step


1 identify hazards
2 profile hazard events
3 inventory assets
4 estimate losses

2

profile hazard events

Lee County, Georgia during the 1995 Spring floods.

Overview

With a list of potential hazards in hand from Step 1, the next step is to develop hazard event profiles, which answers the question: *How bad can it get?*

The information gathered in this step will help determine the assets in the hazard areas you will inventory in Step 3.

Each hazard type has unique characteristics that can impact your community or state. For example, an earthquake causes ground shaking that will affect a community much differently than the wind of a tornado. In addition, a given hazard type can produce different effects depending on its magnitude, duration, or intensity. For example, no two wildfires will impact a community in the same way twice because the wildfire is driven by distinct wind and fuel conditions, which can change very rapidly. Furthermore, the same hazard events will affect different communities in different ways, based on geography, development, population distribution, age of buildings, etc. A **hazard event** is a specific occurrence of a particular type of **hazard**.

The glossary in Appendix A explains the relationship between a hazard and hazard event.

For these reasons, the information you gather for each of your hazard event profiles will reflect these different characteristics. Some hazards, such as floods, coastal storms, wildfires, tsunamis, and landslides will be profiled by mapping the geographic extent of identifiable hazard events because they occur in predictable areas of the community or state. Once the extent of these events is mapped you will be able to determine which portion of your community or state is vulnerable in Step 3 and begin taking inventory of the elements that can be damaged. Other hazards, such as tornadoes (which can occur anywhere), may be profiled simply by recording the maximum potential wind speed. This type of information will be used in Step 4 to evaluate the potential impact to individual structures or elements in your jurisdiction.

This step is structured to explain the basic procedures and techniques for profiling hazard events. It then instructs you on how to gather specific hazard event profile information. Use **Worksheet #2: Profile Hazard Events** in Appendix C (see example on page 2-2) to help you record and keep track of your results.

Worksheet #2 — Profile Hazard Events — step 2

Date: May, 2001

How Bad Can It Get?

Task A. Obtain or create a base map.

You can use existing maps from:

- *Road maps*
- *USGS topographic maps or Digital Orthophoto Quarter Quads (DOQQ)*
- *Topographic and/or planimetric maps from other agencies*
- *Aerial topographic and/or planimetric maps*

OR you can create a base map using:

- *Field surveys*
- *GIS software*
- *CADD software*
- *Digitized paper maps*

Title of Map	Scale	Date
USGS topographic	1:24,000	1995

Hazard	**Task B. Obtain a hazard event profile.** Check box when complete and fill in source of information.	**Task C. Record your hazard event profile information.** Check box when complete.
Flood	☑ 1. Get a copy of your FIRM. FEMA Map Service Center ☑ 2. Verify the FIRM is up-to-date and complete. Hazardville Planning Dept. & floodplain manager	☑ 1. Transfer the boundaries from your FIRM onto your base map (floodway, 100-yr flood, 500-yr flood). ☑ 2. Transfer the BFEs onto your base map.
Earthquake	☑ 1. Go to the http://geohazards.cr.usgs.gov Website. ☑ 2. Locate your planning area on the map. ☑ 3. Determine your PGA.	☑ 1. Record your PGA: ____________ ☑ 2. If you have more than one PGA print, download or order your PGA map.
Tsunami	☑ 1. Get a copy of your tsunami inundation zone map. West Coast/Alaska Tsunami Warning Center of NOAA	☑ 1. Copy the boundary of your tsunami inundation zone onto your base map.
Tornado	☑ 1. Find your design wind speed. Hazardville Building Inspector/Building Code	☑ 1. Record your design wind speed: ________ ☑ 2. If you have more than one design wind speed, print, download, or copy your design wind speed zones, copy the boundary of your design wind speed zones on your base map, then record the design wind speed zones on your base map.
Coastal Storm	☑ 1. Get a copy of your FIRM. FEMA Map Service Center ☑ 2. Verify that the FIRM is up-to-date and complete. Hazardville Planning Dept. & floodplain manager ☑ 3. Determine the annual rate of coastal erosion. State Coastal Zone Manager ☑ 4. Find your design wind speed. Hazardville Building Inspector/Building Code	☑ 1. Transfer the boundaries of your coastal storm hazard areas onto your base map. ☑ 2. Transfer the BFEs onto your base map. ☑ 3. Record the erosion rates on your base map: ____________ ☑ 4. Record the design wind speed here and on your base map: ________
Landslide	☑ 1. Map location of previous landslides. University study ☑ 2. Map the topography. USGS topographic maps ☑ 3. Map the geology. U.S Natural Resources Conservation Service soil maps ☑ 4. Identify the high-hazard areas on your map.	☑ 1. Mark the areas susceptible to landslides onto your base map.
Wildfire	☑ 1. Map the fuel models located within the urban-wildland interface areas. National Fire Danger Rating ☑ 2. Map the topography. USGS topographic map ☑ 3. Determine your critical fire weather frequency. State Fire Marshall ☑ 4. Determine your fire hazard severity. How-To pg. 2-34	☑ 1. Draw the boundaries of your wildfire hazard areas onto your base map.
Other	☐ 1. Map the hazard. ____________	☐ 1. Record hazard event info on your base map.

Procedures & Techniques

Task A. Obtain/create a base map.

When you start the hazard event profiling process, you should locate or create a base map so that you can show the areas that are subject to various hazards. A base map should be as complete, accurate, and current as possible and should be planimetric, which is a flat representation of information in true geographic relationship (to scale) with measurable horizontal distances. Other than distinguishable buildings, roads, rivers, coastlines, place names, and a north arrow, the map should be as uncluttered as possible. Use an existing map or controlled photograph as a base to avoid the cost of producing a new map.

Maps provide common frames of reference when describing where and how hazards can affect you. Your base map will be essential in Step 3 by showing the human and structural assets that should be inventoried. HAZUS should be considered first as your primary source of hazard data. (See "Tip" on page 2-5 for information on base maps.)

HAZUS

HAZUS – A Risk Assessment Tool

Hazards U.S. (HAZUS), is a standardized, nationally applicable earthquake loss estimation methodology that uses PC-based GIS software. HAZUS contains an extensive inventory of data that can help you conduct your loss estimation in a timely, cost-efficient manner.

Although HAZUS was originally designed to be used to estimate earthquake losses, it has a wider applicability to be used as a mapping and inventory collection tool. For example, you can use the HAZUS default data to identify the census tracts located in your community or state as your base map.

Default data contained in HAZUS

- Demographic data (population, age, ethnicity, and income);
- General building stock (square footage of occupancy classes for each census tract);
- Medical care facilities;
- Emergency response facilities (fire, police, emergency operation centers);
- Schools;
- Dams;
- Hazardous material facilities;
- Roads, airports, and other transportation facilities; and
- Electric power, oil, and gas lines and other utility facilities.

Minimum System Requirements for HAZUS99

- Intel Pentium® class IMP compatible, 400 MHz or greater is recommended
- CD-ROM drive
- Hard drive (minimum 1 GB free space required)
- Color printer or plotter
- Microsoft Windows® 95 or greater
- MapInfo® 5.5/5.0 software or ArcView® 3.2/3.1 GIS software

Minimum System Requirements for HAZUS97

- Intel 486® or greater IBM compatible computer, Pentium® preferred
- CD-ROM drive
- Hard drive (minimum 200 MB free space required)
- Color printer or plotter
- Microsoft Windows® 3.1 or greater
- MapInfo® 4.1.2 software or ArcView® 3.0 GIS software

HAZUS is available from the FEMA Distribution Center at http://www.fema.gov/hazus/hazus6.htm.

The HAZUS package contains a user manual to get you started. If your community does not have someone with the technical resources or expertise needed to use HAZUS ask your regional/or state planning, geology, or transportation department, or enlist the help of your local college or university geography, planning, or landscape architecture department to create the maps for you. You may also consider partnering with a private business in your planning area or hiring someone to assist you.

Task B. Obtain hazard event profile information.

In each of the seven hazard-specific sections that follow, you will be given guidance on how to obtain, download, view, or order the relevant hazard map or other profile information. The suggested choice of return frequency for each hazard is based on the most commonly available information for a particular hazard.

You will purposely consider just one hazard event in each hazard section that follows to keep the process simple. For example, you will consider only the 100-year flood event. A more comprehensive hazard profile that considers all possible events, such as floods with different probabilities, may still be needed at some future date, but for now, this simplified version will be adequate to help you learn more about your community's risks and narrow your focus for future planning efforts.

Level of Risk

If your planning team determines that the level of acceptable risk is different than the level identified by the suggested hazard event in this guide, it may be necessary to revise your risk assessment by profiling a lesser or greater hazard event. For example, you may choose to evaluate an area greater than the 100-year flood elevation established on the FIRM by assessing the 100-year flood elevation plus one additional foot (or other amount).

Task C. Record your hazard event profile information.

Use **Worksheet #2: Profile Hazard Events** to record your research for each hazard profile. Keep track of where you found various maps, such as FIRMs, or hazard event data, such as your design wind speed.

The type of hazard will determine whether you will record the relevant data on the worksheet or copy the boundaries of the hazard event onto your base map.

Practical Considerations when Using Maps

Hazard profile maps can range from simple traced maps to elaborate GIS productions. Both renditions will illustrate your hazard prone areas and will assist you in the next step of taking inventory of the elements that can be damaged.

Often the individual hazard maps to be used are at different scales. This may require an enlargement or reduction to the scale of the base map selected. Use of controlled photographic or computer mapping methods makes this process easy and accurate.

Copies of maps can be made on large format copying machines used by most reprographic companies. Maps also can be professionally photographed and transferred onto your base map.

Summary

When you are finished with this step, you'll either have a map showing the area impacted by each hazard type or you will have an important piece of data regarding the characteristics of hazard events affecting your planning area. In some cases, such as those involving floods, you will have both.

The hazard specific sections that follow contain step-by-step instructions to help you profile your hazards. Visit the library at the end of this guide for more information on specific hazards, contacts, or additional resources to help you profile your hazards.

When you have completed all of your hazard profiles

Go to Step 3

where you will inventory the assets in your planning area that can be damaged by the hazard events you profile.

Base Map Options

Different maps have different advantages and limitations. Some alternatives (listed in order of increasing price and utility) include:

- **Road maps.** There are usually detailed road maps available for areas in and around urban centers. It is important to verify the date the map was produced because it may be outdated and inaccurate. Also, although the street network will be depicted, it is unlikely that buildings will show up on the map. Therefore, you'll have to convert the map for use in risk assessment.
- **USGS Topographic Maps.** Maps showing topographic relief are available for the entire country at 1:24,000 scale (see Scale and Coverage below) from the United States Geological Survey (USGS). Some structures are indicated although not in great detail. Most roads are shown but few are identified. These maps can be obtained via the Internet at http://mapping.usgs.gov/mac/nimamaps/topo.html, or in hard copy from USGS by calling 1-888-ASK-USGS. These maps will have to be converted for use as a base map, just like the road maps. Like road maps, it is important to verify the date the mapping was completed to determine the relative accuracy of the mapped information.

USGS Digital Orthophoto Quarter Quad (DOQQ)

A DOQQ is a computer generated image of an aerial photograph in which displacements caused by camera orientation and terrain have been removed. These products combine the image characteristics of a photograph with the geometric qualities of a map and can be used in numerous GIS applications either alone or in combination with other digital data.

For more information on the USGS digital orthophoto program and DOQQ products visit the USGS Web site at http://mapping.usgs.gov/www/ndop/ or visit the National Mapping Information Web page at http://mapping.usgs.gov/index.html

- **Topographic and/or Planimetric Maps from other agencies.** Local agencies such as county or regional planning commissions often have maps. If there have been major roadwork or infrastructure projects within recent years, public works and transportation departments may have detailed maps that cover all or part of an area of interest.
- **Aerial Topographic and/or Planimetric Maps.** Communities can get new aerial topographic (indicating all built features as well as contour lines that represent the physical shape of the land) or planimetric (indicating built features only) from companies that specialize in aerial photography and photogrammetry. These days, this type of map is always produced in digital as well as reproducible formats. Topographic maps are usually more expensive but may be quite useful for other efforts including follow-up planning for mitigation projects identified later in the planning process. At a minimum, aerial photographs are useful in basic planning efforts as they provide a reliable, recognizable representation of the assets of the community at a reasonable cost.
- **Field Surveys.** In unusual circumstances, it may be practical to have field surveys done. However, for areas of any significant size, this option is more expensive than aerial topographic and planimetric maps and may not yield significantly better information for the mitigation planning efforts.

Scale and Coverage

Scale determines the area covered on the map. The scale is a proportion used in determining a dimensional relationship, which 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. For example, the scale 1:500,000 means that one centimeter on the map equals 500,000 centimeters (or 5,000 meters or 5 kilometers) on the ground. Small-scale maps show less detail for a large area. Smaller scales are more common for regional (1:500,000 through 1:50,000), and community plans (1:24,000 through 1:12,000).

The scale selected will depend upon the map's purpose. There are no best scales, only more appropriate ones to coincide with planning requirements. Consider the following scales for example:

- World: 1:30,000,000
- Continent: 1:5,000,000 to 1:2,000,000
- Region: 1:500,000 to 1:50,000
- Community or settlement: 1:24,000 to 1:12,000
- Building sites: 1:10,000 to 1:2,500

The level of detail, the hazards shown, and the format of a risk assessment map can range widely depending on the scale you choose. The scale used for a risk assessment is dependent upon not only the hazard information to be shown but also upon the scale of the base map. If a choice of scales is available, then the following factors become important in making the selection:

- Number of hazards to be shown.
- Hazard characteristics to be shown.
- Range of relative severity of hazards to be shown.
- Area to be covered.
- Use of the map in conjunction with other planning documents.
- Function of the map, for example, whether it is to be an index or detail map.

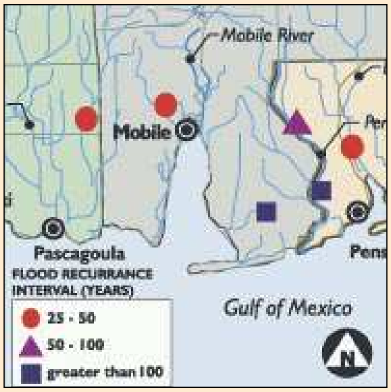
You may want to recommend that communities use a consistent base map, particularly if your state has already developed mapping at a suitable scale that can be used locally and covers the entire state. For example, a statewide Geographic Information System (GIS) would allow you to easily incorporate local information into state planning efforts.

As you proceed, keep in mind you will want to incorporate the results of individual communities' risk assessments into your own. This will give you more details on hazards and risks throughout the state. You may want to provide guidance to communities on the level of detail and return frequencies to use in local risk assessments in order to produce a uniformly consistent state risk assessment. You may also want to fill in the gaps for the areas of the state or communities that do not have local risk assessments.

You will also need to decide whether you will conduct the loss estimation state properties or request that local governments do this as part of community-level planning. Either way, you should make sure communities are aware how to treat state-owned facilities in their loss estimation.

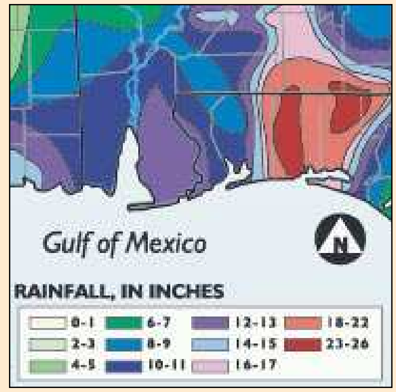
Map Symbols

Mapped hazard areas can show various degrees of risk (e.g., seismic risk) or can identify a zone where risk is present (e.g., a floodplain). Map symbols represent reality by conveying a sense of the hazard. Symbols that represent hazard characteristics are selected for their legibility, clarity, and/or map production characteristics. There are three distinct map symbols: points, lines, and areas. The maps below depict characteristics of Hurricane Georges using points, lines, and areas.



Points can be used to show location of fire and police stations, hospitals, and emergency shelters, as well as points of impact from hurricanes, epicenters of earthquakes or locations of specific flood frequencies.

Lines can be used to separate areas of landslide frequency, to represent earthquake intensity, or to show tracks of storms, fault rupture, or tsunamis.



Areas can be used to show the extent of certain hazard conditions, such as flooding as well as erosion and wildfire zones.

Advanced computer programs have been developed for displaying and analyzing hazard identification data. Three of the most common computer programs used for hazard mapping are FEMA's Hazards U.S. (HAZUS), Geographic Information Systems (GIS), and Computer Aided Design & Drafting (CADD).

HAZUS

HAZUS contains an extensive inventory of data that communities can use and build upon as a loss estimation tool. HAZUS is currently being expanded into a multi-hazard methodology with new models for estimating potential losses from wind (hurricanes, thunderstorms, tornadoes, and extra-tropical cyclones) and flood (riverine and coastal) hazards. HAZUS is a flexible tool that has potential for use in risk assessment, response and recovery, and awareness and preparedness programs.

GIS

GIS is a computer-based tool for mapping and analyzing physical elements and events that occur on earth. GIS is a database that relates detailed information directly to a geographical area for mapping and analysis purposes. Software for GIS is available from many distributors. ArcView® and MapInfo® are two of the most commonly used sources of GIS software.

GIS allows users to overlay different kinds of data to determine relationships among them. Maps produced with GIS can help to explain hazard events, predict outcomes, visualize scenarios, and plan strategies. Some communities and regional planning authorities maintain GIS databases for planning land uses and managing utilities. GIS can map hazard areas and present hazard identification information, allowing the user to compare these areas with existing land uses. GIS also allows the user to:

- Import geographic data such as maps;
- Manipulate geographic data and update community zoning maps;
- Store and analyze attributes associated with geographic data;
- Perform queries and analyses to retrieve data (for example, show all child care centers within five miles of a fire station); and
- Display results as maps or graphs.

CADD

CADD is a computer system that allows users to perform drawing and design tasks, enabling quick and accurate electronic drawings. There are hundreds of CADD programs available in the CADD industry today, furnishing 2D drawings, 3D drawings, topographic base maps, site plans, and profiles/cross sections. Detailed hazard maps in a variety of dimensions can be made using CADD products on a computer.

Digitizing

Digitizing maps is the process of converting points, lines and area boundaries shown on maps into x, y coordinates (e.g. latitude and longitude, universal transverse mercator (UTM) or table coordinates). If your community does not already have this capability, you should contact local civil engineering or land surveying companies to investigate opportunities for contracting this work.

Data Availability

If a particular hazard map is not available for your planning area, you can create one using a variety of methods depending on the level of detail and accuracy required. The following examples range from simplest to the most complex.

Historical hazard event. The chosen event will determine the physical extent of the hazard and the severity. This method will provide a "snapshot" of one potential event. Later in this step, the hazard-specific sections that follow offer suggestions of how to gather information for historic hazard events.

Detailed hazard profile. You can create a detailed hazard profile by researching:

- how likely it is that hazard will impact the area (probability);
- how severe the hazard will be (magnitude);
- where hazards will affect the community or state (geographic extent); and
- conditions in the community that may increase or reduce the effects of hazards.

These elements are closely related, and are often combined in expressions linking probability (or frequency) and magnitude (or extent). Some examples of the types of factors that can exacerbate (increase) or mitigate (reduce) hazard effects are:

- topography (for most hazards)
- soil characteristics (earthquakes and landslides)
- soil saturation (floods and landslides)
- presence of fuel load (wildfires)
- presence of development in the hazard area (floods)
- existence of hazardous materials facilities in or near hazard zones (for all hazards)

Some of the factors are aspects of the planning area over which people have some control. For example, while you cannot control the duration of a hurricane, you can decide not to build on or near steep slopes. The hazard-specific sections that follow offer suggestions of how to gather information to conduct a detailed hazard profile, and the library in Appendix B offers suggestion of where to find more information on specific hazards. These factors will become important when planning the mitigation actions to protect your community or state from natural hazards in phase three of the natural hazard mitigation planning process.

Engineering study. Hydraulic engineers calculate flood elevations through stream gauge data and information on drainage area, rainfall potential, characteristics of the source of flooding (usually a river or stream), and soil saturation. The hazard-specific sections that follow offer suggestions of various computer modeling programs, as well as information about who you should contact for additional help.

Data Limitation

Data about what's happened in the past is often used to estimate what's likely to happen in the future. For example, chances are that "tornado alley" in the midwest, will experience more tornadoes this year than other parts of the United States. This assumption is simply based on the fact that tornadoes have often impacted that area in the past. The same is true in a small town whose main street has flooded numerous times in the past. However, there's a big difference between a particular street being flooded and an entire state being impacted by tornadoes. There are a number of site-specific characteristics that determine flood potential. On the other hand, a state that has experienced an average of 100 tornadoes each year for the last 30 years does **not** mean that a tornado will hit any particular point in the state next year.

The Hazardville Post

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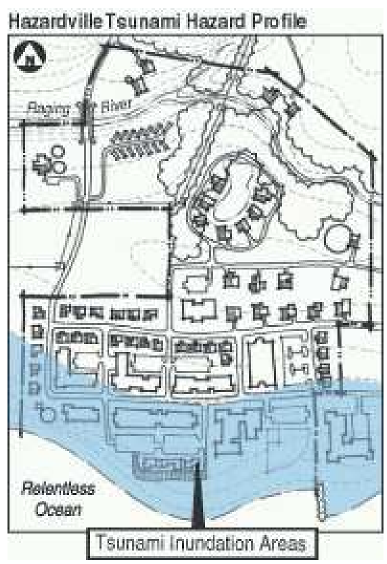
THORR Profiles Hazardville's Hazards

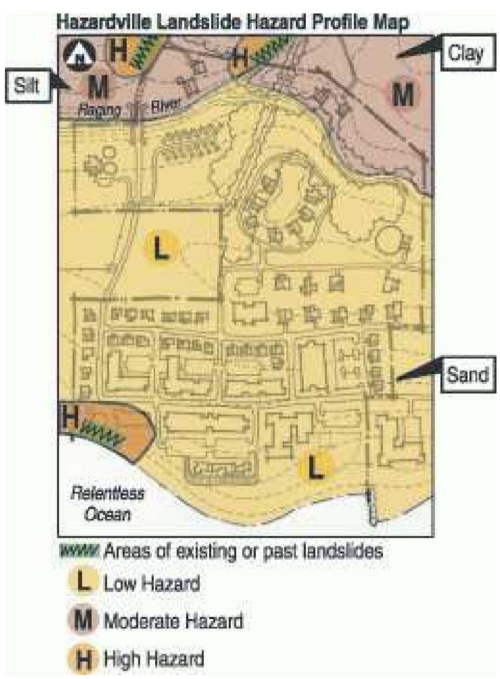
(Part 2 of a 4 Part Series on the Risk Assessment Process)

[Hazardville, EM] In April, the Hazardville Post reported the ongoing work of the Town of Hazardville Organization for Risk Reduction (THORR). THORR recently completed its hazard research and has developed a series of hazard profiles that represent the next big step in describing the problems.

Joe Norris, lead planner of the task force, emphasized, "Our motto, 'A Small Town with Big Problems' is certainly accurate when it comes to natural hazards, but our recent efforts of identifying and profiling the hazards will help us deal with them effectively in the future." Norris said that a host of hazards, including floods, earthquakes, tsunamis, tornadoes, hurricanes, landslides, and wildfires, pose potential threats to the Town of Hazardville. THORR presented its hazard profiles at last night's Board of Supervisors meeting.

Mary Tremble, director of the Hazardville Emergency Management Agency (HEMA) and head of the Earthquake, Tsunami and Landslide Workgroup, revealed that Hazardville has a moderate earthquake threat. "After learning about our seismic potential from the state geologist, the Workgroup contacted Emergency State University's Geology Department for more information on seismicity. Using maps produced by the U.S. Geological Survey, we found that the entire town is within a seismic zone that has a 10% chance of exceeding 0.3g in 50 years." The %g refers to the percent of acceleration due to gravity and is used to measure the strength of ground movements.





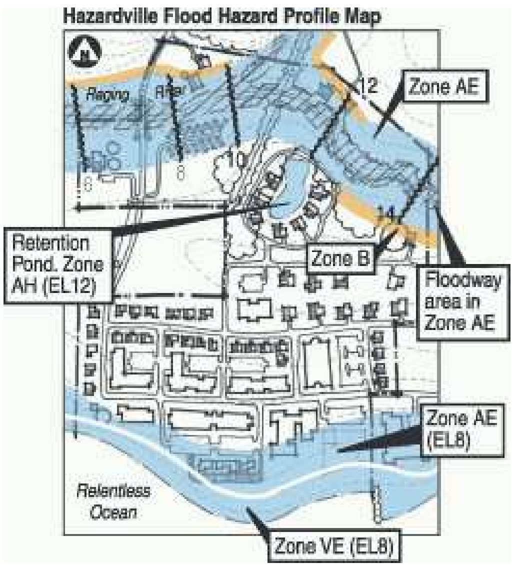
For Hazardville, that generally means that an earthquake of that size could cause moderate to severe damage according to Tremble. For example, it could cause moderate damage to structures with un-reinforced masonry chimneys or severe damage to poorly constructed buildings. A large off-shore earthquake could also cause a tsunami that could impact up to one-mile inland of the Hazardville coastline within 15 minutes of the quake.

Tremble reported that the biggest concern for the Workgroup is the area of town that is susceptible to landslides. Several landslides have been recorded on the bluffs following heavy rains. These areas are susceptible to slides mostly because of ground saturation but also present a danger when earthquakes occur because of the steep slopes, Tremble said. Hazardville has three landslide zones. “The areas of past landslides are shown as high hazard areas,” Ms. Tremble said. “The moderate hazard area is north of Raging River and includes areas with steep slopes and unstable soils.”

(continued on page 2–9)

(continued from page 2-8)

Mr. David Waters, head of the Flood and Hurricane Workgroup, explained Hazardville's flood risk. Waters, who is also the town's Floodplain Manager, explained that Hazardville's Flood Insurance Rate Map (FIRM) shows the 100-year floodplain (areas with a 1% chance of flooding each year) in the coastal region to the south and in the vicinity bordering Raging River in the northern part of town. The coastal region is designated as AE and VE zones, meaning that floods will have wave action and will travel quickly. A map of the town with its flood hazard zones illustrates that floods pose a threat to a significant portion of the community.

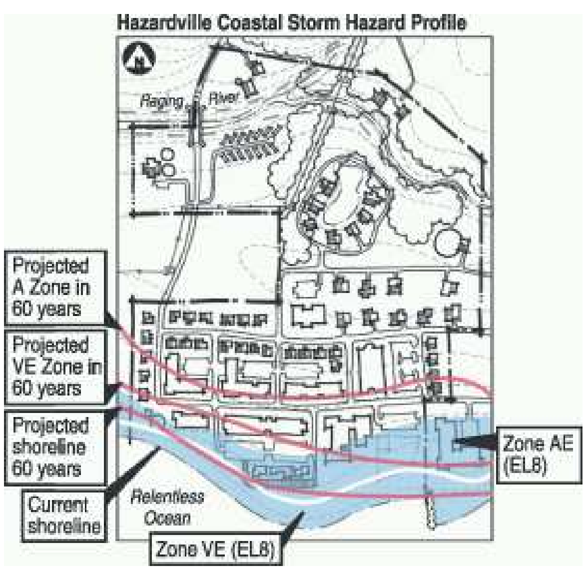


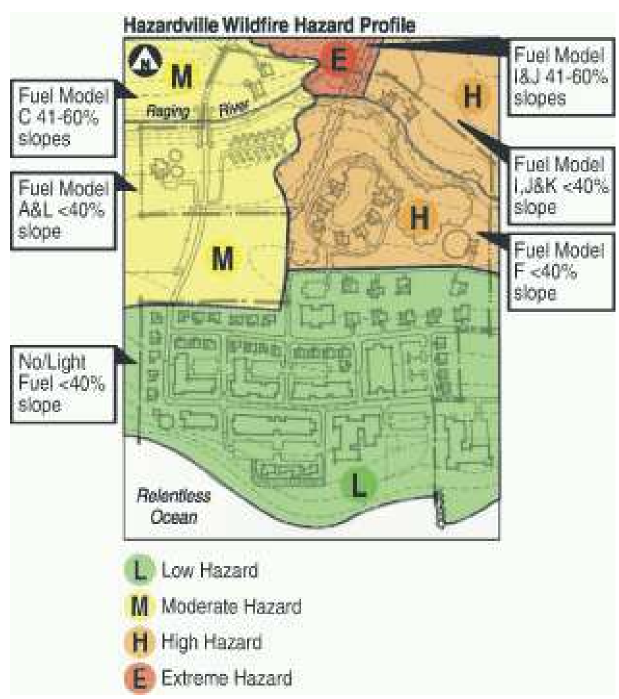
Ms. Wendy Soot, head of the Tornadoes and Wildfires Workgroup, cautioned that Hazardville is also susceptible to tornadoes. "Hazardville is located in a 200 mph wind zone, which means we could experience a severe (F3) tornado. A tornado of this severity could remove roofs, knock over walls, and even overturn cars and trains."

Soot, who is also the town's Fire Marshal, added that Hazardville has four wildfire zones. "We have an extreme and high wildfire hazard area on the northern edge of town due to the steep topography and heavy fuel of the forest," Ms. Soot said. "The area of town south of Raging River is considered a moderate and high wildfire hazard area, due to the light fuel and proximity to the forest.

When asked about the professional look of the maps, Norris responded that all mapping was done using the town's own resources. "In fact," he explained, "the base was traced from a USGS map by the Hazardville Planning Office." The hazard profiles were compiled from various sources including soil maps, topography maps, and storm surge maps. A map specialist from the transportation department helped us trace the hazard profiles on to our base map. Some of the maps had to be reduced or enlarged on a copy machine to produce the same scale as the base map.

Norris expects the risk assessment process to continue to be successful. He credited the hard work of THORR members and the state and federal government workers who have assisted them. "This has been and will continue to be a truly cooperative effort," he said.





Task B. Obtain flood hazard event profile information.

The best source of local flood hazard information is the Flood Insurance Study (FIS) developed under the National Flood Insurance Program (NFIP) administered by FEMA. An FIS contains a Flood Insurance Rate Map (FIRM), which is an official map of a community that shows areas at risk from flooding from the base flood (see page 2-12 for more information on floods). Another element of the FIS is a graph, also known as a flood profile, which shows potential flood elevations plotted along the waterways. This information will help you delineate the boundaries of the floodplain in your planning area.

At the very least, you should research past or historic flood events. You can use old watermarks and eyewitness accounts to delineate the approximate flood boundaries and depths of flooding on your base map, or especially if there is not a FIRM or Q3 available for your community. Contact your state NFIP coordinator for more information on flooding in your area. In addition, the USGS, U.S. Army Corps of Engineers, or a civil engineer skilled in hydraulic analysis can help you conduct a flood study.

The following is the system FEMA uses on the FIRMs to categorize different floodplain areas.

Flood Zones

Zone A		The 100-year or base floodplain. There are six types of A zones:
	A	The base floodplain mapped by approximate methods, i.e., BFEs are not determined. This is often called an unnumbered A zone or an approximate A zone.
	A1-30	These are known as numbered A zones (e.g., A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format).
	AE	The base floodplain where base flood elevations are provided. AE zones are now used on new format FIRMs instead of A1-A30 zones.
	AO	The base floodplain with sheet flow, ponding, or shallow flooding. Base flood depths (feet above ground) are provided.
	AH	Shallow flooding base floodplain. BFEs are provided.
	A99	Area to be protected from base flood by levees or Federal flood protection systems under construction. BFEs are not determined.
	AR	The base floodplain that results from the de-certification of a previously accredited flood protection system that is in the process of being restored to provide a 100-year or greater level of flood protection.
Zone V and VE	**V**	The coastal area subject to a velocity hazard (wave action) where BFEs are not determined on the FIRM.
	VE	The coastal area subject to a velocity hazard (wave action) where BFEs are provided on the FIRM.
Zone B and Zone X (shaded)		Area of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods. B zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from the 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than 1 square mile.
Zone C and Zone X (unshaded)		Area of minimal flood hazard, usually depicted on FIRMs as exceeding the 500-year flood level. Zone C may have ponding and local drainage problems that do not warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood.
Zone D		Area of undetermined but possible flood hazards.

1. Get a copy of your FIRM.

By using a copy of the FIRM, you will evaluate the 100-year flood (a flood that has a 1 percent chance of occurring in any one year).

Copies of FIRMs can be requested by calling the FEMA Map Service Center at 1.800.358.9616, on the Internet at http://www.fema.gov/maps, or by contacting a FEMA Regional Office. Additionally, the NFIP's Guide to Flood Maps is available on the web at http://www.fema.gov/nfip/readmap.htm, and flood risk and map information is available at http://www.fema.gov/nfip/fmapinfo.htm.

FEMA is currently involved in converting FIRMs to digital format (DFIRM). The DFIRM product will be designed to allow for the creation of interactive multi-hazard digital maps that can be used on a personal computer using GIS.

Digital Q3 flood data is available for 1,200 counties in CD-ROM format. The Q3s are digital representations of certain features of FIRMs and are intended for use with desktop mapping and GIS technology. 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 location of the Special Flood Hazard Area (SFHA). The main differences between the Q3s and the official paper FIRMs is that the Q3s do not include the following:

- hydrographic features (streams and rivers, lake and coastal shorelines);
- base flood elevations;
- cross-section lines;
- roads, road names, or address ranges; and
- locations, elevations and descriptions of benchmarks and elevation reference marks.

The Digital Q3 Flood Data and DFIRMs are also available from the FEMA Map Service Center, in addition, the Q3 maps are available on the FEMA HAZUS CD.

If you participate in the NFIP you should have FIRMs locally. Contact your NFIP coordinator or floodplain manager, usually located in the planning, building, engineering, or natural resources department, or your state NFIP coordinator for copies of your FIRM or to help you identify areas that are prone to flooding. Your state NFIP coordinator or state floodplain manager can be found at http://www.floods.org/stcoor.html.

2. Verify that the FIRM is up-to-date and complete.

No map is perfect and floodplains change due to a number of reasons. From time to time, FEMA, communities or individuals may find it necessary for a FIRM to be updated, corrected, or changed.

Review the FIRM to determine whether any of the following circumstances apply to your planning area:

(continued on page 2-14)

Most flood information is provided on a community-wide scale. Rather than compiling a FIRM for each community in your state, you can use Q3s. The Q3 maps are available on the state-specific supplemental data CD ROMs for use with FEMA's GIS-based HAZUS Loss Estimation software program.

You should also be prepared to assist communities with obtaining flood mapping, and understanding the information presented on FIRMs.

FEMA uses two methods to make flood map changes. The first is to actually change the map and publish new copies. The other method is to issue a letter that describes the map change. There are two types of letters indicating map changes:

LOMR – Letter of Map Revision

LOMA – Letter of Map Amendment

These letters officially amend or revise the effective NFIP map. Contact your FEMA regional office for more information on map changes.

What is a flood?

A flood is a natural event for rivers and streams. Excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto the banks and adjacent floodplains. Floodplains are lowlands, adjacent to rivers, lakes, and oceans that are subject to recurring floods. Hundreds of floods occur each year, making it one of the most common hazards in all 50 states and U.S. territories. Floods kill an average of 150 people a year nationwide. They can occur at any time of the year, in any part of the country, and at any time of day or night. Floodplains in the U.S. are home to over nine million households. Most injuries and deaths occur when people are swept away by flood currents, and most property damage results from inundation by sediment-filled water.

Several factors determine the severity of floods, including rainfall intensity (or other water source) and duration. A large amount of rainfall over a short time span can result in flash flood conditions. A small amount of rain can also result in floods in locations where the soil is saturated from a previous wet period or if the rain is concentrated in an area of impermeable surfaces such as large parking lots, paved roadways, or other impervious developed areas.

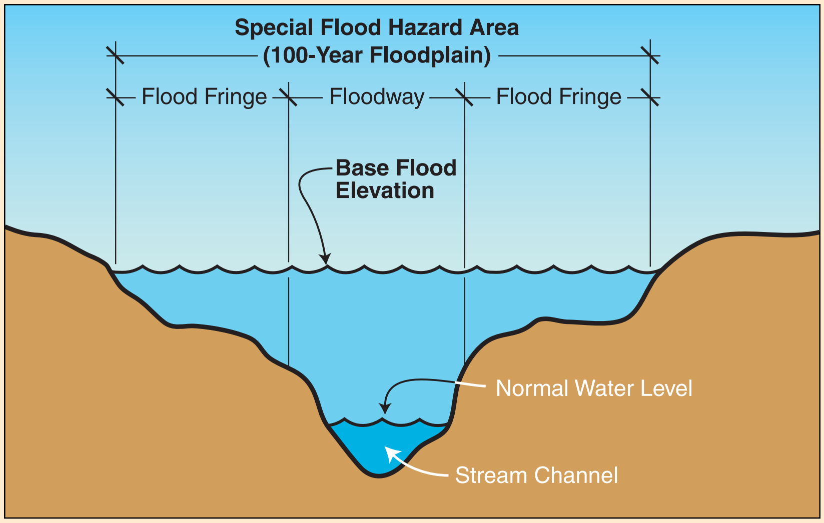
Topography and ground cover are also contributing factors for floods. Water runoff is greater in areas with steep slopes and little or no vegetative ground cover.

Frequency of inundation depends on the climate, soil, and channel slope. In regions where substantial precipitation occurs in a particular season each year, or in regions where annual flooding is derived principally from snowmelt, the floodplains may be inundated nearly every year. In regions without extended periods of below-freezing temperatures, floods usually occur in the season of highest precipitation. In areas where flooding is caused by melting snow, and occasionally compounded by rainfall, the flood season is spring or early summer.

Fortunately, most of the known floodplains in the United States have been mapped by FEMA, which administers the NFIP. When a flood study is completed for the NFIP, the information and maps are assembled into a Flood Insurance Study (FIS). An FIS is a compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community and includes causes of flooding.

The FIS report and associated maps delineate Special Flood Hazard Areas (SFHAs), designate flood risk zones, and establish base flood elevations (BFEs), based on the flood that has a 1% chance of occurring annually, or the 100-year flood. The study may have three components:

- The FIS – Flood Insurance Study text;
- The FIRM – Flood Insurance Rate Map; and
- A separate Flood Boundary and Floodway Map (FBFM) that was issued as a component of the FIS for each community studied prior to 1986. No BFE or flood zone names are shown on the floodway map and people often confuse the white floodway with the white area representing land that is free from flooding. FIS reports published since 1986 have corrected this problem by delineating the floodways as diagonally hatched areas on the FIRMs.



The **100-year flood** designation applies to the area that has a 1 percent chance, on average, of flooding in any given year. However, a 100-year flood could occur two years in a row, or once every 10 years. The 100-year flood is also referred to as the **base flood**. The base flood is the standard that has been adopted for the NFIP. It is a national standard that represents a compromise between minor floods and the greatest flood likely to occur in a given area and provides a useful benchmark.

Base Flood Elevation (BFE), as shown on the FIRM, is the elevation of the water surface resulting from a flood that has a 1% chance of occurring in any given year.

The BFE is the height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum (NGVD) of 1929, the North American Vertical Datum (NAVD) of 1988, or other datum referenced in the FIS report.

Special Flood Hazard Area (SFHA) is the shaded area on a FIRM that identifies an area that has a 1% chance of being flooded in any given year (100-year floodplain).

FIRMs show different floodplains with different zone designations. These are primarily for insurance rating purposes, but the zone differentiation can be very helpful for other floodplain planning purposes. The more common zones were listed in the table on page 2-10.

Floodway is the stream channel and that portion of the adjacent floodplain that must remain open to permit passage of the base flood without raising the water surface elevation by more than one foot.

NGVD – National Geodetic Vertical Datum of 1929, the national datum used by the NFIP. NGVD is based on mean sea level. It was known formerly as the "Mean Sea Level Datum of 1929 (MSL)." NAVD 88 = North American Vertical Datum of 1988 is being phased in.

It's important to recognize that there is actually a range of floods, other than just the 100-year flood, that could happen within your planning area. For example, a house located close to a flood source might experience some level of flooding every 5 to 10 years. The level or depth of flooding is determined by the probability.

The probability of a flood is based on a statistical chance of a particular size flood (expressed as cubic feet per second of water flow) occurring in any given year. The annual flood is usually considered the single greatest event expected to occur in any given year. The percent annual chance of floods is estimated based on watershed and climatic characteristics or watershed models, water surface elevations, and hydraulic models that reflect topographic characteristics.

The risk created by the 100-year flood would be much greater than the risk from the annual flood based on the amount of damages each event produces – once. But the annual flood would occur much more frequently and over time may in fact produce a much greater risk to the structure than the 100-year flood.

Flood frequencies can be determined by plotting a graph of the size of all known floods for an area and determining how often floods of a particular size may occur. In addition, hydrologic and hydraulic data gathered from rivers and streams is a valuable but time-consuming effort to calculate flood frequencies. If at least 20 years worth of data are available through stream gauging, models can be used to determine the statistical frequency of given flood events.

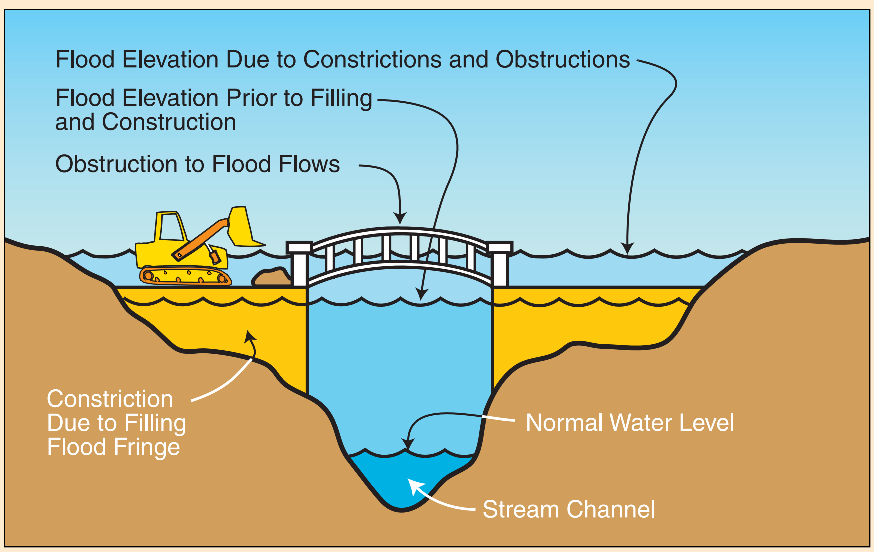
The USGS maintains river gauge records. Historical and current river gauge information can be observed at its Website at http://water.usgs.gov. Some local agencies may also have gauge records.

The process of conducting a more rigorous risk assessment to include all of the possible hazard events will be discussed in the "how-to" for the third phase of the Natural Hazard Mitigation Planning Process, "Develop a Mitigation Plan."

Conditions that may exacerbate or mitigate the effects of floods

The following factors will affect the severity of a flood:

- **Impermeable Surfaces:** Excessive amounts of paved areas or other surfaces upstream or in the community can increase the amount and rate of water runoff. Development affects the runoff of stormwater and snowmelt when buildings and parking lots replace the natural vegetation, which normally would absorb water. When rain falls in an undeveloped area, as much as 90 percent of it will infiltrate the ground; in a highly developed area, as much as 90 percent of it will run off.
- **Steeply sloped watersheds:** In hilly and mountainous areas, a flood may occur minutes after a heavy rain. These flash floods allow little or no warning time and are characterized by high velocities.
- **Constrictions:** Re-grading or filling within or on the edge of floodplains obstructs flood flows, backing up floodwaters onto upstream and adjacent properties. It also reduces the floodplain's ability to store excess water, sending more water downstream and causing floods to rise to higher levels. This also increases floodwater's velocity downstream of the constriction.
- **Obstructions:** Bridges, culverts and other obstructions can block flood flow and trap debris, causing increased flooding upstream and increased velocity downstream.
- **Debris:** Debris from the watershed, such as trees, rocks, and parts of damaged buildings, increases the hazard posed by moving water. Moving water will float, drag or roll objects, which then act as battering rams that can knock holes in walls and further exacerbate the effects of debris.
- **Contamination:** Few floods have clear floodwater, and the water will pick up whatever was on the ground within the floodplain, such as soil, road oil, farm and lawn chemicals, and animal waste. In addition, if a wastewater treatment plant was inundated, the floodwaters will likely include untreated sewage. Contamination is also caused by the presence of hazardous material storage in the floodplain and in the community, as well as upstream from the community.
- **Soil saturation:** Rainfall in areas already saturated with water will increase the runoff.
- **Velocity:** Flood velocity is the speed of moving water, measured in feet per second. High velocities (greater than 5 feet per second) can erode stream banks, lift buildings off their foundations, and scour away soils around bridge supports and buildings.



If you live in a community that could be affected if an upstream dam were overtopped or breached, contact your state dam safety official identified on the Website of the Association of State Dam Safety Officials (ASDSO), at http://crunch.tec.army.mil/nid/webpages/nid.cfm and click on "State Links". The state official will assist you in determining whether there are any large dams that could flood your community if breached or overtopped. There are thousands of significant and high-hazard potential dams in the U.S. About 60 percent have Emergency Action Plans, which delineate the inundation area if the dam fails or is overtopped. The inundation areas are usually much larger than the 100-year floodplain.

As you map your flood hazard areas and plan for mitigation of flood hazards, consider applying for credit for Community Floodplain Management Planning under FEMA's Community Rating System (CRS). If you are not currently enrolled in CRS, contact your state floodplain manager.

(continued from page 2-11)

- Significant construction has occurred within the already identified floodplains on your FIRM.
- Upstream communities have had significant development since the FIRM was published.
- There has been a flood for which inundation pattern indicates that the FIRM boundaries are no longer accurate.
- A major flood control project has been completed within your community, or upstream of your community.
- Changes in topography in or adjacent to existing mapped floodplains.

If the area you're considering is not within the 100-year floodplain, you may elect to concentrate on other hazards because your risk is, by definition, relatively small. However, you may still have flood risks that arise from one or more of the following, which are not shown on the FIRM:

- Drainage areas of less than one square mile;
- Sewer backup;
- Drainage system backup;
- Dam breaches; and
- Stormwater runoff problems.

Task C. Record your hazard event profile information.

1. Transfer the boundaries from your FIRM onto your base map.

2. Record the base flood elevations onto your base map.

Go to the next hazard on your list to profile

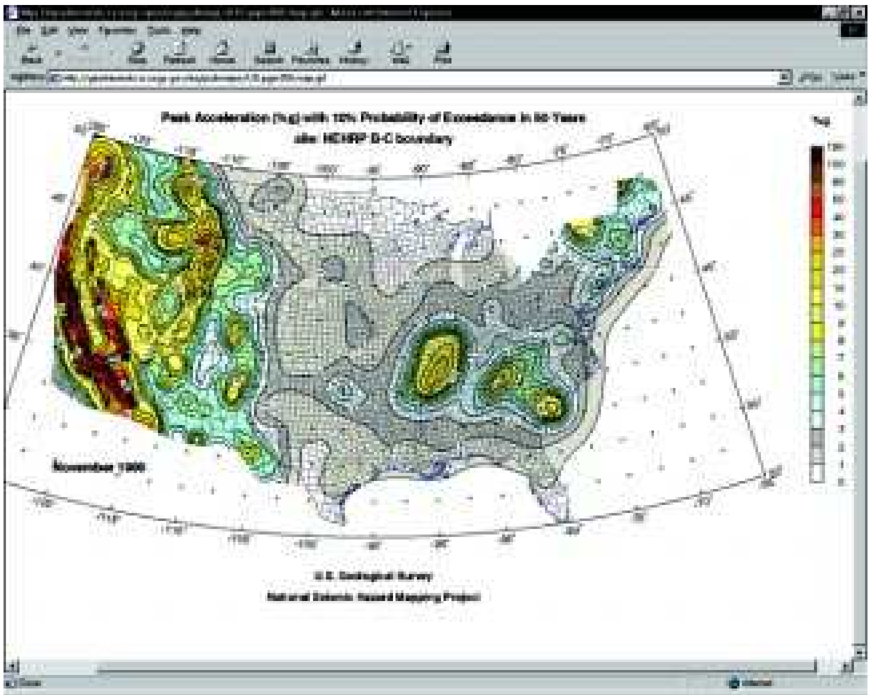
or if you are finished with all your hazard profiles

Go to Step 3

Earthquakes

Task B. Obtain earthquake hazard event profile information.

1. Go to the http://geohazards.cr.usgs.gov Website.



Source: http.geohazards.cr.usgs.gov/eq/pubmaps/US.pga.050.map.gif

The map shows the national Peak Ground Acceleration (PGA) values for the United States with a 10% chance of being exceeded over 50 years. This is a common earthquake measurement that shows three things: the geographic area affected (all colored areas on the map), the probability of an earthquake of each given level of severity (10% chance in 50 years), and the severity (the PGA is indicated by color).

2. Locate your planning area on the map.

You can also generate maps based on zip codes or longitude and latitude by following the directions on the Website.

3. Determine your Peak Ground Acceleration.

Determine the PGA zone(s) in which your planning area is located. This is done by identifying the color associated with your planning area and correlating it with the color key located on the map. Large planning areas may be located in more than one zone.

Peak ground acceleration (PGA) is a measure of the strength of ground movements. The PGA measures the rate in change of motion relative to the established rate of acceleration due to gravity (g) (980 cm/sec/sec). For example, in an earthquake with an acceleration of the ground surface of 244 cm/sec/sec, the PGA or rate in change of motion is 25%g where:

%g = Ground Surface Acceleration / Rate of Acceleration due to Gravity;

%g = 244 cm / sec/ sec/ 980 cm / sec / sec; and

%g = 25%

Seismic hazard maps are available for the whole country, as well as regional maps of Alaska, California, Nevada, and the Central and Eastern United States. For California, the USGS and the California Division of Mines and Geology have earthquake fault zone maps and seismic hazard zone maps. You can order these maps by calling USGS at 1-888-ASK-USGS. You should also contact your state geologist for additional hazard information.

What is an Earthquake?

Earthquakes are one of nature's most damaging hazards. An earthquake is a sudden motion or trembling that is caused by a release of strain accumulated within or along the edge of Earth's tectonic plates. The severity of these effects is dependent on the amount of energy released from the fault or epicenter. The effects of an earthquake can be felt far beyond the site of its occurrence. They usually occur without warning and after just a few seconds can cause massive damage and extensive casualties. Common effects of earthquakes are ground motion and shaking, surface fault ruptures, and ground failure.

Earthquakes are more widespread than is often realized. The area of greatest seismic activity in the United States is along the Pacific Coast in California and Alaska, but as many as 40 states can be characterized as having at least moderate earthquake risk. For example, seismic activity has been recorded in Boston, Massachusetts; New Madrid, Missouri; and Charleston, South Carolina, places not typically thought of as earthquake zones. Areas prone to earthquakes are relatively easy to identify in the Western United States based on known geologic formations; however, predicting exactly when and where earthquakes will occur is very difficult everywhere.

There are several common measures of earthquakes. These include Richter Magnitude, Modified Mercalli Intensity (MMI), Moment Magnitude and Peak Ground Acceleration (PGA), among others. For this guide, we're using PGA for measuring earthquake hazard.

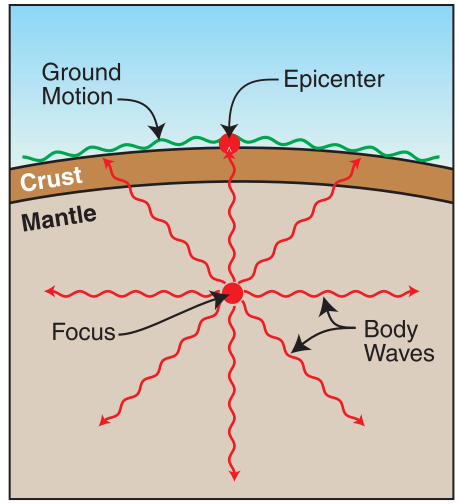
Acceleration: One way to express an earthquake's severity is to compare its acceleration to the normal acceleration due to gravity. If you're standing on the surface of the earth and drop an object (ignoring wind resistance), it will fall toward the earth faster and faster, until it reaches terminal velocity. This principle is known as acceleration and represents the rate at which speed is increasing. The acceleration due to gravity is often called "g", a term you may have heard associated with roller coasters, rockets, or even stock car racing. The acceleration due to gravity at the earth's surface is 9.8 meters (980 centimeters) per second squared. That means that every second that something falls toward the surface of earth its velocity increases by 9.8 meters per second. A 100% g earthquake is very severe.

An analogy would be if you floor your car's gas pedal and your groceries get smashed against the back of the trunk. The quicker you press on the gas, the more eggs are likely to get broken. That's because the quick acceleration caused the contents of your trunk to shift rapidly and violently, not slowly and smoothly. In fact, the eggs might not have moved at all if you had sped up slowly. The same thing is true in an earthquake. If ground acceleration is rapid, more things tend to break than if the shaking is relatively slow, even if the ground moves the same distance.

Earthquake Motion: The variables that characterize earthquakes are ground motion, surface faulting, ground failure, and seismic activity. **Ground motion** is the vibration or shaking of the ground during an earthquake. When a fault ruptures, seismic waves radiate, causing the ground to vibrate. The severity of the vibration increases with the amount of energy released and decreases with distance from the causative fault or epicenter, but soft soils can further amplify ground motions.

Surface faulting is the differential movement of two sides of a fracture – in other words, the location where the ground breaks apart. The length, width, and displacement of the ground characterize surface faults.

Liquefaction is the phenomenon that occurs when ground shaking causes loose soils to lose strength and act like viscous fluid. Liquefaction causes two types of **ground failure**: lateral spread and loss of bearing strength. **Lateral spreads** develop on gentle slopes and entail the sidelong movement of large masses of soil as an underlying layer liquefies. **Loss of bearing strength** results when the soil supporting structures liquefies. This can cause structures to tip and topple.



Definition sketch for earthquake.

The HAZUS Loss Estimation Tool

FEMA developed a standardized, nationally applicable earthquake loss estimation methodology. This methodology is implemented with PC-based software called HAZUS (Hazards U.S.),which runs on a Geographic Information System (GIS) platform.

The HAZUS loss estimation methodology is a software program that uses mathematical formulas and information about building stock, local geology and the location and size of potential earthquakes, economic data, and other information to estimate losses from a potential earthquake. HAZUS is capable of using two separate GIS systems (MapInfo® or ArcView®) to map and display ground shaking, the pattern of building damage, and demographic information about a community.

Once the location and size of a hypothetical earthquake are identified, HAZUS will estimate the violence of ground shaking, the number of buildings damaged, the number of casualties, the amount of damage to transportation systems, disruption to the electrical and water utilities, the number of people displaced from their homes, and the estimated cost of repairing projected damage and other effects.

- **Level 1** – All of the information needed to produce a rough estimate of losses from an earthquake is included in the HAZUS software. This is data from national databases and describes in general terms the geology of the region and the building inventory and economic structure of the community. The default data that HAZUS includes are used to provide a basic estimate of losses and are useful in mitigation planning.
- **Level 2** – More accurate estimates of losses require more detailed information about the community. To produce a Level 2 estimate of losses, detailed information will be required about local geology, an inventory of buildings in the community, and data about utilities and transportation systems. Assistance from geotechnical and structural engineers may be necessary for this analysis, as well as a GIS specialist to add the detailed information into the HAZUS model.
- **Level 3** – The most accurate estimate of loss will require detailed engineering and geotechnical input to customize the methodology to the specific conditions of the community.

While Level 1 HAZUS studies can typically be carried out by local government emergency services or planning staff, the assistance of structural engineers, geologists and GIS specialists is generally needed for Level 2 and Level 3 estimates.

Task C. Record your hazard event profile information.

1. Record your PGA value.

If you are located in only one PGA zone, note that zone on Step 2 Worksheet and go to the bottom of this page; otherwise, continue with part 2 of this task.

2. Print, download, or order your PGA map.

If you are located in more than one PGA zone, you will need a copy of your PGA map. Maps can be printed, downloaded or ordered from the USGS Website.

Unlike communities, states may have many different PGA zones. Your proximity to faults and soil and subsurface characteristics all affect the level of earthquake hazard. Here it is also important to note the pattern or gradation of seismic characteristics across the state.

3. Transfer the boundary of your PGA zones onto your base map.

4. Record the PGA value(s) on your worksheet.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles,

Go to Step 3

Tsunamis

What is a Tsunami?

A tsunami is a series of long waves generated in the ocean by a sudden displacement of a large volume of water. Underwater earthquakes, landslides, volcanic eruptions, meteor impacts, or onshore slope failures can cause this displacement. Most tsunamis originate in the Pacific "Ring of Fire," the area of the Pacific bounded by the eastern coasts of Asia and Australia and the western coasts of North America and South America that is the most active seismic feature on earth. Tsunami waves can travel at speeds averaging 450 to 600 miles per hour. As a tsunami nears the coastline, its speed diminishes, its wavelength decreases, and its height increases greatly. Unusual heights have been known to be over 100 feet high. However, waves that are 10 to 20 feet high can be very destructive and cause many deaths and injuries.

After a major earthquake or other tsunami-inducing activity occurs, a tsunami could reach the shore within a few minutes. From the source of the tsunami-generating event, waves travel outward in all directions in ripples. As these waves approach coastal areas, the time between successive wave crests varies from 5 to 90 minutes. The first wave is usually not the largest in the series of waves, nor is it the most significant. One coastal community may experience no damaging waves while another may experience destructive deadly waves. Some low-lying areas could experience severe inland inundation of water and deposition of debris of more than 1000 feet inland.

Along the West Coast, the Cascadia Subduction Zone threatens California, Oregon, and Washington with devastating local tsunamis. Earthquakes of Richter scale magnitude of 8 or more have happened in the zone, and there is a 35 percent chance that an earthquake of this magnitude could occur before 2045 (estimated between the years 1995 and 2045). The Alaska and Aleutian Seismic Zone that threatens Alaska has a predicted occurrence (84 percent probability between 1988 to 2008) of an earthquake with magnitude greater than 7.4 in Alaska. If an earthquake of this magnitude occurs, Alaska's coastlines can be expected to flood within 15 minutes.

What are the Characteristics of Tsunamis?

Debris: As the tsunami wave comes ashore, it brings with it debris from the ocean, including man-made debris like boats, and as it strikes the shore, creates more on-shore debris. Debris can damage or destroy structures on land.

Distance from shore: Tsunamis can be both local and distant. Local tsunamis give residents only a few minutes to seek safety and cause more devastation. Distant tsunamis originating in places like Chile, Japan, Russia, or Alaska can also cause damage.

High tide: If a tsunami occurs during high tide, the water height will be greater and cause greater inland inundation, especially along flood control and other channels.

Outflow: Outflow following inundation creates strong currents, which rip at structures and pound them with debris, and erode beaches and coastal structures.

Water displacement: When a large mass of earth on the ocean bottom impulsively sinks or uplifts, the column of water directly above it is displaced, forming the tsunami wave. The rate of displacement, motion of the ocean floor at the earthquake epicenter, the amount of displacement of the rupture zone, and the depth of water above the rupture zone all contribute to the intensity of the tsunami.

Wave runup: Runup is the height that the wave extends up to on steep shorelines, measured above a reference level (the normal height of the sea, corrected to the state of the tide at the time of wave arrival).

Wave strength: Even small wave heights can cause strong, deadly surges. Waist-high surges can cause strong currents that float cars, small structures, and other debris.

Task B. Obtain tsunami hazard event profile information.

Get a copy of your tsunami inundation zone map.

Tsunami inundation zone maps show low-lying areas that could be affected by tsunamis. Communities can obtain state-level inundation maps and other information about tsunamis from:

- West Coast/Alaska Tsunami Warning Center of NOAA/NWS by calling 907.745.4212 or by writing 910 S. Felton Street, Palmer AK 99645-6552.
- Pacific Tsunami Warning Center in Hawaii at 808.689.8207 or 91-270 Fort Weaver Road, Ewa Beach, HI 96706.

Communities in Oregon can request maps from the Oregon Department of Geology and Mineral Industries (DOGAMI) by calling 503.731.4100 or by writing 800 NE Oregon Street, #28, Portland, OR 97232.

Washington and California communities should contact their state geologist for mapping information.

In addition, information is available from the following Websites:

- U.S. Geological Survey: www.usgs.gov/themes/coast.html
- University of Washington: www.geophys.washington.edu
- Pacific Marine Environmental Laboratory: www.pmel.noaa.gov

Task C. Record your hazard event profile information.

Transfer the boundary of your tsunami hazard area onto your base map.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles,

Go to Step 3

If you cannot find the necesary information to produce a tsunami profile, research past tsunami events in your area and contact your state coastal zone manager for help identifying areas that would be susceptible to tsunami inundation. Indicate any areas threatened by tsunami waves on your base map.

Most tsunami mapping has been done at a statewide level. If no local-level mapping has been done, you may consider hiring a consultant to help develop or provide the following information:

- Historic 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, their heights, arrival times, and inundation depths and distances;
- Calculations of water velocities and debris loads; and
- Estimates of the probabilities of occurrence and levels of certainty.

Conditions that may exacerbate or mitigate the effects of tsunamis

The following factors will affect the severity of a tsunami:

- **Coastline configuration**: Tsunamis impact long, low-lying stretches of linear coastlines, usually extending inland for relatively short distances. Concave shorelines, bays, sounds, inlets, rivers, streams, offshore canyons, and flood control channels may create effects that result in greater damage. Offshore canyons can focus tsunami wave energy, and islands can filter the energy. The orientation of the coastline determines whether the waves strike head-on or are refracted from other parts of the coastline. Tsunami waves entering flood control channels could reach a mile or more inland, especially if it enters at high tide.
- **Coral reefs**: Reefs surrounding islands in the western North Pacific and the South Pacific generally cause waves to break, providing some protection to the islands.
- **Earthquake characteristics**: Several characteristics of the earthquake that generates the tsunami contribute to the intensity of the tsunami, including the area and shape of the rupture zone, and:
  - **Fault movement**: Strike-slip movements that occur under the ocean create little or no tsunami hazard. However, vertical movements along a fault on the seafloor displace water and create a tsunami hazard.
  - **Magnitude and depth**: Earthquakes with greater magnitude cause more intense tsunamis. Shallow-focus earthquakes also have greater capacity to cause tsunamis.
  - **Human activity**: With increased development, property damage increases, multiplying the amount of debris available to damage or destroy other structures.

Tornadoes

What is a Tornado?

A tornado is a violently rotating column of air extending from a thunderstorm to the ground. The most violent tornadoes are capable of tremendous destruction with wind speeds of 250 mph or more. Damage paths can be in excess of 1 mile wide and 50 miles long.

Tornadoes are among the most unpredictable of weather phenomena. While tornadoes can occur almost anywhere in the world, they are most prevalent in the United States. According to the National Weather Service, about 42 people are killed because of tornadoes each year. Tornadoes can occur in any state but are more frequent in the Midwest, Southeast, and Southwest.

Tornado season runs ordinarily from March through August; however, tornadoes can strike at any time of the year if the essential conditions are present.

What Causes a Tornado?

Thunderstorms and hurricanes spawn tornadoes when cold air overrides a layer of warm air, causing the warm air to rise rapidly. The winds produced from hurricanes, earthquake-induced fires, and wildfires have also been known to produce tornadoes.

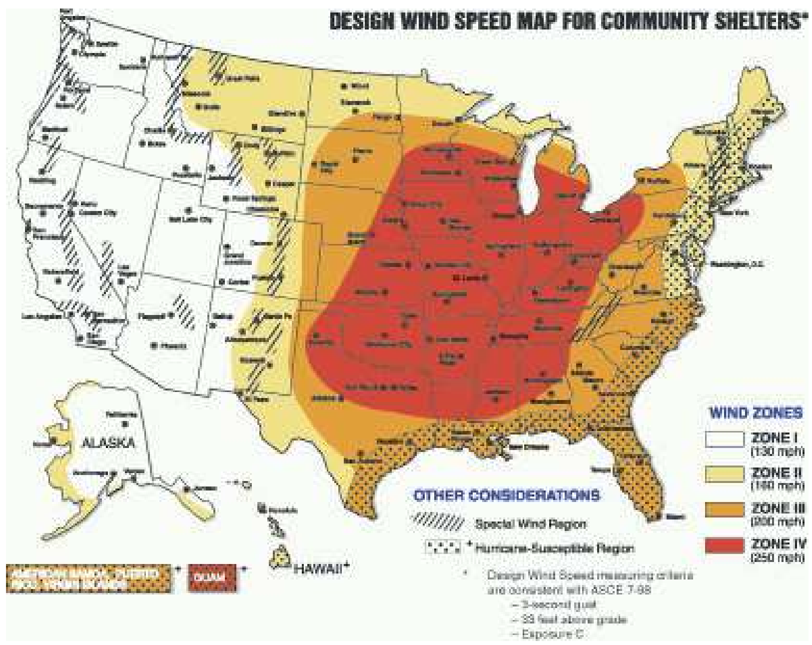
The frequency of tornadoes in the nation's midsection is the result of the recurrent collision of moist, warm air moving north from the Gulf of Mexico with colder fronts moving east from the Rocky Mountains.

States may have more than one wind speed designation. You can either represent all of the wind speeds on your base map or decide to use the higher wind speed for the whole state.

Task B. Obtain tornado hazard event profile information.

Find your design wind speed.

Find your planning area on the "Design Wind Speed" map from FEMA's ***Taking Shelter from the Storm: Building a Saferoom in Your House*** publication 320. This map is based on design wind speeds set forth by the American Society of Civil Engineers (ASCE).



Source: ASCE 7-98

(This publication can be viewed at http://www.fema.gov/mit/tsfs01.html or ordered from the FEMA Publication Center.) Look up the wind zone and indicated speed for your planning 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-mph wind speeds.

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 (from Step 1) and then proceed to determine their design wind speed. (See "Tip" on page 2-21.)

The nature of tornadoes is that they strike at random. While it is known that some areas of the country experience tornadoes more than others, predicting exactly what parts of your community or state have a greater chance of being struck by a tornado is difficult. The NOAA Website http://www.outlook.noaa.gov/tornadoes has tornado statistics broken out by state. It also identifies tornado events per 1,000 square miles.

In order to determine the likelihood and potential severity of tornado events in your state or community, you should ascertain the number of tornadoes that have affected the area in the past and their intensity. Take note, however, that the past number and severity of events is not necessarily a predictor of future occurrences.

To determine the magnitude of tornadoes that have affected your community or state in the past, go to www.tornadoproject.com, click on "All Tornadoes" in the navigation frame, and then click the link, "Every state in the USA." The site provides by state and county a list of all tornado occurrences and magnitudes for the years 1950 to 1995. Find your county and collect the recorded tornado history.

Tornadoes are categorized by damage pattern, F0 through F5. The table below shows the tornado category, expected damages, and corresponding wind speed.

Fujita Tornado Measurement Scale

Category F0	Gale tornado (40-72 mph)	Light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
Category F1	Moderate tornado (73-112 mph)	Moderate damage. The lower limit is the beginning of hurricane wind speed; peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
Category F2	Significant tornado (113-157 mph)	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
Category F3	Severe tornado (158-206 mph)	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.
Category F4	Devastating tornado (207-260 mph)	Devastating damage. Well-constructed houses leveled; structure with weak foundation blown off some distance; cars thrown and large missiles generated.
Category F5	Incredible tornado (261-318 mph)	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized missiles fly through the air in excess of 100 yards; trees debarked; incredible phenomena will occur.

The accuracy of expected damage at particular wind speeds has never been scientifically proven.

Task C. Record your hazard event profile information.

1. If you are located in only one Design Wind Speed zone, note that zone on Worksheet #2 and go to the bottom of this page, otherwise, continue with this task.

2. If you are located in more than one Design Wind Speed zone, you will need a copy of the Design Wind Speed maps.

3. Transfer the boundary of your Design Wind Speed zones on to your base map.

4. Record the Design Wind Speed zones on your base map.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles

Go to Step 3

Coastal Storms

What is a Coastal Storm?

Coastal storms can cause increases in tidal elevations (called storm surge), wind speed, and erosion, caused by both extratropical events and tropical cyclones.

Extratropical events include **Nor'easters** and **severe winter low-pressure systems**. Both West and East coasts can experience these non-tropical storms that produce gale-force winds and precipitation in the form of heavy rain or snow. These cyclonic storms, commonly called Nor'easters on the East Coast because of the direction of the storm winds, can last for several days and can be very large – 1,000-mile wide storms are not uncommon.

A "tropical cyclone" is a generic term for a cyclonic, low-pressure system over tropical or sub-tropical waters. Tropical cyclones with maximum sustained winds of less than 39 mph are called **tropical depressions**. A **tropical storm** is a cyclone with maximum sustained winds greater than 39 mph and less than 74 mph, and **hurricanes** are intense tropical weather systems with maximum sustained winds of 74 mph or higher that develop over the north Atlantic Ocean, northeast Pacific Ocean, or the south Pacific Ocean east of 160E longitude. A special category of tropical cyclone is a **typhoon**, which is peculiar to the western North Pacific Basin, frequently affecting areas in the vicinity of Guam and the North Mariana Islands. Typhoons whose maximum sustained winds attain or exceed 150 miles per hour are called **super typhoons**.

The primary focus of this section is on the effects of hurricanes although all these types of coastal storms can have similar impacts in terms of wind damage, flooding and coastal erosion.

What is a Hurricane?

A hurricane is a category of tropical cyclone characterized by thunderstorms and defined surface wind circulation. Hurricanes develop over warm waters and are caused by the atmospheric instability created by the collision of warm air with cooler air.

Hurricane winds blow in a large spiral around a calm center called the eye, which can be 20-30 miles wide. When a hurricane nears land, it may bring torrential rains, high winds, storm surges, coastal flooding, inland flooding, and, sometimes, tornadoes. A single hurricane can last for more than two weeks over water and can extend outward 400 miles. The hurricane season for the Atlantic Coast and Gulf of Mexico is June 1 to November 30. On average, five hurricanes strike the United States every year. In a two-year period, an average of three significant (category 3 or higher; see Saffir-Simpson scale on page 2-23) hurricanes will strike the United States. Duration depends on the forward motion of the storm and the availability of a warm water source for energy.

Some hurricanes are characterized primarily by water – a rainy or wet hurricane – while others are primarily characterized by wind – a windy or dry hurricane. Wet hurricanes can flood both coastal and inland areas, even as the storm dissipates in wind strength, while windy hurricanes primarily affect coastal areas with their high winds and storm surge. You should, therefore, determine the location and the expected severity of flooding, storm surge, and winds from hurricanes and tropical storms that may affect the community or state by finding expected areas of flooding and peak gusts.

Because hurricanes are large, moving storm systems, they can affect entire states or entire coastlines. Not only will coastal development be affected, but also areas far inland can suffer direct impacts from hurricanes and tropical storms.

Task B. Obtain coastal storm hazard event profile information.

The state hurricane program manager, who usually works for the state emergency management office, will have information on hurricanes, Nor'easters, storm surge, and coastal erosion and can provide a history of storms that have affected the state. Another source of information or assistance is the 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. Torrential rains of even Category One hurricanes and tropical storms have been known to cause 500-year floods (which have a 0.2% chance of occurring each year) and greater flooding in inland communities. Coastal communities will need to determine how severe the high winds, storm surge and erosion could be from their storm surge inundation map.

1. Get a copy of your FIRM.

Coastal flooding is shown on the FIRM. Copies of FIRMs can be requested by calling the FEMA Map Service Center at 1.800.358.9616, on the Internet at http://www.fema.gov/maps, or by contacting a FEMA Regional Office. Additionally, the National Flood Insurance Program

(NFIP) Guide to Flood Maps is available on the web at http://www.fema.gov/nfip/readmap.htm and Flood Insurance Rate Map (FIRM) information is available at http://www.fema.gov/fmapinfo.htm. For more information on FIRMs, see page 2-10 to 2-14.

To request copies of your FIRM or to help you identify areas that are prone to coastal hazards and storm surge, contact your NFIP coordinator or floodplain manager. They usually work in the planning, building, engineering, or natural resources department.

Coastal communities or states with a coastline should determine areas of coastal flooding, characterized as V zones and A zones, oriented approximately parallel to the shoreline.

(continued on page 2-25)

Coastal A zones are not currently mapped or regulated by FEMA any differently than inland A zones; however, flood hazards in coastal A zones, like those in V zones, can include the effects of waves, velocity flow, and erosion (although the magnitude of these effects will be less than those in V zones.)

Saffir-Simpson Scale

Category	Wind Speed	Storm Surge (feet above normal sea level)	Expected Damage
1	74-95 mph	4-5 ft.	**Minimal:** Damage is done primarily to shrubbery and trees, unanchored mobile homes are damaged, some signs are damaged, no real damage is done to structures.
2	96-110 mph	6-8 ft.	**Moderate:** Some trees are toppled, some roof coverings are damaged, major damage is done to mobile homes.
3	111-130 mph	9-12 ft.	**Extensive:** Large trees are toppled, some structural damage is done to roofs, mobile homes are destroyed, structural damage is done to small homes and utility buildings.
4	131-155 mph	13-18 ft.	**Extreme:** Extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; some curtain walls fail.
5	> 155 mph	> 18 ft.	**Catastrophic:** Roof damage is considerable and widespread, window and door damage is severe, there are extensive glass failures, and entire buildings could fail.

Also, see page 3-26 for additional implications of coastal erosion on loss estimation.

How are Pacific Coast States Different than Atlantic and Gulf Coast States?

Eastern and Central Pacific hurricanes sometimes affect the West Coast of North America and the Hawaiian Islands. Easterly winds push tropical cyclones that form off the Mexican and Central American coasts out toward the Central Pacific. In the Eastern Pacific, hurricanes or tropical storms are more likely to bring heavy rains, flash floods, mudslides, and high winds to Mexico's Pacific Coast than the U.S southern California coast.

Although the California coast has not been hit by a hurricane-strength storm, it has experienced heavy rain from tropical storms and depressions in the past. While many hurricanes form off the west coast of Mexico, they tend to move seaward. Rarely, when a tropical cyclone reaches the extreme southern California coast, they tend to be weak compared to East Coast hurricanes. Remnant moisture from dissipated hurricanes or tropical storms sometimes brings monsoon-like rains to the Southwest.

Under tropical cyclone conditions, the Pacific Coast experiences storm surges of limited magnitude because of the great ocean depths close to shore.

What are the Characteristics of Coastal Storms?

Storm surge: The most dangerous and damaging feature of a coastal storm is storm surge. Storm surges are large waves of ocean water that sweep across coastlines where a storm makes landfall. The more intense the storm, the greater the height of the water. The higher the storm surge, the greater the damage to the coastline. Storm surges inundate coastal areas, wash out dunes, cause backwater flooding in rivers, and can flood streets and buildings in coastal communities. Storm surge areas can be mapped by the probability of storm surge occurrences using Sea, Lake, and Overland Surges from Hurricanes modeling (SLOSH) (see page 2-26).

Storm tide: If a storm surge occurs at the same time as high tide, the water height will be even greater. Storm tide is the combination of the storm surge and the normal tide. For example, a 15-foot storm surge along with the normal 2-foot high tide creates a storm tide of 17 feet.

Inland Flooding: In recent years, most deaths related to hurricane and tropical storm activity have been the result of inland flooding. As hurricanes move across land bringing torrential rains and backwater flooding from the ocean, rivers and streams overflow. Hurricanes and tropical storms have been known to cause floods whose elevations represent greater than a 500-year probability of occurring in inland areas.

Water force: During hurricanes and other coastal storms, coastal areas will experience flooding with velocity or "wave action," defined as areas subject to receiving waves on top of the rising water from coastal flooding. The velocity and the force of the water make flooding even more destructive. The velocity and wave action knock over buildings, move debris, erode dunes, scour the shoreline, and displace and redeposit sand. Areas subject to coastal flooding with velocity are designated as V or VE zones on FIRMs.

Wind velocity: The higher the wind speed, the greater the damage. Hurricane force winds can travel hundreds of miles inland, creating substantial damage to buildings, vegetation, and infrastructure.

Coastal erosion: Coastal erosion is the wearing away of coastal land. It is commonly used to describe the horizontal retreat of the shoreline along the ocean, or the vertical downcutting along the shores of the Great Lakes. Erosion is considered a function of larger processes of shoreline change, which includes erosion and accretion. Erosion results when more sediment is lost along a particular shoreline than is redeposited by the water body. Accretion results when more sediment is deposited along a particular shoreline than is lost. When these two processes are balanced, the shoreline is said to be stable.

In assessing the erosion hazard in your community or state, it is important to realize that there is a temporal, or time aspect associated with the average rate at which a shoreline is either eroding or accreting. Over a long-term period (years), a shoreline is considered either eroding, accreting or stable. When you evaluate coastal erosion in your community or state, you should focus on the long-term erosion situation. However, in the short-term, it is important to understand that storms can erode a shoreline that is, over the long-term, classified as accreting, and vice versa.

Erosion is measured as a rate, with respect to either a linear retreat (i.e., feet of shoreline recession per year) or volumetric loss (i.e., cubic yards of eroded sediment per linear foot of shoreline frontage per year). Erosion rates are not uniform, and vary over time at any single location. Annual variations are the result of seasonal changes in wave action and water levels.

Erosion is caused by coastal storms and flood events; changes in the geometry of tidal inlets, river outlets, and bay entrances; man-made structures and human activities such as shore protection structures and dredging; long-term erosion; and local scour around buildings and other structures.

Further information on coastal erosion can be found in FEMA-55, *Coastal Construction Manual*, FEMA's *Multihazard Identification and Risk Assessment*, *Evaluation of Erosion Hazards* published by The Heinz Center, and *Coastal Erosion Mapping and Management*, a special edition of the Journal of Coastal Research.

(continued from page 2-23)

2. Verify that the FIRM is up-to-date and complete.

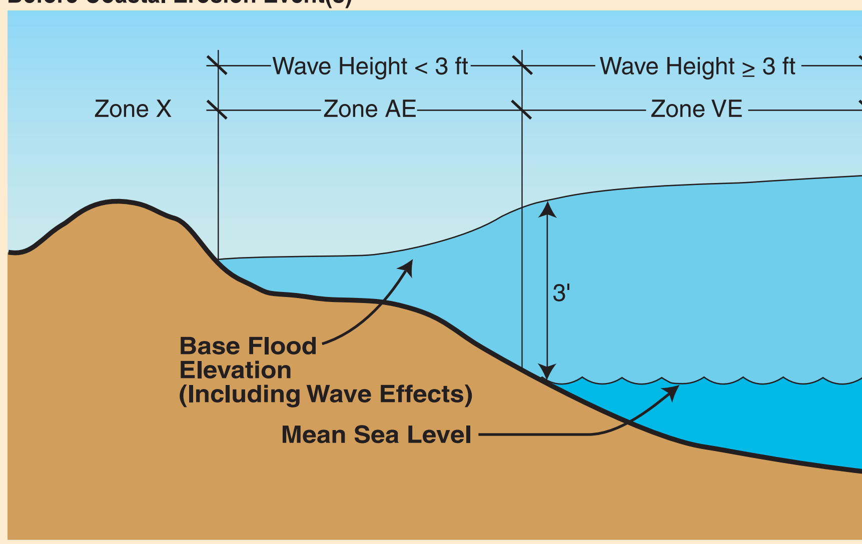
If there has been a coastal storm since the date of the FIRM, the coastline and hazard zones may no longer be accurate. Coastal storms can either erode or extend the coastline, possibly causing the flood hazard zones to change. Consult your local floodplain manager for further advice.

3. Determine the annual rate of coastal erosion in your coastal area.

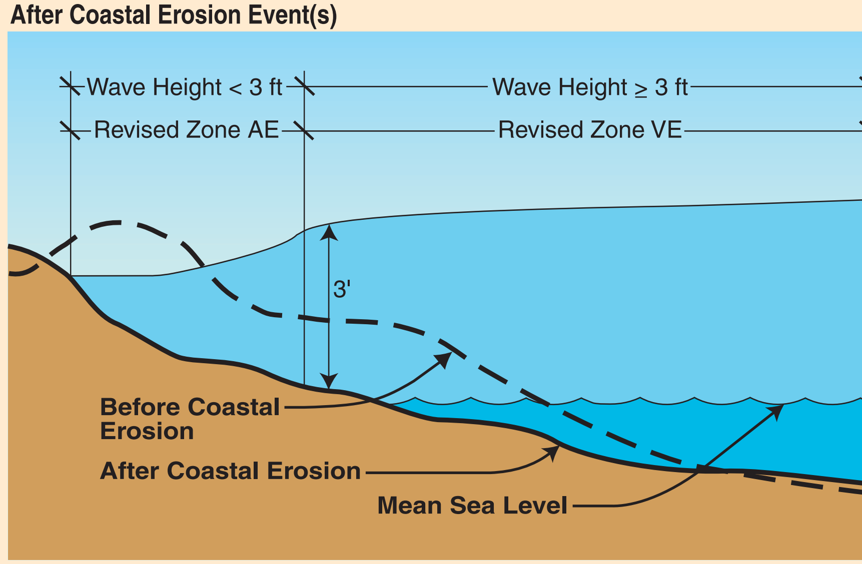
Contact your State Coastal Zone Management Program to determine the annual long-term erosion rate in your area of the state. This program may be housed in a separate coastal agency, an environmental agency, or a water resources agency. Once you know the annual rate, multiply this rate by the number of years over which you are planning. Most erosion maps consider a 30- or 60-year time frame. You would then measure the amount of erosion that would take place over the 30- or 60-year time-frame from the existing shoreline and mark this on your basemap.

When coastal erosion occurs, shoreline geometry changes, possibly causing flood hazard zones to change.

Before Coastal Erosion Event(s)



After Coastal Erosion Event(s)



4. Find your design wind speed.

Contact your state or local building code official to determine your design wind speed.

Task C. Record your hazard event profile information.

1. Transfer the boundaries of your hurricane hazard areas (flooding erosion) onto your base map.

2. Record the base flood elevations and wind zones on your base map.

States should be prepared to assess the severity of a hurricane statewide. Considerations like sheltering and evacuation can be especially problematic because, although these may occur only along the coast, the repercussions of relocating thousands of people inland may be felt across the state.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles

Go to Step 3

For more in-depth analysis of the hurricane probability and effects in your area, you should contact your state coastal zone manager and/or your SHMO. Go to http://www.nhc.noaa.gov/aboutmeow.html to find information on the inland wind model, which estimates the maximum sustained surface wind as a storm moves inland. This model can be used to estimate the maximum inland strength of hurricane force winds (or any wind threshold) for a given initial storm intensity and forward storm motion. You can find examples of the Maximum Envelope of Winds (MEOW) based on the strength and forward motion of hurricanes in three tables shown on the Web page, one for each of the regions: Gulf Coast, East Coast, and Northeast Coast.

The National Hurricane Center (NHC), the U.S. Army Corps of Engineers (USACE), the National Oceanographic and Atmospheric Administration (NOAA), the Federal Emergency Management Agency (FEMA), and your state emergency management agency have detailed information about the hurricane risk in your community. These organizations are important when doing detailed analysis of hurricane probabilities through SLOSH modeling and Hurricane Evacuation Studies. SLOSH is a computerized model run by the NHC to estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes by taking into account pressure, size, forward speed, track, and winds.

The SLOSH boundaries may differ from the base flood boundary on the FIRM. The SLOSH flood areas are determined by compositing the model surge values from 200-300 hypothetical hurricanes. The point of a hurricane's landfall is crucial to determining which areas will be inundated by the storm surge. Where the hurricane forecast track is inaccurate, SLOSH model results will be inaccurate. As a result, the SLOSH model is best used for defining the potential maximum surge for a location.

To determine whether a hurricane or tropical storm may affect your community or state, you should find historical evidence of hurricane or tropical storm activity. At http://www.nhc.noaa.gov/pastall.html you will find historical data and maps to locate past hurricane tracks that may have passed through or near your community or state. The maps show all Atlantic tropical cyclone tracks and their wind strength from 1927 to the present.

Conditions that may exacerbate or mitigate the effects of coastal storms

The following factors will affect the severity of a coastal storm:

- **Coastal shape:** Concave shoreline sections sustain more damage because the water is driven into a confined area by the advancing storm, thus increasing storm surge height and storm surge flooding.
- **Storm center velocity:** The slower the storm moves, the greater the damage. The worst possible situation is a storm that stalls along a coast, through several high tides.
- **Nature of coast:** Rocky coasts are least disturbed. Cliffs along coasts with sedimentary deposits can retreat by slumping or rock falls, but damage is most severe on low-lying barrier island shorelines because they are easily overwashed by storm waves and storm surge.
- **Previous storm damage:** A coast weakened by even a previous minor storm may be subject to proportionally greater damage in a subsequent storm.
- **Human activity:** With increased development, property damage increases, multiplying the amount of floating debris available to damage or destroy other structures.
- **Hardened sand and flood control structures:** Structures such as groins, jetties, or seawalls exacerbate localized scour and erosion and can be undermined, resulting in collapse (particularly seawalls).

Landslides

Task B. Obtain landslide hazard event profile information.

The best predictor of future landslides is 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 start 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 maps, as well as information about causes, damage, deaths, injuries, and areas impacted by past landslides. If current maps are not available, the specialists mentioned above can help create one for your community.

It is important to consult with a local geologist or other professional familiar with past landslides in order to interpret landslide hazard information.

1. Identify high-hazard areas on your map.

Identify existing or old landslides:

- 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 steep cut slope; or
- Developed hillsides where leach field septic systems are used.

2. Map the topography.

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

3. Map the geology.

Underlying geology also plays an important part in the review of slope. In addition to slope angle, the presence of rock or soil that weakens when saturated, as well as poorly drained rock or soil are indicators of slope instability as well. Contact a local geologist or state geological survey for more information or assistance in identifying the various geological features of your community or state.

What is a Landslide?

Landslides are described as downward movement of a slope and materials under the force of gravity. The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Landslides are influenced by human activity (mining and construction of buildings, railroads, and highways) and natural factors (geology, precipitation, and topography). They are common all over the United States and its territories.

What Causes a Landslide?

Landslides occur when masses of rock, earth, or debris move down a slope. Therefore, gravity acting on an overly steep slope is the primary cause of a landslide. They are activated by storms, fires, and by human modifications to the land. New landslides occur as a result of rainstorms, earthquakes, volcanic eruptions, and various human activities.

Measures of Landslides

Mudflows (or debris flows) are flows of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or "slurry."

Slurry can flow rapidly down slopes or through channels and can strike with little or no warning at avalanche speeds. Slurry can travel several miles from its source, growing in size as it picks up trees, cars, and other materials along the way.

Other types of landslides include: rock slides, slumps, mudslides, and earthflows. All of these differ in terms of content and flow.

The three most useful types of landslide maps are (1) landslide inventories, (2) landslide susceptibility maps, and (3) landslide hazard maps.

Landslide inventories identify areas that appear to have failed due to 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, geological age, rate of movement, and other pertinent data on the depth and type of materials involved in sliding. Overlaying a geologic map with an inventory 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 depict areas that have the potential for landslides by correlating some of the principal factors that contribute to landslides – steep slopes, geologic units that lose strength when saturated, and poorly drained rock or soil – with the past distribution of landslides. 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.

Landslide hazard 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. They contain detailed information on the types of landslides, extent of slope subject to failure, and probable maximum extent of ground movement. These maps can be used to predict the relative degree of hazard in a landslide area.

Conditions that may exacerbate or mitigate the effects of landslides

The following factors will affect the severity of a landslide:

- **Erosion** – Erosion caused by rivers, glaciers, or ocean waves created by overly steep slopes.
- **Unstable slopes** – Rock and soil slopes are weakened through saturation by snowmelt or heavy rains.
- **Earthquakes** – The shaking from earthquakes creates stress that makes weak slopes fail.
- **Volcanic eruptions** – Eruptions produce loose ash deposits and debris flows.
- **Vibrations** – Machinery, traffic, blasting, and even thunder may cause vibrations that trigger failure of weak slopes.
- **Increase of load** – Weight of rain/snow, fills, vegetation, stockpiling of rock or ore from waste piles, or from man-made structures may cause weak slopes to fail.
- **Hydrologic factors** – Rain, high water tables, little or no ground cover, numerous freeze/thaw cycles may cause weak slopes to fail.
- **Human activity** – These include development activities such as cutting and filling along roads and removal of forest vegetation. Such activities are capable of greatly altering slope form and ground water conditions which can cause weak slopes to fail.
- **Removal of lateral and underlying support** – Erosion, previous slides, road cuts and quarries can trigger failure of weak slopes.
- **Increase of lateral pressures** – Hydraulic pressures, tree roots, crystallization, swelling of clay soil may cause weak slopes to fail.
- **Regional tilting** – Geological movements can trigger weak slopes to fail.

Task C. Record your hazard event profile information.

Mark the areas susceptible to landslides on your base map.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles

Go to Step 3

Wildfires

Task B. Obtain wildfire hazard event profile information.

Wildfire hazard maps won't show the extent or range of where a wildfire will occur because they are dependent on the amount of fuel available, weather conditions, and wind speed and direction. On the other hand, wildfire hazard maps should show geographic locations of where wildfires have taken place in the past and areas that are prone to wildfires.

Contact your state forest service at http://www.stateforesters.org/sflist.html or your USFS Region office at http://www.fs.fed.us/intro/directory/orgdir.htm for wildfire mapping information.

1. Map the fuel models located within the urban-wildland interface area of your community.

Use the fuel model key (page 2-31) excerpted from the National Fire Danger Rating (NFDR) System, 1978, U.S. Department of Agriculture (USDA) Forest Service, as a guide, to determine the fuel model classifications within your community or state. It represents all wildfire fuels from Florida to Alaska and from the East Coast to California, so they are only general descriptions.

You can also download the USDA fuel model map from the Internet at: http://www.fs.fed.us/land/wfas/nfdr_map.htm. The USDA map was designed to assess fire danger across the continental United States and may not be site specific.

Using the fuel model key, map the various fuel classifications based on the following categories:

- **Heavy Fuel** is vegetation consisting of round wood 3 to 8 inches in diameter. **(fuel models G, I, J, K and U on the fuel model key)**
- **Medium Fuel** is vegetation consisting of round wood 1/3 to 3 inches in diameter. **(fuel models B, D, F, H, O, Q, and T on the fuel model key)**
- **Light Fuel** is vegetation consisting of herbaceous plants and round wood less than ¼ inch in diameter. **(fuel models A, C, E, L, N, P, R and S on the fuel model key)**

For more information or assistance contact your local arborist or state forestry or natural resources department.

What is a Wildfire?

A wildfire is an uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures. They often begin unnoticed and spread quickly and are usually signaled by dense smoke that fills the area for miles around. Naturally occurring and non-native species of grasses, brush, and trees fuel wildfires.

A **wildland fire** is a wildfire in an area in which development is essentially nonexistent, except for roads, railroads, power lines and similar facilities. An **Urban-Wildland Interface fire** is a wildfire in a geographical area where structures and other human development meet or intermingle with wildland or vegetative fuels.

States with a large amount of wooded, brush and grassy areas, such as California, Colorado, New Mexico, Montana, Kansas, Mississippi, Louisiana, Georgia, Florida, the Carolinas, Tennessee, Massachusetts, and the national forests of the western United States are at highest risk of wildfires. Additionally, areas anywhere that have experienced prolonged droughts, or are excessively dry, are also at risk of wildfires.

People start more than four out of every five wildfires, usually as debris burns, arson, or carelessness. Lightning strikes are the next leading cause of wildfires.

Wildfire behavior is based on three primary factors:

- Fuel
- Topography
- Weather

The type, and amount of fuel, as well as its burning qualities and level of moisture affect wildfire potential and behavior. The continuity of fuels, expressed in both horizontal and vertical components is also a factor, in that it expresses the pattern of vegetative growth and open areas.

Topography is important because it affects the movement of air (and thus the fire) over the ground surface. The slope and shape of terrain can change the rate of speed at which the fire travels.

Weather affects the probability of wildfire and has a significant effect on its behavior. Temperature, humidity and wind (both short and long term) affect the severity and duration of wildfires.

Visit the USFS Website at http://www.fs.fed.us /links/maps.shtml/ or the USGS Website at http:// mcmcweb. er.usgs.gov/ topomaps/ for general information about topographic maps, finding and ordering topographic maps, and an explanation of topographic map symbols.

Most communities or regions should have one critical fire weather frequency number; however, states may have more than one zone depending on climatic and atmospheric conditions. The state forester should be prepared to assist communities in determining their critical fire weather frequency, as well as the type of fuel models to use, and the fuel loading levels.

If you cannot find the necessary information to produce a wildfire profile contact your fire marshall or state forest service for help identifying fire prone areas of grasslands or dense wooded areas. Research past or historic wildfire events and use eyewitness accounts to delineate the approximate wildfire boundaries. Indicate these areas on your base map as potential wildfire hazard areas.

2. Map the topography.

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 community or state with slopes less than 40%, between 41% and 60%, and greater than 61%, corresponding to low, moderate and steep gradients relative to the spread of wildfires.

Contact your state geological survey or natural resources department for more information or help with topographic maps.

3. Determine your critical fire weather frequency.

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

4. Determine your fire hazard severity.

Using the Fire Hazard Severity Table below, determine your fire hazard severity. You may have more than one classification in your community or state depending on the degrees of the slope and fuel models. For example, if you experience an average of five critical fire weather days per year, have heavy fuel, and less than 40° slopes, then you are in a high fire hazard area. If your average number of days of critical fire weather per year increases above eight, you would be in an extreme fire hazard area.

Task C. Record your hazard event profile information.

Draw the boundaries of your wildfire hazard areas onto your base map.

Fire Hazard Severity

	Critical Fire Weather Frequency								
	< 1 Day/Year			2 to 7 Days/Year			> 8 Days/Year		
	Slope (%)			Slope (%)			Slope (%)		
Fuel Classification	< 40	41-60	> 61	< 40	41-60	> 61	< 40	41-60	> 61
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

Source: Urban Wildland Interface Code: 2000

M = Moderate hazard H = High hazard E = Extreme hazard

Fuel Model Key

Source: Urban Wildland Interface Code: 2000

I. Mosses, lichens, and low shrubs predominate ground fuels.
   A. An overstory of conifers occupies more than one-third of the site: MODEL Q.
   B. There is no overstory, or it occupies less than one-third of the site (tundra): MODEL S.
II. Marsh grasses and/or reeds predominate: MODEL N.
III. Grasses and/or forbs predominate.
   A. There is an open overstory of conifer and/or hardwood trees: MODEL C.
   B. There is no overstory.
      1. Woody shrubs occupy more than one-third, but less than two-thirds of the site; MODEL T.
      2. Woody shrubs occupy less than one-third of the site.
         a. The grasses and forbs are primarily annuals; MODEL A.
         b. The grasses and forbs are primarily perennials: MODEL L.
IV. Brush, shrubs, tree reproduction or dwarf tree species predominate.
   A. Average height of woody plants is 6 feet or greater.
      1. Woody plants occupy two-thirds or more of the site.
         a. One-fourth or more of the woody foliage is dead.
            (1) Mixed California chaparral: MODEL B.
            (2) Other types of brush: MODEL F.
         b. Up to one-fourth of the woody foliage is dead; MODEL Q.
         c. Little dead foliage: MODEL O.
      2. Woody plants occupy less than two-thirds of the site: MODEL F.
   B. Average height of woody plants is less than 6 feet.
      1. Woody plants occupy two-thirds or more of the site.
         a. Western United States; MODEL F.
         b. Eastern United States: MODEL O.
      2. Woody plants occupy less than two-thirds but more than one-third of the site.
         a. Western United States; MODEL T.
         b. Eastern United States; MODEL D.
      3. Woody plants occupy less than one-third of the site.
         a. The grasses and forbs are primarily annuals: MODEL A.
         b. The grasses and forbs are primarily perennials: MODEL L.
V. Trees predominate.
   A. Deciduous broadleaf species predominate.
      1. The area has been thinned or partially cut, leaving slash as the major fuel component; MODEL K.
      2. The area has not been thinned or partially cut.
         a. The overstory is dormant; the leaves have fallen: MODEL E.
         b. The overstory is in full leaf: MODEL R.
   B. Conifer species predominate.
      1. Lichens, mosses, and low shrubs dominate as understory fuels: MODEL Q.
      2. Grasses and forbs are the primary ground fuels: MODEL C.
      3. Woody shrubs and/or reproduction dominate as understory fuels.
         a. The understory burns readily.
            (1) Western United States: MODEL T.
            (2) Eastern United States:
               (a) The understory is more than 6 feet tall: MODEL O.
               (b) The understory is less than 6 feet tall: MODEL D.
         b. The understory seldom burns; MODEL H.
      4. Duff and litter, branchwood, and tree boles are the primary ground fuels.
         a. The overstory is overmature and decadent; there is a heavy accumulation of dead tree debris: MODEL G.
         b. The overstory is not decadent; there is only nominal accumulation of debris.
            (1) The needles are 2 inches or more in length (most pines).
               (a) Eastern United States: MODEL P.
               (b) Western United States: MODEL U.
            (2) The needles are less than 2 inches long: MODEL H.
VI. Slash is the predominant fuel.
   A. The foliage is still attached; there has been little settling.
      1. The loading is 25 tons/acre or greater; MODEL I.
      2. The loading is less than 25 tons/acre but more than 15 tons/acre: MODEL J.
      3. The loading is less than 15 tons/acre: MODEL K.
   B. Settling is evident; the foliage is falling off; grasses, forbs, and shrubs are invading the area.
      1. The loading is 25 tons/acre or greater: MODEL J.
      2. The loading is less than 25 tons/acre: MODEL K.

The Wildland Fire Assessment System (WFAS) was created to help evaluate risk factors, which vary depending on current and past weather conditions, fuel types and moisture. Observations are reported daily during peak wildfire season, from late winter to early spring, to the Weather Information Management System (WIMS). The information is processed by the National Fire Danger Rating System (NFDRS), which creates national maps of selected fire weather and fire danger components.

Copies of the maps can be viewed on the WFAS Website (the address is located in Appendix A).

The fire danger map described above indicates low to extreme fire danger values for the United States based on past and current weather, fuel types, and the presence of live and dead fuel moisture.

In addition to the fire danger maps referenced above, communities and states should map areas of past wildfire damages. This information is available from the local or state emergency management agency or fire department. Areas with significant fuel sources located adjacent to developed areas are prime risks for wildfire damage and should be mapped as well.

Even if your community is not especially close to a source of burning, you should be aware that fires in nearby areas could quickly and easily spread into your community.

Conditions that may exacerbate or mitigate the effects of wildfires

The following factors will affect the severity of a wildfire:

- **Climatic Considerations** – Areas of extreme climate conditions, including temperature, relative humidity, wind speed and duration of high velocity, precipitation, wind direction, fog and other atmospheric conditions.
- **Topographic Considerations** – elevation and ranges of elevation, location of ridges, drainages and escarpments, percent of grade (slope), location of roads, bridges and railroads.
- **Geographic Considerations** – Fuel types, concentration in a mosaic and distribution of fuel types, earthquake fault zones, hazardous material routes.
- **Flammable material** on structure exteriors.
- **Narrow roadways** leading to developed areas.
- **Inadequate hydrants** or poorly placed hydrants.
- **Combustible landscaping** or debris near structures.
- **Development** – increased development and human activity in and near the wildland interface.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles

Go to Step 3