Chapter 3

Natural Hazards Risk Assessment

Federal Requirement

Section 201.6(c)(2) of the mitigation planning regulation requires local jurisdictions to provide sufficient hazard and risk information from which to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards. This includes detailed descriptions of all the hazards that could affect the jurisdiction along with an analysis of the jurisdiction’s vulnerability to those hazards. Local risk assessments coupled with the local mitigation strategies are the basis of the State’s evaluation of its resources and facilitate the establishment of statewide goals.

As defined by the Federal Emergency Management Agency (FEMA), risk is a combination of hazard, vulnerability, and exposure. “It is the impact that a hazard would have on people, services, facilities, and structures in a community and refers to the likelihood of a hazard event resulting in an adverse condition that causes injury or damage.”

The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards. The process allows for a better understanding of a jurisdiction’s potential risk to natural hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

Methodology

This risk assessment followed the methodology described in the FEMA publication “Local Multi-Hazard Mitigation Planning Guidance”, July, 2008 which breaks the assessment down to a four-step process:

1) Identify Hazards
2) Profile Hazard Events
3) Inventory Assets
4) Estimate Losses

Data collected through this process has been incorporated into the following sections of this chapter:

Hazard Identification - Identifies the hazards which threaten the planning area and describe why some hazards have been omitted from further consideration. It also discusses the research methodology utilized to gather the data in this plan.
Hazard Profiles - Discusses each of the included hazards which threaten the planning area. Provides a brief definition and overview of the hazard and reviews significant previous occurrences of the hazard. This section includes the following sub-sections for each hazard: description, geographic extent, previous occurrences, probability of future occurrences, exposure assessment, impact assessment, estimating potential losses, and overall summary.

Vulnerability Summary - Provides a county-wide analysis of exposure to hazards. This is a general picture that assesses common exposures for all hazards and includes specific data such as demographics, property values, and critical facilities. It combines the estimation of a hazard’s occurrence probability with the associated vulnerabilities of critical infrastructure and populations. Includes a summary of the hazard risk ratings and prioritizes hazards for mitigation implementation purposes.

Mitigation Capabilities Assessment - An inventory of existing mitigation activities and existing policies, regulations, and plans that pertain to mitigation and affect the County’s net vulnerability.

Hazard Identification

The Luce County Hazard Mitigation Plan, 2005, served as the starting point for the initial risk assessment in which 17 hazards were identified that the County was determined to be most susceptible to.

Additionally, a survey was distributed to local units of governments, the Luce County Hazard Mitigation Planning committee (LCHMPC) and other stakeholders with various expertise to gather information and opinions on the hazards that had been identified in the 2005 plan. (See Appendix A for a complete listing.)

An on-line community survey was made available through the Eastern U.P. Regional Planning and Development Commission’s website. An on-line mapping tool was also made available for citizens to add input. Information on how to access and complete the survey and edit the map was announced to the public through a news release in the area’s local newspaper “The Newberry News” as well as on the EUP Regional Planning’s Facebook page and quarterly newsletter. Local units of government that have websites were asked to create links to this information.

Additionally, research was conducted on hazard events that occurred over the past five years. The hazard analysis committee met in March, 2014 where they re-examined these hazards, as well as examined additional gathered information. County-wide participation from townships, and the Village of Newberry provided localized knowledge and information to update the hazard identification.

Based on the recommendations by FEMA, the LCHMPC, and historical records for Luce County, the following hazards (listed alphabetically), were considered during the plan update:
Drought
• Extreme Temperatures
• Flooding
• Severe Winter Weather
• Subsidence/Ground Movement
• Thunderstorm/Hail/Lightning/High Wind
• Tornadoes
• Wildfires

In the 2005 Plan the following criteria was used to determine the level of importance to assess each hazard by. The criteria included:

1) Likelihood of Occurrence = Low (1-3), Medium (4-6), High (7-10)
2) Casualty potential = Low (1-3), Medium (4-6), High (7-10)
3) Local capability = Low (7-10) (not very capable), Med (4-6) (somewhat capable), High (1-3) (very capable)
4) Population affected = Low (1-3) (less than 5% of population), Medium (4-6) (5% - 25% of population), High (7-10) (more than 25% of population)
5) Economic impact = Low (1-3) (less than $5,000), Medium (4-6) ($5,000 – $25,000), High (greater than $25,000)

Each of these aspects was assigned a weight as determined by the hazard analysis committee to balance the total score. The following weight was assigned to each criteria: the likelihood of occurrence and casualty potential were weighted at 35%, local capability at 15%, population affected at 10% and economic impact at 5%. Based upon this criteria the hazards ranked as follows in 2005:

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Likelihood of Occurrence</th>
<th>Casualty Potential</th>
<th>Local Capability</th>
<th>Population Affected</th>
<th>Economic Impact</th>
<th>Total Score</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazmat Transportation Incidents</td>
<td>2.1</td>
<td>1.05</td>
<td>0.75</td>
<td>0.1</td>
<td>0.15</td>
<td>4.15</td>
<td>1</td>
</tr>
<tr>
<td>Structural Fires</td>
<td>2.8</td>
<td>0.7</td>
<td>0.15</td>
<td>0.1</td>
<td>0.15</td>
<td>3.9</td>
<td>2</td>
</tr>
<tr>
<td>Infrastructure Failure</td>
<td>1.1</td>
<td>0.7</td>
<td>1.05</td>
<td>0.4</td>
<td>0.5</td>
<td>3.7</td>
<td>3</td>
</tr>
<tr>
<td>Transportation Accidents</td>
<td>2.8</td>
<td>0.35</td>
<td>0.15</td>
<td>0.1</td>
<td>0.25</td>
<td>3.65</td>
<td>4</td>
</tr>
<tr>
<td>Thunderstorms, Lightning, Hail, Tornadoes</td>
<td>2.1</td>
<td>0.35</td>
<td>0.45</td>
<td>0.4</td>
<td>0.3</td>
<td>3.6</td>
<td>5</td>
</tr>
<tr>
<td>Wildfires</td>
<td>2.5</td>
<td>0.35</td>
<td>0.3</td>
<td>0.1</td>
<td>0.25</td>
<td>3.45</td>
<td>6</td>
</tr>
<tr>
<td>Terrorism/Sabotage/WMD</td>
<td>1.4</td>
<td>0.7</td>
<td>0.75</td>
<td>0.3</td>
<td>0.25</td>
<td>3.4</td>
<td>7</td>
</tr>
<tr>
<td>Extreme Temperatures</td>
<td>2.1</td>
<td>0</td>
<td>0.6</td>
<td>0.5</td>
<td>0.15</td>
<td>3.35</td>
<td>8</td>
</tr>
<tr>
<td>Public Health Emergencies</td>
<td>1.4</td>
<td>0.35</td>
<td>0.9</td>
<td>0.2</td>
<td>0.25</td>
<td>3.1</td>
<td>9</td>
</tr>
</tbody>
</table>
After conducting a cursory review of Luce County’s geographic location and climate, several of the natural hazards included in the initial composite list were discarded because they are not relevant to Luce County. These include: Avalanche, Earthquake, Expansive Soils, Hurricane, Tsunami, and Volcano. High Wind, Hail and Lightning were combined with Thunderstorms as those hazards typically occur during a passing storm system. Blizzards, Ice Storm and Sleet were combined in Severe Winter Weather category. Scrap Tire Fire category was combined with Structural Fires.

### Hazard History

As part of the hazard identification process, the EUPRP&DC staff researched past events which triggered federal and/or state emergency or disaster declarations in the planning area. Federal and/or state disaster declarations may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local government’s capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. Should the disaster be so severe that both the local and state governments’ capacities are exceeded, a federal emergency or disaster declaration may be issued allowing for the provision of federal assistance.

According to state police data, from January 1977 through July 2012, there have been 21 presidential declarations and 63 gubernatorial declarations of emergency or disaster in Michigan. The State Budget Office notes that since 2005, the state has expended more than $12 million in responding to tornadoes, wind storms and floods, as well as more extensive disasters like the Duck Lake fire in 2012 and the Sleeper Lake fire in 2007.
The number of natural disasters in Luce County (3) is a lot smaller than the US average (12).

Although none from Luce County, the following table represents Michigan Weather Related Fatalities from the period 2005-2009 according to the National Weather Service.

<table>
<thead>
<tr>
<th>Year</th>
<th>Wind</th>
<th>Flooding</th>
<th>Lightning</th>
<th>Winter</th>
<th>Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>1</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7 - Michigan Weather Related Deaths

Note: All the injuries listed above are “direct” injuries, in which the weather hazard is the major cause of injury. Heat Wave injuries are considered “illnesses.” And are not are not tabulated above. Likewise, nearly all injuries attributed to vehicle injuries on highways in Winter Storms are “indirect” injuries, since the driver was driving too fast for the conditions, etc. In other words, the snow or ice did not injure the individual; the injury was the result of a vehicle accident. Source: National Weather Service.

According to the National Climatic Data Center, Luce County listed 127 storm events during the period January 1, 2005 to August 31, 2013 listed in the following table:

<table>
<thead>
<tr>
<th>Number of Events</th>
<th>Type of Event</th>
<th>Property Damage Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Thunderstorm Winds</td>
<td>$80,000</td>
</tr>
<tr>
<td>6</td>
<td>Hail</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Tornado</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Heavy Rain</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Lightning</td>
<td>$70,000</td>
</tr>
<tr>
<td>1</td>
<td>Sleet</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Heavy Snow</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Blizzard</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Lake Effect Snow</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Winter Storm</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Cold/Wind Chill</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Frost Freeze</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Dense Fog</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Wildfire</td>
<td>$12.4M</td>
</tr>
<tr>
<td>38</td>
<td>Winter Weather</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>High Wind</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Seiche</td>
<td></td>
</tr>
</tbody>
</table>

Table 8 - Luce County Storm Events 2005-2013
In addition to property losses, there is potential for death or injury from many of the natural hazards that threaten the County. The past and potential impacts for each of the identified hazards are described in greater detail in each specific hazard profile.

2013 Hazard Profile

The hazards identified to have significant impact on Luce County are profiled individually in this section. Much of the profile information came from the same sources used to identify the hazards during the initial planning effort in 2005. These sources include records and information from the State of Michigan Emergency Management Division, FEMA, National Weather Service, Luce County Office of Emergency Management, as well as local research of news articles and inquiries to the many public and private stakeholders relevant to the project. The information was reviewed for accuracy and applicability and updated where required. Significant occurrences of hazards that have occurred since the original plan’s adoption in 2005 are also included in the updated hazard profiles. Significant historical events prior to 2005 are listed in Appendix G.

Profile Methodology

Each hazard is profiled in a similar format that is described below. This approach helps create a uniform planning basis and enables comparisons between the hazards. The basic outline is:

Description: This subsection gives a generic description of the hazard and associated problems, followed by details on the hazard specific to Luce County.

Geographic Extent: Here we discuss which areas of the County are most likely to be affected by a hazard event at any given time:

- Isolated: Single site occurrences for each incident (Points = 1)
- Limited: Less than 10 percent of the planning area (Points = 2)
- Significant: 10 to 50 percent of the planning area (Points = 3)
- Extensive: 50 to 100 percent of the planning area (Points = 4)

Historical Events: This subsection contains information on historic incidents, including impacts where known. The extent or location of the hazard within or near the Luce County Planning area is also included here.

Likelihood of Future Occurrences: The frequency of past events is used here to gauge the likelihood of future occurrences. Based on historical data, the likelihood of future occurrences is categorized into one of the following classifications:

- Low – less than a 1% chance of occurring annually (Points = 1)
- Medium – 1% - 50% chance of occurring annually (Points = 2)
- High – 51%-100% chance of occurring annually (Points = 3)
The frequency, or chance of occurrence, was calculated where possible based on existing data. Frequency was determined by dividing the number of events observed by the number of years and multiplying by 100. This gives the percent chance of event happening in any given year. Where this data results in a percent above 100 percent, the hazard is assumed to have a yearly frequency rating. Example: Three droughts over a 30-year period equates to 10 percent chance that the hazard will occur in a given year, and is then rated as “medium”.

Impact Assessment

This examines the potential impacts of the hazard on Luce County using qualitative assessment methods. Based on past experiences in Luc County, in the State of Michigan, and nationwide, this is a qualitative discussion of the consequences that could be expected in the aftermath of each of the hazard events. Impacts are divided into two categories:

**Direct Impacts**
This describes the short-term consequences to people and property which occur directly as a result from the hazard.

**Indirect Impacts**
This describes the short-term and long-term consequences, including social and economic impacts. Secondary hazards are also examined here. Because indirect impacts are much broader and difficult to quantify than direct impacts, the section is abbreviated where appropriate to maintain mitigation focus.

**Impact Magnitude and Severity Summary**
This subsection summarizes the qualitative magnitude and severity of a hazard based on previous occurrences and the potential direct and indirect impacts. For most hazards the impacts are based on the event of record, or estimated worst case if history of events is limited. Impact magnitude and severity are classified in the following manner:

- Population affected: **Low** (less than 5% of population) (Points = 1); **Medium** (5% - 25% of population) (Points = 2); **High** (more than 25% of the population affected) (Points = 3)
- Casualty Potential: **Low** (no fatalities, treatable injuries) (Points = 1); **Medium** (fatalities possible, injuries probable) (Points = 2); **High** (fatalities, and/or life changing injuries probable) (Points = 3)
- Economic Impact: **Low** (less than $5,000) (Points = 1); **Medium** ($5,000-$25,000) (Points = 2); **High** (greater than $25,000) (Points = 3)
- Local Capability – **Low** (not very capable) (Points = 3); **Medium** (somewhat capable) (Points = 2); **High** (very capable) (Points = 1)
Vulnerability Assessment

This section provides an analysis of the exposed properties, people and resources in the county specific to the hazard. For clarification and ease of mitigation planning, exposures are broken into four major categories:

- Population
- General Property
- Essential Infrastructure, Facilities, and Other Important Community Assets
- Natural, Historic and Cultural Resources

Estimating Potential Losses

Potential losses are determined based on available data, so the methodology varies by hazard. For some hazards this may be based on average annualized losses, or using the documented event of record for the hazard and identifying the corresponding damage in dollars, adjusting them for inflation to reflect 2013 costs. Where the hazard occurs in a specific area, such as flood, GIS methods were used estimate losses to structures and critical facilities, as available data permitted.

Mitigation Capabilities Assessment

A review of the existing mitigation activities and existing policies, regulations, and plans that pertain to mitigation and strategies that have been proven to be effective in reducing the risks and impact of a hazard.

Overall Risk Summary

Overall vulnerability for the hazard is measured in terms of geographic extent, impacts, magnitude and severity, probability of occurrence, and exposure. These findings are summarized in this section and analyzed to reveal an overall risk rating for the hazard. This rating is calculated by averaging the numeric ratings for each measurement and then assigning a corresponding interpretation to the average. This determines the vulnerability of the County to the hazard, relative to the other hazards profiled.

- Low: Minor risk (0 to 1.9 average)
- Medium: Moderate risk (2.0 to 2.5 average)
- High: High risk. (2.5 or higher average)
Natural Hazards

Drought

Description: Common to all types of drought is the fact that they originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (say, a few weeks or a couple months), the drought is considered short-term. But if the weather or atmospheric circulation pattern becomes entrenched and the precipitation deficits last for several months to several years, the drought is considered to be a long-term drought. It is possible for a region to experience a long-term circulation pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-term wet spells. Likewise, it is possible for a long-term wet circulation pattern to be interrupted by short-term weather spells that result in short-term drought.

Many quantitative measures of drought have been developed in the United States, depending on the discipline affected, the region being considered, and the particular application. Several indices developed by Wayne Palmer, as well as the Standardized Precipitation Index, are useful for describing the many scales of drought.

The Palmer Z Index measures short-term drought on a monthly scale. The Palmer Crop Moisture Index (CMI) measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing season.

The Palmer Drought Severity Index (PDSI) (known operationally as the Palmer Drought Index (PDI)) attempts to measure the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months. Since weather patterns can change almost literally overnight from a long-term drought pattern to a long-term wet pattern, the PDSI (PDI) can respond fairly rapidly.

The Palmer Drought Index uses temperature and rainfall information to determine dryness or wetness over a period of time. The index is based on the supply-and-demand concept of the water balance equation, which takes into account not only the precipitation deficit at a specific location, but the water content of the soil as well. The values generated for the Palmer Index generally range from −6.0 to +6.0, with negative values indicating drier conditions and positive values indicating wetter conditions. A value range of −/+0.5 indicates “normal” conditions, while values greater than +4.0 or −4.0 indicate periods of extreme wetness or extreme drought, respectively.

The hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) take longer to develop and it takes longer to recover from them. The Palmer Hydrological Drought Index (PHDI), another long-term drought index, was developed to quantify these hydrological effects. The PHDI responds more slowly to changing conditions than the PDSI (PDI).
While Palmer's indices are water balance indices that consider water supply (precipitation), demand (evapotranspiration) and loss (runoff), the **Standardized Precipitation Index (SPI)** is a probability index that considers only precipitation. The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. The SPI is computed by NCDC for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term and long-term drought.

**Geographic Extent:** Drought is a regional phenomenon and affects the entirety of Luce County relatively simultaneously. The geographic extent rating is considered **extensive**.

**Historical Events:** The history of past drought events was gathered from NCDC data, newspaper reports and other data sources as cited.

**8/7/2007** - Drought conditions (severe, D2) expanded eastward into Eastern Upper Michigan during August. It was a dry summer in the region, especially in the Upper Peninsula. A burning ban was issued for the majority of the state in mid-August, the first such ban since 1998.

**9/1/2007** - Drought conditions (severe, or D2) carried over from August in Eastern Upper Michigan and far Northern Lower Michigan. Several rain events eased the drought by mid-month. The area received half an inch to an inch of rain on September 3-4, again on the 7th, and again on the 11th.

**July-September, 2005** - According to the Midwestern Regional Climatic Center both Lake Superior and Lake Michigan-Huron levels started declining in August, 2005, a full month ahead of the normal lake level seasonal cycle. While a few wet weeks can greatly help the soil moisture situation, as happened in August, the long term hydrological dryness will require months of copious moisture during the cold season to recover fully.

**From 1998-2001,** Michigan experienced a series of droughts. These droughts caused considerable damages to the industries in these areas. In Michigan, during the summer of 2001, a severe drought caused damage to, or destroyed, 1/3 of the state's crops, such as fruits and vegetables. This resulted in a U.S. Department of Agriculture Disaster Declaration that included 82 of Michigan's counties.

**Probability of Future Occurrences:** Figure 1 shows the average Palmer Index values from 1895 to 2010. The graph also indicates a period of moderate drought over a four year period from 1998-2001. More recent years show drought levels in 2006 and 2007. This graph takes into consideration all months of the year.
Using the formula established in Profile Methodology, the assessment reflects (9 drought incidents where the NDSI was -3.0 or lower over [divide by] 114 years) x 100 = 8 percent chance of occurrence and a medium likely occurrence rating.

Impact Assessment:

Direct Impacts: There are many ways a community can be affected if a drought were to occur. There can be a shortage of water in the area for drinking, agriculture, power generation, or other uses. This is often accompanied by a drop in both the quality and quantity of crops in the area, as well as a drop in the quality of natural bodies of water. Due to a lack of water, there can also be increased numbers of wildfires in the area. These are just a few of the many problems that can occur due to a drought.

Urban areas will suffer because they are more vulnerable to water shortages. This is because of the increased number of people competing for a limited water supply. This is especially true for children and the elderly who may be more affected by the warmer weather. Restrictions may be imposed on watering lawns or washing vehicles.

The rural areas of Michigan can be affected as well. A drought is most influential on the crops and livestock that are found in these areas. The drought can greatly affect the quantity and quality of these crops. This effect on crops can hurt the financial well-being of the people who depend on them. The size of forest fires in the area can also be influenced.
**Indirect Impacts:** Major highway damage was noted in several states due to heaving of road surfaces. Crops were stunted in the southern and eastern parts of the Midwest due to the combination of heat and lack of rainfall. Milk production at dairy farms was also hard hit, and thousands of cattle, pigs, and chickens died due to the heat.

**Vulnerability Assessment:** Community water supply systems that obtain their water from surface water sources have the potential to be affected by severe drought conditions when stream flow amounts and the flow of shallow groundwater that feeds surface water bodies are reduced. For many communities in Luce County, the lack of any serious drought threat in recent memory and living in the Great Lakes basin has fostered a sense of security concerning the adequacy of their supply. In many cases a sense of security is warranted; in other cases, it is not. With record low water levels in the Great Lakes the communities of Luce County need to be aware of the potential vulnerability to drought.

**Population:** The general population of Luce County is vulnerable to severe drought situations with the elderly and very young at most risk. Entire communities in the County may be affected if water supplies dry up. During periods of drought there is a higher incident rate of certain infectious diseases.

**General Property:** Luce County’s watershed’s, wetlands, agriculture land and forest land is all vulnerable to drought. In the forest, dry conditions lead to lower overall production of fruits and nuts, something called “mast.” Although, in some cases, the current year response may be the opposite. Trees and other plants produce less palatable browse, in both quantity and quality. Some herbaceous species go into dormancy earlier. Reductions of these energy rich food sources result in less fat build-up among herbivores. Those wildlife species that remain resident throughout the winter may not have enough reserves to survive. Those that migrate will have a more difficult passage and will need good food supplies at their destinations, if they arrive.

Poorer habitat quality has ramifications beyond the summer. Trees and shrubs will produce fewer flower buds. That means that next year, there will, again, be a lower amount of fruits and nuts. Aspen will have fewer flower buds to feed wintering ruffed grouse. Increased mortality of perennial vegetation leaves cover gaps needed for over-wintering, breeding and shelter from predators and foul weather. Vegetation on sandy and shallow soils is particularly vulnerable.

Reduced lake levels are more than just a recreational inconvenience. Exposed structure reduces habitat for certain fish species. Wider shorelines increase the risk of predation by animals that utilize these riparian zones. Of course, this is good if you’re a hawk, owl or coyote. It also may be good to re-establish and invigorate some wetland plant species – if the lake reductions aren’t long term.

**Essential Infrastructure, Facilities, and Other Important Community Assets:** Production of electricity will be less and more costly if the power company has to purchase the power from other sources. Without the normal water pressure holding them up, seawalls will buckle and
collapse, requiring expensive repairs. Also threatened are freshly exposed wood pilings under many docks. Long-submerged sections are prone to rot when exposed to air. Low water levels are threatening to local marinas and recreational boaters. Canals are too shallow, launching ramps fall short of the water's edge, and many boat slips are simply off-limits. High cost of dredging face many local resort owners who rely on water recreational tourism for their living.

**Natural, Historic and Cultural Resources:** A long term drought accompanied by higher seasonal temperatures will have a detrimental effect on older buildings making them more vulnerable to fire hazard. Natural and historic resources are a big tourism draw to the area, some of which are related to water levels in lake and rivers and low levels will have an economic effect as well as being detrimental to the plants and wildlife.

**Estimating Potential Losses:** Low water levels hurt shippers and manufacturers and create inflationary pressure. The impact is widespread. Giant cargo ships must lighten their loads to avoid running aground. And with their supply lines pinched, steel manufacturers and coal-burning power plants have to dip into their stocks of iron ore, coal, and other raw materials. The low water is lifting power prices, too. Less water means hydropower plants can't generate as much electricity, and producers are increasing prices where possible. Many communities rely on lakes and rivers for recreational tourism as well as livelihoods for commercial fisherman. The economic impact is far reaching.

**Mitigation Capabilities:** Strategies for drought preparedness focus mainly on water conservation. Local communities should consider drought contingency planning in their emergency planning efforts because drought conditions will lead to higher risk for other hazards such as wildfires or public health emergencies.

Sustainable agriculture is good for the environment as well as for people. Sustainable agriculture refers to practices that optimally utilize resources to provide the best quality agricultural products. There are numerous ways in which agriculture can be considered sustainable. Taking advantage of the unique characteristics of local resources is one of the hallmarks of sustainable agriculture. Planting crops that are native to an area often means that they will be more resilient and grow with fewer complications. Additionally these local crops often require less fertilizer and pesticides and are believed to be healthier for us to eat. Consistently employing these practices helps to keep land viable for longer periods of time. This allows more high quality food to be produced locally. If these practices are used, particularly in areas where food production is limited, there will be greater access to higher quality food in more places.

The following are established practices of soil and water conservation:

- Crop rotation
- Contoured row crops
- Terracing
- Tillage practices
- Erosion-control structures
- Water retention and detention structures
- Windbreaks and shelterbelts
- Litter management
- Reclamation of salt-affected soil.

Soil and water conservation can be approached through agronomic and engineering measures. Agronomic measures include contour farming, off-season tillage, deep tillage, mulching and providing vegetative barriers on the contour. These measures prevent soil erosion and increase soil moisture.

Engineering measures differ with location, slope of the land, soil type, and amount and intensity of rainfall. Measures commonly used are the following:

- **Contour bunds, trenches and stone walls**
  
  These features prevent soil erosion and obstruct the flow of runoff. The retained water increases soil moisture and recharges the groundwater.

- **Check dams and other gully-plugging structures**
  
  Check dams are temporary structures constructed with locally available materials. Types of check dams are the brush-wood dam (Fig. 2 a), the loose-rock dam (Fig. 2 b) and the woven-wire dam.

- **Percolation ponds**
  
  These features store water for livestock and recharge the groundwater. They are constructed by excavating a depression to form a small reservoir, or by constructing an embankment in a natural ravine or gully to form an impoundment.

  Water-supply projects can also be implemented for drought mitigation, with a view to strengthen drought preparedness. Activities such as water-use planning, rain-water harvesting, runoff collection using surface and underground structures, improved management of channels and wells, exploration of additional water resources through drilling and dam construction, are implemented as a part of a drought-mitigation plan.

  To increase moisture availability, the following in-situ moisture-conservation practices can be adopted:

- For agricultural crops, measures include ridges and furrows, basins, and water spreading.
- For tree crops, measures include saucer basins, semi-circular bunds, crescent-shaped bunds, catch pits and deep pitting.
- Rainwater harvesting collects rainfall or moisture for immediate or eventual use in irrigation or domestic supplies. Part of the rainwater collected from roofs can be stored in a cistern or tank for later use.
- Landscape contouring is used to direct runoff into areas planted with trees, shrubs, and turf.

Summary:

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Extreme Temperatures

**Description:** Extended periods of extreme temperatures, either extreme summer heat or extreme winter cold, can pose severe and possibly life-threatening problems for residents of Luce County. The discussion of the natural hazard of extreme temperature includes both acute and long-term effects. While short-term occurrences of extreme heat or cold can have dramatic effect, prolonged exposure and successional events can result in cumulative effects severely impacting residents within Luce County.

**Extreme Summer Heat**

Extreme summer weather is characterized by a combination of very high temperatures and exceptionally humid conditions. When persisting over a long period of time, this phenomenon is commonly known as a heat wave.

Extreme summer heat is also hazardous to livestock and agricultural crops, and it can cause water shortages, exacerbate fire hazards, and prompt excessive demands for energy. Roads, bridges, railroad tracks and other infrastructure are susceptible to damage from extreme heat.

Air conditioning is probably the most effective measure for mitigating the effects of extreme summer heat on people. Unfortunately, many of those most vulnerable to this hazard do not live or work in air-conditioned environments, especially in major urban centers where the vulnerability is highest. The use of fans to move air may help some, but recent research indicates that increased air movement may actually exacerbate heat stress in many individuals.

**Extreme Winter Cold**

Like heat waves, long periods of unusually cold weather can result in a significant number of temperature-related deaths. A significant number of cold-related deaths are not necessarily the direct result of “freezing” conditions. Rather, many deaths are the result of illnesses and diseases that are negatively impacted by severe cold weather, such as stroke, heart disease and pneumonia.

**Geographic Extent:** Shoreline areas are less susceptible to extreme temperatures, due to the effect of the water. The entire county can be affected by extreme temperature, therefore the geographic extent is deemed to be **significant**.

**Historical Events:**

**Winter 2013 – 2014:** Captured in the national media by the term “Polar Vortex”, this phenomenon is largely the result of a shift of the jet stream regionally bringing prolonged weather patterns out of the north. In the winter spanning 2013 and 2014 this phenomenon has resulted in below zero (Fahrenheit) temperatures for nearly two months. Additionally high winds have pressed wind chill temperature below minus 20 degrees.
January 22, 2013: The Luce County Airport ASOS reported wind chill values to 25 to 30 below zero on the mornings of the 22nd. Area schools were closed on the 22nd due to the extreme cold.

January 19, 2012: Bitter cold air in the wake of an Arctic cold front resulted in wind chill values lowering to 20 and 30 below zero across much of the area on the 19th and 20th. The cold air flooding the region also generated heavy lake effect snow showers from the 18th into the 19th over northwest and eastern areas of Upper Michigan along Lake Superior.

February 17-18, 2006: Low pressure originating over the southern Plains deepened rapidly as it moved into the Great Lakes region on the afternoon and evening of the 16th. Deep moisture associated with this system brought heavy synoptic and lake-enhanced snow to portions of central Upper Michigan on the 16th and 17th. Measured 12-hour snowfall amounts included 8 inches at Rainbow Lodge in Luce County. A blast of arctic air behind the departing low brought another round of briefly heavy lake effect snow and near-blizzard to blizzard conditions to western Upper Michigan on the 17th and 18th. Snowfall amounts generally ranged from 3 to 6 inches across much of Ontonagon, Houghton and Keweenaw counties while wind gusts of 30 mph or more lowered visibilities to one-half mile or less. Frequent wind gusts to 35 mph or more and visibilities below one-quarter mile lead to blizzard conditions over the Keweenaw Peninsula during the afternoon hours. Wind chill values also fell to 35 to 45 below zero at the automated observing sites at Ironwood, Iron Mountain and Escanaba on the evening of the 17th and morning of the 18th. Across the rest of west and central Upper Michigan wind chill readings commonly fell into the 25 to 35 below zero range.

Winter 1998-1999: This event was probably the result of the similar “polar vortex” phenomenon listed above for 2013. The winter was characterized by cold temperatures and heavy snowfall within the early winter and icing over of Lake Superior and extreme cold temperature and low snowfall in the latter winter. Damage to water and sewer infrastructure from this event occurred through the region.

Probability of Future Occurrences: Based on the historical occurrences the likelihood of future occurrences is deemed to be high. Periodic occurrences of extreme temperatures on both a short-term and longer-term basis are realities of climate in the region.

Impact Assessment:
Direct Impacts: Direct impacts of extreme temperatures can include dehydration, heat exhaustion or heatstroke in the case of heat or frostbite and hypothermia in the case of severe cold. Illness and death can occur from both heat and cold. Excessive demands on power supply can cause power outages and increased costs. Businesses and school closures are common as the road condition worsens. Prolonged exposure to extreme cold as one event or successional events can lead to freezing of water distribution lines (municipal or residential) and sewer collection pipes. The resulting freezes and efforts to thaw can directly cause breaks and leaks in water distribution often interrupting supply and system pressure.
**Indirect Impacts:** During times of extreme heat people tend to move less which would decrease economic activities of shopping and recreation. Extended power outages or restrictions on use could occur because of the excessive demand on the system. Increase demand on the medical field as illness or death increases. Possible restriction on water system pressure or supply impacts availability to potable water and fire suppression supply.

**Vulnerability Assessment:**

**Population:** The most vulnerable population are the elderly who live alone on a fixed income, or individuals who have lower income or are impoverished, those who cannot afford air conditioning or the higher cost of heating, also the very young – babies and young children.

**General Property:** Extreme temperatures can affect livestock and pets. Extreme cold can result in damage of plumbing within structures and residences. Damage to water pipes can result in additional water damage to structures and residences from leaks, pooling, etc.

**Essential Infrastructure, Facilities, and Other Important Community Assets:** Extreme heat and cold can affect the transportation infrastructure such as roads and railroads. Excessive demand on the supply of electricity may cause black outs. Excessive demand on propane for heating can lead to shortages and higher prices, making it difficult for those on a fixed income. Extreme cold can result in direct damage to roadway pavement and indirect damage to pavement through water line breaks and erosion of road base and fill material. Prolonged extreme cold can result in permanent damage or impairment of water distribution or sewer lines.

**Natural, Historic and Cultural Resources:** Extended periods of heat can cause drought conditions, damaging the environment and increasing the risk of wildfire and other fire hazards.

**Estimating Potential Losses:** Estimating potential losses from extreme temperature events is difficult. Based on the historical data, it is determined that the economic impact would be low, however, that would change dependent upon the situation and length of time the event took place. As data tracking and use of asset management systems increase, the correlation and ability to track costs to community infrastructure is becoming apparent both through direct costs to yearly budgets, but also to assessment of the condition and viability of structures and facilities.

**Mitigation Capabilities:**

Establishing and opening shelters for relief from the extreme temperatures and getting that information out to the public.

Providing community assistance and networks to check on the elderly or other vulnerable population members during these times of extreme temperatures.
Ensuring the building codes and landlord regulations are in place for appropriate insulation or heating appliances.

Use of alternative bedding of water distribution pipes and sewer pipes to prevent water infiltration, frost permeation, and heat loss. Replacement of older relatively shallow water distribution and sewer pipes below the anticipated frost line to prevent line freezing. Note: The Community and Local Departments have limited resources for events of system water distribution freezing.

Distribution of educational brochures or make information available on a web-site.

**Summary**

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Flooding

Description: Floods are the most common and widespread of all natural disasters--except fire. Most communities in the United States have experienced some kind of flooding, after spring rains, heavy thunderstorms, or winter snow thaws.

A flood, as defined by the National Flood Insurance Program is: "A general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties (at least one of which is your property) from:

- Overflow of inland or tidal waters,
- Unusual and rapid accumulation or runoff of surface waters from any source, or
- A mudflow.

[The] collapse or subsidence of land along the shore of a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood."

The following terminology is used when describing floods:

The term **Minor Flooding** is used to indicate minimal or no property damage. However, some public inconvenience is possible.

The term **Moderate Flooding** is used to indicate the inundation of secondary roads. Transfer to higher elevation may be necessary to save property. Some evacuation may be required.

The term **Major Flooding** is used to indicate extensive inundation and property damage, usually characterized by the evacuation of people and livestock, and the closure of both primary and secondary roads.

Riverine Flooding

The most common and most damaging floods occur along rivers and streams and this is called over bank flooding. Over bank flooding of rivers and streams can be caused by one or more of three factors:

1. Too much precipitation in the watershed for the channels to convey.
2. Obstructions in a channel, such as an ice jam or beaver dam, and
3. Large release of water when a dam or other obstruction fails.

Flooding can also occur in streets when rainwater cannot flow into a storm sewer. Basements can flood when rainwater cannot flow away from the house or when the sewers back up. These problems are usually caused by heavy local rains and are often not related to over bank flooding or floodplain locations.
Shoreline Flooding

Flooding and erosion of shoreline areas caused by high Great Lakes water levels, storm surges, or winds is known as shoreline flooding. Luce County has approximately 31 miles of shoreline on Lakes Superior.

Geographic Extent: Luce County has four major watersheds basins. The geographic extent for flooding is deemed to be significant.

Historical Events: There are no flood events recorded in the NCDC Storm Event database since 1996.

Probability of Future Occurrences: Based on the historical data the likelihood of future flood occurrences is rated at Low.

Impact Assessment:

Direct Impacts: Direct and indirect impacts of flooding can be classified in four categories: impact on people (e.g., safety and health), damage to buildings, damage to critical facilities, and economic disruption (damage to businesses and infrastructure). Direct impact can include loss of life, disease caused by contamination of water supplies, damage to crops, stress: physical and mental health problems, damage to infrastructure: roads and communications, rebuilding costs, loss in the value of properties, and increase in insurance premiums.

Indirect Impacts: Indirect impacts can be disruption to traffic which costs businesses money, and disrupts transport, effects of reduced spending power in the local area as people lose money, jobs etc. Loss in tourist spending in the area, survivors feel vulnerable, and also have difficulty getting insurance for their properties, there could potentially be less investment in the area.

Vulnerability Assessment:

Population: People who live in the flood zone areas near lakes, rivers and streams. Developed areas where storm water can overflow or back-up. Shoreline communities and areas that have major rivers and a more clay soil base, towards the north, central and east areas of the county.

General Property: Households or structures and the contents, especially those with basements, agricultural land and livestock in low-lying areas, near water, behind a levee or downstream from a dam. Even very small streams, gullies, creeks, culverts, dry streambeds or low-lying ground that appear harmless in dry weather can flood.

Essential Infrastructure, Facilities, and Other Important Community Assets

Critical facilities are those community components that are most needed to withstand the impacts of disaster. Included in this classification are police and fire stations, hospitals, schools that serve as emergency shelters, and lifeline utilities; power, water and sewer system components as well as transportation infrastructure such as road ways and bridges.
**Natural, Historic and Cultural Resources**

Historical museums, historical societies, libraries or courthouses that house historical documents or artifacts. Wetland and low lying agricultural areas.

**Mitigation Capabilities**

Engaging in floodplain management activities, constructing barriers, such as levees, and purchasing flood insurance will help reduce the amount of structural damage to a home and financial loss from building and crop damage should a flood or flash flood occur. Monitoring of current weather conditions and weather forecasts gives advanced notification of potential flooding. Hazardous weather outlooks and forecasts give vital information on the amounts of precipitation, wind intensity and direction, time and extent, etc. thus, the severity of potential flooding can be assessed and prepared for effectively. Creating a household emergency communications plan and developing an emergency kit. Local units of government can provide informational handouts or create a website to disseminate general flood mitigation information to the public.

**Summary**

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Severe Winter Weather (including Blizzard, Heavy Snow, Lake Effect Snow, Ice Storms, Sleet and Frost/Freeze)

Description: Winter storms can range from a moderate snow over a few hours to a blizzard with blinding, wind-driven snow that lasts for several days. Some winter storms are large enough to affect several states, while others affect only a single community. Many winter storms are accompanied by dangerously low temperatures and sometimes by strong winds, icing, sleet, and freezing rain.

There are many ways for winter storms to form, but certain key ingredients are needed. First temperatures must be below freezing in the clouds and near the ground. There must be a source of moisture in the form of evaporating water. Then lift in the atmosphere causes the moisture to rise and form clouds of precipitation.

Winter storms in the Midwest are caused by Canadian and Arctic cold fronts that push snow and ice deep into the interior region of the United States. Our area is also subject to lake effect snowstorms that develop from the passage of cold air over the relatively warm surface of Lake Superior and Lake Huron that can cause heavy snowfall and blizzard conditions.

Winter storms can occur as heavy snowfalls, ice storms or extreme cold temperatures. Winter storms can occur as a single event or they can occur in combination which can make an event more severe. For example, a moderate snowfall could create severe conditions if freezing rain and subsequent extremely cold temperatures followed it. The aftermath of a winter storm can impact a community or region for weeks, and even months.

Heavy snowfalls can range from large accumulations of snow over many hours to blizzard conditions with blowing snow that could last several days. The National Weather Service’s snow classification is in the table below:

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<th>Snow Classifications</th>
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<tr>
<td>Blizzard</td>
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<tr>
<td>Winds of 35 miles per hour or more with snow and blowing snow reducing visibility to less than ¼ mile for at least 3 hours.</td>
</tr>
<tr>
<td>Blowing Snow</td>
</tr>
<tr>
<td>Wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground picked up by the wind.</td>
</tr>
<tr>
<td>Snow Squalls</td>
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<tr>
<td>Brief, intense snow showers accompanied by strong, gusty winds. Accumulation may be significant.</td>
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<tr>
<td>Snow Showers</td>
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<tr>
<td>Snow falling at varying intensities for brief periods of time. Some accumulation possible.</td>
</tr>
<tr>
<td>Snow Flurries</td>
</tr>
<tr>
<td>Light snow falling for short duration with little or no accumulation.</td>
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Source: National Weather Service
Weather changes are frequent because many pressure systems pass eastward through this section of the United States and Canada. Winter snows are most often associated with northwest winds.

In Luce County Snow usually covers the ground from late October until mid-April. The snowfall is an economic advantage to the area, especially for snowmobiling. However, the potential for transportation accidents increases as more snowmobilers hit the trails.

**Average Annual Snowfall**

Luce County 119.51 inches  
Michigan 60.66 inches  
U.S. 23.27 inches

*Figure 8 - Average Snowfall in Inches – National Weather Service snow fall was calculated from the historical data of 18,000+ U.S weather stations for the period of time from 1980 to 2010.*

The likelihood of snow falling is highest around January 21, occurring in 80% of days. The season in which it is relatively likely for snow to fall spans from October 28 to April 13.

*Figure 9 – Likelihood of Snow Falling – National Weather Service*
An ice storm occurs when freezing rain falls from clouds and freezes immediately upon impact. Freezing rain is found in between sleet and rain. It occurs when the precipitation falls into a large layer of warm air and then does not have time to refreeze in a cold layer (near or below 32°F) before it comes in contact with the surface which is also near or below 32°F.

Geographic Extent: Winter weather is a regional event that occurs across the entire county or sometimes the entire state. Snowfall can occur anytime between October and May. More substantial winter storms occur during the winter months, most frequently between December and February. February has the most documented occurrences of severe winter weather. Rating for the geographic extent is Extensive.

Historical Events: The history of past winter storm events was gathered from NCDC data, newspaper reports and other data sources as cited. Winter storms have been a common occurrence for Luce County residents for as long as the area has been settled. Every winter provides some challenges to the population. Some of the most recent outstanding events are listed below.

- April 11, 2013: There were public reports of six to seven inches of wet snow at McMillan and Newberry over a 12-hour period. Northeast winds gusting over 25 mph also caused drifting of snow. Tahquamenon Area Schools were closed on the 12th due to the storm.
- February 10, 2008: Winds gusting over 40 mph at times caused widespread whiteout conditions in lake effect snow and blowing snow, especially along the Lake Superior shoreline. Visibility reported by the Luce County Airport AWOS was one-quarter mile or
less through much of the period as wind chills lowered to 20 below zero on the 10th.

The observer in Two Heart reported a snowfall total of 12 to 14 inches in the 24-hour period ending on the morning of the 10th. Many area roads and highways were closed due to the blizzard conditions.

- **January 30, 2008:** Widespread near-zero visibility in snow and blowing snow was reported across much of Northern Luce County. Northwest winds frequently gusting over 35 mph caused significant drifting of snow and whiteout conditions. Many area schools were closed on the 30th.

- **October 12-13, 2006:** A large and cold low pressure system settled southward from the Canadian Arctic. Unseasonably cold air allowed precipitation to turn to snow, particularly away from the Lake Michigan shoreline (where warm water temperatures resulted in more rain and less snow). The heaviest snow was lake enhanced, and thus somewhat isolated. A brief period of thunder and lightning occurred with the heavy snow in this region. The heavy, wet snow caused a tree to fall on a major transmission line, knocking out power to almost all of Eastern Upper Michigan, east of M-129, for several hours. Local power outages, caused by fallen tree limbs, were also reported in isolated areas across Northern Lower Michigan. There was $5,000 in property damage reported with this storm.

**Probability of Future Occurrences:** Severe winter weather incidents (including heavy snow, winter storms) are documented more than once yearly. Using the formula established in **Profile Methodology**, the assessment reflects (60 events over [divide by] 6 years) x 100 = over 100 percent chance of occurrence, which corresponds to a **high** likely to occur rating.

**Impact Assessment:** The occurrence of major snowstorms, ice storms, and blizzards can have a considerable impact on communities, utilities and transportation systems. Ice storms often produce extensive damage over large regions. The impacts of an ice storm are amplified when frigid temperatures follow the storm. Snow and ice accumulates on roads, highways, railroads, and airport runways and halts transportation efforts. Ice can cause telephone and power lines and tree branches to break and fall, which may damage property, cause injury, and create hazardous conditions. Power outages may last for days, and in some cases, it may be weeks before power is restored to more remote rural areas. As people have become increasingly dependent on electricity for heating and cooking, the possibility of experiencing a loss of electricity for an extended period has become more critical. While some of the direct impacts of ice or heavy snowstorms are easily identified, these can produce a wide range of indirect impacts. Many of these are summarized below.

**Direct Impacts:** Ice or heavy accumulations of snow, particularly with blowing and drifting, temporarily impact the roadway system. Roads can become impassable with heavy icing or as snow accumulates faster than it can be cleared. Snow and ice resulting in icy road conditions lead to major traffic accidents and numerous minor accidents. Similarly, if roads and streets are icy or snow covered, it is also difficult for emergency service personnel to travel and may pose a
secondary threat to life safety if police, fire, and EMS crews cannot respond to calls. Schools typically have to close. Ice or heavy accumulations of snow also require vast amounts of overtime for County and local highway and streets departments to remove snow and melt ice. Additionally, a hypothermia situation may arise due to prolonged exposure to the cold when a person attempts to walk during the height of a major winter storm. Heavy accumulations of snow on rooftops can cause roofs to collapse, resulting in possible injury or death to those inside the building as well as damaging the contents of the building. Ice storms or high winds in winter storms can cause extensive loss of overhead utility lines due to buildup either on the lines or on adjacent trees that either collapse due to the weight or blow down onto the utility lines. Services such as telephone, electricity, and cable TV are frequently affected by winter storms.

**Indirect Impacts:** The indirect impacts are what separate an ordinary winter snowstorm, even a heavy snow, from a disaster. Heavy accumulations of snow or ice can bring down trees, utility lines, and communications towers. This can disrupt communications and electrical power for days while utility companies repair the damage. Loss of power, in conjunction with impassible roads can isolate people in rural areas and essentially shut down urban areas, effectively paralyzing the entire region. Also, many of the deaths that occur are indirectly related to the storm itself. Many of these results are from traffic accidents or heart attacks while shoveling snow. The indirect impacts of severe winter storms ripple past the actual hazard event. Economic costs incurred by loss of business as a result of the storm, property damages, overtime costs, loss of income due to closed business, and missed school days all have long-reaching effects. Increased amounts of snow may increase the risk of flooding in the spring. Other examples of indirect impacts include:

- **Agricultural losses.** Livestock, particularly dairy cattle can be highly vulnerable to the impacts of an ice storm, especially if freezing conditions exist for a long time and are accompanied by an extensive power outage. Daily operations are dependent on electricity for milking and watering the animals. Loss of revenue or even disease and death of the animals can result.

- **Home Health Care Services.** Recipients of home health care services, particularly in rural areas face disruption of services in the aftermath of an ice or heavy snowstorm. Providers may have difficulty in reaching patients due to debris or downed power lines blocking roadways. Electrically powered life support equipment will fail to operate in a power outage. This can have dire consequences to the patient if the outage is prolonged.

- **Communications.** Telecommunications can be disrupted due to a variety of factors. Most telephone and cellular carriers have emergency back-up power supplies for primary equipment. In many cases, the back-up power supply is designed to provide power for 48-hours or less. In the prolonged power outages possible with a major ice storm, this equipment will fail when the fuel for the generator runs out or the back-up batteries become discharged. Overhead telephone lines are also susceptible to the same problems as overhead electrical lines. The consequences of communications failure can be far reaching. Coordination of the public safety response to the event relies heavily on
the ability to communicate. The response is invariably hampered when these systems fail.

- **Public water supply and wastewater treatment.** Water supply pumps and wastewater lift stations are vulnerable to prolonged loss of power. Many of these have back-up power supply for short-term power outages. An ice storm, however, has the potential to cause power outages that may last for days. Underground water lines can freeze and break leading to loss of fresh water.

- **Severely damaged trees.** Ice or exceedingly heavy snow can cause substantial damage to trees in urban and rural areas. Damaged or fallen trees in urban areas block roads and sidewalks and can take down power lines. Downed or fallen trees in rural areas can lead to fire hazards in subsequent years as dead trees add to the fuel load. In either case, removal of downed trees and branches can be a significant problem and cost.

- **Residential impacts.** Loss of power for residential use can lead to a loss of household heating, freezing and bursting water pipes leading to loss of fresh water supply and flooded basements, sewage back-up, and the loss of the ability to cook food.

- **Provisions.** As is common in many disasters, supplies of flashlights, batteries, shovels, bottled water, fuel, and food supplies may be short in areas immediately affected by the storm. This creates a particular stress on low-income individuals and families that are not able to stock-up on these supplies, and may cause a panic on certain supplies as stock levels drop.

- **Economic loss.** Luce County residents rely heavily on roadways and automobiles to commute to and from work. When employees cannot get to their jobs, commerce can be affected, especially if the situation lasts for days. In addition, all of the primary and indirect impacts of a major snow or ice storm can have cascading economic consequences.

**Vulnerability Assessment:**

**Population**

While virtually all aspects of the population are vulnerable to severe winter weather, there are segments of the population that are more vulnerable to the potential indirect impacts of a severe winter storm than others, particularly the loss of electrical power. As a group, the elderly or disabled, especially those with home health care services that rely heavily on an uninterrupted source of electricity. Resident populations in nursing homes, Community Based Residential Facilities, or other special needs housing may also be vulnerable if electrical outages are prolonged. If they do not have a back-up power source, rural residents and agricultural operations reliant on electricity for heating and water supplies are also especially vulnerable to power outages.

Severe winter weather also increases the vulnerability of the commuting population. According to the Michigan Traffic Crash Database records indicate that traffic accidents occurring in winter conditions (snow or blowing snow) accounted for 268 accidents during the period January 1, 2005 – December 31, 2012 in Luce County. Where road conditions were snowy, icy or slushy it is reported that there were 275 crashes over this 7 year period in Luce
County. There were a total of 26 snowmobile accidents, 8 of which were due to snowy weather conditions over the same period. While there is no way to quantify which of these accidents occur during severe winter storms versus regular winter storms, the numbers indicate that winter driving conditions raise the vulnerability of the commuting population. Overall, the population affected by severe winter weather is **high**.

**General Property**

Property vulnerabilities to severe weather include damage caused by high winds, ice, or snow pack and subsequently melting snow. Vehicles may be damaged by the same factors, or temporarily un-useable due to the driving conditions created by severe winter weather. Contents of homes, storage units, warehouses and storefronts may be damaged if the structures are compromised or fail due to the weather, or during potential flooding caused by melting snow. Very wet snow packs down densely and is very heavy. This may create strains on structures, causing partial or entire collapses of walls, roofs, or windows. This is impacted both by architecture and construction material, and should be assessed on a building-by-building basis. These records are probably tracked via insurance or other private vendors.

**Essential Infrastructure, Facilities, and Other Important Community Assets**

The physical structures which comprise essential infrastructure are as vulnerable as those outlined in the General Property subsection of this profile. Severe winter weather may also disrupt the availability of services from essential infrastructure, including utility delivery (gas, electric and water), telephone service, emergency response personnel capabilities, road plowing, and childcare availability. Severe winter storms may even halt the operation of the county for periods of time, making the vulnerability of the entire County even higher. As mentioned previously, ice or heavy accumulations of snow, particularly with blowing and drifting, can temporarily impact the roadway system. Snowbanks can become so high it makes it difficult to see at intersections resulting in a greater risk of traffic accidents. These accumulations also require vast amounts of overtime for County and local highway and streets departments to remove snow and melt ice. Ice storms or high winds in winter storms can cause extensive loss of overhead utility lines due to buildup either on the lines or on adjacent trees that either collapse due to the weight or blow down onto the utility lines. Services such as telephone, electricity, and cable TV are frequently affected by winter storms.

**Natural, Historic and Cultural Resources**

Natural resources may be damaged by the severe winter weather, including broken trees and death of unsheltered wildlife. Unseasonable storms may damage or kill plant and wildlife, which may impact natural food chains until the next growing season. Historical areas may be more vulnerable to severe winter storms due to construction and age of structures. Historical assets destroyed may never be able to be replaced resulting in a devastating loss for the public. Cultural resources generally experience the same vulnerabilities outlined in **General Property**, in addition to lost revenue impacts due to transportation impacts.

**Estimating Potential Losses:** The economic impact can be rated as **High** as the potential for property damage from snow accumulation, loss of life and injury resulting from transportation
accidents or loss of power, and cost of response and clean-up would most likely total above the threshold of $25,000.

**Mitigation Capabilities:** Luce County participates in national and state programs to mitigate or reduce the effects of severe winter weather including:

- **National Weather Service Doppler Radar** - The National Weather Service (NWS) has Doppler Weather Surveillance Radar, which can more easily detect severe weather events that threaten life and property – including storms that are likely to produce damaging hail. Most important, the lead time and specificity of warnings for severe weather have improved significantly.

  Doppler technology calculates both the speed and the direction of wind motion inside of severe storms. By providing data on the wind patterns within developing storms, the system allows forecasters to better identify the conditions leading to severe weather such as tornadoes, severe straight-line winds, lightning and damaging hail. This means early detection of the precursors to severe storms, as well as information on the direction and speed of storms once they form.

- **National Weather Service Watches/Warnings** - The National Weather Service issues winter storm watches and winter weather warnings to notify the public of severe winter weather conditions. A winter storm watch indicates that severe winter weather conditions (freezing rain, sleet, or heavy snow) may affect an area, while a winter weather warning indicates that severe winter weather conditions are imminent.

  Winter storm warnings can be issued for snow alone, but they also can take on different varieties. For example, a blizzard warning signifies that blizzard conditions are imminent or occurring. Blizzard conditions mean that the visibility will frequently be one-quarter mile or less in falling or blowing snow, with wind speeds at least 35 miles per hour. A wind chill warning is issued when wind chills drop below -30 degrees Fahrenheit, with winds equal to or greater than 10 miles per hour. Finally, an ice storm warning is issued for a significant accumulation of ice, normally a coating of at least one-quarter inch.

  The National Weather Service also issues a number of different advisories for winter weather. These advisories can be issued for snow, freezing rain, blowing snow, and wind chill, among other things. Advisories mean that conditions are expected to cause significant inconveniences and may be hazardous. However, if caution is exercised, the situation should not become life threatening.

  The State and local government agencies are warned via the Law Enforcement Information Network (LEIN), National Oceanic and Atmospheric Administration (NOAA) weather radio, and the Emergency Managers Weather Information Network (EMWIN). Public warning is provided through the Emergency Alert System (EAS). The National Weather Service stations in Michigan transmit information directly to radio and television
stations, which in turn pass the warning on to the public. The National Weather Service also provides detailed warning information on the Internet, through the Interactive Weather Information Network (IWIN).

- **Urban Forestry/Tree Maintenance Programs** - Urban forestry programs can be very effective in minimizing snowstorm damage caused by falling trees or tree branches. In almost every severe snowstorm, falling trees and branches cause power outages and clog public roadways with debris. However, a properly designed, managed and implemented urban forestry program can help keep tree-related damage and impact to a minimum. To be most effective, an urban forestry program should address tree maintenance in a comprehensive manner, from proper tree selection, to proper placement, to proper tree trimming and long-term care.

When proper pruning methods are employed, and when the work is done on a regular basis with the aim of reducing potential storm-related damage, these programs can be quite effective. Often, however, tree trimming work is deferred when budgets get tight or other work is deemed a higher priority. When that occurs, the problem usually manifests itself in greater storm-related tree debris management problems down the line.

**Mitigation Alternatives for Snowstorms**

- Increased coverage and use of NOAA Weather Radio.
- Producing and distributing family emergency preparedness information relating to severe winter weather hazards.
- Including safety strategies for severe weather events in driver education classes and materials.
- Tree trimming and maintenance to prevent limb breakage and safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines. (NOTE: May cause additional problems and costs in case of breakage, due to the increased difficulty in locating and repairing the problem.)
- Establishing heating centers/shelters for vulnerable populations.
- Organizing outreach to isolated, vulnerable, or special-needs populations.
- Encouraging residents to develop a Family Disaster Plan which includes the preparation of a Disaster Supplies Kit.
- Proper building/site design and code enforcement relating to snow loads, roof slope, snow removal and storage, etc.
- Farmer preparedness to address livestock needs/problems.
- Pre-arranging for shelters for stranded motorists/travelers, and others.
- Maintaining adequate road and debris clearing capabilities.
- Using snow fences or "living snow fences" (rows of trees or vegetation) to limit blowing and drifting of snow over critical roadway segments.
Pre-planning for debris management staging and storage areas. (Debris is usually the sleet and ice itself being cleared from roads and roofs, or vegetation such as tree branches that have fallen under the impact of winds or the weight of ice. Broken power or phone lines that had frozen or been weighted down by ice or fallen branches could be part of the problem. In some cases, roofs may collapse under the weight of ice and snow. Some storage areas will definitely be needed for snow removal during blizzards.)

Summary

Overall, severe winter storms present a high risk for Luce County. The events occur frequently and over significant portions of the county, maximizing the potential to impact exposed population and structures, and have far reaching indirect impacts. Reports of damage to property and the impacts on essential infrastructure are high. The following table provides the methodology for how all aspects of the hazard profile were evaluated to establish an overall hazard rating.

<table>
<thead>
<tr>
<th>Measurement</th>
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<th>Score</th>
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<tr>
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<td>Economic Impact</td>
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<tr>
<td>Total Overall Risk Rating</td>
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</table>
Subsidence/Ground Movement

Description: Subsidence is the lowering or collapse of the land surface due to loss of subsurface support. It can be caused by a variety of natural or human-induced activities. Natural subsidence occurs when the ground collapses into underground cavities produced by the solution of limestone or other soluble materials by groundwater. Human-induced subsidence is caused principally by groundwater withdrawal, drainage of organic soils, and underground mining.

Geographic Extent: Subsidence is most likely in areas within the County where slopes are steep such as those greater than 35%. The steeper slopes usually occur along banks of rivers or creeks and high ridges. Subsidence can also occur where ground water aquifers are drained and sink holes occur. Water saturation in the soil can also cause ground movement.

Historical Events: No recorded events.

Probability of Future Occurrences: Based on the historical events there is a low probability of future occurrences. However, during seasons of heavy rainfall the risk of subsidence or ground movement would be significantly higher. Spontaneous ground openings can be dangerous if a sinkhole were to open below an occupied structure.

Impact Assessment:

Direct Impacts: Direct impacts of subsidence could include infrastructure function loss, environmental contamination, property damage, possible casualties and emergency response. The consequences of improper utilization of land subject to ground subsidence will generally consist of excessive economic losses. This includes high repair and maintenance costs for buildings, irrigation works, highways, utilities and other structures. At times, structures are condemned because of the damage. This results in direct economic losses to citizens.

Indirect Impacts: Indirect losses may be realized through increased taxes and decreased property values. Lawsuits may also occur if property damage or loss of life occurs because of man induced activities.

Vulnerability Assessment:

Population
In general subsidence causes more of a risk to property than to humans. However, if infrastructure is damaged excessively it could potentially increase the risk to human life, such as a washed away roadway.
**General Property**
Some subsidence incidents may cause private property damage and casualties, others may affect roadways or other public infrastructure, and thus cause a more general impact on the population of an area.

**Essential Infrastructure, Facilities, and Other Important Community Assets**
Infrastructure such as roads, water lines, pipelines and utility lines would create a significant impact if affected by ground movement.

**Natural, Historic and Cultural Resources**
Water aquifers would be vulnerable if the densely populated areas of the County were to drain the reservoirs capacity leading to collapse and compaction. Changes in an area’s landscape, wildlife habitat and the natural ecosystem could also occur. Historical and aged structures would be more vulnerable.

**Estimating Potential Losses:** Although research indicates a certain amount of land subsidence hazard in Luce County, it also indicates very low risk to population and property. Additionally, the extremely localized and virtually unpredictable nature of land subsidence makes it nearly impossible to estimate potential loss.

**Mitigation Capabilities**
Community education and awareness is probably the most effective way to mitigate subsidence hazards. Local officials in subsidence-prone areas need to be aware of their community’s potential vulnerability to subsidence, and that awareness needs to be communicated to the public. Provisions in zoning ordinances that relate to new development need to be adopted to prevent developing in risk-prone areas.

**Summary**

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Thunderstorm/High Wind/Hail/Lightning

Description: A **thunderstorm** is a form of weather characterized by the presence of lightning and its acoustic effect on the earth's atmosphere known as thunder. The meteorologically-assigned cloud type associated with the thunderstorm is the cumulonimbus. Thunderstorms are usually accompanied by strong winds, heavy rain and sometimes snow, hail, or no precipitation at all and therefore those hazards have been combined into this one profile. Those thunderstorms which cause hail to fall are known as hailstorms. Thunderstorms may line up in a series or rainband, known as a squall line. Strong or severe thunderstorms may rotate, known as supercells. While most thunderstorms move with the mean wind flow through the layer of the troposphere that they occupy, vertical wind shear causes a deviation in their course at a right angle to the wind shear direction. Thunderstorms result from the rapid upward movement of warm, moist air. They can occur inside warm, moist air masses and at fronts. As the warm, moist air moves upward, it cools, condenses, and forms cumulonimbus clouds. As the rising air reaches its dew point, water droplets and ice form and begin falling the long distance through the clouds towards earth's surface. As the droplets fall, they collide with other droplets and become larger. The falling droplets create a downdraft of air that spreads out at earth's surface and causes strong winds associated with thunderstorms. Thunderstorms are most likely to happen in the spring and summer months and during the afternoon and evening hours but can occur year-round and at all hours. The biggest threats from thunderstorms are flash flooding and lightning. In most cases, flash flooding occurs in small drainage areas where water quickly accumulates before it drains to the flood plains. When taken together, these local drainage problems can be as great a problem as over bank flooding.

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

Other threats from thunderstorms include downburst winds, **high winds**, **hail** and tornadoes. Downburst winds are strong, concentrated, straight-line winds created by falling rain and sinking air that can reach speeds of 125 mph (200 km/h).

Hailstones are ice crystals that form within a low-pressure front due to warm air rising rapidly into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight, they fall as precipitation. The size of hailstones is a direct function of the severity and size of the storm. Significant damage does not result until the stones reach 1.5 inches in diameter, which occurs in less than half of all hailstorms.

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

**Geographic Extent:** Thunderstorms can occur anywhere in Luce County and typically travel across the whole County. Given these facts, the geographic extent rating is **extensive.**

**Historical Events:** The National Weather Service and the National Climatic Data Center (NCDC) maintains a listing of reported thunderstorms from January 1, 2005 to October 31, 2013 including: strong winds, high winds, thunderstorm winds, lightning and hail events. In Luce County there were no strong wind events, 5 high wind events, 17 thunderstorm wind events, 1 lightning event, and 6 hail events.

**August 26, 2013:** A surface trough moving through a very warm and unstable air mass provided the focus for scattered severe thunderstorms over north central Upper Michigan during the early morning of the 26th. The Luce County Emergency Manager reported trees down across northern Luce County. A tree fell on a tent at the Blind Sucker Campground and at Muskallonge State Park power lines were down as well. No injuries were reported, but there was $5,000 in property damage.

**July 18, 2013:** A cold front moving slowly across the region served as the focus for severe thunderstorms over portions of Upper Michigan from the evening of the 18th into the afternoon of the 19th. Fifty trees were knocked down at Muskallonge Lake State Park. Some trees fell on campers, tents, and outbuildings, but no injuries were reported. Property damage from this event was listed at $50,000. A house fire caused by a lightning strike resulted in the death of a 79-year-old man. The fire was reported by a storm spotter located one mile away, and it was confirmed by local media.

**October 15, 2011:** A rapidly deepening low pressure system lifting northeast of Upper Michigan into Ontario caused damaging winds across much of Upper Michigan near Lake Superior from the 14th into the early morning of the 17th. Several trees were reported down across the road near Pine Stump Junction. Several three-foot diameter trees were reported down near the Pike Lake area along County Road 414. Approximately $4,000 in property damage was recorded.

**October 26, 2010:** A storm system developing over the Plains deepened to record minimum low pressure as it moved across Minnesota on the 26th and 27th. This storm caused widespread damaging winds across west and central Upper Michigan. Numerous trees and power lines were reported down on County Road 441 in the Hiawatha National Forest. Tahquamenon Area Schools closed on the 27th due to the storm. Property damage costs were estimated at $2,000.
**September 3, 2010:** A powerful low pressure system and cold front sweeping across Lake Superior caused extensive wind damage at several locations along Lake Superior on the 3rd. Strong winds knocked down approximately 50 large trees at Muskallonge State Park on the evening of the 3rd and forced the evacuation of 343 people to Tahquamenon Area Schools in Newberry or to local motels. Trees fell on campers and blocked roads forcing park officials to close the park at 930 pm that evening. Campers were allowed to return to the park on the afternoon of the 4th. Property damage was estimated at $50,000.

**May 13, 2008:** Thunderstorms marched across Eastern Upper Michigan early in the morning of the 13th. Lightning struck a large pine tree just outside the administration building of Tahquamenon Falls State Park. The tree was blasted into pieces, and most of the electronic equipment in the administration building was destroyed. Some electrical damage also occurred in a staff building, not quite an eighth of a mile away.

**July 16, 2006:** An upper disturbance interacting with a very warm airmass and frontal boundary over southern Lake Superior helped set the stage for severe thunderstorms across portions of northern Upper Michigan during the late evening of the 15th into the morning hours of the 16th. Houghton County was the hardest hit, but Keweenaw, Alger, Luce and northern Schoolcraft counties also observed damaging winds and/or large hail from the storms. Twelve-fourteen trees up to twelve inches in diameter came down across Highway M-123 between Newberry and Tahquamenon Falls. One tree fell on a house causing $10,000 in property damage.

**Probability of Future Occurrences:** Thunderstorms are infrequent in the area and tornadoes rarely occur. Thunderstorms occur on about 27 to 29 days each year. The frequencies of past thunderstorm/high wind/lightning/hail events provide a base line to predict the risk of future occurrences. Thunderstorm winds and Hail events are documented multiple times each year, and there are no climactic indications that these occurrences will change in the measurable future. Based on the past history of events, severe thunderstorms including high wind, lightning and hail has a 100 percent chance of occurrence in a given year, which correlates to a highly likely occurrence rating.

**Impact Assessment:** Many hazardous weather events are associated with thunderstorms. Lightning is responsible for starting forest fires, as well as causing deaths when people are
struck. Under the right conditions, rainfall from thunderstorms causes flash flooding, which can change small creeks into raging torrents in a matter of minutes. Hail up to the size of softballs damages cars and windows, and kills wildlife caught out in the open. Strong (up to more than 120 mph) straight-line winds associated with thunderstorms can knock down trees and power lines. Tornadoes (with winds up to about 300 mph) can destroy all but the best-built man-made structures.

**Direct Impacts:** High winds, heavy rains, and hail can damage vegetation and stir up sediment in waterways disrupting the ecosystems. The impact that severe summer storms have on the environment is through the spawning tornados, flooding, and increased chance of wildfires from lightning strikes. Strong winds associated with severe thunderstorms or other phenomena can cause extensive damage and can result in deaths or injuries. Damage depends on both the wind speed and the nature of the objects in the path of the storm. Strong winds can turn debris and un-tethered objects into missiles. Even heavy vehicles can be rolled over. Homes and large buildings can sustain damage from the direct force of the wind. Broken windows and damaged roofs are common. Falling limbs and trees are also common and can contribute to property damages and downed power lines. Manufactured homes and metal sheds can be destroyed, particularly if they are not fastened to a foundation. Power and communications outages are also common, and storm debris in roads can disrupt transportation and delay emergency response vehicles. Farm operations can also be heavily impacted by windstorms. Winds can flatten farm crops such as corn and tobacco, and destroy orchard crops such as apples.

**Indirect Impacts:** The indirect social and economic impacts of wind damage are typically associated with the loss of electrical power. Given our society’s heavy reliance on electric power, any disruption in the supply, even for a short time period, can have significant consequences.

**Vulnerability Assessment:**

Essentially all Luce County buildings, critical facilities, and populations are vulnerable to damage during a thunderstorm.

**Population**

Some segments of the population are especially vulnerable to the indirect impacts of damaging wind, particularly the loss of electrical power. As a group, the elderly or disabled, especially those with home health care services relying on rely heavily on an uninterrupted source of electricity. Resident populations in nursing homes, Community Based Residential Facilities, or other special needs housing may also be vulnerable if electrical outages are prolonged. Without a back-up power source, rural residents and agricultural operations reliant on electricity for heating, cooling, and water supplies are also especially vulnerable to power outages.
**General Property**

In terms of property losses, the actual damages will depend on the building density in the impacted area. This is highly variable across the County. A severe thunderstorm with high winds in an older residential area with older homes, large trees, and overhead utility lines will have a significantly greater impact with the same storm in a new development with lower building density, modern constructed buildings, small or newly planted trees, and underground power lines.

In terms of crop losses, the actual damages that occur will depend on the type of crop and the growth stage of the plants. A wind storm in a rural area in the early spring when the plants are just emerging will have much less of an impact than a storm of the same intensity occurring later in the growing season when the plants are more susceptible to damage and when there is no time to replant if the crop is a total loss.

**Essential Infrastructure, Facilities, and Other Important Community Assets**

Critical facilities are susceptible to the same damage and disruption from thunderstorms as other buildings. Power lines, communications networks, and other above-ground infrastructure are vulnerable to the effects of windstorms both directly and indirectly. The wind itself may damage the infrastructure, or the wind may damage tree branches and throw other debris into the air, which may cause secondary damage to buildings and critical facilities or capabilities. Emergency response vehicles with high profiles may be more exposed to high winds, which may hinder response times. Emergency operations can be disrupted as thunderstorms and lightning affect radio communications and antennas are a prime target for lightning. In addition, wind may exacerbate dangerous conditions, such as fires, making response more difficult and dangerous. These are unlikely events but they are severe in occurrence.

**Natural, Historic and Cultural Resources**

Age and construction may impact the vulnerability of cultural or historic resources. Natural resources are vulnerable to damage such as broken or uprooted trees, flattened plant life, or, when wind is combined with extreme heat, severe drying and heightened fire risks. In addition, there is limited means of protecting these resources from wind damage.

**Estimating Potential Losses:** The economic impact has the potential to be high depending upon the damage a storm inflicts on the community. Damage to property and power lines and the resulting repairs and clean up could see costs rising above the $25,000 limit set for the high criteria, therefore, the Economic Impact is rated at high for this hazard.

**Mitigation Capabilities:** Luce County will continue efforts to become designated as a StormReady Community. The StormReady program is intended to encourage severe weather preparedness activities in communities that have achieved a notable level of preparedness. The public recognition comes in the form of "accreditation" when the community has met criteria collaboratively established by Emergency Managers and the National Weather Service.
The primary beneficiaries of the StormReady program will be the people who live in the accredited communities. They can take comfort in the fact that their community leaders have achieved some standard level in protecting them from hazardous weather. Although StormReady does not mean storm proof, it can provide people with a greater sense of safety.

**Mitigation Alternatives**

- Increased coverage and use of NOAA Weather Radio.
- Producing and distributing family emergency preparedness information relating to thunderstorm hazards.
- Public education and awareness of thunderstorm dangers.
- Training and increased use of weather spotters.
- Public early warning systems and networks.
- Tree trimming and maintenance to prevent limb breakage and to safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines. (NOTE: May cause additional problems and costs in case of breakage, due to the increased difficulty in locating and repairing the problem.)
- Inclusion of safety strategies for severe weather events in driver education classes and materials.
- Encourage residents to develop a Family Disaster Plan which includes the preparation of a Disaster Supplies Kit.
- Pre-planning for debris management staging and storage areas. (Debris could be rubble, vehicles, objects from destroyed/damaged structures, vegetation or other items knocked down or blown by winds.)
- Using structural bracing, window shutters, laminated glass in window panes, and hail-resistant roof shingles to minimize damage to public and private structures.
- Pre-planning for debris management staging and storage areas. (Debris is usually vegetation such as tree branches that have fallen under the impact of hail, or broken power or phone lines that had frozen or been weighted down by ice or fallen branches.)

**Summary**

Based on the previous assessments, the overall risk rating for Thunderstorms including high wind, hail and lightning is high.

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Tornadoes

**Description:** A tornado is a swirling column of air extending from a thunderstorm to the ground. Tornadoes can have wind speeds from 40 mph to over 300 mph. A majority of tornadoes have wind speeds of 112 mph or less. Tornadoes in Michigan are most frequent in the spring and early summer when warm, moist air from the Gulf of Mexico collides with cold air from the polar regions to generate severe thunderstorms.

Debris hurled by the wind can hit with enough force to penetrate walls. Tornadoes create localized low-pressure areas that can make a building explode. Window, chimneys and roofs are the most vulnerable parts of building to tornado damage.

Tornadoes can move forward at up to 70 mph, pause, slow down and change directions. Most have a narrow pat, less than 100 yards wide and a couple of miles long. However, damage paths can be more than 1 mile wide and 50 miles long.

The northern Michigan tornado season runs from March into October with the most active period occurring during June and July. The most active time of the day for tornadoes is during the late afternoon and early evening.

In 1971, Dr. T. Theodore Fujita of the University of Chicago devised a six-category scale to classify U.S. tornadoes into six damage categories, called F0-F5. F0 described the weakest tornadoes and F5 described only the most destructive tornadoes. From 2000-2004, the Wind Science and Engineering Research Center at Texas Tech University, in cooperation with numerous expert meteorologists, civil engineers and the National Weather Service (NWS), developed an Enhanced Fujita scale, or EF-scale. In addition to improving the ranking process, it was essential to the development team that the new EF-scale support and be consistent with the original F-scale.

### The Enhanced Fujita Scale of Tornado Intensity

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<th>F-Scale Number</th>
<th>Intensity Descriptor</th>
<th>Wind Speed (mph)</th>
<th>Type/Intensity of Damage</th>
<th>EF-Scale Number</th>
<th>3-Second gust (mph)</th>
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<tbody>
<tr>
<td>F0</td>
<td>Gale tornado</td>
<td>40-72</td>
<td>Light damage. Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.</td>
<td>0</td>
<td>65-85</td>
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<tr>
<td>F1</td>
<td>Moderate tornado</td>
<td>73-112</td>
<td>Moderate damage. The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.</td>
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<td>86-110</td>
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<tr>
<td>F2</td>
<td>Significant tornado</td>
<td>113-157</td>
<td>Considerable damage. Roots torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.</td>
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### Enhanced Fujita Scale for Tornadoes

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<td>F3</td>
<td>Severe tornado</td>
<td>158-206</td>
<td>Severe damage. Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown.</td>
<td>3</td>
<td>136-165</td>
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<tr>
<td>F4</td>
<td>Devastating tornado</td>
<td>207-260</td>
<td>Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.</td>
<td>4</td>
<td>166-200</td>
</tr>
<tr>
<td>F5</td>
<td>Incredible tornado</td>
<td>261-318</td>
<td>Incredible damage. Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged; incredible phenomena will occur.</td>
<td>5</td>
<td>Over 200</td>
</tr>
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**Figure 12 - Enhanced Fujita Scale for Tornadoes**

NOTE: When describing tornadoes, meteorologists often classify the storms as follows: F and F1 - weak tornado; F2 and F3 - strong tornado; F4 and F5 - violent tornado

(Source: The Tornado Project; Storm Data, National Climatic Data Center)

**Geographic Extent:** The entire county is vulnerable to a tornado as one could occur anywhere, but tornado's typically are funnel shaped with the narrow end touching the ground and encircled by a cloud of debris. They usually only travel a few miles before dissipating, although they could be bigger and travel further. The geographic extent is rated to be **limited**.

**Historical Events:**

**Probability of Future Occurrences:** Based on historical events there is a **low** probability of future occurrences.

**Impact Assessment:**

**Direct Impacts:** The direct impact of a tornado and the swirling debris will cause damage or destruction to property and injury or fatalities to animals and people. Utility lines are often downed by high winds or falling debris. Explosions, electrocutions or fires could occur with the damage to the utility lines.

**Indirect Impacts:** Injuries could occur during the rescue attempt/clean-up aftermath. Power and other utilities may be out of service for a period of time. People may be displaced from their homes and commercial businesses may be affected. Communities that are struck by a damaging tornado will experience economic losses while recuperating from the aftermath.

**Vulnerability Assessment:**

**Population:** Those people in the direct path of a tornado would be at high risk. Vulnerable populations include the elderly and young, those in hospitals or nursing homes, trailer courts,
and campgrounds. People who do not have a place to take shelter or who do not have a basement to go to for protection will be especially vulnerable if in the path of a tornado.

**General Property:** A tornado can cause minor damage or total destruction without any warning. Most tornadoes are relatively weak and therefore, primarily damage only damage roofs, windows and trees. A tornado that generates wind speed over 200 is going to destroy anything in its path as well as creating flying debris.

**Essential Infrastructure, Facilities, and Other Important Community Assets:** Critical facilities such as fire and ambulance stations need to protect the equipment housed for rescue efforts in the aftermath of a tornado. Buildings used as shelters need to be constructed to be able to withstand high winds and flying debris. Power utility substations, power lines, communication towers, gas pipelines are most likely to be damaged in the path of a tornado or flying debris.

**Natural, Historic and Cultural Resources:** Luce County has several communities with small museums that house the artifacts, photos, and history of the area. Cultural resources in and around the County include Tahquamenon Area Logging Museum, Luce County Historical Museum and Crisp Point Light House.

**Estimating Potential Losses:** Using historical data, and estimating the impact and potential destruction of property and environment, as well as the possible need for rescue operations and clean up the economic impact of a tornado incident is rated to be high.

**Mitigation Capabilities:** Mitigation strategies include having building codes that require structures that are capable of withstanding strong winds and that have protection for large windows. Construction of safe houses around campgrounds or trailer courts would give people a place of shelter in case of an emergency.

Advanced warning through the National Weather Service or County Emergency Management Office can prepare residents to take shelter. Warning sirens are located throughout the County. Public education programs, tv or radio spots to provide information to the public about the siren warning system and what to do.

Creating brochures or a website to distribute information on shelters and educating the public what to do or where to go in the event of a tornado warning would help prepare the County’s population to take measures to protect themselves and their property.

Minimizing debris potential by trimming dead trees and branches that could potentially fall on buildings or power lines. Establishing a community forestry program.

Ensuring tie-downs, fasteners, reinforcements are in place and maintained on building components. Requiring manufactured homes have proper anchoring. Retrofitting buildings with shutters for the windows and strengthening components such as doors, skylights, roofs, and walls.
Developing local severe weather emergency planning. Requiring large businesses and schools to have emergency plans in place and having weather radios or other equipment available to monitor conditions.

### Summary

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Wildfires

**Description:** A wildfire is an uncontrolled fire in forested areas, grass or brushlands. The most immediate dangers from wildfires are the destruction of homes and timber, wildlife, and injury or loss of life to persons who live in the affected area or who are using the recreational facilities in the area. Long-term effects can be numerous and include scorched and barren land, soil erosion, landslide/mudflows, water sedimentation, and loss of recreational opportunities.

The Michigan Department of Natural Resources (MDNR) Forest Management Division directs and coordinates wildfire prevention, containment and suppression activities on all non-federal lands in the state, as well as Indian Reservations (under contract with the U.S. Bureau of Indian Affairs). The MDNR places great emphasis on wildfire prevention and public education, since the vast majority of wildfires in Michigan are caused by human activity. The MDNR Forest Management Division’s philosophy is that preventing fires from starting in the first place, and taking precautionary measures around rural homes to stop the spread of wildfires, are the best means of avoiding or minimizing wildfire losses. When conditions of extreme fire hazard exist, the MDNR can request the Governor to issue an outdoor burning ban to mitigate the potential for wildfire in all or part of the state. Such a ban restricts smoking, fireworks, and outdoor burning activities to approved locations.

**Geographic Extent:** Forests cover the largest area in Luce County covering almost 90% of the County. The forest cover is good for both industry and recreation. However, it also makes many areas of the county potentially vulnerable to wildfires. Most Michigan wildfires occur close to where people live and recreate, which puts people, property and the environment at risk. Development in and around rural forested areas often increases the potential for loss of life and property from wildfires. The rating for geographic extent is *Extensive*.

**Historical Events:**
**May 20-31, 2012:** Lightning from a line of thunderstorms ignited the Duck Lake wildfire 14 miles north of Newberry on the evening of the 20th. Strong south winds gusting over 30 mph on the 24th quickly fanned the fire and caused it to spread rapidly toward the Lake Superior shore forcing mandatory evacuations for people in the Pike Lake, Bodi Lake, Culhane Lake and Little Lake Harbor areas. The 21,069 acre wildfire, the third largest in modern Michigan history, burned 136 structures (including one store and one motel) before it was fully contained in mid-June. No injuries or deaths occurred from the fire.

*Figure 13 – 2012 Duck Lake Fire; Photo Credit: MDNR*
Road closures included County Road 414 east from the intersection with County Road 410 and County Road 500 from M-123 north to Little Lake Harbor. As a precaution, Tahquamenon Falls State Park was also closed for several days but was completely untouched by the fire. The total cost of property lost and resources used to fight the fire was estimated to be about $12 million. Governor Rick Snyder declared a state of disaster in Luce County on the 25th.

August 2-31, 2007: On August 2, a lightning strike ignited a wildfire over the Lake Superior State Forest in Luce County during a period of moderate to extreme drought conditions. The Sleeper Lake Fire grew to more than 15,000 acres within a week and eventually swept across 28 square miles, consuming more than 18,000 acres of forests and wetlands before it was fully contained in late August.

The fire threatened permanent and seasonal residences as well as commercial business along County Road 407 north of Halfway Lake to Pine Stump Junction and east along County Road 420 toward Stuart Lake. At the height of fire, approximately 250 people per day were working the fire, along with four National Guard Blackhawk helicopters, two CL215 water bombers from Minnesota and a helicopter aerial ignition team from Ontario. Equipment and personnel costs for fighting the fire were in excess of $7 million.

No major injuries were reported, but property damage was estimated at $40,000.

Probability of Future Occurrences: Records from the DNR report that there were on average 8.6 wildfires annually from 2005-2013 in Luce County. The majority of these fires originated from lightning strikes with the second leading cause being debris burning. The probability of wildfires occurring increases during times of drought conditions. Based on this information the rating is highly likely for future occurrences.

Impact Assessment: Wildfires in the state of Michigan are generally underestimated in regard to number and losses. The Michigan Department of Natural Resources estimates that 8,000 to 10,000 wildfires occur each year in this state. While most of these are small wildfires - burning between 5 and 50 acres -- many wildfires exceed 100 acres and some have consumed thousands of acres. In addition, each year 100 to 200 homes and buildings are either lost or damaged due to wildfires. Because most wildfires are caused by human activities, the number of wildfires and losses can be reduced if residents would take more precautions. Wildfires encompass environment, properties, economic loss, and most unfortunately many lives.
lands use, private lands, animals, tourism, merchants, schools and health institutions are just a few that experience losses. To assess an exact dollar amount may never be touchable. After the wildfires, there are years of recovery in all of these areas.

**Direct Impacts:** When a wildfire burns in an uncontrolled or unexpected manner it can have major direct impacts on life and property. It is particularly dangerous when it encroaches into urban areas, or when it moves faster than the local capability of fire suppression technology can handle. Sometimes, wildfires can exceed the warning time and evacuation capabilities of the population which greatly increases the direct impact on human life. Power lines can be destroyed if in the path of a wildfire. Wildfires also exhibit a number of positive direct impacts, mostly connected to the continued renewal of a healthy ecological balance in natural areas. However, according to the Michigan Department of Natural Resources, the majority of fires in Michigan are started by humans and are not, therefore, part of the natural ecologic process.

**Indirect Impacts:** Indirectly, wildfires create a significant drain on resources and manpower, as large fires are extremely complicated, require large commitments of resources and personnel, and may cause extensive personal and property damage. Soils can become contaminated and agriculture crops damaged or destroyed.

**Vulnerability Assessment:** The large number of permanent and seasonal homes in the County, coupled with the increase in tourists during the most dry (and therefore most vulnerable) times of the year, greatly increases the vulnerability risk from wildfires.

**Population**

The most vulnerable population are those living in the wildland-urban interface (WUI) zones, where residential properties are directly intruding into traditional wildland areas. The exposure of the population in these zones increases with the exposure of the corresponding general property, examined in the section below. Other exposed groups include children, the elderly, or those with breathing conditions who may be exposed to high levels of smoke. Populations living in long term care facilities or other skilled care facilities face additional exposures because of increased evacuation times and the potential that the population may be required to shelter in place. Overall, the vulnerability of the population to wildfires is medium.

**General Property**

Any material that is flammable is vulnerable during a wildfire, including structures and personal property. The vulnerability of general property increases as the distance of the property to wildfire-prone areas decreases, and is particularly high for structures located in the WUI. These structures receive an even higher level of vulnerability if the properties surrounding them are not properly mitigated for fire. Appropriate mitigation techniques include using non-flammable materials such as concrete for construction, leaving appropriate spaces between buildings and vegetation areas filled with non-flammable materials (such as decorative rock or stone), and clearing of underbrush and trees. However, the majority of general property is not located in these WUI zones and therefore experiences a minimal exposure to the hazard. If a wildland fire were to cross completely into an urban zone, the
damage would be extensive and there would likely be a higher exposure of property. Overall, the exposure of general property in the County is **high**.

**Essential Infrastructure, Facilities, and Other Important Community Assets**

These aspects of the County may be exposed directly or indirectly to wildfire. Direct exposures are similar to those of General Property and increase as the infrastructure or facilities and capabilities moves into the WUI zone. Communications lines passing through susceptible areas such as forests are more exposed than those located in cities and other more urban areas. The indirect exposure of response capability increases seasonally and with the number of occurrences. Though the populations making up the response capability are not directly exposed to all fire events, the response of some of the personnel to an event lessens the capabilities overall for response to other emergency situations. If there is a large increase in the number of simultaneous wildland fires, even small ones, the response capability of the County could easily be compromised. This is not considered likely, however, and the overall vulnerability rating is **low**.

**Natural, Historic and Cultural Resources**

Some natural resources and natural areas may benefit from wildland fire, as at some level they must also be exposed to wildfire for a healthy ecological development of the area. Historic and cultural resources exhibit a vulnerability rating similar to those in general property, where vulnerability ratings increase the further into the WUI the property is, and the less mitigated the landscaping surrounding the property is. In addition, older buildings may be exempt from internal fire mitigation such as sprinklers and fire suppression technology, which may increase the vulnerability of the resource as a total loss once already on fire. Overall, the vulnerability rating is **low**.

**Estimating Potential Losses:** The cost of suppression resources as well as potential life and property damage allow for the economic impact for the wildfire hazard to be rated **High**.

**Mitigation Capabilities:** In 2010, EUPRP&DC assisted Luce County in the development of a Community Wildfire Protection Plan. Strategies identified in this plan include the formation of a Firewise Committee with Response Zone Subcommittees, holding events such as an annual Firewise Community Day, public awareness campaigns, identifying areas for dry hydrants, and property assessments.

**Mitigation Alternatives:**

- Proper maintenance of property in or near wildland areas (including short grass; thinned trees and removal of low-hanging branches; selection of fire-resistant vegetation; use of fire resistant roofing and building materials; use of functional shutters on windows; keeping flammables such as curtains securely away from windows or using heavy fire-resistant drapes; creating and maintaining a buffer zone (defensible space) between structures and adjacent wild lands; use of the fire department's home safety inspections; sweeping/cleaning dead or dry leaves, needles, twigs, and combustibles from roofs, decks, eaves, porches, and yards; keeping woodpiles and other combustibles away from
structures; use of boxed or enclosed eaves on houses; thorough cleaning-up of spilled flammable fluids; and keeping garage areas protected from blowing embers).

- Safe disposal of yard and house waste rather than through open burning.
- Keep handy household items that can be used as fire tools; a rake, axe, hand/chainsaw, bucket and shovel. (Installation and maintenance of smoke detectors and fire extinguishers, smoke alarms on each floor of buildings and homes, with monthly tests and batteries changed twice per year and family members instructed in fire extinguisher use—these are all relevant for preventing structural fires that might spread to adjacent lands, but are of limited value in the reverse case in which an existing wildfire threatens structures, escape routes, etc.)
- Post fire emergency telephone numbers.
- Use of structural fire mitigation systems such as interior and exterior sprinklers, smoke detectors, and fire extinguishers.
- Arson prevention activities, including reduction of blight (cleaning up areas of abandoned or collapsed structures, accumulated junk or debris, and lands with a history of flammable substances stored, spilled, or dumped on them).
- Public education on smoking hazards and recreational fires.
- Proper maintenance and separation of power lines. Ask the power company to clear branches from power lines.
- Efficient response to fallen power lines.
- Training and exercises for response personnel.
- GIS mapping of vegetative coverage, for use in planning decisions and analyses through comparison with topography, zoning, developments, infrastructure, etc.
- Create and enforce local ordinances that require burn permits and restrict campfires and outdoor burning.
- Mutual aid pacts with neighboring communities.
- Prescribed burns and fuel management (thinning of flammable vegetation, possibly including selective logging to thin out some areas. Fuels cleared can be given away as firewood or made into wood chips for distribution.)
- The creation of fuel breaks (areas where the spread of wildfires will be slowed or stopped due to removal of fuels, or the use of fire-retardant materials/vegetation) in high-risk forest or other areas.
- Keeping roads and driveways accessible to vehicles and fire equipment—driveways should be relatively straight and flat, with at least some open spaces to turn, bridges that can support emergency vehicles, and clearance wide and high enough for two-way traffic and emergency vehicle access (spare keys to gates for properties should be provided to the local fire department, and an address should be visible from the road so homes can be located quickly).
- Enclosing the foundations of homes and buildings rather than leaving them open with their underside exposed to blown embers or materials.
- Have adequate water supplies for emergency firefighting (in accordance with NFPA standards). For residents, identify and maintain an adequate outside water source such as a small pond, cistern, well, swimming pool or hydrant; have a garden hose that is long enough to reach any area of the home and other structures on the property; install freeze-
proof exterior water outlets on at least two sides of the home and near other structures on the property. Install additional outlets at least 50 feet from the home; consider obtaining a portable gasoline powered pump in case electrical power is cut off.

- Obtaining insurance.
- Including wildfire safety information in materials provided by insurance companies to area residents.

**Summary:** The following table shows the overall risk for wildfires rating to be **High**.

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Man-made/Technological Hazards

Civil Disturbances

Description: Large-scale civil disturbances rarely occur, but when they do they are usually an offshoot or result of one or more of the following events: 1) labor disputes where there is a high degree of animosity between the participating parties; 2) high profile/controversial judicial proceedings; 3) the implementation of controversial laws or other governmental actions; 4) resource shortages caused by a catastrophic event; 5) disagreements between special interest groups over a particular issue or cause; 6) a perceived unjust death or injury to a person held in high esteem or regard by a particular segment of society; or 7) a “celebration” of an important victory by a sports team.

Prison uprisings are normally the result of perceived injustice by inmates regarding facility rules, operating policies and/or living conditions, or insurrections started by rival groups or gangs within the facility.

Prison uprisings are handled first by Michigan Department of Corrections riot units composed of trained Corrections Officers. Additional units may be brought in from other nearby facilities, if necessary, to quell the disturbance. If those resources are not sufficient to manage and end the uprising, specially trained officers from the Michigan State Police can be activated to assist Department of Correction’s personnel. The Michigan State Police may also be mobilized to provide perimeter security around the facility, and to augment resource needs. In extreme cases, Michigan National Guard military police personnel can be activated to assist with the restoration of order within the facility.

Geographic Extent: With just one prison system located in Pentland Township, the geographic extent is rated to be Limited.

Historical Events: There is no history of public riots or civil disturbances in Luce County.

Probability of Future Occurrences: Since the prison facility was opened in the mid 1990’s there have been no “riots”. Sporting events have the potential for large group disturbances when emotions run hot and tempers flare.

Impact Assessment: Civil disturbances can have far reaching impacts.

Direct Impacts: The direct impact of a civil disturbance can include serious injuries or fatalities to people directly involved and also cause emotional distress to those directly involved. Destruction of property and use of public utilities may be disrupted.

Indirect Impacts: Indirect impacts could affect the local population not directly involved in a civil disturbance by having their lives significantly disrupted. They may not be able to work or enjoy recreational activities and may even lose the ability to obtain necessities.
Vulnerability Assessment:

**Population:** The emergency responders and those in law enforcement would be most vulnerable, as well as the general population in the vicinity of a disturbance. Overall the population affected is rated to be **low**.

**General Property:** Depending upon the reason for a civil disturbance public utilities, local government facilities and critical facilities may be most vulnerable. Private and commercial property could also be vulnerable if located in the midst of the disturbance.

**Essential Infrastructure, Facilities, and Other Important Community Assets:** Public utility systems that provide water, electricity, gas/fuel for heating and communications as well as critical facilities including cyberspace are vulnerable to tampering or destruction.

**Natural, Historic and Cultural Resources:** Depending upon the nature of a civil disturbance the historical government Courthouse may be vulnerable if the civil unrest were related to governmental issues. Sports facilities and the local schools may be vulnerable in the event of a riot at a sporting event.

**Estimating Potential Losses:** The cost of responding to a civil disturbance and potential for property destruction is rated to be **medium**.

**Mitigation Capabilities:** Mitigation basically implies efforts to prevent or minimize the damage which can result from civil unrest. These efforts can be developed using lessons learned from previous civil disturbances in large, medium, and small cities.

Police presence at local events and demonstrations may be enough to prevent a disturbance, however, mutual aid agreements with fire departments and additional enforcement personnel such as a National Guard unit may be necessary in the event of a large civil disturbance. Planning and training can help prepare for such events. Good communication between departments and the community can reduce the risk. Installation of sprinkler systems in vulnerable facilities can reduce the damage to property in the event of arson or other fire-related incidents.

**Summary**

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**Infrastructure Failures**

**Description:** The increasing complexity and interconnectedness of energy, telecommunications, transportation and financial infrastructures pose new challenges for secure, reliable management and operation. No single entity has complete control of these multi-scale, distributed, highly interactive networks, or the ability to evaluate, monitor, and manage them in real time. Loss of one infrastructure could lead to failures in other areas.

Citizens are dependent on the public and private utility infrastructure to provide essential life supporting services such as electric power, heating and air conditioning, water, sewage disposal and treatment, storm drainage, communications, and transportation.

These are just some examples of the types of infrastructure failures that can occur, and all of these situations can lead to disastrous public health and safety consequences if immediate mitigation actions are not taken.

**Geographic Extent:** Inhabited structures throughout the County. The geographic extent for infrastructure failure is rated at **significant**.

**Historical Events:** Luce County has had numerous widespread and severe electrical power outages and telephone/communications disruptions, caused mostly by severe weather such as windstorms or ice and sleet storms and are discussed more under those categories. However, damage has also been known to occur by man with construction equipment cutting underground lines. Other infrastructures such as water and sewer lines are damaged due to extreme temperatures or ground heaving. The transportation network is always affected by the heaving movement of frozen ground and must be attended to each spring.

**Probability of Future Occurrences:** Luce County can expect power/communication outages possibly numerous times a year usually due to severe weather conditions. Freezing ground is also expected annually. Heavy snow or ice can bring down power lines or cause entire trees or tree limbs to fall on power lines taking out power. High winds during thunderstorms can also cause power outages due to falling trees or tree limbs coming down across power lines. The likelihood of future occurrences of an infrastructure failure is determined to be **High**.

**Impact Assessment:**

**Direct Impacts:** Direct impacts of infrastructure failures such as electricity or loss of heat during an extreme winter event for a prolonged period could potentially mean loss of life. Communication is essential in cases of emergency and would have a direct impact on emergency services if there were not a backup system in place. Fresh food supplies and storage would be directly impacted. Telecommunications, transportation, financial, medical, governmental, utilities would all be impacted and interrupted.

**Indirect Impacts:** Indirect impacts of loss of electricity for a prolonged period would induce economic losses to individuals and businesses in the affected area. Rioting and looting could
also take place. Repair and/or clean-up costs of a major infrastructure failure would most likely have a high economic impact.

**Vulnerability Assessment:**

**Population:** Typically, it is the most vulnerable members of society (i.e., the elderly, children, impoverished individuals, and people in poor health) that are the most heavily impacted by an infrastructure failure. If the failure involves more than one system, or is large enough in scope and magnitude, whole communities and possibly even regions can be severely impacted. Individuals who rely on electricity for heat or medical reasons would be more vulnerable.

**General Property:** Depending upon the type of infrastructure failure households, businesses, and transportation networks could all be affected.

**Essential Infrastructure, Facilities, and Other Important Community Assets:** Hospitals, nursing homes and other medical facilities and emergency shelters or emergency command centers are critical assets that need to be protected from a prolonged infrastructure failure. Critical information centers such as financial institutions and public records would also be vulnerable.

**Natural, Historic and Cultural Resources:** The historical documents, artwork, or artifacts that are in a temperature controlled environment would be most vulnerable.

**Mitigation Capabilities:**
Purchase and installation of back-up power sources or burying power lines to prevent loss of electrical power. System redundancies so if one system fails, there is a back-up that can take over. Installation of back-up heating sources such as wood burning fireplaces or woodstoves. Regular maintenance and equipment checks, replacement or renovation of aging infrastructure and equipment will help to reduce the chances of a failure. Protection from lightning on communication towers and other critical assets. Develop a community program/network to inform and aid the most vulnerable citizens in the event of a prolonged period of infrastructure failure.

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Fixed Site – Hazardous Material Incidents

Hazardous materials are present in quantities of concern in business and industry, agriculture, universities, hospitals, utilities, and other facilities in our communities. Hazardous materials are materials or substances that because of their chemical, physical, or biological nature pose a potential risk to life, health, property, or the environment if they are released. Examples of hazardous materials include corrosives, explosives, flammable materials, radioactive materials, poisons, oxidizers, and dangerous gasses.

Hazardous materials are highly regulated by federal and state agencies to reduce risk to the general public and the environment. Despite precautions taken to ensure careful handling during the manufacture, transport, storage, use, and disposal of these materials, accidental releases do occur. Often, these releases can cause severe harm to people or the environment if proper mitigation action is not immediately taken.

Industrial accidents differ from hazardous material incidents in the scope and magnitude of offsite impacts. Whereas hazardous material incidents typically involve an uncontrolled release of material into the surrounding community and environment that may necessitate evacuations or in-place sheltering of the affected population, the impacts from industrial accidents are often confined to the site or facility itself, with minimal physical outside impacts. Nonetheless, industrial accidents such as fires, explosions, and excessive exposure to hazardous materials, may cause injury or loss of life to the workers at the facility, and often significant property damage. In addition, industrial accidents can cause severe economic disruption to the facility and surrounding community, as well as significant, long-term impacts on the families of the workers injured or killed.

Geographic Extent: An Industrial park is located in Pentland Township on the outskirts of the Village of Newberry. The extent of a fixed site incident would be considered to be isolated.

Historical Events:

Probability of Future Occurrences: As long as there are industries and other sites storing and using hazardous material, a threat of a potential incident will also be there. Homemade meth labs seem to be on the rise. Based on historical data and the minimal amount of industry in the County the likelihood of future occurrence is rated to be low.

Impact Assessment:
Direct Impacts: Industrial accidents differ from hazardous material incidents in the scope and magnitude of offsite impacts. Whereas hazardous material incidents typically involve an uncontrolled release of material into the surrounding community and environment that may necessitate evacuations or in-place sheltering of the affected population, the impacts from industrial accidents are often confined to the site or facility itself, with minimal physical outside impacts. Nonetheless, industrial accidents such as fires, explosions, and excessive exposure to
hazardous materials, may cause injury or loss of life to the workers at the facility, and often significant property damage

**Indirect Impacts:** Industrial accidents can cause severe economic disruption to the facility and surrounding community, as well as significant, long-term impacts on the families of the workers injured or killed.

**Vulnerability Assessment:**

**Population:** Those who would be most affected by a hazardous materials fixed site incident would be the ones in the immediate vicinity, possibly employees. If a chemical is released into the air the general population downwind of the incident will be vulnerable. First responders may be at higher risk and exposed to toxic chemicals.

**General Property:** The risk to the environment through air, water or ground contamination may be detrimental to the surrounding area of an incident and affect it for years.

**Essential Infrastructure, Facilities, and Other Important Community Assets:** Essential infrastructure such as water supply sources, ground wells or intakes would be vulnerable to nearby air, water or ground contamination.

**Natural, Historic and Cultural Resources:** Luce County relies heavily on its natural resources for economic and recreational activities. A significant hazardous materials release and contamination would be detrimental to the environment.

**Estimating Potential Losses:** Estimating potential losses for a fixed site hazardous materials incident would depend on the size of the incident and the site. For the purposes of this plan it is estimated that the potential economic impact at a minimum would be medium.

**Mitigation Capabilities:** Advanced planning, preparing and training, as well as a good communication system with various federal, State, and local officials and stakeholders can make the County better prepared to handle an incident. Traffic controls or road closures may be needed. Having the correct equipment, trained personnel and participating in practice drills and exercises.

Adopting policies and establishing zoning regulations for industries. Ensuring that industries have a buffer zone and proper separation between other land uses such as residential or recreational. Requiring site plans and emergency plans be in place.

Educational awareness campaigns, brochures and information on a website for the general public to find out more information. Use of advance warning sirens or systems.

Ensuring compliance with federal, State, and local regulations. Purchasing and maintaining insurance policies. Brownfield cleanup activities on identified sites.
### Summary

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**Transportation Accidents/Hazardous Materials Transportation Accidents**

**Description:**

**Land Transportation Accidents**

A land transportation accident in Luce County could involve a local public transit bus, a school bus, recreational vehicles, or a train. Although these modes of land transportation have a good safety record, accidents do occur. Typically, the bus slipping off a roadway in inclement weather, or colliding with another vehicle causes bus accidents. Train accidents usually involve a collision with a vehicle attempting to cross the railroad tracks before the train arrives at the crossing. Unless the train accident results in a major derailment, serious injuries are usually kept to a minimum. Bus accidents, on the other hand, can be quite serious – especially if the bus has tipped over. Numerous injuries are a very real possibility in those types of situations.

Luce County has hundreds of miles of recreational trails used by both non-motorized and motorized vehicles. Accidents in remote areas with lack of communication capability or location identification can make it difficult on the emergency response team.

**Air Transportation Accidents**

There are four circumstances that can result in an air transportation accident: 1) an airliner colliding with another aircraft in the air; 2) an airliner crashing while in the cruise phase of a flight due to mechanical problems, sabotage, or other cause; 3) an airliner crashing while in the takeoff or landing phases of a flight; or 4) two or more airliners colliding with one another on the ground during staging or taxi operations. When responding to any of these types of air transportation accidents, emergency personnel may be confronted with a number of problems, including: 1) suppressing fires; 2) rescuing and providing emergency first aid for survivors; 3) establishing mortuary facilities for victims; 4) detecting the presence of explosive or radioactive materials; and 5) providing crash site security, crowd and traffic control, and protection of evidence.

**Water Transportation Accidents**

A water transportation accident could have significant life safety consequences. With the many rivers and Lake Superior as the northern border, Luce County is susceptible to water transportation accidents with the many recreational users of this natural resource.

The one commonality all transportation accidents share – whether air, land or water-based – is that they can result in mass casualties. Air transportation accidents, in particular, can result in tremendous numbers of deaths and injuries and major victim identification and crash scene management problems. Water transportation accidents, on the other hand, may require a significant underwater rescue and recovery effort that few local jurisdictions may be equipped or trained to handle.

**Hazardous Materials Transportation Accident**

As a result of the extensive use of chemicals in our society, all modes of transportation – highway, rail, air, marine, and pipeline – are carrying thousands of hazardous materials shipments on a daily basis through local communities. A transportation accident involving any
one of those hazardous material shipments could cause a local emergency affecting many people.

Local and state emergency responders and hazardous material response teams usually effectively deal with a small hazardous material transportation accident. Larger incidents, however, pose a whole new set of problems and concerns for the affected community. Large-scale or serious hazardous material transportation incidents that involve a widespread release of harmful material (or have the potential for such a release) can adversely impact the life safety and/or health and well-being of those in the immediate vicinity of the accident site, as well as those who come in contact with the spill or airborne plume. In addition, damage to property and the environment can be severe as well. Statistics show almost all hazardous material transportation incidents are the result of an accident or other human error. Rarely are they caused simply by mechanical failure of the carrying vessel.

Having a northern border on Lake Superior, one of the most dangerous hazardous material transportation accident scenarios that could occur in Luce County would be a spill or release of oil, petroleum or other harmful materials into one of the lakes from a marine cargo vessel. Such an incident, if it involved a large quantity of material, could cause environmental contamination of unprecedented proportions. Fortunately, the Great Lakes states, working in partnership with oil and petroleum companies and other private industry, have taken significant steps to ensure that a spill of significant magnitude is not likely to occur on the Great Lakes.

**Probability of Future Occurrences:** Based on historical incidents in Luce County there is a Low probability of future occurrences.

**Geographic Extent:** The geographic extent would be isolated for a site specific accident.

**Historical Events:** Most recently in summer of 2004 a car collided with a train in the Village of Newberry. There was serious injury to the conductor and damage to the vehicles.

**Impact Assessment:** Accidents involving hazardous materials pose a significant impact to the environment, public health and safety and community well-being. They can also produce long lasting economic, social and psychological impacts on a community.

**Direct Impacts:** Direct impacts can include contamination of the air, land and ground water affecting humans, plants and animals. Depending on the situation evacuation of people may be necessary. If an accident happens in a remote area, responding to the scene may be difficult leading to a greater impact to the environment.

**Indirect Impacts:** Indirect impacts can include the social and psychological effects on the community that is long lasting after the event where concerns for health can create long-term anxiety and alarm. Loss of trust, social conflict and division and social stigma are common and reduces the quality of life in a community.
Vulnerability Assessment:

Population: The most vulnerable of the population would be those in the direct vicinity or down wind, or down water of the incident where exposure to the air, land and water has occurred. The population affected is rated as Low.

General Property: The immediate surrounding environment will be the most vulnerable and depends on the type and amount of hazardous material that is released.

Essential Infrastructure, Facilities, and Other Important Community Assets: Vulnerable infrastructure includes drinking water sources, transportation infrastructure and utilities.

Natural, Historic and Cultural Resources: Luce County relies heavily on tourism as an economic base and much of that is from the natural environment and recreational activities on land and water. The potential destruction from a hazardous materials incident on these natural resources would have a tremendous negative impact on the County.

Estimating Potential Losses: Every situation is different therefore making it difficult to estimate potential losses. For the purposes of this plan it is estimated that the economic impact would be rated medium at a minimum.

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