- Upslope Fog is common near the Rockies, including the Denver area. If the winds are out of the east, the air flows up as it rises in elevation, approaching the mountains. This can cool the air to its dew point and result in widespread fog.
- Rain Fog is created when late afternoon or evening showers and thunderstorms during the spring and summer leave the ground soaked just as the sun sets. Though the rain usually stops overnight, the high humidity level created by the rainfall won't allow the moisture to evaporate, and as a result, fog forms. This occurs especially at times when there are light winds. As the air warms up the next morning, this rain-enhanced fog will usually burn off by midday.
- Precipitation Fog forms when rain or snow falls. As precipitation falls into drier air below the cloud, the liquid drops or ice crystals evaporate or sublimate directly into water vapor. The water vapor increases the moisture content of the air while cooling the air. This often saturates the air below the cloud and allows fog to form.

Frequency of Occurrence

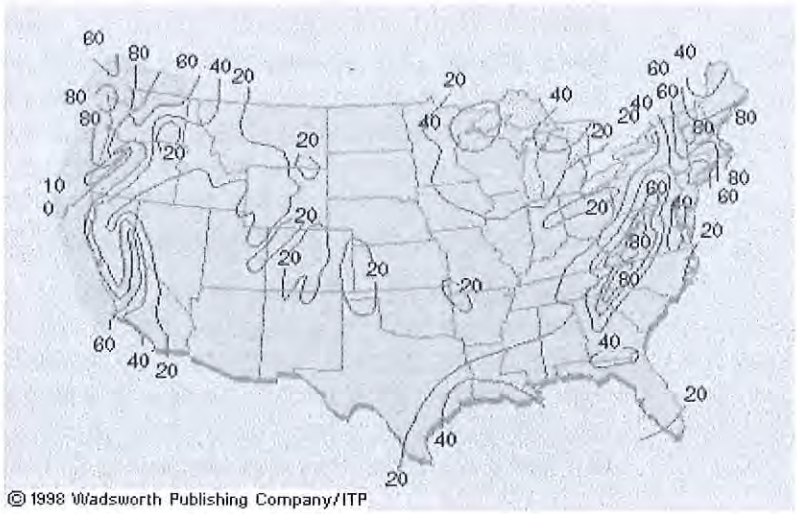
Some locations on this planet have weather conditions that are conducive to making fog frequently.

- San Francisco, California, with an average of 18 days of heavy fog each year
- Cape Disappointment, Washington, is the foggiest place on the western U.S. coast with an average of 106 days of heavy fog per year.
- The foggiest area on the east coast of the United States is found along the rockbound coast of Maine. Moose Peak Lighthouse on Mistake Island, at an elevation of 72 feet, averages 1580 hours of heavy fog each year. Many other locations have problems with fog, such as Eastport, Maine, with 65 days annually, and Portland, with 55 days of heavy fog each year.
- Inland areas with regular heavy fog include parts of the Appalachian Mountains, such as a peak area in West Virginia that averages over 100 days each year. Elkins, at

an elevation of 1948 feet, has about 81 days annually with heavy fog.

- Milwaukee averages about 26 days with some heavy fog.

Average Annual Number of Days with Heavy Fog in the United States



Tables showing fog events recorded by the National Weather Service can be found in Appendix B. Green Lake County has a low probability of fog occurrence in the future, and the likelihood of damage due to fog is also considered low. The Towns of Mackford and Green Lake are the most susceptible.

Vulnerability

Fog is a concern for the boaters, both commercial and recreational. While the U.S. Coast Guard does not publish reports showing the statistics for fatalities, injuries, and property damage due to boating accidents involving fog, one can make a reasonable supposition that this is a concern. Boaters caught in heavy fog may strike another vessel, dock, or natural feature such as a rock or bluff. The loss of a vessel may be compounded by the fact that most fog occurs when the temperatures are colder, and victims forced to evacuate their vessel may suffer from hypothermia more readily than they would in warmer months. Boaters may lose their way in the fog, and fog makes it much more difficult for rescuers to find the victims to provide aid.

Perhaps the largest vulnerability to fog is due to automobile traffic crashes. According to the Wisconsin Department of Transportation, dense fog contributes to hundreds of car accidents per year in the state. The following are the Wisconsin Department of Transportation's statistics for fog-related traffic crashes from 1999-2004:

Death and Injury Statistics for Fog-Related Traffic Crashes						
	1999	2000	2001	2002	2003	2004
Total Crashes	1259	1008	1066	595	772	1141
Fatal Crashes	14	12	19	12	11	16
People Killed	15	13	22	22	11	19
Injury Crashes	528	445	425	238	274	423
People Injured	777	643	593	372	391	615
Property Damage Crashes	717	551	622	345	487	702

Traffic Conditions at the Time of Fog-Related Traffic Crashes						
	1999	2000	2001	2002	2003	2004
Total Crashes	1259	1008	1066	595	772	1141
Daylight	467	340	295	158	257	398
Dark/Lighted	130	107	130	324	80	140
Dark/Unlit	547	439	491	46	343	456
Dusk	9	18	16	56	7	16
Dawn	99	101	126	9	77	122
Unknown Light Conditions	7	3	8	2	8	9

Some notable fog-related traffic crashes in the area of eastern Wisconsin follow:

- On the morning of Friday, October 11, 2002, 50 vehicles were involved in a massive vehicle accident on Interstate 43 in Sheboygan County near Cedar Grove, Wisconsin. This accident was the deadliest pile-up in Wisconsin history, with ten individuals killed and over 40 people injured. Of the injured, seven were in critical condition and one was in serious condition at area hospitals immediately after the incident. 28 other people were treated and released for injuries ranging from burns to broken bones. The accident occurred as cars heading south collided into one another, and some vehicles slowed down in dense fog. This led to a chain reaction as numerous cars were unaware of the scene hidden behind a veil of fog. Chad Kruse, a driver interviewed after the accident, described it by saying, "I entered the wall of fog, like someone took a blanket and threw it over the

windshield." At the same time, but separate from this incident, four other accidents occurred nearby on the interstate; all the individuals involved in these accidents survived.[118]

- Fourteen people were injured in January 1996 in a 26-car pileup on southbound I-43 near Ozaukee County Highway KK. The first driver struck said he had missed his exit

[118] http://www.stoutonia.uwstout.edu/2002-2003/stories/021024/ne_04.html

because of heavy fog and had slowed down to look for another when he was hit from behind. [119]

- In March 1990, three people were killed and 31 injured in a 52-vehicle pileup on the Tower Drive Bridge in Green Bay after dense fog and smoke from nearby paper mills created a "white wall" that reduced visibility to less than 10 feet. The accident was believed to have been triggered when a tanker truck overturned and a ruptured gas tank ignited. Vehicles following too closely on the fog-shrouded bridge slammed into the tanker and were engulfed by a sheet of flames. [120]

Because Green Lake County has a smaller population and does not have a major interstate, it is at less risk for very large, multi-car traffic accidents. It is also important to note that, as a smaller county, response to an accident relies on volunteer fire and EMS responders who generally have longer response times than the full-time departments found in more heavily populated areas. Also, there is no hospital within the county, and crash victims will need to be transported further to facilities for treatment. These factors can severely affect the medical outcomes of crash victims.

As seen in the true examples above, fog-related incidents can cause death, injury, and property loss to the vehicle owners and occupants and their insurance companies. Responding governmental agencies also may suffer losses due to the cost of response, for damage done to roadways and structures due to fires, and for potential injuries to responders working in a reduced-visibility zone. Citizens may be impacted by the closure of roadways and delay of activities; businesses may suffer losses due to the absence of workers due to delay, injury, and/or death, and because of the delay of product on the roadways and direct loss of product in the crash (e.g., due to fire).

Hazard Mitigation Strategies

Fog in Wisconsin is most prevalent on spring mornings as the snow cover is melting and tends to be in low-lying areas. The most cost-effective hazard mitigation strategy for fog in Green Lake County is public education. This project is a low priority that will be done across the entire county on an ongoing basis as needed, when

[119] The Fog, The Deadliest Traffic Crash in Wisconsin History; Trooper Tim Austin; Wisconsin Trooper, Callan Publishing Ins., Minneapolis, MN; Spring 2003.
[120] http://www.jsonline.com/news/state/oct02/87083.asp

hazardous conditions are noticed, as a cooperative project between law enforcement and the emergency manager, with their existing budget.

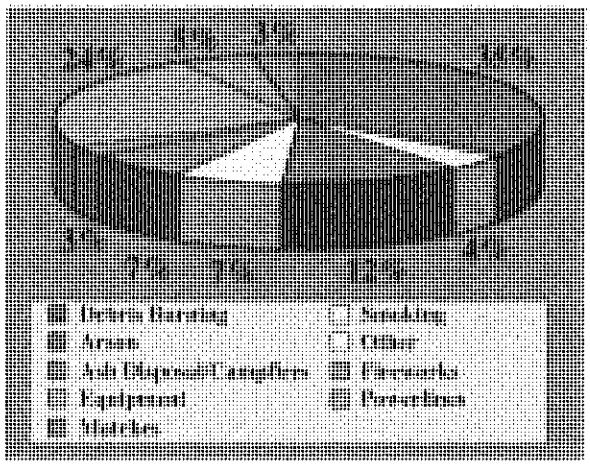
Forest and Wildfires

Wildfire (fires in forested, open, and/or agricultural land) season in Green Lake County begins in March and continues through November, although fires can occur at any time during any month of the year. The fall season carries the highest risk of cropland fires (fields are stubble), while the spring season is riskiest for grassland fires (before new growth develops). However, fires are more likely to occur whenever vegetation is dry as a result of a winter with little snow or a summer with sparse rainfall.

The Wisconsin Department of Natural Resources (DNR) is responsible for forest fire protection on approximately 18 million acres of forest and wildland in Wisconsin. The U.S. Forest Service maintains forest fire protection on two million acres of this land while local fire departments retain responsibility for the remaining wooded acreage.

Physical Characteristics

According to the DNR, there are approximately 1,500 fires annually that burn over 5,000 acres of the land that they protect; 98% of these fires are human-caused. It should be noted that these figures do not include areas of the state where a local fire department has primary responsibility for service.



Frequency of Occurrence

While the total number of open fires in Wisconsin has decreased over the years, the potential danger to lives and property remains due to the increased encroachment of development into previously open lands.

According to the Wisconsin DNR Fire Management Dashboard,[121] since 2012, Green Lake County has experienced 151 separate instances of wildfires burning a total of 1,391.34 acres. As such, the overall probability for a wildfire in Green Lake County is medium. The probability of damage from wildfire is considered low.

The probability of a forest fire is low, and the probability of damage or losses from forest fires is very low. The areas at highest risk for wildfire in the county are the less improved parts, where the damage is more to the environment than to improved property.

There has been one statewide wildfire event recorded since 1950 by the National Weather Service. This event occurred on 23 April 1994 and caused no injuries or deaths but did cause $500,000 in crop and property damage (each).

The University of Wisconsin-Madison, Nelson Institute for Environmental Studies/ Wisconsin DNR's Wisconsin Initiative on Climate Change Impacts[122] shows a scientific consensus that, "Wisconsin is likely to become a much warmer state over the next few decades...and...our state is also likely to become somewhat wetter, with a modest increase in total precipitation and in the number of intense rainfall events. The amount of climate change varies by season, with winter experiencing the greatest warming and most likely increase in precipitation." The site's information shows that Green Lake County is likely to experience warmer weather and an increase in precipitation for all four seasons of the year. This is likely to increase the growth rate of vegetation, but the additional rainfall is likely to reduce the number of fires.

[121] https://dnrmaps.wi.gov/wildfiredashboard/

[122] Trends and Projections | Wisconsin Initiative on Climate Change Impacts (WICCI)

As noted earlier in this plan, the National Risk Index (NRI) tool [123] has been made available by the Federal Emergency Management Agency (FEMA). It calculates a baseline relative risk measurement for 18 natural hazards based on expected annual loss, social vulnerability, and community resilience. Below is data relevant to the hazard discussed in this chapter. It should be noted that the NRI information may not necessarily match the hazard ratings reached by the county and is only being included for reference.

Number of Events	N/A
Annualized Frequency	0
Expo. - Building Value ($)	720,718,328
Expo. - Population	1,757.63
Expo. - Agricultural Value ($)	11,261,617
Expo. - Population Equiv. ($)	20,388,506,294
Expo. - Total ($)	21,120,486,239
HLR - Overall Rating	Relatively Moderate
EAL - Building Value ($)	77,970
EAL - Population	0
EAL - Population Equiv. ($)	3,821
EAL - Total ($)	81,791
Risk Score	61.9
Risk Rating	Very Low

"Expo." = Exposure / "HLR" = Historic Loss Ratio / "EAL" = Expected Annual Loss

Vulnerability

Forest and wildfires can impact the ecology of the open lands and while fire within park areas would not cause great impacts, a fire could erase the usability of this habitat for wildlife and/or recreational purposes for many years. Other impacts in the event of a fire include effects on the water supply, crop damage, and smoke over roadways causing a driving hazard.

In 2003, the National Association of State Foresters produced a Field Guidance for Identifying and Prioritizing Communities-at-Risk (CAR). The purpose of the guide was to provide states with a nationally consistent approach for assessing and displaying the

[123] https://hazards.fema.gov/nri/map

risks to communities from wildfire. The DNR, in cooperation with its federal and tribal partners, began working on the statewide assessment of Communities-at-Risk in 2004.

Communities-at-Risk is a model to identify broad areas of the state that are at relatively high exposure to resource damage due to wildfire. Results of the model can then be used by local governments developing Community Wildfire Protection Plans (CWPP) and by the DNR to reduce local risks of wildland fire by prioritizing hazard mitigation and fire protection efforts.

The approach used in this risk assessment model is based on the "Methodology" section of the NASF Field Guidance document, which recommends assessing and mapping four factors:

- Historic Fire Occurrence
- Hazard
- Values Protected
- Capabilities

Modifications to this methodology were made to fit the GIS mapping data layers available for Wisconsin. The Wisconsin DNR uses three factors to assess Communities-at-Risk of wildfire damage:

- Hazard – the relative likelihood that an ignited wildfire will achieve sufficient intensity to threaten life or property based on land cover type and historic fire regime.
- WUI (Values at Risk) – the relative vulnerability of each 2000 census block to wildfire damage based on housing density and spatial relationship with undeveloped vegetation based on housing density and proximity to vegetation (Wisconsin's Wildland-Urban Interface). Wisconsin's WUI was layered with a weighted vegetation layer to accentuate proximity to flammable vegetation.
- Ignition Risk – the relative likelihood of a wildfire ignition within a given 30-m pixel based on historic fire occurrence, population density, and proximity to a potential ignition source.

Models were developed in GIS to create statewide grids representing each of the three weighted {Hazard (40%), WUI (30%), and Risk (30%)} inputs. This composite grid represents communities-at-risk (CAR) on a 0-9 scale of threat, with zero representing no threat and nine a very high threat. The data was then represented by municipal civil divisions (MCDs), which are city and village boundaries. Quantitative markers were assigned for five threat levels: very low, low, moderate, high, and very high, and

those MCDs determined to have a high or very high threat of wildfire were considered CARs. 337 communities met the requirements for being "at risk."

Communities in Wisconsin vary considerably in size. This is particularly evident in a north-south pattern, with smaller, more rural towns in northern Wisconsin and larger, more urban towns in southern Wisconsin. Because of this variation in size, the potential for missing areas of high risk due to smoothing out by other parts of the town was greater for larger towns. For this reason, the WI DNR incorporated a "Community of Concern" category to identify those towns that have portions of their town in high risk of wildfire but were not otherwise included as a Community-at-Risk. A Community-of-Concern was determined to be an area of at least two contiguous square miles at high or very high risk; 237 communities were named as Communities-of-Concern.[124]

The following were identified as Communities at Risk or Communities of Concern: [125]

Communities at Risk – High:

- Town of Brooklyn
- Town of Princeton

Communities of Concern:

- Town of Berlin
- Town of Kingston
- Town of Marquette
- Town of Seneca

Hazard Mitigation Strategies

Government at all levels is developing mitigation programs in fire control and firefighting tactics with the goal of protecting lives and property from loss due to forest and wildfire. Local fire departments attend regular training on firefighting tactics to keep their skills honed. The County Emergency Management Office assists local departments and their staff with available grant applications for training, exercising, equipment, and planning as able and requested.

[124] Wisconsin State Hazard Mitigation Plan

[125] https://dnr.wisconsin.gov/sites/default/files/topic/ForestFire/communitiesAtRiskWildfire.pdf

The Wisconsin Department of Natural Resources (DNR) provides annual training for firefighters in the spring. The DNR does not have a forestry office in Green Lake County and also does not pre-stage resources (e.g., rangers, equipment, supplies) there. If there were a large wildfire for which local firefighters would request state assistance, the DNR may be able to provide limited assistance based upon their deployment level at that time; the closest DNR office is in Montello (Marquette County).

The emergency management office also partners with the local fire departments to provide information about fire safety and other mitigation strategies (e.g., protecting structures from wildfires, obtaining burn permits), especially during Fire Safety Week in October of each year.

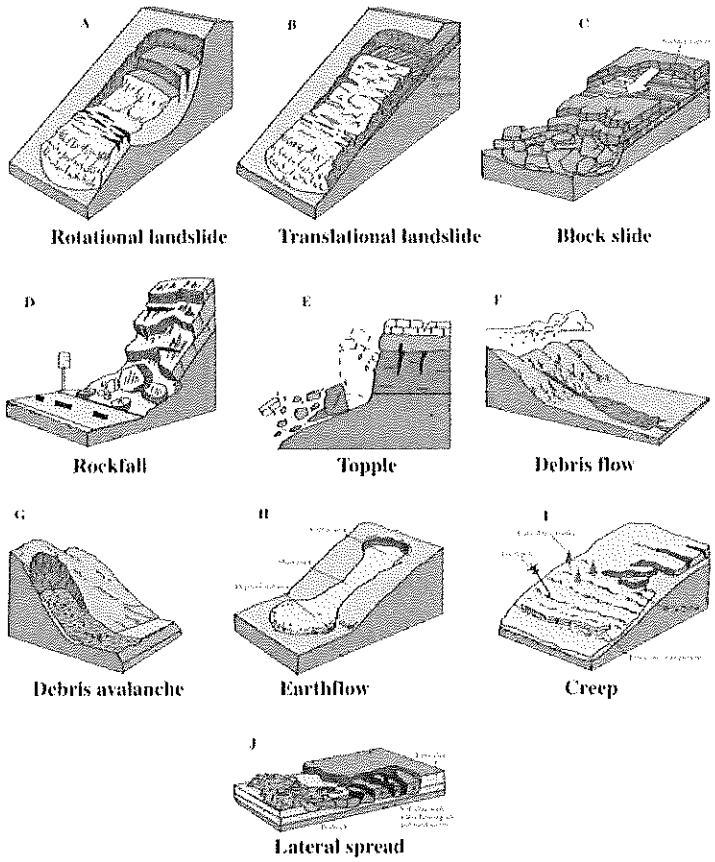
The Village of Kingston Fire Department would like to explore the possibility of creating dry hydrants for filling trucks for fires. There are currently no other dry hydrant projects in the county.

The hazard mitigation strategies listed above primarily involve providing information on general fire safety measures to the public for residential and commercial structures and providing ongoing training to the firefighters who fight these types of fires. These measures provide basic fire safety information but, since Green Lake County has few forested areas (primarily parks and other non-inhabited recreational areas) and most open areas are utilized for agriculture with no buildings or infrastructure on them, there is no need to have measures designed to reduce damages to existing or future buildings and infrastructure.

Landslide

The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on an over-steepened slope is the primary reason for a landslide, there may be other contributing factors. Factors likely to be seen in Green Lake County include:

- erosion by rivers or lakes, creating over-steepened slopes
- rock and soil slopes are being weakened through saturation by snowmelt or heavy rains
- excess weight from the accumulation of rain or snow, stockpiles of rock or ore, waste piles, or from man-made structures stressing weak slopes to failure[126]



[126] http://landslides.usgs.gov/html_files/nlic/page5.html and https://editors.eol.org/eoearth/wiki/Landslide

Physical Characteristics

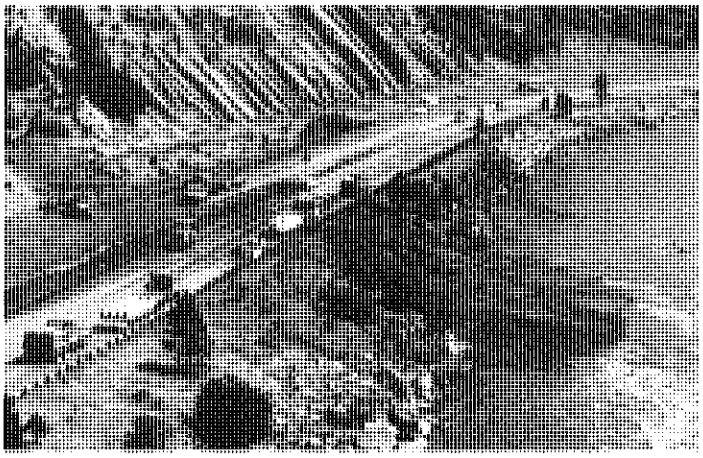
Landslides may include any combination of natural rock, soil or artificial fill and are classified by the type of movement and the type of material. The types of movement are slides, flows, lateral spreads and falls, and topples; a combination of two or more landslide movements is a complex movement:

- Slides: straight or rotating downward displacements along one or more failure surfaces of soil or rock as a single intact mass or a number of pieces
- Flows: a rapid, downhill mass movement of a "slurry" comprised of loose soil, rocks, organic matter, air, and water
- Lateral spreads: large movements of rock, fine-grained soils, or granular soils distributed laterally
- Falls and Topples: masses of rocks or material that rapidly detach from a steep slope or cliff and free-fall, roll, or bounce.

Almost any steep or rugged terrain is susceptible to landslides under the right conditions. The most hazardous areas are steep slopes on ridges, hills, and mountains; incised stream channels and slopes excavated for buildings and roads. Slide potentials are enhanced where slopes are destabilized by construction, heavy rainfall, floods, or river erosion. Debris flows generally occur during intense rainfall on water-saturated soil. Surface runoff channels along roadways and below culverts are common sites of debris flows.

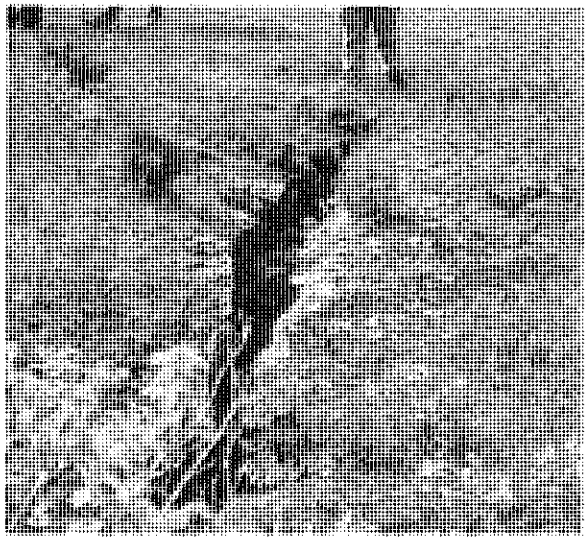
Landslides often occur together with other major natural disasters, thereby exacerbating relief and reconstruction efforts:

- Floods and landslides are closely related and both involve precipitation, runoff, and ground saturation that may be the result of severe thunderstorms.
- Landslides into a reservoir may indirectly compromise dam safety, or a landslide may even affect the dam itself.
- Wildfires may remove vegetation from hillsides, significantly increasing runoff and landslide potential.



Landslide from fire damage in CO[127]

Sinkholes can form naturally in areas with karst geology (i.e., areas with limestone or other bedrock that can be dissolved by water). As the limestone rock under the soil dissolves over time from rainfall or flowing groundwater, a hollow area may form underground into which surface soil can sink. Sinkholes can also be caused by human activity, such as collapsed, abandoned underground mines. Even though sinkholes have not been a factor in any natural disaster, identifying areas with karst conditions is important for not only public safety and protection of structures, but also because karst features provide direct conduits to groundwater. Areas with karst conditions are vulnerable to groundwater contaminants from pollutants entering a sinkhole, fissure, or other karst feature.



Enlarged fracture in Brown County, WI[128]

[127] http://landslides.usgs.gov/html_files/landslides/slides/slide15.htm
[128] http://www.uwex.edu/wgnhs/enlargedjoint.htm

Frequency of Occurrence

According to the U.S. Geological Survey, landslides are a widespread geologic hazard, occurring in all 50 states, where they cause, on average, $1 to $2 billion in damages and more than 25 fatalities annually. Landslides pose serious threats to highways, railroads, and structures that support fisheries, tourism, timber harvesting, mining, and energy production. Expanding urban development and other land uses have increased the incidence of landslide disasters in the United States.

Even though there have been no recent reports of landslides in Green Lake County, Wisconsin Emergency Management has determined that Green Lake County has a low likelihood of occurrence and a low probability of damage if it does occur. If there was an incident, the damages would likely be environmental and not to improved property. (See the map in Appendix A).

The karst potential map in Appendix A shows that Green Lake County has a mixture of deep and shallow karst features throughout the southeast portion county. The presence of this geologic feature supports the low probability of incidents (e.g., sinkholes, fissures to groundwater) to residents in that portion of the county and a very low probability in the rest of the county. The good news is that the complications due to karst geology have a low probability of causing significant damage, injury or death.

Sinkhole in Monroe County, WI[129]

[129] http://www.uwex.edu/wgnhs/cavesink.htm

As noted earlier in this plan, the National Risk Index (NRI) tool [130] has been made available by the Federal Emergency Management Agency (FEMA). It calculates a baseline relative risk measurement for 18 natural hazards based on expected annual loss, social vulnerability, and community resilience. Below is data relevant to the hazard discussed in this chapter. It should be noted that the NRI information may not necessarily match the hazard ratings reached by the county and is only being included for reference.

Number of Events	0
Annualized Frequency	0
Expo. - Building Value ($)	1,805,657,652
Expo. - Population	4,310.1
Expo. - Agricultural Value ($)	N/A
Expo. - Population Equiv. ($)	49,997,113,140
Expo. - Total ($)	51,802,770,792
HLR - Overall Rating	Relatively Low
EAL - Building Value ($)	4,500
EAL - Population	0
EAL - Population Equiv. ($)	17,400
EAL - Total ($)	212,900
Risk Score	43.8
Risk Rating	Relatively Low

"Expo." = Exposure / "HLR" = Historic Loss Ratio / "EAL" = Expected Annual Loss

Vulnerability

The most likely consequences of landslides in Green Lake County would be damage due to underlying karst geology, which has been identified in Green Lake County. This feature can lead to sinkholes under structures such as homes, businesses, roadways, and railroads, causing economic losses and possible injury to residents and the community. Fissures and/or holes that form because of karst geology can also open a direct channel to the aquifer. Water may then enter the aquifer that has not had the benefit of filtering through the soil, allowing contaminants into wells.

[130] https://hazards.fema.gov/nri/map

Hazard Mitigation Strategies

The goal of landslide mitigation activities is to reduce, in a cost-effective manner, the loss of lives and property due to these events. Although the physical cause of many landslides cannot be removed, geologic investigations, good engineering practices, and effective enforcement of land-use management regulations can reduce landslide hazards. Karst features should be considered in land use planning, stormwater management, and hazardous materials planning to avoid possible damage to structures due to sinkholes or contamination of groundwater.

Green Lake County will continue to work with its municipal partners to ensure that areas at risk of landslide and karst-related complications are identified and mitigation strategies are employed as appropriate. This will include evaluating areas with known karst geological features for new fissures and ensuring that direct access to the water table (i.e., without filtering through the soil) is not opened in a fissure.

This coordination and cooperation among the private sector and various state, county, and municipal planning and zoning departments will reduce effects on existing and future buildings and infrastructure by ensuring that safety is regulated and engineered into them.

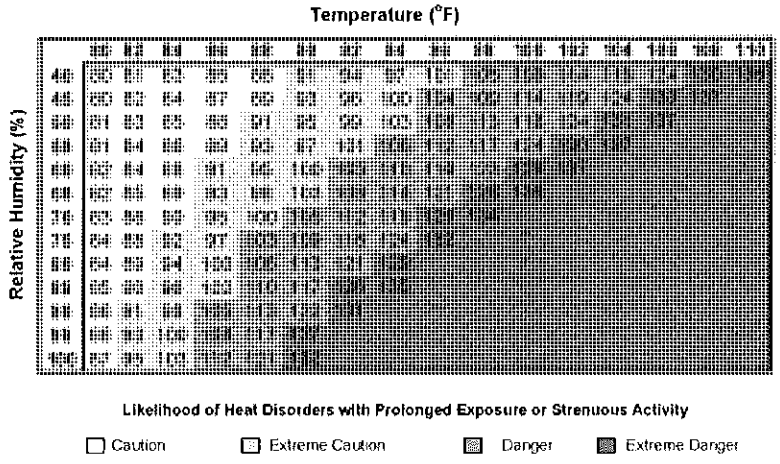
Severe Temperatures

Characteristics

Temperature extremes can cause disruption of normal activities for the population, property loss, and even the loss of life, especially among the more vulnerable members of our population, such as children and the elderly.

Physical Characteristics: Heat

Heat emergencies are a result of the combination of very high temperatures and very humid conditions.



The Heat Index estimates the relationship between these two conditions and reports them as a danger category, as can be seen in the following table[131]:

[131] FEMA, 1997; NWS, 1997

Heat Index and Disorders Table			
Danger Category		**Heat Disorders**	**Apparent Temperatures [°F]**
IV	Extreme Danger	Heatstroke or sunstroke imminent.	>130
III	Danger	Sunstroke, heat cramps, or heat exhaustion are likely; heat stroke is possible with prolonged exposure and physical activity.	105-130
II	Extreme Caution	Sunstroke, heat cramps, and heat exhaustion are possible with prolonged exposure and physical activity.	90-105
I	Caution	Fatigue is possible with prolonged exposure and physical activity.	89-90

The major risks to people due to extreme heat are:

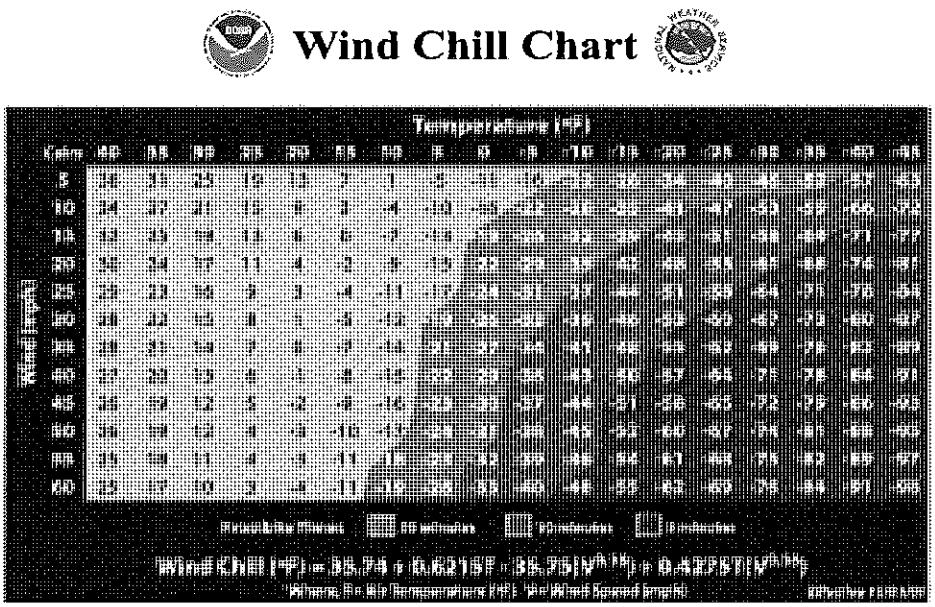
- Heatstroke – a potentially lethal medical emergency where the ability of a person to thermo-regulate is compromised, resulting in the rise of the body's core temperature to above 105°F (Fahrenheit).
- Heat Exhaustion – a less threatening medical condition where the victim complains of dizziness, weakness, and/or fatigue. The victim may have a normal or slightly elevated temperature and usually can be successfully treated with fluids.
- Heat Syncope – a sudden "faint" or loss of consciousness usually brought on by exercising in warmer weather than one is accustomed to, usually with no lasting effect.
- Heat Cramps – muscular cramping brought on by exercising in warmer weather than one is accustomed to, with no lasting effect.

Extreme heat conditions may also affect pets and livestock, decreasing agricultural output by the latter. Crops may suffer reduced yield due to extremely hot conditions.

Physical Characteristics: Cold

Wind chill is a relationship between wind and cold that is based on the rate of heat loss from exposed skin. As the wind speed increases, heat is drawn from the body, driving down skin

temperature and eventually core body temperature. The following table illustrates this relationship.[132]



The major risks to people due to extreme cold are:

- Hypothermia - occurs when, due to exposure to cold, the body is unable to maintain its proper core temperature. It may occur in temperatures above freezing and may lead to death.

- Frostbite – describes local cooling, usually to an extremity, which occurs when exposure to cold air or liquid causes constriction of the blood vessels. There are three degrees of frostbite:

    - Frostnip – brought on by direct contact with a cold object or exposure to cold air or water. Tissue damage is minor, and the response to treatment is usually very good.

    - Superficial Frostbite – involves the skin and subcutaneous layers.

[132] National Weather Service: https://www.weather.gov/safety/cold-wind-chill-chart

- Freezing – is deep frostbite in which the skin, subcutaneous layers, and deeper structures (e.g., muscles, bone, deep blood vessels, organ membranes) of the body are affected and can become frozen.

- Chilblains - lesions that occur from repeated/chronic exposure of bare skin to temperatures of 60°F or lower.

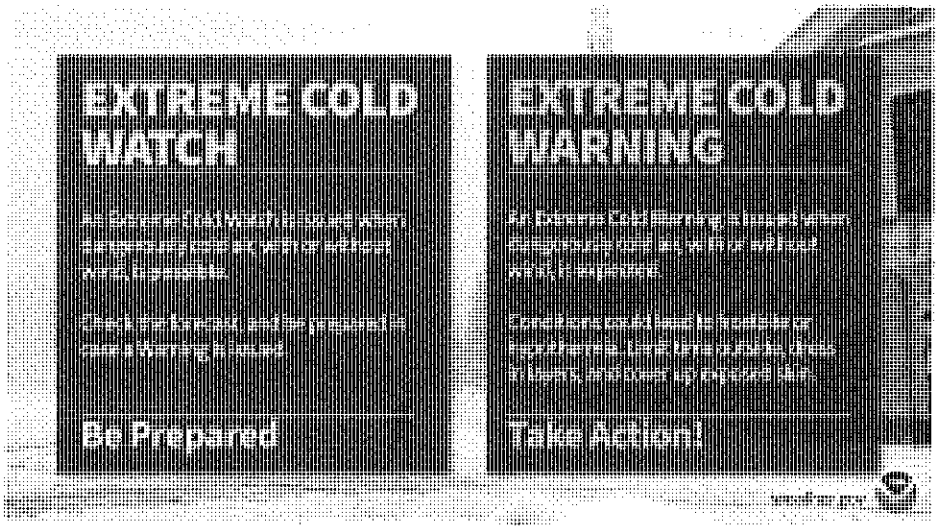
- Trench foot – a condition that occurs when the lower extremities remain in cool water for a prolonged period of time.

In October 2024, the National Weather Service simplified its cold-weather forecast products[133] to improve the messaging of winter hazards and provide better decision support. They noted that *"These changes seek to clarify that cold can be dangerous with or without wind, addressing a common misconception that extreme cold is only tied to colder temperatures when there is wind. Dangerously cold weather can accompany or follow wintry precipitation, and the cold messaging can be overshadowed by the wintry precipitation."*

Extreme Cold Consolidation and Renaming
- Wind Chill Watches renamed to Extreme Cold Watch
- Wind Chill Warnings renamed to Extreme Cold Warning
- Wind Chill Advisory renamed a Cold Weather Advisory

Freeze Consolidation
- Hard Freeze Watches renamed to Freeze Watch
- Hard Freeze Warnings consolidated to Freeze Warning

[133] https://www.weather.gov/news/243009-cold-hazard-simplification



Frequency of Occurrence: Heat

Wisconsin has been affected by several bouts of extreme heat, including during the Dust Bowl period from 1934-1936. Other heat events occurred in 1979, 1995, 2001, 2011, and 2012.

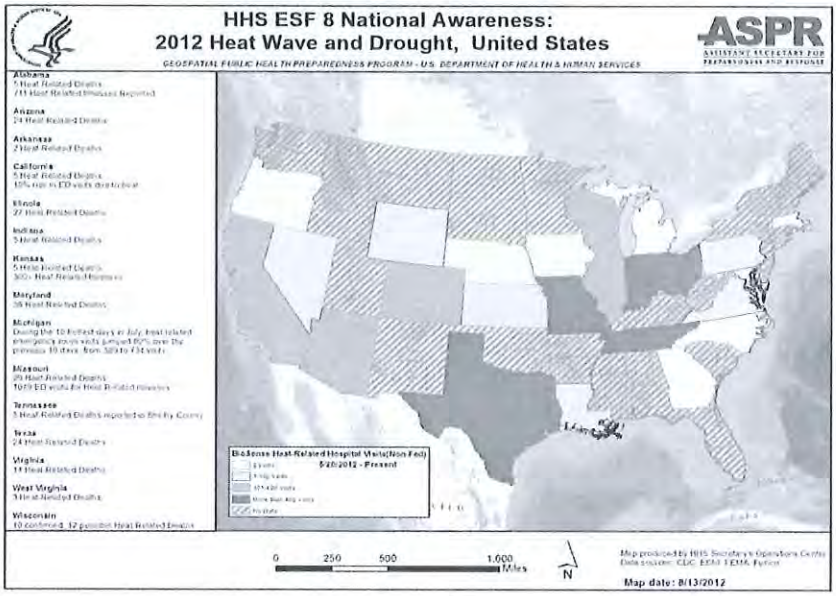
Tables showing the excessive heat and heat events recorded by the National Weather Service in Green Lake County [134] can be found in Appendix B.

It should be noted that during the summer of 2012, much of the country, including Green Lake County, experienced a heat wave, resulting in significant droughts across more than half the country as well as increases in heat-related illnesses and deaths. July was the hottest month in US history, eclipsing the record set during the heart of the Dust Bowl in 1936. The worst of the heat was in the Midwest, the Plains, and along the Eastern Seaboard. Most of the contiguous US had record and near-record warmth for the seven-month period, except the Pacific Northwest, which was near average.

With the increase in heat-related illnesses comes an increase in emergency department (ED) admissions across the country. Dehydration, heat exhaustion, and heat stroke were the most common causes for patients' heat-related ED admissions. Most heat-related visits occurred in patients between the ages of 19 and

[134] http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=55%2CWISCONSIN

70. In Wisconsin, there were ten confirmed and possibly 12 heat-related deaths. [135]



According to the State of Wisconsin Hazard Mitigation Plan, extreme heat is the number one weather killer in Wisconsin, with most heat deaths attributed to major heat waves. As can be seen by the historical tables, Green Lake County, like the rest of the state, is likely to experience extreme heat events every two to three years, with extended, major heat waves occurring about every two decades.

The workgroup therefore felt that there was a medium likelihood of occurrence in any given year. The committee also felt that the loss of property, primarily crop and livestock output; and the loss of life or injury to people have a low likelihood of occurrence for the general population but the committee recognized that the likelihood increases for certain populations such as the elderly, chronically ill, children, those who work outdoors, and those with limited financial resources (i.e., to pay for air conditioning). The county has been able to provide community support during excessive heat.

The University of Wisconsin-Madison, Nelson Institute for Environmental Studies/ Wisconsin DNR's Wisconsin Initiative on

[135] 2012 Heat & Drought Federal Report, HHS ESF 8, UPDATE #2, US Department of Health and Human Services, Assistant Secretary for Preparedness and Response

Climate Change Impacts[136] shows a scientific consensus that, "Wisconsin is likely to become a much warmer state over the next few decades...and...our state is also likely to become somewhat wetter, with a modest increase in total precipitation and in the number of intense rainfall events. The amount of climate change varies by season, with winter experiencing the greatest warming and most likely increase in precipitation." The site's information shows that Green Lake County is likely to experience warmer weather and an increase in precipitation, which means that the likelihood of additional severe heat days will increase. This could be even more concerning because of the additional atmospheric moisture, which will make it harder for people and animals to evaporatively cool.

As noted earlier in this plan, the National Risk Index (NRI) tool [137] has been made available by the Federal Emergency Management Agency (FEMA). It calculates a baseline relative risk measurement for 18 natural hazards based on expected annual loss, social vulnerability, and community resilience. Below is data relevant to the hazard discussed in this chapter. It should be noted that the NRI information may not necessarily match the hazard ratings reached by the county and is only being included for reference.

Number of Events	14
Annualized Frequency	0.9
Expo. - Building Value ($)	7,556,668,010
Expo. – Population	18,977
Expo. - Population Equiv. ($)	220,133,200,000
Expo. - Agricultural Value ($)	103,951,226
Expo. - Total ($)	227,793,819,236
HLR - Overall Rating	Relatively Low
EAL - Building Value ($)	900
EAL - Population	0.02
EAL - Population Equiv. ($)	217,236
EAL - Total ($)	223,112
Risk Score	69.8
Risk Rating	Relatively Low

"Expo." = Exposure / "HLR" = Historic Loss Ratio / "EAL" = Expected Annual Loss

[136] Trends and Projections | Wisconsin Initiative on Climate Change Impacts (WICCI)

[137] https://hazards.fema.gov/nri/map

Frequency of Occurrence: Cold

Wisconsin regularly has extreme cold temperatures as part of its winter climate. Tables that outline extreme cold/wind chill and cold/wind chill events, which have been recorded by the National Weather Service in Green Lake County[138] can be found in Appendix B.

After examining this data, the workgroup believed that cold and/or extreme cold has a medium likelihood of occurrence in any given year. Since there are no crops out during the winter and most properties (homes, businesses, barns) are insulated for this climate, the loss of property due to temperature extremes is low, although individuals may suffer damage due to water main breaks and other such problems. They further believed that the loss of life or injury to people has a low likelihood of occurrence among the general population when there are cold/extreme cold weather events. Again, the workgroup recognized that people who work outdoors, who have limited financial resources, the elderly, the young, and the chronically ill have a higher risk profile.

The Wisconsin Initiative on Climate Change Impacts study[139] also means that Green Lake County is likely to have fewer extreme cold weather incidents.

As noted earlier in this plan, the National Risk Index (NRI) tool [140] has been made available by the Federal Emergency Management Agency (FEMA). It calculates a baseline relative risk measurement for 18 natural hazards based on expected annual loss, social vulnerability, and community resilience. Below is data relevant to the hazard discussed in this chapter. It should be noted that the NRI information may not necessarily match the hazard ratings reached by the county and is only being included for reference.

Number of Events	9
Annualized Frequency	0.6
Expo. - Building Value ($)	7,556,668,010
Expo. - Population	18,977
Expo. - Population Equiv. ($)	220,133,200,000

49 & 138 http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=55%2CWISCONSIN

139 Trends and Projections | Wisconsin Initiative on Climate Change Impacts (WICCI)

140 https://hazards.fema.gov/nri/map

Expo. - Agricultural Value ($)	103,951,226
Expo. - Total ($)	227,793,819,236
HLR - Overall Rating	Very Low
EAL - Building Value ($)	161
EAL - Population	0.01
EAL - Population Equiv. ($)	133,938
EAL - Agricultural Value ($)	21,760
EAL - Total ($)	155,858
Risk Score	66.8
Risk Rating	Relatively Moderate

"Expo." = Exposure / "HLR" = Historic Loss Ratio / "EAL" = Expected Annual Loss

Vulnerability

There has been a trend toward higher temperatures that is expected to continue. As with drought, periods of high temperatures can cause decreased poultry and bovine production rates, which impact the economy of the community's large agricultural base.

More frequent and longer sub-zero stretches have been noted during the winter. These, coupled with concerns about utility failures, can disrupt agriculture, particularly with water supply disruption and with wind chill effects posing a risk to livestock and farmer health. Temperature extremes also pose significant problems for functional needs populations such as the elderly, the young, and the disabled. The primary general effects of extreme cold consist of water lines and mains freezing and breaking, disrupting the water supply; shutting down of rural bus lines due to safety risks for children; and school closings, most often due to wind chill concerns.

Vulnerability to temperature extremes is generally assessed on an individual basis, with the most vulnerable sections of our community's population having the greatest risk. These people may include the elderly, the very young, and the chronically ill. People from economically disadvantaged backgrounds, especially those listed in the categories above, are even more vulnerable since they are least able to afford the cost of adequate heating or air conditioning systems.

It should be noted that the propane shortage experience in primarily northern Wisconsin in the winter of 2012-13 highlighted issues with utility reliability. The workgroup recognized that utility failures will exacerbate both the likelihood of occurrence and the severity of effects of extreme temperature incidents.

Green Lake County social services agencies are aware of many of these people who reside in our communities, and they, along with the public health department, have plans and access to economic assistance programs to help these people in times of concern.

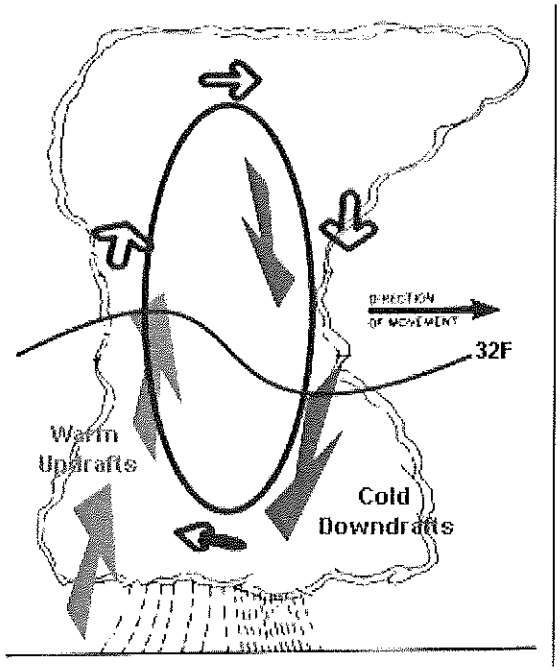
Hazard Mitigation Strategies

The goal of severe temperature mitigation activities is to reduce, in a cost-effective manner, the loss of lives and property due to these events. Temperature extremes are difficult for a community to mitigate, and the risks are to the health and safety of citizens, animals, and crops. There are no strategies that need to be employed to reduce damage to buildings and infrastructure, and the county and its municipalities will continue to monitor the impact of climate change on communities.

The Green Lake County Emergency Management Office participates in the statewide public information campaigns for Winter and Heat Awareness Weeks each year and provides links to personal preparedness information on its website. The county and its municipalities will also continue to prepare so that they can provide sheltering services to citizens in need during severe weather incidents.

Storms: Hail

Studies of thunderstorms indicate that two conditions are required for hail to develop: sufficiently strong and persistent updraft velocities and liquid water accumulated in a supercooled state in the upper parts of the storm. Hailstones are formed as water vapor in the warm surface layer rises quickly into the cold upper atmosphere. The water vapor is frozen and begins to fall; as the water falls, it accumulates more water vapor. This cycle continues until there is too much weight for the updraft to support, and the frozen water falls too quickly to the ground to melt along the way. The graphic below depicts hail formation: [141]



Injury and loss of life are rarely associated with hailstorms. However, extensive property damage is possible, especially to crops.

[141] NWS, January 10, 2003

Physical Characteristics

Hail may be spherical, conical, or irregular in shape and can range in size from barely visible to grapefruit-sized. Hailstones equal to or larger than a penny are considered severe.

Hail Size Estimates[142]	
Size	**Inches in Diameter**
Pea	1/4 inch
Marble/mothball	1/2 inch
Dime/Penny	3/4 inch
Nickel	7/8 inch
Quarter	1 inch
Ping-Pong Ball	1 1/2 inch
Golf Ball	1 3/4 inches
Tennis Ball	2 1/2 inches
Baseball	2 3/4 inches
Tea cup	3 inches
Grapefruit	4 inches
Softball	4 1/2 inches

Hail falls in swaths that can be from twenty to one hundred miles long and from five to thirty miles wide. A hail swath is not a large continuous path of hail but generally consists of a series of hail cells that are produced by individual thunderstorm clouds traveling in the same area.

Frequency of Occurrence

Hailstorms usually occur from May through August, and Wisconsin averages two or three hail days per year. Green Lake County has a high probability of hail occurrence in Wisconsin. The likelihood of damage due to hail for roofs, vehicles, and crops is considered medium. Over the past 25 years, hail has occurred 44 times for an average of between one and two times per year.

Most hail damage occurs in rural areas because maturing crops are particularly susceptible to bruising and other damage caused by hailstones. The four months of hailstorm activity correspond to the growing and harvesting seasons for most crops. A table showing

[142] NWS, January 10, 2003

the hail events recorded by the National Weather Service in Green Lake County[143] can be found in Appendix B.

It should be noted that the data represents only the hail incidents reported to the National Weather Service. One limitation of the source data is that it showed no property or crop loss, death, or injury, while it is likely that there was some loss incurred.

After a careful review of the data by the workgroup, it was believed that there has been more accurate record-keeping and recording since the 1990s, but that the table also shows an increasing frequency in the occurrence of hailstorms.

The University of Wisconsin-Madison, Nelson Institute for Environmental Studies/ Wisconsin DNR's Wisconsin Initiative on Climate Change Impacts[144] shows a scientific consensus that, "Wisconsin is likely to become a much warmer state over the next few decades...and...our state is also likely to become somewhat wetter, with a modest increase in total precipitation and in the number of intense rainfall events. The amount of climate change varies by season, with winter experiencing the greatest warming and most likely increase in precipitation." The site's information shows that Green Lake County is likely to experience warmer weather and an increase in precipitation for all four seasons of the year, with the greatest increases in winter and summer. This shows an increased likelihood of severe thunderstorms in spring, summer, and fall in Green Lake County. These thunderstorms generate hailstorms, which should also increase in frequency.

As noted earlier in this plan, the National Risk Index (NRI) tool [145] has been made available by the Federal Emergency Management Agency (FEMA). It calculates a baseline relative risk measurement for 18 natural hazards based on expected annual loss, social vulnerability, and community resilience. Below is data relevant to the hazard discussed in this chapter. It should be noted that the NRI information may not necessarily match the hazard ratings reached by the county and is only being included for reference.

Number of Events	133
Annualized Frequency	3.9
Expo. - Building Value ($)	7,556,668,010

[143] http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=55%2CWISCONSIN

[144] Trends and Projections | Wisconsin Initiative on Climate Change Impacts (WICCI)

[145] https://hazards.fema.gov/nri/map

Expo. - Population	18,977
Expo. - Population Equiv. ($)	220,133,200,000
Expo. - Agricultural Value ($)	103,951,226
Expo. - Total ($)	227,793,819,236
HLR - Overall Rating	Relatively High
EAL - Building Value ($)	781,116
EAL - Population	0
EAL - Population Equiv. ($)	24,485
EAL - Agricultural Value ($)	65,882
EAL - Total ($)	871,484
Risk Score	88.6
Risk Rating	Relatively Moderate

"Expo." = Exposure / "HLR" = Historic Loss Ratio / "EAL" = Expected Annual Loss

Vulnerability

Hail, typically occurring in conjunction with thunderstorms and lightning, can damage many types of infrastructure. Public and private vehicles (e.g., campers, boats, cars, trucks) are liable to have their windshields cracked, bodies dented, and paint damaged as a result of hail. This damage can occur, depending on the size of the hail, whether the vehicle is moving through the storm or is stationary. Hail on the roadway can also cause vehicles to slide off the road. Vehicle damage and iced roadways are of particular concern when you consider the need for emergency vehicles such as police cars, fire trucks, and ambulances to quickly move to assist victims in a disaster.

Hail can also damage critical infrastructure such as street signs, electric lines/poles/transformers, telephone lines and radio communication equipment. These pieces of infrastructure are

needed by both first response agencies and the general community to ensure safe transport, warm, safe homes, and good internal and external communications abilities.

Residential and business properties are liable to receive damage to signs, siding, billboards, trees, and windows. Manufactured housing is particularly vulnerable to damage due to its lower construction standards.

Hail can be particularly damaging to agricultural concerns, including farm buildings, standing crops, and livestock. As described previously, the agricultural sector is an important economic driver in Green Lake County. Hail is a localized phenomenon, and it would be difficult to estimate losses, but there have been four events ranging from $300 (2000) to $10,000 (1997) in crop loss, and the potential is much greater with over 75,000 acres in harvested cropland with an average value of $203.53 per acre.

Hazard Mitigation Strategies

The goal of mitigating hail is to reduce the amount of financial loss due to these incidents. Insurance is the most widely used adjustment for crop and property damages due to hail. Hail crop insurance is available from two sources: commercial stock and mutual companies, and the Federal Crop Insurance Corporation (FCIC). Farmers rarely purchase insurance coverage up to the full value of the losses that would result from a severe hailstorm. The County Extension Agent distributes information on various hail insurance options. In the event of major damage, a team composed of county and federal agricultural agency representatives and the County Emergency Management Director has primary responsibility for assessing and documenting hail damage.

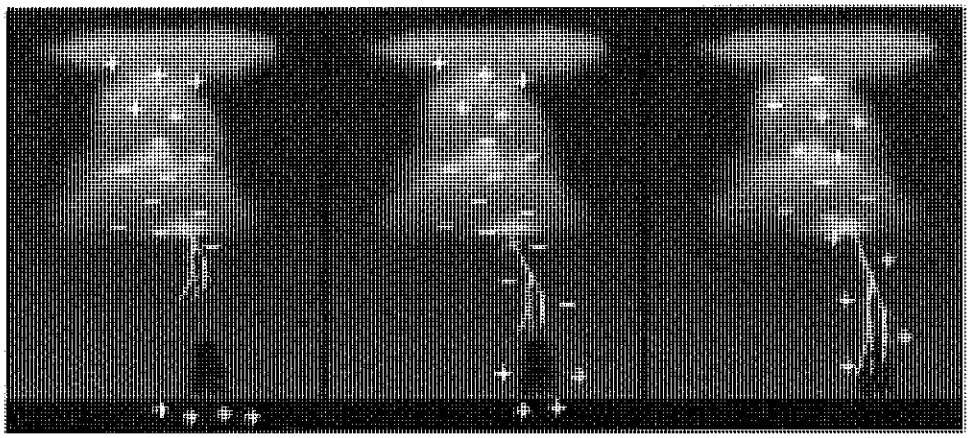
Green Lake County Emergency Management provides hail information to the public as part of the spring severe weather awareness week. The office also provides information about hail in displays in the courthouse and on the website. Federal emergency assistance is available in the form of low-interest loans when a Presidential Disaster is declared or when the FmHA declares that a county is eligible for aid. Damage from hailstorms alone is generally not extensive enough to invoke a disaster declaration.

The hazard mitigation strategies listed above primarily involve providing information on safety measures and insurance to the

public for agricultural concerns and residential and commercial structures. These measures provide basic safety information, but since there is little one can do to prevent hail damage, these measures will do little to reduce damage to existing or future buildings and infrastructure, although the recommended insurance may make recovery easier.

Storms: Lightning

Lightning is a phenomenon associated with thunderstorms; the action of rising and descending air separates and builds up positive and negative charge areas. When the built-up energy is discharged between the two areas, lightning is the result.[146]



Lightning may travel from cloud to cloud, cloud to ground, or if there are high structures involved, from ground to cloud.

Physical Characteristics

The temperatures in a lightning stroke rise to 50,000°F (Fahrenheit). The sudden and violent discharge, which occurs in the form of a lightning stroke, is over in one-millionth of a second.

Lightning damage occurs when humans and animals are electrocuted, fires are caused by a lightning stroke, materials are vaporized along the lightning path, or sudden power surges cause damage to electrical or electronic equipment. Lightning, an underestimated hazard, kills more people in an average year than do hurricanes or tornadoes.

[146] University Corporation for Atmospheric Research [UCAR]

Frequency of Occurrence

Nationwide, forty-five percent of the people killed by lightning have been outdoors, about sixteen percent were under trees, six percent were on heavy road equipment, and thirty-three percent were at various unknown locations. Less than ten percent of the deaths involved individuals inside buildings; these deaths were primarily due to lightning-caused fires.

Wisconsin has a high frequency of property losses due to lightning. Insurance records show that annually, one out of every fifty farms has been struck by lightning or had a fire, which may have been caused by lightning. Generally, rural fires are more destructive than urban fires because of limited lightning protection devices, isolation, longer response times, and inadequate water supplies. Green Lake County has a high probability of lightning occurrence at any one location within it. This was determined by recognizing that lightning usually happens in conjunction with thunderstorms, and that Wisconsin and Green Lake County generally have several severe thunderstorms per summer. The likelihood of damage due to lightning is considered medium.

A table showing the lightning events recorded by the National Weather Service (NWS) in Green Lake County[147] can be found in Appendix B. This table from the NWS is obviously not reporting all of the incidents of lightning strikes, but those with notable/reportable losses from the past, and can reasonably be inferred to show that there is exposure to potential future losses.

The University of Wisconsin-Madison, Nelson Institute for Environmental Studies/ Wisconsin DNR's Wisconsin Initiative on Climate Change Impacts[148] shows a scientific consensus that, "Wisconsin is likely to become a much warmer state over the next few decades...and...our state is also likely to become somewhat wetter, with a modest increase in total precipitation and in the number of intense rainfall events. The amount of climate change varies by season, with winter experiencing the greatest warming and most likely increase in precipitation." The site's information shows that Green Lake County is likely to experience warmer weather and an increase in precipitation for all four seasons of the year, with the greatest increases in winter and summer. This shows an increased likelihood of severe thunderstorms in spring, summer,

[147] http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=55%2CWISCONSIN
[148] Trends and Projections | Wisconsin Initiative on Climate Change Impacts (WICCI)

and fall in Green Lake County. Thunderstorms generate lightning, which should also increase in frequency.

As noted earlier in this plan, the National Risk Index (NRI) tool [149] has been made available by the Federal Emergency Management Agency (FEMA). It calculates a baseline relative risk measurement for 18 natural hazards based on expected annual loss, social vulnerability, and community resilience. Below is data relevant to the hazard discussed in this chapter. It should be noted that the NRI information may not necessarily match the hazard ratings reached by the county and is only being included for reference.

Number of Events	833
Annualized Frequency	37.8
Expo. - Building Value ($)	7,556,668,010
Expo. - Population	18,977
Expo. - Population Equiv. ($)	220,133,200,000
Expo. - Total ($)	227,689,868,010
HLR - Overall Rating	Relatively Moderate
EAL - Building Value ($)	12,607
EAL - Population	0
EAL - Population Equiv. ($)	42,541
EAL - Total ($)	55,148
Risk Score	35
Risk Rating	Relatively Low

"Expo." = Exposure / "HLR" = Historic Loss Ratio / "EAL" = Expected Annual Loss

Vulnerability

Lightning, which often occurs in conjunction with thunderstorms and hail, can damage many types of infrastructure, including electric lines/poles/transformers, telephone lines, and radio communication equipment. These pieces of infrastructure are needed by both first response agencies and the general community to ensure safe transport, warm, safe homes, and good internal and external communications abilities.

[149] https://hazards.fema.gov/nri/map

Residential and business properties are liable to receive damage either because of a lightning strike causing a fire or other type of direct damage, or by overloading electronic equipment (e.g., computers, televisions) that has not been properly connected to a surge protector. The latter concern is especially important to business and government, which in modern America rely on computers and other electronic equipment to manage the large amounts of data manipulated in our information-based economy.

Lightning can damage agricultural assets, including farm buildings, standing crops, and livestock. It is also one of the major sources of ignition for forest fires and wildfires.

Hazard Mitigation Strategies

The goal of lightning mitigation activities is to reduce, in a cost-effective manner, the loss of lives and property due to these events. The two primary ways to effectively reduce lightning losses are modifying human behavior and protecting structures (e.g., using fire-resistant materials in building construction).

The use of fire-resistant materials will make existing buildings and future construction less likely to catch fire or will minimize fire damage and spread due to lightning strikes. Surge protectors limit data losses. The 9-1-1 center was upgraded in 2023 to manage the surge. In 2010, the government center was built with back-up power, power surge, and grounding – these will be incorporated moving forward (i.e., if a new highway facility is built).

The Green Lake County Emergency Management Office has awareness and educational materials in a display rack and online that inform the public of safety procedures to follow during a lightning storm. Severe summer weather safety information is also emphasized during Tornado Awareness Week.

The City of Princeton is concerned about the effects of a lightning strike on its utility control (SCADA) system. This system is very old and can no longer be serviced because of its advanced age; its upgrade is on the capital improvement projects list. There may be other municipalities with similar concerns (e.g., the City of Berlin).

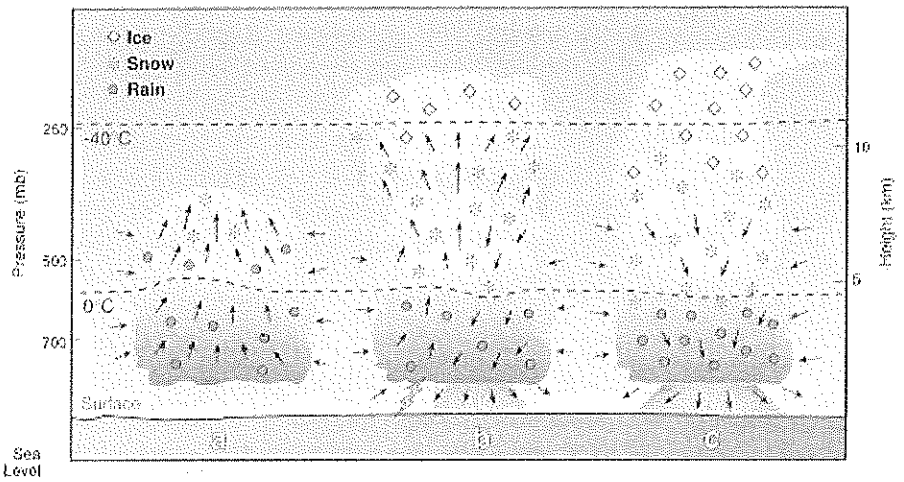
Storms: Thunderstorms

There are three distinct stages of development for thunderstorms (birth, growth, maturity), each of which can be seen in the following schematic. [150]

In the first stage of development, an updraft drives warm air up beyond condensation levels where clouds form.

The second stage of development occurs as levels of water vapor in the expanding cloud rise past saturation and the air cools sufficiently to form solid and liquid particles of water. At this point, rain or snow begins to fall within the cloud.

A thunderstorm's mature stage is marked by a transition of wind direction within the storm cells. The prevailing updraft, which initiated the cloud's growth, is joined by a downdraft generated by precipitation. Lightning may occur soon after precipitation begins. Hail and tornadoes may also develop during this stage.[151]



Physical Characteristics

A thunderstorm often is born, grows, reaches maturity, and dies in a thirty-minute period. The individual thunderstorm cell often travels between thirty and fifty miles per hour. Strong frontal systems may

[150] National Weather Service – Flagstaff, Arizona
[151] National Weather Service – Flagstaff, Arizona

create one squall line after another, each composed of many individual thunderstorm cells. These fronts can often be tracked across the state from west to east with a constant cycle of birth, growth, maturity, and death of individual thunderstorm cells.

Frequency of Occurrence

Thunderstorm frequency is measured as the number of days per year with one or more incidents. There are approximately 100,000 thunderstorms in the United States every year, and approximately 10% of those are considered severe (i.e., have at least ¾" hail, winds of at least 58 mph, or a tornado). Most Wisconsin counties, including Green Lake County, average between 30 and 40 thunderstorm days per year, although a portion of southwestern and south-central Wisconsin average 40 to 50 thunderstorm days per year. In Green Lake County, there are typically several severe thunderstorms per year. Thunderstorms can occur throughout the year, with the highest frequency during the months of May through September. Most storms occur between the hours of noon and midnight.

The probability of severe thunderstorms occurring in Green Lake County is high, as these storms usually occur one or more times annually during the summer in Green Lake County. The severity of effects in thunderstorms is considered medium. Damage from thunderstorms usually is a result of the hail, lightning, winds, and/or flash flooding that can occur as part of the storm. The likelihood of damage from these causes is also discussed in the appropriate chapters.

The University of Wisconsin-Madison, Nelson Institute for Environmental Studies/ Wisconsin DNR's Wisconsin Initiative on Climate Change Impacts[152] shows a scientific consensus that, "Wisconsin is likely to become a much warmer state over the next few decades...and...our state is also likely to become somewhat wetter, with a modest increase in total precipitation and in the number of intense rainfall events. The amount of climate change varies by season, with winter experiencing the greatest warming and most likely increase in precipitation." The site's information shows that Green Lake County is likely to experience warmer weather and an increase in precipitation for all four seasons of the year, with the greatest increases in winter and summer. This shows

[152] Trends and Projections | Wisconsin Initiative on Climate Change Impacts (WICCI)

an increased likelihood of severe thunderstorms in spring, summer, and fall in Green Lake County. Thunderstorms can generate lightning, hail, tornadoes, and strong winds, which should also increase in frequency.

Tables showing the thunderstorm events that have been recorded in Green Lake County by the National Weather Service in Green Lake County[153] can be found in Appendix B.

Vulnerability

Thunderstorms, which often produce hail and lightning and may occasionally spawn tornadoes, high windstorms, or flash flooding, can damage many types of infrastructure. Green Lake County's thunderstorm vulnerabilities due to associated hail, lightning, winds, and flood waters are discussed in the other hazard chapters of this plan.

Hazard Mitigation Strategies

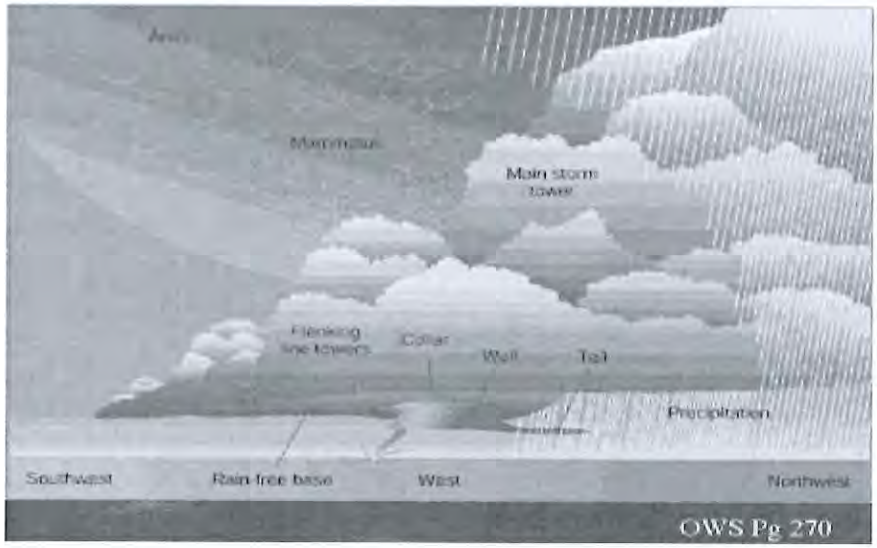
The goal of thunderstorm mitigation activities is to reduce, in a cost-effective manner, the loss of lives and property due to these events. The Green Lake County Emergency Management Office has developed severe weather safety information that it disseminates to the public. During Tornado Awareness Week, there is extensive media coverage of safety tips. Additionally, the department assists the National Weather Service (NWS) in conducting tornado spotter training programs and in organizing local tornado spotter networks. The communities would also like to work with their special events fair/festival boards, as requested, to create emergency plans in case of bad weather. Emergency Management regularly works with the county fair board and other large events. In 2022, they completed a plan with the Sheriff's Department for the fairgrounds.

The damage to buildings and infrastructure in a thunderstorm is generally caused by components of the storm, such as hail, flooding, lightning, or wind. A discussion of strategies to reduce effects on existing and future buildings and infrastructure is discussed in the chapters that discuss each of these components in detail.

[153] http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=55%2CWISCONSIN

Storms: Tornadoes and High Winds

A tornado is a violently rotating funnel-shaped column of air. The lower end of the column may or may not touch the ground. Average winds in the tornado are between 173 and 250 miles per hour, but winds can exceed 300 miles per hour. It should also be noted that straight-line winds may reach the same speeds and achieve the same destructive force as a tornado.

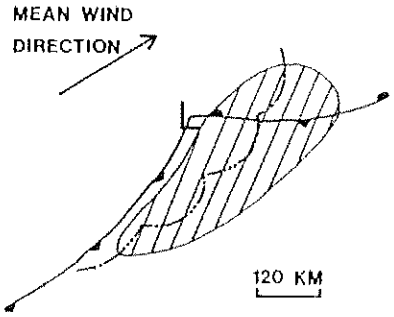


A derecho is a widespread, long-lived, violent, convectively induced straight-line windstorm that is associated with a fast-moving band of severe thunderstorms usually taking the form of a bow echo. Derechos blow in the direction of movement of their associated storms; this is similar to a gust front except that the wind is sustained and generally increases in strength behind the "gust" front. A warm weather phenomenon, derechos occur mostly in summer, especially July, in the northern hemisphere. They can occur at any time of the year and occur as frequently at night as in the daylight hours.

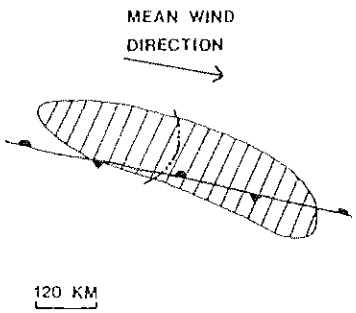
The traditional criteria that distinguish a derecho from a severe thunderstorm are *sustained* winds of 58 mph during the storm as opposed to gusts, high and/or rapidly increasing forward speed, and geographic extent (typically 250 nautical miles in length). In addition, they have a distinctive appearance on radar (bow echo); several unique features, such as the rear inflow notch and bookend

vortex and usually manifest two or more downbursts. There are four types of derechos:[154]

- Serial: Multiple bow echoes embedded in a massive squall line, typically around 250 miles long. This type of derecho is usually associated with a very deep low. Also, because of embedded supercells, tornadoes can easily spin out of these types of derechos.
- Progressive: A small line of thunderstorms takes the bow shape and can travel for hundreds of miles.
- Hybrid: Has characteristics of a serial and progressive derechos. Hybrid derechos are associated with a deep low like serial derechos, but are relatively small in size like progressive derechos.
- Low Dewpoint: Occurs in an environment of comparatively limited low-level moisture, with appreciable moisture confined to the mid-levels of the atmosphere.



Serial Derecho



Progressive Derecho

Physical Characteristics

Tornadoes are visible because low atmospheric pressure in the vortex leads to cooling of the air by expansion and to condensation and formation of water droplets. They are also visible as a result of the airborne debris and dust in its high winds. Wind and pressure differential are believed to account for ninety percent of tornado damage in most cases. Because tornadoes are associated with

[154] http://en.wikipedia.org/wiki/Derecho

storm systems, they are usually accompanied by hail, torrential rain, and intense lightning.

Tornadoes typically produce damage in an area that does not exceed one-fourth mile in width or sixteen miles in length. Tornadoes with track lengths greater than 150 miles have been reported, although such tornadoes are rare.

Tornado damage severity is measured by the Fujita Tornado Scale, which assigns an "F" ("Fujita") value from 0 – 5 to denote the wind speed.

The Fujita Tornado Scale[155]		
Category	**Wind Speed**	**Description of Damage**
F0	40-72 mph	Light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
F1	73-112 mph	Moderate damage. The lower limit is the beginning of hurricane speed. Roof surfaces peeled off; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
F2	113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
F3	158-206 mph	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.
F4	207-260 mph	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off; cars thrown and large missiles generated.
F5	261-318 mph	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized missiles fly through the air in excess of 100-yards; trees debarked.

On 1 February 2007, the National Weather Service began rating tornadoes using the EF-scale. It is considerably more complicated than the F-scale, and it will allow surveyors to create more precise assessments of tornado severity. Below is a comparison between the Fujita Scale and the EF Scale:

Fujita Scale			Derived EF Scale		Operational EF Scale	
F Number	**Fastest ¼ 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

[155] FEMA, 1997

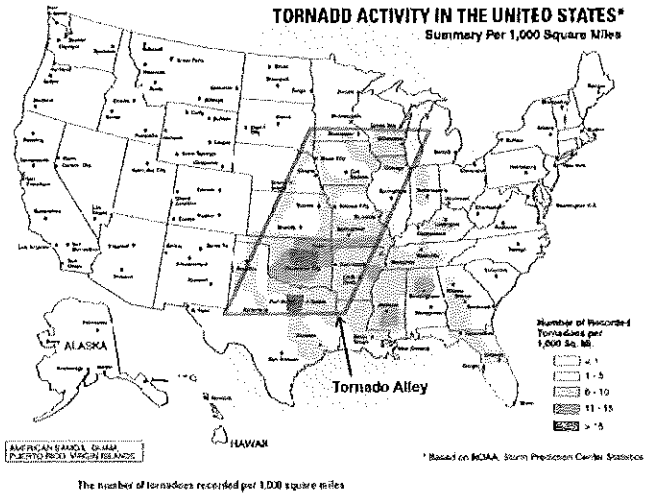
Downburst Characteristics

Downburst damage is often highly localized but resembles damage caused by a tornado. In some cases, even an experienced investigator cannot identify the nature of a storm without mapping the direction of the damaging winds over a large area. There are significant interactions between tornadoes and nearby downbursts.

A classic downburst example occurred on 4 July 1977 [156] when a severe thunderstorm moved across Northern Wisconsin. Extensive areas of tree and property damage, somewhat like a tornado, were reported. After an aerial survey was completed to map both direction and F-scale intensity of the damaging winds, it was determined that no evidence of a tornado was found anywhere within the path of the damage swath, which was 166 miles long and 17 miles wide. The survey revealed that there were scattered local centers from which straight-line winds diverged outward. These local wind systems were identified as downbursts with at least 25 specific locations recognized by the low-flying aircraft.

Frequency of Occurrence

Wisconsin lies along the northern edge of the nation's tornado belt, which extends northeastward from Oklahoma into Iowa and across to Michigan and Ohio. Winter, spring, and fall tornadoes are more likely to occur in southern Wisconsin, which includes Green Lake County, than in northern counties.



The number of tornadoes recorded per 1,000 square miles

[156] https://www.spc.noaa.gov/misc/AbtDerechos/casepages/jul41977page.htm

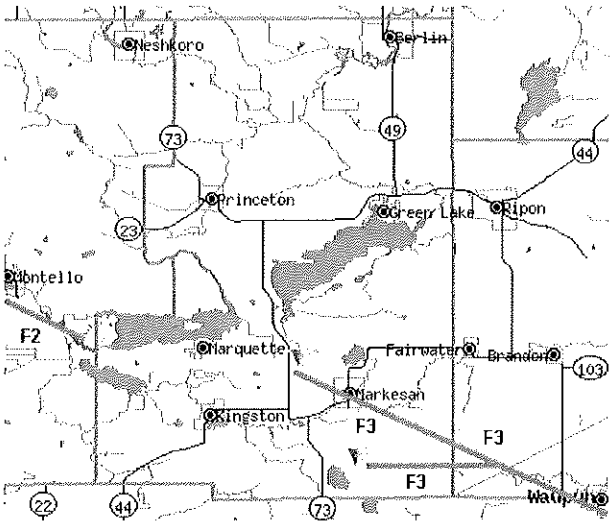
Wisconsin's tornado season runs from the beginning of April through September, with the most severe tornadoes typically occurring in April, May, and June. Tornadoes have, however, occurred in Wisconsin during every month of the year. Many tornadoes strike in late afternoon or early evening, but they do occur at other times. Deaths, injuries, and personal property damage have occurred and will continue to occur in Wisconsin.

Tables showing the frequency of high winds, funnel clouds, and tornadoes as reported by the National Weather Service can be found in Appendix B.[157] There have been seven funnel clouds and 18 tornadoes reported for the county over the past 25 years, for an average of less than one per year. The probability of Green Lake County being struck by a tornado in the future is high, and the likelihood of damage from future tornadoes is very high. The probability of high wind (derecho) is high, and the likelihood of damage is high. All parts of Green Lake County are equally susceptible to tornadoes and high winds.

Two of the State of Wisconsin's most notable tornadoes occurred in Green Lake County[158]:

- "On April 3, 1956, a tornado struck the southeast sector of the City of Berlin, Green Lake County, at approximately 1:40 p.m. after damaging at least three farms south and west of the city. It came within a few yards of the high school where 400 students were in class. The terrified students watched the tornado churn towards the high school, but the twister veered to the right, barely missing the school. Witnesses saw cars and buildings lifted and carried through the air. The tornado killed 7 people and injured 50. Damage was estimated at more than $1 million."
- On June 23, 2004, two F3 tornadoes merged and struck Green Lake, Fond du Lac, and Dodge Counties, causing $20 million in damages and killing one person. A map of the tornado paths in Green Lake County and a photograph of sample damage follow:[159]

[157] http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=55%2CWISCONSIN
[158] Wisconsin State Hazard Mitigation Plan, v 2008, pp 4-50 through 4-52
[159] http://www.crh.noaa.gov/mkx/document/tor/062304.php



The University of Wisconsin-Madison, Nelson Institute for Environmental Studies/ Wisconsin DNR's Wisconsin Initiative on Climate Change Impacts[160] shows a scientific consensus that, "Wisconsin is likely to become a much warmer state over the next few decades...and...our state is also likely to become somewhat wetter, with a modest increase in total precipitation and in the number of intense rainfall events. The amount of climate change varies by season, with winter experiencing the greatest warming and most likely increase in precipitation." The site's information shows that Green Lake County is likely to experience warmer weather and an increase in precipitation for all four seasons of the

[160] Trends and Projections | Wisconsin Initiative on Climate Change Impacts (WICCI)

year, with the greatest increases in winter and summer. This shows an increased likelihood of severe thunderstorms in spring, summer, and fall in Green Lake County. Extra atmospheric energy can increase the frequency and intensity of the severe thunderstorms that generate tornadoes and strong winds.

As noted earlier in this plan, the National Risk Index (NRI) tool [161] has been made available by the Federal Emergency Management Agency (FEMA). It calculates a baseline relative risk measurement for 18 natural hazards based on expected annual loss, social vulnerability, and community resilience. Below is data relevant to the hazard discussed in this chapter. It should be noted that the NRI information may not necessarily match the hazard ratings reached by the county and is only being included for reference.

(Tornadoes)

Number of Events	39
Annualized Frequency	0.3
Expo. - Building Value ($)	7,556,668,010
Expo. - Population	18,977
Expo. - Agricultural Value ($)	103,951,226
Expo. - Population Equiv. ($)	220,133,200,000
Expo. - Total ($)	227,793,819,236
HLR - Overall Rating	Relatively High
EAL - Building Value ($)	1,194,649
EAL - Population	0.07
EAL - Agricultural Value ($)	18,039
EAL - Population Equiv. ($)	774,506
EAL - Total ($)	1,987,194
Risk Score	70.1
Risk Rating	Relatively Moderate

"Expo." = Exposure / "HLR" = Historic Loss Ratio / "EAL" = Expected Annual Loss

(Strong Winds)

Number of Events	132
Annualized Frequency	3.9

[161] https://hazards.fema.gov/nri/map

Expo. - Building Value ($)	7,556,668,010
Expo. - Population	18,977
Expo. - Population Equiv. ($)	220,133,200,000
Expo. - Agricultural Value ($)	103,951,226
Expo. - Total ($)	227,793,819,236
HLR - Overall Rating	Relatively Moderate
EAL - Building Value ($)	525,570
EAL - Population	0.02
EAL - Population Equiv. ($)	179,990
EAL - Agricultural Value ($)	65,691
EAL - Total ($)	771,250
Risk Score	77.4
Risk Rating	Relatively Moderate

"Expo." = Exposure / "HLR" = Historic Loss Ratio / "EAL" = Expected Annual Loss

Vulnerability

Injury to people is a primary concern in tornado and high wind events. Two of the highest risk places are mobile home parks and campgrounds; Green Lake County has several of each type of property. Both have high concentrations of people in a small area, generally have structures that provide less protection than standard construction homes, and generally do not provide storm shelters. Other places of concern during these types of events include critical emergency facilities such as hospitals and public works/highway garages, police stations, and fire departments, which contain equipment and services needed by the public after a tornado.

Mobile Home Parks [162]

Park Name	Location
Markesan Mobile Home Park	Markesan
Grand Fox Mobile Home Court	Markesan

162 https://www.mobilehome.net/mobile-home-park-directory/wisconsin/county/green-lake-county
https://dsps.wi.gov/Credentialing/ManufacturedHomes/Park%20Table%2001232018.pdf

Lamplighter	Green Lake
Coachlite Mobile Home Park	Green Lake
Pine View Estates	Princeton
Welks Landing	Markesan
Rivers End Resort	Markesan
Sadie Hawk Mobile Home Court	Green Lake
Shady Oaks Trailer & Lock LLC	Markesan

Campgrounds [163] [164] [165]

Campground Name	Location
Shady Oaks Campground	Markesan
Riverside Park	Berlin
Grand Valley Campground	Kingston
Green Lake Campground	Green Lake
Lake Arrowhead Campground	Montello
Hattie Sherwood Campground	Green Lake
Green Lake Conference Center	Green Lake
Cahoon's Resort	Marquette

Schools, in addition to holding children, are the major type of structure used as community disaster shelters, and their loss might therefore affect the community on several levels (e.g., the death or injury of children, the loss of a community housing shelter). School gymnasiums are often the specific location of the community shelter, but they are especially vulnerable in tornadoes because the large-span roof structure is often not adequately supported.

163 http://www.glcountry.com/lodging/campgrounds/
164 https://www.visitgreenlake.com/lodging/campgrounds/
165 http://www.wisconline.com/cgi-bin/aaw_campgroundsearch.pl (now archived)

Community infrastructure such as power lines, telephone lines, radio towers, and street signs is often vulnerable to damage from tornadoes and high winds and can be expensive to replace. The loss of radio towers that hold public safety communications repeaters can adversely impact the ability of first responders to mount an effective response; damage to towers that hold public media equipment may adversely impact the ability to distribute adequate public information.

Residential property is likely to have siding and roofing materials removed, windows broken from flying debris, and garages blown down due to light construction techniques. Perhaps one of the largest types of loss on private property is due to tree damage, which is generally not covered by federal disaster assistance.

Business properties are at risk of having damage to infrastructure, including signs, windows, siding, and billboards. Agricultural buildings, such as barns and silos, are also generally not constructed in a manner that makes them wind resistant, which can lead to the loss of livestock and harvest. Standing crops are also at risk from high winds and tornadoes.

Hazard Mitigation Strategies

The goal of tornado and high wind mitigation activities is to reduce, in a cost-effective manner, the loss of lives and property due to these events. Green Lake County has a history of damage to buildings and infrastructure due to tornadoes and high winds. Some strategies below will deal with public information, alert, and notification, while others will enable the community to make current and future buildings and infrastructure more disaster-resistant by enacting more "bricks and mortar" solutions.

An effective warning system is the single most important resource for alerting the public to a tornado hazard, which is critical to the main goal of saving lives and reducing property losses. Forecasting of tornadoes is difficult, however, because of the suddenness of their onset, their relatively short duration, the extreme variability of a tornado striking area, limited knowledge of tornado dynamics, and the limitations of the weather observation system. Tornado sirens are municipally owned and maintained in Green Lake County, although some are activated by the county. The Emergency Management Office promotes the use of NOAA weather radios for

public alert and notification. The office also continues to evaluate various technologies to determine if they can be effectively integrated into the county's alert and notification systems.

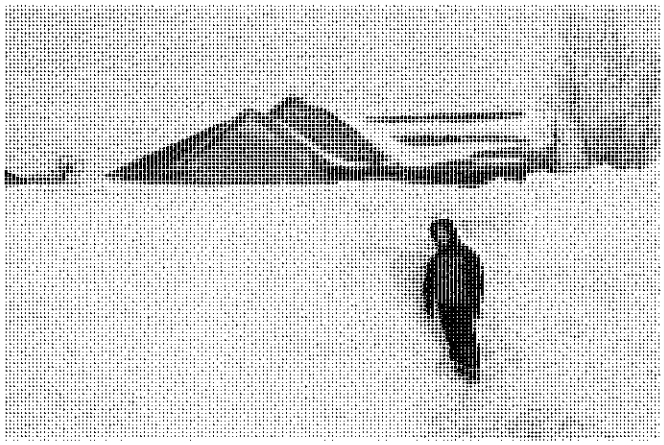
During the past several years, there has been a statewide Tornado Awareness Week in late March or April. Media information packets are distributed to reemphasize and alert the public to tornado warning procedures. Green Lake County and many of the municipalities actively promote tornado safety public information as well as other summer severe weather public awareness and educational efforts, including applicable links on the county website. Green Lake County also assists the National Weather Service with sponsoring tornado spotter training and in organizing local tornado spotter networks.

The mitigation planning workgroup recognizes that mobile home parks and campgrounds are particularly vulnerable locations for people and property during a tornado. To help mitigate the danger, communities are considering projects that include:

- Green Lake County: Exploring the feasibility of increasing the wind resistance of the roofs of community storm shelters.
- Green Lake County and the City of Markesan: Exploring the feasibility of constructing tornado shelters in areas where deficient, especially in mobile home parks and/or campgrounds. The U. S. Department of Commerce Community Development Block Grants may be an avenue to achieve the necessary funding.

Storms: Winter

Due to its position along the northern edge of the United States, Wisconsin, including Green Lake County, is highly susceptible to a variety of winter weather storm phenomena.



Picture of snow drifts after the "Groundhog Day Blizzard" in 2011.

Physical Characteristics

The National Weather Service descriptions of winter storm elements are:

- Heavy snowfall - Accumulation of six or more inches of snow in a 12-hour period or eight or more inches in a 24-hour period.
- Blizzard - An occurrence of sustained wind speeds in excess of 35 miles per hour (mph) accompanied by heavy snowfall or large amounts of blowing or drifting snow.
- Ice storm - An occurrence of rain falling 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 with 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 incorporates the combined effect of wind and low air temperatures on exposed skin.

In October 2024, the National Weather Service simplified its cold-weather forecast products[166] to improve the messaging of winter hazards and provide better decision support. They noted that *"These changes seek to clarify that cold can be dangerous with or without wind, addressing a common misconception that extreme cold is only tied to colder temperatures when there is wind. Dangerously cold weather can accompany or follow wintry precipitation, and the cold messaging can be overshadowed by the wintry precipitation."*

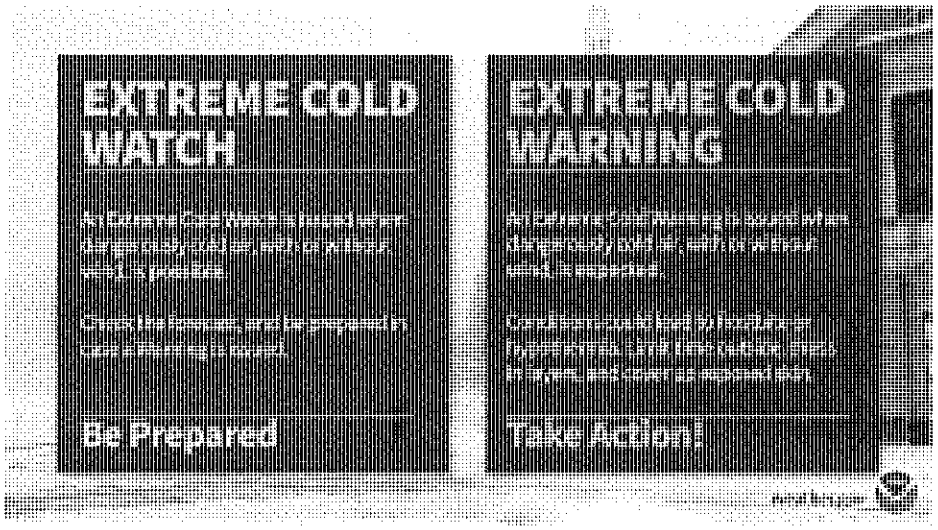
Extreme Cold Consolidation and Renaming

- Wind Chill Watches renamed to Extreme Cold Watch
- Wind Chill Warnings renamed to Extreme Cold Warning
- Wind Chill Advisory renamed a Cold Weather Advisory

Freeze Consolidation

- Hard Freeze Watches renamed to Freeze Watch
- Hard Freeze Warnings consolidated to Freeze Warning

[166] https://www.weather.gov/news/243009-cold-hazard-simplification



In Wisconsin, the winter storm season generally runs from November through March, and Wisconsin residents are most familiar with heavy snowstorms, blizzards, sleet, and ice storms. Most Wisconsin snowfalls are between one and three inches per occurrence, although heavy snowfalls that produce at least ten inches may occur four or five times per season. Northwestern Wisconsin encounters more blizzards than the southeastern portions of the state.

Damage from ice storms can occur when more than half an inch of rain freezes on trees and utility wires, especially if the rain is accompanied by high winds. Another danger comes from the accumulation of frozen rain pellets on the ground during a sleet storm, which can make driving hazardous.

Frequency of Occurrence

Annual snowfall in Wisconsin varies between thirty inches in southern counties to one hundred inches in the north. Green Lake County averages approximately 42 inches of snow annually. Storm tracks originating in the southern Rockies or Plains states that move northeastward produce the heaviest precipitation, usually six to twelve inches. Low-pressure systems originating in the northwest (Alberta) tend to produce only light snowfalls of two to four inches. Snowfalls associated with Alberta lows occur more frequently with colder weather.

Although massive blizzards are rare in Wisconsin, blizzard-like conditions often exist during heavy snowstorms when gusty winds cause blowing and drifting of snow. For example, blizzard conditions existed in Wisconsin in February 2011 when record snowfalls were recorded in many areas and very strong northeast winds were gusting from 45 to 60 mph for an extended period of time. Green Lake County received from seven to fifteen inches of snow over this three-day storm. It should be noted that there were two additional large snowstorms that occurred in late February and late March of 2011.[167]

Both ice and sleet storms can occur at any time throughout the winter season, from November to April. Ice storms of disastrous proportions occurred in central Wisconsin in February 1922 and in southern Wisconsin in March 1976. A Presidential Disaster Declaration occurred because of the 1976 storm. Utility crews from surrounding states were called in to restore power, which was off for up to ten days in some areas. Other storms of lesser magnitude caused power outages and treacherous highway conditions.

Tables showing winter storm statistics as reported by the National Weather Service can be found in Appendix B.[168] The tables show that there is little property damage, but this does not take into account the public costs of managing the snow and ice, as well as the costs of managing utility repairs to power, telephone, and water lines. There have been three recorded blizzard events for the county over the past 25 years.

The probability that there will be severe winter storms in Green Lake County is high, and the likelihood that those storms will cause significant damage is high for both snow and ice.

The University of Wisconsin-Madison, Nelson Institute for Environmental Studies/ Wisconsin DNR's Wisconsin Initiative on Climate Change Impacts[169] shows a scientific consensus that, "Wisconsin is likely to become a much warmer state over the next few decades...and...our state is also likely to become somewhat wetter, with a modest increase in total precipitation and in the number of intense rainfall events. The amount of climate change varies by season, with winter experiencing the greatest warming

[167] http://readywisconsin.wi.gov/news/Top%20Weather%20Events%20in%20Wisconsin%20for%202011.pdf and http://www.crh.noaa.gov/mkx/?n=020211_blizzard

[168] http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=55%2CWISCONSIN

[169] Trends and Projections | Wisconsin Initiative on Climate Change Impacts (WICCI)

and most likely increase in precipitation." The site's information shows that Green Lake County is likely to experience warmer weather and an increase in precipitation for all four seasons of the year, with the greatest increases in winter and summer. This shows a decreased likelihood of severe winter storms in Green Lake County. It should be noted that this change does not mean that Green Lake County is unlikely to have freezing weather. Instead, it is more likely that the additional atmospheric moisture forecasted will fall as freezing rain, sleet, and ice instead of as snow.

As noted earlier in this plan, the National Risk Index (NRI) tool [170] has been made available by the Federal Emergency Management Agency (FEMA). It calculates a baseline relative risk measurement for 18 natural hazards based on expected annual loss, social vulnerability, and community resilience. Below is data relevant to the hazard discussed in this chapter. It should be noted that the NRI information may not necessarily match the hazard ratings reached by the county and is only being included for reference.

(Winter Weather)

Number of Events	55
Annualized Frequency	3.4
Expo. - Building Value ($)	7,556,668,010
Expo. - Population	18,977
Expo. - Agricultural Value ($)	103,951,226
Expo. - Population Equiv. ($)	220,133,200,000
Expo. - Total ($)	227,793,819,236
HLR - Overall Rating	Relatively Low
EAL - Building Value ($)	1,373
EAL - Population	0
EAL - Agricultural Value ($)	410
EAL - Population Equiv. ($)	32,051
EAL - Total ($)	33,834
Risk Score	42.2
Risk Rating	Relatively Low

"Expo." = Exposure / "HLR" = Historic Loss Ratio / "EAL" = Expected Annual Loss

[170] https://hazards.fema.gov/nri/map

(Ice Storms)

Number of Events	17
Annualized Frequency	0.2
Expo. - Building Value ($)	7,546,861,509
Expo. - Population	18,937.93
Expo. - Population Equiv. ($)	219,679,995,513
Expo. - Total ($)	227,226,857,023
HLR - Overall Rating	Relatively Low
EAL - Building Value ($)	4,530
EAL - Population	0
EAL - Population Equiv. ($)	27,878
EAL - Total ($)	32,408
Risk Score	39.5
Risk Rating	Relatively Low

"Expo." = Exposure / "HLR" = Historic Loss Ratio / "EAL" = Expected Annual Loss

Vulnerability

Winter storms present a serious threat to the health and safety of affected citizens and can result in significant damage to property. Heavy snow or accumulated ice can cause the structural collapse of homes, commercial buildings, and agricultural structures; down power lines or isolate people from assistance or services by impeding transportation by the public, emergency responders, and public transportation resources.

The loss of electrical service and/or the blocking of transportation routes can adversely affect the ability of commercial enterprises to conduct business. This economic injury may be felt by both the business owner and employees, unable to work during this period.

Hazard Mitigation Strategies

The goal of winter storm mitigation activities is to reduce, in a cost-effective manner, the loss of lives and property due to these events. Communities prepare for severe winter weather by ensuring that plowing and sanding equipment is operational and available to

handle potential emergencies. Funding is budgeted for the overtime hours of extra personnel, but in a large emergency, this may not be adequate. Redundant communication modes (e.g., radio, telephone) exist between government, police, fire, EMS, hospitals, and highway departments. The Green Lake County Emergency Operations Plan provides for the coordination of public safety support agencies such as the American Red Cross and for resource acquisitions during winter emergencies.

Winter safety information is prepared and distributed to the media and the public by the Green Lake County Emergency Management Office and some of its municipal partners during Winter Awareness Week in November. Preparedness information is also available from display racks in the courthouse and the website. During a storm, the public is advised to monitor local radio, television, and NOAA weather alert radios for up-to-date forecasts.

The hazard mitigation strategies listed above primarily involve providing information on general safety measures to the public. These measures provide basic safety information, but since the response to winter storms is primarily a government and/or corporate function comprised of tasks such as clearing roads of snow and ice and repairing downed utility lines, there are few measures that can be employed to reduce damages to existing or future buildings and infrastructure.

Utility Failure

A utility emergency is a disruption to the building services, usually defined as electrical power, water, natural gas, and/or sewage that restricts the ability of people to safely occupy the facility. Electrical power or natural gas outages are often caused by a fuel shortage caused by an oil embargo, power failure, or natural disaster. Disruptions to the water and sewage systems are often the direct result of a natural disaster (e.g., flooding) or are indirect losses due to another failure (e.g., a power outage disrupts the pumping of water and/or sewage).

Physical Characteristics

Modern society is very dependent on electrical power for normal living and is therefore quite disrupted by the loss of power. Most power outages last about fifteen minutes to one hour. If longer, the utilities will inform the local news media of the anticipated duration of the outage. Most of Green Lake County is served by Alliant Energy.

Thunderstorms with lightning are a possible cause of power failure. Fuel shortages can be caused by localized imbalances in supply. Labor strikes, severe cold weather, or snowstorms can also cause a local shortage.

Rural residents usually heat their homes with propane. During the winter of 2014, there was a propane shortage due to five factors:

1. An increase in the amount of propane used to dry corn due to a late crop harvest, coinciding with heavy rains, depleted supplies last fall.
2. From November 28 to December 18, a major pipeline supplying propane to Wisconsin, Minnesota, and Iowa was temporarily closed for maintenance.
3. Colder-than-normal winter temperatures.
4. An increase in exports of propane.
5. Constrained rail service.

On January 25, 2014, the Governor declared a state of emergency in response to the shortage, and the state provided an estimated $31.2 million in funding to residents of Burnett, Polk, and Washburn Counties. During this period, suppliers were rationing propane, forcing people to use alternative heat sources, which can cause carbon monoxide poisoning or may lead to fires.

Thunderstorms with lightning are a possible cause of power failure. Fuel shortages can be caused by localized imbalances in supply. Labor strikes, severe cold weather, or snowstorms can also cause a local shortage.

The water and sewage systems are most often a function of a municipal system and are usually found in more urbanized areas. Rural water is often provided by individual wells found on each property, and sewage is managed by a septic system, also found on each individual property. Both municipal and individual systems are vulnerable to flooding, which can overwhelm the sewage systems and contaminate both municipal and private wells. Both types of systems are also vulnerable to electrical power loss because the electrical system powers the pumps and lift stations that move and treat the water and sewage.

Frequency of Occurrence

Green Lake County has short power outages (i.e., lasting less than six hours) per year but does not have a history of extended power outages. The possibility always exists that a man-made or natural disaster could affect the power system for an extended period of time.

In general, Green Lake County has a high likelihood of utility failures with a high risk of death or injury due to a loss, and a high risk of damage to infrastructure. Obviously, power outages are more likely to occur, and the severity is greater in areas of higher human population (i.e., urban areas) but the loss of power to rural customers, while affecting fewer people, generally lasts longer and can be as life-threatening, especially if a person with functional or access needs (e.g., the elderly, the young, those on special medical equipment) is involved.

Vulnerability

The failure of a utility to function can have a wide-ranging impact in Green Lake County. People, especially those with functional and access needs, in residential properties may not be able to safely live in their homes because of inadequate heat, the inability to cook, the inability to manage waste, etc. Businesses, including the utilities themselves, may lose money due to the inability to produce goods and services for which they can bill, and they may be non-operational due to damaged infrastructure, which can be very expensive to replace and/or repair. Critical infrastructure such as hospitals, schools, and governmental facilities may not be able to operate or may have to operate at a reduced capacity due to the loss of utility services. Facilities with hazardous materials that are required to report under the Emergency Planning and Community Right-to-Know Act (EPCRA) may not be able to adequately control and contain their chemicals, and there may be a release of hazardous materials that can impact people or the environment.

Agricultural assets may be impacted by the loss of utilities because animals require fresh water, extreme temperatures reduce the production volume of products such as milk, and may not be able to be properly stored. Modern farms also require a large amount of automation for feeding, watering, and managing the wastes of the facility.

Finally, transportation on roadways may become unsafe due to the loss of directional and streetlights.

Hazard Mitigation Strategies

The goal of utility failure mitigation activities is to reduce, in a cost-effective manner, the loss of lives and property due to these events. Green Lake County has worked directly with the utility companies and emergency management responders in formulating emergency management plans. During a fuel or power shortage, residents, schools, industry, and businesses will be asked to take measures to conserve fuel. If the fuel shortage reaches a critical stage, all non-essential facilities will be closed, and contingency plans will be activated.

In the event of a prolonged power outage, Green Lake County has generators available to provide power for radio communication and EOC operation. Evacuation and shelter arrangements have been prepared in case of a severe power outage. It should be noted that schools are often top choices as community disaster shelters, but few of the county's schools have backup generators. They have some emergency power to run minimal lighting (e.g., "EXIT" lights) in the pre-identified shelters, but this would not be adequate for long-term operations. The Green Lake County Emergency Management Office would like to complete a feasibility study (including a cost-benefit analysis) to selectively upgrade shelter facilities and/or facilities that would host mass clinics and other emergency centers for electricity needs.

Other projects that are being considered:

- City Markesan
    - There are 3 lift-station locations, none of which have generator backup. The city would like to install three permanent generators. There are external panels at each of the lift stations, but permanent generators were not obtained during the last plan period.
    - Install backup power at wells to have backup power to the well in the city for fire suppression.
    - Install backup power at the water tower to have backup power for the towers. The towers control the pumps under emergency conditions, and also our SCADA system for the water and sewer systems.
- City of Berlin

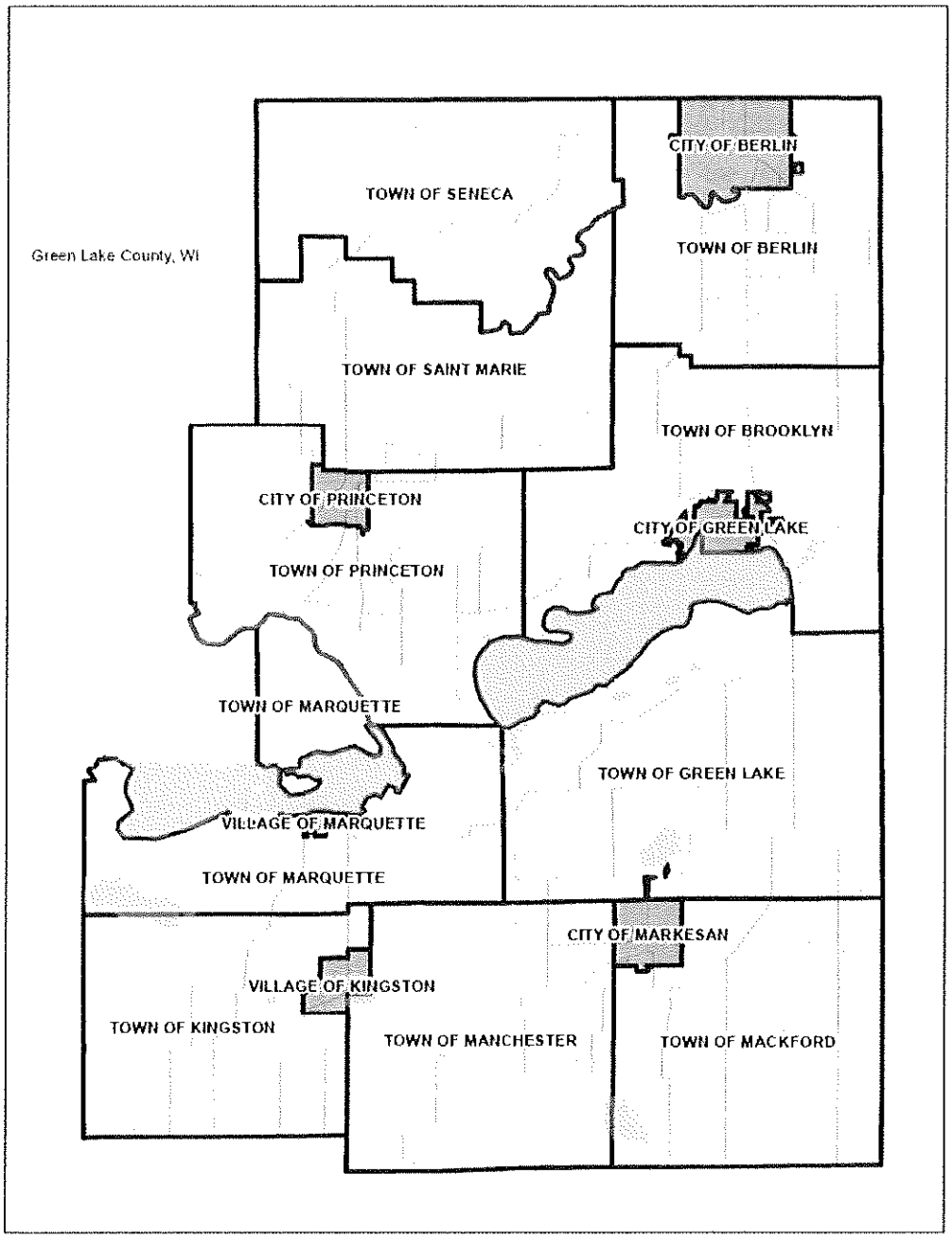
- Install backup power at Well # 5 to have backup power to more than one well in the city (Berlin has three wells). They would like a permanent generator for at least one well.
- Install backup power at water towers to have backup power to the towers. The towers control the pumps under emergency conditions, and our supervisory control and data acquisition (SCADA) system for the water and sewer systems.
- Provide and install a permanent backup generator at Cumberland Street.

- Village of Kingston

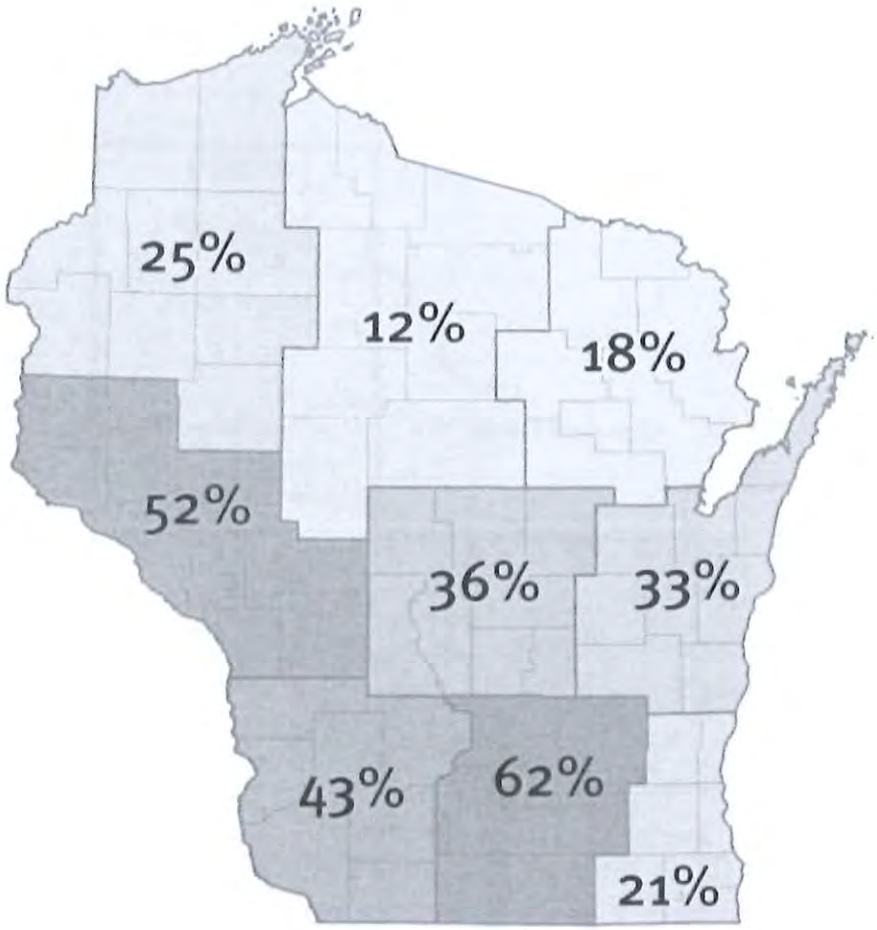
- There are 3 lift-station locations, none of which have generator backup. The city would like to install three permanent generators.

Appendix A: Maps

Green Lake County Base Map



Percentage of Private Wells with Detectable Herbicides or Herbicide Metabolites (2001)[171]

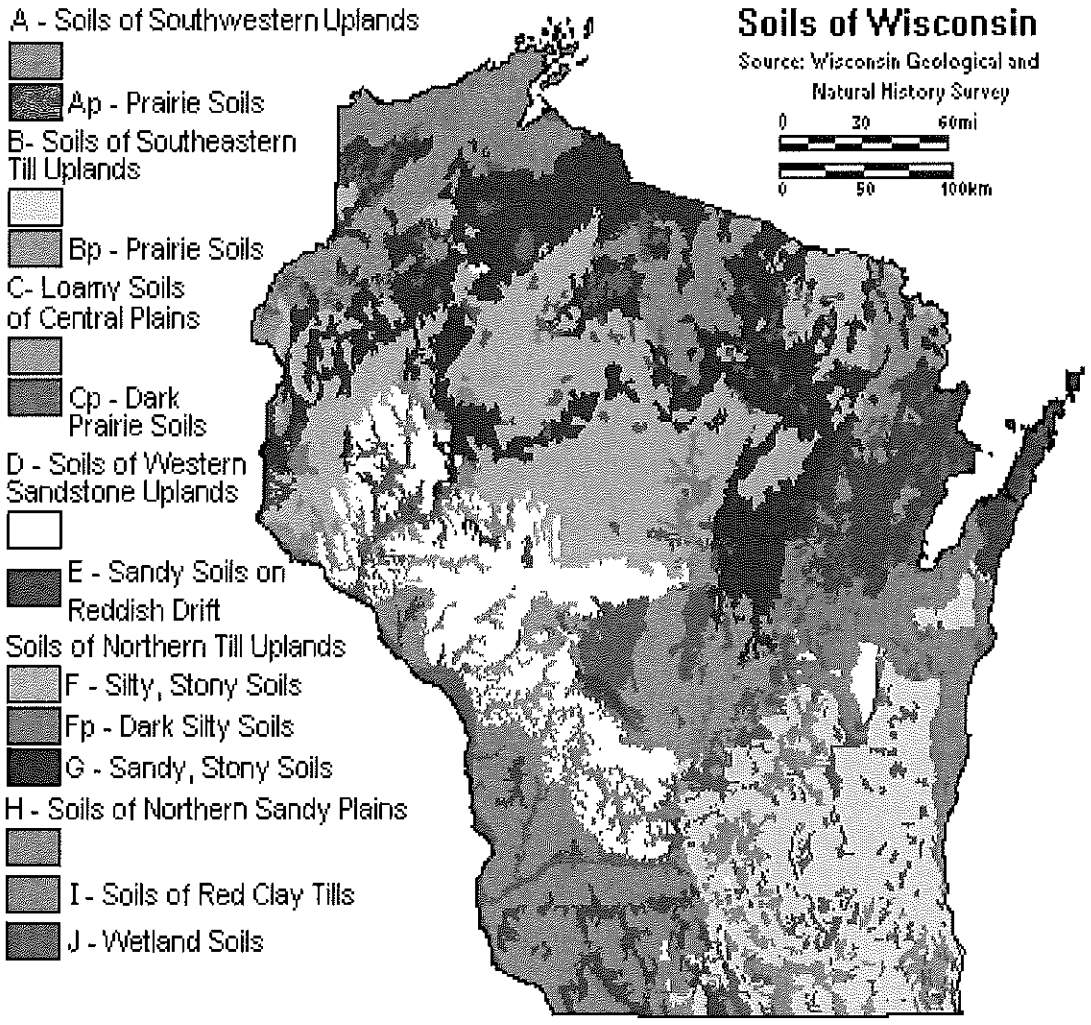


Herbicide data: Wisconsin Department of Agriculture, Trade and Consumer Protection, 2002, Agricultural chemicals in Wisconsin groundwater: final report, *http://www.datcp.state.wi.us/arm/agriculture/land-water/environ_quality/pdf/arm-pub-98.pdf*

Figure created for the "Protecting Wisconsin's Groundwater Through Comprehensive Planning" web site, 2007, *http://wi.water.usgs.gov/gwcomp/*

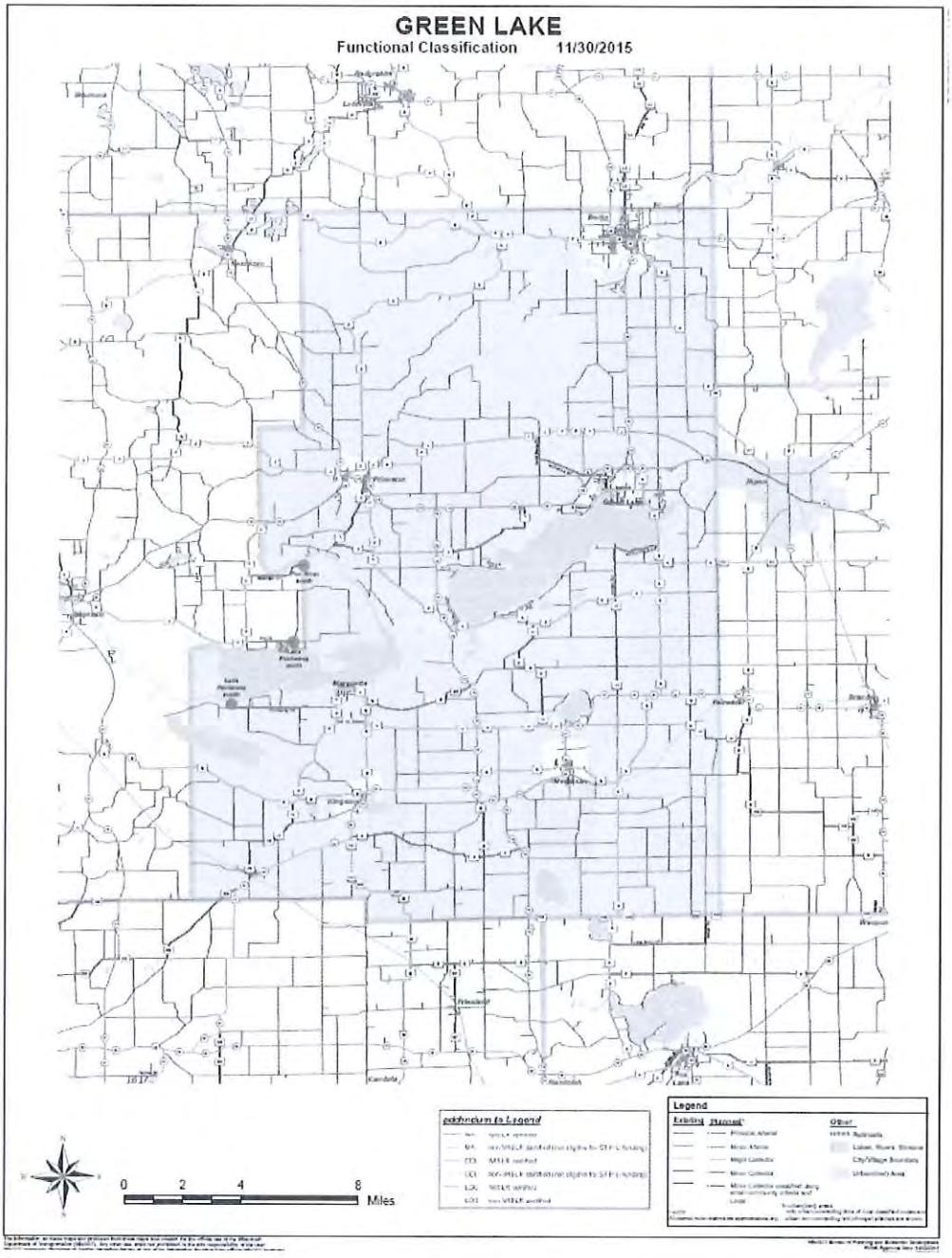
[171] https://wi.water.usgs.gov/gwcomp/find/greenlake/pesticidestate.html

Soils Types[172]



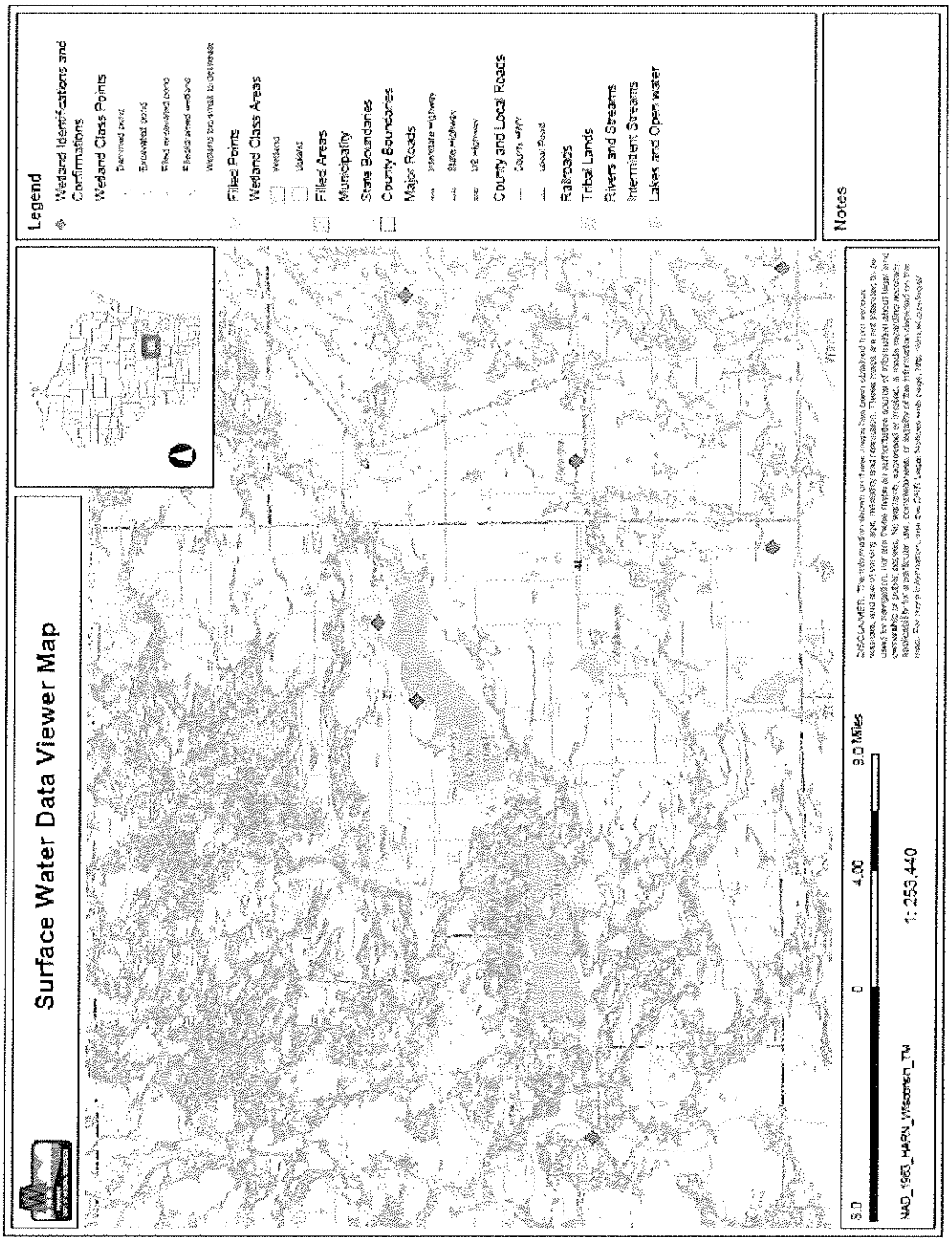
[172] Source: *Soils of Wisconsin* compiled by F. D. Hole, 1973; Wisconsin Geological and Natural History Survey Map, scale (approx.) 1: 3,150,000.

Green Lake County Road Functional Classification [173]



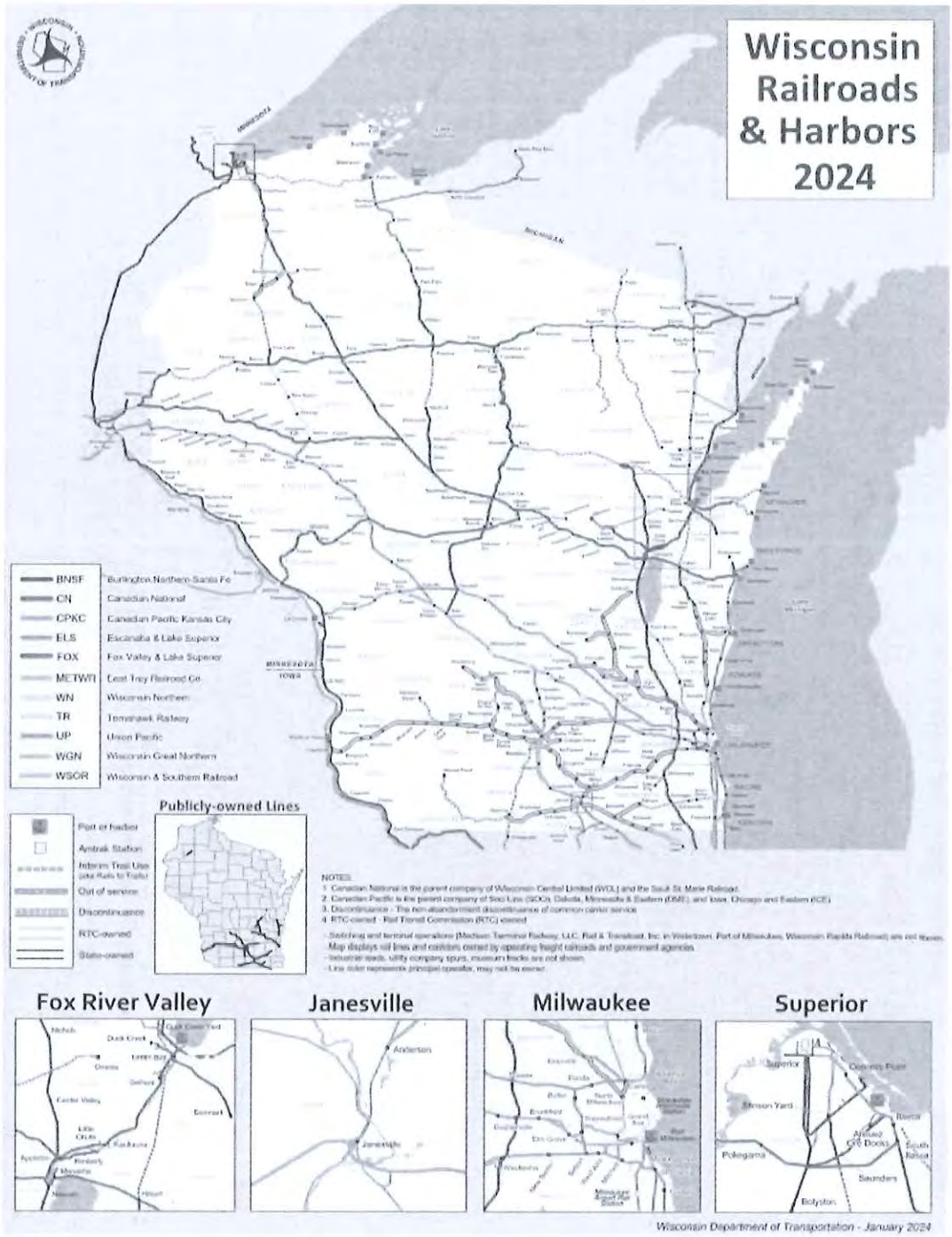
[173] https://wisconsindot.gov/Documents/projects/data-plan/plan-res/functional/rural/greenlake.pdf

Green Lake County Surface Water[174]



[174] https://dnr.wi.gov/maps/applist.html

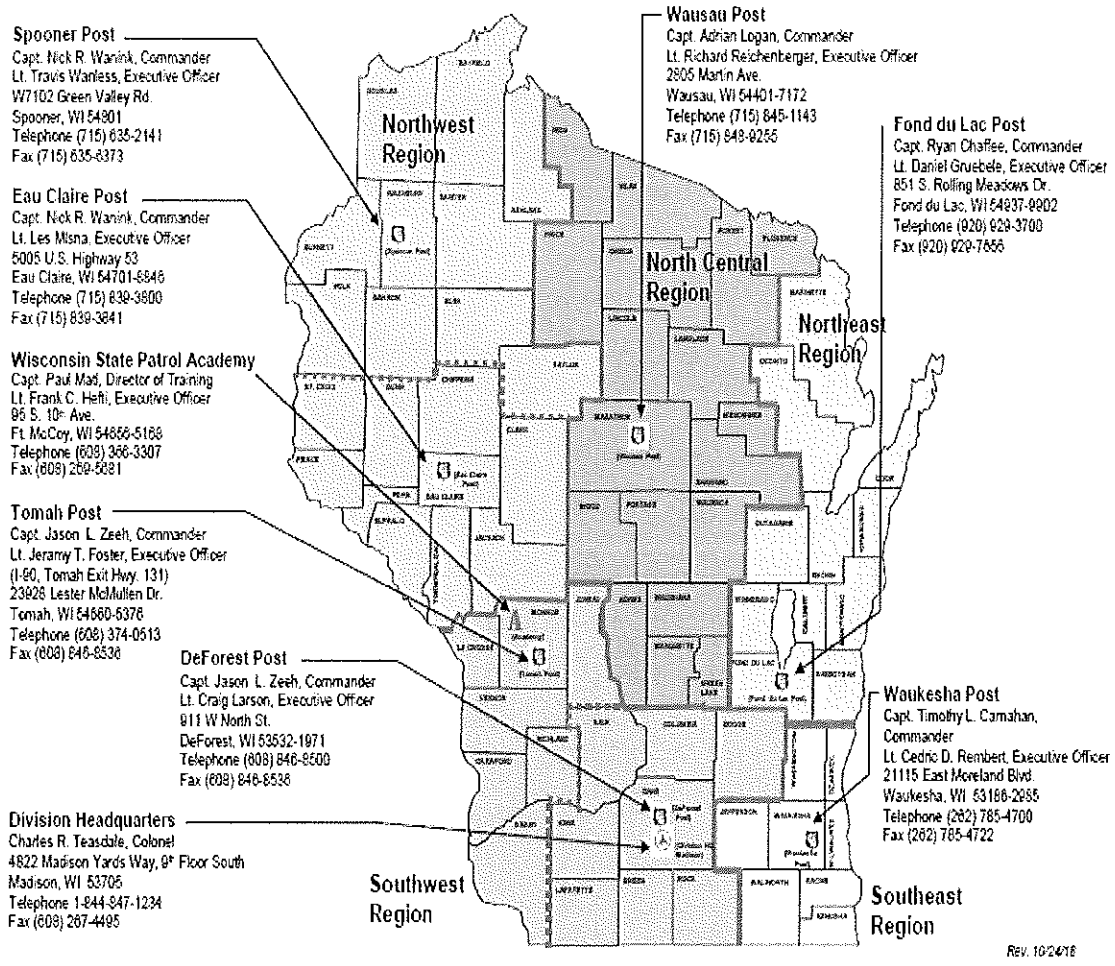
Wisconsin Railroads and Harbors [175]



[175] https://wisconsindot.gov/Documents/travel/rail/railmap.pdf

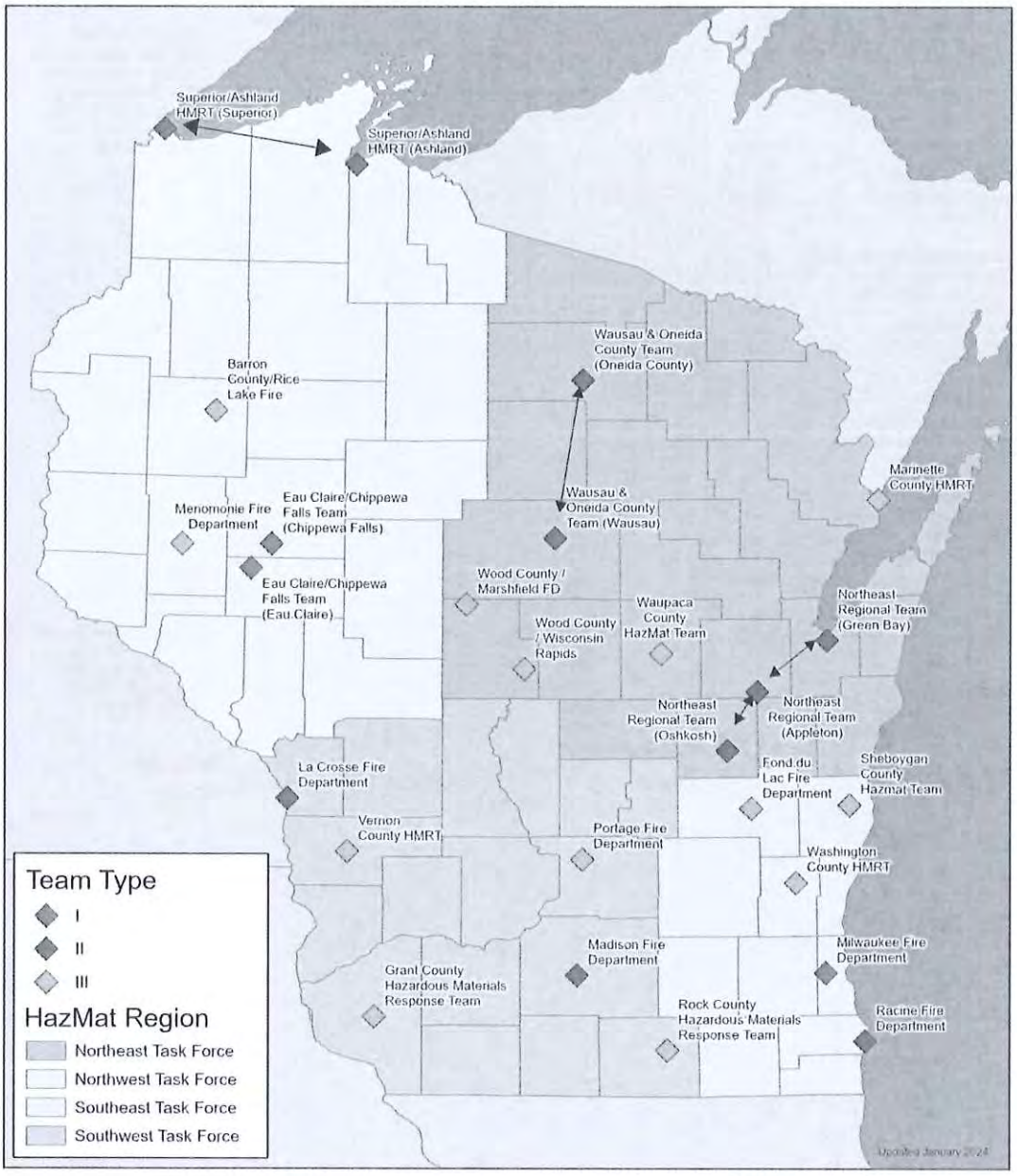
Wisconsin State Patrol Regions

Division of State Patrol Regions Map



Wisconsin's Regional & County/Local HazMat Response Teams[176]

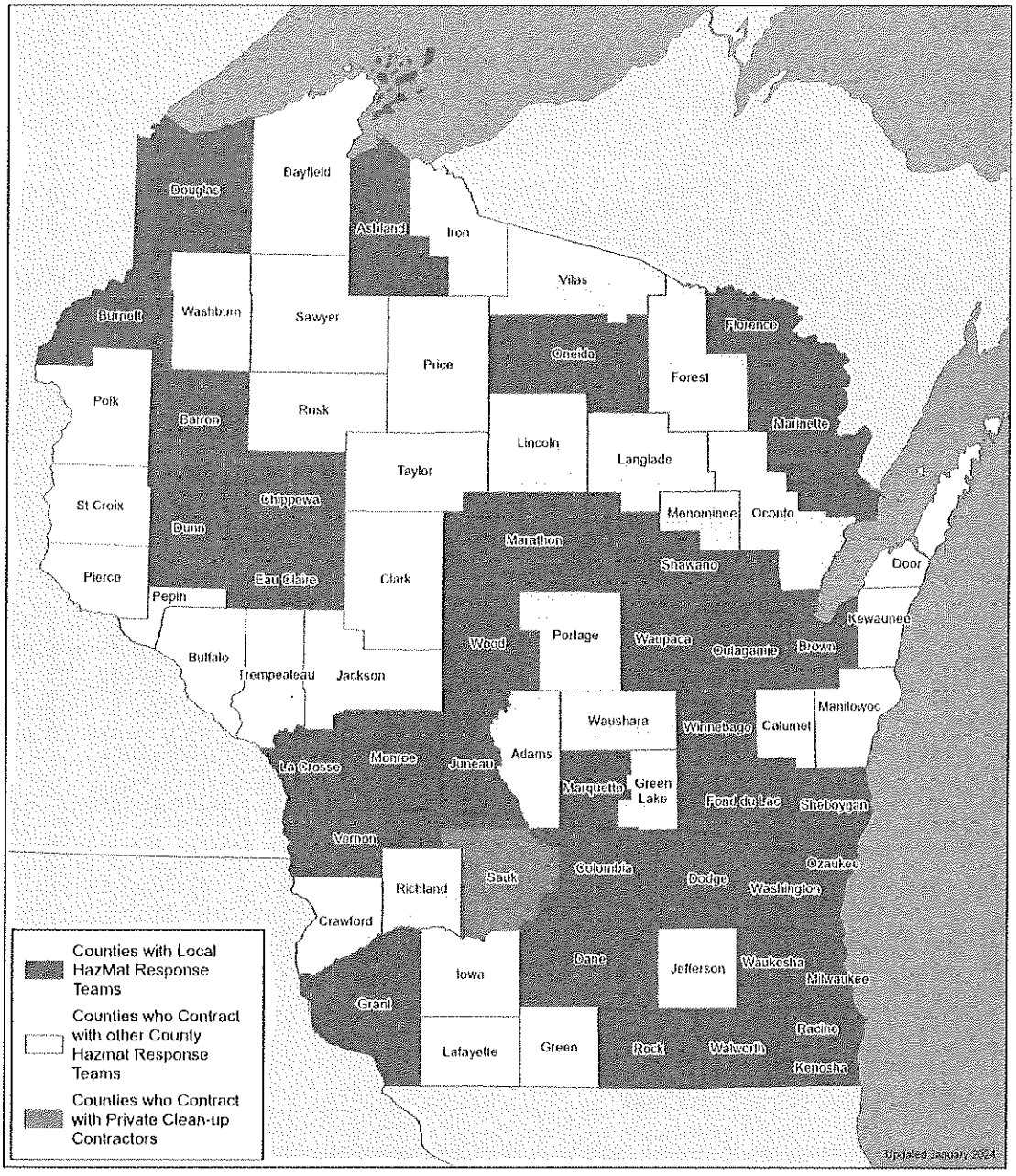
Wisconsin's Hazardous Materials Response System



[176] https://wem.wi.gov/response-teams/#whmrs

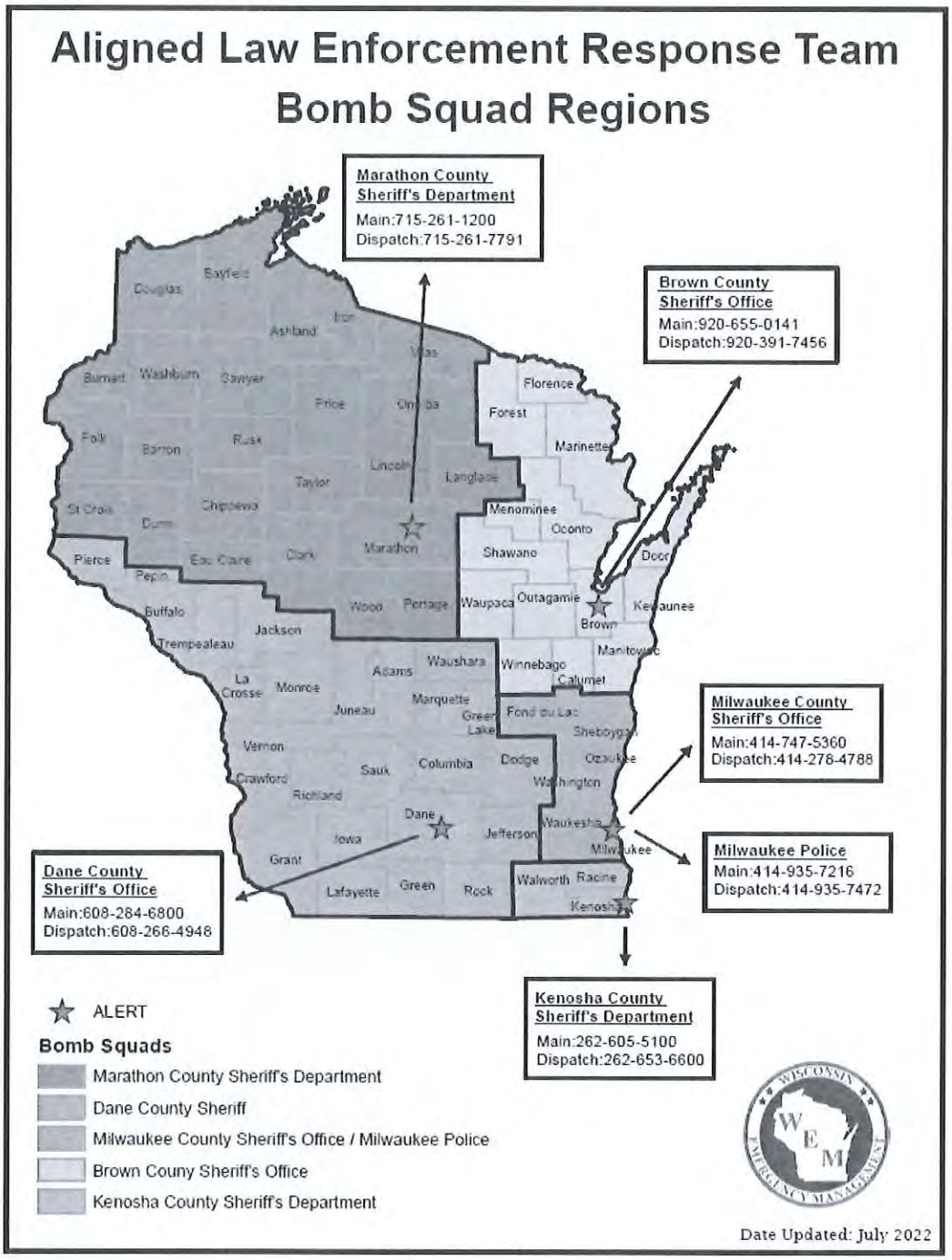
Wisconsin Hazardous Materials Response Teams[177]

Wisconsin Local and County HazMat Response Teams



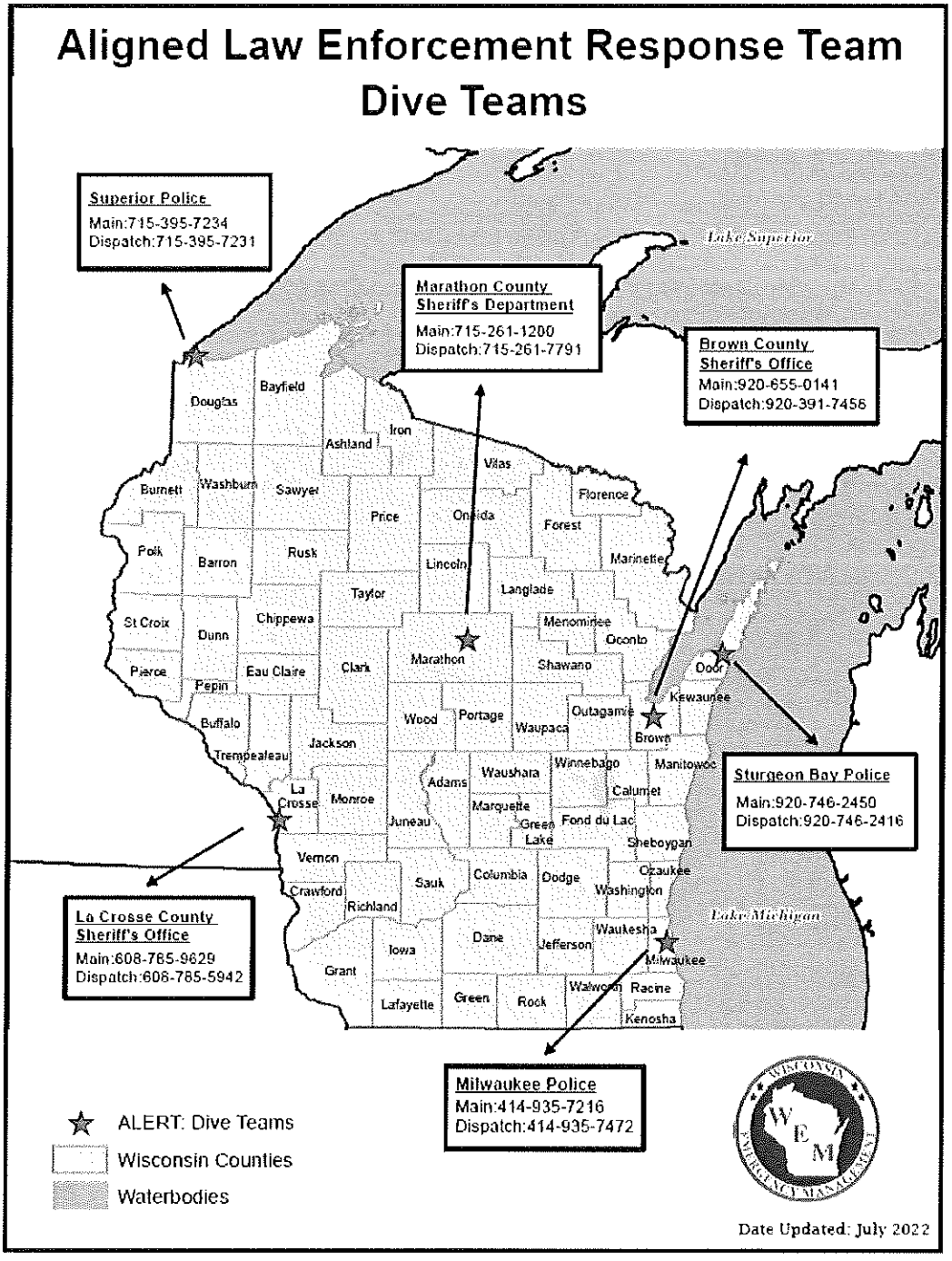
[177] https://wem.wi.gov/response-teams/#whmrs

Wisconsin Bomb Squad Regions [178]



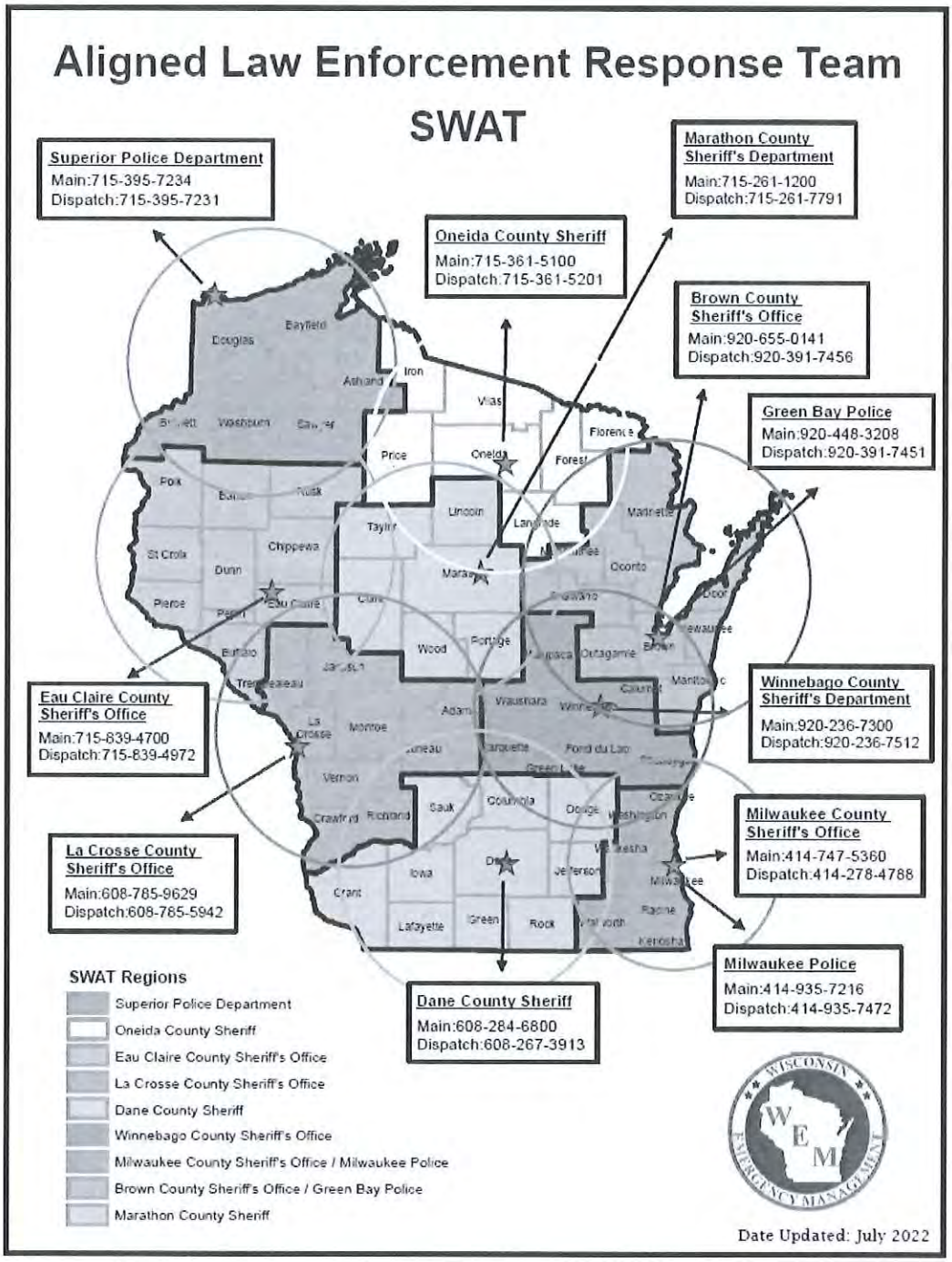
[178] https://wem.wi.gov/wp-content/library/response/ALERT_BombSquad_Map_22.pdf

Wisconsin Dive Teams [179]



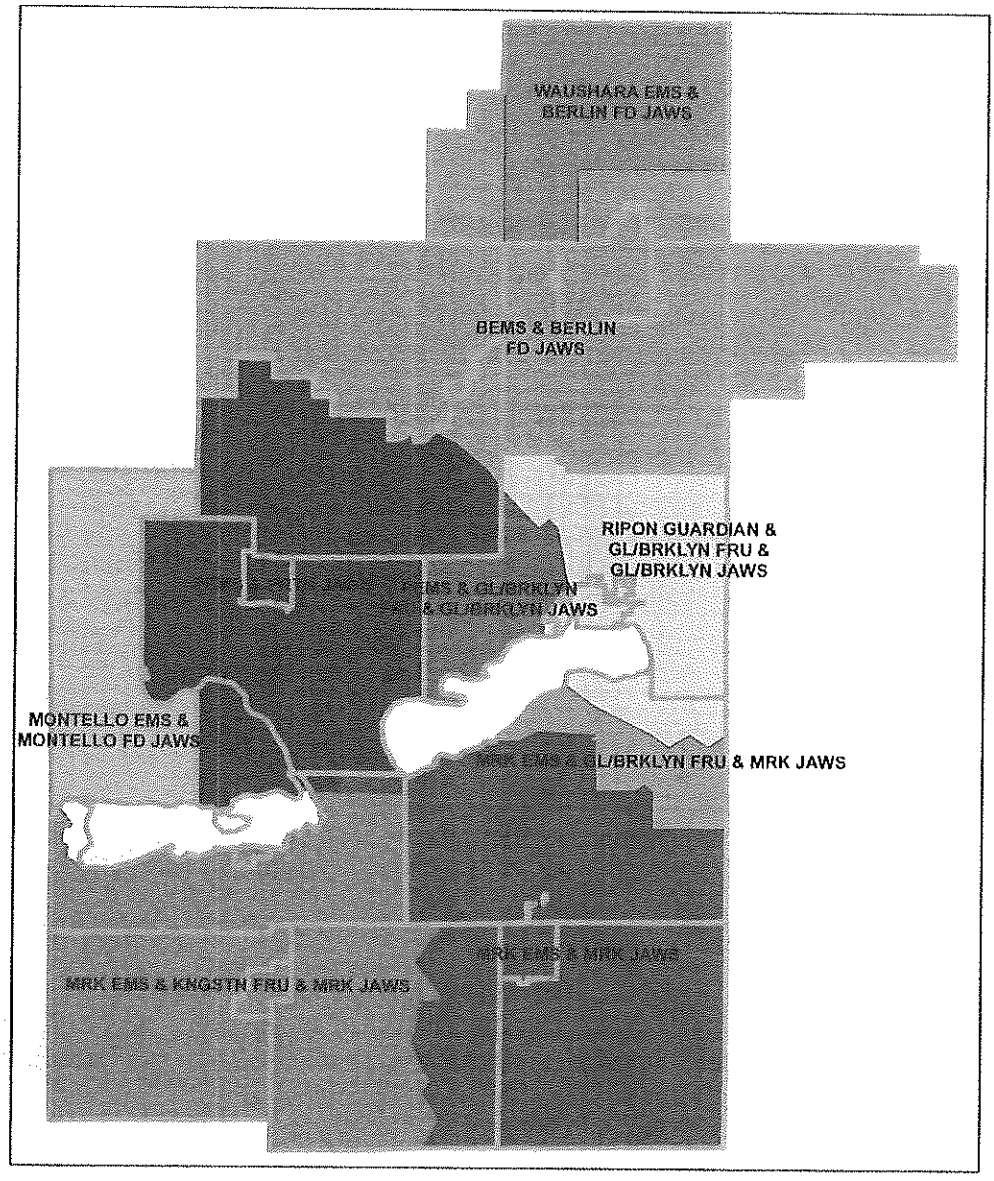
[179] https://wem.wi.gov/wp-content/library/response/ALERT_Dive_Teams_22.pdf

Wisconsin SWAT Regions [180]



[180] https://wem.wi.gov/wp-content/library/response/ALERT_SWAT_Map_7_22.pdf

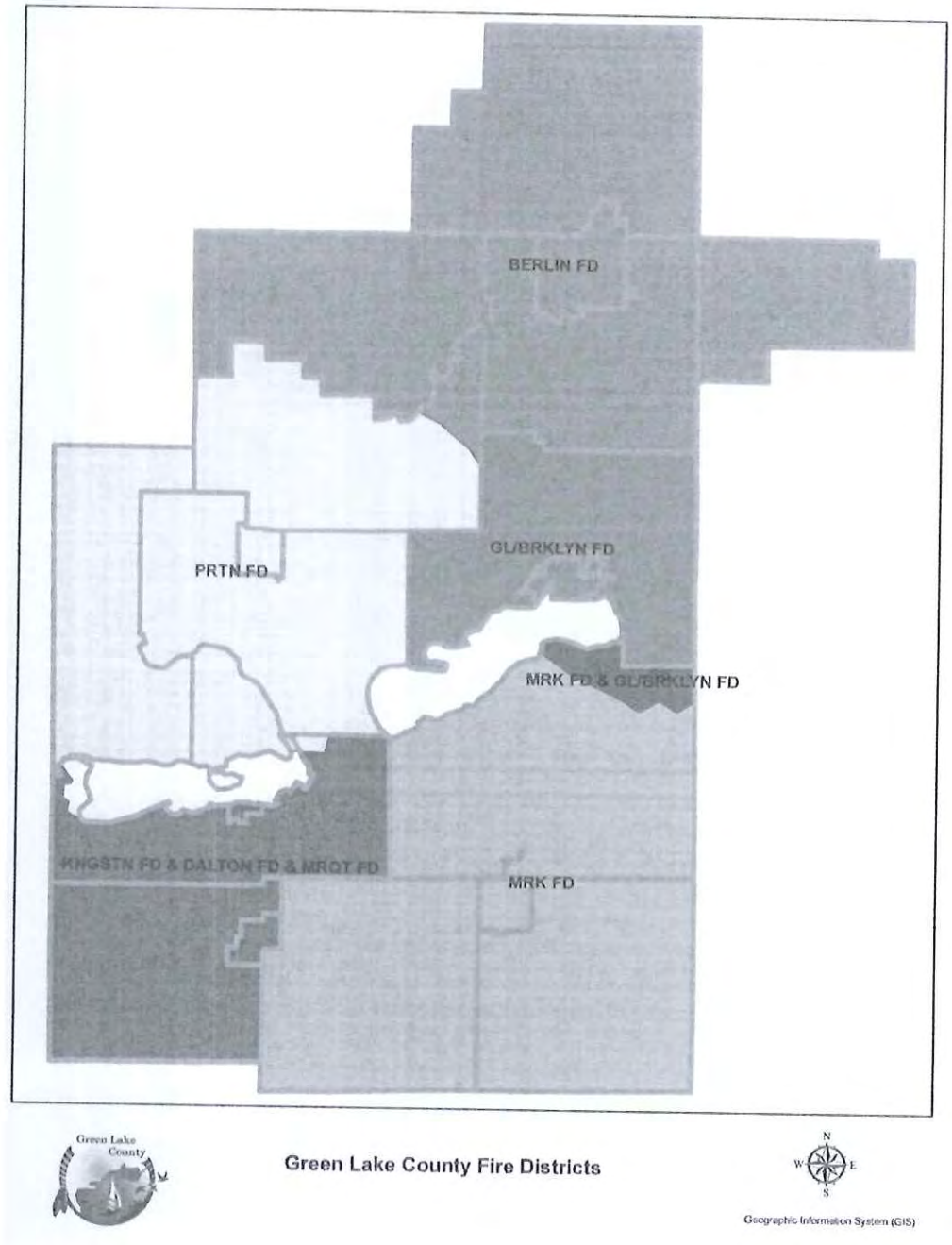
Green Lake County Ambulance Districts



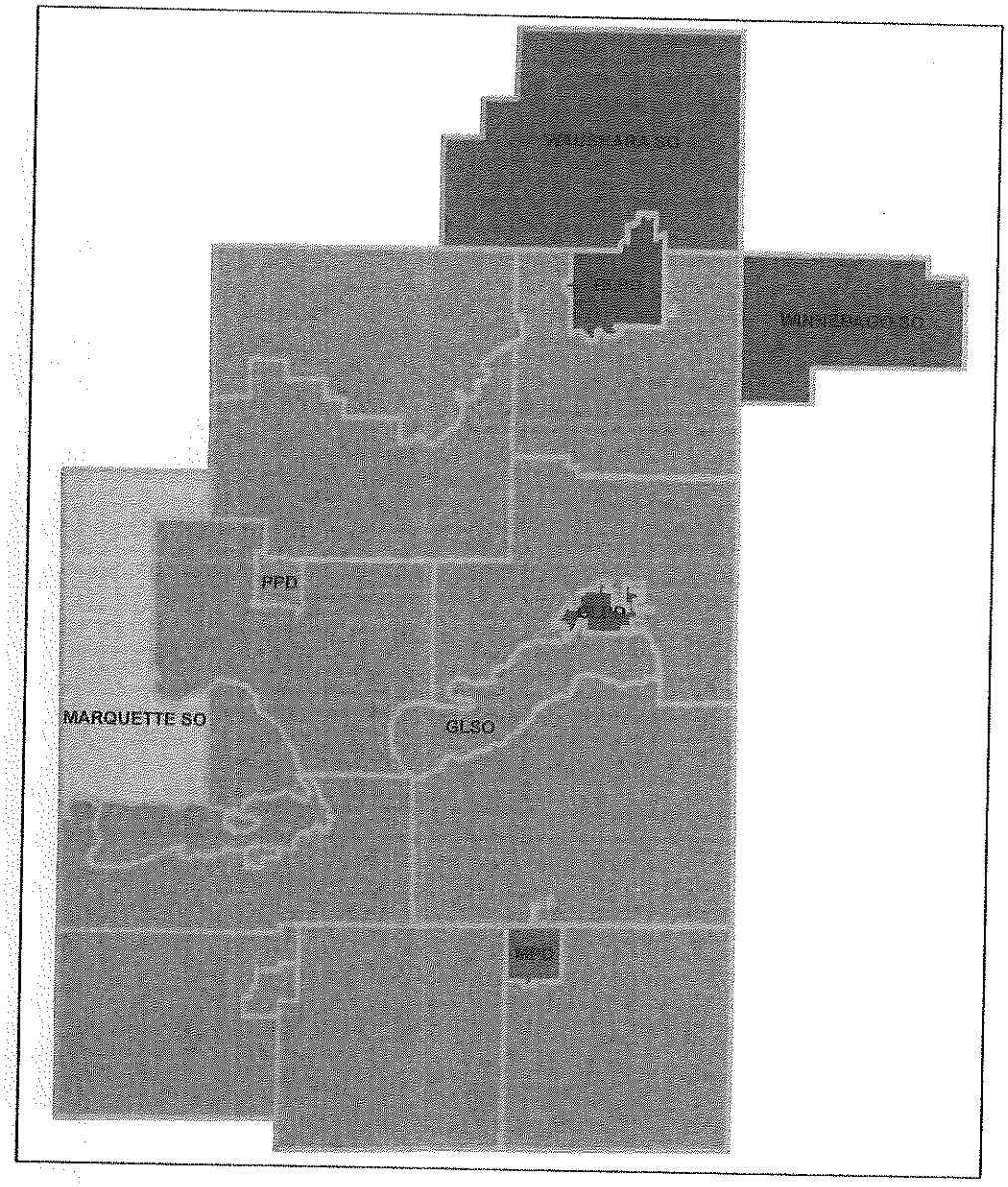
Green Lake County EMS Districts

Geographic Information System (GIS)

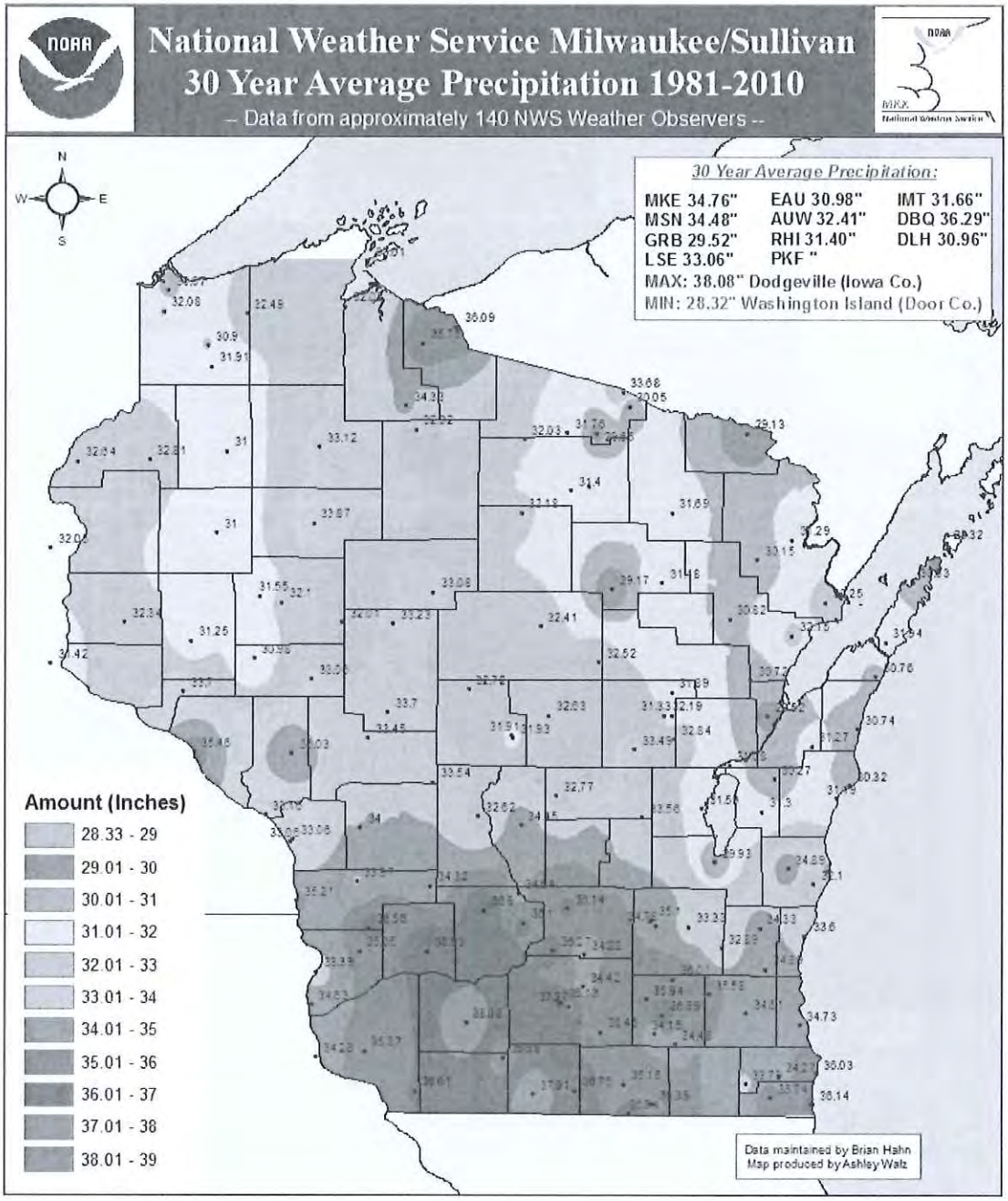
Green Lake County Fire Districts



Green Lake County Law Enforcement Districts

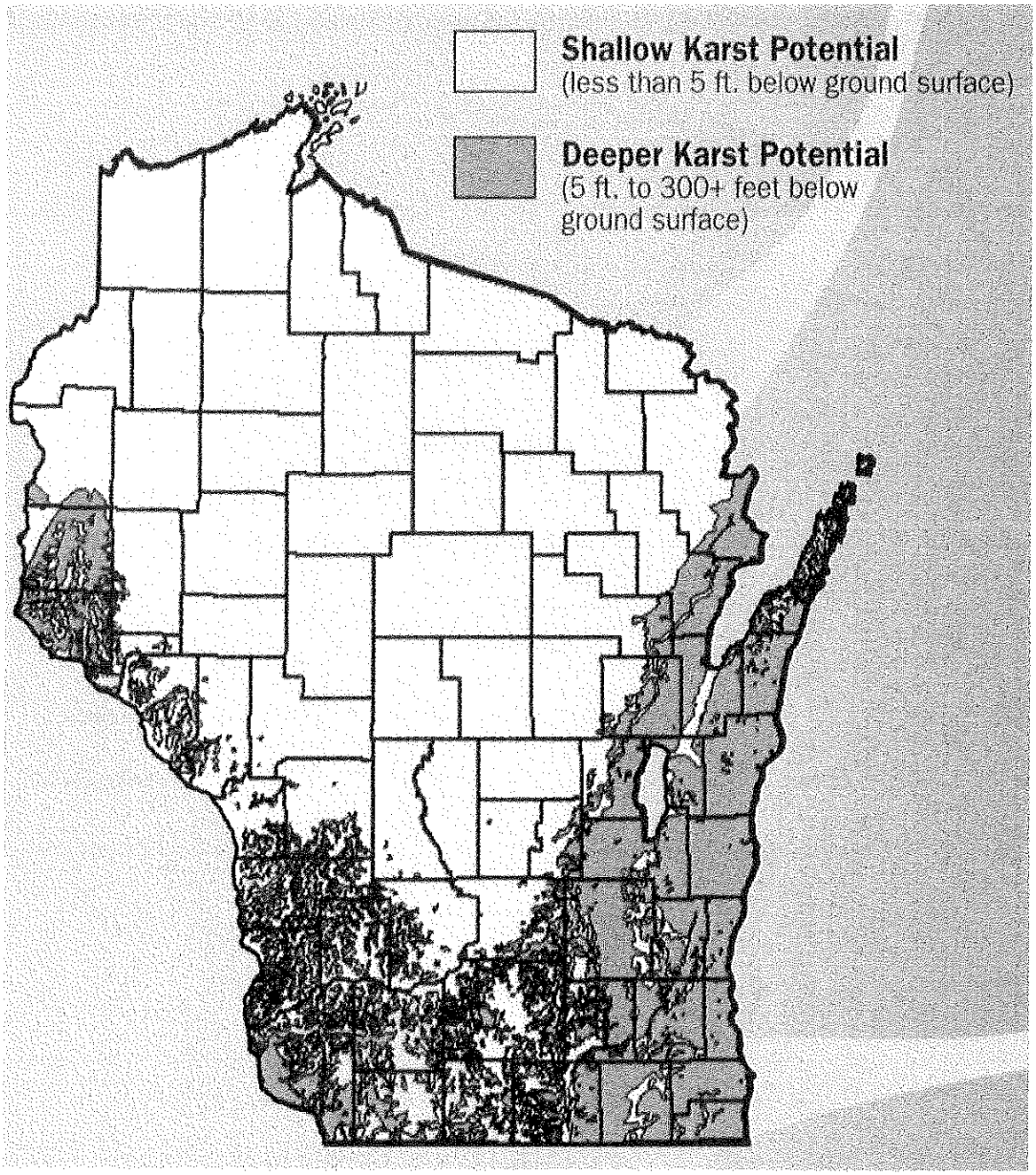


Wisconsin 30-Year Average Precipitation [181]



[181] http://www.crh.noaa.gov/images/mkx/climate/avg_30_year_precip.png

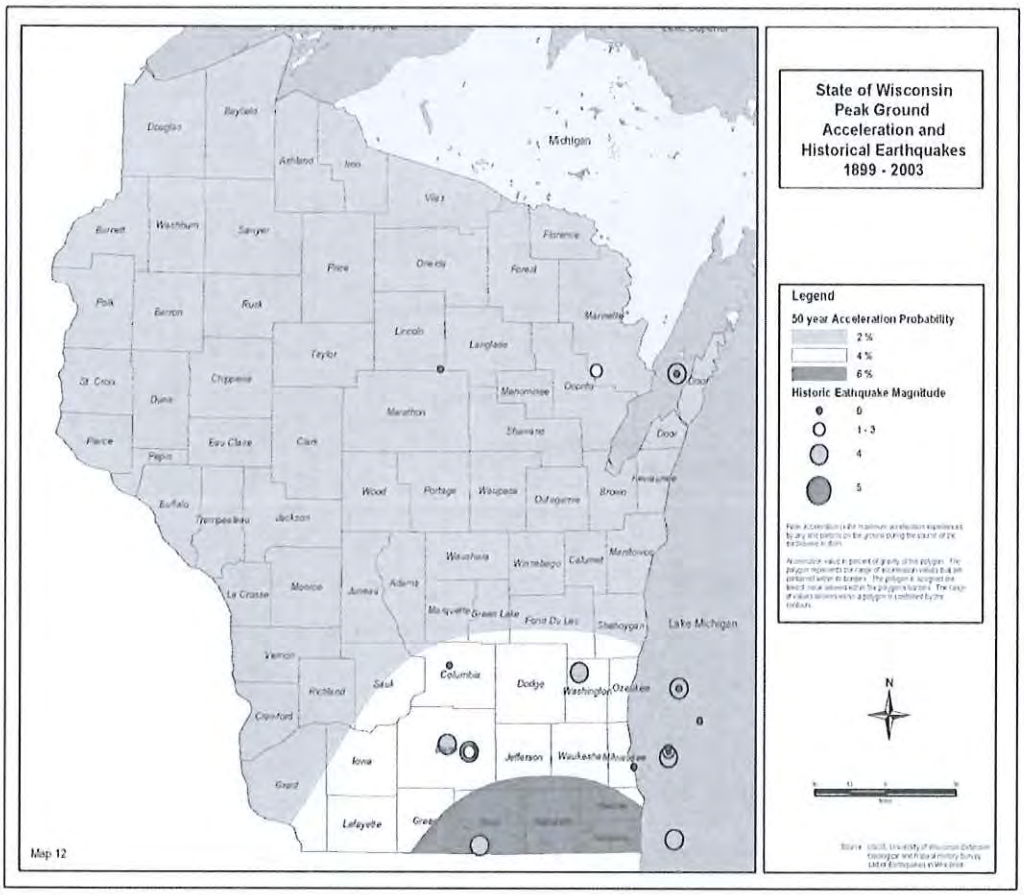
Karst Potential [182]



[182] Wisconsin State Hazard Mitigation Plan

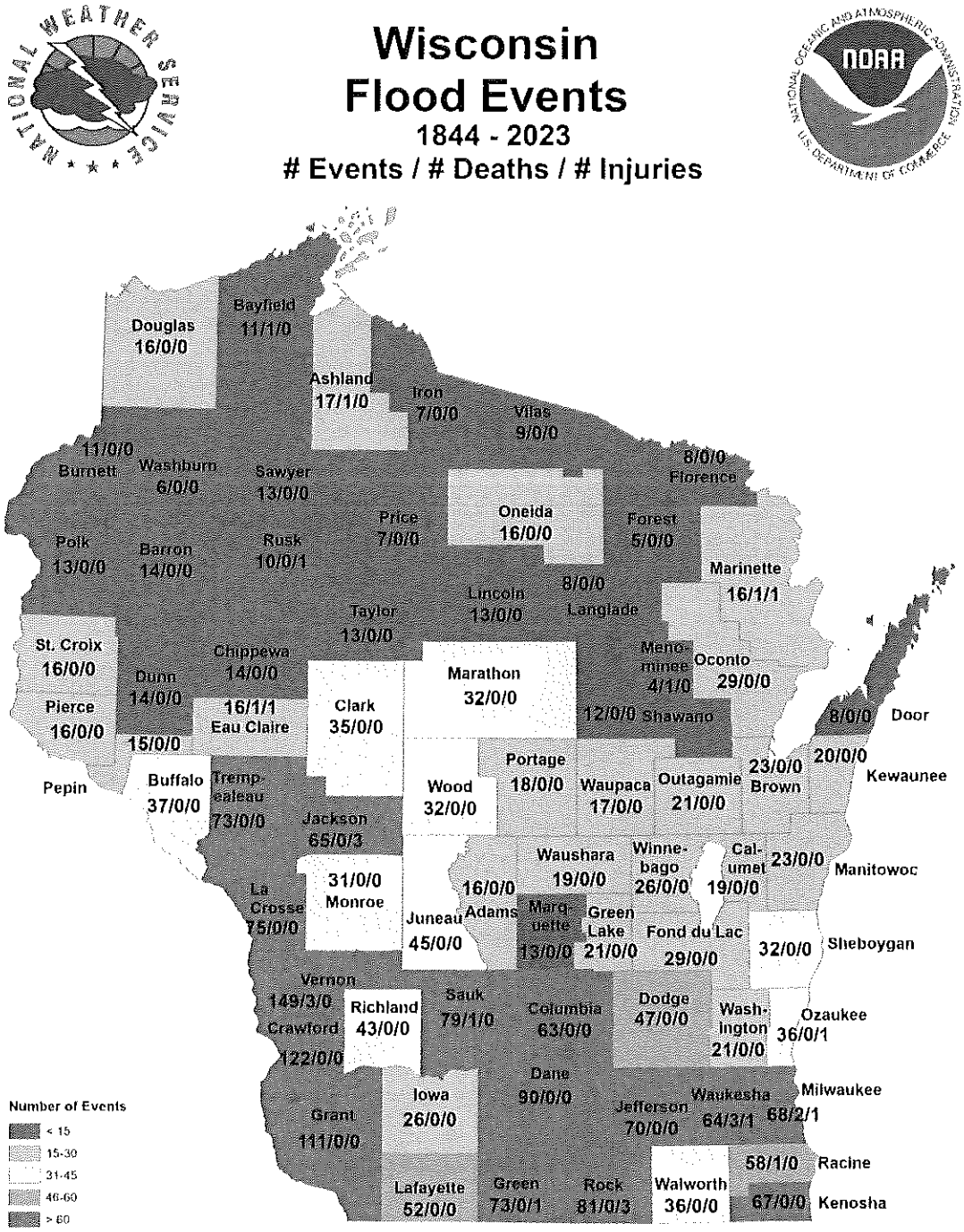
Earthquakes in Wisconsin

Peak Ground Acceleration Contours and Historical Earthquakes in Wisconsin[183]



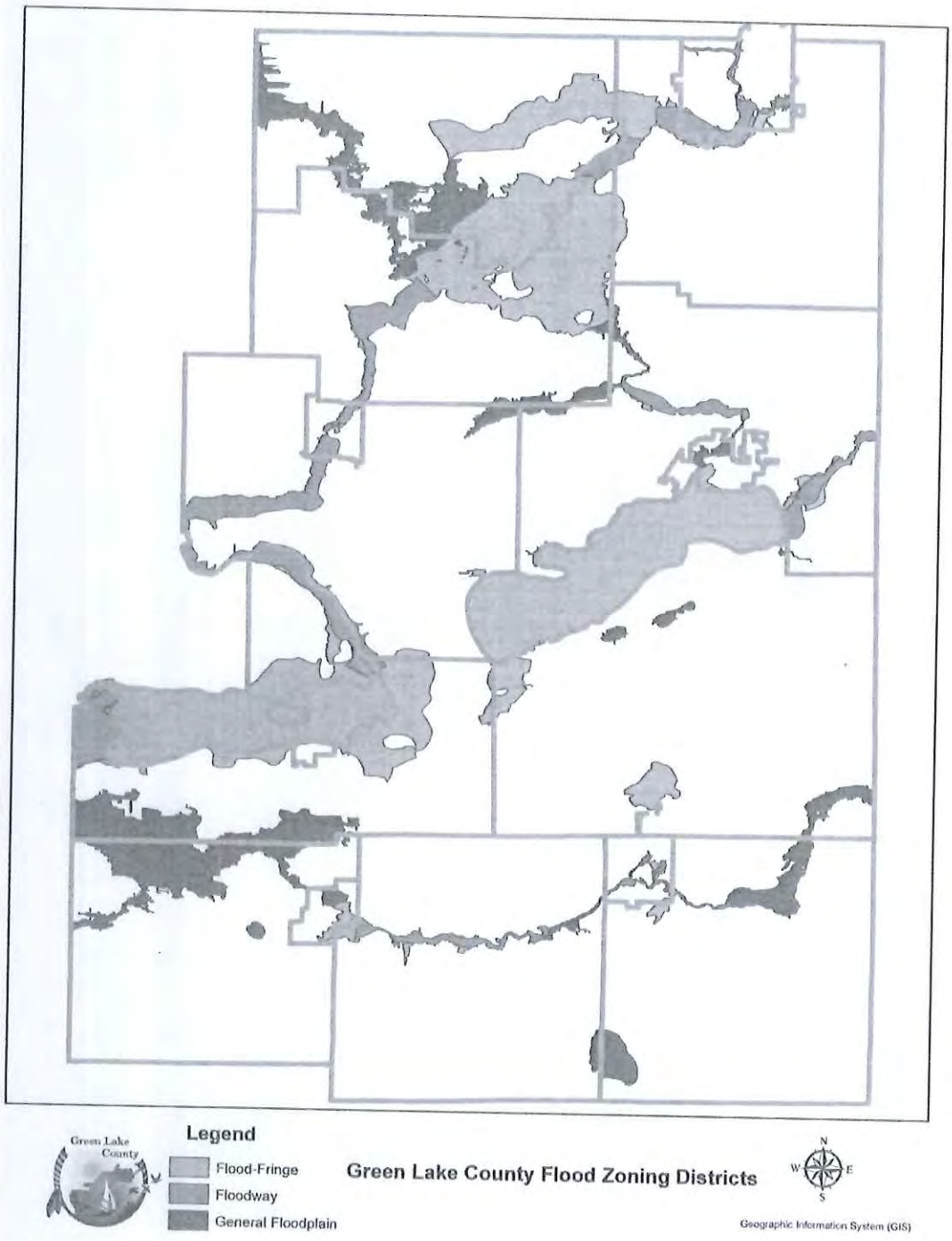
[183] Wisconsin State Hazard Mitigation Plan, 2008, page 4-105

Wisconsin Total Flood Events

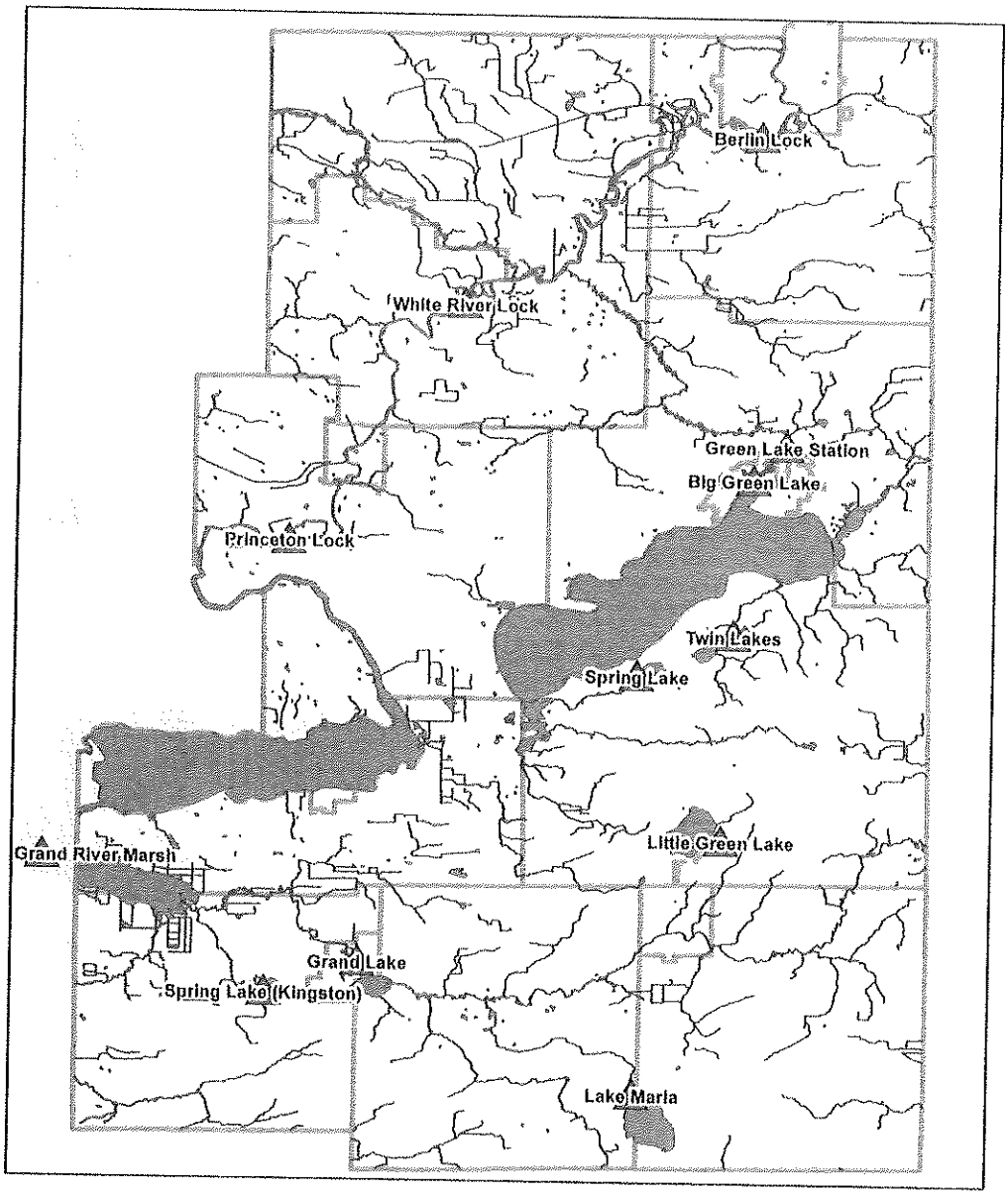


Appendix A: Maps

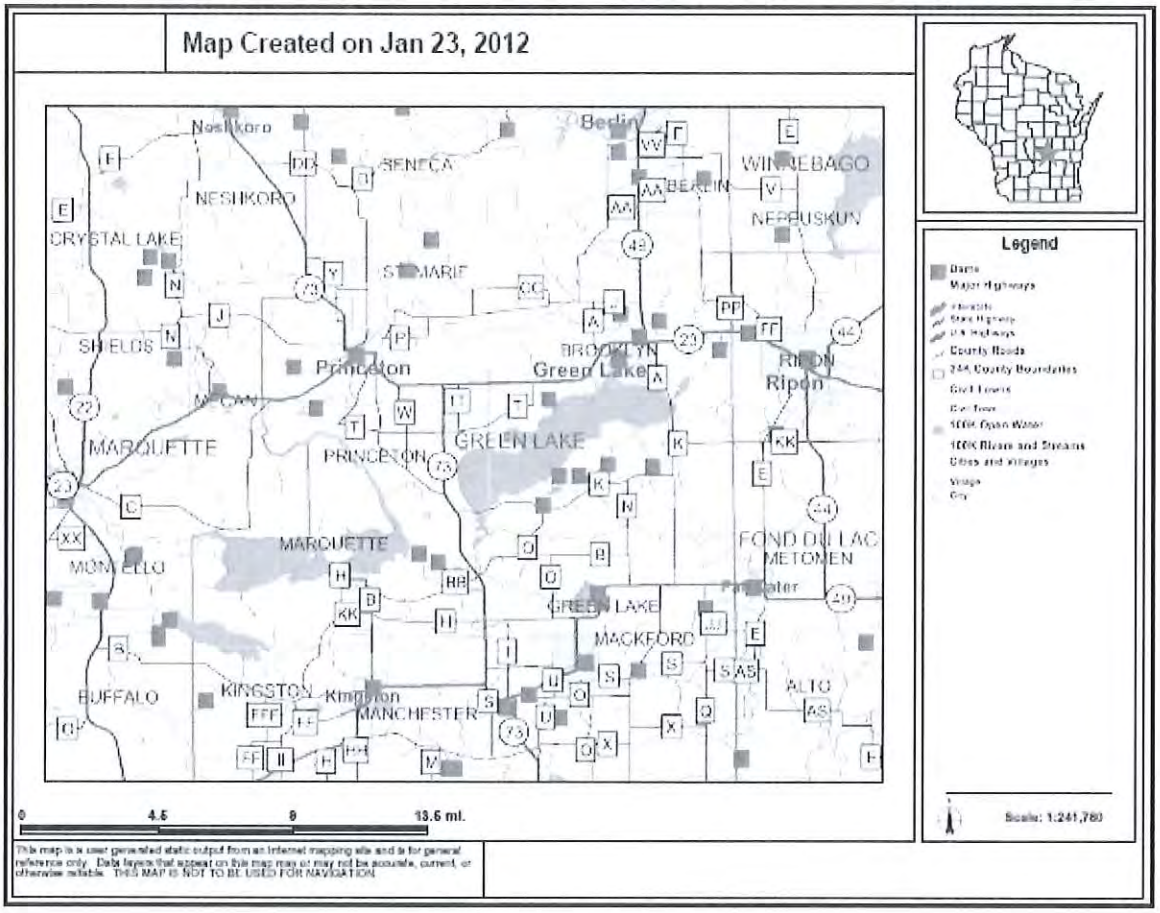
Green Lake County Floodplain



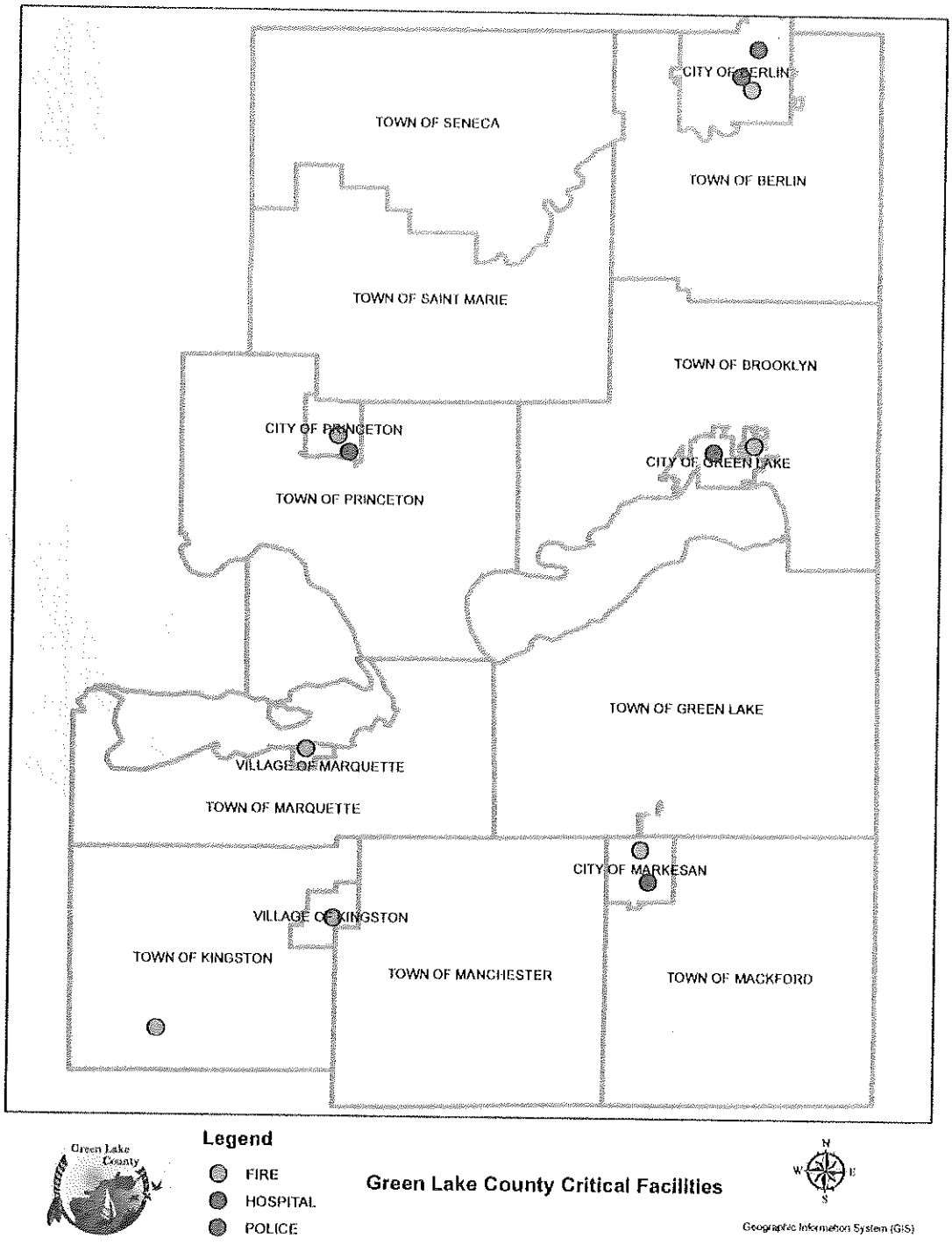
Green Lake County Dams – County Data



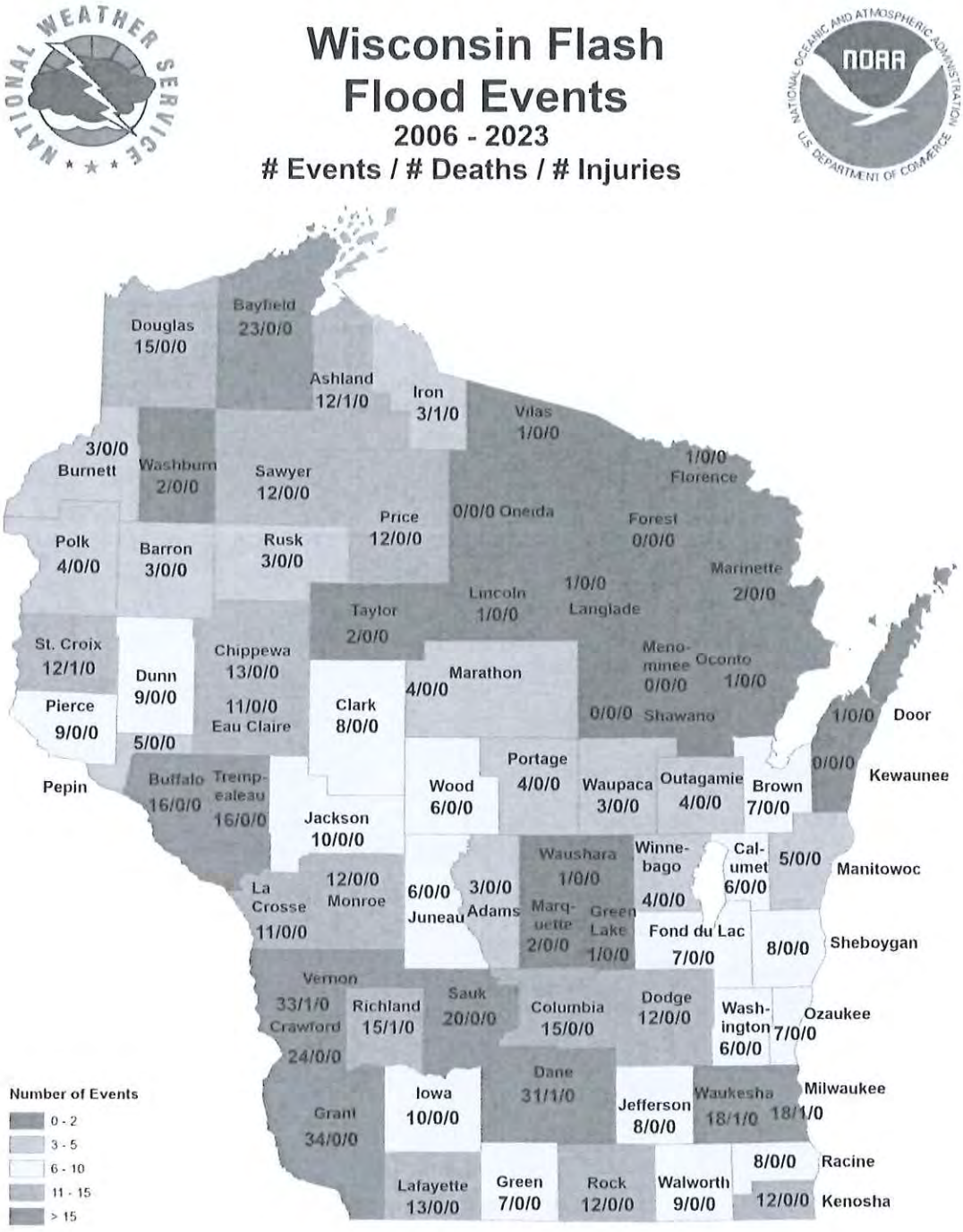
Green Lake County Dams – WI DNR Data



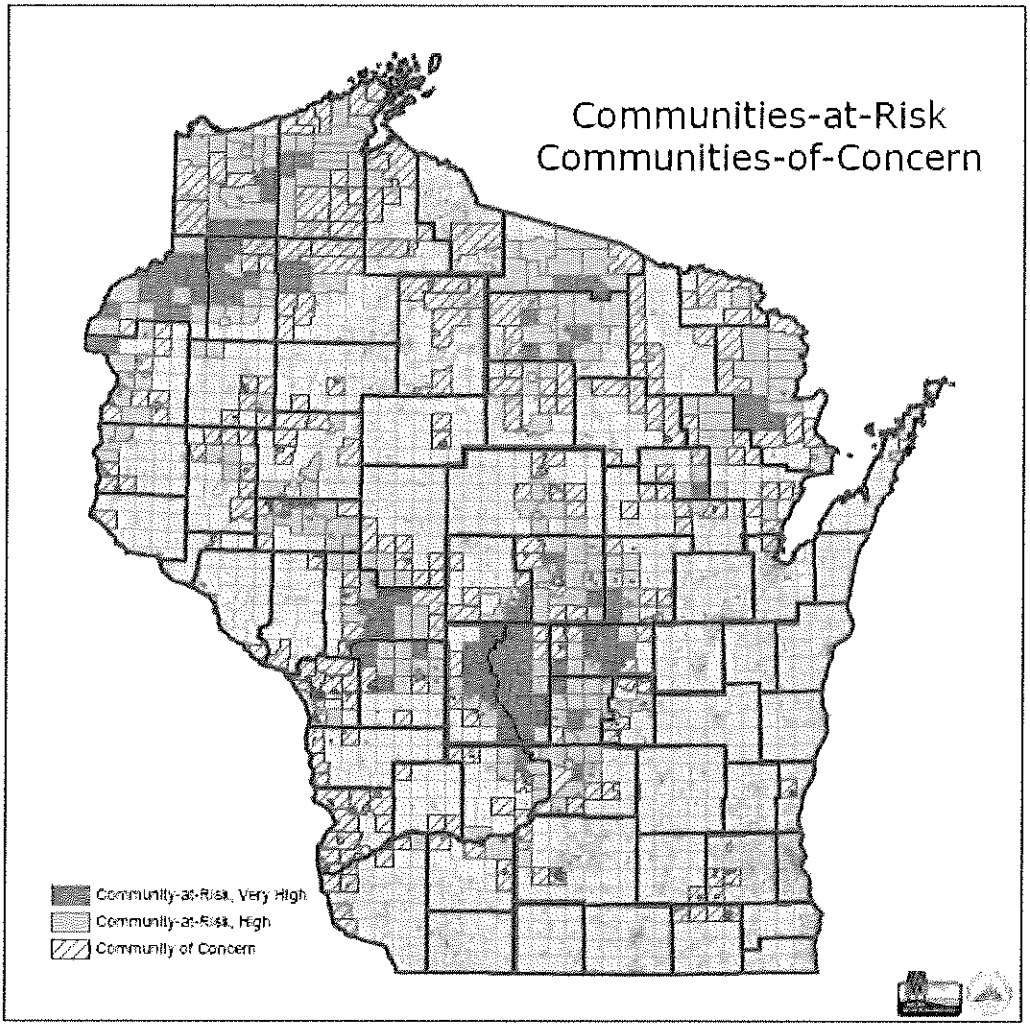
Green Lake County Critical Facilities



Wisconsin Flash Flood Events



Wildfire Communities at Risk



Introduction to Communities-at-Risk

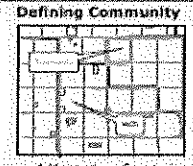
The purpose of this model is to identify broad areas of the state that are at relatively high exposure to resource damage due to wildfire.

As mandated by the NASF, Wisconsin's Communities-At-Risk are divided into three categories:

1) Very High
2) High
3) Community of Concern*

** A Community of Concern is a Wisconsin DNR concept whereby it is demonstrated that a significant portion of the community (more than 2 adjoining square miles) are at high or very high risk, but where the community as a whole falls below the Community-at-Risk threshold.*

Defining Community

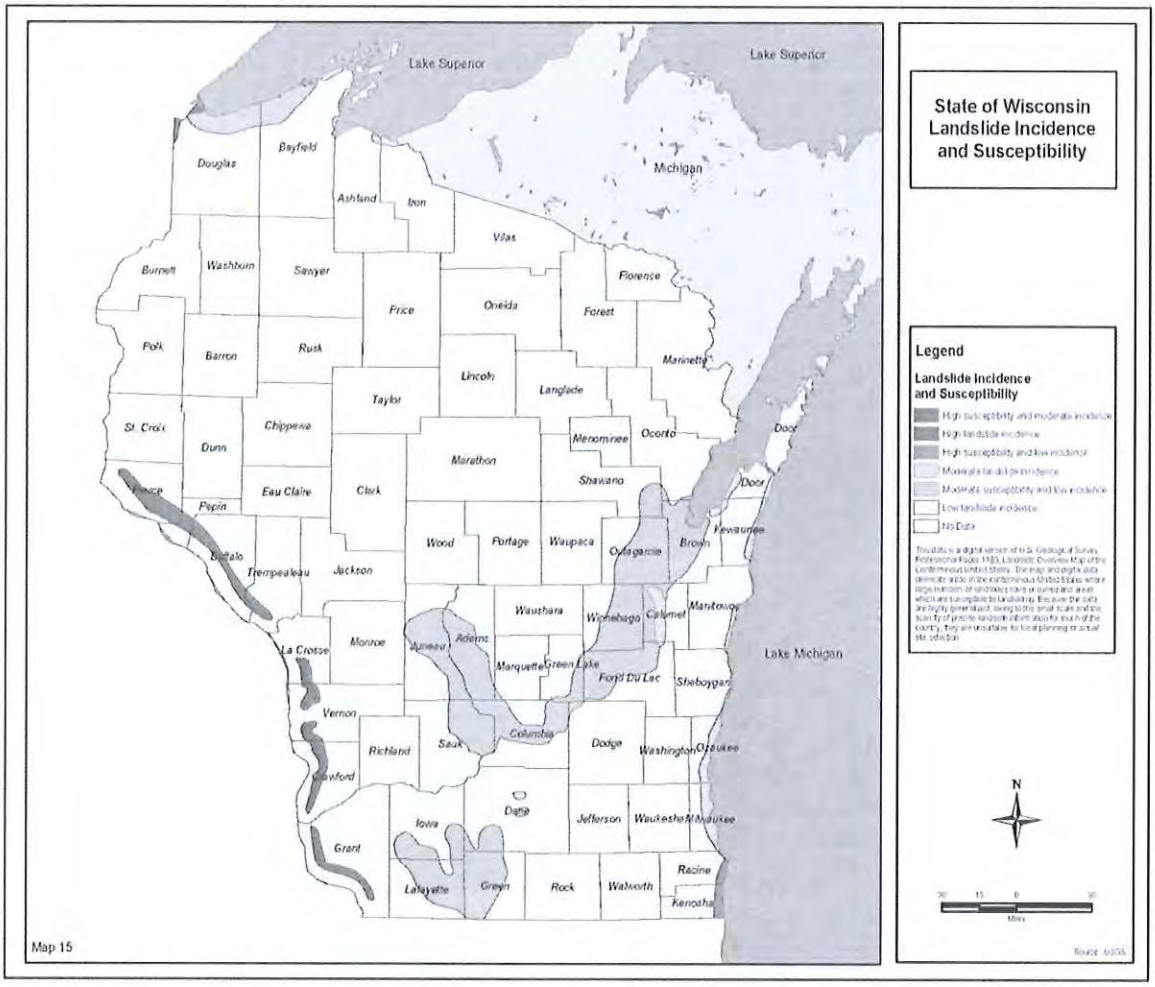


For Wisconsin, Communities-at-Risk are reported at the MCD (municipal civil division) level*. MCD was chosen due to its identifiable legal boundaries, ease in reporting, and usage in the development of Community Wildfire Protection Plans.

** Menominee County is an exception due to its lack of MCD's (civil townships). Therefore, Menominee county is reported by legal township.*

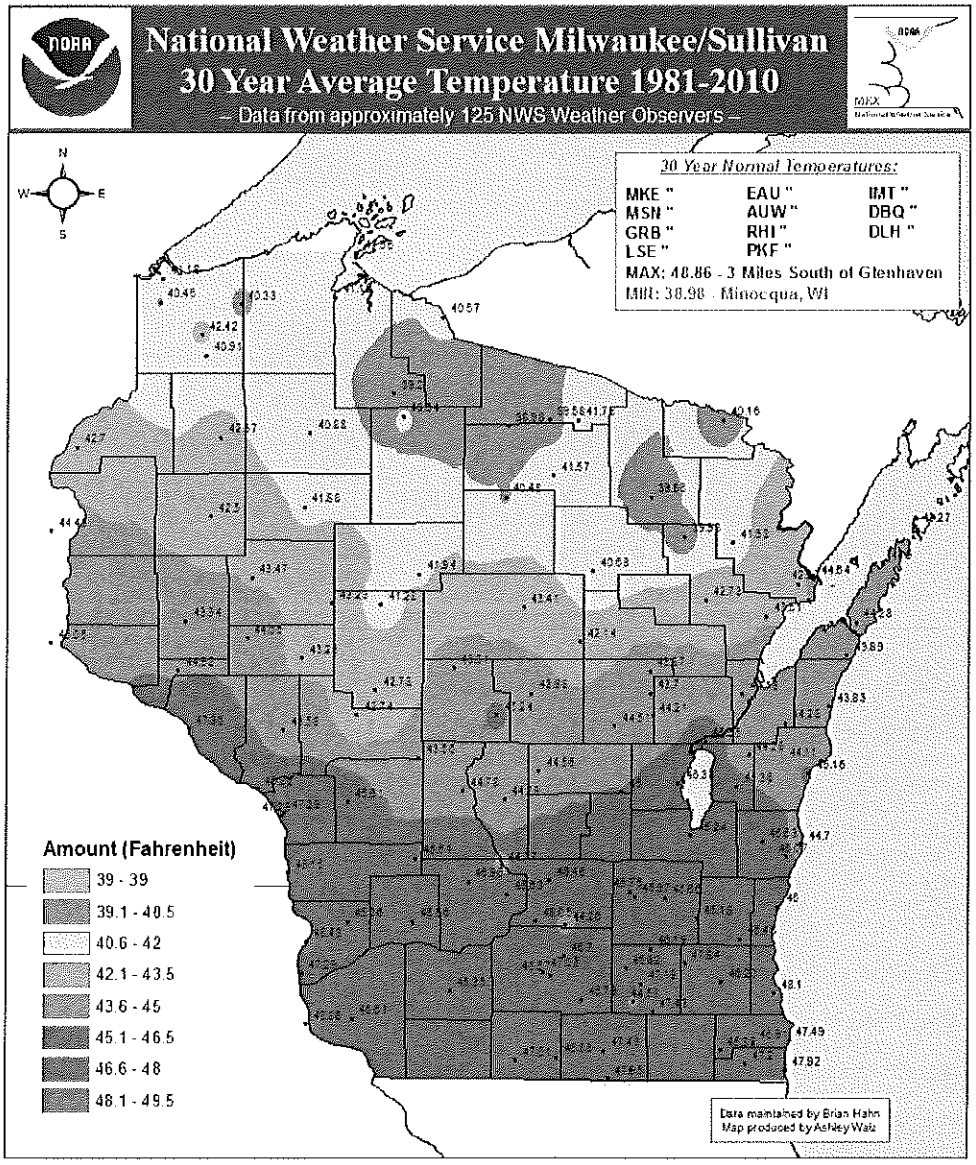
10/5/07

Landslide Incidence and Susceptibility[184]



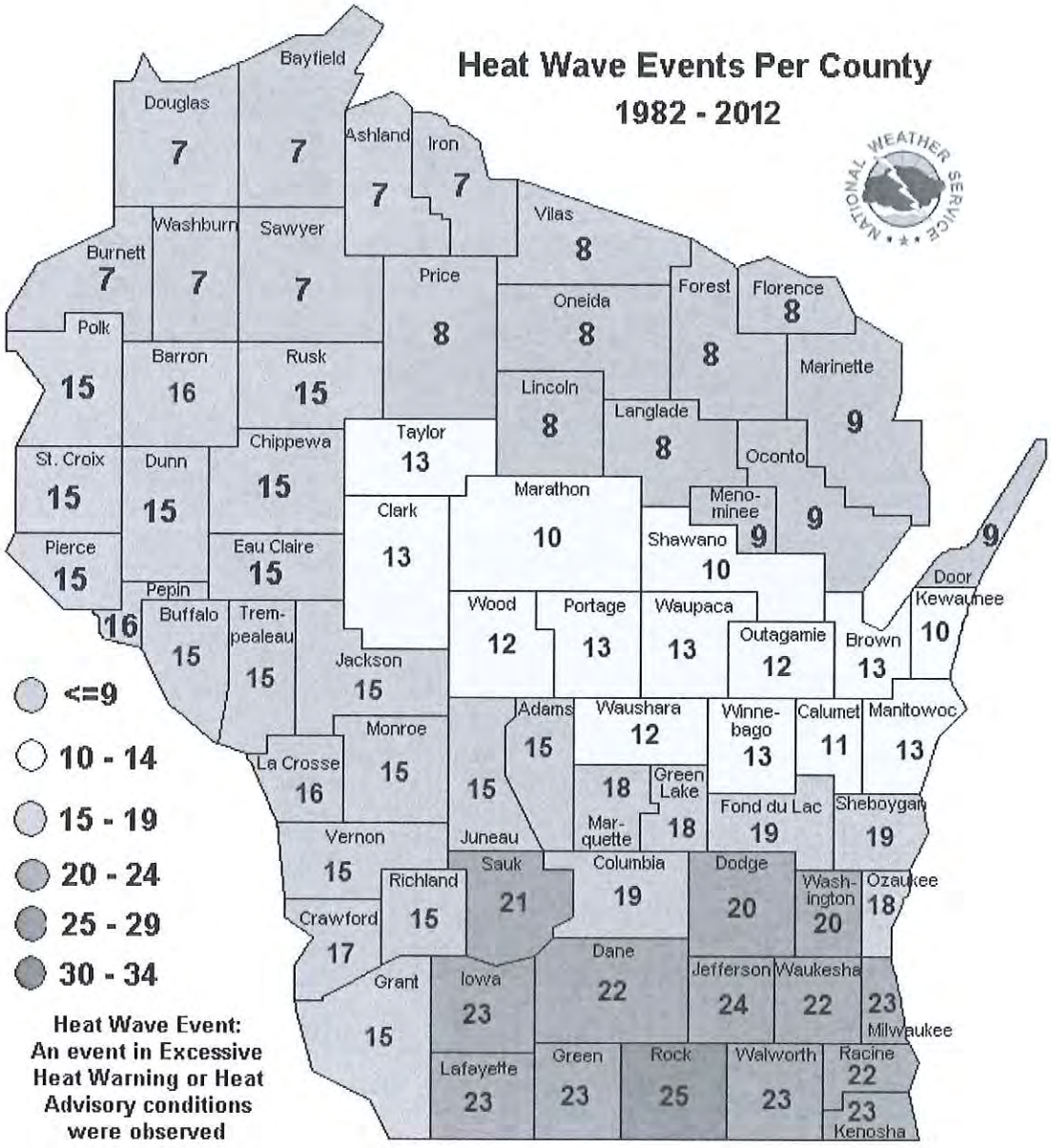
[184] Wisconsin State Hazard Mitigation Plan, 2008, page 4-131

Wisconsin 30 Year Average Temperature [185]



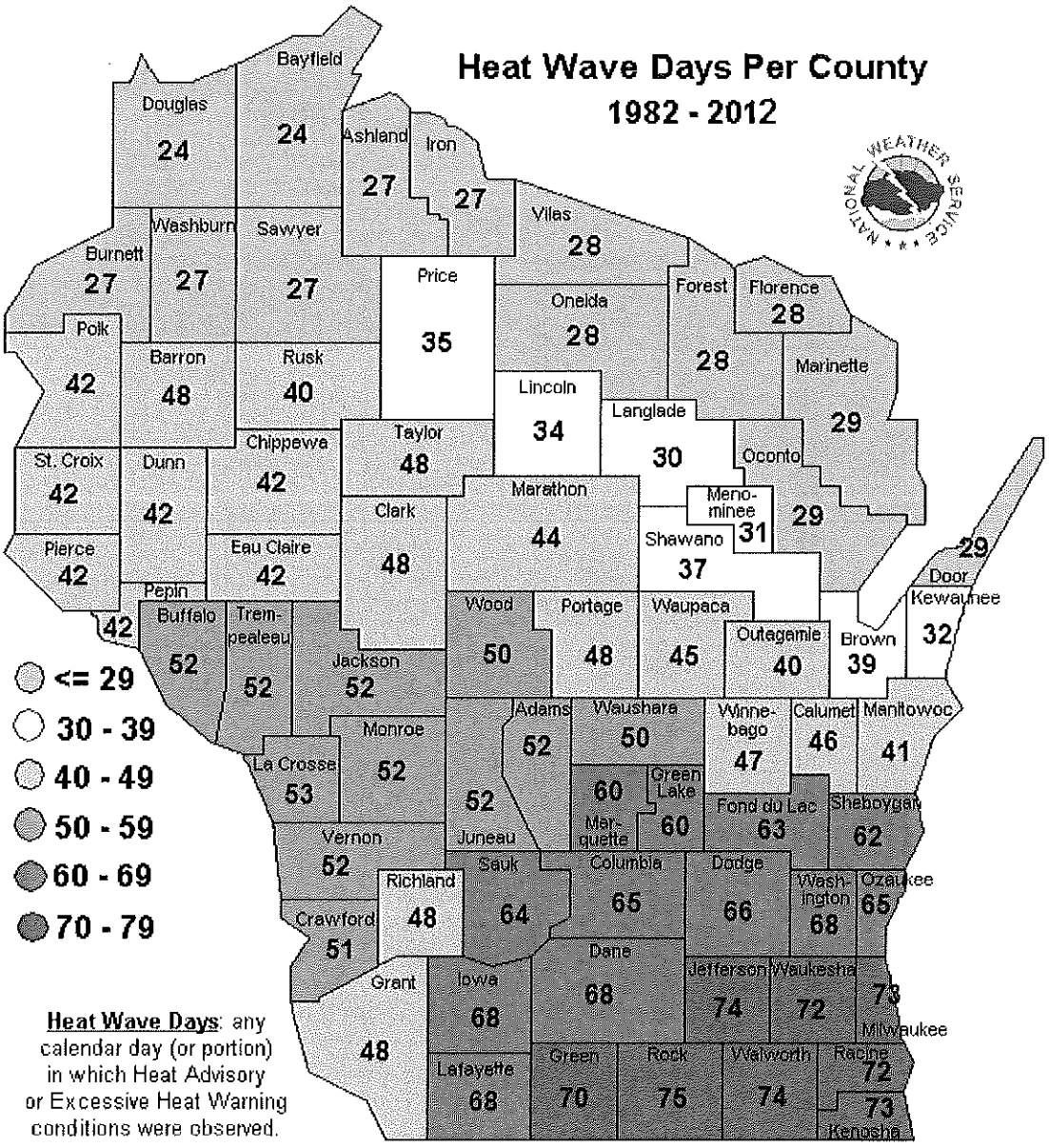
[185] http://www.crh.noaa.gov/images/mkx/climate/avg_30_year_temp.png

Wisconsin Heat Wave Events[186]



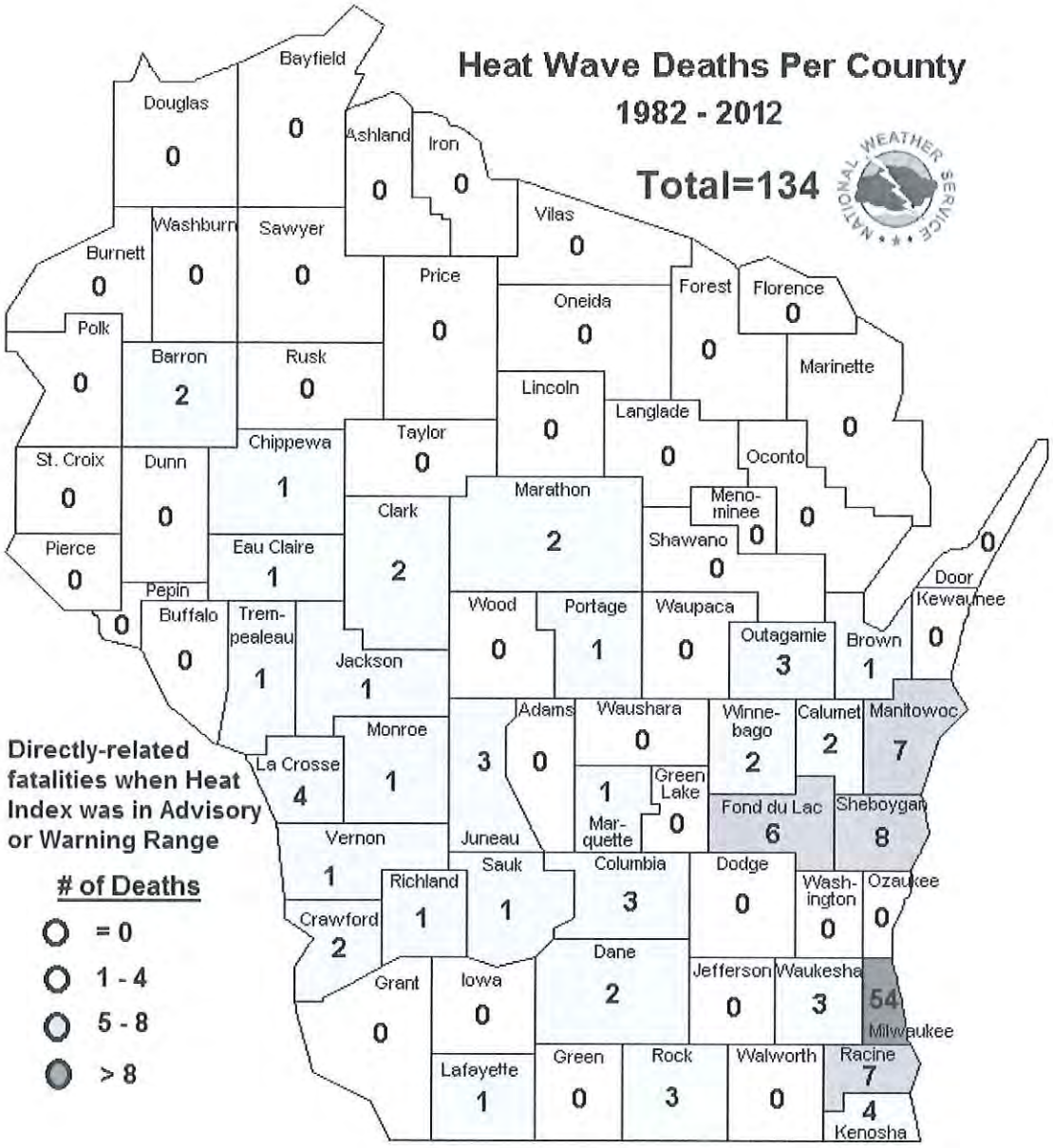
[186] http://www.crh.noaa.gov/images/mkx/severe/htwaveevents.gif

Wisconsin Heat Wave Days[187]



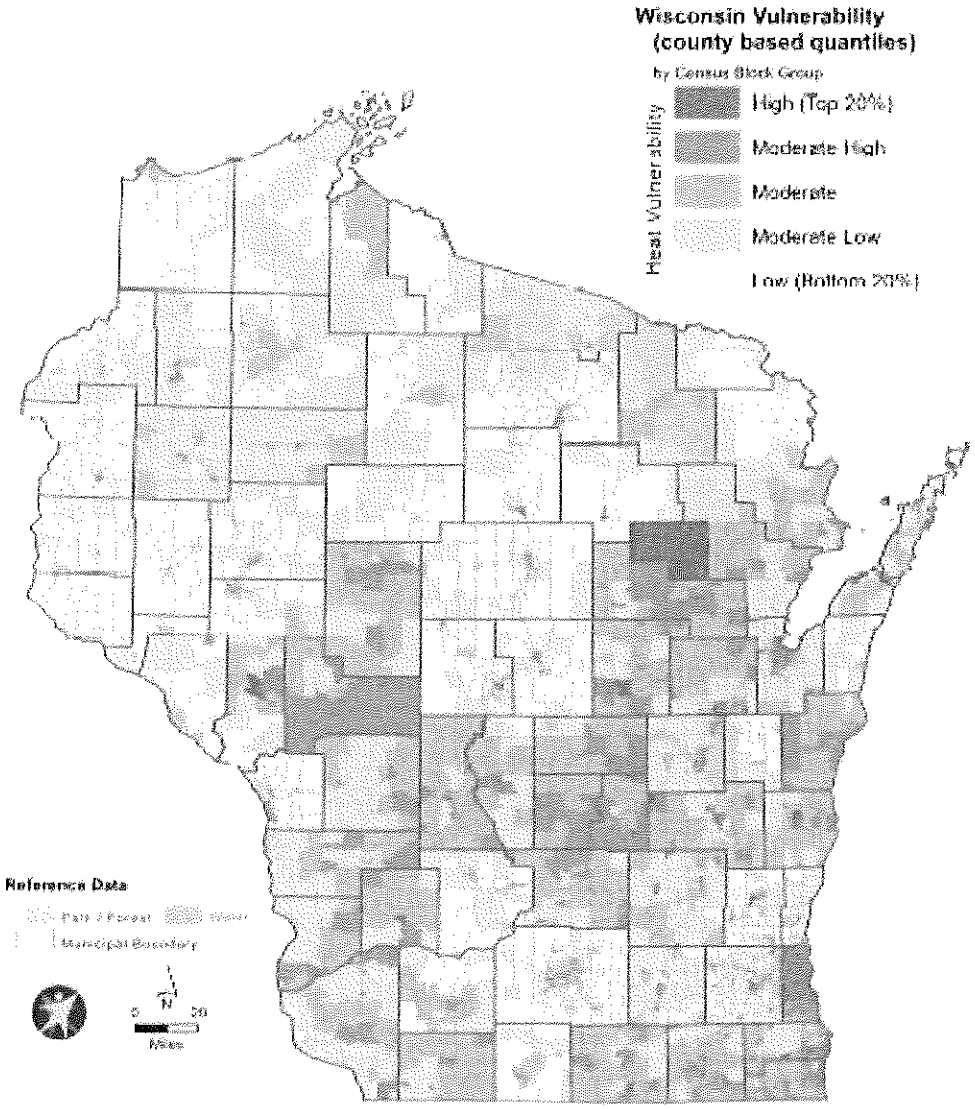
[187] http://www.crh.noaa.gov/images/mkx/severe/htwavedays.gif

Wisconsin Heat Wave Deaths[188]



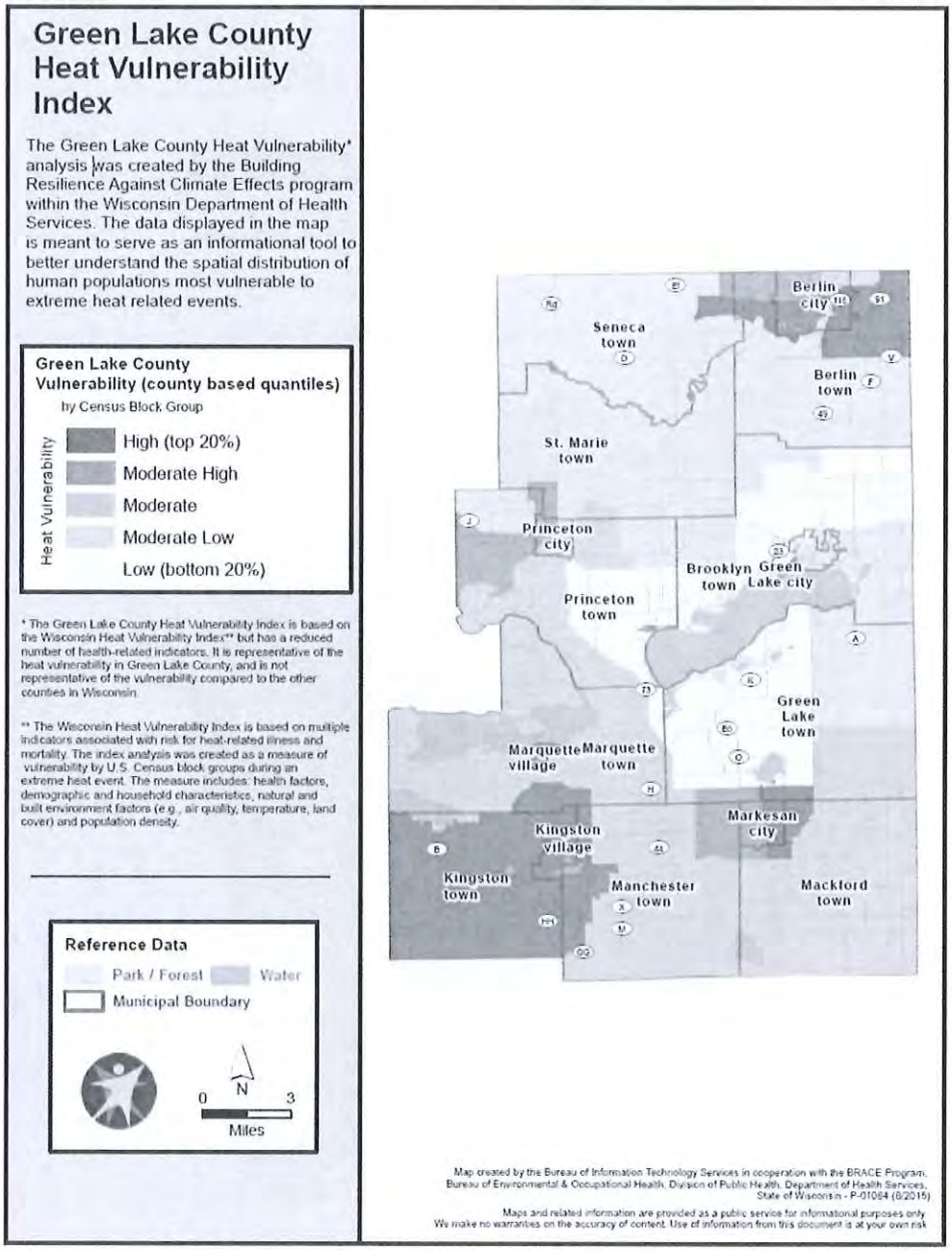
[188] http://www.crh.noaa.gov/images/mkx/severe/htwavedeaths.gif

Wisconsin Heat Vulnerability Index[189]



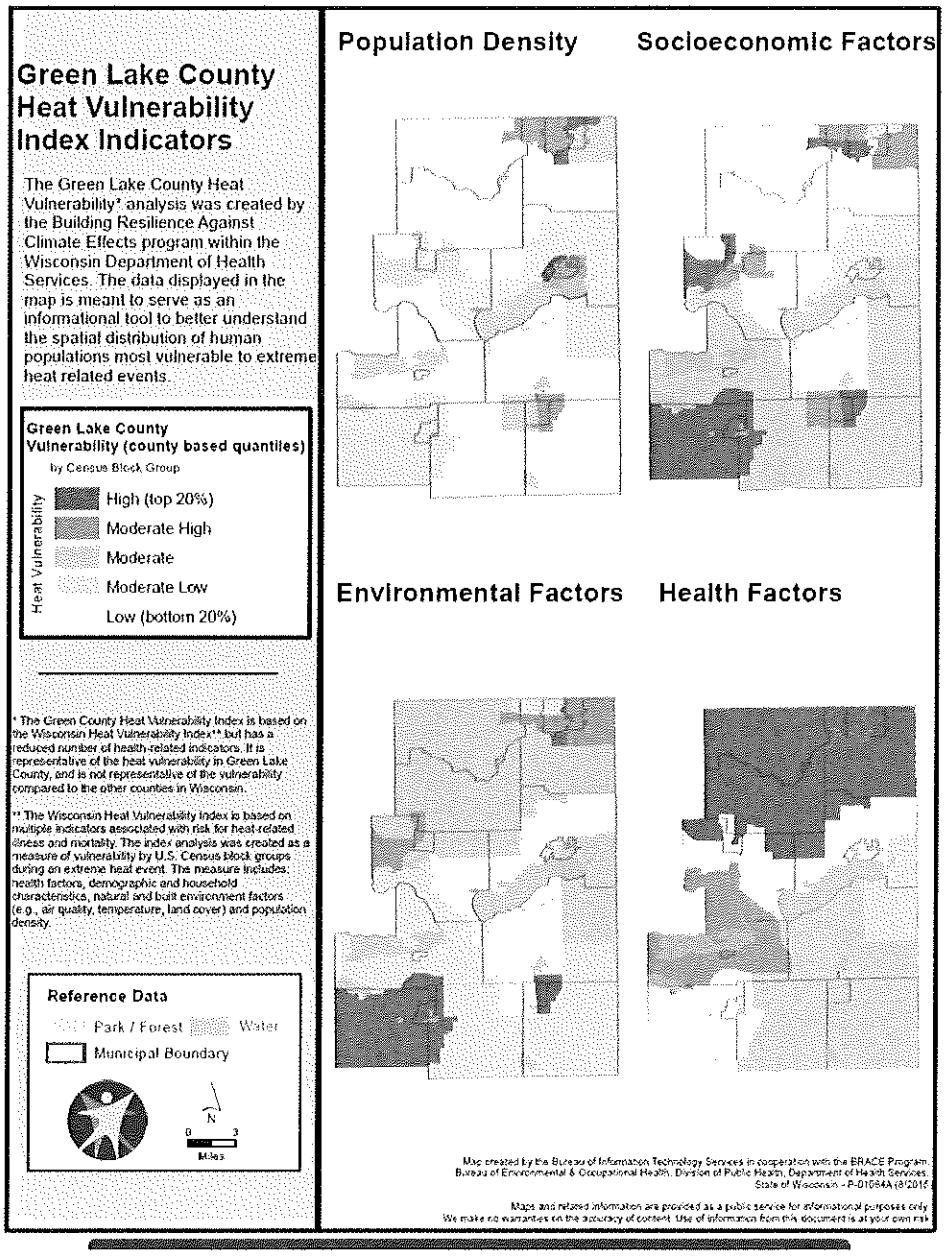
[189] https://www.dhs.wisconsin.gov/images/map-hvi-wi.jpg

Green Lake County Heat Vulnerability Index[190]



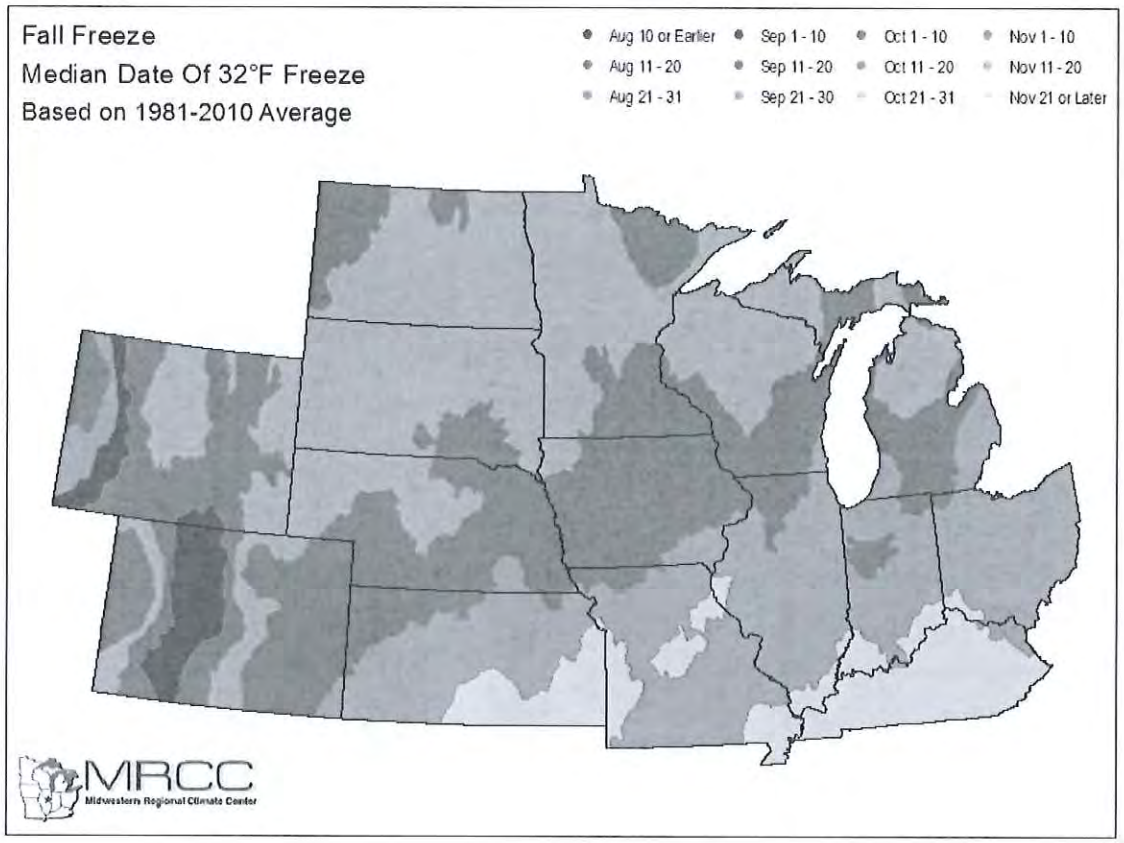
[190] https://www.dhs.wisconsin.gov/publications/p01084-greenlake.pdf

Green Lake County Heat Vulnerability Index Indicators[191]



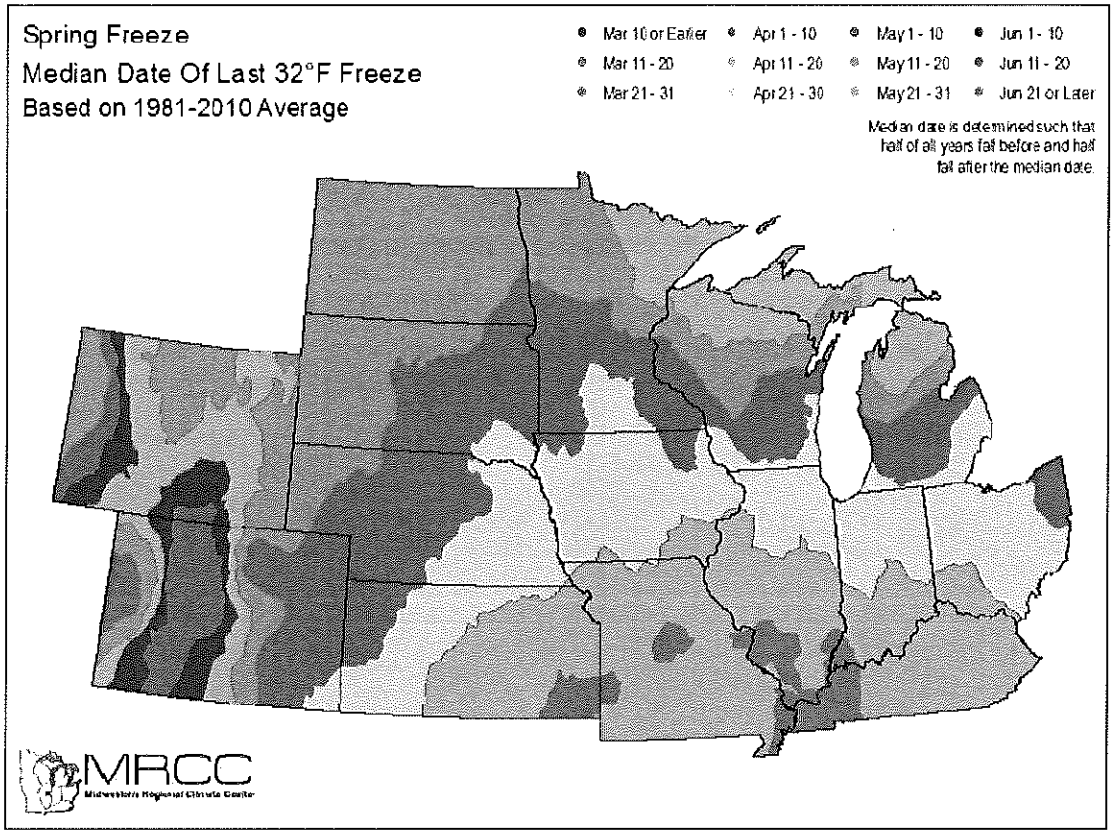
[191] https://www.dhs.wisconsin.gov/publications/p01084a-greenlake.pdf

Median Date of First Freeze[192]



[192] http://www.crh.noaa.gov/images/mkx/climate/FallFirstFreeze.png

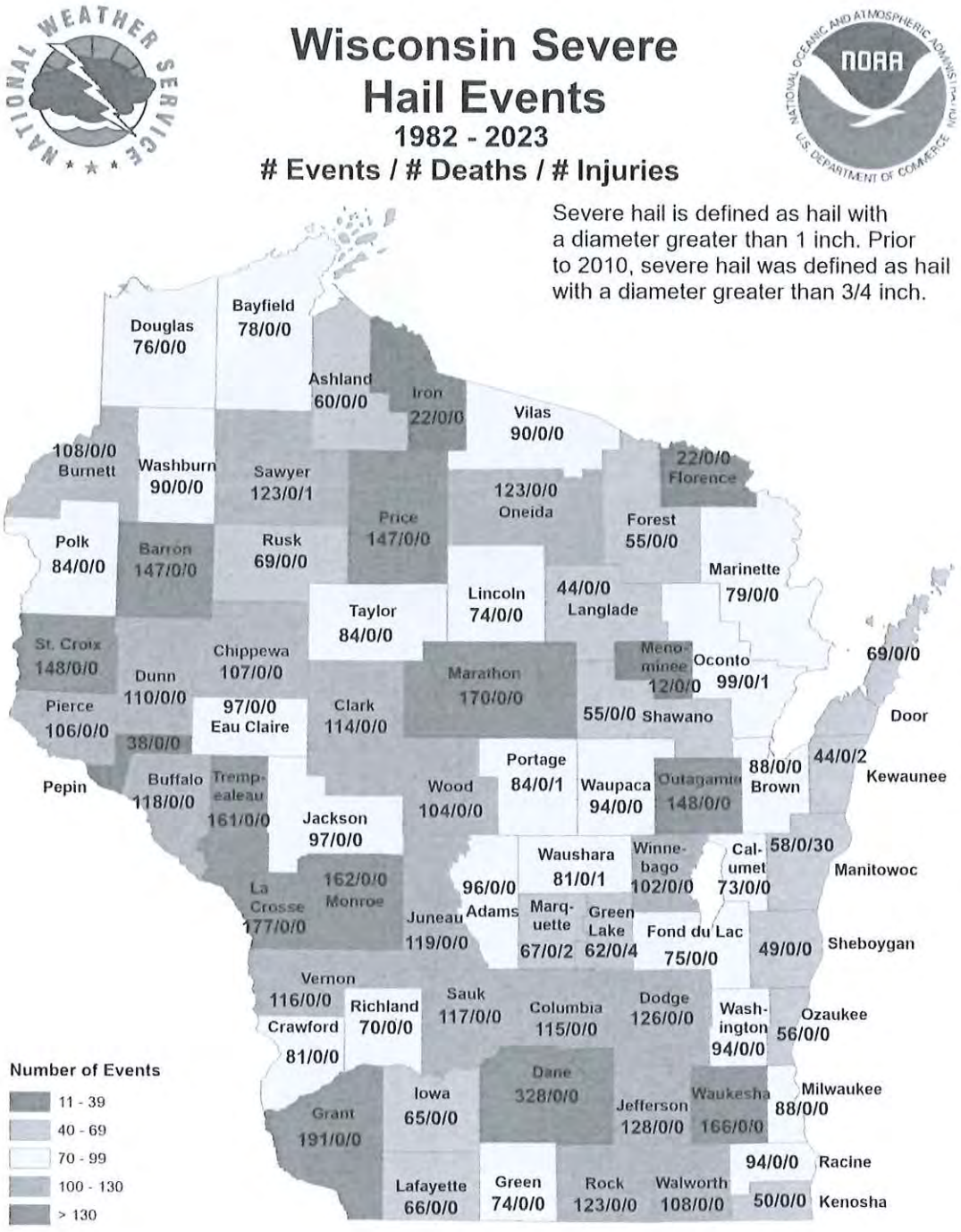
Median Date of Last Freeze[193]



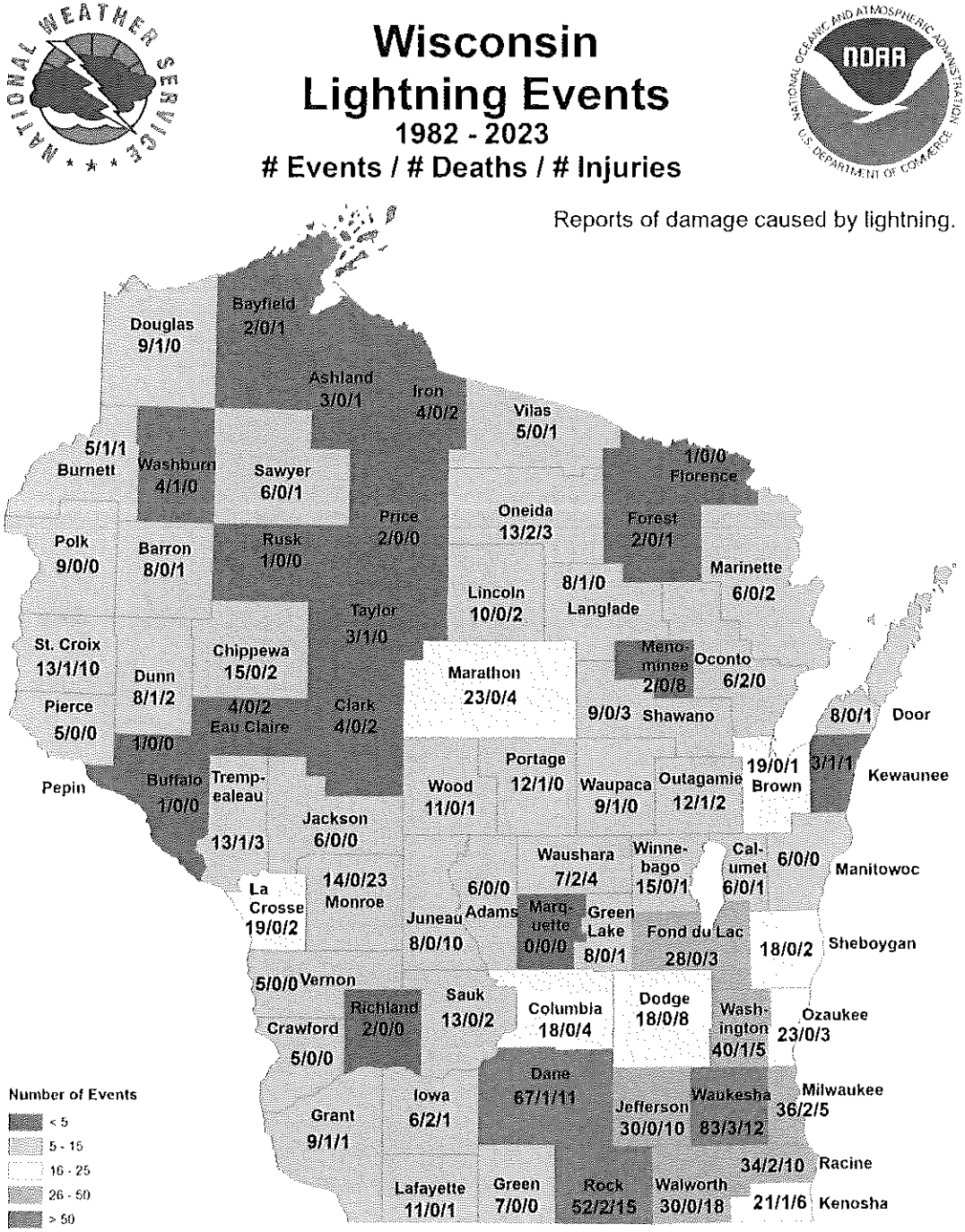
[193] http://www.crh.noaa.gov/images/mkx/climate/springlastfreeze.png

Appendix A: Maps

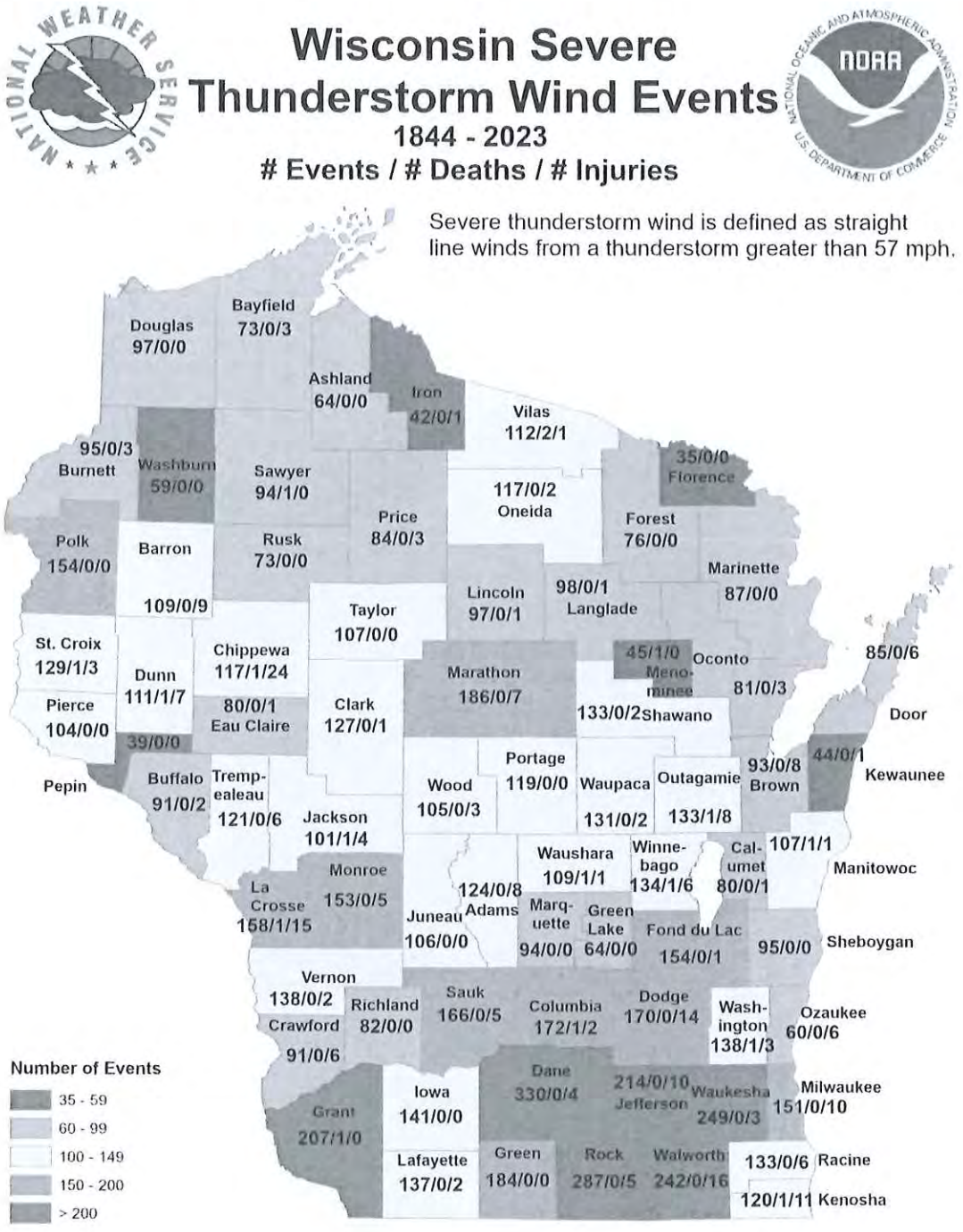
Wisconsin Hail Events



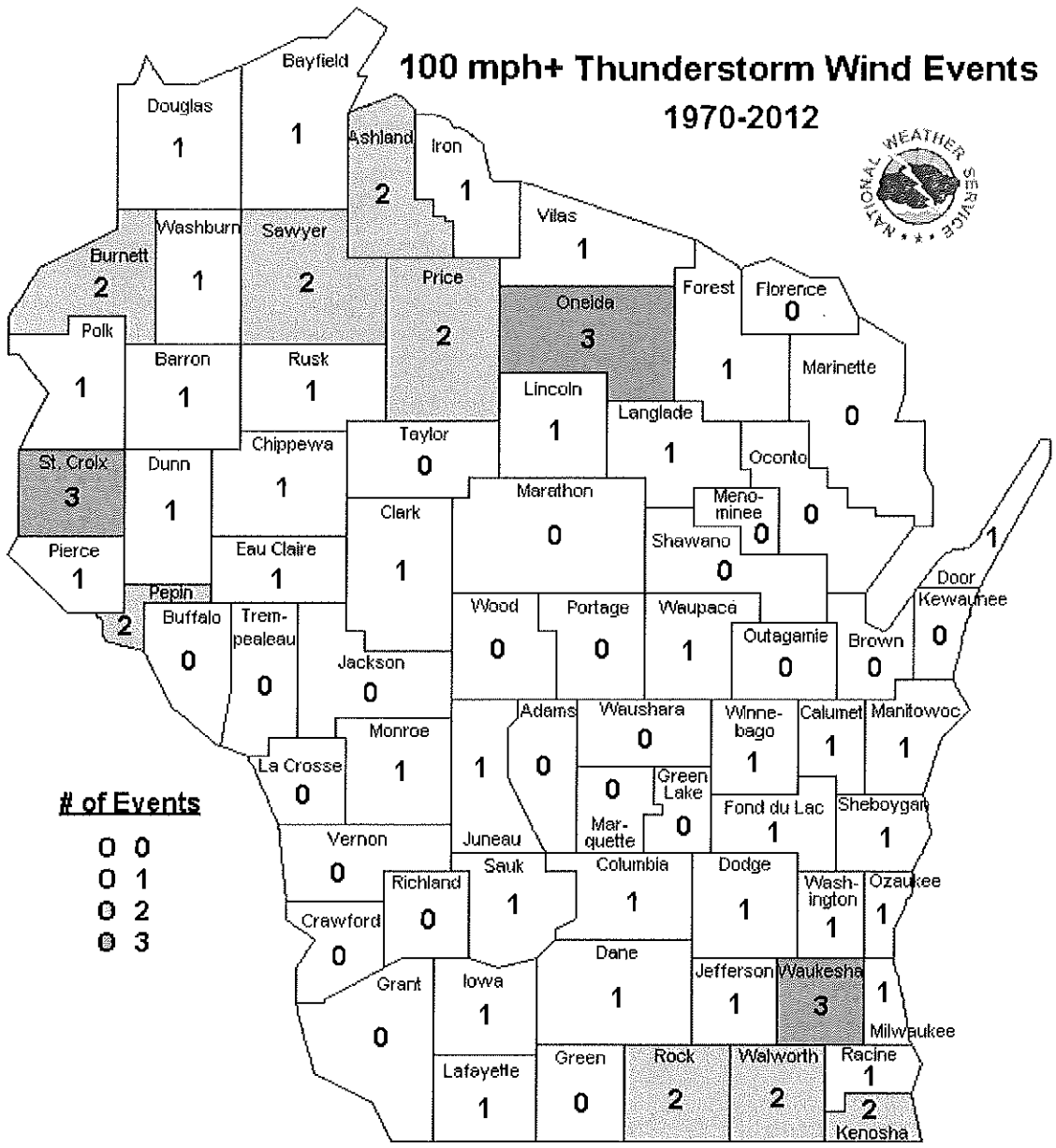
Wisconsin Lightning Events



Wisconsin Severe Thunderstorm Winds

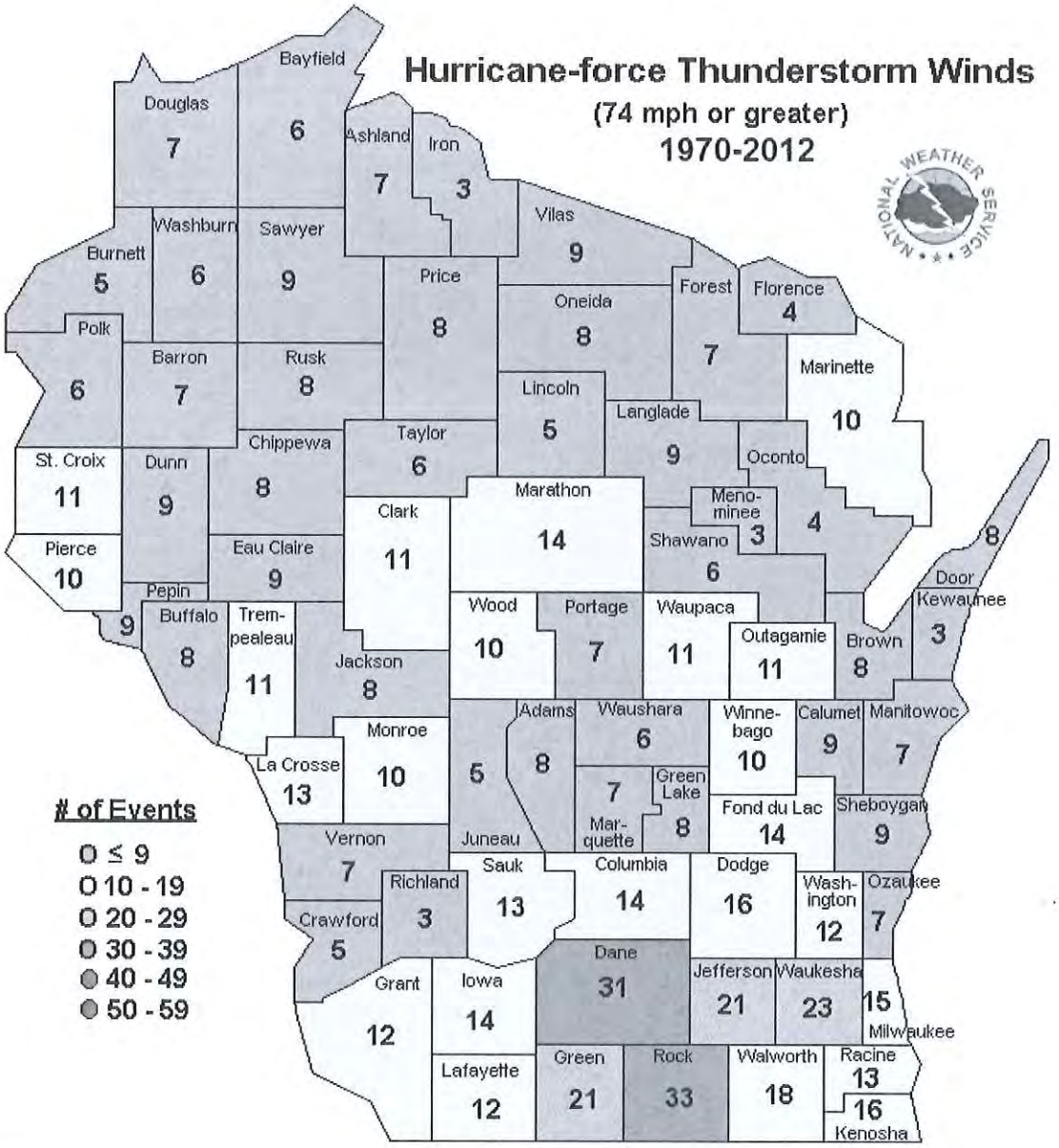


Wisconsin 100+ mph Thunderstorm Wind Events[194]



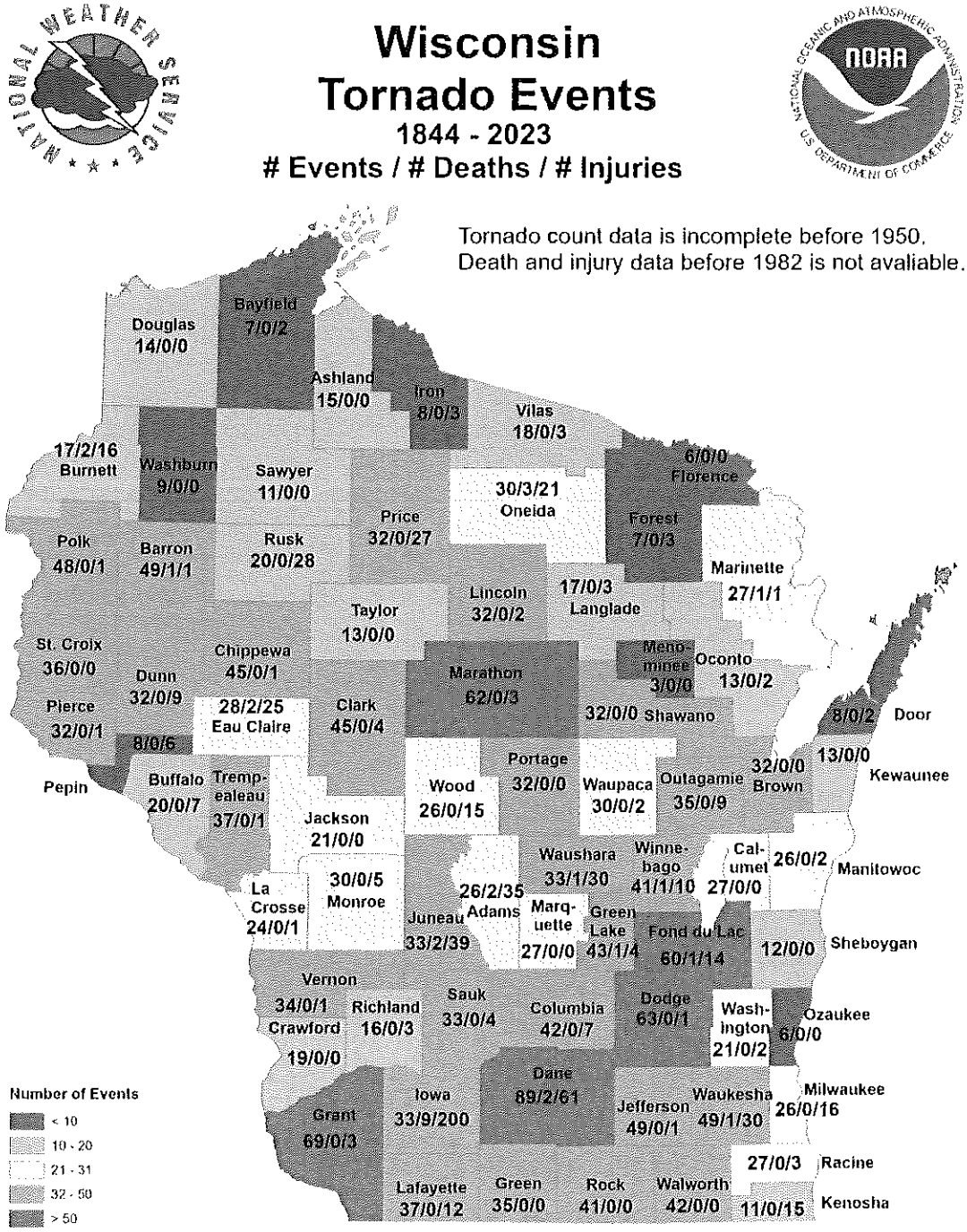
[194] http://www.crh.noaa.gov/images/mkx/severe/hurricwinds100mph.gif

Wisconsin Hurricane-force (74+ mph) Thunderstorm Winds[195]

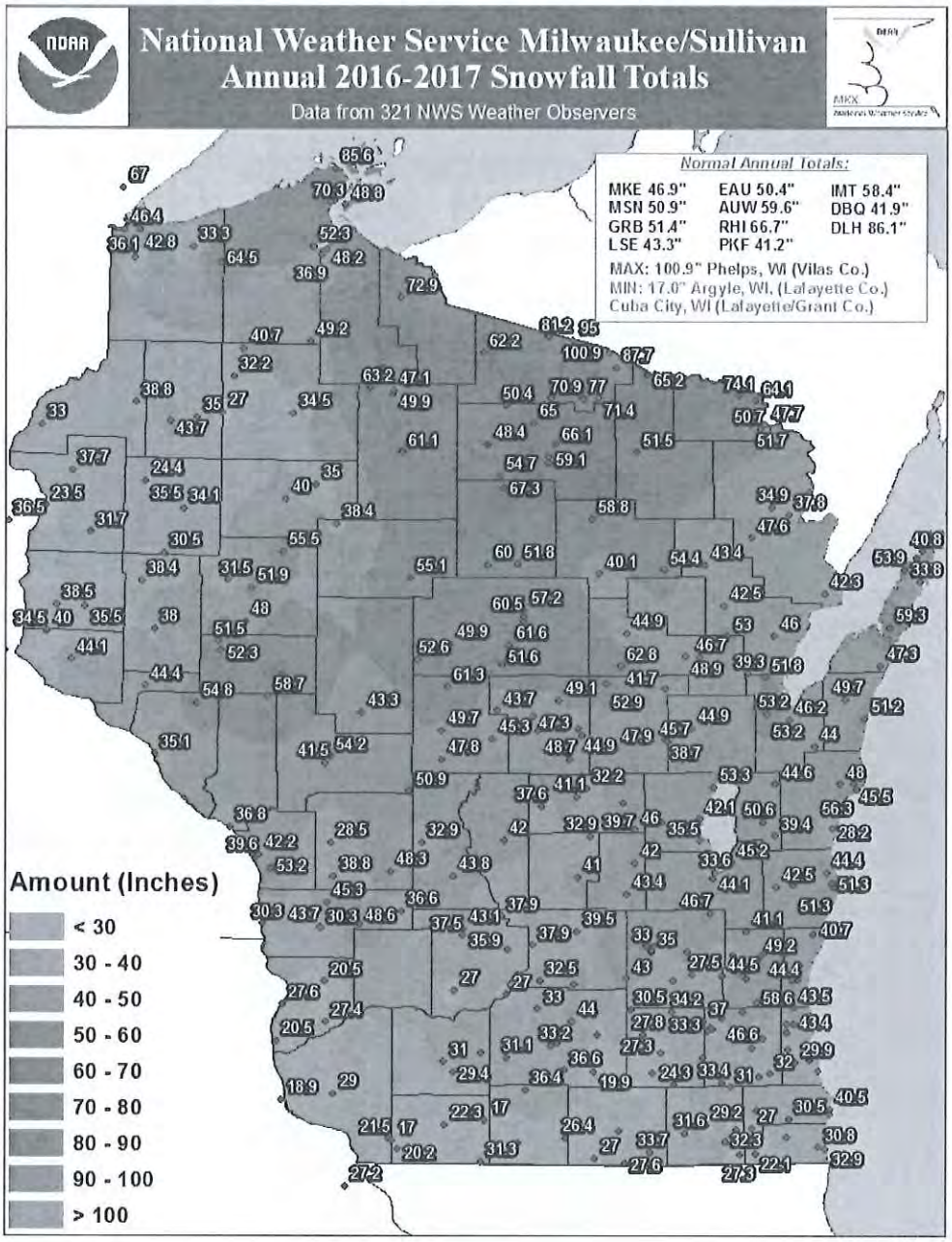


[195] http://www.crh.noaa.gov/images/mkx/severe/hurricwinds75mph.gif

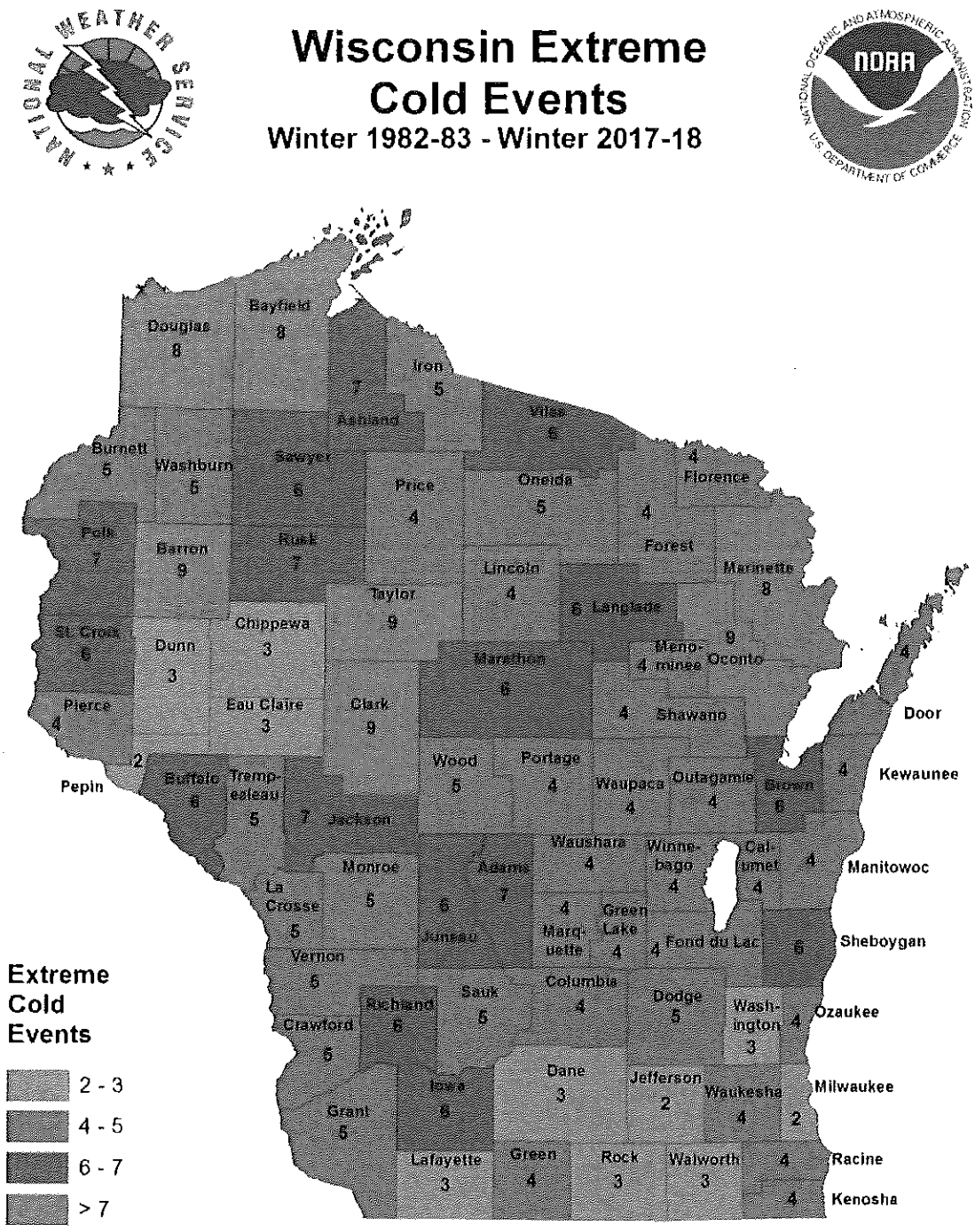
Wisconsin Tornado Events



Wisconsin Annual 2016-2017 Snowfall Totals

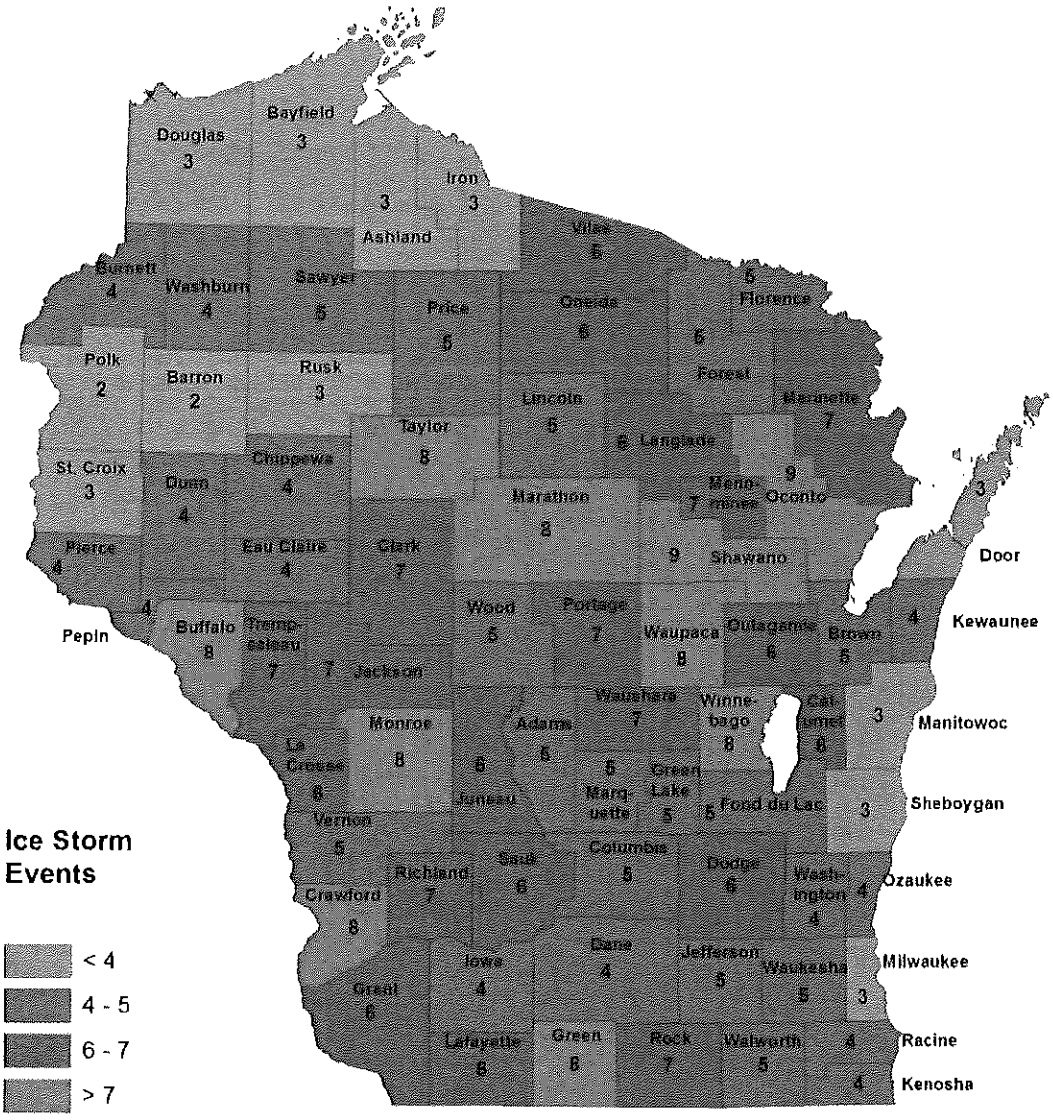


Wisconsin Extreme Cold Events



Wisconsin Blizzard Events

Wisconsin Ice Storm Events



Wisconsin Winter Storm Events