Guide to Hazard Mitigation Planning for Wisconsin Coastal Communities

Prepared by:
Bay-Lake Regional Planning Commission
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GUIDE TO HAZARD MITIGATION PLANNING FOR WISCONSIN COASTAL COMMUNITIES

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ABOUT THE BAY-LAKE REGIONAL PLANNING COMMISSION

The Bay-Lake Regional Planning Commission was created in April 1972 under section 66.945 of the Wisconsin Statutes as the official area-wide planning agency for northeastern Wisconsin.

At the request of seven county boards within the region, Governor Lucey established the Bay-Lake Regional Planning Commission by Executive Order 35. In December 1973, Florence County joined the Commission, bringing the total number of counties within the region to eight.

The Commission serves a region in northeastern Wisconsin consisting of the counties of Brown, Door, Florence, Kewaunee, Manitowoc, Marinette, Oconto, and Sheboygan. The Bay-Lake Region is comprised of 185 units of government: 8 counties, 17 cities, 39 villages, 120 towns, and the Oneida Nation of Wisconsin. The total area of the region is 5,433 square miles or 9.7 percent of the area of the State of Wisconsin. The region has over 400 miles of coastal shoreline along Lake Michigan and Green Bay and contains 12 major watershed areas that drain into the waters of Green Bay and Lake Michigan. The official Wisconsin Department of Administration 2006 population estimate of the region is 574,623 persons or 10.4 percent of the State of Wisconsin's estimated population of 5,532,955 persons.

The Bay-Lake Regional Planning Commission has been assisting communities within its region with hazard mitigation planning since 2003.

Bay-Lake Region

Source: Bay-Lake Regional Planning Commission. 2006.

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FOREWORD

The *Guide to Hazard Mitigation Planning for Wisconsin Coastal Communities* ("Guide") was designed to help Wisconsin coastal communities identify, profile, and mitigate Great Lakes coastal hazards and develop a multi-hazard mitigation plan. Although, the "target audience" for this Guide is Wisconsin coastal communities, this Guide could be helpful to any community developing their hazard mitigation plan.

This Guide is aimed at Wisconsin coastal communities that are developing a multi-hazard mitigation plan. For the purposes of this Guide, a community includes counties or incorporated municipalities (such as cities and villages). Towns in Wisconsin are covered under a county multi-hazard mitigation plan.

CONTENTS

The *Guide to Hazard Mitigation Planning for Wisconsin Coastal Communities* contains a foreword, an introduction, seven chapters, three appendices, a bibliography, a glossary, an index, and a digital copy of the Guide in PDF format on CD-ROM.

The *Foreword* lists the contents of the Guide and explains its purpose and funding.

The *Introduction* offers a brief description/overview of hazard mitigation planning by describing the Disaster Mitigation Act of 2000 and providing an explanation for county hazard mitigation planning in Wisconsin. The *Introduction* also explains how to use this guide and how it may be helpful.

Chapter 1 describes the steps of organizing community resources, which is the first task undertaken in the development of a hazard mitigation plan. It assesses the resources available to the community for mitigation planning and provides information on developing community support, establishing the planning team, and involving the public.

Chapter 2 provides the community with information on methods and resources available to identify and assess risks, and profile hazards for their hazard mitigation plan.

Chapter 3 describes the specific contents of a hazard mitigation plan and the content requirements of Wisconsin Emergency Management and the Federal Emergency Management Agency. This chapter will assist the community with documenting the planning process, assessing their capability to complete the plan, developing hazard mitigation goals, identifying and analyzing mitigation measures, and funding sources available to communities for plan development and implementation of mitigation goals.

Chapter 4 provides information on implementing the plan and monitoring its progress. This chapter covers the plan adoption process, implementing mitigation measures, and evaluating, revising, and updating the plan.

Chapter 5 assists the reader with pulling the elements of a hazard mitigation plan together into a single document. It has been designed in the format of a typical hazard mitigation plan.

Chapter 6 provides hazard information on all natural hazards that can affect Wisconsin coastal communities. The chapter starts with a breakout of coastal hazards addressed separately from other natural hazards. For each hazard, there is a discussion on the areas at greatest risk in Wisconsin.

Chapter 7 discusses the projected impacts of climate change in Wisconsin and the anticipated alterations to natural hazard impacts.

Appendix A offers two example methodologies for identifying natural hazards risk rankings, *Appendix B* offers a sample resolution of adoption, and *Appendix C* contains a list of recommended reading of documents and websites to further assist in the development of a comprehensive and functional hazard mitigation plan. A list of references and definitions, along with an index has been included. A digital PDF copy of this Guide is available on CD-ROM and has been enclosed in the last page of this document.

PURPOSE

While working with coastal communities and counties on their hazard mitigation plans, it became evident that guidance was needed on hazard mitigation planning as it relates specifically to coastal hazards. Many coastal communities are not familiar with the specific coastal hazards that affect them. Much of the hazard mitigation planning guidance currently available does not provide information or examples on coastal hazards as they do for other hazards. Most readily available coastal hazards mitigation planning information pertains to ocean coastal areas, and there is little information on the hazards mitigation planning process for Great Lakes coastal areas.

FUNDING

The *Guide to Hazard Mitigation Planning for Wisconsin Coastal Communities* was funded by the Wisconsin Coastal Management Program (WCMP) and the Bay-Lake Regional Planning Commission. The WCMP is part of the Wisconsin Department of Administration, with financial assistance provided by the National Oceanic and Atmospheric Administration (NOAA), Office of Ocean and Coastal Resource Management (OCRM) under the Coastal Zone Management Act of 1972 (amended). The WCMP was established in 1978 to preserve, protect, and manage the resources of the Lake Michigan and Lake Superior coastline.

WISCONSIN GREAT LAKES COASTAL ZONE

Fifteen counties border the Great Lakes in Wisconsin (Figure 1). The coastal counties define the Wisconsin coastal zone. The coastal zone is a popular place to live and recreate in the state. Although the coastal zone accounts for only 19 percent of the area of the state, it holds 39 percent of Wisconsin’s population.

The Lake Michigan coastal counties in southeastern Wisconsin (Kenosha, Racine, Milwaukee, and Ozaukee counties) are part of the Southeastern Wisconsin Regional Planning Commission. Of the fifteen Wisconsin coastal counties, those counties in southeast Wisconsin have the greatest population density with 1,218 people per square mile.

The Lake Michigan coastal counties in northeastern Wisconsin (Sheboygan, Manitowoc, Kewaunee, Door, Brown, Oconto, and Marinette counties) are part of the Bay-Lake Regional Planning Commission. These counties have a moderate population density of 101 people per square miles.

The Lake Superior coastal counties in northern Wisconsin (Iron, Ashland, Bayfield, and Douglas counties) are part of the Northwest Regional Planning Commission. These counties have a much smaller population density (17 people per square mile) compared to those of the Lake Michigan coastal counties (Hart, 1997).

Figure 1: Wisconsin Coastal Zone

Source: Bay-Lake Regional Planning Commission. 2007.

The *Guide to Hazard Mitigation Planning for Wisconsin Coastal Communities* has been developed to assist Wisconsin Great Lakes coastal communities with developing hazard mitigation plans in accordance with the Federal Emergency Management Agency (FEMA) standards, Code of Federal Regulations, Title 44, Volume 1 (44 CFR 201.6, revised 10/01/2004) using guidance from the FEMA *State and Local Mitigation Planning How-To Guides.*

HISTORICAL CONTEXT – DISASTER MITIGATION ACT OF 2000

The *Disaster Mitigation Act of 2000* (Pub. L. 106-390), or "DMA 2000", represents a change in emergency management policy from disaster response to mitigation, including mitigation planning to prepare for and avoid disasters.

The federal requirements for DMA 2000-compliant hazard mitigation plans include the development of a risk assessment that provides the foundation for developing a mitigation strategy. The risk assessment requirements for county and community plans are provided in 44 CFR 201.6(c)(2). State plan requirements are covered under 44 CFR 201.4(c)(2). DMA 2000 only requires hazard mitigation plans to address natural disasters, but communities may choose to include manmade/technological hazards.

HAZARD MITIGATION PLANNING

Natural hazards are inevitable. Floods, hurricanes, tornadoes, earthquakes, wildland fires, and other hazardous events are normal occurrences in the natural environment. Disasters occur when humans and the built environment meet with a natural hazard. Although natural hazards cannot themselves be managed, many disasters can be avoided or mitigated. The purpose of hazard mitigation is to take actions to minimize the impact of natural hazards on human activity and the built environment. Hazard mitigation planning provides an outline for the how, when, and where of mitigation actions for a community.

Hazard mitigation planning makes good economic sense. Current dollars spent on mitigation significantly reduce the demand for large amounts of future dollars when natural disasters strike. Natural disasters not only cause destruction or loss of property, but also job interruption or loss. According to a 2005 study of the Multihazard Mitigation Council of the National Institute of Building Sciences, every dollar spent on hazard mitigation provides the nation four dollars in future savings from natural disasters.

WHAT IS MITIGATION PLANNING?

Hazard Mitigation:
Any sustained action taken to reduce or eliminate long-term risk to life and property from a hazard event.

Mitigation planning:
A process for systematically identifying policies, activities, and tools that can be used to implement those actions. This process has four steps: organizing resources, assessing risks, developing a mitigation plan, and implementing the plan and monitoring progress.
Source: FEMA

Hazard mitigation planning analyzes a community's risk from natural hazards, coordinates available resources, and develops actions to eliminate risk. It is a collaborative process involving the identification of hazards affecting the community, assessment of vulnerabilities, and reaching consensus on how to minimize or eliminate the effects of hazards.

FUNDING HAZARD MITIGATION

The FEMA Pre-Disaster Mitigation Competitive (PDM-C) Grant Program provides funding to states, Indian tribes, communities, and colleges and universities for pre-disaster mitigation planning and implementation of cost-effective mitigation project that address natural hazards. Applicants must have a FEMA-approved Multi-Hazard Mitigation Plan to be eligible to receive project grant funding under the PDM-C **Project** Grant Program. However, PDM-C **Planning** Grant funding is available for the development of Multi-Hazard Mitigation Plans.

PDM-C planning grants provide 75 percent federal funding through FEMA, with the remaining 25 percent comprised of a local match in the form of contributions, cash, in-kind services, and/or other non-federal sources.

In Wisconsin, the FEMA PDM-C Grant Program is coordinated locally through Wisconsin Emergency Management (WEM). WEM specializes in hazard mitigation, warning and communications, emergency police services, emergency fire services, disaster response and recovery, hazardous materials and public information, radiological emergency preparedness, and exercise and training for Wisconsin. WEM efforts are coordinated with local, state, tribal, and federal agencies, as well as volunteer and private sector partners.

HOW TO USE THIS GUIDE

The hazard mitigation planning process aims to reduce or eliminate the loss of life and property damage resulting from natural and technological hazards. This process is undertaken in four phases; Phase 1: Organizing Resources, Phase 2: Identifying and Assessing Risks; Phase 3: Developing the Hazard Mitigation Plan; and Phase 4: Implementing the Plan and Monitoring Progress. The chapters of the *Guide to Hazard Mitigation Planning for Wisconsin Coastal Communities* are organized to coincide with the four phases of a multi-hazard mitigation plan. The Guide outlines a systematic process for communities to develop their multi-hazard mitigation plan with emphasis on Wisconsin Great Lakes coastal communities.

Although this Guide makes every attempt to create a comprehensive guide for Wisconsin coastal communities to develop a multi-hazard mitigation plan, communities are encouraged to seek out additional source materials and review completed plans from other coastal communities when developing their multi-hazard mitigation plans. *Appendix C* provides recommended reading suggestions, which serves as a good starting place of publications, and web sites for additional information.

CHAPTER 1: ORGANIZING RESOURCES

When starting a hazard mitigation plan, communities need to focus on developing a successful process. This includes identifying and organizing interested members of the community as well as the technical expertise that will be required throughout the planning process.

The first phase of the hazard mitigation planning process focuses on organizing community resources, including a determination of the planning area, gathering community support, assessing the readiness to plan, establishing a planning team, securing political support, and engaging the community.

PLANNING AREA

One of the first steps in the planning process is to determine the planning area. Hazard mitigation plans can be completed at a local community level or a multi-jurisdictional level such as a county. Many state emergency management agencies encourage the development of plans at a county level to achieve a more comprehensive evaluation. Disasters do not stop at jurisdictional borders; therefore, completing a multi-jurisdictional/countywide plan provides a more comprehensive approach to hazards.

Although planning on a broader county level can bring additional resources, such as staff and experience, to the effort, it also carries challenges when bringing together differing views or opinions. These differences can be overcome early in the process if each participant is kept on even ground with no one entity holding more value than the next, and the process maintains transparency. Utilizing a regional planning agency may help overcome multi-jurisdictional planning obstacles.

However the planning area is defined, all jurisdictions within the planning area are encouraged to take an active part in the planning process. If the planning area is defined as a county, the towns within that county are covered under an adopted plan. In contrast, incorporated communities (such as cities and villages) are required to be actively involved in the process in order to adopt the final plan. Any jurisdiction may choose not to be involved in the process or adopt the final plan; however, they will not be qualified for future funding under the FEMA PDM-C grant program (predisaster mitigation – competitive grant program) or the HMGP (hazard mitigation grant program) (unless it is to apply for funding to develop their own hazard mitigation plan).

COMMUNITY SUPPORT

It is important for a community to be aware of the level and source of support it has and work on acquiring help where gaps are identified. The mitigation planning process involves learning about the community and then acting on the findings. The more the community understands its issues, concerns, and capabilities, the more they can develop a planning process that embodies the community's values and generates support for the process and its results.

Public support is essential to ensure the success and longevity of planning implementation. The following questions should be addressed when developing strategies to garner public support:

- What kinds and levels of public support are necessary to make the implementation of your hazard mitigation plan successful and sustainable?
- What public relations activities will you engage in to promote the effective long-term implementation of your plan?

- How will you create opportunities for the public to share information?
- How will you connect and interact with the public and organizations to improve public hazard awareness?

Hazard mitigation planning is a process with implications that go beyond the office originating the plan. An active, ongoing involvement of interested and affected parties is a key feature of hazard mitigation planning and is critical to the plan's success. It is essential to build coalitions and reach consensus about hazard concerns, issues, and goals. The broader the base of support for the plan, the greater the chance the plan will be accepted and used.

READINESS TO PLAN

Determine if the community is ready to begin the planning process by assessing the availability of three key elements necessary for a successful planning process: Knowledge, Support, and Resources.

Knowledge

A community needs to determine the level of understanding about hazard mitigation planning and risk reduction among public officials, citizens, and others whose support will be needed. Some up-front educational activities may be necessary if a community finds that participants are either unfamiliar with hazard mitigation or skeptical about the savings of investing in mitigation measures before a disaster strikes versus the cost of recovering from a disaster. Touting the benefits of hazard mitigation planning can often be dismissed as hype, but community buy-in is an essential element of the planning process. It may be beneficial to find a community that could share their mitigation success stories.

Support

Public officials, businesses, and citizens need to know how they can support hazard mitigation planning. It may be necessary for a community to develop strategies early in the process that will increase the level of support for hazard mitigation planning.

Resources

A community may find it necessary to take measures to familiarize themselves with resources such as plans, programs, agencies, or funding that can help in the planning process. Some helpful resources to acquire include:

- Emergency operations or action plans
- Comprehensive plans
- Relevant zoning ordinances (e.g. floodplain/shoreland zoning ordinances)
- Drought contingency plans
- Flood assessments
- Hazard analyses
- Evacuation plans
- Hospital emergency plans
- Mass casualty plans
- Disaster plans
- Hazardous materials plans
- Dam emergency action plans

REMOVING OBSTACLES

Mitigation planning obstacles related to knowledge, support, and resources can be overcome in various methods, such as the following (acquired from FEMA "How-To Guide"):

- Educate public officials about the benefits of reducing potential losses through pre-disaster mitigation planning and about the costs of not having a mitigation plan.

- Identify leaders in other communities who were successful in developing a hazard mitigation plan.
- Identify a convincing team leader in a position of authority, such as a community leader, elected official, or influential agency head.
- Capitalize on new regulations such as DMA 2000, which requires states and local communities to have an approved hazard mitigation plan to be eligible for pre- and post-disaster mitigation funding.
- Identify existing processes such as comprehensive planning that can be expanded to include the development of a hazard mitigation plan or included hazard mitigation elements.
- Identify self-interests in the community for hazard mitigation planning.
- Identify potential funding and technical resources to support the planning process.

Table 1 lists activities that can help increase knowledge, support, and resources for hazard mitigation planning.

Table 1: Knowledge, Support, and Resource Building Activities

Knowledge	Educate public officials on hazards and risks to your area. - Have statistics ready about the last disaster. - Discuss general mitigation options. - Remember the bottom line. - Be informative but brief. - Provide examples and success stories from nearby communities. Tout the benefits of hazard mitigation and mitigation planning. - Planning leads to sensible selection of risk reduction actions. - Planning builds partnerships. - Planning contributes to sustainable communities - Planning establishes funding priorities.
Support	Support from local government. Support from state government. Support from federal government. Support from private sector. Citizen Support Support from academic institutions. Support from a champion. Capitalize on new regulations. Create support by expanding current planning initiatives. - Comprehensive plans - Stormwater management plans - Open space and recreation plans - Redevelopment and housing plans - Transportation plans - Capital improvement plans - Floodplain remapping or updating - Existing mitigation plans and other emergency management plans - Post-disaster recovery planning Support from other programs. - National Flood Insurance Program (NFIP) - Community Rating System (CRS) - Flood Mitigation Assistance Program (FMA) - Pre-Disaster Mitigation Program (PDM) - Hazard Mitigation Grant Program (HMGP) - Repetitive Flood Claims (RFC) Program - Severe Repetitive Loss (SRL) Program
Resources	Technical Resources - Planning, engineering, and scientific resources on staff - GIS - Local universities and colleges - Regional planning agencies - State geologists, climatologists, foresters, etc. Financial Resources - Pre-Disaster Programs * Pre-Disaster Mitigation Program (PDM) * Flood Mitigation Assistance Program (FMA) - Post-Disaster Programs * The Stafford Act (Public Law 100-107) * Hazard Mitigation Grant Program (HMGP) * Assistance to Individuals and Households Grant Program * Public Assistance Program (PA) Human Resources - Citizens, businesses, public officials, association leaders, etc.

Source: FEMA "How-To Guide." September 2002.

PLANNING TEAM

The planning team typically consists of the county emergency management director, representatives from each participating jurisdiction, community leaders, representatives of local government agencies, business owners and operators, and interested citizens. Some specific people that would be beneficial on the planning team include representatives from health departments, hospitals, large corporations/industries, television/radio stations, highway departments, water/wastewater treatment facilities, Red Cross, Police/Fire/EMS, public safety communications, planning and zoning departments, land conservation department, land information officer, and neighborhood associations. Whenever possible, the planning team should be built on existing boards or committees such as the Local Emergency Planning Committee (LEPC).

The planning team must be willing and able to participate regularly at meetings. Smaller subcommittees may have to be established at various times throughout the planning process.

Steering Committee

Depending on the size of the planning team, many communities may find it helpful to develop a steering committee from the larger group that will provide leadership and support to guide the mitigation planning process and serve as a point of contact for the various interest groups in the community.

It is important for coastal communities to ensure that they have representation on either their planning team or the steering committee from someone knowledgeable about coastal hazards. At a minimum, they should have someone to consult with during the development of the plan. The Wisconsin Coastal Management Program can assist communities with getting in contact with people knowledgeable about coastal hazards for their planning team/steering committee.

PUBLIC INVOLVEMENT

Although the planning team represents a cross-section of the public, it is important to include broad public involvement in the planning process. Involving the public throughout the process will expose the planning team to different points of view regarding the needs of the community, and will provide the opportunity to educate the public about hazard mitigation planning. Public involvement can often be challenging, the following are some tips to encourage participation from the public:

- Ensure all meetings are open to the public and publicly posted in advance of the meeting.
- Allow time for public comment at each meeting.
- Hold open houses/public informational meetings throughout the process.
- Release informational articles to local newspapers, and involve the media and encourage them to report on activities throughout the process.
- Include a public review process for the draft plan.
- Public involvement can also be encouraged through events such as workshops and focus group sessions.

CHAPTER 2: IDENTIFYING AND ASSESSING RISKS

The second phase of the hazard mitigation planning process involves identifying and evaluating hazards, assessing vulnerabilities, and preparing damage loss estimates. Knowing where hazards can affect the built environment and the probable outcome of damages and losses resulting from a hazard event will help communities prioritize their focus toward the most critical assets, which will build the foundation of their mitigation strategy.

IDENTIFY HAZARDS (NATURAL AND MAN-MADE/TECHNOLOGICAL)

The hazard identification process should begin with a listing of all the hazards that might affect the planning area before narrowing the list to those hazards that are most likely to impact the planning area. The full range of potential hazards should be assessed even though the hazard may not have affected the area recently, because it may have a future impact.

Various methodologies can be used to identify the hazards that are likely to affect the planning area. The methodology chosen should incorporate a rating system based on a variety of factors. *Appendix A* provides two examples of methodologies that may be used to determine the hazards for further analysis.

PROFILE HAZARD EVENTS

After developing a list of potential hazards, the next step in assessing risk is to profile each identified hazard. Each hazard type has unique characteristics that can impact the planning area and a given hazard event can affect the area differently depending on its extent, magnitude, duration, and intensity. In addition, the same hazard event will affect different areas in different ways, based on geography, development, population distribution, age of buildings, etc. *Chapter 6* of this Guide provides information on coastal hazards and other natural hazards that could affect Wisconsin communities.

> Multi-jurisdictional plans must assess each jurisdiction's risks where they vary from the risks facing the entire community.

A hazard profile consists of a description of the hazard; historical data on past occurrences within the planning area; the community's vulnerability to the hazard event; the probability of future occurrences; a discussion on the impacts to critical facilities and other strucctures, public health, safety, infrastructure, and the local economy; areas at greatest risk (extent of the hazard); and an estimate of potential losses. In addtion, the community may find it useful to include an assessment of cumulative effects, an inventory of plans and programs, and an evaluation of gaps and deficiencies that exist for the community. Identifying plans and programs, and gaps and deficiencies will greatly assist with the identification of mitigation strategies later in the plan.

Description and History

For each identified hazard, the profile begins with a general description of the hazard and a discussion of past occurrences that have occurred in the community. There are various sources for information on past hazard occurrences that might affect the planning area. Some good sources for historical hazard event information include:

- National Climatic Data Center (http://lwf.ncdc.noaa.gov/oa/climate/severeweather/extremes.html)

- Wisconsin Emergency Management Agency/State Hazard Mitigation Officer and/or State Hazard Mitigation Plan (http://emergencymanagement.wi.gov/)
- Wisconsin Department of Natural Resources (http://dnr.wi.gov/)
- Wisconsin Geological and Natural History Survey (http://www.uwex.edu/wgnhs/)
- Plans and Reports
  - Local Hazard Analysis Plan (completed annually by the county emergency management departments)
  - Hazard identification reports (acquire from county and/or state emergency management departments/agencies)
  - Risk assessment reports (acquire from county and/or state emergency management departments/agencies)
  - Flood insurance studies and insurance rate maps
  - Transportation, environmental, dam, or public works reports or plans (acquire from local, county or regional planning departments/commissions and/or the Department of Natural Resources)
  - Comprehensive plans, land use plans, capital improvement plans, building codes, land development regulations, and flood ordinances (acquire from local, county or regional planning departments/commissions)
- Newspapers and Historical Records
- Community Experts
  - Emergency Management Director
  - University
  - Private sector
  - Floodplain managers
  - Departments of public works, engineering, planning and zoning, and transportation
- American Red Cross – local chapters (http://www.redcross.org/where/where.html)
- National Climatic Data Center (http://lwf.ncdc.noaa.gov/oa/ncdc.html)
- U.S. Geological Survey – Natural Hazards Gateway (http://www.usgs.gov/hazards)
- Army Corps of Engineers – Detroit District (http://www.lre.usace.army.mil/greatlakes/hh/flood%20monitoring/)

Additional sources for information can be found in this Guide under *Appendix C: Recommended Reading*.

Vulnerability

A description of the community's vulnerability to the hazard is required under DMA 2000. According to 44 CFR 201.6(c)(2)(ii), vulnerabilities should be described in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas, and an estimate of the potential dollar losses to those vulnerable structures.

A vulnerability assessment may include:

- Identification of vulnerable populations such as elderly or disabled people; people who may require special medical care after a disaster; non-English speaking people; and disadvantaged populations that may lack access to television or radio.
- Identification of important facilities that help ensure a full recovery of the community after a hazard event, such as government functions, major employers, banks, and certain commercial establishments (e.g. grocery stores, hardware stores, and gas stations).
- Identification of economic elements such as major employers and financial centers that could affect the local or regional economy if significantly disrupted.
- Identification of areas with special considerations such as areas of high-density residential or commercial development that if damaged could result in high death tolls and injury rates.
- Identification of historic, cultural, and natural resource areas, including areas that may be identified and protected under state or federal law.

Probability of Occurrence

Typically, historical records can be used to make a determination of the probability of future hazard occurrence. Probability can be expressed in percentages as the chance of a hazard occurring in any given year or as a ratio representing the number of occurrences likely in any given year. For example, the most widely accepted design and regulatory standard for floods in the United States is the 1-percent annual flood (often referred to as the 100-year flood) because it has a 1 percent change of occurring in any particular year. A ratio can be determined by breaking the number of occurrences over a multi-year period down to a one-year time-period.

Impacts

The hazard mitigation plan should discuss potential impacts to various aspects of the community from hazard events. Some impacts that should be addressed are those that affect critical facilities, public health, safety, infrastructure, and the local economy. A thorough assessment of hazard impacts to the community will ease the identification of mitigation strategies and ensure a comprehensive evaluation.

Critical Facilities

To assess the vulnerabilities of the community's assets to each hazard, a critical facilities listing and map is very useful. With the critical facilities mapped, hazard area mapping can be overlaid to view the critical facilities that are located within delineated hazard area.

A critical facility is a structure that, if destroyed, would present an immediate threat to life, public health, and safety. A jurisdiction should determine criticality based on the relative importance of its various assets for the delivery of vital services, the protection of special populations, economic activity influences, regional impacts, and other important functions.

Some facilities in the community may influence people and economic activity far from the area where the hazard may occur. For example, extensive tornado damage to a coal-loading facility in Superior Harbor would affect power generation and dependent industries far beyond the Superior area.

Critical facilities can include:

- Hospitals
- Police Stations
- Fire Stations
- Emergency Medical Facilities
- Emergency Rescue
- Emergency Operation Centers
- Shelters
- Schools
- Nursing Homes
- Transportation Systems (roads, bridges, airports, rail terminals, maritime ports)
- Utilities (power plants, substations, power lines)
- Potable Water Facilities
- Wastewater Facilities
- Oil/Natural Gas/Electric Power Facilities
- Communication Systems
- Hazardous Material Facilities
- Jails and Juvenile Detention Centers

According to FEMA, a hazard mitigation plan should provide enough information regarding critical facilities to enable the jurisdiction to identify and prioritize appropriate mitigation actions. Some information may be deemed as highly sensitive and should not be made available to the public. Such information that the jurisdiction considers sensitive could be treated as an addendum to the mitigation plan so that it is still a part of the plan, but access can be controlled.

Once a community has inventoried its critical facilities, it is much easier to evaluate vulnerabilities to each hazard, and identify mitigation action steps (discussed in the next chapter).

Areas at Greatest Risk

An assessment of the extent of the hazard will enable a determination of the critical facilities and vulnerable populations in the area. Mapping software, such as Geographic Information Systems (GIS), allow the creation of accurate location maps of risk areas. Some hazards, such as lightning and thunderstorms, do not have easily definable risk boundaries and could impact any location within the planning area; thus, the area of greatest risk for such hazards will be the entire planning area.

It is always a good idea for the community to use the best available data and software that is accessible to them. Communities could also utilize available resources such as Regional Planning Commissions, Sea Grant Institute, and Department of Natural Resources for help developing their hazards mapping.

Potential Losses Estimate

After the areas of greatest risk have been identified, coupled with a completed inventory of buildings in the community, a determination of the potential losses can be estimated. This estimation involves an assessment of the total approximate replacement value of the buildings within the identified hazard area. It may be necessary to estimate the potential losses for the entire planning area since some hazards may affect the entire planning area. An estimation of potential losses must be conducted for each hazard the community addresses. The hazard mitigation plan must also include an explanation of the methodology used to estimate potential losses. An estimate of potential losses is just that, an estimate, and will likely not be an exact number. Since some creative calculations may be in order, the community must provide a clear explanation on how the numbers were derived.

The following is an example of a potential losses estimate for flooding:

- *There are 20 homes in the defined hazard area of the community (e.g. floodplain).*
- *The fair market value for the homes is $50,000.*
- *Content loss within the home was estimated at 30% or $15,000 ($50,000 x 30% = $15,000).*
- *The average flood depth in past occurrences is 2 feet over the first floor, which leaves the top floors undamaged. Therefore, an estimated 80% of the home is damaged or $40,000 ($50,000 x 80% = $40,000).*
- *The damage estimate of $40,000 x 20 homes = $800,000 in structural damage; $15,000 x 20 homes = $300,000 in contents damage.*
- *Total damages: $1.1 million ($800,000 + $300,000 = $1,100,000).*

Cumulative Effects

Cumulative effects are the combinations of hazards that occur in relationship to each other. There is no requirement that cumulative effects be evaluated; however, it may be useful to include such information in the hazard mitigation plan. Often one hazard results from another or can occur in combination with other hazards. For example, drought conditions can lead to fires, and hailstorms often occur in combination with lightening and thunderstorms. Cumulative effects can also take on a cascading effect when one hazard intensifies another such as storm surges rising rapidly as on-shore wind speed increases. It is a sensible to be conscious of the cumulative effects of hazard events.

Keep in mind that human actions in coastal development can lead to cumulative impacts. For example, development that adds large areas of impervious surfaces to a watershed without stormwater management will make streams more susceptible to flash flooding. Human activity can cause cumulative effects without having been anticipated

Inventory of Plans and Programs

An inventory of plans and program established to address each hazard will help a community to organize all aspects of hazard mitigation management. Often communities will have flood assessments, drought contingency plans, comprehensive plans, relevant zoning ordinances, emergency operation plans, community hazard analyses, etc. Better awareness and organization of available resources will equip a community to address a hazard situation more efficiently.

Gaps and Deficiencies

To develop gaps and deficiencies it is necessary to look critically at the community while thinking about how each hazard is or is not being addressed with programs, policies, equipment, procedures, staff, or regulations. An identification of gaps and deficiencies that are evident for each hazard can be very helpful when it comes to developing mitigation strategies later in the plan. For example, the following items are gaps and deficiencies identified in a community for tornadoes:

- *A significant number of homes and elderly resident facilities in the county lack basements that would provide shelter in the event of a tornado.*
- *A majority of the power lines in the county are above ground and subject to damage from wind and falling tree limbs.*
- *Not all of the county's tornado siren systems have a generator that will enable them to work during a power failure.*

CHAPTER 3: DEVELOPING THE MITIGATION ACTION PLAN

The third phase of the hazard mitigation planning process requires the development of mitigation goals and objectives that focus on the identified risks and potential losses. This phase will guide the identification of mitigation measures to address potential losses, help achieve the community's goals and objectives, and limit future disaster-related losses.

MITIGATION GOALS, OBJECTIVES, AND ACTIONS

The hazard mitigation plan must include goals, objectives, and actions for the mitigation of each hazard. **Goals** are general guidelines that explain what the community wants to achieve. Goals are usually general policy-type statements, long-term, and represent large-scale visions, such as:

- *The economic vitality of the community will not be threatened by future flood events*
- *Minimize wildfire losses in the wildfire urban interface area.*
- *The continuity of local government operations will not be significantly disrupted by disasters.*

Objectives define strategies or implementation steps to attain the identified goals. Unlike goals, objectives are specific and measurable, such as:

- *Protect structures in the historic downtown area from flood damage.*
- *Educate citizens about wildfire prevention actions in the home ignition zone.*
- *Prepare plans and identify resources to facilitate reestablishing county operations after a disaster.*

Mitigation actions are specific activities that help the community to achieve their goals and objectives. For example:

- *Elevate three historic structures located in the downtown district.*
- *Sponsor a community fair to promote wildfire prevention actions in the home ignition zone.*
- *Retrofit the police department to withstand high wind damage.*

Mitigation goals, objectives, and actions will often read like a "wish list" of activities, programs, policies, and purchases that will make the community better prepared or protected from hazards events. Listing a mitigation goal, objective, or action asserts a community's desire to accomplish the stated task. However, just because the goal, objective, or action is stated in the plan does not mean the community is bound to accomplishing it.

Figure 2 provides an example of mitigation goals and objectives. The information gathered in the gaps and deficiencies section (if undertaken) can be very helpful in shaping the mitigation goals and objectives and ensuring that each hazard is fully addressed.

Figure 2: Examples of Community Goals and Objectives

Example of community goals and objectives:

Village of Gurnee, Illinois, Mitigation Goals (excerpted from the November 15, 2001 plan)

Goal 1 Protect existing properties.

Objectives:

- Use the most effective approaches to protect buildings from flooding, including acquisition or relocation where warranted.
- Enact and enforce regulatory measures that ensure new development will not increase flood threats to existing properties.
- Use appropriate actions to mitigate against the danger and damage posted by other hazards.

Goal 2 Protect health and safety.

Objectives:

- Advise everyone of safety and health precautions to take against flooding and other hazards.
- Improve traffic circulation during floods and at other times.
- Improve water quality and habitat.

Goal 3 Improve the quality of life in Gurnee.

Objectives:

- Preserve and improve the downtown core of businesses and services.
- Ensure that current owners can maintain and improve their properties.
- Use acquisition programs to expand open space and recreational opportunities.
- Maintain an attractive riverfront and other public open spaces.

Goal 4 Ensure that public funds are used in the most efficient manner.

Objectives:

- Prioritize mitigation projects, starting with sites facing the greatest threat to life, health, and property.
- Use public funding to protect public services and critical facilities.
- Use public funding for projects on private property where the benefits exceed the costs.
- Maximize the use of outside sources of funding.
- Maximize owner participation in mitigation efforts to protect their own properties.
- Encourage property-owner self-protection measures.

Source: FEMA "How-To Guide." FEMA 386-3. April 2003.

Mitigation action steps will develop from the goals and objectives as a variety of initiatives to achieve mitigation objectives for each hazard. FEMA offers many guides and worksheets on their website and in their *How-To Guide* to generate mitigation action ideas and Wisconsin Emergency Management has a very helpful guide on their website titled "Mitigation Ideas" (see *Recommended Reading* in *Appendix C* for more information). In addition, local and state agencies/departments, universities, organizations, businesses, and residents may provide valuable input regarding methods to mitigate hazards. It may also be helpful to review recommendations from community plans, and mitigation initiatives identified in the County Hazard Analysis and the State Hazard Mitigation Plan. Figure 3 provides some examples of mitigation actions.

Figure 3: Examples of Mitigation Actions

Examples of alternative mitigation actions include:

- Adopting land use planning policies based on known hazards
- Developing an outreach program to encourage homeowners to buy hazard insurance to protect belongings
- Relocating structures away from hazard-prone areas
- Developing an outreach program to encourage homeowners to secure furnishings, storage cabinets, and utilities to prevent injuries and damages during an earthquake
- Retrofitting structures to strengthen resistance to damage
- Developing, adopting, and enforcing effective building codes and standards
- Engineering or retrofitting roads and bridges to withstand hazards
- Requiring the use of fire-retardant materials in new construction
- Requiring disclosure of hazards as part of real estate transactions
- Adopting ordinances to reduce risks to existing hazard-prone buildings
- Imposing freeboard requirements in special flood hazard areas
- Implementing V Zone construction requirements for new development located in coastal A Zones

Source: FEMA “How-To Guide.” FEMA 386-3. April 2003.

Some mitigation opportunities may be low-cost, easy-to-implement policies, while others may require a costly purchase or regulation change that could take years to implement. Some mitigation actions may take decades for the opportunity to present itself. For example, a structure located in a coastal hazard area could be removed or relocated when the property is in need of replacement. The cost of implementing this mitigation action plan will likely be much greater than the funds available; therefore, prioritization is necessary.

PRIORITIZING MITIGATION ACTIONS

Prioritization of the mitigation action plan is important to ensure that the most beneficial initiatives get implemented as resources become available. It may be helpful to start the process of prioritizing mitigation actions by reviewing the hazard profiles to determine which hazards have occurred more frequently and/or caused major losses. When prioritizing each action step, consider the ease of implementation, if the action will address more than one objective, length of time needed to accomplish the action, and potential funding sources.

Various methodologies can be utilized to develop a prioritized mitigation action list. A common method is “multi-voting”, also referred to as a “weighted system”, which allows each member of the planning team to vote on the mitigation actions that are being considered. Each member is given a number of voting opportunities that equal half the total list. For example, if ten actions were listed, each member would select their top five choices. The action receiving the most votes is the highest priority; the action with the second most votes is the second priority, and so on.

Another common method is “numerical ranking”, which asks each planning member to rank all listed actions based on their professional experience or the knowledge they have gained through the process. An average ranking is then calculated for each action to determine the overall ranking. For example, if a particular action received two “#1” rankings and one “#3” ranking, the rankings add to five (1+1+3=5), which is then divided by three (the total number of votes) to equal 1.33. If 1.33 is the closest number to one, then that action receives top priority.

Prioritizing mitigation actions can also be as simple as assigning “high”, “medium”, and “low” designations to each identified mitigation action.

CAPABILITY ASSESSMENT

The capability assessment identifies the community's existing programs, policies, regulations, funding, and practices that promote and support mitigation efforts within the community. In addition, the capability assessment will help a community to determine if there are any hindrances to implementation of the prioritized mitigation activities. Such an assessment will determine the types of mitigation actions that may be prohibited by law, potential limitations to undertaking actions, and the range of local and/or state resources available to assist in implementation of the mitigation strategy.

When developing mitigation actions consider the following questions:

- *Is the action socially acceptable and consistent with community value?*
- *Is the action technically feasible?*
- *Does the community have the capability to implement and maintain the action?*
- *Is there public support to implement and maintain the action?*
- *Does the community have the authority to implement the proposed action?*
- *Is the action cost-effective?*
- *Does the action affect the environment (land/water/endangered species)?*

Although, a capability assessment is not required by DMA 2000, it is highly recommended by FEMA. The capability assessment within the state multi-hazard mitigation plan will likely be very helpful in determining the viability of certain mitigation actions.

IMPLEMENTATION STRATEGY

Once mitigation actions are identified and prioritized, an implementation strategy must be developed. An implementation strategy will help identify resources and steps necessary to implement mitigation projects. The implementation strategy should break out each task necessary to accomplish each mitigation action and identify the parties, resources, and timetable for each task. A capability assessment (if undertaken) can be very helpful in developing the implementation strategy.

Responsible Parties

The implementation strategy should identify a party (agency, department, organization, etc.) that will be charged with implementation of each of the identified mitigation actions. It is important to ensure that the identified party responsible for each task has the time and ability to follow through on the action.

Resources

An inventory of resources needed to accomplish each task should be part of the implementation strategy, including funding, labor, technical assistance, materials, equipment, etc. By working with the identified responsible party cost estimates for the needed resources can be developed and a total cost estimate to complete each task can be calculated.

Beyond local budgeting, potential sources of funding for mitigation actions included FEMA (often administered through the state emergency management agency), U.S. Department of Agriculture, Department of Housing and Urban Development and its Community Development Block Grant (CDBG), the state department of natural resources (or similar agency), private businesses and organizations, and academic institutions.

Timetable

The planning team and the responsible parties should work together to develop a timeframe for implementing each mitigation action. The timetable should detail when the action will start, when any interim steps will be completed, and when the action will be fully implemented. It may be useful to state whether an action is "short-term" or "long-term." Short-term project is typically completed within one year. Long-term maintenance projects can be listed as "on-going."

When identifying start dates, the planning team should keep in mind any special scheduling considerations that may affect the schedule such as seasonal climate conditions, funding cycles, agency work plans, and budgets. After identifying start dates, the planning team should review the mitigation action priorities to determine if the timetable created a need to reprioritize some actions.

Document the Implementation Strategy

Once all the elements of the implementation strategy are complete, the planning team should determine the format in which to present the strategy. Figure 4 provides an example of an implementation strategy format that can be used.

Figure 4: Example Implementation Strategy Format

Example Implementation Strategy Format

Action: (From your list of selected actions)

Goal(s) and Objective(s) Addressed: (Sometimes the action will address more than one goal and objective)

Lead Agency: (Provide the name and a brief description of the agency)

Support Agency or Agencies: (Provide the name and a brief description of each support agency)

Budget: (Provide the dollar amount or an estimate, if known; put TBD—to be determined, if not known; and/or indicate staff time if staff will be used)

Funding Source(s): (List the funding sources—e.g., operating budget, capital improvement budget, XYZ grant, XYZ foundation, etc.)

Start and End Date: (Indicate start and end dates; short-term, long-term, or on-going; and milestones for longer term projects)

Source: FEMA "How-To Guide." FEMA 386-3. April 2003.

Before finalizing the implementation strategy, the planning team should review the mitigation actions to ensure that the identified projects address the goals and objectives of the team and the community. The planning team should work towards reaching consensus on the completed implementation strategy.

Benefit-Cost Review of Mitigation Actions

The mitigation plan must include a benefit cost analysis discussion that considers the benefits that would result from the mitigation actions (including projects) versus the cost of those actions. At a minimum, the plan should make a statement to the effect of the following: *"Project costs are continually changing. Therefore, a benefit cost analysis will be completed as funds become available and during project development".*

CHAPTER 4: PLAN IMPLEMENTATION, MONITORING PROGRESS, AND UPDATING

The fourth phase of the hazard mitigation planning process involves adopting, implementing, monitoring, and reviewing the plan to ensure that the plan's goals and objectives are met. Periodic review and revision of the plan helps ensure that it remains current and continues to reflect the changing needs of the community.

PLAN REVIEW

Before the plan is adopted, review by the affected agencies, the public, and the state is necessary. After the planning team has reviewed the plan and made revisions, a draft should be reviewed by the agencies that have been charged with implementation in the mitigation strategy and any other affected agencies such as emergency management, public health and safety, and community planning. A copy of the draft plan should be sent to the State Hazard Mitigation Officer for review and comment prior to formal local adoption to ensure that the plan meets state and federal requirements. Public review of the plan is an essential step before the plan is formally adopted and can be done concurrently with state review.

Public review is a very important component of the plan review process. Public review can be accomplished by holding open houses and/or public hearings and the draft plan can be made accessible for public comment through the community's website and at local libraries or other public facilities. Documentation on public involvement and the community's response to public comment is a valuable element of the hazard mitigation plan.

PLAN ADOPTION

After the draft multi-hazard mitigation plan has been reviewed by all relevant or interested parties and all comments have been incorporated, the plan should be revised and a final draft prepared. The next step is presentation of the final draft to the local government body for adoption. In addition, multi-jurisdictional plans, such as countywide plans, must be adopted by all participating communities included in the plan in order for each jurisdiction to be eligible for future FEMA disaster mitigation funding. Formal adoption of the plan is required before it is eligible for approval consideration by FEMA. Keep in mind that FEMA will not approve a jurisdictions' adoption of a hazard mitigation plan if they have not participated in development of the plan.

PLAN IMPLEMENTATION

Implementation puts the plan in motion and focuses on the actions necessary to establish and maintain the effectiveness of the plan as a fundamental tool for risk reduction. Implementation of the multi-hazard mitigation plan helps the mitigation strategy to be carried out in an effective manner. The mitigation strategy will likely contain both short and long-term recommendations and by the time implementation is underway, the identified sources of funding, staff time, and staffing needs may change.

The plan needs to establish a clear "custodian of the plan" who is responsible for the hazard mitigation plan. The plan needs to make clear who has the overall responsibility of overseeing the plan implementation as well as the monitoring, evaluating, and updating of the plan.

The planning team and the custodian of the hazard mitigation plan should always be on the lookout for alternative sources of funding, new opportunities, and new partnerships through which to carry out the recommendations detailed within the plan. Establishing the responsible party to carry out each objective is vital to setting implementation of the plan in motion.

MONITORING AND EVALUATING THE PLAN

On at regular basis, the community and its implementation partners should evaluate the progress of each mitigation strategy and compile summary progress reports to maintain a record of implementation. This collaborative implementation approach provides a forum for identifying additional mitigation needs. Monitoring and evaluating the results of the mitigation actions will enable the community to determine if the plan is having the desired effect and if they should continue as they are or make some changes to the mitigation strategy. The evaluation process should include documentation of successes and limitations of the plan. It is important to keep all players and the public informed of the progress. The media can be helpful for this step.

REVISING AND UPDATING THE PLAN

The community and its assets are constantly changing, requiring periodic updates to the hazard mitigation plan. While DMA 2000 regulations require a formal review and revision of the hazard mitigation plan every five years, the community should reevaluate plan as new opportunities, unexpected challenges, and disasters arise. Keep in mind that a concise, logical, and straightforward plan is easier to review and update, especially for those not involved in the original plan development process.

The 5-year plan review and revision process provides a complete update to the plan and requires the plan development process to be repeated. Funding under the FEMA Pre-Disaster Mitigation Grant Program will likely continue to be available for such updates.

Additionally, as mitigation strategies are addressed, there may be a need to reevaluate, reprioritize, add, or delete objectives as tasks are accomplished. Newly identified mitigation needs should be addressed through the development of additional goals, objectives, or strategies. An annual review of the plan is suggested and an after-disaster review is highly recommended.

An annual review does not call for a complete update to the plan, but only that the plan be evaluated and perhaps an annual report compiled that involves the public. For example, the annual review could include public notices with annual review meetings that bring in stakeholders.

CHAPTER 5: WRITING THE PLAN - PULLING IT ALL TOGETHER

Multi-hazard mitigation plans are typically divided into five chapters; *Chapter 1: Introduction*; *Chapter 2: Community Profile*; *Chapter 3: Risk Assessment*; *Chapter 4: Mitigation Strategies*; *and Chapter 5: Plan Adoption and Maintenance.*

Chapter 1 – Introduction is the executive summary of the Multi-Hazard Mitigation Plan. It provides documentation of the purpose for the plan and the planning process used to develop the plan.

Chapter 2 – Community Profile characterizes the community by its physical, social, economic, and governance structure. This chapter also details a community's critical infrastructure and emergency response resources.

Chapter 3 – Risk Assessment profiles a range of potential hazards that could pose a threat to the community including hazard type, location, geographic extent, past occurrences, and probability of future occurrences. This chapter assesses vulnerabilities to the potential hazards based on a variety of considerations.

Chapter 4 – Mitigation Strategies establishes the community's goals, objectives, and prioritized strategies for reducing potential losses identified in the risk assessment and addressing identified gaps and deficiencies.

Chapter 5 – Plan Adoption and Maintenance describes the method and schedule of monitoring, evaluation, and updating the mitigation plan, how the plan will be incorporated into other planning processes, and how public participation will continue. This chapter includes documentation that the plan has been formally adopted by the governing body of the community requesting approval of the plan.

PLAN INTRODUCTION

The introduction to the plan offers a summary to the multi-hazard mitigation plan and the regulatory context for the plan. It includes the purpose for the plan, and the process followed during development of the plan.

Purpose

The purpose of the plan establishes the reason the process is being undertaken in the community. Information may include such topics as the governing regulation for the plan, funding secured to develop the plan, and a discussion of the content of the plan.

Process

A discussion on the planning process undertaken to develop the plan is required. This section must discuss how the plan was prepared, who was involved in the process, and how the public was involved.

COMMUNITY PROFILE

The community profile provides key physical and demographic information about the planning area, whether it is defined as a community or a multi-jurisdictional area such as a county. The plan must provide a general description of land uses and development trends within the community. Additional physical and demographic information about the community helps provide a better understanding of the community's hazard vulnerabilities, and provides background information for the mitigation strategies. Much of the information in the community profile chapter of the multi-hazard mitigation plan can come directly from the community's comprehensive plan (if the community has one), or from the U.S. Census Bureau if a comprehensive plan is not available or current.

The community profile may include such information as the following:

- Historical Setting
- Climate
- Geology
- Topography and Soils
- Hydrology
- Land Cover and Land Use
- Transportation
- Community Infrastructure
- Critical Facilities
- Utilities
- Public Facilities
- Population and Housing Trends
- Emergency Services and Facilities
- Economic information
- Coastal information such as recession rates

DMA 2000 only requires the community to provide a "general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions" (44 CFR 201.6(c)(2)(ii)(C)). However, the community may find it useful to go through the exercise of gathering other information that may be essential before, during, or after a hazard event, such as emergency services and facilities, and pre- and post-disaster services and facilities to include:

- Police, Fire, and Ambulance Services and Facilities
- Hospitals and Medical Clinics
- Emergency Warning Systems
- Emergency Operations Center
- Heavy Equipment Inventory
- Community Contacts
- Private Contractors
- Bulk Fuel Haulers
- Elderly Housing
- Pre-Disaster Staging Areas
- Temporary and Long-Term Shelters
- Hazardous Waste Landfills
- Temporary Pet Shelters
- Pet Shelters

Critical Community Infrastructure ("Critical Facilities")

The community profile chapter of the multi-hazard mitigation plan is the place to identify the critical facilities or infrastructure of the community (some examples are provided in the bulleted list above). With the critical facilities clearly defined in the community profile, the next chapter -- the risk assessment chapter -- can focus on assessing the impact of each hazard on critical facilities, and only those critical facilities located within the particular hazard area.

RISK ASSESSMENT

The risk assessment chapter consists of hazard profiles for all hazards that affect the planning area. The risk assessment should include a description of the hazard; past occurrences; a vulnerability assessment; the probability of future occurrences; a discussion on the impacts of the hazard; areas at greatest risk; an estimate of potential losses, and other optional, but useful information regarding the cumulative effects of a hazard event, an inventory of plans and programs, and an evaluation of gaps and deficiencies.

For further assistance with developing the risk assessment, refer to *Chapter 2* of this Guide as it has been presented in a format that addresses all items required under DMA 2000. In addition, *Chapter 6* of this Guide provides hazard information on coastal hazards and other natural hazards that could affect Wisconsin communities.

MITIGATION STRATEGIES

The mitigation strategy chapter develops mitigation goals and objectives that focus on addressing the risks and potential losses to the community as identified in the risk assessment. The mitigation strategy guides the identification of actions and tasks to address hazard risks, limit future disaster-related losses, and achieve the community's goals and objectives.

For further assistance with developing the mitigation strategy, refer to *Chapter 3* of this Guide as it has been presented in a format that addresses all items required under DMA 2000.

"THE CROSSWALK"

After a community has drafted their hazard mitigation plan and it is ready for submittal to Wisconsin Emergency Management for review, the "Local Hazard Mitigation Plan Review Crosswalk" ("the crosswalk") must be completed and submitted with the draft plan. The crosswalk is a form created by the Federal Emergency Management Agency that includes a series of questions to help the planning committee ensure that the plan is consistent with the Disaster Mitigation Act of 2000 and 44 CFR Part 201. The crosswalk is provided in the *Multi-Hazard Mitigation Planning Guidance under the Disaster Mitigation Act of 2000* (FEMA, 2004), which is available through the Wisconsin Emergency Management website (see *Websites* under *Recommended Reading* in *Appendix C*).

PLAN ADOPTION AND MAINTENANCE

The plan adoption and maintenance chapter documents the adoption process and discusses the plan for implementing, monitoring, and reviewing the completed document to ensure that the plan's goals and objectives are met and that they remain current.

Plan Adoption

The hazard mitigation plan must discuss the process of adoption. The plan will be in effect upon its adoption by the communities/county and approval by the state emergency management agency and the Federal Emergency Management Agency The plan should include the resolution of adoption from the community; or in the case of a multi-jurisdictional plan, resolutions from each community represented. See *Appendix B* for a sample resolution of adoption.

Public Review Process

The plan will document how public comments were received during the drafting of the plan and how public comments were addressed in the final plan. The plan will document how the public was involved in the planning process.

Plan Implementation, Evaluation, and Updates

The plan will include and discuss the community's intentions for tracking and evaluating implementation of the mitigation strategy and the responsible custodian of the plan. The plan will identify the responsible party and the intended process and schedule for reviewing the plan on a regular basis and updating at least every five years.

PLAN COORDINATION

Communities are strongly encouraged to incorporate their hazard mitigation plans into newly developed or updated comprehensive plans. The Wisconsin comprehensive planning law includes a detailed description of elements that need to be addressed in all comprehensive plans. The following items should be considered when incorporating the hazard mitigation plan into the required elements of local comprehensive plans:

Issues and Opportunities Element
A summary of major hazards that local governments are vulnerable to, and what should be done to mitigate future losses from hazards.

Housing Element
An inventory of the properties that are within floodplain boundaries, the location of mobile homes, recommendations concerning building codes, shelter opportunities, and a survey of homeowners that may be interested in participating in a voluntary buyout and relocation program.

Transportation Element
An inventory of transportation routes and facilities that are at risk during flooding or winter storms.

Agricultural, Natural, and Cultural Resources Element
An inventory of the agricultural, natural, and cultural areas that are at risk during hazardous events. Incorporate recommendations on mitigating future losses to these areas.

Economic Development Element
Describe the impacts that past hazards have had on area businesses.

Intergovernmental Cooperation Element
Identify intergovernmental police, fire, and rescue service sharing/mutual agreements that are in effect or which may merit further investigation, and consider cost sharing and resource pooling of government services and facilities.

Land Use Element
Describe how flooding has impacted land uses and what is being done to mitigate negative land use impacts from flooding; and map and identify natural hazard areas such as floodplains and soils with development limitations.

Implementation Element
Provide mitigation actions from the hazard mitigation plan in the implementation element.

CHAPTER 6: HAZARD INFORMATION FOR WISCONSIN COASTAL COMMUNITIES

While preparing mitigation plans for coastal hazards, it is important to keep in mind that all of the coastal hazards affecting Great Lakes coastal communities are best mitigated through natural defenses whenever possible. Nearshore shoals and beaches of boulders, sand, bedrock, and gravel provide some natural defenses against coastal hazards such as erosion, seiches, and ice jams. These natural defenses cause storm waves to break and lose most of their energy before reaching land. Wetlands, sand dunes, or beach ridges provide buffers that absorb wave energy. In addition, maintaining natural areas or low-impact recreational areas along the shore reduces concerns of flood damage and lake level fluctuations.

COASTAL HAZARDS

In Wisconsin, coastal hazards are natural hazards occurring along the shores of Lake Michigan and Lake Superior. According to the Wisconsin Coastal Management Program of the National Oceanic and Atmospheric Administration, the coastal hazards of concern in Wisconsin include:

- Erosion of coastal bluffs, banks, beaches and near shore lake beds (including erosion from freezing and thawing of lake ice);
- Flooding from upland runoff, high lake levels and storm-induced surge (temporary water level changes); and
- Damage to shorelines and shoreline structures from storm waves.

This chapter provides hazard information on each Great Lakes natural hazard that is known to affect coastal communities in Wisconsin, beginning with a discussion of coastal hazards and then addressing other natural hazards that impact Wisconsin coastal communities. The coastal hazards discussed in this chapter include coastal flooding, coastal erosion, lake level fluctuations, storm surges and seiches, and coastal ice shove and jams. For each of the hazards presented in this chapter, a general description will be provided along with a discussion on the areas at greatest risk, including specific Wisconsin counties that are most vulnerable.

Coastal Flooding

A flood is a natural event that occurs when excess water from snowmelt, rainfall, or storm surge accumulates and the lake overflows onto the shore. Coastal flooding is a concern not only when lake levels are high, but during storm surges and seiches as well.

Areas at Greatest Risk

Many coastal areas in Wisconsin experience some coastal flooding. Two low-lying areas of the Lake Michigan shore are seriously impacted by coastal flooding: southern Kenosha County and the western shore of Green Bay from the city of Green Bay to the Michigan-Wisconsin state border in the city of Marinette (WCMP 2006).

Wisconsin counties at greatest risk for coastal flooding:

- Kenosha County (southern)
- Marinette County
- Oconto County
- Brown County
- Douglas County (City of Superior)
- Bayfield County (Bark Bay and Chequamegon Bay)
- Ashland County (Chequamegon Bay)

Wisconsin counties at medium risk for coastal flooding:

- Racine County
- Milwaukee County
- Ozaukee County
- Sheboygan County
- Manitowoc County
- Door County
- Kewaunee County

Mitigation Strategies

Efforts to limit exposure, such as strict building codes, land-use planning, and coastal setbacks are the most effective and cost-beneficial means of mitigating coastal flooding damages. Post-disaster mitigation efforts include buyout programs and relocation. Extensive public awareness campaigns can also help reduce injuries and prevent loss of life and property from coastal erosion. In addition, evacuation of residents in high hazard areas may be necessary before major storm events to limit injuries and deaths attributed to episodic coastal flooding.

Coastal Erosion

Geologically speaking, the Great Lakes are relatively young, and erosion of the shore and recession of the bluffs is an active natural phenomenon. Coastal erosion can be caused by wind action; heavy rains or melting snow; elevated groundwater levels; increased load on top of the bluff (buildings, heavy equipment, machinery, etc.); decreased soil strength from groundwater, soil drying and cracking, freezing and thawing, and water saturation; loss or removal of vegetation on the slope; erosion of the bluff toe during storms; erosion of the lakebed; and wind action.

Areas at Greatest Risk

Many coastal properties along Lake Michigan and Lake Superior are susceptible to erosion and recession of bluffs. Nearly 80 percent of Wisconsin's erodable shoreline is affect by coastal erosion and bluff recession (WCMP 2006).

The Lake Michigan shore is most vulnerable to erosion along the 185-mile stretch from the Illinois-Wisconsin state border to the Sturgeon Bay Canal in Door County. In addition, shore erosion vulnerabilities exist along bays and clay banks along the Door Peninsula from the Sturgeon Bay Canal around the northern tip of Door County to Green Bay (WCMP 2006).

The Lake Superior shoreline is impacted by more localized bluff erosion. The areas most vulnerable to bluff erosion are found along the high clay bluffs extending from Bark Point in Bayfield County to Wisconsin Point in Douglas County, and from Iron County to the White River in Ashland County (Springman and Born 1979).

Wisconsin counties at greatest risk for recurring coastal erosion:

- Kenosha County
- Racine County
- Milwaukee County
- Ozaukee County
- Brown County (northeastern)
- Bayfield County (northwestern)
- Sheboygan County
- Manitowoc County
- Kewaunee County
- Douglas County
- Door County
- Ashland County (northeastern)

Mitigation Strategies

Efforts to limit exposure such as strict building codes, land-use planning, and coastal setbacks are the most effective and cost-beneficial means of mitigating coastal erosion damages. Post-disaster mitigation efforts include buyout programs and relocation. Extensive public awareness campaigns can also help reduce injuries and prevent loss of life and property from coastal erosion.

Other mitigation strategies for coastal erosion will likely be site-specific and costly, artificial measures taken to slow natural processes such as beach nourishment and dune restoration. Beach nourishment is used to increase the amount of sand, adjust the shoreline profile, and to replenish depleted sand supplies. Both beach nourishment and dune restoration attempt to restore the shore protection capacity of the natural beach and dune system.

In addition, relocation of utility lines, water mains, sewer lines, and roadways in the immediate area of severe erosion may avoid or delay future damages. Evacuation of residents in high hazard areas before major storm events could limit injuries and deaths attributed to episodic erosion.

Lake Level Fluctuations

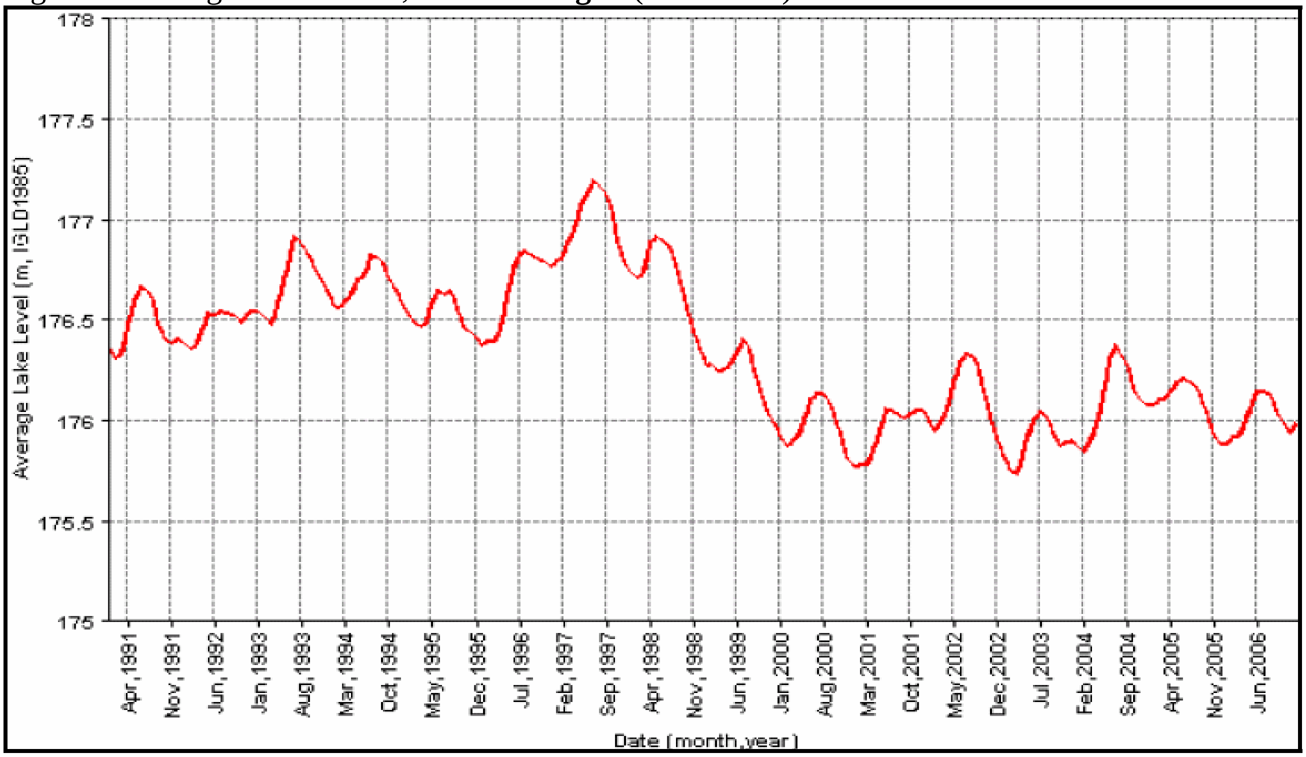
Lake levels can fluctuate on a short-term, seasonal basis or on a long-term basis over periods of months or years. Heavy seasonal rainfall, storm surges, and wave run-up can cause high lake levels for short periods; and snowmelt can result in higher seasonal water levels. Storm surges and wave run-up hazards are addressed under "storm surges and seiches."

Long-term lake level elevation changes are seasonal occurrences as well as changes that last years to decades. These fluctuations can cause property damage and economic hardship for citizens, communities, and industry (especially the shipping industry). Often site planning studies, building design, or community planning may neglect to consider future fluctuations. Higher water levels can lead to increased coastal erosion and flooding. Lower water levels can cause increased near-shore erosion, along with additional expense and challenges for ports and the shipping industry, water intake facilities, and marinas.

Lake Michigan

Figure 5 details the average water levels for Lake Michigan every 7 months for the period from April 1991 through June 2006. The Lake Michigan record low lake level of 576.05 feet (175.58 meters) occurred in March 1964 and the record high lake level of 582.35 feet (177.50 meters) occurred in October 1986 (U.S. Army Corp of Engineers).

Figure 5: Average Lake Levels, **Lake Michigan** (1991-2006)



Source: United States Army Corps of Engineers, Detroit District, Engineering and Technical Services, Great Lakes Hydraulics and Hydrology Office. April 2007.

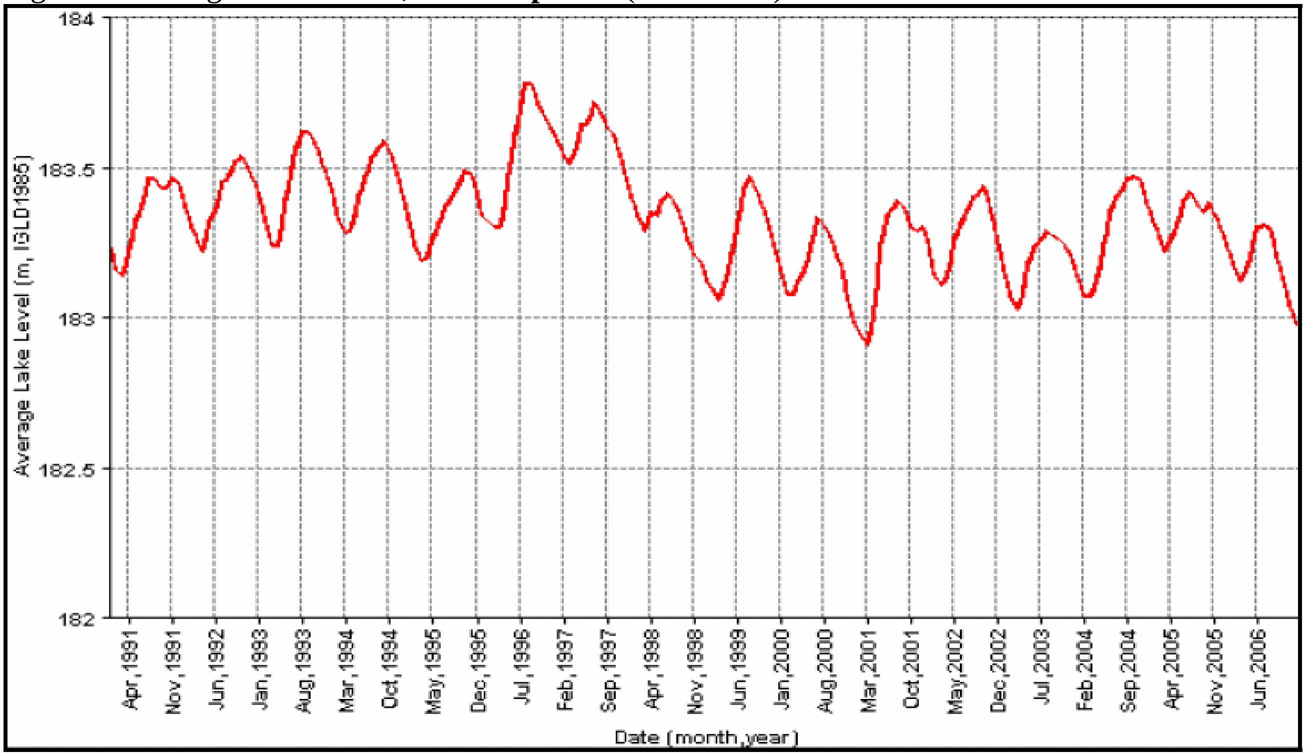
Lake Superior

Figure 6 details the average water levels for Lake Superior every 7 months for the period from April 1991 through June 2006. The Lake Superior record low lake level of 599.48 feet (182.72 meters) occurred in April 1926 and the record high lake level of 603.38 feet (183.91 meters) occurred in October 1985 (U.S. Army Corp of Engineers).

Water levels on Lake Superior are modified by human activity. The release of water from Lake Superior has been completely regulated by the International Joint Commission (IJC) - International Lake Superior Board of Control since 1921. Water flows out of Lake Superior through the St. Marys River into Lake Huron. The water from Lake Superior flows through dam gates that stretch across the river. These structures include three hydropower plants, five navigation locks, and a gated dam at the head of the rapids known as the Compensating Works. This water is used for domestic water supply, navigation through the locks, hydropower production, and to maintain fish habitat in the river.

According to the IJC - International Lake Superior Board of Control, the ability to regulate the outflow from Lake Superior does not provide full control of lake levels. Full control of lake levels is not possible due to major factors affecting the water supply to the Great Lakes such as over-lake precipitation, evaporation, and runoff.

Figure 6: Average Lake Levels, **Lake Superior** (1991-2006)



Source: United States Army Corps of Engineers, Detroit District, Engineering and Technical Services, Great Lakes Hydraulics and Hydrology Office. April 2007.

Areas at Greatest Risk

Areas or sites at greatest risk for <u>low</u> lake levels are those operations or businesses that are dependant on access to water at all times; commercial harbors, marinas, and near shore water intakes that cannot withstand a temporary drop in water level are at greatest risk for damages during low lake levels.

Areas or sites at greatest risk for <u>high</u> lake levels are those areas or sites that are at risk for coastal flooding and ice jams, which includes all the coastal counties of Wisconsin. Even during periods of lower water levels, severe storms can result in flooding and ice jams.

The U.S. Army Corp of Engineers advises property owners who plan to own coastal property for a long time to anticipate future lake levels beyond the ranges indicated in the historical records. The very short recorded history of Great Lakes water levels is inadequate to forecast lake levels that will occur in the next 20, 50, or 100 years as future climatic conditions may be quite different.

Mitigation Strategies

The best mitigation strategy for facilities that depend on adequate lake elevation is through planning before development to ensure that intake pipes will continue to pull in water even during low lake levels, which can be calculated by determining the *lowest lake level elevation minus the moderate set down* (Keillor 1998). Setdown is the comparable temporary lake level drop resulting after one side of the lake has had a temporary rise in water level (storm surge).

The most effective and cost-beneficial means of mitigating damages from high lake levels includes efforts to limit exposure such as strict building codes, land-use planning, coastal setbacks, and buyout and relocation programs.

Storm Surges, Waves, and Seiches

A storm surge is a temporary rise in water level caused by storm winds blowing across the open water. They last as long as the storm wind lasts, which can be several days.

Storm waves can be unpredictable and can increase rapidly. Deep-water storm wave development depends on factors that include the length of water surface exposed to the wind, the wind speed, and the duration of the wind blowing from roughly the same direction over water. Deep-water waves move toward shore and form large breakers in the near-shore area and harbor entrances.

Seiches are temporary water level oscillations due to sudden changes in wind direction or atmospheric pressure.

Storm surges, waves, and seiches routinely raise and lower water levels in harbors and have caused vessels to run aground. Freighters often schedule docking and departing times to avoid storm surges or seiches on the Great Lakes when possible. Temporary rises in lake levels from storm surges, waves, and seiches need to be considered in hazard mitigation planning in order to minimize property damage or worse from flooding and large waves (Keillor and White, 2003).

Areas at Greatest Risk

Vulnerability to storm surges, waves, or seiches are greater in navigation channels and at beaches that are located near bays heads or at the mouths of coastal rivers. The greatest storm surges occur in shallow bays exposed to long distances of open water. For Great Lakes coastal communities, the areas of greatest risk are those coastal and harbor areas where critical and valuable facilities and/or vulnerable populations are located.

Mitigation Strategies

The most effective tools for mitigation the effects of storm surges, waves, and seiches focus on public safety and structures. Loss of life and injuries can be reduced significantly through planning zoning, and building setbacks; public awareness campaigns; and the implementation of evacuation plans during impending emergencies. The influx of coastal residents who are unaware of storm surge, waves, and seiche hazards requires the continuation of public awareness campaigns and evaluation planning programs.

Structural damage mitigation is most successful where strict building codes for flood-prone areas are adopted and enforced. Post-disaster mitigation efforts include stringent building codes, buyout programs, relocation, elevation of structures, improved open-space preservation, and land-use planning.

Along select reaches of Lake Michigan and Lake Superior, beach nourishment and dune restoration or construction could serve as short-term measures to prevent storm surge flooding and to protect upland property. Although expensive, such projects replenish depleted sand supplies and rebuild dunes to maintain a buffer zone between developed properties and the lake.

Coastal Ice Shove and Jams

Lake ice can have detrimental effects on the lakeshore due to on- and off-shore movement of floating ice. Drifting ice can damage shore structures and destroy vegetation; move sand and stones from beaches; dump sand, rock, and other debris on beaches; and cause flooding. Ice shove can damage shoreline structures and erode the base of steep banks causing them to become unstable and subject to landslides when the ice disappears, hastening the recession of shorelines. Stream outlets can become blocked by ice jams causing confined backwaters to build up pressure and rupture the stream bank resulting in flooding of low-lying inland areas and damage to near-stream structures.

Areas at Greatest Risk

The type and amount of ice that forms along the shores varies from location to location and from day to day. Ice jams are most likely to occur where the water channel slope naturally decreases, where culverts freeze solid, at headwaters of reservoirs, at natural channel constrictions such as bends and bridges, and along shallow channels that may freeze solid. However, just about any coastal property can be significantly damaged by ice shove and jams and coastal structures not designed to withstand the forces of ice could receive extensive damage.

Mitigation Strategies

Efforts to limit exposure from ice shoves and jams such as strict building codes, land-use planning, and coastal setbacks are the most effective and cost-beneficial means of mitigating structural damages. Post-disaster mitigation efforts include buyout programs and relocation.

OTHER NATURAL HAZARDS

This section discusses natural hazards known to affect communities in Wisconsin. The previous section specifically addressed coastal hazards; however, many other natural hazards could affect coastal communities in Wisconsin including flooding, tornadoes and high winds, severe storms, dam failure, drought, wildland fires, extreme temperatures, winter storms, landslides and land subsidence, fog, and earthquakes.

Riverine Flooding

A flood is a natural event for waterways that occurs when excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto the banks and adjacent floodplains. Floodplains are lowlands, adjacent to rivers, and lakes that are subject to recurring floods. Most flood-related injuries and deaths occur when people are swept away by flood currents, and the majority of property damage is caused from sediment-laden floodwaters.

The severity of flooding is determined by rainfall intensity (or other water source) and duration. A large amount of rainfall over a short time span can result in flash flood conditions. However, several factors beyond intensity and duration also come into play. For instance, a small amount of rain can cause flooding in areas where the soil is saturated or in areas 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.

Areas at Greatest Risk

The area inundated by the base flood is the “base floodplain.” A base flood is a flood having a 1-percent probability of being equaled or exceeded in any given year; also referred to as the 100-year flood. FEMA maps (called Flood Insurance Rate Maps or FIRMs) also refer to this area as the “Special Flood Hazard Area”, or “A Zone.” The central part of the floodplain is called the “floodway.” The floodway is the channel and that portion of the adjacent floodplain that must remain open to permit passage of the base flood. Floodwaters generally are deepest and swiftest in the floodway, and anything in this area is in the greatest danger during a flood. The remainder of the floodplain is called the “fringe,” where water may be shallower and slower.

Mitigation Strategies

Table 2 provides some basic flood mitigation strategies from which to develop goals and objectives to mitigate flooding.

Table 2: Basic Flood Mitigation Strategies

Modify Susceptibility to Flood Damage and Disruption	**Modify the Impacts of Flooding**
Acquisition and demolition, and relocation of properties in flood-prone areas	Information and education
Floodplain regulations and building codes	Flood insurance
Development and redevelopment policies	Tax adjustments
Floodproofing and elevation-in-place	Flood emergency measures
Disaster preparedness and response plans	Disasters assistance
Flood forecasting and warning systems	Post-flood recovery
Manage Natural and Cultural Resources	**Modify Flooding**
Preservation and restoration strategies	Preservation of floodplains and wetlands
Regulations to protect floodplain natural and cultural resources	Stormwater management
Development and redevelopment policies and programs	High flow diversions and spillways
Information and education	
Tax adjustments	
Administrative measures	

Source: L.R. Johnson Associates; Federal Interagency Floodplain Management Task Force Report (FIA-18); 1992. Bay-Lake Regional Planning Commission. 2007.

Tornadoes and High Winds

The tornado is a rapidly rotating column of air spawned by a cumulonimbus cloud. When a tornado funnel drops to the ground, it can create significant damage and loss of life. A tornado is a relatively short-lived storm composed of an intense rotating column of air, extending from a thunderstorm cloud system. It is nearly always visible as a funnel, although its lower end does not necessarily touch the ground. Average winds in a tornado, although never accurately measured, are between 100 and 200 miles per hour, but some tornadoes may have winds in excess of 300 miles per hour.

A tornado path averages four miles, but may reach up to 300 miles in length. Widths average 300 to 400 yards, but severe tornadoes have cut swaths a mile or more in width, or have formed groups of two or three funnels traveling together. On average, tornadoes move between 25 and 45 miles per hour, but speeds over land of up to 70 miles per hour have been recorded. Tornadoes rarely last more than a couple of minutes in a single location or more than 15 to 20 minutes in a ten-mile area, but their short periods of existence do not limit their devastation of an area.

Table 3 shows the Enhanced Fujita Scale (EF scale), which has become the accepted tornado magnitude measurement rating since February 1, 2007 for operational use in the United States. The EF scale accounts for different degrees of damage that occur with different types of structures, as well as damage to things other than structures. This new scale relates to how most structures are designed. The wind speeds on the original scale were deemed by meteorologists as being too large and engineering studies have shown that slower winds can cause the same damage as that of winds of 300 mph. The new scale lists an EF-5 as a tornado with winds at or above 200 mph, which corresponds to the wind speeds of F3 or F4 in the original Fujita scale. None of the tornadoes recorded before January 31, 2007 on the original Fujita scale will be re-categorized to the new EF scale.

Table 3: Comparing the Tornado Scales

FUJITA SCALE			DERIVED EF SCALE		**OPERATIONAL EF SCALE**	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	**EF Number**	**3 Second Gust (mph)**
0	40-72	45-78	0	65-85	**0**	**65-85**
1	73-112	79-117	1	86-109	**1**	**86-110**
2	113-157	118-161	2	110-137	**2**	**111-135**
3	158-207	162-209	3	138-167	**3**	**136-165**
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	**5**	**Over 200**

Source: NOAA Storm Prediction Center. 2007.

Based on 40 years of tornado history and more than 100 years of hurricane history, the United States has been divided into four zones that geographically reflect the number and strength of extreme windstorms (FEMA). FEMA Wind Zone IV, which includes most of the southern two-thirds of Wisconsin, has experienced the most and the strongest tornado activity that has affected the entire U.S., with wind speeds of up to 250 miles per hour being recorded at some point. The northern remainder of Wisconsin excluding the Lake Superior coastal area is rated Wind Zone III and the Lake Superior coastal area is within Wind Zone II. Wind Zone III experiences wind speeds up to 200 miles per hour, and Wind Zone II experiences wind speeds up to 160 miles per hour.

Areas at Greatest Risk

Wisconsin lies along the northern edge of the nation's maximum frequency belt for tornadoes (commonly known as "tornado alley"), which extends northeastward from Oklahoma into Iowa and then across to Michigan and Ohio. Generally, the southern and western portions of Wisconsin have a higher frequency of tornadoes; however, every county in Wisconsin has experienced tornadoes and every county is susceptible to tornado damage. Tornadoes have occurred in Wisconsin in every month except February.

Mobile homes are at greatest risk during tornadoes and high winds. An EF-1 tornado might cause minor damage to a site-built house; but could do significant damage to a manufactured home, especially an older model or one that is not properly secured. RV Parks, campgrounds, and marinas are also at significant risk from tornadoes and high winds.

Mitigation Strategies

The most effective mitigation strategies to address tornado threat are afforded by quality construction and reinforcement of walls, floors, and ceilings. Proper anchoring of walls to foundations and roofs to walls is essential for a building to withstand certain wind speeds.

Loss of life and injuries may be reduced if more individuals had access to basements, constructed safe rooms, or community tornado shelters, especially in or near buildings with a large roof span or in areas where there is a large density of manufactured or mobile homes.

Thunderstorms and Lightning

Lightning

Lightning, which occurs during all thunderstorms, can strike anywhere. Generated by the buildup of charged ions in a thundercloud, the discharge of a lightning bolt interacts with the best conducting object or surface on the ground. The air in the channel of a lightning strike reaches temperatures higher than 50,000ºF. The rapid heating and cooling of the air near the channel causes a shock wave that produces thunder (National Weather Service).

Thunderstorms

Thunderstorms are most likely to happen in the spring and summer months and during the afternoon and evening hours, but can occur throughout the year and at all hours. The biggest threats from thunderstorms are flash flooding and lightning. In most cases, flash flooding occurs in small drainage areas where water quickly accumulates before it drains to waterways. Other threats from thunderstorms include downburst winds, high winds, hail, and tornadoes.

The National Weather Service classifies a thunderstorm as severe if its winds reach or exceed 58 miles per hour, produces a tornado, or drops surface hail at least 0.75 inch in diameter. Compared with other atmospheric hazards (such as tropical cyclones and winter low-pressure systems), individual thunderstorms affect relatively small geographic areas. The average thunderstorm system is approximately 15 miles in diameter, covers 75 square miles, and lasts less than 30 minutes at a single location. However, weather-monitoring reports indicate that coherent thunderstorm systems can travel intact for distances in excess of 600 miles.

Areas at Greatest Risk

The State of Wisconsin experiences severe thunderstorms 30 days per year on average; however, the southwestern corner of the state experiences severe thunderstorms slightly more frequently with approximately 44 days per year (Wisconsin Emergency Management, 2004).

Mitigation Strategies

Building grounding techniques are the most effect measures to reduce lightning hazard threat. Although there are no clearly defined approaches designed specifically to mitigate thunderstorms, mitigation measures that address tornadoes, hailstorms, windstorms, and flooding can be expected to achieve damage reduction for both lightning and thunderstorms.

Hailstorms

Hailstorms are often produced by severe thunderstorms. Hailstones are ice crystals that form within a low-pressure front due to warm air rising rapidly into the upper atmosphere and the subsequent air mass cooling. Frozen droplets gradually accumulate on the ice crystals until they develop sufficient weight and fall as precipitation. The size of hailstones is a direct function of the severity and size of the storm. Significant damage usually does not result until the hailstones reach 1.5 inches in diameter, which occurs in less than half of all hailstorms. Hail in Wisconsin ranges from pea-sized to golf ball-sized. Area coverage of individual hailstorms is highly variable and spotty because of the unstable nature of cumulonimbus clouds.

Areas at Greatest Risk

The area affected by hailstorms is similar to the area affected by the associated thunderstorm, which typically covers about 15 miles in diameter around the center of the storm. The areas at greatest risk from hail damage are locations of structures and crops that could be damaged from hail impact (Wisconsin Emergency Management, 2004).

Mitigation Strategies

Building codes and public awareness campaigns are the best mitigation strategies for hailstorms. In addition, improvements and updates to weather warning systems and implementation of National Weather Service monitoring systems will improve prediction of the severe weather potential.

Dam Failure

There are approximately 3,800 dams in existence in the State of Wisconsin. Sixty percent of the dams in Wisconsin are owned by a private company or individual, nine percent by the State of Wisconsin, seventeen percent by a municipality such as a town or county government, and fourteen percent by other ownership types (Wisconsin Department of Natural Resources).

The federal government has jurisdiction over most large dams in Wisconsin that produce hydroelectricity - approximately 5 percent or nearly 200 dams. The Wisconsin Department of Natural Resources regulates the rest of the dams.

A dam with a structural height of over 6 feet and impounding 50 acre-feet or more, or having a structural height of 25 feet or more and impounding more than 15 acre-feet is classified as a "large" dam. There are approximately 1,160 large dams in the State of Wisconsin (Wisconsin Department of Natural Resources).

Dams are classified with a rating of either "Low", "Significant", or "High" hazard. A dam is assigned a high hazard rating when its failure would put lives at risk. The hazard rating is not based on the physical attributes, quality, or strength of the dam itself, but rather the potential for loss of life or property damage should the dam fail.

Areas at Greatest Risk

The areas vulnerable to dam failure damage/flooding include those areas within the hydraulic shadow of the dam. The hydraulic shadow of the dam is the area of land downstream from a dam that would be inundated by water upon failure of the dam. The vulnerability is especially high for those areas in the hydraulic shadow of an older or poorly maintained dam.

The areas of greatest risk from dam failure are those areas within the hydraulic shadow of a large dam that has a "high" hazard rating as determined by the Wisconsin Department of Natural Resources.

Mitigation Strategies

Mitigation strategies for dam failure should include regulations such as zoning to limit new construction and exposure downstream of dams in the shadow of the dam, and the development of Emergency Action Plans (EAPs) that focus on evacuation of people and closure of roads when the threat of dam failure is imminent.

Drought

A drought is an extended period of little measurable precipitation that results in serious hydrologic imbalance in groundwater and surface water. Droughts are associated with water supply shortages, crop failure, and increased wildfires. The severity of a drought is determined by the duration, intensity, and geographic extent as well as regional water supply demands by humans and vegetation.

Areas at Greatest Risk

Agriculture areas, forested areas, and properties dependant upon private wells, especially shallow wells, are at greatest risk from the effects of drought.

Mitigation Strategies

Drought Response needs to move away from being reactive and become more timely and effective. Drought contingency planning, water conservation programs, and public awareness campaigns are effective steps towards preparing for drought hazards.

Wildland Fire

A wildland fire is any instance of uncontrolled burning in brush, marshes, grasslands, or field lands. Typical causes of these fires are lightning, human carelessness, or arson. Wildland fires can occur at any time of the year and during any time of the day. The primary factors that generally contribute to the start of a wildland fire are land use, vegetation, amount of combustible materials present, and weather conditions such as wind, low humidity, and lack of precipitation. Generally, fires are more likely to occur when vegetation is dry from a winter with little snow or a spring and summer with sparse rainfall. In recent times, development of homes and other structures in areas of highly flammable vegetation have caused an increase in wildland fire danger. This condition is known as the wildland-urban interface or WUI.

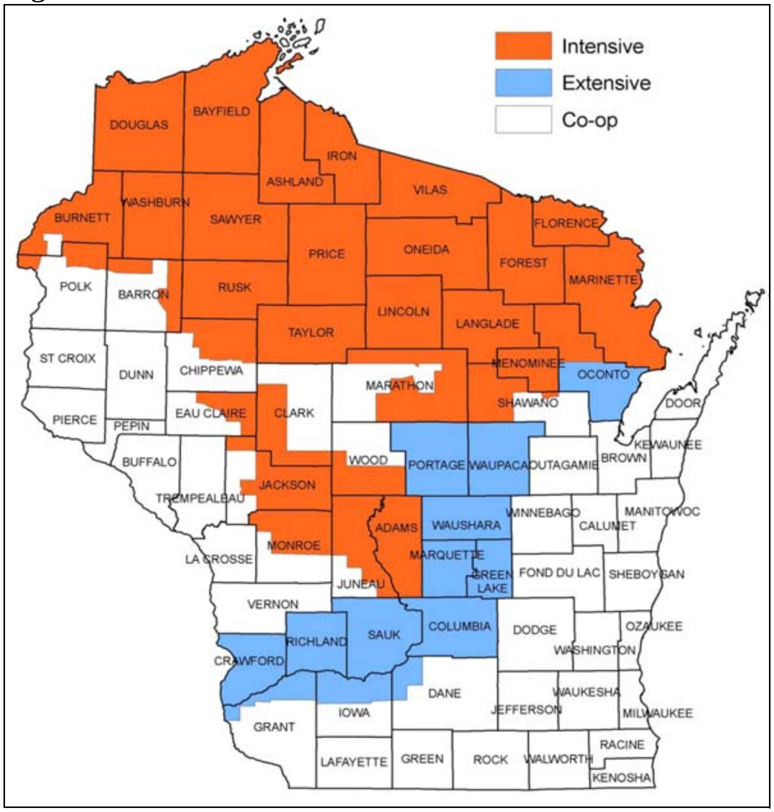
Areas at Greatest Risk

The Wisconsin Department of Natural Resources has divided the state into different levels of forest fire protection need, called Fire Protection Areas, which include “intensive”, “extensive”, and “cooperative” (or co-op) zones (Figure 7). Intensive areas, followed by extensive areas, are at greatest risk for incidents of wildland fires. The degree of perceived protection needed has been determined by the amount of forested lands, hazards, and risks present in the various parts of the state.

Mitigation Strategies

Effective wildland fire mitigation should include the use of planning, zoning, and building codes; a public education campaign that includes information on fuel reduction; and sufficient, routine training for fire management personnel.

Figure 7: Fire Protection Areas



Source: Wisconsin Department of Natural Resources. 2007.

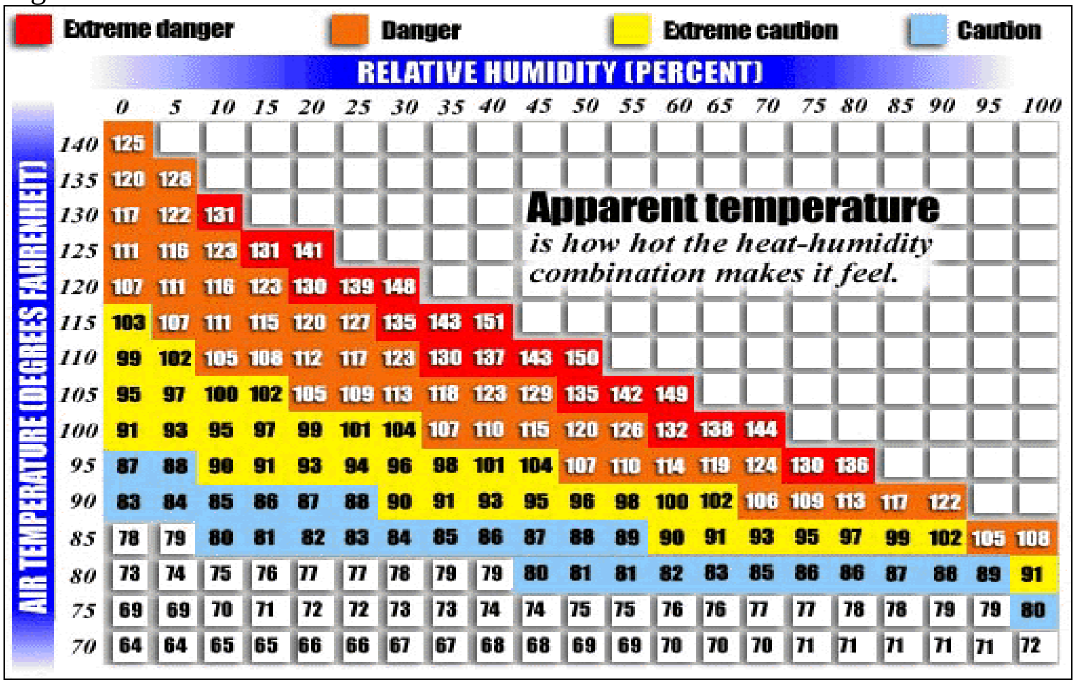
Extreme Heat

Extreme heat and humidity associated with heat waves directly kill over 300 people a year in the US, making heat the number one weather killer in this country. This number is based on information obtained from the Centers of Disease Control and Prevention for the period of 1979 to 1998.

Extended periods of warm, humid weather can create significant risks for people, particularly the elderly, homeless, or poor who may lack access to air conditioning. Animals are also at risk during extended periods of heat and humidity.

The National Weather Service issues a Heat Advisory when the Heat Index ranges from 105 to 114 degrees during the day and remains at or above 80 degrees at night, during a 24-hour period. Figure 8 displays the National Weather Service Heat Index chart. The heat index combines the effects of heat and humidity to reflect the risk of warm weather to people and animals. When heat and humidity combine to reduce the amount of evaporation of sweat from the body, outdoor activity becomes dangerous even for those in good shape. The index measures the apparent temperature in the shade. People exposed to the sun would experience an even higher apparent temperature. A heat index between 95 and 105 is considered dangerous and prolonged exposure can result in heat stroke, heat exhaustion, and heat cramps. On average, at least five people die in Wisconsin each year due directly to heat (National Weather Service). In addition, evidence suggests that a similar number of people die each year in Wisconsin from heat as an indirect or secondary cause.

Figure 8: Heat Index Chart



Extreme danger | Danger | Extreme caution | Caution

Apparent temperature *is how hot the heat-humidity combination makes it feel.*

AIR TEMPERATURE (DEGREES FAHRENHEIT) \ RELATIVE HUMIDITY (PERCENT)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
140	125																				
135	120	128																			
130	117	122	131																		
125	111	116	123	131	141																
120	107	111	116	123	130	139	148														
115	103	107	111	115	120	127	135	143	151												
110	99	102	105	108	112	117	123	130	137	143	150										
105	95	97	100	102	105	109	113	118	123	129	135	142	149								
100	91	93	95	97	99	101	104	107	110	115	120	126	132	138	144						
95	87	88	90	91	93	94	96	98	101	104	107	110	114	119	124	130	136				
90	83	84	85	86	87	88	90	91	93	95	96	98	100	102	106	109	113	117	122		
85	78	79	80	81	82	83	84	85	86	87	88	89	90	91	93	95	97	99	102	105	108
80	73	74	75	76	77	77	78	79	79	80	81	81	82	83	85	86	86	87	88	89	91
75	69	69	70	71	72	72	73	73	74	74	75	75	76	76	77	77	78	78	79	79	80
70	64	64	65	65	66	66	67	67	68	68	69	69	70	70	70	71	71	71	71	71	72

Source: University of Delaware, Research, and Education Center. 2006.

Areas at Greatest Risk

Urban areas are typically at great risk for extreme heat events because buildings, especially those with dark roofs, and dark paving materials replace vegetation in urban areas. In urban areas, heat absorbing during the day increases, and cooling from shade and evaporation of water from soil and leaves is decreased. Urban areas may experience reduced airflow because of tall buildings, and increased amounts of waste heat generated from vehicles, factories, air conditioners, etc. These factors can contribute to the development of an "urban heat island", which has higher daytime maximum temperatures and less nighttime cooling than surrounding rural areas. Urban heat islands can cause urban areas to become areas of greater risk during extreme heat events.

In addition to affecting people, extreme heat conditions place significant stress on plants and animals. Thus, areas with agricultural crops and livestock are vulnerable to negative effects from extreme heat.

Mitigation Strategies

Public education about the effects of extreme heat, and how to mitigate those effects, is the most effective means of reducing heat related injuries and fatalities. Local television and radio announcements alerts people about the onset of extreme heat and advises high-risk populations to reduce physical activity and stay in air-conditioned buildings. Extreme heat risk can also be mitigated by ensuring that air-conditioned centers are available and accessible.

<u>Extreme Cold</u>

Dangerously cold conditions can result from extremely cold temperatures or the combination of cold temperatures and high winds. The combination of cold temperature and wind creates a perceived temperature known as "wind chill." Wind chill is the apparent temperature that describes the combined effect of wind and air temperature on exposed skin. When wind blows across the skin, it removes the insulating layer of warm air adjacent to the skin. When all factors are the same, the faster the wind blows the greater the heat loss, which results in a colder feeling and a quicker loss of heat. As winds increase, heat is carried away from the body at a faster rate, driving down both the skin temperature and eventually the internal body temperature. Extremely cold temperatures accompanied by strong winds can result in wind chills that cause bodily injury such as frostbite, hypothermia, and death. Figure 9 displays the National Weather Service Wind Chill Temperature Index chart.

Figure 9: Wind Chill Temperature Index Chart

Wind (mph) \ Temperature (°F)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Note: Wind speeds above 40 mph have little additional chilling affect.

Source: National Weather Service Office of Climate, Water, and Weather Services. 2006.

Areas at Greatest Risk

Extreme cold events occur throughout Wisconsin. Northern Wisconsin counties experience extreme cold events at a higher frequency then the rest of the state, and are therefore at greatest risk from extreme cold.

Mitigation Strategies

Public education about the dangers of extreme cold is the most effective means of reducing injuries and fatalities. Local television and radio announcements alerts people about the onset of extreme cold and advises people to reduce outdoor exposure. Extreme freezing risks can also be mitigated by ensuring that shelters are available and accessible for those without proper heating in their homes or those without a home.

Severe Winter Storms

Winter storms can vary in size and strength, and can include heavy snowstorms, blizzards, freezing rain, sleet, ice storms, and blowing and drifting snow conditions. Winter storms can occur as a single event or in combination making an event more severe. For example, a moderate snowfall could create severe conditions if it were followed by a freezing rain and subsequent extremely cold temperatures. The aftermath of a winter storm can impact a community or region for weeks, and even months.

A variety of weather phenomena and conditions can occur during winter storms. For purposes of classification, the following are National Weather Service approved descriptions of winter storm elements:

Heavy Snowfall – the accumulation of six or more inches of snow in a 12-hour period, or eight or more inches in a 24-hour period.

Winter Storm – the occurrence of heavy snowfall accompanied by significant blowing snow, low wind chills, sleet, or freezing rain.

Blizzard – the occurrence of sustained wind speeds in excess of 35 miles per hour accompanied by heavy snowfall or large amounts of blowing or drifting snow.

Ice Storm – an occurrence where rain falls from warmer upper layers of the atmosphere to the colder ground freezing upon contact with the ground and exposed objects near the ground.

Freezing drizzle/freezing rain – the effect of drizzle or rain freezing upon impact on objects that have a temperature of 32 degrees Fahrenheit or below.

Sleet – solid grains or pellets of ice formed by the freezing of raindrops or the refreezing of largely melted snowflakes. This ice does not cling to surfaces.

Wind chill – an apparent temperature that describes the combined effect of wind and low air temperatures on exposed skin.

Winter storms present a serious threat to the health and safety of affected citizens, and can result in significant damage to property when the heavy snow or accumulated ice causes structural collapse of buildings, downs power lines, severely affects electrical power distribution, or cuts off people from assistance or services.

Areas at Greatest Risk

Winter storms occur throughout Wisconsin. Blizzards are more likely to occur in northwestern Wisconsin than in northeastern portions of the state, even though heavy snowfalls are more frequent in southeastern Wisconsin. With the exception of blizzards and ice and sleet storms being generally restricted to northern Wisconsin, the majority of winter storms occur in southern Wisconsin.

Mitigation Strategies

Along with local television and radio announcements alerting people about the onset of severe winter storms, mitigation strategies such as enhanced building codes, planned deployment of resources, underground utility lines for critical facilities, and increased tree trimming along utilities can reduce property and critical facility damages from severe winter storms.

Landslides

The term “landslide” includes a wide range of ground movement, including rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on an overly steep slope is the primary reason for a landslide, there can be other contributing factors such as erosion by rivers, excess weight from the accumulation of rain or snow, or built structures stressing weak slopes to the point of failure. In addition, slope material that becomes saturated with water may develop a debris flow or mudflow.

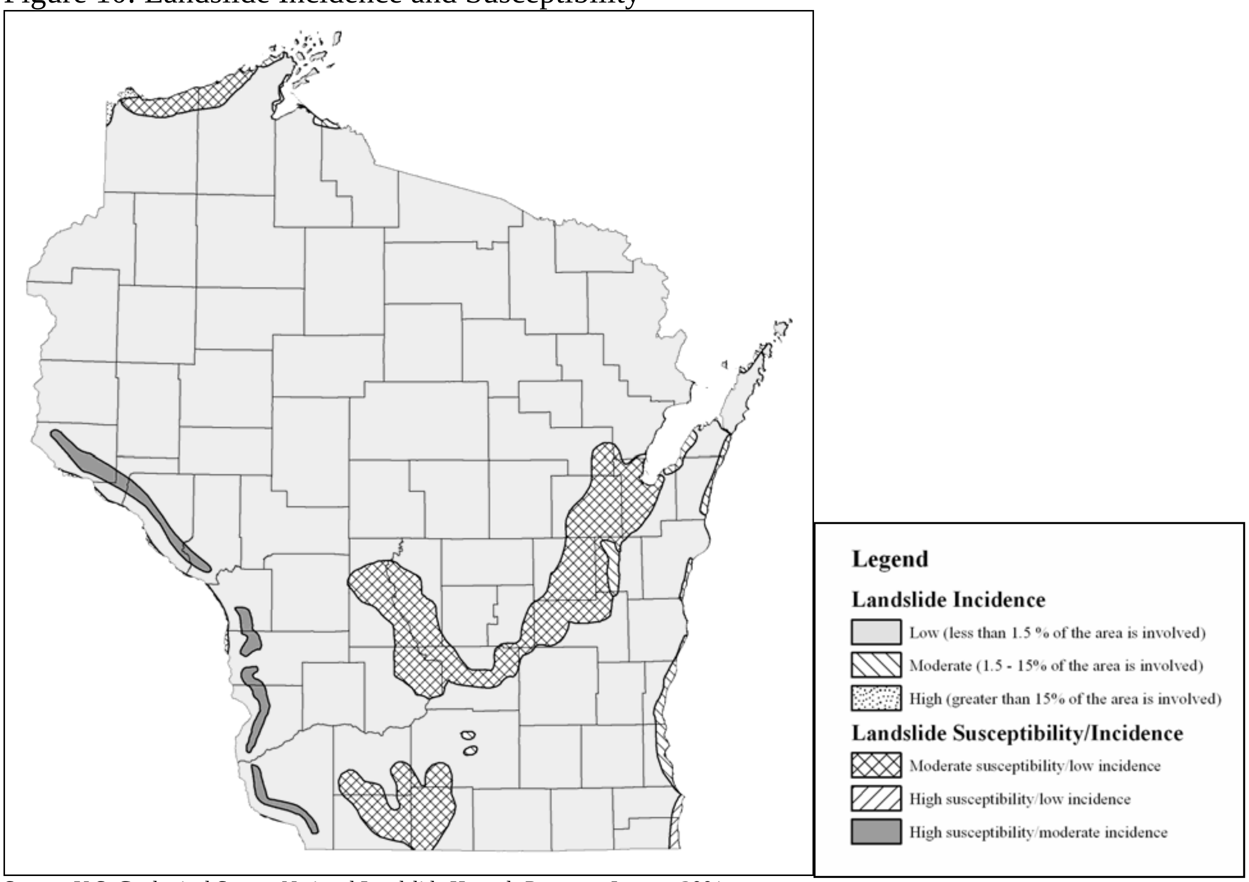
Areas at Greatest Risk

Landslide incidence and susceptibility mapping developed by the U.S. Geological Survey (USGS) identifies areas of landslides occurrences and areas susceptible to future landslide events (Figure 10). In Wisconsin, landslide susceptibility risks exists along the shorelines of Kenosha, Racine, Milwaukee, Ozaukee, Sheboygan, Manitowoc, Kewaunee, Door, Brown, Iron, Ashland, Bayfield, and Douglas Counties; along the Mississippi River corridor; and in central and southwestern portions of the state.

Mitigation Strategies

Landslides are best mitigated by reducing their occurrence, which can be accomplished by requiring that excavation, grading, landscaping, and construction be undertaken in ways that do not contribute to slope instability. Landslide damage can be minimized by restricting development in landslide-prone terrain and by protecting buildings and other structures from landslide damage.

Figure 10: Landslide Incidence and Susceptibility



Source: U.S. Geological Survey National Landslide Hazards Program. January 2001.

<u>Land Subsidence</u>

Land subsidence is an event in which a portion of the land surface collapses or settles. Common causes of subsidence are located in an area with karst topography or location in an area where large amounts of groundwater have been withdrawn. "Karst" is the term commonly used to describe areas containing distinctive surficial and subterranean features, such as fissures, tubes, and caves, developed by solution of carbonate and other rocks. Karst areas are characterized by closed depressions, sinking streams, and cavern openings. When used in its broadest sense, the term karst encompasses many surface and subsurface conditions that give rise to problems in engineering geology. Most of these problems pertain to subterranean features that affect foundations, tunnels, and diversion of surface drainage.

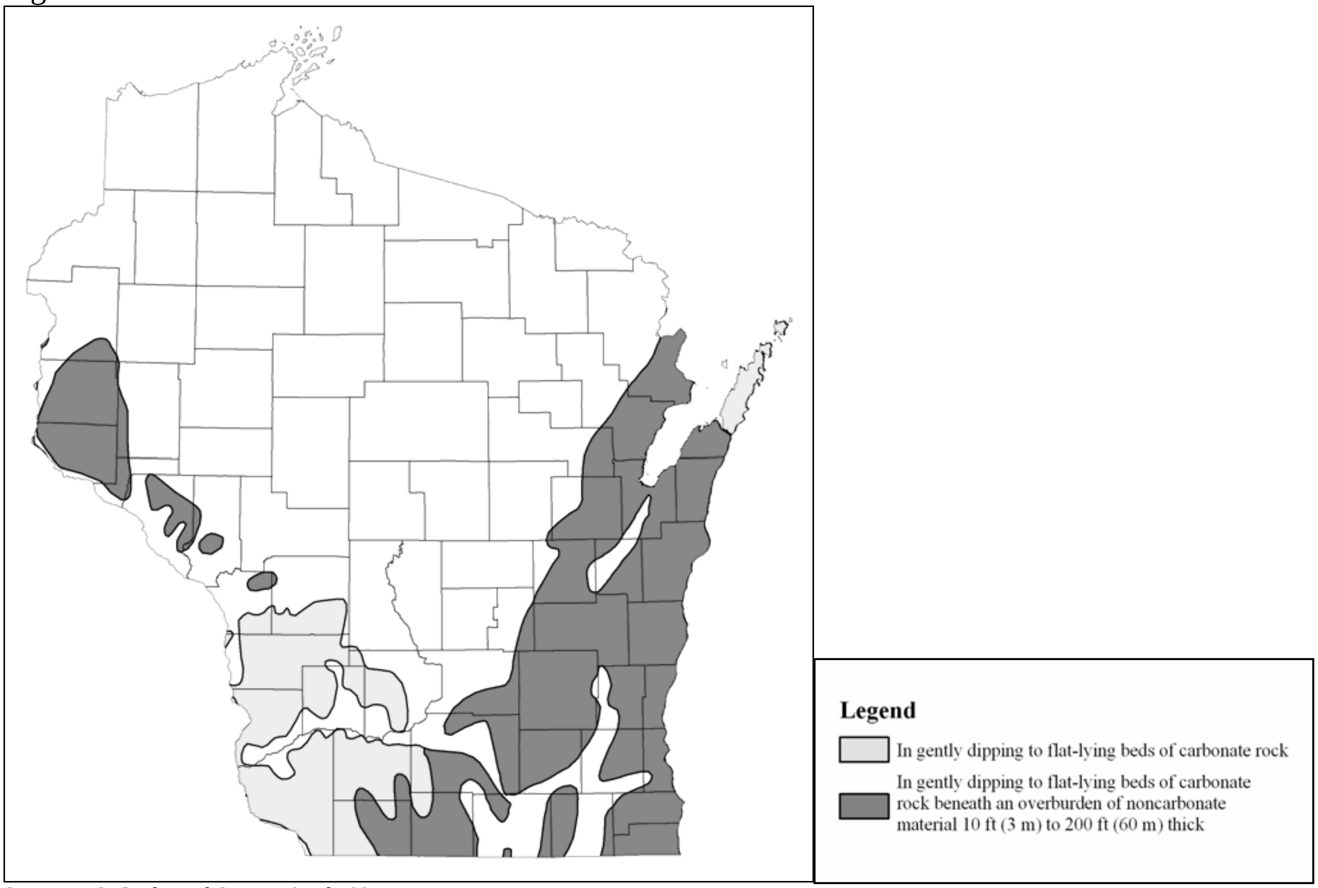
Areas at Greatest Risk

Karst mapping developed by the USGS identifies areas of karst features such as caves, fissures, and tubes that are generally less than 100 feet long and 50 feet or less in vertical extent (Figure 11). In Wisconsin, karst areas generally represent the only subsidence susceptibility risks. Karst areas of Wisconsin exist along the Lake Michigan coastal zone and extend into central Wisconsin, additional karst areas exist in the southern and southwestern portions of the state.

Mitigation Strategies

Land subsidence risks can be reduced by ensuring the public is informed about the risk and areas of concern. Other strategies to mitigate land subsidence include improved mapping of land subsidence areas of concern, regulation of resource and land development, land use management, and building codes.

Figure 11: Karst Areas



Source: U.S. Geological Survey. April 2005.

Fog

Reduced visibility is the primary reason that fog is identified as a hazard. Airport delays, automobile accidents, shipwrecks, plane crashes, and many other problems are frequently caused by fog. When air pollution combines with fog, visibility greatly decreases and air quality worsens. In addition, acid fog, resulting from the combination of air pollutants (such as nitrogen and sulfur oxides) with water droplets can create health problems, especially for people who have respiratory conditions.

The National Weather Service forecasts fog and issues dense fog advisories when visibility is decreased to less than one quarter of a mile. These advisories alert travelers to potentially dangerous conditions. Traveling in fog requires reduced speed and careful navigation. At night, traveling in fog is especially dangerous because darkness combines with fog to reduce visibility even more. In addition, light from automobile headlights and other navigational lights is scattered off the water droplets of the fog, limiting sight to only a short distance. Fog can lead to property damage and injuries or death. The financial cost of transportation delays caused by fog can be substantial.

Areas at Greatest Risk

Areas of Wisconsin situated along Lake Michigan and Lake Superior as well as in river valleys and other low-lying areas can be at greater risk for fog under certain meteorological conditions. However, no part of the state is free of the possibility of experiencing fog occasionally.

Mitigation Strategies

The primary risk associated with fog is related to poor driving visibility. The most effective method to mitigate fog risk is to inform drivers of areas where fog conditions will greatly reduce visibility and encourage drivers to slow down and be attentive. Drivers can be informed through road signs and television and radio announcements.

Earthquakes

According to the USGS, there have been nineteen earthquake events in Wisconsin. Where readings were available, these events were relatively small, most being 3.0 to 4.2 on the Richter scale in intensity with the largest being an intensity of 5.3, which occurred in Beloit in 1909. This intensity may be strong enough to crack some plaster but typically does not cause serious damage. Due to the lack of recent events, some geologists question whether many of these events were true earthquakes or were perhaps caused by quarry collapses or some type of explosion.

Areas at Greatest Risk

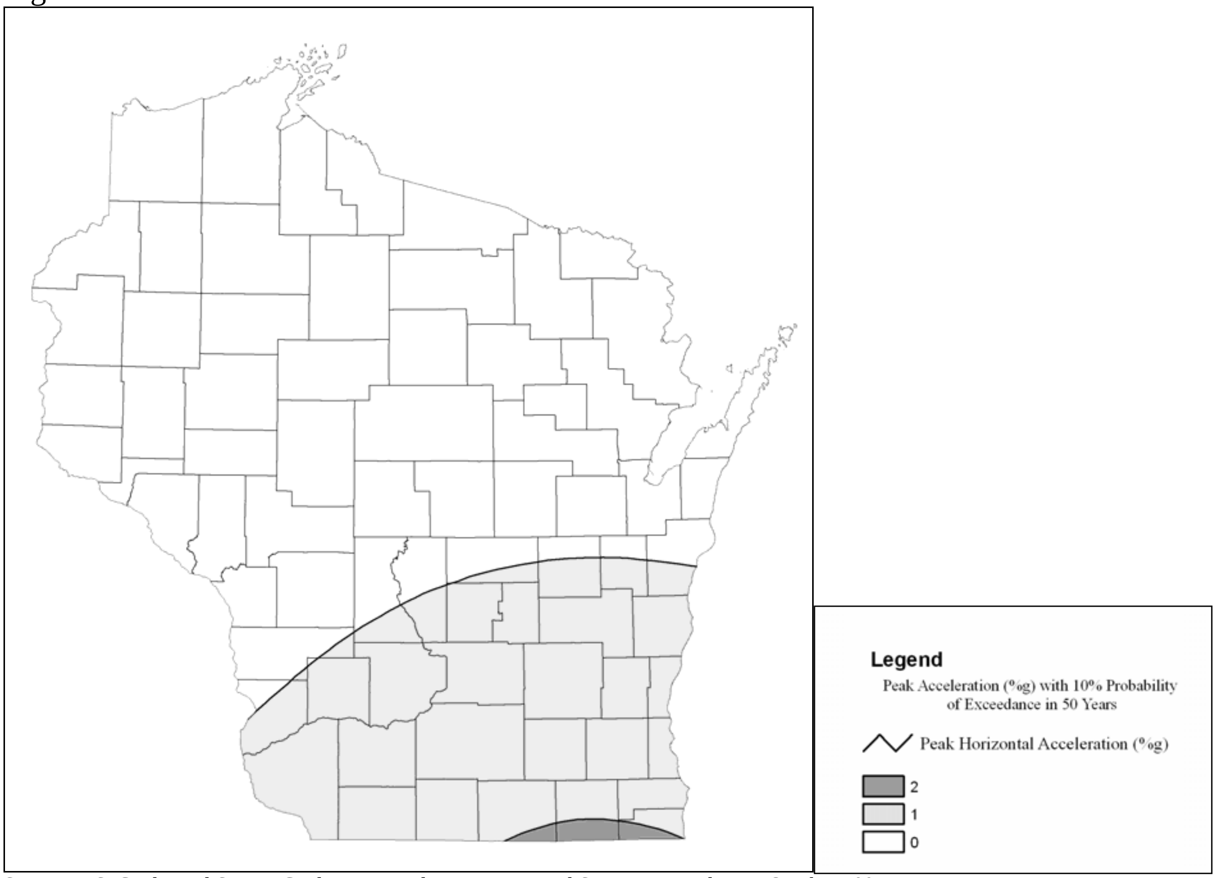
The nearest active earthquake fault to Wisconsin is the New Madrid Fault, which stretches from northeast Arkansas to southern Illinois. Some of southern Wisconsin is within a low earthquake hazard shaking areas, referred to as the peak horizontal ground acceleration (the fastest measured change in speed, for a particle at ground level that is moving horizontally because of an earthquake). A peak horizontal ground acceleration zone map shows the probability that ground motion in particular areas will reach a certain level during an earthquake with a 10 percent probability of being exceeded in 50 years.

Wisconsin is within a 0%g to 2%g peak horizontal ground acceleration zone as shown on the USGS PGA values map (Figure 12). Thus, Wisconsin is considered unlikely to be substantially affected by earthquakes in the long-term future. The southern third of Wisconsin has a greater earthquake risk than the northern two-thirds based primarily on proximately to the New Madrid Fault. Overall, the earthquake threat to the state is considered very low.

Mitigation Strategies

Although earthquake risk is very low in Wisconsin, safe seismic building design may still be a good idea for very tall buildings in southern Wisconsin. Beyond building design, a method to quickly inform the public and instruct them on protective actions in the event of earthquake threat from the New Madrid Fault is important.

Figure 12: Peak Horizontal Ground Acceleration Contours



Source: U.S. Geological Survey Geologic Hazards Team; National Seismic Hazard Map. October 2002.

CHAPTER 7: INFLUENCE OF CLIMATE CHANGE ON NATURAL HAZARDS

Climate encompasses more than just average temperatures and precipitation; it includes the type, frequency, and intensity of weather events. Climate change has the potential to affect the frequency and severity of hazard events such as temperature extremes, severe storms, floods, and droughts.

Although agreement on impact predictions regarding climate change is not always achieved, consensus that rapid, drastic changes in the climate are occurring has become generally consistent and unequivocal. There are strong indicators that Wisconsin and the western Great Lakes region has been experiencing the effects of climate change with a noticeable trend in regional warming since 1970 (Magnuson, 2000; and Austin and Colman, 2007). It is important for emergency managers and community planners to understand their vulnerabilities to such changes.

Our current level of understanding regarding the influence of climate change on natural hazards, as summarized in the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC, 2007b), is as follows:

> *"…some weather events and extremes will become more frequent, more widespread and/or more intense during the 21st century due to changes in the variability of climate, so it can be expected that the severity of their impacts will also increase in concert with global warming."*

With the anticipation that most natural hazards will intensify and become more frequent from the effects of climate change, it is crucial that planners, local officials, and the public develop an awareness of the impacts of climate change and plan for the anticipated changes, especially when it comes to public safety and hazard mitigation planning. Risk assessments based on past hazards will require additional evaluation because hazards will not occur as they have in the past due to climate change. Additional precautions will be necessary.

According to the Intergovernmental Panel on Climate Change, the United States is projected to warm by about 32.4ºF on average for the next two decades at anticipated emission levels. Even if greenhouse gas concentrations were to be stabilized today, human-influenced climate warming and sea level rise would continue for centuries due to the timescales associated with climate processes (IPCC, 2007a).

Projections of Wisconsin's future climate combine historical data for Wisconsin with the current circulation models of the Earth's climate system to reveal that Wisconsin's climate will likely grow considerably warmer and drier during this century, especially in the summer. By 2030, Wisconsin is expected to experience an increase in average summer temperature of 5 to 8ºF above present average summer temperatures causing Wisconsin summers to resemble those of current-day Illinois. By the end of the century, Wisconsin temperatures are expected to increase about 5 to 12ºF in the winter and 5 to 20ºF in the summer – similar to current-day Arkansas (Kling, et al, 2005).

Although average annual precipitation may not change much, Wisconsin is expected to grow drier overall because precipitation cannot compensate for the increased evaporation rates resulting from greater temperatures. Seasonally precipitation is expected to change as well with winter precipitation increasing by as much as 30 percent and summer precipitation decreasing by as much as 20 percent. Temperature and precipitation changes will continue to cause declines in ice cover and lowered water levels on the Great Lakes and inland lakes (Kling and Wuebbles, 2003).

Wisconsin will see drier soils, increased summer droughts, and increased flooding from winter runoff. With the anticipated changes for Wisconsin, extreme heat events and drought will be more common, and the frequency of heavy rainstorms will increase and could occur 50 to 100 percent more frequently (Kling and Wuebbles, 2003).

ANTICIPATED NATURAL HAZARD CHANGES

Extreme events such as heavy downpours, floods, heat waves, droughts, tornadoes, lightning, and winter storms are expected to increase in frequency, intensity, duration, and extent over the course of this century. Greater awareness of the nature of natural hazards will increase a community's options for addressing climate change effects. By mitigating natural hazards, communities can increase their ability to adapt to climate change and become better prepared for changes.

As discussed previously, it is anticipated that Wisconsin will experience drier conditions with increased temperatures, resulting in natural hazard changes. Communities and their emergency management, public works, and health care services need to be prepared as best they can for the increased burden and expense. Wisconsin will likely experience an increase in heat-related injuries and deaths, increased intensities and frequencies of storms and flooding, increased wildland fires and drought, and decreases in ice thickness and water levels on the Great Lakes.

Extreme Heat

During this century, the number of days exceeding 90ºF in Wisconsin is projected to increase to 30 or more days annually and up to 20 days annually of extreme heat days exceeding 97ºF (Kling and Wuebbles, 2003). Extreme heat-related incidents are often brought about or exacerbated by the combination of very high temperatures and exceptionally humid conditions.

Deaths and/or injuries associated with extreme heat conditions include heat strokes, heat exhaustion, heat syncope (sudden loss of consciousness), and heat cramps. Heat-related injuries and deaths will especially affect older adults and urban poor. In addition to affecting people, extreme heat stresses plants and animals affecting agricultural production including reduced crop yields and milk production.

Drought

The anticipated increased temperatures in the summer will increase drying and associated risk of hydrologic drought. In addition to the impacts to agriculture and water supply from increased drought events, water quality impacts can be expected as quantity decreases reduce the dilution effect of runoff and direct contaminate inputs.

Heavy Rainstorms

The frequency of heavy rainstorms, both 24-hour and multi-day, is projected to increase for Wisconsin over the course of the century. More frequent heavy rainstorms will likely lead to increased flooding. In addition, rainstorms are projected to occur more often during the winter when the ground may be frozen (or partially frozen) leading to increased runoff and flooding. Increased runoff and flooding could lead to an increased frequency of landslides, coastal erosion issues, and crop failure.

Flooding

As discussed previously, an increase in the frequency of rainstorms will likely cause increased flooding. In addition, development leading to more impervious surface coupled with climate change impacts will degrade or destroy the natural flood-absorbing capacities of floodplains and some wetlands, further exacerbating flooding conditions. More runoff in winter and spring from rain falling on snow or frozen ground, and in summer from heavy rainstorms will cause increased flooding, erosion, and crop failure.

Flooding could overwhelm water-related infrastructure. Therefore, in anticipation of a changing climate, many communities in Wisconsin may need to upgrade infrastructure such as levees, dams, storm sewer pipes, and wastewater treatment plants.

Dam Failure Flooding

An increased frequency of rainstorms during times when the ground is frozen or partially frozen will increase the risk of dam failure. Many dam tenders will need to be more diligent about ensuring dam gates and control structures are operational during such conditions. In addition, many dams control structures could get clogged with ice and/or debris causing the water to rise and overtop the dam. At some times during the year, Wisconsin could experience rainstorms combined with melting snow, which would further increase the risk of dam failure and resulting downstream flooding.

Coastal Erosion

Greater erosion including more bluff failures can be expected as climate changes bring warmer, wetter winters with more freeze-thaw events, and more extreme precipitation events. With less lake ice due to warmer winters, there is likely to be less formation of shoreline ice ridges to shield erodable shores from wave action (Lulloff and Keillor, 2007).

Lake Level Fluctuations

Despite the projected increase in heavy rain events, lake levels are expected to drop due to higher rates of evaporation from increased temperatures. In addition, the increasing temperatures will cause a decline in ice cover, which will also contribute to a greater rate of evaporation.

Lower lake levels will have costly implications for recreational marinas, shipping, and other economic activities on the Great Lakes. The decreased lake levels will require more frequent dredging of channels and harbors as well as adjustments to docks, water intake pipes, and other infrastructure, and decreased shipping capacity causing greater costs.

Wildland Fires

Studies suggest that climate change is likely to increase the number of days of severe burning conditions, prolong the fire season, and increase lightning activity, all of which lead to probable increases in fire frequency and areas burned. Extended hydrologic drought conditions will lead to drier vegetation conditions providing greater fuel volume for wildland fires (Kling and Wuebbles, 2003). In addition, studies have shown a correlation between increasing temperatures and increased lightning frequency (IPCC, 2001). With increased lightning frequency, the risk for wildland fires becomes greater.

Concerns regarding increased wildland fire risk is heightened by the increasing development pressures in areas of highly flammable vegetation as more people are choosing to live in the wildland-urban interface (WUI), defined as the area where structures and other human development meet or intermingle with undeveloped wildland.

Population sprawl has resulted in increased development in the outlying fringe of urban areas and in rural areas with attractive recreational and aesthetic amenities, especially forests. This demographic change increases the size of the WUI. The expansion of the WUI in recent decades has significant implications for wildfire management and impact. The WUI creates an environment that enables fire to move readily between structural and vegetation fuels. Expansion of the WUI has increased the likelihood that wildland fires will present a greater threat to structures and people.

APPENDIX A: EXAMPLE METHODOLOGIES FOR IDENTIFYING NATURAL HAZARDS RISK RANKINGS

The Risk Assessment Matrix is the first methodology illustrated below. It was developed as part of the *Resource Guide to All Hazards Mitigation Planning in Wisconsin* by the Association for Wisconsin Regional Planning Commissions. This matrix is useful for non-coastal hazards, but must be expanded when assessing coastal hazards. Additional hazards such as coastal storms, coastal flooding, and coastal erosion must be added to the matrix.

The Hazard Profile Worksheet is the second methodology illustrated below. It was developed by the Bay-Lake Regional Planning Commission.

Natural Hazard Identification and Risk Assessment Matrix

Name of Community or Planning Area ______________________

For each hazard your community or planning area is vulnerable to in column one, assign a risk rating of 1-low, 2-medium, or 3-high for each of the risk assessment criterion (columns two through ten). Totaling each hazard's row should give you an appreciation of what hazards form the highest risk. This table is provided as a tool to help local governments and tribal organizations analyze their risks and should not be construed as a precise way for determining these risks. See the directions on Page 12 for further assistance in completing this table.

1 Hazard Identification	2 Hazard Frequency	3 Hazard Probability	4 Health & Public Safety	5 Home Damage	6 Business Disruption	7 Public Expenditures	8 Magnitude of Population At Risk	9 Magnitude of Homes At Risk	10 Magnitude of Businesses At Risk	11 Adjustment	12 Risk Assessment Rating Total
NATURAL HAZARDS	Frequency of past hazard occurrences 1 2 3	Probability of hazard occurring in the future 1 2 3	Degree of past hazard events causing injuries, sickness and/or deaths 1 2 3	Degree of past hazard events causing damage to homes 1 2 3	Degree of past hazard events causing damage to business and/ or interruption of business trade 1 2 3	Amount of local, state, & federal funds expended on past hazard recovery activities 1 2 3	Amount of population still vulnerable to injury, sickness, and/or death from hazard 1 2 3	Amount of homes still vulnerable to damage from hazard 1 2 3	Amount of businesses still vulnerable to damage or interruption of business trade 1 2 3		
Hail Storms											
Lightening Storms											
Thunderstorms											
Tornado/High Winds											
Flash Flooding											
Riverine Flooding											
Lake Flooding											
Stormwater Flooding											
Dam Failure Flooding											
Forest Fires											
Wildland Fires											
Coastal Hazards											
Heavy Snow Storm											
Ice Storm											
Blizzard											
Extreme Cold											
Earthquake											
Extreme Heat											
Agricultural											
Drought											
Fog											
Landslide											
Subsidence											

Hazard Profile Worksheet

Hazard:

Description of Hazard:

Please circle the number you believe most accurately describes the above hazard.

Geographic Extent: How large an area would likely be affected?

3 = County-wide

2 = Community-wide

1 = Localized

Frequency of Occurrence: How often can this be expected to occur?

4 = Highly Likely: 100% probable in the next year

3 = Likely: $>$10% but $<$100% probability in the next year or at least one chance in 10 years

2 = Occasional: 1-10% probability of occurrence in the next year or at least one chance in next 100 years

1 = Unlikely: $<$1% probability of occurrence in the next 100 years

Warning Time: How much time will there be to alert people to hazard conditions?

4 = None/minimal

3 = 3-6 hours

2 = 6-12 hours

1 = More than 12 hours

Likely Adverse Impact on critical facilities, housing, casualties and injuries, businesses, and the environment.

4 = Catastrophic: More than 50% of area affected

3 = Critical: 25 to 50% of area affected

2 = Limited: 10 to 25% of area affected

1 = Negligible: Less than 10% of area affected

Please provide a narrative description for the following items:

Existing Plans/Programs/Training/etc.:

Existing Warning Systems:

APPENDIX B: SAMPLE RESOLUTION OF ADOPTION

Sample Multi-Hazard Mitigation Plan Adoption Resolution

RESOLUTION # ________

ADOPTING THE ______(name of county or community)______ **MULTI-HAZARD MITIGATION PLAN**

WHEREAS, ______(name of county or community)______ recognizes the threat that natural hazards pose to people and property; and

WHEREAS, undertaking hazard mitigation actions before disasters occur will reduce the potential for harm to people and property and save taxpayer dollars; and

WHEREAS, an adopted all hazards mitigation plan is required as a condition of future grant funding for mitigation projects; and

WHEREAS, ______(name of county or community)______ participated jointly in the planning process with the other local units of government within the County to prepare an All Hazards Mitigation Plan;

NOW, THEREFORE, BE IT RESOLVED, that the______(name of board or council)______, hereby adopts the (name of county or community) All Hazards Mitigation Plan as an official plan; and

BE IT FURTHER RESOLVED, that the________(name of county)________County Emergency Management Department will submit on behalf of the participating municipalities the adopted All Hazards Mitigation Plan to Wisconsin Emergency Management and Federal Emergency Management Agency officials for final review and approval.

PASSED: ________(date)________

____

Certifying Official

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Racine County Hazard Mitigation Plan. Community Assistance Planning Report No. 266. Southeastern Wisconsin Regional Planning Commission. August 2004.

WEBSITES

- Association of State Floodplain Managers:
  http://www.floods.org/

- Community Planning Resource Website -- a service of the Land Information and Computer Graphics Facility:
  http://www.aqua.wisc.edu/cpr/

- Federal Emergency Management Agency - Mitigation Division:
  http://www.fema.gov/about/divisions/mitigation/mitigation.shtm
  - Region V Disaster History:
    http://www.fema.gov/regions/v/disasters_region5.fema#WI
  - Pre-Disaster Mitigation Grant Program:
    http://www.fema.gov/government/grant/pdm/index.shtm

- National Climatic Data Center:
  http://lwf.ncdc.noaa.gov/oa/climate/severeweather/extremes.html

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  http://www.oceanservice.noaa.gov/
  - Coastal Services Center:
    http://www.csc.noaa.gov/themes/coasthaz/.html
  - Office of Coastal Resource Management, Coastal Hazards:
    http://www.coastalmanagement.noaa.gov/hazards.html
  - Office of Coastal Resource Management, Shoreline Management Technical Assistance Toolbox:
    http://www.coastalmanagement.noaa.gov/shoreline.html
  - Risk and Vulnerability Assessment Steps (Critical Facilities Analysis):
    http://www.csc.noaa.gov/rvat/critical.html
  - Sea Grant Program Natural Hazards Theme Team:
    http://www.haznet.org/

- U.S. Army Corp of Engineers – Detroit District:
  http://www.lre.usace.army.mil/_kd/go.cfm?destination=Page&Pge_ID=1242

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  http://www.usgs.gov/hazards/
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Apparent Temperature	The perceived temperature in degrees Fahrenheit derived from either a combination of temperature and wind (Wind Chill) or temperature and humidity (Heat Index) for the indicated hour.
Asset	Any manmade or natural feature that has value, including, but not limited to people; buildings, infrastructure like bridges, roads, and sewer and water systems; lifelines like electricity and communication resources; or environmental, cultural, or recreational features like parks, dunes, wetlands, or landmarks.
Bank	The edge and face of land closest to a body of water, generally less than 10 feet above water level, containing a few simple soil layers and no groundwater. Often a bank is located landward and above a beach.
Base Flood	A flood having a 1-percent probability of being equaled or exceeded in any given year; also referred to as the 100-year flood.
Bluff	The edge and face of land closest to a body of water, generally higher than 10 feet and high enough to contain complex, multiple layers of soil and groundwater.
Coastal Zone	The area along the shore where a Great Lake meets the land and extending inland to the county boundary. Thus, the Wisconsin coastal zone is comprised of Wisconsin counties adjacent to Lake Michigan and Lake Superior including barrier islands, estuaries, beaches, and coastal wetlands. See Figure 1.
Contour	A line of equal ground elevation on a topographic (contour) map.
Debris	The scattered remains of assets broken or destroyed in a hazard event. Debris caused by a wind or water hazard event can cause additional damage to other assets.
Flood Hazard Area	The area shown to be inundated by a flood of a given magnitude on a map.
Floodplain	The land covered during a flood. Commonly used as the land covered by a flood have a 1 percent chance of occurring each year.
Groundwater	Water within the soil. Includes the water within bluff soils that is slowly moving toward the bluff face.
Hazard	A source of potential danger or adverse condition.

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

Hazard Identification The process of identifying hazards that threaten an area.

Hazard Mitigation Sustained actions taken to reduce or eliminate long-term risk from hazards and their effects.

Ice shove Caused when wind and wave energy is transmitted to an existing ice sheet and pushed onshore.

Infrastructure Refers to the public services of a community that have a direct impact on the quality of life. Infrastructure includes communication technology such as phone lines or internet access, vital services such as public water supplies and sewer treatment facilities, and includes an area's transportation system such as airports, heliports, highways, bridges, tunnels, roadbeds, overpasses, railways, rail yards, depots; and waterways canals, locks, seaports, ferries, harbors, dry-docks, piers, and regional dams.

Karst A type of topography that is formed over limestone, dolomite or gypsum by solution of the rock and is characterized by closed depressions or sinkholes, caves and underground drainage.

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

Mitigation Planning A process for systematically identifying policies, activities, and tools that can be used to implement hazard mitigation actions.

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

Recession The landward movement of a shoreline caused primarily by erosion of the shore.

Richter scale A logarithmic scale that measures the amount of energy released during an earthquake on the basis of the amplitude of the highest peak recorded on a seismogram. Each unit increase in the Richter scale represents a 10-fold increase in the amplitude recorded on the seismogram and a 30-fold increase in energy released by the earthquake.

Runoff Water from precipitation, flowing over land surfaces to streams, lakes, and oceans.

Sediment Residual soil repeatedly moved and deposited by moving water bodies.

Seiche (Pronounced "saaysh.") Seiches are a back-and-forth sloshing of water in a lake caused by a disturbance from a storm, wind shift, or rapid atmospheric pressure change, Small seiches are occurring all of the time on the Great Lakes.

Setdown A drop in water level along a shore due to a strong wind blowing off the shore (away from the shore).

Shoal An offshore lakebed feature that is an area of shallow water.

Shore Erosion The process by which soil moves down coastal slopes and away from coastal boundaries.

Storm Surge A temporary rise in water levels along a downwind coasts caused by the drag of storm winds on the surface of a lake or ocean.

Note: The definitions contained within this glossary were obtained from the following:

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NOTES

CD-ROM

The following CD-ROM contains a copy of the *Guide to Hazard Mitigation Planning for Wisconsin Coastal Communities* in PDF format.

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