An Overview of HAZUS – Multi-Hazard:

FEMA's GIS-based, Multi-hazard Risk Assessment Program for Analyzing Potential Losses

Mid - Atlantic Regional Workshop for Historically Black Colleges and Universities (HBCUs) and Local Communities: Partnering through Emergency Management and Mitigation

March 30, 2004

Presenter: Kevin Mickey
The Polis Center at Indiana University
Purdue University Indianapolis
(317) 278-2582
kmickey@iupui.edu

What is HAZUS-MH?

Mid - Atlantic Regional Workshop for Historically Black Colleges and Universities (HBCUs) and Local Communities: Partnering through Emergency Management and Mitigation

March 30, 2004

Why HAZUS?

- Earthquakes, floods, and hurricanes generate billions of dollars in losses
- Knowing potential losses:
  - Enables better planning
  - Allows for improved infrastructure to protect people and reduce economic losses
- HAZUS can estimate potential future losses

What is HAZUS-MH?

- GIS-based software tool used on personal computer
- Loss estimation software that estimates physical damage from earthquakes, hurricanes, and floods
- Available from FEMA free of charge (www.fema.gov/hazus)

Requires ArcGIS 8.3 (ArcView license) and Spatial Analyst (Flood)

What does HAZUS-MH do?

- Estimates physical damage to:
  - Buildings and their contents
  - Bridges
  - Pipelines
  - Other types of infrastructure
- Assesses how populations might be affected by damage from natural hazards
  - Can be used to plan for shelters, casualties, emergency power and water

HAZUS Accomplishments

- Program initiated in 1992
- Earthquake model versions developed in 1997, 1999, 2000, 2001 and 2002
- Development of Hurricane and Flood models initiated in 1998
- Multi-hazard HAZUS (HAZUS-MH) with models for hurricane, flood and earthquake hazards now available
- Hurricane Model development will continue through at least 2005
  - Other wind hazard models - thunderstorm, hail, tornado – to be developed for future releases

Benefits

- HAZUS-MH allows user to:
  - IDENTIFY vulnerable areas that may require planning considerations
  - ASSESS level of readiness and preparedness to deal with a disaster before disaster occurs
  - ESTIMATE potential losses from specific hazard events (before or after a disaster hits)
  - DECIDE on how to allocate resources for most effective and efficient response and recovery
  - PRIORITIZE mitigation measures that need to be implemented to reduce future losses (what if)

Who are HAZUS Users?

- Thousands of copies distributed to federal agencies, states, local emergency managers, fire departments, universities and others
- Considerable international interest
- Major HAZUS consortiums in San Francisco, Los Angeles, San Diego, the Midwest, and New York (www.hazus.org)

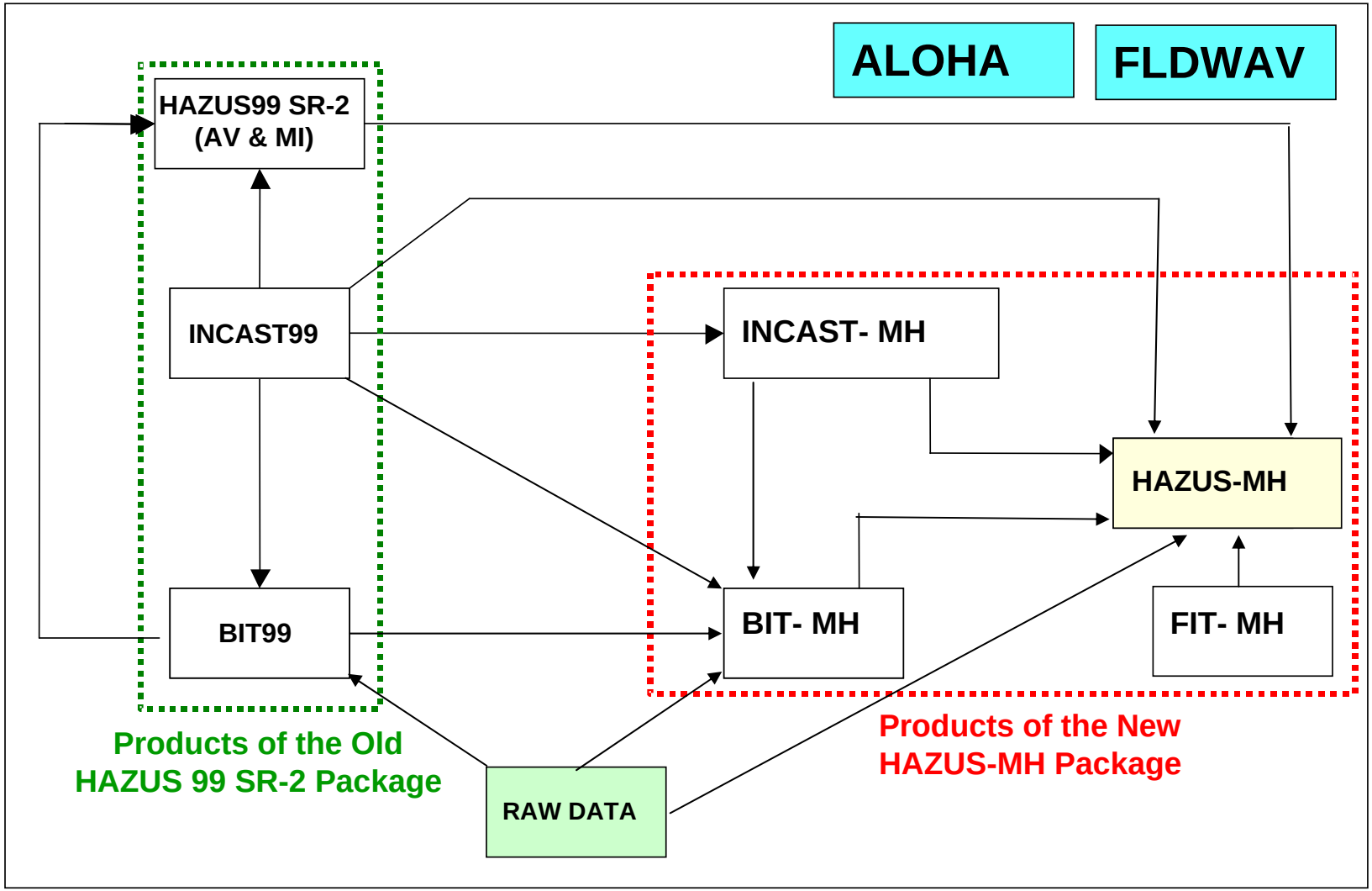
Who are HAZUS Users?

- Financial institutions (banks and insurance companies) assess their exposure to disasters (Schwab, Wells Fargo, Bank of America, Insurance Services Org.)
- Universities use it for applied research (MIT, Georgia Tech, Illinois, Princeton, Stanford, UC Berkeley, Indiana University….and many others) More later…
- Transportation and utility agencies assess reliability of their systems (CalTrans, LA Dept. of Water and Power, Pacific Gas & Electric)

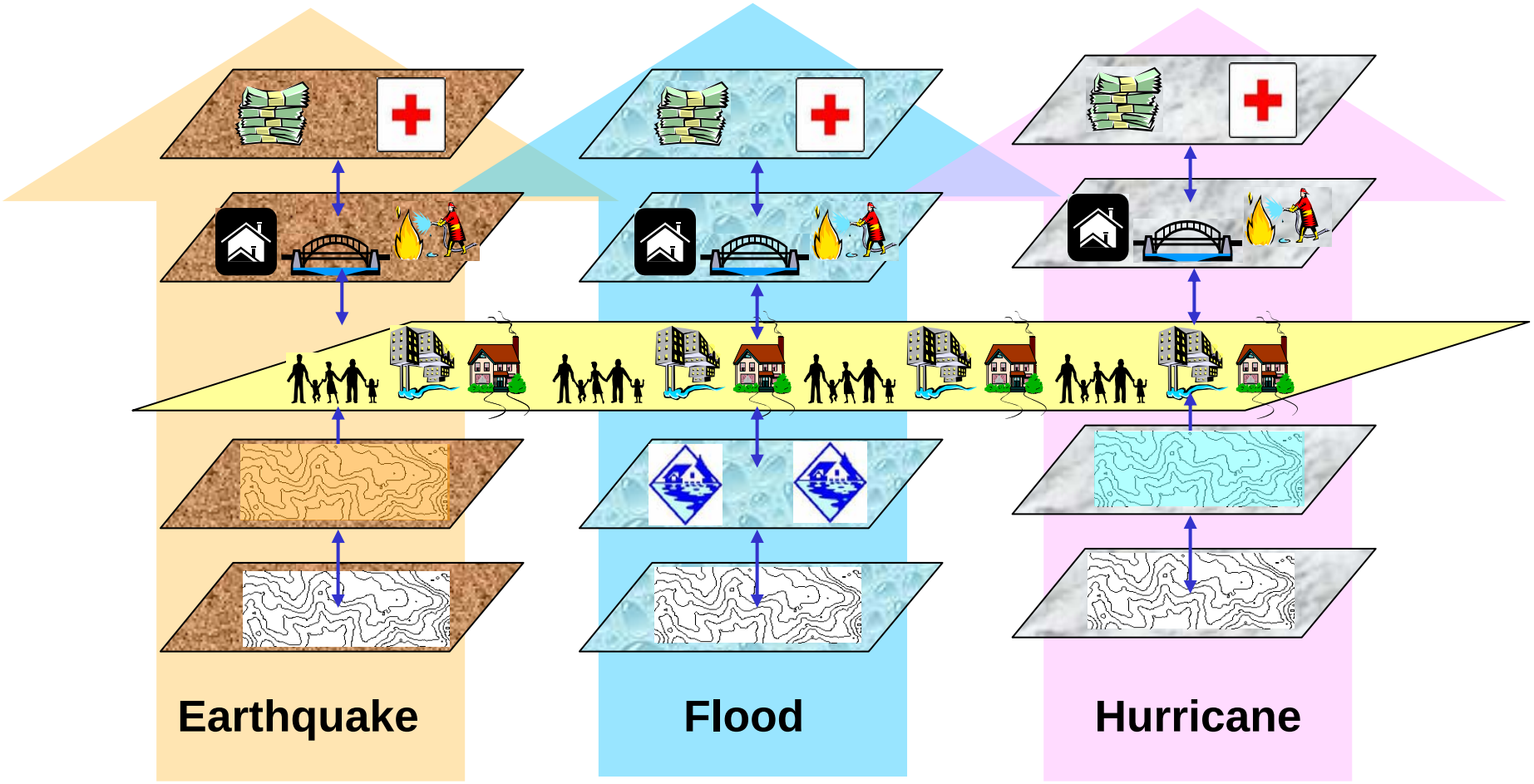
HAZUS-MH Family of Products

- HAZUS-MH main software has 3 models:
  - Earthquake
  - Flood
  - Hurricane
- Inventory Collection And Survey Tool (InCAST)
- Building Import Tool (BIT)
- Flood Information Tool (FIT)
- Linkage to third-party Models
  - Areal Locations of Hazardous Atmospheres (ALOHA)
  - Flood Waves (FLDWAV)

Overview of HAZUS Family of Products



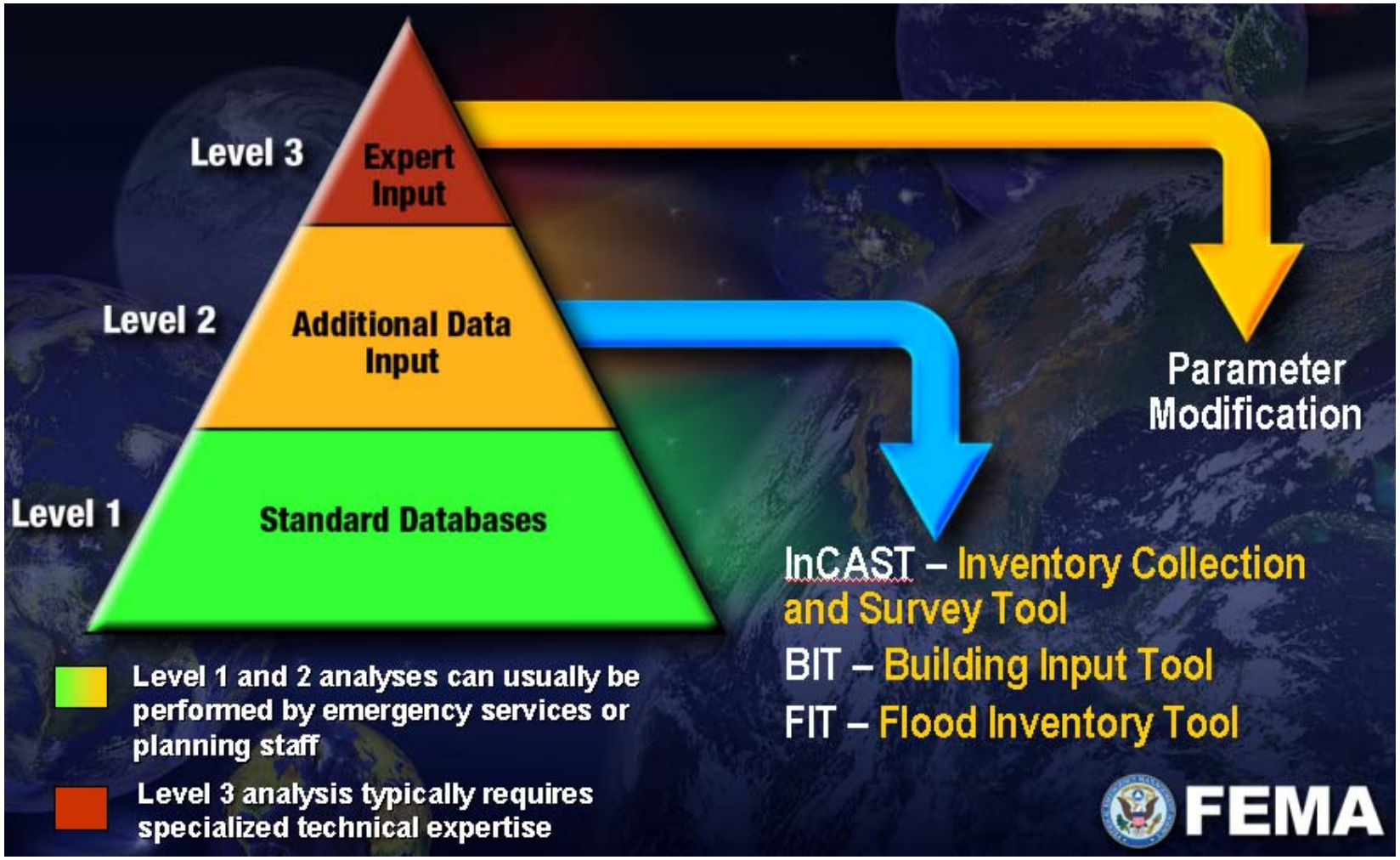
HAZUS-MH Loss Estimation Methodology



HAZUS-MH Output

	Earthquake Ground Shaking Ground Failure	Flood Frequency Depth Discharge Velocity	Hurricane Wind Pressure | Missile | Rain
Direct Damage			
General Building Stock	✓	✓	✓
Essential Facilities	✓	✓	✓
High Potential Loss Facilities	✓		✓
Transportation Systems	✓	✓	
Utility Systems	✓	✓	
Induced Damage			
Fire Following	✓		
Hazardous Materials Release	✓		✓
Debris Generation	✓	✓	✓
Direct Losses			
Cost of Repair	✓	✓	✓
Income Loss	✓	✓	✓
Crop Damage		✓	
Casualties	✓	Generic Output	
Shelter Needs	✓	✓	✓
Indirect Losses			
Supply Shortages	✓	✓	
Sales Decline	✓	✓	
Opportunity Costs	✓	✓	
Economic Loss	✓	✓	

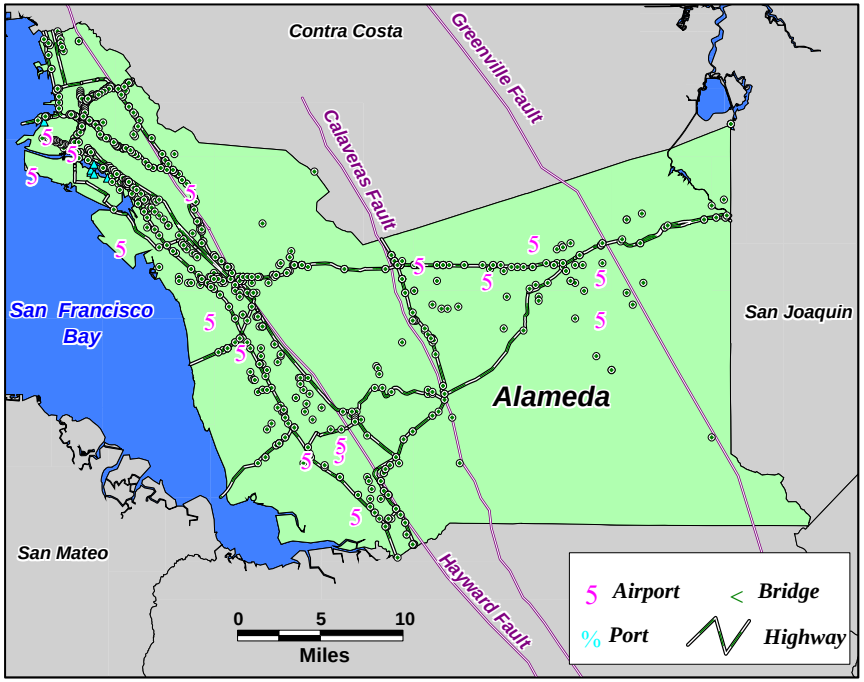
Levels of Analysis



Users can supplement inventory for better results.

HAZUS-MH Inventory Data

- Inventory data is divided into two types, for example:
  - Common to all hazards
    - General building types and occupancies
    - Lifelines
    - Replacement costs
    - Demographics
  - Hazard-specific
    - Specific building types
    - Elevation
    - Building configurations



Hazard Scenarios

- Flood
  - Specific Return Intervals
  - Specific Discharge Frequency
  - Annualized Losses
  - Quick Look

- Earthquake
  - Simulate user defined, historic, or probabilistic events

Hazard Scenarios

- Hurricane
  - Probabilistic
    - 100,000 year database of peak gust wind speeds in each census tract
    - Wind speeds have been pre-generated
  - Single User-Defined Event
    - Single storm scenario
    - Program generates wind field given storm characteristics
    - Allows user to specify track, speed, and intensity of hurricane
    - Designed to work with National Hurricane Center's Forecast Advisories
  - Historic Event
    - Database of Category 3-5 storms that impact the US since 1900

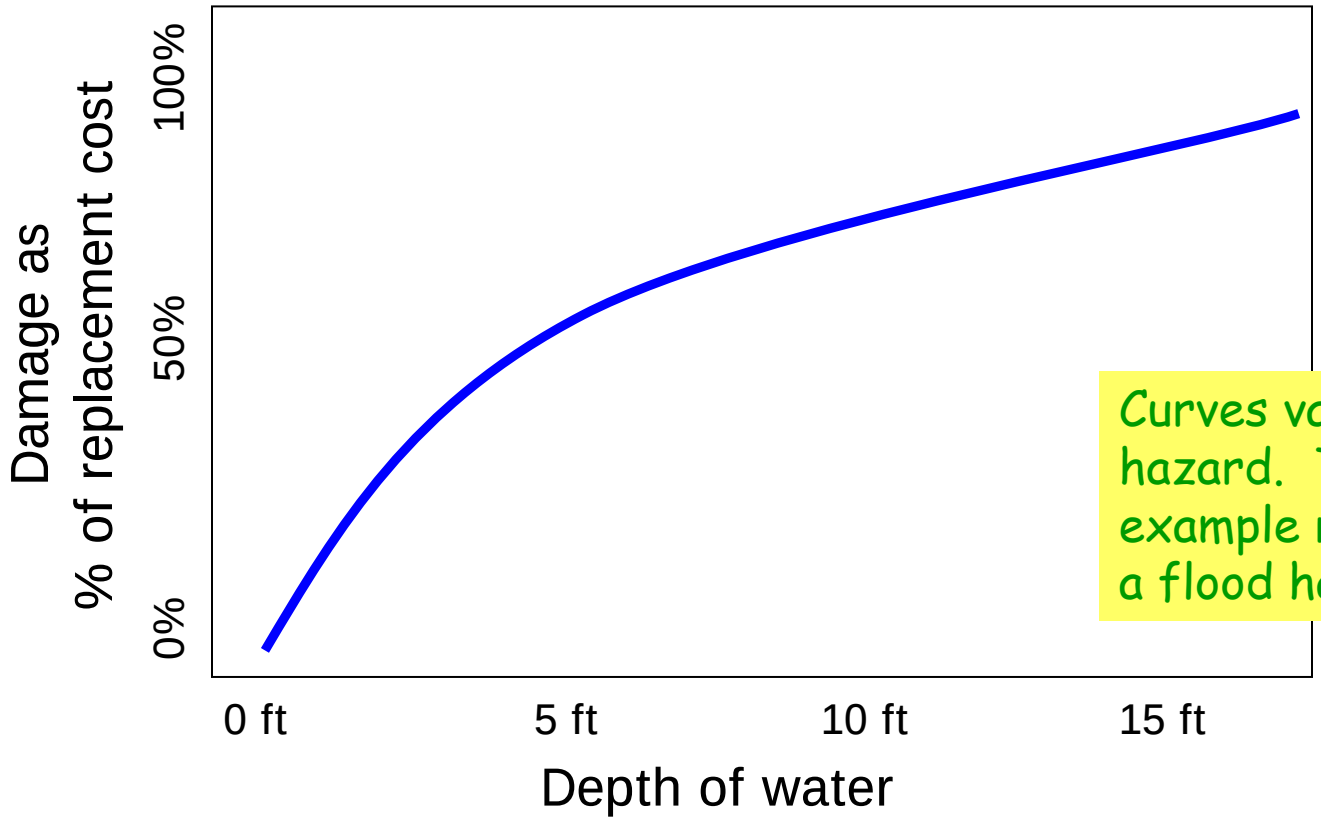
Hazard Scenarios

- Simulate "What-If" Scenarios
  - Incorporate building code changes
  - Add levees or dams
  - Assess impact of erosion prevention practices
  - ..and much more

Over 800 curves – and you can create your own as well!

Damage Functions

- Damage curves are assigned to each building specific occupancy class and each facility



Curves vary by hazard. This example represents a flood hazard.

Depreciated losses are specific to flood.

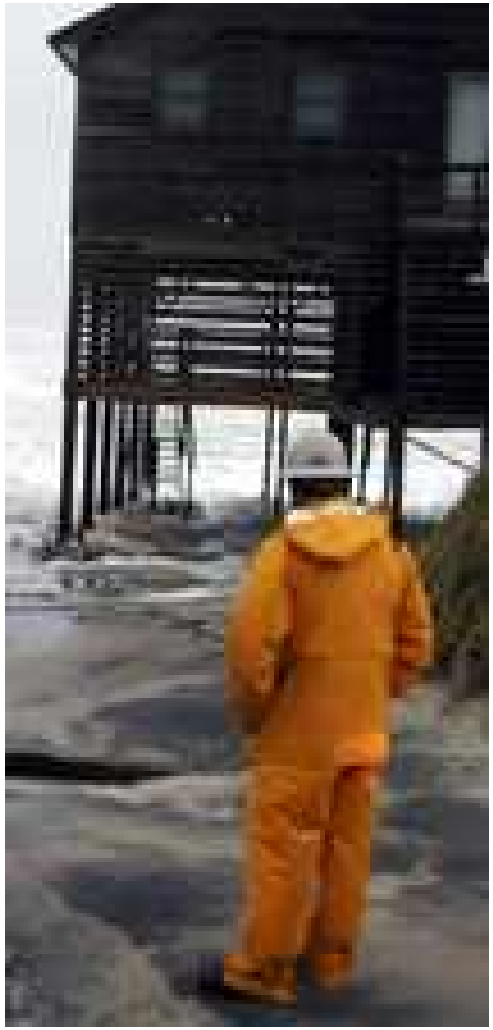
HAZUS Flood Model Results

- Hazard maps
  - Flood depth
  - Eroded terrain surface (coastal only)
- Building losses
  - By occupancy and by building type
  - By full replacement value and depreciated replacement value
  - Building, content, and inventory losses
  - Costs of relocation, wage and income losses, rental income loss
  - Direct employee output losses and employment loss (days)

HAZUS Flood Model 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)
- Vehicles and agriculture losses
- Shelter requirements

HAZUS Flood Model Results



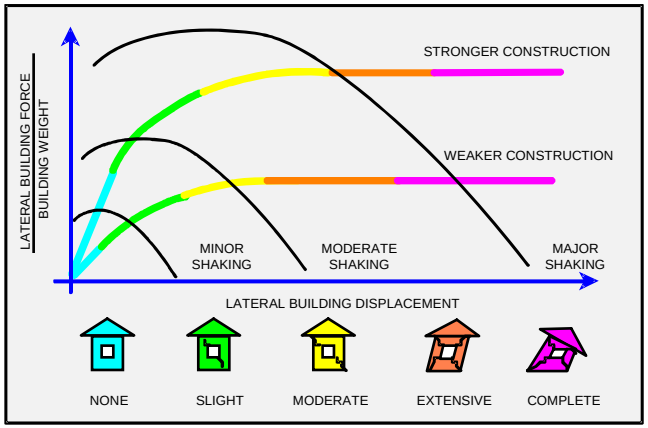
- Casualties
  - No casualties calculated
  - Report on US annual flood-related casualties included
- Indirect economic losses
  - Income and employment impact with and without aid by market sector
    - Agriculture, Mining, Construction, Manufacturing, Transportation, Trade, Services, Government, Misc.

HAZUS Earthquake Model Results

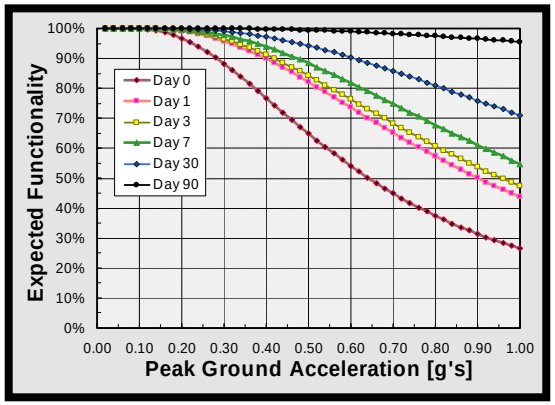
Physical Damage

Nonstructureal Components = (e.g., electrical and mechanical systems, ceilings, etc.)

- Physical Description of Damage
- Structural and Nonstructural Damage for Buildings
- Leaks and Breaks for Pipelines



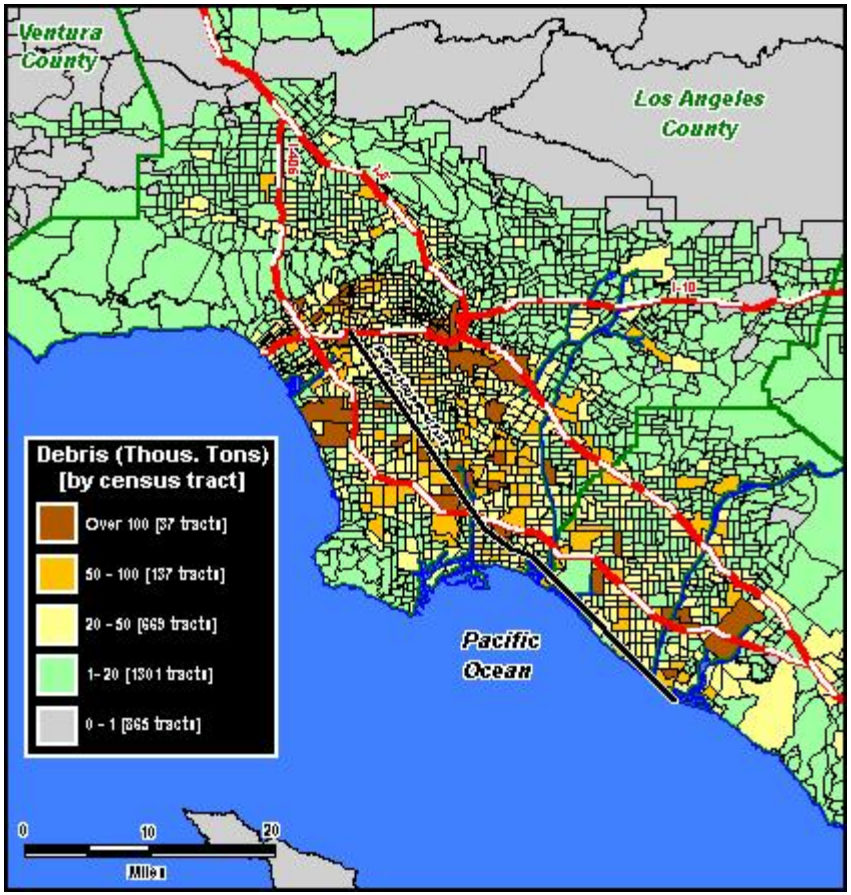
- Functionality Estimates for Lifelines & Essential Facilities [hospitals & Schools]
- System Performance Evaluation for Potable Water & Electric Power



HAZUS Earthquake Model Results

Induced Physical Damage

- Fire Following
  - Number of Ignitions
  - Extent of Burned Areas
- Debris Generation
  - Wood and Masonry
  - Steel and Concrete
- Inundation
  - Dollar Exposure at Risk
  - Population at Risk
- Hazardous Materials

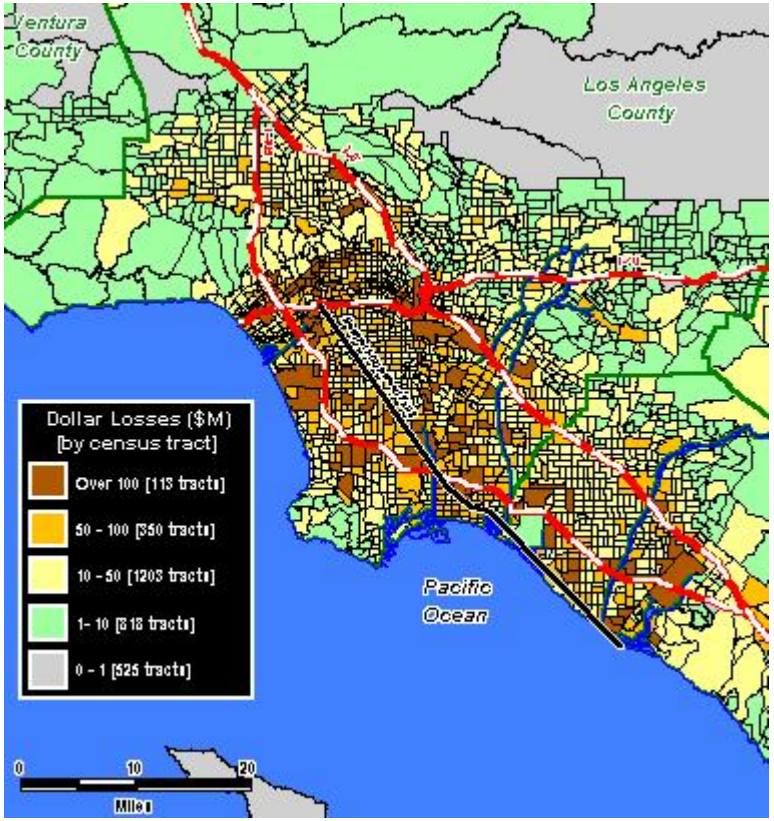


Debris Generated from a HAZUS Simulated EQ Scenario

HAZUS Earthquake Model Results

Direct Economic Losses

- General Building Stock Loss
  - Building:
    - Structural
    - Non-structural
    - Content
    - Business Inventory
  - Business Interruption:
    - Wage
    - Income
    - Rental & Relocation
    - Proprietor
- Lifelines
  - Direct Cost of Repair

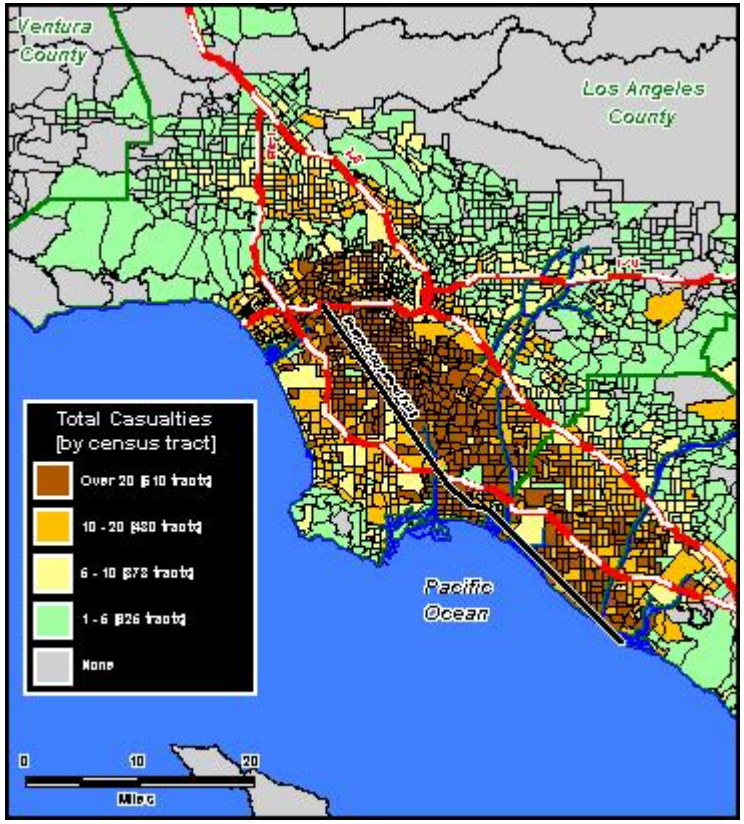


Economic Losses from a HAZUS Simulated EQ Scenario

HAZUS Earthquake Model Results

Direct Social Losses

- Casualties
  - No Hospitalizations
  - Hospitalization
    - Non-Life Threatening
    - Life Threatening
- Parameters
  - Damage to various Building Types
  - Bridge Damage Contribution
  - Time Dependent

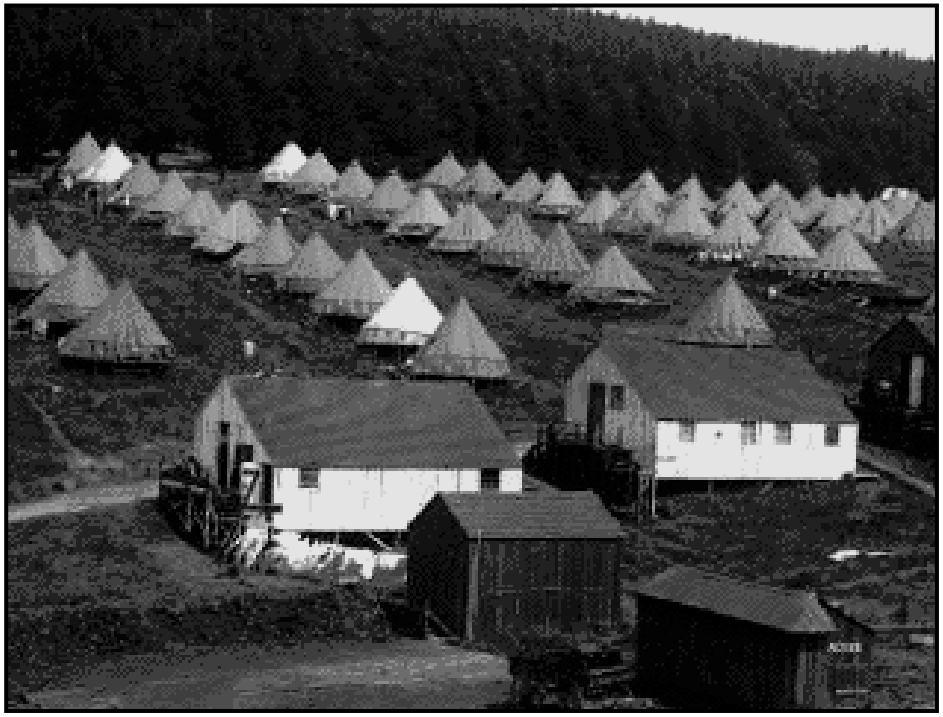


Expected Casualties from a HAZUS Simulated EQ Scenario

HAZUS Earthquake Model Results

Direct Social Losses

- Shelter
  - Number of Displaced Households
  - Temporary Housing Requirements
- Parameters
  - Based on Demographic Considerations [Ethnicity, Income, Age, Ownership]
  - Accounts for Loss of Utility Services



Shelter Camp during the 1906 San Francisco Earthquake

Primarily, ethnicity and income factors play a key role with respect to shelter demands.

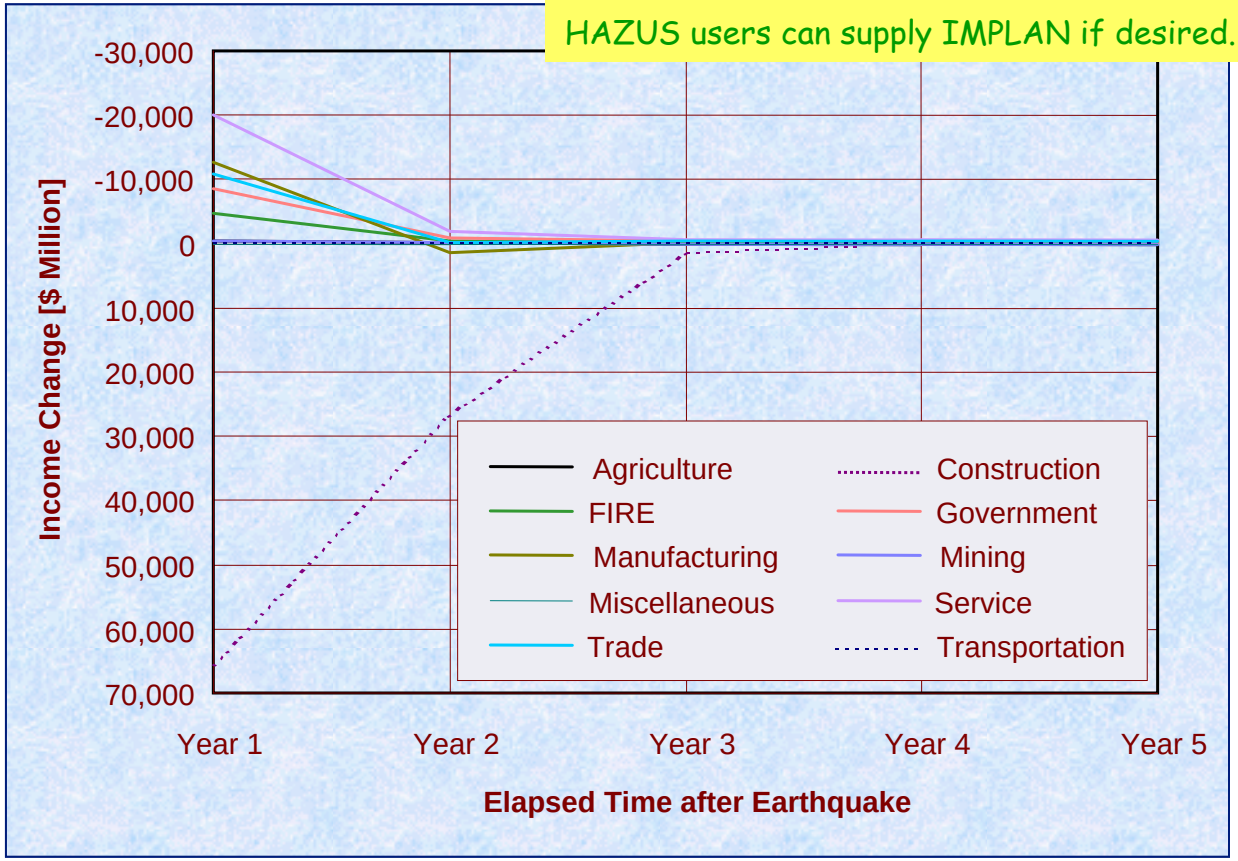
HAZUS Earthquake Model Results

Economic Losses

IMPLAN is an economic impact assessment modeling system. IMPLAN allows the user to easily build economic models to estimate the impacts of economic changes in their states, counties, or communities. http://economicimpact.ifas.ufl.edu/what_is_implan.htm

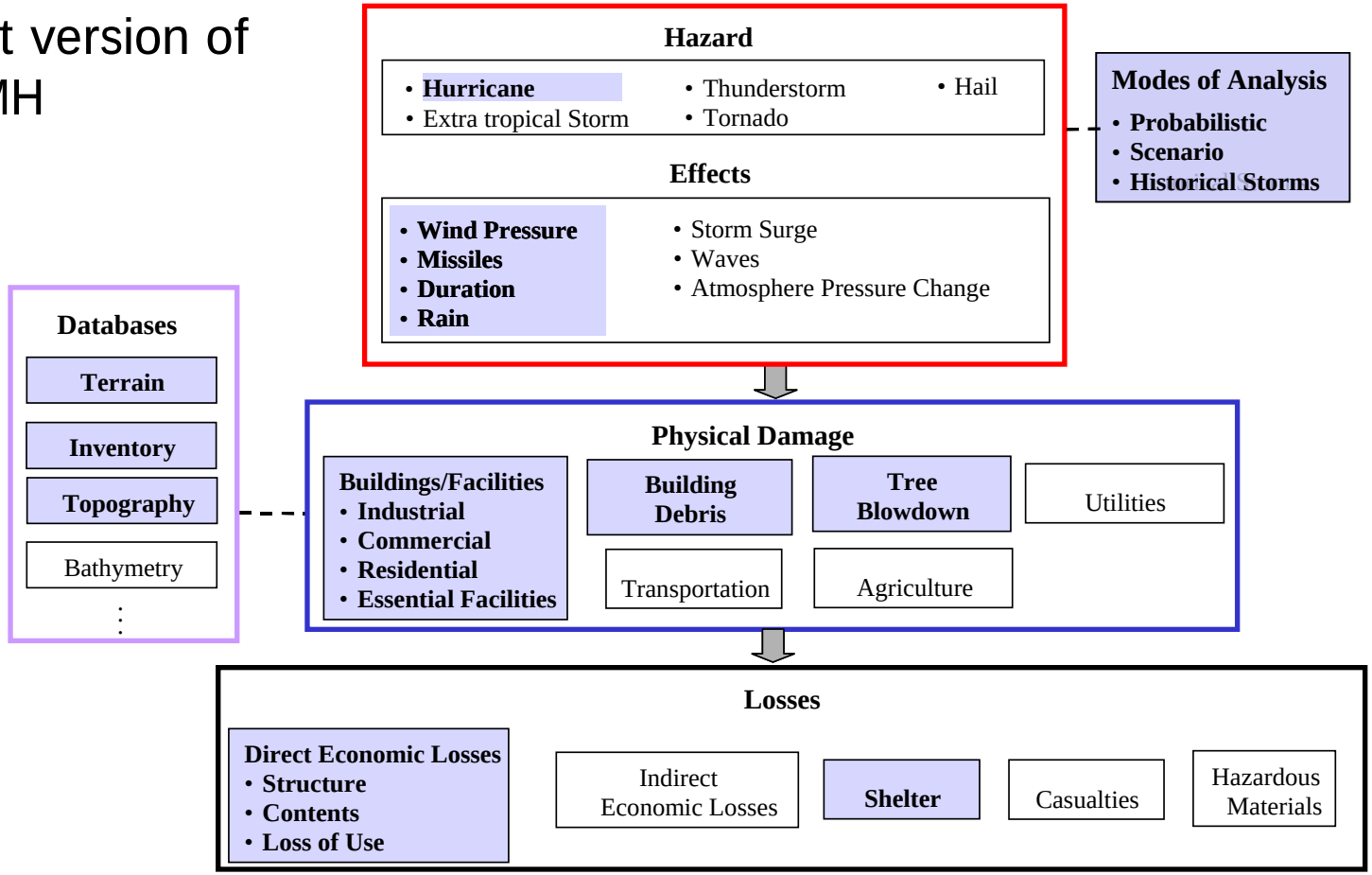
HAZUS users can supply IMPLAN if desired.

- Modeling of 10 Economic Sectors
- IMPLAN Data
- Income Changes vs. Time
- Employment Changes vs. Time



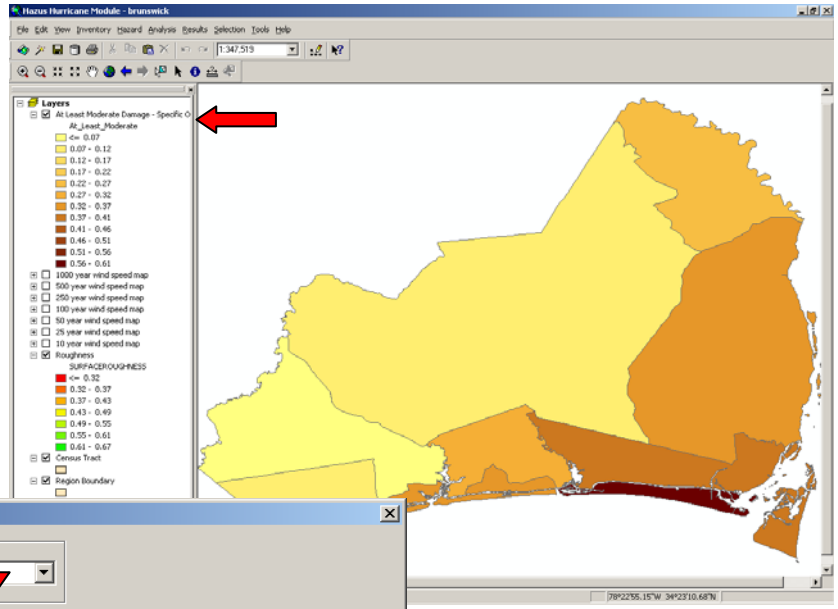
HAZUS Wind Model Results

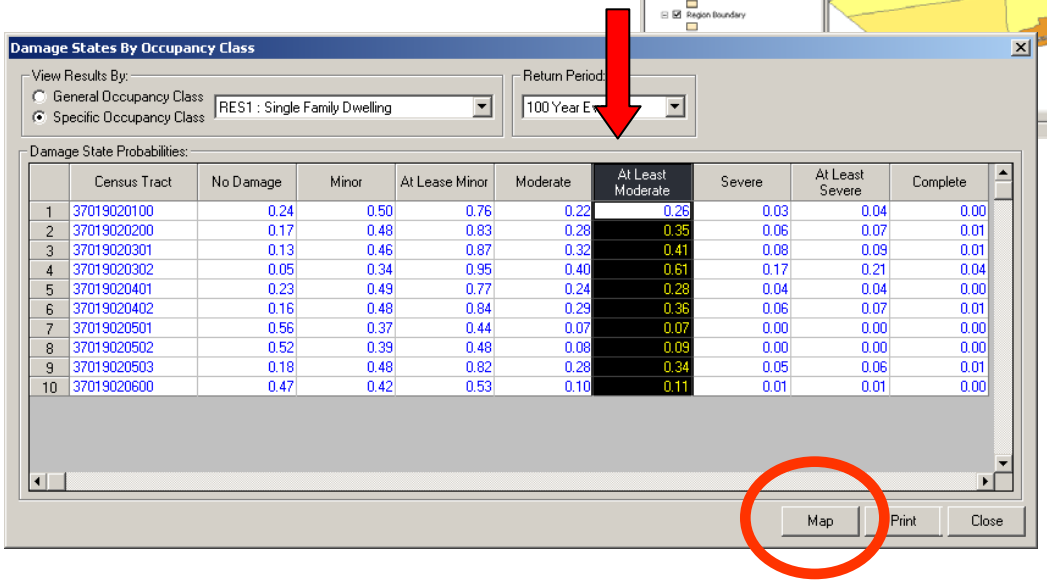
- Items in Blue are included in current version of HAZUS-MH



Results – Maps and Tables

- Almost all table data can be plotted in a map layer
  - View any results table
  - Select column header
  - Click on Map button

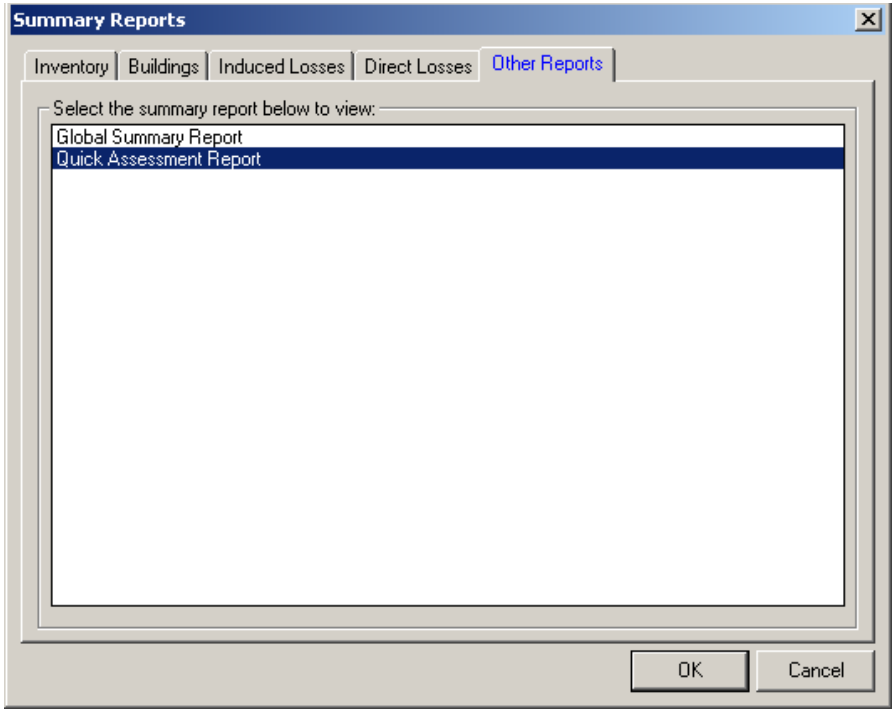




	Census Tract	No Damage	Minor	At Lease Minor	Moderate	At Least Moderate	Severe	At Least Severe	Complete
1	37019020100	0.24	0.50	0.76	0.22	0.26	0.03	0.04	0.00
2	37019020200	0.17	0.48	0.83	0.28	0.35	0.06	0.07	0.01
3	37019020301	0.13	0.46	0.87	0.32	0.41	0.08	0.09	0.01
4	37019020302	0.05	0.34	0.95	0.40	0.61	0.17	0.21	0.04
5	37019020401	0.23	0.49	0.77	0.24	0.28	0.04	0.04	0.00
6	37019020402	0.16	0.48	0.84	0.29	0.36	0.06	0.07	0.01
7	37019020501	0.56	0.37	0.44	0.07	0.07	0.00	0.00	0.00
8	37019020502	0.52	0.39	0.48	0.08	0.09	0.00	0.00	0.00
9	37019020503	0.18	0.48	0.82	0.28	0.34	0.05	0.06	0.01
10	37019020600	0.47	0.42	0.53	0.10	0.11	0.01	0.01	0.00

Results - Reports

- Variety of Crystal Reports Summary Reports supplied that cover
  - Inventory damage/loss
  - Direct Building damage/loss
  - Induced Losses
  - Direct Losses
  - Other Reports – Summaries appear here



Example of HAZUS Economic Loss

Direct Economic Losses For Buildings

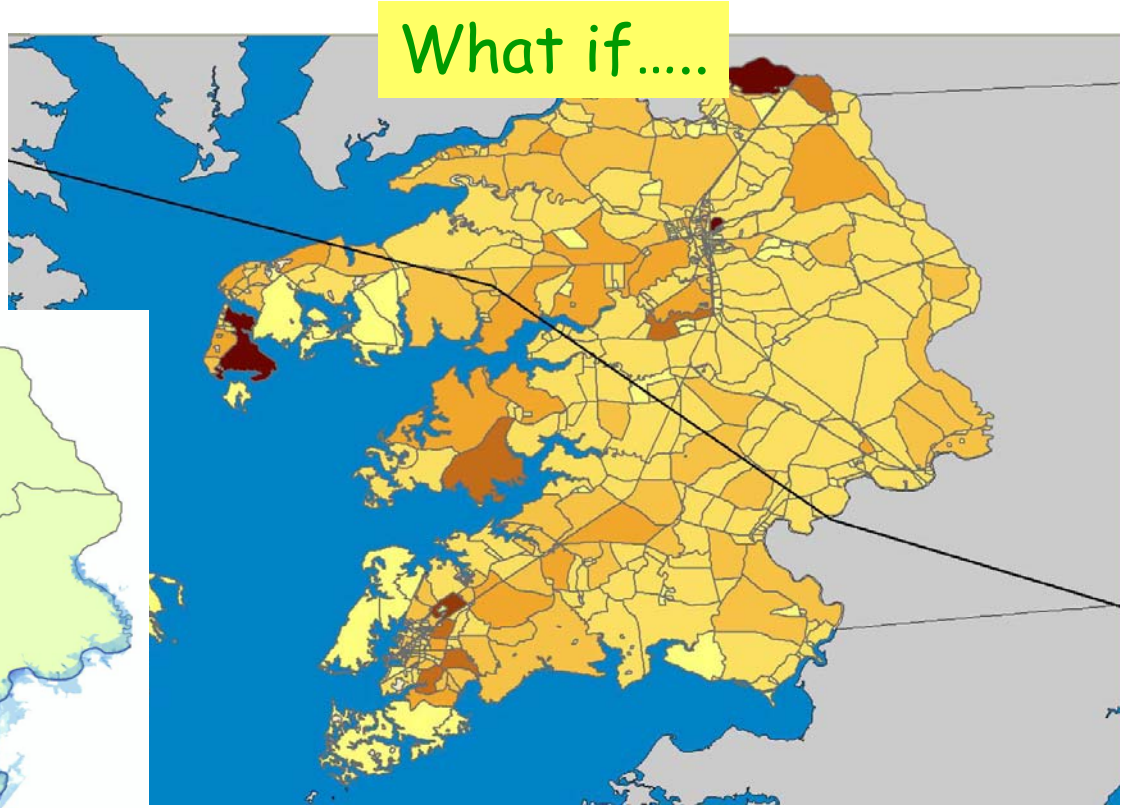
June 1, 2003

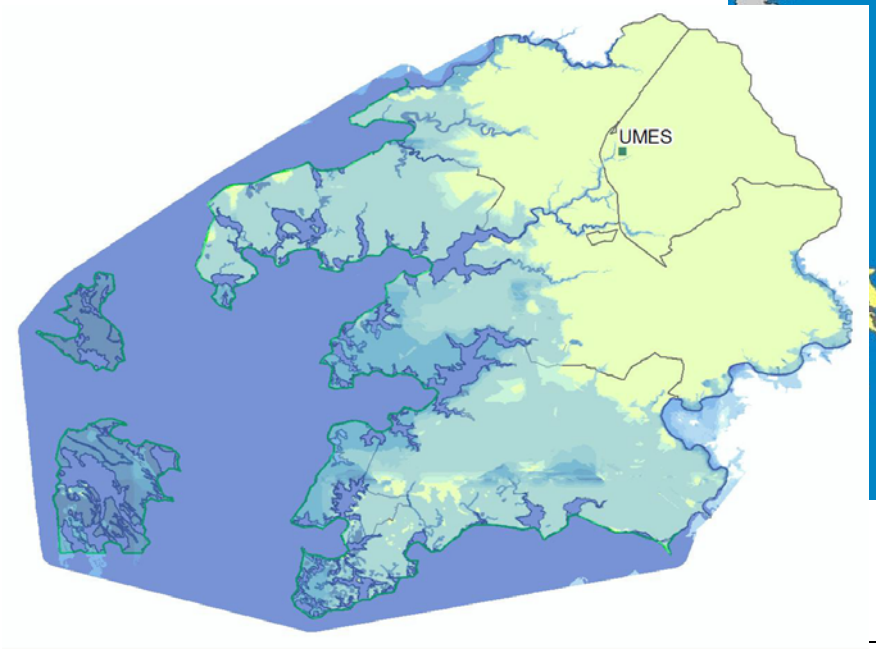
All values are in thousands of dollars

	Capital Stock Losses					Income Losses				
	Cost Structural Damage	Cost Non-struct. Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
North Carolina										
Anson	3,739	22,532	9,896	368	2.00	34,968	329	519	24,038	96,379
Richmond	38,507	184,397	73,217	1,643	9.23	342,191	3,768	5,498	288,299	937,521
Union	10,909	52,391	20,097	201	0.50	78,579	463	663	52,916	216,220
Total State	53,155	259,320	103,210	2,213	3.91	455,727	4,561	6,680	365,254	1,250,120
Study Region Total	53,155	259,320	103,210	2,213	3.91	455,727	4,561	6,680	365,254	1,250,120

Demonstration – Somerset County, MD

- Category 5 Hurricane
- 500 Year Coastal Flood





Category 5 Hurricane

180 MPH maximum winds

900 mb minimum pressure

Quick Assessment Report

March 28, 2004

Regional Statistics

Area (Square Miles)	329
Number of Census Tracts	7
Number of Buildings	
Residential (x 1000)	8
Total (x 1000)	8
Number of People in the Region (x 1000)	24
Building Exposure ($ Millions)	
Residential	1,155
Total	1,265

Scenario Results

Peak Gust Wind Speed (mph)	215

Number of Buildings Damaged

Occupancy	*Minor*	*Moderate*	*Severe*	*Destruction*	*Total*
Residential	1	24	351	8,089	8,465
Other	0	0	14	21	35
Total	1	25	364	8,110	8,500

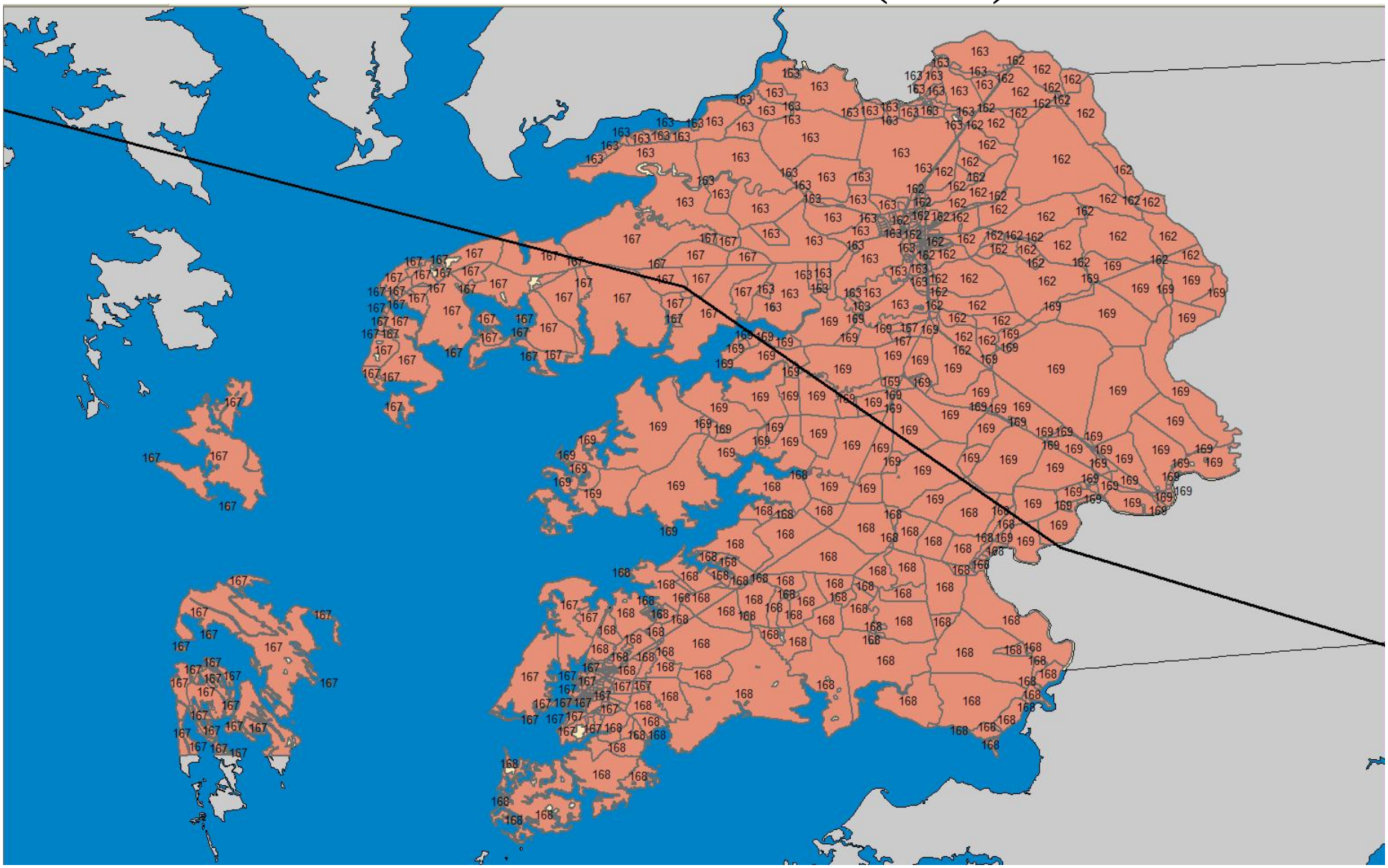
Shelter Requirements

Displaced Households (# Households)	7,667
Short Term Shelter (# People)	2,227

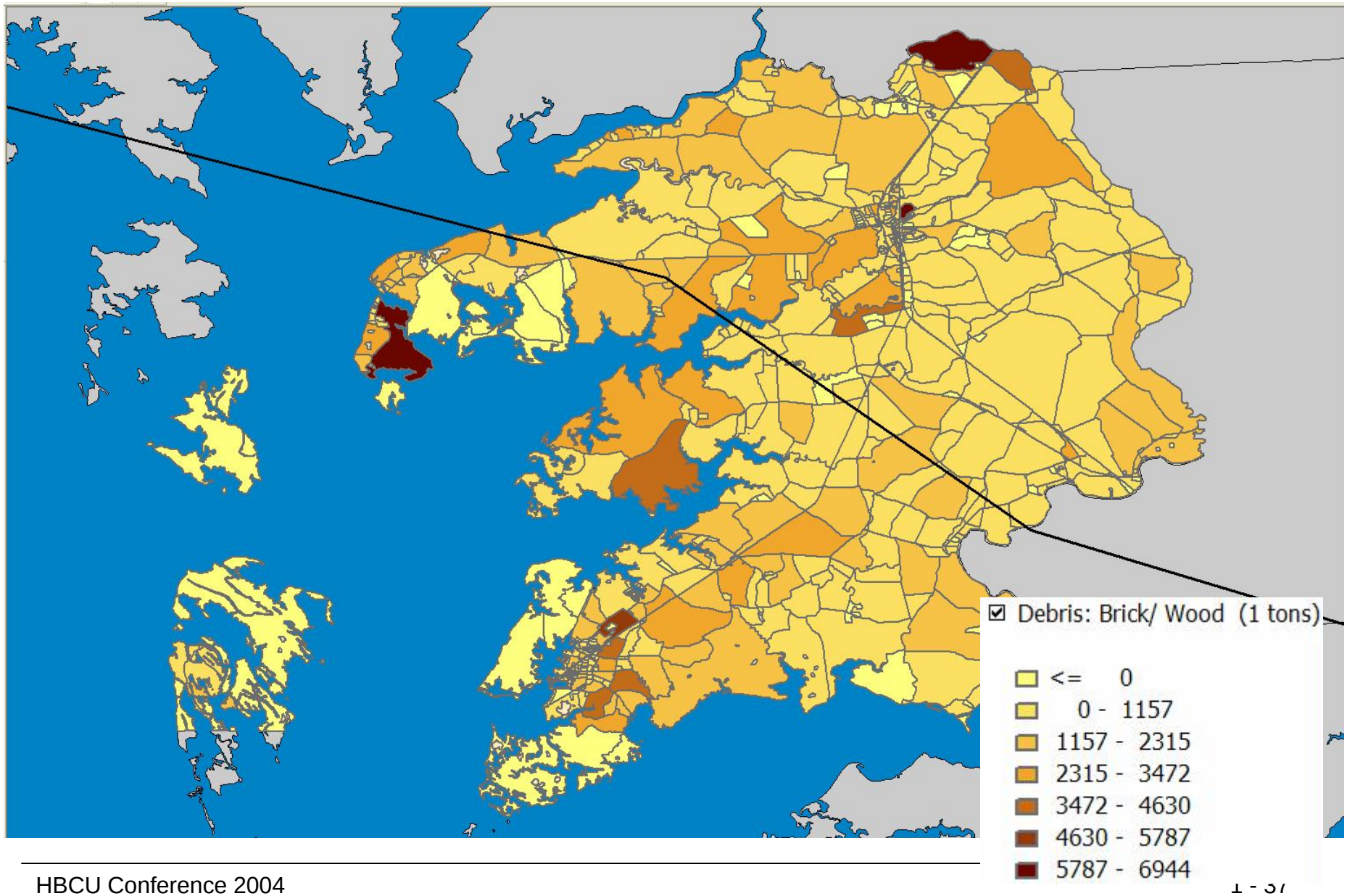
Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	1,653.7
Total Property (Capital Stock) Losses ($ Millions)	1,862.2
Business Interruptions (Income) Losses ($ Millions)	212.2

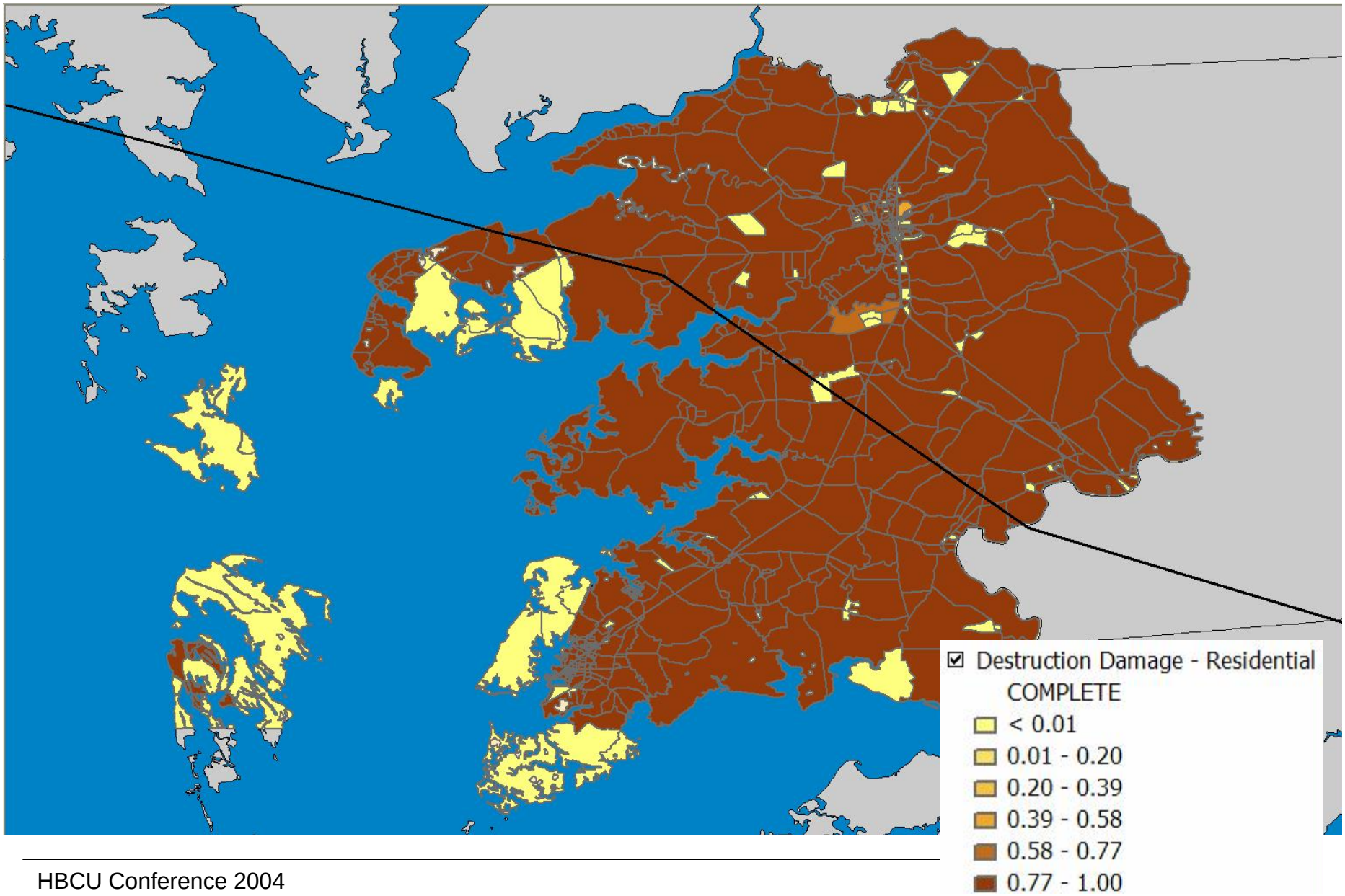
Maximum Sustained Winds (MPH)



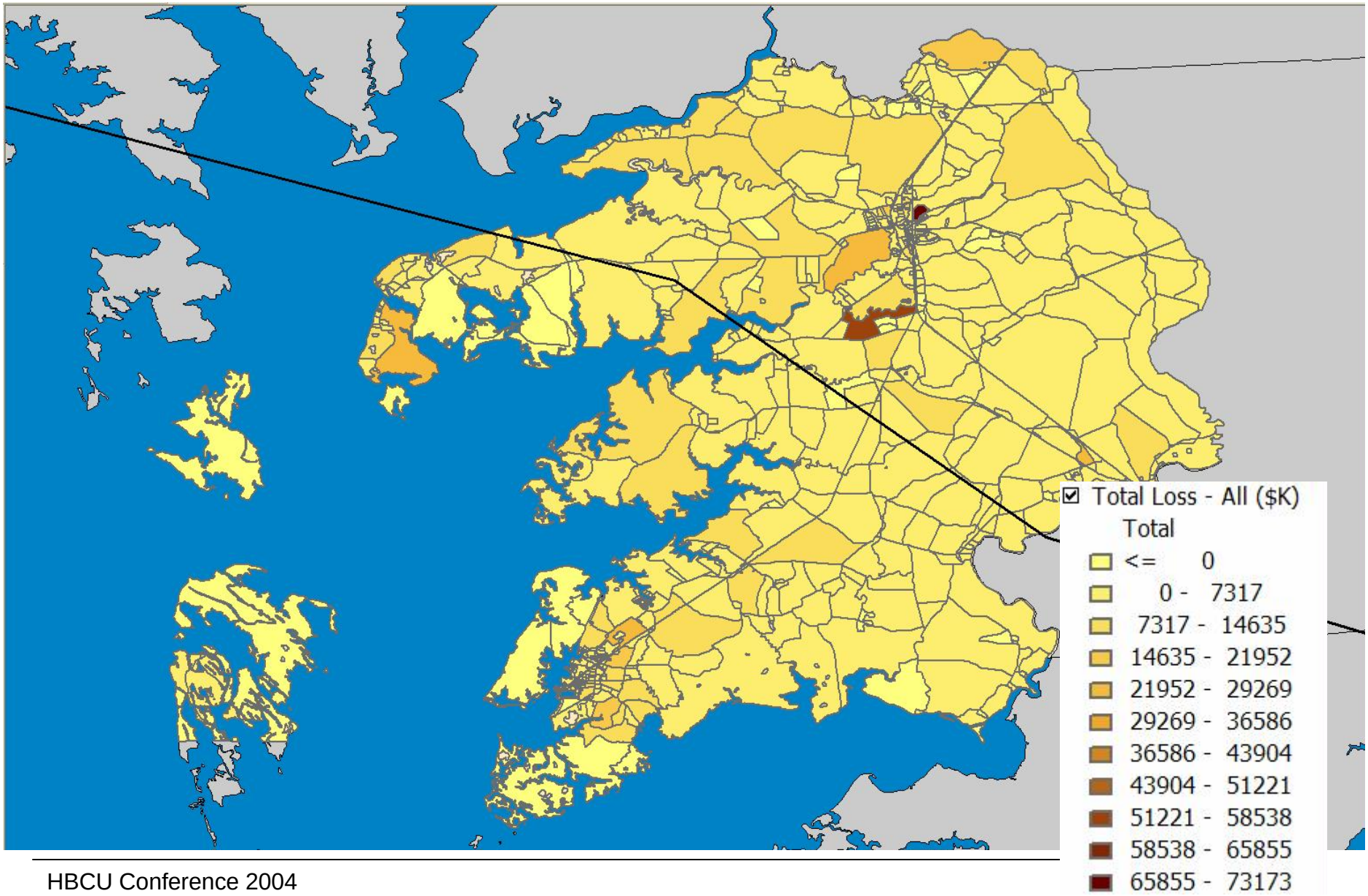
Debris Generation



Probability of Complete Residential Structure Destruction



Total Economic Loss



Economic Loss by General Occupancy

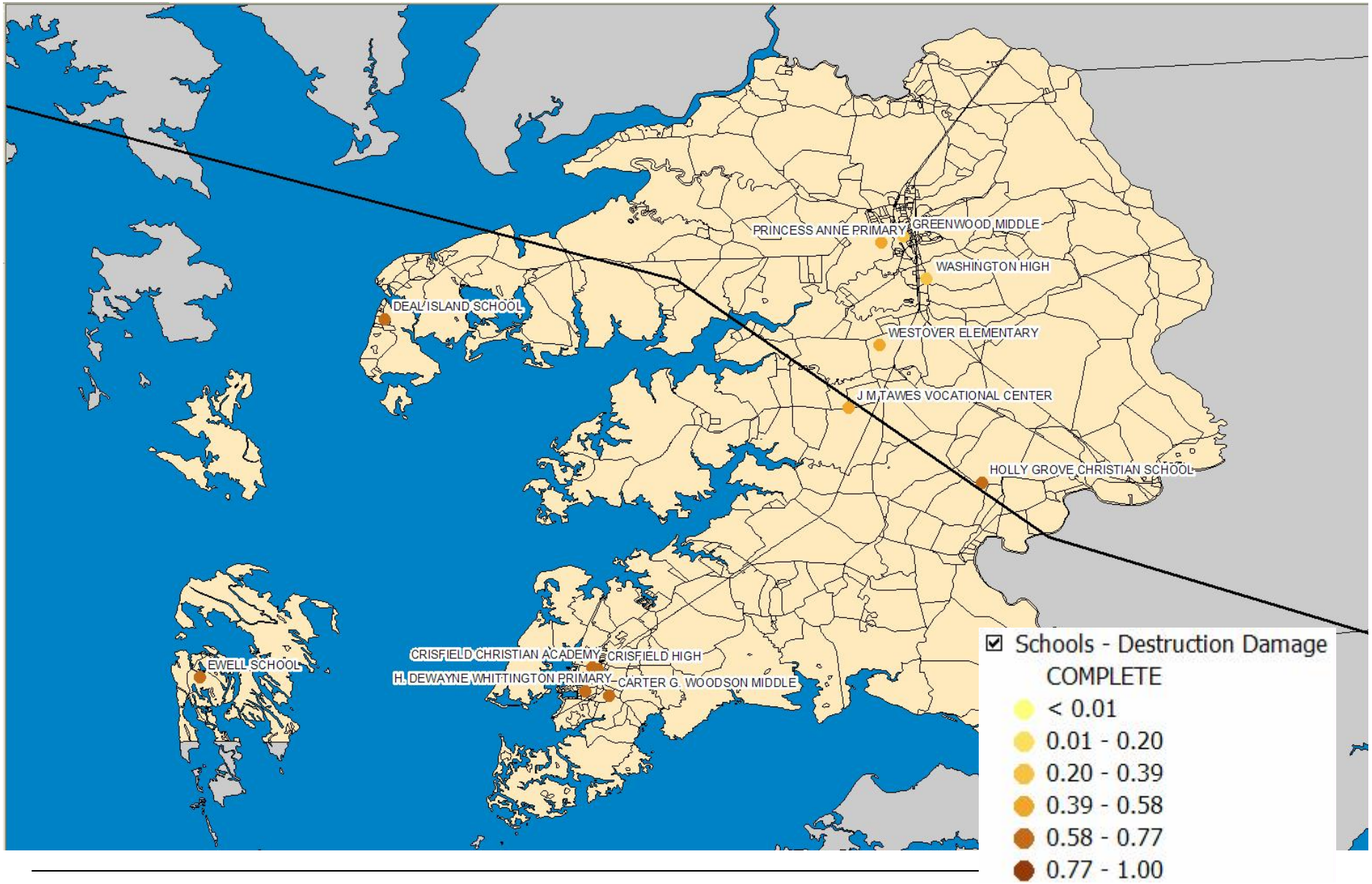
Building Stock Exposure By General Occupancy

March 28, 2004

All values are in thousands of dollars

	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Maryland								
Somerset	1,155,967	74,525	17,056	2,606	9,879	3,085	2,518	1,265,636
Total State	**1,155,967**	**74,525**	**17,056**	**2,606**	**9,879**	**3,085**	**2,518**	**1,265,636**
Total Study Region	**1,155,967**	**74,525**	**17,056**	**2,606**	**9,879**	**3,085**	**2,518**	**1,265,636**

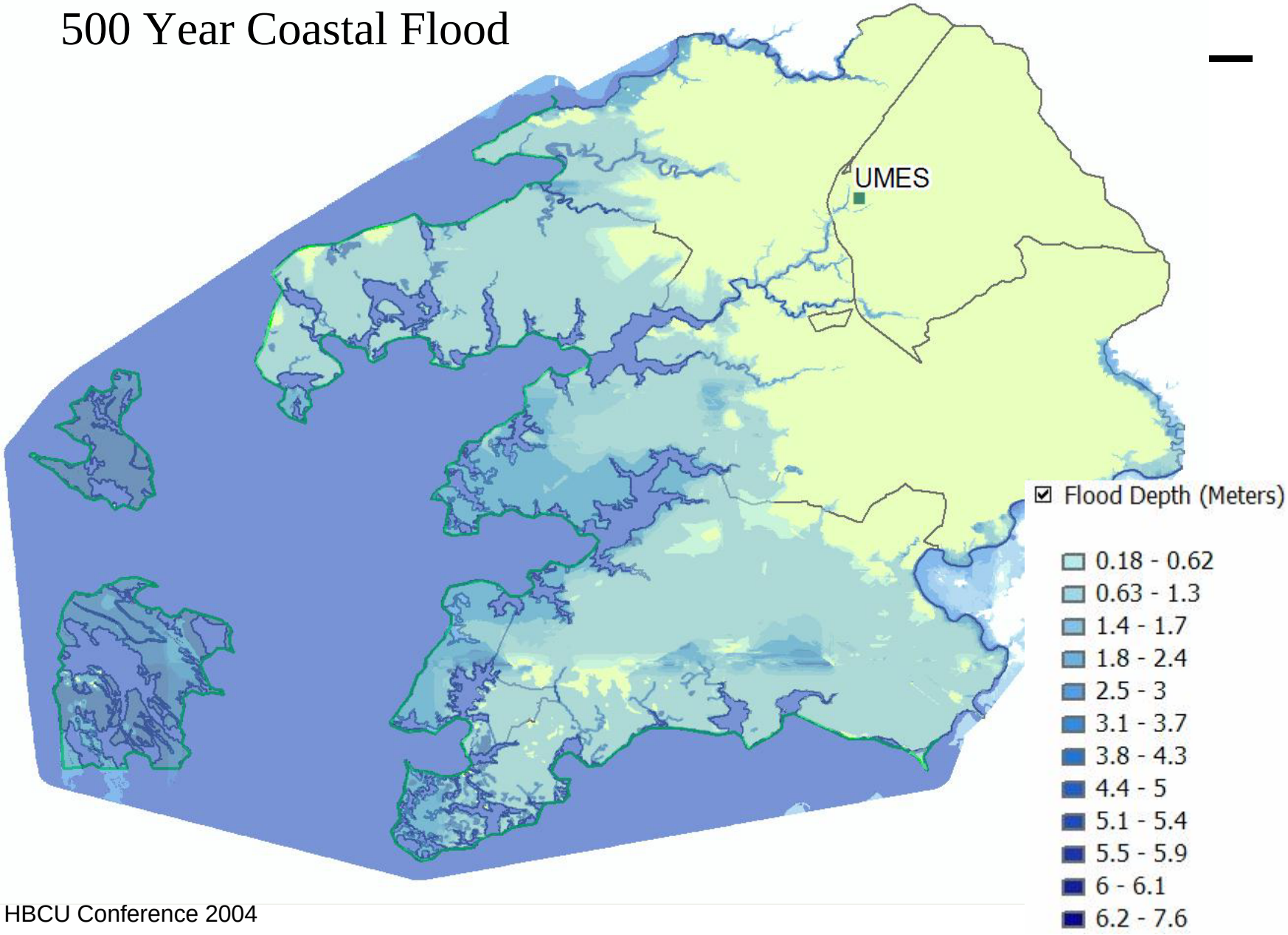
Schools – Probability of Destruction



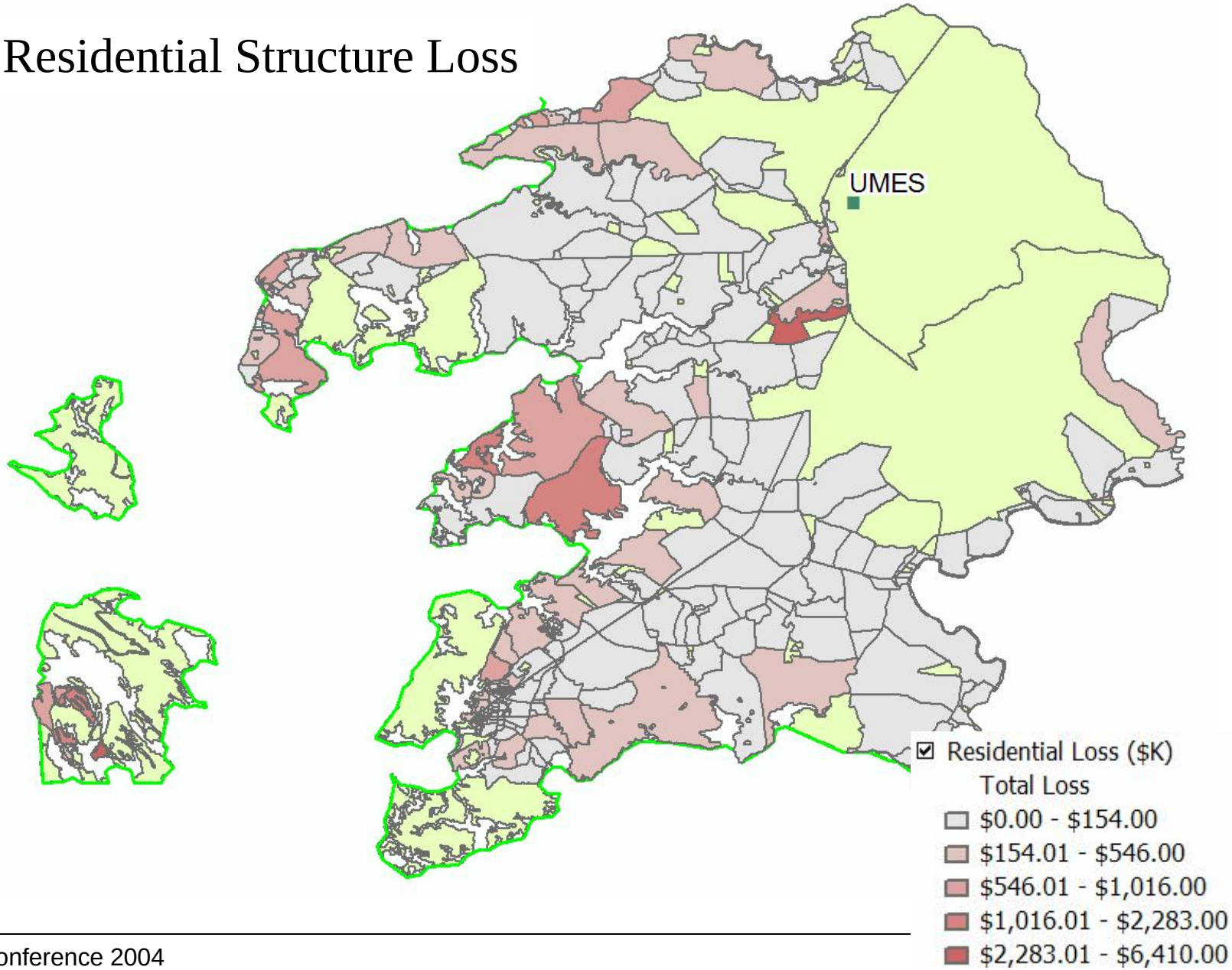
500 Year Coastal Flood

Somerset County, MD

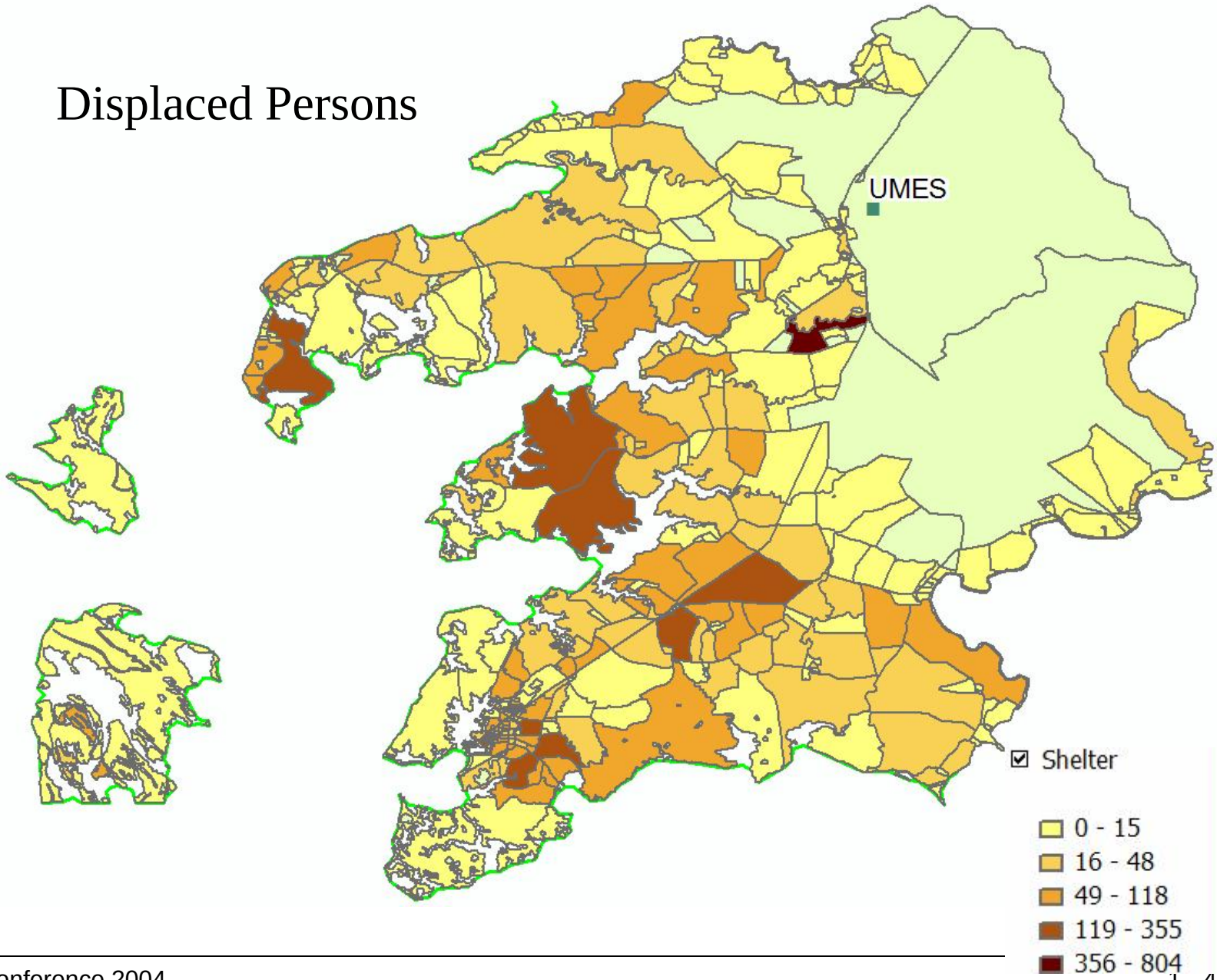
500 Year Coastal Flood



Total Residential Structure Loss



Displaced Persons



Vehicle Loss – Day and Night

Vehicle Dollar Exposure (Day)

March 28, 2004

Study Case Name: 500YrFL
Study Case Description:

Return Period: 500
Analysis Options: 0

All values are in dollars.

	Cars	Light Trucks	Heavy Trucks	Total
Maryland				
Somerset	$12,946,000	$5,444,179	$10,077,807	$28,467,987
Average for Maryland	**$12,946,000**	**$5,444,179**	**$10,077,807**	**$28,467,987**
Study Region Total	**$12,946,000**	**$5,444,179**	**$10,077,807**	**$28,467,987**

Vehicle Dollar Exposure (Night)

March 28, 2004

Study Case Name: 500YrFL
Study Case Description:

Return Period: 500
Analysis Options: 0

All values are in dollars.

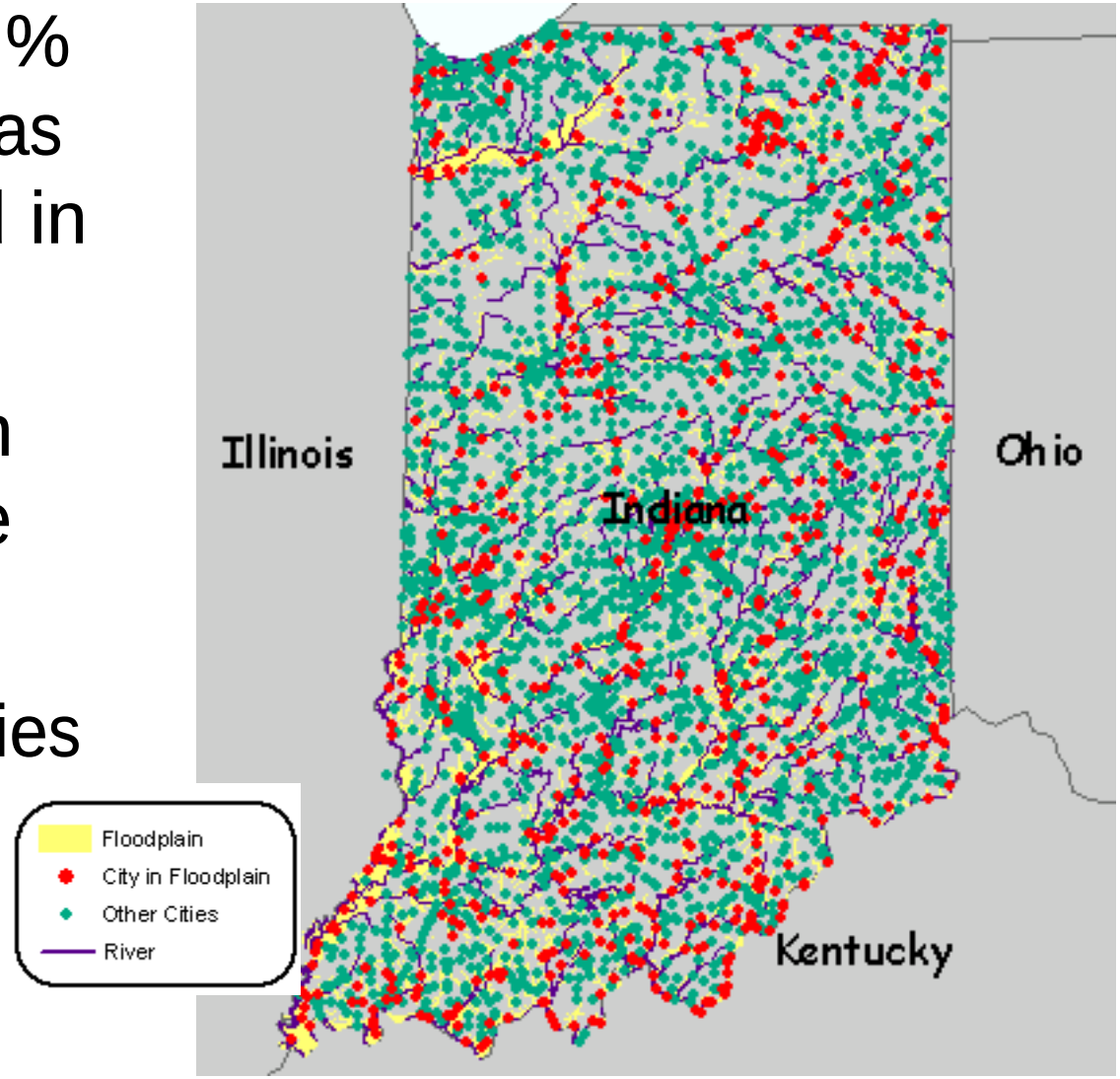
	Cars	Light Trucks	Heavy Trucks	Total
Maryland				
Somerset	$25,291,042	$10,635,638	$19,687,798	$55,614,478
Average for Maryland	**$25,291,042**	**$10,635,638**	**$19,687,798**	**$55,614,478**
Study Region Total	**$25,291,042**	**$10,635,638**	**$19,687,798**	**$55,614,478**

Opportunities for Higher Education Institutions: The Indiana Model

Mid - Atlantic Regional Workshop for Historically Black Colleges and Universities (HBCUs) and Local Communities: Partnering through Emergency Management and Mitigation

The Indiana Model

- Approximately 22% of cities have areas which are located in a floodplain.
- Other cities are in earthquake prone areas.
- Many of these cities have substantial populations.

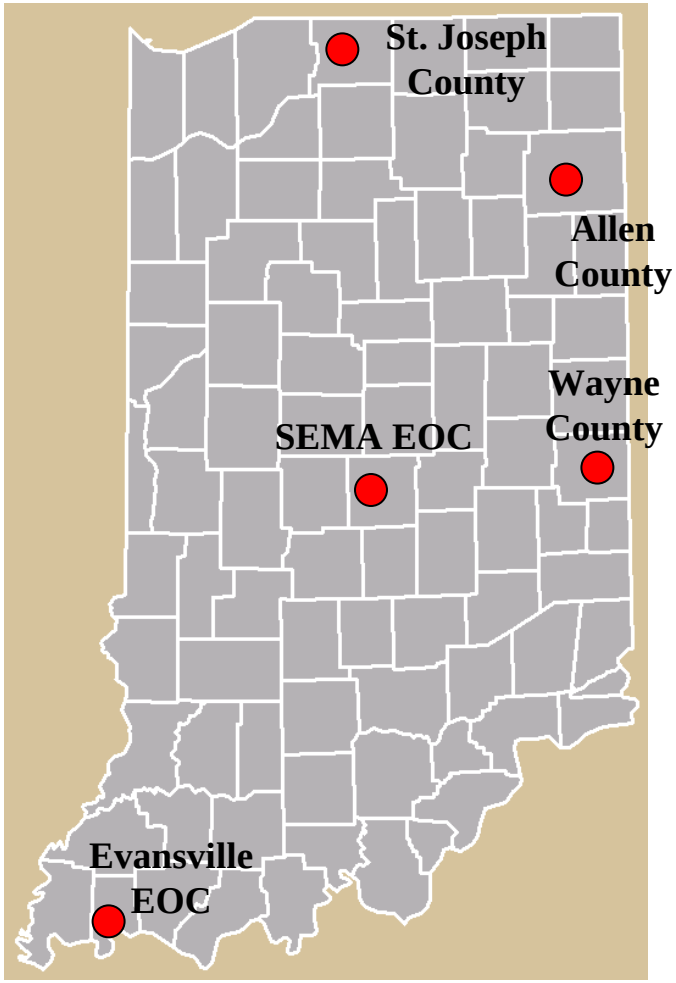


Indiana and Emergency Management

- State has a multitude of cities, towns, and local planning agencies that manage the activities of various combinations of these entities.
- Goal is develop a cadre of professional Emergency Managers.
  - Technologically literate
  - Access to all tools (such as HAZUS-MH) to maximize their limited resources and time.
  - Build awareness in the need to incorporate GIS in planning, response and preparedness.

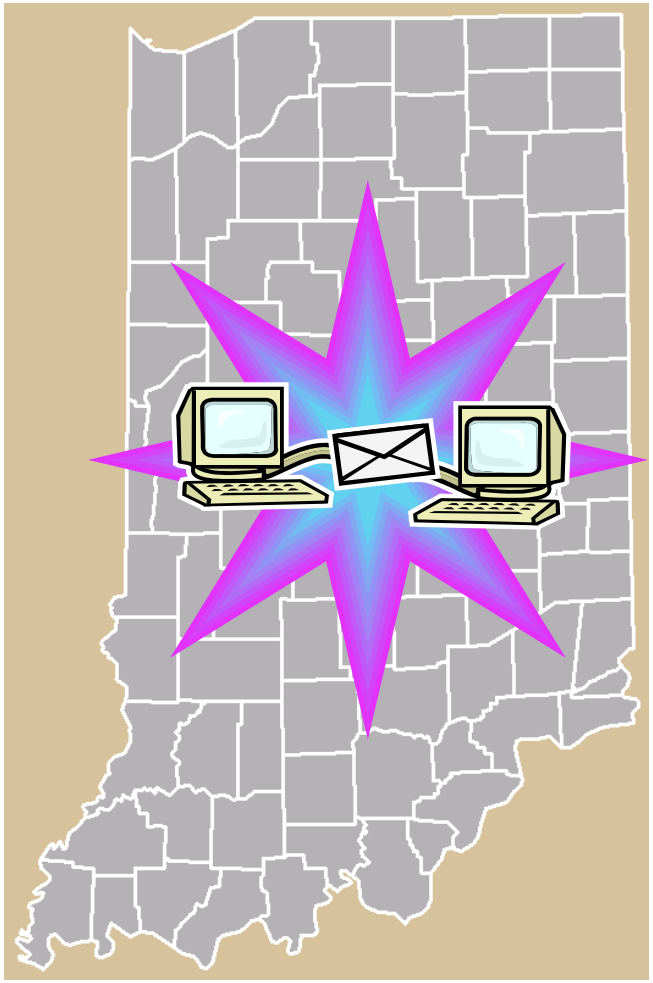
Indiana HAZUS Support Strategy

- HAZUS-MH training is offered at locations throughout Indiana.
- Free of charge to participants.
- Limited travel necessary to acquire training.



Indiana HAZUS Support Strategy

- Creation of network of experts in higher education institutions as well as private sector organizations to support HAZUS Level II/III users.
- HAZUS-MH Users Group.
- Encourage higher education students to perform internships with local agencies to assist with collection and possibly analysis of HAZUS related data.
- Identify data resources



Benefits of Academic Institution and State/Local Agency Collaboration

Mid - Atlantic Regional Workshop for Historically Black Colleges and Universities (HBCUs) and Local Communities: Partnering through Emergency Management and Mitigation

Benefits of the Indiana Strategy

- The Indiana strategy offers many benefits.
- Beneficiaries include:
  - FEMA
  - State planning agencies
  - Local emergency management agencies
  - Higher education institutions
  - Private industry

Benefits to FEMA

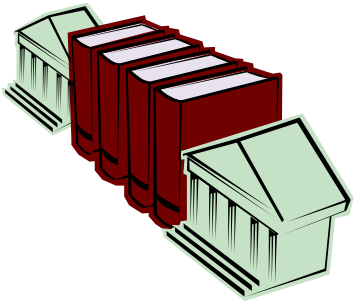
- Provides a means by which to support the anticipated demand for HAZUS-MH training and support.

  Some studies suggest as many as 20,000 HAZUS users.

- Represents an effective collaboration between federal, state, and local agencies that supports the needs of an important federal program.

Benefits for State Emergency Management Agencies

- Higher education institutions have a long standing commitment to serving the educational needs of communities and thus offer a logical resource for educational support.
- Many higher education institutions have existing facilities for educational programs.
- Local expertise may enhance effectiveness of classroom instruction.



Benefits for State Emergency Management Agency

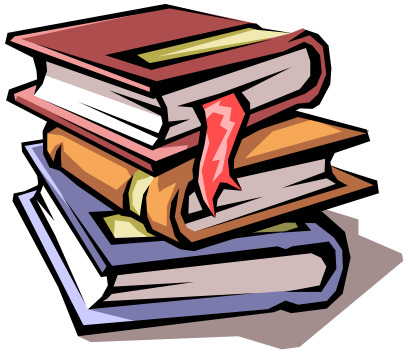
- Local resource leads to reduced cost to state/local agency as a result of limited travel expense.
- Better trained local and state staff to deal with changing demands of their jobs.

Benefits for Local Emergency Planning Agencies

- Local training resource
  - Expense limited to time – no travel cost
- Local expertise
  - Access to experts with knowledge of local landscape and familiarity with local issues
- Develop appreciation of GIS as an effective information management technology
  - Emergency management
  - Facility / infrastructure management
  - ...and many other purposes

Benefits for Higher Education Institutions

- Provides a tool for assessing risk to higher education institution facilities.
- Fulfills the mission of higher education to support the needs of communities.
- Research opportunities for faculty.
- Opportunities for student internships.



Benefits to Private Industry

- Developing an awareness of GIS technology in communities may lead to opportunities for data development.
- Many counties are anticipated to pursue the development of GIS beyond the immediate applications associated with HAZUS-MH.
- GIS service providers are a valuable resource that stands ready to address this need.

Could this strategy work in your state?