Section 11
City of Makoti: HIRA, Capability Assessment, and Mitigation Strategy

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11.1 Interim Final Rule for Hazard Identification and Risk Assessment

Requirement §201.6(c)(2): *The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.*

Requirement §201.6(c)(2)(i): *[The risk assessment shall include a] description of the type…location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.*

Requirement §201.6(c)(2)(ii): *[The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community.*

Requirement §201.6(c)(2)(ii): *[The risk assessment]* ***must*** *also address National Flood Insurance Program (NFIP) insured structures that have been repetitively damaged floods.*

Requirement §201.6(c)(2)(ii)(A): *The plan* ***should*** *describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard area .*

Requirement §201.6(c)(2)(ii)(B): *[The plan* ***should*** *describe vulnerability in terms of an] estimate of*

the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimate ..

Requirement §201.6(c)(2)(ii)(C): *[The plan **should** describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.*

Requirement §201.6(c)(2)(iii): *For multi-jurisdictional plans, the risk assessment **must** assess each jurisdiction's risks where they vary from the risks facing the entire planning area.*

This section addresses the specific requirements of the Interim Final Rule (IFR) with regard to hazards and risks in the city of Makoti.

11.2 Hazard Identification (Updated)

In accordance with IFR requirements, and as part of its efforts to support and encourage hazard mitigation initiatives, the Steering Committee prepared this general assessment of the hazards that have the potential to impact the city of Makoti. This section provides an overview of past hazard events in the city and descriptions of potential hazards to the city.

11.2.1 Overview of Makoti's History of Hazards and Potential Hazards

Numerous federal agencies maintain a variety of records regarding losses associated with natural hazards. Unfortunately, no single source is considered to offer a definitive accounting of all losses. The Federal Emergency Management Agency (FEMA) maintains records on federal expenditures associated with declared major disasters. The United States Army Corps of Engineers (USACE) and the Natural Resources Conservation Service (NRCS) collect data on losses during the course of some of their ongoing projects and studies. Additionally, the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC) database collects and maintains data about natural hazards in summary format. The data includes occurrences, dates, injuries, deaths, and costs. It should be noted that many of these databases and other data collection services, including the NCDC, have inherent data limitations when searching for information at a scale as small as a single municipality. The best available data and records were used throughout this section.

According to the NCDC database, at least 10 weather-related hazard events have occurred in the city of Makoti since 1998, including the following number and types of hazard events:

- Hail – 8
- Tornado/Funnel Cloud – 2

In the absence of definitive data on some of the hazards that may occur in the city, illustrative examples are useful. Table 11.2.1-1 (below) provides information on the Presidential Disaster and Emergency Declarations that have included the city since 1957.

Table 11.2.1-1
Presidential Disaster Declarations – City of Makoti

Presidential Disaster and Emergency Declarations – 1957-2012	
Date and Disaster or EM Number	**Nature of Event**
May 2011 DR-1986	Severe Winter Storm
May 2011 DR-1981	Flooding
April 2011 EM-3318	Flooding
November 2005 DR-1616	Severe Winter Storm and Record and/or Near Record Snow
September 2005 EM-3247	Hurricane Katrina Evacuation
July 2005 DR-1597	Severe Storms, Flooding, and Ground Saturation
April 2004 EM-3196	Snow
June 1999 DR-1279	Severe Storms, Tornadoes, Snow and Ice, Flooding, Ground Saturation, Landslides, and Mudslides
April 1997 DR-1174	Severe Storms/Flooding
January 1997 DR-1157	Severe Winter Storms/Blizzard
April 1979 DR-581	Storms, Snowmelt, Flooding
July 1976 EM-3016	Drought
April 1976 DR-501	Flooding
May 1975 DR-469	Flooding from Rains, Snowmelt
May 1974 DR-434	Heavy Rains, Snowmelt, Flooding
June 1972 DR-335	Severe Storms, Flooding
June 1970 DR-287	Severe Storms, Flooding
April 1969 DR-256	Flooding

Potential Hazards to the City of Makoti

In the initial identification process, the Steering Committee considered potential hazards to identify those with the most chance to significantly affect the planning area. The hazards include those that have occurred in the past and may occur in the future. A variety of sources were used to develop the list of hazards considered by the Steering Committee. These included national, regional, and local sources such as emergency operations plans, the State of North Dakota Multi-Hazard Mitigation Plan, the 2008 Ward County Hazard Mitigation Plan, FEMA's *How-To Series,* websites, published documents, databases, and maps, as well as discussion among the Steering Committee members.

In the initial phase of the planning process, the Steering Committee considered 23 natural, manmade, and technological hazards and the risks they create for the city and its material assets, operations, and staff. The hazards initially considered, and the determination as to the treatment of those hazards, are shown in Table 11.2.1-2 (below).

Table 11.2.1-2
Preliminary Hazard Identification and Determinations – City of Makoti

Hazard	Included in SHMP (2011)	Included in Ward County HMP (2008)	Preliminary Hazards Identified by LEPC Members	Included in Ward County HMP Update (2012)	City of Makoti	Reason for Exclusion and other notes
Natural Hazards						
Avalanche						Not a hazard in the area
Communicable Disease (Including human animal and plant diseases)	✓			✓	X	NA
Drought	✓	✓		✓	X	
Extreme Heat	✓					Included under severe summer storms
Flood	✓	✓	✓	✓	X	
Geologic Hazards (including landslide, earthquake, and other geologic/mining hazards)	✓			✓		Include for county only
Rabid Animals			✓			Include under Communicable Diseases
Severe Winter Storm	✓	✓		✓	X	
Summer Storm (including tornadoes, hail, strong winds, lightning and extreme heat)	✓	✓	✓	✓	X	
Volcano	✓			✓		Low probability with sufficient advance warning
Structural Fire	✓	✓		✓		Changed from Urban to Structural Fire

Hazard	Included in SHMP (2011)	Included in Ward County HMP (2008)	Preliminary Hazards Identified by LEPC Members	Included in Ward County HMP Update (2012)	City of Makoti	Reason for Exclusion and other notes
Wildland/Rural Fire	✓	✓		✓	X	Combine structural and wildfire into a single profile
Intentional Hazards						
Civil Disorder/Terrorism		✓				Excluded due to duplication of planning efforts
Homeland Security Incident	✓					Excluded due to duplication of planning efforts
Mass Casualty		✓				Excluded as hazard, included under planning considerations
National Security Emergency		✓				Excluded due to duplication of planning efforts
Population Influx (including lack of housing infrastructure)			✓			Excluded as hazard, included under planning considerations
Technological Hazards						
Abandoned Buildings			✓			Excluded as hazard
Dam Failure	✓	✓				Include under Flood Hazard
Hazardous Material Incident (Fixed Site and Transport)	✓	✓	✓	✓	X	
Levee Failure	✓		✓			Include under Flood Hazard as applicable
Shortage of Critical Materials	✓	✓				Excluded as hazard, discuss under vulnerabilities
Transportation Accident (including vehicular, railway, and aircraft)	✓		✓			Excluded as hazard, discuss under vulnerabilities

The following pages profile the seven hazards identified above, and include a description of the hazard, the location of the hazard, the extent and severity of the hazard, the potential impact to

life and property that the hazard may have, past occurrences of the hazard, and the probability of future occurrences of the hazard.

Future Occurrence Probability Methodology
In order to determine the probability of future occurrences of each hazard profiled, the following scale was developed:

High – any hazard with the probability of occurring at least once per year
Moderate – any hazard with the probability of occurring at least once every five years
Low – any hazard with the probability of occurring less than every five years

The methodology is based on frequency of impact within a 5 year planning period, hence the 5 year break point between moderate and low.

11.2.2 Hazard Profiles

Note on the maps: the maps in this section provide estimates of municipal and county boundaries based on data available as of February and March 2013. In some cases, the boundaries depicted may not reflect recent annexations or other changes to corporate limits. However, these images reflect the best available data at the time of plan development. Future updates to this plan will reflect changes to municipal and county boundaries.

11.2.2.1 Communicable Disease

Description of the Hazard
Infectious pathologies are also called communicable diseases or transmissible diseases due to their potential of transmission from one person or species to another by a replicating agent (as opposed to a toxin). An infectious disease is a clinically evident illness resulting from the presence of pathogenic microbial agents, including pathogenic viruses, pathogenic bacteria, fungi, protozoa, multi-cellular parasites, and aberrant proteins known as prions. Transmission of an infectious disease may occur through one or more pathways including physical contact with infected individuals. These infecting agents may also be transmitted through liquids, food, body fluids, contaminated objects, airborne inhalation, or through vector-borne spread.

Transmissible diseases which occur through contact with an ill person or their secretions, or objects touched by them, are especially infective, and are sometimes referred to as contagious diseases. Infectious (communicable) diseases which usually require a more specialized route of infection, such as vector transmission, or blood or needle transmission, are usually not regarded as contagious.

The term infectivity describes the ability of an organism to enter, survive and multiply in the host, while the infectiousness of a disease indicates the comparative ease with which the disease is transmitted to other hosts. An infection however, is not synonymous with an infectious disease, as an infection may not cause important clinical symptoms or impair host function.

Examples of communicable or infectious diseases include plague, malaria, tuberculosis, rabies, hepatitis B, influenza, HIV, and measles.

Location of the Hazard

This hazard impacts people, rather than physical assets. Therefore, all populated areas of the city are at risk from the communicable disease hazard.

Extent and Severity of the Hazard

The Center for Disease Control and Prevention (CDC) categorizes various diseases in levels of biohazard. In this scale, Level 1 equates to a minimal risk, and Level 4 describes extreme risk. Table 11.2.2.1-1 (below) describes these levels, and provides examples of communicable diseases that would typically fall in to these classifications, and the typical protections that would be necessary to prevent transmission of the disease.

Table 11.2.2.1-1
Biohazard Classification Levels
(Source: Center for Disease Control and Prevention)

Level	Examples	Typical Protection to Prevent Transmission
Biohazard Level I (BSL-I)	*E. Coli* Canine Hepatitis Chicken Pox	Precautions are minimal, most likely involving gloves and some sort of facial protection. Usually, contaminated materials are left in open (but separately indicated) waste receptacles. Decontamination procedures for this level are similar in most respects to modern precautions against everyday viruses (i.e.: washing one's hands with anti-bacterial soap, washing all exposed surfaces of the lab with disinfectants, etc.).
Biohazard Level II (BSL-2)	Hepatitis A, B, C Lyme disease Salmonella Mumps Measles Scrapie Dengue Fever HIV	These bacteria and viruses cause mild disease in humans, or are difficult to contract via aerosol. Routine diagnostic work with clinical specimens can be done safely at BSL-2, using BSL- 2 practices and procedures.
Biohazard Level III (BSL-3)	Anthrax West Nile Virus SARS Virus Smallpox Tuberculosis Typhus Yellow Fever Malaria	These bacteria and viruses cause severe to fatal disease in human, but vaccines or other treatments do exist to combat them. Laboratory personnel have specific training in handling pathogenic and potentially lethal agents, and are supervised by competent scientists who are experienced in working with these agents. This is considered a neutral or warm zone.

Level	Examples	Typical Protection to Prevent Transmission
Biohazard Level IV (BSL-4)	H5N1 (Bird Flu) Dengue Hemorrhagic Fever Marburg Virus Ebola Virus Hantaviruses Lassa Fever Crimean-Congo Hemorrhagic Fever Other Hemorrhagic Diseases	These viruses and bacteria cause severe to fatal disease in humans, for which vaccines or other treatments are *not* available. When dealing with biological hazards at this level the use of a Hazmat suit and a self-contained oxygen supply is mandatory. The entrance and exit of a BSL-4 lab will contain multiple showers, a vacuum room, an ultraviolet light room, autonomous detection system, and other safety precautions designed to destroy all traces of the biohazard. Multiple airlocks are employed and are electronically secured to prevent both doors opening at the same time. All air and water service going to and coming from a BSL- 4 lab will undergo similar decontamination procedures to eliminate the possibility of an accidental release.

Potential Impact of the Hazard

Communicable disease outbreaks and pandemics will have the most immediate impact on life and health safety. The extent of the impact will be contingent on the type of infection or contagion, the severity of the outbreak, and the speed at which it is transmitted. Property and infrastructure could be affected if large portions of the population were affected and unable to perform maintenance and operations tasks. This would be particularly disruptive if those impacted were first responders or other essential personnel.

Past Occurrences of the Hazard

In general, North Dakota overall has been spared the devastating outbreaks of communicable disease that have impacted other areas. For example, the 1918 Spanish Flu pandemic killed an estimated 20-40 M people worldwide; 675,000 of those fatalities occurred in the US. In North Dakota, this same pandemic infected 6,000 people, and resulted in 2,700 fatalities – a significantly lower proportion of the population than other states.

Communicable diseases statistics are maintained by the state at the county level, and are not generally available at the municipal levels. The exception to this is when a geographically-specific outbreak occurs. Based on information obtained from the North Dakota Department of Health, all available data rests at the county level, and is not available for the municipal level. Therefore, this discussion will focus on occurrences in the county, and will reasonable assume that some of the occurrences could have or did occur in or otherwise impact the city of Makoti.

Influenza is an illness that is specifically tracked by the State Department of Health, and detailed records are maintained for this illness. The table following (Table 11.2.2.1-2) provides information regarding influenza in Ward County and the State of North Dakota since the 2007-2008 influenza season, including the 2012-2013 season as of April.

Table 11.2.2.1-2
Influenza Occurrences
(Source: North Dakota Department of Health)

Years	Cases (Statewide)	Cases (Ward County)	Percentage of ND Cases in Ward County
2007-2008	3,817	178	5%
2008-2009	1,755	115	7%
2009-2010	3,259	221	7%
2010-2011	2,089	125	6%
2011-2012	1,487	115	8%
2012-2013	4,757	307	7%

Another communicable disease that is tracked by the State Health Department is pertussis, also known as whooping cough. Table 11.2.2.1-3 (below) provides the details of pertussis outbreaks since 2007.

Table 11.2.2.1-3
Pertussis Occurrences
(Source: North Dakota Department of Health)

Years	Cases (Statewide)	Cases (Ward County)	Percentage of ND Cases in Ward County
2007	12	1	9%
2008	Unavailable	Unavailable	NA
2009	30	0	NA
2010	58	6	11%
2011	70	1	2%
2012	215	59	28%
2013 (as of April)	4	0	NA

As is evident in the table above, occurrences of pertussis have increased significantly in both North Dakota and in Ward County. This dramatic increase prompted the State Health Department to issue a Health Advisory in October 2012, which recommended that health care providers consider testing for pertussis for any patient that presented possible symptoms of the disease and also recommended immunizations be administered as recommended for children and infants.

Rabies is also a concern for the State Health Department, which specifically tracks reports of the illness by species infected. Table 11.2.2.1-4 (following) provides occurrence information for rabies.

Table 11.2.2.1-4
Rabies Occurrences
(Source: North Dakota Department of Health)

Years	Cases (Statewide)	Cases (Ward County)	Percentage of ND Cases in Ward County	Species Impacted
2007	30	1	4%	Horse
2008	34	3	9%	Cow, Dog
2009	16	0	NA	NA
2010	22	0	NA	NA
2011	23	0	NA	NA
2012	58	2	4%	Cow, Skunk

The city of Makoti did not report any incidents of the communicable disease hazard. While there is no available data to confirm that any of these occurrences either occurred in or otherwise impacted the city of Makoti, there is also no available data to determine that they did not. Because of the non-spatial nature of communicable disease, it is possible that any of these occurrences could have happened in Makoti, and that any communicable illness could occur in the city in the future.

Probability of a Future Occurrence of the Hazard
Based on the available data, there have been no occurrences of communicable disease within the city of Makoti. Therefore, using the scale provided earlier in this section, the probability of a future occurrence of this hazard is low, meaning that it is likely to occur less than once every five years.

11.2.2.2 Drought

Description of the Hazard
Drought is a normal part of virtually all climatic regions, including areas with high and low average rainfall. Drought is the consequence of anticipated natural precipitation reduction over an extended period of time, usually a season or more in length. Drought is one of the most complex of all natural hazards, as it is difficult to determine a precise beginning or end. In addition, drought can lead to or be exacerbated by other hazards, such as extreme heat or wildfires.

Droughts are a slow-onset hazard. Over time, however, they can result in damage to agriculture, municipal water supplied, recreation and wildlife. Prolonged droughts can produce significant economic impacts, both directly and indirectly.

Location of the Hazard
Drought is a hazard that is not restricted to particular areas or types of environments. All areas within the city of Makoti are subject to the drought hazard.

Extent and Severity of the Hazard

Droughts are classified as meteorological, hydrologic, agricultural and socioeconomic. The following bullets illustrate how the classifications of drought are defined:

- **Meteorological drought** is defined by a period of substantially diminished precipitation duration and/or intensity. The commonly used definition of meteorological drought is an interval of time, generally on the order of months or years, during which the actual moisture supply at a given place consistently falls below the climatically appropriate moisture supply.
- **Agricultural drought** occurs when there is inadequate soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought usually occurs after or during meteorological drought, but before hydrological drought and can affect livestock and other dry-land agricultural operations.
- **Hydrological drought** refers to deficiencies in surface and subsurface water supplies. It is measured as stream flow, snow pack, and as lake, reservoir, and groundwater levels. There is usually a delay between lack of rain or snow and less measurable water in streams, lakes, and reservoirs. Therefore, hydrological measurements tend to lag behind other drought indicators.
- **Socio-economic drought** occurs when physical water shortages start to affect the health, well-being, and quality of life of the people, or when the drought starts to affect the supply and demand of an economic product.

Droughts are measured using the Palmer Drought Severity Index (PDSI), also known as the Palmer Index. The Palmer Index was developed by Wayne Palmer in the 1960s and uses temperature and rainfall information in a formula to determine dryness. It has become the semi-official drought index.

The Palmer Index is most effective in determining long term drought—a matter of several months—and is not as good with short-term forecasts (a matter of weeks). It uses a 0 as normal, and drought is shown in terms of minus numbers; for example, -2 is moderate drought, -3 is severe drought, and -4 is extreme drought. The Palmer Index is also useful for reflecting excess rain using a corresponding level reflected by plus figures; i.e., 0 is normal, +2 is moderate rainfall, etc.

The advantage of the Palmer Index is that it is standardized to local climate, so it can be applied to any part of the country to demonstrate relative drought or rainfall conditions. The negative is that it is not as good for short term forecasts, and is not particularly useful in calculating supplies of water locked up in snow, so it works best east of the Continental Divide. Despite these shortcomings, it remains a useful tool for easily explaining the severity of a drought.

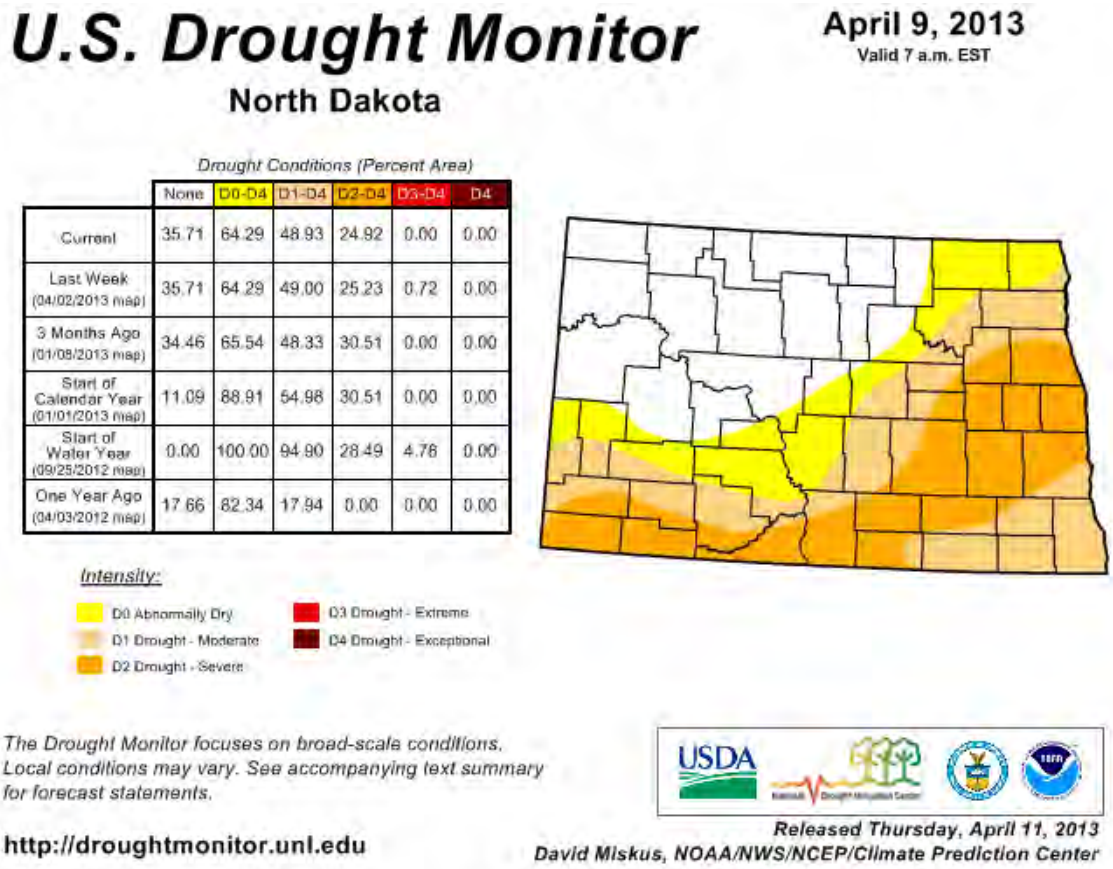
Table 11.2.2.2-1 (following) provides the PDSI classifications.

Table 11.2.2.2-1
Palmer Drought Severity Index
(Source: http://drought.unl.edu/whatis/indices.htm)

Classification	Description	Range of Possible Impacts
4.00 or more	Extremely wet	
3.00 to 3.99	Very wet	
2.00 to 2.99	Moderately wet	
1.00 to 1.99	Slightly wet	
0.50 to 0.99	Incipient wet spell	
0.49 to -0.49	Near normal	
-0.50 to -0.99	Incipient dry spell	
-1.00 to -1.99	Mild drought	Going into drought: short-term dryness slowing planting, growth of crops or pastures; fire risk above average Coming out of drought: some lingering water deficits; pastures or crops not fully recovered
-2.00 to -2.99	Moderate drought	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested
-3.00 to -3.99	Severe drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed
-4.00 to -4.99	Extreme drought	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions
-5.0 or less	Exceptional drought	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies

Drought is monitored nation-wide by the National Drought Mitigation Center (NDMC). Indicators are used to describe broad scale drought conditions across the country. Indicators correspond to the intensity of the drought. Portions of North Dakota are currently classified as abnormally dry, in moderate drought, or in severe drought; however, Ward County and the city of Makoti are not included in any of these classifications, and are not considered to be experiencing drought conditions at this time. This current status is demonstrated by Figure 11.2.2.2-1 (following).

Figure 11.2.2.2-1
US Drought Monitor – North Dakota
(source: http://droughtmonitor.unl.edu/DM_state.htm?ND,HP)



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	35.71	64.29	48.93	24.92	0.00	0.00
Last Week (04/02/2013 map)	35.71	64.29	49.00	25.23	0.72	0.00
3 Months Ago (01/08/2013 map)	34.46	65.54	48.33	30.51	0.00	0.00
Start of Calendar Year (01/01/2013 map)	11.09	88.91	54.98	30.51	0.00	0.00
Start of Water Year (09/25/2012 map)	0.00	100.00	94.90	28.49	4.76	0.00
One Year Ago (04/03/2012 map)	17.66	82.34	17.94	0.00	0.00	0.00

Potential Impact of the Hazard

As illustrated by Figure 11.2.2.2-1 (above), droughts can affect a large geographic area, and can range in size from a few counties to a few states. Their potential to impact wildlife and agricultural concerns can be enormous. Droughts can kill crops, edible plants and wildlife habitat, and destroy grazing lands and trees. Dead or dying vegetation, a normal result of drought, can then serve as a prime ignition source for wildfires or grass fires.

The impacts of drought directly impact both economic and social stability in the affected area. Impacts do not generally include direct structural damages, but rather focus on the impacts to living things.

Perhaps the best known example of the impacts on life and property from drought is the Dust Bowl. The phenomenon was caused by severe drought coupled with decades of poor farming and land management practices. Deep plowing of the virgin topsoil of the Great Plains killed the natural grasses that normally kept the soil in place and trapped moisture even during periods of drought

and high winds. This led to widespread crop failure throughout the Great Plains, including throughout North Dakota.

During the Dust Bowl period, impressive drought-related research was carried out by the USDA, State Agricultural Experiment Station Systems, and agricultural colleges and universities. Notable accomplishments were technologies for soil erosion control, soil moisture conservation, higher yielding grain varieties, improved fertilizers, and better farm management.

When drought struck again in the early 1950's, the impact was much less severe. The widespread financial distress, interstate migration, and regional disruption characteristic of the Dust Bowl era were largely absent. Although comparable in meteorological severity (even if not spatially uniform) the impact was moderated by the trends in adjustment, as well as by improved farm prices and a healthy economy. Again, attention was directed to drought adjustment and research. Strong emphasis was placed on water conservation and augmentation, weather modification research, weather prediction and control, groundwater recharge, irrigation and river basin development, increasing runoff, evaporation control, desalination, phreatophyte control, and irrigation canal lining.

The worst drought since the Dust Bowl years affected at least 35 states – including North Dakota - during the summer of 1988 and into 1989. In some areas the lack of rainfall dated back to 1984. In 1988, rainfall totals over the Midwest, Northern Plains, and the Rockies were 50-85% below normal. Crops and livestock died and some areas became desert. To make matters worse, this event was accompanied by heat waves, which were estimated to kill 4,800-17,000 people, nationwide.

North Dakotans – including those in the city of Makoti – are familiar with the impacts of drought. Given the areas dependence on agriculture, a significant drought in the modern era could have equally devastating consequences. Widespread crop failure, livestock death, inadequate drinking water, illness or diseases from inadequate sanitation – all of these are potential impacts from a widespread or prolonged drought.

A number of secondary hazards are often associated with drought. Rural grassland fires increase because of dry vegetation. Reduction in vegetation cover will expose the soil to wind, and dust storms and soil erosion will occur. Because of reduction in flow, the chemical quality of river and lake water will change, and the sediment transport regimes of streams will be altered.

Deterioration in water quality, in turn, results in injury and death to plants and animals. Stagnant pools along river courses will provide favorable habitats for insects, particularly mosquitoes and grasshoppers. Finally, with the return of the rains, the dry and unstable topsoil is vulnerable to gullying and flooding.

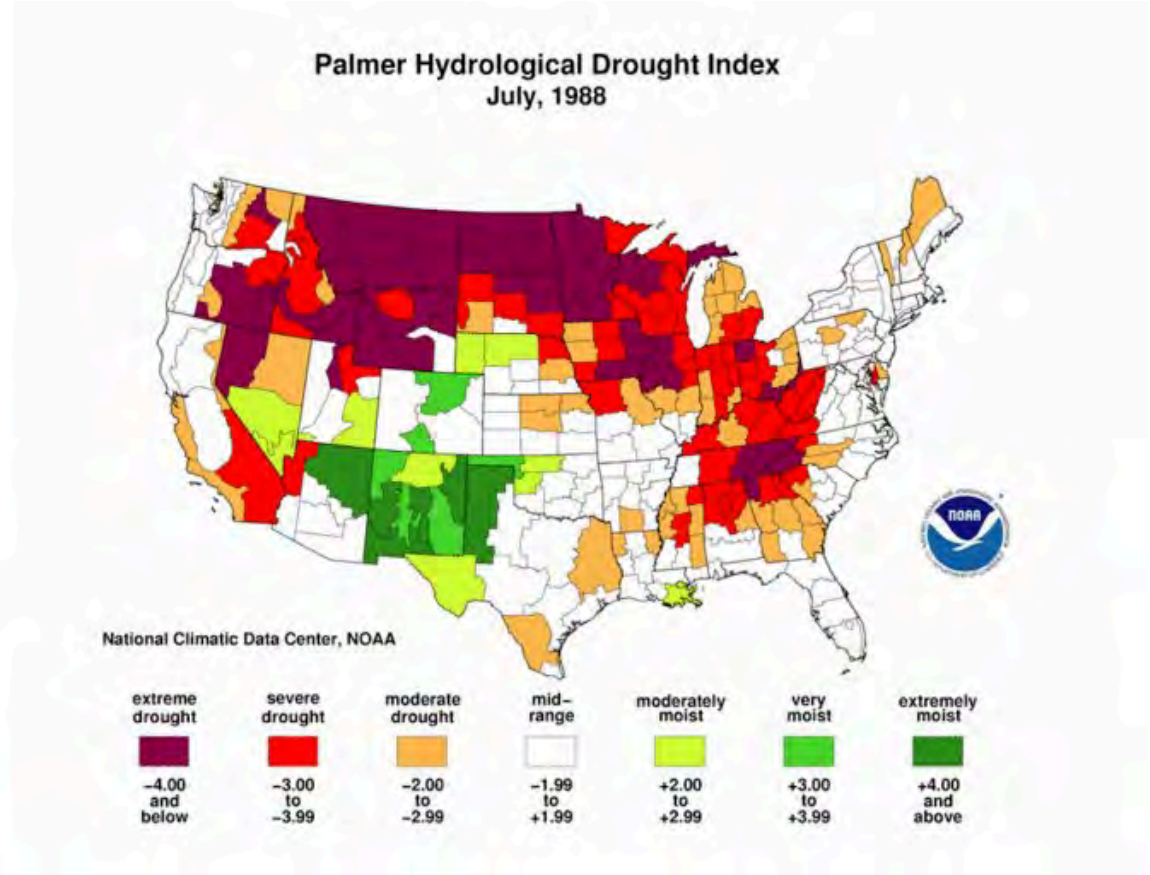
Past Occurrences of the Hazard

Information obtained from the State Hazard Mitigation Plan (SHMP) indicates that Ward County has a documented history of drought. For the purposes of this Plan, the assumption is made that all jurisdictions within Ward County would have experienced the hazard, including the city of Makoti. According to the SHMP, 58-75 impacts from drought were recorded for Ward County for the period of July 1990 through June 2010. Most of these impacts were collected from newspaper articles.

The following are some notable occurrences of drought in the vicinity of the planning area. This list is not exhaustive, and includes only those occurrences that were notable.

- 1930s: The decade began with dry years in 1930 and 1931. By 1934, extremely dry conditions were recorded over 80% of the US, including most of North Dakota. By the end of the decade, the Great Plains were in extreme drought conditions. As rain continued to elude the area, crops and livestock failed. Exposed topsoil blew away in heat-driven winds, creating dust storms. According to the State Historical Society, thousands of North Dakotans lost their farms, and moved either to cities or towns, while others left the state altogether. One historian cited by the Society estimates that 70% of the state's population required one form of public assistance or another, but also notes that most North Dakotans held on, husbanding their resources wherever they could.
- 1950s: This drought, lasting most of the decade, was one of the most severe to impact the Great Plains. A pattern of low precipitation began in 1952 and continued until 1957. According to the USGS, this drought was intensified by the diversion of moisture-laden air masses away from drought-stricken areas by the formation of stronger-than-normal high pressure cells. Ground water throughout the Great Plains declined; in some areas, this decline was measured in tens of feet. Compared to other Great Plains states, North Dakota fared reasonably well during this drought, though significant hardships did occur. The USGS estimated that in 1955, approximately 614,000 acres throughout the State were damaged by wind, resulting in significant erosion. During this period, precipitation ranged from 50% to 75% of normal throughout North Dakota.
- 1988-1992: According to a report published by the ND State Water Commission, the drought of 1988-1992 was the second most severe drought to occur in North Dakota since 1930. Streams throughout the state had record low flows, and groundwater levels were impacted. These impacts included Rice Lake, which was strongly impacted by the drought. As depicted in Figure 11.2.2.2-2 (following), the entire state – including the city of Makoti – was categorized as being in extreme drought during this time.

Figure 11.2.2.2-2
Palmer Hydrological Drought Index – July 1988
(source: http://localtvwqad.files.wordpress.com/2012/07/july1988drought.jpg)



- 2006: The meteorological summer of June, July, and August 2006 turned out to be the 3rd warmest and 14th driest in state history. Then-Governor John Hoeven issued a statewide agricultural drought emergency declaration in response to drought conditions that continued to deteriorate in southwest and south central portions of North Dakota. Drought declarations were issued in Grant, Hettinger, McIntosh, Sioux and Emmons County. According to the U.S. Drought Monitor, Ward County was in the moderate to severe intensity for the 2006 drought. No deaths or injuries were reported.
- 2012: The 2012 growing season in North Dakota was the 8th warmest and 13th driest on record. By August of 2012, 87% of North Dakota was experiencing drought conditions. Twenty counties were classified as being in severe drought. Pasture and range conditions were declining across the state. This prompted Governor Jack Dalrymple to declare an agricultural emergency in North Dakota; Ward County and its municipalities (including Makoti) were included in this declaration.

Probability of a Future Occurrence of the Hazard
Based on the available data, drought occurs in the planning area less than once per year. Using the scale provided earlier in this section, this equates to a moderate probability of a future occurrence, as the hazard occurs at least one time every 5 years in more recent history.

11.2.2.3 Fire

This profile includes both structure fire and wildfire.

Description of the Hazard
Fire is the rapid oxidation of a material in the chemical process of combustion, releasing heat, light, and various reaction products. Slower oxidative processes like rusting or digestion are not included by this definition. The flame is the visible portion of the fire and consists of glowing hot gases. If hot enough, the gases may become ionized to produce plasma. Depending on the substances alight, and any impurities outside, the color of the flame and the fire's intensity might vary.

Fire in its most common form can result in conflagration, which has the potential to cause physical damage through burning. Fire is an important process that affects ecological systems across the globe. The positive effects of fire include stimulating growth and maintaining various ecological systems. Fire has been used by humans for cooking, generating heat, signaling, and propulsion purposes. The negative effects of fire include decreased water purity, increased soil erosion, an increase in atmospheric pollutants and an increased hazard to human life.

Wildfires, also known as a wild land fire, are any fire that occurs on grassland, forest or prairie, regardless of ignition source, damages or benefits. Wildfires are usually a naturally-occurring phenomenon, though they can be caused by human action – namely arson. A wildfire differs from other fires by its extensive size, the speed at which it can spread out from its original source, its potential to change direction unexpectedly, and its ability to jump gaps such as roads, rivers and fire breaks. Wildfires are characterized in terms of the cause of ignition, their physical properties such as speed of propagation, the combustible material present, and the effect of weather on the fire.

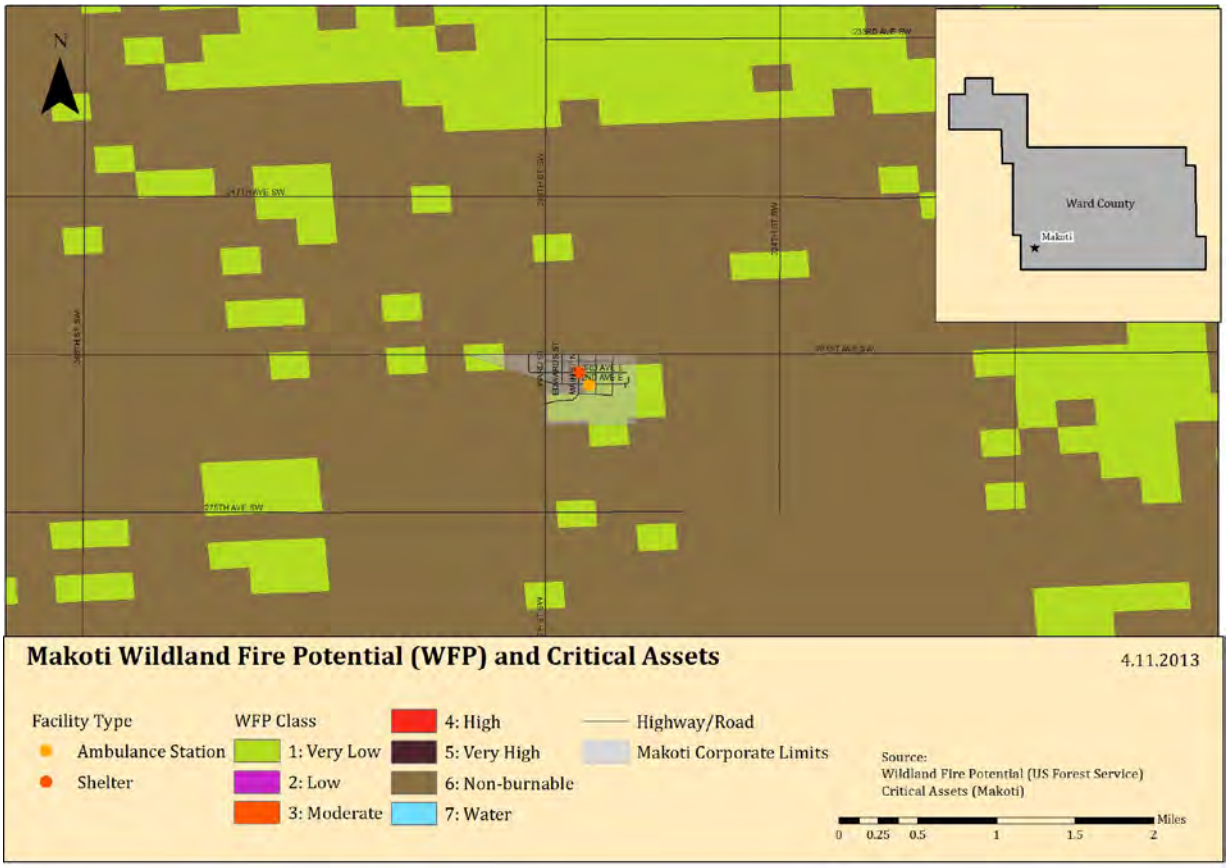
Structures fires are considered a man-made hazard, in that their origins often arise from human activity and be fueled by dense development. (For the purposes of this hazard profile, structures fires are assumed to be accidental and their consequences unintended.)

Location of the Hazard
While fire is a hazard that can occur anywhere, some areas are more prone to fire than others. Structure fires can and do occur anywhere that a structure exists. Wildfires can occur anywhere that burnable vegetation exists.

The US Forest Service has a new product available, called the Wildland Fire Potential assessment. This product provides an overview assessment of the areas within a defined area that have the potential to experience wildland fire. Figure 11.2.2.3-1 (following) illustrates the wildland fire potential for the city of Makoti, as defined by the US Forest Service.

Note that the areas designated as "non-burnable" in the figure below are predominantly either developed or agricultural land, and that they are subject to other types of fire. By definition of the US Forest Service, however, they are outside of the wildland fire potential area.

Figure 11.2.2.3-1
City of Makoti – Wildland Fire Potential Areas
(Source: US Forest Service)



Extent and Severity of the Hazard

The National Fire Danger Rating System (NFDRS) is a set of computer programs and algorithms that allow land management agencies to estimate fire danger for a given rating area. NFDRS characterizes fire danger by evaluating the approximate upper limit of fire behavior in a fire danger rating area during a 24-hour period. Calculations of fire behavior are based on fuels, topography and weather. NFDRS output give relative ratings of the potential growth and behavior of any wildfire. Fire danger ratings are guides for initiating presuppression activities and selecting the appropriate level of initial response to a reported wildfire in lieu of detailed, site- and time-specific information.

Table 11.2.2.3-1 (following) depicts the NFDRS, from the US Forest Service's Wildland Fire Assessment System

Table 11.2.2.3-1
Fire Danger Rating System
(Source: US Forest Service)

Rating	Basic Description	Detailed Description
CLASS 1: Low Danger (L) COLOR CODE: **Green**	Fires not easily started	Fuels do not ignite readily from small firebrands. Fires in open or cured grassland may burn freely a few hours after rain, but wood fires spread slowly by creeping or smoldering and burn in irregular fingers. There is little danger of spotting.
CLASS 2: Moderate Danger (M) COLOR CODE: **Blue**	Fires start easily and spread at a moderate rate	Fires can start from most accidental causes. Fires in open cured grassland will burn briskly and spread rapidly on windy days. Woods fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel – especially draped fuel -- may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and control is relatively easy.
CLASS 3: High Danger (H) COLOR CODE: **Yellow**	Fires start easily and spread at a rapid rate	All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High intensity burning may develop on slopes or in concentrations of fine fuel. Fires may become serious and their control difficult, unless they are hit hard and fast while small.
CLASS 4: Very High Danger (VH) COLOR CODE: **Orange**	Fires start very easily and spread at a very fast rate	Fires start easily from all causes and immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high-intensity characteristics - such as long-distance spotting - and fire whirlwinds, when they burn into heavier fuels. Direct attack at the head of such fires is rarely possible after they have been burning more than a few minutes.
CLASS 5: Extreme (E) COLOR CODE: **Red**	Fire situation is explosive and can result in extensive property damage	Fires under extreme conditions start quickly, spread furiously and burn intensely. All fires are potentially serious. Development into high-intensity burning will usually be faster and occur from smaller fires than in the Very High Danger class (4). Direct attack is rarely possible and may be dangerous, except immediately after ignition. Fires that develop headway in heavy slash or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions, the only effective and safe control action is on the flanks, until the weather changes or the fuel supply lessens.

Wildfire is a hazard with a somewhat unpredictable nature. While it is at least somewhat possible to determine the areas that may be subject to experiencing wildfire, it is not possible to determine in advance how or where a wildfire will begin. Only the conditions for a wildfire can be predicted with any accuracy.

Structure fires are often described in terms of the number of "alarms" required to suppress it. The number of alarms indicates the level of response from the fire department required to extinguish the fire. The level of response is typically measured in terms of the number of firefighters and equipment called to a scene.

Potential Impact of the Hazard

Though often a naturally occurring phenomenon, wildfires can devastate wooded or grassland areas by burning the natural resources of the area and disrupting habitat. In addition to the

destruction of valuable forestland and the impacts on the economy through the loss of this important natural resource, wildfires seriously threaten countless rural structures and equipment on a daily basis. Millions of dollars' worth of property and crops can be severely threatened by wildfire, but damage can be minimized by timely and effective wildfire suppression.

Structure fires have the potential for similar impacts in more developed areas, where there are more structures and more people in closer proximity. If not suppressed in time, fires can spread from one structure to another, endangering a large number of people. In addition, some structures (such as grain elevators) require specialized teams and equipment, and so response to these events may be delayed.

The increasing cost of natural gas and fuel oil has caused families to utilize alternate heating methods during colder months. As a result, the use of space heaters, fireplaces, and wood burning stoves has increased the structure fire hazard. Portable LP (propane) gas or kerosene heaters with self-contained fuel supplies can be hazardous appliances, even when used according to the manufacturer's instructions, as their open flame design is a potential fire hazard. Fuel leaks can result in explosions, and vapors are a source of indoor air pollution, which is unhealthy for residents of the structure. Wood burning stoves can also be a point of ignition, if the stove or chimney is incorrectly installed or maintained.

Past Occurrences of the Hazard
Note: Makoti's Fire Department works in conjunction with the city of Ryder, and all statistics are combined for both cities. Therefore, the statistics below assume that 50% of the reported fires occurred in each city.

Based on data obtained from the National Reporting System and from the Makoti/Ryder Fire Department, the city of Makoti has experienced 3.5 structure fires from January 2008 through December 2012, an average of .70 structure fires per year. For this same time period, 23 wildland fires were responded to, an average of 4.6 per year.

Probability of a Future Occurrence of the Hazard
Based on the available data, fire occurs in the city of Makoti annually. Using the scale provided earlier in this section, this equates to a high probability of a future occurrence.

11.2.2.4 Flood

Description of the Hazard
Floods are naturally occurring events. Excess water from snowmelt, rainfall, or dam release (controlled or uncontrolled) accumulates and either overflows onto banks or backs up into adjacent floodplains.

The National Flood Insurance Program (NFIP) defines flood in the following way:

> *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 from overflow of inland or tidal waters, from unusual and rapid accumulation or runoff of surface waters from any source, or from mudflow.*

This hazard profile considers flooding from all relevant sources. The Steering Committee determined that all sources of flooding should be treated in the same profile, as the effect on the area was generally the same, regardless of the source of origin of the flood. Flooding sources considered include:

- Snowmelt;
- Dam failure; and
- Excessive rain events.

Regional Hydrology Discussion

In order to understand the flood hazard, it is important to understand the larger hydrology of the region.

Much of North Dakota's terrain was shaped by glacial activity. The path of the Missouri River parallels the approximate limit of continental glaciers. Glaciers scoured much of the northeastern two-thirds of the state and then buried it under glacial debris, leaving a band of rich, black soil behind. The southwestern third of the state was largely unaffected by glaciers and has a more rugged, bedrock-controlled topography.

Ward County straddles the transition between the glacial flattened terrain and the relatively rougher terrain of the Missouri escarpment. It is important to note that rivers north of the Missouri escarpment (the Souris, the Des Lacs, and the Sheyenne) flow northward to Canada via the Nelson River to Hudson Bay. The Missouri River drains southward into the Mississippi River and eventually to the Gulf of Mexico.

The Souris (or Mouse) River originates in the Yellow Grasslands Marshes north of Weyburn, Saskatchewan, Canada and flows southeast, crossing into North Dakota, passing through Ward County and then looping back north into Canada to eventually flow into the Assiniboine River near Brandon, Manitoba.

The Des Lacs River flows south through Ward County to converge with the Souris River at a point six miles northwest of the City of Minot.

The Souris River originates in southeastern Saskatchewan and flows southeasterly to enter North Dakota near the northwestern corner of Renville County. From this point, it continues to flow in a southeasterly direction through the city of Minot in Ward County to Velva in McHenry County where its course changes to the northeast until it re-enters Canada west of the Turtle Mountains in north-central Bottineau County. The Souris River drains portions of Saskatchewan, Montana, North

Dakota, and Manitoba. In North Dakota, the area drained by the Souris is 9,112 mi^2. Stream length in the state is 357 river miles.

In North Dakota above Minot, the Souris River Valley is comparatively straight with a fairly constant width of about one-half mile. Throughout this 64-mile reach of the river, valley walls rise sharply 100 feet or more to broad, comparatively level benches. Between Minot and Verendrye, the valley displays the same general characteristics; however, it is wider in places and has benches which are somewhat lower and more broken. Below Verendrye, the north-side bench diminishes to low ridge and the lands toward Bantry and Upham tend to merge with the valley. The channel of the Souris River follows a meandering course, averaging slightly less than 100 feet wide and 15 to 25 feet deep, and meanders such that the total length of the channel is approximately twice the length of the valley through which it flows.

Principle tributaries above Minot are the Des Lacs River, which enters the Souris River approximately seven miles north of Minot near Burlington; Moose Creek, which receives runoff from the Moose Mountains in Canada; and Long Creek. Of these three streams, only the Des Lacs River, which rises just north of the US-Canada boundary, enters the Souris River in North Dakota.

Other important tributaries outside the Souris River "Loop" include the Wintering River, which flows through southern McHenry County, and Willow Creek, which arises in the Turtle Mountains and flows in a southwesterly direction to its confluence with the Souris River about eight miles east of Upham. The interior of the Souris River "Loop" is drained principally by a single stream system, the Deep River. Principal tributaries of the Deep River are Cut Bank Creek (north), Little Deep Creek, and Cut Bank Creek (south).

Location of the Hazard

There are no identified or mapped floodplains within the city of Makoti.

Extent and Severity of the Hazard

In support of the NFIP, FEMA identifies those areas that are more vulnerable to flooding by producing Flood Hazard Boundary Maps (FHBM), Flood Insurance Rate Maps (FIRM), and Flood Boundary and Floodway Maps (FBFM). Several areas of flood hazards are commonly identified on these maps. One of the areas identified in the Special Flood Hazard Area (SFHA), which is a high-risk area defined as any land that would be inundated by a flood having a 1% chance of occurring in any given year (also known as the base flood). The flood zone designations are defined and described in Table 11.2.2.4-1 (following).

Table 11.2.2.4-1
Flood Zone Designations and Descriptions
(Source: FEMA and NFIP)

Zone Designation	Percent Annual Chance of Flood	Description
Zone V	1%	Areas along coasts subject to inundation by the 1% annual chance of flooding with additional hazards associated with storm-induced waves. Because hydraulic analyses have not been performed, no BFEs or flood depths are shown.
Zones VE and V1-30	1%	Areas along coasts subject to inundation by the 1% annual chance of flooding with additional hazards associated with storm-induced waves. BFEs derived from detailed hydraulic analyses are shown within these zones. (Zone VE is used on new and revised maps in place on Zones V1-30.)
Zone A	1%	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas, no depths or base flood elevations are shown within these areas.
Zone AE	1%	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. In most instances, base flood elevations derived from detailed analyses are shown at selected intervals within these zones.
Zone AH	1%	Areas with a 1% annual chance of flooding where shallow flooding (usually areas of ponding) can occur with average depths between one and three feet.
Zone AO	1%	Areas with a 1% annual chance of flooding, where shallow flooding average depths are between one and three feet.
Zone X (shaded)	0.2%	Represents areas between the limits of the 1% annual chance flooding and 0.2% chance flooding.
Zone X (unshaded)	Undetermined	Areas outside of the 1% annual chance floodplain and 0.2% annual chance floodplain, areas of 1% annual chance sheet flow flooding where average depths are less than one (1) foot, areas of 1% annual chance stream flooding where the contributing drainage area is less than one (1) square mile, or areas protected from the 1% annual chance flood by levees. No Base Flood Elevation or depths are shown within this zone.

In addition, the National Weather Service (NWS) issues official watches and warnings, to alert those that may be at risk from potential flooding. Table 11.2.2.4-2 (below) defines the terms used by the NWS in these watches and warnings.

Table 11.2.2.4-2
Flood Watch/Warning Terminology
(Source: The National Weather Service)

Term	Definition
Flood Potential Outlook	In hydrologic terms, a NWS outlook that is issued to alert the public of potentially heavy rainfall that could send area rivers and streams into flood or aggravate an existing flood
Flood Watch	Issued to inform the public and cooperating agencies that current and developing hydrometeorological conditions are such that there is a threat of flooding, but the occurrence is neither certain nor imminent.

Term	Definition
Flood Warning	In hydrologic terms, a release by the NWS to inform the public of flooding along larger streams in which there is a serious threat to life or property. A flood warning will usually contain river stage (level) forecasts.
Flood Statement	In hydrologic terms, a statement issued by the NWS to inform the public of flooding along major streams in which there is not a serious threat to life or property. It may also follow a flood warning to give later information.
Flash Flood Watch	Issued to indicate current or developing hydrologic conditions that are favorable for flash flooding in and close to the watch area, but the occurrence is neither certain or imminent.
Flash Flood Warning	Issued to inform the public, emergency management and other cooperating agencies that flash flooding is in progress, imminent, or highly likely.
Flash Flood Guidance	Forecast guidance produced by the River Forecast Centers, often model output, specific to the potential for flash flooding (e.g., how much rainfall over a given area will be required to produce flash flooding).
Flash Flood Statement	In hydrologic terms, a statement by the NWS which provides follow-up information on flash flood watches and warnings.

Ward County has a series of naturally occurring coulees that channel water towards the Souris and Des Lacs Rivers. Flows of water through these coulees have measured three feet or more during localized heavy rain (6-9 inches in 3 hours). This type of flooding has washed out roads, breached culverts and damaged bridges. Adding to these phenomena, as the water flows down through the coulees it picks up a great deal of debris and deposits it into the river, compounding the flood hazard.

Flood Control and the National Flood Insurance Program

North Dakota has long recognized that good floodplain management involves the utilization of a variety of tools to reduce the impact of flood disasters. It is also recognized that a balance must be reached between the four aspects of floodplain management which are: structural works designed to modify the flood itself, regulatory functions which may reduce susceptibility to flooding, emergency preparedness actions which may reduce susceptibility to flooding, and emergency preparedness actions which minimize a flood's effects during a flood event.

Flood control development had its beginning with the Flood Control Act of 1936. This act provided a basic plan and an authorized program for the control of water resources. In the early 1940's, the North Dakota State Water Commission cooperated with the federal agencies to plan and engineer the overall program for North Dakota.

The US Army Corps of Engineers occupies one of the major roles in flood control planning and construction. Two reservoirs built by the US Soil Conservation Service have contributed materially to flood control by the construction of watershed projects in North Dakota. These watershed projects include channel work and flood retention structures. In such projects, the Soil Conservation District has the responsibility for ensuring that 50% of the farms above a structure are under a basic conservation plan.

The Federal Disaster Protection Act of 1973 requires state and local governments to participate in the National Flood Insurance Program (NFIP) as a condition to the receipt of any federal loan or grant for construction projects in identified and mapped flood prone areas.

Participation in the NFIP requires communities to adopt floodplain regulations that meet NFIP objectives, which are: New buildings must be protected from flooding damages that occur as a result of the 1% annual chance flood, and new development must not cause an increase in flood damages to other property.

Communities have been provided assistance through passage, in 1981, of the state's first Floodplain Management Act which directed the State Engineer to aid local governments to reduce flood damages through sound floodplain management. As a start, the state legislature provided the State Engineer with an appropriation to be used in assisting communities to obtain base flood (1% annual chance flood) elevation data.

Makoti has no mapped or identified floodplains, and is not a member of the NFIP, nor are they sanctioned by the NFIP. There are no designated Repetitive Loss or Severe Repetitive Loss properties within the city of Makoti.

Potential Impact of the Hazard

Any flood event could have significant impacts in the city. Moving water exerts hydrodynamic pressure on such structures, whereas still water exerts hydrostatic pressure. Both hydrostatic and hydrodynamic forces can cause serious damage, including complete destruction, of non-mitigated structures. Utility systems, such as HVAC systems, water and sewer lines, and electrical systems, can be compromised, damaged or destroyed by flood waters, even if not completely inundated.

In addition, flooding could impact transportation routes in and around the city, and could result in delays in receiving supplies and in decreased ingress and egress.

Past Occurrences of the Hazard

Both the Souris River and the Des Lacs River, a major tributary, overflow their banks to some extent almost annually. Most of these floods are small and short in duration causing only minor problems. Floods which result in more severe damages originate primarily from snowmelt in the Canadian portion of the Souris River Basin and have occurred seven times since 1969.

The one-half to one-mile wide valley along the river reach, between the upper Souris and J. Clark Salyer National Wildlife Refuge, usually sustains the basin's most significant flood losses.

Since 1936, Lake Darling Reservoir, owned and operated by the US Fish and Wildlife Service, has been a major factor in reducing damages in the Souris River Valley by controlling several small floods. The protection provided by the reservoir reduced concern about flooding and numerous residential and commercial developments were constructed at Minot in the river's floodplain. A

major flood occurred in the Souris River Basin in 1969, which greatly impacted the region (though not specifically the city of Makoti). More recently, in 2011, the basin was again inundated with severe flooding, resulting in hundreds of millions of dollars in damages throughout the valley.

The city of Makoti reported no occurrences of flooding within the city.

Probability of a Future Occurrence of the Hazard
Based on the available data, flooding occurs at less than once every five years in the city of Makoti. Therefore, using the scale provided earlier in this section, the probability of a future occurrence of flooding is low.

11.2.2.5 Severe Summer Storms

This hazard profile includes the following elements of severe summer storms: extreme heat, hail, lightning, tornadoes, and thunderstorms.

Description of the Hazard
Severe summer storms occur throughout the country, and can be seriously damages in areas where they occur. Severe summer storms can encompass a variety of hazards, including:

Extreme Heat
Extreme heat is defined as summertime weather that is substantially hotter and/or more humid than average for a location at that time of year. Extreme heat conditions can increase the incidence of mortality and morbidity in affected populations.

Hail
Hail is defined as falling ice, roughly round in shape and at least 0.2' in diameter. Hail develops in the upper atmosphere as ice crystals that are bounced about by high velocity updraft winds; the ice crystals accumulate frozen droplets and fall after developing enough weight. The size of hailstones varies and is a direct consequence of the severity and size of the storm that produces them – the higher the temperatures at the Earth's surface, the greater the strength of the updrafts and the amount of time hailstones are suspended, the greater the size of the hailstone.

Lightning
Lightning is an atmospheric discharge of electricity accompanied by thunder, which typically occurs during thunderstorms, and sometimes during volcanic eruptions or dust storms. In the atmospheric electrical discharge, a leader of a bolt of lightning can travel at speeds of 130,000 MPH, and can reach temperatures approaching 54,000°F, hot enough to fuse silica sand into glass. There are some 16 M lightning storms in the world every year.

Lightning rapidly heats the air in its immediate vicinity to about 36,000°F - about three times the temperature of the surface of the sun. This compresses the surrounding air and creates a supersonic shock wave, which decays to an acoustic wave that is heard as thunder.

Some lightning strikes exhibit particular characteristics; scientists and the general public have given names to these various types of lightning. The lightning that is most-commonly observed is streak lightning. This is nothing more than the return stroke, the visible part of the lightning stroke. The majority of lightning occurs inside a cloud and is not observed during a thunderstorm.

Tornadoes

The most destructive of all atmospheric phenomena, tornadoes are violently rotating columns of air. These columns extend between and in contact with a cloud and the Earth's surface. The most violent tornadoes have rotational wind speeds of 250 MPH; in extreme cases, rotational wind speeds may approach 300 MPH. Tornadoes are often produced by severe thunderstorms.

Thunderstorms

Thunderstorms are caused by an atmospheric imbalance from warm unstable air rising rapidly into the atmosphere. Strong winds, rain, and hail can accompany large thunderstorm systems. 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 channel of a lightning strike can reach temperatures higher than 50,000°F. The National Weather Service defines a severe thunderstorm as a thunderstorm that produces ¾ inch hail or larger in diameter and/or produces winds that equal or exceed 58 MPH

Thunderstorms are a unique threat because of their complex nature. Multiple hazards are present within a single system.

Location of the Hazard

Severe summer storms are a non-spatial hazard, and can occur anywhere in the city of Makoti.

Extent and Severity of the Hazard

Severe summer storms have a wide range of extent and severity markers and characteristics.

Extreme Heat

The National Weather Service (NWS) issues a range of watches and warnings associated with extreme heat, as illustrated below:

- **Excessive Heat Outlook**: when the potential exists for an excessive heat event in the next 3 to 7 days. An outlook is used to indicate that a heat event may develop. It is intended to provide information to those who need considerable lead time to prepare for the event, such as public utilities, emergency management and public health officials.

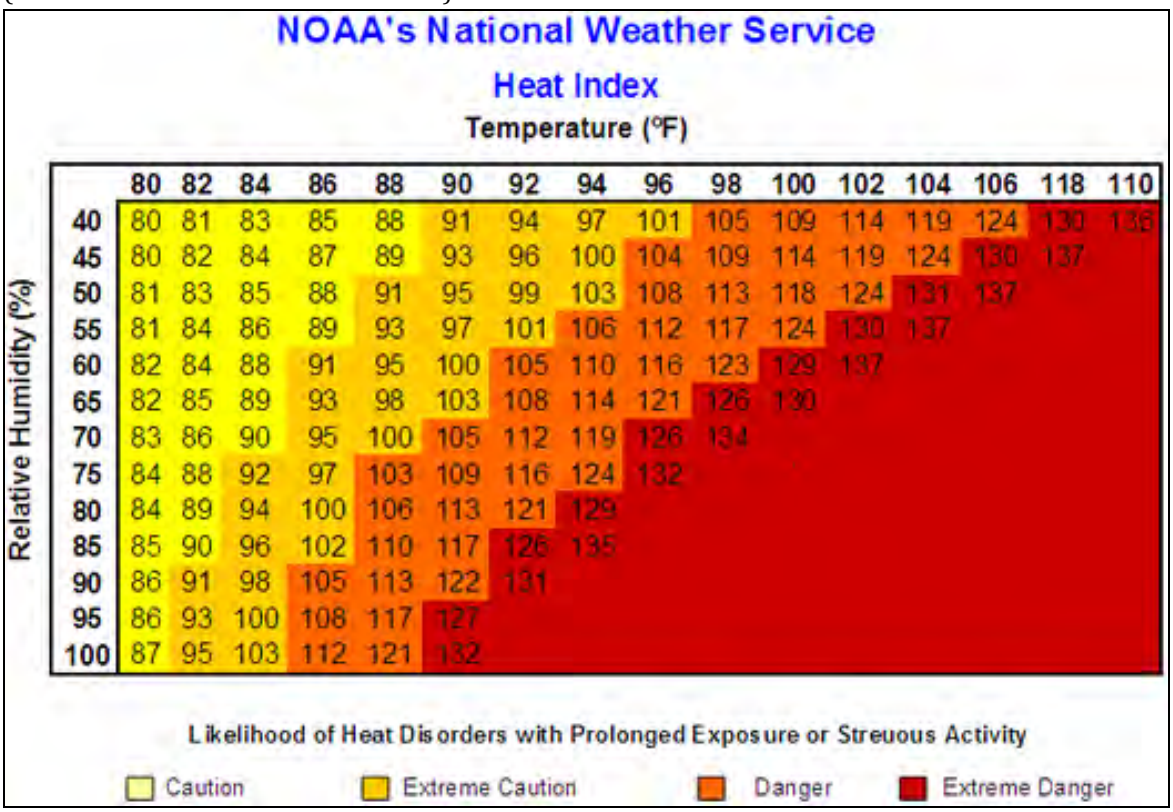
- **Excessive Heat Watch**: when conditions are favorable for an excessive heat event in the next 12 to 48 hours. A watch is used when the risk of a heat wave has increased, but its occurrence and timing is still uncertain. It is intended to provide enough lead time so those who need to set their plans in motion can do so, such as established individual city excessive heat event mitigation plans.
- **Excessive Heat Warning/Advisory**: when an excessive heat event is expected in the next 36 hours. These products are issued when an excessive heat event is occurring, is imminent, or has a very high probability of occurrence. The warning is used for conditions posing a threat to life or property. An advisory is for less serious conditions that cause significant discomfort or inconvenience and, if caution is not taken, could lead to a threat to life and/or property.

The NWS also developed the Heat Index (HI). The HI is sometimes referred to as the "apparent temperature". The HI, given in degrees F, is a measure of how hot it really feels when relative humidity (RH) is added to the actual air temperature. To find the HI, NWS uses the Heat Index Chart, found in Figure 11.2.2.5-1(following). As an example, if the air temperature is 96°F (found on the top of the table) and the RH is 65% (found on the left of the table), the HI - or how hot it really feels - is 121°F. This is the intersection of the 96°F column and the 65% row.

Since HI values were devised for shady, light wind conditions, exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

Note the shaded zone above 105°F on the Heat Index Chart. This corresponds to a level of HI that may cause increasingly severe heat disorders with continued exposure and/or physical activity.

Figure 11.2.2.5-1
Heat Index Chart
(Source: The National Weather Service)



Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	118	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	126	130					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Recent research has shown that a heat index threshold does not fully account for a variety of factors which impact health including the impact of consecutive stressful days on human health, the time of year, or the location where excessive heat events occur. For example, studies indicate large urban areas are particularly sensitive to heat early in the summer season. Based on this research, NOAA/NWS has supported the implementation of new Heat Health Watch/Warning System (HHWS) that its forecasters use as guidance in producing their daily warning and forecast products.

Hail

The National Oceanic and Atmospheric Administration (the parent agency for the NWS) and the Tornado and Storm Research Organization (TORRO) both created Hailstorm Intensity Scales. Table 11.2.2.5-1 (following) provides details of these scales.

Table 11.2.2.5-1
Combined NOAA/TORRO Hailstorm Intensity Scale
(Source: noaa.gov and torro.org)

Size Code	Intensity Category	Typical Hail Diameter	Approximate Size	Typical Damage Impacts
H0	Hard Hail	Up to 0.33"	Pea	No damage
H1	Potentially Damaging	0.33" – 0.60"	Marble or mothball	Slight damage to plants and crops
H2	Potentially Damaging	0.60" – 0.80"	Dime or grape	Significant damage to fruit, crops and vegetation
H3	Severe	0.80" – 1.20"	Nickel to quarter	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
H4	Severe	1.20" – 1.60"	Half dollar to ping pong ball	Widespread glass damage, vehicle body damage
H5	Destructive	1.60" – 2.0"	Silver dollar to golf ball	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	2.0" – 2.4"	Lime or egg	Aircraft body dented, brick walls pitted
H7	Very Destructive	2.4" – 3.0"	Tennis ball	Severe roof damage, risk of serious injuries
H8	Very Destructive	3.0" – 3.5"	Baseball to orange	Severe damage to aircraft body
H9	Super Hailstorms	3.5" – 4.0"	Grapefruit	Extensive structural damage, risk of severe or fatal injuries to persons caught in the open

Lightning

The following are descriptions of various terms used to describe lightning, both scientific and common usage:

- **Cloud-to-Ground Lightning.** This is the best known and second most common type of lightning. Of all the different types of lightning, it poses the greatest threat to life and property since it strikes the ground. Cloud-to-ground lightning is a lightning discharge between a cumulonimbus cloud and the ground. It is initiated by a leader stroke moving down from the cloud.
- **Bead Lightning**. Bead lightning is a type of cloud-to-ground lightning which appears to break up into a string of short, bright sections, which last longer than the usual discharge channel. It is relatively rare. Several theories have been proposed to

explain it; one is that the observer sees portions of the lightning channel end on, and that these portions appear especially bright. Another is that, in bead lightning, the width of the lightning channel varies; as the lightning channel cools and fades, the wider sections cool more slowly and remain visible longer, appearing as a string of beads.

- **Ribbon Lightning.** Ribbon lightning occurs in thunderstorms with high cross winds and multiple return strokes. The wind will blow each successive return stroke slightly to one side of the previous return stroke, causing a ribbon effect.
- **Staccato Lightning**. Staccato lightning is a cloud to ground lightning strike which is a short-duration stroke that appears as a single very bright flash and often has considerable branching.
- **Ground-to-Cloud Lightning.** Ground-to-cloud lightning is a lightning discharge between the ground and a cumulonimbus cloud initiated by an upward-moving leader stroke. It is much rarer than cloud-to-ground lightning. This type of lightning forms when negatively charged ions called the stepped leader rises up from the ground and meets the positively charged ions in a cumulonimbus cloud. Then the strike goes back to the ground as the return stroke.
- **Cloud-to-Cloud Lightning.** Lightning discharges may occur between areas of cloud without contacting the ground. When it occurs between two separate clouds it is known as inter-cloud lightning and when it occurs between areas of differing electric potential within a single cloud, it is known as intra-cloud lightning. Intra-cloud lightning is the most frequently occurring type.
- **Heat Lightning**. Heat lightning is a common name for a lightning flash that appears to produce no thunder because it occurs too far away for the thunder to be heard. The sound waves dissipate before they reach the observer.
- **Dry Lightning.** Dry lightning is a term used for lightning that occurs with no precipitation at the surface. This type of lightning is the most common natural cause of wildfires. Pyrocumulus clouds produce lightning for the same reason that it is produced by cumulonimbus clouds. When the higher levels of the atmosphere are cooler, and the surface is warmed to extreme temperatures due to a wildfire, volcano, etc., convection will occur, and the convection produces lightning. Therefore, fire can beget dry lightning through the development of more dry thunderstorms which cause more fires.

The National Weather Service (NWS) uses a Lightning Activity Level scale to indicate the frequency and character of cloud-to-ground (C/G) lightning, the most common form of lightning on Earth. The scale uses a range of 1 – 6, with 6 being the high end of the scale. Table 11.2.2.5-2 (following) provides this severity scale.

Table 11.2.2.5-2
Lightning Activity Level
(Source: http://www.crh.noaa.gov/gid/?n=fwfintro)

Lightning Activity Level Scale					
Rank	**Cloud and Storm Development**	**Areal Coverage**	**Counts C/G per 5 Minutes**	**Counts C/G per 15 Minutes**	**Average C/G per Minute**
1	No Thunderstorms	None	None	None	None
2	Cumulus clouds are common but only a few reach the towering stage. A single thunderstorm must be confirmed in the rating area. The clouds mostly produce virga but light rain will occasionally reach ground. Lightning is very infrequent.	<15%	1-5	1-8	<1
3	Cumulus clouds are common. Swelling and towering cumulus cover less than 2/10 of the sky. Thunderstorms are few, but 2 to 3 occur within the observation area. Light to moderate rain will reach the ground, and lightning is infrequent.	15% to 24%	6-10	9-15	1-2
4	Swelling cumulus and towering cumulus cover 2-3/10 of the sky. Thunderstorms are scattered but more than three must occur within the observation area. Moderate rain is commonly produced, and lightning is frequent.	25% to 50%	11-15	16-25	2-3
5	Towering cumulus and thunderstorms are numerous. They cover more than 3/10 and occasionally obscure the sky. Rain is moderate to heavy, and lightning is frequent and intense.	>50%	>15	>25	>3
6	Dry lightning outbreak. (LAL of 3 or greater with majority of storms producing little or no rainfall.)	>15%	None	None	None

Tornadoes

Tornado wind forces are measured and described according to the Fujita Scale. The Fujita Scale is largely a residential structure damage scale, which tends to have much more standardized construction than commercial structures. The Fujita Scale is intended to describe the expected damage to well-built residential structures. This makes its use often misleading, as poorly built structures can suffer significant structural damage under lesser

winds than the Scale would suggest. The Storm Prediction Center, a NOAA office, states the following regarding the use of the Fujita Scale:

> Do not use F-scale winds literally. These precise wind speed numbers are actually guesses and have never been scientifically verified. Different wind speeds may cause similar-looking damage from place to place -- even from building to building. *Without a thorough engineering analysis of tornado damage in any event, the actual wind speeds needed to cause that damage are unknown.*

In February 2007, use of the Fujita Scale was discontinued. In its place, the Enhanced Fujita Scale is used. The Enhanced Fujita Scale retains the same basic design as its predecessor, but reflects a more refined assessment of tornado damage surveys, standardization and damage consideration to a wider range of structure types. The new scale takes into account how most structures are designed, and is thought to be a much more accurate representation of the surface wind speeds in the most violent tornadoes. It is important to note the date a tornado occurred, as tornadoes which occurred prior to February 2007 are classified by the old scale and will not be converted to the Enhanced Fujita Scale. Table 11.2.2.5-3 (below) illustrates the Fujita Scale in use prior to February 2007.

Table 11.2.2.5-3
Fujita Tornado Scale (Pre-February 2007)
(Source: Storm Prediction Center)

F-Scale Number	Intensity Phrase	Wind Speed	Type of Damage
F0	Gale tornado	40-72 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1	Moderate tornado	73-112 mph	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.
F2	Significant tornado	113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
F3	Severe tornado	158-206 mph	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted
F4	Devastating tornado	207-260 mph	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	Incredible tornado	261-318 mph	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.
F6	Inconceivable tornado	319-379 mph	These winds are very unlikely. The small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds. Missiles, such as cars and refrigerators would do serious

F-Scale Number	Intensity Phrase	Wind Speed	Type of Damage
			secondary damage that could not be directly identified as F6 damage. If this level is ever achieved, evidence for it might only be found in some manner of ground swirl pattern, for it may never be identifiable through engineering studies

Table 11.2.2.5-4 (below) illustrates the Enhanced Fujita Scale, currently in use.

Table 11.2.2.5-4
Enhanced Fujita Tornado Scale (Post-February 2007)
(Source: Storm Prediction Center)

Enhanced Fujita Category	Wind Speed (mph)	Potential Damage
EF0	65-85	**Light damage.** Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	86-110	**Moderate damage.** Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	**Considerable damage.** Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136-165	**Severe damage.** Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200	**Devastating damage.** Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	>200	**Incredible damage.** Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (109 yd); high-rise buildings have significant structural deformation; incredible phenomena will occur.

Thunderstorms

Thunderstorms affect relatively small areas. The typical thunderstorm is 15 miles in diameter and lasts an average of 30 minutes. Given that Makoti is smaller than 15 miles in diameter, it is possible for the entire jurisdiction to be impacted by the same thunderstorm at any given time. Despite their small size and relatively short duration, all thunderstorms are potentially dangerous. Of the estimated 100,000 thunderstorms that occur each year in the United States, about 10% are classified as severe by the NWS. People most at risk from

thunderstorms are those who are outdoors, especially under or near tall trees; in or on water; or on or near hilltops.

All assets and people within the city of Makoti are at risk from the effects of severe summer storms, and can expect to experience the complete range of the component hazards.

Potential Impact of the Hazard

Extreme Heat

On average, more than 1,500 people in the US die each year from extreme heat. This number is greater than the 30-year mean annual number of deaths due to tornadoes, hurricanes, floods and lightning combined. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the disastrous heat wave of 1980, more than 1,250 people died. In the heat wave of 1995 more than 700 deaths in the Chicago, IL area were attributed to this event. And in August 2003, a record heat wave in Europe claimed an estimated 50,000 lives.

Heat-related disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating or a chemical (salt) imbalance caused by too much sweating. When the body heats too quickly to cool itself safely, or when fluid or salt is lost through dehydration or sweating, the body's temperature rises and heat-related illness may develop.

Studies indicate that, other things being equal, the severity of heat disorders tend to increase with age. Conditions that cause heat cramps in a 17-year-old may result in heat exhaustion in a 40-year-old and heat stroke in a person over 60.

Sunburn, with its ultraviolet radiation burns, can significantly impair the skin's ability to shed excess heat.

Hail

Hail typically impacts property by damaging structures, cars, and utilities as it falls. Dents in cars, broken glass, and holes in roofs are common impacts of hail. Injuries to people from hail are less common, though they can happen, as hail is a hard object falling in an unpredictable manner at a fairly high rate of speed.

Lightning

Lightning is the leading cause of weather-related personal injuries. Perhaps because lightning is a common weather phenomenon, most people do not take the associated risks of exposure to lightning as seriously as they should.

Lightning is a major cause of storm related deaths in the US, out pacing hurricanes and tornados in most years. A lightning strike can result in a cardiac arrest (heart stopping) at

the time of the injury, although some victims may appear to have a delayed death a few days later if they are resuscitated but have suffered irreversible brain damage.

On average, for every person actually struck by lightning, 10 additional people are affected by the strike. According to *Storm Data*, a National Weather Service publication, over the last 30 years the US has averaged 58 *reported* lightning fatalities per year. Due to under reporting, the figures are more realistically at least 70 deaths per year. Only about 10% of people who are struck by lightning are killed, leaving 90% with various degrees of disability.

Table 11.2.2.5-5 (below) illustrates statistics from the National Weather Service. Assuming a US population of 313 million (based on the 2010 Census estimate), the NWS has calculated the likelihood of the average person being struck or killed by lightning.

Table 11.2.2.5-5
Injury or Death from Lightning Probability Statistics
(Source: NWS - http://www.lightningsafety.noaa.gov/medical.htm)

Odds of Becoming a Victim of Lightning	
Characteristic	**Probability or Statistic**
Number of Deaths Reported	60
Estimated Number of Deaths	70
Number of Injuries Reported	340-400
Estimated Number of Injuries	540-600
Odds of Being Struck by Lightning in a Given Year (using reported numbers)	1 in 750,000
Odds of Being Struck by Lightning in a Given Year (using estimated numbers)	1 in 500,000
Odds of Being Struck by Lightning in Average Lifetime (80 years)	1 in 6,250
Odds of Being Affected by Someone Else Being Struck	1 in 625

While approximately one third of all injuries occur during work, workers compensation companies are often reluctant to acknowledge the injury or pay related medical expenses. An estimated third of injuries occur during recreational or sports activities. The last third occurs in diverse situation, including injuries to those inside buildings.

Those struck by lightning report a variety of affects, including:

- Personality changes, likely due to frontal lobe damage
- Fatigue
- Brain and nervous system damage
- Headaches
- Ringing in the ears
- Dizziness
- Nausea and vomiting
- Sleep difficulties

- Seizures
- Chronic pain

In addition to the impact lightning can have on people, lightning can have significant impact on property, including utility infrastructure, such as lift stations and electrical sub-stations. Lightning is the leading natural cause of wildfires, and can lead to structure fires as well. The historic structures and districts are particularly vulnerable, as they are primarily wood-frame construction and are closer together than modern residences.

The Lightning Protection institute, a non-profit organization dedicated to promoting lightning safety and protection, conducted a study that demonstrates that:

- 32% of lightning strikes hit roofs and projections such as satellite dishes or chimneys;
- 29 % of lightning strikes hit overhead power lines and phone lines;
- 29% of lightning strikes hit television antennas; and
- 10% of lightning-strikes hit trees near structures.

On average, lightning strikes cause 30% of the church fires and at least 18% of lumberyard fires in the United States annually. They also cause significant losses to more than 18,000 houses and 12,000 other buildings.

In addition to direct losses such as property damage to buildings, a lightning strike may result in the indirect losses that often accompany the destruction or damage of buildings and their contents. For example, municipalities rely upon the integrity of their structures as they provide services to their communities. A stroke of lightning to an unprotected building that houses the police or fire station may result in an interruption of vital services to the community. The consequences of such an interruption can range from the public's loss of confidence to a citizen's death when a department is unable to respond to an emergency call.

Tornadoes

Tornadoes have the potential to impact property, people, and operations throughout the city by disrupting the power supply (through downed power lines), transportation (by blocking roads with downed trees or other debris), and the habitability of buildings (by damaging roofs, windows, or other weak points in the envelope).

People caught in the open during a tornado are exposed to high winds and debris, and could be injured or killed.

Thunderstorms

Most impacts occur when trees or tree limbs are pushed over by the wind onto houses or vehicles. Vehicles are also sometimes pushed off roads during high wind events. The impact

on life due to thunderstorm and associated hazards in Makoti would typically be minimal. Likewise, the impact to property would be minor unless exacerbated by falling trees and/or tree limbs due to wind or lightning.

Since thunderstorms and associated events often result in power failure, the operations of the city could be interrupted in the short-term. In terms of fallen tree limbs and other potential transportation hazards, thunderstorms may also cause disruption to community activities due to a lack of access.

Past Occurrences of the Hazard

Information obtained from the National Climatic Data Center (NCDC) indicates that there have been at least10 occurrences of the summer storm hazard since 1998. (Note: Records prior to 1998 were kept at the county level, and therefore occurrences within a particular jurisdiction cannot be reliably determined.) Table 11.2.2.5-6 (below) provides details of these recorded incidents.

Table 11.2.2.5-6
Summer Storm Occurrences
(Source: National Climatic Data Center)

Date	Description	Magnitude (if applicable)
July 06, 1998	Tornado/Funnel cloud	Unknown
August 21, 2001	Hail	1.75”
June 06, 2004	Tornado/Funnel Cloud	Unknown
July 20, 2004	Hail	.75”
July 21, 2005	Hail	.88”
May 21, 2007	Hail (3 occurrences)	1.75”; .88” and 1.25”
August 01, 2008	Hail	1.5”
July 20, 2010	Hail	1”

Probability of a Future Occurrence of the Hazard

In the 18 year period for which records are available, the summer storm hazard has occurred at least nine times. Many of these occasions included multiple hazards occurring simultaneously. Therefore, based on the scale provided earlier in this section, the probability of a future occurrence is moderate, as the summer storm hazard occurs at least once every five years.

11.2.2.6 Severe Winter Storms

This hazard profile includes the following elements of severe winter storms: extreme cold, excessive snow or blizzard, and ice.

Description of the Hazard

Severe winter storms occur throughout the country, and can be seriously damages in areas where they occur. Severe winter storms can encompass a variety of hazards, including:

Blizzard/Excessive Snow

The National Weather Service defines snow as "precipitation is the form of ice crystals, mainly of intricately branched, hexagonal form and often agglomerated into snowflakes, formed directly from the freezing [disposition] of the water vapor in the air." Heavy snow accumulations, generally more than 8" of snow in less than 24 hours, can immobilize a community by bringing transportation to a halt. Until the snow can be removed, transportation routes are slowed or closed completely, limiting or halting the transportation of goods, services, and people. These closures also disrupt emergency services. In addition, accumulations of snow on roofs can cause collapse, and can cause trees and power lines to fall. A quick thaw after a significant snowfall can lead to substantial flooding, particular in urban areas where there is more impermeable surface. Injuries and fatalities related to heavy snow are often associated with physical exertion (from shoveling) and from hypothermia.

Blizzards, as defined by the National Weather Service, are a combination of sustained winds or frequent gusts of 35 MPH or greater and visibilities of less than 1/4 mile from falling or blowing snow for three hours or more. A blizzard, by definition, does not indicate heavy amounts of snow, although they can happen together. The falling or blowing snow usually creates large drifts from the strong winds. The reduced visibilities make travel, even on foot, particularly treacherous. The strong winds may also support dangerous wind chills.

Blizzard conditions can also exist without a major storm system being in the area. Strong surface winds can blow already fallen snow, which is known as a "ground blizzard. Visibility can be reduced to near zero even though the sun is shining and the tops of power poles and trees are seen easily. These conditions are extremely variable in duration, from hours to even greater than a day. Ground blizzards are usually accompanied by very cold temperatures and wind chill conditions, making them as potentially deadly as a conventional blizzard.

Extreme Cold

What is considered an excessively cold temperature varies according to the normal climate for that region. Excessive or extreme cold can accompany severe winter weather, or it can occur without severe weather. The greatest danger from extreme cold is to people, as prolonged exposure can cause frostbite or hypothermia, and can become life-threatening.

Ice

The National Weather Service defines an ice storm as "occasions when damaging accumulations of ice are expected during freezing rain situations. Significant accumulations

of ice pull down trees and utility lines resulting in loss of power and communication. These accumulations of ice make walking and driving extremely dangerous. Significant ice accumulations are usually accumulations of ¼" or greater." The term "ice storm" is used to describe occasions when damaging accumulations of ice are expected during freezing rain situations. Ice storms can be the most damaging of winter phenomena, and are often the cause of automobile accidents, utility failures, personal injury, and death. Moreover, they significantly impact the delivery of emergency services.

Location of the Hazard

Severe winter storms are a non-spatial hazard, and can – and do - occur anywhere in the city of Makoti.

Extent and Severity of the Hazard

Severe winter storms have a wide range of extent and severity markers and characteristics.

Blizzard/Excessive Snow

Various intensities of snowfall are defined differently:

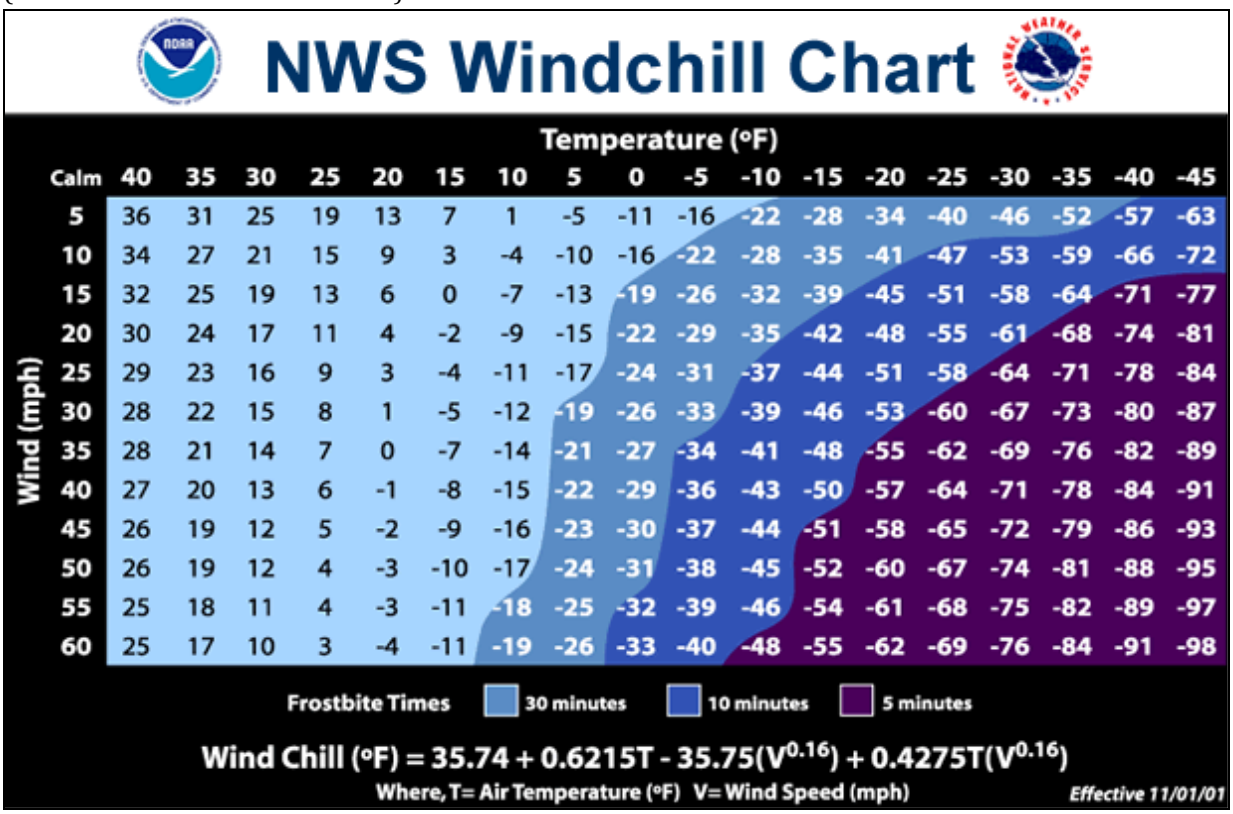
- **Blizzard** describes winds of 35 miles (56 kilometers) per hour or more with snow and blowing snow that reduce visibility to less than one-quarter mile (0.4 kilometer) for at least three hours.
- **Blowing snow** describes wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground that is picked up by the wind.
- **Snow squall** describes a brief, intense snow shower accompanied by strong, gusty winds. Accumulation from snow squalls can be significant.
- **Snow shower** describes snow that falls at varying intensities for short durations with little or no accumulation.

Extreme Cold

Winter temperatures in Makoti typically range from the 20s and 30s (high) to single digits to 20s (lows.)

Figure 11.2.2.6-1 (following) depicts the National Weather Service's methodology for determining wind chill, using wind speed and actual temperature. Winter storm severity is a function of wind chill and other factors, such as precipitation amount (rain, sleet, ice, and/or snow).

Figure 11.2.2.6-1
Methodology for Determining Windchill
(Source: National Weather Service)



NWS Windchill Chart

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

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

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

Effective 11/01/01

Ice

Heavy accumulations of ice can bring down trees and topple utility poles and communication towers. Ice can disrupt communications and power for days while utility companies repair damage. Even small accumulations of ice can be severely dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

Ice forms in different ways:

- **Sleet** is rain that freezes into ice pellets before it reaches the ground. Sleet usually bounces when hitting a surface and does not stick to objects; however, it can accumulate like snow and cause roads and walkways to become hazardous.
- **Freezing rain** is rain that falls onto a surface that has a temperature below freezing. The cold surface causes the rain to freeze so the surfaces—trees, utility wires, vehicles, and roads—become glazed with ice.

Potential Impact of the Hazard

Severe winter weather can bring a community to a standstill by inhibiting transportation, knocking down trees and utility lines, and by causing structural collapse in buildings not designed to withstand the weight of accumulated snow. Repair and snow removal costs can be significant, and can easily surpass an entity's annual salt and snow removal budget, often before the end of the winter weather season. Ice buildup can cause utilities to fail, and communication towers to cease functioning. Without electricity, heaters and pumps fail to work, causing water and sewer pipes to freeze or rupture. If extreme cold temperatures are combined with low snow cover, the ground's frost level can change, creating the possibility of failure in underground infrastructure.

Structure fires and carbon monoxide poisoning are also possible impacts of severe winter weather, as people rely on auxiliary heating devices, such as candles, portable heaters, and fuel burning lanterns. According to NOAA observations, 20% of all winter deaths attributed to exposure to cold occur in the home, whereas 25% of all winter deaths attributed to ice and snow involve people caught in the storm.

Rural residents can be hit particularly hard by severe winter storms, if they do not have adequate stockpiles of food, water, and heating fuel. The livestock industry can be severely impacted by severe winter weather as well. The inability to get feed and water to livestock can quickly escalate to a critical situation, and can lead to dehydration, a major cause of livestock causalities. Cattle cannot lick enough snow to satisfy their thirst, and will die of dehydration before they succumb to cold or suffocation.

In addition to the threat posed to humans, severe winter storms pose a significant threat to utility production, which in turn threatens facilities and operations that rely on utilities, specifically climate stabilization. As temperature drop and stay low, increased demand for heating places a strain on the electrical grid, which can lead to temporary outages.

Past Occurrences of the Hazard

According to the ND State Hazard Mitigation Plan (SHMP), winter in North Dakota can begin as early as September and last into May, though the bulk of winter weather occurs from mid-November until early April. On average, there are approximately 10 winter storms each year; three or four of these storms will reach severe status. North Dakota typically leads the nation in blizzard and severe winter storm frequency.

There is a long history of severe winter storm events, going back to when North Dakota was a territory and not a state:

- 1886-1887: A severe winter storm in the western part of the state put an end to open range ranching.
- January 12, 1888: This storm, known as the "Schoolhouse Blizzard," swept through the entire territory in an afternoon. The day began relatively warm, around 32°F. Temperatures reportedly dropped to -20°F in a matter of minutes,

accompanied by winds so strong that people were unable to stand upright. Schools throughout the state were closed, and children sent home. Many of those children, as well as adults, became disorientated in the storm, and lost their sense of direction, eventually succumbing to hypothermia. An estimated 400 people died throughout the state, and thousands of head of cattle perished. Transportation came to a standstill, and many buildings collapsed under the weight of the snow.

- March 1966: This severe storm was notable for its excessive duration. Bismarck (100 miles to the south) recorded near zero visibility for 42 consecutive hours. More than 100,000 head of livestock, and 15 people, died in the storm.
- January 09, 1997: Bitter cold wind chills ranged from 40-60 below in the south and east and 30-45 below in the northwest. Some schools closed for as many as nine days. A National Weather Service report indicated snow depths up to 30 inches in eastern and south central North Dakota. The state livestock industry sustained approximately $32.8 M in losses. FEMA had approximately $5 M in snow removal costs, National Guard exceeded $1.1 M and the North Dakota Department of Transportation spent approximately $3.7 M. All but one county in North Dakota, and 75 cities and 3 Indian Reservations issued emergency or disaster declarations. A total of 7 deaths across the state were reported along with many injuries due to traffic accidents.
- March 12, 1997: .Approximately $15 K in damages was reported in North Dakota. Snowfall amounts were up to 4 inches in Minot. Many of the smaller school districts cancelled school and I-94 was also closed. A car accident near Berthold sent 4 to the hospital. Roads were very icy and visibility near zero.
- April 4, 1997: This blizzard was the worst of the season and brought much of the state to a complete halt. Snow accumulations were on average 1.5 to 2 inches an hour with 50 to 60 mph winds as well. The additional snow at Bismarck brought the season snowfall total to 101.4 inches, which set an all-time record. An estimated 100,000 head of cattle (10% of the state's herd) was lost with an estimated dollar loss across the state of over $5 M. An estimated 75,000 homes in North Dakota were without power for some time over the weekend. The reported property damage was $44.7 M with 16 injuries and 2 deaths were reported statewide.

The National Climatic Data Center (NCDC) records winter storm hazards at the state level, rather than at the county or municipal level. NCDC has recorded hundreds of occurrences of winter storm hazards (with each hazard recorded as a separate entry).

Probability of a Future Occurrence of the Hazard

Based on the data available, winter storms occur in or otherwise impact the city of Makoti at least annually. Therefore, using the scale previously provided, the probability of a future occurrence of the winter storm hazard is high.

11.2.2.7 Hazardous Materials Incident

This hazard profile includes all types of hazardous materials incidents – transportation routes, fixed sites, and pipelines.

Description of the Hazard

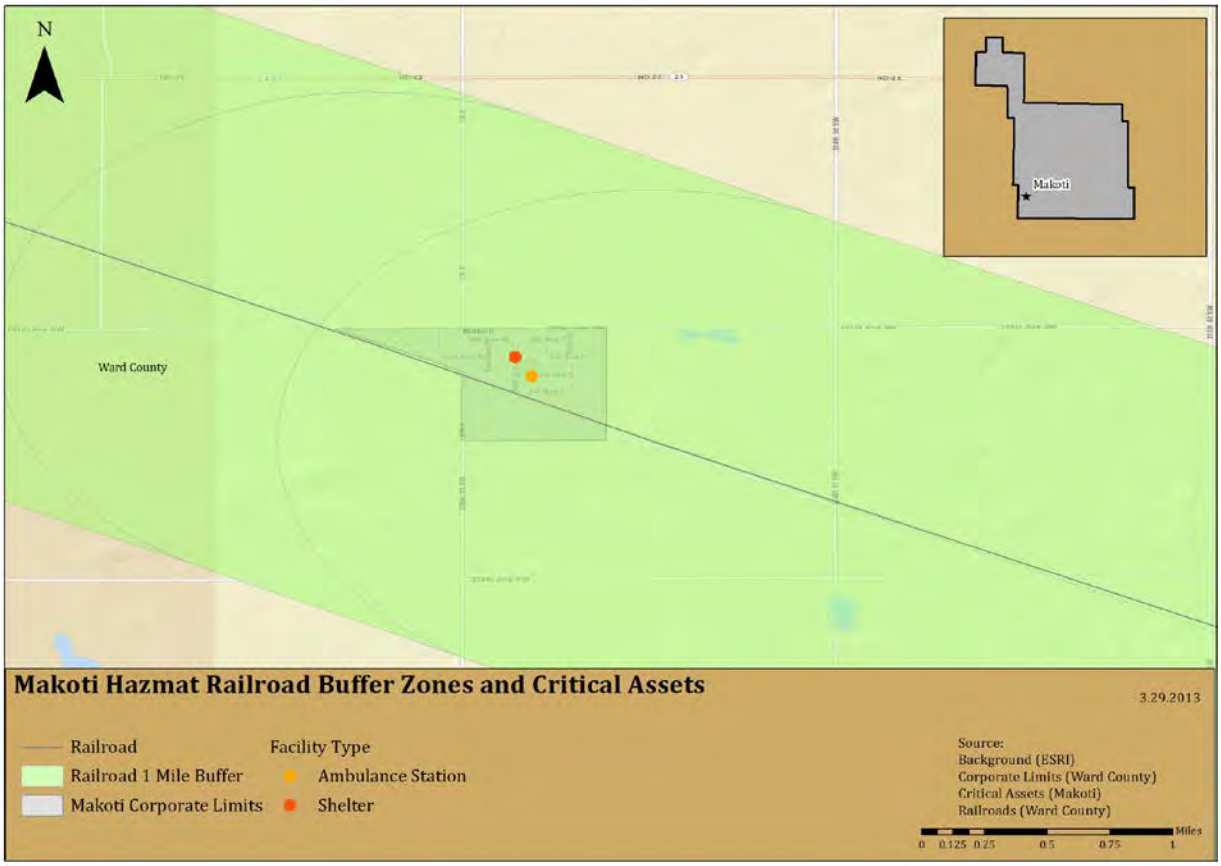
Hazardous materials incidents are technological (meaning non-natural hazards created or influenced by humans) events that involve large-scale accidental or intentional releases of chemical, biological, or radiological materials. These incidents may occur at fixed site locations, such as factories or storage facilities, or may occur while these materials are being transported to another location.

Hazardous materials come in the form of explosives, corrosive, reactive, flammable and combustible substances, toxic releases and waste materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in fixed facilities. Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are routinely used and stored in homes and offices. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines.

Location of the Hazard

The locations in Makoti most at risk from a hazardous materials incident are those that are in proximity to either locations that store/use hazardous materials or that are adjacent to transportation lines. The following figure (11.2.2.7-1) illustrates these locations in Makoti.

Figure 11.2.2.7-1
Hazardous Materials Locations – Railroads



Extent and Severity of the Hazard

The severity of a hazardous materials release depends upon the type of material released, the amount of the release, and the proximity to populations or environmentally sensitive areas such as wetlands or waterways. The release of materials can lead to injuries or evacuation of nearby residents. Wind direction at the time of the release can also have a bearing on the severity (as well as the location and extent) of a hazardous materials releases.

Potential Impact of the Hazard

The primary threat from the hazardous materials incident hazard is to the structures located along transmission lines and transportation routes, or near facilities that use or store hazardous materials. Minor incidents would likely cause no damage and little disruption. Major incidents could have fatal and disastrous consequences. The severity of a hazardous material release relates primarily to its impact on human safety and welfare and on the threat to the environment.

Threats to Human Safety and Welfare:

- Poisoning of water or food sources and/or supply

- Presence of toxic fumes or explosive conditions
- Damage to personal property
- Need for the evacuation of people
- Interference with public or commercial transportation

Threats to the environment:

- Injury or loss of animals or plants or habitats that are of economic or ecological importance such as; commercial, recreation, or subsistence fisheries (marine plants, crustaceans, shellfish, aquaculture facilities) or livestock; seal haul outs; and marine bird rookeries
- Impact to ecological reserves, forests, parks, archaeological, and cultural sites

In terms of property, property and people could be either directly impacted by an explosion or fire resulting from a hazardous materials release, contamination of buildings and contents, or indirectly impacted by the release of materials that necessitates evacuation and long-term abandonment of facilities.

Past Occurrences of the Hazard

Based on Tier II reporting data obtained from the EPA, no Tier II reports from the city of Makoti have been submitted to the EPA since 1987, the year that the EPA began keeping such reports.

According to the EPA's Tier II database, there were more 4,211 releases of hazardous materials in Ward County in 2011 that resulted in a reportable incident. Data for 2010 was unavailable during the development of this update. In 2009, there were 18, 031 reported releases in Ward County. In 2008, there were 22,292 reported releases in Ward County.

Probability of a Future Occurrence of the Hazard

Based on the data available, hazardous materials incidents occur with regularity in Ward County, though not necessarily in the city of Makoti. Therefore, based on the scale provided at the beginning of this section, the probability of a future occurrence is low.

11.3 Risk Assessment (Updated)

The following table (Table 11.3-1) provides a summary of the risk assessment findings from the 2008 Ward County Hazard Mitigation Plan, as it relates to the city of Makoti.

Table 11.3-1
Summary of 2008 Ward County Hazard Mitigation Plan Risk Assessment Data

Hazard Risk Ranking from 2008 Ward County Hazard Mitigation Plan		
Hazard	**Ranking**	**Disposition in the 2013 Plan Update**
Flood	Frequency: Likely Severity: Critical	Included; qualitative and quantitative risk assessment (where applicable)
Winter Storm	Frequency: Highly Likely Severity: Catastrophic	Included; qualitative and quantitative risk assessment (where applicable)
Summer Storm	Frequency: Highly Likely Severity: Catastrophic	Included; qualitative and quantitative risk assessment (where applicable)
Hazardous Materials Incident	Frequency: Likely Severity: Critical	Included; qualitative and quantitative risk assessment (where applicable)
Urban Fire	Frequency: Highly Likely Severity: Negligible	Included; qualitative and quantitative risk assessment (where applicable) Note: hazard is combination of structure and wildland fire
Rural Fire	Frequency: Highly Likely Severity: Negligible	Included; qualitative and quantitative risk assessment (where applicable) Note: hazard is combination of structure and wildland fire
Drought	Frequency: Likely Severity: Catastrophic	Included; qualitative risk assessment
Civil Disorder/Terrorism	Frequency: Possible Severity: Critical	Excluded from profiling and risk assessment
Mass Casualty	Frequency: Possible Severity: Negligible	Excluded from profiling and risk assessment
Dam Failure	Frequency: Unlikely Severity: Limited	Included in flood profile and assessment (where applicable)
Shortage of Materials	Frequency: Unlikely Severity: Critical	Excluded from profiling and risk assessment
National Security Incident	Frequency: Unlikely Severity: Catastrophic	Excluded from profiling and risk assessment

11.3.1 Risk Assessment Methodology

The risk assessment describes and analyzes the risks and vulnerabilities to the city of Makoti from the hazards profiled. The assessment includes a vulnerability description and information as to the identified risk to public and private assets (where applicable).

The Steering Committee conducted a risk assessment exercise to determine the vulnerabilities to assets within the planning area. The updated hazard profiles were used as the basis to determine

the vulnerability of and risk to assets within the city. A variety of data sources were used to complete this risk assessment, including:

- Local knowledge and experience of Steering Committee, city staff, and county staff
- Plans and documents produced and maintained by the city
- Reports and studies provided by other agencies, both state and federal

In all instances, the best available data was utilized.

Impact Scale Methodology

The potential impacts of each hazard were discussed by the Steering Committee. For the purposes of this discussion, a qualitative impact scale was developed, and was used by the Steering Committee in their discussions. As a result of these discussions, each hazard was assigned a qualitative impact ranking. This scale appears in Table 11.3.1-1 (below).

Table 11.3.1-1
Hazard Impact Scale

Term	Potential Impact to People or Life Safety	Potential Impact to Assets or Infrastructure	Potential Impacts to Service Delivery
Low	Some minor injuries possible, but no fatalities	Cosmetic damages expected to assets; Infrastructure loss of function for less than 24 hours expected	System delivery delayed or temporarily interrupted; Interruptions in service delivery of less than 24 hours expected
Moderate	Injuries expected; Fatalities possible	Some structural damages to light construction (<50 % damage); Infrastructure loss of function for 24-72 hours expected	System delivery failures expected; Interruptions in service delivery of 24-72 hours expected
High	Serious and numerous injuries expected; Fatalities expected	Some structures irreparably damaged (>50% damage); Infrastructure loss of function for 72+ hours expected	Long-term system failures/damages expected; Cancellation of services (72+ hours) expected
Not Applicable	Hazard does not have the potential to impact people or life safety	Hazard does not have the potential to impact assets or infrastructure	Hazard does not have the potential to impact service delivery

The following risk and vulnerability assessment uses a GIS-based methodology, with accompanying narrative and calculations, to demonstrate the assessed risk and vulnerability of the city of Makoti to the identified and profiled hazards.

Critical Assets
The table below (Table 11.3.1-1) provides details of the critical assets contained within the city of Makoti.

Table 11.3.1-1
Critical Assets – City of Makoti

Asset Name	Asset Use /Function	Street Number	Street Name	Insured or Estimated Value
Ryder/Makoti Fire Protection District – Makoti Fire Hall	Emergency Services	61	2nd Avenue East	$175,469
Makoti School	Shelter	--	3rd Avenue East	$16,115
Total estimated value of identified critical assets:				**$191,584**

Note on asset values: Valuation data for assets within the city was unavailable at the time this plan update was developed. All valuations used in the following estimates of potential losses are derived from an average of available data for the same or similar types of assets from other jurisdictions. The assessment that follows is an estimate only, and may not correlate with actual occurrences of the damage caused by the hazards described.

Note on the maps: the maps in this section provide estimates of municipal and county boundaries based on data available as of February and March 2013. In some cases, the boundaries depicted may not reflect recent annexations or other changes to corporate limits. However, these images reflect the best available data at the time of plan development. Future updates to this plan will reflect changes to municipal and county boundaries.

11.3.2 Risk and Vulnerability Assessment

11.3.2.1 Communicable Disease

Vulnerability to the Hazard
Vulnerability to the communicable diseases hazard resides in the population of a given area, both human and animal. While it is possible that assets and infrastructure could be impacted by communicable disease, these impacts would come as a secondary impact to the illness of human operators and caretakers, and not as a result of the hazard itself.

As of the 2010 Census, there were 154 people residing in Makoti. Each of these persons is vulnerable to communicable disease, particularly if it is a pathogen that that individual has not been immunized against, or for which no immunization exists. Prolonged outbreaks could result in a loss of city services, failure of infrastructure (from lack of operators or maintenance), and closure of facilities, including schools and social centers.

In general, the very young and the elderly, as well as those with underlying health conditions or who are immunocompromised, are more vulnerable to communicable disease.

Estimate of Potential Losses

According to the 2012 Census estimate, there are 64,798 people in Ward County. The city of Makoti represents ~1% of the total population of Ward County, or 154 people. While an outbreak of communicable disease in Makoti is unlikely to have significant impacts outside of Makoti, an outbreak could have significant impacts within the city.

As discussed in the communicable disease profile, influenza and pertussis are both communicable diseases that are tracked by the State Health Department. For each of these illnesses, cases were reported in Ward County between 2007 and 2012. Assuming an illness rate in Makoti that is similar to the illness rate across the county, the following numbers of people in Makoti could be expected to be at risk from these illnesses:

- **Influenza:** Ward County accounted for an annual average of 7% of the cases in the state from 2007 through 2012, equating to 4,536 people. Makoti accounts for ~1% of the county population. This equates to 45 cases of influenza in Makoti, on average, that could potentially impact the city.
- **Pertussis:** Ward County accounted for an annual average of 10% of the cases in the state from 2007 through 2012, equating to 6,479 people. Makoti accounts for ~1% of the county population. This equates to 65 cases of pertussis in Makoti, on average, that could potentially impact the city.

Identified Data Limitations

There is a wealth of technical information available for communicable disease, but limited data available regarding risk or vulnerability of specific populations. No municipal-level data regarding potential impacts was available for this risk assessment, and only limited county level data was available. Much of the data that does exist is protected by HIPPA or other privacy policies. Therefore, performing a highly detailed quantitative assessment for this hazard is very difficult. Data that could be collected prior to the next update in order to improve this methodology includes:

- Data regarding infection rates at the municipal level; and
- Data regarding absenteeism and increased operating costs as a result of absenteeism.

11.3.2.2 Drought

Vulnerability to the Hazard

Though there are obvious vulnerabilities for people and animals that will result from a prolonged drought, the most common impacts are generally felt in the area's economy. This is particularly true in areas whose economies depend largely on agriculture, such as Makoti and

Ward County as a whole. Agricultural losses from drought can be staggering, and can be in the billions of dollars. Shortages as a result of drought can have far-reaching consequences, given the centralized food system that currently exists in modern society.

As water becomes more and more precious, the value of that water will increase, resulting in issues of supply and demand. The decrease in availability of this necessary resource can result in significant societal disruption, which can worsen as the resource becomes more and more precious.

Estimate of Potential Losses

Given that the entire state of North Dakota is experiencing a significant wet cycle, that this cycle has been evolving for the previous two decades, and that scientists do not anticipate that this cycle will end in the near future, the Steering Committee directed that no risk assessment should be conducted for this hazard. It was the decision of the Steering Committee that this hazard does not present a significant threat to the planning area, and is unlikely to present a threat for the foreseeable future.

In light of this determination, no risk assessment has been performed for this hazard.

Identified Data Limitations

Data that could be collected prior to the next update in order to develop a quantitative risk assessment includes:

- Data regarding the volume of water required to maintain and support municipal operations; and
- Estimates of potential increases in operating costs that would result from a lack of water.

11.3.2.3 Fire

Vulnerability to the Hazard

Fire has the potential to devastate a community. All people and assets within a community are vulnerable to fire.

Fire can result in fatalities and injuries, in property damage or destruction, in the interruption of services, in transportation disruptions, and in economic losses.

The ability to suppress and fight a fire is contingent on having the necessary training, personnel, and equipment to bring the fire under control and to extinguish it. If one of these areas is lacking or is unavailable, the community can suffer extensive losses as a result of fire.

Estimate of Potential Losses

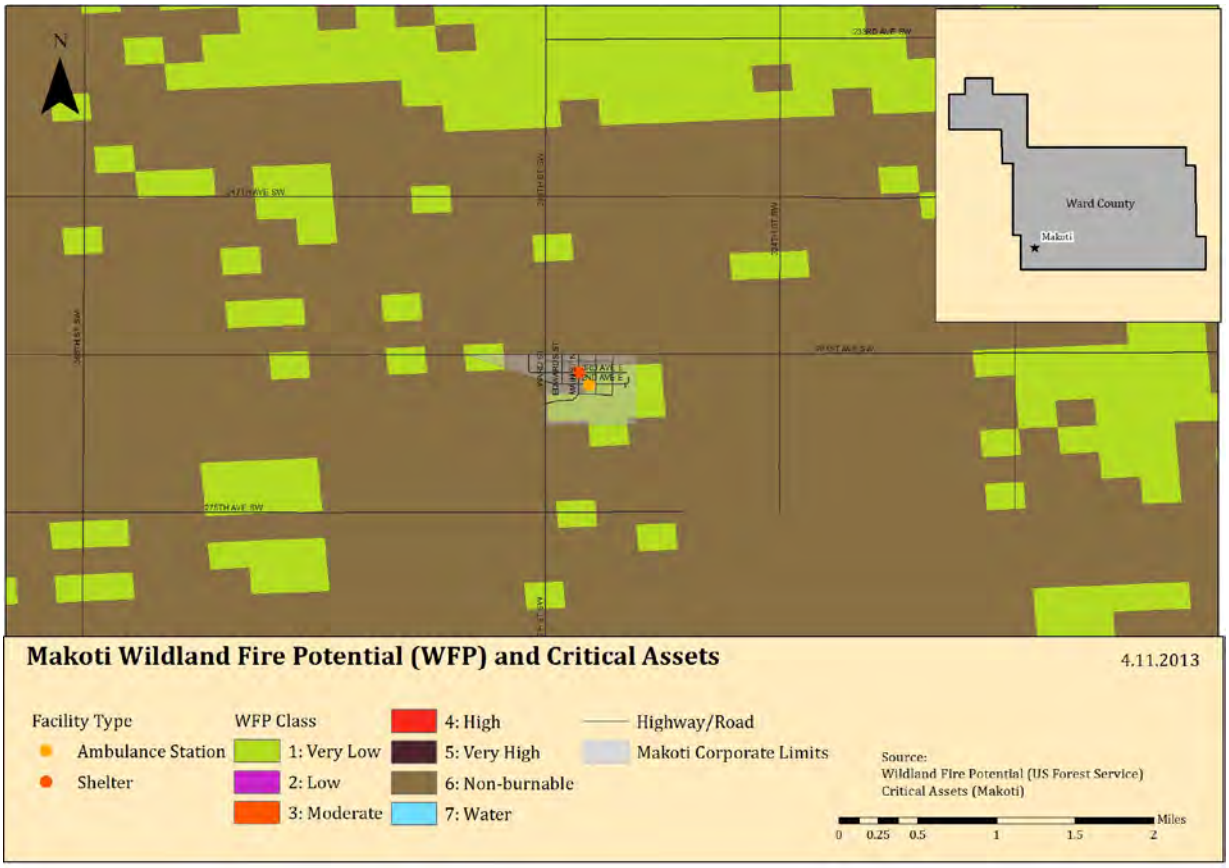
All structures within the city of Makoti are at risk from fire. According to the 2010 Census, there are 102 housing units in the city; 92 of these units are occupied, and 10 are vacant. The majority of these structures are heated by bottled gas or electricity. The median value of single family housing in Makoti is $72,200, according to the Census. This equates to potential residential losses of $7,364,400.

In addition, all identified critical assets (identified in Table 11.3.1-1) within the city have the potential to be lost to fire. These assets have a combined estimated value of $191,584.

Using the US Forest Service's Wildland Fire Potential data, the city of Makoti and its critical assets were mapped. Based on this data set, the city of Makoti has very low potential for wildland fires. However, this data set does not account for agricultural lands, and so may present a diminished risk where a higher level of risk actually exists.

Figure 11.3.2.3-1 (below) illustrates this fire potential in relation to the identified critical assets for the city.

Figure 11.3.2.3-1
Wildland Fire Potential and Critical Assets



Identified Data Limitations
Data that could be collected prior to the next update in order to develop a more detailed quantitative risk assessment includes:

- Data regarding building construction types and age;
- Building valuations for all assets within the city limits; and
- Data regarding fire protection systems within individual buildings, particularly those where flammable or combustible materials are routinely used or stored.

11.3.2.4 Flood

Vulnerability to the Hazard
Flooding affects people and property in a variety of ways – from forced evacuations to property damage to transportation interruptions to service disruptions, there is almost no facet of modern society that cannot be impacted by flooding.

Flood damages also take considerable time to recover from. The 2011 flooding that occurred throughout the county had far-reaching impacts, and recovery for many areas remains a work in progress as of this Plan update.

The city of Makoti has no mapped or identified SFHAs, and is not a member of the NFIP. As of February 2013, there were no NFIP-designated Repetitive Loss or Severe Repetitive Loss structures within the city of Makoti.

Estimate of Potential Losses
It was the determination of the Steering Committee that risk assessments related to flooding should be performed for those areas within Ward County that contained a mapped or identified flood hazard area.

In light of this determination, no risk assessment has been performed for this hazard for the city of Makoti.

Identified Data Limitations
Data that could be collected prior to the next update in order to develop a detailed quantitative risk assessment includes:

- Data regarding building construction (materials, location of utilities and connections);
- Building valuations for all assets within the city limits; and
- Data regarding the first floor elevation of all buildings within the city, as well as the elevation of all critical assets and infrastructure.

11.3.2.5 Severe Summer Storms

Vulnerability to the Hazard

People, structures, and assets are all vulnerable to the impacts associated with severe summer storms. Infrastructure can be damaged or destroyed by hail, wind, lightning, or tornadoes, which can result in service interruptions and outages. Structures can be damaged or destroyed by wind, lightning, or tornadoes, and thus be useless to humans for protection from the elements. People can be injured or killed by wind, tornadoes, lightning, hail, or extreme heat.

Those who reside in mobile homes, RVs, or other lightweight housing are more vulnerable than those who reside in traditional construction, as these lightweight types of structures generally fail in the face of summer storms much sooner than their heavier counterparts.

In addition, some portions of the population are more at risk to the effects of extreme heat. The very young and the elderly are generally more vulnerable to the effects of extreme heat, and are more likely to suffer illness or death as a result. This is especially true if exposure is extended for a period of time.

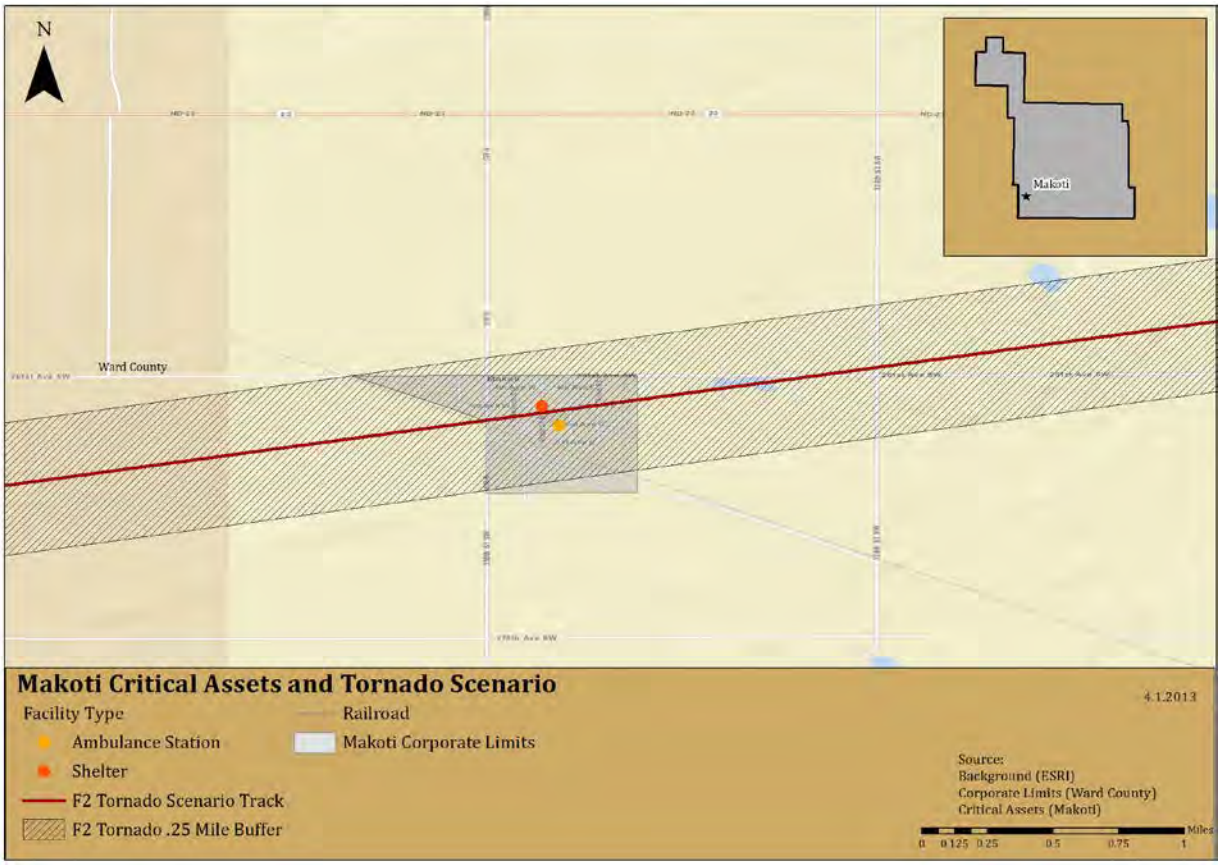
Estimate of Potential Losses

Severe summer storms are a non-spatial hazard that can and do affect the entire city of Makoti. Each of the hazards associated with severe summer storms can result in losses throughout the planning area.

All structures within the city of Makoti are at risk from severe summer storms. According to the 2010 Census, there are 102 housing units in the city. The median value of these structures is $72,200, according to the Census. This equates to residential assets of approximately $7,364,400. If 10% of these residential assets were damaged by a severe summer storm, this would result in losses of $736,440.

In addition, all identified critical assets (identified in Table 11.3.1-1) within the city have the potential to be damaged or destroyed by severe summer storms. These assets have a combined estimated value of $191,584. For the purposes of this assessment, a scenario was created, based on the documented tornado touchdown history for Ward County. The track of the most likely tornado (based on history) was overlaid onto the city of Makoti. Figure 11.3.2.5-1 (following) illustrates the results of this scenario, and shows the critical assets that would be at risk during such an event.

Figure 11.3.2.5-1
Tornado Scenario – City of Makoti



As seen in the above figure, in such a scenario the majority of the city of Makoti would be damaged, including critical assets (government and emergency services). This scenario would result in significant damages to the city's infrastructure, and would greatly impact its ability to provide basic services, such as emergency response.

Finally, the 154 residents of Makoti are all at risk from the severe summer storm hazard. As previously stated, those most at risk from the extreme heat hazard are the very young and the elderly. These two groups account for 6.5% (children under 5) and 17.5% (those over 70) of the population of Makoti. Combined, these two groups account for 24% of the population, a total of 37 people.

Identified Data Limitations

Data that could be collected prior to the next update in order to develop a more detailed quantitative risk assessment includes:

- Data regarding building construction (materials, roof types, wind ratings, etc.);
- Building valuations for all assets within the city limit; and

- Data regarding the location of vulnerable populations that may require services or special attention during severe summer storm events.

11.3.2.6 Severe Winter Storms

Vulnerability to the Hazard

People, structures, and assets are all vulnerable to the impacts associated with severe winter storms. Infrastructure can be damaged or destroyed by wind or ice, which can result in service interruptions and outages. Structures can be damaged or destroyed by wind, ice, or snow weight, and thus be useless to humans for protection from the elements. People can be injured or killed by transportation accidents (resulting from icy roadways) or extreme cold.

The majority of the vulnerability related to severe winter storms is related to either transportation accidents or to utility failures. Utility failure results in disruption to electrical service, water, and natural gas, which results in loss of heat to structures.

Transportation accidents occur when roadways and bridges become impacted and ice over, which results in loss of vehicular control and subsequent accidents.

In addition, some portions of the population are more at risk to the effects of extreme cold. The very young and the elderly are generally more vulnerable to the effects of extreme cold, and are more likely to suffer illness or death as a result. This is especially true if exposure is extended for a period of time.

Estimate of Potential Losses

Severe winter storms are a non-spatial hazard that can and do affect the entire city of Makoti. Each of the hazards associated with severe winter storms can result in losses throughout the planning area.

All structures within the city of Makoti are at risk from severe winter storms. According to the 2010 Census, there are 102 housing units in the city. The median value of these structures is $72,200, according to the Census. This equates to residential assets of approximately $7,364,000. If 1% of these residential assets were damaged by a severe winter storm, this would result in losses of $73,644.

In addition, all identified critical assets (identified in Table 11.3.1-1) within the city have the potential to be damaged or destroyed by severe winter storms. These assets have a combined estimated value of $191,584. If these critical assets suffered a 10% loss, the resulting damage would equate to at least $19,158.

Finally, the 154 residents of Makoti are all at risk from the severe winter storm hazard. As previously stated, those most at risk from the extreme heat hazard are the very young and the elderly. These two groups account for 6.5% (children under 5) and 17.5% (those over 70) of

the population of Makoti. Combined, these two groups account for 25% of the population, a total of 37 people.

Identified Data Limitations

Data that could be collected prior to the next update in order to develop a more detailed quantitative risk assessment includes:

- Data regarding building construction (materials, roof types, wind ratings, etc.);
- Building valuations for all assets within the city limits; and
- Data regarding the location of vulnerable populations that may require services or special attention during severe winter storm events.

11.3.2.7 Hazardous Materials Incident

Vulnerability to the Hazard

Vulnerabilities to people are often significant during hazardous materials incidents. Depending on the exact material and concentration released, the health impacts to humans can be short term, long term, minor, or significant. Those in the area of the immediate release would have little or no warning prior to exposure, and would have little or no time to evacuate. Those further away may have more time to evacuate, depending on the circumstances and the conditions.

Vulnerabilities also exist to the environment, in particular air, water, and soil. For example, water sources can be threatened or contaminated by hazardous releases. A single release can create hazardous conditions for an entire area or an entire watershed. Sensitive habitats can be damaged by a reduction in air, water, and soil quality, which can lead to plant and wildlife injury or death.

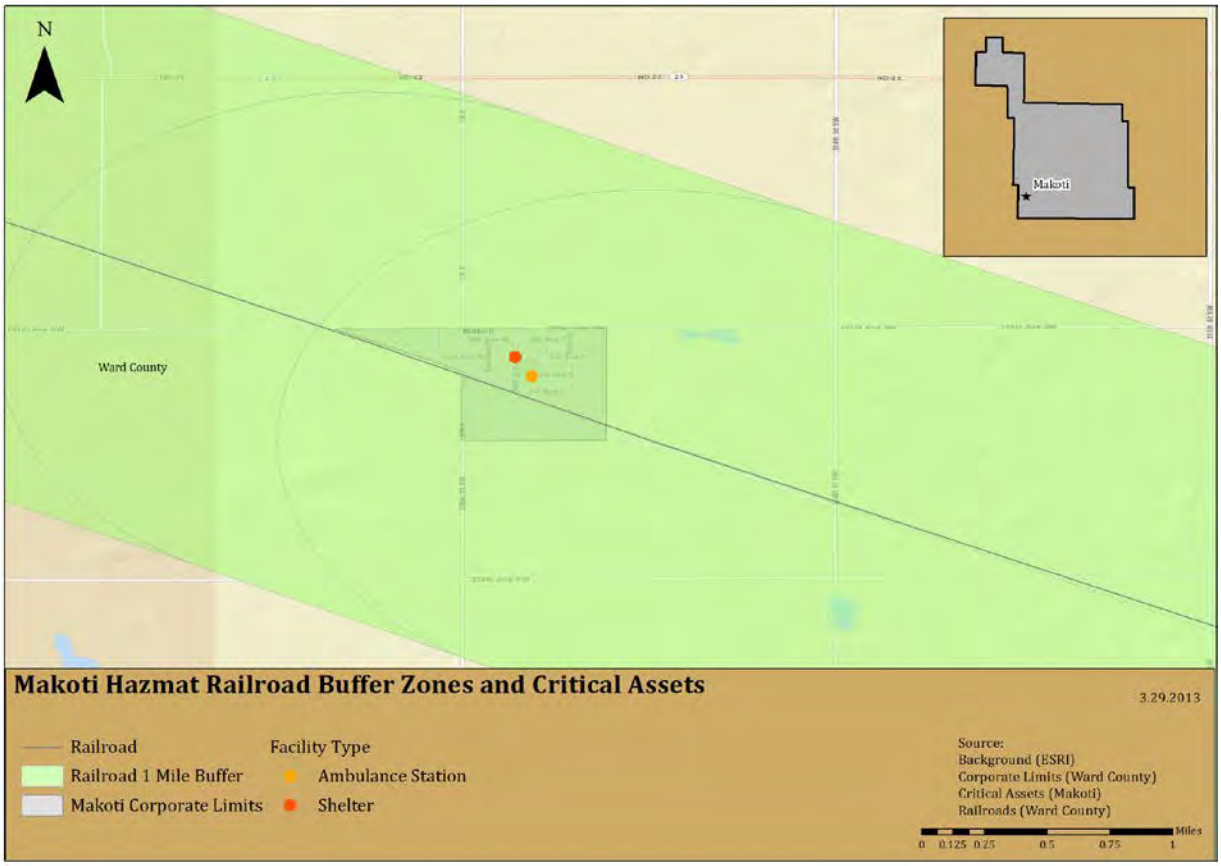
While it is possible that structural losses would occur, these are more likely to occur in the immediate area of an incident involving an explosion or fire. In most cases, the vulnerability lies in contamination and in the resulting loss of use/function prior to clean up.

Estimate of Potential Losses

For the purposes of this assessment, a series of scenarios were created. Too many variables exist to specifically assess the quantitative risks to the city of Makoti – variations in material, concentration, location, weather, wind, time of day, etc., will all result in differing losses. These created scenarios assume that all assets and populations within the area are equally at risk, and no assumptions are made regarding health impacts to people.

Makoti's hazardous materials risk comes from the railroad, and from the materials that are moved on the railroad. Figure 1.3.2.7-1 (following) illustrates the location of the railroad in relation to the city of Makoti, and provides designated buffer zones around it. For the purposes of this assessment, all assets within these buffers would be impacted to some degree.

Figure 11.3.2.7-1
Hazardous Materials Incident Scenario – Railroad



As is evident from the above image, the entire city could be impacted by an incident hazardous materials and the railroad, as could all critical assets within the city.

Identified Data Limitations

Data that could be collected prior to the next update in order to develop a more detailed quantitative risk assessment includes:

- Building valuations for all assets within the city limits; and
- Data regarding the location of vulnerable populations that may require services or special attention during hazardous materials incidents.

11.4 Capability Assessment (Updated)

A capability assessment adds context to a mitigation plan by providing an inventory of a municipality's programs and policies, and an analysis of its capacity to carry them out. These are essential for developing mitigation strategies and actions.

This capability assessment is a review of the city of Makoti's resources in order to identify, review, and analyze what the city is currently doing to reduce losses, and to identify the framework that is in place for the implementation of new mitigation activities. In addition, this assessment will be useful in gauging whether the current local organizational structures and inter-jurisdictional coordination mechanisms for hazard mitigation could be improved, and how.

This local capability is extremely important, because the municipal officials know their own landscape best. Additionally, many of the most critical and effective hazard mitigation strategies and programs, including enforcement of floodplain management, building codes, and land-use planning, require a strong local role to achieve effective implementation.

This capability assessment primarily results from research and interviews with City staff. Relevant documents were reviewed related to hazard mitigation, including the State of North Dakota Hazard Mitigation Plan, as well as state and federal sources related to funding, planning, and regulatory capability. Summary information from these sources can be found in Section 03.

For this assessment, a written questionnaire was provided to the jurisdiction, with a request that it be completed by a person or persons knowledgeable of the topics. The survey generally covered a variety of topics, including administrative and fiscal capacity, planning and zoning, floodplain management, and inter- and intra-governmental coordination.

The general findings of the survey were:

- **Knowledge of mitigation programs and practices** – the city has limited familiarity with hazard mitigation programs, and hazard mitigation does not currently play a role in the decision-making process for the city.
- **Current/ongoing mitigation efforts** – currently, the city's mitigation efforts include participating in the development of the Ward County Hazard Mitigation Plan Update.
- **Intra- and inter-governmental coordination** – the city does participate in intra- and intergovernmental coordination efforts, including participating in planning efforts. For example, the city is working with the county to be part of the Emergency Operations Plan, which will provide some framework for emergencies and disasters in the city.
- **Planning** –the city does not have a great deal of formalized planning efforts. There is no recovery plan, no evacuation plan, and no COOP/COG. There is no master plan, but the city does a land use plan, and is moving towards additional planning efforts. The city is not a member of the NFIP.

- **Staff, personnel, and technical capability** – as of this Plan update, the city has a limited capability and capacity regarding hazard mitigation, and has limited confidence in their abilities to administer hazard mitigation projects and programs. Additional experience and resources would be beneficial to building this capacity.

Like other municipalities within Ward County, Makoti depends on the framework established by the county and state government for technical assistance, and on the state and federal government for funding.

Conclusions and Recommendations
Makoti should continue to build its capability and capacity for disaster recovery and hazard mitigation, and should continue to work with the county towards this end.

11.5 Mitigation Strategy (Updated)

Requirement §201.6(c)(3): *[The plan **shall** include the following] a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs, and resources, and its ability to expand on and improve these existing tools. This section **shall** include:*

Requirement §201.6(c)(3)(i): *A description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.*

Requirement §201.6(c)(3)(ii): *A section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure. All plans approved by FEMA after October 1, 2008 **must** also address the jurisdiction's participation in the NFIP, and continued compliance with NFIP requirements, as appropriate.*

Requirement: §201.6(c)(3)(iii): *An action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization **shall** include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.*

Requirement §201.6(c)(3)(iv): *For multi-jurisdictional plans, there **must** be identifiable action items specific to the jurisdiction requesting FEMA approval or credit of the plan.*

11.5.1 Mitigation Goals

Table 11.5.1-1 (following) provides the mitigation goals that guide the city of Makoti's mitigation strategy.

Table 11.5.1-1
Mitigation Goals (2008 and 2013)

2008 Goals	2013 Goals	Notes
Reduce flood effects in county.	Reduce the effects of hazards throughout the planning area.	Goal remains valid, with minor language change.
Increase public awareness of hazards and support for mitigation activities.	Increase public and local leadership awareness of hazards, risks, and vulnerabilities; increase support for mitigation activities through increased awareness.	Goal remains valid, with minor language change.
Protect health and safety.	Protect public health and safety before, during, and after hazard events.	Goal remains valid, with minor language change.
Improve county-wide communications abilities.	Ensure post-disaster operability of critical assets and infrastructure.	Communications has been addressed through other means; new goal identified as valid.
Improve county-wide capability of response to a hazard event.	Provide long-term mitigation solutions to vulnerable areas/structures that experience hazard damage or loss, particularly those with repetitive damage or loss.	Response capability addressed through other means; new replaced with more focus on mitigation and repetitive loss.

11.5.2 Mitigation Actions

Potential Mitigation Actions
Potential actions were identified in the Steering Committee meetings. This was based in part on consideration of the range of potential mitigation actions for hazards faced by the city.

Flood Mitigation Actions
Retrofitting structures prone to periodic flooding is an effective mitigation technique to reduce the flood loss of property. Techniques include the elevation of structures, mitigation reconstruction, dry flood proofing, wet flood proofing, and drainage improvements and installation of generators.

Elevation: involves raising a structure on a new foundation so that the lowest floor is above the Base Flood Elevation (BFE). Almost any type and size of structure can be elevated.

Dry flood proofing: is completely sealing the exterior of a building to prevent the entry of flood waters. Techniques include the building of floodwalls adjacent to existing walls, the installation of

special doors to seal out floodwaters, and special backflow valves for water and sewer lines. Unlike wet flood proofing, which allows water to enter the house through wall openings, dry flood proofing seals all openings below the flood level and relies on the walls of the house to hold water out.

Wet flood proofing: includes measures applied to a structure that prevent or provide resistance to damage from flooding while allowing floodwaters (this includes flooding of interior spaces with clean water from city water or wells, instead of flood water) to enter the structure or area. Generally, this includes properly anchoring the structure, using flood resistant materials below the determined flood elevation, protection of mechanical and utility equipment, and use of openings or breakaway walls. Wet flood proofing includes low-cost mitigation measures such as raising air conditioners, heat pumps, and hot water heaters on platforms above the determined flood elevation.

Generators: Another cost-effective retrofitting technique includes the installation of generators. By providing power with generators during and after severe storms many critical facilities may continue to provide necessary services to the community. The installation of generators serves to assist the communities with problems experienced from floods, hurricanes, tornadoes, and extreme wind events.

NFIP/CRS Membership: Being a member of the NFIP and/or the CRS program would provide the community with access to flood insurance and with increased floodplain management and regulation, which will lead to a decrease in the level of risk and vulnerability faced by the community as a whole.

Wind Retrofitting Mitigation Actions

Structures can be retrofitted to withstand high winds by installing hurricane shutters, roof tie-downs and other storm protection features. The exterior integrity (i.e. building envelope) is maintained by protecting the interior of the structure and providing stability against wind hazards associated with extreme winds This also improves the ability to achieve a continuous load path. These types of measures can be relatively inexpensive and simple to put in place.

Early Warning Systems

With sufficient warning of a hazard event, a community and its residents can take protective measures such as moving personal property, cars, and people out of harm's way. When a threat recognition system is combined with an emergency response plan that addresses the community's hazard vulnerabilities, considerable damage can be prevented. This system must be coupled to warning the public, carrying out appropriate tasks, and coordinating the hazard response plan with operators of critical facilities. A comprehensive education and outreach program is critical to the success of early warning systems so that the public, operators of critical facilities, and emergency response personnel will know what actions to take when warning is disseminated.

Early warning systems include siren systems, reverse 911 systems, and other technologies used to warn faculty and students of impending events.

Early warning systems serve to assist the communities with problems experienced from floods, hurricanes, tornadoes, and thunderstorms, and can also be used to notify people regarding announced evacuations.

Drought

In general, communities can have little influence or impact on mitigating the impact of droughts except through ensuring adequate water supplies for normal circumstances and through implementation of water conservation measures when drought conditions are imminent. Undertaking drought impact studies, as well as searching for alternative water supplies can both set the foundation for future mitigation measures.

Prioritized Mitigation Actions

The following table (11.5.2-2) identified specific mitigation actions to achieve the stated goals of the Plan. For each action, an appropriate responsible party has been identified, as well as the action's applicability to either new or existing development. Also, each action has been assigned an estimated cost and suggested funding sources.

For all of the actions in the following table (11.5.2-2), the timeframe for implementation is 1-4 years, depending on availability of funding and resources.

Each of these actions has been prioritized. Priorities were determined on a qualitative basis; factors such as general feasibility and anticipated effectiveness of risk reduction. Detailed cost-benefit analyses were not performed, but general cost-effectiveness of the actions was taken into account.

The method that was used to determine prioritization is called STAPLEE. This methodology considers a variety of factors; specifically, Social, Technical, Administrative, Political, Legal, Economic, and Environmental factors. This method helped the city of Makoti to weigh the pros and cons of different alternatives and actions for each of the actions described in Table 11.5.2-2. Table 11.5.2-1 (below) describes the basic criteria considered as part of the prioritization process.

Table 11.5.2-1
STAPLEE Criteria

STAPLEE	Criteria Explanation
S-Social	Mitigation actions are acceptable to the community if they do not adversely affect a particular segment of the population, do not cause relocation of lower income people, and if they are compatible with the community's social and cultural values.
T-Technical	Mitigation actions are technically most effective if they provide long-term reduction of losses and have minimal secondary adverse impacts.

STAPLEE	Criteria Explanation
A-Administrative	Mitigation actions are easier to implement if the jurisdiction has the necessary staffing and funding.
P-Political	Mitigation actions can truly be successful if all stakeholders have been offered an opportunity to participate in the planning process and if there is public support for the action.
L-Legal	It is critical that the jurisdiction or implementing agency have the legal authority to implement and enforce a mitigation action.
E-Economic	Budget constraints can significantly deter the implementation of mitigation actions. Hence, it is important to evaluate whether an action is cost-effective, as determined by a cost benefit review, and possible to fund.
E-Environmental	Sustainable mitigation actions that do not have an adverse effect on the environment, that comply with federal, state, and local environmental regulations, and that are consistent with the community's environmental goals, have mitigation benefits while being environmentally sound.

Cost-Effectiveness

Per the IFR, communities are required to use cost-effectiveness in the prioritization of projects and actions. At this point, the analysis of costs and benefits has been completed at a general level. As funding becomes available, a more extensive and specific process will be completed.

Benefit-cost analysis (BCA) compares the benefits of mitigation actions to the costs, and is a technique used for evaluating the cost-effectiveness of mitigation actions. FEMA requires a BCA for all mitigation projects that received FEMA-funding.

The following Table (11.5.2-2) provides the identified and prioritized mitigation strategy for the city of Makoti.

Table 11.5.2-2
Mitigation Strategy

Goal	Action	Hazard(s)	New or previous action	New or existing development	Responsible department(s)	Resource(s)	Estimated cost	Priority	Notes/Updates
Goal 01: Reduce the effect of hazards throughout the planning area.	Join the NFIP; enforce floodplain management ordinance and practices	Flood	New	New and existing	City Council	General funds; Ward County EMA	$500+	Low	
Goal 01: Reduce the effects of hazards throughout the planning area.	Consider joining the NFIP's Community Rating System program	Flood	New	New and existing	City Council	General funds; Ward County EMA	$500+	Low	
Goal 02: Increase public and local leadership awareness of hazards, risks, and vulnerabilities; increase support for mitigation activities through increases awareness.	Establish public information and outreach program, to educate leaders, residents and business owners about hazards and mitigation	Communicable disease; Drought; Fire; Flood; Severe summer storm; Severe winter storm; Hazardous materials incident	New	NA	City Council	NDDES & FEMA mitigation grant funding; First District Health Unit; American Red Cross; staff time and labor; in-kind contributions; Ward County EMA	$500+	Low	

Goal	Action	Hazard(s)	New or previous action	New or existing development	Responsible department(s)	Resource(s)	Estimated cost	Priority	Notes/Updates
Goal 03: Protect public health and safety before, during, and after hazard events.	Purchase and install emergency power generators for critical assets	Fire; Flood; Severe summer storm; Severe winter storm; Hazardous materials incident	New	Existing	City Council	NDDES & FEMA mitigation grants; general funds; in-kind contributions; Ward County EMA	$25,000+	Moderate	
Goal 03: Protect public health and safety before, during, and after hazard events.	Purchase and install additional warning sirens	Fire; Flood; Severe summer storm; Severe winter storm; Hazardous materials incident	New	Existing	City Council	NDDES & FEMA mitigation grants; general funds; in-kind contributions; Ward County EMA	$25,000+	Moderate	
Goal 04: Ensure post-disaster operability of critical assets and infrastructure.	Develop GIS data regarding recent annexations and/or recently constructed assets, to provide for better hazard and risk mapping	Communicable disease; Drought; Fire; Flood; Severe summer storm; Severe winter storm; Hazardous materials incident	New	New	City Council	Ward County EMA	$500+	Low	

Goal	Action	Hazard(s)	New or previous action	New or existing development	Responsible department(s)	Resource(s)	Estimated cost	Priority	Notes/Updates
Goal 05: Provide long-term mitigation solutions to areas / structures that experience repetitive hazard damage or loss.	Continue collection and storage of data regarding the vulnerabilities of public assets and infrastructure, to develop mitigation actions to better protect them.	Fire; Flood; Severe summer storm; Severe winter storm; Hazardous materials incident	New	New and existing	City Council	General fund; in-kind contributions; Ward County EMA	$500+	Low	