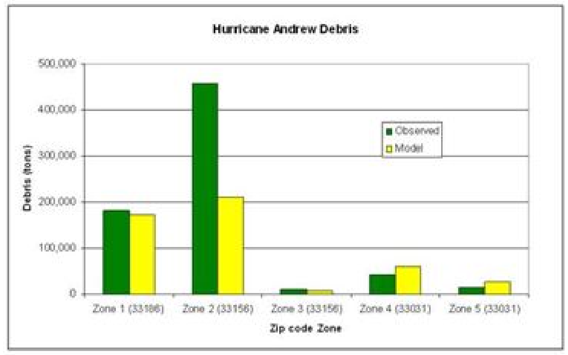
The Instructor will lead the class to

- Explore the Analysis Menu
- Answer the following questions:
    - In the Building Damage Function Viewer, for a masonry single-family 1-story home with default characteristics, what is the probability of moderate damage at 130 mph?
    - In the Building Loss of Use Function Viewer, for a manufactured home built between 1976 and 1994 with tie downs but without shutters, what is the loss of use in days at 120 mph in light suburban terrain?

Visual 9: Building Debris Model

Building Debris model is based on:

- Damage state for structural and non-structural components of Hazus model buildings
- Weight statistics for components
    - ASCE 7-98 Commentary
    - Manufacturer's manuals
    - RSMeans 2001
- Typical density of debris type



Visual 10: Activity 13.2

The Instructor will

- Explore the Debris Function Viewer

Visual 11: Tree Analysis Parameters

Estimates based on:

- Tree coverage database (can be edited)
- Tree Blowdown model

Expected green weight of tree stems for trees greater than 30-ft tall

Eligible tree debris

Debris estimates made for all areas

- Unpopulated areas may not be collected

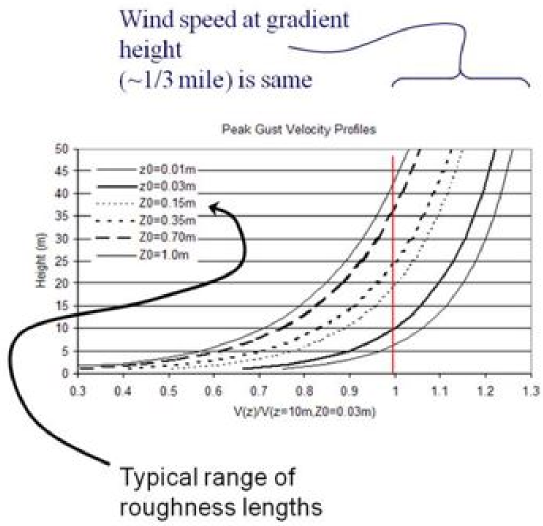
Volume based on 10 cubic yards/ton

Visual 12: Terrain Analysis Parameters

Roughness lengths

- Higher roughness creates more drag at surface, which yields lower wind speeds at surface.

Wind speed increases with height.

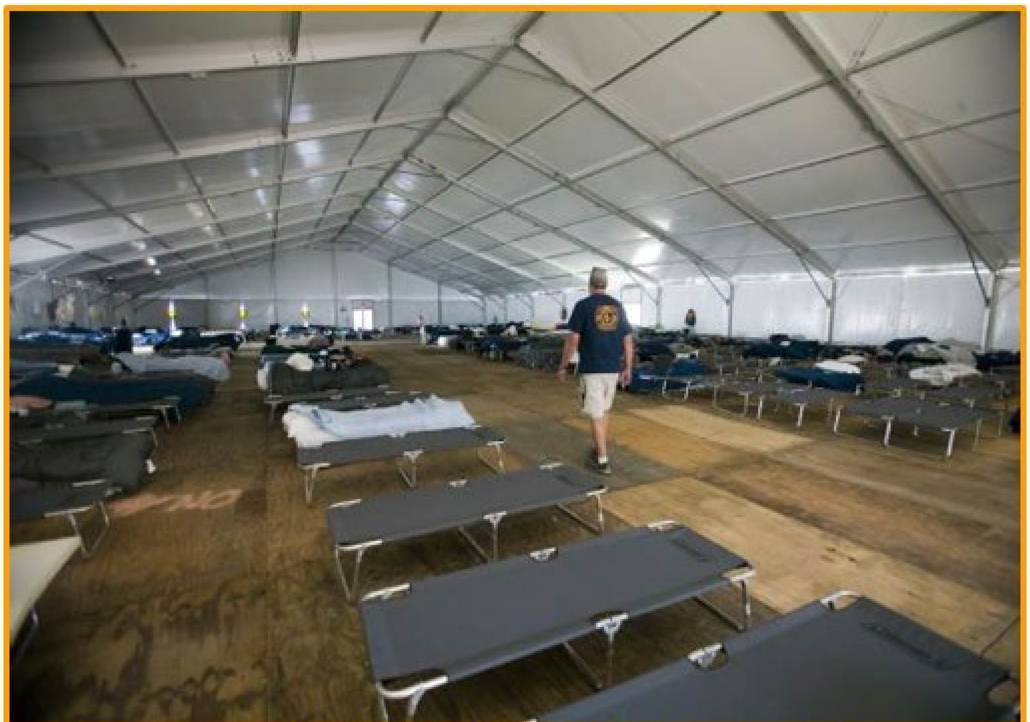


Visual 13: Social Losses - Shelter

Calculates need for public shelters.

Parameters:

- Age
- Ethnicity
- Income
- Home Ownership
- Damage States of different types of buildings.

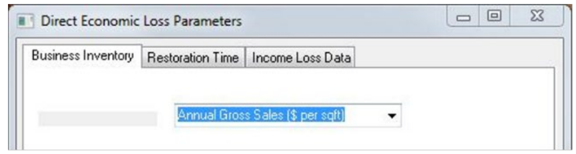


Algiers, La., 10/29/2005: Lines of cots and rescue workers inside a temporary shelter (frame tent) at a base camp. Base camps were set up for rescue workers and volunteers needing housing following Hurricane Katrina. FEMA Photo/Andrea Booher

Visual 14: Economic Impacts

Direct Economic Loss Parameters include:

- Annual Gross Sales
- Business Inventory
- Disruption
- Restoration Time
- Income and Wage Losses



Specific Occupancy	Annual Gross Sales Per SqFt
COM1	53
COM2	77
IND1	713
IND2	226
IND3	697
IND4	656
IND5	437
IND6	768
AGR1	148

Example values for Annual Gross Sales ($ per sqft)

***Many locations nationally have the same default values.

Visual 15: Activity 13.3

Explore the hurricane analysis options:

- Run the Hurricane Fran hazard and complete the analysis.
- View the windfield model outputs.
- Explore the Hazus provided tree inventory and review the results of the analysis for tree debris.
- Modify the tree inventory and review the updated tree debris results.

Visual 16: Review

Briefly summarize how the physical damage model works.

What kinds of building characteristics can you alter in the building damage function viewers?

What are the parameters for sheltering that can be altered by the user?

What are the two wind-borne missile models used in Hazus?

Visual 17: Questions?

Lesson 14: Hurricane Results

Visual 1: Lesson 14: Hurricane Wind Results

Visual 2: Goal and Objectives

Goal

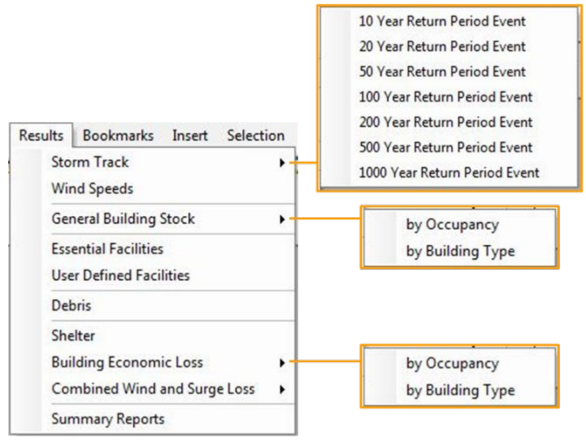
This lesson will provide an overview of the results of a hurricane wind model results.

After completing this lesson you will be able to:

- List the key outputs of the aggregate inventory analysis
- List the key outputs of the site-specific inventory analysis
- Identify the key guidelines for properly interpreting and applying the outputs of the hurricane wind model

Visual 3: Viewing Results

Results menu is enabled when a hurricane scenario has been run



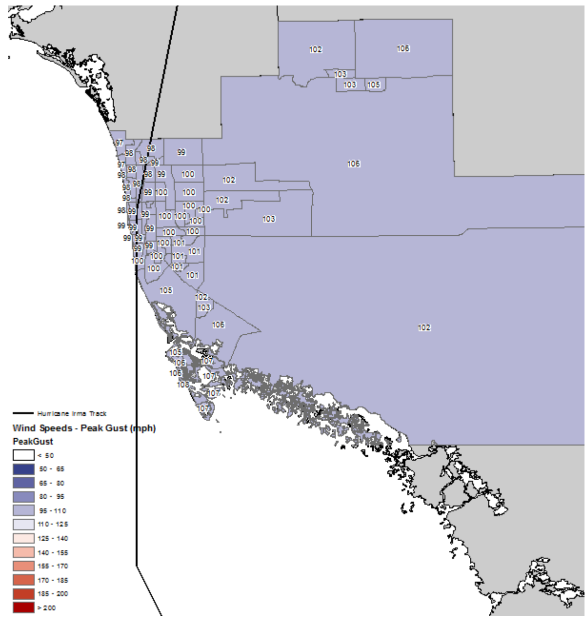
Visual 4: Hazard Maps

To show the hazard map, choose:

- Results | Wind Speeds

Click on the column you wish to map

Click the Map button



Visual 5: Direct Physical Damage

Structural Damage for Buildings:

- Damage State Probability Counts and Losses by Occupancy and Building Type
- The Technical Manual describes damage states for building types

Roof damage and debris from wind

Visual 6: Direct Physical Damage

Example of Damage States for Residential Building

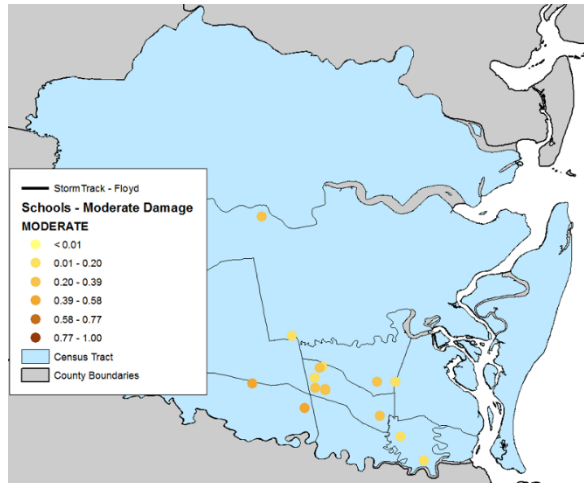
Damage State	Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
1	No Damage or Very Minor Damage: Little or no visible damage from the outside. No broken windows, or failed roof deck. Minimal loss of roof cover, with no or very limited water penetration	≤ 2%	No	No	No	No	No
2	Minor Damage: Maximum of one broken window, door or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for	> 2% and ≤ 15%	One window, door, or garage door failure	No	< 5 impacts	No	No

Damage State	Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
	repair.						
3	Moderate Damage: Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.	> 15% and ≤ 50%	> one and ≤ the larger of 20% & 3	1 to 3 panels	Typically 10 to 20 impacts	No	No
4	Severe Damage: Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	> 50%	> the larger of 20% & 3 and ≤ 50%	> 3 and ≤ 25%	Typically 10 to 20 impacts	No	No
5	Destruction: Complete failure and/or, failure of wall frame. Loss of more than 50% of roof sheathing.	Typically > 50%	> 50%	> 25%	Typically > 20 impacts	Yes	Yes

Visual 7: Direct Physical Damage

Essential Facilities:

- Loss of Use (Days)
- Damage State Probability



Visual 8: Debris

Building Debris

- Wood and Masonry
- Steel and Concrete

Tree Blowdown

- Tree Debris
- Eligible Tree Debris
    - Determined by building density, length of roads, and census block shapes
    - Trees downed in close proximity to streets, highways, or buildings make up the great majority of trees brought to the curb for collection and disposal

Census Tract	Brick/ Wood (tons)	Concrete/ Steel (tons)	Eligible Tree Weight (tons)	Eligible Tree Volume (cubic yards)	Trees (tons)	Tree Volume (cubic yards)
13039010100	10,331	179	48,007	480,069	1,077,596	10,775,960
13039010200	31,804	872	43,345	433,450	732,303	7,323,028
13039010301	20,059	482	14,618	146,181	106,484	1,064,839
13039010302	7,954	103	18,329	183,294	295,683	2,956,830
13039010401	64,311	444	17,089	170,894	57,399	573,990
13039010402	33,085	805	14,127	141,267	67,878	678,778
13039010403	27,653	515	11,459	114,594	57,794	577,938

Visual 9: Shelter

Shelter:

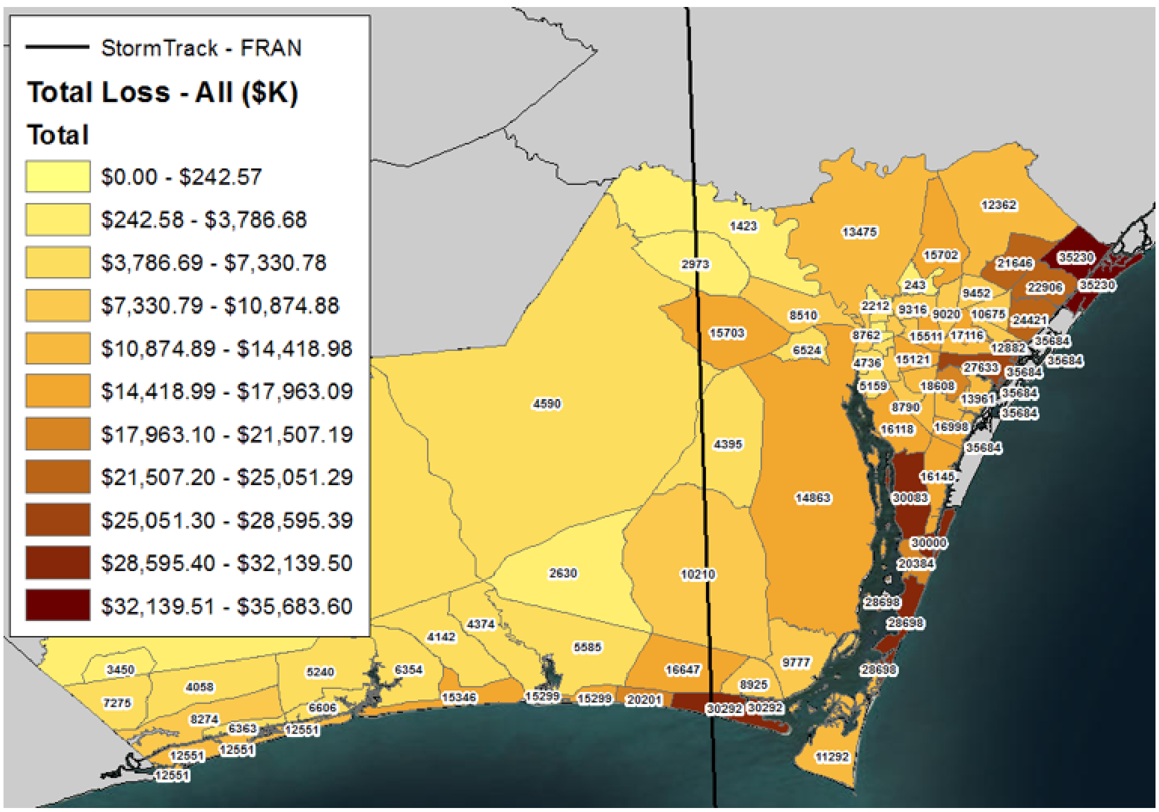
- Number of Displaced Households
- Temporary Housing Requirements
- Based on Demographic Considerations (Ethnicity, Income, Age, Ownership)

Houston, TX, 9/1/2005: Hurricane Katrina survivors arrive at the Houston Astrodome Red Cross Shelter after being evacuated from New Orleans. FEMA photo/Andrea Booher

Visual 10: Direct Economic Losses

General Building Stock Loss

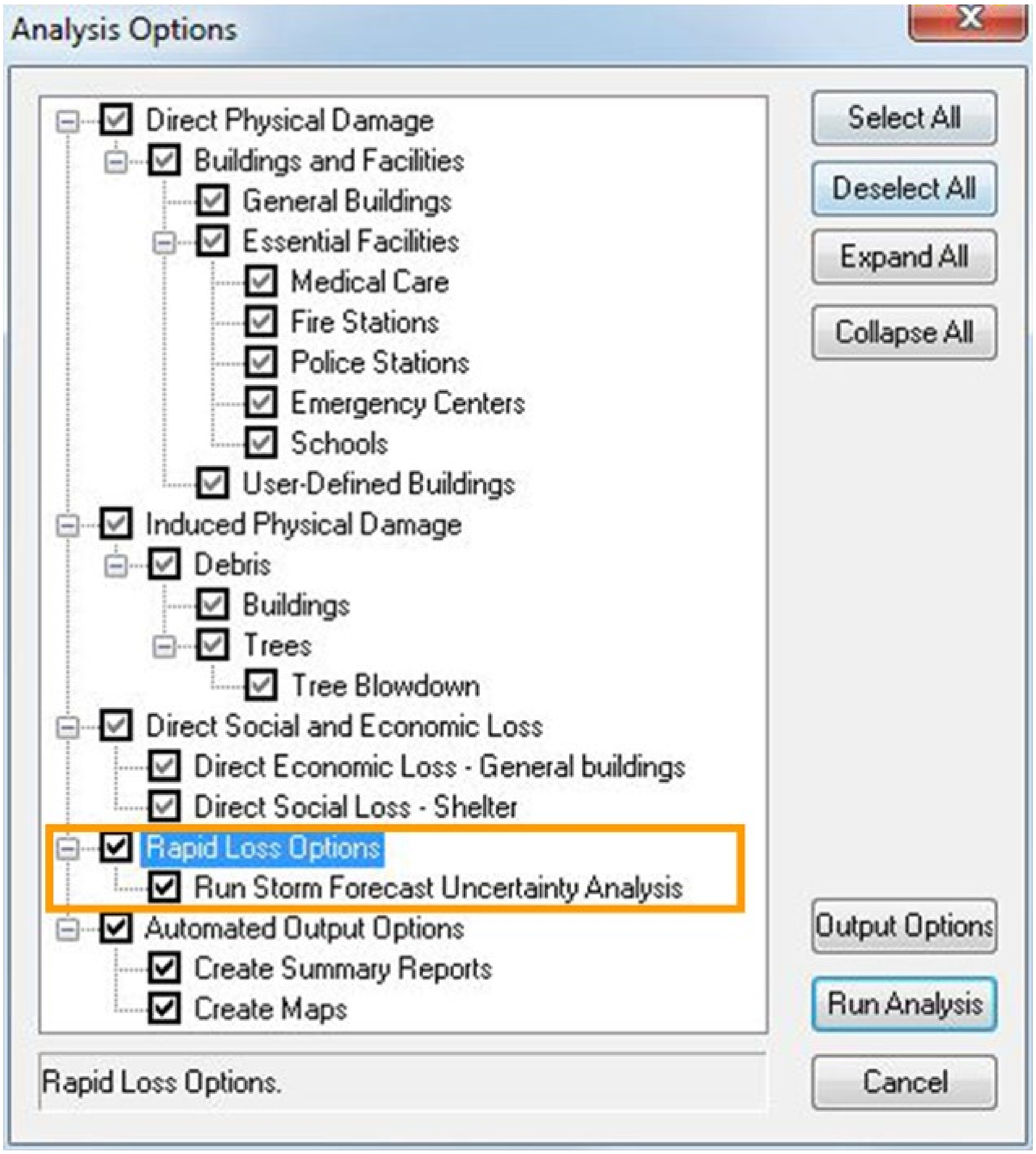
- Building Losses:
  - Structural
  - Non-Structural
  - Content
  - Business Inventory
- Business Interruption Losses:
  - Wage
  - Income
  - Rental & Relocation
  - Proprietor



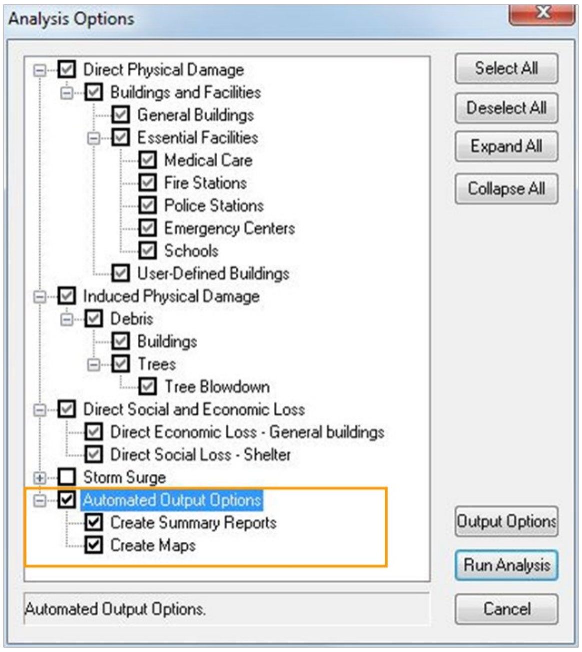
Economic Losses from a Hazus Simulated Hurricane Scenario

Visual 11: Uncertainty Analysis

The Forecast Uncertainties Model uses statistics to forecast errors compiled from the period 1993- 2004 to simulate a range of possible outcomes. This report displays the 5th and 95th percentiles of the simulated outcomes.



Visual 12: Automated Output Options



Automatically save reports.

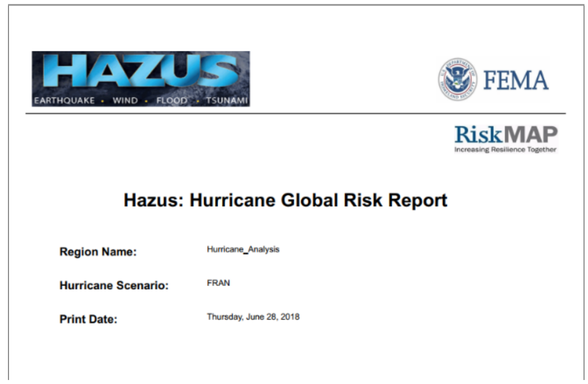
Create thematic maps of results on the fly.

Drawback: Increases analysis processing time.

Uncheck Automated Output Options to make analysis faster

Visual 13: Automated Output Options

- Auto-generated reports are saved in the study region folder
  - Reports can be saved as PDF, Word, Excel, or HTML files
- User can also auto – generate map layers



Hazus: Hurricane Global Risk Report

Region Name: Hurricane_Analysis

Hurricane Scenario: FRAN

Print Date: Thursday, June 28, 2018

Visual 14: Activity 14.1

Explore the results:

- Duplicate a study region
- Define the Hurricane Fran scenario
- Run the analysis
- Explore single family residential structure damage
- Explore the building damage summary reports.
- Explore the debris result
- Explore the estimated shelter requirements
- View the exported reports

Visual 15: Review

Answer the following questions in groups:

- Which school is estimated to be unusable for the longest period of time after the hurricane?
- Which Census Tracts are expected to have the highest need for tree collection by the government for this event?
- For estimated Moderate building damage, rank the Building Types based on the loss ratio (not building counts).

Visual 16: Questions?

Lesson 15: Hurricane Storm Surge

Visual 1: Lesson 15: Hurricane Storm Surge Results

Visual 2: Goal and Objectives

Goal

This lesson provides an overview of the storm surge model within Hazus.

After completing this lesson you will be able to:

- Describe the purpose of the Hazus surge model
- Understand the procedure for running a storm surge analysis in Hazus

Visual 3: Factors Influencing a Surge's Size

Storm surge

- Abnormal rise in the water level by a storm that is above the predicted astronomical tide

Storm tide

- The combination of the storm surge at high tide

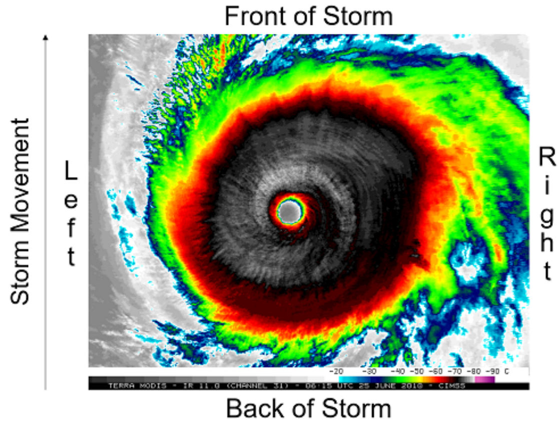
Wave breaking

- Can increase the height of the surge and is dependent on the continental shelf

Visual 4: Factors Influencing a Surge's Size

Wind and Storm Motion

- Strongest winds and thus highest surge (without coastline effects) occur in the right - front quadrant of hurricane
- Here the forward speed of the hurricane is added to the rotational winds of the hurricane to get the highest wind speeds



Satellite image of Celia (2010)
Cooperative Institute for Meteorological Studies (CIMSS), University of Wisconsin

Visual 5: Coastline Effects and Surge Size

- The orientation of the hurricane with respect to the coastline can influence the surge magnitude
- Water can ‘pile up’ with favorable orientations. If hurricane winds are pushing against the coastline, water is caught along the coast.
- Water can also be trapped in bays

Visual 6: Storm Surge Modeling in Hazus

User works in Hurricane Wind model then in Flood model

Utilizes industry standard models:

- SLOSH - Sea, Lake, and Overland Surges from Hurricanes, National Weather Service's Meteorological Development Laboratory.
- SWAN - Simulating Waves Nearshore, Delft University of Technology
- Modified WHAFIS - to propagate waves inland from the shoreline

Allows for estimation of combined economic losses to general building stock for hurricane scenarios on coastal flood regions

Avoids double counting of flood and wind losses

Visual 7: Storm Surge Steps

Create study region with Hurricane and Flood

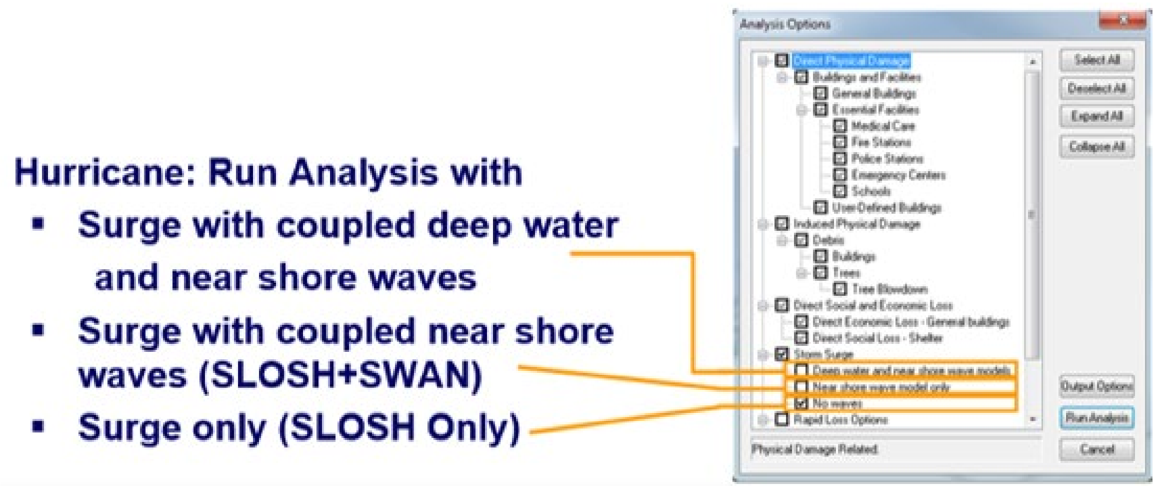
Hurricane: Define/Select Hurricane Scenario

- Surge supported for: Historic, User-Defined, HurrEvac Import, Hazus Import
- NOT supported for: Probabilistic, H*Wind Import

Hurricane: Run Analysis with

- Surge with coupled deep water and near shore waves
- Surge with coupled near shore waves (SLOSH + SWAN)

Surge only (SLOSH only)



Visual 8: Storm Surge Steps (Cont'd.)

Hurricane: Enter Initial Water Level

Hurricane: Can display Wind-Only Loss Results at this point

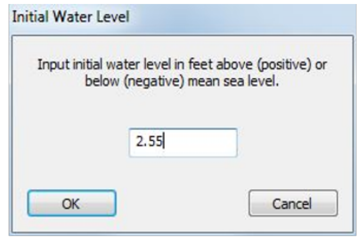
Hurricane: Can check status of coastal surge

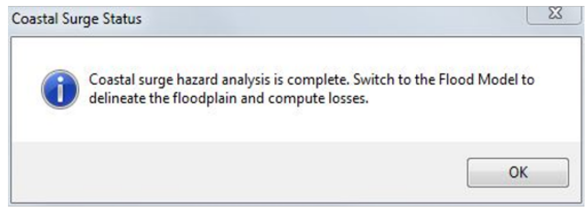
Switch to Flood Hazard

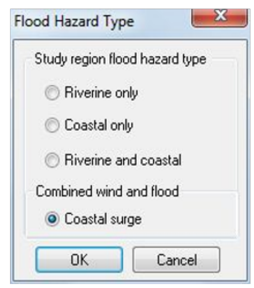
Flood: Select Coastal surge

Flood: Define Topography (DEM)

Flood: Define Scenario







Visual 9: Storm Surge Steps (Cont'd.)

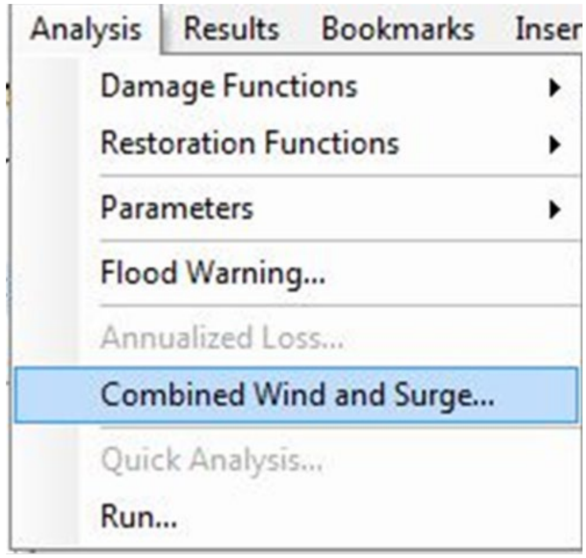
Flood: Delineate Floodplain

Flood: Run General Building Stock Analysis*

Flood: Run Combined Loss Analysis

View Results

* Run any additional flood-only results you want, but GBS is all that is needed to support combined surge analysis - ONLY GBS is analyzed in a surge analysis.



Visual 10: View Results

Hurricane: View Hurricane Wind Only Results

- Includes any analysis chosen

Flood: View Flood Only Results

- Includes any analysis chosen

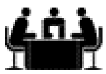
Hurricane or Flood: View Combined Wind and Surge Results

- Direct Economic Losses Only
- As a table or report

Visual 11: Activity 15.1

Student Activity

- Import a completed hurricane wind/ storm surge combined loss study region
- Explore the results of the analysis


Activity

See separate activity information for details.

Visual 12: Review

What is the purpose of the Hazus surge model?

Which hazard do you analyze first when doing a combined wind/storm surge analysis in Hazus?

Visual 13: Questions?

Lesson 16: Course Wrap-Up

Visual 1: Course Wrap-Up

HAZUS®

EARTHQUAKE • WIND • FLOOD • TSUNAMI

Visual 2: Goals and Objectives

Goal

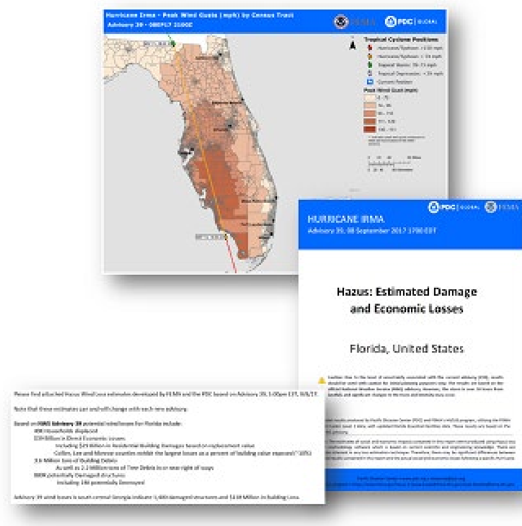
Review the major themes of the course and discuss opportunities for learning more about Hazus.

After completing this lesson, you will be able to:

- Identify the courses that are available for enhancing your Hazus skills
- Identify additional resources that are available for you to explore to enhance your Hazus experience

Visual 3: What have we learned?

- Steps for running a “Basic” Hazus analysis
- A basic understanding of Hazus inputs and outputs
- Ideas for using Hazus for mitigation and planning
- An idea about both what Hazus is intended to do and what it is not intended to do (proper usage)



Visual 4: Additional Training

Classroom courses

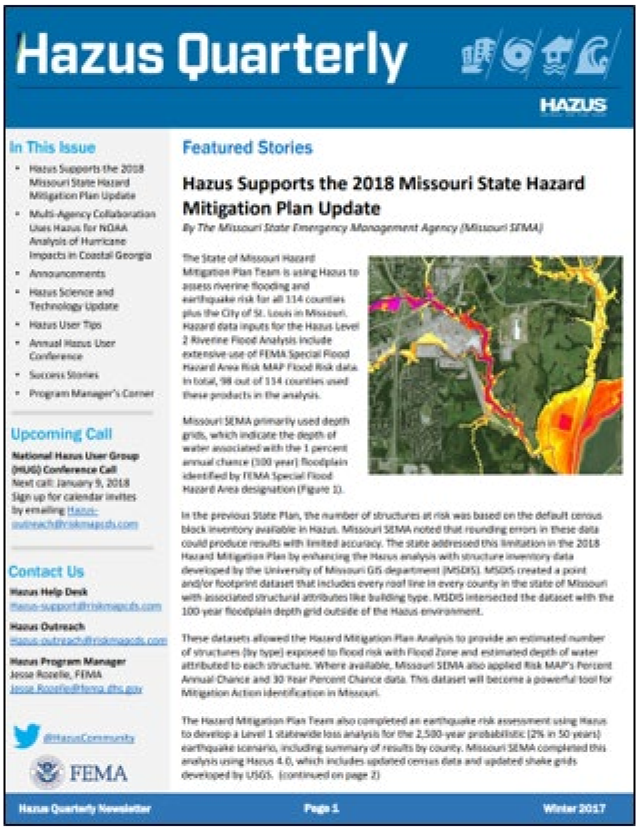
- E0170 – Hazus for Hurricanes
- E0172 – Hazus for Floods
- E0174 – Hazus for Earthquake and Tsunami
- E0317 – Comprehensive Data Management for Hazus
- E0179 – Applications of Hazus for Disaster Operations
- E0177 – Advanced Hazus Applications

Visual 5: Become A Hazus Expert!

- Hazus Trained User
  - E0190 ArcGIS for Emergency Managers (or prior GIS experience may substitute)
  - E0313 Basic Hazus
  - E0317 Comprehensive Data Management (CDMS)
  - Minimum of Two of the follow:
    - E0170 Hazus for Hurricanes
    - E0172 Hazus for Floods
    - E0174 Hazus for Earthquakes and Tsunami
- Hazus Practitioner
  - E0190 ArcGIS for Emergency Managers (or prior GIS experience may substitute)
  - E0313 Basic Hazus
  - E0317 Comprehensive Data Management (CDMS)
  - Minimum of two of the follow:
    - E0170 Hazus for Hurricanes
    - E0172 Hazus for Floods
    - E0174 Hazus for Earthquakes and Tsunami
  - E0177 Advanced Hazus Applications
  - E0179 Hazus for Disaster Operations

Visual 6: Hazus Community Participation

- Annual Hazus User Conference Hazus
- Quarterly Newsletter
- National Hazus User Group calls
- Local Hazus User Groups
- Hazus Outreach Email: hazus-outreach@riskmapcds.com


Hazus Quarterly

HAZUS

In This Issue

- Hazus Supports the 2018 Missouri State Hazard Mitigation Plan Update
- Multi-Agency Collaboration Uses Hazus for NOAA Analysis of Hurricane Impacts in Coastal Georgia
- Announcements
- Hazus Science and Technology Update
- Hazus User Tips
- Annual Hazus User Conference
- Success Stories
- Program Manager's Corner

Upcoming Call

National Hazus User Group (HUG) Conference Call
Next call: January 9, 2018
Sign up for calendar invites by emailing Hazus-outreach@riskmapcds.com

Contact Us

Hazus Help Desk
Hazus-support@riskmapcds.com

Hazus Outreach
Hazus-outreach@riskmapcds.com

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Jesse Rozelle, FEMA
Jesse.Rozelle@fema.dhs.gov

@HazusCommunity

FEMA

Featured Stories

Hazus Supports the 2018 Missouri State Hazard Mitigation Plan Update

By The Missouri State Emergency Management Agency (Missouri SEMA)

The State of Missouri Hazard Mitigation Plan Team is using Hazus to assess riverine flooding and earthquake risk for all 114 counties plus the City of St. Louis in Missouri. Hazard data inputs for the Hazus Level 2 Riverine Flood Analysis include extensive use of FEMA Special Flood Hazard Area Risk MAP Flood Risk data. In total, 98 out of 114 counties used these products in the analysis.

Missouri SEMA primarily used depth grids, which indicate the depth of water associated with the 1 percent annual chance (100 year) floodplain identified by FEMA Special Flood Hazard Area designation (Figure 1).

In the previous State Plan, the number of structures at risk was based on the default census block inventory available in Hazus. Missouri SEMA noted that rounding errors in these data could produce results with limited accuracy. The state addressed this limitation in the 2018 Hazard Mitigation Plan by enhancing the Hazus analysis with structure inventory data developed by the University of Missouri GIS department (MSDIS). MSDIS created a point and/or footprint dataset that includes every roof line in every county in the state of Missouri with associated structural attributes like building type. MSDIS intersected the dataset with the 100-year floodplain depth grid outside of the Hazus environment.

These datasets allowed the Hazard Mitigation Plan Analysis to provide an estimated number of structures (by type) exposed to flood risk with Flood Zone and estimated depth of water attributed to each structure. Where available, Missouri SEMA also applied Risk MAP's Percent Annual Chance and 30 Year Percent Chance data. This dataset will become a powerful tool for Mitigation Action identification in Missouri.

The Hazard Mitigation Plan Team also completed an earthquake risk assessment using Hazus to develop a Level 1 statewide loss analysis for the 2,500-year probabilistic (2% in 50 years) earthquake scenario, including summary of results by county. Missouri SEMA completed this analysis using Hazus 4.0, which includes updated census data and updated shake grids developed by USGS. (continued on page 2)

Hazus Quarterly Newsletter Page 1 Winter 2017

Visual 7: Getting Help

Hazus Help Desk - email

hazus-support@riskmapcds.com

Consult the User Manuals and Technical Manuals

https://www.fema.gov/hazus-mh-user-technical-manuals

Visual 8: So in closing...

What is Hazus and why should you use it?

Visual 9: Questions?

Handouts: Reference Materials

Activity 4.1 - Flood Analysis

Background

Any change to the default inventory or default parameters in Hazus results is what is termed an Advanced analysis. Hazus provides a wide range of options that empower users with the ability to impact the accuracy of the analysis for a study region. This activity will explore a few of the more advanced options in Hazus that you can further explore on your own or that you can learn more about by choosing to attend an E0172: Hazus for Floods course. In the activity, you will import a user-defined depth grid, briefly explore the damage curves and then run an analysis of the hazard defined for the scenario.

Part 1: Import a depth grid into the Study Region

Setup the Region

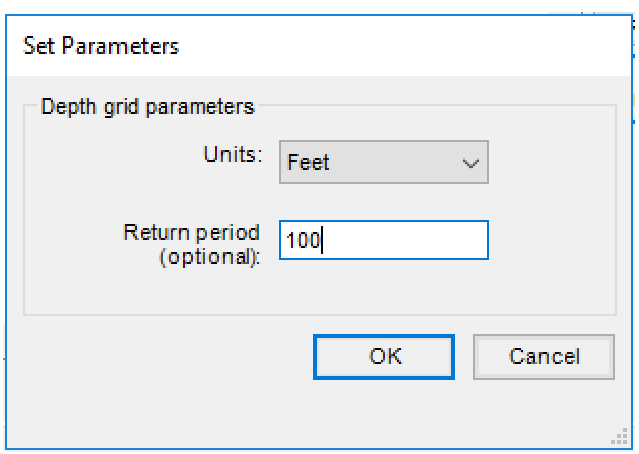
Import the Activity4.1.hpr file into Hazus. This region will contain the base data for Mecklenburg County but it will not have a depth grid associated with it.

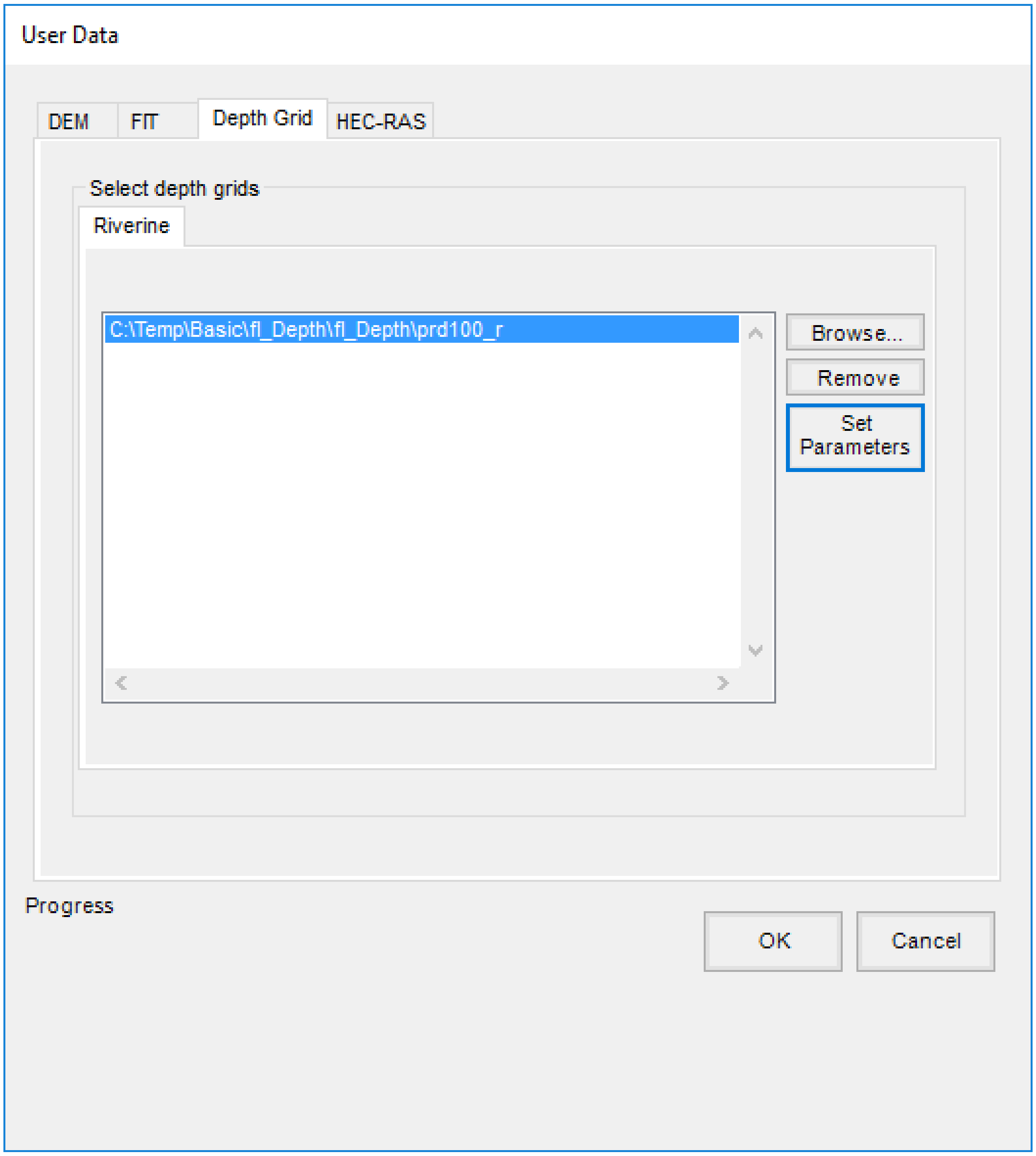
After the hpr file has finished importing open the new region in Hazus.

Select **Hazard** from the menu and select **Flood Hazard Type** and click **Riverine only**.

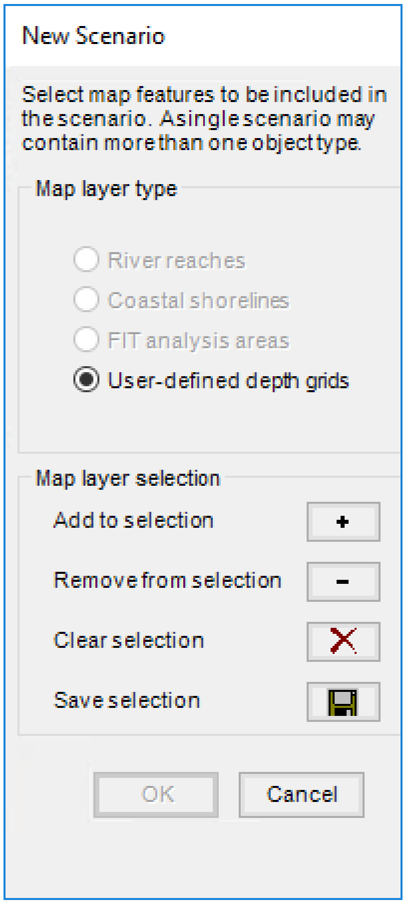
Select **Hazard** again from the menu and this time select **User data**. On the User Data menu select **Depth Grid** and then click **Browse**. Navigate to the location of the depth grid in the student data folder located on the C: drive, select the file named **Meck_DG** and then click **Select**.

Next, click **Set Parameters**. Leave the Units as Feet and enter 100 in the Return period text box. Click **OK** when complete.

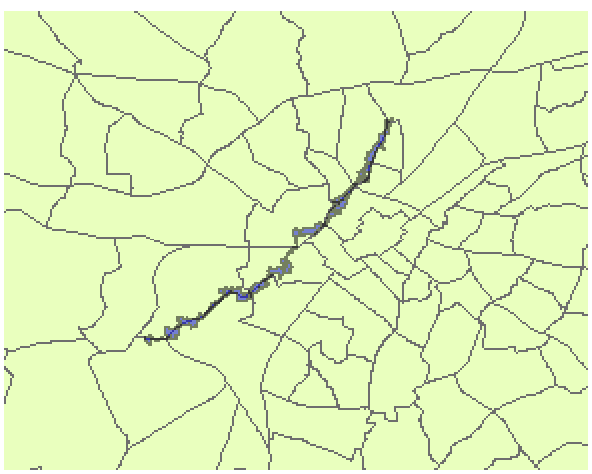




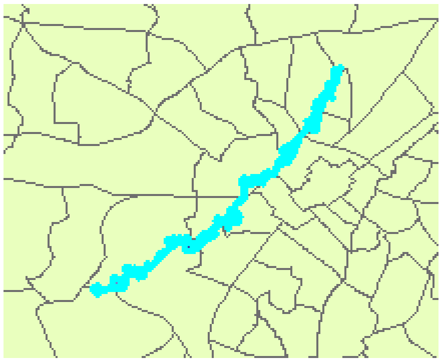
Click **OK** after selecting the depth grid. This will start the processing of the depth grid which may take a minute. When complete select **Hazard** again and select **Scenario -->New Scenario**. The menu below will appear.



Click the Add to Selection (+) sign to select the imported depth grid which is the area below.

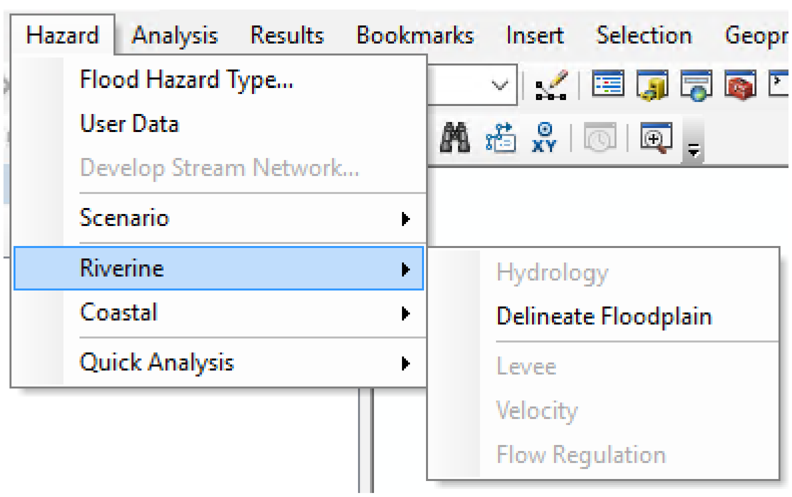


The map will look like this when the data has been selected.

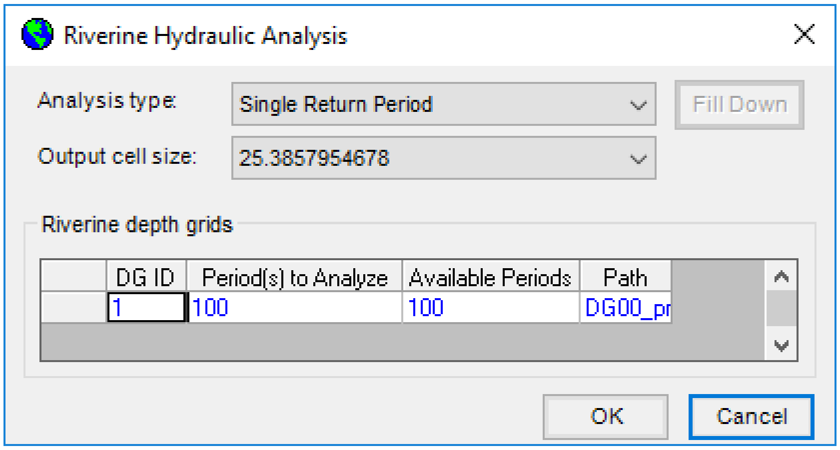


Click the **Save** selection button when complete. The selected depth grid will now turn blue. Click **OK** when finished.

Next click **Hazard --> Riverine --> Delineate Floodplain**.



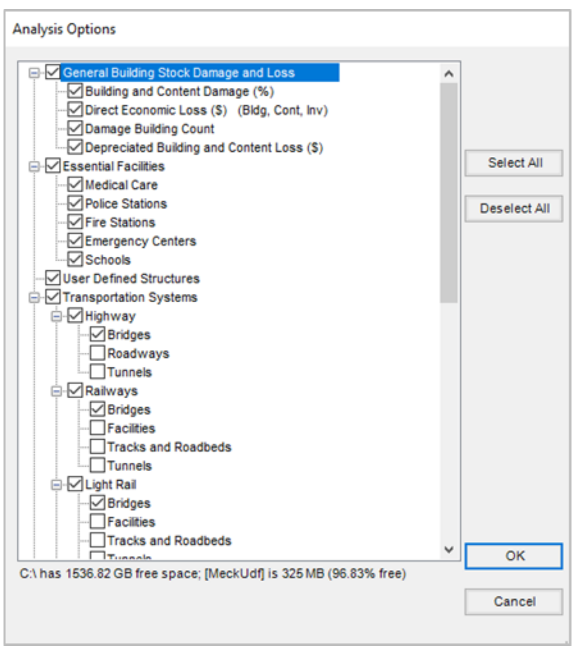
Click OK on the menu that appears.



Click Yes on the informational window that appears. The processing time should only be 15-20 seconds.

Run the Analysis

Select Analysis --> Run from the menu.



You can click the Select All button to select all the analysis options. Since the depth grid only covers s small area the analysis should not take very long. Click OK to run the analysis.

Click the Save button to save your map so that the next time you open the study region, it will appear as it currently does.

Explore the Flood Occupancy Mapping Scheme

Task 1: Select a Census Block for which you want to explore the mapping scheme characteristics

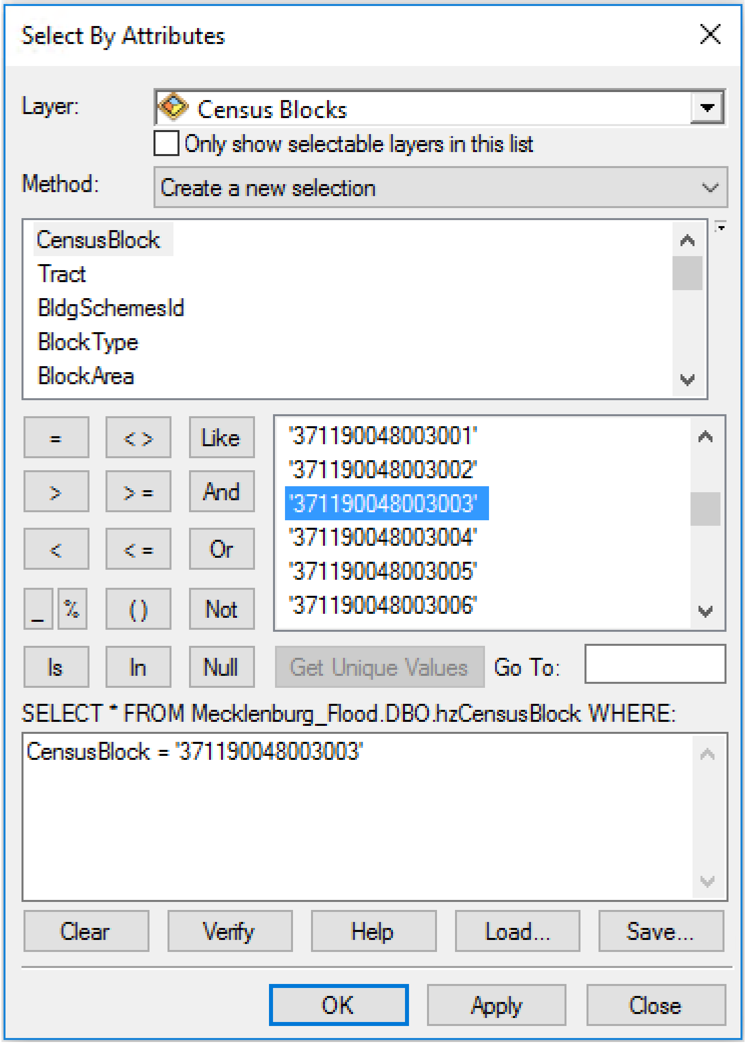
Open the Mecklenburg_Flood study region if it is not already open.

From the Selection menu, choose Select by Attributes to open the Select by Attributes window.

Set the Layer to Census Blocks, set the Method to Create a new selection, and enter the expression:

CensusBlock = ’371190048003003’ in the entry area at the bottom of the window.

> *Be sure to enter the Census Block number by clicking the Get Unique Values button and scrolling down to and double-clicking ‘371190048003003’. The final code should appear as is does in the following example. Verify that there are single quotation marks before and after the census block number as shown below.*



Click the **Apply** button and then click the **Close** button.

Right-click on the Census Blocks layer and select **Selection --> Zoom to Selected Features** from the layer context menu.

> *You will work with census block 371190048003003 throughout this activity. This block is important because it is contained within the boundary of the 500-year flood that you are analyzing during this course.*

Task 2: View the Flood Specific Occupancy Mapping Scheme

From the Inventory menu, choose **General Building Stock --> Specific Occupancy Mapping** to open the Flood Specific Occupancy Mapping window.

> *The options in the Flood Specific Occupancy Mapping window address the distribution of foundation types of all structures that are analyzed as part of the*

general building stock. It also identifies whether each census block is subject to floodplain regulations.

Use the scroll bars in the upper-right corner of the window to scroll down the list of census blocks until you find block number **371190048003003**.

This should be record # 4745 (unless you are using a more recent version of the Hazus state data than the one used in the preparation of this course).

Find the row with census block number **371190048003003**.

#	Census Block	Mapping Scheme	Entry Date	Block Type
4739	371190048002021	RiverineDflt	1978	R
4740	371190048002022	RiverineDflt	1978	R
4741	371190048002023	RiverineDflt	1978	R
4742	371190048003000	RiverineDflt	1978	R
4743	371190048003001	RiverineDflt	1978	R
4744	371190048003002	RiverineDflt	1978	R
4745	371190048003003	RiverineDflt	1978	R
4746	371190048003004	RiverineDflt	1978	R
4747	371190048003005	RiverineDflt	1978	R
4748	371190048003006	RiverineDflt	1978	R

The entry date is 1978, meaning this census block became subject to flood regulations in that year. If you have local knowledge about the date in which floodplain regulations were implemented in your community, you can use the tools that Hazus provides to change this important value if it is incorrect.

Task 3: View the Flood Specific Occupancy Mapping Distribution

Hazus ships with three default mapping schemes for the nation: riverine communities, coastal communities, and Great Lakes communities. These schemes define the assumed distribution of structures—by foundation type—within each of the census blocks contained in a study region. The county you are working with in your activity contains census blocks that are all classified as using the RiverineDflt mapping scheme.

Click the number 3 to the left of RiverineDflt in the lower left corner of the window.

Block Type	Scheme Name	Editable	Date Created	Date Updated	Description
C	CoastalDflt	System	Feb 13 2003	Feb 13 2003	
L	GreatLakesDflt	System	Feb 13 2003	Feb 13 2003	
R	RiverineDflt	System	Dec 8 2016	Dec 8 2016	

Click the **View** button on the right side of the window to open the Flood Building Characteristics Distribution window.

Click the plus sign to the left of the word **Occupancy** to list each of the specific occupancy classes.

Click the occupancy class named RES1 – Single Family Dwelling to view the building distribution characteristics for that occupancy class.

> *The information presented in this window describes how buildings are distributed within census blocks that are assigned the RiverineDflt mapping scheme.*

Pre-Firm Foundation Type:

#	FoundationType	FoundationDistribution
1	Pile	0
2	Pier	0
3	SolidWall	0
4	Basement	23
5	Crawl	35
6	Fill	0
7	Slab	42

Post-Firm Foundation Type:

#	FoundationType	FoundationDistribution
1	Pile	0
2	Pier	0
3	SolidWall	0

4	Basement	23
5	Crawl	35
6	Fill	0
7	Slab	42

Click the **OK** button to close the Flood Building Characteristics Distribution window.

It is possible that the default mapping schemes may not accurately represent the distribution of structures within your local area. Although you cannot edit the default schemes, Hazus does provide you with the ability to copy one of the default schemes and edit it to satisfy your needs—simply click the Copy and Edit buttons on the Flood Specific Occupancy Mapping window.

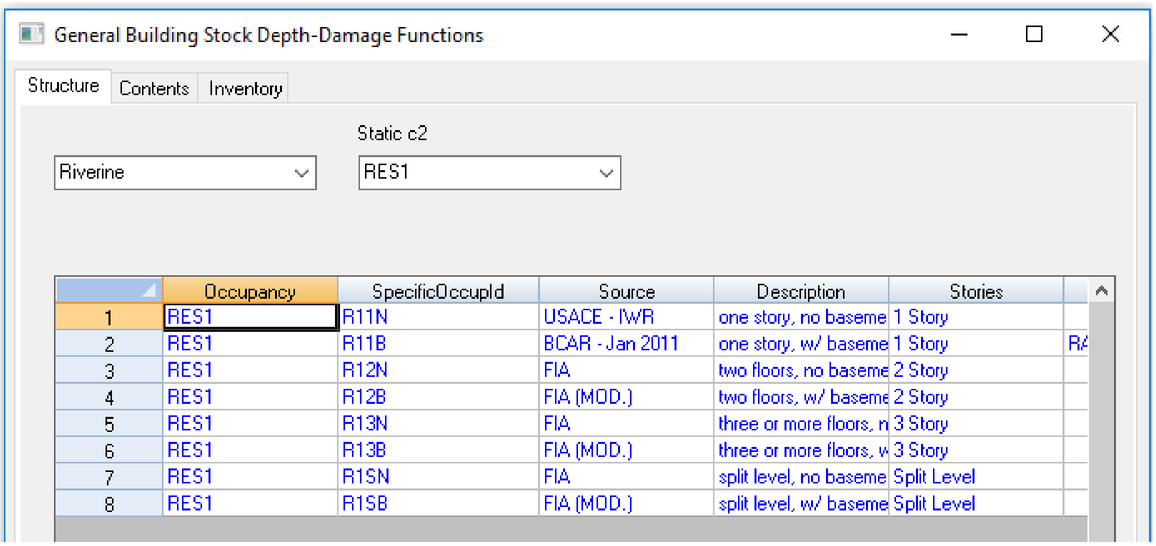
Click the **OK** button to close the Flood Specific Occupancy Mapping window. If a window appears asking if you would like to save changes, select **No**.

Part 3: Explore the Damage Functions

Damage functions are used to assess the amount of damage that will be incurred based upon the depth of water that is present. Hazus comes with hundreds of damage curves that make it possible to analyze structures based on how they are used and how they are constructed. In the next few steps, you will explore the damage functions for single-family residential homes.

From the Analysis menu, choose **Damage Functions --> Buildings** to open the **General Building Stock Depth-Damage Functions** window.

The General Building Stock Depth-Damage Functions table provides information on the default damage function associated with each specific occupancy class (e.g., RES1) and subclass (e.g., RES1, 1 story, no basement). By scrolling to the right in this window, you will see the percent of damage expressed in terms of building replacement cost that is calculated at different water depths.



Make sure that the Structure tab is clicked, the Hazard Type is set to Riverine, and the Occupancy type is set to RES1. Click the Library button in the lower-left corner of the window to open the Structure Damage Functions window.

Viewing the library of damage functions allows you to review other damage functions applicable to the occupancy under consideration and relative to the current default. It also includes tools that enable you to replace the current default function with another function from the library.

In the left-hand window, make sure that R11N is highlighted.

R11N is the abbreviation for a single-family residential home (R1) with one story (1) and no basement (N).

In the table below, write down the percentages of damage for 0 ft., 1 ft. and 2 ft. of water.

Thus far, you have used only damage functions from the library of damage functions supplied with Hazus. Damage functions and their intended use are explained in detail in the flood technical manual. Although damage functions have been created for nearly every part of the country, it is possible that you might want to develop a damage function that addresses conditions that are unique to your study region.

	0 feet	1 foot	2 feet
Percentage of Damage for given flood depths for RES1 structures (1 story, no basement)			

Click the **OK** button to close the Structure Damage Functions window.

Click the **Close** button to close the General Building Stock Depth Damage Functions window.

Part 4: Explore the User Defined Facilities

The study region you imported came pre-loaded with user defined facilities. In this part you will explore those facilities.

From the Inventory menu select User Defined Facilities.

Scroll across the columns to view the various fields that have been entered into the user defined facilities dataset.

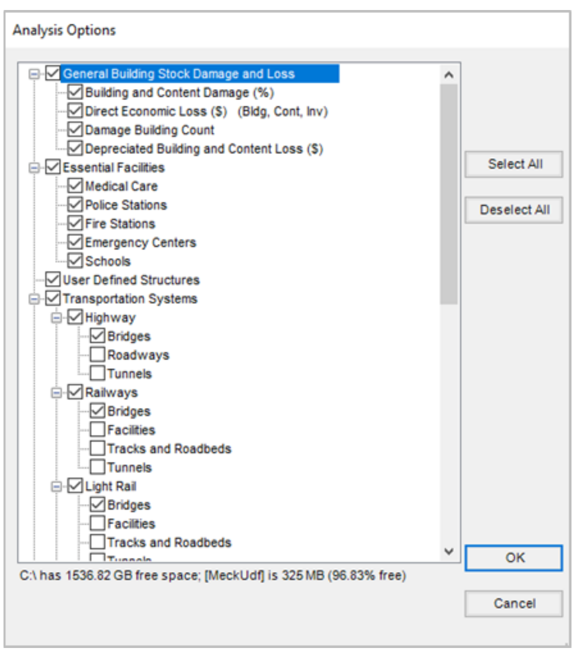
Click the Map button at the bottom of the window and then Close the window.

Part 5: Run the Analysis

From the Analysis menu, choose Run to open the Analysis window.

Click the check boxes next to each of the analysis modules <u>except</u> for Agricultural Products, Indirect Economic Loss and What-If modules.

> *Notice the dialog at the bottom of the window. This dialog alerts you to what system resources are available to complete the analysis.*



Click **OK** to close the Analysis window and to begin the analysis.

The analysis will take a few minutes to complete. Please be patient.

When the analysis has finished, click the Save button to save your map.

Leave your study region open (unless otherwise instructed by your course instructor).

Activity 6.2 - Earthquake Scenarios

Activity 6.2– Earthquake Scenarios

Type: Student-Led Activity

Time: 15 minutes

Instructions

As part of the activity you will be exploring a variety of case studies that will illustrate different scenario options. Responses to each case are to be entered into the table found at the end of the activity. To save time, you might want to remove the last page of the activity from your manual so that you can record your answers as you are moving through the activity (rather than having to flip back and forth between the activity steps and the table).

> *Note: due to ongoing improvements in modeling methodologies between Hazus releases, you may see loss estimation results outputs that differ slightly from those that are reflected in the activity.*

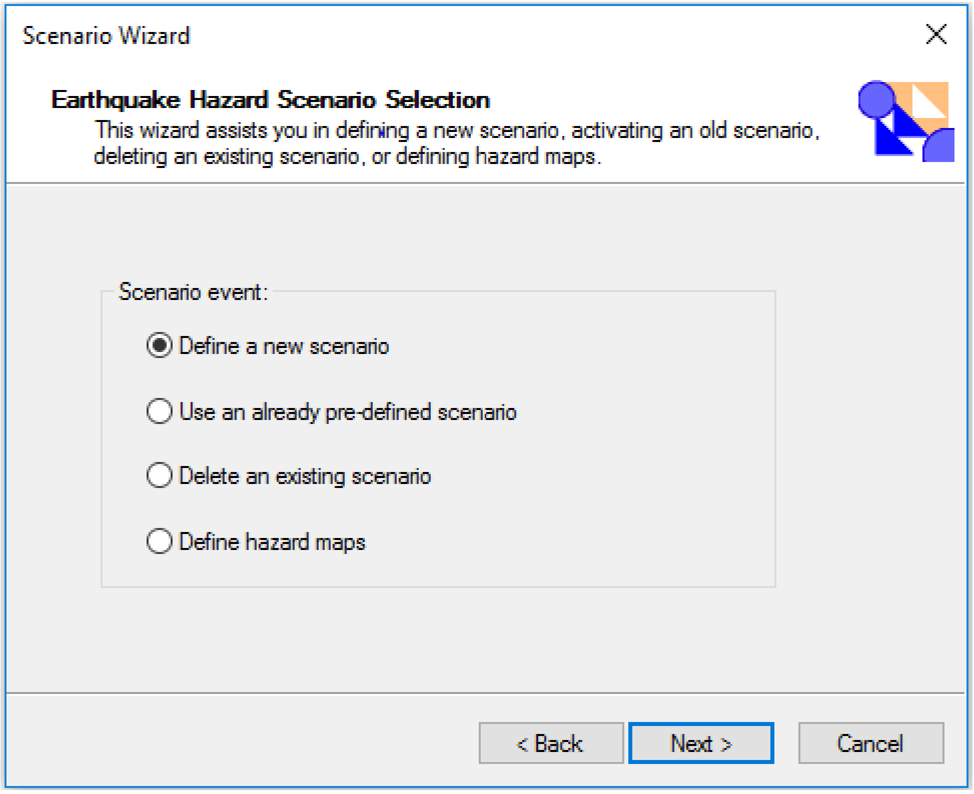
<u>Case One – Arbitrary Scenario</u>

Task 1: Define the Scenario

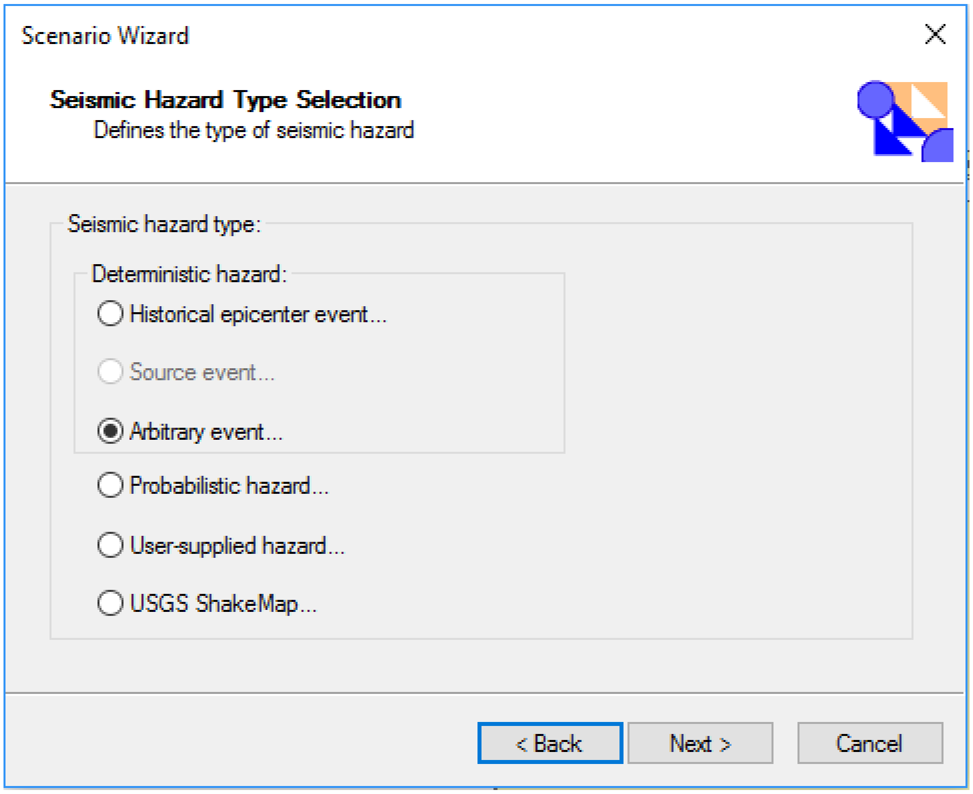
From the Hazard menu, select **Scenario**. Click Next to advance the first screen of the Scenario Wizard.

> *An arbitrary scenario examines an earthquake that is entirely defined by the user. It may be based on a historic event or on an entirely user-defined event that may or may not have a scientific basis. For this reason, it is recommended that users consult a technical expert when determining appropriate parameters for an arbitrary scenario.*

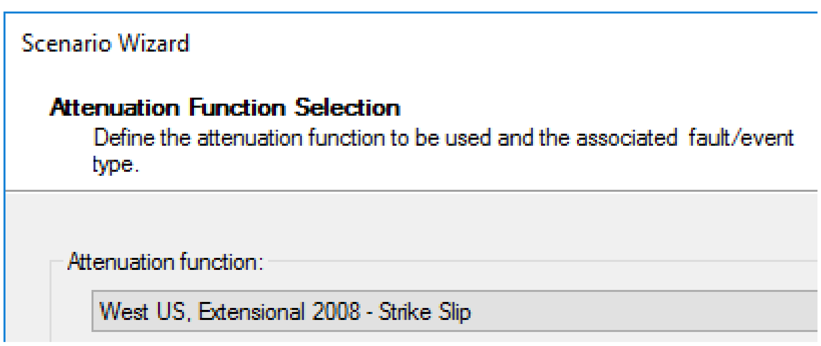
Select Define a new scenario and click Next.



Select Arbitrary event.

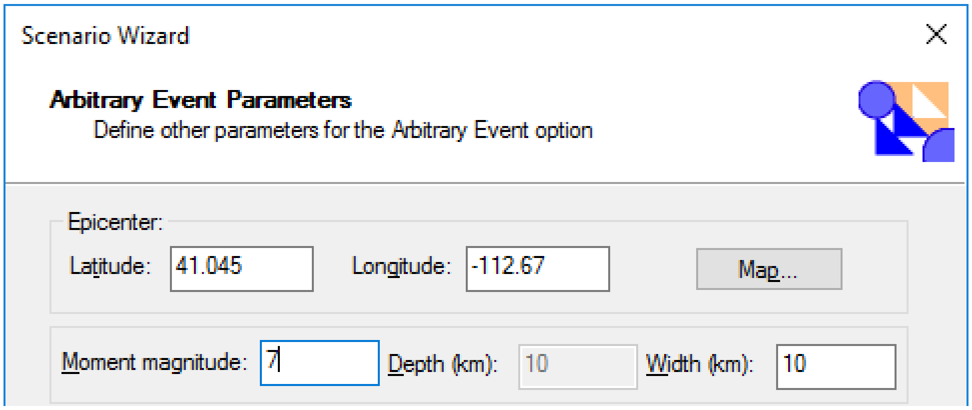


Click **Next** to move to the next window. Select **West US Extensional 2008 – Strike Slip** from the Attenuation function dropdown selection window and then click Next.



Enter 41.045 for the Latitude of the event and -112.67 for the Longitude of the event. Make the Moment Magnitude 7 and the Depth 10 km as shown in the graphic below.

The epicenter location, magnitude, and depth are all critical parameters that impact the amount of damage that will be produced in the event of an earthquake.

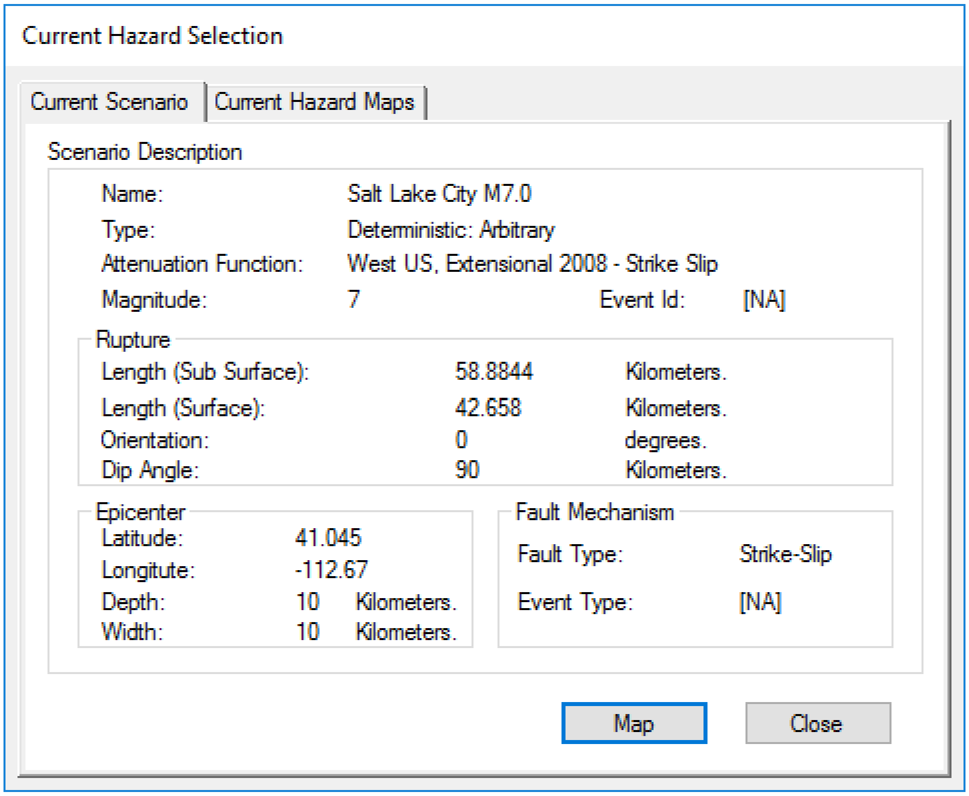


Verify your information and click Next when finished.

Enter **Salt Lake City M7.0** as the name of the scenario and click **Next**.

Review the selection you made in the final window of the Scenario Wizard, then click Finish to close the Scenario Wizard.

View the current scenario, selecting **Show Current** from the Hazard menu.



Click the **Close** button to close the Current Hazard Selection window.

Task 2: Perform the Analysis

From the Analysis menu, choose Run to run the analysis.

From the Analysis Options window, only select General Buildings, Essential Facilities, Induced Physical Damage, and Direct Social Losses.

> *These options are all derived from analysis of the general building stock. You will explore impacts of earthquakes on site-specific inventory later in the course.*

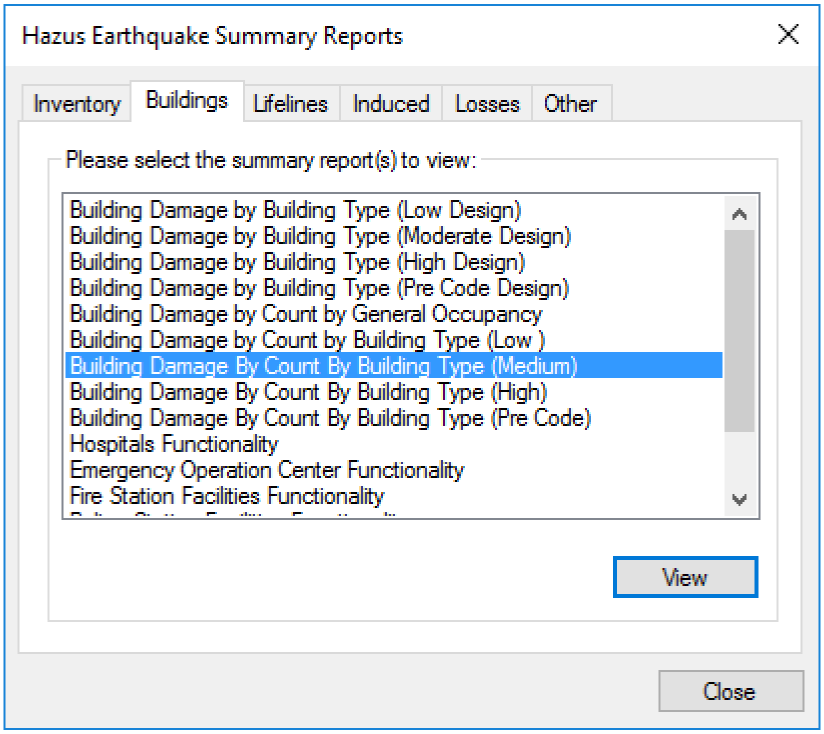
Click the **OK** button and then select Yes when asked if you want to run analysis with the options selected.

> *Please be patient. The analysis will take a couple of minutes to complete.*

Task 3: Explore the Results

From the Results menu, choose Summary Reports to open the Hazus-MH Earthquake Summary Reports window.

Click the Buildings tab. Select the Building Damage by Count by Building Type (Medium) report.



Click the **View** button.

In the table at the end of the activity, write down the Total Number of Buildings, Total Number of Buildings Damaged, and the Total Number of Buildings which sustained At Least Moderate Damage.

Consult the instructions under Case One for how to determine these values.

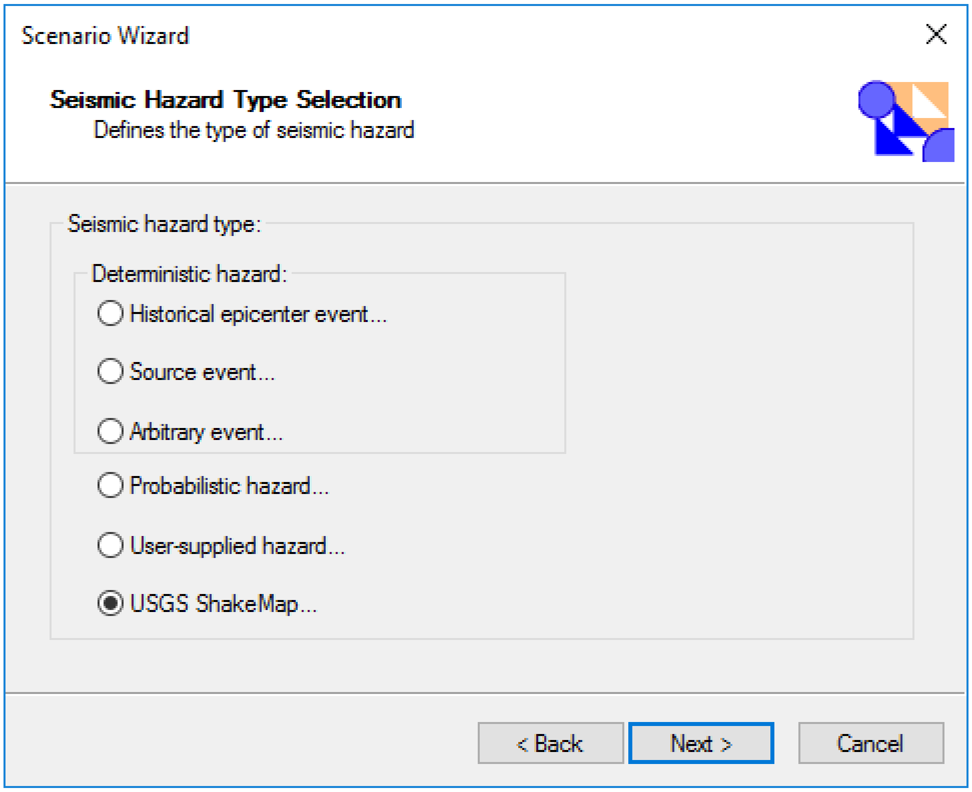
Close the Summary Report and then close the Hazus-MH Earthquake Summary Reports window.

Case Two – USGS ShakeMap Scenario

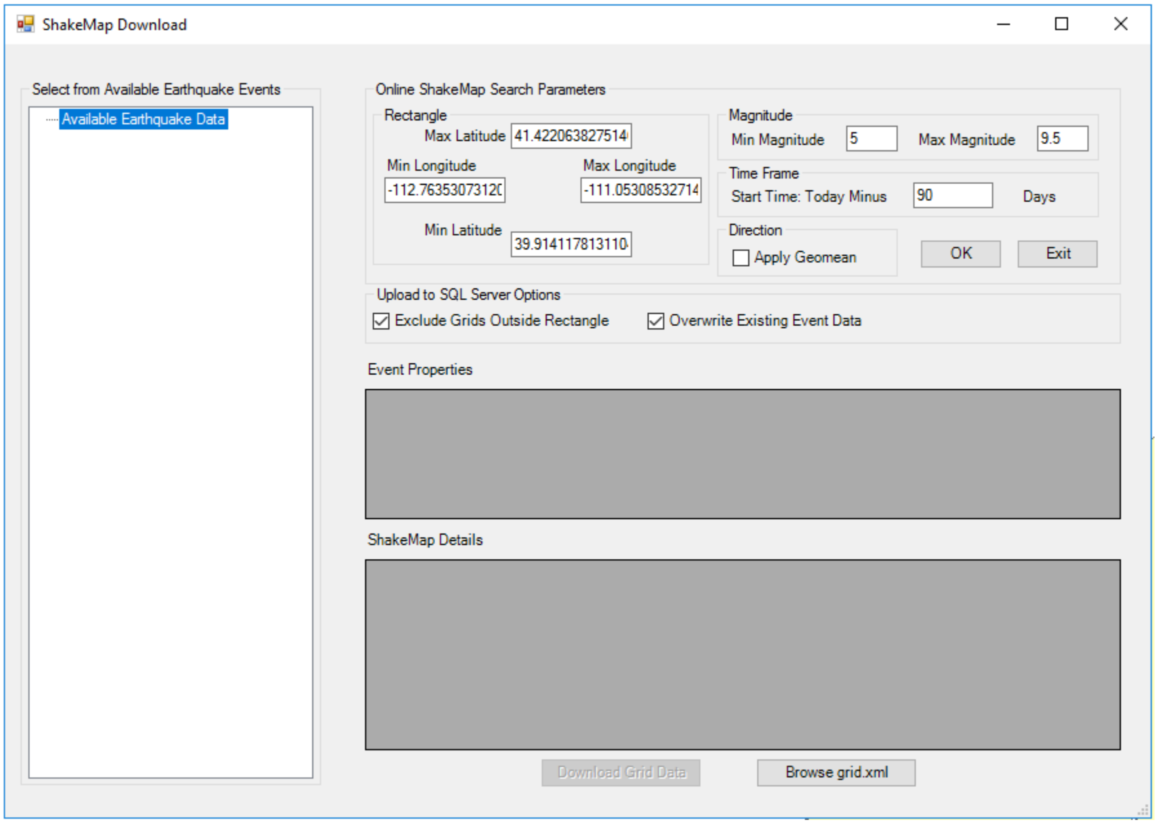
Task 1: Define the Scenario

From the Hazard menu, Hazard --> Next --> Define a new scenario -->USGS ShakeMap.

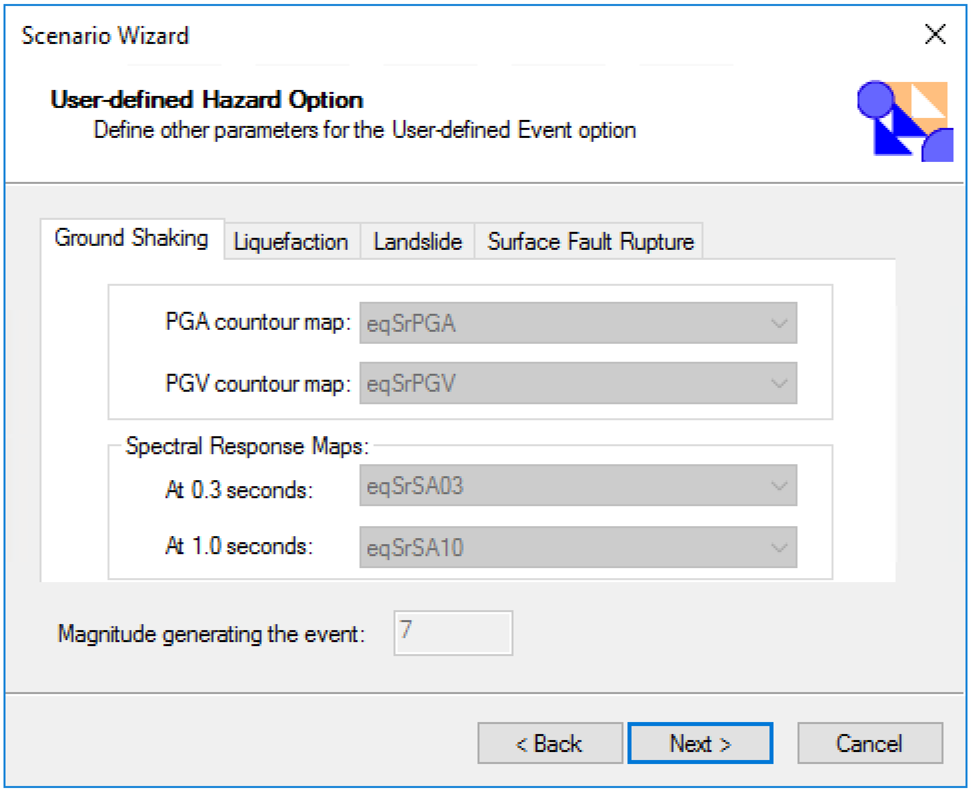
USGS ShakeMaps provide near-real-time maps of ground motion and shaking intensity following significant earthquakes. These maps are used by federal, state, and local organizations, both public and private, for post-earthquake response and recovery, public and scientific information, as well as for preparedness exercises and disaster planning.



The ShakeMap Download window will appear.

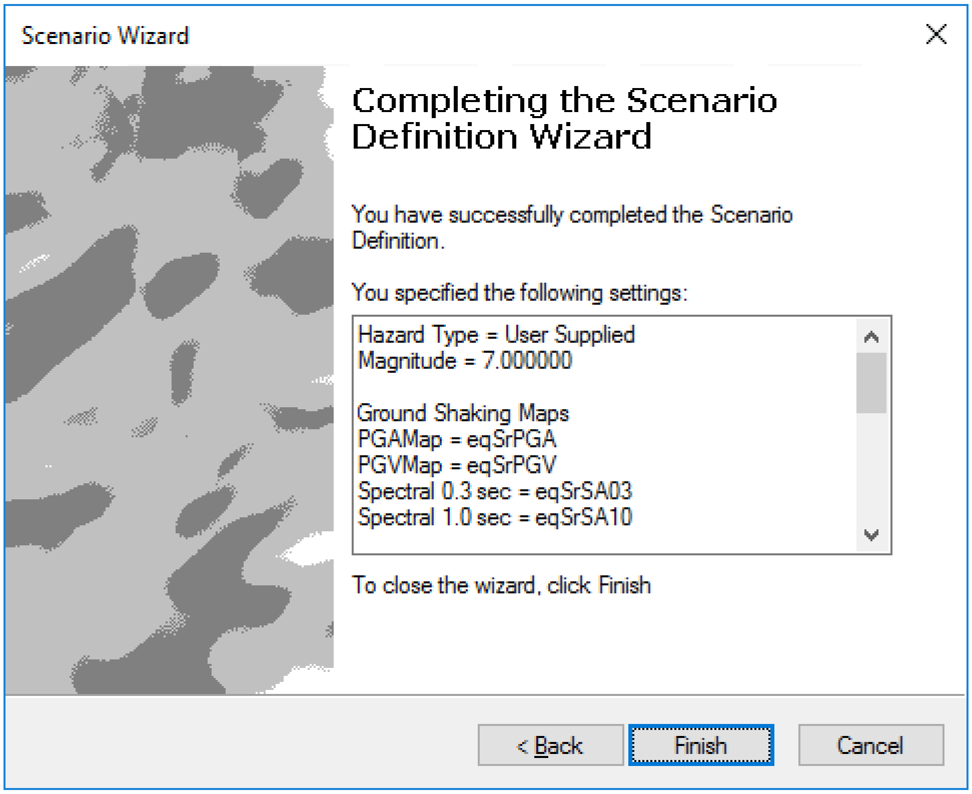


Select the Browse grid xml, navigate the student data location, select the SLC_grid.xml file and click Open The grid will need to be processed with could take a short period of time. When the processing is complete the following widow will appear.



Click **Next** to proceed. Click **Next** when the Hazard Scenario Event Name appears.

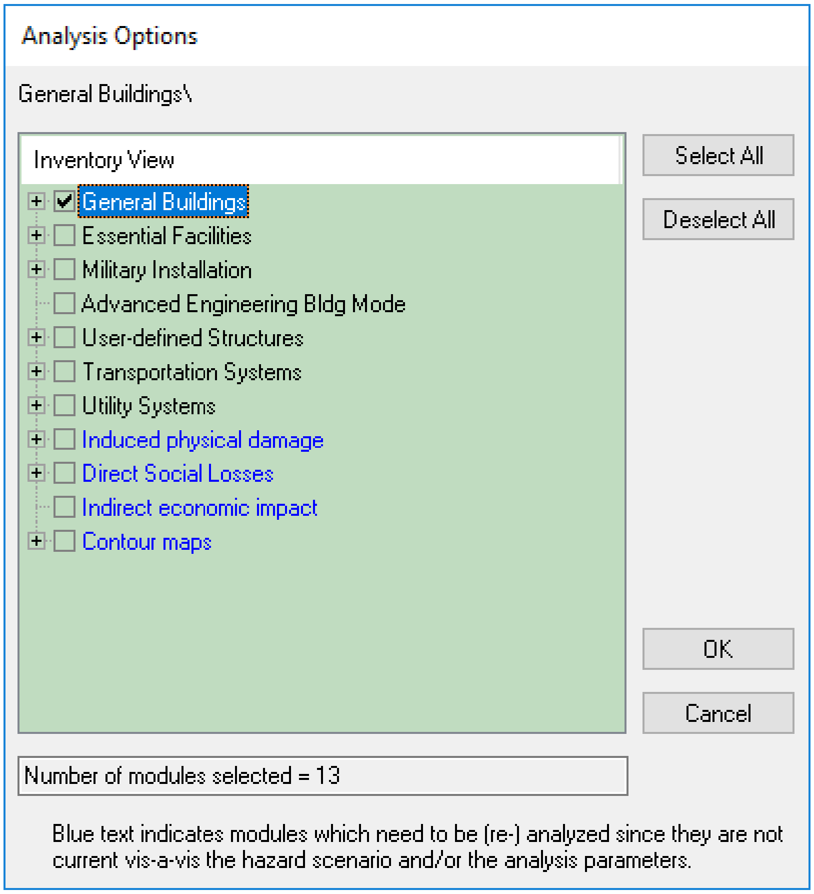
The scenario settings will appear next and this will give you a chance to view the data inputs one last time.



Click Finish to complete the process.

Task 2: Perform the Analysis

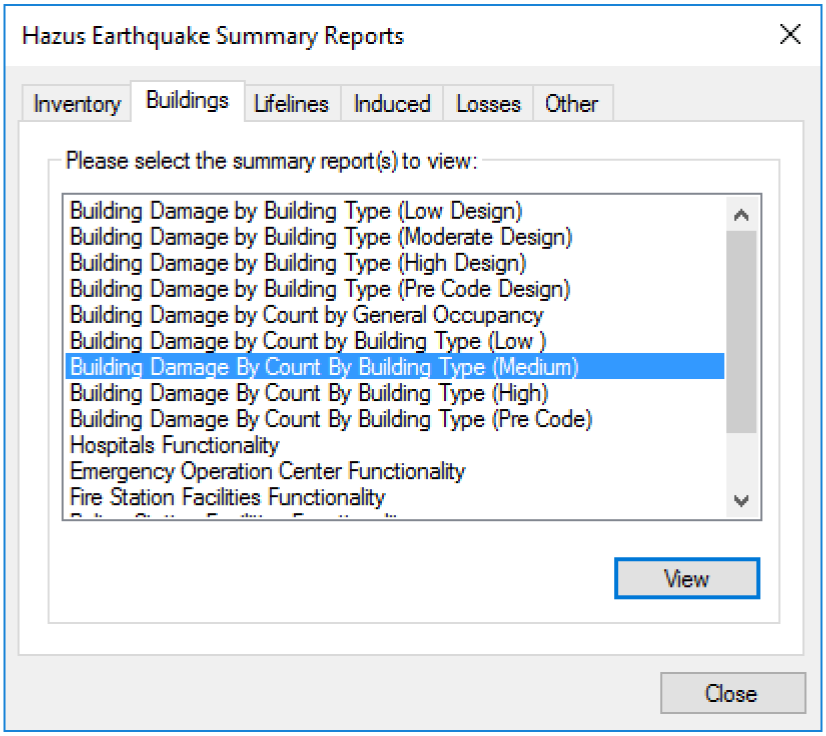
You can now run the Analysis process which determine the damages and other impacts to the Salt Lake City from the earthquake. To do that select Analysis and then Run from the menu. The Analysis Options will appear. You can select all the options to do a complete analysis but that can be time consuming so for this exercise you can select General Buildings and click OK. The processing dialog box bar will appear again and the time to complete the analysis will be less than one minute.



Task 3: Explore the Results

From the Results menu, choose Summary Reports to open the Hazus-MH Earthquake Summary Reports window.

Click the Buildings tab. Select the Building Damage by Count by Building Type (Medium) report.



Click the View button.

In the table at the end of the activity, write down the Total Number of Buildings, Total Number of Buildings Damaged, and the Total Number of Buildings which sustained At Least Moderate Damage.

Consult the instructions under Case One for how to determine these values.

Close the Summary Report and then close the Earthquake Summary Reports window.

Results Table

	Total Buildings Damaged	Buildings With at Least Moderate Damage
Case #1: Arbitrary Scenario		
Case #2: USGS ShakeMap Scenario		

Activity 6.3 - Earthquake Analysis Parameters

Activity 6.3 - Earthquake Analysis Parameters

Type: Student-Led Activity

Time: 15 minutes

Background

The purpose of the following activity is to help you become familiar with the impact of modifying earthquake analysis parameters.

Instructions

In a previous activity, you examined the Salt Lake City M7.0 scenario. In this activity, you will be modifying that scenario with various changes to the analysis parameters to study their impacts. At the end of the activity, you will compare the results you obtained in each part of the activity so that you can better understand which parameters have the most significant impact. Responses to each case are to be entered the table found at the end of the activity. To save time, you might want to remove the last page of the activity from your manual so that you can record your answers as you are moving through the activity (rather than having to flip back and forth between the activity steps and the table).

Note that due to ongoing improvements in modeling methodologies between Hazus releases, you may see loss estimation results outputs that differ slightly from those that are reflected in the activity.

Case One – Soil Effect Scenario

In the first case, you will modify the soil characteristics to the Salt Lake City M7.0 scenario, using the following parameters.

- Epicenter = Latitude 41.04 | Longitude -112.67
- Moment Magnitude = 7
- Depth = 10 kilometers
- Soil Class = B
- Liquefaction Susceptibility: None

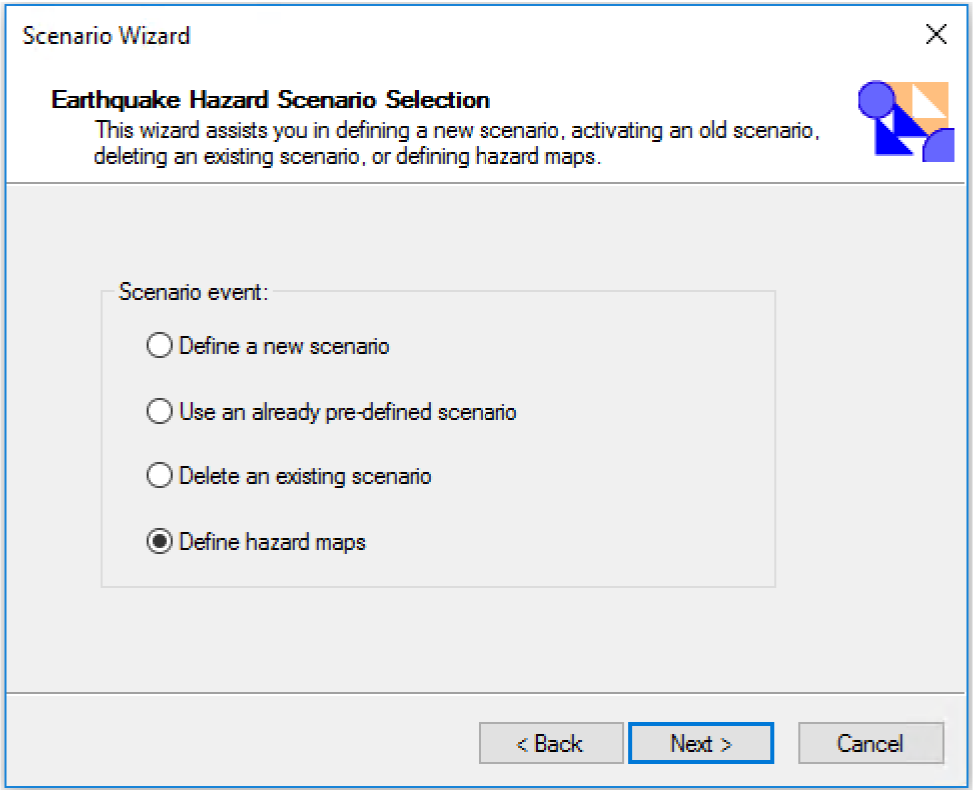
Task 1: Set the Parameters

Start Hazus and open the Salt Lake City study region if it is not already open. When prompted, indicate that you want to open the Earthquake hazard.

From the Hazard menu, choose **Scenario** to open the **Scenario Wizard**.

Click the **Next** button to move to the scenario selection window.

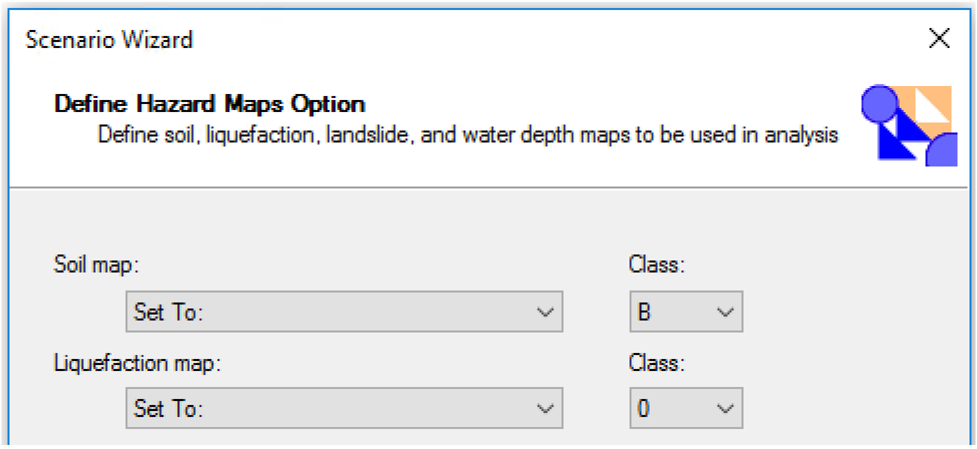
Click the **Define hazard maps** button.



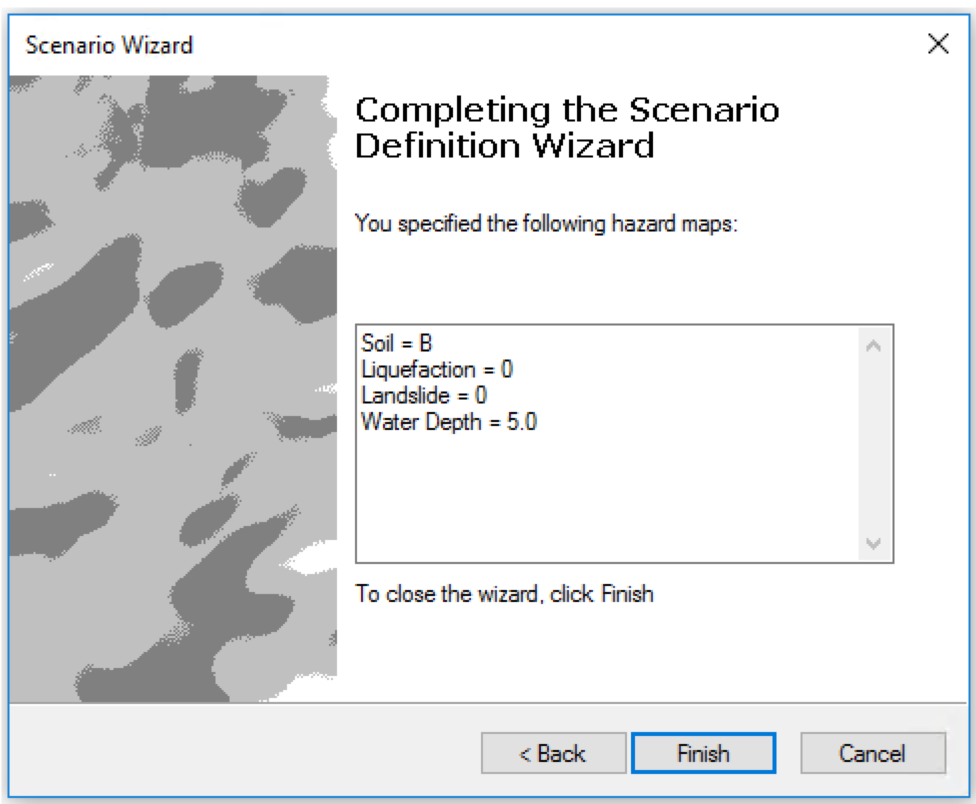
Click the **Next** button to open the Hazard maps window.

Change the class for the soil map to B as shown in the following example.

> *Hazus soil types are based on shear wave velocities in the first 30 meters of soil. Soil type can have a significant impact on shear wave velocities. The default soil type for the part of the country in which Salt Lake City is located is class D—a stiff soil. By changing the soil type to B, you are indicating that the soil is Rock. It is important to note that, without the addition of user-developed local soil data, the entire study region will be assessed for the same soil type. With this in mind, one of the most important efforts that users can undertake toward improving Hazus earthquake analysis is the development or acquisition of good soils information.*



Click the **Next** button to view the parameters that you set.

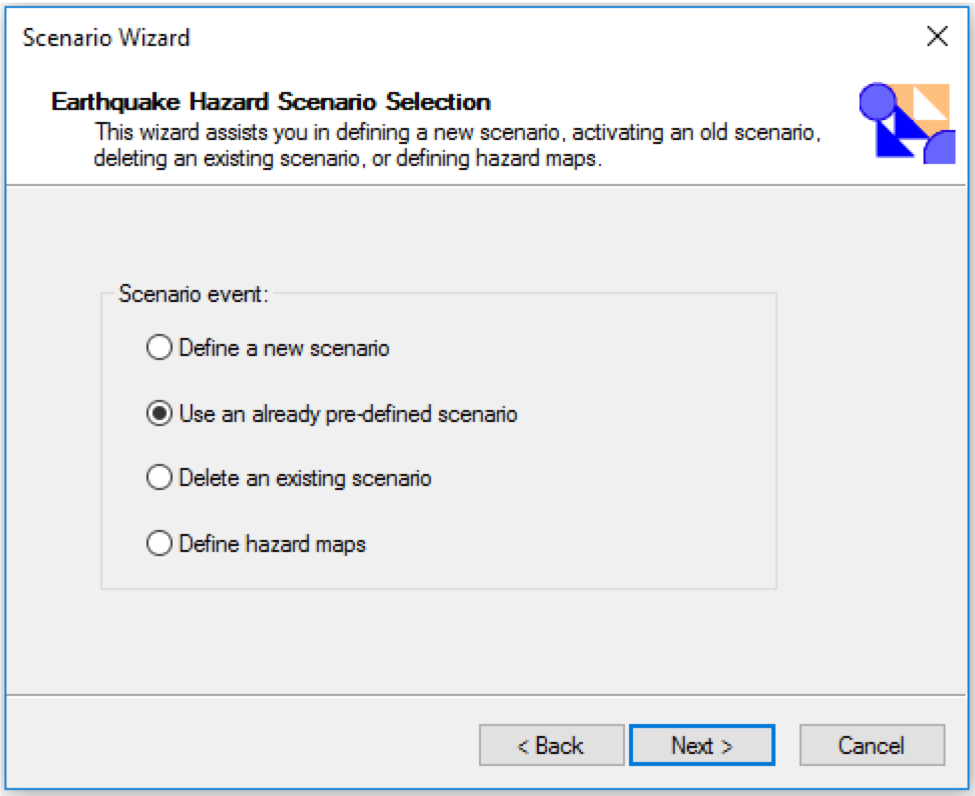


Click the Finish button to finish updating the hazard map settings.

A message box will appear that indicates the processing status. Allow this process to complete before proceeding with the next step.

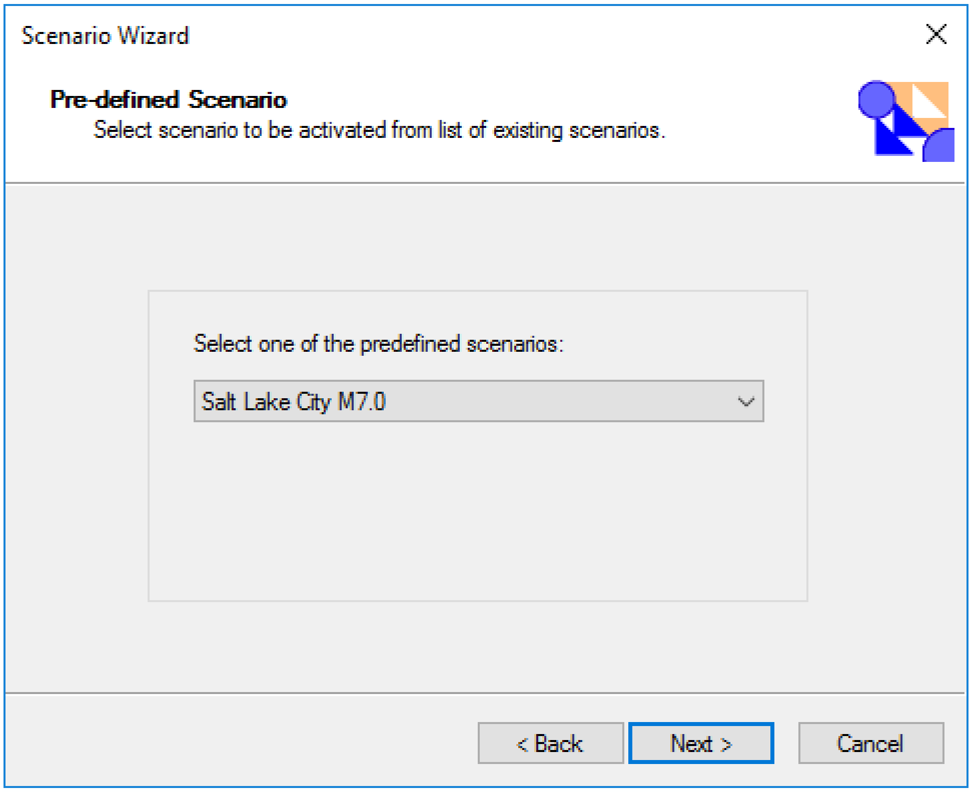
From the Hazard menu, choose Scenario and click Next to advance the scenario wizard.

Select Use an already pre-defined scenario.



Click **Next** to move to the next window of the scenario wizard.

Choose the Salt Lake City M7.0 scenario as the pre-defined scenario.



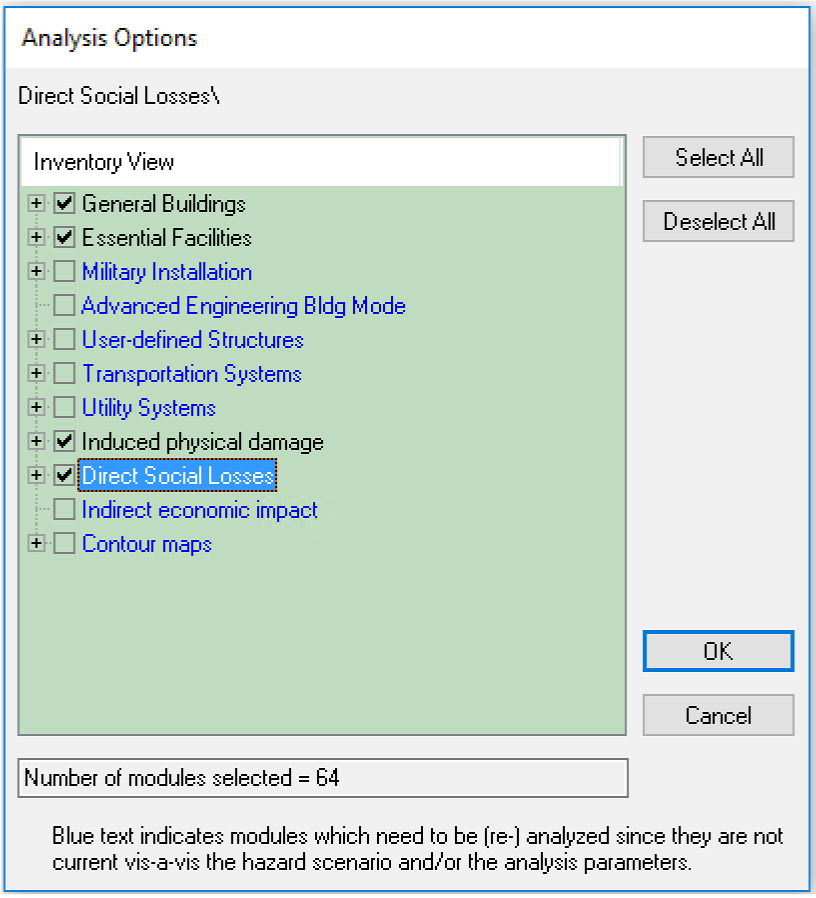
Click **Next** to move to the next window of the scenario wizard.

Verify that all of the settings are correct; click **Finish** to finish the scenario wizard.

Task 2: Run the Analysis

From the Analysis menu, choose Run to open the Analysis Options window.

Select General Buildings, Essential Facilities, Induced Physical Damage, and Direct Social Losses.



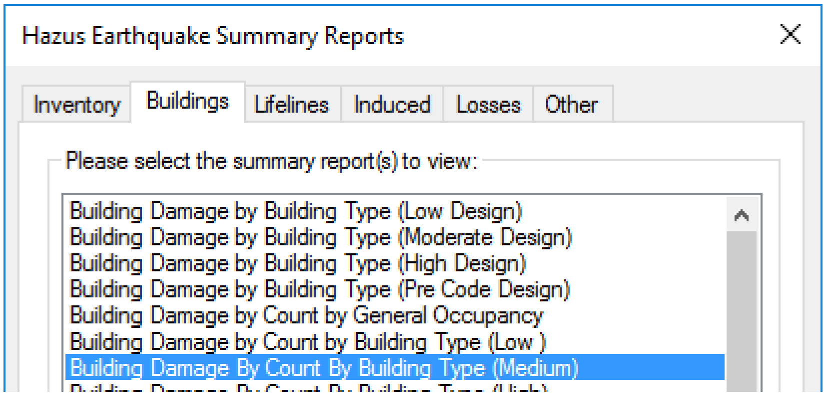
Click the **OK** button and then select **Yes** when asked if you want to run analysis with the options selected.

Please be patient. The analysis will take a couple of minutes to complete.

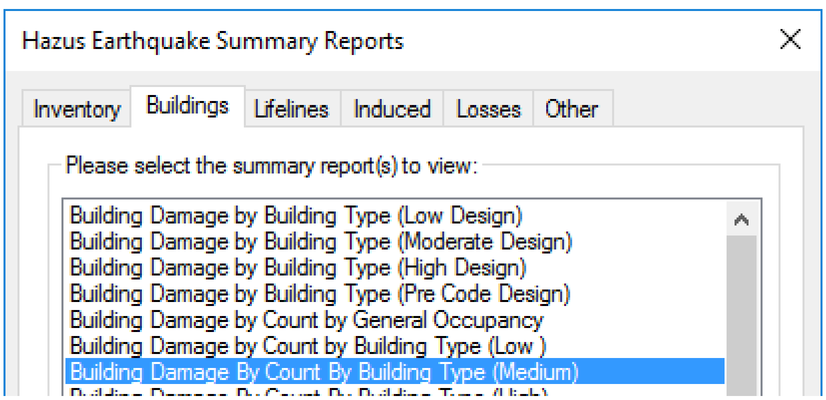
Click **OK** when the analysis completes.

Task 3: Explore the Results

From the **Results** menu, choose **Summary Reports** to open the Hazus Earthquake Summary Reports window.



Click the Buildings tab. Select the Building Damage by Count by Building Type (Medium).



Click the **View** button.

In the table at the end of the activity, note the Total Number of Buildings which sustained At Least Moderate Damage and the Total Number of Buildings Damaged.

> *To determine the number of buildings that received damage, you will need to subtract the number of buildings that sustained no damage from the total number of buildings. To determine the total number of buildings that received at least moderate damage, you will have to subtract the buildings that received no damage and slight damage from the total number of buildings.*

Close the Summary Report and then close the Earthquake Summary Reports window.

<u>Case Two – Magnitude Effect Scenario</u>

In this scenario, you will study the impact of modifying earthquake magnitude. The parameters for this scenario are as follows:

- Epicenter = Latitude 41.04 Longitude -112.67
- Moment Magnitude = 8
- Depth = 10 kilometers, Soil Class = D
- Liquefaction Susceptibility: None
- Attenuation Function: West US Extensional 2008 – Strike Slip

Task 1: Set the Parameters

From the Hazard menu, choose Scenario. Click **Next** to advance the first screen of the Scenario Wizard.

Select **Define a new scenario**.

Click **Next** to move to the next window of the Scenario Wizard.

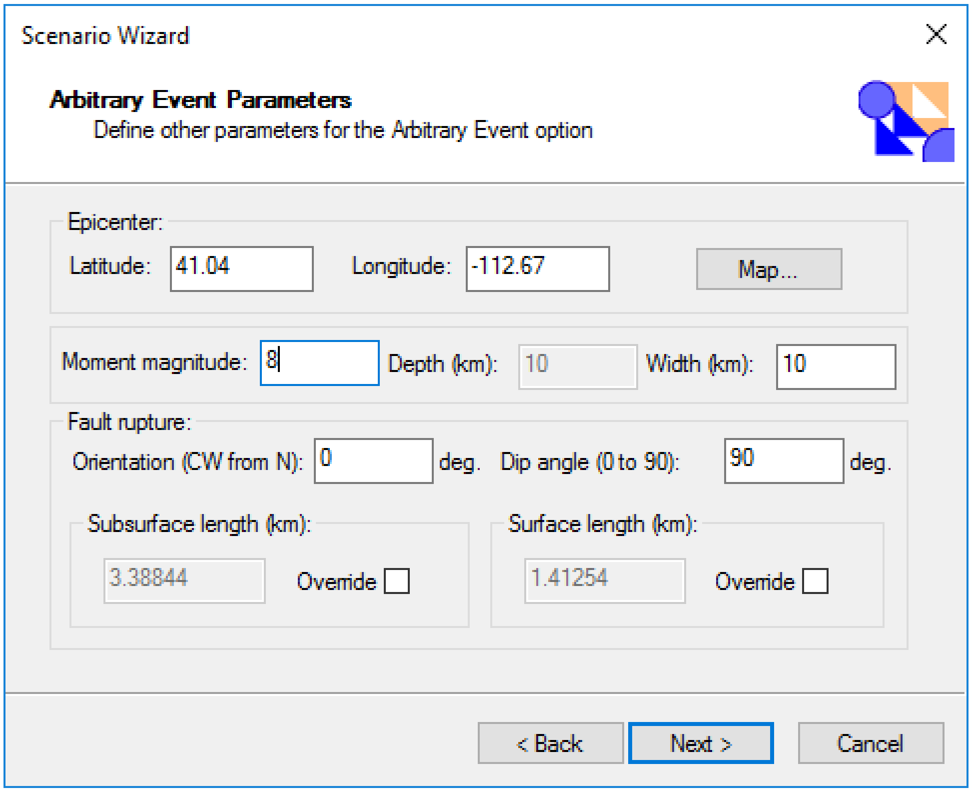
Select **Arbitrary** event.

Click **Next** to move to the next window of the Scenario Wizard.

Select **West US Extensional 2008 – Strike Slip** from the Attenuation function dropdown selection window.

Click **Next** to move to the next window of the Scenario Wizard.

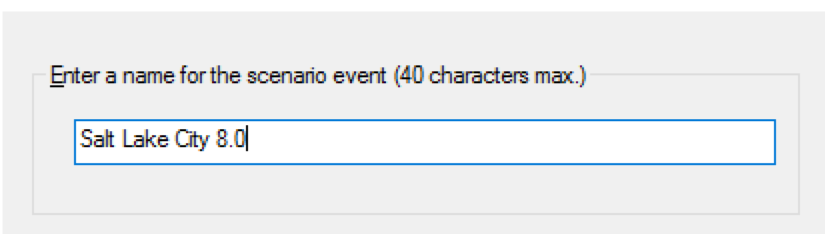
Enter 41.04 for the Latitude of the event and -112.67 for the Longitude of the event. Make the Moment Magnitude 8 and the Depth 10 km as shown in the graphic below.



Click **Next** to move to the next window of the Scenario Wizard.

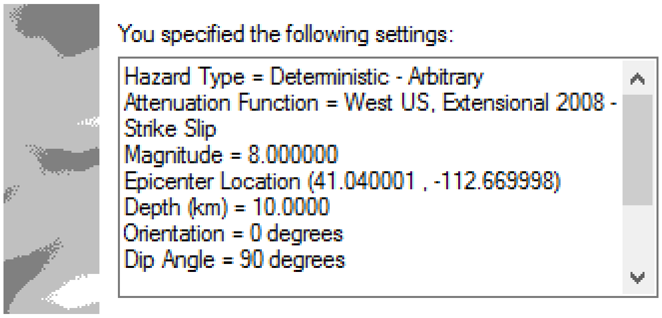
Enter Salt Lake City M8.0 for the name of the scenario.

> *You are increasing the magnitude from 7 to 8. This represents approximately 30 times as much energy release.*



Click **Next** to move to the summary window, which should appear as follows.

If your screen appears as shown below, click Finish to close the Scenario Wizard. If it does not appear as shown below, click the Back button to return to the window where you need to make changes.



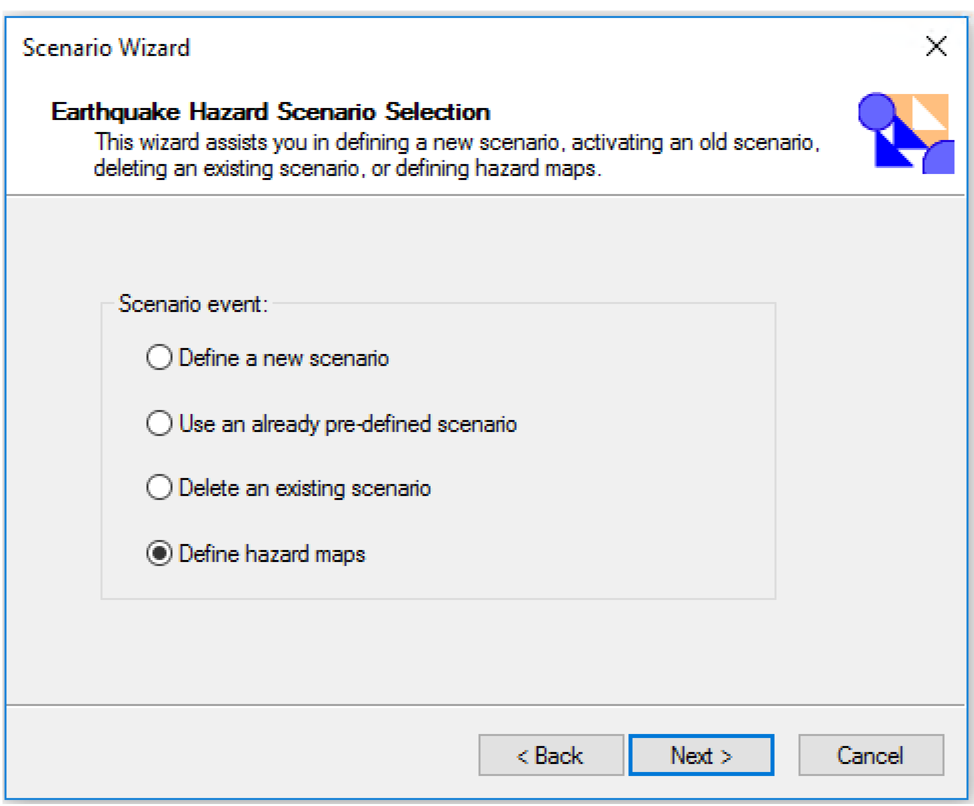
Click **Finish**.

Task 2: Review the Hazard Map Settings

From the **Hazard** menu, choose **Scenario** to open the Scenario Wizard.

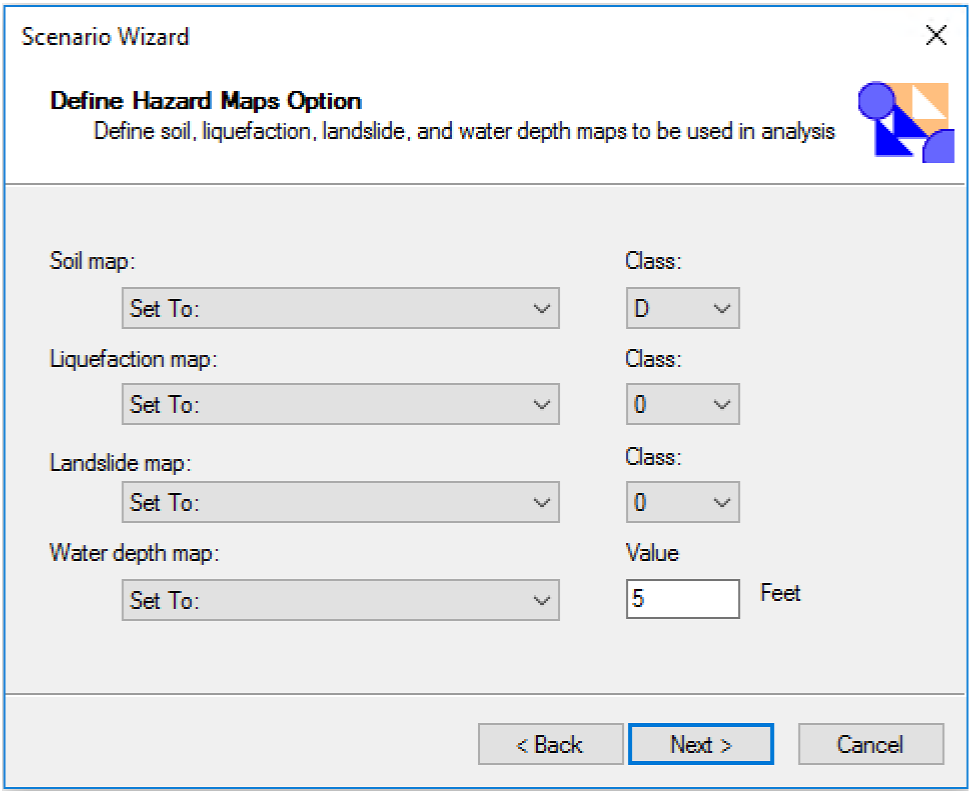
Click the **Next** button to move to the scenario selection window.

Click the **Define hazard maps** button.



Click the **Next** button to open the Hazard maps window.

Verify that the Soil type is set to class D, Liquefaction is set to 0, Landslide class is set to 0, and water depth is set to 5 feet.



Click the **Next** button to view the summary window and then click the **Finish** button to close the Scenario Wizard.

Hazus will update the hazard map parameters. This may take a few moments to complete.

Task 3: Run the Analysis

To run the analysis, go to Analysis --> Run

From the Analysis Options window, only select General Buildings, Essential Facilities, Utility Systems, Induced Physical Damage, and Direct Social Losses.

Click the **OK** button and then select **Yes** when asked if you want to run analysis with the options selected.

Click **OK** when the analysis completes.

Task 4: View the Results

From the **Results** menu, choose **Summary Reports** to open the Hazus Earthquake Summary Reports window.

Click the Buildings tab. Select the Building Damage by Count by Building Type (Medium).

Click the **View** button.

In the table at the end of the activity, note the Total Number of Buildings which sustained At Least Moderate Damage and the Total Number of Buildings Damaged.

> *Consult the instructions under Case One if you do not recall how to derive the requested numbers from the report.*

Close the Summary Report and then close the Earthquake Summary Reports window.

Results Table

	Total Buildings Damaged	Buildings With at Least Moderate Damage
Salt Lake City M7.0 Scenario *(from previous activity)*		
Case #1: B Soil Type		
Case #2: Magnitude Change		

The results in the first row have been copied from the output of the previous activity for the arbitrary magnitude 7.0 scenario.

Compare these results with the results generated by changing the soil type and magnitude.

Activity 8.2 - Earthquake Model Results

Activity 8.2 – Earthquake Model Results

Type: Student-Led Activity

Time: 15 minutes

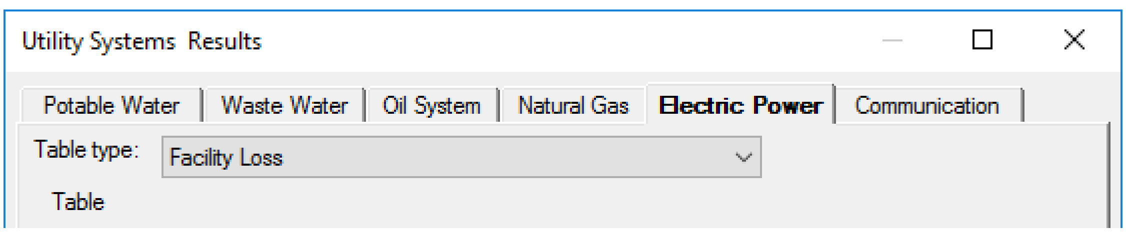
Background

The purpose of the following activity is to help you become familiar with the information found under the earthquake results menu. In the previous Activity (3.3) (NOW 8.3), your instructor should have walked you through importing a study region and you should still have the Salt Lake City Results study region open. The Salt Lake City M8.0 should be the last analysis you completed in Activity 3.3. If you do not have the region open, open the region. If you did not import the region in the previous exercise, please see your instructor.

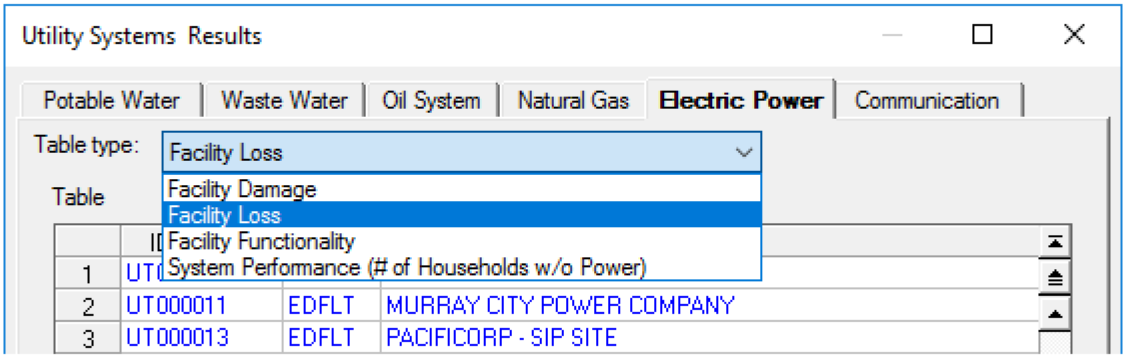
Prior to starting the exercises, it is a good idea to run the Analysis for Utility and Transportation Systems. Make sure that all the options are selected by clicking on the plus next to each category.

Task 1: Explore Dollar Losses to Pipelines

Open the **Results** menu and select **Utility Systems**.



From the Electrical Power tab selected Facility Loss from the table type menu.



Scroll all the way to the right side of the Facility Loss table until you see the Repair Costs (thous. $) field. If you do not see any losses in the column you may need to run the Analysis menu again by clicking the plus sign Utility Systems and selecting all the available options.

Click on the Repair Costs (thous. $) field and then click Map.

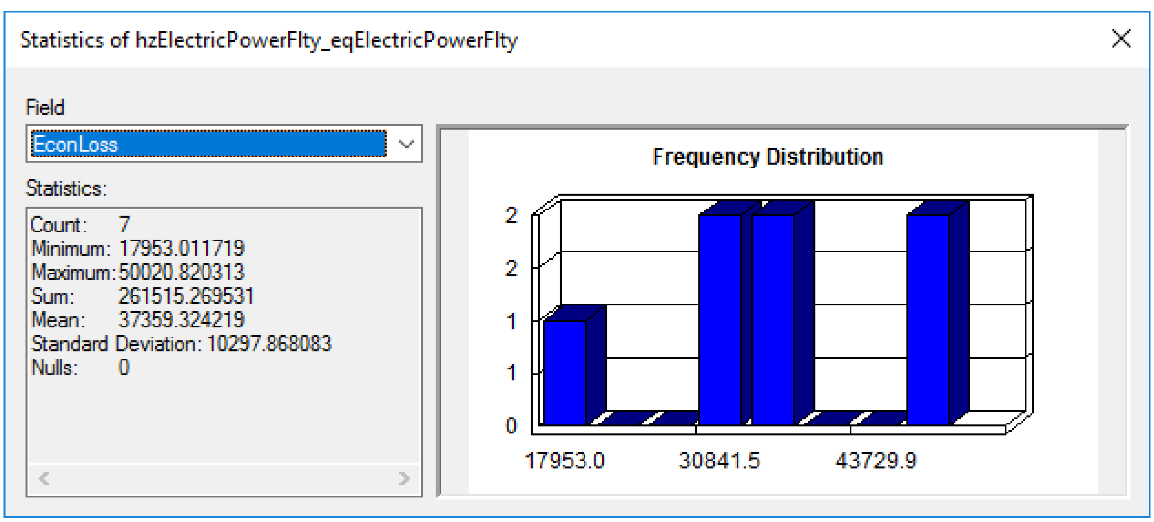
A layer named eqElectricPowerFlty_EconLoss should appear in the table of contents window.

Close the Utility Systems Results window.

Right-click on the eqElectricPowerFlty_EconLoss layer and select Open Attribute Table.

Scroll all the way to the right side of the eqElectricPowerFlty_EconLoss attribute table until you come to the EconLoss field. Right-click on the field name and select Statistics.

> *The dollar loss to pipelines is reported in the Sum field. Remember this value is in thousands of dollars.*



Close the Statistics of eqElectricPowerFlty_EconLoss window.

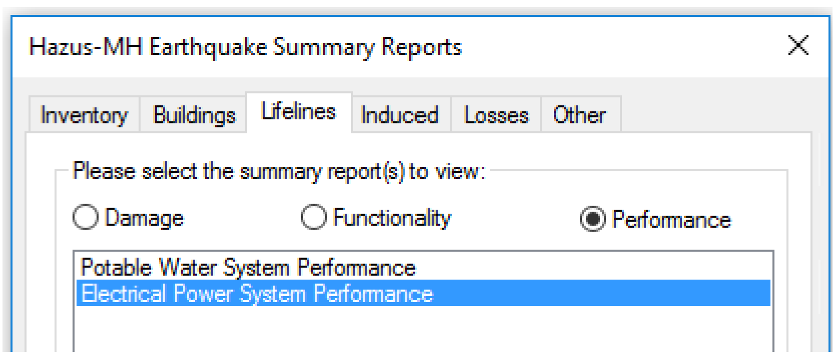
Then close the Attributes of eqElectricPowerFlty_EconLoss window.

Task 2: Explore Power Outage Issues

From the Results menu choose Summary Reports to open the Summary Reports window.

Click the Lifelines tab to see the building related reports. Then select the Performance choice to view the utility performance results.

> *Lifelines are those things considered vital to a community. These are typically the items that require immediate attention if they are damaged by an earthquake.*



Click on the **Electric Power System Performance** report and then click **View**.

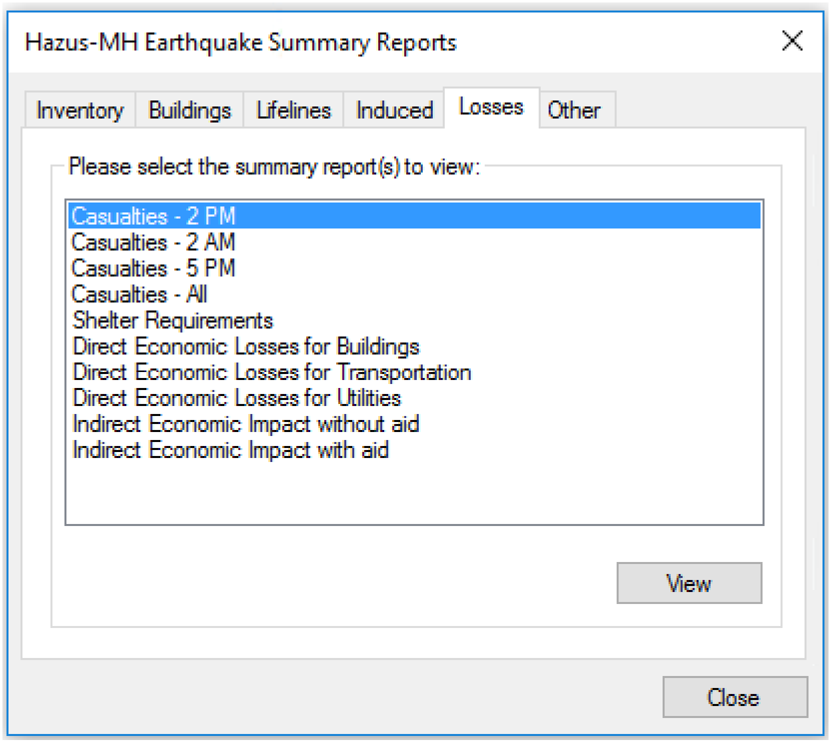
> *Hazus indicates that 0% of households may be affected by power outages at day 1.*

Close the Electrical Power System Performance report, but leave the Hazus Earthquake Summary Report window open since you will need it to complete the next task.

Task 3: Explore the Number of Major Injuries for an Afternoon Earthquake

Click the Losses tab on the Hazus Summary Report window to view the loss related reports.

> *The losses tab only provides access to a few of the loss estimations produced by Hazus. All of the other tabs, excluding the Inventory tab, also provide loss estimations.*



Click on the Casualties – 2 PM report and then click the View button to view the report. Add the values in Severity level 2 and 3 columns to determine the number of major injuries.

The total is 87. The following page provides a breakdown of the types of injuries that may occur at each severity level.

Severity levels in Hazus are categorized based on the following definitions.

Injury Severity Level	Injury Description
Severity 1	Injuries requiring basic medical aid that could be administered by paraprofessionals. These types of injuries would require bandages or observation. Some examples are: a sprain, a severe cut requiring stitches, a minor burn (first degree or second degree on a small part of the body), or a bump on the head without loss of consciousness. Injuries of lesser severity that could be self-treated are not estimated by Hazus.

Injury Severity Level	Injury Description
Severity 2	Injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life threatening status. Some examples are third degree burns or second degree burns over large parts of the body, a bump on the head that causes loss of consciousness, fractured bone, dehydration or exposure.
Severity 3	Injuries that pose an immediate life threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.
Severity 4	Instantaneously killed or mortally injured

Close the Casualties – 2 PM report, but leave the Hazus Summary Report window open since you will need it to complete the next task.

<u>Task 4: Determine the Total Direct Economic Impact</u>

Click the Losses tab.

Click the Direct Economic Losses for Buildings report and then click the View button to open that report. Write down the total loss value in the space below.

Total Loss: $_____________

Close the Direct Economic Loss for Buildings report and open the Direct Economic Losses for Transportation report and write down the total loss value from that report in the space below.

Total Loss: $_____________

Close the Direct Economic Loss for Transportation report and then open the Direct Economic Losses for Utilities report and write down the total value from that report in the space to the right.

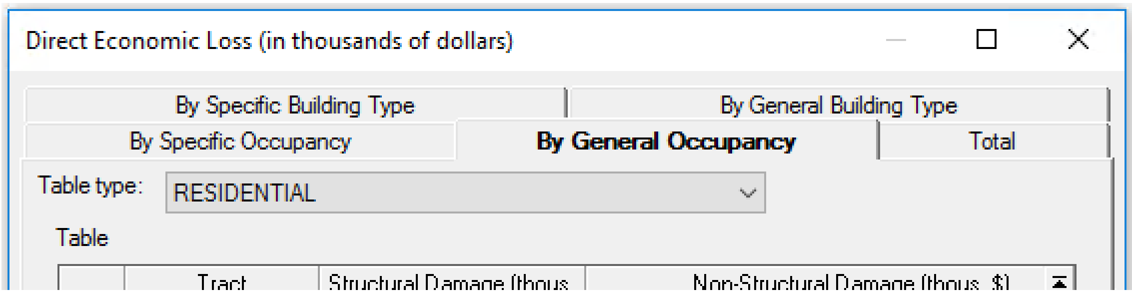
Total Loss: $_____________

Close the summary reports window.

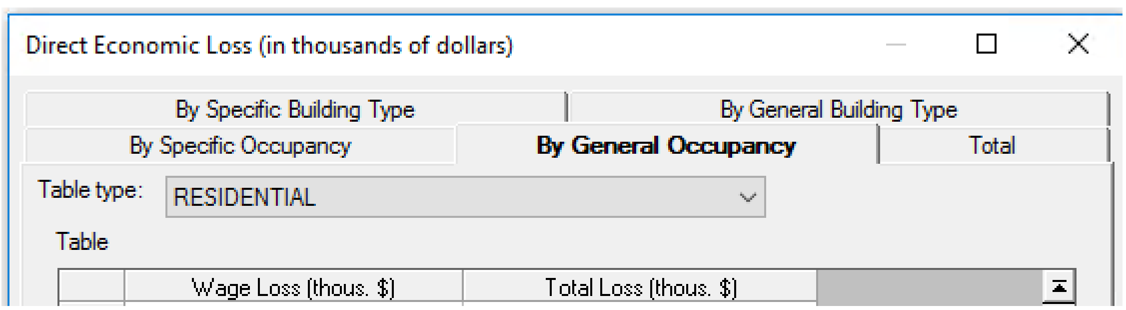
<u>Task 5: Determine the Economic Loss to Residential Structures</u>

From the Results menu choose the General Building Stock>Building Economic Loss>Direct Economic Loss to open the Direct Economic Loss table.

Click the By General Occupancy tab and choose Residential for the table type.



Scroll all the way to the right side of the Direct Economic Loss window. Select the Total Loss (thous. $) field and click the Map button to create a map layer.

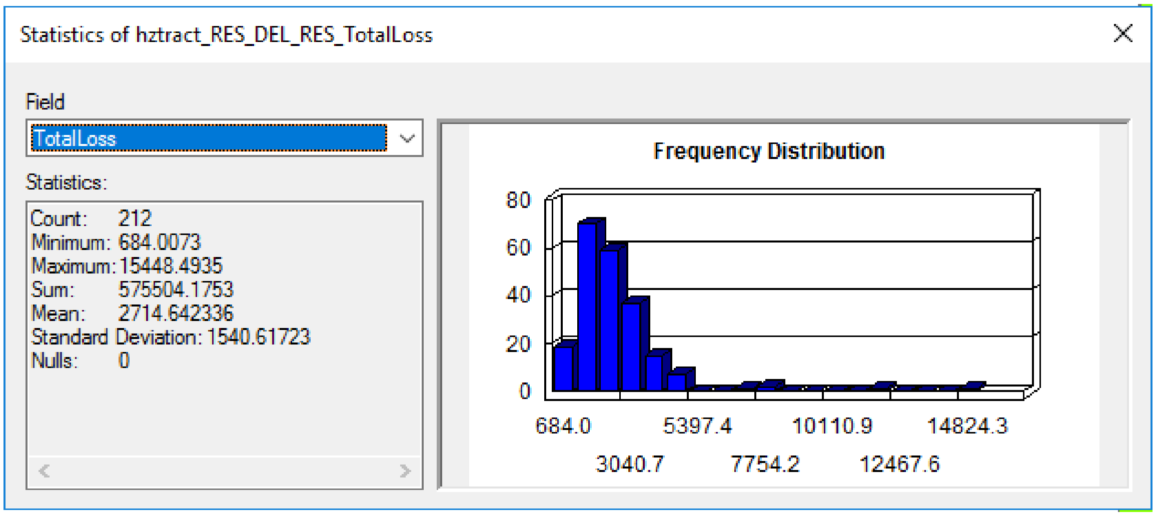


Close the Direct Economic Loss results window.

In the table of contents window, right-click on the EqTractThMap_RES_DEL_RES_TotalLoss layer and choose Open Attribute Table from the layer context menu.

Right-click on the TotalLoss field and choose Statistics.

> *The Sum value indicates the economic loss to residential structures.*



Close the Statistics window and the Attributes of EqTractThMap_RES_DEL_RES_TotalLoss table.

Task 6: Explore Anticipated Need for Hospital Beds

Open the Summary Reports window.

Results -> Summary Reports

Click the Buildings tab to view the building related reports.

Open the Hospitals Functionality report.

Review the number of hospital beds in the column labeled At Day 1. There are 2,135 available after Day 1 of this earthquake event in the study region.

Close the Hospitals Functionality report and close the Hazus Earthquake Summary Report window.

Click Save to save your map document.

Leave Hazus open unless otherwise instructed by your instructor.

Challenge Questions

Use the skills that you have developed to answer the following questions that will test your understanding of the information covered in the earthquake material thus far. Your instructor will review these questions with you latter in the class.

1. Determine the number of severity level 1 (minor) indoor casualties that would occur in Industrial type buildings if the scenario earthquake were to occur at 2 p.m.
2. Identify the General Occupancy class that is most likely to sustain the least total casualties if the earthquake were to occur at 2 p.m.
3. Determine the number of households that are anticipated to be without electrical power on the day of the earthquake.

4. Determine the time of day at which the highest number of fatalities is likely to occur.

Determine whether (a) brick, wood, and other types of debris or (b) concrete and steel are more likely to generate more debris in terms of total tons.

Activity 10.1 - Tsunami Scenarios

Type: Student-Led

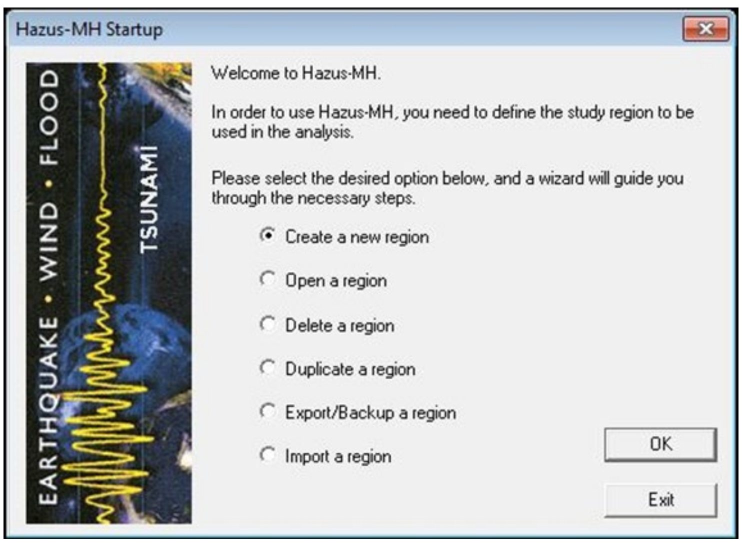
Activity Time: 1 hour

Background

The Hazus tsunami model provides a powerful tool that enables the users to understand the losses associated with tsunami inundation and velocity. This exercise focuses specifically on the use of the Basic Tsunami Model, including a basic level analysis and casualty analysis. The Advanced Model and Combined Earthquake and Tsunami analysis will be addressed in separate courses.

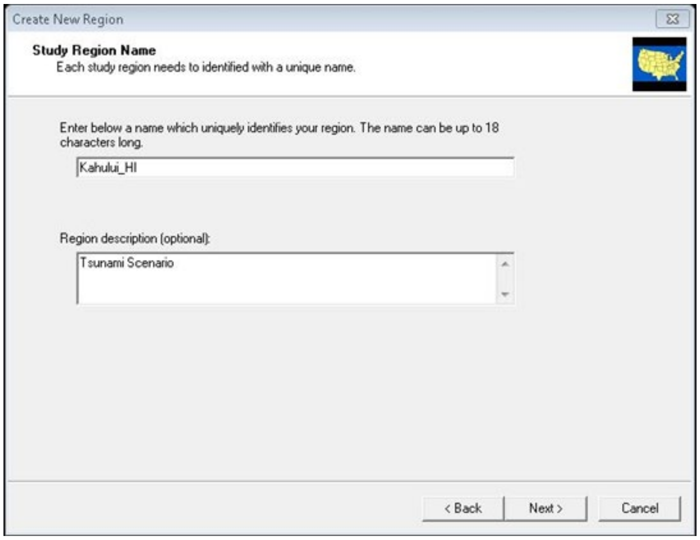
Task 1: Defining a Basic Level Analysis

Start Hazus. In the Hazus Startup Window, select Create a new region, and then select OK.

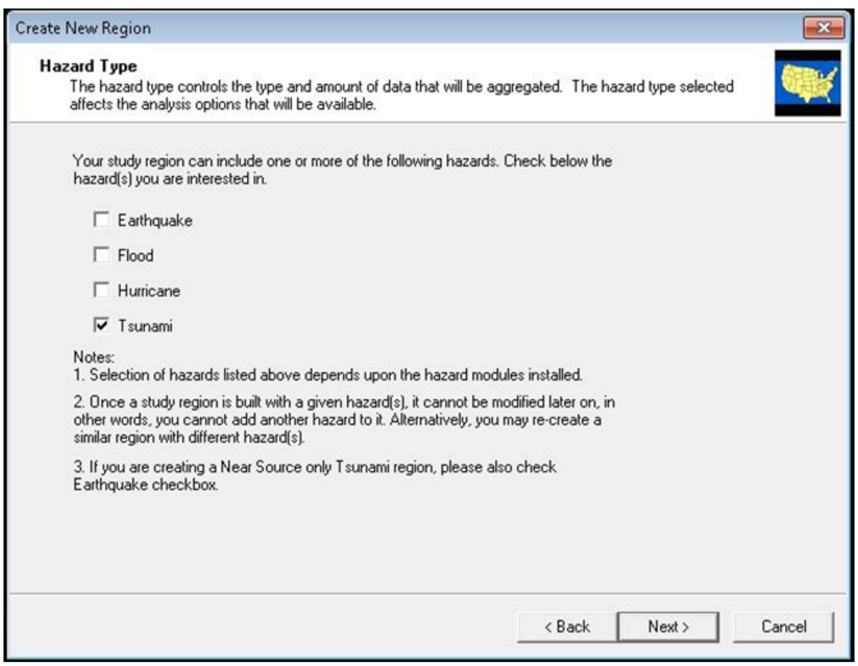


In the **Create New Region** window, select **Next**.

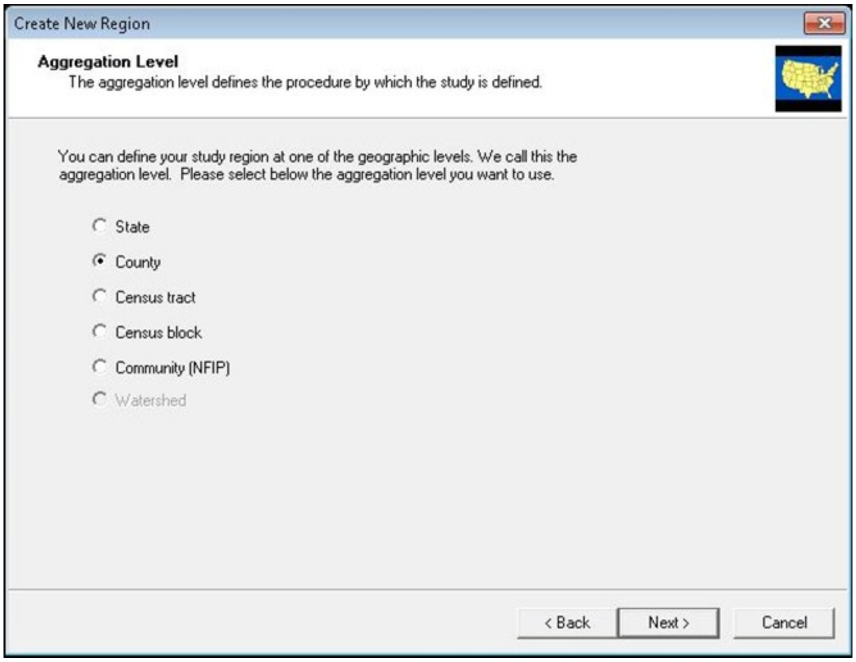
In the **Study Region Name** window, name the region **Kahului_HI** and add a **Region Description** stating, "**Tsunami Scenario**". Select Next.



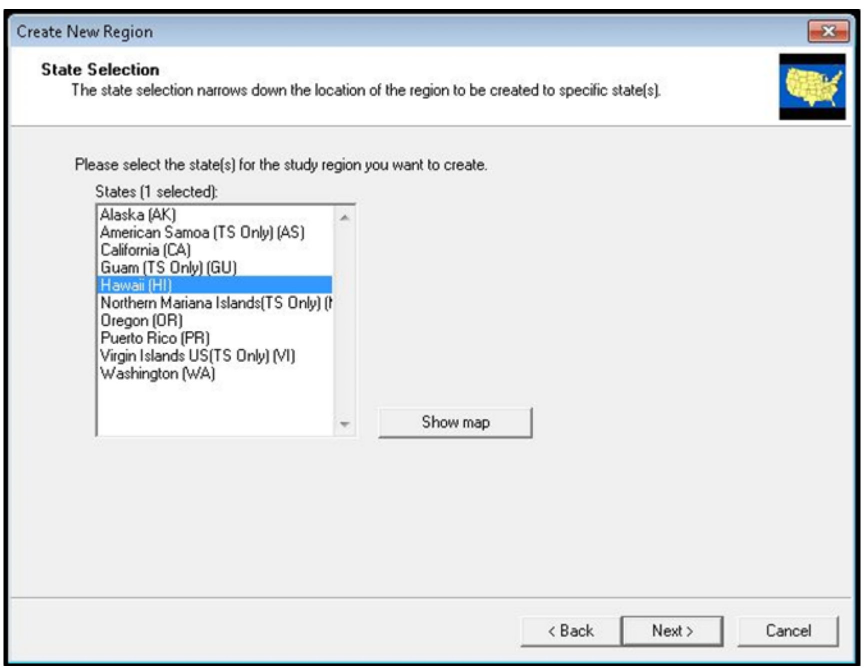
In the Hazard Type window, select **Tsunami**, and then select **Next**.



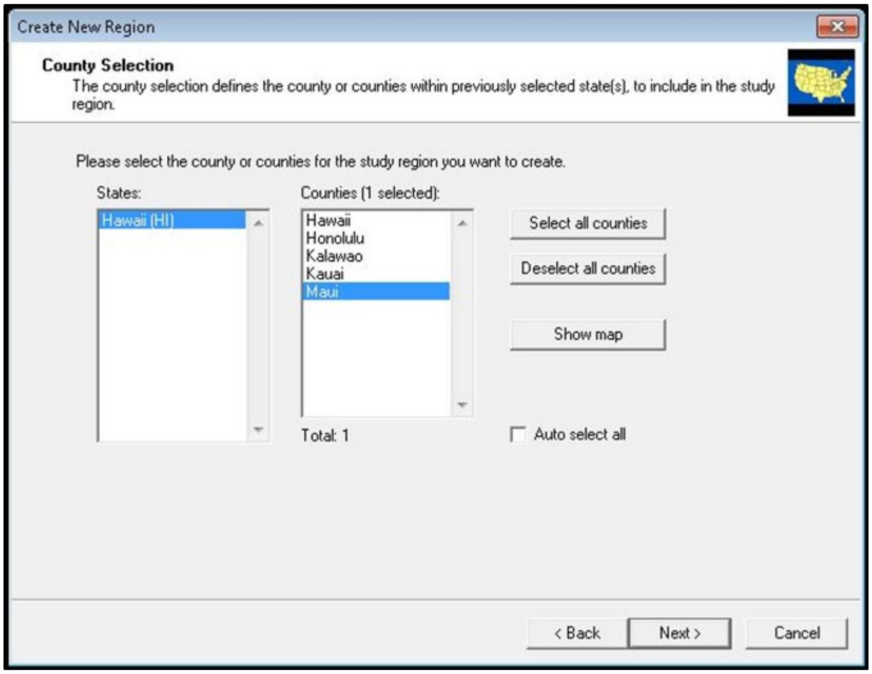
In the Aggregation Level window, select **County**, and then select **Next**.



In the State Selection window, select **Hawaii**, and then select **Next**.

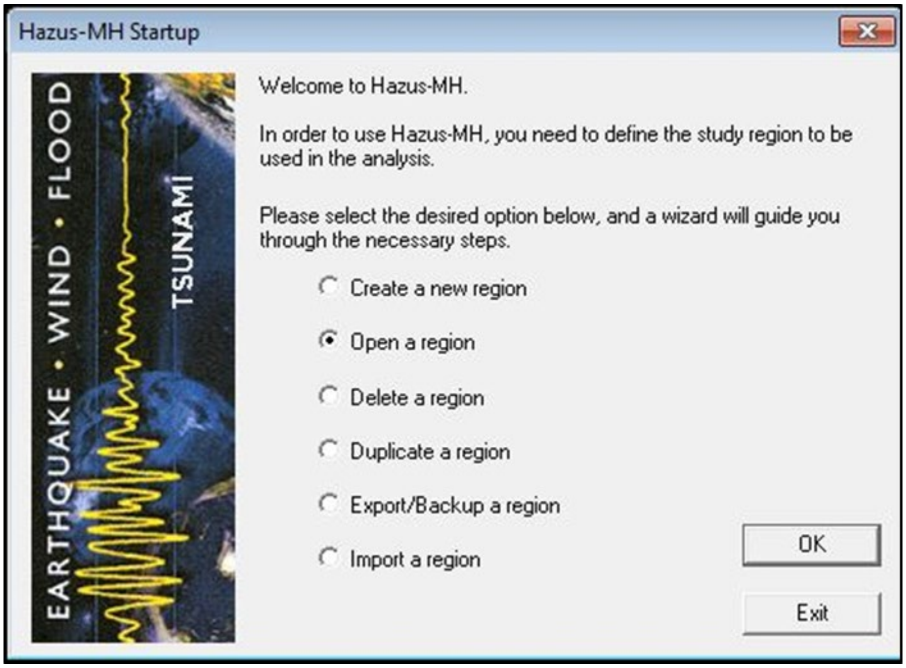


In the County Selection window, select **Maui**, and then select **Next**.

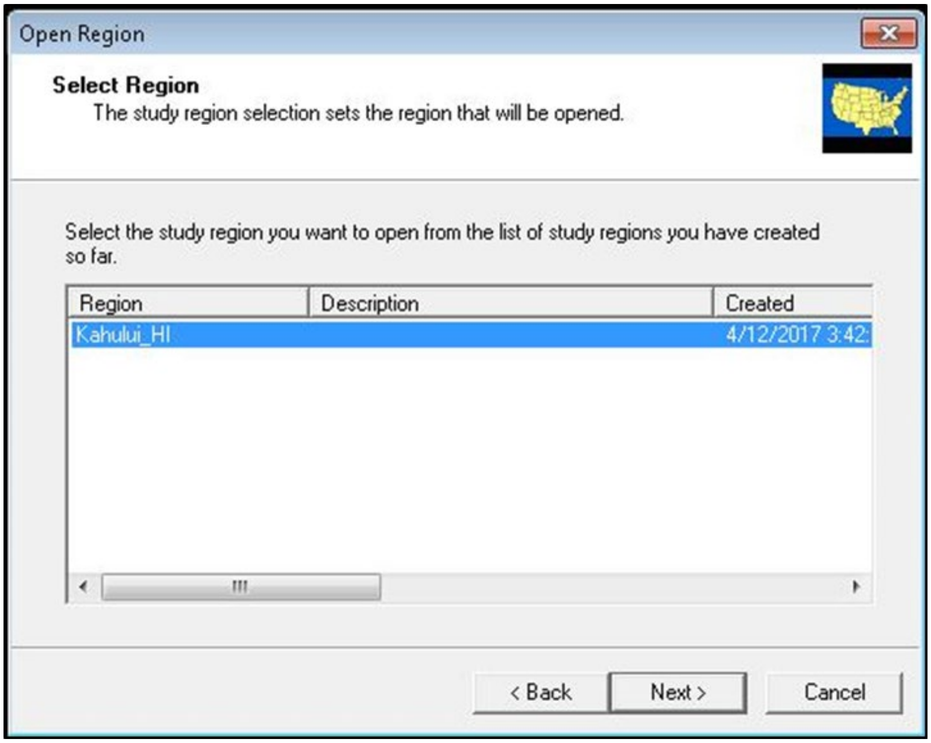


In the Scenario completion window, select **Finish**.

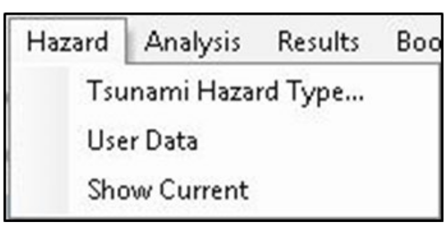
From the Welcome Window, select **Open a region**, and then select **OK**.



In the Open Region Window, select **Next**.
In the Select Region Window, select **Kahului_HI**, and select **Next**.



In the Scenario completion window, select **Finish** to open the region.
From the Tool Bar, Select **Hazard**
Select **Tsunami Hazard Type**



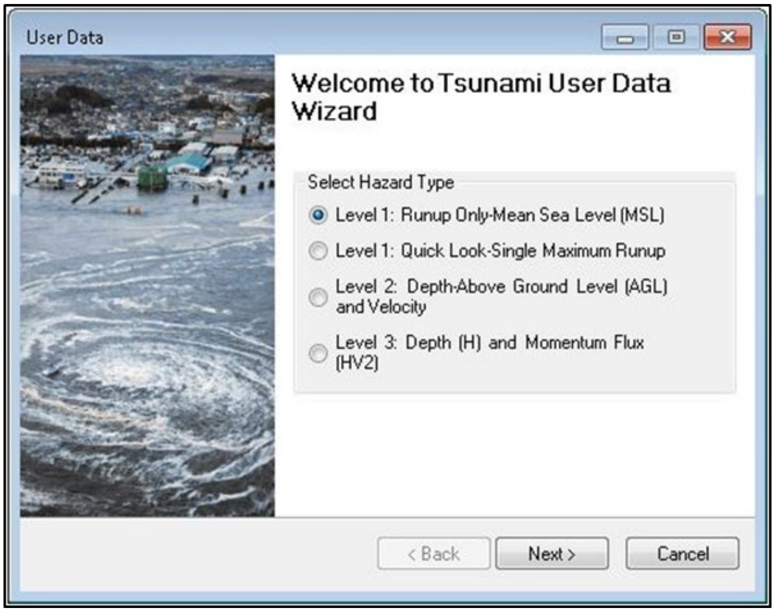
This will open the Tsunami Hazard Type dialog where the user can choose between a Near Source (Tsunamigenic source nearby, Earthquake impacts may be expected) or Distant Source (Tsunamigenic source far away, no Earthquake impacts).

Select **Distant Source**

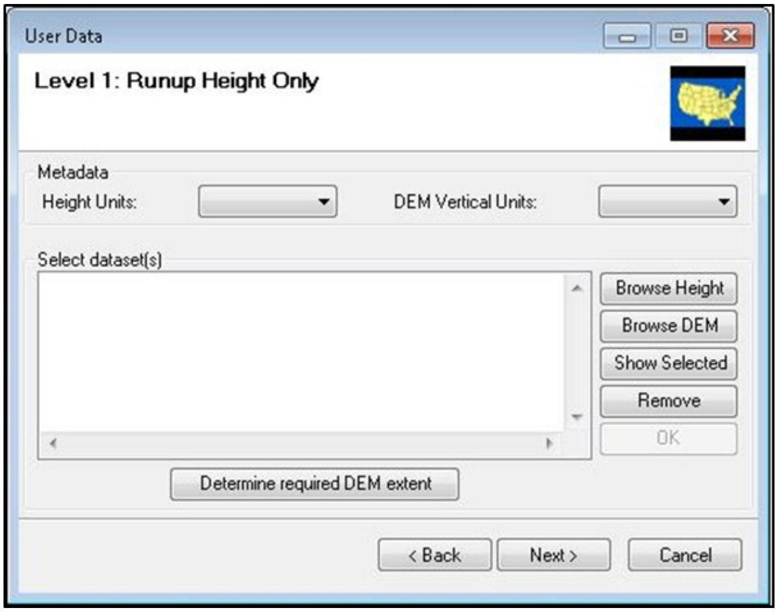
Select **OK**

From the Toolbar, under **Hazard**, select **User Data**.

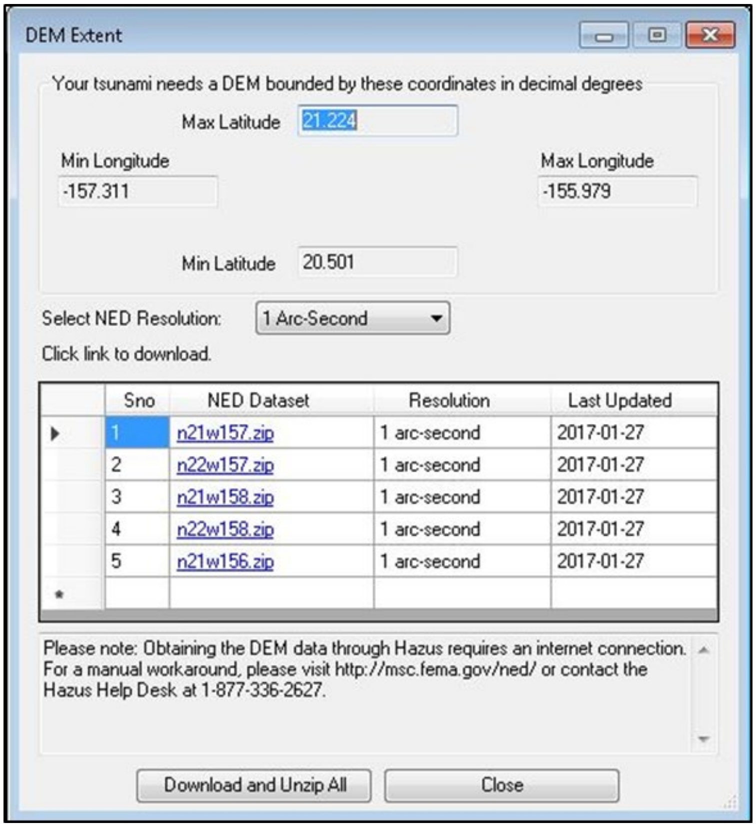
Select **Level 1: Runup Only-Mean Sea Level (MSL)**



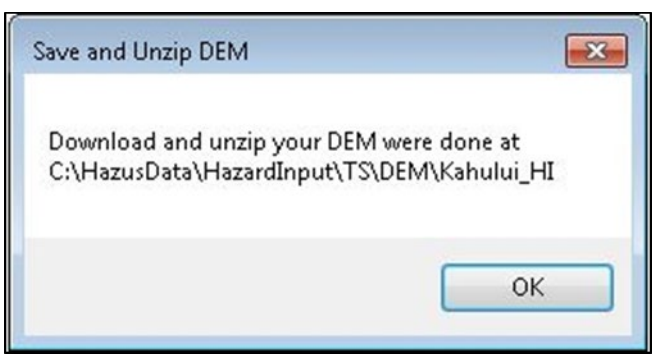
Select the **Determine required DEM extent** button.



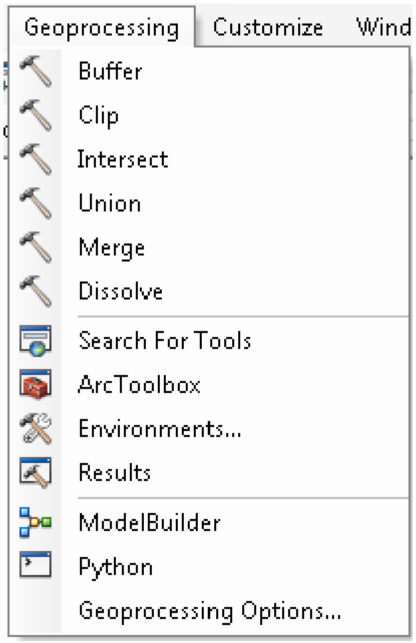
The model will determine the **NED raster grids** needed for the study region. When it is complete, the window below will appear. Select **Download and Unzip All** to download the DEMs for the next step.

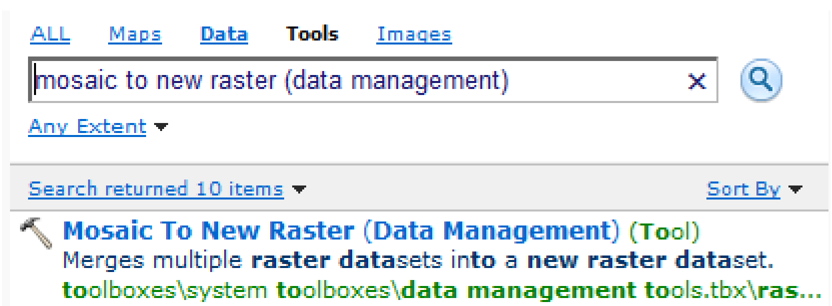


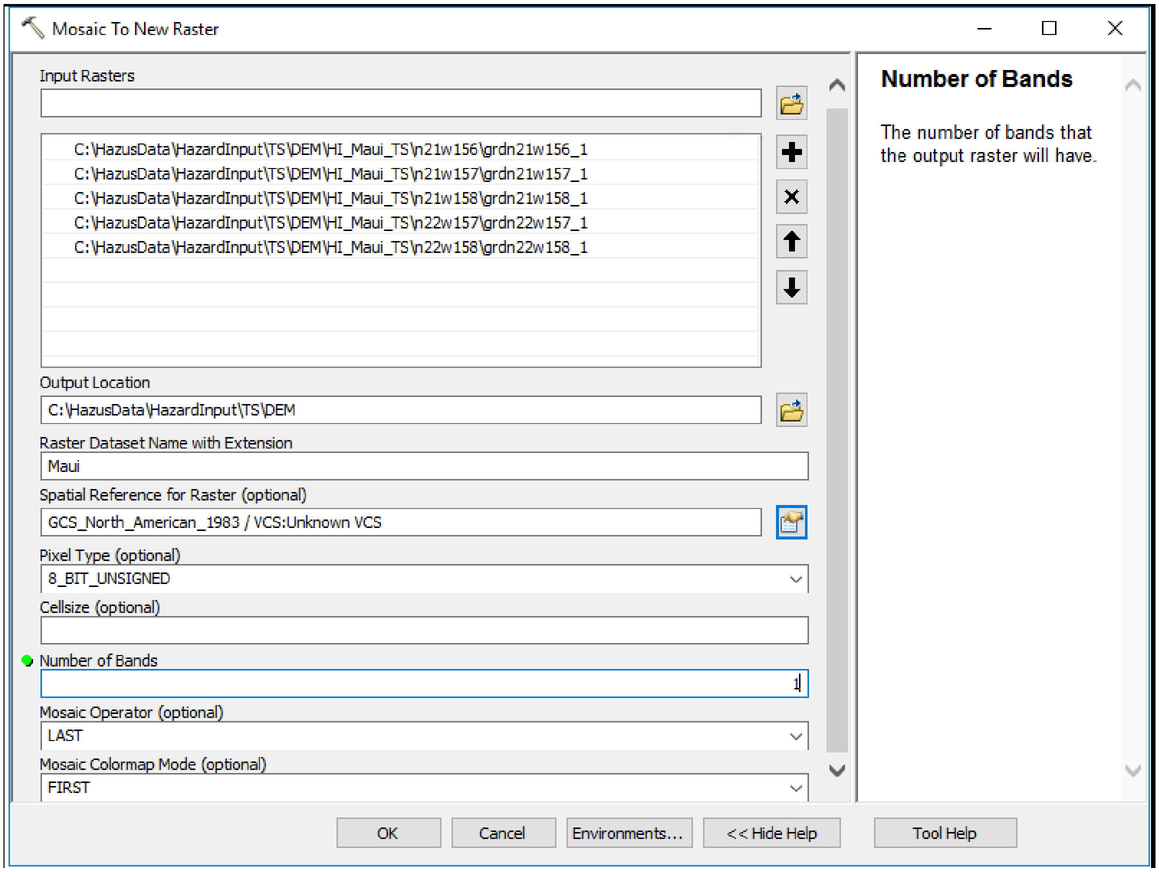
The Save and Unzip DEM window will display the location the DEMs are saved to. Select **OK** to close the window



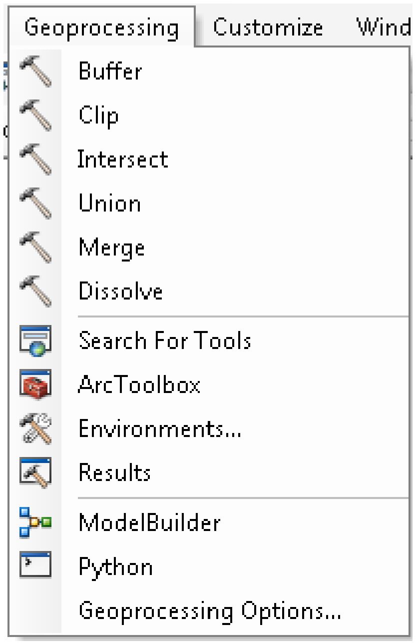
Once the files have been downloaded and unzipped, the DEMs should be merged into a single DEM which will be easier to process. This can be done under **Geoprocessing** on the Tool bar, select **Search for Tools**. The tool is **Mosaic to New Raster (data management).** Add all the downloaded DEM files to the tool and give it a new name, without giving it a file extension. See example below on how to locate and fill in the parameters for the tool.



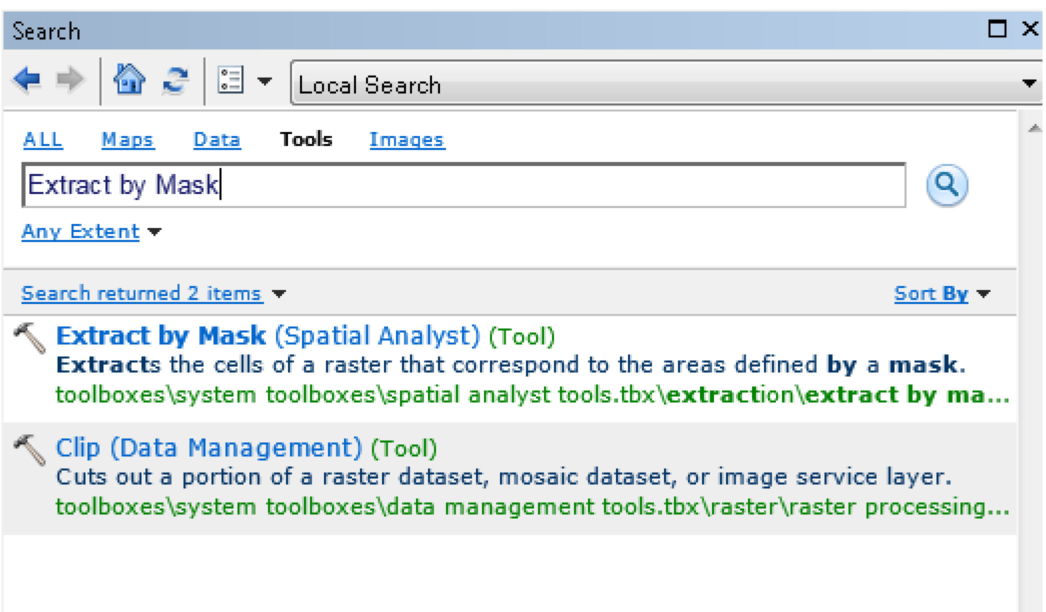




The next step is to Mask (or clip) the DEM to Add the **Mani** raster (for Maui - generated in the above step) from the location above to the viewer. This step reduces helps to reduce processing time. This can be done under Geoprocessing on the Tool bar, select **Search for Tools**. The tool is **Extract by Mask (Spatial Analyst Toolbox).**



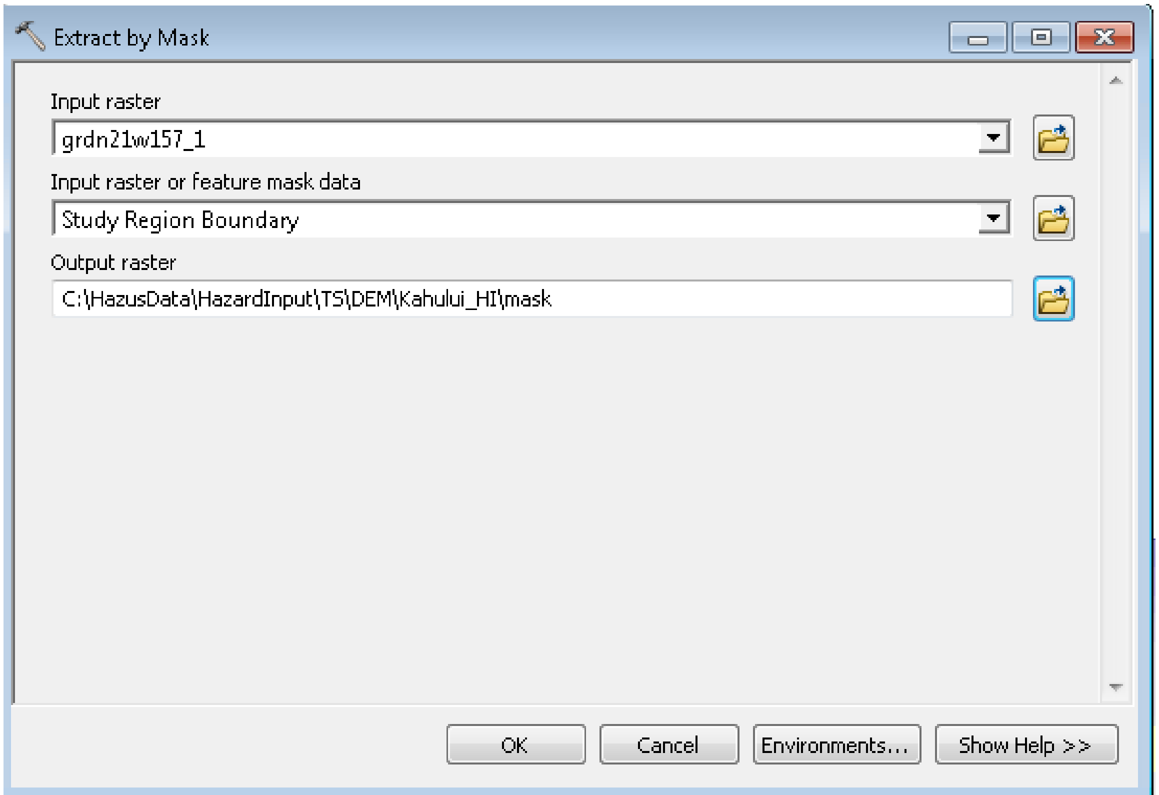
Search for **Extract by Mask.**



Open tool and enter the following:

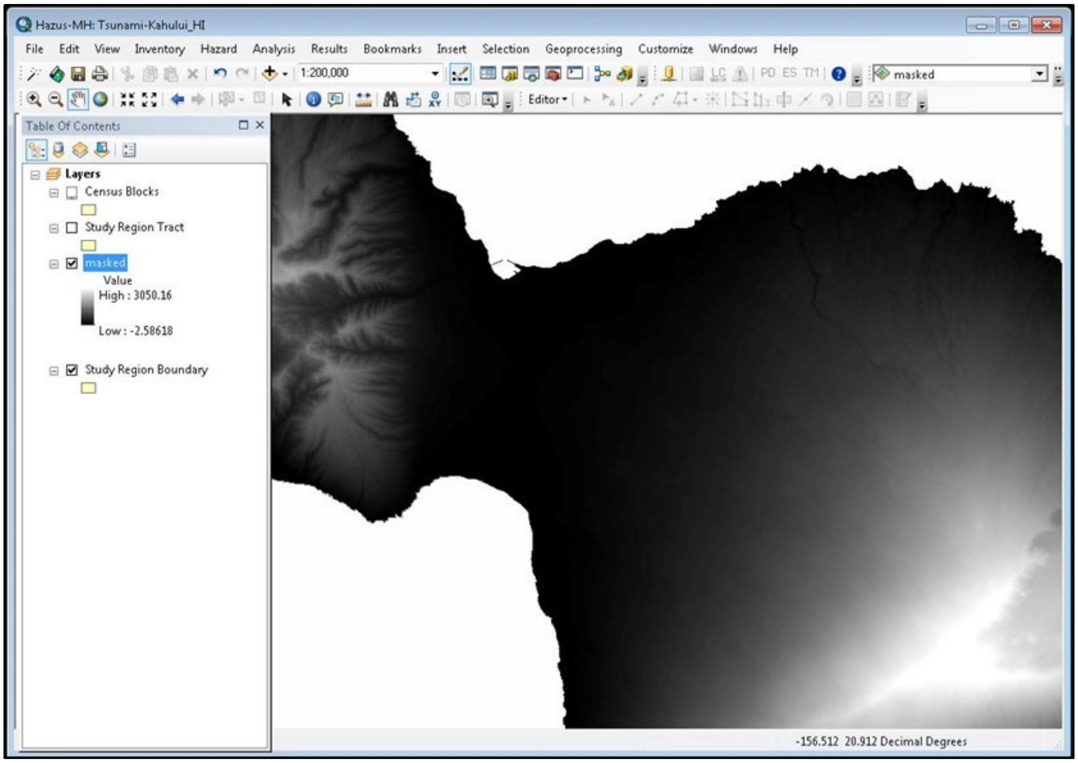
- Input raster: **Maui** (output file from the Moasic to New Raster)

- Input raster or feature mask data: **Study Region Boundary** (layer in ArcMap)
- Output raster: **C:\HazusData\HazardInput\TS\DEM\Kahului_HI\mask**



When processed, the mask should look like the image below:

For example: The High Value (3050.16) is represented where flat terrain features on the map are present and the Low Value (-2.58618) is represented where the mountainous terrain features on the map are present.

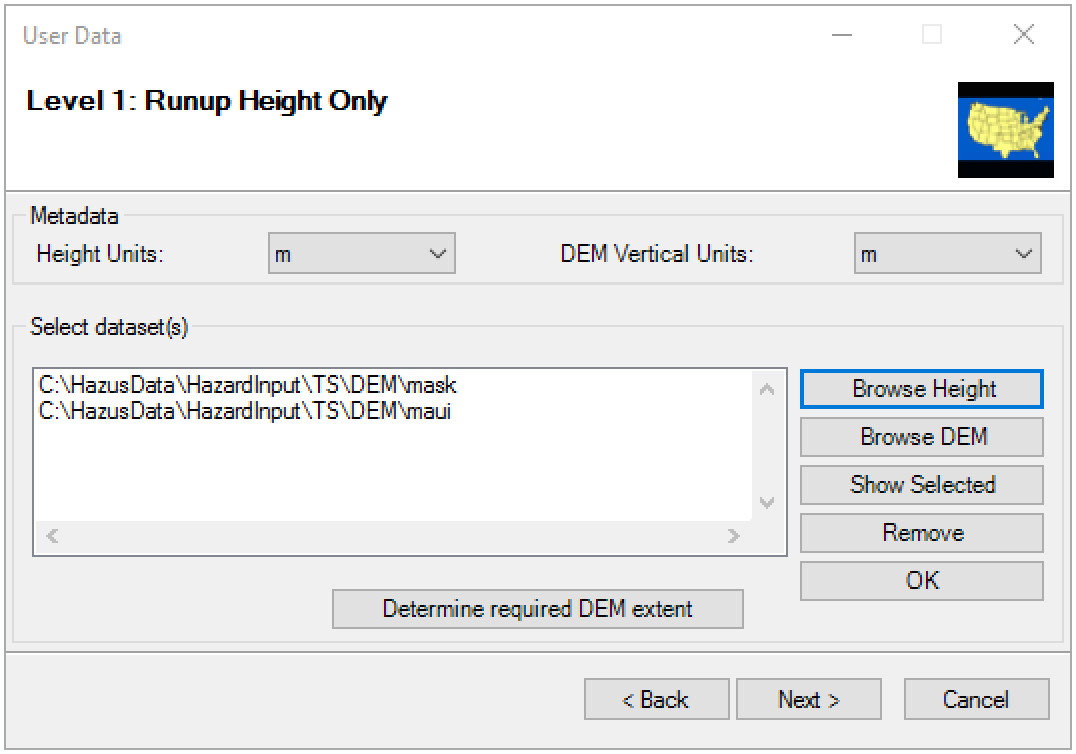


Fill out the remaining parameters to execute the Level 1: Runup Height Only

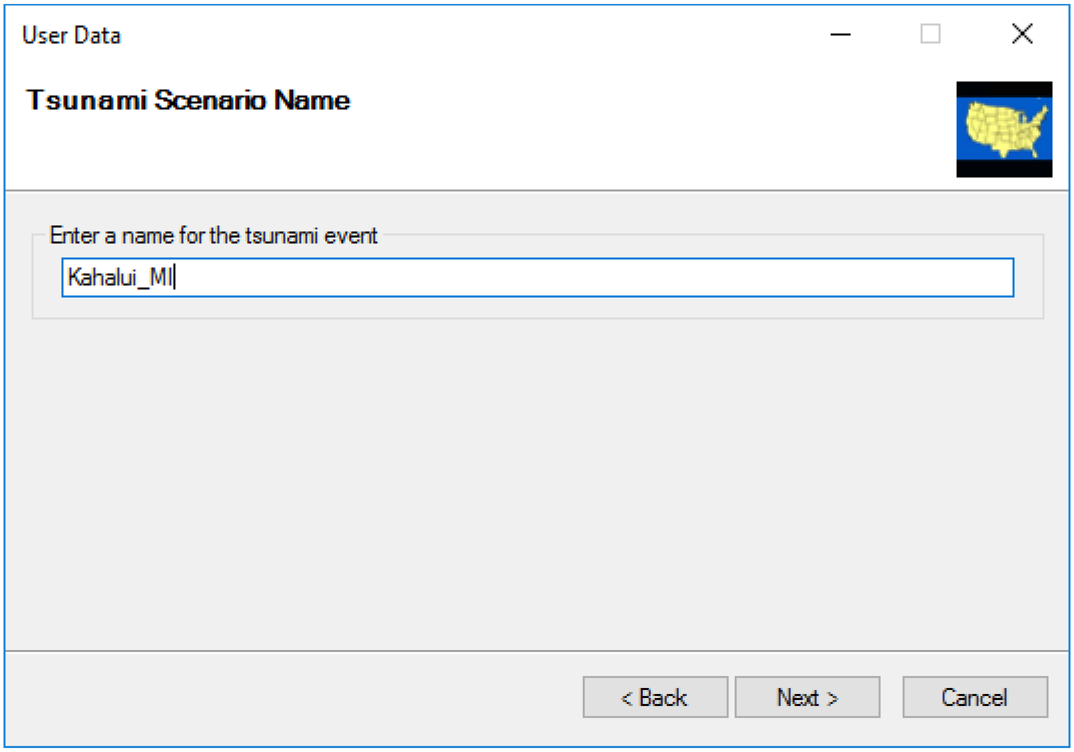
Browse DEM: **Mask**

Browse Height: **Maui**

Click OK and then Next when the processing is complete.



Enter a name for the scenario. The processing may take a few minutes to complete.



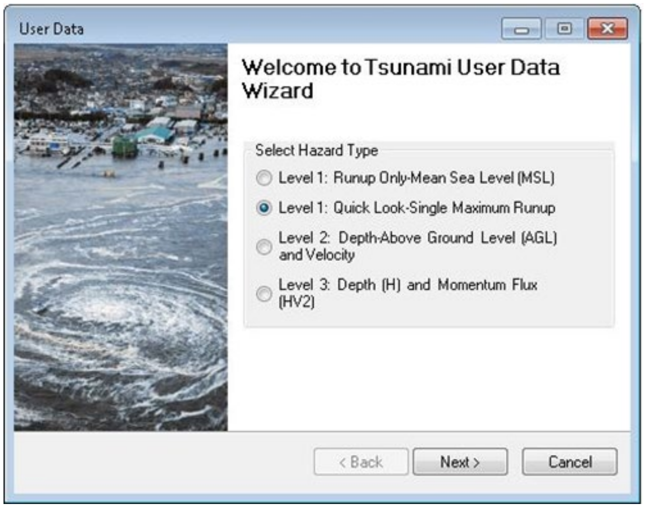
In the previous step, the Level 1: Runup Only-Mean Sea Level (MSL) option was used so that the DEM could be selected and downloaded. This task will now switch to the Level 1: Quick Look-Single Maximum Runup option to calculated runup.

> *For the Level 1: Quick Look-Single Maximum Runup option, the user is able to enter a height value for the maximum tsunami runup. For the Level 1: Runup Only-Mean Sea Level (MSL) option, the required input for tsunami maximum runup is a raster grid.*

From the Toolbar, under **Hazard**, select **User Data**.

Select the **Level 1: Quick Look-Single Maximum Runup** option

Click **Next**



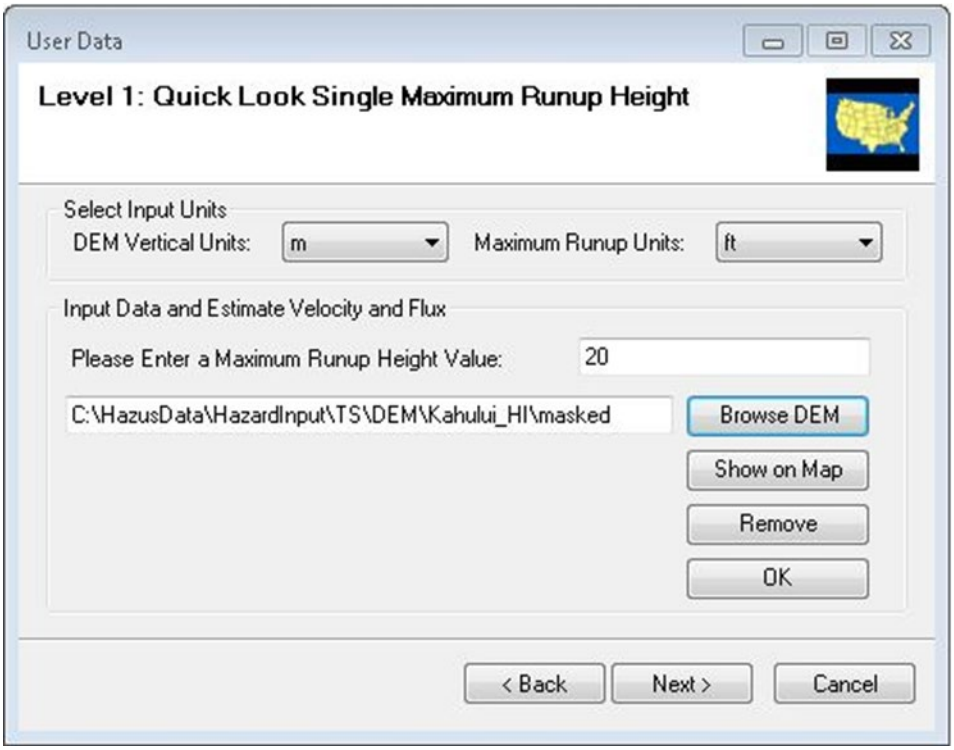
In the Quick Look Window, enter the following:

Input Units:

- DEM Vertical Units: **m** (Note: NED DEMs are all in meters)
- Maximum Runup Unit: **ft**
- Maximum Runup Height Value: **20**

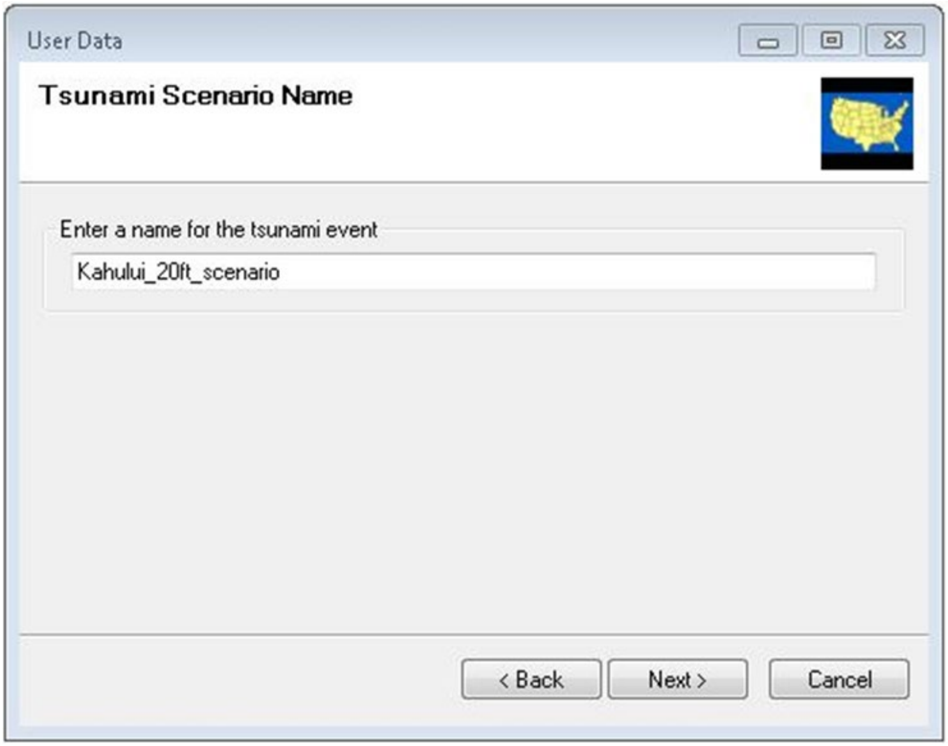
Click the Browse DEM button and select the **masked DEM** from the earlier steps. Options to Show the DEM on the Map or Remove the DEM are also provided.

Click **OK**

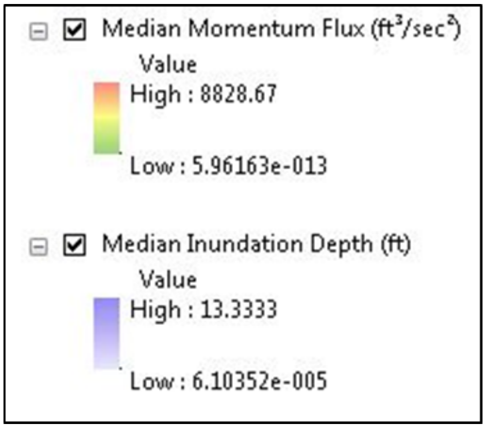


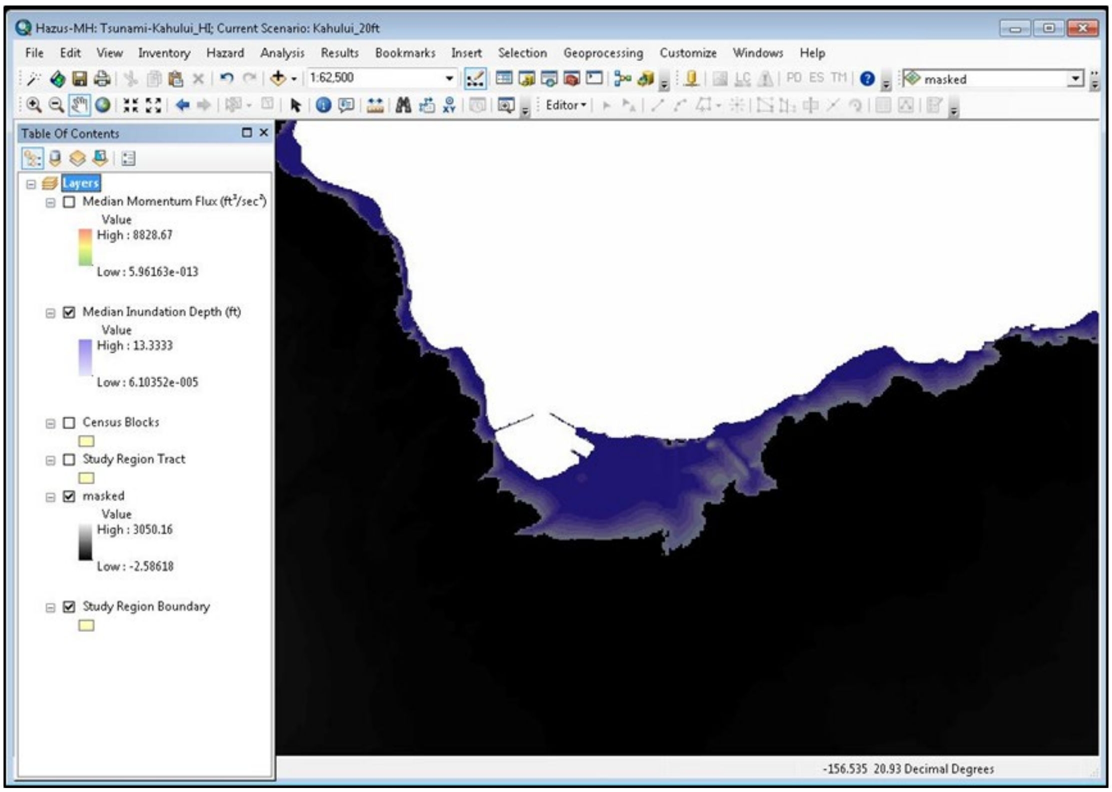
The processing window will popup. It may take a couple minutes.

In the Tsunami Scenario Name window. Enter: **Kahului_20ft_scenario**
Click **Next**



The Create Hazard Boundary processing window will popup. The model uses the DEM and entered Maximum Runup Height Value to create a Hazard Boundary for the analysis. The boundaries also include a Median Inundation Depth (ft) and a Median Momentum Flux (ft3/sec2). The layers will be added to the study region view. Click **OK** to continue.

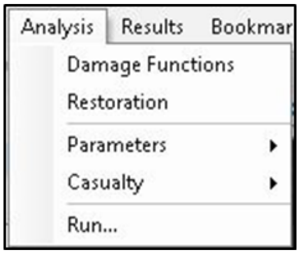


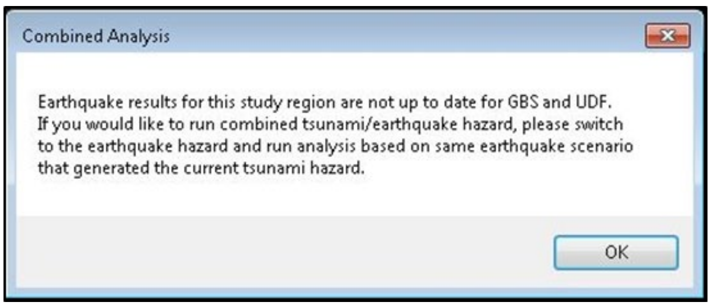


The next step will combine the depth and momentum flux layers with the infrastructure data to estimate potential damages and losses.

From the Tool Bar, Under Analysis, select **Run…**

A Combined Analysis Window will appear. This note refers to the combined earthquake/tsunami analysis. For the purpose of this exercise, click **OK** to continue.

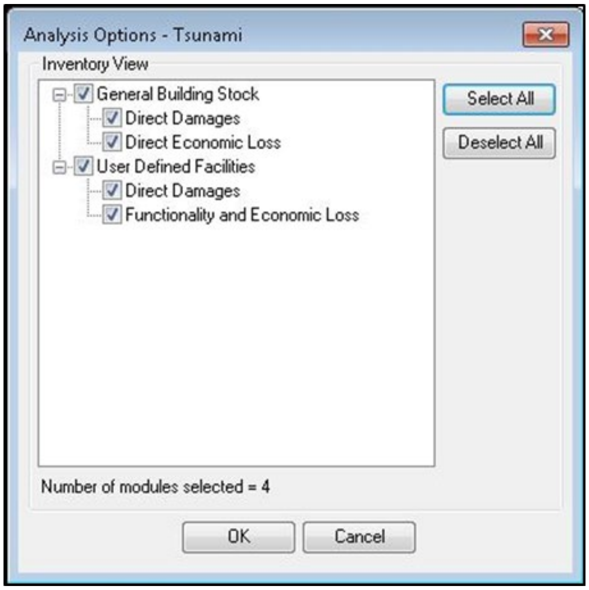




In the Analysis Option-Tsunami Window:

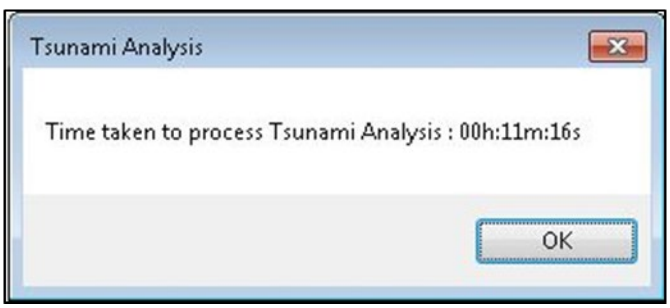
Click the **Select All** button.

> *You can also select just the General Building Stock by clicking in the box. The Hawaii default database does not contain User Defined Facilities at the moment. Results for this option will be blank.*



The processing window for Populating Tsunami NSI GBS Data will popup. It may process for a few minutes.

When the analysis is complete is complete, a popup window will appear. Click **OK** to complete.



Task 2 will walk the user through a Casualty Level 1 Analysis for Kahului, Maui, and builds on the results from Task 1. The Casualty Level 1 Analysis uses the Hazard Boundaries, the road networks, the topography, and the NSI demographic data to estimate: Evacuation Travel Time, Injuries, and Casualties. The results are reported by age, time of day, and preparedness level of the community. These estimates can be used to promote awareness, identify areas where vertical evacuation may be an option, etc.

From the Toolbar, select **Analysis**, then select **Casualty**.

The first step is to download the road data. To do this, select **Download TIGER Roadway Network**.

The TIGER Roadway Network has already been downloaded to the student data folder.

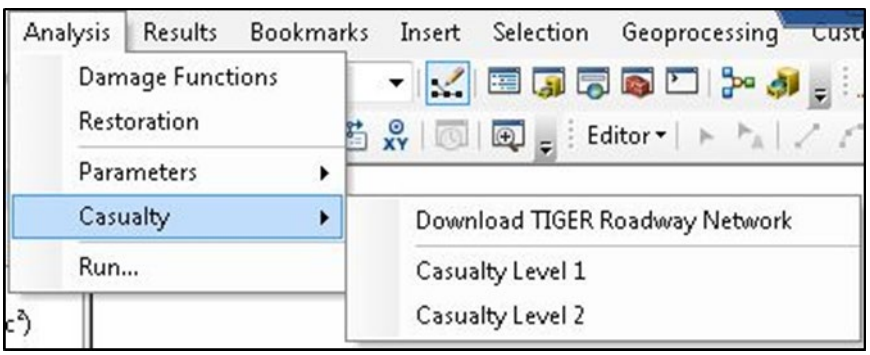
This step will identify the TIGER road data (US Census) for the study region. The data will be saved to **C:\HazusData\HazusInput\TS\TIGER** under the id number for the County FIPS.

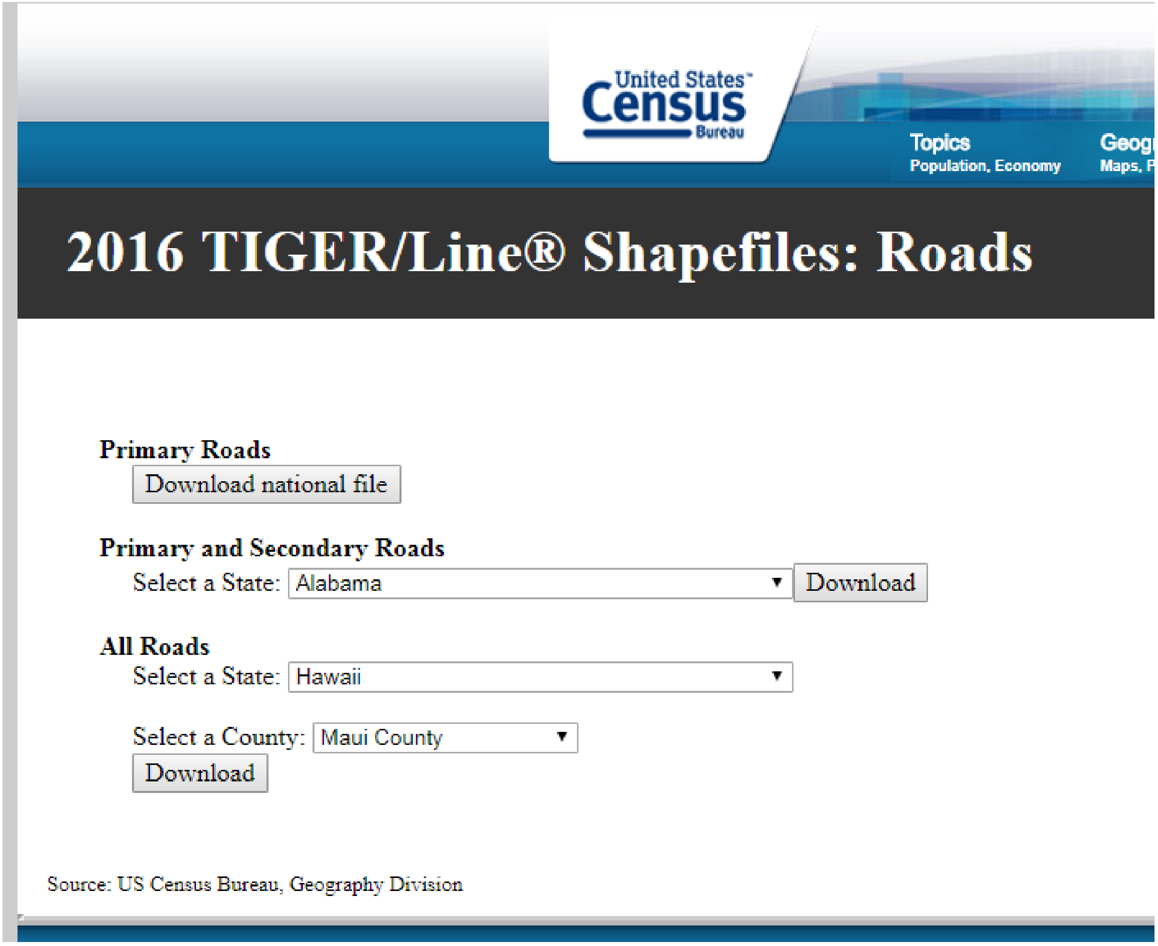
Note: If the data does not download, it can be obtained straight from the website at: https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2016&layergroup=Roads

Save the downloaded data to the address above.

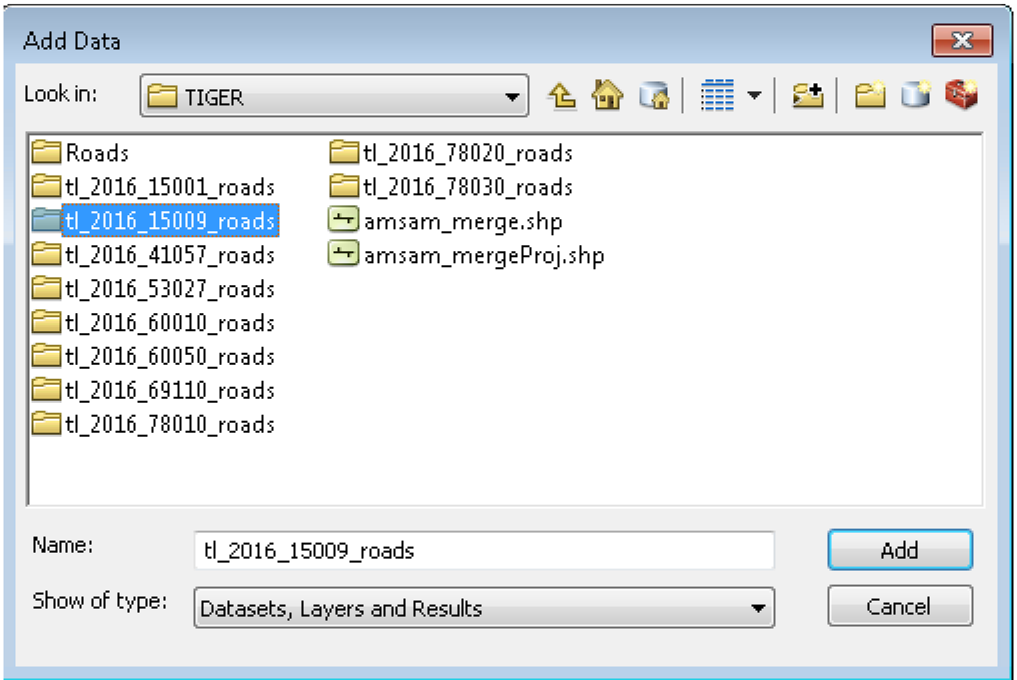
The roads for Maui County are: **tl_2016_15009_roads**

Add the **roads** to the viewer.

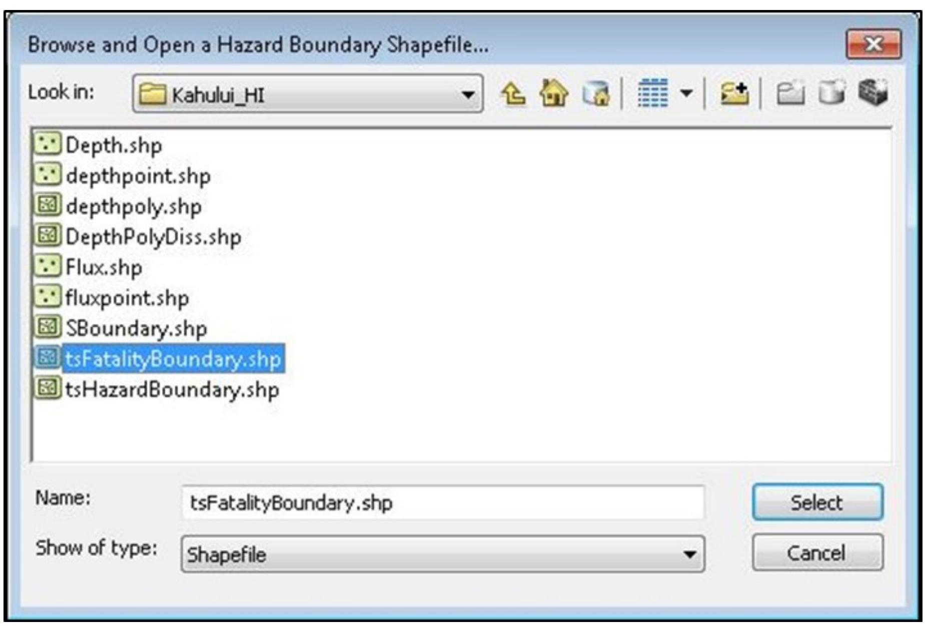




Source: US Census Bureau, Geography Division

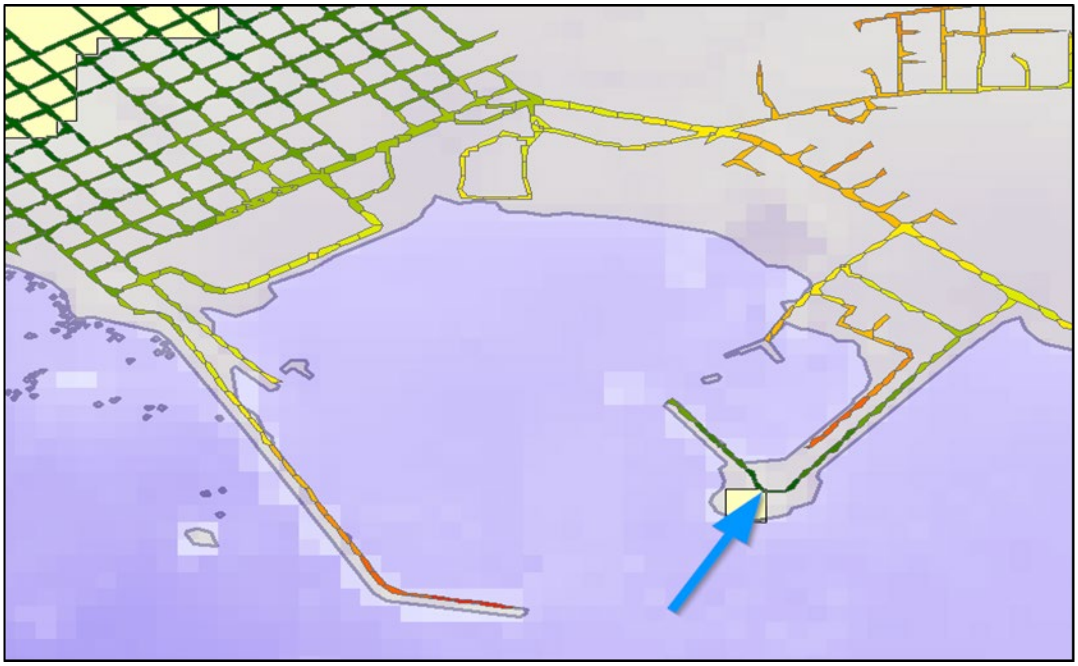


Review the Hazard and Fatality Boundary layers for slivers (or gaps) in the data. These layers are processed by the model and are located in the Study Region folder: **C:\HazusData\HazusInventory\Regions\Kahului_HI**



Add the data to the viewer and compare with the roads data from the step above.

If the gaps overlap with the road data, the model will read this as a safe place for evacuation (represented in the image – see blue arrow). If the gap does not overlap with a road, it will not be considered in the calculation.



For this scenario, there are gaps at the Kahului Harbor inside the red box. To fix the layer, use the **Editor** toolbar.

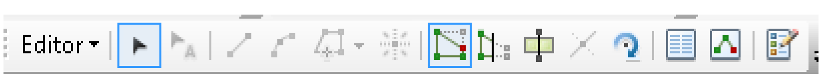
In the drop down menu, select '**Start Editing'**.

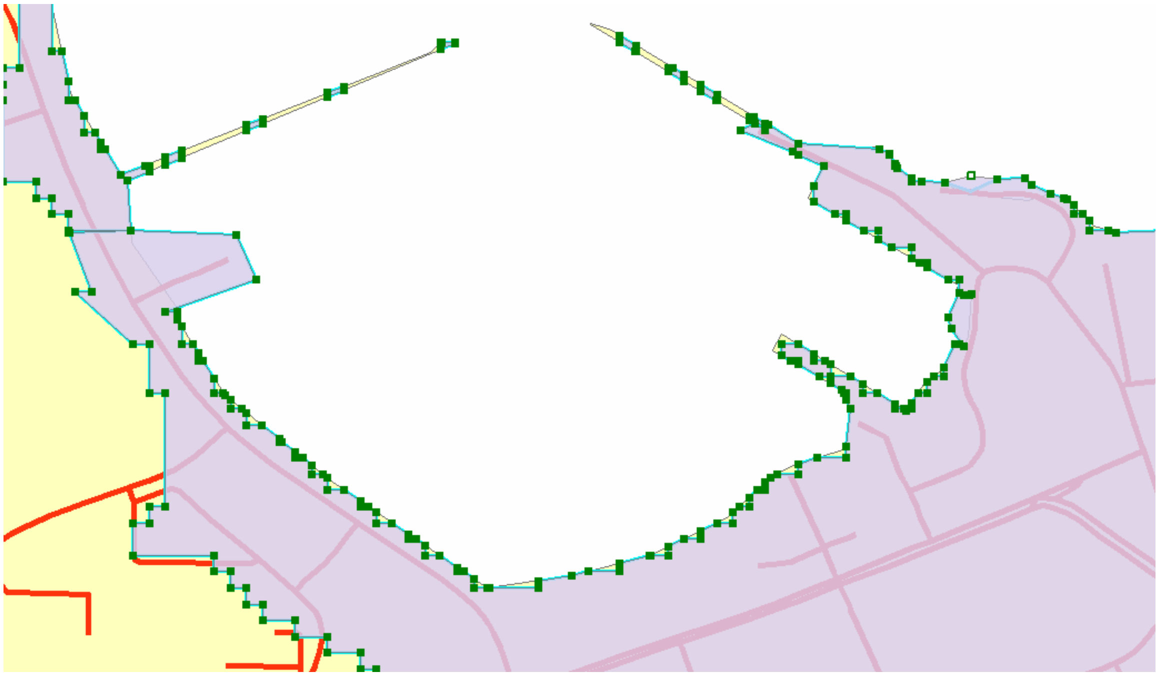
Select the **Fatality Boundary**, and use the **Edit Vertices** option.

Click on the green square and drag the polygon to cover the road.

When finished elect '**Stop Editing'** from the drop down menu, and **Save** the edits.

Repeat with **Hazard Boundary.**





From the Tool bar, Under **Analysis**, Select **Casualty Level 1.**

In the Casualty Level 1 Wizard, enter:

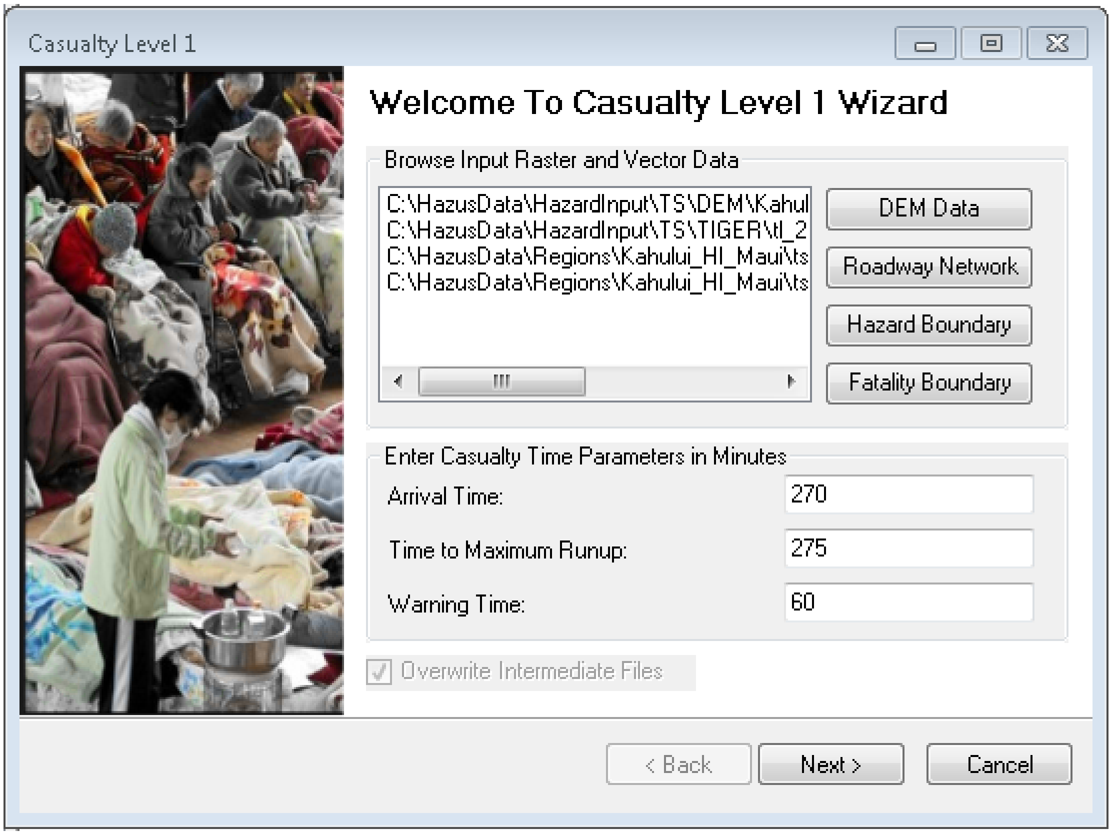
- DEM Data: **masked raster**
- Roadway Network: **tl_2016_15009_roads**
- Hazard Boundary: **tsHazardBoundary**
- Fatality Boundary: **tsFatalityBoundary**

Enter the Time in Minutes:

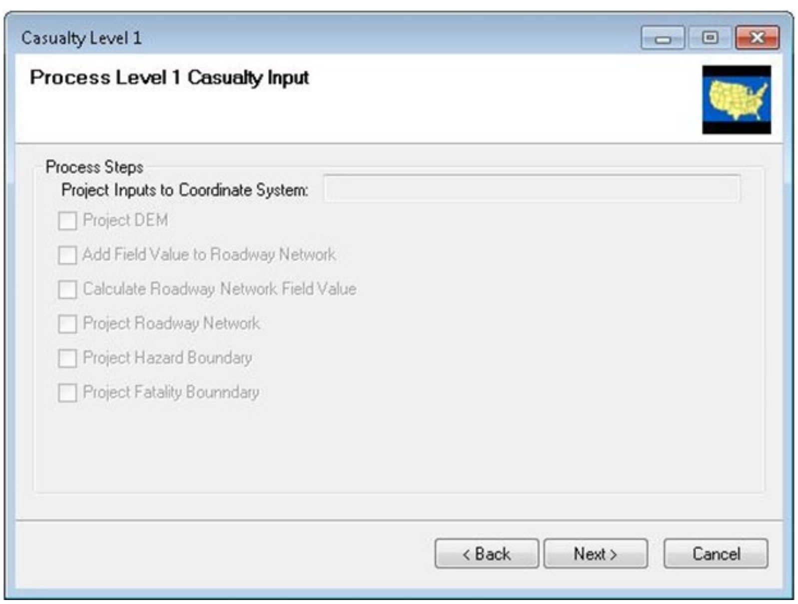
- Arrival Time (of the first wave): **270 minutes**
- Time to Maximum Runup (largest wave): **275 minutes**
- Warning Time (to community): **60 minutes**

Note: 0 is not a valid entry. Also, the Time to Maximum Runup and Warning time will fill with default values after the user enters the Arrival Time of the first wave.

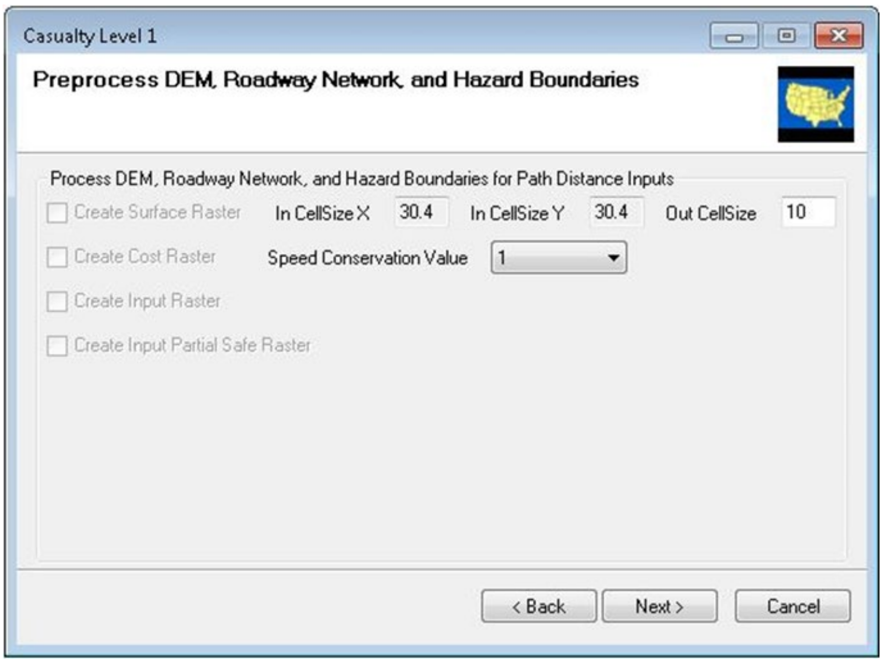
Click **Next** to continue.



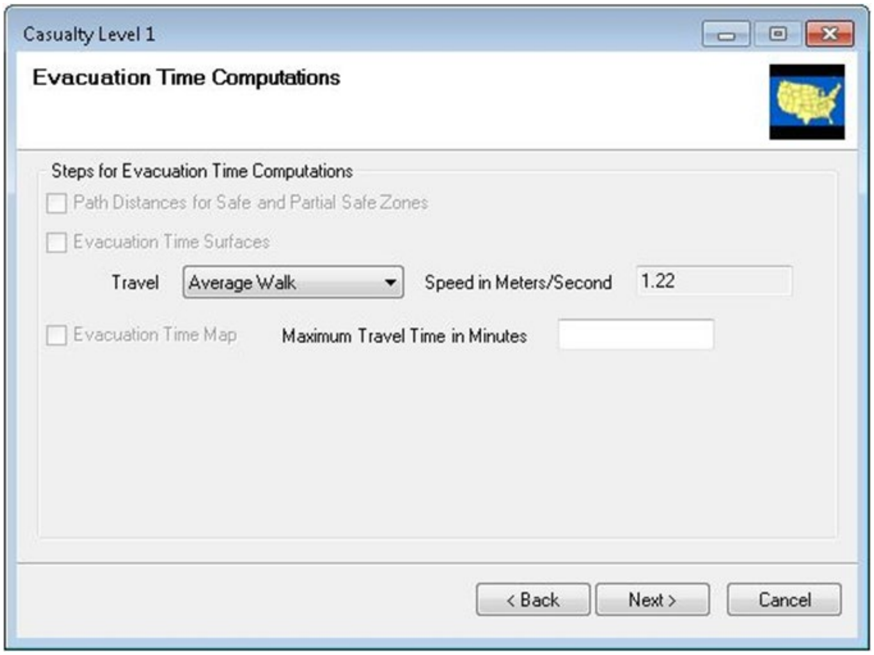
The next couple of steps are processed by the model. The first projects the inputs to the same coordinate system. Click **Next** to continue.



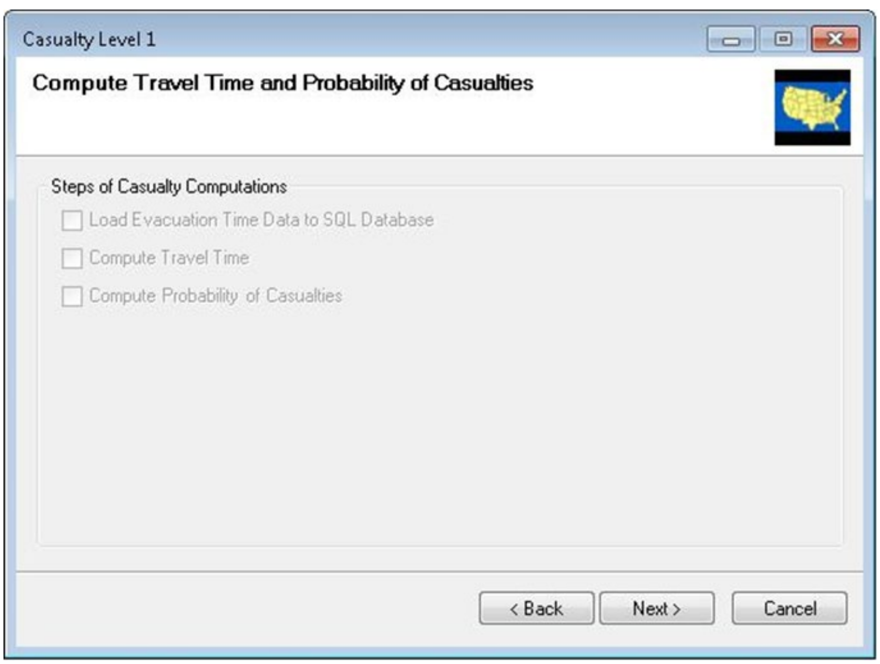
The next step preprocesses the DEM, Road Network and Hazard Boundaries. The Output Cell Size can be entered by the user – or use the default of 10 m. The Speed Conservation Value allows the user to determine potential resistance to the evacuees – like impassible brush. However, for this analysis, a default of **1** is suggested. This represents little to no resistance – or that the evacuees will be traveling along open roads. Click **Next** to continue.



Next, the travel speed of the population can be selected. The model considers a difference between speed based on population over or under age 65. For this step, the user selects one. **Average Walk** is the default. Click **Next** to continue.



Next the model computes the Travel Time and Probability of Casualties. Click **Next** to continue.



The Complete Casualty Level 1 Wizard window is the last. Click **OK** to finish.

The results can be accessed via the Results menu, from the Tool Bar, after running the Tsunami GBS Scenario and Casualty Analysis. A few examples are provided in the task below.

Building Damage:

Find out how many residential buildings were impacted by the scenario tsunami, using the results table and summary report.

To access the results table: From the Tool Bar, under **Results**, select **General Building Stock**.

Select **Damage by Count**

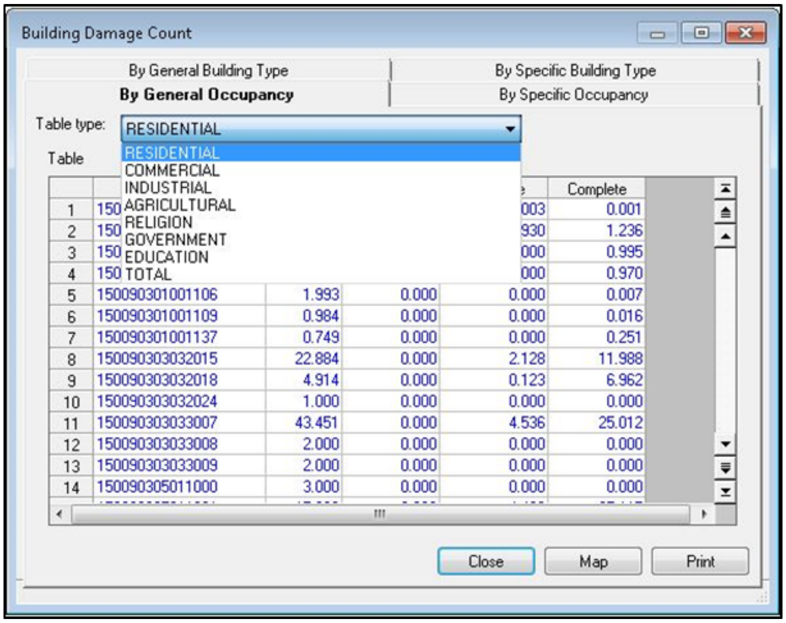
In the Building Damage Count Window:

Select the **By General Occupancy** tab

Select **RESIDENTIAL** from the drop-down menu

The data is displayed by Census Block for four levels of damage: None, Moderate, Extensive, and Complete.

> *With tsunami losses, Moderate is a rare damage state since light frame construction buildings enter the Extensive damage state once exposed to a minimal threshold of tsunami inundation. The Moderate damage category will occur for Mid- and High-rise as well as reinforced concrete and steel structures.*
>
> *The values for damage are building counts aggregated by damage state probabilities. This may lead to "counts" of damaged buildings with decimals, giving the appearance that fractions of the buildings were counted. This provides more accurate aggregated damage counts since no fractions are discarded.*

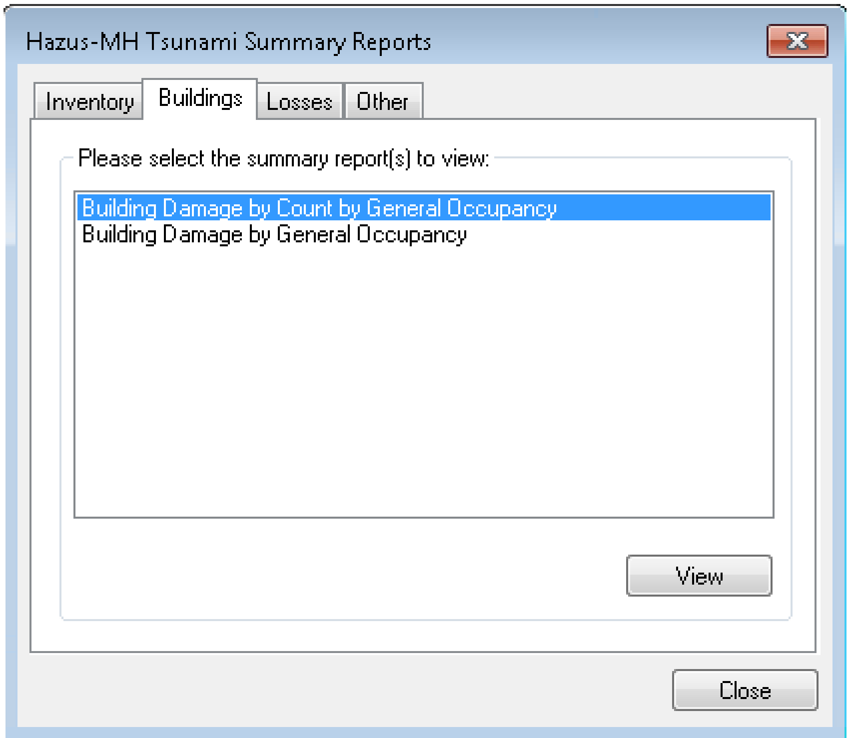


The data can also be accessed in report form. From the Tool Bar, under **Results**, select **Summary Reports**.

In the Hazus Tsunami Summary Reports window:

Select the **Buildings Tab**

Select **Building Damage by Count by General Occupancy**.



Direct Economic Losses

Find out the Total Losses for Residential Damages produced by the scenario tsunami, using the results table and summary report.

From the Tool Bar, under **Results**, select **General Building Stock.**

Select **Direct Economic Losses**

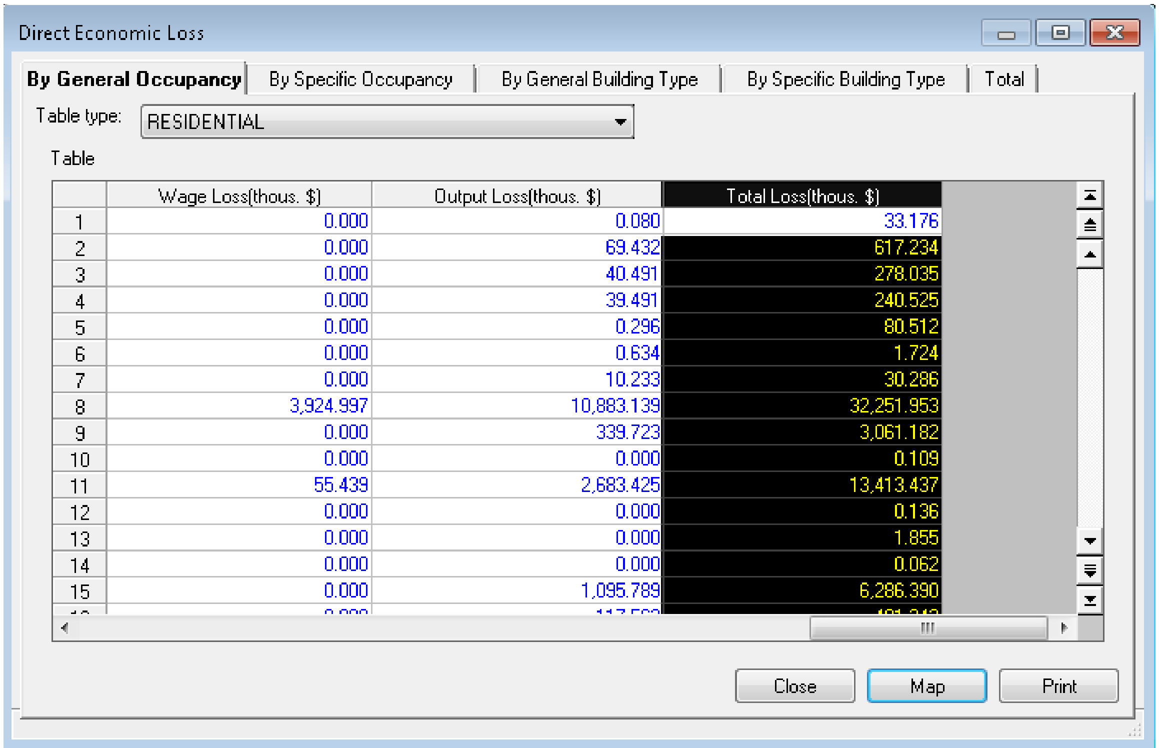
In the Direct Economic Loss window, select:

By General Occupancy tab

Table type: **RESIDENTIAL**

Scroll all the way to the right to view **Total Losses (in thousands of $)**

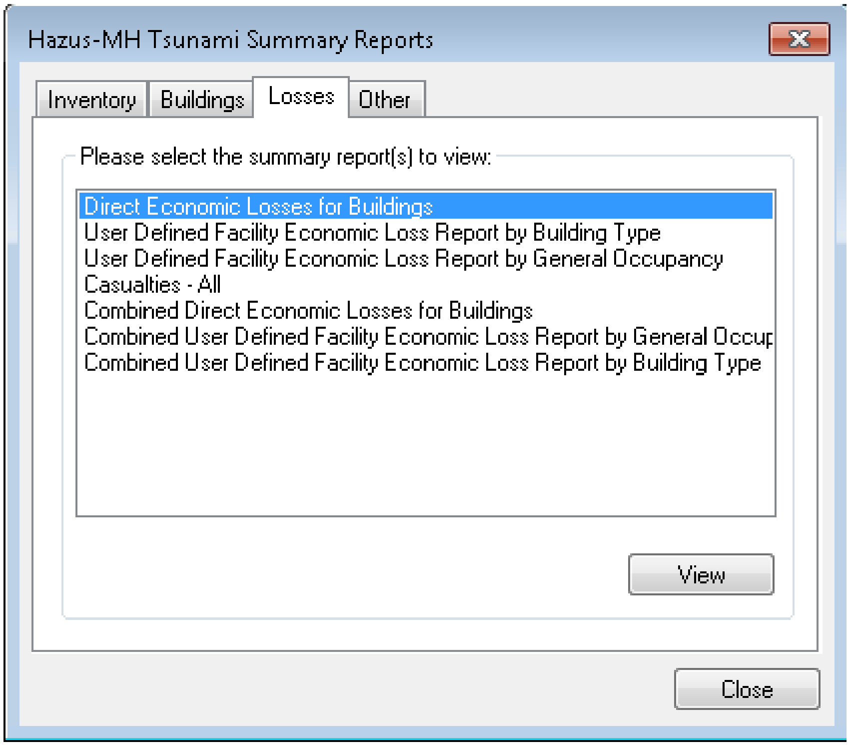
> *Note: data is displayed by Census Block.*



The data is also accessible in report form.

Under the **Results** Menu, select **Summary Reports**

In the Hazus Tsunami Summary Reports, select the Losses tab and then select **Direct Economic Losses for Buildings**



Casualties

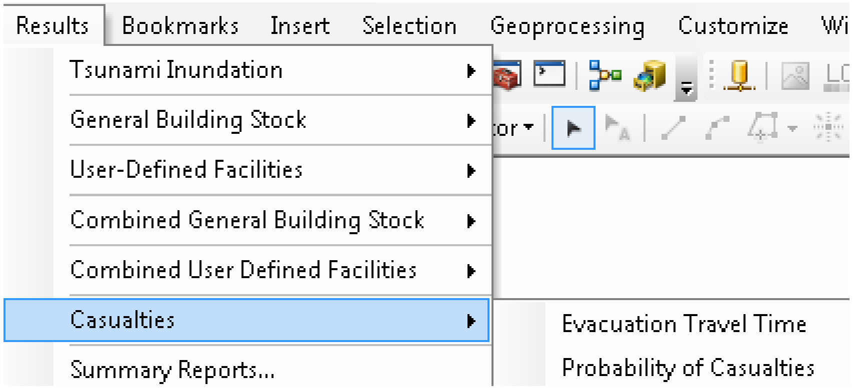
Find out the Evacuation Travel Times for the scenario.

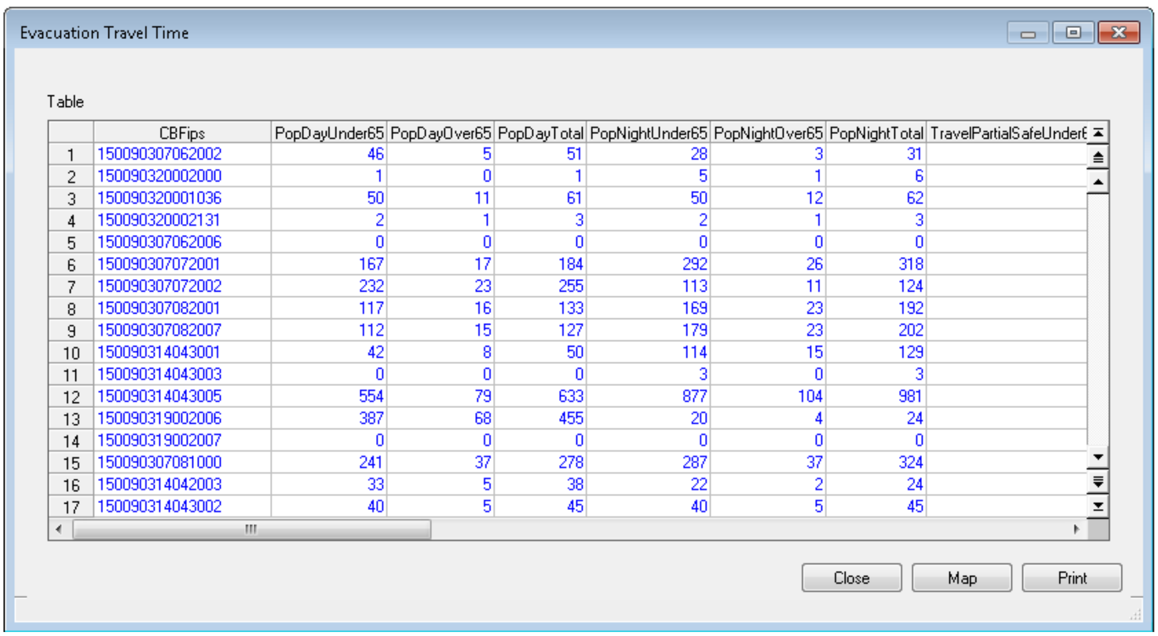
From the Tool Bar, under **Results**, select **Casualties**.

Select **Evacuation Travel Times**.

The table displays:

- Day/Night population by Age – Over/Under 65
- Day/Night population by total
- Time to Partial Safety
- Time to Safety



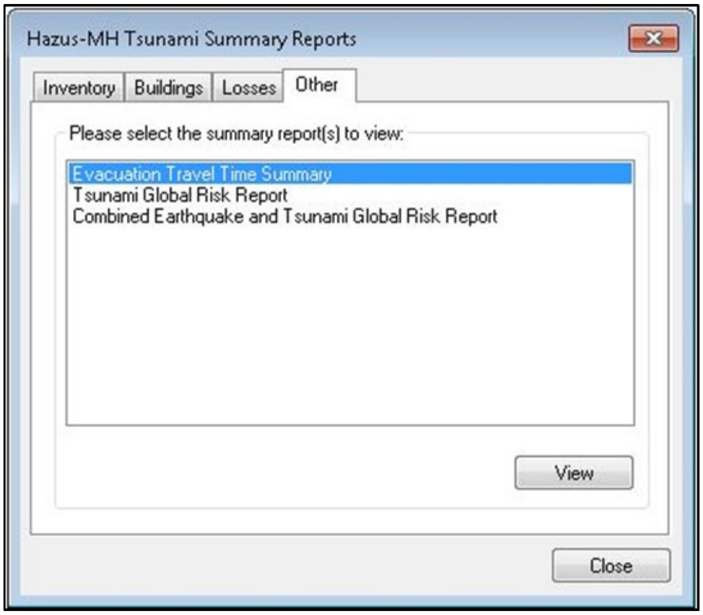


	CBFips	PopDayUnder65	PopDayOver65	PopDayTotal	PopNightUnder65	PopNightOver65	PopNightTotal	TravelPartialSafeUnder6
1	150090307062002	46	5	51	28	3	31	
2	150090320002000	1	0	1	5	1	6	
3	150090320001036	50	11	61	50	12	62	
4	150090320002131	2	1	3	2	1	3	
5	150090307062006	0	0	0	0	0	0	
6	150090307072001	167	17	184	292	26	318	
7	150090307072002	232	23	255	113	11	124	
8	150090307082001	117	16	133	169	23	192	
9	150090307082007	112	15	127	179	23	202	
10	150090314043001	42	8	50	114	15	129	
11	150090314043003	0	0	0	3	0	3	
12	150090314043005	554	79	633	877	104	981	
13	150090319002006	387	68	455	20	4	24	
14	150090319002007	0	0	0	0	0	0	
15	150090307081000	241	37	278	287	37	324	
16	150090314042003	33	5	38	22	2	24	
17	150090314043002	40	5	45	40	5	45	

Under the **Results** Menu, select **Summary Reports.**

In the Hazus Tsunami Summary Reports window, select **Other tab**, and then select **Evacuation Travel Time Summary**.

Note: the Casualties report is located under the Losses tab.

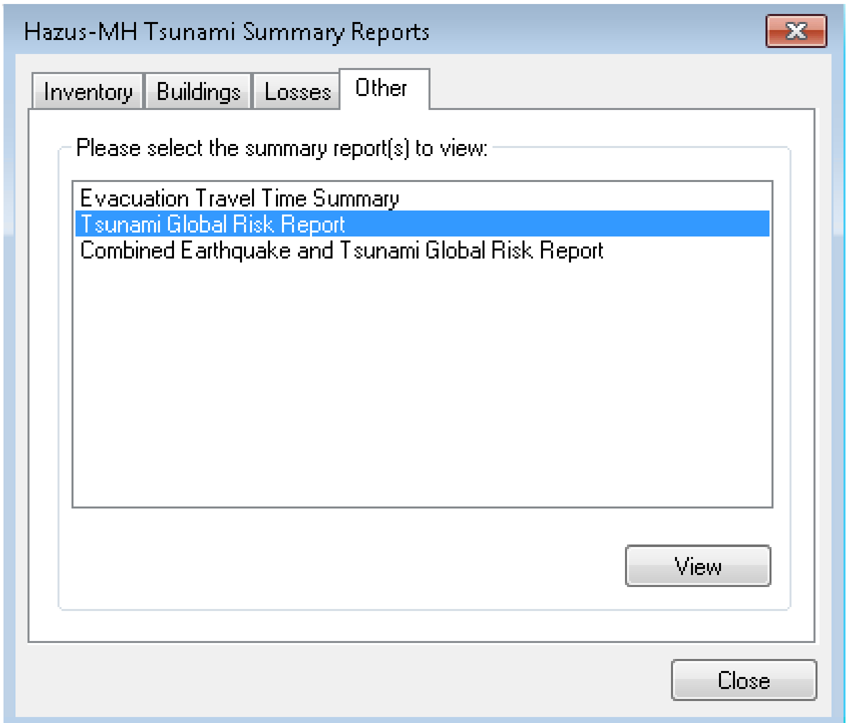


Summary Reports

The data is also available in the Tsunami Global Risk report. This 14 page report presents the damages, losses and casualties in text, table and graphic format.

From the **Results** Menu, select **Summary Reports.**

In the Hazus Tsunami Summary Reports window, select the **Other** tab and then select **Tsunami Global Risk Report**


Hazus-MH Tsunami Summary Reports
Inventory
Buildings
Losses
Other
Please select the summary report(s) to view:
Evacuation Travel Time Summary
Tsunami Global Risk Report
Combined Earthquake and Tsunami Global Risk Report
View
Close

Activity 12.1 - Historic Hurricane Scenario

Type: Student-Led Activity

Time: 10 minutes

Background

This activity is designed to familiarize you with the capabilities of the Hazus hurricane model. In the process of completing this activity you will use the large database of historic storms that comes with Hazus to model the impacts of a storm like the 1996 Hurricane Fran, but based on more recent information about the vulnerabilities of the study area.

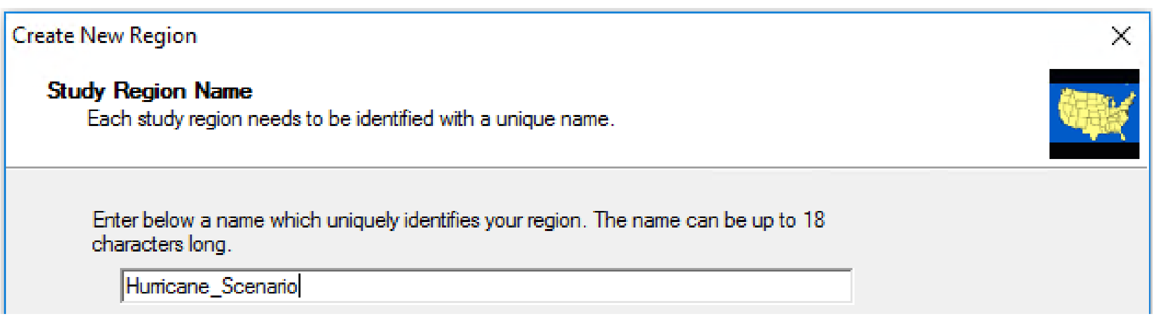
Task 1: Create a New Study Region

Start Hazus.

Click the Create a new region button and then click the OK button to start the Create New Region wizard.

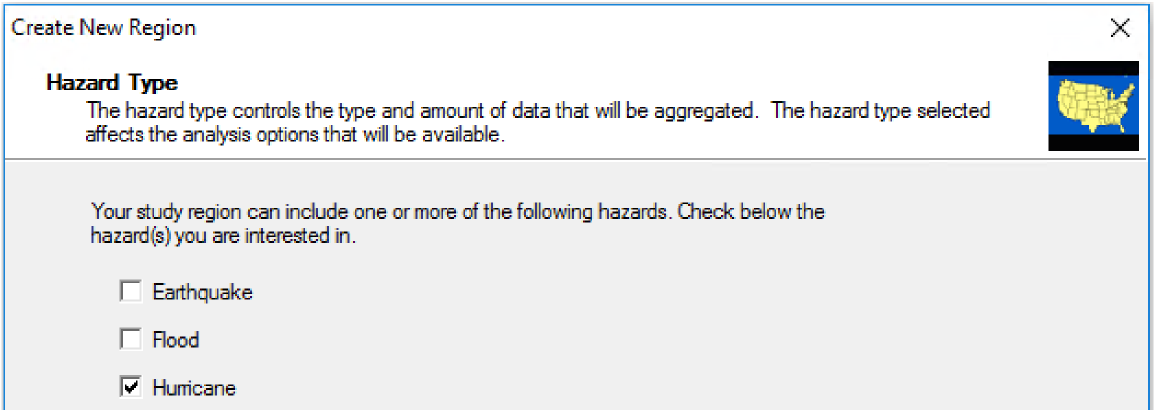
Click the Next button to move to the next Study Region name edit box.

Type Hurricane_Scenario in the Name edit box.



Click the Next button to move to the Hazard Type screen of the Create New Region wizard.

Click the Hurricane hazard button as shown on the example below.



Click the Next button to move to the scenario wizard option screen.

When prompted to indicate whether you wish to create a study region using the Hurricane Scenario Wizard, click No.

Click the County button.

Click the Next button to open the State Selection window.

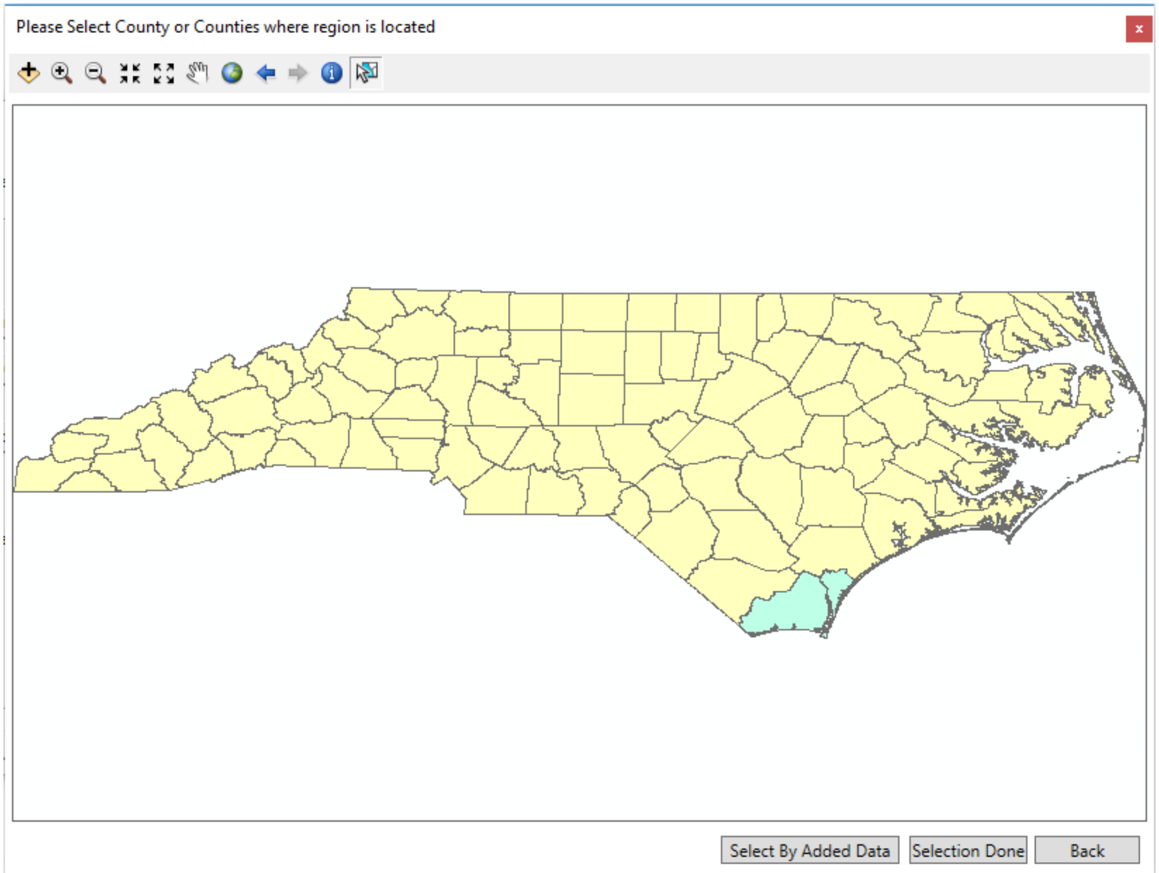
Scroll down in the State selection list until you see North Carolina. Click North Carolina.

Click the Next button to move to the County Selection window.

Click the Show Map button to open the interactive map window.

The Show Map utility is very helpful in situations where you know the approximate location in which you want to model a hazard but where you are unfamiliar with the names of the counties.

While holding the Shift key, select the two counties in the southernmost part of the state (Brunswick and New Hanover) as shown below.



Click Selection Done to close the interactive map window.

Brunswick and New Hanover Counties should now be highlighted in the list of counties.

Click the Next button to move to the final screen of the Create New Region wizard.

Click the Finish button to complete the Create New Region wizard and to begin creating your study region.

Click OK to close the Region aggregation successful message and to return to the Hazus startup screen.

Open the Hurricane_Scenario region.

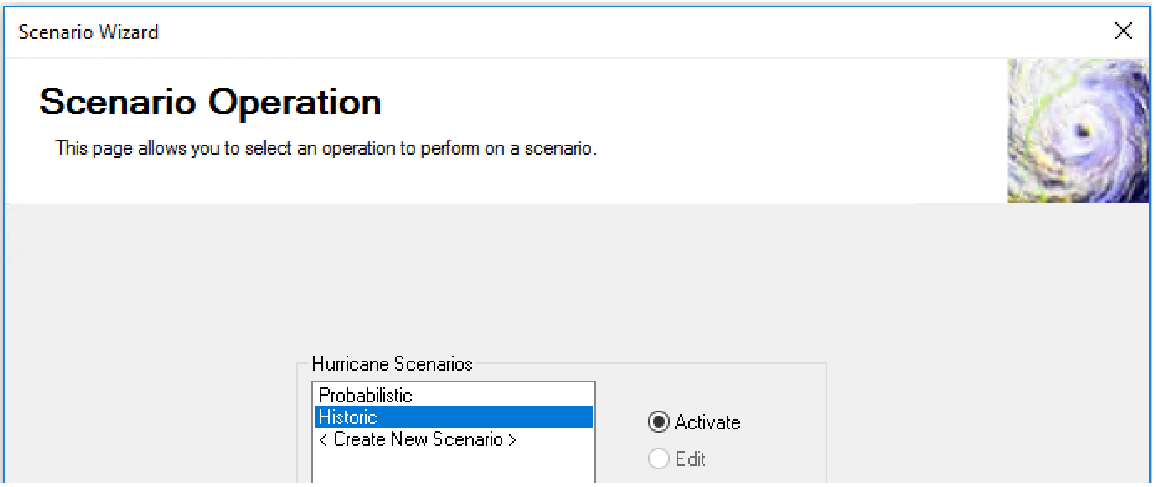
Task 2: Define a Hazard Using the Historical Storm Database

From the Hazard menu select Scenario to open the Scenario Wizard.

Click Next to move to the Scenario Operation window.

Choose the Historic option.

Hazus comes with a database of historic hurricanes. This database can be accessed to analyze the impact that a previous storm would have today if it were to strike in the same location.



Click the Next button to move to the Historic storm list. An example of this list is provided below.

Year	Name	Peak Gust (mph)	States Affected	Landfall States
1900	UN-NAMED-1900-1	122	FL LA MS NY TX	TX
1906	UN-NAMED-1906-6	123	AL FL LA MS	AL
1906	UN-NAMED-1906-5	130	FL GA SC	FL
1906	UN-NAMED-1906-5	93	GA NC SC	SC
1909	UN-NAMED-1909-4	118	TX	TX
1909	UN-NAMED-1909-8	126	LA MS	LA

1910	UN-NAMED-1910-5	129	FL GA NC SC	FL
1915	UN-NAMED-1915-6	126	AL LA MS WV	LA

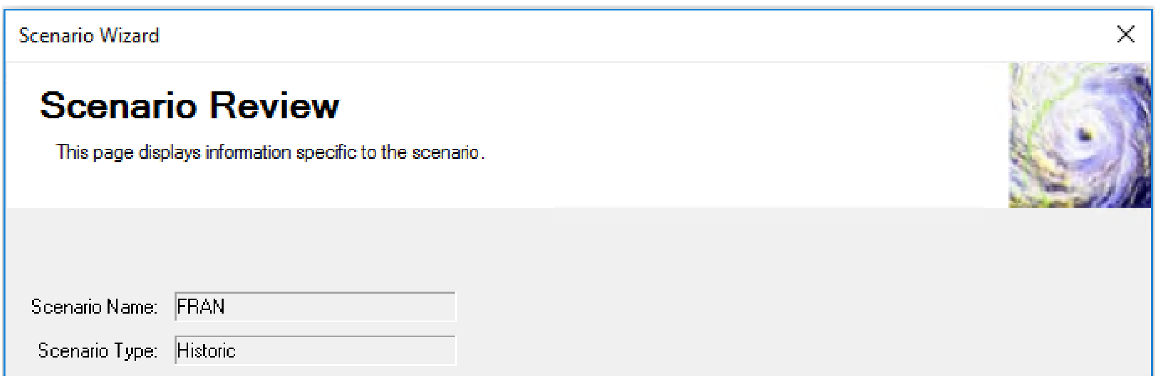
Click the Region Filter button to hide all storms that did not impact North Carolina.

The Region Filter button hides all storms that did not have an impact on the study region.

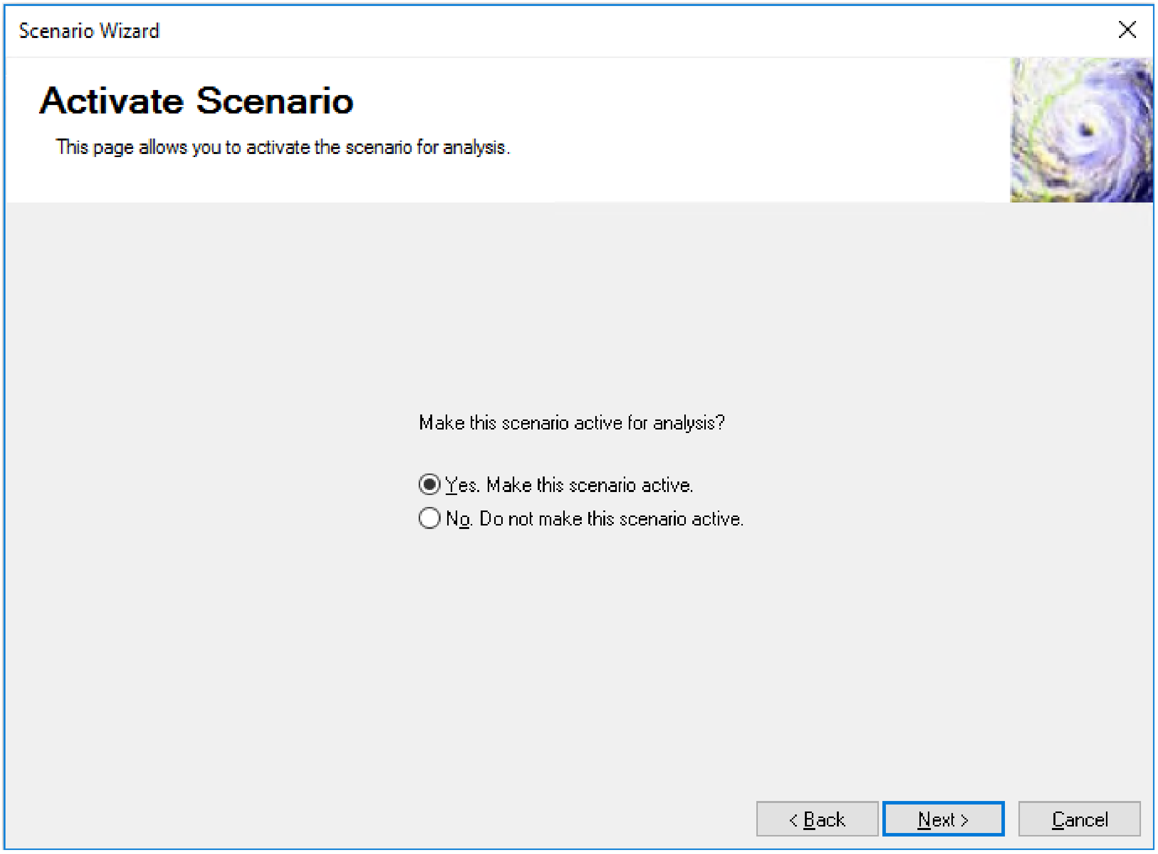
Click the 1996 FRAN storm record.

The historical storm inventory includes information about which states were impacted by the storm as well as statistics about each storm such as peak wind gust. This information can be useful when trying to determine which storm you want to analyze.

Click the Next button to view the Scenario Review window.



Click the Next button to view the Activate Scenario window.



Click Yes to indicate that you want to make this the active scenario and click the Next button to move to the final window of the Scenario Wizard.

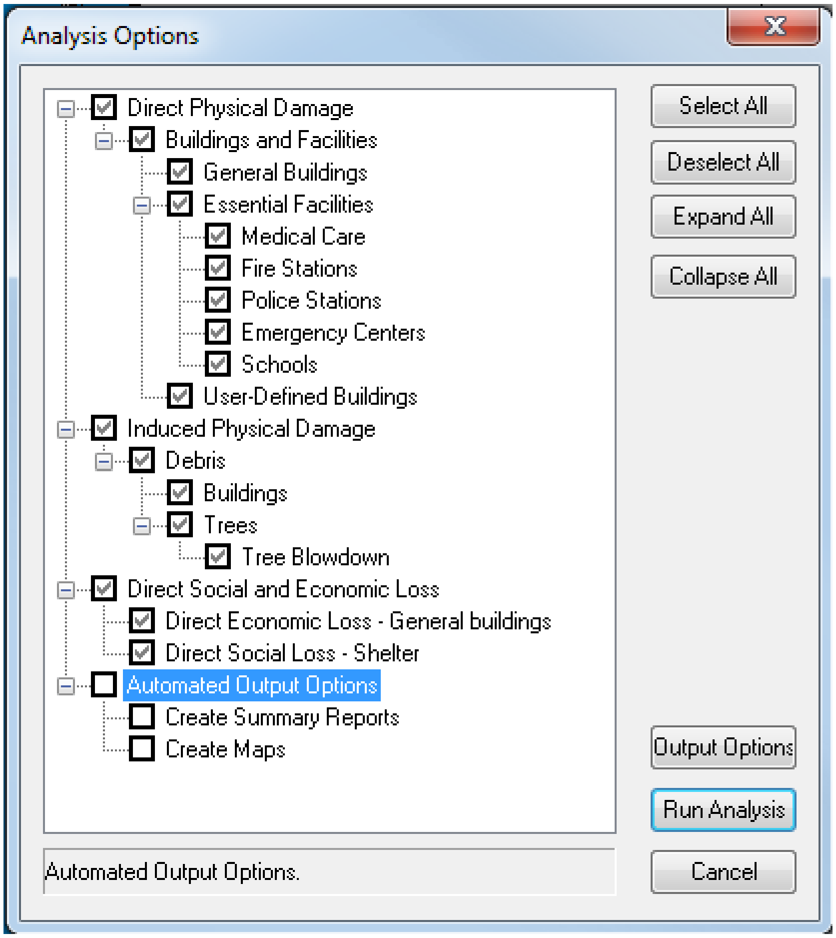
Making a scenario active does not automatically update analysis results. It only prepares Hazus to run an analysis based on the chosen scenario parameters.

Click Finish to finish defining the scenario.

Task 3: Run the Analysis

From the Analysis menu choose Run to open the Analysis Options window. Uncheck the Automated Output Options button.

By default all analysis options are automatically selected.



Click Run Analysis to run the analysis.

When the analysis is complete a box indicating that to be the case will display. It will take about 5 minutes to complete the analysis.

Click OK when the analysis has completed.

Task 4: View the Windfield Model Outputs

From the Results menu click Storm Track > FRAN Storm Track.

From the Results menu choose Wind Speeds to open the Wind Speeds by Census Tract window.

	Peak Gust (mph)	Maximum Sustained (mph)
37019020101	96	75
37019020102	97	76

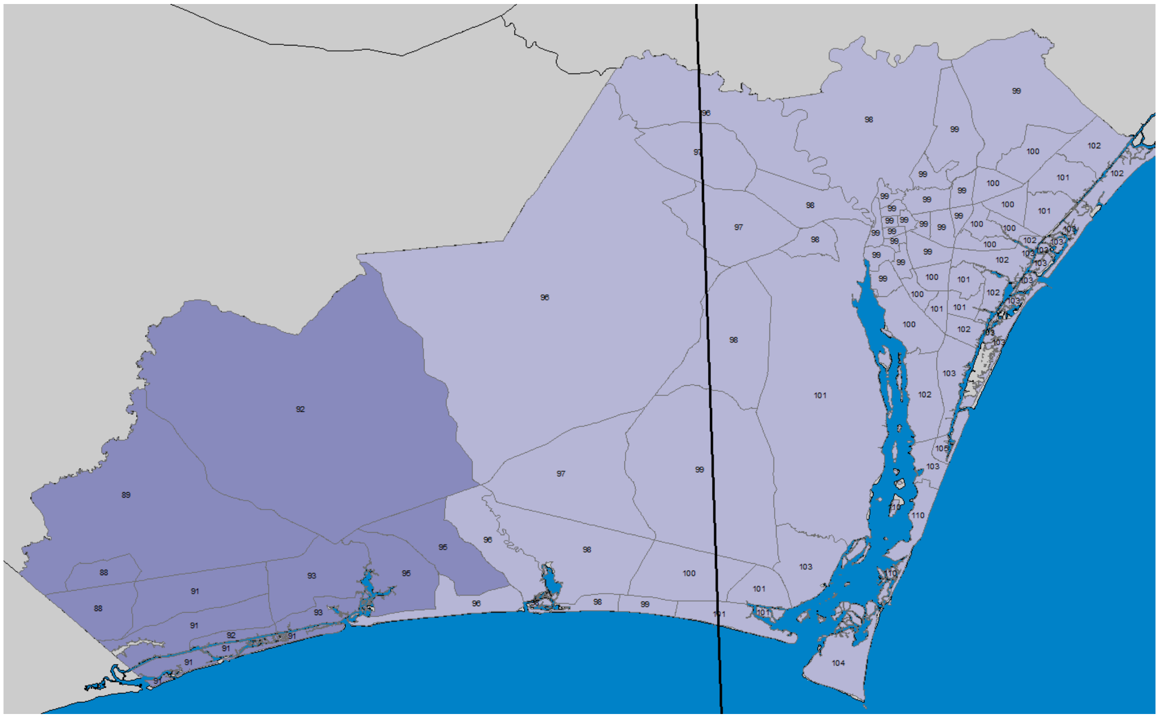
37019020103	97	76
37019020104	98	77
37019020201	98	77
37019020202	101	79
37019020203	98	77
37019020204	99	78
37019020303	98	77
37019020304	100	79
37019020305	101	79

Click the Peak Gust (mph) field and then click the Map button.

The windspeeds table provides you with detailed information about estimated winds by census tract.

Click the Close button to close the Windspeeds by Census Tract window.

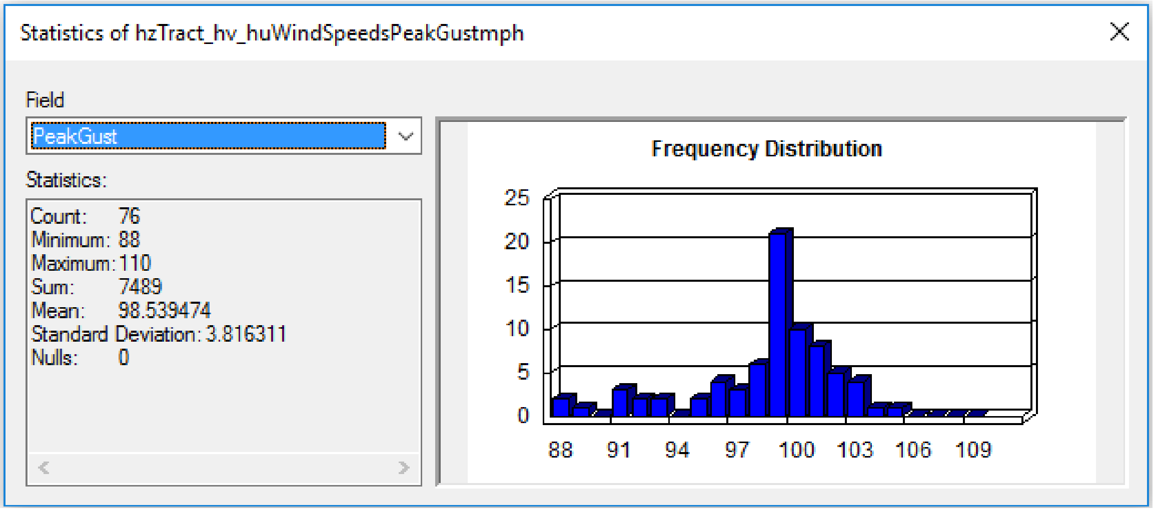
The map should be updated to show the distribution of wind speeds.



Right-click on the Wind Speeds – Peak Gust (mph) layer and choose Open Attribute Table.

Layer attribute tables generally contain the same information found in the Hazus tables plus some additional fields such as those that describe the type of shape, area of the shape, and so forth.

Right-click on the PEAKGUST field in the Attributes of Wind Speeds layer and choose Statistics from the field context menu. The Maximum value is the peak wind gust. Enter this value in the Peak Wind Gust column of the Activity Results table at the end of the activity.



Close the Statistics window and the Attributes of Wind Speeds (Peak Gust MPH) table.

Task 4: Explore the Economic Impact to Buildings

From the Results menu choose Summary Reports to open the Summary Reports window. Click on the Direct Losses tab.

Open the Direct Economic Loss for Buildings report.

In the Activity Results table at the end of the activity, record the Study Region Total under the Building Damage Cost column and the Total Loss column.

Close the Direct Economic Losses for Buildings Summary Report and close the Summary Reports window.

Leave the study region open so that it is ready for the next activity.

Activity Results

	Peak Gust (mph)	Building Damage Loss	Total Loss
Hurricane Fran Scenario			

Activity 12.2 - Probabilistic Hurricane Scenario

Type: Student-Led Activity

Time: 10 minutes

Background

In this exercise you will create a probabilistic hurricane analysis.

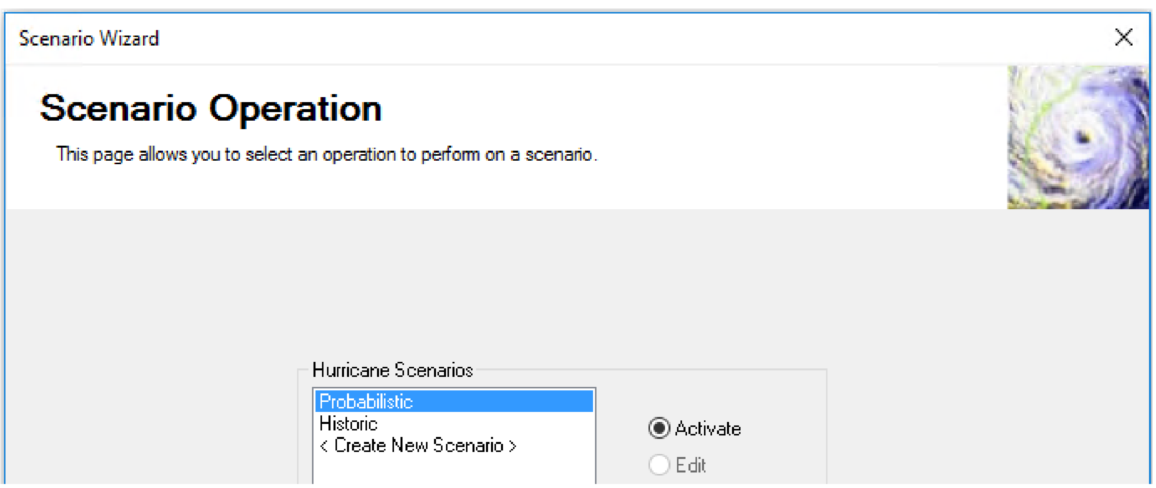
Task 1: Define a Probabilistic Scenario

From the Hazard menu select Scenario to open the Scenario Wizard.

As is the case with an earthquake hazard, a probabilistic hurricane analysis explores the statistical likelihood of a type of storm rather than any one storm.

Click Next to move to the Scenario Operation window.

Choose the Probabilistic option and click Next.



Click Yes to indicate that you want to make this the active scenario and then click Next to view the final window of the Scenario Wizard.

Click Finish to complete the scenario.

Task 2: Run the Analysis

From the Analysis menu choose Run to open the Analysis Options window. Unselect the Automated Output Options.

As earlier noted, you must run the analysis after making a scenario active in order to update the results.

Click Run Analysis to run the analysis.

It will take about 5-10 minutes to complete the analysis.

Click OK when you are told that the analysis has completed.

Task 3: Explore the Windfield Model Outputs

From the Results menu choose Wind Speeds to open the Wind Speeds by Census Tract window.

Due to the way the probabilistic scenario is calculated your track and windspeeds could be slightly different, and thus the next few graphics could be slightly different as well.

	10 Year Event Peak Gust (mph)	20 Year Event Peak Gust (mph)	50 Year Event Peak Gust (mph)	100 Year Event Peak Gust (mph)
37019020101	63	78	91	111
37019020102	64	78	94	112
37019020103	63	79	94	114
37019020104	62	82	88	113
37019020201	62	83	89	114
37019020202	62	86	91	117
37019020203	64	81	97	116
37019020204	65	82	102	119
37019020303	69	78	110	118
37019020304	66	83	106	122
37019020305	65	88	100	121
37019020306	64	91	95	120
37019020307	63	94	91	116
37019020308	72	77	116	121
37019020309	69	81	111	124

Click the 100 Year Event Peak Gust (mph) field and then click the Map button.

Observe that a probabilistic hurricane analysis provides estimates for multiple return periods. This layer may take a while to draw. Be patient and allow the map to finish drawing the layer.

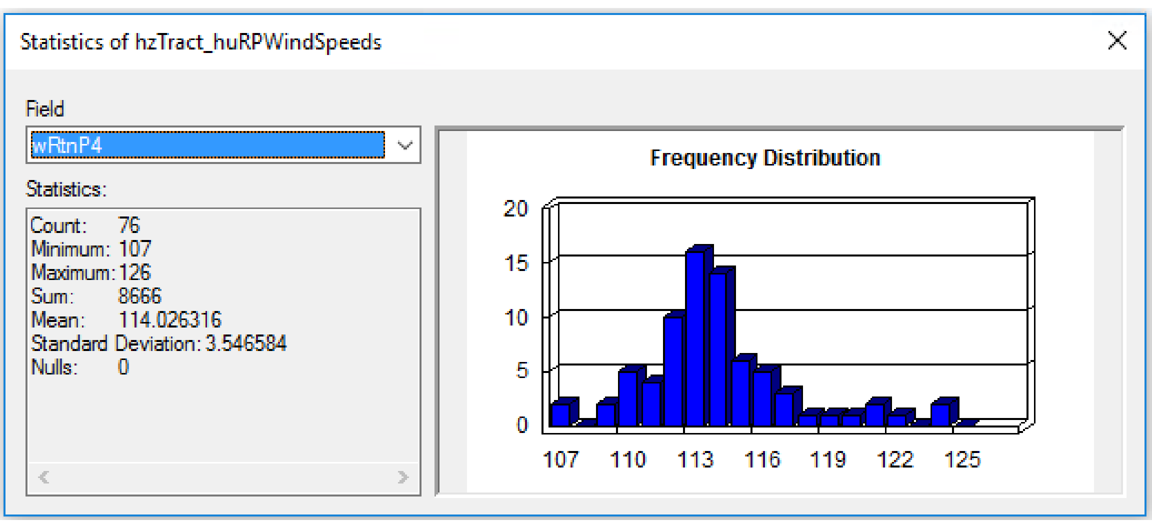
Click the Close button to close the Windspeeds by Census Tract window.

Turn off the StormTrack – FRAN layer and the Wind Speeds - Peak Gust (mph) layer in your table of contents window.

Right-click on the Wind Speeds – 100 Year Event Peak Gust (mph) layer and choose Open Attribute Table.

This table illustrates the anticipated peak wind speeds that might be seen from a storm based on a 100 year return period.

Right-click on the wRtnP4 field in the Attributes of Wind Speeds – 100 Year Event Peak Gust (mph) layer and choose Statistics from the field context menu. The Maximum value is the answer to the question. Enter this value in the Peak Wind Gust column of the Activity Results table at the end of the activity.



Close the Statistics window and the Wind Speeds – 100 Year Event Peak Gust (mph) table.

Task 4: Explore the Economic Impact to Buildings

From the Results menu choose Summary Reports to open the Summary Reports window. Click on the Other Reports tab.

Open the Global Summary Report: 100 year Return Period report.

Advance to Page 13 in order to view the results of the 100 Year Event.

In the Activity Results table at the end of this activity record the Building Total Damage under the Cost Building Damage column and the Total Loss column.

Close the Global Summary Report: 100 year Return Period Summary Report and close the Summary Report window.

Click Save to save the map document.

Close Hazus unless otherwise instructed by your instructor.

Activity Results

	Peak Wind Gust	Building Damage Cost	Total Loss
100 Year Probabilistic Scenario			

Note that the units of measurement in each report are not consistent.

Activity 15.1 - Combined Surge Model

Type: Student-Led Activity

Time: 10 minutes

Background

This activity is designed to familiarize you with the basics of the Hazus surge process and outputs in both the Hurricane and Flood models.

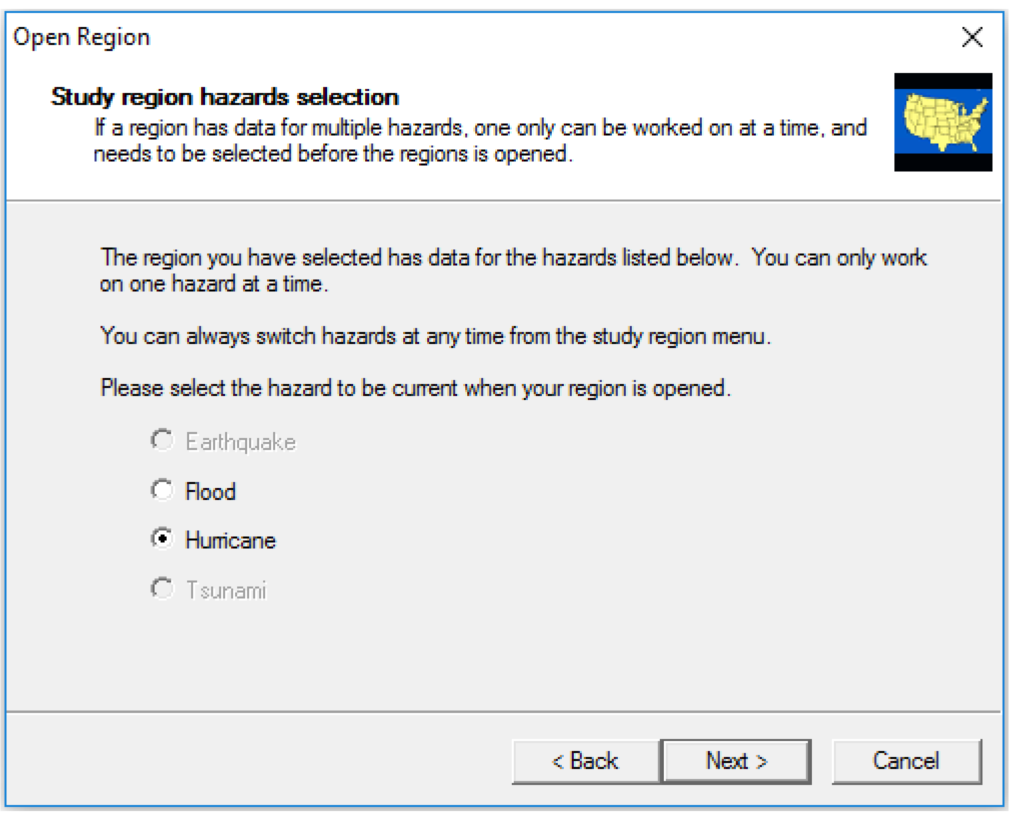
Task 1: Import the Study Region

Start Hazus.

Import the HPR file named Activity15.1_Surge_Results.hpr located in C:\HazusBasic\HPRs. Name the imported study region Surge_Results.

Open the Surge_Results study region to the Hurricane hazard.

It is possible that some of the layers in the Table of Contents window will have red exclamation marks indicating those layers have lost their connection to the datasets. You can remove those layers, save the map document, and then re-open the region to restore those connections.



Task 2: Explore the Hurricane Wind Results

From the Results menu choose Summary Reports.

Click the Other Reports tab.

Select the Global Risk Report and then click the View button.

Navigate in the Global Risk Report to pages 13/14. In Table 6 you will find the total losses for Buildings, Contents and Inventory.

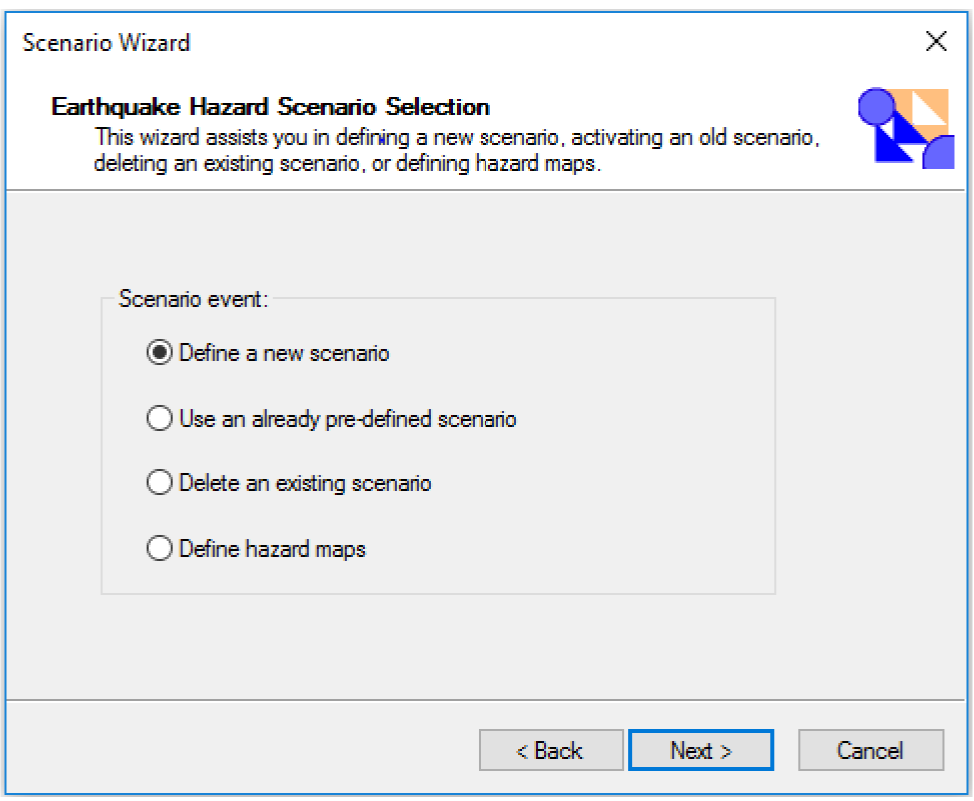
Record the total losses in the Hurricane Wind Only Losses column of the Results table at the end of the activity.

Close the Global Risk Report and the Summary Reports window.

Task 3: Explore the Flood Results

Click the Switch Hazard button in the upper left corner of the Hazus screen.

Select the Flood hazard.

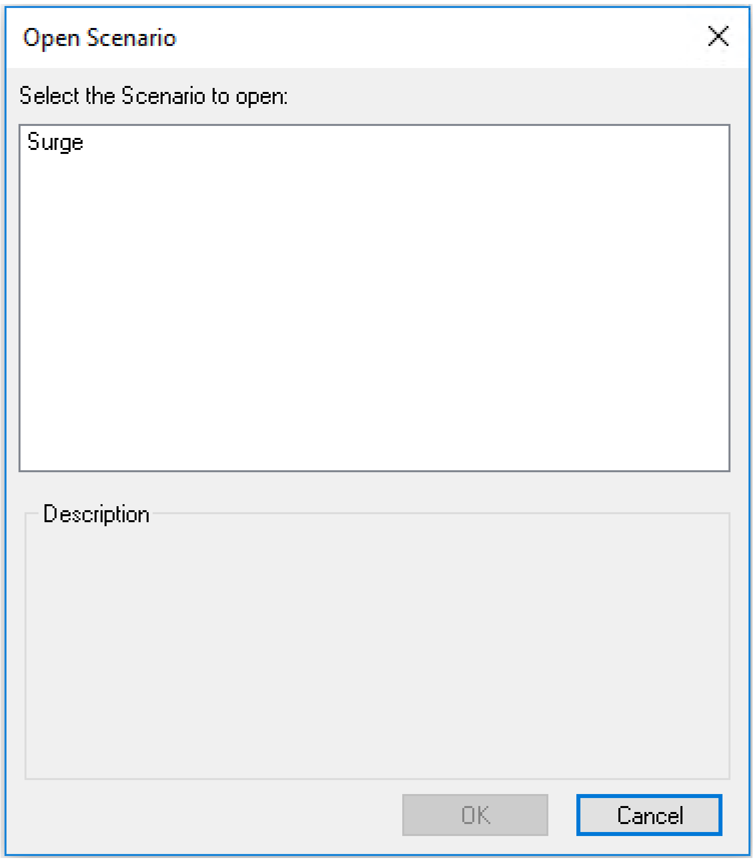


Click OK. Select No if prompted to save changes to the Hurricane study region.

It is possible you will receive an error message after this step. If you do, re-open the study region with the flood hazard active.

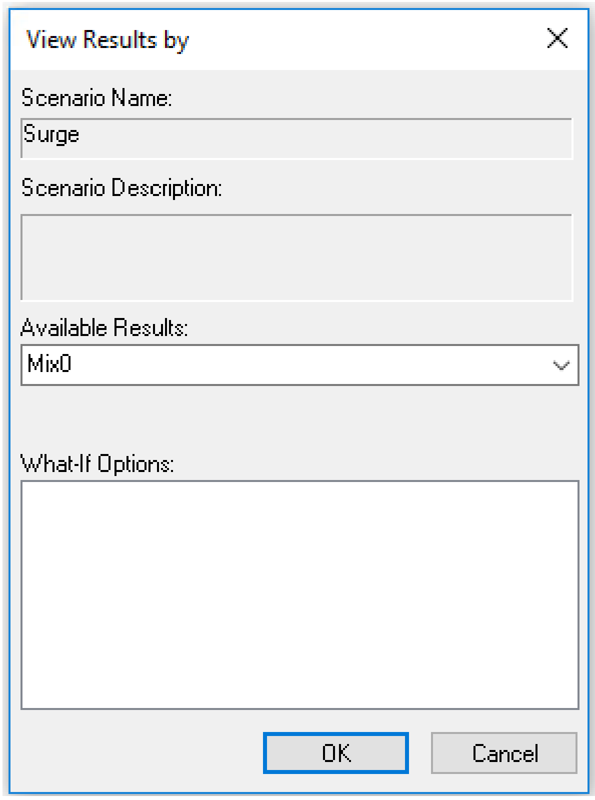
From the Hazard menu choose Scenario > Open.

Select the Surge Scenario.



From the Results menu choose View Current Scenario Results by.

Select the Mix0 option.



From the Results menu, choose Summary Reports to open the Summary Reports window.

Click the Other tab, select the Global Risk Report, and click the View button to open the report.

Navigate to page 14 of the report. In Table 6, you will find the total losses for Buildings, Contents and Inventory.

Record the total losses in the Flood Only Losses column of the Results table at the end of the activity.

Close the Global Risk Report.

Task 4: Explore the Combined Wind and Surge Results

Click the Losses tab.

Select the Combined Wind and Surge Loss report and then click the View button to open the report.

This report will report the total combined losses for Buildings, Contents and Inventory.

As discussed in the lecture, the losses reported in the wind only loss reports and flood only loss reports, when the losses are added together, may actually exceed the total exposure in the study region. This is because some of the damage reported in the flood *only or wind only reports may actually be caused by the other hazard. The Combined Wind and Surge Loss report, however, reflects an estimation that takes into account that some building components are more likely to be damaged by wind than by flood waters and vice versa.*

Record the total losses in the Combined Wind & Surge Losses column of the Results table at the end of the activity.

Exit Hazus when you have completed the activity.

Results Table

	Flood Only Losses (Millions $)	Hurricane Wind Only Losses	Combined Wind and Surge Losses (Thousands $)
Building Damage			
Contents Damage			
Inventory Loss			
Total Loss			

Note that the units of measurement in each report are not consistent.