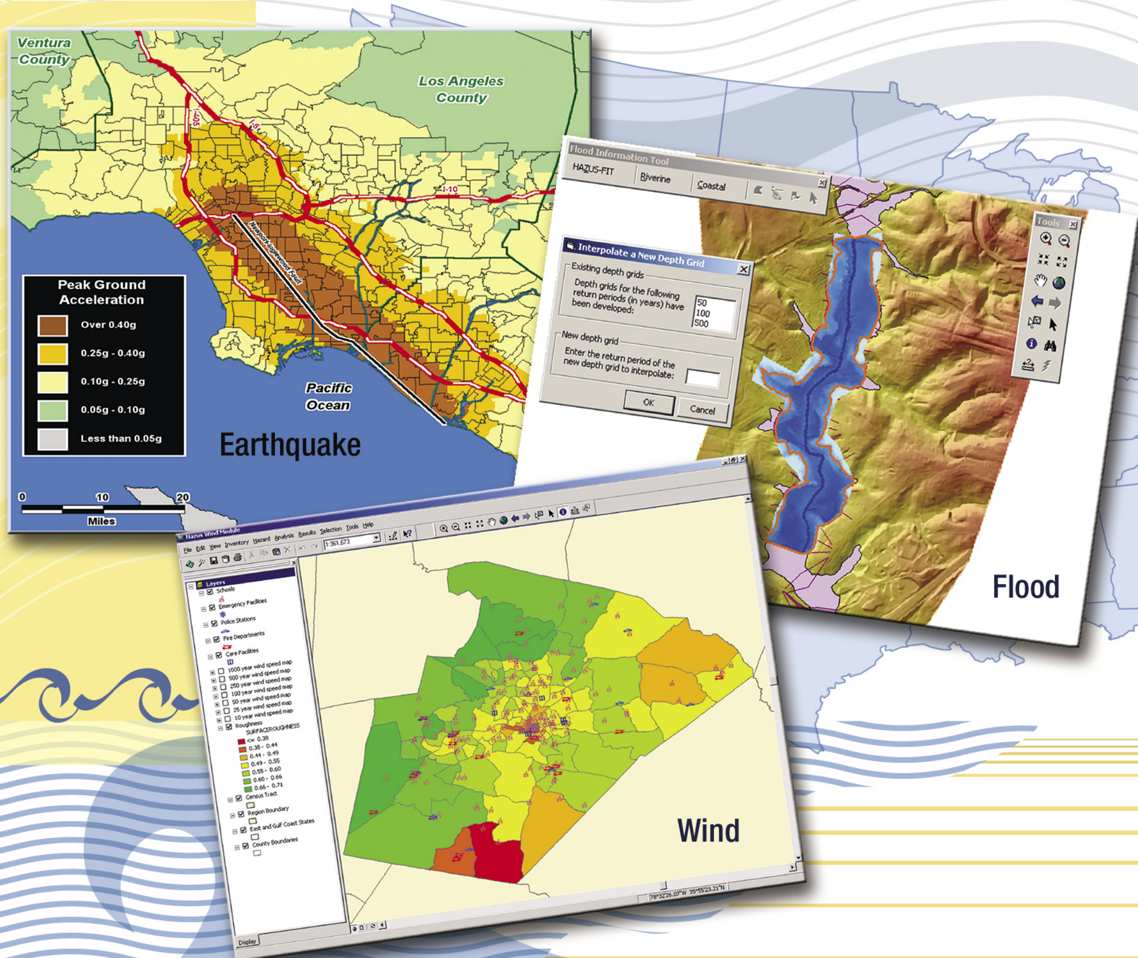


HAZUS®-MH Risk Assessment and User Group Series

Using HAZUS-MH for Risk Assessment

How-To Guide

FEMA 433/August 2004

FEMA

HAZUS®-MH Risk Assessment and User Group Series

Using HAZUS-MH for Risk Assessment

How-To Guide

FEMA 433/August 2004

FEMA

TABLE OF CONTENTS

TABLES

FIGURES

WORKSHEETS

EXAMPLES

ACKNOWLEDGMENTS

This How-To Guide is designed to help prepare standardized, scientifically-based risk assessments using the Hazards U.S. Multi-Hazard (HAZUS-MH) software. The Federal Emergency Management Agency (FEMA) prepared this guide based on field-implemented HAZUS-MH risk assessment pilot projects across the country that are responding to the requirements of the Disaster Mitigation Act of 2000 (DMA 2000). FEMA prepared this guide for users who have had exposure to HAZUS-MH and are interested in using HAZUS-MH to support risk assessment studies.

Principal Authors:

Carla Buriks, Tetra Tech EM Inc.

William Bohn, Tetra Tech EM Inc.

Milagros Kennett, FEMA, Project Officer, Risk Management Series Publications

Lisa Scola, Tetra Tech EM Inc.

Bogdan Srdanovic, Spring International Consulting Group

Contributors:

Scott Lawson, PBS&J

Thomas Adkisson, Tetra Tech EM Inc.

Ross Berman, Tetra Tech EM Inc.

Jawhar Bouabid, PBS&J

Wanda Rizer, design4impact

Deb Daly, Greenhorne & O'Mara, Inc.

This manual was prepared under contract to FEMA. It will be revised periodically, and comments and feedback to improve future editions are welcome. Please send comments and feedback by e-mail to riskmanagementseriespubs@dhs.gov.

OVERVIEW

This Introduction presents the layout and organization of the How-To Guide, an overview of mitigation planning, information about HAZUS-MH and risk assessments, and activities to help establish your risk assessment team.

Layout and Organization of the How-To Guide

This How-To Guide focuses on the basic steps and tasks necessary to complete your risk assessment. The guide presents pertinent information in text boxes that provide specific software and technical information, key definitions, examples, and references. Hazard icons indicate hazard-specific information for several natural disasters. These text boxes and icons provide guidance and helpful suggestions to accomplish the tasks described in this How-To Guide.

REFERENCE

This How-To Guide should be used in conjunction with the HAZUS-MH software; and the user and technical manuals that are provided with your HAZUS-MH software. Other references listed throughout the guide also will assist

Informational Icons

The following icons indicate the topic of each text box:

HAZUS — The **HAZUS** icon indicates information about the HAZUS-MH software, its advantages, and its uses.

DEFINITION — The **Definition** icon identifies key terms, definitions, and acronyms.

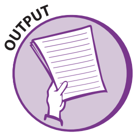
EXAMPLE — The **Example** icon provides examples of how pilot project communities have applied HAZUS-MH in their risk assessments.

NOTE — The **Note** icon identifies additional technical information, including useful reminders and tips based on lessons learned from the pilot projects.

REFERENCE — The **Reference** icon lists additional useful materials and regulatory citations.

WIZARD — The **Wizard** icon refers to two HAZUS-MH utility tools – the Flood Macro Wizard and the Risk Assessment Tool; both tools simplify and shortcut the process of obtaining HAZUS-MH risk assessment outputs.

The **Job Aid** icon indicates resources that can help you complete the risk assessment process using HAZUS-MH.



The **Output** icon indicates outputs for each step of the risk assessment process obtained by implementing the tasks in the How-To Guide and the worksheets included for each step.

Hazard-Specific Icons

The hazard-specific icons provide information and instructions for the following specific natural hazards:

Earthquakes

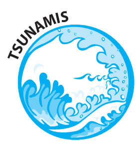
Coastal Floods

Hurricanes

Riverine Floods

Tornadoes

Landslides



Tsunamis

Wildfires

Contents of the How-To Guide

This How-To Guide is organized into an Introduction, five steps, and seven appendices:

- Introduction
- Identify Hazards (Step 1)
- Profile Hazards (Step 2)
- Inventory Assets (Step 3)
- Estimate Losses (Step 4)
- Consider Mitigation Options (Step 5)
- Appendix A: Acronyms and Abbreviations
- Appendix B: Glossary of Terms
- Appendix C: DMA 2000 Job Aids
- Appendix D: Job Aids for Step 2
- Appendix E: Job Aids for Step 3
- Appendix F: Job Aids for Step 4
- Appendix G: Job Aids for Step 5

The sections of this guide are organized around the five steps of conducting a risk assessment using HAZUS-MH. Each step includes:

- Text and graphics that describe the risk assessment steps
- Instructions and corresponding HAZUS-MH screen captures to support the steps
- Practical implementation examples and lessons learned from field-based pilot projects
- Worksheets and associated job aids as training tools to help you complete each step

The remainder of this Introduction provides an overview of mitigation planning, an introduction to HAZUS-MH, and steps to establish your risk assessment team.

Overview of Mitigation Planning

Hazard mitigation is any action that reduces the destructive and disruptive effects of future disasters. Mitigation efforts generally offer the best and most cost-effective methods of addressing the impacts associated with disasters. To support better mitigation planning for future disasters, Congress enacted the DMA 2000. FEMA is the lead agency supporting implementation of the DMA 2000 requirements and makes funds available to support efforts to meet these requirements. In 2002, FEMA issued regulations and guidelines to implement the DMA 2000 requirements for mitigation planning by states and communities. To be eligible for FEMA funds, state and local entities are required to prepare DMA 2000 Hazard Mitigation Plans for natural hazards. Hazard Mitigation Plans can be developed using the general process shown in Figure 1. In addition, the DMA 2000 Job Aids in Appendix C provide a summary of DMA 2000 requirements and how HAZUS-MH resources can support these requirements.

REFERENCE

FEMA developed an Interim Final Rule (for DMA 2000) that specifies the mitigation planning requirements for states and local governments. This rule is available at: http://www.fema.gov/fima/planning10.shtm.

The DMA 2000 Job Aids in Appendix C summarize the rule and list resources available to help you meet DMA requirements.

FEMA developed a series of mitigation planning guides that provide additional information and tools related to DMA 2000 requirements. Information about these guides is available at: http://www.fema.gov/fima/planhowto.shtm.

Additional information, including DMA 2000 Multi-Hazard Mitigation Guidance is available at: http://www.fema.gov/fima/planning_toc4.shtm.

The primary purpose of hazard mitigation planning is to help communities identify the most effective policies, actions, and tools to decrease risk and the potential for future losses in a community. Before implementing mitigation measures, communities must assess potential hazards and the risks that they pose. For purposes of hazard mitigation, risk assessments estimate the social and economic impact that hazards can have on people, buildings, services, facilities, and infrastructure in a community. The usefulness of a risk assessment is directly dependent upon the quality and appropriateness of the data incorporated.

> REFERENCE
>
> Frequently asked questions about the DMA 2000 planning process and its requirements are answered at the following web site: http://www.fema.gov/fima/planfaq.shtm.

Introduction to HAZUS-MH

HAZUS-MH is a nationally applicable software program and standardized methodology for estimating potential losses from earthquake, flood, and hurricane hazards. FEMA developed HAZUS-MH in partnership with the National Institute of Building Sciences (NIBS). Loss estimates produced with HAZUS-MH are based on current scientific and engineering knowledge regarding the effects of earthquake, flood, and hurricane hazards. These loss estimates can support the risk assessment component of your planning effort.

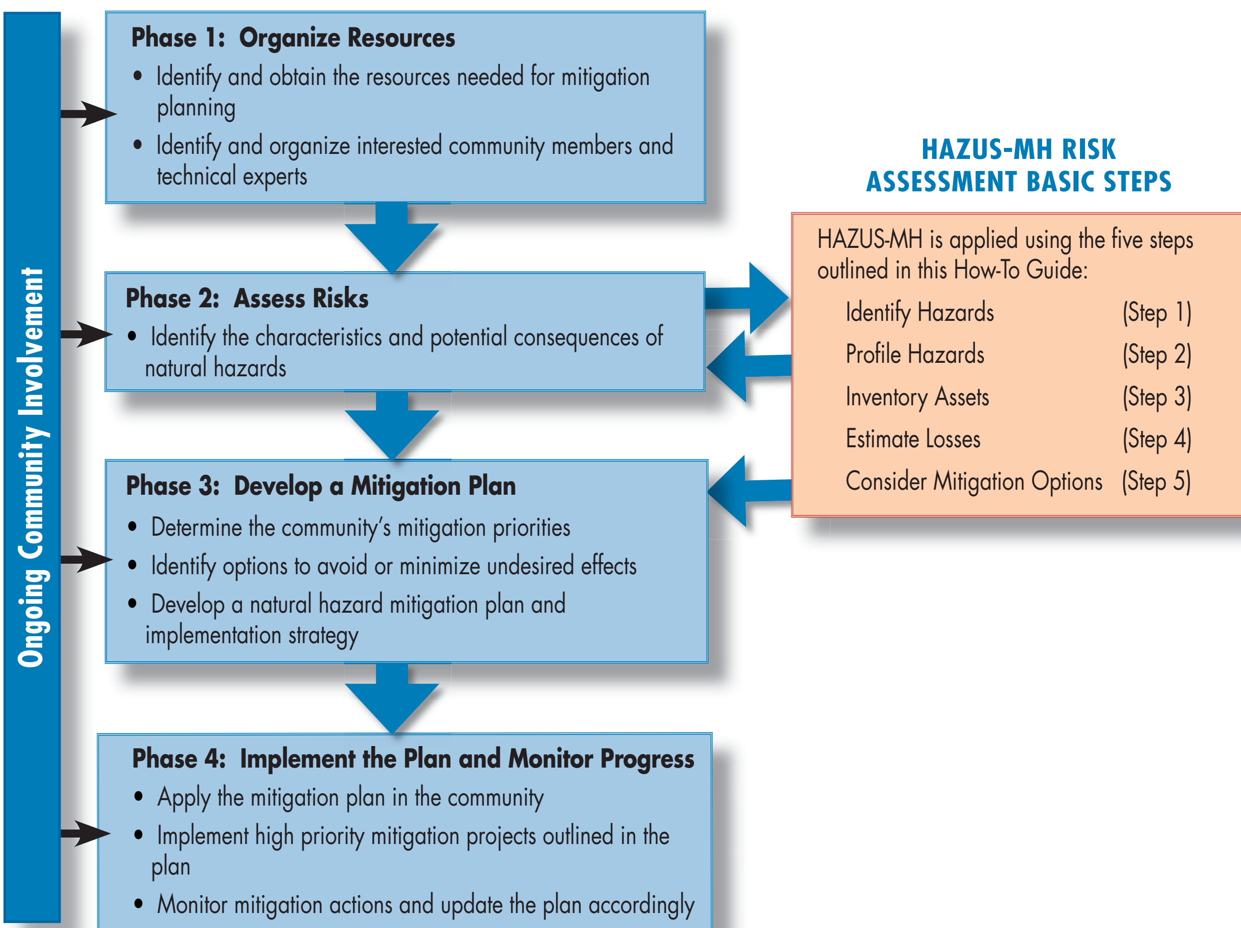


Figure 1 The hazard mitigation planning process

The following user capabilities are recommended for HAZUS-MH:

- Familiarity with Microsoft® Windows-based environments and Geographic Information System (GIS) software (ArcGIS®)
- Knowledge and experience with electronic data manipulation

To order HAZUS-MH software at no cost, complete the order form available at http://www.fema.gov/hazus.

Table 1 shows the computer system specifications required to run HAZUS-MH.

HAZUS-MH includes the largest compilation of geo-referenced data made available by the federal government at no cost. In addition to data provided with HAZUS-MH, a variety of data (presented in further detail throughout the document) are available that can be used in risk assessment studies as follows:

Hazard information to supplement HAZUS-MH provided data may be obtained from sources in the fields of meteorology, hydrology, geomorphology, and seismology.

Inventory data regarding the people and structures at risk are provided in HAZUS-MH from national and regional databases (such as the United States Census) and can be refined with local data.

Vulnerability data regarding areas and assets at particular risk can best be refined at the local level.

Table 1: System Specifications for HAZUS-MH

Area	Minimal	Moderate	Recommended
Computer Speed Memory	Pentium® III, 1 gigahertz (GHz) core speed and 512 megabyte (MB) random access memory (RAM). Allows moderately fast analysis of small communities only.	Pentium® IV, 2 GHz core speed and 512 MB RAM. Allows fast analysis of medium-sized communities and real-time analysis for small communities.	Pentium® IV with 800 MHz system bus and 2.6 GHz (or better) core speed and 1 GB RAM. Allows fast analysis of large urban areas and real-time analysis for all communities.
Computer Storage: Free Hard Disk Space	10 Gigabytes (GB). Allows installation of HAZUS-MH and storage of three scenarios for a medium-sized community.	40 GB. Allows installation of HAZUS-MH and storage of three scenarios for large urban areas.	80 GB. Allows installation of HAZUS-MH and storage of 25 or more scenarios for large urban areas.
Hardware and Software	• CD-ROM reader with 32x minimum read speed • DVD-ROM reader with 12x minimum read speed • Graphics Card with 800x600 minimum resolution • Mouse, keyboard, and computer monitor	• Microsoft® Windows XP or 2000 • ArcGIS® 8.3 GIS software (ArcGIS® 9 in Fall 2004)* • ESRI's Spacial Analyst 8.3	

*HAZUS-MH platform upgrade to version 9

HAZUS-MH has distinct advantages for risk assessment, including:

- Consistent platform and methodology for assessing risk across geographic and political entities
- Framework that can be used to save and update data as population, inventory, and other factors change, and as planning efforts evolve
- Strong mapping capabilities for hazard and inventory data
- Visual mapping and tabular outputs that promote communication and interaction with local stakeholders, a requirement of the mitigation planning process

HAZUS-MH for Risk Assessment

HAZUS-MH can be used to evaluate a variety of hazards and associated risks to support mitigation planning efforts. HAZUS-MH provides natural hazard and inventory data; it estimates losses and has strong mapping and layout capabilities. HAZUS-MH outputs can be presented in map and tabular formats for easy review, use, and communication to stakeholders. HAZUS-MH provides risk assessment outputs and loss estimates for use in:

- Planning for and mitigating the possible consequences of disaster events
- Anticipating the possible nature and scope of emergency response needed to cope with disaster events
- Developing plans for recovery and reconstruction following a disaster

FEMA provides a number of training courses and other resources to support HAZUS-MH. You can learn more about these resources at http://www.fema.gov/hazus/. Look for the "Training/Conferences" link.

The models in HAZUS-MH are designed to estimate the consequences to a city or other defined study region from three primary types of hazard events - earthquakes, floods, and hurricanes. The resulting loss estimates describe the scale and extent of damage and disruption that may result from a potential hazard event. To generate this information, HAZUS-MH uses data provided with the software and/or user-provided local data to estimate the type and extent of damage for each specific hazard. Also, HAZUS-MH can be used to estimate the exposure of local assets to other hazards not included in the software.

HAZUS-MH Levels of Analysis

HAZUS-MH is a flexible software tool that allows for varied levels of customization, based on your resources and analysis needs. The flexibility provided with HAZUS-MH is described as analysis Levels 1 through 3, which are defined as follows:

Level 1: Level 1 involves using HAZUS-MH provided hazard and inventory data with minimal outside data collection or mapping. You can conduct a Level 1 analysis using the inventory and hazard data sets provided with HAZUS-MH. Limited additional data are required to complete a Level 1 flood hazard analysis (e.g., for a coastal analysis, the digital elevation model, 100-year still water area, and still water elevation are required). Level 1 analysis, relying on HAZUS-MH provided data, can be an acceptable level of information for mitigation planning.

NOTE

If a jurisdiction chooses to use HAZUS-MH in support of risk assessment, the minimum level of analysis that is acceptable will vary, depending on the community's resources, data availability, and technical capabilities.

Level 2: Level 2 involves augmenting the HAZUS-MH provided hazard and inventory data with more recent or detailed data for your study region. These additional data are referred to as "local data" throughout this How-To Guide. Use of local data will refine the HAZUS-MH analyses and generally will produce more accurate results.

Level 3: Level 3 involves adjusting the built-in loss estimation models used for the earthquake, flood, and hurricane loss analyses. This typically is done in concert with the use of local data (Level 2 analysis). It is only pursued by advanced users with knowledge of the hazard models developed for HAZUS-MH and when the users need more accurate results or need to solve specific problems.

This How-To Guide focuses on the use of Level 1 and Level 2 analyses using HAZUS-MH. Level 3 analysis techniques are not addressed in detail.

HAZUS-MH Provided Data

HAZUS-MH includes sophisticated models that combine data regarding the vulnerability of the study region to each hazard with data that describe the region's population and social and economic bases. Hazard data include historic events and area characteristics that influence how each hazard impacts a given area. The inventory data for all of the HAZUS-MH models use basic information on population, buildings, and facilities obtained from the United States Census and other national databases.

HAZUS-MH and Local Data

HAZUS-MH includes national data sets that can be supplemented with local data. If local detailed data are available, you may consider using this data to perform more refined studies using HAZUS-MH Level 2 and Level 3 analyses. HAZUS-MH is flexible and allows you to update HAZUS-MH provided data with local data or use a combination of both. Augmenting the HAZUS-MH provided data with local data can improve the accuracy and resolution of your analysis results. However, collecting local data can be time-consuming and costly. Decisions about collecting this information should be balanced against the possible benefits of the data to support mitigation planning.

Evaluation of Hazards Not Included in HAZUS-MH

HAZUS-MH can support the evaluation of some hazards that are not included as models in the current HAZUS-MH software. If your studies and data allow you to map hazard areas for other hazards, you can display these maps using the GIS functionality provided with HAZUS-MH. Also, you can estimate the inventory exposed within the hazard areas for these hazards. If you also have probability data for hazards or strong historical loss data, you can estimate the probability of different levels of losses using techniques outside of the HAZUS-MH software. Approaches to support exposure estimates using hazard area maps are described in Step 4 of this guide.

Risk Assessment Process Using HAZUS-MH

A specific risk assessment process for using HAZUS-MH was documented during the field pilots. This process, shown in Figure 2, outlines the steps, tasks, and subsequent outputs involved in applying HAZUS-MH for your risk assessment. Each of these steps, tasks, and outputs is discussed in more detail in the subsequent steps of this How-To Guide. Note that normally a risk assessment has four steps and concludes with loss estimation; however, for this How-To Guide, a fifth step, Consider Mitigation Options, has been added. The purpose of the added step is to help you with your mitigation planning and assist in identifying, reviewing, and evaluating mitigation measures.

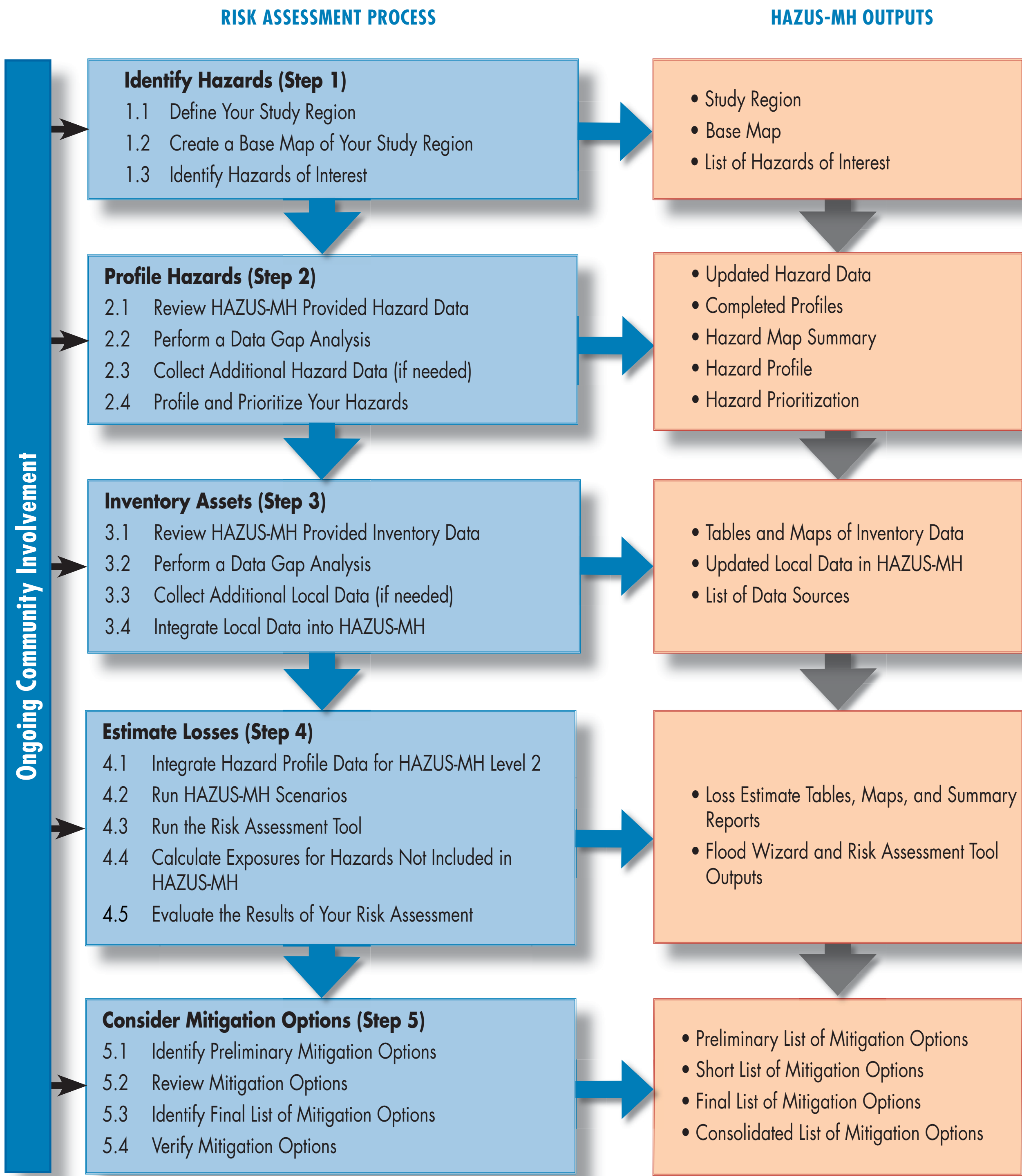


Figure 2 HAZUS-MH risk assessment process and outputs

Establishing Your Risk Assessment Team

Prior to beginning the steps and tasks of your risk assessment, it is prudent to identify and establish your risk assessment team. Table 2 shows the types of personnel who may be useful in mitigation planning and HAZUS-MH risk assessment efforts. Generally, a local planning or emergency management representative will lead this team. The lead person will be primarily responsible for developing the Hazard Mitigation Plan. However, a wide variety of persons may be useful to your team and should be included (e.g., engineers, natural hazard experts, public works directors, and economists). Involving a variety of people from different segments of the community will ensure that all relevant issues and concerns are considered when planning and implementing your risk assessment. It is important to emphasize that because HAZUS-MH runs from a GIS platform, a GIS specialist should be part of the team. Worksheet 1 includes a format for listing your team members and their contact information. Example 1 describes pilot project risk assessment team members. Key team members should meet regularly to develop and implement the risk assessment and subsequent mitigation planning efforts.

Table 2: Members of a Risk Assessment Team

Type of Team Member	Type of Personnel
Members with Specific Responsibilities	Local planning or emergency management representative (team leader)
	Representatives of state and local government agencies
	GIS specialists
	Multidisciplinary subject-matter experts
	Utility companies and public works experts
Support Members (providing advice or technical input)	Community leaders and elected officials
	Business owners and operators and representatives of development organizations
	Representatives of neighborhood groups and other nonprofit organizations
	Interested citizens
	Representatives of Federal Government agencies
	Personnel affiliated with academic institutions

SUMMARY

The introduction should have familiarized you the requirements of DMA 2000 and HAZUS-MH, and how HAZUS-MH can support your risk assessment. Each step of this guide ends with a checklist of activities and outputs that should be completed. Table 3 will help you make sure you have completed these activities. Review the list below and add check marks in the third column where you have completed the activities or outputs indicated.

Table 3: Introduction Activities and Outputs Checklist

Activity	Output	Check Completed Items
Understand the DMA 2000 requirements	Understanding of the DMA 2000 requirements	
Obtain your free copy of HAZUS-MH software from the FEMA distribution center	HAZUS-MH software, user manuals, and technical manuals	
Review the system specifications for HAZUS-MH provided in Table 1	System that has the specifications required for the HAZUS-MH software	
Identify key and support members of your risk assessment team	Risk assessment team documented using Worksheet 1	
Review Introduction text and the examples provided	Understanding of how to get started and how HAZUS-MH can support the risk assessment process	

Complete any missing items in your checklist and then continue to Step 1.

GO TO STEP 1: IDENTIFY HAZARDS

WORKSHEET 1: RISK ASSESSMENT TEAM MEMBERS

Worksheet 1 will help you to keep track of your team members and their roles in preparing the risk assessment for your community.

RISK ASSESSMENT TEAM			
NAME	**TITLE**	**TEAM ROLE**	**CONTACT INFORMATION**
Key team members having specific responsibilities for developing and implementing the risk assessment			
Members providing advice or data during the risk assessment study			
Members providing technical input and support during implementation of the risk assessment			

EXAMPLE 1: PILOT PROJECT RISK ASSESSMENT TEAM MEMBERS

This example illustrates focus areas and team members for the pilot projects communities.

Pilot Project Community Risk Assessment Objectives and Focus Areas	Hazard Mitigation Team Members and Risk Assessment Support Team
City of Austin, Texas • Focus on impacts potentially associated with the Colorado River and specific manmade hazards. • City of Austin personnel had some knowledge of HAZUS-MH and a solid GIS foundation.	Primary team members: • FEMA Headquarters and Region VI • State of Texas Department of Public Safety • State of Texas Division of Emergency Management • City of Austin Office of Emergency Management Planning and GIS Departments Partnering agencies: • Austin Water Protection and Development Review Department • Austin Fire Department • Lower Colorado River Authority • Austin Energy • Texas Geographic Society Consultants: • H20 Partners (City of Austin) • FEMA consultants for Austin, Texas
Eight-County Effort for Wyoming • Focus on impacts potentially associated with flood and earthquake hazards. • HAZUS-MH expertise has developed. • Due to the low population density in WY, some Census tract data needed adjustment to smaller areas called Census blocks. • Local expertise was used to integrate local hazard and inventory data into HAZUS-MH.	Representatives are supporting mitigation planning across the state, including the eight counties of interest. Representatives supporting the mitigation team include: • FEMA Headquarters and Region VIII • Wyoming Geological Society • State and county emergency management representatives • FEMA consultants for Wyoming A focus area for this effort included updating local inventory data for essential facilities and translating Census data from the tract level to a block/grid format to support user needs.
Louisville Metro, Kentucky • Focus on impacts potentially associated with flood and earthquake hazards. • Louisville Metro area boundaries were used as the study area. • A strong GIS capability was provided through a local not-for-profit organization. • Area's flood committee was designated as the All-Hazards Mitigation team. • Timing of the pilot project provided a strong foundation to start the mitigation planning process.	Primary team members: • FEMA Headquarters and Region IV • Louisville Metro Emergency Management Agency representatives • Louisville/Jefferson County Information Center (LOJIC, a GIS support entity) • Members of local planning agencies and utility companies • FEMA and local consultants for Louisville Metro, Kentucky Because of the importance of the flood hazard to this area, Louisville Metro determined that the area's flood committee would serve as the foundation for the risk assessment team and long-term mitigation planning team. This group included representatives from the organizations supporting the risk assessment as well as other local flood committee personnel.

EXAMPLE 1: PILOT PROJECT RISK ASSESSMENT TEAM MEMBERS (continued)

Pilot Project Community Risk Assessment Objectives and Focus Areas	Hazard Mitigation Team Members and Risk Assessment Support Team
Marion and Hamilton Counties, Indiana • Focus on impacts potentially associated with flood and earthquake hazards. • The two counties work together on their emergency planning efforts and, therefore, the study area combined the two counties for this pilot.	The pilot project risk assessment team included a range of parties drawn from organizations such as: • FEMA Headquarters and Region V • State of Indiana Emergency Management Agency (SEMA) • IndyGov - City of Indianapolis and Marion County • Hamilton County Emergency Management Agency • FEMA Consultants for Marion and Hamilton Counties, Indiana Partnering agencies: • Indianapolis Mapping and Geographic Infrastructure Systems (IMAGIS) • Indiana University - Purdue University Indianapolis (IUPUI) The lead for mitigation planning efforts is the area emergency management agency.
City of Portland, Oregon • Focus on performing a refined analysis for earthquake and flood, and using HAZUS-MH as a support tool to consider the landslide and wildfire hazards. • Portland includes a strong GIS capability, refined local data for hazards, and a strong knowledge of HAZUS-MH. • The local team was experienced with HAZUS-MH and supported refinement of the HAZUS-MH provided data.	Primary team members: • FEMA Headquarters and Region IX • State of Oregon Office of Emergency Management • Oregon Department of Geology and Mineral Industries (DOGAMI) • City of Portland Office of Emergency Management • FEMA Consultants for Portland, Oregon Partnering agencies: • City of Portland Bureau of Technology Services • City of Portland Bureau of Environmental Services • City of Portland Bureau of Planning • Metro Regional Service • Multnomah County Office of Emergency Management • Clackamas County Emergency Management The earthquake and flood hazards were analyzed using HAZUS-MH. Exposure was calculated for the landslide and wildfire hazards with HAZUS-MH support and local hazard area maps provided by the community.

STEP 1: IDENTIFY HAZARDS 1

OVERVIEW

The first step in the risk assessment process is to identify hazards that are of interest in your area. This will help you focus on the most important hazards facing your community or region.

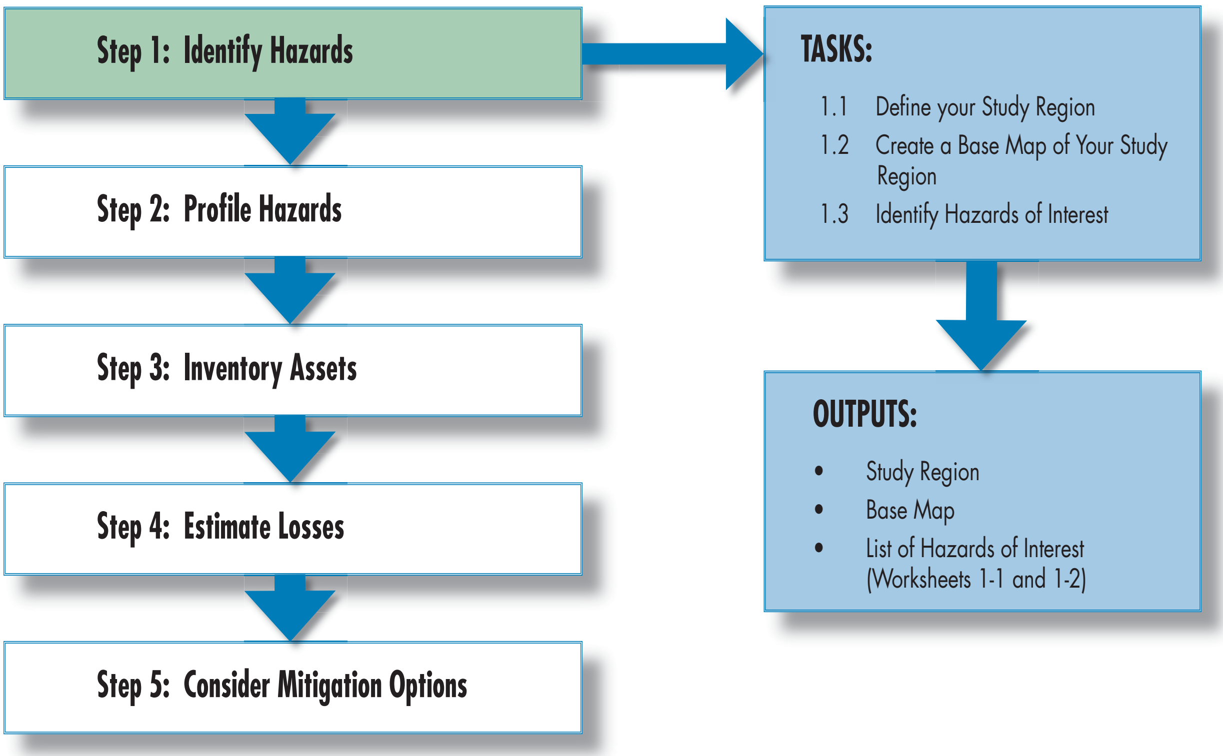


Figure 1-1 Step 1 tasks and outputs

Your hazards of interest will be influenced by the extent of your study region, which will be established as part of Task 1.1. Task 1.2 involves developing your study region base map, which includes important features for your community. Task 1.3 involves listing the potential hazards of interest for your study region. This step discusses each of these tasks. Examples of how pilot project communities addressed this step are also provided. Worksheets 1-1 and 1-2 at the end of this step can help your risk assessment team identify and document hazards on which to focus your risk assessment. The tasks and outputs for Step 1 are shown in Figure 1-1.

> DEFINITION
>
> FEMA defines a hazard as "a source of potential danger or adverse condition." Natural phenomena like earthquakes and floods represent hazards when they have a potential to harm people or property. When a hazard occurs in a particular location, it is referred to as a hazard event.

Define Your Study Region (Task 1.1)

Before identifying the principal hazards in your area, you must first define the boundaries of your study region. Defining your study region means identifying

> The HAZUS-MH Setup DVD-ROM is required to create a study region. This DVD-ROM comes with the software and includes HAZUS-MH data for your area.

the specific geographic area that your risk assessment will address. Your study region may encompass a single jurisdiction or may focus on a multi-jurisdictional geographic area. Considerations for both single- and multi-jurisdictional study regions are described below.

1. **Single-jurisdiction boundaries**. For this approach, you will define the area within your jurisdictional boundaries (e.g., city or town limits) as your study region. This is appropriate in cases where the organization of emergency management functions and the local data available focus on one community or a single jurisdictional area.

2. **Multi-jurisdictional boundaries**. Where counties, cities, towns, and communities implement multi-jurisdictional mitigation planning efforts and risk assessments by pooling resources, the study region could be defined by the geographic boundaries of the participating jurisdictions. This approach should be considered when counties, cities, or towns are in close proximity; when emergency planning is coordinated across jurisdictions; and when a region faces a common or shared hazard threat. For example, an area such as a watershed could be defined as a study region, to support analysis of hazard impacts on an area managed by multiple organizations to protect specific, natural resources.

Start HAZUS-MH

To create a study region in HAZUS-MH, first launch HAZUS-MH on your computer by double-clicking the HAZUS-MH icon. The startup menu will be the first dialogue box displayed when you run HAZUS-MH for the first time. Figure 1-2 displays the first dialogue box that appears when HAZUS-MH is launched. Options for beginning will appear as choices. Select “Create a new region,” and click on the “OK” button.

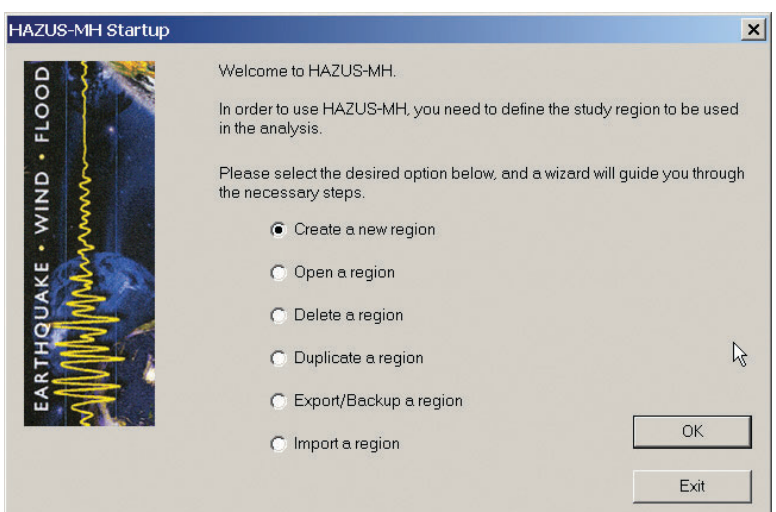


Figure 1-2 HAZUS-MH startup menu

Create a Study Region

After the “Create a new region” function has been activated, the Setup Wizard will guide you through the steps required to create a study region. Figure 1-3 shows the first menu that will be displayed; this menu allows you to enter a name and a description for your study region.

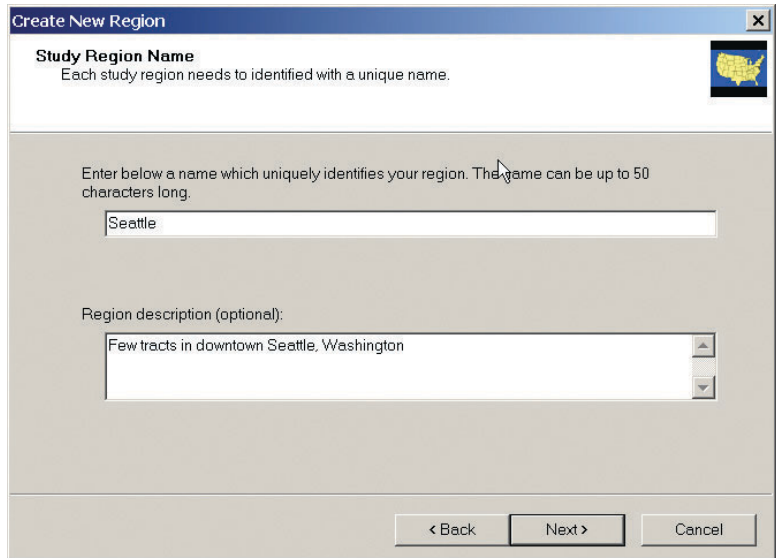


Figure 1-3 Entering the study region name

Figure 1-4 shows the next menu, which requests that you select the types of hazards to be analyzed. This menu represents the current hazard models included in HAZUS-MH. It is recommended that you select all of the hazards when setting up your study region. Once you define your study region and select hazards, you cannot add more hazards as you progress. If you want to drop hazards later in the process, you can simply stop using the menus for those hazards in HAZUS-MH. It should be pointed out that your selection of hazards in HAZUS-MH is not related to Task 1.3, where you will identify all of the hazards of interest that threaten your study region.

> **NOTE**
>
> It is important that adequate disk space be available before you start the aggregation process. The minimum recommended disk space is 10 GB, which will provide the capacity for three scenarios for a study region.

Select a Level of Aggregation

The next activity is to select an aggregation level, as shown in Figure 1-5. You can select the state, county, or Census tract level. HAZUS-MH allows aggregation at different levels, the smallest of which is generally the Census tract for the

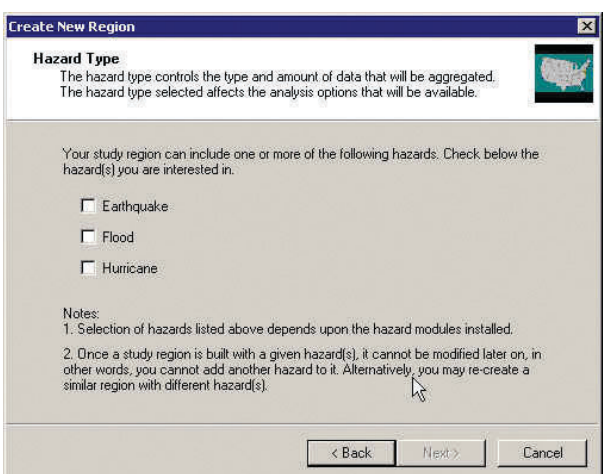


Figure 1-4 Selecting hazards

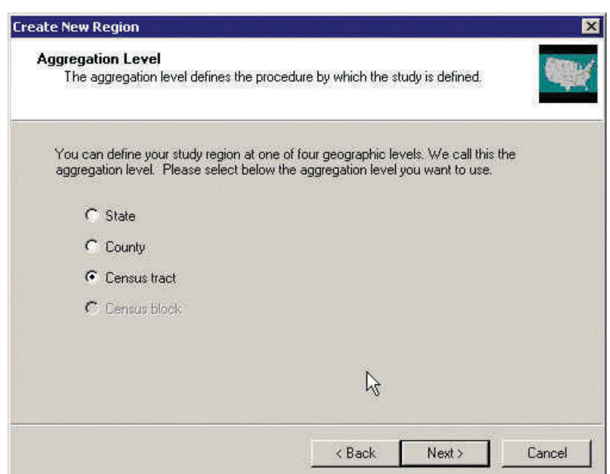


Figure 1-5 Aggregation level menu

earthquake and hurricane modules, and the census block for the flood module. The aggregation level is either equal to or smaller than the study region. A smaller aggregation level provides more detail. The aggregation level represents the scale at which population and general building stock values will be evaluated to estimate losses for your risk assessment study (Step 4).

Figure 1-6 shows the menu list for selecting the state or states included in your study region. Only one state should be selected unless your study region crosses state lines. To select a state, simply click on the state's name in the pull-down menu. To select multiple states, hold down the <Ctrl> key and click on the names of all the states to be included. In Figure 1-6, the user has selected the State of Washington. When you have finished selecting the state or states, click on the "Next" button.

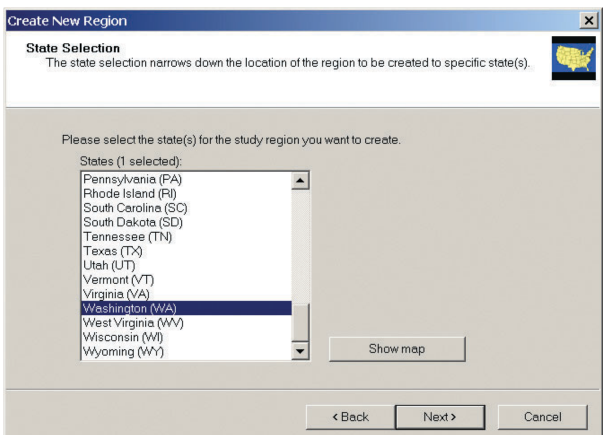


Figure 1-6 State selection list

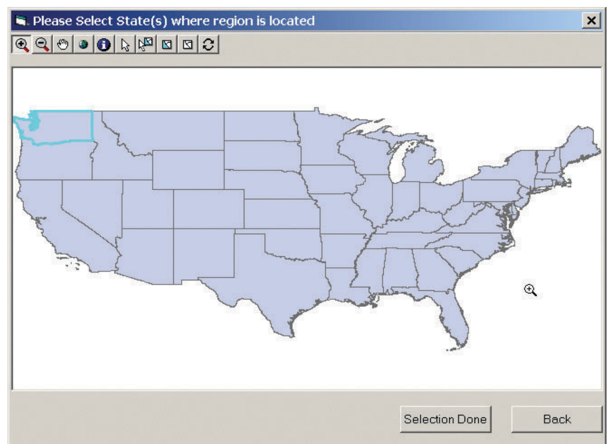


Figure 1-7 State selection map

Alternatively, you can select the state or states in your study region by clicking on the "Show map" button and then on the applicable areas on the map shown in Figure 1-7. To select multiple states, hold down the <Ctrl> key while clicking on the desired states. Click on the "Selection Done" button when you are finished to move to the next activity.

After the state or states have been chosen, you will be prompted to select the relevant counties within each state included in the study region by clicking on the names of those counties in the menu, as shown in Figure 1-8. You can select multiple counties by holding down the <Ctrl> key and clicking on the names of the desired counties. When you have finished selecting the counties, click on the "Next" button. Alternatively, you can click on the "Show map" button and choose the counties from a map of the state as shown in Figure 1-9. Click on the "Selection Done" button when you are finished to move to the next activity.

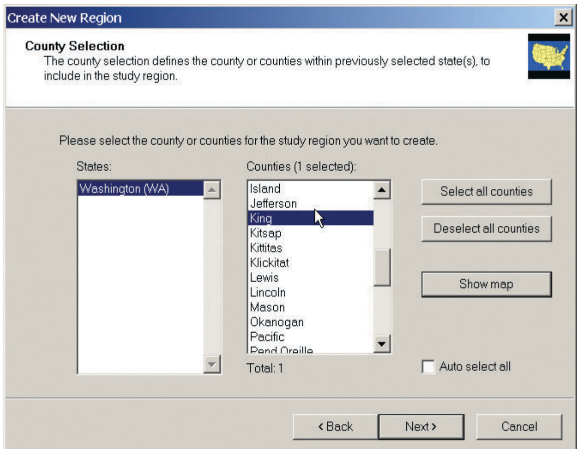


Figure 1-8 County selection list

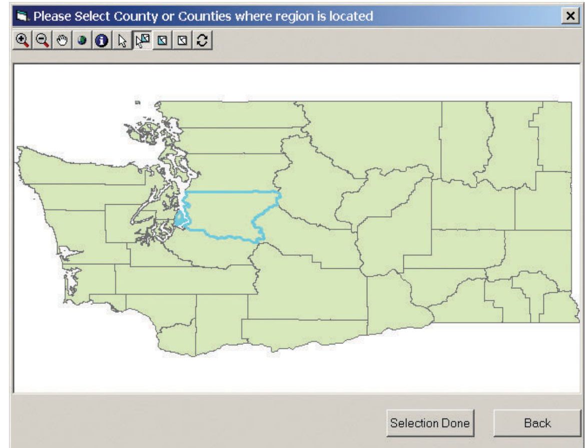


Figure 1-9 County selection map

After a county or counties have been selected, a list of all of the Census tracts in each selected county will appear (see Figure 1-10). Alternatively, you can select the Census tracts that define your study region from the list of tracts or from a map (see Figure 1-11). Census tracts selected for the study region do not have to be sequentially numbered or adjoining. The map is useful when you know the areas of interest, but not all of the specific Census tract numbers of interest.

When you have selected the Census tracts for your study region, click on the "Next" or "Selection Done" button, as applicable. A processing status window will appear and will indicate the progress of aggregation. At this point, you will be prompted to load a DVD-ROM containing the HAZUS-MH provided inventory data for your state(s) of interest. The DVD-ROM is provided with the HAZUS-MH software.

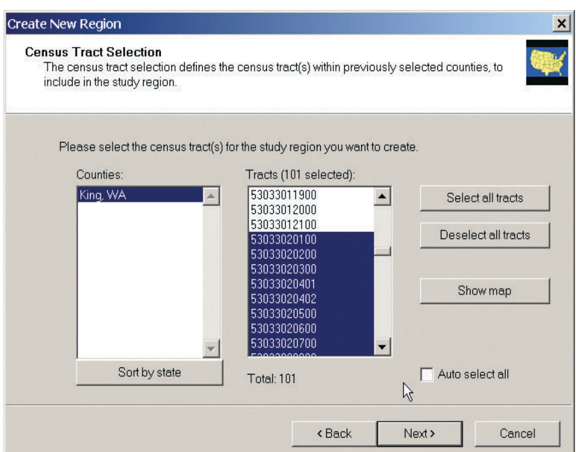


Figure 1-10 Census tract selection list

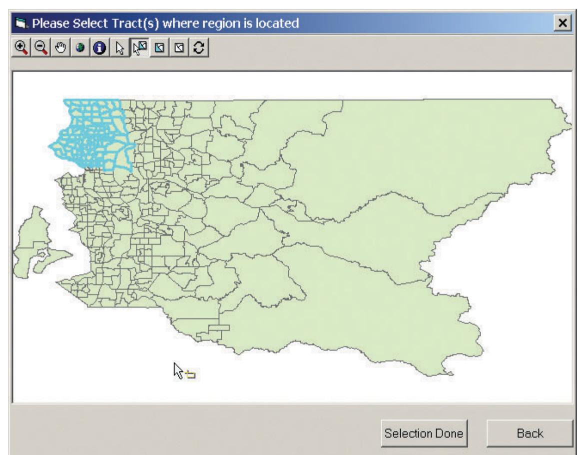


Figure 1-11 Census tract selection map

Congratulations! You have now defined your study region and can proceed to create your base map.

REFERENCE

FEMA HAZUS-MH courses can help you learn more about using GIS to support HAZUS-MH. Additional information on HAZUS-MH training opportunities can be found at:

http://www.fema.gov/hazus/tr_main.shtm.

Create a Base Map of Your Study Region (Task 1.2)

Once your study region is defined, you will use HAZUS-MH to create a base map that graphically presents the defined area. The base map should be shared with your risk assessment team to support hazard identification and to provide a common frame of reference throughout the risk assessment. The base map also is useful for describing your study region to stakeholders and for focusing the risk assessment team on identifying hazards. Base map layers might include the study region boundary, jurisdictional boundaries, and geographic frames of reference, including roads, water bodies, hospitals, and schools.

Base Map Using HAZUS-MH Provided Data

HAZUS-MH will include maps with features that are important to your study region. You may want to create several map layers showing different features for your intended audiences. You can create a base map showing HAZUS-MH provided data such as demographic or economic information derived from the most recent Census. You can also show buildings, roads, rivers, coastlines, and place names. The data layer functions in HAZUS-MH will help you map and view HAZUS-MH provided data. Base maps always should include a north arrow, legend, title, date, and scale.

Base Maps Using Local Data

Local data can be added to your HAZUS-MH base map to supplement provided data, establish location and main characteristics of key natural and physical inventories, and reflect features important to your community. HAZUS-MH runs from Environmental Systems Research Institute Inc.'s (ESRI's) ArcGIS platform. Before local GIS data are imported into HAZUS-MH, they must be in a format compatible with ArcGIS. The GIS data also must be projected in the correct coordinate system. To be compatible with HAZUS-MH, data often must be converted and projected, as described below.

Data Conversion. Local source data selected for use in the HAZUS-MH base map may be in hard copy or electronic format. Hard copy maps need to be digitized and converted to the ArcGIS format. A digitizing tablet will be required for this activity. For more information on the digitizing process, consult your tablet's instruction manual. These electronic data will include electronic maps and data tables. Electronic data may have been developed using a number of software packages such as MapInfo, Intergraph, and AutoCAD. If you have a GIS layer

DEFINITION

Digitizer: A device used to convert hard copy maps into an electronic format. The digitizer consists of an electronic tablet that is overlain with the paper map. A puck is then used to trace the map features and electronic data are created.

that needs to be converted into the ArcGIS format, follow the directions below.

1. Open the ArcGIS folder and select the ArcToolbox icon.
2. Select “Conversion Tools” and then “Import to Shapefile” (see Figure 1-12).
3. Select the option that corresponds to your data. For example, if you are converting data from MapInfo to ArcGIS, you would select the “MapInfo (MIF) to Shapefile” option.
4. Select your source data file. For the example above, you would select the MapInfo file.
5. Select a prompted menu and choose the destination folder. This is the location where the new shapefile will be created. The folder’s name and location are not constrained by HAZUS-MH. You should develop a folder system that is clear to you and others on your team who may need to access this information.
6. Select “OK” in the menu box.

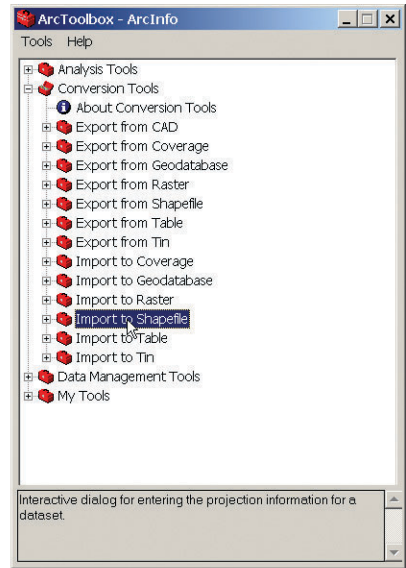


Figure 1-12 ArcToolbox data conversion utility

Data Projection. All data used by HAZUS-MH must be in the same projection, or coordinate system. Your local base map data needs to be in the Latitude/Longitude (Lat/Long) coordinate system, (WGS84) datum, and in decimal degrees. If your data are not in the correct projection, follow the directions below.

1. Open the ArcGIS folder and select the ArcToolbox icon.
2. Select “Projections” and then “Define Projection Wizard (overlaps/grids/TINs)” (see Figure 1-13).
3. Select your shapefile by browsing to its location.
4. Select “Next,” and then select the coordinate system in which your shapefile resides. If you are unsure about your current data projection, view the metadata file. Typically, this file is named after your shapefile and has a “.met,” “.html,” or “.xml” extension. For example, if you had a soil map called “soils.shp,” the metadata file would be called “soils.html.” The metadata file should show the projection used.
5. Select “Next” and then “Finish.” You have now assigned the current projection to your data set.
6. Select “Projections” and then “Project Wizard (shapefiles).”

Figure 1-13 ArcToolbox data projection utility

7. Select your shapefile by browsing to its location.

8. Select "Next," and then browse to the folder where the new shapefile will be created.

9. Select "Next," and then select the Lat/Long projection.

10. Select "OK" and then "Next" and your correctly projected shapefile will be created.

Display Local Data on Your Base Map

You can now bring your local base map data directly into your HAZUS-MH study region. Select "Add Layer" under "File" on the HAZUS-MH main menu, and browse to your local data (see Figure 1-14). Your data can be displayed on the base map using the same standard symbols that you use for other mapping purposes. All of the ArcGIS functionality is preserved when you bring the data into HAZUS-MH.

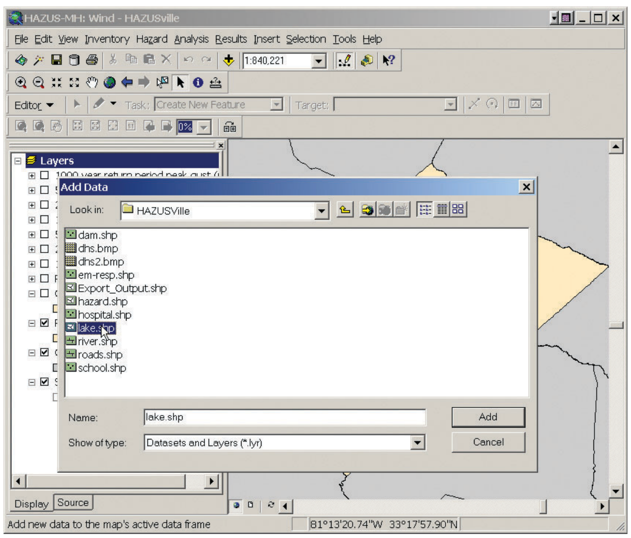


Figure 1-14 Adding local base map data

After all of the layers are visible and symbolized logically, select "View" from the main menu, then "Layout View." A base map containing your study region will be generated with a title, description, legend, scale, date, and the HAZUS-MH logo. This layout can be used "as-is" or can be further developed and edited to complement other maps you create. To save your base map, select "File" from the main menu, then "Save."

Congratulations! You have now created your base map and can proceed to identify hazards of interest.

Identify Hazards of Interest (Task 1.3)

Task 1.3 will help you to identify hazards of interest in your study region and to focus on further risk assessment efforts. This initial list of hazards of interest is intended to ensure the risk assessment team has considered the range of likely hazards that could impact your study region. This list will typically be developed based on community input, the professional judgment of the team, and local knowledge of past hazard events.

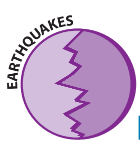
This list can be developed by collecting data, having meetings with knowledgeable personnel, and using your own information regarding hazards that are, or might become, priority concerns in your area. Your initial list of hazards will be used to document all of the hazards considered; those dropped from consideration in Step 1; and those carried forward for further evaluation under Step 2, Profile Hazards.

This section presents an overview of various natural hazards that could occur in your study region. This section also discusses how you can manage your hazard data and provides a foundation for further study in Step 2.

Potential Hazards of Interest and HAZUS-MH

The general perception of natural hazards is that earthquakes occur in California, floods in many riverine and coastal locations, tornadoes in the Midwest, and hurricanes along the Atlantic and Gulf coasts. Although there is some truth to this perception as it relates to the highest probabilities for each hazard, hazard maps show that the entire United States is vulnerable to one or more of these primary natural hazards. Earthquakes are predominant in the West, but also threaten specific regions in the Midwest, Northeast, and Southeast. Riverine floods occur along rivers, largely but not exclusively in the Midwest, and coastal flooding is associated with storm surges caused by high winds. Flash floods caused by sudden, intense rainstorms may occur anywhere. Extreme winds are regional (e.g., hurricanes along the Atlantic and Gulf coasts, the Caribbean, and the South Pacific; tornadoes typically in the Midwest; and downslope winds adjoining mountain ranges), but high winds can also occur anywhere.

Hazards that may affect your study region are discussed below. The hazards include those that can be evaluated using HAZUS-MH and those that can be evaluated with HAZUS-MH support. Hazards that can be evaluated using HAZUS-MH are earthquakes, floods (coastal and riverine), and hurricanes; therefore, these three hazards are presented first. Step 2 provides a detailed discussion and sources of information on the hazards.



Earthquakes

The surface of the earth consists of solid masses, called tectonic plates, that float on a liquid core. The areas where separate plates meet each other are called faults. An earthquake is a sudden movement of the earth's crust caused by the abrupt release of strain that has accumulated over a long period of time. Records show that some seismic zones in the United States experience moderate to major earthquakes approximately every 50 to 70 years, while other areas have recurrence intervals for the same size earthquake of about 200 to 400 years. Records also show that building inventories in 39 states are vulnerable to earthquake damage. Most of the well-known areas of strain, or faults, are located in the Western United States, where most recent earthquakes have occurred. However, the Eastern and Central United States are also vulnerable to devastating earthquakes. Earthquake risk is related to the following factors: a) ground motion; b) fault rupture under or near a building, often occurring in buildings located close to faults; c) reduction of the soil bearing capacity under or near a building; d) earthquake-induced landslides near a building; and e) earthquake-induced waves in bodies of water near a building (tsunami on the ocean and seismic seiche on lakes).

Earthquakes are low probability, high-consequence events. Although they may occur only once in the lifetime of a particular asset, they can have devastating effects. Moderate earthquakes occur more frequently than major earthquakes. Nevertheless, a moderate earthquake can cause serious damage to unreinforced buildings (i.e., unreinforced masonry buildings, buildings constructed without seismic requirements, or buildings designed to obsolete standards), building contents, and non-structural systems, and can cause serious disruption in building operations. Major earthquakes can cause catastrophic damage, including collapse and massive loss of life.

Earthquake fault rupture causes ground motion over a wide area. This ground motion acts as a powerful force on the building inventory. The most drastic effects occur chiefly near the causative fault where there is often appreciable ground displacement as well as strong ground shaking. As the shaking propagates to the surface, it may be amplified depending on the intensity of shaking, topography, nature of the rock, and, above all, by the surface soil type (earthquake damage tends to be more severe in areas of soft soils) and depth. Impact to the building can depend on the type of earthquake waves (i.e., whether they are quick and abrupt or slow and rolling).

Structures subject to earthquake risk must be designed for higher force resistance if they are located on poor soils. Most structures are principally designed to resist the force of gravity, but resistance to earthquake forces requires specialized earthquake engineering. Horizontal earthquake forces cause rapid movement of the foundation and displacement of upper levels of the structure. When inadequately designed to resist or accommodate these earthquake forces, structures fail, leading to serious structural damage, and, in the worst case, total collapse.

Moderate and even very large earthquakes are inevitable, although very infrequent, in areas of normally low seismic activity. Consequently, in these regions buildings are seldom designed to deal with an earthquake threat; therefore, they are extremely vulnerable. In many parts of the United States, the greatest earthquake risk is associated with buildings that were designed and constructed before the use of modern building codes. For many parts of the United States, this includes structures built as recently as the early 1990s. In other places, such as California, the earthquake threat is quite familiar and adequate building codes have taken this threat into consideration since the mid-1970s.

An earthquake is a primary hazard included in HAZUS-MH. In addition, hazard event data are included with the software. You can determine earthquake risk by using the data provided in HAZUS-MH.

Floods (Coastal and Riverine)

Flooding is a common hazard in the United States, affecting over 20,000 local jurisdictions. Several evaluations have estimated that 10 percent of the Nation's land area is subjected to flooding. Some communities have very little land that is identified as exposed to flooding, although others lie entirely within the floodplain. Floods are fairly specific and predictable in their location, and effective design against floods is less a matter of design concept than of siting. A building can be located in such a way that floods will never be a problem; however, our floodplains are full of existing buildings.

Flooding is a natural process that may occur in a variety of forms: long-duration flooding along rivers that drain large watersheds; flash floods that send a devastating wall of water down a mountain canyon; and coastal flooding that accompanies high tides and on-shore winds, hurricanes, and Nor'easters. Flooding is only considered a problem when human development is located in flood-prone areas. Problems can result, exposing people to dangerous situations and property to damage, but also disrupting the natural function of floodplains and redirecting surface flows onto lands that are not normally subject to flooding.

The flood hazard can be characterized by a relationship between the depth of flooding and the annual chance of inundation to that depth. Depth, duration, and velocity of water are the primary factors contributing to flood losses. Other impacts associated with flooding that contribute to losses include channel erosion and migration, sediment deposition, bridge scour, and the impact of flood-borne debris.

Flood frequency studies define the flood hazard in terms of the chance that a certain magnitude of flooding is exceeded in any given year. What is commonly called the 100-year flood is not a flood that occurs every 100 years, but is a flood that has a 1 percent chance of occurring in any year. Flood magnitude is usually measured as discharge value, flood

> REFERENCE
>
> Manmade hazards are an increasing concern. FEMA has developed the Risk Management Series to help communities assess and address these hazards. Documents are available at:
>
> http://www.fema.gov/fima/rmsp.shtm

elevation, or depth. For example, the 100-year flood elevation is the elevation at the point of interest that has a 1 percent annual chance of being exceeded by floodwaters. Using the flood hazard frequency convention, flood hazard is defined by a relation between depth of flooding and annual chance of inundation greater than that depth. This relation is called a depth-frequency curve.

Coastal flooding refers to the inundation of land areas along the oceanic coast caused by sea waters over and above normal tidal action. Coastal flooding is experienced along the Atlantic, Gulf, and Pacific coasts, and many larger lakes, including the Great Lakes. Coastal flooding is influenced by storm surges associated with tropical cyclonic weather systems (hurricanes, tropical storms, tropical depressions, typhoons), extratropical systems (Nor'easters), and tsunamis (surges induced by seismic activity). Coastal flooding also is generally characterized by wind-driven waves. Wind-driven waves affect reaches along the Great Lakes shorelines, where wind blowing across the broad expanses of water generate wind-driven waves that can rival those experienced along oceanic coastal shorelines. Some Great Lakes shorelines experience coastal erosion, in part associated with fluctuations in water levels.

Riverine flooding is due to the accumulation of runoff from rainfall or snowmelt such that the volume of flow exceeds the capacity of waterway channels and therefore, water spreads out over the adjacent land. Riverine flooding flows downstream under the force of gravity. Inundation, duration, and velocity are functions of many factors, including watershed size and slope, degree of upstream development, soil types, nature and extent of vegetation, steepness of the topography, and characteristics of the storm (or depth of snowpack and rapidity of melting).

Riverine and coastal flood hazards are primary hazards included in HAZUS-MH. You can determine riverine and coastal flood hazards risk by using the data provided in HAZUS-MH.

Hurricanes

A hurricane is a severe tropical storm that forms in the southern Atlantic Ocean, Caribbean Sea, Gulf of Mexico, or eastern Pacific Ocean under the following conditions: warm, tropical oceans; moist air; and light winds. If the right conditions last long enough, a hurricane can result and can produce violent winds, enormous waves, torrential rains, and floods. On average, six Atlantic hurricanes occur each year. When hurricanes move onto land, associated rain, strong winds, and large waves can damage buildings, trees, and cars.

Hurricanes are grouped into five categories according to their prevailing wind speeds, with Category 5 hurricane winds exceeding 155 miles per hour (mph) and having a minimum sustained speed of 74 mph. High sustained winds may cause extensive structural damage to buildings and houses. These winds can also roll cars, blow over trees, and erode beaches (both by blowing sand and by blowing waves against the beach).

Hurricanes can trigger storm surges, tornadoes, and extensive and damaging inland flooding. While storm surge is always a potential threat, more people have died from inland flooding associated with hurricanes in the last 30 years. Intense rainfall, as much as 10 to 12 inches in 48 hours, is not directly related to the wind speed of tropical storms. In fact, some of the greatest rainfall amounts occur from weaker storms that drift slowly or stall over an area. Inland flooding can be a major threat to communities hundreds of miles from the coast as intense rain falls from these huge tropical air masses.

In terms of wind interaction with buildings, hurricanes create both positive and negative (i.e., suction) pressures. A particular building must have sufficient strength to resist the applied wind loads in order to prevent wind-induced building failure or damage. The magnitude of the pressure is a function of building exposure. Building exposure is based on characteristics of the ground roughness and surface irregularities in the vicinity of a building that influence the wind loading. Exposure can be explained in terms of the roughest terrain and the smoothest. Rough terrain includes urban, suburban, and wooded areas. Smooth terrain includes flat open terrain with scattered obstructions and areas adjacent to water surfaces in hurricane-prone areas. The smoother the terrain, the greater the wind loads. Important factors regarding building vulnerability include:

- Topography (abrupt changes in topography)
- Building height (relationship between the wind speed and the height of the building above the ground)
- Internal pressure (wind can cause either an increase in the pressure within the building, known as positive pressure, or it can cause a decrease in pressure, known as negative pressure)
- Aerodynamic pressures (interactions between the wind and the building affecting primarily the roof corners)

Hurricanes are a primary hazard included in HAZUS-MH. Historic event data are included with the software. You can determine hurricane hazards risk by using the data provided in HAZUS-MH.

Landslides

Landslides are rock, earth, or debris flows on slopes due to gravity. They can occur on any terrain, given the right conditions of soil, moisture, and the angle of slope. Integral to the natural process of the earth's surface geology, landslides serve to redistribute soil and sediments in a process that can include abrupt collapses or slow gradual slides. Landslides are a widespread geologic hazard and result in about $2 billion in damages and more than 25 fatalities annually. They pose a serious threat to highways and buildings and commonly occur in association with other major natural disasters such as earthquakes and floods. Landslides can be triggered by other hazards, but also can take place independently.

Landslides can occur in developed or undeveloped areas, and in any area where the terrain was altered for roads, houses, utilities, buildings, or even for backyard lawns. Factors affecting landslides can be geophysical or manmade. The resulting slurry of rock and mud may pick up trees, houses, and cars, thus blocking bridges and tributaries and causing flooding along its path. Any area composed of weak or fractured materials resting on a steep slope can, and will likely, experience landslides. Landslides occur in all 50 states with varying frequency and more than half of the states have rates sufficient to classify landslides as a significant natural hazard.

As discussed in Step 4, HAZUS-MH can support your exposure assessment of the landslide hazard.

Tornadoes

Tornadoes are one of nature's most violent storms. A tornado can be defined as a rapidly rotating column of air extending from the base of a thunderstorm to the ground. In an average year, approximately 1,000 tornadoes are reported across the United States, resulting in 80 deaths and over 1,500 injuries. The most violent tornadoes, with wind speeds of 250 mph or more, are capable of tremendous destruction. Damage paths can be more than 1 mile wide and 50 miles long. Tornadoes can occur anywhere in the United States, but they are most common in the Great Plains region that includes parts of Texas, Oklahoma, Kansas, and Nebraska. Tornadoes are responsible for the greatest number of wind-related deaths each year in the United States.

Tornadoes come in all shapes and sizes. In the southern states, peak tornado season is March through May; peak months in the northern states are during the summer. Tornadoes can also occur in thunderstorms that develop in warm, moist air masses in advance of eastward-moving cold fronts. These thunderstorms often produce large hail and strong winds, in addition to tornadoes. During the spring in the central plains, thunderstorms frequently develop along a "dryline," which separates warm, moist air to the east from hot, dry air to the west. Tornado-producing thunderstorms may form as the dryline moves east during the afternoon hours. Along the front range of the Rocky Mountains, in the Texas panhandle, and in the southern high plains, thunderstorms frequently form as air near the ground flows "upslope" toward higher terrain. If other favorable conditions exist, these thunderstorms can produce tornadoes. Tornadoes occasionally accompany tropical storms and hurricanes that move over land. They are most common to the right and ahead of the path of the storm center as it comes onshore.

As discussed in Step 4, HAZUS-MH can support your exposure assessment of the tornado hazard.

Tsunamis

Tsunamis are a series of very long waves generated by rapid, large-scale disturbances of the sea. Most tsunamis are generated by sea floor displacements resulting from large undersea earthquakes. Oceanographers often refer to tsunamis as seismic sea waves because they are usually the result of a sudden rise or fall of a section of the earth's crust under or near the ocean. A seismic disturbance can displace the water column, creating a rise or fall in the level of the ocean above. This rise or fall in sea level is the initial formation of a tsunami wave. Tsunami waves can also be created by volcanic activity and landslides occurring above or below the sea surface. These types of activities produce tsunamis with much less energy than those produced by submarine faulting. The size and energy of these tsunamis dissipates rapidly with increasing distance from the source, thus resulting in more localized devastation.

Tsunamis can quickly inflict great damage on shore areas near their source. Some tsunamis can cause destruction across an entire ocean basin within hours. Most tsunamis occur in the Pacific region, but they can occur in every ocean and sea. There have been tsunamis in most oceans of the world, but most notably in the Pacific Ocean. The coastline of Hilo, Hawaii, has seen inundation several times and a major earthquake in Alaska in 1964 resulted in a tsunami with a height of 6 meters in Crescent City, California, killing several people.

Just like other water waves, tsunamis begin to lose energy as they rush onshore; part of the wave energy is reflected offshore, while the shoreward-propagating wave energy is dissipated through bottom friction and turbulence. Despite these losses, tsunamis still reach the coast with tremendous amounts of energy. Tsunamis have a great potential to cause erosion, stripping beaches of sand that may have taken years to accumulate and undermining trees and other coastal vegetation. Capable of inundating, or flooding, hundreds of yards inland past the typical high-water level, the fast-moving water associated with the inundating tsunami can crush homes and other coastal structures. Tsunamis may reach a maximum vertical height onshore above sea level, often called a run-up height, of 10, 20, and even 30 meters.

As discussed in Step 4, HAZUS-MH can support your exposure assessment of the tsunami hazard.

Wildfires

A wildfire is an undesirable fire occurring in the natural environment and is a serious and growing hazard over much of the United States. Wildfires pose a great threat to life and property, particularly when they move from forest or rangeland into developed areas. An average of 5 million acres burns every year in the United States as a result of wildfires, causing millions of dollars in damage. Each year more than 100,000 wildfires occur in the United States, almost 90 percent of which are started by humans; the rest are caused by lightning. Weather is one of the most significant factors in determining the severity of wildfires. The intensity of fires and the rate with which they spread is directly related to wind speed, temperature, and relative humidity. Climatic conditions such as long-term drought also play a major role in the number and the intensity of wildfires.

As discussed in Step 4, HAZUS-MH can support your exposure assessment of the wildfire hazard.

Other Hazards

Other hazards that may affect your study region include avalanches, coastal erosion, dam failures, drought, expansive soils, extreme heat, hailstorms, land subsidence, severe winter storms, volcanoes, and manmade hazards. For some of these hazards, the HAZUS-MH framework can support mapping of hazard areas and exposure assessments.

Documenting Hazards of Interest

Worksheet 1-1 provides a tool to help you list hazards of interest and historic data sources that are readily available. Worksheet 1-2 summarizes the hazards you explored and the hazards you decided to carry forward for additional analysis in Step 2. Worksheets 1-1 and 1-2 can be used as tools to explain hazards that impact the community to team members, decision-makers, and community stakeholders. Example 1-1 illustrates how Worksheets 1-1 and 1-2 were used for a FEMA pilot project in Austin, Texas.

At this stage, you can mark potential areas of concern (e.g., areas where floods or tornadoes have occurred in the past) on your base map, either electronically or by hand-drawing the areas. Later, you can refine these maps or import hazard area maps as part of Step 2, Profile Hazards.

Congratulations! You have now a list of preliminary hazards of interest in your study region.

SUMMARY

During Step 1 you should have defined your study region, created a base map, and identified the potential hazards for your area. Table 1-1 will help you make sure you have completed these activities. Review the list below and add check marks in the third column where you have completed the activities or outputs indicated.

Table 1-1: Identify Hazards Activities and Outputs Checklist

Activity	Output	Check Completed Items
Define your study region (Task 1.1)	HAZUS-MH study region with hazards selected • Defined study region • Data files aggregated at the proper level	
Create a base map of your study region (Task 1.2)	Base map with local GIS data incorporated into HAZUS-MH • Local data properly converted and projected • Base map with HAZUS-MH provided layers • Local data layers added to the base map	
Identify hazards of interest (Task 1.3)	Worksheet 1-1 (Identify Your Hazards) • List of hazards of interest for your study region • Include hazard event descriptions and corresponding list of data sources, as available Worksheet 1-2 (Summary of Hazard Identification) • Summarize hazards of interest • Summarize the data you collected for those hazards	

Complete any missing items in your checklist, and then continue to Step 2.

GO TO STEP 2: PROFILE HAZARDS

WORKSHEET 1-1: IDENTIFY YOUR HAZARDS

To complete Worksheet 1-1, first check the box in the "Hazard of Interest" column next to each potential hazard that could occur in your study region. If you are unsure about a hazard, select it at this stage of the process.

Hazard or Event Description - For hazards for which you have some preliminary data, list that information below. This will serve as a starting point to identify the hazards that affect your community and to fill out Worksheet 1-2. Information you may list below includes the type of hazard and any summary information on the dates of hazard events, numbers of injuries, costs, areas impacted, and damages and losses that occurred (see example).

Potential Hazard	Hazard of Interest	Description	Source of Information
Avalanche			
Coastal Erosion			
Dam Failure			
Drought			
Earthquake			
Expansive Soils			
Extreme Heat			
Flood (Coastal)			
Flood (Riverine)			
Hailstorm			
Hurricane		**Example: Hurricane Hugo.** Sept. 21-22, 1989. Charleston, SC. Struck Francis Marion National Forest, about 20 miles northeast of the city. Highest storm surge near Cape Romain (15–20 feet, 10-12 feet near the Harbor). Left wide path of damage with hurricane conditions as far inland as Charlotte, NC. Highest winds were in northern Charleston County where Category 4 conditions were experienced. Winds of 78-100 mph recorded at Charleston Airport. Much higher downtown (120 mph). Highest wind speed recorded by Coast Guard Cutter in Cooper River (138 mph winds). Over $7 billion in damages and 82 deaths associated with this event.	NOAA web site, historic newspapers
Landslide			
Land Subsidence			
Severe Winter Storm			
Tornado			
Tsunami			
Volcano			
Wildfire			
Other*			
Other*			

Notes: HAZUS-MH includes hazard event data for the earthquake and hurricane hazards. * Specify hazard for other hazards of interest in your area. Hazards in bold are discussed further in Step 2. Hazards in italics are included in HAZUS-MH.

WORKSHEET 1-2: SUMMARY OF HAZARDS IDENTIFICATION

Hazard or Event Description - Worksheet 1-2 will help you summarize findings from Worksheet 1-1. Use column A to indicate the initial hazards identified by the team. Use column B to show hazards of interest carried forward for further study based on group discussion and available information regarding the relative risk of each hazard in your study region. Summarize event data in the table.

A	B	HAZARD	Hazard	Years	No. of Events	Impacts	Available Data Sources and Maps
☐	☐	Avalanche	Avalanche				
☐	☐	Coastal Erosion	Coastal Erosion				
☐	☐	Dam Failure	Dam Failure				
☐	☐	Drought	Drought				
☐	☐	Earthquake	***Earthquake***				
☐	☐	Expansive Soils	Expansive Soils				
☐	☐	Extreme Heat	Extreme Heat				
☐	☐	Flood (Coastal)	***Flood (Coastal)***				
☐	☐	Flood (Riverine)	***Flood (Riverine)***				
☐	☐	Hailstorm	Hailstorm				
☐	☐	Hurricane	***Hurricane***				
☐	☐	Landslide	**Landslide**				
☐	☐	Land Subsidence	Land Subsidence				
☐	☐	Severe Winter Storm	Severe Winter Storm				
☐	☐	Tornado	**Tornado**				
☐	☐	Tsunami	**Tsunami**				
☐	☐	Volcano	Volcano				
☐	☐	Wildfire	**Wildfire**				
☐	☐	Other	Other*				
☐	☐	Other	Other*				

Notes: Hazards in bold are discussed further in Step 2. Hazards in italics are addressed as HAZUS-MH models.

EXAMPLE 1-1: IDENTIFY HAZARDS SUMMARY WORKSHEET FOR AUSTIN, TX

This example summarizes the hazard identification and selection process conducted by the risk assessment team in Austin, TX (a pilot project community). The table summarizes preliminary data available to support further analysis of each of the hazards of interest.

A	B	HAZARD
☑	☑	Dam Failure
☑	☐	Drought
☑	☐	Earthquake
☑	☐	Extreme Heat
☐	☐	Flood (Coastal)
☑	☑	Flood (Riverine)
☑	☑	Hail Storm
☑	☑	HazMat Release - fixed
☑	☐	HazMat Release - mobile
☑	☐	Major Utility Failure
☑	☑	Severe Winter Storm
☑	☑	Fuel Pipeline Breach
☑	☐	Terrorism
☑	☑	Tornado
☑	☐	Traffic Disruption
☑	☑	Urban Fire
☑	☑	Hurricane

Acronyms used in the summary worksheet that are not defined elsewhere in this How-To Guide:

AWPDRD – Austin Water Protection and Development Review Department

LCRA – Lower Colorado River Authority

Summary of Hazards of Interest for Austin

Hazard	Years	No. of Events	Impacts	Available Data Sources and Maps
Flood (Riverine)	1869 to 2001	64	35 deaths (1915) 215 deaths (1921) $3 M (1981) $4.5 M (1991)	FIRM, USGS DEM, AWPDRD, historical data, HAZUS-MH
Hurricane	1897 to 2002	50	1 wind storm caused 1 death, 3 caused 17 injuries	ASCE wind speed and NOAA hurricane track maps, historic data, HAZUS-MH
Dam Failure	1889 to 2002	2	Failure Old Austin (1900) Failure Rebuilt Austin (1915)	Historical records, LCRA inundation maps
Fuel Pipeline Breach	1969 to 2001	1 event	7 deaths, 14 injuries $3.7 M (for the event)	Historical knowledge, DOT data, map of pipelines
Urban Fire	1990 to 2001	151	Average of 4 deaths/year	Historical knowledge, City of Austin Fire Department, maps of past events
HazMat Release (fixed site)	1993 to 2000	223	N/A	DOT data, maps of Haz Mat sites (Austin data, EPA and HAZUS-MH)
Hailstorm	1980 to 2001	86	$90 M (1984) $100 M (1993)	NOAA hail strike maps
Tornado	1897 to 2001	37	94 deaths total 12 deaths (1897)	NOAA tornado strike maps, Austin data
Severe Winter Storm	1980 to 2001	68	$1.8 M (1996) 3 deaths and 400 traffic accidents (1998)	Austin data

Source: Modified from FEMA 386-2, Worksheet 1

OVERVIEW

The second step in the risk assessment process is to profile the hazards of interest in your study region and consider which ones are priorities based on their likelihood of occurrence, potential magnitude, and past impacts on your community. This step will help you: (1) profile and prioritize hazards for further study, (2) communicate concerns and risks to the public and to decision makers, and (3) develop hazard scenarios that you will use in Step 4, Estimate Losses, for selected hazards.

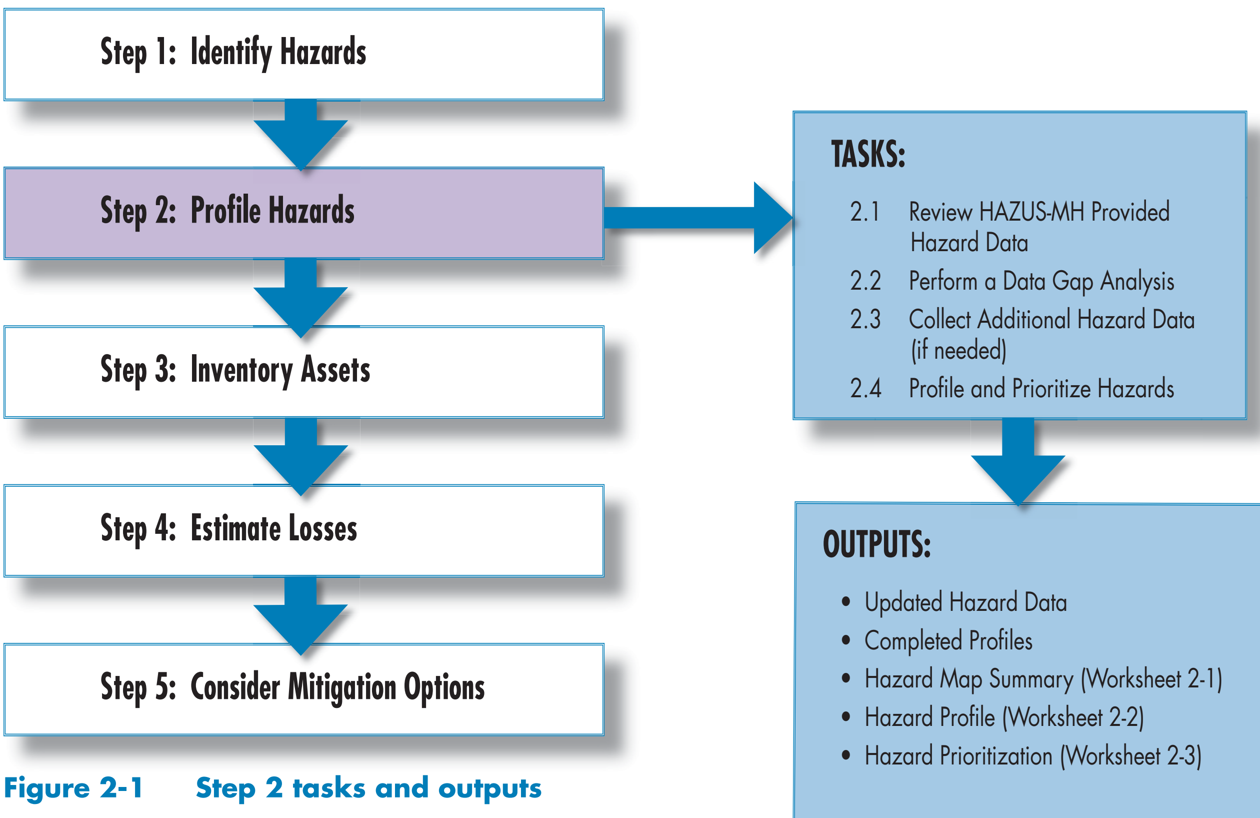


Figure 2-1 Step 2 tasks and outputs

Profiling your hazard is a key element in the preparation of your risk assessment. HAZUS-MH will assist you in this process. Task 2.1 helps you access data residing in HAZUS-MH. Task 2.2 helps you to perform a data gap analysis to understand the quality and relevance of your data and need for additional data collection. Task 2.3 helps you to identify the sources for additional data collection. Task 2.4 provides information on how to prepare hazard profiles and prioritize the hazards that may affect your community. Worksheet 2-1 at the end of this step can be used to identify your hazard data. Worksheets 2-2 and 2-3 can be used to summarize and prioritize your hazards, respectively. The tasks and outputs for Step 2 are shown in Figure 2-1.

Review HAZUS-MH Provided Hazard Data (Task 2.1)

HAZUS-MH provides information that can help you profile earthquake, flood, and hurricane hazards. The text below will help you access and review this data. It will also help you understand hazard characteristic data used to assess risk for these three hazards.

EARTHQUAKES

Access HAZUS-MH Provided Earthquake Data

HAZUS-MH provided data includes historic data on the location and magnitude of earthquakes that have occurred in the U.S. The HAZUS-MH historical scenario menus can be used to view the historic earthquake event data. The steps to access this data include:

1. Open the earthquake module and under the Hazard menu, select "Scenario" on the drop-down menu (see Figure 2-2).
2. Select the "Define a new scenario" option shown in Figure 2-3. Then select the "Historical epicenter event" option under Seismic hazard type (see Figure 2-4).

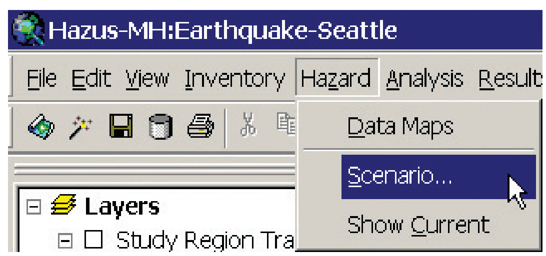


Figure 2-2 Earthquake screen

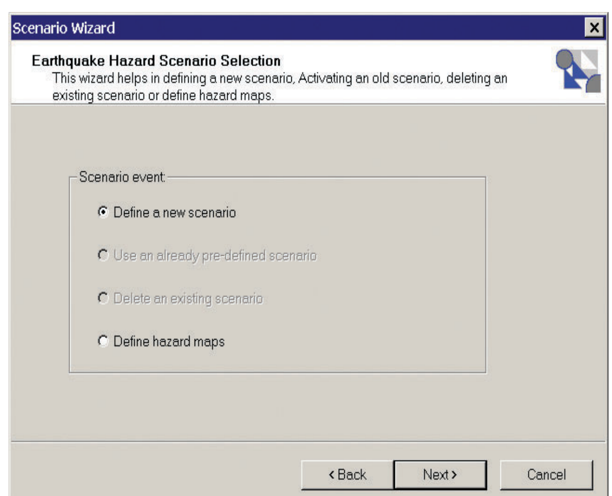


Figure 2-3 Ground motion menu

DEFINITION

def-a-

Hazard Profiling Terms

Hazard event – A specific occurrence of a particular hazard.

Frequency – How often a type of hazard occurs.

Probability – A statistical measure of the likelihood that a hazard event will occur.

Duration – How long a hazard event lasts.

Magnitude – A measure of the severity of a hazard event. The magnitude of a given hazard event is usually determined using technical measures that are specific to the hazard.

Intensity – A measure of the effect of a hazard event at a particular place.

Hazard areas – Geographic areas within your study region where specific hazard events are likely to occur or be more intense.

3. Click on the “Next” button, and a window displaying the earthquake epicenter database will appear (see Figure 2-5). The database contains epicenter details, including the fault name, state, magnitude, fault depth (in kilometers), event date, epicenter latitude and longitude, and source of event information.

4. View earthquake events that have occurred in your particular state for your assigned study region. Click on “State ID” to select the entire column, then right click your mouse while you have the column highlighted and select the “sort” option from the menu. Scroll down to your state to view the historic events.

5. Map historic epicenters by right clicking the mouse button on a specific event record. Select “Map” on the option menu and a window will open with historical epicenters and your study region plotted. The historical epicenters are not physically labeled on the map (see Figure 2-6), but the underlying details of the information can be obtained by selecting a specific epicenter and then using the select button on the toolbar.

6. Position your mouse directly over the epicenter of interest and click the left mouse button once. Click on “Selection Done” to return to the database list, where the selected epicenter record will be highlighted.

7. Add to the information you recorded in Step 1, Identify Hazards, by recording key data from the earthquake epicenter database on Worksheet 1-1 (e.g., year, fault, location, epicenter, and magnitude). You will use this information to further profile the earthquake hazard as part of Tasks 2.3 and 2.4.

In addition to historic event data, several local characteristics are important to the earthquake

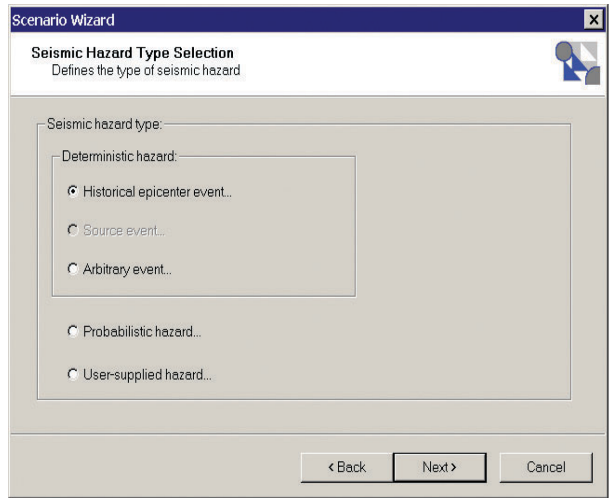
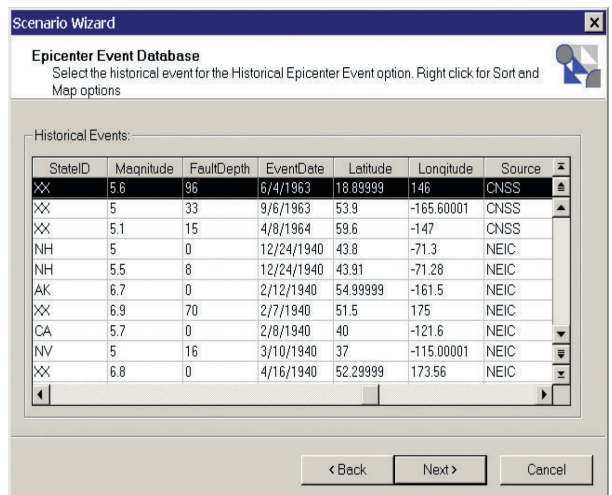


Figure 2-4
Earthquake scenario selection



StateID	Magnitude	FaultDepth	EventDate	Latitude	Longitude	Source
XX	5.6	96	6/4/1963	18.89999	146	CNSS
XX	5	33	9/6/1963	53.9	-165.60001	CNSS
XX	5.1	15	4/8/1964	59.6	-147	CNSS
NH	5	0	12/24/1940	43.8	-71.3	NEIC
NH	5.5	8	12/24/1940	43.91	-71.28	NEIC
AK	6.7	0	2/12/1940	54.99999	-161.5	NEIC
XX	6.9	70	2/7/1940	51.5	175	NEIC
CA	5.7	0	2/8/1940	40	-121.6	NEIC
NV	5	16	3/10/1940	37	-115.00001	NEIC
XX	6.8	0	4/16/1940	52.29999	173.56	NEIC

Figure 2-5
Earthquake epicenter database

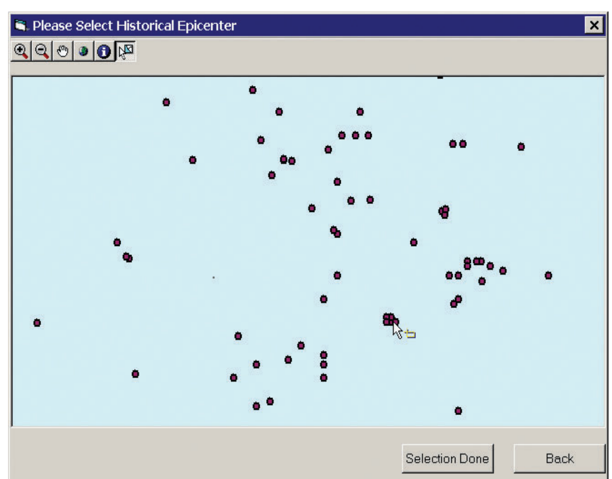


Figure 2-6 **Epicenter event map**

NOTE

Accessing the map feature also will show you epicenters that may affect your study area, but lie in other states. Record these events as well.

hazard and are addressed by HAZUS-MH provided data. These characteristics include: soil type, liquefaction and landslide potential, and water depth. HAZUS-MH includes a menu that shows you the assumptions used in a HAZUS-MH Level 1 analysis. The assumptions are summarized below:

- The soil type is assumed to be "stiff." Definitions of this soil type are included in the user manuals for the earthquake hazard (Appendix B of the *HAZUS-MH Earthquake User Manual*).
- Liquefaction potential is assumed to be zero (i.e., liquefaction is not assumed to be a concern).
- Landslide potential is assumed to be zero (i.e., no potential for landslides is assumed).
- Water depth is not included in the provided data. Water depth is the depth to groundwater and is only important for the earthquake hazard analysis if liquefaction potential exists.

Based on these assumptions, HAZUS-MH will provide a Level 1 analysis for your risk assessment.

Access HAZUS-MH Provided Flood Data

Unlike earthquakes and hurricanes, floods are frequent occurrences in most areas of the country. HAZUS-MH does not currently provide historic flood event data. HAZUS-MH does provide stream gauge data that shows high water marks reached during flood events; however, those data do not indicate the year that each high water level was reached. Flood zone maps you will integrate to support flood analyses address the probability that a flood of a particular intensity will occur in a given period of time. For this hazard, instructions in Task 2.3 will help you collect the hazard data needed to run HAZUS-MH and profile the flood hazard for your study region.

NOTE

As you proceed, remember to keep records of information you have found and where you found it. Your records can include data tables from the HAZUS-MH provided data, copies of documents, maps, notes regarding to whom you talked and when you talked to them, and useful website references.

Access HAZUS-MH Provided Hurricane Data

HAZUS-MH provided hurricane data include historical data on the locations, frequencies (dates of events), and magnitudes of hurricanes in the United States. The HAZUS-MH historical scenario menus can be used to view all of the historical hurricane event data included in HAZUS-MH. The steps to access the data for the hurricane hazard include:

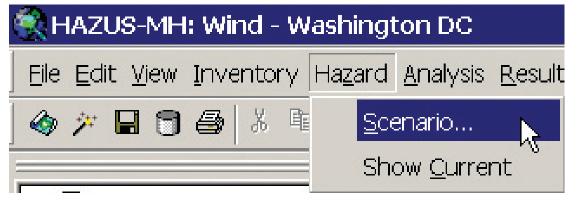


Figure 2-7 Hurricane screen

1. Under the Hazard menu, select "Scenario" on the drop-down list (see Figure 2-7).
2. Select "Next" from the Welcome to the Hurricane Scenario Management Wizard.
3. Select the "Historic" option in the scenario operation menu.
4. Click on the "Next" button, and a window (see Figure 2-8) displaying a list of historic hurricane events, including the hurricane name, year, peak wind gust (in mph), states affected, and landfall states will appear.
5. Select the "Region Filter" button on the top right hand side of the screen. The table will now display only the hurricane events that have affected your study region. Record these events on Worksheet 1-1; you will use this information to support further profiling of the hurricane hazard as part of Task 2.3.

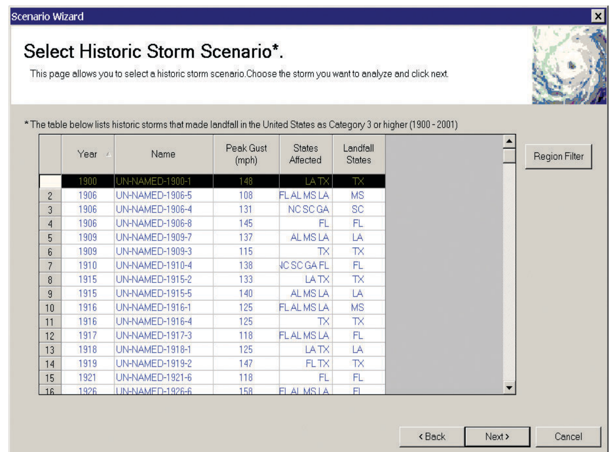


Figure 2-8 Hurricane scenario operation

The HAZUS-MH hurricane module also includes information on local characteristics that will impact how much damage is incurred should a hurricane occur. This information includes regional surface roughness and tree coverage for your study region. These maps have been developed from national land use and land cover maps. You can view these coverage layers in HAZUS-MH using the parameters function under the analysis option. Based on this information, HAZUS-MH will provide a Level 1 analysis for your risk assessment.

Congratulations! You have now accessed hazard data provided in HAZUS-MH. The data that you have accessed and reviewed will help you to prepare your risk assessment and determine if you need further information to support your written hazard profiles.

By now, you should have gained an understanding of the main hazards in your area and you may have determined additional information you wish to obtain for applying the varying levels of HAZUS-MH analysis. The next step is to consider the data you have against the data you may need.

Perform a Data Gap Analysis (Task 2.2)

The data gap analysis is performed to consider the data you have compared to the data you may want for your risk assessment. Three areas of potential data gaps will be considered:

1. **Hazard data for HAZUS-MH hazard analysis**. Job Aid 2-1 in Appendix D summarizes the types of hazard maps or characteristic data needed for each level of analysis for HAZUS-MH.
2. **Hazard data to map other hazards**. This includes hazard area or characteristic maps you would like to collect for hazards other than earthquakes, floods, or hurricanes. If you wish to map a hazard area in HAZUS-MH, you will need to obtain or create certain hazard characteristic maps.
3. **Hazard data not used for mapping but useful for written hazard profiles (all hazards)**. This includes available historic data on events, impacts, severity, intensity, and the probability of future hazard events.

These three areas of consideration are described below.

Hazard Data for HAZUS-MH Hazard Analysis

In order to determine additional local data that you may need for your risk assessment, first, review Job Aid 2-1 in Appendix D. This Job Aid shows the hazard data that HAZUS-MH requires for various levels of analysis. Consider what level of locally-added hazard data is realistic given your risk assessment timeline, resources, and needs.

If you decide to run a HAZUS-MH Level 2 analysis, Worksheet 2-1 will help you review the hazard characteristic information you need. Complete Worksheet 2-1 at the end of this step. First check the box in the "Hazard of Interest" column for each hazard that you identified as a hazard of interest on Worksheet 1-1. The hazard profile maps and data that will support analysis using HAZUS-MH are shown. These maps and data also will help you prepare your written hazard profiles (Task 2.4).

After completing Worksheet 2-1, for the earthquake, flood, and hurricane hazards, you will have a better understanding of the data you have and the data you may need to run a HAZUS-MH Level 2 or Level 3 analysis. Also, you will have an idea of the amount of work and resources that may be required to obtain additional, local data. At this point, you may decide to substitute large segments of HAZUS-MH provided data or you may become aware that a more complex level of HAZUS-MH analysis is not feasible. In the latter case, you may choose to use HAZUS-MH provided data in combination with limited local data or run a HAZUS-MH Level 1 analysis initially and work toward a Level 2 analysis as local data become available. Remember, a HAZUS-MH Level 1 analysis may be sufficient for your mitigation plan in terms of earthquakes, floods, and hurricanes.

> HAZUS
>
> Some communities are developing partnerships with a wide range of parties through HAZUS-MH User Groups (HUGs). A HUG is a group of stakeholders who work together to develop local data and apply HAZUS-MH. Your regional HUG can be a great source of information for your risk assessment. It can assist you with local data collection, refinement, and preparation for input into HAZUS-MH. Check with your local planning contacts or FEMA regional office to see if a HUG exists in your region. Additional information on HUGs can be found on FEMA's website at http://www.fema.gov/hazus/us_main.shtm.

Hazard Data to Map Other Hazards

For hazards not included in HAZUS-MH, a range of maps also can be useful to help profile and evaluate the hazards. Continue with Worksheet 2-1 for the other hazards listed. You will not be able to estimate losses for these hazards using HAZUS-MH, but you can map the hazard areas to support the needs of your risk assessment. In some cases, you can estimate exposure for these hazards using HAZUS-MH. For evaluating reasonable exposure, see Chapter 4 of this How-To Guide.

Hazard Data Not Used for Mapping but Useful for Written Hazard Profiles (All Hazards)

For all hazards, you will need data to help you consider each hazard's overall profile and priority in your region. Worksheet 2-2 shows the categories of data that will be useful. For HAZUS-MH hazards, you can start with historic event data you obtained in Task 2.1 and research further information about these events.

Evaluate Available and Desired Data

For your hazards of interest, review the unchecked boxes in Worksheet 2-1 to potentially identify your data gaps for the hazard area and characteristic maps. As part of Task 2.3, you may want to work to obtain missing mapping data that you have determined is warranted. You will also collect additional data to supplement the analysis for your risk assessment.

All communities face limited budgets and have mandated schedules for their planning efforts. Therefore, your risk assessment team will have to decide how much additional data you can collect based on available funding and schedules. The basis for pursuing or not pursuing further data collection should be sound, defensible, and documented.

REFERENCE

FEMA is implementing the Multi-hazard Mapping Initiative (MMI) to encourage data sharing, support standards development, and provide access to hazard event and hazard map data. You can learn more about this initiative and see what data are available for your study region at: http://www.hazardmaps.gov

When considering the level of HAZUS-MH analysis to use, you must consider your schedule, the resources available, and the ultimate end uses of the data. When evaluating these factors, remember that local data collected to support HAZUS-MH can also support other local planning, emergency, and mapping needs.

When evaluating additional data collection needs, consider the following questions:

- Do you feel the hazard area, characteristics, and profile data are the "best available data" that you can obtain for your risk assessment?
- Are there other experts or sources that you should contact to make sure that your data are current and to feel confident that you are using the "best available data"?
- Are the missing data related to a hazard that you feel is very important to your community?
- Are there alternate approaches that you can use to address data gaps if you do not have enough data about an important hazard?

Based on your team's data gap analysis, you may want to collect additional hazard data that you feel are important and reasonable to obtain. Task 2.3 provides information on general and specific sources for additional hazard information.

Congratulations! You have now performed a data gap analysis and can proceed to collect additional hazard data (if needed).

Collect Additional Hazard Data (If Needed) (Task 2.3)

At this point, you may have decided to collect additional data. Much of the required data may be available already, but it is often located in a number of places and can be in various formats that are not readily usable by HAZUS-MH. Other data, such as a landslide potential map, may need to be created. Both general and specific information sources for hazard event and characteristic data are discussed in this section. Much of this data is being developed and consolidated through efforts such as FEMA's MMI. For this task, you will perform the following steps to obtain additional data: (1) access general hazard data sources, and (2) access specific hazard data sources.

Access General Hazard Data Sources

Data on natural hazards that might threaten your study region are available from various sources. However, the quality of data can vary widely between communities and between organizations within the communities. During the data collection process, it is important that you maintain a detailed log of your sources (including contact names, dates of telephone conversations or personal meetings, and Internet site addresses) and the quality of the data collected to document in your mitigation plan.

Use Worksheet 2-1 at the end of this chapter to help you track the hazard event data you collect. When possible, electronic data should be obtained to facilitate implementation of HAZUS-MH. You will use specific hazard event dates and locations (obtained from HAZUS-MH for earthquake and hurricane or from other sources) as a starting point to search further for additional data. Based on FEMA's field pilot projects, the following sources of information are typical hazard data sources.

Newspapers and Other Historical Records

These records will often contain the dates of major hazard events, the magnitude of the events, the damage incurred, and references to other past natural disasters in your study region. This type of information is often available at local historical societies or in public libraries.

> NOTE
>
> The Internet can support searches on specific hazards and even hazard events. You can complete a key word search and obtain information quickly and at low cost. For example, if HAZUS-MH indicated a CA earthquake in your area in 1906, you could search "California Earthquake 1906" and obtain information about that event to support your written hazard profile.

Existing Plans and Reports

Plans and documents developed for a range of purposes may have information on natural hazards in your community or state. For example, many states already have developed mitigation plans, hazard identification reports, or risk assessment reports. State transportation, environmental, emergency management, and public works departments may have prepared reports or plans that contain relevant information. Local comprehensive plans, land use plans, and capital improvement plans, as well as building codes, land development regulations, and flood ordinances also can contain hazard provisions that indicate the presence of local hazards. When plans are identified, you can review them to identify hazards that may occur in your study region or that have occurred in the past.

Experts in Your Community, State, or Region

Hazard information is generally available from representatives of the government, colleges and universities, and the private sector. The State

Hazard Mitigation Officer usually has access to the most current and accurate data regarding hazards in a state. Local floodplain managers; public works department employees; and engineering, planning and zoning, and transportation department personnel also maintain information about natural hazards. Emergency response personnel such as police and fire department employees or local emergency management staff also are excellent sources of information on past hazard events. In addition, many state agencies, including water, natural resources, geological survey, and emergency management agencies, have detailed knowledge about the nature and extent of hazards in your state. Local university departments, including planning, landscape architecture, geography, and engineering departments, may have hazard maps, recent research studies, or other useful data. Local businesses that provide hazard-related services are also a good source of data.

Internet Sites

The Internet sites of many Federal, state, and local government agencies provide access to data regarding natural hazards and their frequency, magnitude, and locations (for example, <http://www.fema.gov> and <http://www.hazardmaps.gov>). In addition, some sites provide general information about the nature of particular hazard events, the probability of their occurrence, and how hazards are measured. Other websites feature state-specific or area-specific information about hazards (such as the historical occurrence of hazard events and the probability and expected severity of potential hazard events). General search engines also can be searched for specific events or key words and often provide a good starting point with information for your written profiles and areas for further research.

Access Specific Hazard Data Sources

Hazards are often described and characterized using data regarding historic events and maps. Some of these data are available in electronic and hard copy forms from local sources and over the Internet. To run a Level 2 analysis, or to obtain information on hazards not included in HAZUS-MH, you will collect additional hazard data and revisit Worksheet 2-1 to update it with the information you collect.

The “unchecked” maps on Worksheet 2-1 will now be located, to the extent that you determined to be reasonable, as part of Task 2.3. The maps needed to support the earthquake, flood, and hurricane modules of HAZUS-MH will be used to model losses when you estimate losses. Maps shown on Worksheet 2-1 for other hazards also can be imported into HAZUS-MH. You can then use these to support your public involvement and planning work or to estimate exposure as described in Step 4, Estimate Losses. The text below provides information on specific data sources that can help you obtain the hazard maps and data that you have decided you may need for your risk assessment. The hazards described below include earthquakes, floods, hurricanes, landslides, tornadoes, tsunamis, and wildfires.

Earthquakes

Job Aid 2-1 (Appendix D) summarizes data recommended for the three levels of analysis of HAZUS-MH. Job Aid 2-2 provides sources of data for the earthquake and other hazards. The HAZUS-MH provided data for the earthquake hazard makes a number of general assumptions for a number of characteristics that can impact earthquake losses. Level 1 analysis will provide a risk assessment based on these assumptions. If you wish to change those assumptions based on local data, you need to provide HAZUS-MH with the appropriate data to perform Level 2 or Level 3 analyses. For these two levels of analysis, you can obtain the four data maps discussed below; these maps update your study region's soil type, liquefaction susceptibility, and landslide potential, and water depth. For a summary of how to obtain these maps see Table 2-1.

Soil Maps

Local geological data in the form of soil maps depict the effects of ground motion on local soils, landslide, and liquefaction. Soil maps describe the surface soils in your area. In order to improve the analytical capabilities of the HAZUS-MH earthquake model, local soil data must replace the general assumptions made in HAZUS-MH. You can refine the data in HAZUS-MH in two ways: (1) changing the soil type assumption provided with HAZUS-MH, or (2) importing a soil map into HAZUS-MH. The most refined analysis is produced by the second option.

Soil maps of high resolution (1:24,000 or greater) or lower resolution (1:250,000) are usually available from geologists, regional USGS offices, state geological agencies, regional planning agencies, or local government agencies. The geological maps typically identify the age, depositional environment, and material type for a particular mapped geologic unit. The soil maps in HAZUS-MH require National Earthquake Hazards Reduction Program (NEHRP) soil classification types (Appendix B of the *HAZUS-MH Earthquake User Manual*). If you have soil survey or other soil classification maps, a geologist can assist in converting data to the required classification scheme.

Liquefaction Susceptibility Map

A Level 1 analysis in HAZUS-MH assumes that your area does not have the potential for soil liquefaction. In areas with a potential for liquefaction, a HAZUS-MH Level 1 analysis may underestimate the potential damage for your study region. You can change this assumption in HAZUS-MH by (1) changing the liquefaction potential parameter, or (2) importing a liquefaction map. The second option provides the most refined analysis.

Liquefaction susceptibility maps, usable for analysis in HAZUS-MH, exist only for a limited number of areas. For example, the Applied Technology Council (ATC) has published a summary of available regional liquefaction hazard maps. If liquefaction susceptibility maps are not available for your region and liquefaction is a potential hazard in your area, a geologist or a geotechnical engineer will need to provide input on the potential for liquefaction or develop a liquefaction map for you. The level of effort required will depend on the size of your region and the desired resolution of the contours. A simple map may require only a month, but a detailed map at a high resolution (1:24,000 to 1:50,000) may require a separate study that could take several months or years to complete. In any case, look for maps available in a digital format to assist your effort.

Landslide Potential Map

Landslide hazard maps show the extent of land area subject to the threat of landslides, including areas where landslides have occurred in the past, where landslides are likely to occur now, and where they could occur in the future. Landslide potential maps contain detailed information on the types of landslides, the extent of the slope subject to failure, and the probable maximum extent of ground movement. These maps can be used to predict the relative degree of hazard in a landslide area. You can change the HAZUS-MH assumption of no landslide potential by (1) changing the landslide potential parameter, or (2) importing a landslide map. The second option provides the most refined analysis.

Water Depth Map

If liquefaction is a concern in your area, water depth data are also important. The water depth data estimate the vertical distance from the land surface to the top of the groundwater aquifer (i.e., the groundwater-saturated layer). You can change the HAZUS-MH provided depth assumption by (1) changing the water depth potential parameter, or (2) importing a water depth map. The second option provides the most refined analysis.

These maps most likely already exist at a state level and can be obtained from state environment or natural resource agencies that manage water resources or control groundwater pollution. Local university hydrogeology departments or regional water authorities may also have current detailed information on groundwater depths in readily available formats.

Sources of Earthquake Hazard Profile Information

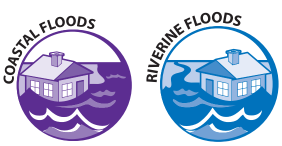
Table 2-1 lists national sources of digital data that can help you prepare your hazard profile. Example 2-1 at the end of this chapter presents an example earthquake hazard profile, compiled from information similar to sources you may access and use. Job Aid 2-2 also lists data sources.

Table 2-1: Earthquake Hazard Characteristic Data Sources

Map	Source
Soil Surveys and Maps	Natural Resources Conservation Service (USDA)
Liquefaction Maps	Applied Technology Council Summary of Regional Maps
Landslide Maps	National Landslide Information Center (USGS)
Groundwater Depth Maps	Various natural resource agencies State Engineer's Offices (State-specific; Data from registered wells in state) USGS Groundwater Site Inventory (contains data from more than 850,000 federal wells)

Manage Your Earthquake Hazard Data

Create a hazard map directory on your hard drive if you have not done so already. Download the digital maps and place the maps in the hazard map directory. Also, be sure to update Worksheet 2-1 as you proceed. These maps or data from them will be integrated into HAZUS-MH during Step 4, Estimate Losses.



Floods (Coastal and Riverine)

HAZUS-MH provides three levels of analysis. Job Aid 2-1 (Appendix D) shows the different hazard data needs to implement a Level 1, 2, or 3 analysis for the flood hazard. The Level 1 analysis level requires the least input by the user. A Level 2 analysis improves the results by considering additional data that are readily available or can be converted to the model requirements. For a Level 2 analysis, users will employ the Flood Information Tool (FIT) to pre-process their flood hazard data. All components of flood analysis using HAZUS-MH can be performed at this level, with the exception of velocity analysis.

A Level 3 analysis is an advanced data and models analysis requiring detailed engineering and hazard studies and is not addressed in this How-To Guide.

Sources of Flood Hazard Profile Information

FEMA has prepared Flood Insurance Studies (FIS) for flood-prone communities. These FISs contain information on historic flood events, flood problems, and other flood information available for local areas. A FIS contains a Flood Insurance Rate Map (FIRM), which is an official map of a community that shows areas at risk from flooding. FEMA has created FIRMs for more than 19,000 communities in the U.S. as part of the FIS program. In addition to base flood zones, or 100-year floodplains, which are defined as areas with a 1 percent chance of flooding in any given year, the FIRMs illustrate coastal high hazard areas, floodways, and 500-year floodplains, which are areas with a 0.2 percent chance of flooding in any given year. Another element of the FIS is a graph, also known as a flood profile, which shows potential flood elevations plotted along waterways. This information will help delineate the boundaries of the floodplain in your study region.

The data categories needed to run the HAZUS-MH flood module include ground elevation data, floodplain boundary, and flood depth maps. Example sources of hazard data are shown in Table 2-2 and are discussed below. The information in the table shows the requirements for different levels of HAZUS-MH analysis. Job Aid 2-2 also lists data sources.

Table 2-2: Flood Hazard Data Needs and Sources

Map	Required for	Source
Ground Elevations, as Digital Elevation Model (DEM)	Riverine and coastal flood (Level 1, 2, or 3, and Flood Wizard)	http://seamless.usgs.gov/ Microsoft TerraServer
Shoreline Maps	Coastal flood (Level 2 or 3)	Local maps to update HAZUS-MH map NOAA Coastline and Bathymetric GIS Data
100-Year Stillwater Elevation	Coastal flood (Level 2 or 3)	FEMA USGS Surface Water Resources
Floodplain Boundary	Riverine flood (Level 2 or 3, and Flood Wizard)	FEMA On-Line Hazard Maps ESRI On-Line Hazard Maps
Base Flood Elevation	Riverine flood (Level 2 or 3)	FEMA On-Line Hazard Maps

Ground Elevations

All three levels of HAZUS-MH analysis will require you to download ground elevation data. The flood wizard discussed in Step 4 also requires these data. Ground elevation data can be in several formats, including a Digital Elevation

Model (DEM), a Triangular Irregular Network (TIN), or contour lines. If your data is a TIN or available as contour lines, you will need to use the FIT to integrate the data into HAZUS-MH. A DEM does not need to be modified. A basic DEM may be downloaded at the USGS web site, http://seamless.usgs.gov/. A higher resolution DEM might be obtained from your local mapping office. The USGS also sells higher resolution DEMs in some parts of the country; visit the USGS web site for more details. The FEMA MMI discussed earlier also provides access to Q3 data and DFIRM maps (see floodplain boundary below).

> DEFINITION
>
> The Flood Information Tool (FIT) is part of the HAZUS-MH family of products provided by FEMA. It is used to integrate local flood maps into HAZUS-MH. The FIT is detailed in Step 4.

Shoreline Map and 100-Year Stillwater Elevation

Local data are required for a more refined coastal flood analysis (Level 2 or 3). A shoreline map is provided with HAZUS-MH, but if the shoreline has changed over time, you will want to update that map with local data. The 100-year stillwater elevation map is usually available for coastal areas as part of the FIS. Coastal hydrologic data are also available from the National Oceanic and Atmospheric Administration (NOAA).

> NOTE
>
> The FEMA Map Modernization Initiative (MMI) is updating flood data across the country. This will provide digital FIRM (DFIRM) data for the entire country and supply the ground elevation, floodplain boundary, and base flood elevation data needed for the riverine and coastal flood analyses.

Floodplain Boundary and Base Flood Elevation

Both the floodplain boundary and the base flood elevation data for your area can be derived from the FIRM. Using a copy of the FIRM, you will evaluate the 100-year flood. FEMA is currently converting FIRMs to a digital format. The DFIRM product will allow the creation of interactive, multi-hazard digital maps that can be used with HAZUS-MH. Digital quality level 3 flood data (Q3) also are available for 1,200 counties in a CD-ROM format. The Q3s are digital representations of certain features of FIRMs and can be used with HAZUS-MH. The Q3s are used for hazard mitigation planning, floodplain management, land use planning, natural resource and environmental analysis, and insurance target marketing. They are designed to provide the general locations of Special Flood Hazard Areas (SFHAs). The main difference between the Q3s and the official paper FIRMs is that the Q3s do not include the following:

> HAZUS
>
> The flood model uses the term "case study" instead of scenario because the selection of an "arbitrary event" is not possible. The flood model allows you to study your entire region as a case study or to focus on particular, smaller areas of concern.

- Hydrographic features (streams, rivers, lake, and coastal shorelines)
- Base Flood Elevations (BFEs)

- Cross-section lines
- Roads, road names, or address ranges
- Locations, elevations, and descriptions of benchmarks and elevation reference marks

REFERENCE

Copies of FIRMs can be requested
(1) by calling the FEMA Map Service Center at 1-800-358-9616
(2) by accessing the Internet at: http://www.fema.gov/maps/
(3) by contacting a FEMA regional office
Additionally, FIRM information is available at: http://www.fema.gov/fhm/

To request copies of the FIRM for your study region, or to identify areas that are prone to coastal hazards and storm surge, contact your National Flood Insurance Program (NFIP) coordinator or floodplain manager. These specialists usually work in the planning, building, engineering, or natural resource departments of local and state agencies. Coastal communities and states with a coastline also should determine areas of coastal flooding, which are characterized as V zones and A zones, oriented approximately parallel to the shoreline.

DEFINITION

Coastal Flood Zone Classifications

"A" Zone – An area with an elevation below the Base Flood Elevation (BFE), where the waves are expected to be less than 3 feet during the 100-year flood.

"V" Zone – An area with an elevation below the BFE, where waves are expected to be greater than 3 feet during the 100-year flood. V zones are subject to coastal high hazard flooding.

Verify that the FIRM is Current and Complete

Floodplains are susceptible to changes. From time to time, FEMA, communities, or individuals may find it necessary to update, correct, or otherwise change the FIRM. Review the FIRM to determine whether any of the following circumstances apply to your study region:

- Significant construction has occurred within the floodplains already identified on your FIRM.
- Upstream communities have had significant development since the FIRM was published.
- Inundation patterns indicate that the FIRM boundaries are no longer accurate.
- A major flood control project has been completed in your community or upstream of your community.
- Changes have impacted topography in, or adjacent to, mapped floodplains.

If there has been a coastal storm since the date of the FIRM, the coastline and hazard zones may no longer be accurate. Coastal storms can either erode or extend the coastline, possibly causing the flood hazard zones to change. Consult your local floodplain coastal zone manager for further advice. Information can be found at http://edc.usgs.gov/index.html.

NOTE

If your study region is not within a 100-year floodplain, you may elect to concentrate on other hazards because your flood risk is, by definition, relatively small. However, you may still have flood risks associated with one or more of the following, which are not shown on the FIRM:

- Drainage areas of less than 1 square mile
- Sewer backup
- Drainage system backup
- Dam breaches
- Stormwater runoff problems

Sources of Flood Hazard Profile Information

In addition to the characteristic data required to support HAZUS-MH, you will need to research historic flood events and the potential for flooding in your area to support your written flood profile. You can use the general and specific sources listed in this section to collect those data. Use Job Aid 2-2 as a starting point to identify other sources of data to help you profile background and local conditions, probability of occurrence, damage, and hazard areas (floodplain boundaries for your area).

Manage Your Flood Hazard Data

Create a hazard map directory on your hard drive if you have not done so already. Download the digital maps found at the sources listed above and place the maps in the hazard map directory. These maps will be integrated into HAZUS-MH in Step 4. Keep the other data you have collected to help you complete Worksheet 2-2, as part of Task 2.4.

Use of the Flood Macro Wizard

FEMA developed a Flood Macro Wizard (Flood Wizard) that facilitates the preparation of flood risk assessments. The Flood Wizard allows you to automatically process flood data to evaluate exposure and develop loss estimates for the inventory in your study region. To use the Flood Wizard, you will (1) install the Flood Wizard, (2) execute the flood program, (3) identify the inputs, (4) run the analysis, and (5) view the results.

1. **To install the Flood Wizard**. Insert the Flood Wizard CD-ROM and wait for the auto run feature to start. The Flood Wizard installation menu will appear. Click "Next" to proceed. The installation menu will prompt you for a destination directory (see Figure 2-9). Type another directory name if the default directory is not your preference. Click "Next" to proceed with the installation. Installation progress is indicated by the status bar in the center of the screen. The installation is complete when the "Next" option becomes available (see Figure 2-10). Click "Next."

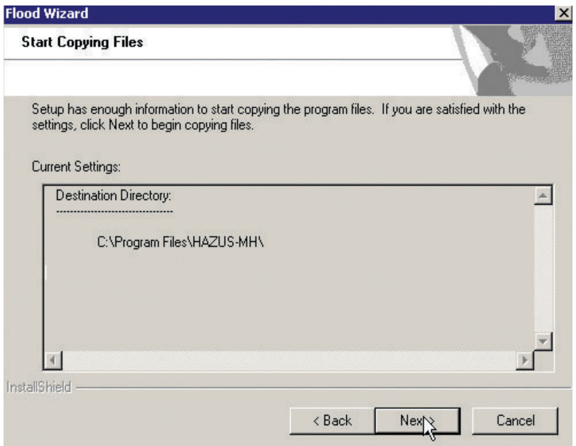


Figure 2-9
Flood Wizard destination directory

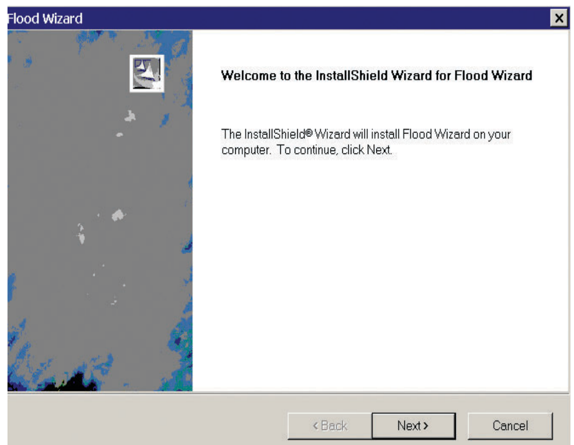


Figure 2-10
Flood Wizard installation complete

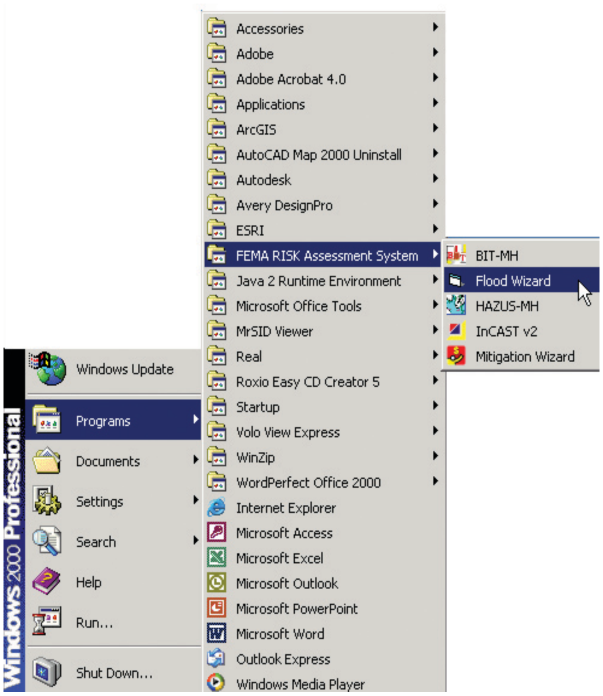


Figure 2-11
Flood Wizard program location

2. **To execute the Flood Wizard program**. Open a flood study region in HAZUS-MH. It is not necessary to have run the flood analysis for the region; setting up the study region is all that is required. Select "Start" from your Windows menu, then select "Programs" and "FEMA Risk Assessment System." Click on the Flood Wizard icon (see Figure 2-11). The Flood Wizard menu will now be displayed (see Figure 2-12). The menu options include:

a) Flood Data – these options allow you to input your local flood data and DEM.

b) Inventory – these options allow you to view the general building stock, including building exposure, content exposure, total exposure, and building count for your study region. Changing the HAZUS-MH provided inventory is discussed in Step 3.

c) Parameters – these options allow you to change the damage functions and show the specified data maps in your study region.

d) Analysis – this option allows you to run the analysis.

e) Results – these options allow you to see the risk assessment results of a 100- and 500-year event in your study region. Results include building exposure, content exposure, total exposure, and building count for the general building stock in the floodplain. It also provides building loss, content loss, and total loss for the general building stock.

Figure 2-12 Flood Wizard menu

3. **To identify the inputs**. You will need two data sets, (1) a flood boundary map in the form of Q3 data, a DFIRM, or a user defined map and (2) a DEM. The flood boundary map is required to be in the shape file format. The DEM should be in the same grid format used to run the flood model. The DEM downloaded from the USGS web site has a vertical distance in meters while the flood wizard requires a vertical distance in feet. A GIS specialist will be able to convert the DEM. Select “Flood Data” from the main menu, then “Q3 Map” (see Figure 2-13). You will be asked to identify the location of the Q3 shape file. Browse to the location and select the file. Select “Flood Data” from the main menu, then “DEM Data.” You will be asked to identify the location of the DEM. Browse to the location and select the file.

Figure 2-13 Flood Wizard data menu

Manage Your Flood Wizard Hazard Data

Create a hazard map directory on your hard drive if you have not done so already. Download the digital maps found at the sources listed above and place the maps in the hazard map directory. These maps will be integrated into HAZUS-MH in Step 4. Keep the other data you have collected to help you complete Worksheet 2-2, as part of Task 2.4.

Congratulations! You have now identified the data sets required to run HAZUS-MH and the Flood Wizard. Step 4 will provide information on how to run the HAZUS-MH and Flood Wizard to obtain loss estimation outputs.

Hurricanes

Level 1 analysis uses the HAZUS-MH provided data on wind pressure, wind-borne debris, tree blow down, and rainfall. The data provided also include information on surface roughness and tree coverage derived from national land use data. No additional local data are used for a Level 1 analysis. For a Level 2 or Level 3 analysis, locally generated tree coverage (vegetation) maps and terrain or surface roughness maps can help you update the HAZUS-MH provided data for your study region.

Sources of Hurricane Hazard Profile Information

Table 2-3 presents potential data sources that will help you to gather additional hurricane information. Job Aid 2-2 (Appendix D) helps you to identify other sources of data regarding specific hurricane events that have impacted your area.

Table 2-3: Hurricane Hazard Data Sources to Support HAZUS-MH

Map	Source
Surface Roughness Maps (for Level 2 or 3 analysis)	Local Wind Engineer (refer to Job Aid 2-2 for potential sources)
Vegetation Maps (also called tree coverage maps) for Level 2 or 3 analysis	Land Cover Maps (refer to Job Aid 2-2 for potential sources)

You can also contact the state hurricane program manager, who usually works for the state emergency management office, for information on hurricanes, Nor'easters, storm surge, and coastal erosion that have occurred in your area. Another source of assistance is your state coastal zone manager, who should have information on state coastal hazards, including information on habitat and environmental resources that may be affected by such hazards.

Inland communities will be most concerned with the flooding aspect of coastal storms. The torrential rains of even Category 1 hurricanes and tropical storms have been known to cause 500-year and greater flooding in inland communities. Coastal communities will need to determine how severe the high winds, storm surges, and erosion could be using their storm surge inundation maps. For all flood hazard information related to hurricane events, refer to the section on floods.

> DEFINITION
>
> To update the HAZUS-MH data, you can change the tree coverage or surface roughness parameters for your study region at the Census tract level.

Manage Your Hurricane Hazard Data

Create a hazard map directory on your hard drive. Download the hurricane-related hazard maps that you have obtained and place these maps in the hazard map directory. Also, be sure you have updated Worksheet 2-1. These maps will be integrated into HAZUS-MH in Step 4. Keep the other data you have collected to help you complete Worksheet 2-2, as part of Task 2.4.

> HAZUS
>
> Future releases of HAZUS-MH will model coastal floods and wind impacts associated with hurricanes as part of the hurricane model. Currently, wind is addressed by the hurricane model and coastal flood as part of the flood model.

Landslides

HAZUS-MH does not currently include a landslide module. However, HAZUS-MH can support evaluation of this hazard. For example, you can map landslide potential areas and inventory to estimate persons and buildings exposed to this hazard. To support this type of analysis, you will need landslide maps that show areas of potential landslide occurrence in your study region.

The best predictors of future landslides are past landslides because they tend to occur in the same places. Landslides, like other geologic hazards, are very complex and require someone with geologic expertise to conduct a geotechnical study. You should begin by talking to your local or state geology, planning, public works, or engineering departments, which should have information on past landslides. These agencies can provide landslide maps as well as information about landslide causes, damages, deaths, and injuries, as well as areas impacted by past landslides. If current landslide maps are not available, the agencies mentioned above can help create one for your community.

Sources of Landslide Hazard Profile Information

It is important that you consult a local geologist or other professional familiar with past landslides when interpreting landslide hazard information. Sources that provide useful background information and data include: (1) maps of landslide potential (high hazard areas), (2) topographic maps, and (3) geologic information. These are discussed below.

High Hazard Areas

You can map these areas by identifying existing or old landslides, particularly those:

- On or at the base of slopes
- In or at the base of minor drainage hollows
- At the base or top of an old fill slope
- At the base or top of a steeply cut slope
- On developed hillsides where leach field septic systems are used

HAZUS

If you are analyzing the flood hazard, your DEM can provide topographic data to support the landslide hazard.

Topographic Maps

Topographic maps can be obtained from the USGS or from your state geologic survey. Specifically, you will need to know where steep slopes are present, as steeper slopes have a greater probability of landslides. Contact your state geological survey or natural resource department for more information or help in interpreting topographic maps. These are discussed below.

Geologic Information

Identifying the underlying geology plays an important part in the review of a slope. In addition to the slope angle, the presence of rock or soil that weakens when saturated and the presence of poorly drained rock or soil are indicators of slope instability. Contact a local geologist or your state geologic survey to obtain more information or assistance in identifying the various geologic features of your community or state.

After reviewing general information, you should try to obtain the most important landslide data, including: (1) landslide inventories, (2) landslide susceptibility maps, and (3) landslide hazard maps. These are discussed below.

Landslide Inventories

These inventories identify areas that appear to have failed because of landslides, including debris flows and cut-and-fill failures. Detailed inventories depict and classify each landslide and show scarps, zones of depletion and accumulation, active versus inactive slides, geologic age, rate of movement, and other pertinent data on the depth and type of materials involved in the sliding. Overlaying a geologic map with a hazard map that shows existing landslides can identify specific landslide-prone geologic units. For this reason, a landslide inventory is essential for preparing a landslide susceptibility map.

Landslide Susceptibility Maps

These maps depict areas that have the potential for landslides by correlating some of the principal factors that contribute to landslides, including steep slopes, geologic units that lose strength when saturated, and poorly drained rocks or soils. These maps indicate the relative stability of slopes; however, they do not make absolute predictions. More complex maps may include additional information such as slope angle and drainage data.

Landslide Hazard Maps

These maps show the real extent of the threat: where landslides have occurred in the past, where they are likely to occur now, and where they could occur in the future. The maps contain detailed information on the types of landslides, the extent of the slope subject to failure, and the probable maximum extent of ground movement. These maps can be used to predict the relative degree of hazard in a landslide area.

Manage Your Landslide Hazard Data

Save electronic data in the hazard directory you are creating. You also can mark the areas that are susceptible to landslides on your base map in HAZUS-MH.

Tornadoes

HAZUS-MH does not currently include a tornado module, although such a module is currently under development. However, HAZUS-MH can support evaluation of the hazard. In most cases, it is difficult to identify specific tornado risk areas because an entire geographic area usually lies in, or outside of, a high risk area. Data that will help you evaluate your area's tornado risk includes the "design wind speed" designation for your

> **NOTE**
>
> Unlike some other hazards, mapping the tornado risk is less important because it is unlikely that a community has variable tornado risks within its jurisdiction. In most cases, communities need only determine that they have a tornado risk (Identify Hazards: Step 1) and then can proceed to determine their design wind speed as described in this section.

community. The design wind speed is the maximum wind speed buildings are designed and constructed to withstand.

Sources of Tornado Hazard Profile Information

First, contact your state or local building code official to determine the design wind speed for your area. Next, find your study region on the "Design Wind Speed" map in FEMA's *"Taking Shelter from the Storm: Building a Safe Room in Your House"* (refer to text box). The map in this document is based on design wind speeds set forth by the American Society of Civil Engineers (ASCE). Next, look up the wind zone and indicated speed indicated for your study region area. For example, if you live in Fayetteville, North Carolina, you would find that you are located in wind zone III, which is associated with 200-mile per hour wind speeds.

Manage Your Tornado Hazard Data

REFERENCE

"Taking Shelter from the Storm: Building a Saferoom in Your House" (FEMA 320). This publication can be viewed at: http://www.fema.gov/fima/tsfs02.shtm or ordered from the FEMA Publication Center.

If your study region is located in only one design wind speed zone, note the zone; however, if your study region is located in more than one design wind speed zone, you will need copies of the "Design Wind Speed" maps. Create a hazard map directory on your hard drive if you have not done so already. Download the wind speed maps into the hazard map directory, or obtain hard copies of the maps. These maps will be integrated into HAZUS-MH in Estimate Losses (Step 4).

TSUNAMIS

Tsunamis

HAZUS-MH does not include a tsunami module. However, HAZUS-MH can support evaluation of this hazard through the mapping of hazard areas and the identification of inventory exposed to the hazard areas.

Sources of Tsunamis Hazard Profile Information

Tsunami inundation zone maps show low-lying areas that could be affected by tsunamis. Communities in Alaska and Hawaii can obtain statewide inundation zone maps and other information about tsunamis from the following sources:

West Coast/Alaska Tsunami Warning Center of NOAA/NWS
910 S. Felton Street
Palmer, AK 99645- 6552

Telephone: 907-745-4212
Pacific Tsunami Warning Center in Hawaii
91-270 Fort Weaver Road
Ewa Beach, HI 96706
Telephone: 808-689-8207

Communities in Oregon can request maps from:

The Oregon Department of Geology and Mineral Industries (DOGAMI)
800 NE Oregon Street, #28
Portland, OR 97232
Telephone: 503-731-4100

Washington and California communities should contact their respective state geologists to obtain inundation zone mapping information.

In addition, tsunami information is available at the following websites:

- USGS: <http://www.usgs.gov/themes/coast.html>
- University of Washington: <http://www.geophys.washington.edu>
- Pacific Marine Environmental Laboratory: <http://www.pmel.noaa.gov/tsunami-hazard>

Most tsunami mapping has been done at a state-wide level. If no local mapping has been certified, you may consider hiring a consultant to develop or obtain the following information:

- Historical tsunami sources
- Potential future local and distant sources
- Potential for ground failures and other geologic effects that could cause tsunamis
- An estimate of the number of waves and their heights, arrival times, and inundation depths and distances
- Calculations of water velocities and debris loads
- Estimates of the probabilities of tsunami occurrence and levels of certainty

Manage Your Tsunami Hazard Data

Draw the boundaries of your study region's tsunami hazard areas on your base map and store any electronic data in your hazard data directory.

Wildfires

HAZUS-MH does not include a wildfire module. However, HAZUS-MH can support evaluation of this hazard through the mapping of hazard areas and the identification of exposed inventory in hazard areas.

Sources of Wildfire Hazard Profile Information

Wildfire hazard maps do not show the extent of locations where wildfires will occur because each fire's location will depend on the amount of fuel available, weather conditions, and wind speed and direction at the time the fire occurs. However, wildfire hazard maps can show geographic locations where wildfires have taken place in the past and areas that are prone to wildfires based on the availability of fuel and weather conducive to fires.

Contact your state forest service at <http://www.stateforesters.org/> or your U.S. Forest Service (USFS) regional office at <http://www.fs.fed.us/contactus/regions.shtml> to obtain wildfire mapping information, such as (1) fuel model maps, (2) topographic data, and (3) critical weather frequency. These data are discussed below.

Fuel Model Maps

Use the fuel model key below (excerpted from the National Fire Danger Rating System [NFDRS]), developed by the USFS in 1978, as a guide to determine the fuel model classifications within your community or state. The key represents all wildfire fuels from Florida to Alaska and from the East Coast to California, so only general descriptions are provided.

You can also download fuel model maps from the Internet at <http://www.fs.fed.us/land/wfas/nfdr_map.htm>. These maps are designed to assess fire dangers across the continental U.S. and may not be site-specific; therefore local updates are recommended.

Using the fuel model key, you can map the various fuel classifications for your area based on the following categories:

- ❍ Heavy Fuel is vegetation consisting of round wood that is 3 to 8 inches in diameter.
- ❍ Medium Fuel is vegetation consisting of round wood that is 1/3 to 3 inches in diameter.
- ❍ Light Fuel is vegetation consisting of herbaceous plants and round wood that are less than 1/3 inch in diameter.

To obtain more information or assistance, contact your state forestry or natural resource department.

Topographic Data

In general terms, the steeper the slope of the land, the faster a fire can spread up the slope. Using a topographic map, identify areas of your study region with slopes less than 40 percent, between 41 and 60 percent, and greater than 61 percent, corresponding to low, moderate, and steep gradients in terms of the spread of wildfires. Contact your state geologic survey or natural resource department to obtain more information or help with topographic maps.

Critical Weather Frequency

Critical fire weather is a set of weather conditions, usually a combination of low relative humidity and wind, whose effects on fire behavior make its control difficult and threaten firefighter safety. The average number of days per year of critical fire weather experienced in your study region can be obtained from your local or state fire marshal, forestry department, or department of natural resources. National Weather Service or NOAA websites also can help you determine past weather conditions in your study region.

Identify Your Fire Hazard Severity

Using Table 2-4, determine your study region's fire hazard severity. For example, if your study region experiences an average of five critical fire weather days per year, has heavy fuel, and has greater than 40 percent slopes, you are in a extreme severity area. You may have more than one severity level in your study region, depending on differing slopes and fuel classifications across the region.

Table 2-4: Fire Hazard Severity Table

Fuel Classification	Critical Fire Weather Frequency								
	<1 Day/Year			2 to 7 Days/Year			> 8 Days/Year		
	Slope (%)			Slope (%)			Slope (%)		
	0-40	41-60	> 60	0-40	41-60	> 60	0-40	41-60	> 60
Light Fuel	M	M	M	M	M	M	M	M	H
Medium Fuel	M	M	H	H	H	H	E	E	E
Heavy Fuel	H	H	H	H	E	E	E	E	E

Severity: M = Moderate, H = High, and E = Extreme

Manage Your Wildfire Hazard Data

Draw the boundaries of your study region's wildfire hazard areas on your base map in HAZUS-MH. Retain electronic data in your hazard directory.

Other Hazards

Table 2-5 shows map data recommended to profile other hazards that may be important to your community; these hazards are not detailed in this guide. In addition to maps, remember to collect historic event, location, and impact (loss) data, as available. The FEMA web site (http://www.hazardmaps.gov) also has data for some of the hazards listed below. Job Aid 2-2 (Appendix D) also lists hazard data sources for a range of hazards.

Table 2-5: Data Sources for Additional Hazards Maps of Interest

Hazard	Map	Source
Avalanche	Elevation Contour Maps	<http://data.geocomm.com/dem/demdownload.html>
Coastal Erosion	Historical Aerial Photographs	<http://edc.usgs.gov/index.html>
Dam Failure	FIRMs	<http://www.fema.gov/fhm/dfm_ovrw.shtm>
	Floodway Maps	Local floodplain manager
Drought	Drought Maps	<http://www.drought.unl.edu/whatis/palmer/pdsihist.htm>
Extreme Heat	Maximum Temperature Maps	<http://www.cpc.ncep.noaa.gov/>
Hailstorm	Hailstorm Maps	<http://www.esri.com/hazards/makemap.html>
Land Subsidence	Land Subsidence Maps	<http://water.usgs.gov/ogw/subsidence.html>
Severe Winter Storm	Winter Storm Maps	<http://www.gismaps.fema.gov/2003pages/lcurrent.shtm>
Volcano	Volcanic Activity Maps	<http://volcanoes.usgs.gov/Hazards/Where/WhereHaz.html>
Windstorm	Windstorm Maps	<http://www.esri.com/hazards/makemap.html>

Develop HAZUS-MH Compatible Hazard Maps

Now that you have collected specific hazard maps, you will want them in an electronic form to support HAZUS-MH. Once you have an electronic map, review its format to determine whether it is in the correct format (ArcView-compatible) and coordinate system (Lat/Long). Place a check in the appropriate column for each requirement in Worksheet 2-1. The HAZUS-MH provided assumptions or hazard maps for earthquakes, floods, and hurricanes should be replaced if you have a more detailed map of your study region. If all of the compatibility columns are checked, place a check in the "Ready for HAZUS-MH" column. If you need to convert maps or projections, refer to Identify Hazards (Step 1) for instructions.

After reviewing hazard maps and historical data, you should have an idea of where hazard events may occur in your study region. You now need to designate these hazard areas on your HAZUS-MH base map by using the HAZUS-MH menus to add a GIS layer. Click on "File," and then scroll down to add data. Browse to the location of your hazard maps and select the files. The hazard maps can now be overlain on your base map. Your base map should now be divided into subareas or polygons that represent the areas susceptible to different hazard types. Some hazard types may affect the entire study region, while others may affect only portions of the region. These map outputs can be used to support your community involvement efforts and as inputs for your risk assessment.

Profile and Prioritize Hazards (Task 2.4)

To create a final prioritized list of hazards, you will use the data in Worksheet 1-1 and the hazard maps and hazard characteristics data that you have collected. Your risk assessment team should take all of the data available and meet as a group to review the data and prioritize the hazards. Worksheet 2-2 should be completed for each hazard of interest. This worksheet will help you compile data and profile each hazard in a consistent manner.

Next, complete Worksheet 2-3. This worksheet is a qualitative ranking form designed to help you prioritize the hazards in your study region. Under frequency, severity, duration, and intensity, you can rank each hazard from 0 (very low) to 5 (high). For each hazard, you can add values for various profile items and assign a "rank." Depending on your team's knowledge and experience, you may be able to rank the hazards numerically (with the highest value a 1), or you may wish to rank them as H, M, and L (High, Medium, and Low) priorities. In the last column, check the hazards that are considered to be priorities for further analysis. Even if you have little data on a hazard, you may feel that you need to assign that hazard a "high" priority for further analysis.

Congratulations! You have now have created a final prioritized list of the natural hazards that may affect your community.

SUMMARY

When you are finished with Step 2, you will have historic event data and maps showing the areas impacted by each hazard of interest and data on the characteristics of hazard events affecting your study region.

You also will have a list of hazard events, websites, articles, reports, local experts and other resources, that can help you later in the risk assessment process as you determine how particular hazards can affect your community. Table 2-6 will help you verify that you have completed the activities for Step 2.

Table 2-6: Profile Hazards Activities and Outputs Checklist

Activity	Output	Check Completed Items
Review HAZUS-MH provided hazard data (Task 2.1)	Worksheet 2-1, Column 1 HAZUS-MH provided hazard event data (updated on Worksheet 1-1)	
Perform a data gap analysis (Task 2.2)	Worksheet 2-1, Column 2	
Collect additional hazard data (if needed) (Task 2.3)	Updated Worksheet 2-1	
Profile and prioritize hazards (Task 2.4)	Worksheet 2-2 with hazard maps and charts (profiles) Worksheet 2-3 (ranking)	

Complete any missing items in your checklist, and then continue to Step 3.

GO TO STEP 3: INVENTORY ASSETS

WORKSHEET 2-1: IDENTIFY REQUIRED HAZARD DATA

Check the first column below for hazards determined to be of interest on Worksheet 1-1. Then use the rest of the table to understand the hazard data you need and to track the status of the data you have. HAZUS-MH hazard maps that are recommended are shown in bold. You can use Job Aid 2-1 (Appendix D) to see which data are required for varying Levels of HAZUS-MH analysis (Levels 1, 2, and 3). For each hazard map you obtain, determine whether the map meets the data status criteria and check the appropriate box(es). Check the "Ready for HAZUS-MH" cell when the map meets all of the criteria. Job Aid 2-2 (Appendix D) lists national hazard data sources. You will best know about local data sources.

Hazard of Interest (From Worksheet 1-1)	Hazard (Italicized text indicates a HAZUS-MH hazard)	Hazard Data/Map Required	LOCAL DATA STATUS CRITERIA		
			Required Format (ArcView required)	Required Coordinate System (Lat/Long required)	Ready for HAZUS-MH
	Earthquake	Soil Maps			
		Liquefaction Susceptibility Maps			
		Landslide Potential Maps			
		Water Depth Maps			
	Flood	Flood Zone Maps			
		Digital Elevation Model			
		Base Flood Elevation			
	Hurricane	Surface Roughness Maps			
		Tree Cover Maps			
	Avalanche	Elevation Contour Maps			
	Coastal Erosion	Historical Aerial Photographs			
	Coastal Storm	Coastal Storm Maps			
	Dam Failure	Inundation Maps			
	Drought	Drought Maps			
	Expansive Soils	Soil Maps			
	Extreme Heat	Maximum Temperature Maps			
	Hailstorm	Hailstorm Maps			
	Landslide	Landslide Maps			
	Land Subsidence	Land Subsidence Maps			
	Severe Winter Storm	Winter Storm Maps			
	Tornado	Tornado Maps			
	Tsunami	Tsunami Inundation Maps			
	Volcano	Lava Flow Areas, Volcanic Activity Maps			
	Wildfire	Fuel Maps, Drought Maps			

Note: Modified from FEMA 386-2. Blank rows are for other hazards of interest. Hazards in bold are discussed in Step 2.

WORKSHEET 2-2: PROFILE HAZARDS

Worksheet 2-2 can be used to summarize hazard profile data for specific hazards of interest in your study region. It presents the information in a manner that will be consistent across hazards. This will help you make sure you are getting the same information for each hazard and help you communicate about the hazards within the risk assessment team and with your community. You will complete a copy of the worksheet for each hazard of interest in your study region.

To use the worksheet, first review Example 2-1. This provides an example of completed a hazard profile and illustrates the type of information to include under the summary of risk factors and the hazard profile cells. Example 2-1 also shows examples of graphics (including maps) that will be useful for your hazard profile.

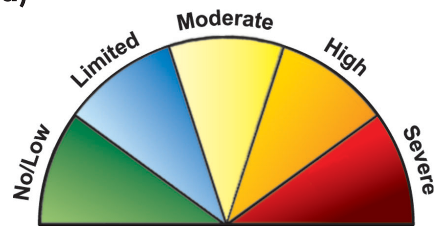
After reading Chapter 2 and reviewing the example, complete the following steps:

1. Complete a hazard profile for each of the hazards of interest identified and retained in Step 1. Start with the Summary of Risk Factors table at the top of Worksheet 2-2 and the Hazard Profile Data table, as this information may assist in deciding if additional hazard data and maps are needed. Fill out as much of the information as you can.

2. Next, attach any graphic illustrations of hazard areas, other representations of the hazard area, or histograms of hazard events following the Hazard Profile Data table. The hazard maps you collected as part of Task 2.3 can be used.

3. Finally, consider all of the profile data you have compiled and evaluate the overall risk of each hazard in your area. Then select an appropriate initial profile ranking for your hazard (from no/low risk to severe risk). Indicate the appropriate level using an indicator arrow on the risk gauge in the upper right hand corner of the worksheet.

WORKSHEET 2-2: PROFILE HAZARDS (continued)



HAZARD: ______________________________

Summary of Risk Factors	
Period of occurrence:	
Probability of event(s):	
Warning time:	
Major contributor(s):	
Risk of injury?	
Potential for facilities shutdown?	
Percent of affected properties that may be destroyed or suffer major damage:	

HAZARD PROFILE DATA

Background and Local Conditions
Historic Frequency and Probability of Occurrence
Severity
Historic Losses and Impacts
Designated Hazard Areas

Attach any maps of hazard areas or other graphic illustrations related to the hazard (e.g., histograms of past hazard events over time).

WORKSHEET 2-3: PRIORITIZE HAZARDS

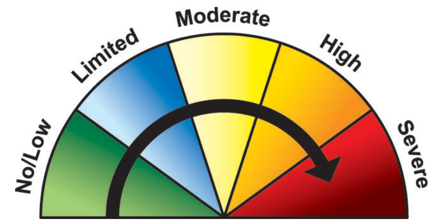
This worksheet provides an example of how you can qualitatively prioritize hazards. It includes ranking factors that impact the priority of a specific hazard in your area. Note that you can modify this worksheet if needed to include additional factors (e.g., community concern). Or you can weight the factors differently if you feel that is appropriate. To use this worksheet, refer back to the data collection and evaluation that you performed to profile hazard events (completed Worksheet 2-2 documentation). Now assign a rating for each factor shown below from 0 (low) to 5 (high) for each hazard of interest. Use the individual factors to consider and assign an overall preliminary profile ranking for each hazard of interest. You can rank numerically from 1 (most important) to X (least important, with X being the number of relevant hazards of interest for your study region). Alternately, you can rank hazards as N/L, L, M, H, or S (for No/Low, Low, Moderate, High, or Severe) for this preliminary profile ranking. Your risk assessment outcomes may help you re-evaluate your initial rankings over time. If you have a hazard that is not listed, use the blank space below.

Hazard (Italicized text indicates a HAZUS-MH hazard)	Ranking Factors				Ranking (Numerical or N/L, M, H, S)
	Frequency (0-5)	Duration (0-5)	Severity (0-5)	Intensity (0-5)	
Avalanche					
Coastal Erosion					
Dam Failure					
Drought					
Earthquake					
Expansive Soils					
Extreme Heat					
Flood (Coastal)					
Flood (Riverine)					
Hailstorm					
Hurricane					
Landslide					
Land Subsidence					
Severe Winter Storm					
Tornado					
Tsunami					
Volcano					
Wildfire					

Note: Modified from FEMA 386-2. Hazards in bold are discussed in Step 2.

EXAMPLE 2-1: HAZARD PROFILE - EARTHQUAKE (Portland, OR)

Multnomah County Hazard Analysis		Summary of Risk Factors	
Severity Score	Severe	Period of occurrence:	At any time
History (2)	20	Probability of event(s):	Highly likely
Vulnerability (5)	50	Warning time:	No warning time
Maximum Threat (10)	100	Major contributor(s):	Highly active seismic zone, local soil characteristics
Probability (7)	70	Cause injuries?	Yes, and risk of death
Total Score	240	Potential facilities shutdown?	30 days or more



Hazard Risk Gauge
Initial Profile Ranking

Magnitude (M) is a measure of earthquake size that represents the amount of energy released by an earthquake. Energy release increases 30 times for each integer on the magnitude scale. Moment Magnitude is a direct measure of energy and is a more accurate measure of the true strength or intensity of an earthquake.

EARTHQUAKE HAZARD PROFILE

Background and Local Conditions

There are several different sources for hazardous earthquakes in the Pacific Northwest. Oregon sits on the Cascadia Subduction Zone where the Pacific / Juan de Fuca Plate is sliding under (or being pushed under) the less dense North American Plate. Although earthquakes along this zone occur infrequently, plate movement can produce major earthquakes. In addition, the western part of Oregon is underlain by a large and complex system of faults (e.g., the Portland Hills) that can produce significant and more frequent earthquakes.

Historic Frequency and Probability of Occurrence

The Metro 1999 study cites research indicating that “major geologic structures capable of magnitude (M) 7 earthquakes” underlie the Portland study area. Since 1820, 7,000 earthquakes within Oregon have been documented. Fifty-six significant earthquakes have occurred in or near the Portland study area between 1872 and 1999. Severe local earthquakes occurred in 1877, 1880, 1953, 1962, and 1993 (Metro, 1999).

Strong Pacific Northwest earthquakes of record also include an 1872 M 7.4 North Cascades event, an M 6.8 earthquake in 1873, a 1949 M 7.1 event near Olympia, Washington, a 1965 M 6.5 event in Seattle-Tacoma, and a 2001 Olympia, Washington, event that caused over $2 billion in property damage (Oregon OEM, 2000). Regional earthquakes, such as the deep, intraplate Nisqually Earthquake that occurred in 2001 in Olympia, Washington, have been felt widely in northwest Oregon. The first figure provided with this profile illustrates the annual probability of exceeding a range of peak ground acceleration levels in Portland. The second figure shows past historic events in terms of moment magnitude.

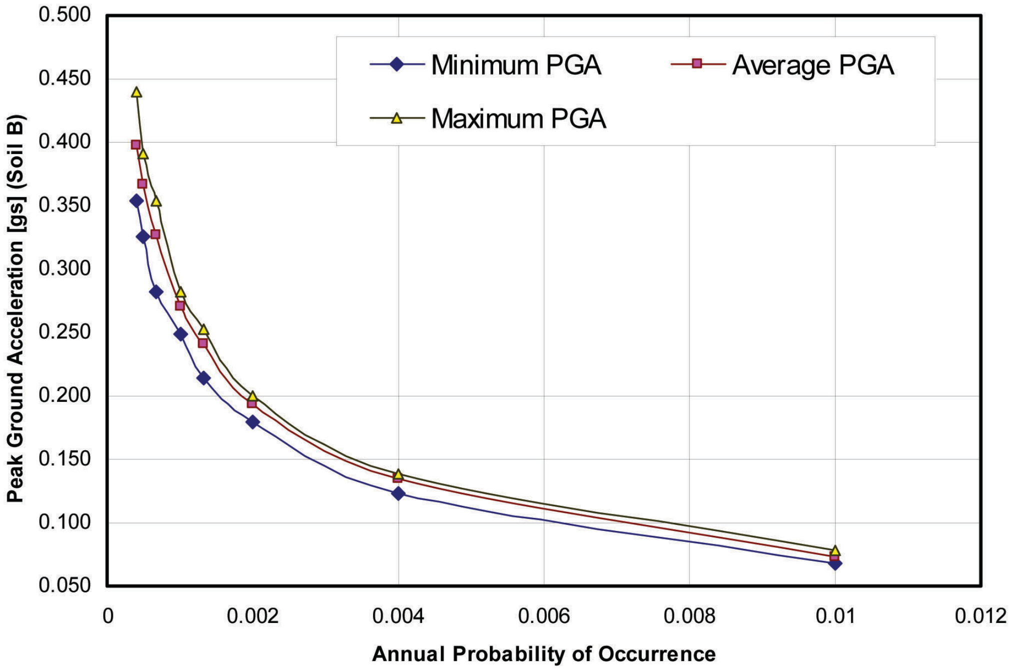
Severity

There is a direct relationship between a fault’s length and location and its ability to generate damaging ground motion. In Portland, smaller, local faults produce lower magnitude quakes, but their ground shaking can be strong and damage can be high as a result of the fault’s proximity to structures. In contrast, offshore or distant subduction zone quakes can generate great magnitudes, but, because of their distance and depth, may result in only moderate shaking in the Portland study area (Metro, 1999). The Cascadia Subduction Zone fault could produce an earthquake of M 8.0 to 9.0 or greater. Geologic evidence shows that earthquakes of similar magnitude have occurred on average every 500 to 600 years in this area. Based on the Mutlnomah County analysis and pilot project, this hazard was given an initial profile ranking of severe.

Historic Losses and Impacts

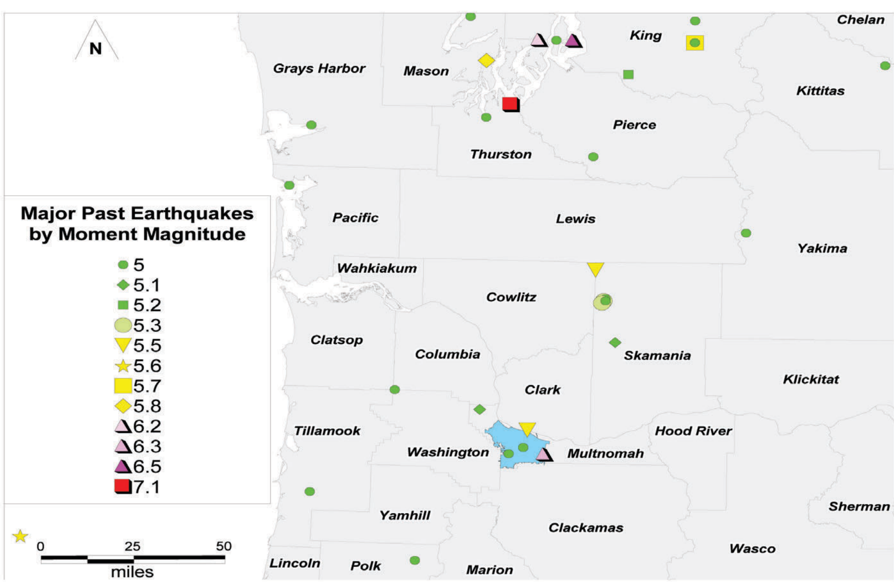
Damage results from earthquakes because structures that cannot withstand the shaking, are situated on ground that amplifies shaking, or are located on soil that is subject to liquefaction. Structures can cause injury or fatalities and suffer content and functionality losses. The 2001 Nisqually event caused over $2 billion in losses. The two 1993 Klamath Falls earthquakes (M 5.9 and 6.0) caused damage to more than 1,000 buildings and $10 million in losses (DOGAMI, 2002). Since 1872, there have been about 25 damaging earthquakes in Washington and Oregon (CREW, 2003).

EXAMPLE 2-1: HAZARD PROFILE - EARTHQUAKE (continued) (Portland, Oregon)



Note: PGA indicates peak ground acceleration. There is a 2 in 1,000 probability of an earthquake with a PGA of 0.2 or greater in any one year.

Major Past Earthquakes for the Pacific Northwest (1600 to 2002)



Note: The Portland study area is highlighted in blue.

Source: HAZUS-MH

OVERVIEW

The third step in the risk assessment is to consider the assets that can be impacted by the prioritized hazards from Step 2. Risk is a combination of hazard, exposure, and vulnerability. During Step 3, you will assemble information about, and document the populations, structures, and lifelines that can be impacted by different hazard events. The tasks and outputs for Step 3 are shown in Figure 3-1.

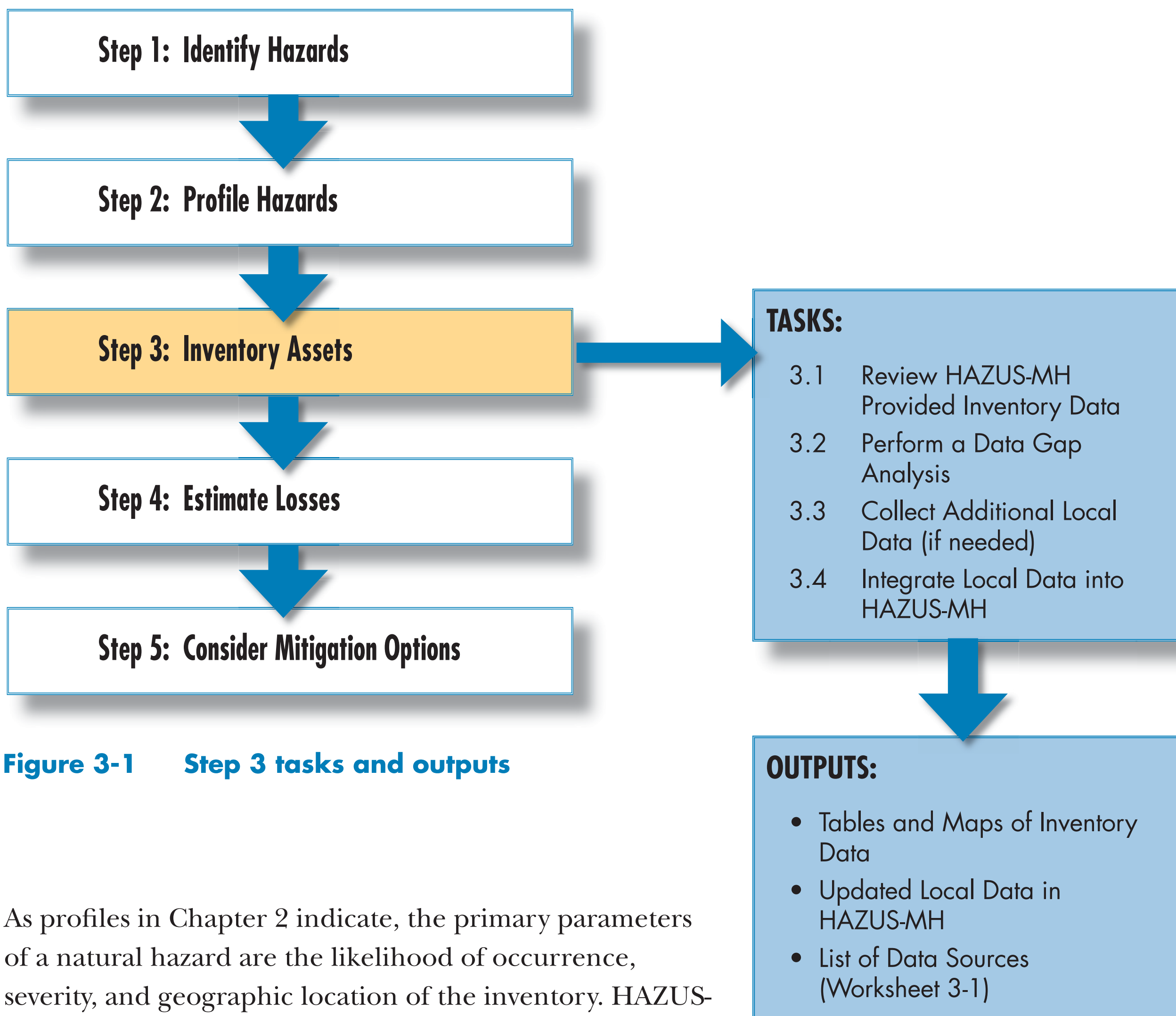


Figure 3-1 Step 3 tasks and outputs

As profiles in Chapter 2 indicate, the primary parameters of a natural hazard are the likelihood of occurrence, severity, and geographic location of the inventory. HAZUS-MH includes general inventories for your geographically assigned study region to support your loss estimates and risk studies. Task 3.1 involves accessing and understanding the inventory provided

HAZUS-MH Inventory Terms

Asset – Any human-developed or natural feature that has value, including but not limited to people, buildings, lifelines, or other features (such as parks or cultural centers)

Inventory – Populations, buildings, and lifelines in your study region

Buildings – Commercial, residential, industrial, essential, and critical facilities and potentially other user-defined buildings

Lifelines – Transportation and utility systems

Exposure – Presence of an inventory asset in an area susceptible to a hazard

Vulnerability – How exposed or susceptible to

by HAZUS-MH. Task 3.2 takes you through the steps of performing a data gap analysis in case you decide to refine your inventory by using local data to perform HAZUS-MH Level 2 and Level 3 analyses. Task 3.3 provides information on where to collect additional data for your risk assessment. Task 3.4 shows you how to integrate local data into HAZUS-MH to perform Level 2 and Level 3 analyses.

Review HAZUS-MH Provided Inventory Data (Task 3.1)

HAZUS-MH includes seven inventory data categories, as follows:

1. **General Building Stock**. General building types and occupancy classes
2. **Essential Facilities**. Facilities essential to the health and welfare of the community
3. **Hazardous Material Facilities**. Storage facilities for industrial hazardous materials
4. **High Potential Loss Facilities**. Facilities that, if affected by disaster, would have a high loss or impact on the community
5. **Transportation Lifeline Systems**. Transportation systems for air, road, rail, and water
6. **Utility Lifeline Systems**. Utilities include potable water, wastewater, oil, natural gas, electric power, and communication systems
7. **Demographics**. Demographics include population statistics.

These inventory data are linked geographically to your study region within HAZUS-MH. On your study region maps, the inventory data categories are symbolized as point, line, and polygon features.

These three types of GIS features include:

> Job Aid 3-1 (Appendix E) lists the inventory provided with HAZUS-MH, the source and year of the data, and potential local data sources that can supplement the HAZUS-MH provided data.

1. **Point Features**. Site-specific facility locations such as essential facilities, high potential loss facilities, and hazardous material facilities. The facilities data will be geographically displayed as an individual point for each facility.
2. **Line Features**. Site-specific facility locations connected by pipelines for utility lifeline systems or roads for transportation lifeline systems. The facilities will be geographically displayed as an individual point for each facility and lines for pipelines and roads.
3. **Polygon Features**. A group of facilities or inventory data within a defined area such as general building stock and demographic data. The features will be geographically displayed as polygons.

The HAZUS-MH provided inventory data is gathered from nationally available data sources for each of the data sets. The specific data sources for each category are presented in Job Aid 3-1 in Appendix E. When accessing and understanding the HAZUS-MH provided data, it is important to check the locations of the inventory assets. The locations may be checked using high-resolution aerial photos, local GIS data overlain in HAZUS-MH, address information, or by personnel familiar with the study region. If the location of a major facility such as a hospital, school, or fire station is not accurate, HAZUS-MH provides tools to easily change the location, and if necessary, the characteristics of the inventory. This section describes the types of inventory data provided in HAZUS-MH for each of the seven categories and guides you on how to modify and supplement this data.

General Building Stock broadly includes residential, commercial, industrial, and public service building types. HAZUS-MH groups the general building stock into 36 model building types and 28 occupancy classes. Examples of model building types include light wood frame, steel-braced frame, concrete frame with unreinforced masonry infill walls, and unreinforced masonry. Each model building type is further subdivided according to the number of stories or other classifications. Examples of occupancy types include single-family dwellings, retail trade, heavy industry, and churches. General building stock is aggregated at the Census block or Census tract level. This means that the total number of buildings and the number of buildings within each model building type and occupancy class are provided for each Census tract or Census block.

To access the HAZUS-MH provided general building stock, select "General Building Stock" from the inventory menu. You will see options to view the general building stock by square footage, building count, occupancy mapping, dollar exposure, and foundation type. Review the information provided in the tables, select a column in the table that is of interest to you, and select the map function at the bottom of the menu to view the general building stock distribution across the study region.

Essential Facilities include hospitals and other medical facilities, police and fire stations, emergency operation centers, and schools (often used as shelters). These facilities are especially important following hazard events. The potential consequences of losing these facilities are so great that you may want to carefully inventory these facilities.

To access the HAZUS-MH provided essential facility inventory, select "Essential Facilities" from the inventory menu. Review the information provided in the tables and select the map function at the bottom of the menu to view the locations of these facilities.

Hazardous Material Facilities include storage facilities for industrial or hazardous materials such as corrosives, explosives, flammable materials, radioactive materials, and toxins.

To access the HAZUS-MH provided hazardous material facility inventory, select "Hazardous Material Facilities" from the inventory menu. Review the information provided in the table and select the map function at the bottom of the menu to view the facility locations.

High Potential Loss Facilities include nuclear power plants, dams, levees, and military installations. These types of facilities would have a high loss or impact on the community if they were impacted by a hazard. HAZUS-MH only provides data on dams. The database provides a placeholder for levees, nuclear power facilities, and military installations.

To access the HAZUS-MH provided high potential loss facility inventory, select "High Potential Loss Facilities" from the inventory menu. Review the information provided in the tables and select the map function at the bottom of the menu to view the asset locations.

Transportation Lifeline Systems include the following types of infrastructure inventory data:

- Airways – airport facilities, airport runways, heliport facilities, and heliport landing pads
- Highways – bridges, tunnels, and road segments

- Railways – light rail systems, tracks, tunnels, bridges, and facilities (rail-yards and depots)
- Waterways – ports (locks, seaports, harbors, dry docks, and piers) and ferries
- Bus Stations

To access the HAZUS-MH provided transportation lifeline system inventory, select "Transportation Lifeline Systems" from the inventory menu. Review the information provided in the tables and select the map function at the bottom of the menu to view the asset locations.

Utility Lifeline Systems include potable water, wastewater, oil, natural gas, electric power, and communication systems. Certain facilities are unique to the flood module and others are found only in the earthquake and hurricane modules. The types of facilities found in each HAZUS-MH module are based on each facility's susceptibility to loss by each hazard. Job Aid 3-1 in Appendix E details these differences.

To access the HAZUS-MH provided utility lifeline system inventory, select "Utility Lifeline Systems" from the inventory menu. Review the information provided in the tables and select the map function at the bottom of the menu to view the asset locations. Because the national data available for utilities may require updating, the HAZUS-MH database provides a placeholder for your local utility data.

> NOTE
>
> The intent of DMA 2000 includes the evaluation of risk to socially vulnerable populations such as the elderly and low-income families.

Demographics inventory data include total population; age, gender, and race distribution; income distribution; number of owners and renters; building age; workforce location data; and other data obtained from the U.S. Census Bureau and Dun & Bradstreet. The demographic data are aggregated at the Census block or Census tract level.

To access the HAZUS-MH provided demographics, select "Demographics" from the inventory menu. Select a column from the table and then the map function at the bottom of the menu to view the data across the study region.

Congratulations! You have now reviewed the inventory data provided in HAZUS-MH and can proceed to perform a data gap analysis, if required, for your study area.

Perform a Data Gap Analysis (Task 3.2)

If you select to use only HAZUS-MH provided data, you will have the necessary inventory data to complete your risk assessment. However, if you decide to add local data and perform a HAZUS-MH Level 2 or Level 3 analysis, you will need to perform a data gap analysis. For this task, you will evaluate schedules, resources, priorities, and needs for local inventory data collection.

The decision to gather additional inventory data should be based on your local needs and available resources. Consider the following questions to help determine whether additional inventory data may be required:

- ❍ Does the general building stock data appear acceptable in terms of number and types of buildings?
- ❍ Are there areas of recent development that are not reflected by the HAZUS-MH provided inventory data?
- ❍ Are there essential facilities that are missing or inaccurately described?
- ❍ Are there additional transportation and utility lifelines that are important?
- ❍ Are there areas within the study region that are of greatest concern, based on hazard profiles, and that should be the focus for local data improvement efforts?
- ❍ Do state or local requirements specify certain categories of assets to be addressed (e.g., special facilities such as museums, historical landmarks, or government buildings)?

Figure 3-2
Local inventory data collection potential levels of effort

Figure 3-2 illustrates the categories of local inventory data and recommended focus areas based on the FEMA field pilot projects performed to date. Certain inventory data, such as the locations of hospitals or bridges, are static and easier to collect than other inventory data, such as gender composition or income levels of the population in a specified area.

Before you begin your gap analysis, determine what resources are available to reduce or eliminate data gaps. Then, prioritize areas of your region or specific inventory categories (e.g., hospitals) for additional inventory data collection. At this point, you may use the hazard maps that you created to determine where you may concentrate further inventory data collection efforts. The review of the inventory data in HAZUS-MH that you conducted in Task 3.1 will help you identify those categories of inventory data that you may want to refine by collecting local data. At the end of this step, Worksheet 3-1 provides a tool that you can use to consider each inventory asset category provided in HAZUS-MH and potential local data sources and available data that you have to support the use of HAZUS-MH. Job Aid 3-2 in Appendix E provides additional detail regarding the attributes included for each inventory category in HAZUS-MH.

EXAMPLE

The City of Austin, Texas, combined general building stock information provided in HAZUS-MH with updated critical facility data for hospitals, schools, and emergency operations centers. Buildings of special interest based on Texas mitigation requirements, such as stadiums and museums, were added as user-specified facilities. Finally, pipeline data for fuel and oil pipelines were incorporated into the inventory data sets.

Congratulations! You have now performed a data gap analysis and can proceed to collect additional inventory data.

Collect Additional Local Data (If Needed) (Task 3.3)

JOB AID

TOOLS

Job Aid 3-2 (Appendix E) lists the inventory categories for HAZUS-MH and the specific attributes required for each category.

If you decide to perform a HAZUS-MH Level 2 or Level 3 analysis, you will need to collect local hazard-related data and use local inventory data. Integrating local data in HAZUS-MH will produce more refined risk assessments. However, collecting extensive new data can become difficult and costly. Job Aid 3-2 in Appendix E shows the attribute data you will need for various data categories. Before deciding to perform a Level 2 or Level 3 HAZUS-MH analysis, you may want to evaluate your resources and determine if you have the staff, time, and funding to proceed further. If your resources are limited, you may decide to: (a) use only HAZUS-MH provided data as your "best available data" and plan future local data collection efforts; or (b) combine readily-available local data with the data provided in HAZUS-MH (see Task 3.4).

If you have the resources to start your data collection, it would be wise to assess which data you need to collect and which efforts would be most cost-effective. You may want to gather detailed information for a particular category of inventory data that you believe has changed significantly since the latest version of the HAZUS-MH software was released. Alternately, you

NOTE

You may want to update site-specific information when you review a list of facilities and know that one of those facilities is no longer used or if you know that additional facilities in that inventory category have been added. For example, if a new school is built, you could add that school to the school inventory category without replacing or updating the entire data set.

may want to refine all of the inventory categories for a particular area of your study region that is vulnerable to one or more significant hazards. You may decide to gather detailed inventory information for all of the essential facilities, or you may focus your attention just on the schools or hospitals. Remember that HAZUS-MH will provide refined risk studies as you provide quality local data.

To start or expand your current efforts in data collection, contact local personnel such as the tax assessor, the department of public works manager, county officials, and GIS specialists, and ask them for the necessary inventory data. Job Aid 3-1 in Appendix E will help you with this process. You may want to share this Job Aid with appropriate personnel so that they can guide you in your effort of data collection. When collecting local data, ask for data in an electronic format when feasible. Keep a log of all data collected so that you can document your risk assessment study in your mitigation plan.

Integrate Local Data into HAZUS-MH (Task 3.4)

Local data can be integrated into HAZUS-MH using the following tools or techniques:

- **Edit or Import Inventory Data Tables**. You can directly update the inventory data tables if you have databases containing all of the required fields shown in Job Aid 3-2 (Appendix E) or if you want to add or remove selected data from a particular inventory category. If you do not have all of the required fields, you may want to develop the data based on assumptions from similar existing inventory contained in your study region or by field data collection.

HAZUS

In HAZUS-MH, you can update the study region or the source files with the local data. Caution: if you do not update the source files, the local data will not be saved for other study region analysis.

HAZUS-MH local data updates generally include:

- Location
- Classification
- Valuation (replacement value)

- **Collect Data Using InCAST**. You can use the Inventory Collection and Survey Tool (InCAST) to collect building and infrastructure data. Use InCAST if you are integrating limited building data or if you do not have existing electronic data.
- **Organize and Import Data Using BIT-MH**. The Building Import Tool for Multi-Hazards (BIT-MH) allows you to incorporate building data

for the general building stock only, and is most useful for integrating large sets of data. Use BIT-MH if you have one or more large sets of databases or spreadsheets and you are importing building information, not infrastructure data.

Instructions for each data integration option are presented in the following subsections.

Edit HAZUS-MH Inventory Data Tables

You can add or edit one or more site-specific (point) feature records directly in the HAZUS-MH data tables. You can use this approach to improve inventories of essential facilities, high potential loss facilities, lifeline components, and facilities storing hazardous materials. When you identify a new site, you will need to add a new feature record with attributes. Follow the directions provided below to update one or more site-specific records:

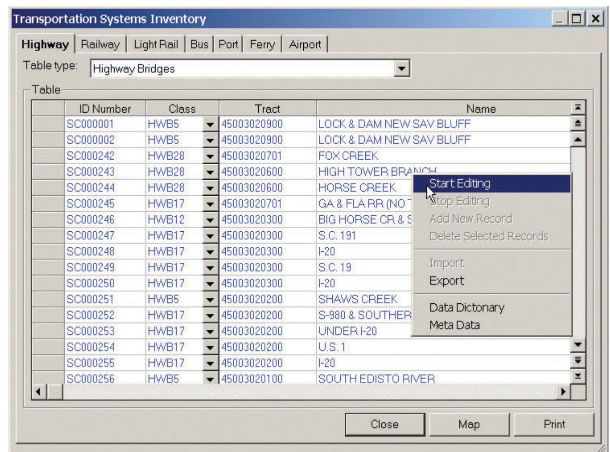


Figure 3-3 Example of an inventory table

1. **To access the appropriate inventory category**. Select a category from the HAZUS-MH inventory menu.
2. **To edit an existing table**. Left-click on a record; then right-click and choose "Start Editing" (see Figure 3-3).
3. **To delete current records**. Highlight the record to be deleted, right-click the table, and select "Delete Selected Records."
4. **To insert a new record.** Right-click the table and select "Add New Record."
5. **To modify a record**. Double click in the appropriate box and make the edit or add new data.
6. **To stop an editing session**. Right-click and choose "Stop Editing."

Import Local Inventory Data Tables into HAZUS-MH

This approach is appropriate if you want to modify, add, or delete a large number of facilities concurrently and develop database files as part of Task 3.3. The following steps will help you import local inventory data tables directly:

1. **To access the appropriate inventory category**. Select a category from the HAZUS-MH inventory menu (see Figure 3-3).
2. **To import electronic data into an existing table**. Left-click on a record; then right-click and choose "Start Editing." Now that you are in

the edit mode, “Import” will appear in bold when you right-click the mouse (see Figure 3-4).

3. **To access your local data file**. Enter the directory and filename for the database that you wish to import as shown in Figure 3-5.

4. **To assist you in converting your electronic database to the appropriate format for HAZUS-MH**. Click the right mouse button while you are in the inventory portion of HAZUS-MH and access the import utility. Select the appropriate database created in Task 3.3 and then click on the “OK” button.

5. **To map your data file (source file) with HAZUS-MH**. Use the mapping menu shown in Figure 3-6. Map each field in your database to the corresponding field in the HAZUS-MH database. The mapping that you have defined will now disappear from the Source and Target menus and will appear in the Mapping Results box at the bottom of the window.

6. **To support the field mapping efforts**. You should first make sure you understand the number of characters and format required for each data item. The Database Dictionary provided as Appendix E of the *HAZUS-MH Earthquake User Manual* contains the names and structures of all the databases used by HAZUS-MH. Using the dictionary, you can determine appropriate titles for target fields. An abbreviated form of the Database Dictionary is available in HAZUS-MH. To access the dictionary, click the right mouse button; using the menu shown in Figure 3-4, click on “Data Dictionary.” An example from the Database Dictionary is shown in Figure 3-7.

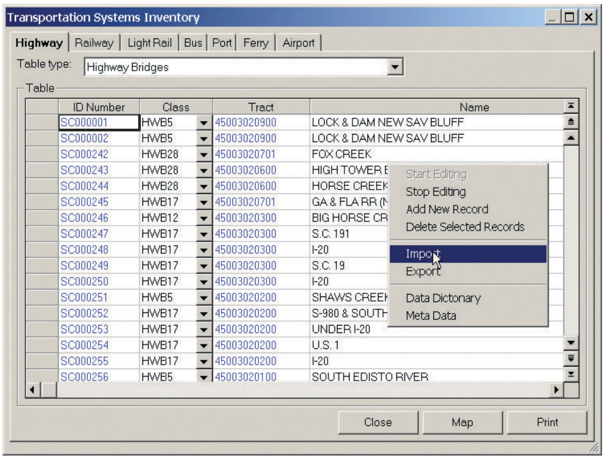


Figure 3-4
Import features with attributes

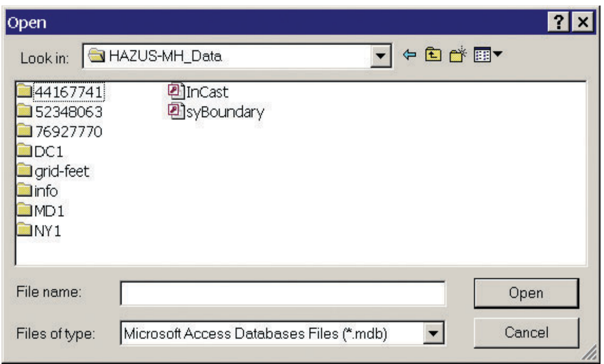


Figure 3-5
Identifying the database to be imported

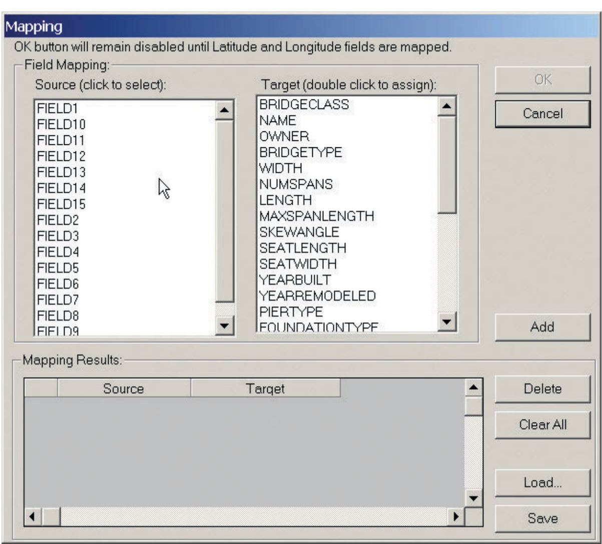


Figure 3-6
Source and target field mapping tool

7. **To assure your data file is appropriately mapped**. Review the mapping menu. If you see a mistake, click on the "Delete" button, and the last mapping pair that you defined will be undone.

8. **To complete your local data imports**. Click on the "OK" button, wait a few seconds, and your imported database will be displayed in HAZUS-MH. You do not have to map all of the fields on the Source (local data) menu. However, any fields that you do not map will not be imported into the target (HAZUS-MH inventory) database.

9. **To use your local database mapping scheme for future data integration efforts**. You can save the mapping scheme you defined so it can be reapplied to other files. Click on the "Save" button shown in Figure 3-6, and the dialog box shown in Figure 3-8 will appear. Enter a name for the mapping scheme, and click on the "OK" button. To retrieve the saved mapping scheme, click on the "Load" button shown in Figure 3-6.

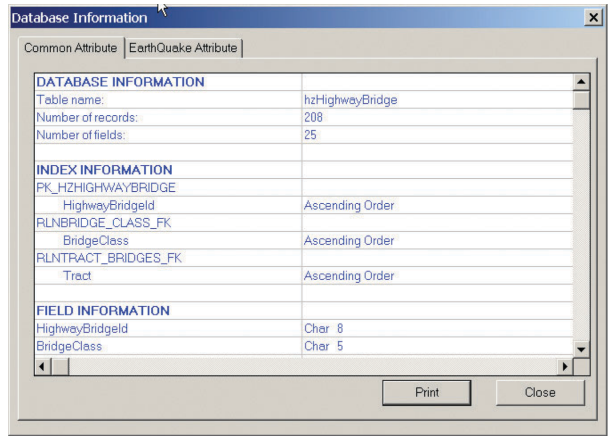


Figure 3-7
Interactive database dictionary

> In HAZUS-MH, the fields of the Source (local data) menu do not have to be in the same order or have the same names as the fields in the target (HAZUS-MH inventory database). To define the desired mapping scheme, simply click on a field name on the Source menu (such as "LON") and the corresponding field name on the Target menu ("Longitude"); then click on the "Add" button.

Collect Data Using InCAST

InCAST allows the user to integrate point data for buildings in a user-friendly, standardized manner. Data integration using InCAST addresses four distinct datasets:

- General data common to all hazards
- Earthquake-related data
- Flood-related data
- Wind-related data

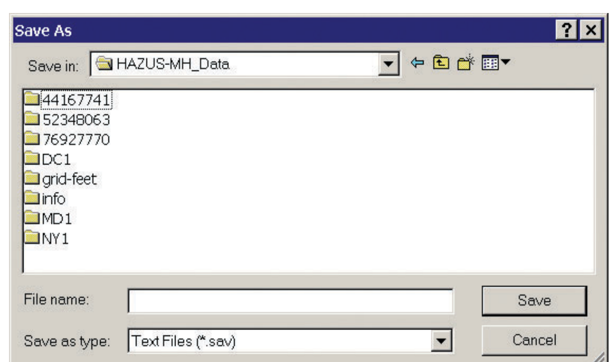


Figure 3-8
Saving a database mapping scheme

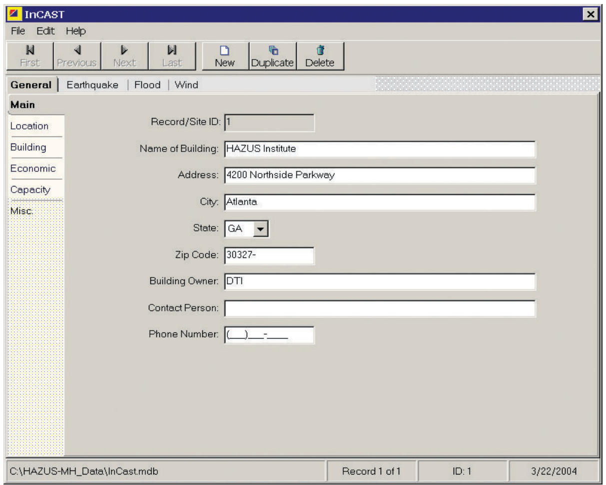


Figure 3-9 InCAST general menu

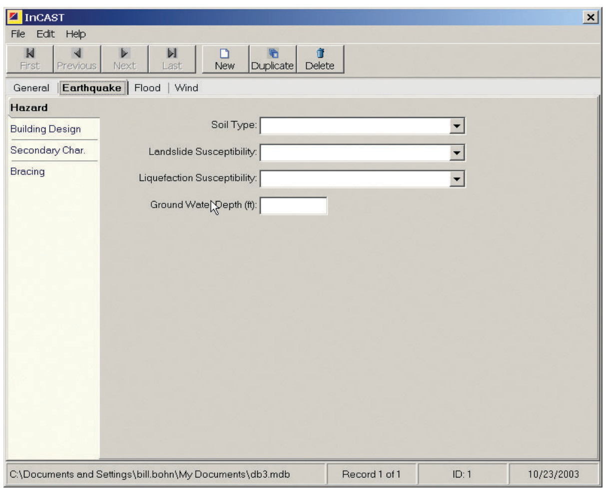


Figure 3-10 InCAST earthquake menu

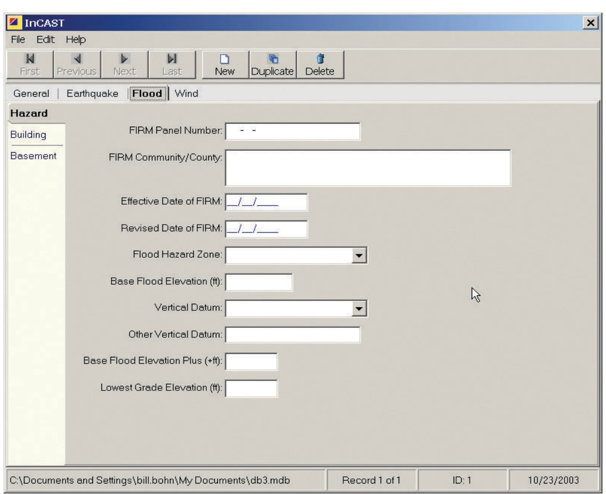


Figure 3-11 InCAST flood menu

InCAST can be run without first opening HAZUS-MH. To use InCAST:

1. **Start the program**. Click on the "Windows Start" button and then on "Programs;" you will find the InCAST program in the "FEMA Risk Assessment System" folder.

2. **Create your InCAST database**. You will be prompted to create a new database or open an existing database. For your first session, you will create a new database and then select its location.

3. **Enter the data**. You are now ready to begin entering building data for your study region. (During future sessions, you can edit your database at this point.) Figure 3-9 presents an example of a data input screen in InCAST. The topic tabs near the top are used to distinguish between hazard datasets. Hazard datasets that are not applicable to your study region do not need to be completed. For example, if the earthquake hazard is not a concern, skip the associated topic tab. Figures 3-10, 3-11, and 3-12 present data input screens for the earthquake, flood, and wind (hurricane) hazards.

4. **Save the database**. When you are finished entering data, click on "File" at the top left, and then click on "Save." This procedure will save the database. You will use this database when you begin running HAZUS-MH, so note its file location.

Organize and Import Data Using BIT-MH

BIT-MH allows a user to integrate existing building datasets (not infrastructure datasets) into HAZUS-MH. BIT-MH also is found in the “FEMA Risk Assessment System” folder. To use BIT-MH, perform the five activities described below:

1. **Specify an input file**. After BIT-MH begins running, you will be prompted to specify an input file (see Figure 3-13). This input file must be an Access table, a dbase table, or a text file. County-specific datasets will be processed individually. Therefore, if your study region encompasses multiple counties, repeat each of these five activities for each county.

2. **Map the attributes**. After specifying the input file, you will be prompted to map the attributes (see Figure 3-14). This process redefines the field names in your local data with names compatible with those used in HAZUS-MH. A minimum of 10 attributes must be mapped: area, building value, content value, building type, occupancy class, age or year of construction, height or number of stories, design code (low, medium, or high), latitude, and longitude. As you proceed, you may also need to convert units of measurement (e.g., HAZUS-MH requires square footage for area attributes).

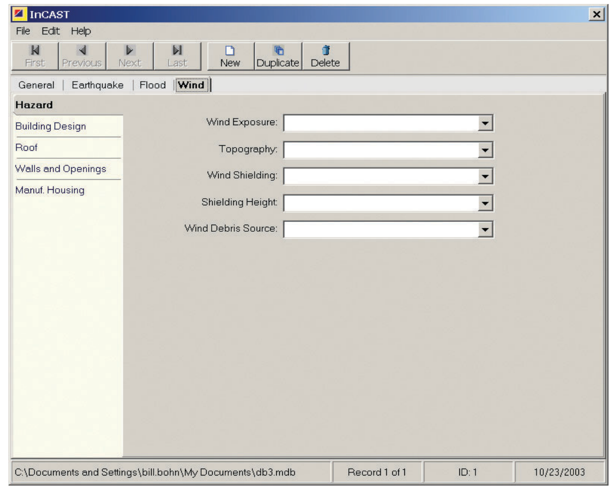


Figure 3-12 InCAST wind menu

For additional information on the BIT-MH tool, see Chapter 8 of the *HAZUS-MH Earthquake User Manual.*

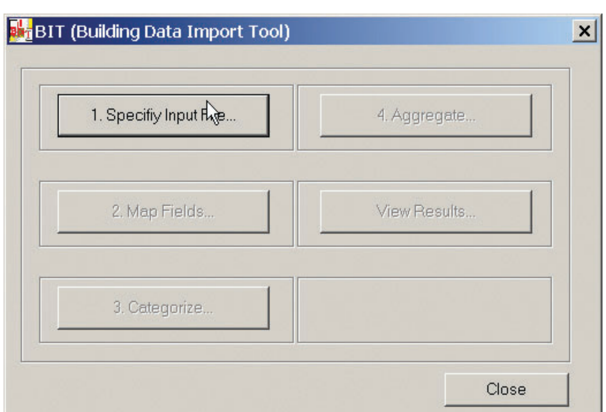


Figure 3-13 BIT-MH startup menu

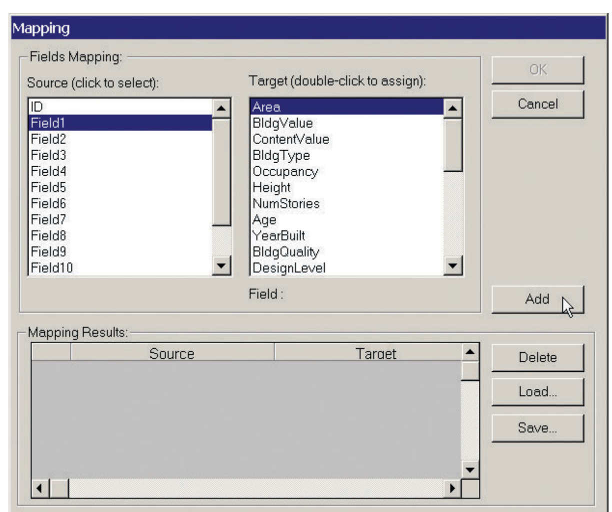


Figure 3-14 Mapping menu

3. **Categorize the attributes.** After mapping the attributes, you will be prompted to categorize them (see Figure 3-15). This process allows the categorization of the 10 or more attributes that you just mapped. The attribute values will be transformed into HAZUS-MH acceptable values (see Figure 3-16). For more information on field categorization, see Chapter 8.5 in the *HAZUS-MH Earthquake User Manual.*

4. **Aggregate the data.** After categorizing the attributes, you will be prompted to aggregate the data at the Census block and Census tract levels (e.g., square footage by “Specific Occupancy” and “Bldg Count” by “Specific Occupancy”). For more information on data aggregation, see Chapter 8.6 in the *HAZUS-MH Earthquake User Manual.*

5. **View results.** After aggregating the data, you will be given the option of viewing the results. This activity is primarily for quality control and assurance purposes and should be completed before the data are used in HAZUS-MH. For more information on BIT-MH results, see Chapter 8.7 in the *HAZUS-MH Earthquake User Manual.*

Congratulations! You have now successfully integrated your local data into HAZUS-MH.

SUMMARY

When you are finished with Step 3, you will have collected and integrated inventory data into HAZUS-MH. These inventory data may include essential facilities, hazardous material storage (HazMat) facilities, high potential loss facilities, transportation and lifeline facilities, demographic data, and general building stock. Table 3-1 will help you verify that you have completed the activities for Step 3.

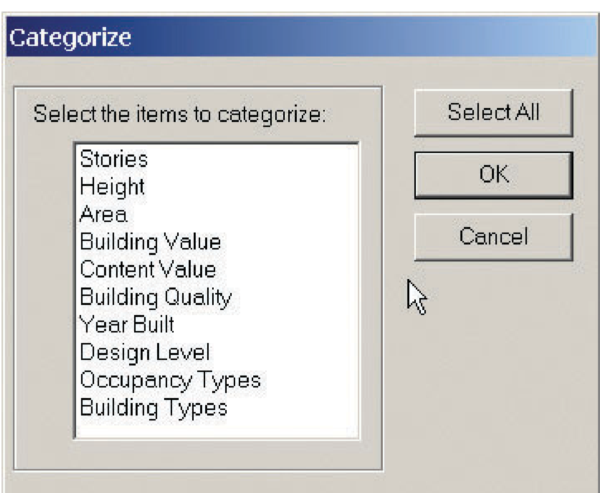


Figure 3-15 Category menu

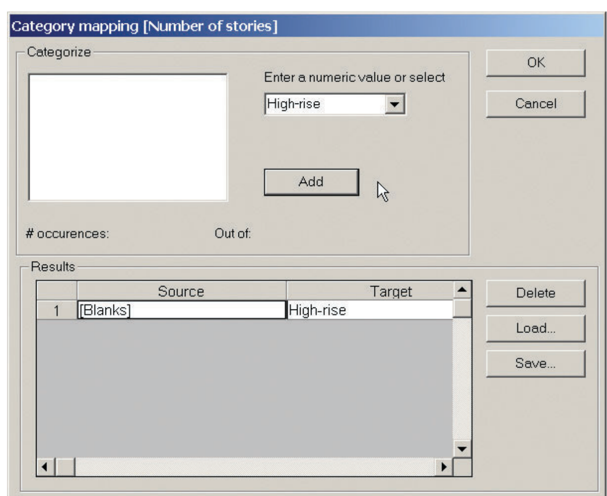


Figure 3-16 Category mapping menu

Table 3-1: Inventory Assets Activities and Outputs Checklist

Activity	Output	Check Completed Items
Review HAZUS-MH provided inventory data (Task 3.1)	Understanding of inventory provided in HAZUS-MH, including: • General building stock • Essential facilities • HazMat facilities • High potential loss facilities • Transportation and utility lifeline systems • Demographic data	
Perform a data gap analysis (Task 3.2)	Determination to use Level 1 inventory data and documentation of basis for decision (go to Step 4) or documentation of determination to collect additional data (go to Task 3.3)	
Collect additional local data (if needed) (Task 3.3)	Worksheet 3-1 and updated inventory data collected for some or all of the following categories: • General building stock • Essential facilities • HazMat facilities • High potential loss facilities • Transportation and utility lifeline systems • Demographic data	
Integrate local data into HAZUS-MH (Task 3.4)	Updated HAZUS-MH data integrated into HAZUS-MH for some or all of the following categories: • General building stock • Essential facilities • HazMat facilities • High potential loss facilities • Transportation and utility lifeline systems • Demographic data	

Complete any missing items in your checklist, and then continue to Step 4.

GO TO STEP 4: ESTIMATE LOSSES

WORKSHEET 3-1: HAZUS-MH INVENTORY DATA AND DATA SOURCES

Worksheet 3-1 shows the sources and dates of data provided by HAZUS-MH. This worksheet can help you to keep track of your local data, sources, and reliability. It helps you compare data provided in HAZUS-MH with data that you have collected or wish to collect. Complete the column on the right to record your local data.

Inventory Asset Category	Supported in Database Model			HAZUS-MH Provided Data Source (Year)	Local Data Source and Comments (Indicate N/A for not applicable if using HAZUS-MH Provided Data)
	EQ	FL	HU		
General Building Stock					
	X	X	X	U.S. Census Bureau (2000) and Dun & Bradstreet (2002)	
Essential Facilities					
Medical Care	X	X	X	American Hospital Association (2000)	
Emergency Response	X	X	X	InfoUSA, Inc. (2001) and previously geocoded data from FEMA	
Schools	X	X	X	National Center for Education Statistics, U.S. Department of Education (2000)	
Fire Stations	X	X	X	InfoUSA, Inc. (2001)	
Police Stations	X	X	X	InfoUSA, Inc. (2001)	
HazMat Facilities					
	X	X	X	Toxic Release Inventory Database, EPA (1999)	
High Potential Loss Facilities					
Dams	X	X	X	National Inventory of Dams, USACE (2003)	
Levees	X	X	X	Source not provided	
Nuclear Power Facilities	X	X	X	Source not provided	
Military Installations	X	X	X	Source not provided	
Transportation Lifeline Systems					
Highway Segments	X	X	X	Tiger/Line Files, U.S. Census Bureau (2000)	
Highway Bridges	X	X	X	National Bridge Inventory Database, FHWA (2001)	

Inventory Asset Category	Supported in Database Model			HAZUS-MH Provided Data Source (Year)	Local Data Source and Comments (Indicate N/A for not applicable if using HAZUS-MH Provided Data)
	EQ	FL	HU		
Highway Tunnels	X	X	X	National Bridge Inventory Database, FHWA (2001)	
Rail Segments	X	X	X	National Rail Network Database, Bureau of Transportation Statistics (2000)	
Rail Bridges	X	X	X	National Bridge Inventory Database, FHWA (2001)	
Rail Tunnels	X	X	X	National Bridge Inventory Database, FHWA (2000)	
Rail Facilities	X	X	X	Amtrak Station Database (2000) and the Intermodal Terminal Facilities Database (1998), BTS, U.S. DOT (2000)	
Light Rail Segments	X	X	X	Fixed-Guideway Transit and Ferry Network Database, BTS, U.S. DOT (2000)	
Light Rail Bridges	X	X	X	National Bridge Inventory Database, FHWA (2001)	
Light Rail Tunnels	X	X	X	Source not provided	
Light Rail Facilities	X	X	X	Source not provided	
Bus	X	X	X	InfoUSA, Inc. (2001)	
Port	X	X	X	Port and Waterway Facilities Database, USACE (2000)	
Ferry	X	X	X	Port and Waterway Facilities Database, USACE (2000)	
Airport Facilities	X	X	X	BTS, U.S. DOT (1999)	
Airport Runways	X	X	X	BTS, U.S. DOT (1999)	
Utility Lifeline Systems					
Potable Water Pipelines	X	X	X	Source not provided	
Potable Water Distribution Pipes (by Census tract)	X			Tiger/Line Files, U.S. Census Bureau (2000)	
Potable Water Facilities	X	X	X	EPA Envirofacts Data Warehouse LRT Tool (2001)	
Wastewater Pipelines	X	X	X	Source not provided	

Inventory Asset Category	Supported in Database Model			HAZUS-MH Provided Data Source (Year)	Local Data Source and Comments (Indicate N/A for not applicable if using HAZUS-MH Provided Data)
	EQ	FL	HU		
Wastewater Distribution Sewers (by Census tract)	X			Tiger/Line Files, U.S. Census Bureau (2000)	
Crude and Refined Oil Pipelines	X	X	X	Source not provided	
Oil System Facilities		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	
Natural Gas Pipelines	X	X	X	No source provided	
Natural Gas Distribution Pipes (by Census tract)	X			Tiger/Line Files, U.S. Census Bureau (2000)	
Electric Power	X		X	EPA Envirofacts Data Warehouse LRT Tool (2001)	
Communication	X		X	Broadcast Auxiliary Microwave File, FCC (2001)	
Demographics					
	X		X	U.S. Census Bureau and Dun & Bradstreet (2000)	

Notes:

BTS = Bureau of Transportation Statistics

EPA = U.S. Environmental Protection Agency

FCC = U.S. Federal Communications Commission

FHWA = Federal Highway Administration

LRT = Locational Reference Tables

USACE = U.S. Army Corps of Engineers

U.S. DOT = Department of Transportation

EXAMPLE 3-1: HAZUS-MH INVENTORY DATA AND DATA SOURCES

Example 3-1 shows the HAZUS-MH provided and local data reviewed and used for the Ausitn, TX pilot project.

Inventory Asset Category	Supported in Database Model			HAZUS-MH Provided Data Source (Year)	Local Data Source and Comments (Indicate N/A for not applicable if using HAZUS-MH Provided Data)
	EQ	FL	HU		
General Building Stock					
	X	X	X	U.S. Census Bureau (2000) and Dun & Bradstreet (2002)	N/A. Revised Travis County Tax Appraisal District data; determined to use HAZUS-MH proivded data because tax data did not include all attributes required for integration into HAZUS-MH.
Essential Facilities					
Medical Care	X	X	X	American Hospital Association (2000)	Used local data supplied by City of Austin Geographic Information System (COA GIS) staff.
Emergency Response	X	X	X	InfoUSA, Inc. (2001) and previously geocoded data from FEMA	COA GIS
Schools	X	X	X	National Center for Education Statistics, U.S. Department of Education (2000)	COA GIS
Fire Stations	X	X	X	InfoUSA, Inc. (2001)	COA GIS
Police Stations	X	X	X	InfoUSA, Inc. (2001)	COA GIS
HazMat Facilities					
	X	X	X	Toxic Release Inventory Database, EPA (1999)	N/A. Reviewed local fire department data. Team determined to use HAZUS-MH data which showed less facilities but generally the larger facilities.
High Potential Loss Facilities					
Dams	X	X	X	National Inventory of Dams, USACE (2003)	N/A.
Levees	X	X	X	Source not provided	N/A.
Nuclear Power Facilities	X	X	X	Source not provided	N/A.

Inventory Asset Category	Supported in Database Model			HAZUS-MH Provided Data Source (Year)	Local Data Source and Comments (Indicate N/A for not applicable if using HAZUS-MH Provided Data)
	EQ	FL	HU		
Military Installations	X	X	X	Source not provided	N/A.
Transportation Lifeline Systems					
Highway Segments	X	X	X	Tiger/Line Files, U.S. Census Bureau (2000)	N/A. Reviewed COA GIS data. For purposes of analysis, considered comparable to HAZUS-MH data.
Highway Bridges	X	X	X	National Bridge Inventory Database, FHWA (2001)	N/A. Reviewed COA GIS data. For purposes of analysis, considered comparable to HAZUS-MH data.
Highway Tunnels	X	X	X	National Bridge Inventory Database, FHWA (2001)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Rail Segments	X	X	X	National Rail Network Database, Bureau of Transportation Statistics (2000)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Rail Bridges	X	X	X	National Bridge Inventory Database, FHWA (2001)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Rail Tunnels	X	X	X	National Bridge Inventory Database, FHWA (2000)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Rail Facilities	X	X	X	Amtrak Station Database (2000) and the Intermodal Terminal Facilities Database (1998), BTS, U.S. DOT (2000)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Light Rail Segments	X	X	X	Fixed-Guideway Transit and Ferry Network Database, BTS, U.S. DOT (2000)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Light Rail Bridges	X	X	X	National Bridge Inventory Database, FHWA (2001)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Light Rail Tunnels	X	X	X	Source not provided	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Light Rail Facilities	X	X	X	Source not provided	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Bus	X	X	X	InfoUSA, Inc. (2001)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.

Inventory Asset Category	Supported in Database Model			HAZUS-MH Provided Data Source (Year)	Local Data Source and Comments (Indicate N/A for not applicable if using HAZUS-MH Provided Data)
	EQ	FL	HU		
Port	X	X	X	Port and Waterway Facilities Database, USACE (2000)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Ferry	X	X	X	Port and Waterway Facilities Database, USACE (2000)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Airport Facilities	X	X	X	BTS, U.S. DOT (1999)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Airport Runways	X	X	X	BTS, U.S. DOT (1999)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Utility Lifeline Systems					
Potable Water Pipelines	X	X	X	Source not provided	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Potable Water Distribution Pipes (by Census tract)	X			Tiger/Line Files, U.S. Census Bureau (2000)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Potable Water Facilities	X	X	X	EPA Envirofacts Data Warehouse LRT Tool (2001)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Wastewater Pipelines	X	X	X	Source not provided	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Wastewater Distribution Sewers (by Census tract)	X			Tiger/Line Files, U.S. Census Bureau (2000)	N/A. COA GIS data reviewed but missing attributes required for HAZUS-MH.
Crude and Refined Oil Pipelines	X	X	X	Source not provided	COA GIS. Based on importance of these pipielines, local data used (locaitonal data).

Inventory Asset Category	Supported in Database Model			HAZUS-MH Provided Data Source (Year)	Local Data Source and Comments (Indicate N/A for not applicable if using HAZUS-MH Provided Data)
	EQ	FL	HU		
Oil System Facilities		X		EPA EnvironFacts Data Warehouse LRT Tool (2001)	COA GIS. Based on importance of these pipeilines, local data used.
Natural Gas Pipelines	X	X	X	No source provided	COA GIS. Based on importance of these pipielines, local data used.
Natural Gas Distribution Pipes (by Census tract)	X			Tiger/Line Files, U.S. Census Bureau (2000)	COA GIS. Based on importance of these pipielines, local data used.
Electric Power	X		X	EPA Envirofacts Data Warehouse LRT Tool (2001)	N/A.
Communication	X		X	Broadcast Auxiliary Microwave File, FCC (2001)	N/A.
Demographics					
	X		X	U.S. Census Bureau and Dun & Bradstreet (2000)	N/A. Reviewed COA GIS data; Census data considered comparable to local data.
Special/User-Defined Facilities					
Stadiums; post offices; historical sites; musems; and convention centers	X	X	X	Not provided with HAZUS-MH; a holder is located in the database for such items.	COA GIS data was used to add these faciltiies so that the city plan could meet the State of TX mtigation requirements.

Notes:

BTS = Bureau of Transportation Statistics

EPA = U.S. Environmental Protection Agency

FCC = U.S. Federal Communications Commission

FHWA = Federal Highway Administration

LRT = Locational Reference Tables

USACE = U.S. Army Corps of Engineers

U.S. DOT = Department of Transportation

OVERVIEW

The fourth step in the risk assessment process involves running the HAZUS-MH loss estimation models. For this step, you will run HAZUS-MH loss estimation models and scenarios, and evaluate your hazard events and inventory results for your study region. In addition, you will be introduced to the Risk Assessment Tool (RAT), a companion software tool to HAZUS-MH that will help you to expedite the preparation of your risk assessment outputs, and to the Flood Wizard, a companion software tool to HAZUS-MH that will quickly assess inventory exposure and loss for a study region. Figure 4-1 provides the tasks and outputs for this step.

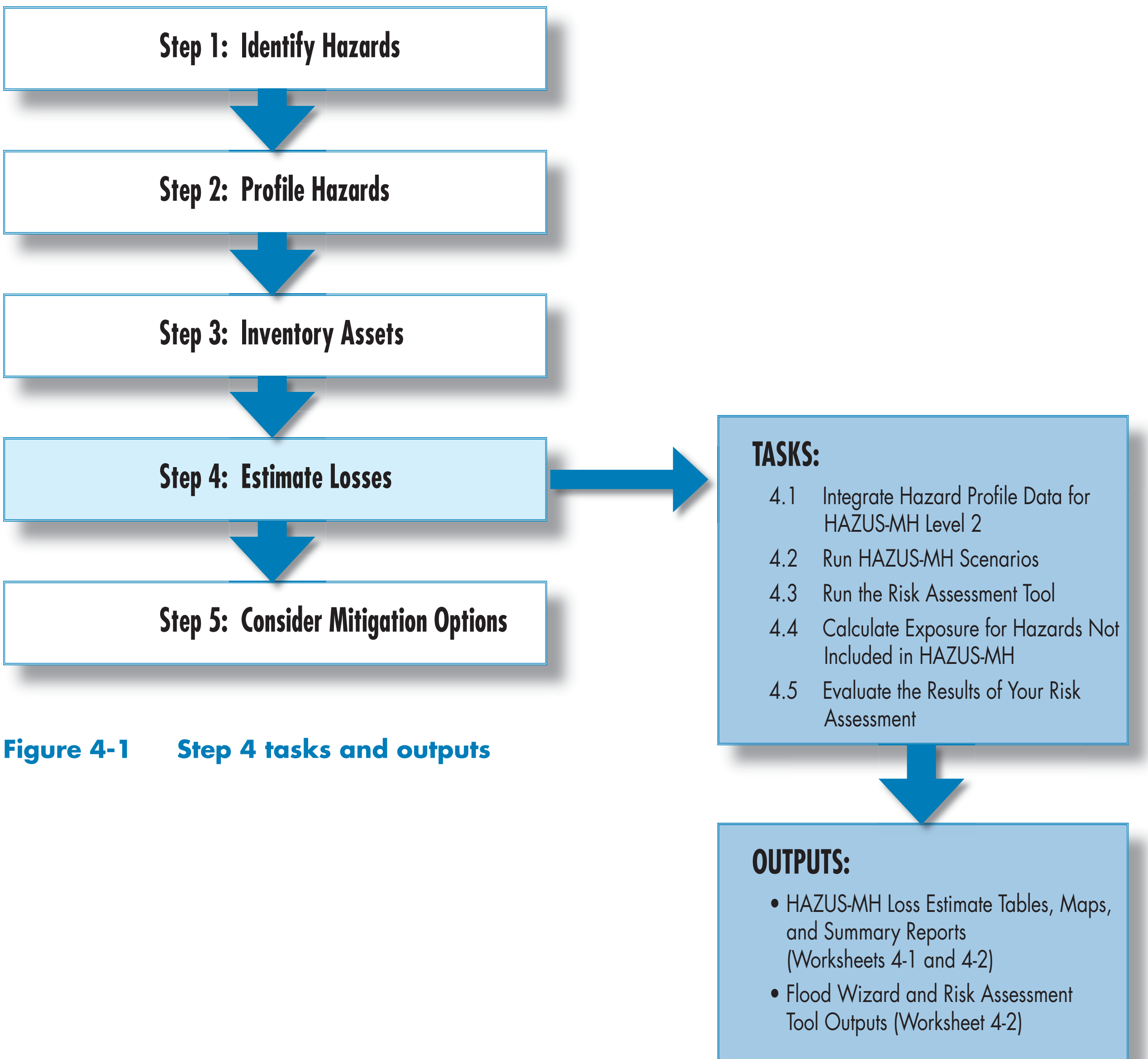


Figure 4-1 Step 4 tasks and outputs

The Risk Assessment Tool

FEMA has developed a companion software tool to HAZUS-MH called the HAZUS-MH Risk Assessment Tool (RAT) to help you produce your risk assessment outputs for earthquakes, floods, and hurricanes. This tool was developed as a third-party model to support HAZUS-MH and is used to display the outputs from the HAZUS-MH risk assessment in an easy-to-use format.

HAZUS-MH includes loss estimation models for earthquake, flood, and hurricane hazards. Task 4.1 involves setting up your scenarios to obtain loss estimates. Task 4.2 explains how to run the HAZUS-MH models. Task 4.3 involves preparing and documenting a risk assessment using the RAT, a companion software tool to HAZUS-MH. Task 4.4 addresses how HAZUS-MH can support the identification of assets exposed to hazards other than earthquakes, floods, and hurricanes. Task 4.5 involves reviewing and evaluating the estimates generated during Tasks 4.1, 4.2, 4.3, and 4.4 to assess their completeness, compare risks, and evaluate acceptability.

HAZUS-MH Loss Estimate Terms

Loss – Structural loss, content loss, and function loss

Functional downtime – The average time (in days) during which a function (business or service) is unavailable to provide its services because of a hazard event

Displacement time – The average time (in days) that a building's occupants must operate from a temporary location because of building damage resulting from a hazard event

Function loss – Functional downtime costs + displacement time costs

Casualties – Impacts on humans (ranging from low impact to severe injury and death)

Return period loss – The average loss over a certain period of time for all hazard events

Deterministic and Probabilistic Scenarios in HAZUS-MH

To obtain loss estimation results, HAZUS-MH runs deterministic and probabilistic scenarios. For the purpose of this How-To Guide, probabilistic scenarios are identified as the best option for the following reasons:

- The estimated losses are the average expected value of loss in any one year.
- An average of expected value of losses can help decision-makers to plan cost-effective budgets to address high priority natural hazard concerns.
- The average annualized losses can help to identify cost-effective mitigation measures.
- Cost-effective mitigation measures can produce savings (avoided losses) and help to address budgetary needs and constraints.

Exposure

Although it is not used in this context in HAZUS-MH, the term "exposure" is insurance parlance for the dollar value of the risk portfolio and is thus applicable to discussions of loss estimation as well as general inventory identification.

Probabilistic analyses can be used to develop estimates of average yearly losses ("annualized losses") as well as the expected distribution of losses ("return period losses"). These estimates reflect the full spectrum of potential events that can occur in a particular region. The probabilistic approach allows the user to generate estimates of damage and loss based on probabilistic hazards for five (flood), seven (hurricane), or eight (earthquake) return periods.

Deterministic analysis relies on the laws of physics or on correlations developed through experience or testing to predict the outcome of a particular hazard scenario. In the deterministic approach, one or more possible scenarios can be developed that represent the worst possible credible events. In this approach, the frequency of possible occurrence needs to be evaluated.

Probabilistic analysis evaluates the statistical likelihood that a specific event will occur and what losses and consequences will result. The probabilistic approach may use both statistics and historical information. This How-To Guide focuses on probabilistic analysis. The *HAZUS-MH User Manuals* contain instructions concerning both scenarios.

Using HAZUS-MH provided data or local data already incorporated into the software, proceed to run HAZUS-MH. Preliminary results will take the form of standardized hazard outputs. These outputs estimate damages and losses, including direct losses, induced losses, social losses, and business interruption.

Developing the loss estimates in HAZUS-MH will require five activities:

- Integrate hazard profile data for HAZUS-MH Level 2
- Run HAZUS-MH scenarios
- Run the RAT

DEFINITION

HAZUS-MH Annualized Losses

HAZUS-MH allows you to estimate annualized losses. Annualized loss is the estimated long-term value of losses to the general building stock averaged on an annual basis for a specific hazard type. Annualized loss considers all future losses for a specific hazard type resulting from possible hazard events with different magnitudes and return periods averaged on a "per year" basis. Like other loss estimates, annualized loss is an estimate based on available data and models. Therefore, the actual loss in any given year can be substantially higher or lower than the estimated annualized loss.

Refer to Chapter 15 of the *Earthquake Technical Manual* for more details.

NOTE

Points To Keep In Mind When Estimating Losses

HAZUS-MH estimates aggregate impacts on buildings and other structures and on general areas. It is an estimation tool and does not identify which specific buildings might be impacted. The loss estimation results are estimates of overall impacts that are intended to guide overall mitigation efforts. However, due to the limited history of observations for some hazards (e.g., hurricanes), limited knowledge of actual building characteristics, modeling simplifications, and other factors, the user may encounter some variation in the results produced by a probabilistic analysis.

- ❍ Calculate exposure for hazards not included in HAZUS-MH
- ❍ Evaluate the results of the risk assessment

These activities are detailed below, for the three major hazards addressed by HAZUS-MH.

Integrate Hazard Profile Data for HAZUS-MH Level 2 (Task 4.1)

Data integration is required if you have collected local data as part of Task 2.3 to supplement the HAZUS-MH provided data. Local hazard data integration is discussed below for the earthquake, flood, and hurricane hazards.

Earthquakes

There are two techniques in the earthquake module to update the hazard assumptions and data provided with HAZUS-MH. The first method involves changing the soil type, landslide, liquefaction, and water depth values for the study region as a whole. The second method involves importing a GIS layer into HAZUS-MH and using the values found in the attribute table of that layer to update the soil type, liquefaction, landslide, and water depth values.

To update the assumptions for the study region, follow the directions below.

1. **To access the Scenario Wizard**, select "Scenario" under the hazard menu. The Earthquake Hazard Scenario Selection menu will become available as shown in Figure 4-2.

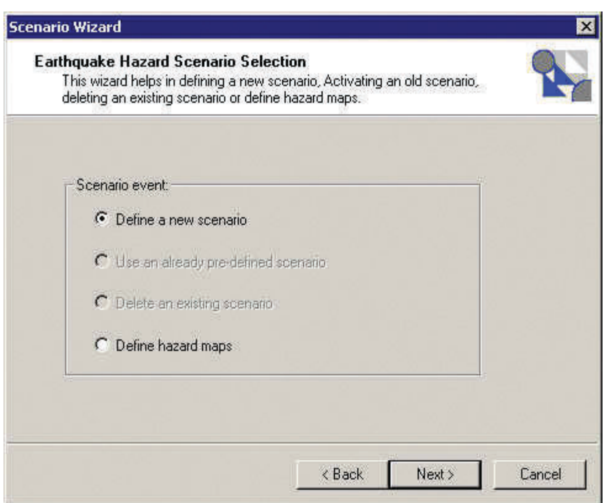


Figure 4-2
Earthquake hazard scenario selection menu

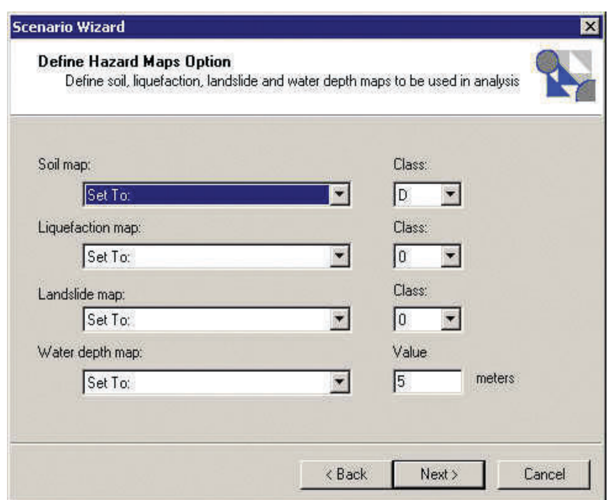


Figure 4-3
Define hazard maps option menu

2. **To begin defining the hazard maps**, select "Define hazard maps" under "Scenario event." Then click "Next." The Define Hazard Maps Option menu will now be available, as shown in Figure 4-3.

3. **To assign a value to the entire study region**, open the drop-down box to the right of "Class" or "Value," and select or type the appropriate value. Refer to Appendix B in the *HAZUS-MH Earthquake Technical Manual* for a more detailed description of the hazard map values.

To integrate the earthquake hazard data as map layers collected in Step 2, follow the directions below.

1. **To begin integrating your local hazard data**, select "Data Maps" under the Hazard menu. The Data Maps Dialog box will become available.

2. **To locate your local data**, select "Add map to list." Then browse to the location of your soil map collected in Step 2. This map should be in the geodatabase file format. Repeat this process for the liquefaction, landslide, and water depth maps at this time.

3. **To begin using your data in a scenario**, select "Scenario" under the Hazard menu. The Earthquake Hazard Scenario Selection menu will become available as shown in Figure 4-2.

4. **To define your local data**, select "Define hazard maps" under "Scenario event." Then click "Next." The Define Hazard Maps Option menu will now be available, as shown in Figure 4-3.

Floods (Coastal)

You will use the Flood Information Tool (FIT) provided with the HAZUS-MH suite of programs, to integrate the local flood hazard maps you collected in Step 2. The FIT allows you to integrate local flood hazard data into HAZUS-MH. The local flood hazard data may include topographic data, a digital elevation model (DEM), flood elevations, floodplain boundaries, Q3 data, FIRM data, and DFIRM data. Before running the FIT, you need to have the following datasets in a common projection:

a. A DEM in grid format

b. Flood elevations in polyline and polygon formats

c. Floodplain boundaries in polygon formats

> Additional instructions for using the FIT are available in Section 3.3 of the *Flood User Manual* and the *FIT User Manual.*

The FIT is run from HAZUS-MH or ArcGIS; it is not a stand-alone program. The FIT is an ArcGIS extension that can not be installed from the HAZUS-MH wizard. FIT must be installed using the Flood Information Tool installer. Start the HAZUS-MH program and load the flood toolbar to begin using the FIT. To load the toolbar (shown in Figure 4-4), right click on the menu and select "Flood Information Tool." The FIT consists of modules for riverine and coastal analyses.

To run the FIT for a coastal analysis, follow the instructions below.

1. **To setup and validate your project**, identify your input map layers (datasets "a" [DEM], "b" [flood elevation], and "c" [floodplain boundary]); collect project information; and ensure that the input data share the same projection, reference datum point, and units. Information needs to be completed under four tabs, as shown in Figure 4-5.

    - The "General" tab allows you to select the flood hazard and define the working directory, basin name, and reach name.

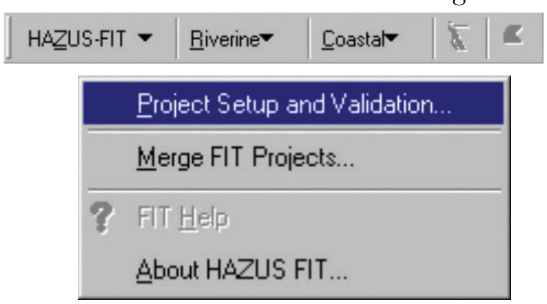


Figure 4-4 FIT startup menu

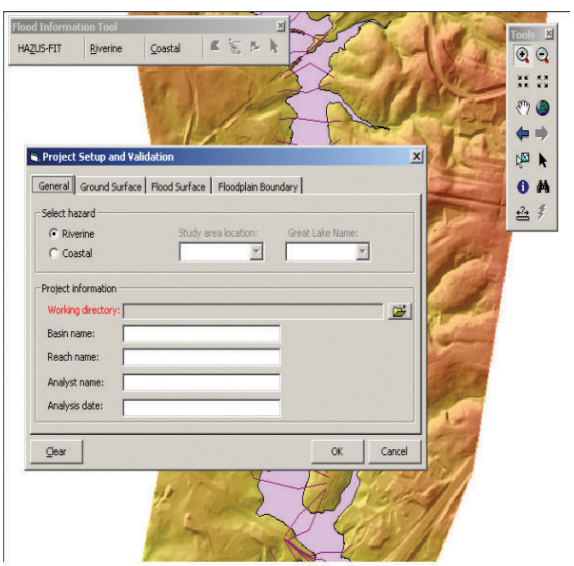


Figure 4-5 Project setup screen

    - The "Ground Surface" tab allows you to specify the DEM layer (data set "a").

    - The "Flood Surface" tab allows you to identify the flood elevation map layer (data set "b").

    - The "Floodplain Boundary" tab allows you to select the floodplain boundary layer (data set "c") and collect description information.

2. **To begin to use the coastal flood depth grid wizard**, define the flood area and characteristics to be analyzed within your study region. You will also develop flood depth grids around coastal areas. To run the FIT for a coastal flood, an onscreen menu will guide you through the following process:

    a. Build the elevation grid

    b. Draw the shoreline at mean sea level

    c. Define the shoreline segments

    d. Define the shoreline characteristics

    e. Compute the flood depth grids

At this point, all your flood hazard profile data should be compatible and loaded into HAZUS-MH.

Floods (Riverine)

HAZUS-MH will support the evaluation of the flood hazard using two methods, a detailed loss estimate described below and an exposure and loss estimation using the Flood Wizard discussed in Step 4.2. The detailed loss estimate requires a significant amount of processing time and may not be feasible for larger study regions.

The FIT allows you to integrate local flood hazard data into HAZUS-MH. The local flood hazard data may include topographic data, a DEM, flood elevations, floodplain boundaries, Q3 data, FIRM data, and DFIRM data. Before running the FIT, you need to have the following datasets in a common projection:

a. A DEM in grid format

b. Flood elevations in polyline and polygon formats

c. Floodplain boundaries in polygon formats

The FIT is run from HAZUS-MH or ArcGIS because the tool is not a stand-alone program. Start the HAZUS-MH program and load the flood toolbar to begin using the FIT. Select the FIT for riverine analysis (see Figure 4-4).

To run the FIT for a riverine analysis, follow the instructions below:

1. **Setup and validate project.** This activity involves identifying your input map layers (datasets a [DEM], b [flood elevation], and c [floodplain boundary]); collecting project information; and ensuring that the input data share the same projection, reference datum point, and units. Information needs to be completed under four tabs as shown in Figure 4-5.

   - The "General" tab allows you to select the flood hazard and define the working directory, basin name, and reach name.
   - The "Ground Surface" tab allows you to specify the DEM (data set "a"), and select the source, elevation units, and vertical datum. Also, it displays the projection and cell units.
   - The "Flood Surface" tab allows you to identify the flood elevation map layer (data set "b"), display metadata, and collect description information.
   - The "Floodplain Boundary" tab allows you to identify the floodplain boundary layer (data set "c"), including the elevation units and vertical datum, and to specify descriptive information.

2. **Use the riverine flood depth grid wizard.** This activity involves defining the flood area to be analyzed within your study region. You will also develop flood depth grids around rivers and backwater areas and merge these grids. To develop and merge your flood depth grids, an onscreen menu will guide you through the following process:

    a. Select the upstream and downstream limits of your analysis areas

    b. Define the width of your analysis areas

    c. Adjust the buffer zone to balance inclusion of flooded areas and processing time

    d. Define flood elevation attribute fields

    e. Draw polygons around backwater areas

    f. Assign elevations to backwater areas

    g. Merge all flood depth grids

At this point, your local flood hazard profile data should be compatible and integrated into HAZUS-MH.

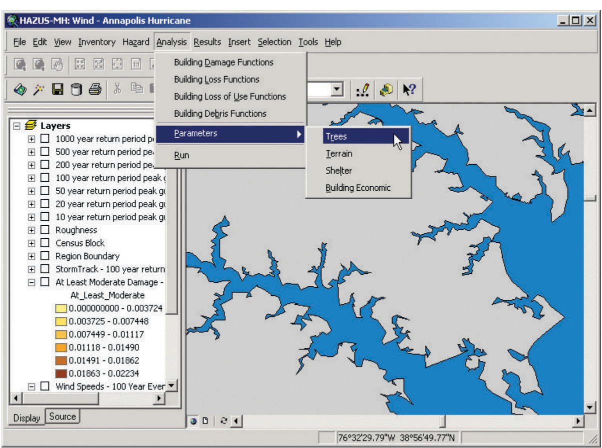


Figure 4-6 Editing the hazard maps

Hurricanes

The HAZUS-MH module assigns values (general parameters) for surface roughness and vegetation from national land use maps based on your geographic location. The “Edit” function of the hurricane model can be used when you have collected surface roughness and vegetation data. In this case, select “Analysis” from the HAZUS-MH main menu and then select “Parameters.” Select “Terrain” or “Trees” to change the values assigned to each Census block or tract.

If you want to update the assigned values, follow the directions below:

1. **To begin updating the terrain map**, select “Analysis” from the HAZUS-MH main menu and then select “Parameters.” These menu items can be seen in Figure 4-6. Select “Terrain” to change the surface roughness values. The table in Figure 4-7 should now be available to edit.

2. **To edit a value in the terrain table**, double click in the box you want to change and edit the number directly. You may also want to map the surface roughness of your study region. To map the values, click on the column title to highlight the entire column and select "Map" below. A GIS layer will show up on your study region.

3. **To save changes to the terrain table**, click "OK." A box will pop up asking if you want to save changes. Click "Yes."

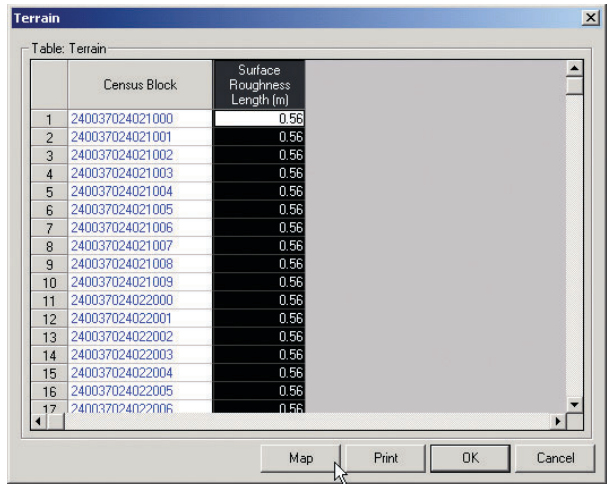


Figure 4-7 Terrain table

4. **To begin updating the trees map**, select "Analysis" from the HAZUS-MH main menu and then select "Parameters." These menu items can be seen in Figure 4-6. Select "Trees" to change the tree parameters. The table in Figure 4-8 should now be available to edit.

5. **To edit a specific parameter in the tree parameters table**, double click in the box you want to change and edit the number directly. You may also want to map the different parameters in your study region. To map the values, click on the column title to highlight the entire column and select "Map" below. A GIS layer will show up on your study region.

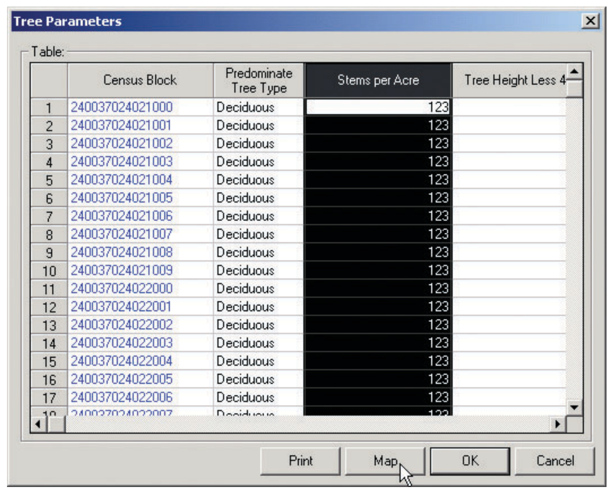


Figure 4-8 Tree parameters table

6. **To save changes to the tree parameter table**, click "OK." A box will pop up asking if you want to save changes. Click "Yes."

Congratulations! You have now integrated in HAZUS-MH the information needed to run your loss estimation analyses.

Run HAZUS-MH Scenarios (Task 4.2)

HAZUS-MH scenarios can be run for the earthquake, flood, and hurricane hazards. The steps to run these scenarios are discussed below. Worksheet 4-1 will help you document the results.

EARTHQUAKES

Run an Earthquake Scenario

To run a probabilistic earthquake scenario, follow the instructions below:

1. **To begin setting up the scenario**, select "Scenario" under the Hazard menu and then select "Next." The Earthquake Hazard Scenario Selection menu will appear with four scenario event options: "Define a new scenario," "Use a pre-defined scenario," "Delete an existing scenario," and "Define hazard maps." Select "Define a new scenario." The Seismic Hazard Type Selection menu shown in Figure 4-9 will now appear.

2. **To run a probabilistic analysis**, select "Probabilistic hazard" under "Seismic hazard type" and click on "Next." The Probabilistic Hazard Selection menu shown in Figure 4-10 will now appear. Select the return period and the moment magnitude of interest. This value could be estimated based on your historical research conducted in Step 2. For your risk assessment, you will want to run a HAZUS-MH analysis for all the return periods available as well as run the annual loss option. Select "Next." The Hazard Scenario Event Name menu shown in Figure 4-11 should now appear.

3. **To identify your scenario**, enter a name for the scenario event (40 characters maximum) in the space provided. Click on "Next" to end the scenario wizard.

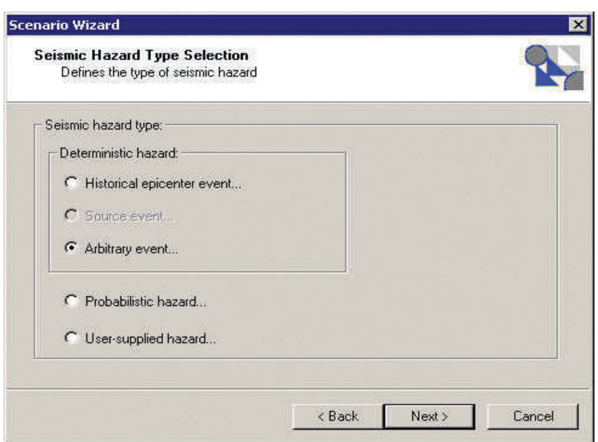


Figure 4-9
Seismic hazard type selection menu

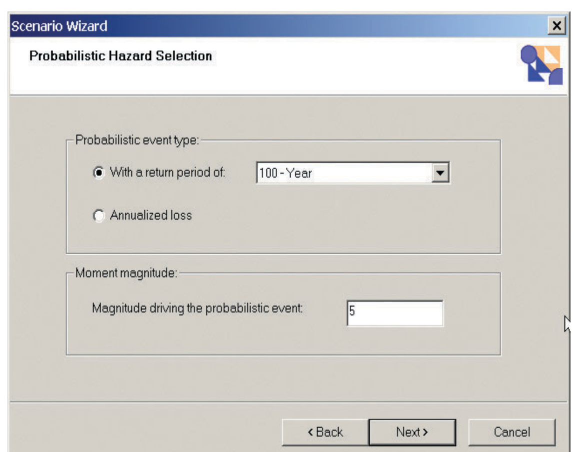


Figure 4-10
Probabilistic hazard selection menu

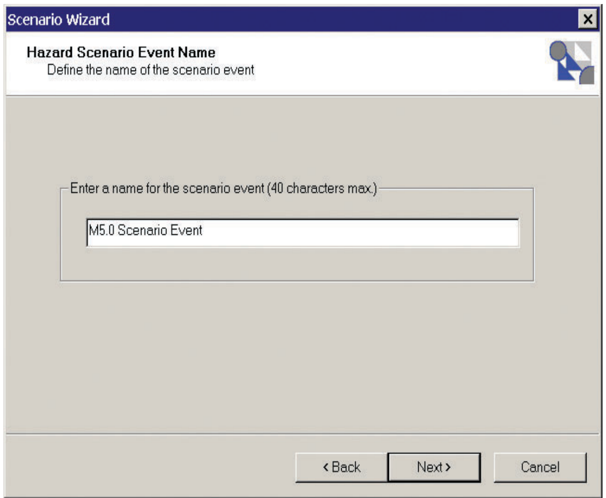


Figure 4-11
Hazard scenario event name menu

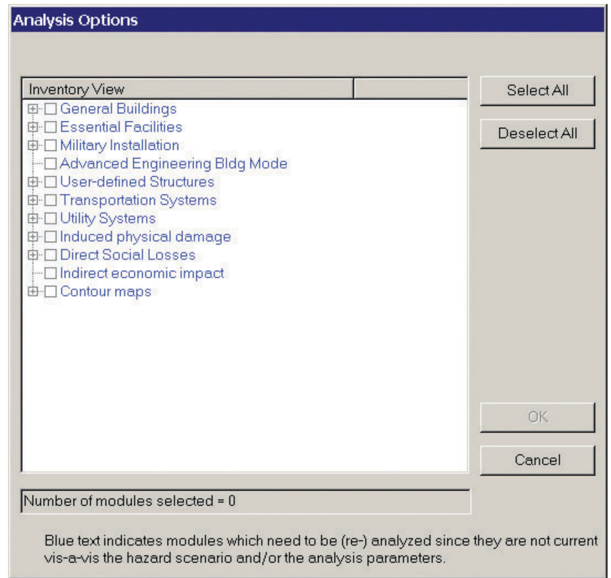


Figure 4-12 Analysis options menu

4. **To run your analysis**, select "Analysis" on the main menu, and then select "Run." The menu shown in Figure 4-12 should now be displayed, click on the plus and minus signs to expand and collapse the lists of available options. You can now run the analysis. The analysis options include general buildings, essential facilities, military installations, advanced engineering building mode, user-defined structures, transportation systems, utility systems, induced physical damage, direct social losses, indirect economic impact, and contour maps. Select the categories of analysis you wish to perform, and click on "OK." The earthquake model can perform all of the analysis options shown; the more you select, the longer the processing time.

Run a Flood Scenario Using HAZUS-MH

To run a probabilistic flood scenario for a riverine or coastal flood, follow the directions below.

> HAZUS
>
> The term "study case" in the flood module is similar to the term "scenario" in the earthquake and hurricane modules.

1. **To begin running a flood scenario**, select "Study Case" on the Hazard menu, and then select "New". The study case defines the specific stream reaches or lengths of coastline and the hydrologic and hydraulic characteristics that you wish to include in one analysis run. A study case could include all the stream reaches in your study region, but because the analysis requires significant computer processing, you may wish to

divide your study region into several smaller study cases. When the "Run Hydrology" option on the Hazard menu is enabled, you will be able to perform the hydrologic and hydraulic analyses.

2. **To identify your scenario**, you will be prompted with a window (see Figure 4-13) to name your study case and to write a description (optional). When you open your study cases in the future, your descriptions will be visible to help you differentiate among similar study cases.

3. **The riverine analysis requires defining the study case reaches and running the hydrologic analysis:**

   a. To begin selecting the stream reaches used in the scenario, use the dialog "New Study Case" shown in Figure 4-14, which will enable you to select the stream reaches that you would like to include in the study case. You may use the "Select Features" tool (the button with the arrow icon) to select particular stream reaches by clicking on them or draw a box around certain areas to select multiple reaches. If you hold down the "Shift" key, you can select or remove additional stream reaches by clicking on them.

   b. To complete stream reach selection and the definition of the study case, click "OK." The color of the highlighting of the selected streams will change when this process is complete. Once you have defined your study case, the "Hydrologic Analysis…" option on the Hazard menu is enabled. You can now perform the hydrologic and hydraulic analysis.

   c. To begin running the hydrology calculation for the study case stream reaches that you have selected, select "Hydrologic Analysis…" on the

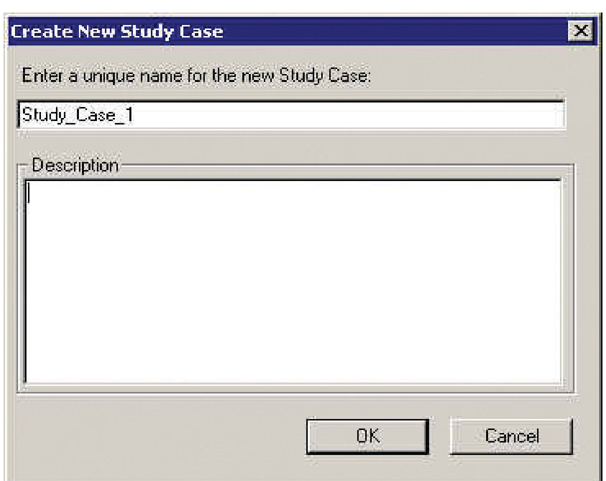


Figure 4-13
Create new study case dialog box

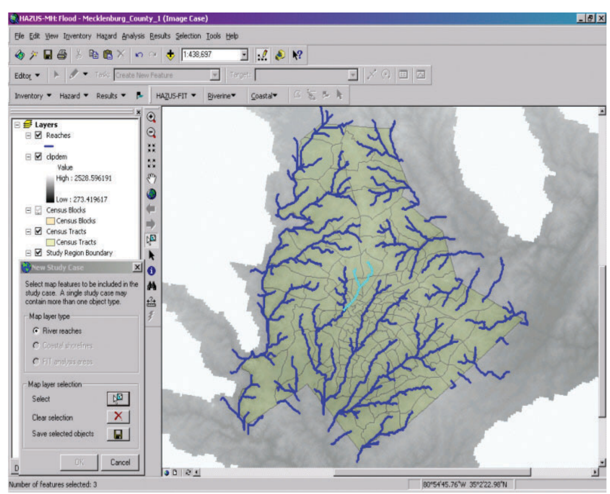


Figure 4-14 Stream reach selection

Hazard menu. HAZUS-MH will analyze the discharge-frequency relationship for each reach in the study case based on USGS data and equations. The hydrology process needs to be performed once for each reach in the study region.

4. **For the coastal analysis, characterizing the shoreline is required**; you will provide the flood model with the information necessary to determine which models will be run, including frontal dune erosion, What-If, and Runup. To characterize the shoreline:

   a. Select "Shoreline Characterization" under the Hazard menu (see Figure 4-15). Activate the Startline Radio button in the "Shoreline Limits" dialog and press the Draw button to identify the start point (Shoreline Start). Activate the Startline Radio button and press the Draw button to identify the finish point (Shoreline Finish) of the shoreline segment to characterize. In between these two points, you may add any breaks in the shoreline (Breaklines) where the geographic characteristics of the shoreline change. Activate the Breakline radio button to draw Breaklines.

   b. Select "Next" and you will be moved to a dialog to define information regarding the shoreline characteristics, wave exposure, and 100-year still water elevation. The "Shoreline Type" tab has two combo boxes to define Wave exposure (Open Coast, Moderate exposure, etc.) and Shoreline type (rocky bluffs, sandy bluffs, little beach, etc.). At the top of the dialog, the user can switch from one shoreline segment (if more than one) to another and back using the arrow buttons. The "100-Year Flood Condition" tab allows you to provide the 100-year still water elevation from a Flood Insurance Study. This information is readily available online at the FEMA Map store at http://www.fema.gov.

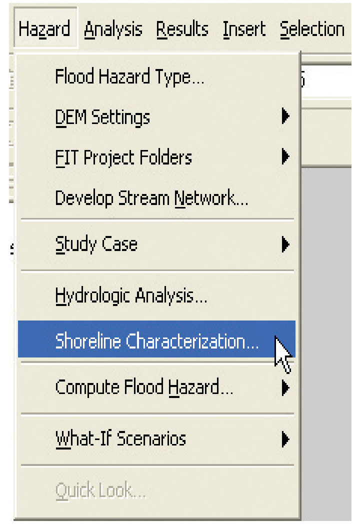


Figure 4-15 Hazard menu

HAZUS

The "What-If" analysis options in the flood module include levee assessment, upstream storage, and simplified velocity for the riverine analysis. The "What-If" analysis options include long-term erosion and shore protection for the coastal analysis.

HAZUS

For the hurricane analysis, there are currently no damage or loss estimates for high potential loss facilities, transportation lifelines, utility lifelines, or hazardous material storage facilities.

5. **To begin running the hydrology**, select "Run Hydrology" on the Hazard menu to launch the hydrologic calculations for the study case stream reaches that you have selected. HAZUS-MH will analyze the discharge-frequency relationship for each reach in the study case based on USGS data and equations. This information is stored at each node for each reach. The hydrology process needs to be performed once for each reach in the study region.

6. **To begin running the scenario**, select Calculate Hazard from the Hazard menu and the window shown in Figure 4-15 will appear.

7. **To select the analysis type**, select the type of hazard analysis you would like to run on the pull-down menu. During the hydraulic analysis, HAZUS-MH computes a flood elevation and a flood depth grid for each user-defined frequency or discharge. You will need to run this analysis for each new return period or each new study case. You can run (1) multiple return periods of 10, 50, 100, 200, and 500 years; (2) a single, user specified return period; and/or (3) annualized loss. It is now time to run the analysis. Select "Analysis" on the main menu, and then select "Run." The menu shown in Figure 4-16 should now be displayed.

8. **To select the analysis options**, click on the plus and minus signs to expand and collapse the lists of available options (see Figure 4-16). Select the analyses to be performed, and click "OK." The analysis options include general building stock damage and loss, essential facilities, user defined structures, transportation systems, utility systems, agricultural products, vehicles, debris, direct social loss, indirect economic loss, and "What-If."

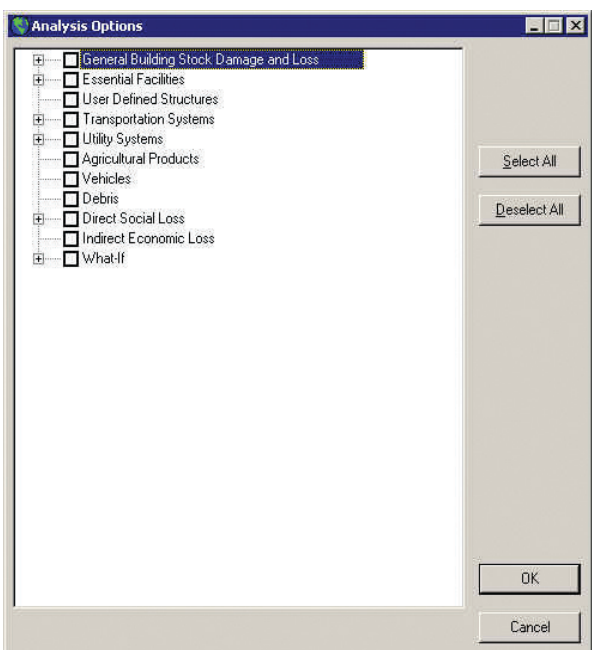


Figure 4-16 Analysis options menu

NOTE

The following section explains how to run a flood analysis using the HAZUS-MH Flood Wizard. You can download the Flood Wizard from the following web site: http://www.fema.gov/hazus/tr_main.shtm. Click on "Latest HAZUS Tools Now Available," to access the file.

Running a Flood Scenario with the Flood Wizard

To run the HAZUS-MH Flood Wizard, you will need to (1) install the Flood Wizard, (2) create a Flood region with the HAZUS-MH Flood module, (3) execute the Flood Wizard program, (4) run the Analysis, and (5) view the outputs. Worksheet 4-2, Flood Wizard Outputs, will help you document your efforts.

1. **To install the Flood Wizard**, insert the Flood Wizard CD (or open the file you downloaded) and follow the installation instructions, which should appear as an autorun feature. The Flood Wizard Installation menu will appear (see Figure 4-17).

   Click “Next” to proceed. The installation wizard will next show the destination directory that is the same as where HAZUS-MH is installed. Click “Next” to proceed. The installation will proceed with the progress indicated by the status bar in the center of the screen. The installation is complete when the “Finish” option becomes available (see Figure 4-18). Click “Finish.”

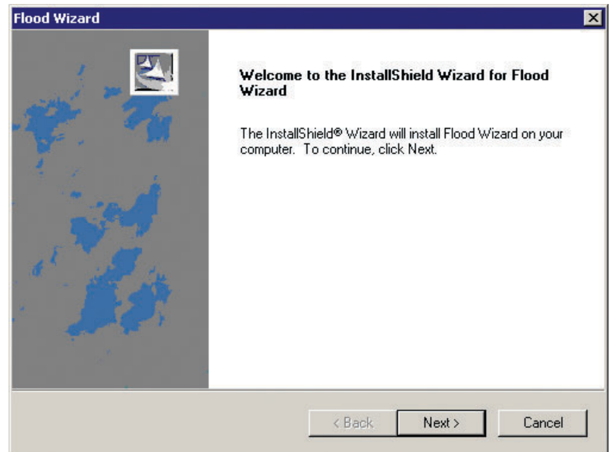


Figure 4-17
Flood Wizard installation menu

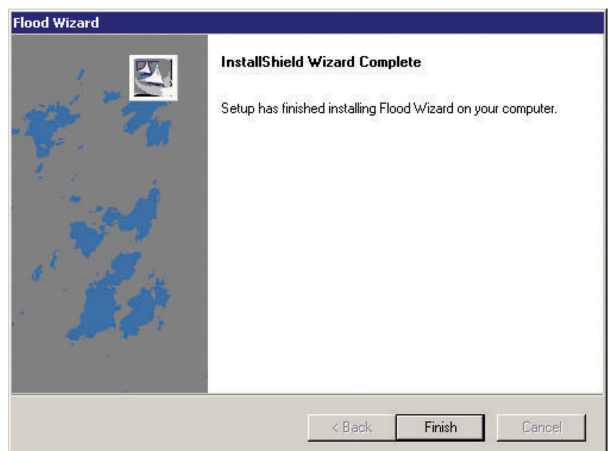


Figure 4-18
InstallShield Wizard complete

2. **If you don’t have a HAZUS-MH Flood region available**, you must create one using the HAZUS-MH Flood module. Once a region is available, exit HAZUS-MH and execute the Flood Wizard.

3. **To execute the program, select “Start” from your windows menu**, then “Programs” and “FEMA Risk Assessment System.” Click on the Flood Wizard icon. The Flood Wizard menu box should become available (see Figure 4-19). Go to the Analysis menu and select “Run.”

   Click over Flood Data in the menu to access the options to select an available Study Region, define the Flood Maps (Q3, FIRM, or user defined), and a Digital Elevation Model (see Figure 4-20).

Figure 4-19 Flood window menu box

Figure 4-20 Flood data menu

4. **To run the analysis**, select "Analysis" from the main menu, then "Run" (see Figure 4-21). The Flood Wizard will take a few minutes to process the data and provide the results in tabular and map formats.

5. **To view the results**, select any of the options under the "Results" menu. The Flood Wizard provides building exposure, content exposure, total exposure, and building count for the general building stock in the floodplain. It also provides building loss, content loss, and total loss for the economic loss of the general building stock.

Figure 4-21 Analysis main menu

Run a Hurricane Scenario

To run a probabilistic hurricane scenario, follow the instructions below:

1. **To activate the scenario wizard for a hurricane event**, click on "Hazard Scenario" on the Hazard menu. Select "Next." The Scenario Operations menu should now be displayed as shown in Figure 4-22.
2. **To select the probabilistic hazard**, click on "Probabilistic." Select "Next" and you will be asked if you want to make this scenario active. Select the button to make it active and then click "Next." Finish the scenario by selecting "Finish."
3. **To run the analysis**, select "Analysis" on the main menu, and then select "Run." The menu shown in Figure 4-23 should now be displayed. Three types of output analysis can be performed: direct physical damage, induced physical damage, and direct social and economic loss. Select the analyses to be performed, and click on "Run Analysis."

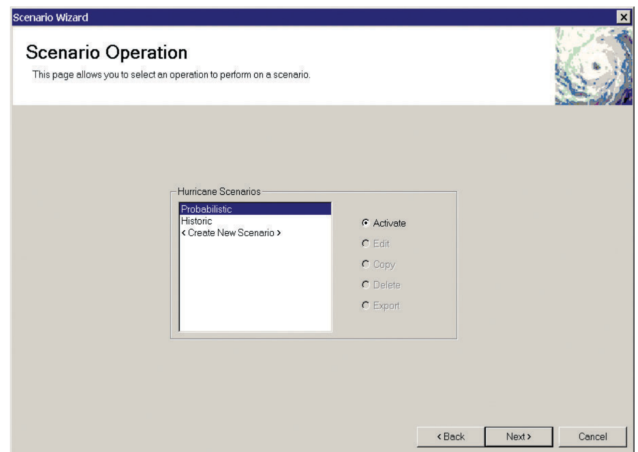


Figure 4-22 Scenario operation menu

Obtain Loss Estimation Results from HAZUS-MH Scenarios

After the hazard scenario has been run, you can access HAZUS-MH outputs by selecting "Results" on the main menu. HAZUS-MH produces results in three formats: tables, maps, and summary reports. Select "Summary Reports" on the "Results" drop-down menu to review your outputs. A summary of the outputs available for each module is provided as several Job Aids (Appendix F). The outputs also can be viewed individually. Select the output of interest to view the individual table. For example, select "Ground Motion" on the "Results" drop-down menu to view the ground motion by Census tract throughout the study region. To map the ground motion, select a column in the table, such as peak ground acceleration (PGA), and click "Map" at the bottom of the page.

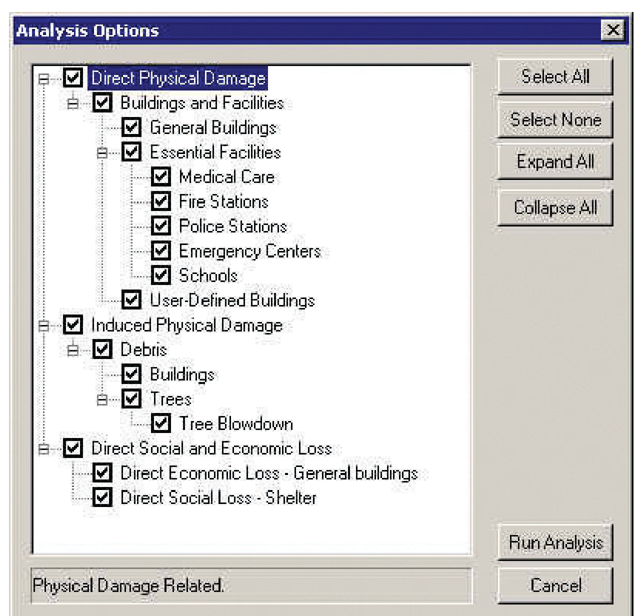


Figure 4-23 Analysis options menu

You can download the Risk Assessment Tool from the following web site: http://www.fema.gov/hazus/tr_main.shtm. Click on "Latest HAZUS Tools Now Available," to access the file.

Run the Risk Assessment Tool (Task 4.3)

FEMA has developed a companion software tool to HAZUS-MH called the HAZUS-MH RAT to help you produce your risk assessment outputs for earthquakes, floods, and hurricanes. This tool was developed as a third-party model to support HAZUS-MH and is used to display the outputs from the HAZUS-MH risk assessment in an easy-to-use format. The RAT pulls natural hazard data (Steps 1 and 2); inventory data (Step 3), and loss estimate data (Step 4) into pre-formatted summary tables and text. These summaries can support the presentation of data to (1) decision-makers and other stakeholders and (2) in your mitigation plan.

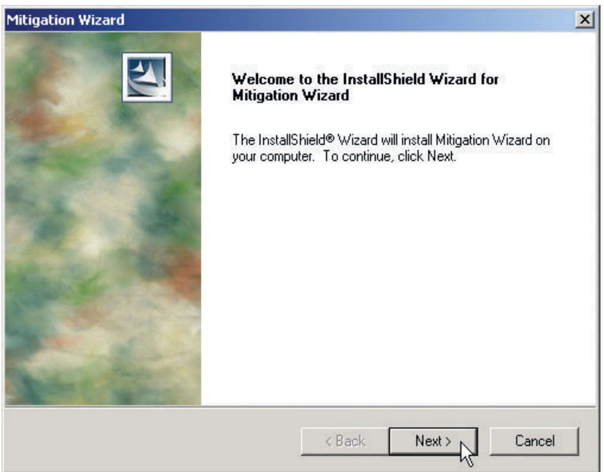


Figure 4-24 RAT installation menu

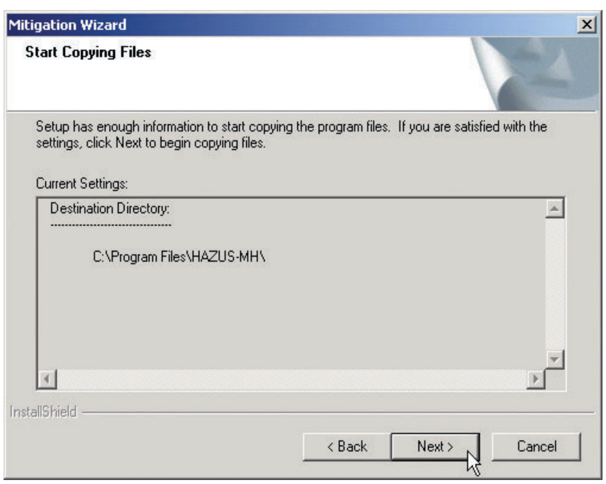


Figure 4-25 RAT destination directory

To run the HAZUS-MH RAT, you will need to: (1) install the RAT, (2) execute the program, and (3) view the outputs.

1. **To install the RAT**, insert the RAT CD (or open the file you downloaded) and follow the installation instructions, which should come up as an autorun feature. The RAT installation menu will appear (see Figure 4-24). Click "Next" to proceed. The installation menu will next prompt you for a destination directory (see Figure 4-25). Type the directory name if the default directory is not your preference. Click "Next" to proceed. The installation will proceed with the progress indicated by the status bar in the center of the screen. The installation is complete when the "Finish" option becomes available (see Figure 4-26). Click "Finish."

2. **To execute the program**, open your study region in HAZUS-MH. Before running the RAT, make sure that you have run the hazard scenarios in Step 4. There are two ways in which to begin using the RAT. If you selected earthquake as one of your hazards, you may run the RAT as a third party model

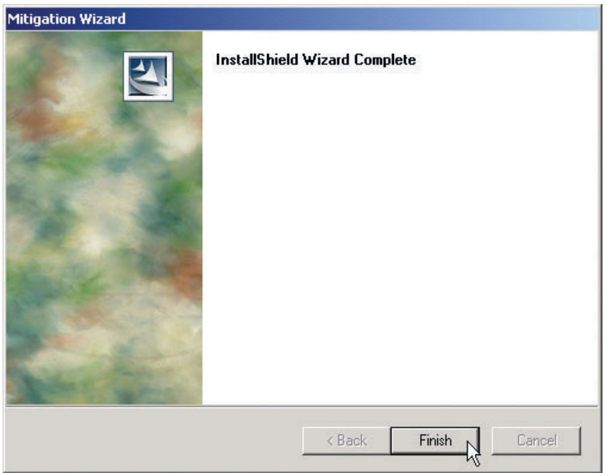


Figure 4-26 RAT installation complete

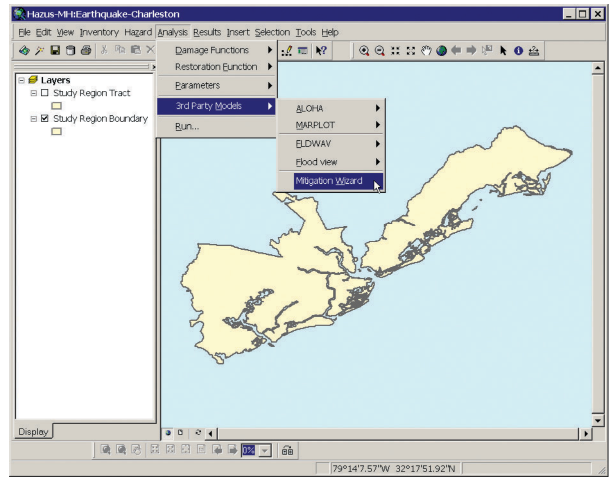


Figure 4-27 Third party model menu

like Aloha or FLDWAV. Begin by switching to the earthquake model if you are currently viewing the flood or hurricane model. Select "Analysis" from the main menu, select "3rd Party Models," and then select "Risk Assessment Tool" (see Figure 4-27). Alternatively, if earthquake is not one of your study region's hazards, you may run the RAT without using the HAZUS-MH menus. Open your study region in HAZUS-MH. Select "Start" from your windows menu, then "Programs" and "FEMA Risk Assessment System." Click on the RAT option (see Figure 4-28). The RAT menu box should become available (see Figure 4-29). Select the County of interest and the Hazard of interest. The RAT can be run for one county and one hazard at a time. When you are finished, select "OK." The RAT will take a few minutes to process the data and provide results.

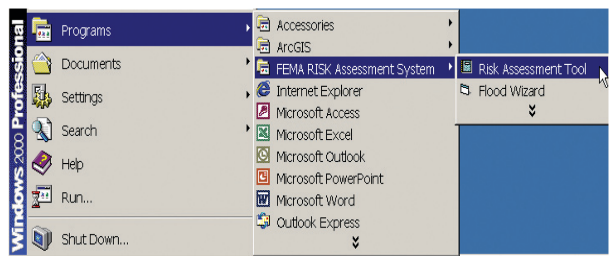


Figure 4-28 RAT program location

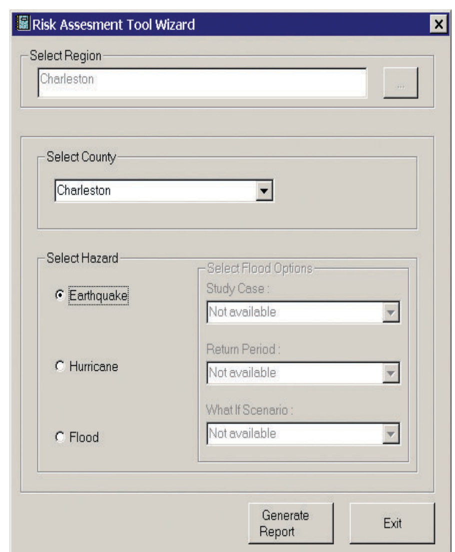


Figure 4-29 RAT menu box

3. **To view the outputs**, scroll through the document (see Figure 4-30) that has been generated by the RAT. The outputs include maps and tabular data that can be placed directly into a mitigation plan. The document can be printed and exported using the features above the report. A summary of the outputs available for the RAT is provided as a Job Aid 4-4 (Appendix F).

Congratulations! You have now completed running the RAT and have obtained a RAT report.

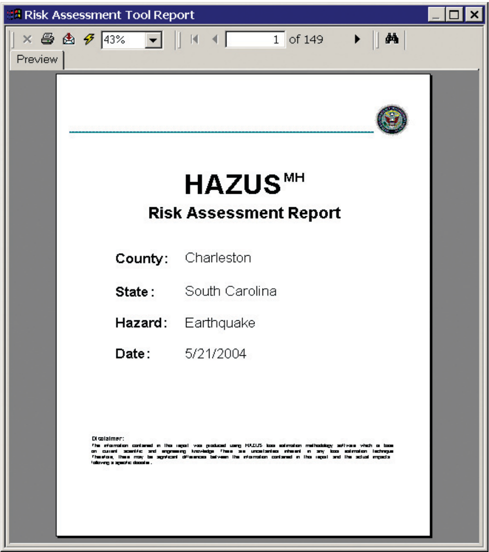


Figure 4-30
Risk assessment tool report

Calculate Exposures for Hazards Not Included in HAZUS-MH (Task 4.4)

To evaluate exposure using the HAZUS-MH GIS tools and inventory databases, you will use the hazard maps created in Step 2, and overlay them with the inventory provided in HAZUS-MH. To overlay a hazard map, select "File," then "Add Data" and browse to a selected hazard map. If Step 2 was completed successfully, the hazard map should be in the correct format and projection. The map will appear over the study region and become a layer on the right. All of the inventory datasets are available under the "Inventory" menu. Review Step 3 for more information on viewing these datasets. Map the inventory of interest over the hazard map and determine what is at risk. Identify subsets of data by selecting inventory layers using the icon with an arrow.

Congratulations! You have now used HAZUS-MH to map the hazards not available in HAZUS-MH and overlaid them with the inventory provided by HAZUS-MH to estimate exposure.

Evaluate the Results of the Risk Assessment (Task 4.5)

You have now obtained risk assessment outputs as either quantitative loss estimates for the earthquake, flood, and hurricane hazards or quantitative estimates of exposure for other hazards that you are able to map (for example, landslide susceptibility and wildfire hazard areas). The next step is to evaluate these data for reasonableness and to compare the risks associated with each hazard.

Consider and Review Your Loss Estimate Results

This activity will help you determine whether the results from the loss estimation study are reasonable and ready for use. To assess the results of your risk assessment, it is recommended that you get input from your risk assessment team, compare HAZUS-MH outputs to anticipated results (e.g., based on historic losses), and consider any hazard expert input on the results you have obtained. Team members and experts can assess the hazard profiles you have prepared, maps you have developed, and risk assessment output tables that are available now. They can help you document any concerns, revise any inputs and re-run results, or document that the results are within the margin of error suitable to support your mitigation strategy.

To consider and review the results of your risk assessment, take the following steps.

1. **Use professional judgment**. You can use the professional judgment of your risk assessment team to evaluate if the results are within a range of the value you expected or within a margin of error that you feel is acceptable for risk assessment purposes.
2. **Review available technical documentation**. You also may want to review the documentation of each model provided with the HAZUS-MH user and technical manuals.
3. **Ask stakeholder experts for input**. It is a good idea to involve appropriate stakeholder experts during all phases of the mitigation planning process. For example, if you are running a risk assessment for a flood, review the HAZUS-MH results with the floodplain manager for the study region. Such experts can assist in data collection, data evaluation, and output consideration. They also can help you "ground-truth" the results of your loss estimation based on their knowledge of past events and their ongoing efforts regarding the hazard of concern. These experts also may support your text regarding the hazard profiles, risk assessment outputs, and long-term data needs to refine your analyses.
4. **Consider if development or other factors are impacting your study region**. A Level 1 analysis is based on HAZUS-MH provided data. These data include assumptions regarding the hazard characteristics in your area, which may require refinement (Step 2, Identify Hazards) and inventory data that is based on national and regional databases (Step 3, Inventory Assets). If your local conditions change or vary significantly from the HAZUS-MH provided data and you have completed a Level 1 analysis, you may identify areas of your risk assessment that require additional explanation or refinement. Some of these refinements may be feasible for this portion of your risk assessment. Other refinements may become part of your long-term data management or improvement efforts and may warrant a mitigation strategy goal or action to help improve data and assumptions for hazards that are of interest and concern in your community.
5. **Revisit your risk assessment, as necessary**. If items 1 through 4 raise concerns that you feel must be addressed, you may want to revisit Steps 2, 3, and 4 (especially, hazard characterization inputs and inventory inputs). If you feel that the results are reasonable for your purposes, you can continue forward to use your risk assessment outputs.

After completing your evaluation of results and making adjustments as needed to your hazard and inventory data, you can rerun HAZUS-MH, as necessary, to obtain revised results and outputs. Remember that these evaluation activities can be continued as your mitigation planning efforts evolve and as local data and hazard-specific knowledge improves.

After you complete your first risk assessment effort, it is important to keep your asset inventory and hazard data current so that you are ready when you need to update your risk assessment (e.g., after a major hazard event or to comply with the schedules provided in DMA 2000). Data maintenance and integrity are critical to successful HAZUS-MH implementation.

SUMMARY

After completing Step 4, you should have a good idea which assets are subject to the greatest potential damages and which hazards are likely to produce the greatest potential losses or present the greatest hazard exposure. Table 4-1 summarizes the activities and outputs for this step.

Table 4-1: Estimate Losses Activities and Outputs Checklist

Activity	Output	Check Completed Items
Integrate hazard profile data for HAZUS-MH Level 2 (Task 4.1)	Updated HAZUS-MH profile data	
Run HAZUS-MH scenarios (Task 4.2)	Tables, maps, and summary reports Worksheets 4-1 and 4-2	
Run the Risk Assessment Tool (Task 4.3)	Risk Assessment Tool Report	
Calculate exposure for hazards not included in HAZUS-MH (Task 4.4)	Inventory at risk	
Evaluate the results of the risk assessment (Task 4.5)	Reasonable HAZUS-MH outputs	

Complete any missing items in your checklist, and then continue to Step 5.

GO TO STEP 5: CONSIDER MITIGATION OPTIONS

WORKSHEET 4-1: INVENTORY AT RISK ESTIMATES

Worksheet 4-1 will help you to organize your estimated losses obtained during Step 4.

LOSS ESTIMATION VALUES			
Inventory Asset Category	Used for HAZUS-MH Model		
	Earthquake	Flood	Hurricane
	US$ in thousands	US$ in thousands	US$ in thousands
General Building Stock-Total			
Essential Facilities			
Medical Care			
Emergency Response			
Schools			
Fire Stations			
Police Stations			
HazMat Facilities			
High Potential Loss Facilities			
Dams			
Levees			
Nuclear Power Facilities			
Military Installations			
Transportation Lifeline Systems			
Highway Segments			NE
Highway Bridges			NE
Highway Tunnels			NE
Rail Segments			NE
Rail Bridges			NE
Rail Tunnels			NE
Rail Facilities			NE
Light Rail Segments			NE

WORKSHEET 4-1: INVENTORY AT RISK ESTIMATES (continued)

LOSS ESTIMATION VALUES			
Inventory Asset Category	Used for HAZUS-MH Model		
	Earthquake	Flood	Hurricane
	US$ in thousands	US$ in thousands	US$ in thousands
Light Rail Bridges			NE
Light Rail Tunnels			NE
Light Rail Facilities			NE
Bus			NE
Port			NE
Ferry			NE
Airport Facilities			NE
Airport Runways			NE
Utility Lifeline Systems			
Potable Water Pipelines			NE
Potable Water Distribution Pipes (by Census tract)			NE
Wastewater Pipelines			NE
Wastewater Distribution Sewers (by Census tract)			NE
Wastewater Treatment Plants			NE
Crude and Refined Oil Pipelines			NE
Oil System Facilities			
Natural Gas Pipelines			NE
Natural Gas Distribution Pipes (by Census tract)			NE
Electric Power			NE
Communication			NE
Demographics			
TOTAL			

Notes: NE = not estimated by hurricane model.

WORKSHEET 4-2: FLOOD WIZARD OUTPUTS

Use Worksheet 4-2 to record the values obtained after running the Flood Wizard analysis.

500-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Building Exposure (x$1000)								
100-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Building Exposure (x$1000)								
500-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Content Exposure (x$1000)								
100-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Content Exposure (x$1000)								
500-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Total Exposure (x$1000)								
100-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Total Exposure (x$1000)								

WORKSHEET 4-2: FLOOD WIZARD OUTPUTS

500-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Number of Buildings in Floodplain								
100-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Number of Buildings in Floodplain								
500-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Building Loss in Floodplain (x$1000)								
100-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Building Loss in Floodplain (x$1000)								
500-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Content Loss in Floodplain (x$1000)								
100-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Content Loss in Floodplain (x$1000)								
500-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Total Loss in Floodplain (x$1000)								
100-Year Return Period	Population	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education
Total Loss in Floodplain (x$1000)								

EXAMPLE

EXAMPLE 4-1: ESTIMATE LOSSES

HURRICANES

HURRICANE LOSS ESTIMATE FOR AUSTIN, TEXAS

The hurricane hazard loss estimate is presented below.

Risk Assessment Data Collection. HAZUS-MH provided inventory data were augmented for Austin-critical facilities. Therefore, the "critical facilities" considered in this risk assessment included Austin-critical facilities, essential facilities, special facilities, HazMat facilities, transportation lifeline systems, and utility lifeline systems, as shown in the table below. Population data were taken from the HAZUS-MH provided data, which is based on the most recent Census conducted in 2000; local data correlated closely to the HAZUS-MH Census data.

Hazard Model Development. Because this hazard was analyzed using the HAZUS-MH software, additional model development efforts were not required. No local hazard data to update the model components were identified as necessary or available.

Risk Assessment Methodology. The hurricane module of HAZUS-MH was used and provided loss estimations for: General building stock and critical facilities. Other loss estimates included displaced households and shelter requirements. The 100- and 500-year mean return period (MRP) events were analyzed. Annualized losses also were estimated.

Estimated Damages and Losses. Property damage due to the hurricane hazard was summarized by occupancy class in the table below. The total estimated loss for a hurricane with a severity equal to a 500-year MRP was approximately $1.4 billion. Residential buildings accounted for about 86 percent of the total losses for this event. Because of differences in building construction, residential structures were more susceptible to wind damage than commercial and industrial structures. The damage counts included buildings damaged at all severity levels from slight damage to total destruction. The total dollar damage represented the overall impact to individual buildings at an aggregate level.

EXAMPLE 4-1 (continued)

Estimated Damages/Losses to General Building Stock For Hurricanes In Austin, Texas*

Occupancy Class	100-year Event Damages	500-year Event Damages
Residential	$159.7M	$1,232.5M
Commercial	$6.1M	$178.7M
Industrial	$0.6M	$29.7M
Total	$166.4M	$1440.9M

Note: Dollars rounded to the nearest hundred thousand. M indicates million.

The hurricane module also provides shelter requirement estimates. For a 100-year event, hurricane shelter requirements are estimated to be negligible. For a 500-year event hurricane, households displaced are estimated to be 1,750 (about 5,000 people); short-term shelter needs are estimated to be required for 460 persons.

The next table presents the impacts to critical facilities associated with the hurricane hazard in Austin, TX. As shown in the table, the damage impact of the hurricane hazard on critical facilities is anticipated to be minor for both the 100- and 500-year MRP events.

The loss ratio represents the percent of the building value that likely would be incurred to repair or restore the facility to its original, pre-hazard state.

HAZUS-MH also estimates average annualized losses, which represent the average loss that can be expected per year. The total expected average annualized loss associated for hurricanes is estimated at $16.9 million. The average annualized loss by occupancy class associated with hurricanes is:

- $14.2 million for the residential occupancy class (accounting for 84 percent of the total annualized losses)
- $2.3 million for the commercial occupancy class
- $0.4 million for the industrial occupancy class

EXAMPLE 4-1 (continued)

Critical Facility Exposure and Loss Ratios for Hurricanes in Austin, Texas

Facility Class	100-Year Event		500-Year Event	
	Number Exposed / At-Risk	Loss Ratio	Number Exposed / At-Risk	Loss Ratio
Austin-Critical Facilities				
Fire Stations	39	< 2%	39	< 5%
Police Stations	9	< 2%	9	< 5%
Essential Facilities				
Schools	191	< 2%	191	< 5%
Colleges	13	< 2%	13	< 5%
Nursing Homes	31	< 2%	31	< 5%
Health Clinics	12	< 2%	12	< 5%
Hospitals	52	< 2%	52	< 5%
Special Facilities				
Stadium	1	< 2%	1	< 5%
Post Offices	24	< 2%	24	< 5%
Historical Sites	4	< 2%	4	< 5%
Museum	6	< 2%	6	< 5%
Convention Center	1	< 2%	1	< 5%
HazMat Sites				
Toxic Release Inventory Facilities	17	< 2%	17	< 5%
Transportation				
Airports/Runways	NE	NE	NE	NE

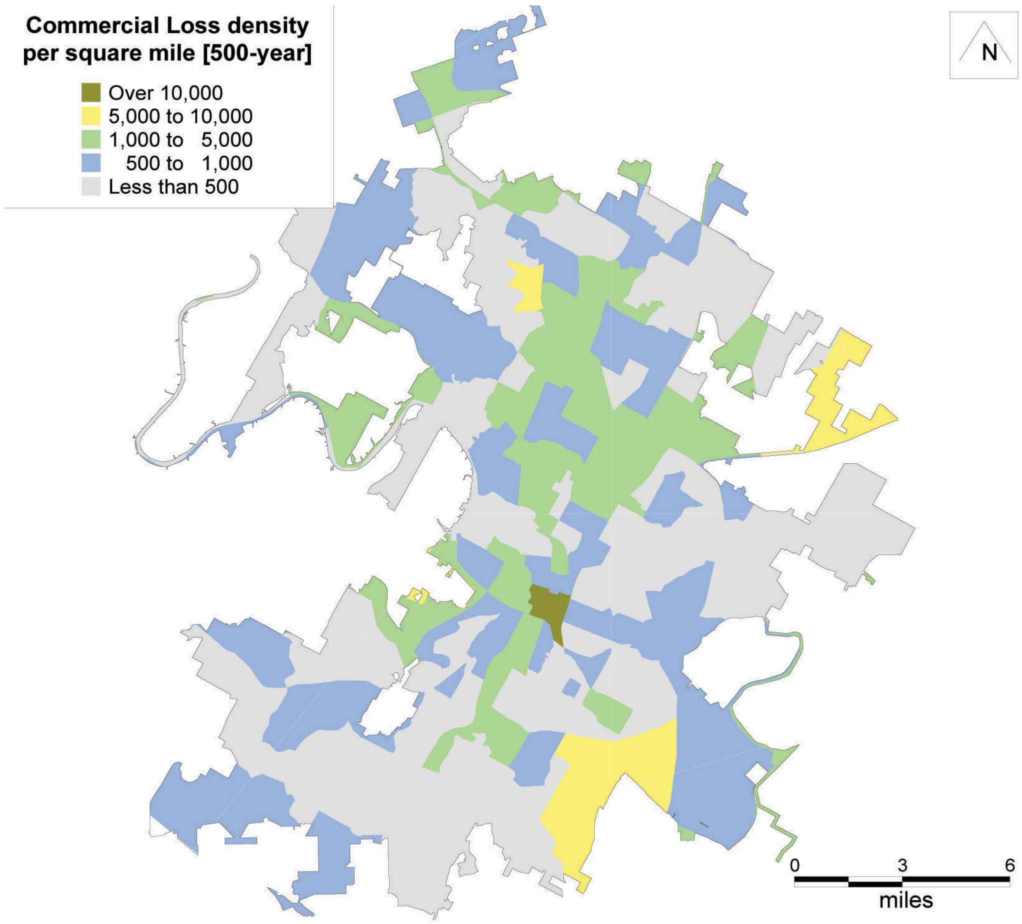
Note: < = less than. For the transportation category, only facilities (airport/runways) are estimated.

The HAZUS-MH hurricane model does not estimate transportation and utility system losses or impacts. It also does not estimate indirect economic losses. Therefore, these results are not presented for this hazard.

The figure below shows the dollar loss density estimates for a 500-year MRP event for the hurricane hazard for the commercial occupancy class. As indicated on the figure's legend, areas in darker colors indicate areas where greater losses are incurred per square mile of land.

EXAMPLE 4-1 (continued)

Figure 4-31
Hurricane loss density for Austin, Texas, for a 500-year hurricane event (commercial occupancy class)



STEP 5: CONSIDER MITIGATION OPTIONS 5

OVERVIEW

The fifth step in this guide will help you to identify and evaluate various mitigation options that are directly associated with, and responsive to, the losses identified during Step 4. Remember that in HAZUS-MH losses are estimated based on the cost to repair or replace damage to, or loss of, the building inventory. The fifth step, therefore, emphasizes mitigation measures that can reduce the destructive effects of earthquakes, floods, and hurricanes on this inventory. Figure 5-1 shows the tasks and outputs associated with Step 5 of this guide.

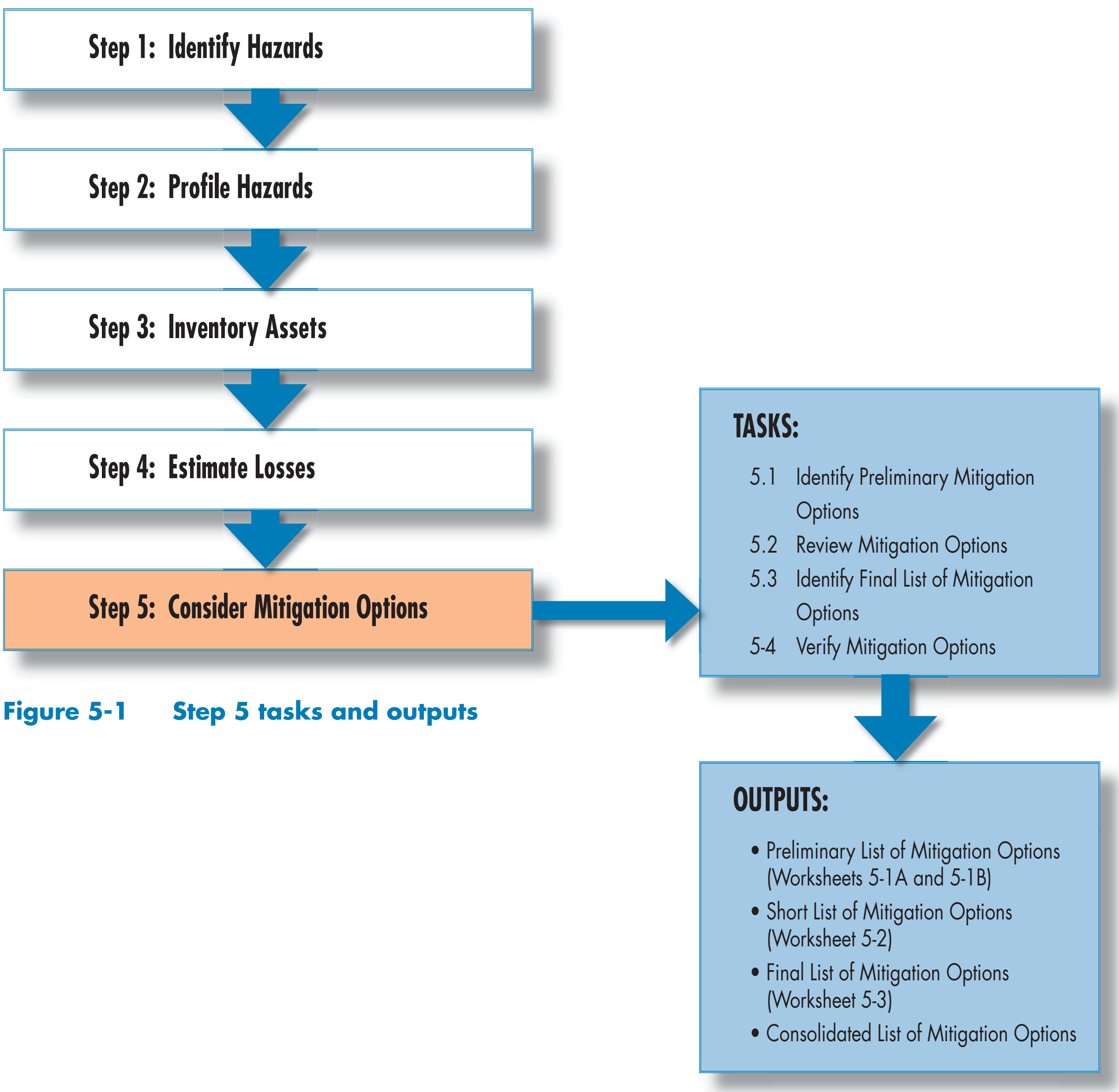


Figure 5-1 Step 5 tasks and outputs

NOTE

Evaluating the effectiveness of a particular mitigation measure, whether it is regulatory or technical (protection or control), is not an exact science. It requires technical, policy, and financial expertise combined with a thorough knowledge of local perspectives and needs.

In Step 5 you will examine mitigation options from the point of view of their effectiveness, acceptability, and feasibility with respect to the prevailing conditions in your community. The proposed procedure for examining the mitigation options is not meant to replace full and thorough analysis of the technical, economic, and social merits of various mitigation measures, which may be a costly and lengthy process requiring highly specialized expert input. It is meant to help you narrow down your options and focus your attention on those measures that have the greatest chance of effective implementation.

REFERENCE

The FEMA How-To Series for Mitigation Planning also includes guidance on mitigation measures (FEMA 386). Information is available at http://www.fema.gov/fima/planhowto.shtm.

In order to identify, select, and implement the most appropriate mitigation measures you will need to examine general mitigation goals and objectives and the merits of each potential mitigation measure. You also will need to consider local and state resources for implementation. This will prepare you to evaluate and prioritize potential mitigation options, according to the criteria that are suggested in this step. The tasks in Step 5 are designed to help you answer the following questions:

- Which mitigation measures are most appropriate for the types of risks our community faces?
- Do we have sufficient capability to implement these measures and what kind of assistance might we need?
- What impacts will the implementation of these measures have on our community?

Task 5.1 will help you to identify a broad range of preliminary mitigation options by hazard or by structure type. Task 5.2 will assist you in reviewing the appropriateness of these measures given the needs and desires of the community. Task 5.3 will help you assess the implementation of proposed mitigation options by indicating which options may be more effective for risk reduction. Task 5.4 will allow you to determine if your identified mitigation options

REFERENCE

FEMA information about regulatory measures, rehabilitation, and protective and control structures can be found at http://www.fema.gov/fima.

are in conflict for a particular combination of hazards. It will also help you to integrate your mitigation options into your mitigation plan, taking into consideration the factors and elements considered in Tasks 5.1 through 5.3.

Identify Preliminary Mitigation Options (Task 5.1)

Mitigation measures can be viewed from many different perspectives. In this How-To Guide, the emphasis is on interventions that address the goal of mitigation with respect to buildings and infrastructure; that is, minimizing the destructive and disruptive effects of hazard events on the built environment. For this task, mitigation options for earthquakes, floods, and hurricanes are described in three broad categories:

- Regulatory measures
- Rehabilitation of existing structures
- Protective and control measures

Regulatory Measures

Regulatory measures include legal and other regulatory instruments that governments use to prevent, reduce, or prepare for the losses associated with hazard events. Examples include:

- Legislation that organizes and distributes responsibilities to protect a community from hazards
- Regulations that reduce the financial and social impact of hazards through measures such as insurance
- New or updated design and construction codes
- New or modified land use and zoning regulations
- Incentives that provide inducements for implementing mitigation measures

In most cases, regulatory measures should be considered first and before other measures because regulatory measures provide the framework for decision-making, organization, and financing of mitigation actions.

> NOTE
>
> In addition to the structural measures discussed in this guide, other mitigation measures are also important to local mitigation efforts. These measures include:
>
> - Emergency preparedness measures that support emergency services to protect people and property during and after the hazard event
> - Public awareness and education measures that inform and educate the general population, public officials and businesses about risks, preparedness, and mitigation measures
> - Natural resource protection measures that protect the environment and preserve and restore natural systems

Rehabilitation of Existing Structures

As its name implies, rehabilitation deals with structural and non-structural modification of elements of existing buildings and infrastructure facilities. Although new and updated design and construction codes and new zoning laws can be effective mitigation measures to protect new construction, they usually cannot be applied retroactively. For this reason, improving the safety and structural integrity of existing buildings and infrastructure facilities is often the best way to reduce the impact of hazard events on such structures.

Buildings and infrastructure are often at risk due to their location in hazard-prone areas (such as floodplains, areas susceptible to landslides, or zones with high seismic activity). The level of damage is impacted by each structure's quality of design and construction. Poorly engineered and constructed buildings and infrastructure are usually not able to resist the forces of nature. Frequently, location and structure combine to increase the vulnerability of buildings and infrastructure facilities, especially those that were built a long time ago (e.g., before the first building codes were introduced). Mitigation measures for these structures must be targeted to the specific causes of vulnerability. For example, it would not make much sense to invest in expensive reinforcement of a structure that remains on unstable soil. Removal, relocation, or elevation of in-place structures located in highly hazardous areas is frequently the only option. Often this may mean that buildings of significant historic or cultural value have to be relocated or rebuilt, usually at great cost, on a different site.

In situations where buildings and infrastructure can benefit from structural improvements in-place, mitigation measures rely on those engineering solutions most appropriate for the substandard structures. Because the cost of these measures varies, a community must prioritize options based on the importance of the facility and its relative vulnerability. For example, essential and high potential loss facilities may generally have a priority for repair and strengthening over other buildings and infrastructure.

Protective and Control Measures

Unlike other mitigation measures that improve the resistance of buildings and infrastructure to disasters, protective and control measures focus on protecting structures by (1) deflecting the destructive forces from vulnerable structures and people or (2) erecting protective barriers. Well-known examples are dams and reservoirs, levees, discharge canals, floodwalls and sea-walls, retaining walls, safe rooms or shelters, protective vegetation belts, and similar structures.

Now that you have a general understanding of the categories of mitigation measures related to structural protection, each of these categories is reviewed for the three primary HAZUS-MH hazards – earthquakes, floods, and hurricanes.

Mitigation measures below are discussed for earthquakes, floods, and hurricanes as they relate to regulatory measures, rehabilitation of existing structures, and protective and control measures.

Task 5.1 is designed to help you identify a set of preliminary mitigation options based on HAZUS-MH loss estimates. Worksheet 5-1A provides information on HAZUS-MH inventory and building elements. It allows you to cross reference this information with that for earthquakes, floods, and hurricanes. List your preliminary mitigation options categorized by mitigation measures and hazards on Worksheet 5-1B. Example 5-1A lists a variety of mitigation measures you may want to consider for buildings and infrastructure. Example 5-1B lists a variety of mitigation options specific to earthquakes, floods, and hurricanes. Worksheet 5-2 allows you to evaluate and compare mitigation options using a number of criteria recommended by FEMA. Worksheet 5-3 helps you document your final consolidated list of options.

Mitigation Measures for Earthquakes

Earthquakes are distinguished by their unpredictability, force, sudden onset, and unparalleled destructive power. The effect of earthquake forces on the built environment can be devastating, both in terms of human casualties and economic loss. In the last few decades, however, significant advances have been made in techniques for mitigating earthquake risk.

REFERENCE

The National Earthquake Hazard Reduction Program provides resources regarding mitigation options for this hazard: http://www.fema.gov/hazards/earthquakes/eqmit.shtm.

Regulatory Measures. Building codes are the most widely used earthquake mitigation strategy in the country. Advances in earthquake engineering in the last few decades are now incorporated in these codes and have been successfully proven in a number of earthquakes. This regulatory measure has been used effectively to raise the standard of earthquake-resistance for newly built structures and significantly reduce casualties and other losses. At the same time, zoning and land use planning regulations have been able to reduce development close to active earthquake faults.

Rehabilitation of Existing Structures. Older buildings and infrastructure pose the greatest safety threat for communities exposed to earthquake hazards.

These structures were generally constructed before regulatory mitigation measures were in place. Rehabilitation of existing structures has been implemented to increase the earthquake-resistance of this older inventory stock. Experience has shown that un-reinforced masonry buildings are especially vulnerable to earthquakes, and many jurisdictions have enacted ordinances that require them either to be retrofitted or demolished. In most cases, however, these structures are not subject to mandatory seismic codes unless substantial improvements or additions are proposed, mainly due to the high cost of these interventions. Cost-effective measures for the rehabilitation of existing buildings and infrastructure have been developed and many structures have been retrofitted, with a focus primarily on the most critical and most vulnerable buildings and facilities. Raising the earthquake resistance of these types of structures also can improve the earthquake response by ensuring that emergency equipment is immediately available after the disaster, and that these services can respond effectively to the community's needs. Many school districts in earthquake-prone regions have instituted retrofitting programs, with a primary focus on the safety of children and staff. Similarly, colleges, universities, public agencies, developers, and private owners have retrofitted facilities that are essential to the survival of their services or businesses after careful analysis of the costs and benefits of these measures.

DEFINITION

Structural elements - walls, columns, beams, and girders that support a building or structure

Non-structural elements - architectural components such as exterior cladding, parapets, glazing, cornices, and corbels, as well as interior partitions, suspended ceilings, and lighting fixtures

Structural engineers have produced a range of techniques to increase the earthquake resistance of structures. Because facility design and the materials and systems of construction differ greatly, a wide variety of strengthening techniques have been developed. The two general aspects of retrofitting that must be addressed are:

- Repair and strengthening of structural elements
- Repair and strengthening of non-structural elements and systems

Structural elements, irrespective of the construction materials used, must be protected from collapse and serious damage that might render the structure unusable or dangerous to people. Non-structural elements may also be protected through engineering retrofits. Additionally, electrical power and gas distribution systems; communication systems; water, waste and fire protection piping; and heating and cooling systems, staircases and elevators can be considered non-structural elements and must be reinforced and protected because damage to any of these elements also may cause casualties and render the buildings unusable.

Protective and Control Measures. In regard to the earthquake hazard, this mitigation category is most frequently employed in conjunction with other mitigation measures. An example of a protective measure for buildings would be securing the slopes around buildings and critical infrastructure. Securing slopes helps to reduce the potential for landslides in the event of an earthquake and, therefore, will reduce the overall impact to a structure if an earthquake should occur. Stabilizing soils and securing hazardous sites before new construction in certain areas also would fall into this category.

COASTAL FLOODS RIVERINE FLOODS

Mitigation Measures for Floods (Coastal and Riverine)

The basic purpose of flood mitigation measures is to avoid or minimize exposure to flooding. This is accomplished through (1) actions that regulate new development and redevelopment and (2) engineering measures that address existing conditions. Selection of specific mitigation measures is highly dependent on the nature of the flood hazard and the types of buildings and infrastructure at risk.

> REFERENCE
>
> The National Flood Insurance Program provides resources regarding mitigation options for this hazard:
> http://www.fema.gov/fima/nfip.shtm

Regulatory Measures. For flooding, regulatory measures can be used to achieve two broad objectives: (1) to guide development to areas that are not flood-prone and (2) to ensure that new development in flood-prone areas addresses flood hazards. Many communities use regulations to guide new development to areas that are not susceptible to flooding or away from identified high hazard areas (such as the floodway, for riverine flooding). In other cases, floodplain regulations and building codes are intended to recognize flood hazards and ensure that flood loads are addressed in the planning and design of new buildings and infrastructure. Those same codes are applied to existing buildings when such buildings sustain damage and require repair and reconstruction. In these cases, the regulations impose the same degree of protection that is required for new buildings, resulting in the rehabilitation of older buildings, such as elevation-in-place and floodproofing to designed flood levels.

Rehabilitation of Existing Structures. For flooding, these measures can reduce flood damage up to pre-selected flood levels, although buildings remain susceptible to damage if more severe flooding occurs. Rehabilitation can include elevation-in-place and floodproofing for buildings. Acquisition and demolition of flood-prone buildings is another effective mitigation measure that reduces exposed inventory in the floodplain and helps to return the floodplain to its natural function. Physically relocating intact buildings out of the floodplain to higher ground (or away from eroding shorelines), though effective, is usually reserved for special cases (such as, moving the historical lighthouse in Cape Hatteras because of beach erosion). Retrofit of infrastructure includes a wide variety of measures, depending on the type of infrastructure and the nature of the flood hazard. Examples include flood-proofed wastewater treatment plants and other public buildings, modified bridges that reduce backwater flooding, and upgraded or stabilized streambeds and banks to protect installations of sewer and water supply lines.

Protective and Control Measures. For floods, these measures are accomplished by modifying the source or path of flooding to keep floodwaters away from existing developed areas. These measures are generally referred to as "structural" flood control measures. They can focus on (1) decreasing runoff, (2) increasing discharge capacities, or (3) containing, diverting, or storing the floodwater. Construction of these protective measures depends on many factors that may limit their applicability in any given location. The most widely used measures for each of these categories are listed below:

- **Decreasing Runoff.** Dams and reservoirs that store floodwater in order to reduce downstream flood discharges
- **Increasing Discharge Capacity.** Drainage improvement measures that enlarge channels and over-bank areas, reduce obstructions (such as undersized bridges and culverts), and/or construct diversion channels that direct floodwater away from the vulnerable areas
- **Containing, Diverting, or Storing Floodwater.** Construction of floodwalls and levees as barriers to prevent inundation of protected areas from floods of a specific recurrence probability

HURRICANES

Mitigation Measures for Hurricanes

Before mitigation measures can be implemented to protect buildings and infrastructure from hurricane and other high-wind risks, you must understand how buildings and other structures behave when exposed to wind forces. High winds can come from any direction and lateral wind forces tend to push inward on windward walls, turn structures over, and sheer them off their bases. In addition, suction forces on the walls and roof tend to pull them away from the building. At the same time, the wind pressure inside

REFERENCE

The National Hurricane Program provides resources regarding mitigation options for this hazard: http://www.fema.gov/hazards/hurricanes/

a structure can build up, adding to the forces that tend to pull a roof and walls outward. Therefore, to withstand hurricanes, structures must be constructed to stay down and stand up.

NOTE

Another wind-related hazard is the tornado. Buildings are not typically designed to resist tornadoes. Safe rooms are sometimes added to these buildings to provide a shelter that protects humans from injury and death.

The extent to which a building is vulnerable to strong winds is a function of design and configuration, the quality of construction, the type of materials used, and the exposure of the site. In general, lightweight wood-framed structures are much more vulnerable than larger, heavier buildings. This means that single-family residential buildings are especially vulnerable.

Regulatory Measures. Planning, design, and engineering standards for new construction in high-wind zones are well developed and their application in hazard-prone areas has been effective. However, local zoning and land-use regulations have, to date, played a more limited role in regulating development to reduce exposure to high winds (except in coastal areas where the risk associated with hurricane-related storm surges and wind is very high).

Rehabilitation of Existing Structures. Rehabilitation of existing buildings concentrates on reinforcing the building and protecting its openings. The most frequently recommended mitigation measures for such cases are:

- The whole building must be tied securely to its foundations.
- Every element of the building structure and building envelope (i.e., the roof and wall covering, doors and windows) must be tied together to resist wind forces.
- Joints between various elements in a building must be strengthened to resist breaking up into separate and vulnerable elements.
- Wind must be prevented from entering the building and blowing the roof off, which is usually accomplished by strengthening the doors and providing impact-resistant glazing or window shutters.

Protective and Control Measures. For the hurricane hazard, the primary mitigation measures fall into the regulatory and rehabilitation categories discussed above.

Congratulations! You have now reviewed your loss estimation outputs and have compiled a preliminary list of mitigation options that can protect your built environment against the impacts of earthquakes, floods, and hurricanes.

Review Mitigation Options (Task 5.2)

At this point, you should have identified a preliminary list of mitigation options (Worksheet 5-1A). These options should have been grouped by hazards and under the regulatory, rehabilitation, and protective and control framework (Worksheet 5-1B). For Task 5.2, a set of criteria are provided to help you to narrow the mitigation options identified during Task 5.1. Worksheet 5-2 will help you develop a short list of your mitigation options using a set criteria that should be reviewed and modified as required by your community and institutional needs. The selected criteria that FEMA has proposed for all jurisdictions to consider consist of a common set of evaluation criteria, known as the STAPLEE evaluation criteria. This set of criteria will enable you to examine the Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLEE) opportunities and constraints of implementing a particular mitigation measure using a consistent framework.

- ❍ **Social criteria** are based on the idea that community consensus is a necessary precondition for successful implementation of mitigation measures (i.e., measures should be supported and accepted by the entire community). This also means that measures should not affect adversely a particular segment of the population or a particular neighborhood, or adversely impact local cultural values or resources.
- ❍ **Technical criteria** address the technical feasibility of the proposed measures, in terms of effectiveness, secondary impacts, and the technical capabilities of your community to implement and sustain these measures.
- ❍ **Administrative criteria** address the administrative capabilities required to implement each mitigation measure. For example, does your jurisdiction have the necessary organization, staff, and funding sources to implement and sustain the mitigation process?
- ❍ **Political criteria** consider the need for political support for mitigation measures. This means that all stakeholders in the political process, especially political organizations and institutions both inside and outside of the community, should support the measure.
- ❍ **Legal criteria** are used to determine the appropriate legal authority necessary to implement each mitigation measure and whether such an authority can be delegated. In addition, you will examine the mitigation measure from the standpoint of current statutes, codes, ordinances, and other regulations, as well as the possible legal ramifications of the measure’s implementation.

- **Economic criteria** address the cost-effectiveness of the proposed measure and its economic impact on the community. It is only reasonable to expect that the benefits of implementation will exceed the costs incurred. Economic considerations also consider the economic impact on the community's future development.
- **Environmental criteria** have become an important consideration in examining mitigation options. Although most mitigation measures are usually beneficial for the environment, some measures may have adverse effects, which must be considered and addressed.

Now that you understand the STAPLEE criteria, you are ready to complete Worksheet 5-2, which will help you consider and compare options related to specific mitigation goals and objectives.

Congratulations! You have now developed a short list of mitigation options that can be introduced in your mitigation plan after verification (Task 5.4). This list may help you to reduce potential impacts of natural hazards on your built environment.

Identify Final List Of Mitigation Options (Task 5.3)

HAZUS-MH features can help you evaluate and compare some common mitigation measures for the earthquake, flood, and hurricane hazards. To prepare a final list of mitigation options (see Worksheet 5-3), you may want to use the tools in HAZUS-MH to rerun pre- and post-event scenarios to determine if your mitigation options are reducing the hazard risk in your community. The activities below will help you use HAZUS-MH to evaluate some of your mitigation measure options in order to refine your identified mitigation options.

Earthquakes

The HAZUS-MH earthquake model can help you test the effectiveness of some strengthening measures on the buildings and infrastructure in your study region. For example, some critical or high potential loss facilities in your area may not meet current seismic codes or may be unsafe for a variety of reasons. The HAZUS-MH Advanced Engineering Building Module (AEBM) includes specific damage and loss functions that are used to assess losses for an individual building (or a group of similar buildings) under existing conditions and after some seismic repair and strengthening measures have been implemented. The comparison of damage and loss estimates before and after mitigation measures are implemented will provide you with a clearer picture of the effectiveness of particular mitigation measures for the buildings in question. However, this technique requires advanced use of HAZUS-MH and the services of seismic engineering specialists. For more information see the *HASUS-MH Earthquake User Manual.*

In order to estimate the effectiveness of a particular building code upgrade and strengthening measures on a whole class of buildings in the study region (e.g., the strengthening of all unreinforced masonry residential buildings in your area), you would need to change the fragility curves for that particular occupancy and building type category, and then repeat an analysis with this new data. This technique also requires the services of an experienced seismic engineer and advanced HAZUS-MH knowledge.

Floods (Coastal and Riverine)

The flood model has a built-in feature specifically designed to support mitigation planning. This "What-If" feature enables analyses that can test the proposed mitigation measures and produce new loss estimates based on the assumption that a proposed measure was implemented.

Currently, this feature allows you to analyze the several mitigation measures for riverine and coastal floods as described below. "What-If" scenarios can be used after you run a baseline flood case study analysis and obtain the associated loss estimate data.

HAZUS

For more information on how to use HAZUS-MH to evaluate mitigation measures, see page 4-37 of the *Flood User Manual.*

Riverine Flood Mitigation Measure Evaluation. After you estimate losses for your case study, you can estimate the effect of a new levee on flood depths by drawing the levee shape on a map and specifying its level of protection by selecting a Levee What-If Scenario under a Hazard menu.

The Riverine Flow Regulation scenario allows you to test the effects of a new reservoir by marking its location on the map and specifying its discharge value.

Coastal Flood Model Mitigation Measure Evaluation. The coastal flood model allows you to test the effects of long-term erosion; therefore, you can estimate and evaluate the additional losses that may result if mitigation measures to control that erosion are not implemented. By modifying the type of shoreline and its level of protection against erosion and waves, you can also estimate the effects of shoreline protection measures. The steps below will help you access and run the "What-If Scenario" feature of the flood model:

HAZUS

The "What-If" analysis options in the flood model include levee assessment, upstream storage, and simplified velocity for the riverine analysis. The "What-If" analysis options include long-term erosion and shore protection for the coastal analysis.

1. **Start the "What-If Scenario."** To begin running a What-If Scenario, select "Hazard" from the HAZUS-MH main menu. Then select "What-If Scenarios."

2. **Three riverine and two coastal options will become available**. The riverine options include: Riverine Levee, Riverine Flow Regulation, and Riverine Velocity Grid (see Figure 5-2). The coastal options include: Coastal Long-Term Erosion and Coastal Shore Protection.

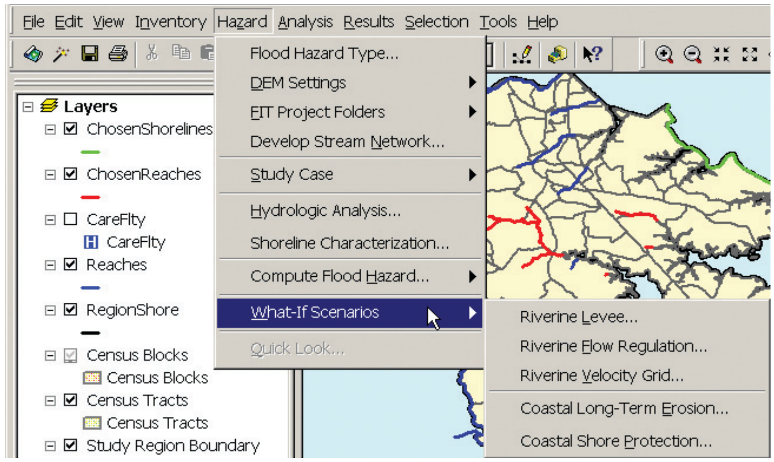


Figure 5-2 "What If" menu

3. **Set up a "What-If Scenario."** To set up the "What-If Scenario" parameters, select the option(s) you want to consider for the analysis.

   a. To include the Riverine Levee in the analysis, draw the levee shape using the "Draw" option on the levee menu (see Figure 5-3). Enter the level of protection (in years) next to "Years" and click "Save," then "OK."

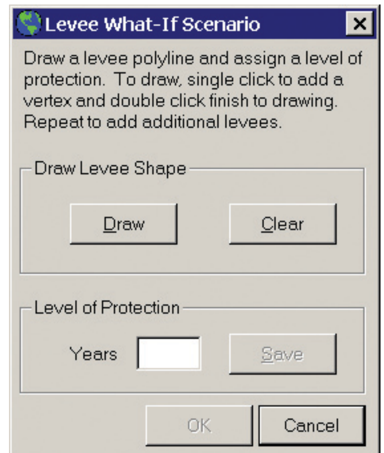


Figure 5-3 Levee options

   b. To include the Flow Regulation in the analysis, draw the flow regulation structure location using the "Draw" option on the flow regulation menu (see Figure 5-4). The existing return period and discharge values (in cfs) will be displayed under "Existing values." Select "Existing values" to change and enter new values for the "Return period" and "Discharge (cfs)" under "New values." Select "OK" after you have entered the new values.

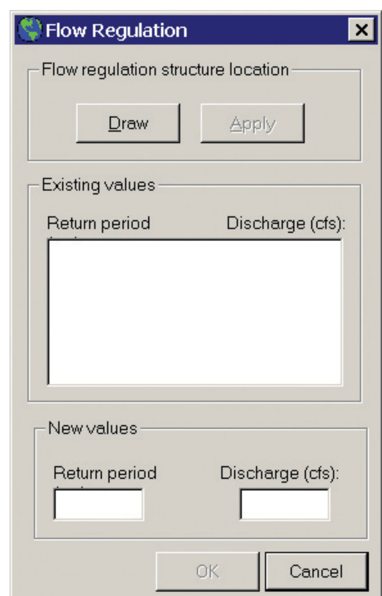


Figure 5-4 Flow regulation

   c. To include the Riverine Velocity Grid in the analysis, select the "Riverine Velocity Grid" option and a box will pop up informing you the process will take time. Click "OK" and allow the process to run to completion. This option will estimate the spatial distribution of the floodwater velocities.

   d. To include the coastal long-term erosion analysis, use the arrows on the top of the menu to select the different coastline segments of your study case (see Figure 5-5). Enter values for rate (feet/year) and duration (years) under "Erosion parameters" for each segment. Click "OK" when you have finished entering the parameters.

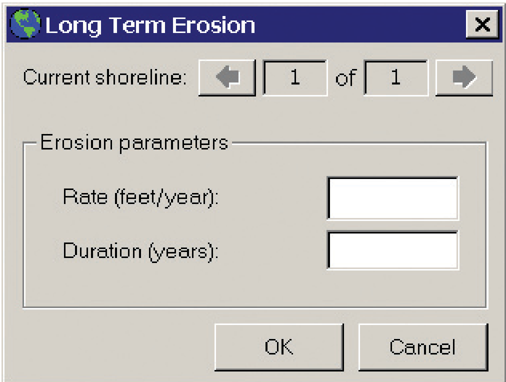


Figure 5-5 Long term erosion

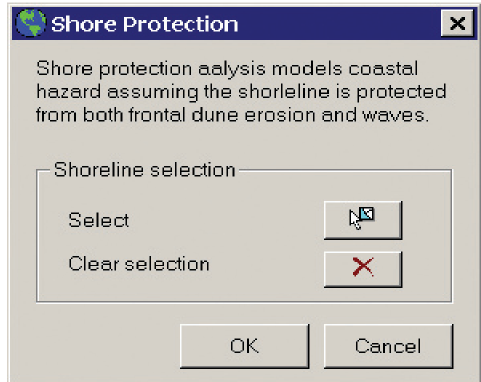


Figure 5-6 Shore protection

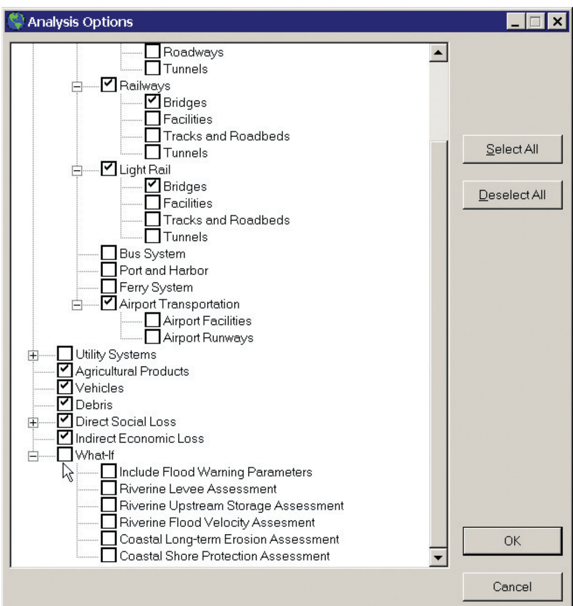


Figure 5-7 Analysis options

For more information on how to use HAZUS-MH to evaluate mitigation measures for hurricanes, see page 7-6 of the *HAZUS-MH Hurricane User Manual.*

e. To include coastal shore protection in the analysis, click the "Shoreline selection" button and select the shoreline segment on the map (see Figure 5-6). When you have finished selecting all the segments with shore protection, click "OK."

4. **Run the analysis**. To run the analysis, select "Analysis" from the HAZUS-MH main menu and then click "Run." The Analysis Options menu should now be displayed (see Figure 5-7). Click the "What-If" option and you will see the five riverine and coastal options discussed above. Select the options you want to run and then click "OK." A new analysis will be modeled using the selected "What-If" options. The results of the analysis can be viewed under the results menu option detailed in Step 4 of this How-To Guide.

Hurricanes

The hurricane model also has specific functionality to support the assessment of various mitigation measures. This function is accessed through the Wind Building Characteristics menu under General Building Stock in the Inventory. When you select the "Mitigate" option, you can assign a new wind building characteristics mapping scheme with different mitigation characteristics for single-family housing and for manufactured homes at the state, county, and Census tract levels.

The model offers four different mitigation options for single-family housing: shutters, roof straps, improved roof decking attachments, and secondary water resistance, and one option for mobile homes: tie-downs.

Using this capability of the hurricane model can help you assess quickly the potential benefits of mitigation measures (i.e., the effectiveness of residential mitigation measures or the proposed building code changes and the effects of their implementation). The steps below will help you use these features.

1. **Access the function**. To begin altering the building inventory to reflect potential mitigation measures, select "Inventory," then "General Building Stock," and "Wind Building Characteristics Distribution" (see Figure 5-8).

2. **Select mapping schemes**. To begin mitigating the building characteristics, select the mapping scheme(s) in your study region and click the "Mitigate" button on the bottom right of the Wind Building Characteristics Distribution menu (see Figure 5-9).

3. **Enter mitigation parameters**. To enter the mitigation parameters, change the values in the Mitigate Hurricane Building Characteristics Scheme Menu (see Figure 5-10). There are parameters for single-family homes and manufactured homes (represented as the percentage of homes that have undergone mitigation measures).

4. **Select options**. Options include Shutters on All Windows and Entry Doors, Roof-wall Connection Clips/Straps, Superior Roof Deck Attachment, and Secondary Water Resistance. The manufactured home option is Tie Downs. After you have entered the new values, select "OK."

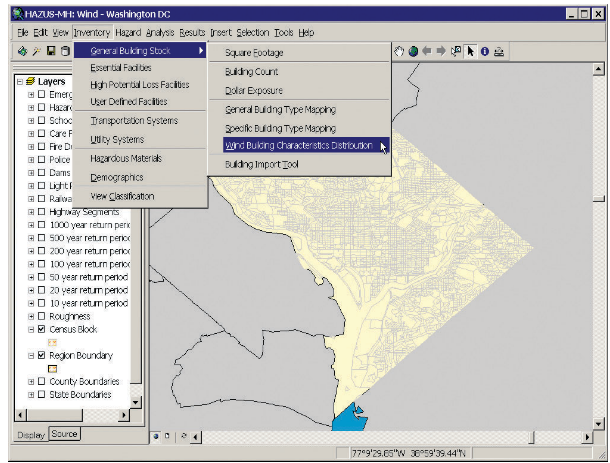


Figure 5-8
Wind building characteristics menu

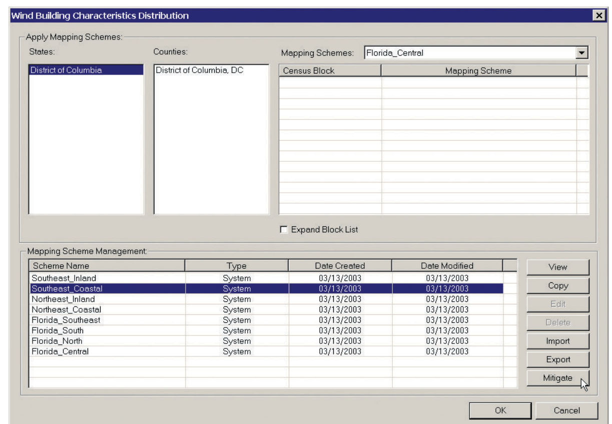


Figure 5-9
Wind building characteristics distribution menu

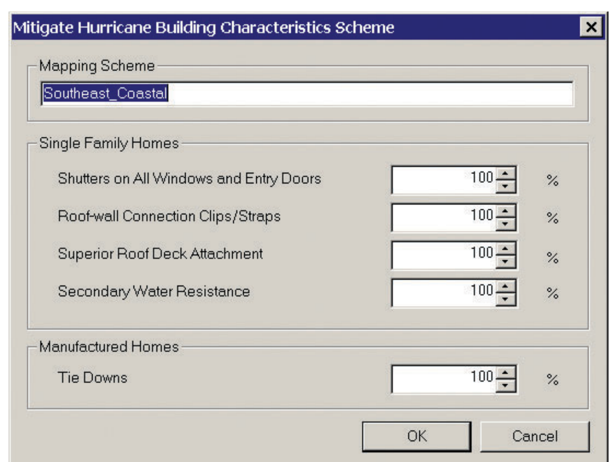


Figure 5-10 Building mitigation menu

5. **Rerun your analysis**. You may now rerun a scenario with the new mitigation measures in place.

Congratulations! You have now completed a final list of mitigation options that can be introduced in your mitigation plan after verification (Task 5.4). This list may help you to reduce the potential impacts of natural hazards on your built environment.

Verify Mitigation Options (Task 5.4)

An important challenge in designing mitigation options for all hazards in an integrated approach is that the methods used for design may reinforce one another or may conflict with one another. In the former case, the costs of multi-hazard design can be reduced, but, in the latter, they may be increased. After you prepare your final list, it would be wise to verify that these conflicts are not present in your selected mitigation options. If you identify potential conflicts, you may want to return to previous steps and review your selection of mitigation options. You can document any changes and maintain a consolidated list of options. Job Aid 5-1 in Appendix G provides a starting point for this task and will help you understand these conflicts. The material presented in this task is based on FEMA 424, *Design Guide for Improving School Safety In Earthquakes, Floods, and High Winds.*

When your final list has been reviewed, you may want to integrate selected mitigation options into your mitigation plan. Fully developing a mitigation plan goes beyond this How-To Guide; however, FEMA 386-3, *Developing the Mitigation Plan* can help you with this task. To start you in that direction, this How-To Guide provides Job Aid 5-2 in Appendix G which summarizes the general requirements of a DMA 2000 mitigation plan and where the outputs of your HAZUS-MH supported risk assessment fit.

Congratulations! You have now verified your final list of mitigation options and are ready to integrate them into your mitigation plan.

SUMMARY

Table 5-1: Consider Mitigation Options Activities and Outputs Checklist

Activity	Output	Check Completed Items
Identify preliminary mitigation options (Task 5.1)	Preliminary list of mitigation options (Worksheets 5-1A and 5-1B)	
Review mitigation options (Task 5.2)	Short list of mitigation options (Worksheet 5-2)	
Identify final list of mitigation options (Task 5.3)	Final list of mitigation options (Worksheet 5-3)	
Verify mitigation options (Task 5.4)	Consolidated list of mitigation options	

WORKSHEET 5-1A: IDENTIFY PRELIMINARY LIST OF MITIGATION OPTIONS BASED ON HAZUS-MH LOSS ESTIMATES

Worksheet 5-1A will help you record areas of major loss estimated in Step 4. First, mark areas of major loss predicted by HAZUS-MH for each hazard. Then consider specific building elements at risk. Review the areas containing check marks as a focus area for mitigation options. Refer to Examples 5-1A and 5-1B to identify potential mitigation measures. The most important mitigation measures identified during this process should be included in Worksheet 5-1B.

	Building Types							Building Occupancies							Essential Facilities						High Potential Loss Facilities and HazMat Facilities					Transportation Systems/Lifelines							Utility Systems					
HAZARDS	Concrete	Pre-cast Concrete	Reinforced Masonry	Steel	Unreinforced Masonry	Wood	Manufactured Homes	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Medical Care Facilities	Fire Stations	Police Stations	EOCs	Schools	Shelters	Dams	Levees	Nuclear Power Facilities	Military Installations	HazMat Facilities	Highway	Railway	Light Rail	Bus Station	Ports	Ferry	Airport	Potable Water	Wastewater	Oil Systems	Natural Gas	Electric Power	Communications
EARTHQUAKE																																						
FLOOD																																						
HURRICANE																																						
BUILDING ELEMENTS																																						
Site																																						
Architectural																																						
Structural Systems																																						
Building Envelope																																						
Utility Systems																																						
Mechanical Systems																																						
Plumbing and Gas																																						
Electrical Systems																																						
Fire Alarm Systems																																						
Communication and Information Technology (IT)																																						

WORKSHEET 5-1B: PREPARE A PRELIMINARY LIST OF MITIGATION OPTIONS

Use this worksheet to list your preliminary mitigation options categorized by mitigation measures and hazards. This preliminary list is the output of Task 5.1, Worksheet 5-1A, and Examples 5-1A and 5-1B. This preliminary list of mitigation options will be further refined in Worksheet 5-2.

LIST OF PRELIMINARY MITIGATION OPTIONS	
Regulatory Measures	
Earthquake	
Flood	
Hurricane	
Rehabilitation	
Earthquake	
Flood	

WORKSHEET 5-1B: PREPARE A PRELIMINARY LIST OF MITIGATION OPTIONS (continued)

LIST OF PRELIMINARY OPTIONS	
Hurricane	
Protective and Control Structure	
Earthquake	
Flood	
Hurricane	

EXAMPLE 5-1A: MITIGATION MEASURES FOR THE BUILT ENVIRONMENT

Example 5-1A should be used in conjunction with Worksheets 5-1A and 5-1B. It provides mitigation examples and focus areas that can be used as a starting point to identify your mitigation options which will be further refined in Worksheet 5-2.

Example Focus Areas for Physical Mitigation Options – Facilities (Community-Specific, Infrastructure, and General Building Stock)	
Site	**Utility Systems**
• Access Points	• Water/Entry Points/Site
• Lighting	• Water Distribution
• Parking	• Water for Fire Suppression
• Roadway/Pedestrian/Paths	• Sanitary and Stormwater Sewer/Site
Architectural	• Sanitary and Stormwater Sewer/Building
• Access Public and Private Entrance	• Fuel Entry Point/Delivery/Storage
• Access Public-Private Space	• Manholes
• Access Public-Private Stairwells	• Above/Underground Tanks
• Access Public-Private Elevators	**Mechanical Systems**
• Egress	• Air Intakes
• Non-Bearing Walls	• Exhaust Louvers
• Non-Structural Elements	• HVAC Systems
Structural Systems	**Plumbing and Gas**
• Repairs/Rehabilitation	• Main Piping Distribution Systems
• Upgrading to New Codes and Standards	• Gas Storage Tanks
• Designing to New Performance Objectives	• Gas Reserve Supplies Location/Protection
• Ductile Structural Elements/Detailing	**Electrical Systems**
• Sheer Reinforcement	• Electrical Wiring
• Connections	• Transformers
• Lateral and Vertical Force Considerations	• Distribution Panels
• Column Spacing, Size, Shape, and Configuration	• Backup Power
• Reinforcement of Masonry	**Fire Alarm Systems**
• Flood Elevations	• Fire Alarm System
Building Envelope	• Fire Hydrant Location
• Shear Walls/Steel Frame Systems	• Smoke Evacuation System
• Reinforcement Non-Bearing Masonry Walls	
• Window Design/Frame/Anchorage/Glazing Mullions	
• Doors	
• Roof	

EXAMPLE 5-1A: MITIGATION MEASURES FOR THE BUILT ENVIRONMENT (continued)

Example Focus Areas for Physical Mitigation Options – Facilities (Community-Specific, Infrastructure, and General Building Stock)	
Bridges	**Communication and IT**
• Build to improve design standards	• Redundancy CCTV
• Retrofit existing bridges	• Telephone System/Distribution
• Use remote sensing to identify problems	• Communication System/Distribution
• Design to new performance objectives	• Radio/Wireless System
Highways	• Redundancy/Backups
• Engineering design improvements	• Mass Communication
• Retrofit existing roadways	**Gas and Oil Pipelines**
• Improve lights and signs (roads and highways)	• Improve leak detection system
• Address potential landslide concerns	• Strengthen supports and joints
• Design to new performance objectives	• Install secondary containment/features
Tunnels	• Design to new performance objectives
• Rehabilitation	**Potable Water Systems**
• Upgrade to new codes and standards	• Improve leak detection system
• Design to new performance objectives	• Strengthen supports and joints
Railways	• Design to new performance objectives
• Maintain railbeds and slopes	**Potable Water Wells**
• Upgrade connections and lines/joints	• Install protection around wellheads
• Improve warning system and problem identification systems	• Upgrade well casing
• Design to new performance objectives	**Wastewater Systems**
	• Improve shut-off and diversion systems
	• Segregate combined overflow systems
	• Design to new performance objectives
	Ports and Ferries
	• Reinforcement of site structures (sea walls)
	• Improve warning systems

EXAMPLE 5-1B: MITIGATION MEASURES FOR THE BUILT ENVIRONMENT BY HAZARD

Example 5-1B should be used in conjunction with Worksheets 5-1A and 5-1B. It provides mitigation examples organized by earthquake, flood, and hurricane and can be used as a starting point to list your mitigation options, which will be further refined in Worksheet 5-2.

EXAMPLES
EARTHQUAKE
• Conduct careful analysis of seismic risk at site or region
• Evaluate for relative seismic risk if choice of sites is available
• Involve all design consultants from the initial stages of the building design
• Ensure that seismic code is correctly applied and that design and construction to code meets the performance requirements of the owner and other stakeholders
• Use as regular a building configuration as possible
• Ensure that support and bracing of all non-structural components and systems is correctly designed and constructed
• Ensure careful quality control on the building site to ensure building is constructed in complete conformance with contract documents
• Develop risk management plan for protection of building occupants and conduct training and exercises
• Consider reprogramming building to increase occupant safety
• Perform careful evaluation of existing building using recognized techniques to determine weaknesses
• Determine acceptable risk for stakeholders
• Study alternative remedial approaches and use benefit/cost analysis to determine appropriate risk management approach
• Investigate opportunities for incremental retrofit measures to increase feasibility of implementation
FLOOD
• Use regulations to guide new development away from identified high hazard areas (such as the floodway, for riverine flooding)
• Use floodplain regulations and building codes for planning and design of new buildings and infrastructure
• Increase discharge capacity by drainage improvement measures that enlarge channels and over-bank areas, and reduce obstructions such as undersized bridges and culverts
• Use elevation-in-place and floodproofing for buildings
• Construct diversion channels that direct floodwater away from the vulnerable areas
• Contain, divert, or store floodwater by constructing floodwalls and levees as barriers to prevent inundation of protected areas from floods of a specific recurrence probability
• Alter channels, to prevent or reduce flooding
• Use acquisition and demolition of flood-prone buildings
• Use physical relocation of high value buildings (i.e., historic, schools, etc.)
• Modify building and relocate contents
• Elevate foundation walls, piers, post or columns, and piles
• Use dry floodproofing by sealing walls with waterproofing compounds, impermeable sheeting, or other covering for openings
• Use continuous wall or block foundation
• Check stability of storage tanks and pipelines through alarms and control panels; consider, buoyancy, impact load, scour of lines, and movement of connection

EXAMPLE 5-1B: MITIGATION MEASURES FOR THE BUILT ENVIRONMENT BY HAZARD (continued)

EXAMPLES
• Install utility component in-place protection
• Elevate and anchor fuel tank on platform with straps
• For utilities, elevate equipment
• Modify bridges to reduce backwater flooding
• Decrease runoff of dams and reservoirs that store floodwater to reduce downstream flood discharges
• Retrofit wastewater treatment plants and other public buildings to floodproof
• Upgrade or stabilize streambeds and banks to protect installations of sewer and water supply lines
HURRICANE
• Implement the International Building Code (IBC) that requires load resistance of the roof assembly to be evaluated by one of the test methods listed in IBC's Chapter 15
• Consider sprayed polyurethane foam and liquid applied roof systems as roof covering options
• Attach vertical flanges of coping and edge flashing as roof attachment options
• Tie the roof structure by strapping it to the walls
• Prevent wind from entering the building and blowing the roof off by strengthening the doors and providing impact-resistant glazing or window shutters
• Apply IBC requirements for glazing
• Recommend reinforced cast-in-place concrete structures, reinforced concrete roof deck, and reinforced concrete and/or reinforced and fully grouted concrete masonry unit exterior walls
• Apply engineering standards for new construction in high-wind zones (e.g., calculate loads, determine load resistance, detailed design systems, material durability, and rain penetration)
• Tie the whole building securely to its foundations
• Tie together every element of the building structure and building envelope to resist wind forces
• Strengthen joints between various building elements to resist having them break into separate and vulnerable elements
• Locate new buildings away from hurricane-prone areas and avoid abrupt changes in topography (e.g., isolated hills, ridges, and escarpments) that can cause wind speed-up

WORKSHEET 5-2: PREPARE A SHORT LIST OF MITIGATION OPTIONS

This worksheet will help you to prepare a short list of your mitigation options. Bring forward your preliminary mitigation options from Worksheet 5-1B and review them against the list of criteria. The criteria, located in the upper portion of the table, are described in Task 5.2. Use a plus "+" or a minus "-" to indicate whether your preliminary mitigation options have a positive or negative impact for each criterion. Use Worksheet 5-3 to identify your final list of options based on your assessment.

	Social		Technical			Admin.			Political			Legal			Economic				Environmental					Other	
Preliminary Mitigation Options **From Worksheet 5-1B**	Community Acceptance	Effects on Segments of Population	Technical Feasibility	Long-term Solutions	Secondary Impact	Staffing	Funding Allocation	Maintenance	Political Support	Local Champion	Public Support	State Authority	Existing Local Authority	Potential Legal Challenges	Benefit of Action	Cost of Action	Contributes to Economic Goals	Outside Funding Required	Effect on Land and Water	Effect on Endangered Species	Effect on HazMat and Waste Sites	Consistent w/Community Env. Goals	Consistent w/Federal Env. Law	Others	Others
EARTHQUAKE																									
Option 1																									
Option 2																									
Option 3																									
Option 4																									
FLOOD																									
Option 1																									
Option 2																									
Option 3																									
Option 4																									
HURRICANE																									
Option 1																									
Option 2																									
Option 3																									
Option 4																									

WORKSHEET 5-3: PREPARE A FINAL LIST OF MITIGATION OPTIONS USING HAZUS-MH

This worksheet will help you to document your final list of your mitigation options. The short list of options identified in Task 5.2 and Worksheet 5-1B can be further refined using HAZUS-MH tools to rerun pre- and post-event scenarios for earthquakes, floods, and hurricanes. You should also include the results of your Worksheet 5-2 evaluation. By using HAZUS-MH tools, you can determine if your mitigation options are reducing the hazard risk in your community.

Mitigation Options
EARTHQUAKE
Option 1
Option 2
Option 3
FLOOD
Option 1
Option 2
Option 3
HURRICANE
Option 1
Option 2
Option 3
COMMENTS:

APPENDIX A: ACRONYMS AND ABBREVIATIONS

A

AEBM	Advanced Engineering Building Module
ALOHA	Areal Locations of Hazardous Atmospheres
ASCE	American Society of Civil Engineers
ASFPM	Association of State Floodplain Managers
ATC	Applied Technology Council
BFE	Base Flood Elevation
BIT-MH	Building Information Tool - Multi-Hazard
BTS	Bureau of Transportation Statistics
CCTV	closed circuit television
CD-ROM	compact disk-read only memory
CFR	Code of Federal Regulations
CREW	Cascadia Region Earthquake Workgroup
DEM	Digital Elevation Model
DFIRM	Digital Flood Insurance Rate Map
DHS	Department of Homeland Security
DMA 2000	Disaster Mitigation Act of 2000
DOGAMI	Oregon Department of Geology and Mineral Industries
DOT	United States Department of Transportation
DVD-ROM	digital video disk-read only memory
EMA	Emergency Management Agency
EOC	Emergency Operations Center

EOP	Emergency Operations Plan
EPA	U.S. Environmental Protection Agency
ESMP	Enhanced State Mitigation Plan
ESRI	Environmental Systems Research Inc.
FCC	Federal Communications Commision
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FLDWAV	Floodwav
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FIT	Flood Information Tool
FPMP	Floodplain Management Plan
FPI	Fire Potential Index
GIS	Geographic Information System
GB	gigabyte
GHz	gigahertz
HazMat	Hazardous Material
HAZUS	Hazards U.S.
HAZUS-MH	Hazards U.S. - Multi-hazard
HGMP	Hazard Grant Mitigation Program
HUG	HAZUS-MH User Group
HVAC	Heating, Ventilation, and Air Conditioning

IBC	International Building Code
InCAST	Inventory Collection and Survey Tool
Lat/Long	Latitude/Longitude
LEPC	Local Emergency Planning Committee
LMP	Local Mitigation Plan
LOJIC	Louisville/Jefferson County Information Center
LRT	Locational Reference Tables
MB	megabyte
MMI	Multi-hazard Mapping Initiative (or Map Modernization Initiative)
MRP	mean return period
MPH	miles per hour
N/A	not applicable
NEHRP	National Earthquake Hazard Reduction Program
NIBS	National Institute of Building Sciences
NFDRS	National Fire Danger Rating System
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OEM	Office of Emergency Management
OMB	Office of Management and Budget
PGA	peak ground acceleration
PGD	peak ground displacement

Q3	digital quality level 3 flood data
RAM	Random Access Memory
RAT	Risk Assessment Tool
SFHA	Special Flood Hazard Area
SHMO	State Hazard Mitigation Officer
SSMP	Standard State Mitigation Plan
STAPLEE	Social, Technical, Administrative, Policy, Legal, Economic, Environmental
TIN	Triangular Irregular Network
TRI	Toxic Release Inventory
U.S.	United States of America
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	United States Geological Survey

APPENDIX B: GLOSSARY OF TERMS

100-year flood. A flood that has a 1 percent chance of occurring in any given year. A 100-year flood is also referred to as a base flood.

500-year flood. A flood that has a 0.2 percent chance of occurring in any given year.

Aggregate data. Data gathered together in an area such as a Census tract.

Areal Locations of Hazardous Atmospheres (ALOHA). A computer program that uses information that you provide along with physical property data from its extensive chemical library to predict how a hazardous gas cloud might disperse in the atmosphere after an accidental chemical release. ALOHA can predict rates of chemical release from broken gas pipes, leaking tanks, and evaporating puddles, and it can model the dispersion of both neutrally buoyant and heavier-than-air gases.

Asset. Any manmade or natural feature that has value, including people; buildings; infrastructure such as bridges, roads, and sewer and water systems; lifelines such as electricity and communication resources; and environmental, cultural, or recreational features such as parks, dunes, wetlands, and landmarks.

Base flood. A flood that has a 1 percent probability of being equaled or exceeded in any given year. It is also known as the 100-year flood.

Base Flood Elevation (BFE). The elevation of the base flood in relation to a specified datum such as the National Geodetic Vertical Datum of 1929. The BFE is used as the standard for the National Flood Insurance Program (NFIP).

Building. A structure that is walled, roofed, principally above ground, and permanently affixed to a site. The term also applies to a manufactured home on a permanent foundation on which the wheels and axles carry no weight.

Critical facility. Facilities that are critical to the health and welfare of the population and that are especially important following hazard events. Critical facilities include essential facilities, transportation systems, lifeline utility systems, high potential loss facilities, and hazardous material facilities.

Dam failure. A breach of a dam that can occur for a number of reasons, such as flash flooding, inadequate spillways, mechanical failure of valves or other equipment, rodent activities (in earthen dams), freezing and thawing cycles, earthquakes, and intentional destruction.

Debris. The scattered remains of assets broken or destroyed in a hazard event. Debris caused by a wind or water hazard event can result in additional damage to other assets.

Digital elevation model (DEM). A data file that contains digital representations of cartographic information in a raster form. DEMs consist of a sampled array of elevations for a number of ground positions at regularly spaced intervals. These digital data files are produced by the U.S. Geological Survey (USGS) as part of the National Mapping Program.

Digital quality level 3 flood data (Q3). Digital representations of certain features of Flood Insurance Rate Maps (FIRMs). Digital Q3s are intended for use with desktop mapping and geographic information system (GIS) technology.

The Disaster Mitigation Act of 2000 (DMA 2000). A law that encourages and rewards local and state pre-disaster planning, promotes sustainability as a strategy for disaster resistance, and is intended to integrate state and local planning with the aim of strengthening statewide mitigation planning.

Displacement time. The average time (in days) that a building's occupants typically must operate from a temporary location while repairs are being made to the building because of damages resulting from a hazard event.

Drought. A period of time without substantial rainfall that persists from one year to the next. Droughts can affect large areas and can range in scope from a few counties to several states. Along with decreasing water supplies for human consumption and use, droughts can damage or destroy crops, grazing land, edible plants, and trees.

Duration. How long a hazard event lasts.

Earthquake. A sudden motion or trembling of the earth's crust that is caused by a release of strain accumulated within or along the edge of the earth's tectonic plates.

Erosion. Wearing away of the land surface by means of detachment and movement of soil and rock fragments. Erosion occurs during a flood or storm or over a period of years through the action of wind, water, or geologic processes.

Erosion hazard area. An area of land anticipated to be lost to shoreline recession over a given period of time. The projected inland extent of the area is measured by multiplying the average annual long-term recession rate by a given number of years.

Essential facility. A facility that is important to a full recovery of a community or state following a hazard event. Essential facilities include government functions; major employers; banks; schools; and certain commercial establishments such as grocery stores, hardware stores, and gasoline stations.

Extent. The size of an area affected by a hazard or hazard event.

Federal Emergency Management Agency (FEMA). An independent agency created in 1978 to provide a single point of accountability for all Federal activities related to disaster mitigation and emergency preparedness, response, and recovery. FEMA is now a part of the Department of Homeland Security.

Fire Potential Index (FPI). Developed by USGS and the U.S. Forest Service (USFS) to assess and map the fire hazard potential over broad areas. Based on geographic information, makers of national policy and fire managers have established priorities for prevention activities in a defined area to reduce the risk of manmade fire and wildfire ignition and spread. Prediction of a fire hazard shortens the time between fire ignition and initial emergency response by enabling fire managers to pre-allocate and stage suppression forces for high fire risk areas.

Flash flood. A flood event occurring with little or no warning where water levels rise extremely quickly.

Flood. A general and temporary condition of partial or complete inundation of normally dry land areas resulting from (1) overflow of inland or tidal waters, (2) unusual and rapid accumulation or runoff of surface waters from any source, or (3) mudflows or the sudden collapse of shoreline land.

Flood depth. The height of the flood water surface above the ground surface.

Flood elevation. The elevation of the flood water surface above an established datum such as the National Geodetic Vertical Datum of 1929, the North American Vertical Datum of 1988, or mean sea level.

Flood hazard area. The area shown to be inundated by a flood of a given magnitude on a map.

Flood Information Tool (FIT). A tool designed to process and convert locally available flood information into data that can be used by the Hazards U.S. (HAZUS) flood module. The FIT is a system of instructions, tutorials, and GIS scripts. When provided with user-supplied inputs (e.g., ground elevations, flood elevations, and floodplain boundary information), the FIT calculates flood depths and elevations for riverine and coastal flood hazards.

Flood Insurance Rate Map (FIRM). A map of a community prepared by FEMA that shows both special flood hazard areas and the risk premium zones applicable to the community.

Flood Insurance Study (FIS). A study that provides an examination, evaluation, and determination of flood hazards and, if appropriate, corresponding water surface elevations in a community or communities.

Floodplain. Any land area, including any watercourse, that is susceptible to partial or complete inundation by water from any source.

Frequency. A measure of how often events of a particular magnitude are expected to occur. Frequency describes how often a hazard of a specific magnitude, duration, or extent typically occurs. Statistically, a hazard with a 100-year recurrence interval is expected to occur once every 100 years on average and has a 1 percent chance (its probability) of happening in any given year. The reliability of frequency information varies depending on the kind of hazard being considered.

Fujita scale of tornado intensity. A scale that rates tornadoes with numeric values ranging from F0 to F5 based on wind speed and damage sustained. An F0 rating indicates minimal damage such as broken tree limbs or signs, while an F5 indicates severe damage.

Geographic Information System (GIS). A computer software application that relates physical features on the earth to a database to be used for mapping and analysis.

Hailstorm. A storm of spherical balls of ice. Hail is a product of thunderstorms or intense showers. It is generally white and translucent, consisting of liquid or snow particles encased with layers of ice. Hail is formed within the high portion of a well-organized thunderstorm. When hailstones become too heavy to be caught in an updraft and carried back into the clouds of a thunderstorm (hailstones can be caught in numerous updrafts, adding a coating of ice to the original frozen droplets each time), they then fall as hail, and a hailstorm occurs.

Hazard. A source of potential danger or adverse conditions. Hazards in this How-To Guide include natural events such as floods, earthquakes, tornadoes, tsunamis, coastal storms, landslides, and wildfires that strike populated areas. A natural event is a hazard when it has the potential to harm people or property.

Hazard event. A specific occurrence of a particular type of hazard.

Hazard identification. The process of identifying the hazards that threaten an area.

Hazard mitigation. Sustained actions taken to reduce or eliminate the long-term risks associated with hazards and their effects.

Hazardous material facilities. Facilities housing hazardous materials such as corrosives, explosives, flammable materials, radioactive materials, and toxins.

Hazard profile. A description of the physical characteristics of hazards and a presentation of various hazard descriptors, including magnitude, duration, frequency, probability, and extent. In most cases, a community can most easily use these descriptors when they are displayed on maps.

Hazards U.S. (HAZUS). A GIS-based, nationally standardized earthquake loss estimation tool developed by FEMA.

Hazards U.S. – Multi-Hazard (HAZUS-MH). A GIS-based, nationally standardized earthquake, flood, and wind loss estimation tool developed by FEMA.

HAZUS-MH analysis. An analysis involving use of default data or local data integrated in HAZUS-MH and performed using a computer. This analysis is used for earthquake, flood, and wind hazards if they are priority concerns in a study region.

HAZUS-MH-driven analysis. An analysis involving use of inventory data in HAZUS-MH combined with knowledge about potentially exposed areas or expected impact areas and knowledge of the likelihood of hazard event occurrence.

High potential loss facilities. Facilities that would present a high loss if they were damaged by a hazard event. These facilities include nuclear power plants, dams, and military installations.

Hurricane. An intense tropical cyclone formed over warm ocean areas. Hurricane winds reach 74 miles per hour or more and blow in a large spiral around a relatively calm center or "eye." Hurricanes develop over the north Atlantic Ocean, the northeast Pacific Ocean, or the south Pacific Ocean east of 160° east longitude. Hurricane circulation is counter-clockwise in the northern hemisphere and clockwise in the southern hemisphere.

Hydraulics. A branch of science or engineering that addresses fluids (specially water) in motion, water's action in rivers and channels, the works of machinery for raising water, water's use as a prime mover, and the like.

Hydrology. A branch of science of dealing with the waters of the earth. A flood discharge is examined in a hydrologic study.

Infrastructure. The public services of a community that have a direct impact on the quality of life. Infrastructure includes communication technologies (e.g., telephone lines and Internet access); vital services (e.g., public water supplies and sewer treatment facilities); transportation system components (e.g., airways, airports, and heliports); highways, (e.g., bridges, tunnels, roadbeds, overpasses, railways, rail yards, and depots); and waterways (e.g., canals, locks, seaports, ferries, harbors, drydocks, piers, and regional dams).

Intensity. A measure of the effects of a hazard event at a particular place.

Inventory. The assets identified in a study region.

Loss estimation. Estimation of potential losses by assigning hazard-related costs and losses to inventory data such as data for populations, building stocks, transportation and utility lines, regulated facilities, and more). HAZUS-MH can estimate economic and social losses based on a specific hazard event. Loss estimation is essential to decision-making at all levels of government and provides a basis for developing mitigation plans and policies. Loss estimation also supports planning for emergency preparedness, response, and recovery.

Lowest floor. Under the National Flood Insurance Program (NFIP), the lowest floor of the lowest enclosed area (including the basement) of a structure.

Magnitude. A measure of the strength of a hazard event. The magnitude (also referred to as the severity) of a given hazard event is usually determined using technical measures specific to the hazard.

Mitigation plan. A document presenting a systematic evaluation of the nature and extent of an area's vulnerability to the effects of natural hazards and a description of actions to minimize future vulnerability to hazards.

National Flood Insurance Program (NFIP). A Federal program created by Congress in 1968 that makes flood insurance available in communities that enact minimum floodplain management regulations presented in 44 Code of Federal Regulations (CFR) §60.3.

National Weather Service (NWS). An agency that prepares and issues flood, severe weather, and coastal storm warnings and that can provide technical assistance to Federal and State entities for preparing weather and flood warning plans.

Outflow. The flow of water resulting from the inundation of an area. An outflow's strong currents rip at structures, pound them with debris, and erode beaches and coastal structures.

Parametric model. A model related to or designed in terms of a parameter.

Pilot projects. HAZUS-MH projects being conducted in several FEMA regions to demonstrate the value and benefits of using HAZUS-MH for the risk assessment portion of the all-hazards mitigation plans required by DMA 2000. The pilot projects demonstrate the value of using HAZUS-MH to evaluate and analyze natural hazards that states or communities might address in their DMA planning process. The pilot projects also demonstrate that HAZUS-MH can provide defensible cost and loss estimates by virtue of the automated engineering and scientific risk calculations included in the software.

Planimetric map. A map that shows only manmade features such as buildings.

Planning. The act or process of making plans and establishing goals, policies, and procedures for a social or economic unit.

Probability. A statistical measure of the likelihood that a hazard event will occur.

Recurrence interval. The time between hazard events of similar size at a given location. The recurrence interval is based on the probability of a given event being equaled or exceeded in any given year.

Repetitive loss property. An insured property for which two or more NFIP losses (occurring more than 10 days apart) of at least $1,000 each have been paid within any 10-year period since 1978.

Replacement value. The cost of rebuilding a structure. This is usually expressed in terms of cost per square foot and reflects the present-day cost of labor and materials to construct a building of a particular size, type, and quality.

Risk. The estimated impact that a hazard event would have on people, services, facilities, and structures in a community, or the likelihood of a hazard event resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate, or low likelihood of damage being sustained above a particular threshold as a result of a specific type of hazard event. Risk also can be expressed in terms of potential monetary losses associated with the intensity of the hazard event.

Risk assessment. A methodology used to assess potential exposures and estimated losses associated with likely hazard events. The HAZUS-MH risk assessment process includes four steps: identifying hazards, profiling hazard events, inventorying assets, and estimating losses.

Riverine. Related to or produced by a river.

Scale. A proportion used in determining a dimensional relationship. A scale is the ratio of the distance between two points on a map and the actual distance between the two points on the earth's surface.

Scour. Erosion of soil or fill material by the flow of flood waters. The term is frequently used to describe storm-induced, localized, conical erosion around pilings and other foundation supports where the obstruction of flow increases turbulence.

Special Flood Hazard Area (SFHA). An area within a floodplain having a 1 percent or greater chance of flood occurrence in any given year (a 100-year floodplain). An SFHA is represented on a FIRM by darkly shaded areas with zone designations that include the letter A or V.

Stafford Act. The Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law [PL] 100-107). The act was signed into law on November 23, 1988, and amended the Disaster Relief Act of 1974 (PL 93-288). The Stafford Act is the statutory authority for most Federal disaster response activities, especially as they pertain to FEMA and its programs.

State Hazard Mitigation Officer (SHMO). The representative of a state government who is the primary point of contact with FEMA, other Federal and State agencies, and local units of government in the planning and implementation of pre- and post-disaster mitigation activities.

Structure. Something constructed (see Building).

Substantial damage. Damage sustained by a structure in an SFHA for which the cost of restoring the structure to its before-damage condition would equal or exceed 50 percent of the market value of the structure before the damage.

Topographic. A map that shows natural features and indicates the physical shape of the land using contour lines. A topographic map may also include manmade features.

Tornado. A violently rotating column of air extending from a thunderstorm to the ground.

Transportation systems. The lifeline systems that include airways (airports and heliports), highways (bridges, tunnels, roadbeds, overpasses, and transfer centers); railways (tracks, tunnels, bridges, rail yards, and depots), and waterways (canals, locks, seaports, ferries, harbors, drydocks, and piers).

Triangular Irregular Network (TIN). A terrain model constructed using adjacent non-overlapping triangles and created based on irregularly spaced points with x, y, and z values.

Utility systems. The lifeline systems that include potable water, wastewater, oil, natural gas, electric power, and communication systems.

Vulnerability. How exposed or susceptible to damage an asset is. Vulnerability depends on an asset's construction, its contents, and the economic value of its functions. Like indirect damages, the vulnerability of one element of a community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power; if an electrical substation is flooded, not only will the substation itself be affected, but a number of businesses as well. Indirect effects can often be much more widespread and damaging than direct ones.

Vulnerability assessment. An assessment of the extent of injury and damage that may result from a hazard event of a given intensity in a given area. The vulnerability assessment should address the impacts of hazard events on both existing and future conditions.

Water displacement. The displacement of a column of water above a large mass of earth on the ocean bottom that sinks or uplifts. Such displacement can form tsunamis. The rate of displacement, the motion of the ocean floor at the epicenter, the amount of displacement in the rupture zone, and the depth of water above the rupture zone all contribute to the intensity of the tsunamis.

Watershed. An area of land that drains downslope to the lowest point. The water moves through a network of drainage pathways, both underground and on the surface. Generally these pathways converge into streams and rivers that become progressively larger as the water moves downstream, eventually reaching an estuary and an ocean.

Zone. A geographic area shown on a FIRM that reflects the severity or type of flooding in the area.

C

JOB AID 1: DMA 2000 REQUIREMENTS AND HAZUS-MH RESOURCES

Requirements for Standard State Mitigation Plan (SSMP) §201.4	Additional Requirements for Enhanced State Mitigation Plan (ESMP) §201.5 And Local Mitigation Plan (LMP) §201.6	HAZUS-MH and Other Resources
A. Plan Requirement		
SSMP- Due date is November 1, 2004* SSMP includes the requirements of the Hazard Mitigation Grant Program (HMGP) Administrative Plan. In order for a state to be eligible for HMGP funding based on 15 percent of the total estimated eligible Stafford Act disaster assistance, the Federal Emergency Management Agency (FEMA) must approve the SSMP by November 1, 2004. SSMPs must be updated every 3 years.	ESMP- Due date is November 1, 2004* ESMP increase eligibility for HMGP funding from 15 to 20 percent of available funding. ESMPs must demonstrate that the state (§201.5[a]): • Has developed a comprehensive mitigation program • Makes effective use of available mitigation funding • Is capable of managing the increased funding LMP- Due date is November 1, 2004* LMPs must be updated every 5 years. Multi-jurisdictional plans can be used as long as each jurisdiction participates in the process and officially adopts the plan. Statewide plans will not be accepted as multi-jurisdictional plans. Up to 7 percent of mitigation funding can be used to support planning, including LMP development.	DMA 2000: State and Local Plan Interim Criteria and Mitigation Planning Workshop for Local Governments: http://www.fema.gov/fima/planning8.shtm HAZUS-MH Software, User Manuals, and Other Products: http://www.fema.gov/hazus/
B. Planning Process		
SSMP- Includes coordination with other State agencies, appropriate Federal agencies, interested groups, and integration, to the extent possible, with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.	ESMP- Same requirements as SSMP. LMP- Additional requirements include: (1) opportunity for public to comment on the LMP during development and before approval; (2) opportunity for involvement by neighboring communities, local and regional agencies supporting hazard mitigation and development activities, and businesses, academia, and other private and non-profit interests; and (3) review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.	Using HAZUS-MH in Local Government Planning: http://www.fema.gov/hazus/dl_hazgov.shtm How to Create A HAZUS User's Group, April 2002, FEMA 404: http://www.fema.gov/hazus/us_main.shtm
C. Plan Content		
1. Planning Process Description		
SSMP- Describes the planning processes used to prepare the plan, including: • How the plan was prepared • Who was involved • How other agencies participated	ESMP- Additional requirements include demonstrating integration to the extent practicable with (1) other State and/or regional planning initiatives (comprehensive growth management, economic development, capital improvement, land development, and/or emergency management plans) and (2) FEMA mitigation programs and initiatives that provide guidance to State and regional agencies. (§201.5[b][1]) LMP: Additional requirements include describing how the public was involved.	HAZUS Frequently Asked Questions: http://www.fema.gov/hazus/fq_main.shtm For more help with HAZUS-MH, get contact information from: http://www.fema.gov/hazus/ct_main.shtm

* Note – FEMA extended the deadline for 1 year.

<table>
<tr><th colspan="3">2. Risk Assessments</th></tr>
<tr>
<td>SSMP- Includes:

• A statewide risk assessment that provides a "statewide overview" characterization and analysis of potential natural hazards and associated risks.

• Comparison of potential losses throughout the State to determine priorities for implementing mitigation measures (item 3 below) and prioritize jurisdictions for technical and financial support in developing more detailed local risk and vulnerability assessments.

The risk assessment shall include:

i. Overview of Hazards
Types and locations of hazards, past occurrences, and probability of future events, using maps, as appropriate.

ii. Overview and Analysis of Vulnerability
Overview and analysis of the State's vulnerability to the hazards based on estimates provided in local risk assessments as well as the State risk assessment. The State will describe vulnerability in terms of the jurisdictions most threatened by the identified hazards and most vulnerable to damage and loss associated with hazard events. State-owned or operated critical facilities in the hazard areas also will be addressed.

iii. Overview and Analysis of Potential Losses
Identification of vulnerable structures and estimate of potential dollar losses to State-owned or -operated buildings, infrastructure, and critical facilities located in the identified hazards areas (based on LMPs and State risk assessment).</td>
<td>ESMP- Same requirements as SSMP.

LMP- (i) Overview of Hazards and (ii) Summary of Each Hazard and its Impacts, including:

(a) Types and number of existing and future buildings, infrastructure, and critical facilities in the identified hazard areas;

(b) Estimate of potential dollar losses and description of how estimate was prepared (similar to item iii for SSMPs);

(c) General description of local land use and development trends so that mitigation options can be considered in future land use decisions.

For multi-jurisdictional plans, the risk assessment section must assess each jurisdiction's risks where they vary from the risks facing the entire planning area.</td>
<td>State and Local Mitigation Planning How-to Guide, Understanding Your Risks; Identifying Hazards and Estimating Losses, 2001, FEMA 386-2: http://www.fema.gov/fima/planning_toc3.shtm

HAZUS-MH software - addresses earthquake, flood, and wind (hurricane) hazards. Methodology can also be applied to other hazards. Features include:

• User's manuals for each hazard

• Census, historic hazard event, and building and critical infrastructure default data

• GIS open architecture and input tools to allow local data integration

• Capability to estimate potential losses for infrastructure and injury

• Ability to evaluate multiple risk scenarios

• Data presentation tools (maps and tables)

Case studies of using HAZUS-MH: http://www.fema.gov/hazus/cs_main.shtm

Compendium of Pilot Projects: Using HAZUS-MH for Risk Assessment (FEMA 463)

How-to Guide and Training Course: How-to Use HAZUS for Risk Assessment (FEMA 433 and E296)

Additional HAZUS-MH National Training course information: http://www.fema.gov/hazus/tr_main.shtm

To request Regional Training, contact: John.Ingargiola@dhs.gov</td>
</tr>
</table>

3. Mitigation Strategy		
SSMP- Documents the following elements of strategy i. State Goals Describes the State goals to guide the selection of mitigation activities to reduce potential losses identified in Item 2 above. ii. State Mitigation Programs Presents the State's pre- and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: • An evaluation of State laws, regulations, policies, and programs related to hazard mitigation and related to development in hazard-prone areas • A discussion of State funding capabilities for hazard mitigation projects • A general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities iii. Analysis Identifies, evaluates, and prioritizes cost-effective, environmentally sound, and technically feasible mitigation actions and activities that the State is considering and explains how each activity contributes to the overall mitigation strategy. Also, this section should link to LMPs, where specific local actions and projects are identified. iv. Funding Identifies current and potential sources of Federal, State, local, or private funding to implement mitigation activities.	ESMP- Also should address the following Project Implementation Capability (§201.5[b][2]) Documents project implementation capability, identifying and demonstrating the ability to implement the plan, including i. Eligibility Criteria Present established eligibility criteria for multi-hazard mitigation measures. ii. Mitigation Actions A system to determine the cost-effectiveness of mitigation measures, consistent with Office of Management and Budget (OMB) Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, and to rank the measures according to the State's eligibility criteria. iii. HMGP Management Demonstration that the State has the capability to effectively manage the HMGP as well as other mitigation grant programs, including a record of the following: a. Meeting HMGP and other mitigation grant application timeframes and submitting complete, technically feasible, and eligible project applications with appropriate supporting documentation; b. Preparing and submitting accurate environmental reviews and benefit-cost analyses; c. Submitting complete and accurate quarterly progress and financial reports on time; and d. Completing HMGP and other mitigation grant projects within established performance periods, including financial reconciliation. iv. Mitigation Assessment A system and strategy by which the State will conduct an assessment of completed mitigation actions and include a record of the effectiveness (actual cost avoidance) of each mitigation action. LMP- Provides the blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs, resources, and local ability to expand on and improve these existing tools. Same content as SSMP, but presented in the HAZUS-MH following subsections focusing on the local level: (1) mitigation goals, (2) mitigation actions, and (3) action plans. For multi-jurisdictional plans, actions must be specific to the jurisdiction requesting FEMA approval or credit of the plan.	*A Guide to Using HAZUS for Mitigation*, April 2002: http://www.fema.gov/hazus/dl_guide.shtm HAZUS supports analyses to assist in prioritizing mitigation measures. Examples are provided below: • Comparison of costs and benefits (reduced potential losses) with various mitigation assumptions used for a hazard • Evaluation of costs and benefits of alternate projects • Assessing potential loss estimates assuming different growth rates (as recommended by Section 322) • Analysis of impacts of various model ordinances HAZUS-MH Wizards are available on the web site above to assist users with common functions (e.g., the Risk Assessment Tool and Flood Wizard are available as third-party models to support HAZUS-MH implementation)

4. Coordination of Local Mitigation Planning		
SSMP - Includes: i. Funding Describes State process to support, through funding and technical assistance, the development of LMPs. ii. Timeframe Describes the State process and timeframe by which the LMPs will be reviewed, coordinated, and linked to the State Mitigation Plan. iii. Prioritization Criteria Describes the criteria to be used in prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs, which should include consideration for communities with the highest risks, repetitive loss properties, and most intense development pressures. Further, for non-planning grants, a principal criterion for prioritization will be the extent to which benefits are maximized according to a benefit/cost review of proposed projects and their associated costs.	ESMP- Also demonstrates State's commitment to a comprehensive State mitigation program (§201.5[b][4]), which can include any of the following: i. Local Support A commitment to support local mitigation planning by providing workshops and training, State planning grants, or coordinated capability development of local officials, including Emergency Management and Floodplain Management certifications. ii. Statewide Support A Statewide program of hazard mitigation through the development of legislative initiatives, mitigation councils, formation of public/private partnerships, and/or other executive actions that promote hazard mitigation. iii. State Funding State provision of a portion of the non-Federal match for HMGP and/or other mitigation projects. iv. Building Code Standards To the extent allowed by State law, the State requires or encourages local governments to use a current version of a nationally applicable model building code or standard that addresses natural hazards as a basis for design and construction of State-sponsored mitigation projects. v. Multi-year Plan A comprehensive, multi-year plan to mitigate the risks posed to existing buildings that have been identified as necessary for post-disaster response and recovery operations. vi. Post-disaster Recovery A comprehensive description of how the State integrates mitigation into its post-disaster recovery operations. LMP- §201.6 does not require a separate section to address local coordination; however, the need for local coordination is clearly documented in the rule. The LMP should clearly document coordination processes; this could be included in section C.1 (above) or included as a separate section on coordination (as required for the SSMP and EMP). Multi-jurisdictional LMPs must document coordination across jurisdictions.	HAZUS-MH stores data from a variety of sources and programs to support cross-agency and program coordination. If used at both State and local levels, HAZUS-MH will allow the LMPs to be more readily integrated into the State planning process.

5. Plan Maintenance Process		
SSMP - Includes: i. Method and schedule for monitoring, evaluating, and updating the plan. ii. A system for monitoring implementation of mitigation measures and project closeouts. iii. A system for reviewing progress toward goals as well as activities and projects identified in Item 3.	ESMP- Same requirements as SSMP. LMP- Describes: i. The method and schedule of monitoring, evaluating, and updating the LMP within a 5-year cycle ii. The process for incorporating the requirements of the LMP into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate iii. How the community will continue public participation in the LMP maintenance process. Annual reviews of the plan are recommended.	HAZUS-MH software facilitates data maintenance. It also supports the creation of output maps and reports to present data and findings. This supports consistent formats and updates of plans and communication of findings and plans to stakeholders.
6. Plan Adoption Process Documents formal adoption by the State before submittal to FEMA for final review and approval.	ESMP- Same as SSMP. LMP- Documents LMP adoption by the appropriate local government body. For multi-jurisdictional plans, each jurisdiction requesting plan approval must document adoption. LMP must identify specific projects if funding is requested.	Not applicable.
7. Assurances Includes state assurance of compliance with all applicable Federal statutes and regulations in effect for the periods for which it receives grant funding, in compliance with 44 Code of Federal Regulations (CFR) 13.11(c). The SSMP will be amended whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d).	ESMP- Should also include a demonstration that the State effectively uses existing mitigation programs to achieve its mitigation goals. ((§201.5[b][3]) LMP- Although a specific section on assurances is not identified for LMPs, assurance regarding use of the LMP to achieve mitigation goals and regulatory compliance are inferred by the rule and a section should be included.	Not applicable.
D. Review and Updates		
SSMP- Plans for review and revision should reflect changes in development, progress in Statewide mitigation efforts, and changes in priorities. Revisions will be resubmitted to the appropriate Regional Director every 3 years. The Regional review will be completed within 45 days after receipt from the State, whenever possible. Note: Although not a requirement, FEMA also encourages States to review their plans in the post-disaster timeframe to reflect changing priorities.	ESMP- Same cycle as SSMPs. LMP- The LMP must be submitted to the State Hazard Mitigation Officer for initial review and coordination. The State then sends the LMP to the appropriate FEMA Regional Office for formal review and approval. The review process occurs as follows: • The Regional review will be completed within 45 days after receipt from the State, whenever possible. • Plans must be reviewed, revised if appropriate, and resubmitted for approval within 5 years in order to continue to be eligible for HMGP project grant funding. • For States with managing authority, (that is, States with delegated approval authority for local mitigation plans), FEMA approval will not be required. Instead, States use the criteria in this part to review each LMP within 45 days of receipt, whenever possible, and provide a copy of the approved plans to the FEMA Regional Office.	HAZUS-MH reflects a standard methodology developed by FEMA; therefore, HAZUS-MH can be used for reviewing and updating your risk assessment to support the mitigation plan.

References: Federal Register, Volume 67, No. 38, February 26, 2002 and Federal Register, Volume 67, No. 190, October 1, 2002.

D

JOB AID 2-1: LEVELS OF HAZUS-MH ANALYSIS: INPUTS, USES, AND OUTPUTS

HAZARD TYPE				
EARTHQUAKE	**FLOOD (RIVERINE)**	**FLOOD (COASTAL)**	**HURRICANE**	**OTHER HAZARDS**
Level 1 Analysis – create a study region, select a scenario, run a scenario, and get results.				
Inputs: No additional data required for this analysis. Soil type is assumed to be stiff soil (Type D as classified by the National Earthquake Hazards Reduction Program [NEHRP]). Level 1analysis assumes no liquefaction and no landslide susceptibility. Note: water depth is not important if no liquefaction potential is assumed. **Use:** Practical for larger areas (county or multi-county), such as statewide risk assessment efforts, and for general prioritization of jurisdictions by potential loss. **Outputs:** Ground shaking and loss estimates (see Job Aid 4-1 in Appendix F).	**Inputs**: Download USGS Digital Elevation Model (DEM) data (available from http://seamless.usgs.gov/) for all watersheds that intersect the boundary of your study region (even if the majority of that watershed lies outside your study region). Generate a stream network, which is a collection of all reaches capable of causing flooding; then use this to specify a drainage area (the minimum area you can specify is 1 square mile). Then you can select a scenario; for the flood hazards, this is called a flood case study. **Use:** Practical for larger areas. (county or multi-county) **Outputs:** Discharge frequency curve, flood depth (done within HAZUS-MH), and loss estimates (see Job Aid 4-3 in Appendix F)	**Inputs:** DEM and geometry of the 100-year still water area. You also can specify the type of coastal characteristics you have (wetlands, protected by rigid structures, or sandy, beaches, and small dunes). You also need to determine the still water elevation. **Use:** Practical for larger areas. **Outputs:** Discharge frequency curve, dune erosion, flood-prone areas, flood depth due to surge (done within HAZUS-MH), and loss estimates (see Job Aid 4-3 in Appendix F)	**Inputs:** None required. Level 1 analysis includes a surface roughness map and a tree map (vegetation map). You can select Census block or tract level analysis. **Use:** Recommended for analysis of either large or small areas. **Outputs:** Wind speed and loss estimates (see Job Aid 4-2 in Appendix F).	Third party models provided with HAZUS-MH or being considered to supplement HAZUS-MH can support the evaluation of other hazards. The **ALOHA model** is a third-party model. This tool allows modeling of chemical release events as air dispersion plumes. **FLOODWAV** is a third-party model that can assist in modeling dam breach impacts. The outputs of these models (hazard areas) can be overlain with inventory data to assess exposure. Other models may be added over time or can be used by knowledgeable parties.

HAZARD TYPE				
EARTHQUAKE	**FLOOD (RIVERINE)**	**FLOOD (COASTAL)**	**HURRICANE**	**OTHER HAZARDS**
Level 2 Analysis – create a study region, refine HAZUS-MH provided data, select a scenario, run a scenario, and get results.				
Inputs: Additional hazard data including: • NEHRP soil type map • Liquefaction susceptibility map • Landslide susceptibility map • Water depth map You also will integrate your improved inventory data, as available. **Use:** Recommended for earthquake-prone areas, where regional or local data for the above items can be obtained. Modeling can then be targeted to smaller geographic areas. **Outputs:** Ground shaking, ground failure, and refined loss estimates (see Job Aid 4-1).	**Inputs**: You will use the Flood Information Tool (FIT) to add locally collected flood and terrain data (USGS DEM/topographic data can be used). Data you will need for FIT include: • DEM • Flood-prone areas (FIRM, DFIRM, Q3, and base flood elevation at different cross sections). Also, you will need updated inventory data (focusing on refining first floor elevation data for buildings and inventory in flood zone areas). **Use:** Level 2 is designed for localized flood analysis (city or smaller) and is not recommended for large areas; use Level 1 or the flood macro (see **Other Options**, below) for large areas. **Outputs:** Discharge frequency, flood depth (done in FIT), and refined loss estimates (see Job Aid 4-3).	**Inputs:** To run a Level 2 analysis you will improve inventory data. You also can refine the 100-year still water boundary (optional). You can refine the shoreline location. **Use:** Can be used for large or small areas. **Outputs:** Discharge frequency curve, dune erosion, flood-prone areas, flood depth due to surge (done within HAZUS-MH), and refined loss estimates (see Job Aid 4-2).	**Inputs:** You may want to refine the surface roughness and vegetation (tree cover) maps, both of which are compiled at the Census tract level in the HAZUS-MH provided data. If you improve these layers data (to the block level), you can take advantage of the model's block-level aggregation level. You also will improve the inventory data to the extent feasible. **Use:** Can be used for large or small areas; block-based analysis will slow your processing time, but is recommended when you need loss detail at that level. **Outputs:** Wind speed and refined loss estimates (see Job Aid 4-1).	Third party models provided with HAZUS-MH or being considered to supplement HAZUS-MH can support the evaluation of other hazards. For a Level 2 analysis, you will use updated inventory data. See text under Level 1 for a brief description of the **ALOHA** and **FLOODWAV** models.

HAZARD TYPE				
EARTHQUAKE	**FLOOD (RIVERINE)**	**FLOOD (COASTAL)**	**HURRICANE**	**OTHER HAZARDS**
Level 3 Analysis - create a study region, refine HAZUS-MH provided data, adjust model parameters, select a scenario, run a scenario, and get results.				
Use: A Level 3 analysis can be used to study mitigation alternatives, including benefit/cost analyses. **Inputs:** Refined data and a strong understanding of each model are needed. In addition, experts that understand the hazard damage functions will be required. **Outputs:** Benefit/cost results and mitigation strategy-related loss estimates.				See text under Level 1 for a brief description of the **ALOHA** and **FLOODWAV** models.
Other Options – tools to assist your analyses and use of scenario data.				
A HAZUS-MH Risk Assessment Tool (RAT) has been developed to support review of loss estimate outputs. The RAT is a third-party model that can be used after your scenarios are run. The tool supports the development of outputs that address the items recommended for inclusion in your risk assessment as part of DMA 2000.	A HAZUS-MH RAT has been developed to support review of loss estimate outputs (see earthquake description). A Flood Wizard model has been developed as a third-party complement to HAZUS-MH. The Flood Wizard provides county or regional flood results using DEM and flood polygon data. Also, the flood module of HAZUS-MH allows mitigation option analysis for the Level 1 and 2 stages of analysis. Options include levees, different first floor building elevations, and upstream storage measures (dams, retention ponds, and diversions).	A HAZUS-MH RAT has been developed to support review of loss estimate outputs (see earthquake description). A Flood Wizard model has been developed as a third-party complement to HAZUS-MH. The Flood Wizard provides county or regional flood results using DEM and flood polygon data. Also, the flood module of HAZUS-MH allows mitigation option analysis for options such as different first floor building elevations.	A HAZUS-MH RAT has been developed to support the review of loss estimate outputs (see earthquake description). Also, the hurricane module supports mitigation analysis for simple mitigation options related to single- and multi-family dwellings.	Other models are being considered for use in conjunction with HAZUS-MH. Also, the inventory data in HAZUS-MH can be overlain with a variety of hazard area maps to assess exposure (see also, Step 4., Estimate Losses).

JOB AID 2-2: HAZARD DATA SOURCES

Hazard	Hazard Maps	Hazard Sources for Data
Multiple	Various maps and hazard event data	A recommended first resource is http://www.hazardmaps.gov. This web site is part of a FEMA multi-hazard mapping initiative. The web site includes information for hazards indicated with a * below.
Earthquake	Liquefaction Maps	State geological survey; USGS web site and offices; University of Washington Soil Liquefaction web site; and Association of Bay Area Governments Liquefaction Maps and Information
	Landslide Maps	http://landslides.usgs.gov/html_files/nlicsun.html (general information); http://landslides.usgs.gov/html_files/landslides/nationalmap/national.html; and state geological survey
	Water Depth Maps	Local floodplain manager
	Soil Maps	http://ngmdb.usgs.gov/ngmdb/ngm_catalog.ora.html (appropriate for identifying NEHRP soil types used in HAZUS-MH model)
	General information on Earthquakes	USGS Earthquake Hazards Program web site; "Seismo-Surfing" Earthquake Information Links, by Pacific Northwest Seismograph Network web site; National Geophysical Data Center (NOAA), including significant earthquake database web site; California Geological Survey Seismic Hazard Mapping Program web site; and FEMA National Earthquake Hazard Reduction Program (NEHRP) web site
Flood	Digital Elevation Models	Recommended site: http://seamless.usgs.gov; other sites: http://rockyweb.cr.usgs.gov/elevation/dpi_dem.html (shows how to download DEM or order them from USGS by fax or phone); http://data.geocomm.com/catalog/RQ/group4.html
	Q3, FIRM, DFIRM, or Floodway Maps showing flood polygons (for example, base flood zone)	http://www.fema.gov/fhm/dfm_ovrw.shtm; digital Q3 floodplain data (where available) at http://www.hazardmaps.gov (shows DFIRM, Q3 availability as well); http://store.msc.fema.gov, or your local or state floodplain manager; and ESRI Hazard Mapping Tool web site

Hazard	Hazard Maps	Hazard Sources for Data
Flood (continued)	Base Flood Elevation	Can be read from FIRM panels where determined, and can be downloaded with the DFIRM where available; DFIRM coverage is summarized at http://www.hazardmaps.gov
	General information about flood hazards	NOAA Operational Significant Event Imagery Archive (National Geophysical Data Center) USGS Hazard Factsheets (Information Clearinghouse) FEMA Hazards Compendium (Flood)National Flood Insurance Program FEMA Flood Hazard Mapping Tool
Avalanche	Elevation Contour Maps	http://data.geocomm.com/dem/demdownload.html
	Information resources for avalanche hazard	U.S. Forest Service (USFS) National Avalanche Center American Avalanche Association (Avalanche Research) web site
Coastal Erosion	Historic aerial photographs	http://edc.usgs.gov/index.html USGS Center for Coastal Geology (Comparative Oblique Photos)
	General information on coastal erosion	FEMA Coastal Erosion Hazard Information National Hurricane Center USGS Center for Coastal Geology
Coastal Storm	Coastal Storm Maps and general information	http://www.noaa.gov/coasts.html NOAA National Hurricane Center USGS Hazard Factsheets (Information Clearinghouse and Hurricane Resources) web site
Dam Failure	Inundation Maps and general information	Dam studies or local flood experts FEMA's National Dam Safety Program web site
Drought	Drought	http://www.drought.unl.edu/whatis/palmer/pdsihist.htm; http://www.cpc.ncep.noaa.gov/ for Climate Prediction Center Expert Assessments: United States Drought Assessment web site
Extreme Heat	Maximum Temperature Maps	http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/usa.html
Land Subsidence	Land Subsidence Maps	http://water.usgs.gov/ogw/subsidence.html NOAA Ocean and Coastal Hazards web site

Hazard	Hazard Maps	Hazard Sources for Data
Landslide	Landslide Maps and general information	http://landslides.usgs.gov/html_files/nlicsun.html (general information); http://landslides.usgs.gov/html_files/landslides/nationalmap/national.html (map) and state geological survey USGS Hazards Factsheets (Multiple Hazards Information Clearinghouse) web site
Severe Winter Storm	Winter Storm Maps and general information	http://www.gismaps.fema.gov/2003pages/lcurrent.shtm (disaster declarations); http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/usa.html (archive data); http://www.srh.noaa.gov/lzk/html/stormrep.htm (storms reported to NOAA); and NOAA Operational Significant Event Imagery Archive (National Geophysical Data Center) web site
Tornado*	Tornado Maps	http://www.hazardmaps.gov/ (events); and ASCE 7 for design wind speeds http://www.strongtie.com/products/highwind/hw-design-wind-speeds.html
	General information on Tornadoes	FEMA Tornado Hazard Information web site; NOAA On-Line Tornado Information web site; and National Weather Service's Tornado Information web site
Tsunami*	Tsunami Maps and general information	http://www.usgs.gov/themes/coast.html; http://www.pmel.noaa.gov; http://www.geophys.washington.edu; Red Cross Information on Tsunamis web site; and National Geophysical Data Center Information on Tsunamis web site
Volcano*	Lava Flow Maps	Local emergency management personnel; and NOAA Operational Significant Event Imagery Archive (National Geophysical Data Center) web site
	Volcanic Activity Maps	http://volcanoes.usgs.gov/Hazards/Where/WhereHaz.html; and NOAA Operational Significant Event Imagery Archive (National Geophysical Data Center) web site
	General information on volcanic hazard	Pacific Northwest Seismograph Network web site; and USGS Hazards Factsheets (Multiple Hazards Information Clearinghouse) web site

Hazard	Hazard Maps	Hazard Sources for Data
Wildfire	Fuel Maps	State or local fire and emergency management personnel; and USFS National Fire Danger Fuel ModelsLive Fuel Moisture Ratings web site
	General information on Wildfire Hazards	NOAA Operational Significant Event Imagery Archive (National Geophysical Data Center); and U.S. Forest Service (USFS) Wildfire Assessment SystemFire Weather Analysis Page
Windstorm*	Windstorm Maps	http://www.esri.com/hazards/makemap.html; and High Winds information, including safety precautions and prediction tools
	General information on Windstorm Hazards	National Weather Service's National Hurricane Center (NOAA) web site; National Weather Service Storm Prediction Center web site; Hurricane Information and Awareness web site; and Severe Thunderstorms Information and Event Index web site

NOTE: Information also may be available from other hazard sources. The table above provides a strong starting point for your hazard data needs, but web site addresses can change over time. If you can not locate one of the above sites, you can search the internet using the hazard terms shown in columns 1 and 2 to locate particular information.

JOB AID 3-1: INVENTORY DATA PROVIDED WITH HAZUS-MH

Inventory Asset Category	Used for HAZUS-MH Model			HAZUS-MH Provided Data Source (Year)	Examples of Potential Local Sources for Data
	EQ	Flood	Hurr		
General Building Stock					
	X	X	X	U.S. Census Bureau and Dun & Bradstreet (2000)	Tax assessors offices, zoning departments, regional and local planning commissions
Essential Facilities					
Medical Care	X	X	X	American Hospital Association (2000)	Electronic Yellow Pages, State EMA, LEPC
Emergency Response	X	X	X	InfoUSA, Inc. (2001)	State EMA, LEPC
Schools	X	X	X	National Center for Education Statistics, Department of Education (2003)	Board of Education, Electronic Yellow Pages
Fire Stations	X	X	X	InfoUSA, Inc. (2001)	State EMA, LEPC, Fire Chief
Police Stations	X	X	X	InfoUSA, Inc. (2001)	State EMA, LEPC, Police Commissioner
HazMat Facilities					
	X	X	X	Toxic Release Inventory Database, EPA (1999)	State EMA, LEPC, Fire Department, State and local environmental organizations
High Potential Loss Facilities					
Dams	X	X	X	National Inventory of Dams, USACE (2003)	Local or regional authorities, State EMA, state and local planning department
Levees	X	X	X	N/A	Local flood mitigation organizations, ASFPM
Nuclear Power Facilities	X	X	X	U.S. Nuclear Regulatory Commission (2003)	Not applicable
Military Installations	X	X	X	N/A	State Reserve Units (to supplement Federal data)

Inventory Asset Category	Used for HAZUS-MH Model			HAZUS-MH Provided Data Source (Year)	Examples of Potential Local Sources for Data
	EQ	Flood	Hurr		
Transportation Systems					
Highway Segments	X	X	X	Tiger/Line Files, U.S. Census Bureau (2000)	State or local DOT, regional or local planning commissions
Highway Bridges	X	X	X	National Bridge Inventory Database, FHWA (2001)	State or local DOT, regional or local planning commissions
Highway Tunnels	X	X	X	National Bridge Inventory Database, FHWA (2001)	State or local DOT, regional or local planning commissions
Rail Segments	X	X	X	National Rail Network Database, Bureau of Transportation Statistics (2000)	State or local DOT, regional or local planning commissions
Rail Bridges	X	X	X	National Bridge Inventory Database, FHWA (2001)	State or local DOT, regional or local planning commissions
Rail Tunnels	X	X	X	National Bridge Inventory Database, FHWA (2001)	State or local DOT, regional or local planning commissions
Rail Facilities	X	X	X	N/A	State or local DOT, regional or local planning commissions
Light Rail Segments	X	X	X	Fixed-Guideway Transit and Ferry Network Database, BOTS, U.S. DOT (2000)	State or local DOT, regional or local planning commissions
Light Rail Bridges	X	X	X	National Bridge Inventory Database, FHWA (2001)	State or local DOT, regional or local planning commissions
Light Rail Tunnels	X	X	X	National Bridge Inventory Database, FHWA (2001)	State or local DOT, regional or local planning commissions
Light Rail Facilities	X	X	X	N/A	State or local DOT, regional or local planning commissions
Bus	X	X	X	InfoUSA, Inc. (2001)	State or local DOT, regional or local planning commissions, Electronic Yellow Pages
Port	X	X	X	Port and Waterway Facilities Database, USACE (2000)	State or local DOT, regional or local planning commissions
Ferry	X	X	X	Port and Waterway Facilities Database, USACE (2000)	State or local DOT, regional or local planning commissions, Electronic Yellow Pages
Airport Facilities	X	X	X	BOTS, U.S. DOT (1999)	State or local DOT, regional or local planning commissions, Electronic Yellow Pages
Airport Runways	X	X	X	BOTS, U.S. DOT (1999)	State or local DOT, regional or local planning commissions

Inventory Asset Category	Used for HAZUS-MH Model			HAZUS-MH Provided Data Source (Year)	Examples of Potential Local Sources for Data
	EQ	Flood	Hurr		
Utility Systems					
Potable Water Pipelines	X	X	X	EPA Envirofacts Data Warehouse LRT Tool (2001)	State or local water departments, private utilities, regional or local planning commissions
Potable Water Distribution Pipes (by Census tract)	X			EPA Envirofacts Data Warehouse LRT Tool (2001)	State or local water departments, private utilities, regional or local planning commissions
Potable Water Network System Pumps		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State or local water departments, private utilities, regional or local planning commissions
Potable Water Control Vaults and Control Stations		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State or local water departments, private utilities, regional or local planning commissions
Potable Water Network System Tanks		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State or local water departments, private utilities, regional or local planning commissions
Potable Water Network System Wells		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State or local water departments, private utilities, regional or local planning commissions, well logs (local environmental agency water division)
Potable Water System Facilities	X	X	X	EPA Envirofacts Data Warehouse LRT Tool (2001)	State or local water departments, private utilities, regional or local planning commissions
Wastewater Pipelines	X	X	X	EPA Envirofacts Data Warehouse LRT Tool (2001)	State or local water departments, private utilities, regional or local planning commissions
Wastewater Distribution Sewers (by Census tract)	X			EPA Envirofacts Data Warehouse LRT Tool (2001)	State, county, or local sewer commission/department
Wastewater Treatment Plants		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State EMA
Wastewater Vaults and Control Stations		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State EMA
Wastewater Lift Stations		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State EMA
Wastewater System Facilities	X		X	EPA Envirofacts Data Warehouse LRT Tool (2001)	State EMA

Inventory Asset Category	Used for HAZUS-MH Model			HAZUS-MH Provided Data Source (Year)	Examples of Potential Local Sources for Data
	EQ	Flood	Hurr		
Crude and Refined Oil Piplines	X	X	X	EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Oil Refineries		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Oil Pumping Plants		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Oil Tank Farm		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Oil Control Vaults and Control Stations		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Crude and Refined Oil Pipeline Facilities	X		X	EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Natural Gas Pipelines	X	X	X	EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Natural Gas Distribution Pipes (by Census tract)	X			EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Natural Gas Compressor Plants		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Natural Gas Control Vaults and Control Stations		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Natural Gas Facilities	X		X	EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Electric Power Plants		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Electric Power Substations		X		EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies

Inventory Asset Category	Used for HAZUS-MH Model			HAZUS-MH Provided Data Source (Year)	Examples of Potential Local Sources for Data
	EQ	Flood	Hurr		
Electric Power	X		X	EPA Envirofacts Data Warehouse LRT Tool (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Communication Central Offices and Switching Stations		X		Broadcast Auxiliary Microwave File, FCC (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Communication Vaults and Control Stations		X		Broadcast Auxiliary Microwave File, FCC (2001)	State and local fire departments, environmental agencies, State EMA and LEPC, private companies
Communication Broadcast Facility		X		Broadcast Auxiliary Microwave File, FCC (2001)	Electronic Yellow Pages
Communications	X		X	Broadcast Auxiliary Microwave File, FCC (2001)	Electronic Yellow Pages
Demographics	X		X	U.S. Census Bureau and Dun & Bradstreet (2000)	Regional and local planning commissions Tax assessor's offices, zoning departments, regional and local planning commissions

Notes:

EPA = U.S. Environmental Protection Agency

FCC = U.S. Federal Communications Commission

BOTS = Bureau of Transportation Statistics

ASFPM = American Society of Floodplain Managers

DOT= Department of Transportation

FHWA = Federal Highway Administration

LRT = Locational Reference Table

State EMA = State Emergency Management Agency

LEPC = Local Emergency Planning Committee

USACE = U.S. Army Corps of Engineers

JOB AID 3-2: INVENTORY DATA BY CATEGORY WITH DATA FIELDS

Inventory Category	General Fields	Hazards-Specific Fields		
		Earthquake	Flood	Hurricane
Essential Facilities				
Emergency Response	ID Number, Building Class, Tract, Name, Address, City, Zip Code, State, Contact, Phone Number, Year Built, Number of Stories, Replacement Cost, Backup Power, Shelter Capacity, Building Area, Kitchen, Latitude, Longitude, Comment	Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	Design Level, Foundation Type, First Floor Height, Building Damage Fnld, Content Damage Fnld, Flood Protection, BU Power	Hurricane Building Type, Hurricane Scheme Name
Fire Stations	ID Number, Building Class, Tract, Name, Address, City, Zip Code, State, Contact, Phone Number, Year Built, Number of Stories, Backup Power, Shelter Capacity, Building Area, Kitchen, Number of Trucks, Latitude, Longitude, Comment	N/A	N/A	Hurricane Building Type, Hurricane Scheme Name
Medical Care	ID Number, Building Class, Tract, Name, Address, City, Zip Code, State, Contact, Phone Number, Use, Year Built, Number of Stories, Replacement Cost, Backup Power, Number of Beds, AHA ID, Latitude, Longitude, Comment	Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	Design Level, Foundation Type, First Floor Height, Building Damage Fnld, Content Damage Fnld, Flood Protection, BU Power	Hurricane Building Type, Hurricane Scheme Name
Police Stations	ID Number, Building Class, Tract, Name, Address, City, Zip Code, State, Contact, Phone Number, Year Built, Number of Stories, Cost, Backup Power, Shelter Capacity, Building Area, Kitchen, Latitude, Longitude, Comment	N/A	N/A	Hurricane Building Type, Hurricane Scheme Name
Schools	ID Number, Building Class, Tract, Name, Address, City, Zip Code, State, Contact, Phone Number, Year Built, Number of Stories, Replacement Cost, Number of Students, Backup Power, Shelter Capacity, Building Area, District, Kitchen, Latitude, Longitude, Comment	Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	Design Level, Foundation Type, First Floor Height, Building Damage Fnld, Content Damage Fnld, Flood Protection, BU Power	Hurricane Building Type, Hurricane Scheme Name
High Potential Loss Facilities				
Dams	ID Number, Dam Class, Tract, Name, County Name, Owner, Cost, River, Near City, Distance City, Purpose, Year Competed, Dam Length, Dam Height, Structural Height, Max Discharge, Hydro Height, Max Storage, Normal Storage, Surface Area, Drain Area, Hazard, EAP, Spill Type, Spill Width, Volume, NAT ID, Primary Agency, Latitude, Longitude, Comment	Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None

Inventory Category	General Fields	Hazards-Specific Fields		
		Earthquake	Flood	Hurricane
High Potential Loss Facilities (continued)				
Levees	ID Number, County FIP, County Name, Levee Name, Levee Width, Levee Height, Levee Crest, Normal Height, Owner, River, Near City, Distance City, Year Completed, Hazard, Comment	Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Military Installations	ID Number, Building Class, Tract, Name, Address, City, Zip Code, State, Contact, Phone Number, Year Built, Number of Stories, Owner, Shelter Capacity, Use, Building Cost, Content Cost, Latitude, Longitude, Comment	Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Nuclear Power Facilities	ID Number, Building Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Year Built, Number of Stories, Replacement Cost, Latitude, Longitude, Capacity, Comment	Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Hazardous Materials Facilities	ID Number, Building Class, Tract, Name, Address, City, State, Zip Code, Contact, Cas #, Chemical Name, Chemical Quantity, SIC Code, Year Built, EPA ID, Permit Amount, Latitude, Longitude, Comment	Building Type, Building Quality, Design Level, Foundation Type, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Transportation Systems				
Highway Segments	Number, Segment Class, County FIP, Name, Owner, Length, Traffic, Cost, Number of Lanes, Pavement, Width, Capacity, Comment	None	None	None
Highway Bridges	ID Number, Bridge Class, Tract, Name, Owner, Bridge Type, Width, Number of Spans, Length, Maximum Span Length, Skew Angle, Seat Length, Seat Width, Year Built, Year Remodeled, Pier Type, Foundation Type, Scour Index, Traffic, Traffic Index, Condition, Cost, Latitude, Longitude, Comment	Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	Elevation	None
Highway Tunnels	ID Number, Tunnel Class, Tract, Name, Owner, Type, Width, Length, Year Built, Traffic, Cost, Latitude, Longitude, Comment	Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Rail Segments	ID Number, Segment Class, County FIP, Name, Owner, Length, Traffic, Cost, Number of Tracks, Comment	None	None	None

Inventory Category	General Fields	Hazards-Specific Fields		
		Earthquake	Flood	Hurricane
Transportation Systems (continued)				
Rail Bridges	ID Number, Bridge Class, Tract, Name, Owner, Bridge Type, Width, Number of Spans, Length, Maximum Span Length, Skew Angle, Seat Length, Seat Width, Year Built, Year Remodeled, Pier Type, Foundation Type, Scour Index, Traffic, Traffic Index, Condition, Cost, Latitude, Longitude, Comment	Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	Elevation	None
Rail Tunnels	ID Number, Tunnel Class, Tract, Name, Owner, Type, Width, Length, Year Built, Traffic, Cost, Latitude, Longitude, Comment	Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Rail Facilities	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Cost, Backup Power, Traffic, Latitude, Longitude, Comment	Anchor, Foundation Type, Building Type, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Light Rail Segments	ID Number, Segment Class, County FIPS, Name, Owner, Length, Traffic, Cost, Number of Tracks, Comment	None	None	None
Light Rail Bridges	ID Number, Bridge Class, Tract, Name, Owner, Bridge Type, Width, Number of Spans, Length, Maximum Span Length, Skew Angle, Seat Length, Seat Width, Year Built, Year Remodeled, Pier Type, Foundation Type, Scour Index, Traffic, Traffic Index, Condition, Cost, Latitude, Longitude, Comment	Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	Elevation	None
Light Rail Tunnels	ID Number, Tunnel Class, Tract, Name, Owner, Type, Width, Length, Year Built, Traffic, Cost, Latitude, Longitude, Comment	Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Light Rail Facilities	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Number of Stories, Cost, Backup Power, Traffic, Latitude, Longitude, Comment	Anchor, Foundation Type, Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Bus	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Cost, Backup Power, Traffic, Latitude, Longitude, Comment	Anchor, Foundation Type, Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Port	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Backup Power, Cost, Capacity, Number of Berths, Number of Cranes, Latitude, Longitude, Comment	Anchor, Foundation Type, Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None

Inventory Category	General Fields	Hazards-Specific Fields		
		Earthquake	Flood	Hurricane
Transportation Systems (continued)				
Ferry	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Number of Stories, Cost, Backup Power, Traffic, Latitude, Longitude, Comment	Anchor, Foundation Type, Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Airport Facilities	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Cost, Cargo, Number of Flights, Number of Passengers, Backup Power, Latitude, Longitude, Comment	Anchor, Foundation Type, Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Airport Runways	ID Number, Facility Class, Tract, Name, Airport ID, Runway Length, Cost, Capacity, Pavement, Latitude, Longitude, Comment	Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	None	None
Utility Systems				
Potable Water Pipelines	ID Number, Pipeline Class, County FIPS, Name, Owner, Material, Diameter, Pipe Length, Joint, Year Built, Cost, Source ID, Comment	None	None	None
Potable Water Distribution Pipes	Tract, Ductile Pipe, Brittle Pipe, Total Pipe, Presented by Census tract	None	N/A	None
Potable Water Distribution Pipes	ID Number, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Class, Description, Usage, Cost, Year Built, Stories, Year Upgraded, System ID, G Class, Backup Power, Capacity, Demand, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Potable Water Control Vaults & Control Stations	ID Number, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Class, Description, Usage, Cost, Year Built, Stories, Year Upgraded, System ID, G Class, Backup Power, Capacity, Demand, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Potable Water Network System Tanks	ID Number, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Class, Description, Usage, Cost, Year Built, Stories, Year Upgraded, System ID, G Class, Backup Power, Capacity, Demand, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Potable Water Network System Wells	ID Number, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Class, Description, Usage, Cost, Year Built, Stories, Year Upgraded, System ID, G Class, Backup Power, Capacity, Demand, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A

Inventory Category	General Fields	Hazards-Specific Fields		
		Earthquake	Flood	Hurricane
Utility Systems (continued)				
Potable Water System Facilities	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Number of Stories, Cost, System ID, G Class, Backup Power, Year Upgraded, Capacity, Demand, Latitude, Longitude, Comment	Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	Flood Protection, Equipment Height, Foundation Type	None
Wastewater Pipelines	ID Number, Pipeline Class, County FIPS, Name, Owner, Material, Diameter, Pipe Length, Joint, Year Built, Cost, Source ID, Comment		None	None
Wastewater Sewers	Tract, Ductile Pipe, Brittle Pipe, Total Pipe		N/A	None
Wastewater Treatment Plants	ID Number, Facility Class, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Usage, Facility Cost, Year Built, Number of Stories, G Class, System ID, Backup Power, Capacity, Demand, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Wastewater Vaults & Control Stations	ID Number, Facility Class, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Description, Usage, Facility Cost, Year Built, Number of Stories, G Class, System ID, Year Upgraded, Backup Power, Capacity, Demand, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Wastewater Lift Stations	ID Number, Facility Class, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Description, Usage, Facility Cost, Year Built, Number of Stories, G Class, System ID, Year Upgraded, Backup Power, Capacity, Demand, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Wastewater System Facilities	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Number of Stories, Cost, System ID, G Class, Backup Power, Year Upgraded, Capacity, Demand, Latitude, Longitude, Comment	Anchor, Foundation Type, Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	N/A	None
Crude and Refined Oil Pipelines	ID Number, Pipeline Class, County FIPS, Name, Owner, Material, Diameter, Pipe Length, Joint, Year Built, Cost, Source ID, Comment	None	None	None
Oil Refineries	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Number of Stories, Cost, System ID, G Class, Backup Power, Capacity, Demand, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Oil Pumping Plants	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Description, Use, Year Built, Number of Stories, Cost, Backup Power, Capacity, Demand, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A

Inventory Category	General Fields	Hazards-Specific Fields		
		Earthquake	Flood	Hurricane
Utility Systems (continued)				
Oil Tank Farm	ID Number, Facility Class, Tract, Name, Address, City, Zip code, State, Owner, Contact, Phone Number, Description, Use, Year Built, Number of Stories, Cost, Backup Power, Capacity, Demand, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Oil Control Vaults and Control Stations	ID Number, Facility Class, Tract, Name, Address, City, Zip code, State, Owner, Contact, Phone Number, Description, Use, Year Built, Number of Stories, Cost, Backup Power, Capacity, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Crude and Refined Oil Pipeline Facilities	ID Number, Facility Class, Tract, Name, Address, City, Zip code, State, Owner, Contact, Phone Number, Use, Year Built, Cost, Backup Power, Capacity, Latitude, Longitude, Comment	Anchor, Foundation Type, Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	N/A	None
Natural Gas Pipelines	ID Number, Pipeline Class, County FIPS, Name, Owner, Material, Diameter, Pipe Length, Joint, Year Built, Cost, Source ID, Comment	None	None	None
Natural Gas Distribution Pipes	Tract, Ductile Pipe, Brittle Pipe, Total Pipe	None	N/A	None
Natural Gas Compressor Plants	ID Number, Facility Class, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Description, Use, Installation Year, Number of Stories, Cost, Backup Power, Capacity, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Natural Gas Control Vaults and Control Stations	ID Number, Facility Class, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Description, Use, Installation Year, Number of Stories, Cost, Backup Power, Capacity, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Natural Gas Facilities	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Cost, Number of Stories, Backup Power, Capacity, Latitude, Longitude, Comment	Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	N/A	None
Electric Power Plants	ID Number, Facility Class, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Description, Use, Year Built, Number of Stories, Cost, Capacity, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A
Electric Power Substations	ID Number, Facility Class, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Description, Use, Year Built, Number of Stories, Cost, Capacity, Latitude, Longitude, Comment	N/A	Flood Protection, Equipment Height, Foundation Type	N/A

Inventory Category	General Fields	Hazards-Specific Fields		
		Earthquake	Flood	Hurricane
Utility Systems (continued)				
Electric Power	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Number of Stories, Capacity, Cost, Latitude, Longitude, Comment	Anchor, Foundation Type, Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	N/A	None
Communication Central Offices and Switching Stations	ID Number, Facility Class, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Description, Use, Cost, Installation Year, Backup Power, Latitude, Longitude, Comment	N/A	None	N/A
Communication Vaults and Control Stations	ID Number, Facility Class, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Description, Use, Cost, Installation Year, Backup Power, Latitude, Longitude, Comment	N/A	None	N/A
Communication Broadcast Facility	ID Number, Facility Class, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Description, Use, Cost, Installation Year, Backup Power, Latitude, Longitude, Comment	N/A	None	N/A
Communications	ID Number, Facility Class, Tract, Name, Address, City, Zip Code, State, Owner, Contact, Phone Number, Use, Year Built, Cost, Backup Power, Latitude, Longitude, Comment	Anchor, Foundation Type, Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	N/A	None
Demographics	Block, Population, Households, Group Quarters, Population Age Distribution, Male Population, Female Population, Race Distribution, Income, Daytime Residency, Night Residency, Hotel, Visitor, Working Com, Working Ind, Commuting 5pm, Number of Home Owners, Number of Renters, Number of Vacant Homes, Building Age, Median Age, Average Rent, Average Value, School Enrollment	None	None	None
General Building Stock	Exposure, Count, and Square Footage by General Occupancy, Specific Occupancy, and Building Type	None	None	None
User Defined	ID Number, Occupancy, Tract, Name, Address, City, Zip code, State, Contact, Phone Number, Year Built, Cost, Backup Power, Number of Stories, Area, Content Cost, Shelter Capacity, Latitude, Longitude, Comment	Building Type, Building Quality, Design Level, Soil Type, Liquefaction Susceptibility, Landslide Susceptibility, Water Depth	Design Level, Foundation Type, First Floor Height, Flood Protection, County	Wind Building Type, Wind Building Scheme Name

JOB AID 4-1: EARTHQUAKE MODULE OUTPUTS FOR RISK ASSESSMENT

Ground Motion/Site Effect Output

Input	Description of Output	Measure
Deterministic Event	HAZUS-MH determines Census tract ground motion and develops region-wide ground motion contour maps based on a user-defined scenario event.	a. Census Tract Ground Shaking b. Peak Ground Acceleration Contour Maps c. Spectral Contour Maps
USGS Probabilistic Seismic Hazard Maps	HAZUS-MH includes spectral contour maps at two seismic hazard levels: 2 percent probability of exceedance in 50 years and 10 percent probability of exceedance in 50 years.	a. PGA Contour Maps b. Spectral Contour Maps
User-Supplied Ground Shaking Maps	The user supplies region-wide ground motion contour maps that are used as the ground motion inputs to HAZUS-MH.	a. Census Tract Ground Shaking b. PGA Contour Maps c. Spectral Contour Maps

Ground Deformation Output

Input	Description of Output	Measure
Liquefaction	HAZUS-MH determines the probability of and expected level of permanent ground deformations for liquefaction-susceptible sites during the deterministic, probabilistic, or user-defined event.	a. Peak Ground Acceleration Contour Maps b. Location-Specific PGD
Landslide	HAZUS-MH determines the probability of and expected level of permanent ground deformations for landslide-susceptible sites during the deterministic, probabilistic, or user-defined event.	a. PGD Contour Maps b. Location-Specific PGD
Surface Fault Rupture	HAZUS-MH determines the probability of an expected level of permanent ground deformations for surface fault rupture-susceptible sites during the deterministic, probabilistic, or user-defined event.	a. PGD Contour Maps b. Location-Specific PGD

Indirect Economic Impact Module Output

Component	Description of Output	Measure
Economic Output	HAZUS-MH determines the indirect economic output loss as a percentage of the original output.	Percentage
Employment	HAZUS-MH determines the indirect employment loss as a percentage of the original employment.	Percentage
Income	HAZUS-MH determines the indirect income loss as a percentage of the original income.	Percentage

Direct Physical Damage - General Building Stock

Input	Description of Output	Measure
Model Building Type	HAZUS-MH determines the damage state probabilities for each model building type by census tract in the study region. Results are presented for each design level and construction quality bias. Damage state probabilities are determined for (1) structural elements, (2) non-structural drift-sensitive elements, and (3) non-structural acceleration-sensitive elements.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Building Counts
General Building Type	HAZUS-MH determines the damage state probabilities for each of seven general building types by Census tract in the study region. Results are presented for each design level and construction quality bias. Damage state probabilities are determined for (1) structural elements, (2) non-structural drift-sensitive elements, and (3) non-structural acceleration-sensitive elements.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Building Counts
Specific Occupancy Class	HAZUS-MH determines the damage state probabilities for each of 28 specific occupancy classes by Census tract in the study region. Results are presented for each construction quality bias. Damage state probabilities are determined for (1) structural elements, (2) non-structural drift-sensitive elements, and (3) non-structural acceleration-sensitive elements.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Occupancy Counts
General Occupancy Class	HAZUS-MH determines the damage state probabilities for each of six general occupancy classes by Census tract in the study region. Damage state probabilities are determined for (1) structural elements, (2) non-structural drift-sensitive elements, and (3) non-structural acceleration-sensitive elements.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Occupancy Counts

Direct Physical Damage - Essential Facilities

Facility Type	Description of Output	Measure
Health Care Facilities	HAZUS-MH determines the damage state probabilities for each health care facility in the study region. Damage state probabilities are determined for (1) structural elements, (2) non-structural drift-sensitive elements, and (3) non-structural acceleration-sensitive elements. The expected reduction in available beds for each facility is also determined.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Loss of Beds and Facility Functionality
Police and Fire Stations, Emergency Operation Centers, Schools	HAZUS-MH determines the damage state probabilities for each facility in the study region. Damage state probabilities are determined for (1) structural elements, (2) non-structural drift-sensitive elements, and (3) non-structural acceleration-sensitive elements.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Functionality at Day 1

Direct Physical Damage - High Potential Loss Facilities*

Component	Description of Output	Measure*
Dams	HAZUS-MH provides the locations of dams in the study region.	List of and Locations of Dams
Nuclear Facilities	HAZUS-MH provides the locations of nuclear power facilities in the study region.	List of and Locations of Nuclear Power Facilities
Military Facilities	HAZUS-MH determines the damage state probabilities for each facility in the study region. Damage state probabilities are determined for (1) structural elements, (2) non-structural drift-sensitive elements, and (3) non-structural acceleration-sensitive elements.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities

*Provides placeholders for qualitative analyses.

Direct Physical Damage - Transportation Systems

System	Description of Output	Measure
Highway, Railway, Light Rail, Bus, Ferry, Port, Airport	a. HAZUS-MH determines the damage state probabilities for each transportation system component in the study region. b. HAZUS-MH determines the probability of functionality for each transportation system component at discrete time intervals.	a. System Damage State Probabilities b. Probability of System Functionality

Direct Physical Damage - Utility Systems

System	Description of Output	Measure
Potable Water	a. HAZUS-MH determines the damage state probabilities for each potable water system component in the study region. b. HAZUS-MH determines the probability of functionality for each potable water system component at discrete time intervals. c. HAZUS-MH supports simplified potable water system analysis for the study region.	a. System Damage State Probabilities b. System Probability of Functionality c. Number of Households without Water
Wastewater, Crude and Refined Natural Gas, Oil Pipelines, Communication	a. HAZUS-MH determines the damage state probabilities for each system component in the study region. b. HAZUS-MH determines the probability of functionality for each system component at discrete time intervals.	a. System Damage State Probabilities b. System Probability of Functionality
Electric Power	a. HAZUS-MH determines the damage state probabilities for each electric power system component in the study region. b. HAZUS-MH determines the probability of functionality for each electric power system component at discrete time intervals. c. HAZUS-MH supports simplified electric power system analysis for the study region.	a. System Damage State Probabilities b. System Probability of Functionality c. Number of Households without Power

Indirect Physical Damage – Inundation

Component	Description of Output	Measure
Tsunami	a. The methodology provides rules to determine whether tsunamis are a threat to the study region. b. The user can import existing tsunami inundation maps and overlay them with population and economic value maps.	a. Qualify Potential Threat b. Exposed Population Exposed Value ($1,000)
Seiche	a. The methodology provides rules to determine if seiches are a threat on any body of water in the study region. b. The user can import existing seiche inundation maps and overlay them with population and economic value maps.	a. Qualify Potential Threat b. Exposed Population Exposed Value ($)
Dam Failure	a. HAZUS-MH displays the locations of all dams in the study region and (for the default database) ranks the potential impact of the dam failure. b. The user can import existing dam failure inundation maps and overlay with population and economic value maps.	a. List of and Locations of Dams and Quantification of Potential Hazard b. Exposed Population Exposed Value ($)
Levee Failure	a. HAZUS-MH displays the locations of the levees in the study region. b. The user can import existing levee failure inundation maps and overlay them with population and economic value maps.	a. List of and Locations of Levees b. Exposed Population

Induced Physical Damage - Fire Following Earthquake

Component	Description of Output	Measure
Ignition	HAZUS-MH determines the expected number of fire ignitions by census tract for the study region.	Number of Ignitions
Burned Area	a. HAZUS-MH determines the expected burned area by Census tract for the study region. b. The expected burned area is combined with population and economic value to estimate the exposed population and inventory.	a. Percentage of Burned Area b. Exposed Population Exposed Value ($)

Induced Physical Damage – Debris

Component	Description of Output	Measure
Brick, Wood, and Others	HAZUS-MH determines the expected amount of brick, wood, and other debris that would be generated in each Census tract of the study region.	Weight of Debris Generated
Reinforced Concrete and Steel	HAZUS-MH determines the expected amount of reinforced concrete and steel debris that would be generated in each Census tract of the study region.	Weight of Debris Generated

Direct Economic and Social Losses - Shelter

Component	Description of Output	Measure
Displaced Households	HAZUS-MH determines the expected number of displaced households by Census tract for the study region.	Number of Displaced Households
Temporary Shelter	HAZUS-MH determines the expected number of people requiring temporary shelter by Census tract for the study region.	Number of People Requiring Temporary Shelter

Direct Economic and Social Losses - Casualties

Component	Description of Output	Measure
Casualties	HAZUS-MH determines the expected number of casualties for each level of casualty severity (medical aid, hospital treatment, life-threatening, death) by Census tract for the study region.	Number of Casualties for Each of the Four Severities

Direct Economic Loss – Buildings

Component	Description of Output	Measure
Repair and Replacement Costs	HAZUS-MH determines the expected dollar loss due to repair and replacement of the general building stock by Census tract for the study region.	Dollar Loss
Content Damage	HAZUS-MH determines the expected dollar loss due to content damage by Census tract for the study region.	Dollar Loss
Business Inventory Damage	HAZUS-MH determines the expected dollar loss due to business inventory damage by Census tract for the study region.	Dollar Loss
Relocation Costs	HAZUS-MH determines the expected dollar loss due to business relocation by Census tract for the study region.	Dollar Loss
Capital-Related Income Loss	HAZUS-MH determines the expected business income loss by Census tract for the study region.	Dollar Loss
Wage Loss	HAZUS-MH determines the expected wage loss by Census tract for the study region.	Dollar Loss
Rental Loss	HAZUS-MH determines the expected dollar loss due to repair and replacement of rental buildings by Census tract for the study region.	Dollar Loss

Direct Economic Loss - Lifelines

Component	Description of Output	Measure
Repair and Replacement Costs	The methodology determines the expected dollar loss due to repair and replacement of lifeline components.	Dollar Loss

JOB AID 4-2: COASTAL STORMS (HURRICANE) MODULE OUTPUTS FOR RISK ASSESSMENT

Wind Speed

Input	Description of Output	Measure
Return Period (50 years, 100 years, and so on)	HAZUS-MH estimates the maximum 3-second gusts in open terrain at 10 meters above the ground at the centroid of each census tract.	Peak Wind Gust

Direct Physical Damage - General Building Stock

Input	Description of Output	Measure
Model Building Type	HAZUS-MH determines the damage state probability for each model building type by Census tract for the study region. Results are presented for each design level and construction quality bias. For probabilistic scenarios, one of seven return periods must be selected.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Building Counts
General Building Type	HAZUS-MH determines the damage state probability for each general building type by Census tract for the study region. Results are presented for each design level and construction quality bias. For probabilistic scenarios, one of seven return periods must be selected.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Building Counts
Specific Occupancy Class	HAZUS-MH determines the damage state probability for each specific occupancy class by Census tract for the study region. Results are presented for each construction quality bias. For probabilistic scenarios, one of seven return periods must be selected.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Occupancy Counts
General Occupancy Class	HAZUS-MH determines the damage state probability for each general occupancy class by Census tract for the study region. For probabilistic scenarios, one of seven return periods must be selected.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Occupancy Counts

Direct Physical Damage - Essential Facilities

Facility Type	Description of Output	Measure
Health Care Facilities	HAZUS-MH determines the damage state probabilities for each health care facility in the study region. For probabilistic scenarios, one of seven return periods must be selected.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Loss of Beds and Facility Functionality
Police and Fire Stations, Emergency Operation Centers, Schools	HAZUS-MH determines the damage state probabilities for each facility in the study region. For probabilistic scenarios, one of seven return periods must be selected.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Functionality at Day 1

Induced Physical Damage - Debris

Component	Description of Output	Measure
Brick, Wood, and Others	HAZUS-MH determines the expected amount of brick, wood, and other debris that would be generated in each Census tract of the study region.	Weight of Debris Generated
Reinforced Concrete and Steel	HAZUS-MH determines the expected amount of reinforced concrete and steel debris that would be generated in each Census tract of the study region.	Weight of Debris Generated
Trees	HAZUS-MH determines the expected amount of tree debris that would be generated in each Census tract of the study region.	a. Weight of Debris Generated b. Volume of Debris Generated

Direct Economic and Social Losses - Shelter

Component	Description of Output	Measure
Displaced Households	HAZUS-MH determines the expected number of displaced households by Census tract for the study region.	Number of Displaced Households
Temporary Shelter	HAZUS-MH determines the expected number of people requiring temporary shelter by Census tract for the study region.	Number of People Requiring Temporary Shelter

Direct Economic Loss - Buildings

Component	Description of Output	Measure
Repair and Replacement Costs	HAZUS-MH determines the expected dollar loss due to repair and replacement of the general building stock by Census tract for the study region.	Dollar Loss
Content Damage	HAZUS-MH determines the expected dollar loss due to content damage by Census tract for the study region.	Dollar Loss
Business Inventory Damage	HAZUS-MH determines the expected dollar loss due to business inventory damage by Census tract for the study region.	Dollar Loss
Relocation Costs	HAZUS-MH determines the expected dollar loss due to business relocation by Census tract for the study region.	Dollar Loss
Capital-Related Income Loss	HAZUS-MH determines the expected business income loss by Census tract for the study region.	Dollar Loss
Wage Loss	HAZUS-MH determines the expected wage loss by Census tract for the study region.	Dollar Loss
Rental Loss	HAZUS-MH determines the expected dollar loss due to repair and replacement of rental buildings by Census tract for the study region.	Dollar Loss

Indirect Economic Impact Module Output

Component	Description of Output	Measure
Economic Output	HAZUS-MH determines the indirect output loss as a percentage of the original output.	Percentage
Employment	HAZUS-MH determines the indirect employment loss as a percentage of the original employment.	Percentage

Flood Depth Output

Input	Description of Output	Measure
Riverine Event	For a riverine flood, HAZUS-MH determines the depth of the flood and creates a flood depth grid map of the flooded area within the study region.	a. Flood Elevations b. Flood Depth Grid
Coastal Event	For a coastal flood, HAZUS-MH determines the ground surface area subjected to erosion; the flood surface, including wave heights; and the depth of the coastal flooding.	a. Eroded Ground Surface b. Flood Surface Considering Wave Height and Runup c. Flood Depth

Direct Physical Damage - General Building Stock

Input	Description of Output	Measure
Model Building Type	HAZUS-MH determines the damage state probability for each model building type by Census tract for the study region. Results are presented for each design level and construction quality bias. For probabilistic scenarios, one of seven return periods must be selected.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Building Counts
General Building Type	HAZUS-MH determines the damage state probability for each general building type by Census tract for the study region. Results are presented for each design level and construction quality bias. For probabilistic scenarios, one of seven return periods must be selected.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Building Counts
Specific Occupancy Class	HAZUS-MH determines the damage state probability for each specific occupancy class by Census tract for the study region. Results are presented for each construction quality bias. For probabilistic scenarios, one of seven return periods must be selected.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Occupancy Counts
General Occupancy Class	HAZUS-MH determines the damage state probability for each general occupancy Class by Census tract for the study region. For probabilistic scenarios, one of seven return periods must be selected.	a. Structural Damage State Probabilities b. Non-structural Damage State Probabilities c. Structural Damage State Occupancy Counts

Direct Economic Loss – Buildings

Component	Description of Output	Measure
Repair and Replacement Costs	HAZUS-MH determines the expected dollar loss due to repair and replacement of the general building stock by Census tract for the study region.	Dollar Loss
Content Damage	HAZUS-MH determines the expected dollar loss due to content damage by Census tract for the study region.	Dollar Loss
Business Inventory Damage	HAZUS-MH determines the expected dollar loss due to business inventory damage by Census tract for the study region.	Dollar Loss
Relocation Costs	HAZUS-MH determines the expected dollar loss due to business relocation by Census tract for the study region.	Dollar Loss
Capital-Related Income Loss	HAZUS-MH determines the expected business income loss by Census tract for the study region.	Dollar Loss
Wage Loss	HAZUS-MH determines the expected wage loss by Census tract for the study region.	Dollar Loss
Rental Loss	HAZUS-MH determines the expected dollar loss due to repair and replacement of rental buildings by Census tract for the study region.	Dollar Loss

Direct Physical Damage - Essential Facilities

Facility Type	Description of Output	Measure
Police and Fire Stations, Emergency Operation Centers, Schools, Health Care Facilities	HAZUS-MH determines the damage state probabilities for each essential facility in the study region. The building and content losses are calculated, the functionality is determined, and the time to restore the facility to 100 percent functionality is determined for each essential facility.	a. Building and Content Losses b. Functionality Assessment (yes/no) c. Restoration Time to 100 Percent Functionality

Direct Physical Damage - Transportation Systems

System	Description of Output	Measure
Highway, Light Rail, Railway, Bus, Ferry, Port, Airport	a. HAZUS-MH determines the damage state probability for each transportation system component in the study region. b. HAZUS-MH determines the probability of functionality for each transportation system component at discrete time intervals.	a. Structure and Equipment Losses b. Functionality Assessment (yes/no)

Direct Physical Damage - Utility Systems

System	Description of Output	Measure
Potable Water, Wastewater, Crude and Refined Oil Pipelines, Natural Gas, Communication, Electric Power	a. HAZUS-MH determines the structural and equipment losses. b. HAZUS-MH determines whether the utility will be functional.	a. Structure and Equipment Losses b. Functionality Assessment (yes/no)

Direct Economic and Social Losses – Shelter

Component	Description of Output	Measure
Displaced Households	HAZUS-MH determines the expected number of displaced households by Census tract for the study region.	Number of Displaced Households
Temporary Shelter	HAZUS-MH determines the expected number of people requiring temporary shelter by Census tract for the study region.	Number of People Requiring Temporary Shelter

Direct Economic and Social Losses – Vehicles

Component	Description of Output	Measure
Vehicles	HAZUS-MH determines the expected damage to the vehicles in the study region.	Vehicle Losses

Direct Economic and Social Losses - Agricultural

Component	Description of Output	Measure
Agriculture	HAZUS-MH determines the expected damage to the agriculture in the study region.	Crop Losses

Indirect Economic Impact Module Output

Component	Description of Output	Measure
Employment	HAZUS-MH determines the indirect employment loss as a percentage of the original employment by market sector (agriculture, mining, construction, manufacturing, transportation, trade, services, government, and miscellaneous).	a. Percentage with Aid b. Percentage without Aid
Income	HAZUS-MH determines the indirect income loss as a percentage of the original income by market sector (agriculture, mining, construction, manufacturing, transportation, trade, services, government, and miscellaneous).	a. Percentage with Aid b. Percentage without Aid

Mitigation Wizard Figures and Tables	Description
Figure 1: County Map	Map of Study Region
Figure 2: Probabilistic Hazard Maps	Maps of Probabilistic Hazard Events
Table 1: Building Inventory by General Occupancy	• Occupancy: Residential, Commercial, Industrial, Agricultural, Religious, Government, and Education • Number of Buildings (total and # in hazard area), Replacement Value (total and # in hazard area), and Number of Occupants (total and # in hazard area)
Table 2: Building Inventory by General Building Type	• Building Type: Wood, Steel, Concrete, Masonry, and Mobile Homes • Number of Buildings (total and # in hazard area), Replacement Value (total and # in hazard area), and Number of Occupants (total and # in hazard area)
Figure 3: Historical Hazard Events	Maps of Historic Hazard Events
Table 3: Transportation System Lifeline Inventory	• System – Highway, Railway, Light Rail, Bus, Ferry, Port, Airport • Components, #Locations/Segments, Replacement Value
Table 4: Utility System Lifeline Inventory	• System – Potable Water, Wastewater, Natural Gas, Oil Systems, Electrical Power, Communications • Component, #Locations/Segments, Replacement Value
Table 5: Essential Facility Inventory	• Building Type – Hospitals, Fire Stations, Police Stations, EOCs, Schools • Number of Buildings (total and # in hazard area), Replacement Value (total and # in hazard area), and Number of Occupants (total and # in hazard area)
Figure 6: Map of Schools	
Table 6: Population by Age and Gender	• Male, Female, Total • Age < 16, 16 < Age < 65, Age > 65, Total
Table 7: Population by Ethnicity	• Population, Percentage • White, Black, Native American, Hispanic, Asian, Pacific Islander, Others, Total
Table 8: Household Distribution by Annual Income	• Population, Percentage • < 10k, 10k < x < 20k, 20k < x < 30k, 30k < x < 50k, 50k < x < 75k, > 75k, Total
Table 9: Household Distribution by Residence Type	• Category – Owner Occupied, Renter Occupied, Total • Single-family, Multi-family, Mobile Homes, Total
Figure 7: Population Density Map	
Figure 8: Hazardous Material Facilities	Map of HazMat Locations
Figure 9: Dams	Map of Dam Locations
Table 10: Building Damage by General Occupancy	• Occupancy – Agricultural, Commercial, Education, Government, Industrial, Religion, Residential, Total • Damage – None, Slight, Moderate, Extensive, Complete, Total
Table 11: Building Damage by Building Type	• Occupancy (Should be Building Type) – Wood, Steel, Concrete, Masonry, Mobile Home, Total • Damage – None, Slight, Moderate, Extensive, Complete, Total
Table 12: Economic Loss by General Occupancy	• Occupancy – Agriculture, Commercial, Education, Government, Industrial, Religion, Residential, Total • Structural Damage, Non-structural Damage, Content Loss, Business Interruption, Total
Table 13: Transportation System Lifeline Losses	• System – Highway, Railway, Light Rail, Bus, Ferry, Port, Airport • Component, Inventory Value, Economic Loss, Loss Ratio

JOB AID 4-4: MITIGATION WIZARD FIGURES AND TABLES (continued)

Mitigation Wizard Figures and Tables	Description
Table 14: Utility System Lifeline Losses	• System – Potable Water, Wastewater, Natural Gas, Oil Systems, Electrical Power, Communications • Component, Inventory Value, Economic Loss, Loss Ratio
Table 15: Building Damage for Essential Facilities	• Classification – Hospitals, Fire Stations, Police Stations, EOCs, Schools • Damage – None, Slight, Moderate, Extensive, Complete, Total
Table 16: Casualty Estimates	• Time/Occupancy – Commercial, Commuting, Educational, Hotels, Industrial, Other-Residential, Single-family • Level 1, Level 2, Level 3, Level 4

APPENDIX G: JOB AIDS FOR STEP 5

JOB AID 5-1: CONFLICTS AND RESOLUTIONS TOOL

Job Aid 5-1 provides information to help you to consider the possible synergy between mitigation options across hazards, as well as potential conflicts for the particular combination of hazards that you face. It is intended to provoke thought and design integration, but does not provide absolute restrictions or recommendations. In general, reinforcement between hazards may be gained, and undesirable conditions and conflicts can be resolved, by coordinating mitigation measures and consulting your community experts. You are encouraged to use the list as a basis for discussion relative to specific projects and to structure the evaluation of the benefits and conflicts of multi-hazard design depending on local hazards. The vertical columns show the three primary hazards. Columns are also included for the blast and fire hazards as these hazards also have pertinence for structural mitigation. The horizontal rows show methods of protection for the building systems and components that have significant interaction, either desirable (reinforcing) or undesirable (conflicting).

Key	
✔	Indicates desirable condition or method for designated component/system
✘	Indicates undesirable condition or method for designated component/system
❑	Indicates little or no significance for designated component/system
		Split box indicates significance may vary, see Discussion Issues

Building System Protection Methods: Reinforcements and Conflicts							
System ID	Existing Conditions or Proposed Protection Methods	The Hazards					
		Earth-quake	Flood	Wind	Security/Blast (FEMA 428)	Fire	Discussion Issues
1	Site						
	1-1 Building elevated on fill	❑	✔	❑	❑	❑	Excellent solution for flood.
	1-2 Two means of site access	✔	✔	✔	✔	✔	Provides positive protection across hazards.
	1-3 In close proximity to other facilities that are high-risk targets for attack	❑	❑	❑	✘	❑	Presents a high risk for blast hazard; can present a somewhat increased risk for fire and earthquake damage.

Building System Protection Methods: Reinforcements and Conflicts (continued)							
System ID	**Existing Conditions or Proposed Protection Methods**	**The Hazards**					
		Earth-quake	Flood	Wind	Security/Blast (FEMA 428)	Fire	Discussion Issues
2	**Architectural**						
2A	Configuration						
	2A-1 Large roof overhangs	✘	❑	✘	✘	❑	Possibly vulnerable to vertical forces in earthquake, uplift wind forces.
	2A-2 Re-entrant corner (L-, U-shape, etc.) building forms	✘	❑	✘	✘	❑	May concentrate wind or blast forces; may cause stress concentrations and torsion in earthquakes.
	2A-3 Enclosed courtyard building forms	✘	❑	✔	✔ ✘	❑	May cause stress concentrations and torsion in earthquakes; courtyard provides protected area against high winds.
	2A-4 Very complex building forms	✘	✘	✘	✘	✘	May cause stress concentrations and torsion in highly stressed structures. Complicates flood resistance by means other than fill.

Building System Protection Methods: Reinforcements and Conflicts (continued)							
System ID	**Existing Conditions or Proposed Protection Methods**	**The Hazards**					
		Earth-quake	Flood	Wind	Security/Blast (FEMA 428)	Fire	Discussion Issues
2B	Planning and Function (No significant impact)						
2C	Ceilings (No significant impact)						
2D	Partitions						
	2D-1 Block, hollow clay tile partitions	✘	✔	✘	✘	✔	Wind and seismic force reactions would be similar for heavy unreinforced wall sections, with risk of overturning.
	2D-2 Use of non-rigid connections for attaching interior non-load bearing walls to structure	✔	❑	✔	✔	✘	Non-rigid connections are necessary to avoid partitions influencing structural response.
	2D-3 Gypsum wallboard partitions	✔	✘	❑	✘	✘	Such partitions can be more easily damaged or penetrated during normal building use.
	2D-4 Concrete block, hollow clay tile around exit ways and exit stairs	✘	❑	❑	✘ ✔	✔	May create torsional structural response and/or stress concentration in earthquakes in frame structures unless separated and, if unreinforced, wall is prone to damage.

Building System Protection Methods: Reinforcements and Conflicts (continued)							
System ID	**Existing Conditions or Proposed Protection Methods**	**The Hazards**					
		Earth-quake	Flood	Wind	Security/Blast (FEMA 428)	Fire	Discussion Issues
2E	Other Elements						
	2E-1 Heavy roof (e.g., slate, tile)	✘	❑	✘	✘	✘ ✔	Heavy roofs are undesirable in earthquakes; slates and tiles may detach. Almost always used on steep-sloped roofs; if wind-blown debris hits them, they become flying debris and dangerous to people outside the building.
	2E-2 Parapet	✘ ✔	❑	✔	✘	✔	Properly engineered parapet is OK for seismic; unbraced unreinforced masonry (URM) is dangerous.
3	**Structural Systems**						
	3-1 Heavy structure: reinforced concrete (RC) masonry, RC or masonry fireproofing of steel	✘	✔	✔	✔	✔	Increases seismic forces, but generally beneficial against other hazards.
	3-2 Light structure: steel/ wood	✔	✘	✘	✘	✘	Decreases seismic forces, but generally less effective against other hazards.
	3-3 URM exterior load bearing walls	✘	✘	✘	✘	✘	
	3-4 Concrete or reinforced CMU exterior structural walls	✔	✔	✔	✔	✔	
	3-5 Soft/weak first story	✘	✘ ✔	✘	✘	✘	Very poor earthquake performance. Generally undesirable for flood and wind. Elevated first floor is beneficial for flood if well constructed, but should not be achieved by a weak structure that is vulnerable to wind or flood loads.

Building System Protection Methods: Reinforcements and Conflicts (Continued)							
System ID	Existing Conditions or Proposed Protection Methods	The Hazards					
		Earth-quake	Flood	Wind	Security/Blast (FEMA 428)	Fire	Discussion Issues
	3-6 Indirect load path	✘	❑	✘	✘	✘	Undesirable for highly stressed structures. Not critical for floods.
	3-7 Discontinuities in vertical structure	✘	❑	✘	✘	✘	Undesirable for highly stressed structures, causes stress concentrations. Not critical for floods.
	3-8 Seismic separation joints	✔	❑	❑	❑	✘	Possible path for toxic gases to migrate to other floors.
	3-9 Ductile detailing and connections/steel	✔	❑	✔	✔	❑	Provides a tougher structure that is more resistant to collapse.
	3-10 Ductile detailing/RC	✔	❑	✔	✔	❑	Provides a tougher structure that is more resistant to collapse.
	3-11 Design for uplift (wind)	✔	❑	✔	✔	❑	Necessary for wind; may assist in resisting seismic or blast forces.
	3-12 Concrete block, hollow clay tile around exit ways and exit stairs	✘	❑	❑	✘	✔	May create torsional structural response and/or stress concentration in earthquakes in frame structures unless separated, and if unreinforced wall is prone to damage.

Building System Protection Methods: Reinforcements and Conflicts (coninued)							
System ID	Existing Conditions or Proposed Protection Methods	The Hazards					
		Earth-quake	Flood	Wind	Security/Blast (FEMA 428)	Fire	Discussion Issues
4	**Building Envelope**						
4A	Wall Cladding						
	4A-1 Masonry veneer on exterior walls	✘	✘	✘	✘	❑	In earthquakes, material may detach and cause injury. In winds, may detach and become flying debris hazard. Flood forces can separate veneer from walls.
4B	Glazing						
	4B-2 Impact-resistant glazing	❑	❑	✔	✔	✘	Can cause problems during fire suppression operations, limiting access and smoke ventilation.
	4B-1 Metal/glass curtain wall	✔	❑	✘	✘	✘	Light weight reduces earthquake forces.
5	**Utilities** (No significant impact)						
6	**Mechanical**						

Notes:
The table refers to typical school structures: steel frame, concrete block or RC walls, wood frame, 1-2 stories suburban, 2-4 stories urban.

JOB AID 5-2: SUMMARY OF DMA REQUIREMENTS AND HAZUS-MH SUPPORT

Step and Related DMA 2000 Requirement(s)	Outputs from HAZUS-MH, How-To-Guide, and Risk Assessment Tool	Application to Mitigation Plan
INTRODUCTION		
Planning process description and plan adoption process	Worksheet 1: risk assessment team	This output helps to illustrate the types of persons who supported the risk assessment portion of your planning process. Accompanying text can explain how these parties were involved in your planning process.
STEP 1: IDENTIFY HAZARDS		
Geographic region description	Base map with local GIS data overlain in HAZUS-MH	Your base map can be used to help illustrate the area being addressed in your hazard mitigation plan. The Risk Assessment Tool (RAT) will also produce a map of your study region (see Appendix F for a list of RAT outputs).
Overview and descriptions of hazards of concern in your area	Worksheet 1-1, Identify Hazards	This worksheet can be used to summarize the results of your initial hazard identification and initial data sources used. Accompanying text will explain how this list was developed using available resources and the professional knowledge of your risk assessment team.
STEP 2: PROFILE HAZARDS		
Overview and descriptions of hazards	Worksheet 2-1 and HAZUS-MH provided hazard event data	Worksheet 2-1 supports profiling efforts and can be used to document the total hazards considered and those carried forward for further study.
	Worksheet 2-2 and hazard maps	Worksheet 2-2 should be completed for each hazard retained on Worksheet 2-1. These worksheets combined with any attached hazard area maps and other figures to describe the hazard serve as the hazard profile and will help you address the same types of data for each hazard.
	Worksheet 2-3 with prioritized hazards	This worksheet helps you document your preliminary ranking of hazards based on your profile efforts. Accompanying text will help explain your team's ranking approach and results.

Step and Related DMA 2000 Requirement(s)	Outputs from HAZUS-MH, How-To-Guide, and Risk Assessment Tool	Application to Mitigation Plan
STEP 3: INVENTORY ASSETS		
Overview and analysis of vulnerability; description of important and critical areas	Updated HAZUS-MH data • General building stock • Demographic data • Critical facilities • Lifeline utility and transportation systems	These data serve as your inventory for the risk assessment. You can use HAZUS-MH to create tables and maps of inventory to support your plan.
	Worksheets 3-1, 3-2, and 3-3 • Building value • Content value • Demographic data • Lifeline utility and transportation systems	These worksheets summarize the inventory data for the risk assessment. Your plan text should describe this data and also should address development trends that may increase or decrease inventory within your study area and discuss how these trends relate to your hazards of concern.
STEP 4: ESTIMATE LOSSES		
Overview and analysis of potential losses; review of loss estimates	Analysis type, scenario inputs	Text in your plan should describe the analyses and inputs selected for this risk assessment. Review hazard characteristic data used, mean return periods selected, hazard areas used to estimate exposure and other factors, as appropriate.
	HAZUS-MH outputs (Models, Risk Assessment Tools, Flood Wizard)	These outputs can be used to support plan development. Specifically, the RAT provides summary text, tables and maps designed to support your DMA plan.

Step and Related DMA 2000 Requirement(s)	Outputs from HAZUS-MH, How-To-Guide, and Risk Assessment Tool	Application to Mitigation Plan
STEP 5: CONSIDER MITIGATION OPTIONS		
Mitigation strategy (basis)	Use the HAZUS-MH Risk Assessment Tool (RAT) to produce various risk assessment maps, graphics, and data that can be directly used in your mitigation plan.	As stated for Step 4, the RAT provides outputs to support your plan. These outputs also serve as the foundation to begin identifying mitigation goals, objectives, and actions as discussed in Step 4.
Mitigation strategy (foundatrion and focus for mitigation actions)	Worksheets 5-1A and 5-1B	These worksheets can be used in your mitigation strategy to support documentation of mitigation focus areas and options for the built environment.
Mitigation strategy (assessment)	Worksheet 5-2	This worksheet will help you document the option evaluation process for FEMA - recommended evaluation criteria and your community's particular criteria and mitigation priorities.
Mitigation strategy (action plan)	Worksheet 5-3	The consolidated list of options and accompanying text will support documentation of your basis for retaining particular mitigation options for implementation. This supports your mitigation action plan.