Chapter 6 - Hazard Identification & Local Risk Assessment

Overview

Crawford County is vulnerable to a wide range of natural, technological and human-related hazards. Managing these many varied threats, and protecting life and property, are challenges faced by emergency management officials at all levels of government. In order to attain an effective emergency management capability to mitigate, prepare for, respond to, and recover from all types of hazards, an understanding of the multitude of hazards that confront the County must first be obtained. The first step is to identify potential hazards within a community. Next, the hazards are ranked according to the relative risk to the community. The final step in the process will be to assess the level of vulnerability for each identified hazard.

When coupled with relevant community profile information, hazard identification and vulnerability assessment becomes a powerful planning tool that can enable emergency management officials to set priorities and goals for resource allocation and mitigation and preparedness activities. This process should not be considered a reliable predictor of the occurrence of any hazard. Hazards have always had an uncanny way of occurring when least expected. This section can give communities a realistic base by which to plan for mitigation, preparedness, response and recovery activities.

High Priority Hazards in Crawford County

Fire Hazards

Wildfire

Wildfire is defined as an uncontrolled fire in grass, brush lands, or forested areas. The most immediate dangers from wildfires are the destruction of homes and timber, wildlife, and injury or loss of life to persons who live in the affected area or who are using recreational facilities in the area. Long-term effects can be numerous and include scorched and barren land, soil erosion, landslides/mudflows, water sedimentation, and loss of recreational opportunities. Forests cover approximately one-half of Michigan's total land base. As a result, much of the state is vulnerable to wildfire. In addition, development in and around forests and grasslands is increasing rapidly, making public safety a primary consideration in wildfire mitigation and suppression efforts.

Table 6.1
Number of Wildfires by County in Northeast Michigan, 2001-May of 2012
(MDNR jurisdiction only)

County	Number of Wildfires	Acres Burned
Otsego	**231**	**329**
Alcona	135	376
Alpena	135	303
Cheboygan	136	328
Crawford	224	11,819
Montmorency	110	416
Oscoda	61	256
Presque Isle	74	424

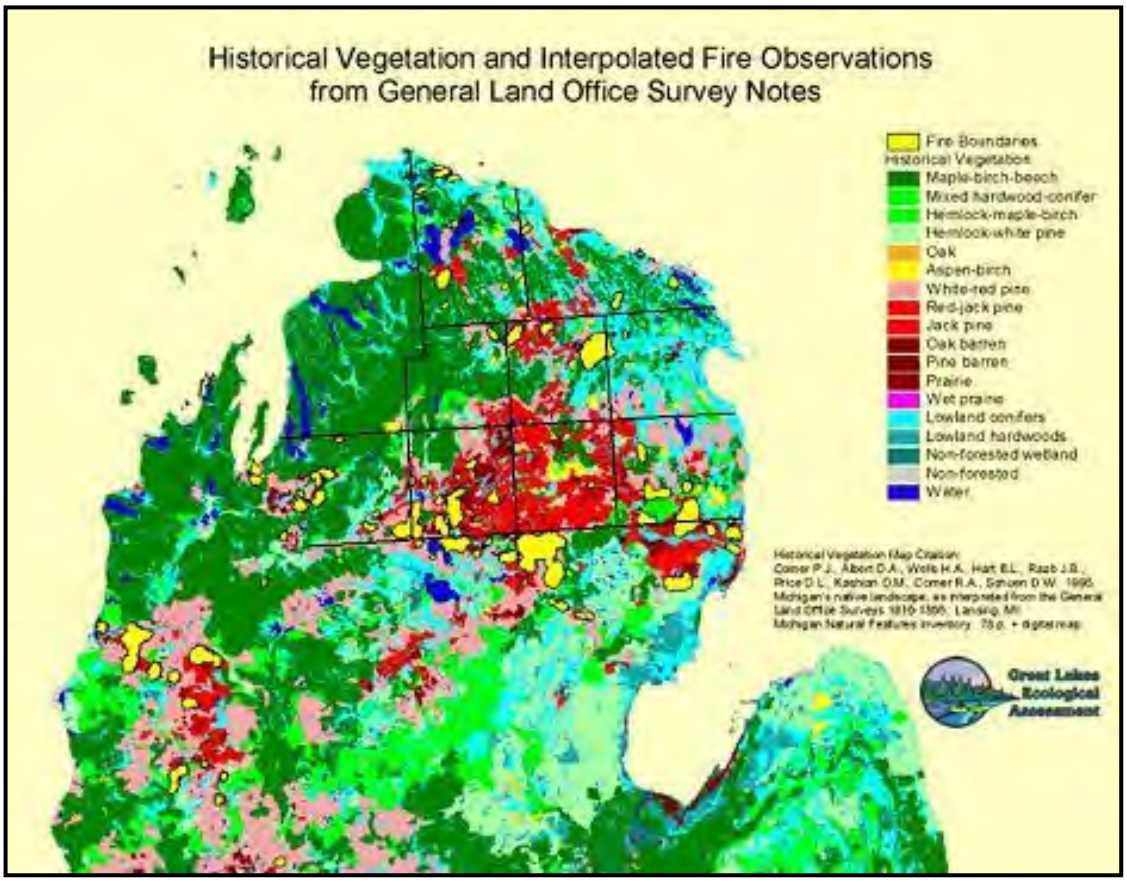
Source: Michigan Department of Natural Resources, Forest Management Division

Almost 91 percent of Crawford County is forested. Forest types vary depending upon the soils, moisture and past activities such as logging, fires and land clearing. Jack pine, aspen-birch and oak are the most common forest types. According to the MIRIS Land Cover/Use Inventory, the most

prevalent forest type is jack pine, covering over 24.8 percent of the county, with dry land oaks covering 21%. The draughty, low fertility sandy soils, found in outwash plains and channels, supported pre-settlement jack pine forests that for thousands of years were perpetuated by wildfires. A review of the pre-settlement vegetation of Crawford County shows extensive areas were covered with pine and oak forests.

Figure 6.1 was compiled by the Great Lakes Ecological Assessment project. The map shows historical vegetation and interpolated fire observations (in yellow) for northern Michigan. Approximate county boundaries were drawn on the maps as a reference. As can be seen on

Figure 6.1, Historic Vegetation/Fire Observations



this map, most of Crawford County was covered with forests prone to wildfires, and wildfires were common. The current distribution of Pine-Oak forest type in Crawford County is depicted in **Figure 6.2**.

Information from the Michigan Department of Natural Resources shows there were 224 wildfires from 2001 to May of 2012 in the county that resulted in 11,819 acres burned. **(Table 6.1)** *It should be noted that the figures shown in the table do not include those wildfires suppressed by local volunteer fire departments or the U.S. Forest Service.* If records from those sources were readily available, the number of wildfires and acres burned would be higher. Nevertheless Crawford County ranks very high among Northeast Michigan counties. The relatively high number of wildfire occurrences in Crawford County during this time may be partially explained by the proximity of population centers and high recreational use within the wildfire prone

pine/oak forests of the County. A review of data provided by the MDNR found between 2001 and 2012 there were seven wildfires greater than 50 acres in size. On April 24 of 2008, a 1,345 acre fire burned to the southern boundary of the community of Grayling. The largest fire in recent history was the Meridian Boundary Fire, which occurred on May 18, 2010, consumed 8,586 acres. **Figure 6.3** shows the location of wildfires in Crawford County from 2001 to May of 2012. **Table 6.2** is a listing of large fires in the Crawford County Area. The table shows number of acres burned and structures lost.

Table 6.2
Large Fire Incidents near Grayling MI

Year	Name	Acres Burned	Structures Damaged or Lost
1980	Mack Lake Fire	over 24,790 acres	1 Fire Fighter Killed 44 homes destroyed
1990	Billman Fire (i.e; Indian Glens)	615 acres	5 houses and 15 outbuildings
1990	Stephan Bridge Fire	5,916 acres	76 houses and 125 outbuildings
	Note- Stephan Bridge and Indian Glens Fires occurred simultaneously, Stephan fire burned over an 8 mile stretch in less than 4 hours		
1992	Luzerne Fire	687 acres	Destroyed several homes
2000	No Pablo Fire	5,200 acres	No structure lost
? 2000	Sunrise Fire	180 acres	1 out building
2001	Jacobs Fire		
2006	Hughes Lake Fire Suppression costs over 1 million	6,000 acres	23 structures
2008	Four Mile Road Fire note this fire closed I-75 for a period and interfaced with the City of Grayling	1,345 acres	4 houses,
2008	Staley Lake Fire	80 acres	0 structures
2010	Meridian Boundary Fire	8,586 acres	12 houses and 39 outbuildings
2010	Range #9 Fire	1,040 acres	4 houses, 3 commercial buildings, 1 outbuilding
	Note, Meridian and Range 9 Fires burned simultaneously		
2011	Howes Lake Fire heavy interface with residential area much potential for loss of homes with this fire	817 acres	2 outbuildings
	Refuge fire		
	Mech Fire		
	Damon Fire		

Source: MDNR | Note, between 1981 and 2000, MDNR recorded 351 wildfires in Kalkaska County, 519 wildfires in Otsego County, 698 wildfires in Crawford County, and 371 wildfires in Roscommon County

Currently, about 2% of all wildfires in Michigan are caused by lightning strikes; the rest are caused by human activity. Outdoor burning is the leading cause of wildfires in Michigan. Most Michigan wildfires occur close to where people live and recreate, which puts both people and property at risk. The immediate danger from wildfires is the destruction of property, timber, wildlife, and injury or loss of life to persons who live in the affected area or who are using recreational facilities in the area.

Although Michigan's landscape has been shaped by wildfire, the nature and scope of the wildfire threat has changed. Michigan's landscape has changed substantially over the last several decades as residential development continues to expand into the same historic wildfire prone areas. A 60% increase in the number of rural homes since the 1980's has increased the potential for loss of life and property from wildfires. There are simply not enough fire suppression forces available in rural areas to protect every structure from wildfire. The large number of permanent and seasonal homes in northeastern Michigan, coupled with increased tourism during driest, and therefore most vulnerable, times of the year greatly increases the risk from wildfires.

Scrap Tire Fires

Any instance of uncontrolled burning scrap tire storage or recycling site. Each year in the U.S., an estimated 250 million vehicle tires have to be disposed of. Michigan alone generates 7.5-9 million scrap tires annually. Many of these scrap tires end up in disposal sites (legal or illegal), some of which may have several hundred thousand tires. Michigan currently has more than 24 million scrap tires at disposal sites scattered across the state. Tire disposal sites can be fire hazards due to the large quantity of "fuel" onsite, coupled with the fact that the shape of a tire allows air to flow into the interior of a tire pile, rendering standard firefighting practices nearly useless. Flowing burning oil released by the burning tires spreads the fire to adjacent areas. Some scrap tire fires have burned for months, creating acrid smoke and an oily residue that can leach into the soil, creating long-term environmental problems. Scrap tire fires differ from conventional fires in several respects: 1) even relatively small scrap tire fires can require significant resources to control and extinguish; 2) the costs of fire management are often far beyond that which local government can absorb; 3) the environmental consequences of a major tire fire can be significant; and 4) the extreme heat from the fire converts a standard passenger vehicle tire into about two gallons of oily residue, which can then leach into the soil or migrate to streams. There are no known tire storage sites in Crawford County.

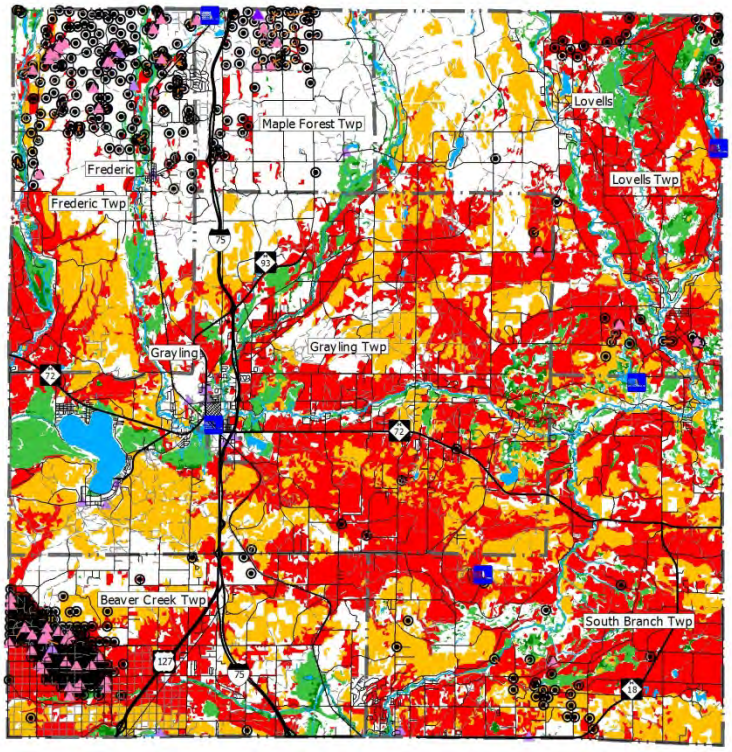


Figure 6.2

CRAWFORD COUNTY

HAZARDS MAP

crawford_fire_forest
Oil/Gas Wells
Crawford_part_615
Crawford_part_201
Contamination Sites
Unimproved Roads
Streets
Railroads
Highways
Dams

NATIONAL WETLANDS INVENTORY

Aquatic Bed
Emergent
Forested
Scrub-Shrub
Unconsolidated Bottom
Unconsolidated Shore
Other

FIRE PRONE FORESTS

Central Hardwood
Pine

0 2 4 6
Miles

NEMCOG

N

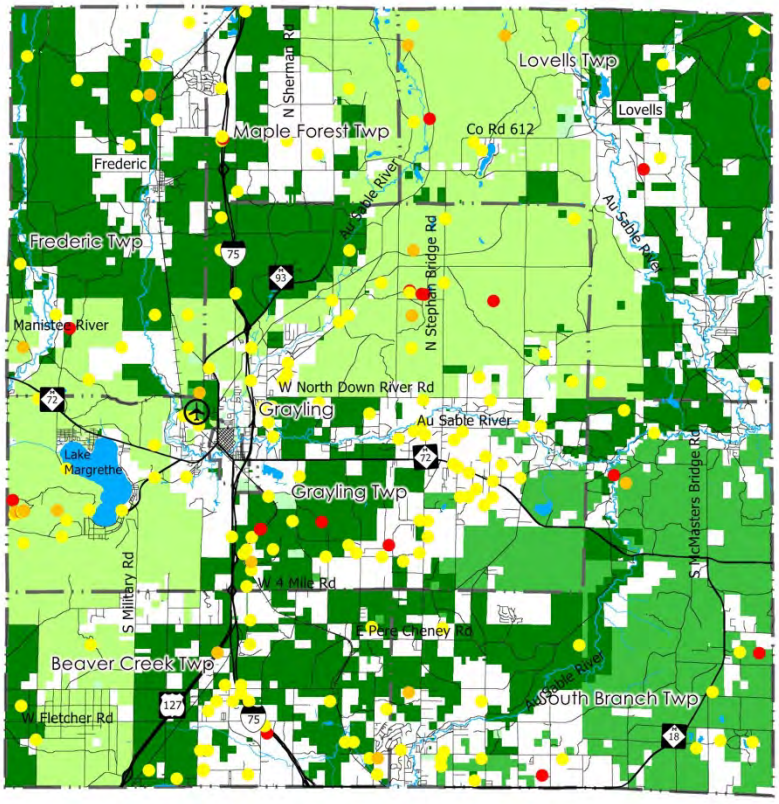


Figure 6.3

CRAWFORD COUNTY

WILDFIRES LOCATION MAP

MICHIGAN
MILITARY
USA
OTHER PUBLIC
STREETS
RAILROADS
HIGHWAYS

WILDFIRES 2001-2012

LESS THAN 5 ACRES
5 to 10 ACRES
GREATER THAN 10 ACRES

0 2.5 5 7.5
Miles

N

DATA SOURCE:
MICHIGAN CENTER FOR GEOGRAPHIC INFORMATION
CRAWFORD COUNTY

MAP BY:
NORTHEAST MICHIGAN COUNCIL OF GOVERMMENTS

Structural Fires

Any instance of uncontrolled burning which results in structural damage to residential, commercial, industrial, institutional, or other properties in developed areas. In terms of average annual loss of life and property, structural fires - often referred to as the "universal hazard" because they occur in virtually every community - are by far the biggest hazard facing most communities in Michigan and across the country. Each year in the U.S., fires result in approximately 5,000 deaths and 300,000 injuries requiring medical treatment. According to some sources, structural fires cause more loss of life and property damage than all types of natural disasters combined. Particularly devastating are large urban conflagrations in which multiple structures are damaged or destroyed. Not surprisingly, Michigan's structural fire experience mirrors the national figures. The State Fire Marshal estimates that a structural fire occurs every 24 minutes in Michigan. The total number of all fires in Crawford County during 2003 was 70, with a total property/contents loss of $318,650.

Crawford County, unlike some of the more rural neighboring counties relays on a combination of paid and non-paid fire departments. **(See Chapter 5)** This provides the county with an excellent array of firefighting services available to the respective communities. Lack of full-time professional fire fighters in outlying rural townships means less time available to conduct fire inspections and take other preventive measures necessary to lessen structural fire threat. Out of necessity, efforts in these communities are directed more at fire suppression. This typical scenario in rural areas of the state poses great challenges for maintaining a sustainable fire prevention and inspection program. Crawford County also benefits from firefighting support from Camp Grayling.

Another major challenge facing Michigan fire service is the lack of a state-mandated fire safety code and code enforcement program for all occupancies. The State enforces fire safety codes in schools, dormitories, health care facilities, and correctional facilities, plus some businesses; the remainder of the job is left to local officials. Since there is no uniform, mandated fire safety code at the state level, a variety of local ordinances have emerged. Some communities may not have fire safety codes. This problem manifests itself more seriously in rural areas and small towns, which typically have few, if any, paid full-time fire fighters. Even if a mandated fire safety code were instituted statewide, it wouldn't totally solve the problem of structural fire prevention because the costs of compliance in existing buildings would often be prohibitive for business owners. Such a measure would, however, help ensure that new construction doesn't compound the problem.

High Priority Technological Hazards

Hazardous Materials Incident -- Fixed Site

A hazardous materials incident is defined as any uncontrolled release of hazardous materials from a fixed site, capable of posing a risk to health, safety, property and the environment. Hazardous materials are present in quantities of concern in business and industry, agriculture, universities, hospitals, utilities, and other community facilities. Hazardous materials are materials or substances, which, because of their chemical, physical, or biological nature, pose a potential threat to life, health, property and the environment if they are released. Examples of hazardous materials include corrosives, explosives, flammable materials, radioactive materials, poisons, oxidizers, and dangerous gases. Hazardous materials are highly regulated by the government to reduce risk to the general public, property and the environment. Despite precautions taken to ensure careful handling during the manufacture, transport, storage, use and disposal of these materials, accidental releases are bound to occur. Areas at most risks

are within a 1-5 mile radius of identified hazardous material sites. Many communities have detailed plans and procedures in place for responding to incidents at these sites, but releases can still cause severe harm to people, property and the environment if proper mitigative action is not taken in a timely manner.

The world's deadliest hazardous material incident occurred on December 4, 1984, in Bhopal, India. A cloud of methyl isocyanate gas, an extremely toxic chemical, escaped from a Union Carbide chemical plant, killing 2,500 people and injuring tens of thousands more. This incident triggered historical Federal legislation intended to minimize such disasters from occurring in the United States.

There are currently six 302 sites located in Crawford County.

Verizon Roscommon/Skyline Central Office. 4279 Skyline Rd. Grayling, MI. Battery Sulfuric Acid.
Shell Western E&P, Frederic 2 CPF, 11700 Newman Rd. Frederic, MI. Hydrogen Sulfide
Northern Pure Ice Company, 427 S- I-75 Business Loop, Grayling, MI. Ammonia, NH_3.
Weyerhaeuser Company, 4111 W. Four Mile Rd. Grayling, MI
Grayling Generating Station, 4400 W. Four Mile Rd. Grayling, MI.
Georgia-Pacific Resins, Inc, 4113 W. Four Mile Rd. Grayling, MI.

There are also three 302 sites located on Camp Grayling property and fall under the mitigative jurisdiction of the Federal Government.

Hazardous Material Incident – Transportation

Transportation related hazardous material incidents are defined as an uncontrolled release of hazardous materials during transport, capable of posing a risk to health, safety, property or the environment. All modes of transportation - highway, railroad, seaway, airway, and pipeline - are carrying thousands of hazardous material shipments on a daily basis through local communities. A transportation accident involving any one of those hazardous material shipments could cause a local emergency affecting many people. The U.S. Department of Transportation regulates the transportation and shipping of over 18,000 different materials. Areas most at risk are within a 1-5 mile radius of a major transportation route along which hazardous material shipments move. All areas in Michigan are potentially vulnerable to a hazardous material transportation incident, although the heavily urbanized and industrialized areas in southern Michigan are particularly vulnerable due to the highly concentrated population.

A complex of transportation routes cross Crawford County. These include a major regional East-West state highway,M-18, M-72, and North-South Interstate I-75, and its junction with U.S.127 in Beaver Creek Township. **(Figure 6.4)**The large volume of hazardous material shipments that pass through the County on a daily basis focus on the City of Grayling and leave the area vulnerable to incidents involving hazardous material.

Air, Land and Water Transportation Accidents

A crash or accident involving an air, land or water-based commercial passenger carrier resulting in death or serious injury. Vulnerable areas would include: 1) communities with, or near, an airport offering commercial passenger service; 2) communities with railroad tracks on which commercial rail passenger service is provided; 3) communities in which commercial intercity passenger bus or local transit bus service is provided; 4) communities with school bus service; and 5) communities in which commercial marine passenger ferry service is provided. A serious accident involving any of the above modes of passenger transportation could result in a mass casualty incident, requiring immediate life-saving community response. In addition, a marine

transportation accident would require a water rescue operation, possibly under dangerous conditions on the Great Lakes.

In terms of commercial passenger transportation service, Michigan has: 1) approximately 19 airports that offer commercial air passenger service; 2) 130 certified intercity passenger bus carriers providing service to 220 communities; 3) 72 local bus transit systems serving 85 million passengers; 4) 19 marine passenger ferry services; and 5) 3 intercity rail passenger routes operating on 568 miles of track, along 3 corridors, serving 22 communities.
The Grayling AAF Airport is a multiple runway airport located on the Grayling Army Airfield and is the only airport in Crawford County. This airport is owned and operated by the U.S. Government but serves the City of Grayling and Crawford County private air traffic (**Figure 6.5).** Although Crawford County does not have a commercial airport, passenger rail service, commercial marine passenger service. School bus transportation and specialized public transit service do exist in the county. Accidents on either system could result in injuries and loss of life.

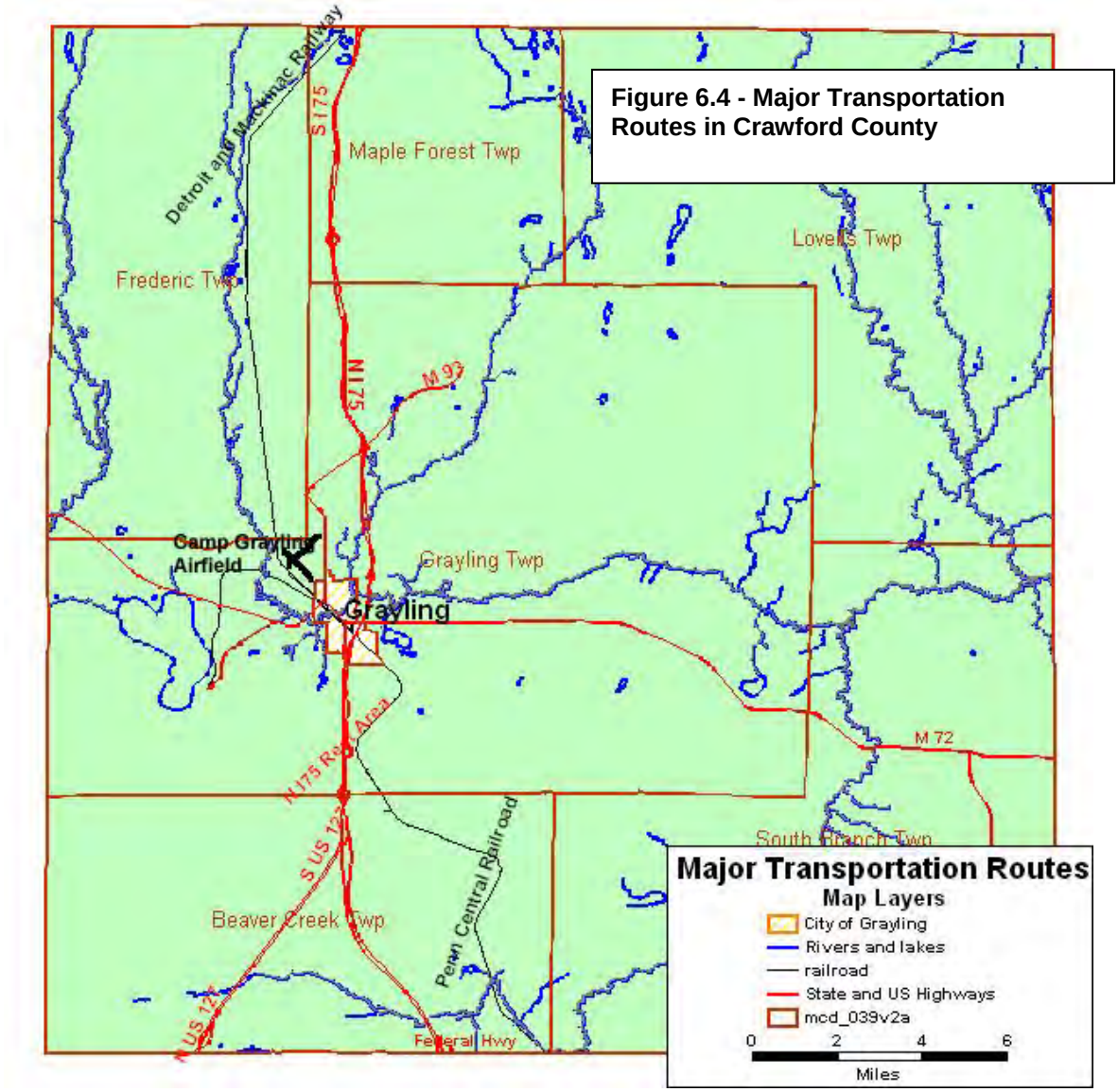
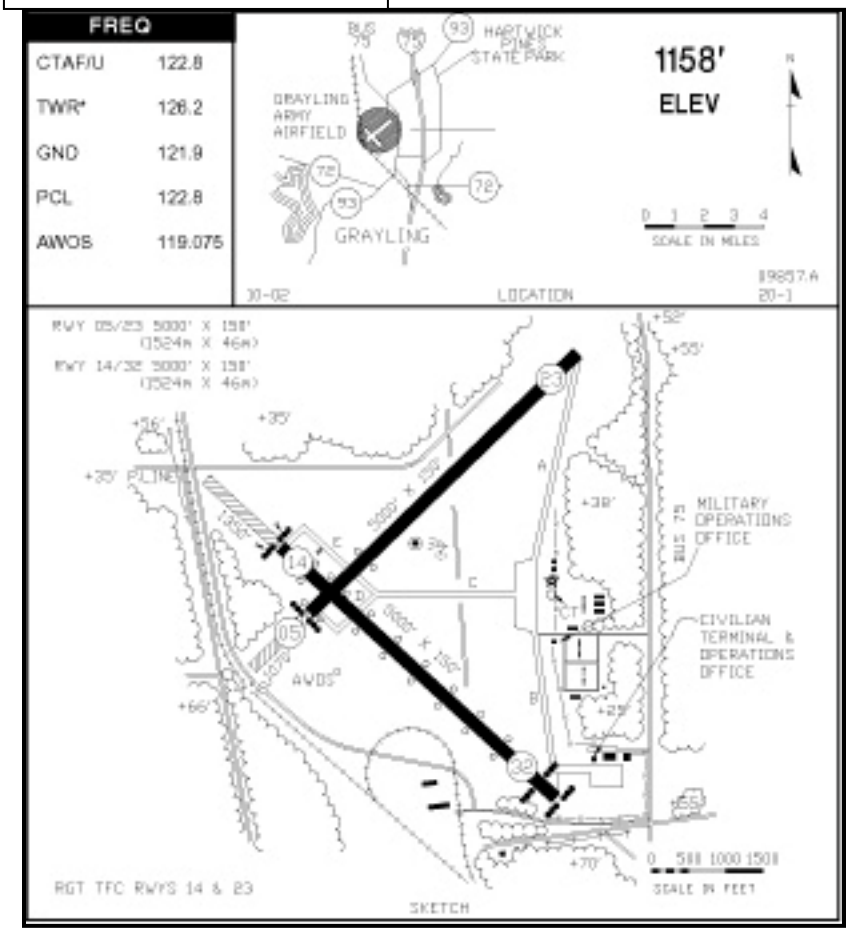


Figure 6.4 - Major Transportation Routes in Crawford County

Figure 6.5
Camp Grayling Airfield



Infrastructure Failures

Infrastructure failure is defined as failure of critical public or private utility infrastructure resulting in a temporary loss of essential functions and/or services. Such interruptions could last for periods of a few minutes to several days or more. Public and private utility infrastructure provides essential life supporting services such as electric power, heating and air conditioning, water, sewage disposal and treatment, storm drainage, communications, and transportation. When one or more of these independent, yet inter-related systems fails due to disaster or other cause - even for a short period of time - it can have devastating consequences. For example, when power is lost during periods of extreme heat or cold, people can literally die in their homes.

When the water or wastewater treatment systems in a community are inoperable, serious public health problems arise that must be addressed immediately to prevent outbreaks of disease. When storm drainage systems fail due to damage or an overload of capacity, serious flooding can occur. All of these situations can lead to disastrous public health and safety consequences if immediate mitigation steps are not taken. Typically, it is the most vulnerable segments of society - the elderly, children, ill or frail individuals, etc., that are most heavily impacted by an infrastructure failure. If the failure involves more than one system, or is large enough in scope and magnitude, whole communities and even regions can be negatively impacted.

Oil and Gas Pipeline Accidents

The potential for an uncontrolled release of oil or gas, or the poisonous by-product hydrogen sulfide, from a pipeline exists in Crawford County. As a major oil and gas consumer in the United States, vast quantities of oil and natural gas are transported through and stored in Michigan. Though often overlooked as a threat because much of the oil and gas infrastructure in the state is located underground, oil and gas pipelines can leak, erupt or explode, causing property damage, environmental contamination, injuries and loss of life. In addition to these hazards, there is also a danger of hydrogen sulfide release. Hydrogen sulfide is an extremely poisonous gas that is also explosive when mixed with air temperatures of 500 degrees or above. In addition to pipelines, these dangers can be found around oil and gas wells, pipeline terminals, storage facilities, and transportation facilities where the gas or oil has a high sulfur content.

Smaller lines from a delivery network that supplies natural gas to homes and businesses. Another network of extractive lines is associated with the 950 oil and gas wells that have been drilled in the county. Of these wells, 412 are producing, 182 are plugged and restored, and 290 have terminated permits. Oil wells account for 222 of the wells, while 220 are gas wells. Lines connect each well to a small processing/compressor facility. Brine and moisture is removed from the natural gas, and then the gas is transmitted through high pressure lines to major processing and storage facilities. There are no documented major incidents, however, with the miles of pipelines associated with extractive and delivery systems the potential of hazardous incidents does exist.

Oil and Gas Well Accidents

Oil and natural gas are produced from fields scattered across 63 counties in the Lower Peninsula. Since 1925, over 44,000 oil and natural gas wells have been drilled in Michigan, of which roughly half have produced oil and gas. To date, Michigan wells have produced approximately 1.4 billion barrels of crude oil and 4 trillion cubic feet of gas. The petroleum and natural gas industry is highly regulated and has a fine safety record, but the threat of accidental releases, fires and explosions still exists.

According to information provided by the MDEQ, there are 412 producing oil and gas wells located around the periphery of Crawford County**. (Figure 6.6**) Most of these wells are located in the northwest quadrant of the County in Frederic and Maple Forest Townships, with another cluster of wells located in the southwest corner of the county in Beaver Creek Township. Numerous small, low-pressure gas lines connect wells to the small processing facilities. Brine and moisture is removed from the natural gas, and then the gas is transmitted through high-pressure lines to major processing and storage facilities. There are no documented major incidents, however, with the miles of pipelines associated with extractive and delivery systems the potential of hazardous incidents does exist.

In addition to these hazards, many of Michigan's oil and gas wells contain extremely poisonous hydrogen sulfide (H2S) gas. Hydrogen sulfide is a naturally occurring gas mixed with natural gas or dissolved in the oil or brine and released upon exposure to atmospheric conditions. Over 1,300 wells in Michigan have been identified as having H2S levels exceeding 300 parts per million (ppm). As the table below indicates, at concentrations of 700 ppm, as little as one breath of hydrogen sulfide can kill. Although hydrogen sulfide can be detected by a "rotten egg" odor in concentrations from .03 ppm to 150 ppm, larger concentrations paralyze a person's olfactory nerves so that odor is no longer an indicator of the hazard. Within humans, small concentrations can cause coughing, nausea, severe headaches, irritation of mucous membranes, vertigo, and loss of consciousness. Hydrogen sulfide forms explosive mixtures

with air at temperatures of 500 degrees Fahrenheit or above, and is dangerously reactive with powerful oxidizing materials. Hydrogen sulfide can also cause the failure of high-strength steels and other metals. This requires that all company and government responders be familiar not only with emergency procedures for the well site, but also with the kinds of materials that are safe for use in **sour gas well** response. Currently there is a hydrogen sulfide well listed as a 302 site for Crawford County.

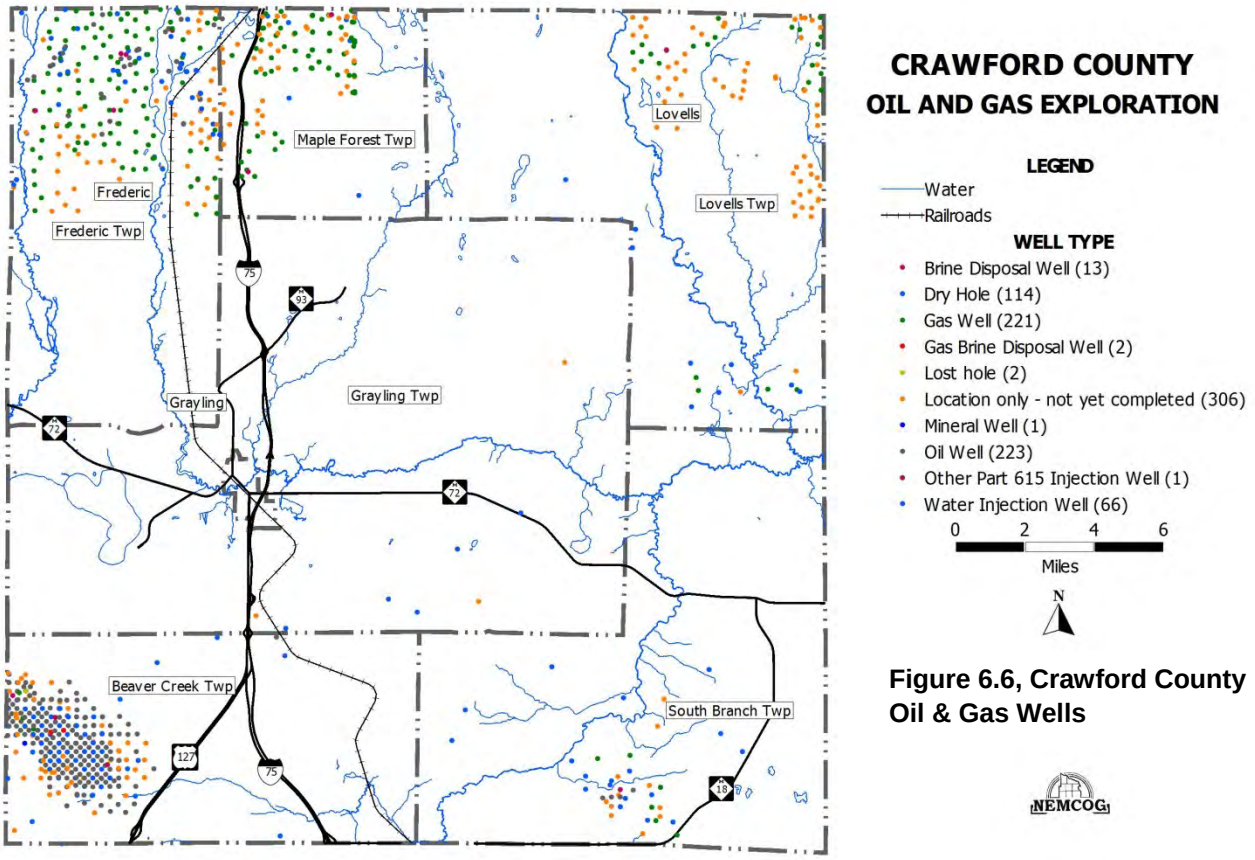


Figure 6.6, Crawford County Oil & Gas Wells

Natural Hazards

Severe Summer Weather Hazards

Although potential for violent storms is not predictable and can occur anywhere in the county, more densely populated urbanized sections of the county provide the greatest human/property risk and require the most concentrated mitigative consideration and action.

Hailstorms:

Hailstorms develop in a condition where atmospheric water particles from thunderstorms form into rounded or irregular lumps of ice that fall to the earth. Hail is a product of the strong thunderstorms that frequently move across the state. As one of these thunderstorms passes over, hail usually falls near the center of the storm, along with the heaviest rain. Sometimes, however, strong winds occurring at high altitudes in the thunderstorm can blow the hailstones away from the storm center, causing an unexpected hazard at places that otherwise might not appear threatened. Hailstones range in size from a pea to a golf ball, but hailstones larger than

baseballs have occurred in the most severe thunderstorms. Hail is formed when strong updrafts within the storm carry water droplets above the freezing level, where they remain suspended and continue to grow larger, until their weight can no longer be supported by the winds. They finally fall to the ground, battering crops, denting autos, and injuring wildlife and people. Large hail is a characteristic of severe thunderstorms, and it often precedes the occurrence of a tornado.

> *According to the Michigan Hazard Analysis Plan: A line of severe thunderstorms that ravaged northern Lower Michigan during the weekend of September 26-27, 1998 produced hail up to 2" in diameter in Manistee County, destroying an estimated 30,000-35,000 bushels of apples at area farms. The same storm system produced tennis ball size hail north of the town of Gladwin, which damaged several homes and vehicles. In Arenac County, near Sterling, 3.5" diameter hail damaged crops and injured some livestock at area farms, and damaged several homes, satellite dishes, and vehicles.*

The National Weather Service began recording hail activity in Michigan in 1967. Statistics since that time indicate that approximately 50% of the severe thunderstorms that produce hail have occurred during the months of June and July, and nearly 80% have occurred during the prime-growing season of May through August. As a result, the damage to crops from hail is often extensive.

The incidence of hail follows the incidence of severe thunderstorms. Therefore, those areas of the state most prone to severe thunderstorms are also the area's most prone to large and damaging hail. Generally, severe thunderstorms that produce hail occur more frequently in the southern half of the Lower Peninsula than any other area of the state. However, damaging hail has occurred in every part of Michigan. The National Weather Service forecasts of severe thunderstorms usually provide sufficient warning time to allow residents to take appropriate action to reduce the effects of hail damage to vehicles and some property. However, little can be done to prevent damage to crops.

The National Climate Data Center reports 25 hail events in Crawford County since July 7, 1980, or an average of one storm each year. The largest diameter hailstone recorded in the County was 1.75 inches, and was recorded for three events during the same period.

Tornadoes**:**

A tornado is defined as a violently whirling column of air extending downward to the ground from a cumulonimbus cloud. The funnel cloud associated with a tornado may have winds up to 300 miles per hour and an interior air pressure that is 10-20 percent below that of the surrounding atmosphere. The typical length of a tornado path is approximately 16 miles, but tracks much longer than that - some even up to 200 miles - have been reported. Tornado path widths are generally less than one-quarter mile wide. Historically, tornadoes have resulted in the greatest loss of life of any natural hazard, with the mean national annual death toll being 111 persons. Property damage from tornadoes is in the hundreds of millions of dollars every year. Michigan averages approximately 16 tornadoes per year, most occurring in the southern Lower Peninsula. On average, one tornado is reported every 3.4 years in Crawford County.

Although relatively rare, tornadoes have occurred in Crawford County and have caused extensive damage. Michigan is located on the northeast fringe of the Midwest tornado belt. The lower frequency of tornadoes occurring in Michigan may be, in part, the result of the colder water of Lake Michigan during the spring and early summer months, a prime period of tornado activity. Michigan averages approximately 15 tornadoes per year. Over the past 31 years, 9

tornadoes have been recorded in Crawford County. Tornadoes are most common in the afternoon although 2 of the tornadoes in Crawford County occurred during the A.M. In Northern Michigan tornadoes are most likely in the summer months, although tornadoes have occurred in the spring and fall. In Crawford County, a tornado did occur on April 19, 1975, but the remainder were during the summer months. The Fujita Scale ranks tornadoes from F0 to F6 based on wind speed and intensity. F0 and F1 tornadoes are described as weak tornados with wind speeds from 40 to 112 mph, F2 and F3 are strong tornados with wind speeds from 113-206 mph, F4 and F5 are violent tornados with wind speeds from 207 to 318 mph and an F6 is an inconceivable tornado with wind speeds above 319 mph. Of the 9 tornadoes that have been recorded in Crawford County since May 20, 1975, two were F0, five were F1 and two were F0. Tornadoes occurred at a rate of about 1 each 10 years. The total accumulated reported damage of all these storms was $353,000.

Severe Winds (Windstorm)

According to the National Weather Service, winds in excess of 58 miles per hour are classified as a windstorm. Windstorms are a fairly common occurrence in many areas in Michigan. Along the Great Lakes shoreline, strong winds occur with regularity, and gusts of over 74 miles per hour (hurricane velocity) do occasionally occur in conjunction with a storm front. Severe windstorms can cause damage to homes and businesses, power lines, trees and agricultural crops, and may require temporary sheltering of individuals without power for extended periods of time. Some severe windstorms that have struck Lower Michigan are summarized in (**Table 6.3).**

Lightning:

The discharge of electricity from within a thunderstorm. Although lightning is often perceived as a minor hazard, it damages many structures and kills and injures more people in the U.S. per year, on average, than tornadoes or hurricanes. Many lightning deaths and injuries could be avoided if people would have more respect for the threat that lightning presents. *Michigan ranks second in the nation in both lightning-related deaths and lightning-related injuries.*
The following information is compiled in the Michigan Hazard Analysis Plan: Statistics compiled by the National Oceanic and Atmospheric Administration (NOAA) and the National Lightning Safety Institute (NLSI) for the period 1959-1994 revealed the following about lightning fatalities, injuries and damage in the United States:

Location of Lightning Strikes
- 40% are at unspecified locations
- 27% occur in open fields and recreation areas (not golf courses)
- 14% occur to someone under a tree (not on golf course)
- 8% are water-related (boating, fishing, swimming, etc.)
- 5% are golf-related (on golf course or under tree on golf course)
- 3% are related to heavy equipment and machinery
- 2.4% are telephone-related

Gender of Victims: 84% are male; 16% are female
Months of Most Strikes: July (30%); August (22%); June (21%)
Days of Most Strikes: #1 – Sunday; #2 – Wednesday; #3 – Saturday
Time of Most Strikes: • 2:00 PM – 6:00 PM
Number of Victims: • One victim (91%); two or more victims (9%)

Table 6.3 – Severe Windstorms in Northern Michigan	
Location	**Summary of Impact**
West Michigan	On April 6-7, 1997, an intense early spring low pressure system moving across the Great Lakes brought gale force winds to much of Lower Michigan. Wind gusts of 50-70 miles per hour created 10-15 foot waves on the Lake Michigan shoreline, causing widespread wind damage and lakeshore beach erosion. Private damage was estimated at $5 million, most of that occurring in a handful of West Michigan counties. The winds downed numerous trees and power lines across the region, causing roof damage to many structures and power outages for nearly 200,000 Consumers Energy electrical customers. No deaths or injuries were reported in this severe wind event.
Lower Michigan	On April 30, 1984 a windstorm struck the entire Lower Peninsula, resulting in widely scattered damage, 1 death, and several injuries. Wind gusts measured up to 91 miles per hour in some areas. Damage was widely scattered, but extensive, with 6,500 buildings, 300 mobile homes, and 5,000 vehicles being damaged. Over 500,000 electrical customers lost power. In addition, 10-16 foot waves on Lake Michigan caused severe shore erosion, collapsing some cottages and driving many boats aground.
Northern Lower Michigan	Sept. 26-27, 1998: During the weekend of September 26-27, 1998, severe thunderstorms ravaged northern Lower Michigan, producing strong winds that damaged or destroyed homes, businesses and public facilities, and downed trees and power lines. Otsego County, and specifically the city of Gaylord, was hardest hit, although damage was also reported in Crawford and Charlevoix counties as well. The storm front, which ran along and north of the M-32 corridor from East Jordan to Alpena, was approximately 12 miles wide and 15 miles long. When the front slammed into Gaylord, wind speeds had reached hurricane force of 80-100 miles per hour. The wind was accompanied by brief heavy rainfall and golf ball size hail. The storm lasted only a few minutes in Gaylord, but the damage was tremendous. Thousands of trees were snapped off at waist level, homes and businesses were torn apart, power lines were downed, and several public facilities were substantially damaged – including the Otsego County Courthouse, which lost half of its roof. Approximately 818 homes were damaged throughout Otsego County, including 47 that were destroyed and 92 that incurred major damage. In addition, the storm injured 11 persons – none seriously. Region-wide, about 12,000 electrical customers lost power. A Governor's Disaster Declaration was granted to the county to provide state assistance in the debris cleanup effort.
West-Central and Central Michigan	On May 31, 1998, a line of severe thunderstorms passed through west-central and central Michigan, producing in some areas hurricane and tornado-force winds that damaged or destroyed 1,500 homes and 200 businesses, severely damaged numerous public facilities, and downed thousands of trees and power lines throughout the 15 county affected area. The downed power lines left nearly 900,000 electrical customers without power, some for up to one week. The storms directly and indirectly caused four fatalities and injured over 140 more. The severe winds were measured at speeds of up to 130 miles per hour in some areas – equivalent to an F2 tornado or strong hurricane. Damage to homes and businesses were estimated at $16 million, while public damage totaled another $36 million. A Presidential Major Disaster Declaration was granted for 13 of the 15 counties, making available both public and hazard mitigation assistance to affected local jurisdictions. In addition, Small Business Administration disaster loans were made available to 11 of the 15counties to help rebuild homes and businesses damaged in the storms.
Statewide	Nov. 10-11, 1998:One of the strongest storms ever recorded in the Great Lakes moved across Michigan on the 10th and 11th of November, 1998, producing strong, persistent winds that damaged buildings, downed trees and power lines, killed one person, and left

	over 500,000 electrical customers in the Lower Peninsula without power. Wind gusts of 50-80 miles per hour were common, and a peak gust of 95 miles per hour was reported on Mackinac Island. Damage was widespread but relatively minor for a storm of that intensity. However, there were several pockets of significant damage across the state. The U.S. Forest Service reported that at least $10 million worth of timber was lost in the Ottawa and Hiawatha National Forests.

NLSI estimates that 85% of lightning victims are children and young men (ages 10-35) engaged in recreation or work-related activities. Approximately 20% of lightning strike victims die, and 70% of survivors suffer serious long-term after-effects such as memory and attention deficits, sleep disturbance, fatigue, dizziness, and numbness.

Unfortunately, lightning has taken a tremendous toll on Michigan's citizens in terms of injury and loss of life. Since 1959 when the National Weather Service began keeping such records, Michigan has incurred 99 lightning deaths, 693 lightning injuries, and 792 lightning casualties (deaths and injuries combined) – consistently ranking it near the top of the nation in all three categories. During the period 1959-1994 (the last period for which composite statistics are available), Michigan was ranked 2nd nationally (behind Florida) in lightning injuries, 12th nationally in lightning deaths, and 2nd nationally (again, behind Florida) in lightning casualties. Undoubtedly, the fact that Michigan is an outdoor recreation-oriented state contributes heavily to its high lightning death and injury tolls. As the table below indicates, Michigan's lightning deaths and injuries are fairly consistent with the national trends in terms of location of deadly or injury-causing strikes: **(Table 6.4).** The National Climatic Data Center reports 3 lightning events in Crawford County, injuring 2 people since September 10, 1993

Table 6.4 -- Lightning-Related Deaths in Michigan: 1959-July 2001

Number of Deaths	Location	Percent of Total
28	Open fields, ball fields	28%
26	Under trees (not golf)	27%
11	Boats/water related	11%
10	Golf Course	10%
4	Near tractors/heavy equipment	4%
2	At telephone	2%
18	Other locations/unknown	18%

Source: Storm Data, National Climatic Data Center

Other Natural Hazards in Crawford County

Drought

According to the Michigan Hazard Analysis, drought is a normal part of the climate of Michigan and of virtually all other climates around the world – including areas with high and low average rainfall. Drought differs from normal arid conditions found in low rainfall areas in that aridity is a permanent characteristic of that type of climate. Drought is the consequence of a natural reduction in the amount of precipitation expected over an extended period of time, usually a season or more in length. The severity of a drought depends not only on its location, duration, and geographical extent, but also on the water supply demands made by human activities and

vegetation. This multi-faceted nature of the hazard makes it difficult to define a drought and assess when and where one is likely to occur.

Droughts can cause many severe impacts to a wide range of communities and economic activity across the Crawford County, including:: 1) water shortages for human consumption, industrial, business and agricultural uses, power generation, recreation and navigation; 2) a drop in the quantity and quality of agricultural crops; 3) decline of water quality in lakes, streams and other natural bodies of water; 4) malnourishment of wildlife and livestock; 5) increase in wildfires and wildfire-related losses to timber, homes and other property; 6) declines in tourism in areas dependent on water-related activities; 7) declines in land values due to physical damage from the drought conditions and/or decreased economic or functional use of the property; 8) reduced tax revenue due to income losses in agriculture, retail, tourism and other economic sectors; 9) increases in insect infestations, plant disease, and wind erosion; and 10) possible loss of human life due to food shortages, extreme heat, fire, and other health-related problems such as diminished sewage flows and increased pollutant concentrations in surface water. Some other drought related economic impacts are reflected in **(Table 6.4).**

In response to the 1988 drought, Michigan communities instituted temporary water use restrictions. To stem the potential for wildfire in Michigan, the Governor issued (in June, 1988) a statewide outdoor burning ban. The summer of 1998 drought / heat wave from Texas to the Carolinas caused an estimated $6-9 billion in damage. The summer of 1999 drought / heat wave caused over $1 billion in damage – mainly to agricultural crops in the Eastern U.S. The summer of 2000 drought / heat wave in the South-Central and Southeastern U.S. resulted in over $4 billion in damages and costs. The drought / heat wave that struck Michigan during the summer of 2001 damaged or destroyed approximately one-third of the state's fruit, vegetable and field crops, resulting in a U.S. Department of Agriculture Disaster Declaration for 82 of the state's counties.

In addition, the drought / heat wave caused water shortages in many areas in Southeast Michigan, forcing local officials to issue periodic water usage restrictions. In Crawford County, impacts from extended drought increased potential for wildfires, reduction in timber production, and loss of tourism and decreased watercraft access large inland lakes.

Severe Winter Weather Hazards

Winter weather hazards consisting of heavy snow from winter storms, freezing rain and blizzards are prevalent natural hazards that occur uniformly across Crawford County and can be expected to occur several times every year. Since January, 1993, 43 heavy snow or ice events have been recorded in Crawford County. Over the past 10 years the county has averaged 4.0 severe winter weather hazards each year. The number and intensity of winter weather hazards can fluctuate dramatically from year to year. According to the National Weather Service, since 2006 there have been 24 winter storm events, with nine classified as heavy snow events.

<u>Ice and Sleet Storms:</u>

A storm that generates sufficient quantities of ice or sleet to result in hazardous conditions and/or property damage. Sleet storms differ from ice storms in that sleet is similar to hail (only smaller) and can be easily identified as frozen rain drops (ice pellets) that bounce when hitting the ground or other objects. Sleet does not stick to trees and wires, but sleet in sufficient depth does cause hazardous driving conditions. Ice storms are the result of cold rain that freezes on contact with the surface, coating the ground, trees, buildings, overhead wires, etc. with ice, sometimes causing extensive damage. When electric lines are downed, inconveniences are felt in households and economic loss and disruption of essential services is often experienced in

affected communities. Michigan has had numerous damaging ice storms over the past few decades. From 1994 to 2004, Crawford County has experienced three freezing rain events as recorded by the National Climatic Data Center of the National Oceanic and Atmospheric Administration.

Table 6.4 -- Economic Impact of Drought	
Costs and losses to agricultural producers	Annual and perennial crop losses Damage to crop quality Income loss for farmers due to reduced crop yields Reduced productivity of cropland Insect infestation and Plant disease Wildlife damage to crops Increased irrigation costs Cost of new or supplemental water supply
Costs and losses to livestock producers	Reduced productivity of rangeland Reduced milk production Forced reduction of foundation stock Closure/limitation of public lands to grazing High cost/unavailability of water for livestock Cost of new or supplemental water supplies High cost/unavailability of feed for livestock Increased feed transportation costs High livestock mortality rates Disruption of reproduction cycles (delayed breeding, more miscarriages) Decreased stock weights Increased predation
Loss from timber production	Wildland fires Tree disease Insect infestation Impaired productivity of forest land Direct loss of trees, especially young ones
Loss from fishery production	Damage to fish habitat Loss of fish and other aquatic organisms due to decreased flows
General economic effects	Decreased land prices Loss to industries directly dependent on agricultural production. Unemployment from drought-related declines in production Strain on financial institutions Revenue losses to federal, state, and local governments Reduction of economic development Fewer agricultural producers
Loss to recreation and tourism	Loss to manufacturers and sellers of recreational equipment Losses related to curtailed activities: hunting and fishing, bird watching, etc.
Energy-related effects	Increased energy demand and reduced supply because of drought-related power curtailments Costs to energy industry and consumers associated with substituting more expensive fuels (oil) for hydroelectric power
Transportation	Loss from impaired navigability of streams, rivers, and canals
Food Production decline	Increase in food prices Increased importation of food (higher costs)
Source: National Drought Mitigation Center, University of Nebraska, Lincoln	

Snowstorms:

A period of rapid accumulation of snow often accompanied by high winds, cold temperatures, and low visibility. Blizzards are the most dramatic and perilous of all snowstorms, characterized by low temperatures and strong winds bearing enormous amounts of snow. Most of the snow accompanying a blizzard is in the form of fine, powdery particles of snow, which are wind-blown in such great quantities that, at times, visibility is reduced to only a few feet. Blizzards have the potential to result in property damage and loss of life. Just the cost of clearing the snow can be enormous. As a result of being surrounded by the Great Lakes, Michigan experiences large differences in snowfall in relatively short distances. The annual mean accumulation ranges from 30 to 170 inches of snow. The highest accumulations are in the northern and western parts of the Upper Peninsula. Since winter storms tend to move from west to east, the western parts of the state usually have greater amounts of snow than the eastern parts. The highest seasonal snowfall recorded in Crawford County was 172.1 inches during the 1989-90 season**. (Table 6.5)**

Northern Michigan, with its extensive Great Lakes coastline is also susceptible to lake-effect snow. There are several main ingredients required to produce lake effect snow. The first is a relatively warm body of water supplied by the Great Lakes. The second ingredient is a source of cold air. In the Great Lakes Region, that source comes from the high latitudes of North America where arctic air masses often "spill southward" over those warm bodies of water. Heat and moisture from the warm lakes rises into the "modified" arctic air where it then cools and condenses into snow clouds. The third ingredient is prevailing wind direction, which determines where the snow will occur. Often these blinding local snowfalls can cause major disruption to automobile traffic. Figure 6.7 is a map that shows lake effect snow vulnerability associated with winter winds from the northwest.

Table 6.5:Crawford County Snowfall Extremes 1991-2010

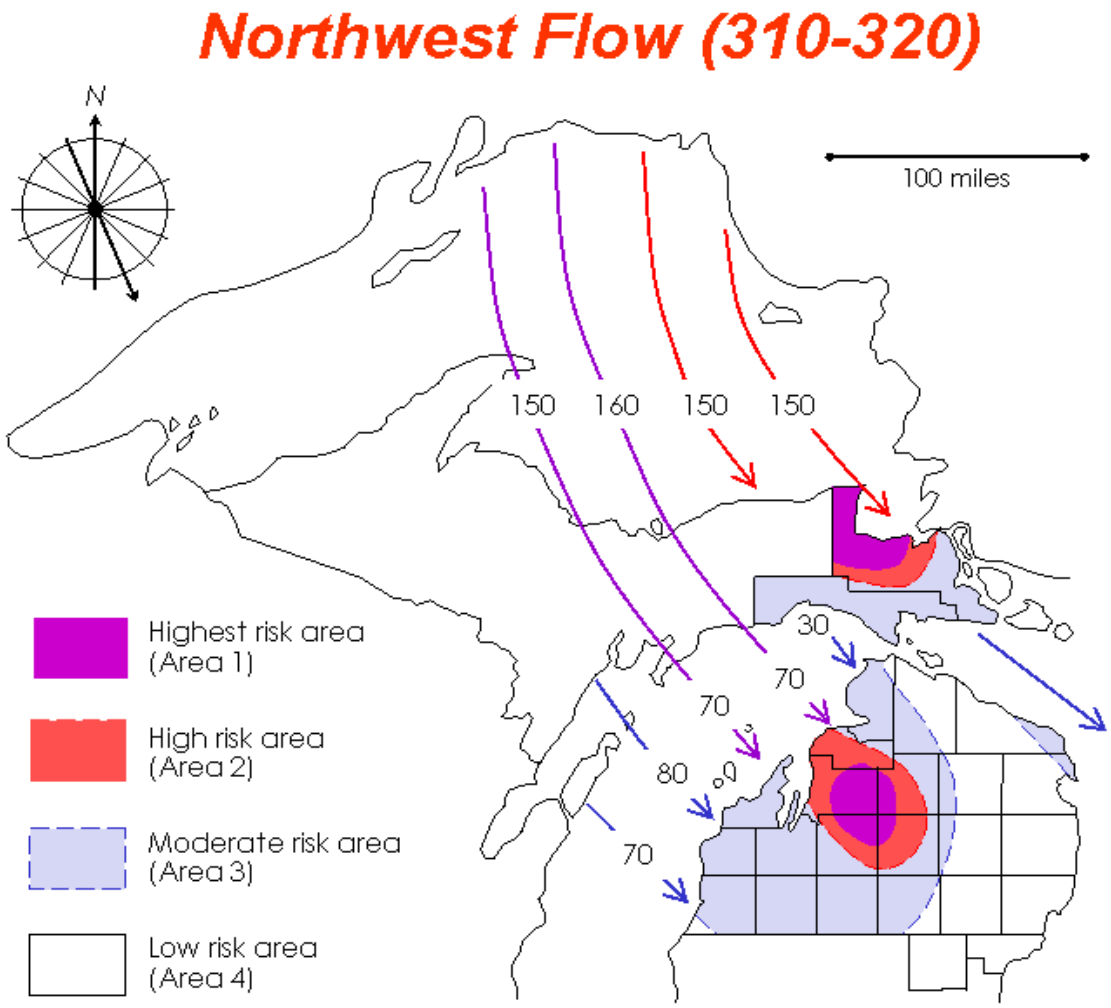
Month	High (in)	Year
January	59.9	1990
February	39.6	2006
March	23.9	1997
April	17.5	1985
May	1.0	1984, 1990, 1996
June	-	-
July	-	-
August	-	-
September	-	-
October	7.8	1992
November	47.8	1995
December	54.3	2008

Recorded at Station: Grayling
Source: Midwest Regional Climate Center

Extreme Temperatures:

Prolonged periods of very high or very low temperatures, often accompanied by other extreme meteorological conditions such as high humidity, lack of rain (drought), high winds, etc. Extreme temperatures - whether it is extreme heat or extreme cold - share a commonality in that they both primarily affect the most vulnerable segments of society such as the elderly, children, impoverished individuals, and people in poor health. The major threats of extreme heat are heatstroke (a major medical emergency), and heat exhaustion. Extreme heat is a more serious problem in urban areas, where the combined effects of high temperature and high humidity are more intense. The major threats of extreme cold are hypothermia (also a major medical emergency) and frostbite. Crawford County is subject to both temperature extremes. The historic low temperature recorded on Feb. 6, 1895 of –38F, and high of 104 F, on Aug. 6, 1946. Monthly extreme temperatures from 1980 and 2010 are shown in **(Table 6.6)**

Figure 6.7, Lake Effect Snow Vulnerability from Northwest Flow
Source: NOAA, Gaylord Michigan



Synoptic Pattern: NW Flow is perhaps the most "classic" of all lake effect snow flow regimes. The surface flow is typically cyclonic, with embedded surface troughs.

Eastern Upper: The west half of Chippewa county is most susceptible. It is often a very close call as to whether heavy snow will extend as far east as Sault Ste Marie. With strong winds, Mackinac county can also receive heavy snow.

Northern Lower: Areas around Charlevoix, Mancelona, Gaylord, Kalkaska, and Grayling are most susceptible. Since low level trajectories into the Traverse City, Manistee, and Cadillac areas don't extend back into central Lake Superior, snowfall in these areas is often less. Snowfall amounts generally decrease rapidly to the east and south of Otsego and Crawford counties. If winds are strong, the heavy snow can extend into northern Roscommon county. An offshore wind component will generally keep intense LES banding offshore from Presque Isle and Alpena counties.

Table 6.6:
Extreme Temperatures – 1980 - 2010

Month	Year*	Maximum High °F		Month	Year*	Minimum Low °F
JAN	1996	53		JAN	1994	-34
FEB	1984	60		FEB	1996	-37
MAR	2000	78		MAR	1982	-25
APR	1990	87		APR	2003	-3
MAY	2006	92		MAY	1983 & 1987	18
JUN	1995	98		JUN	1982	26
JUL	1995	98		JUL	1987	33
AUG	2001, 2006, 2007	96		AUG	1986	26
SEP	2002	92		SEP	1989	16
OCT	2007	87		OCT	1986	11
NOV	1990, 1999, 2008	73		NOV	2005	-4
DEC	2001	64		DEC	1983	-26

Recorded at Station: Grayling
Source: Midwest Regional Climate Center

Earthquakes:
A sudden motion or trembling in the earth caused by an abrupt release of slowly accumulating strain, which results in ground shaking, surface faulting, or ground failures. Most areas of the United States are subject to earthquakes including parts of Michigan, and they occur literally thousands of times per year. Northeastern Michigan to date has been out of known earthquakes impact areas and Crawford County is located in an area with less than a 2%g (peak acceleration) and has a relatively low seismic risk.

Subsidence:
Geologic subsidence can cause depressions, cracks, and sinkholes in the ground surface, which can threaten people and property. Subsidence depressions, which normally occur over many days to a few years, may damage structures with low strain tolerances, such as dams, nuclear reactors, and utility infrastructure. The sudden collapse of the ground surface to form sinkholes poses an immediate threat to life and property. Such ground movements may continue for several days, weeks, months or even years, until the walls stabilize. The population most at risk would be in areas where industrial or residential development has occurred above active or abandoned mines where underground cavities are present near the surface, as well as areas where an extensive amount of groundwater has been withdrawn. The population most at risk would be in areas where industrial or residential development has occurred above active or abandoned mines where underground cavities are present near the surface, as well as areas where an extensive amount of groundwater has been withdrawn. The most prevalent subsidence features in Northern Michigan are Karst sinkholes. Collapse of a sink is usually a localized natural hazard. Karst subsidence also offers the threat of exposing groundwater to rapid contamination in certain circumstances. There is no known karst activity in Crawford County.

Societal Hazards

Nuclear Attack:
Any hostile attack against the United States, using nuclear weapons, which results in destruction of military and/or civilian targets. All areas of the United States are conceivably subject to the threat of nuclear attack. However, the strategic importance of military bases, population centers and certain types of industries place these areas at greater risk than others. The nature of the nuclear attack threat against the U.S. has changed dramatically with the end of the "Cold War" and the conversion of previous adversaries to more democratic forms of government. Even so, the threat still exists for a nuclear attack against this country. Despite the dismantling of thousands of nuclear warheads aimed at U.S. targets, there still exists in the world a large number of nuclear weapons capable of destroying multiple locations simultaneously. In addition, controls on nuclear weapons and weapons components are sporadic at best in the former Soviet Union, and the number of countries capable of developing nuclear weapons continues to grow despite the ratification of an international nuclear non-proliferation treaty. It seems highly plausible that the threat of nuclear attack will continue to be a hazard in this country for some time in the future.

At this point, attack-planning guidance prepared by the Federal government in the late 1980s still provides the best basis for a population protection strategy for Michigan. That guidance identified potential target areas using the following categories: 1) commercial power plants; 2) chemical facilities; 3) counterforce military installations; 4) other military bases; 5) military support industries; 6) refineries; and 7) political targets. For each of these target areas, detailed plans have been developed for evacuating and sheltering the impacted population, protecting critical resources, and resuming vital governmental functions in the post-attack environment. The Camp Grayling and the airbase would have been identified as one of the targets.

Sabotage/Terrorism
An intentional, unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political, social, or religious objectives. Sabotage/terrorism can take many forms or have many vehicles for delivery, including: 1) bombings; 2) assassinations; 3) organized extortion; 4) use of nuclear, chemical and biological weapons; 5) information warfare; 6) ethnic/religious/gender intimidation (hate crimes); 7) state and local militia groups that advocate overthrow of the U.S. Government; 8) eco-fanaticism, designed to destroy or disrupt specific research or resource-related activities; and 9) widespread and organized narcotics smuggling and distribution organizations. Because sabotage/terrorism objectives are so widely varied, so too are the potential targets of such actions. Virtually any public facility or infrastructure, or place of public assembly, can be considered a potential target. In addition, certain types of businesses engaged in controversial activities are also potential targets, as are large computer systems operated by government agencies, banks, financial institutions, large businesses, health care facilities, and colleges/universities.

Public Health Emergencies
A widespread and/or severe epidemic, incident of contamination, or other situation that presents a danger to or otherwise negatively impacts the general health and well-being of the public. Public health emergencies can take many forms: 1) disease epidemics; 2) large-scale incidents of food or water contamination; 3) extended periods without adequate water and sewer services; 4) harmful exposure to chemical, radiological or biological agents; or 5) large-scale infestations of disease-carrying insects or rodents. Public health emergencies can occur as

primary events by themselves, or they may be secondary events another disaster or emergency, such as a flood, tornado, or hazardous material incident. The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people. Public health emergencies can be statewide, regional, or localized in scope and magnitude.

Perhaps the greatest emerging public health threat would be the intentional release of a radiological, chemical or biological agent with the potential to adversely impact a large number of people. Such a release would most likely be an act of sabotage aimed at the government or a specific organization or segment of the population. Fortunately, to date Michigan has not experienced such a release aimed at mass destruction. However, Michigan has experienced hoaxes and it is probably only a matter of time before an actual incident of that nature and magnitude does occur. If and when it does, the public health implications – under the right set of circumstances – could be staggering.

Civil Disturbances

A public demonstration or gathering (such as a sports event), or a prison uprising, that results in a disruption of essential functions, rioting, looting, arson or other unlawful behavior. Large-scale civil disturbances rarely occur, but when they do they are usually an offshoot or result of one or more of the following events: 1) labor disputes where there is a high degree of animosity between the two dissenting parties; 2) high profile/controversial judicial proceedings; 3) the implementation of controversial laws or other governmental actions; 4) resource shortages caused by a catastrophic event; 5) disagreements between special interest groups over a particular issue or cause; or 6) a perceived unjust death or injury to a person held in high esteem or regard by a particular segment of society.

Areas subject to civil disturbances may encompass large portions of a community. Types of facilities that may be subject to or adversely impacted by civil disturbances may include government buildings, military bases, Community College, businesses, and critical service facilities such as our hospital, police and fire facilities. Civil disturbances (including jail uprisings) often require the involvement of multiple community agencies in responding to and recovering from the incident. There have been no recorded incidences of civil disturbances in recent history.

Nuclear Power Plant Accidents

An actual or potential release of radioactive material at a commercial nuclear power plant or other nuclear facility, in sufficient quantity to constitute a threat to the health and safety of the off-site population. Such an occurrence, though not probable, could affect the short and long-term health and safety of the public living near the nuclear power plant, and cause long-term environmental contamination around the plant. As a result, the construction and operation of nuclear power plants are closely monitored and regulated by the Federal government.

Communities with a nuclear power plant must develop detailed plans for responding to and recovering from such an incident, focusing on the 10 mile Emergency Planning Zone (EPZ) around the plant, and a 50 mile Secondary EPZ that exists to prevent the introduction of radioactive contamination into the food chain. Michigan has 3 active and 1 in-active commercial nuclear power plants, in addition to 4 small nuclear testing/research facilities located at 3 state universities and within the City of Midland. Crawford County does not have a Nuclear power plant.

Flooding Hazards

Dam Failures
The collapse or failure of an impoundment resulting in downstream flooding. Dam failures can result in loss of life and extensive property or natural resource damage for miles downstream from the dam. Failure of a dam does not only occur during flood events, which may cause overtopping of a dam. Failure can also result from miss-operation, lack of maintenance and repair, and vandalism. Such failures can be catastrophic because they occur unexpectedly, with no time for evacuation. The Michigan Department of Environmental Quality (MDEQ) has documented approximately 278 dam failures in Michigan. There are no critical dams in Crawford County

Riverine and Urban Flooding:
Riverine flooding is defined as the periodic occurrence of overbank flows of rivers and streams resulting in partial or complete inundation of the adjacent floodplain. Riverine floods generally caused by prolonged, intense rainfall, snowmelt, ice jams, dam failures, or any combination of these factors. Most riverine flooding occurs in early spring and is the result of excessive rainfall and/or the combination of rainfall and snowmelt. Ice jams also cause flooding in winter and early spring. Severe thunderstorms may cause flooding during the summer or fall, although these are normally localized and have more impact on watercourses with smaller drainage areas. Oftentimes, flooding may not necessarily be directly attributable to a river, stream or lake overflowing its banks. Rather, it may simply be the combination of excessive rainfall and/or snowmelt, saturated ground, and inadequate drainage. With no place to go, the water will find the lowest elevations – areas that are often not in a floodplain. That type of flooding is becoming increasingly prevalent in Michigan, as development outstrips the ability of the drainage infrastructure to properly carry and disburse the water flow. Flooding also occurs due to combined storm and sanitary sewers that cannot handle the tremendous flow of water that often accompanies storm events. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns. Riverine flooding is not a common occurrence in Crawford County.

Pre-existing homes and businesses, though, could remain as they were. Owners of many of these older properties could obtain insurance at lower, subsidized, rates that did not reflect the property's real risk. In addition, as the initial flood risk identified by the NFIP has been updated over the years, many homes and businesses in areas where the revised risk was determined to be higher have also received discounted rates. This "Grandfathering" approach prevented rate increases for existing properties when the flood risk in their area increased.

In 2012, the U.S. Congress passed the Flood Insurance Reform Act of 2012 which calls on the Federal Emergency Management Agency (FEMA), and other agencies, to make a number of changes to the way the NFIP is run. As the law is implemented, some of these changes have already occurred, and others will be implemented in the coming months. Key provisions of the legislation will require the NFIP to raise rates to reflect true flood risk, make the program more financially stable, and change how Flood Insurance Rate Map (FIRM) updates impact policyholders. The changes will mean premium rate increases for some – but not all -- policyholders over time.

Flood Insurance Rate Maps (FIRM) were developed for Crawford County. *A review of the State of Michigan database found no incidents of repetitive loss properties in Crawford County.*

Mitigation Planning Sectors

The hazard mitigation planning approach being used is to divide Crawford County into geographic sub-parts (sectors) for the purpose of developing a more detailed, targeted hazard analysis and set of mitigation, preparedness, and response and recovery strategies. Sectoring is being accomplished by using existing municipal boundaries. Each planning sector has a map of the area showing community facilities and infrastructure and some general information on population, housing and land use. Information received from the communities was used to help define the potential hazards the community may encounter.

Beaver Creek Township

- 2010 population 1,736; 1,317 housing units, 733 occupied, 524 seasonal. 24.6% of housing units are 40+ years old.
- Predominant land cover is upland forest, large tracts of jack pine and oak.
- Oil/gas wells located in the west side of the township.
- Township bisected by I-75, junction with M-127.

Potential Hazards
Natural: Wildfire.
Technological: Transportation (air/land/rail), military accident, structural fire.
Societal: Terrorism/sabotage

City of Grayling

- 2010 Population: 1,884. 890 Housing units, 764 occupied, 66.7% are 40+ years old.
- City is bisected by Lake State Rail line, M-72 and I-75.
- Adjacent to Air National Guard Base. Predominant land cover is residential.

Potential Hazards
Natural: Wildfire**.**
Technological: Transportation accident (vehicle/train/aircraft, infrastructure failure, structural fire.
Societal: Terrorism/sabotage, public health,

Grayling Township

- 2010 population 5,827; 4,289 housing units, 2,464 occupied, 1,629 seasonal. 33.7%% of housing units are 40+years old.
- Township is bisected by I-75, M-72 and Lake State Rail line. Home to Camp Grayling training facility and ranges.
- Predominant land cover is upland forest consisting of large tracts of jack pine.

Potential Hazards
Natural: Wildfire
Technological: Transportation accident (vehicle/train/aircraft), military accident, infrastructure failure, structural fire.
Societal: Terrorism/sabotage

Frederic Township

- 2010 population 1,341; 1,231 Housing units, 576 occupied, 586 seasonal. 31.9% housing units 40+ years old
- Lake State rail line, Manistee River and North Branch of AuSable bisect the township. A large numbers of oil/gas wells located in north half of township.
- Predominant land cover is upland forest with large tracts of jack pine and oak in south half of township.

Potential Hazards
Natural: Wildfire
Technological: Transportation accidents (air/rail/land), oil/gas wells, industrial/structural fire
Societal: Sabotage/Terrorism

Maple Forest Township

- 2010 population 653; 470 housing units, 263 occupied, 181 seasonal 24.3% of housing units are 40+ years old.
- Predominant land cover is upland forest, mostly hardwoods, largest concentration of agricultural land use in the county.
- Military range located in north east corner of the township.

Potential Hazards
Natural: Wildfire
Technological: Transportation accident (air/land/rail), military accident, structural fire
Societal: Terrorism/sabotage

Lovells Township

- 2010 population 626; 1,034 housing units, 315 occupied, 694 seasonal. 36.9% of housing units are 40+ years old
- Predominant land cover is upland forest, large tracts of jack pine and oak.
- Military range located in northwest corner of the township.
- Bisected by three rivers, confluence in south west portion of township.

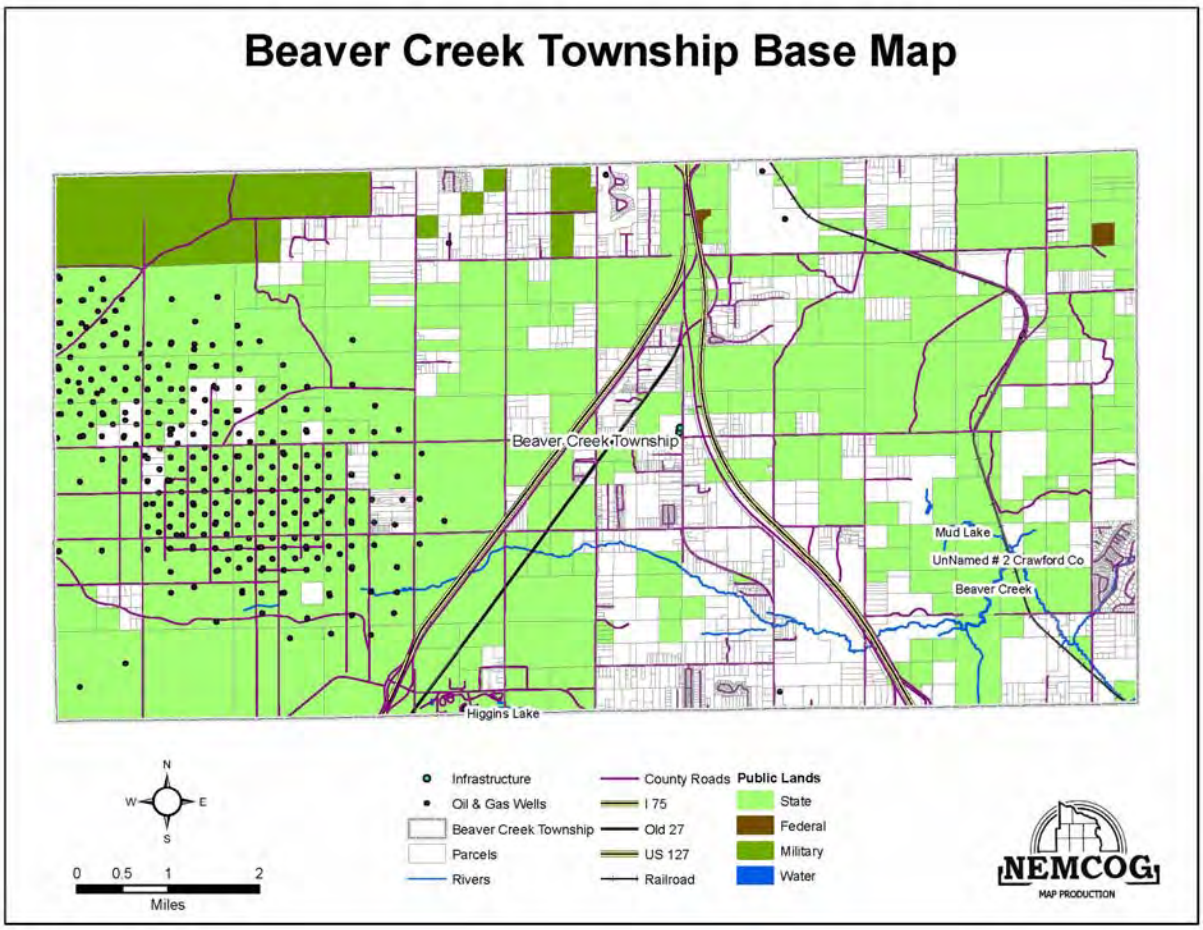
Potential Hazards
Natural: Wildfire.
Technological: Transportation accident (air, land), military accident, structural fire.
Societal: Terrorism/sabotage.

South Branch Township

- 2010 population 2,007; 1,861 housing units, 901 occupied, 901 seasonal. 30.2% of housing units are 40+ years old.
- Predominant land cover is upland forest, large tracts of jack pine and oak.
- Military range located in north west corner of the township.
- North portion of township bisected by AuSable River, confluence with South Branch.

Potential Hazards
Natural: Wildfire.
Technological: Transportation (air/land), military accident.
Societal: Terrorism/sabotage.

Figure 6.8


Beaver Creek Township Base Map
Beaver Creek Township
Mud Lake
UnNamed # 2 Crawford Co
Beaver Creek
Higgins Lake
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Infrastructure
Oil & Gas Wells
Beaver Creek Township
Parcels
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County Roads
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US 127
Railroad
Public Lands
State
Federal
Military
Water
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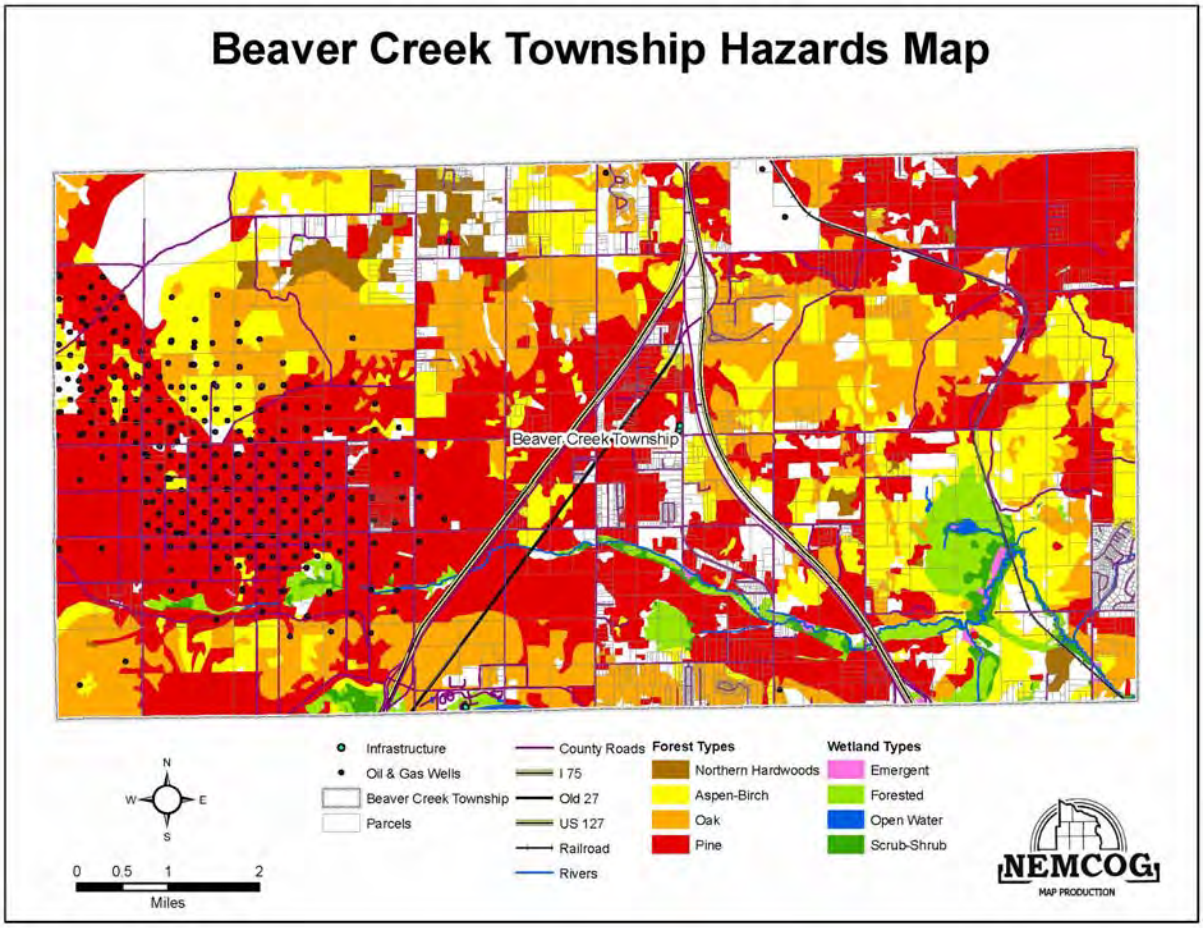
MAP PRODUCTION

Figure 6.9


Beaver Creek Township Hazards Map
Beaver Creek Township
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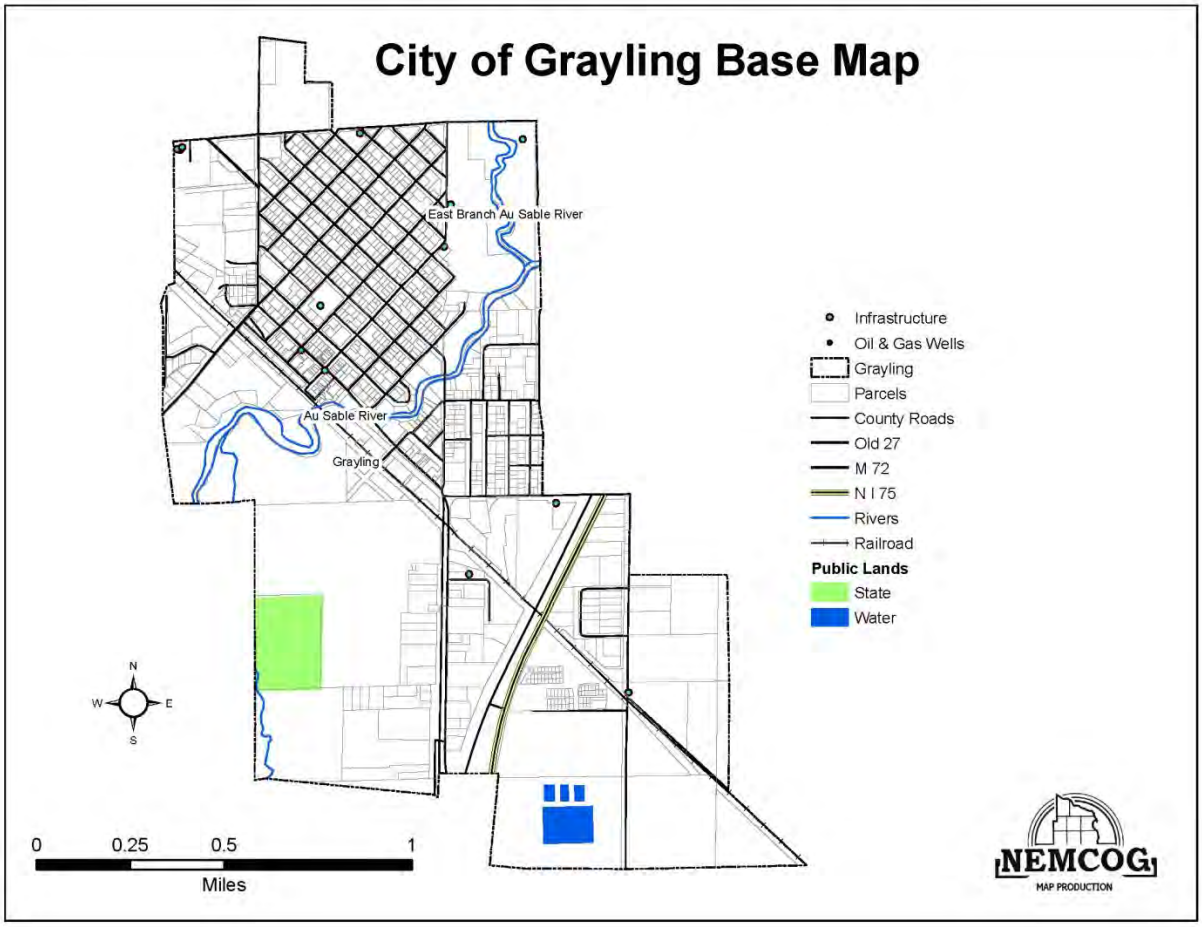
S
0 0.5 1 2
Miles
Infrastructure
Oil & Gas Wells
Beaver Creek Township
Parcels
County Roads
I 75
Old 27
US 127
Railroad
Rivers
Forest Types
Northern Hardwoods
Aspen-Birch
Oak
Pine
Wetland Types
Emergent
Forested
Open Water
Scrub-Shrub
NEMCOG
MAP PRODUCTION


City of Grayling Base Map
East Branch Au Sable River
Au Sable River
Grayling
Infrastructure
Oil & Gas Wells
Grayling
Parcels
County Roads
Old 27
M 72
N I 75
Rivers
Railroad
Public Lands
State
Water
N
W
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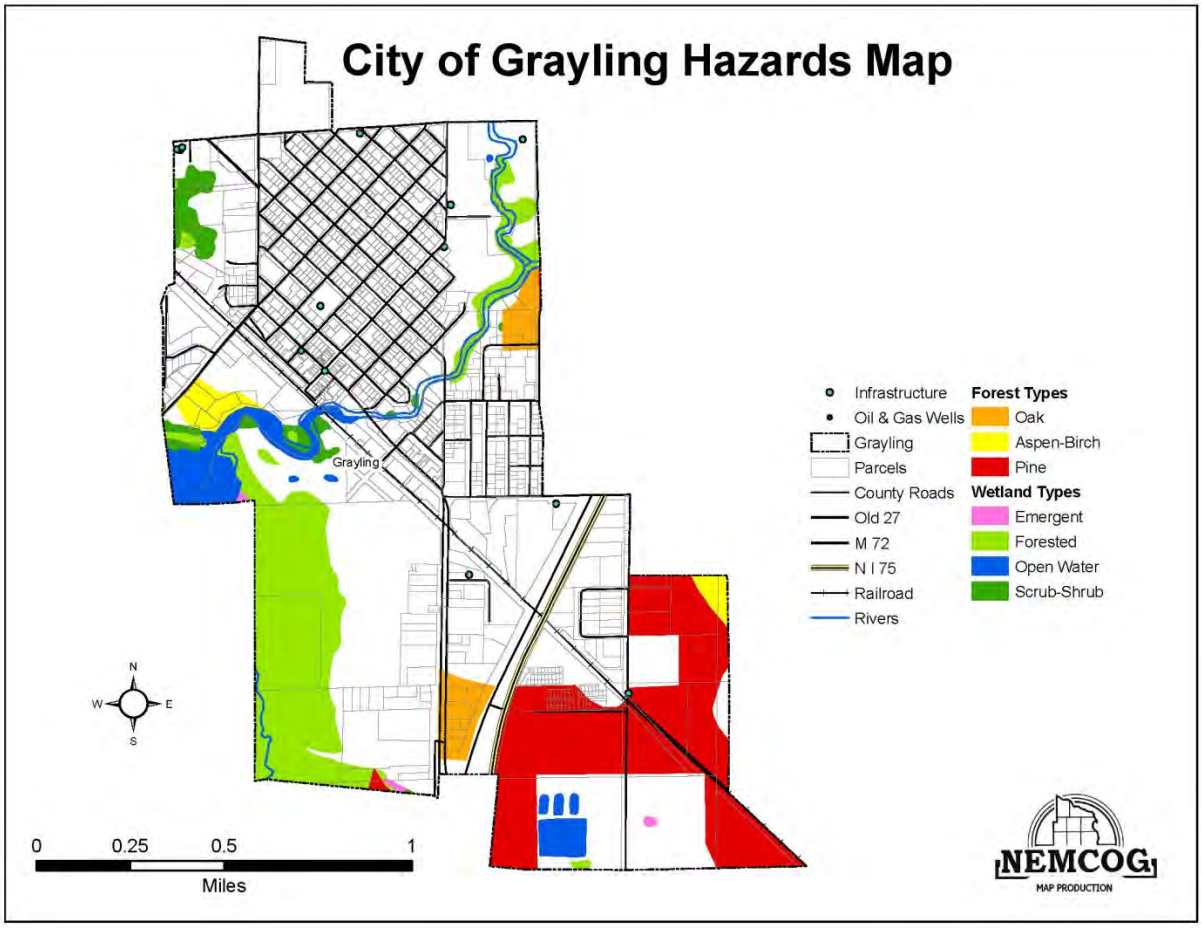
S
0
0.25
0.5
1
Miles
NEMCOG
MAP PRODUCTION

Figure 6.10


City of Grayling Hazards Map
Grayling
Infrastructure
Oil & Gas Wells
Grayling
Parcels
County Roads
Old 27
M 72
N I 75
Railroad
Rivers
Forest Types
Oak
Aspen-Birch
Pine
Wetland Types
Emergent
Forested
Open Water
Scrub-Shrub
N
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0
0.25
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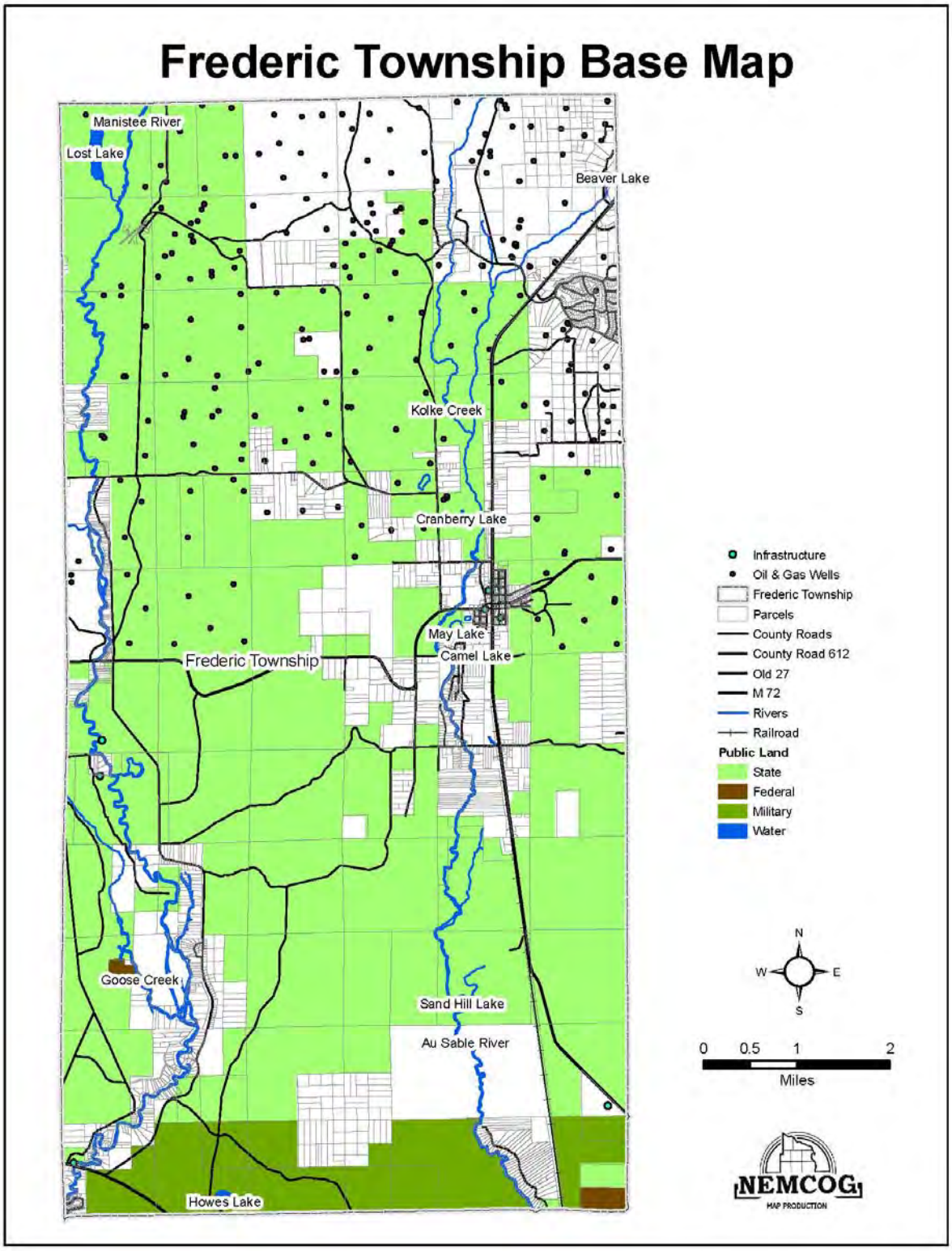
1
Miles
NEMCOG
MAP PRODUCTION

Figure 6.12


Frederic Township Base Map
Manistee River
Lost Lake
Beaver Lake
Kolke Creek
Cranberry Lake
May Lake
Camel Lake
Frederic Township
Goose Creek
Sand Hill Lake
Au Sable River
Howes Lake
Infrastructure
Oil & Gas Wells
Frederic Township
Parcels
County Roads
County Road 612
Old 27
M 72
Rivers
Railroad
Public Land
State
Federal
Military
Water
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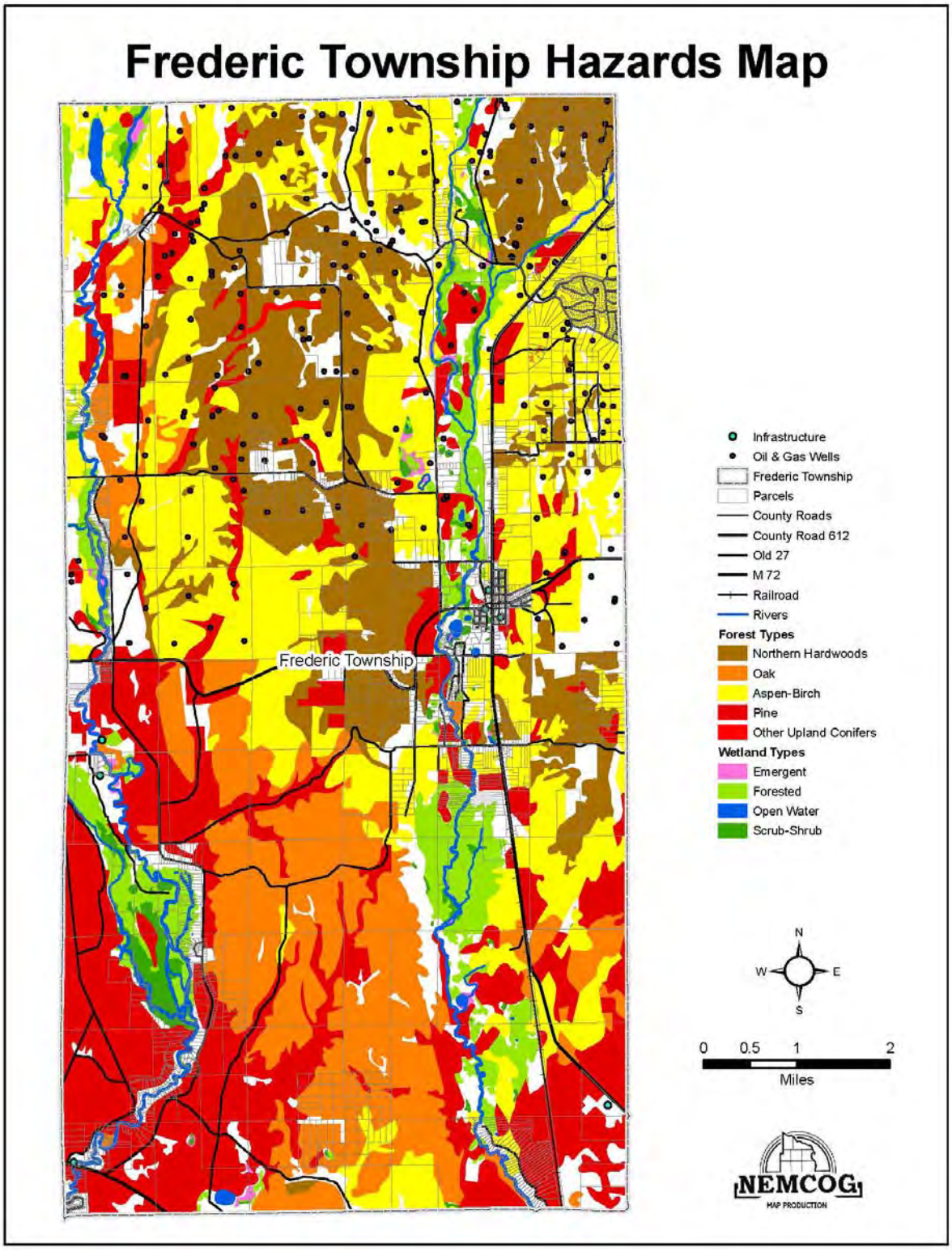
0 0.5 1 2
Miles
NEMCOG
MAP PRODUCTION

Figure 6-13


Frederic Township Hazards Map
Frederic Township
Infrastructure
Oil & Gas Wells
Frederic Township
Parcels
County Roads
County Road 612
Old 27
M 72
Railroad
Rivers
Forest Types
Northern Hardwoods
Oak
Aspen-Birch
Pine
Other Upland Conifers
Wetland Types
Emergent
Forested
Open Water
Scrub-Shrub
N
W
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0 0.5 1 2
Miles
NEMCOG
MAP PRODUCTION

Figure 6-14

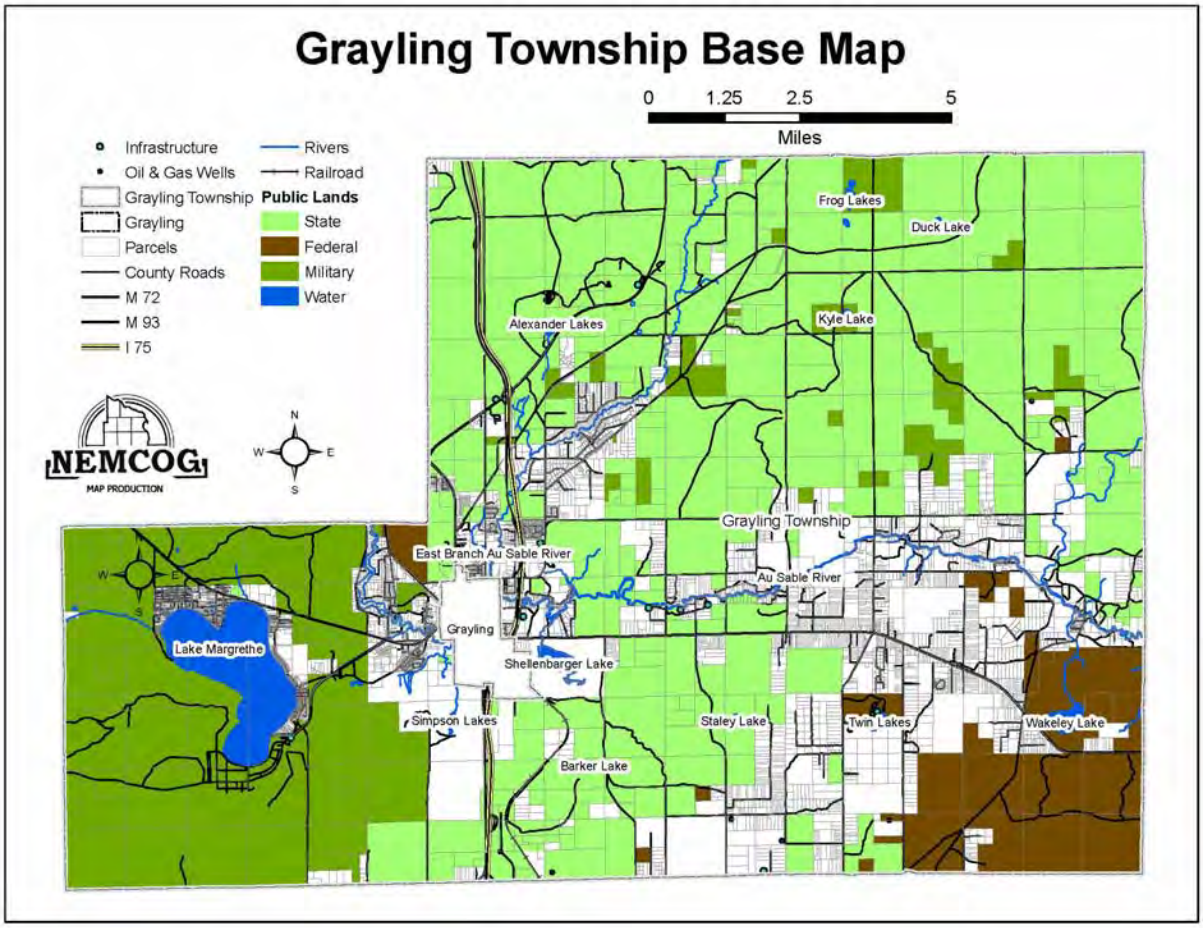
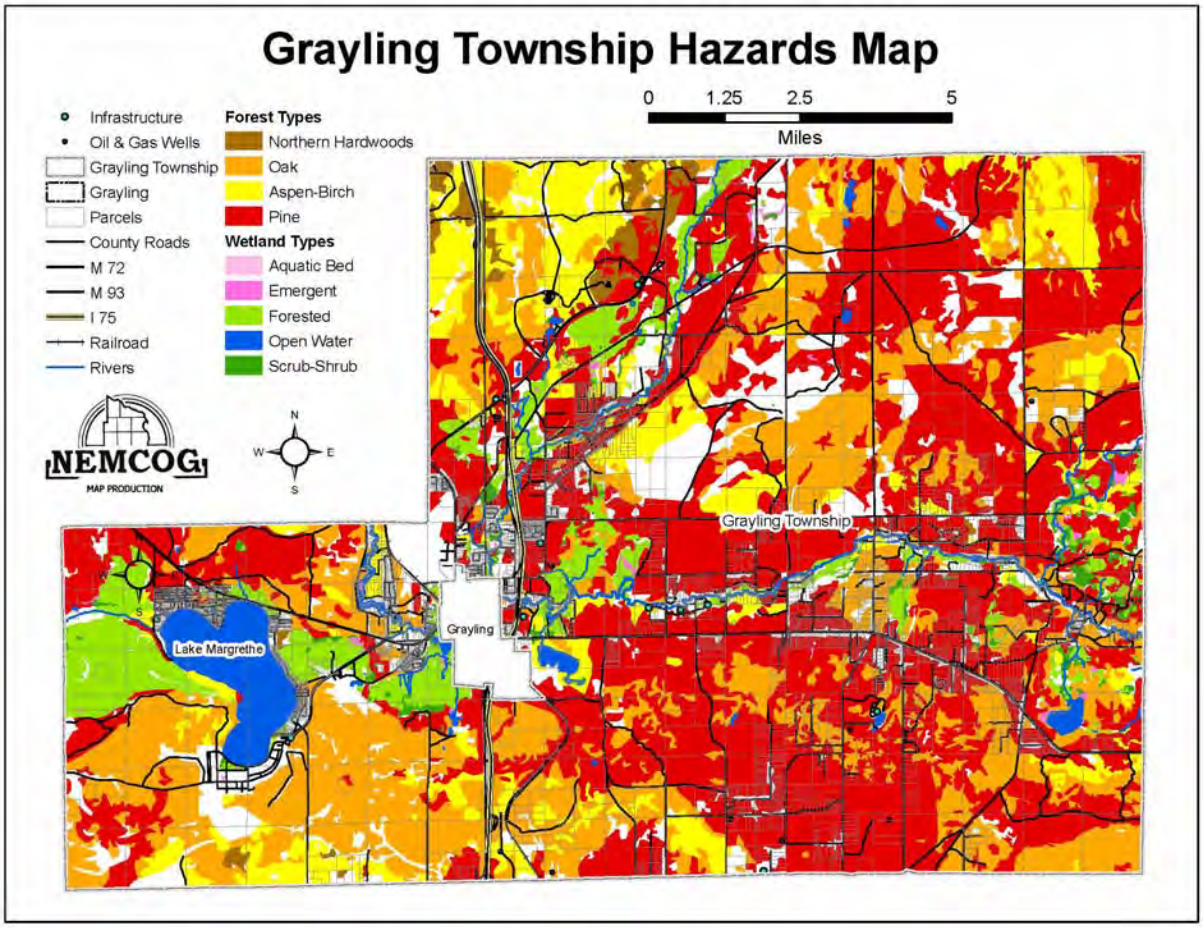

Grayling Township Base Map
0 1.25 2.5 5
Miles
Infrastructure
Oil & Gas Wells
Grayling Township
Grayling
Parcels
County Roads
M 72
M 93
I 75
Rivers
Railroad
Public Lands
State
Federal
Military
Water
NEMCOG
MAP PRODUCTION
N
W
E
S
Frog Lakes
Duck Lake
Alexander Lakes
Kyle Lake
Grayling Township
East Branch Au Sable River
Au Sable River
Grayling
Lake Margrethe
Shellenbarger Lake
Simpson Lakes
Staley Lake
Twin Lakes
Wakeley Lake
Barker Lake

Figure 6-15


Grayling Township Hazards Map
0 1.25 2.5 5
Miles
Infrastructure
Oil & Gas Wells
Grayling Township
Grayling
Parcels
County Roads
M 72
M 93
I 75
Railroad
Rivers
Forest Types
Northern Hardwoods
Oak
Aspen-Birch
Pine
Wetland Types
Aquatic Bed
Emergent
Forested
Open Water
Scrub-Shrub
NEMCOG
MAP PRODUCTION
N
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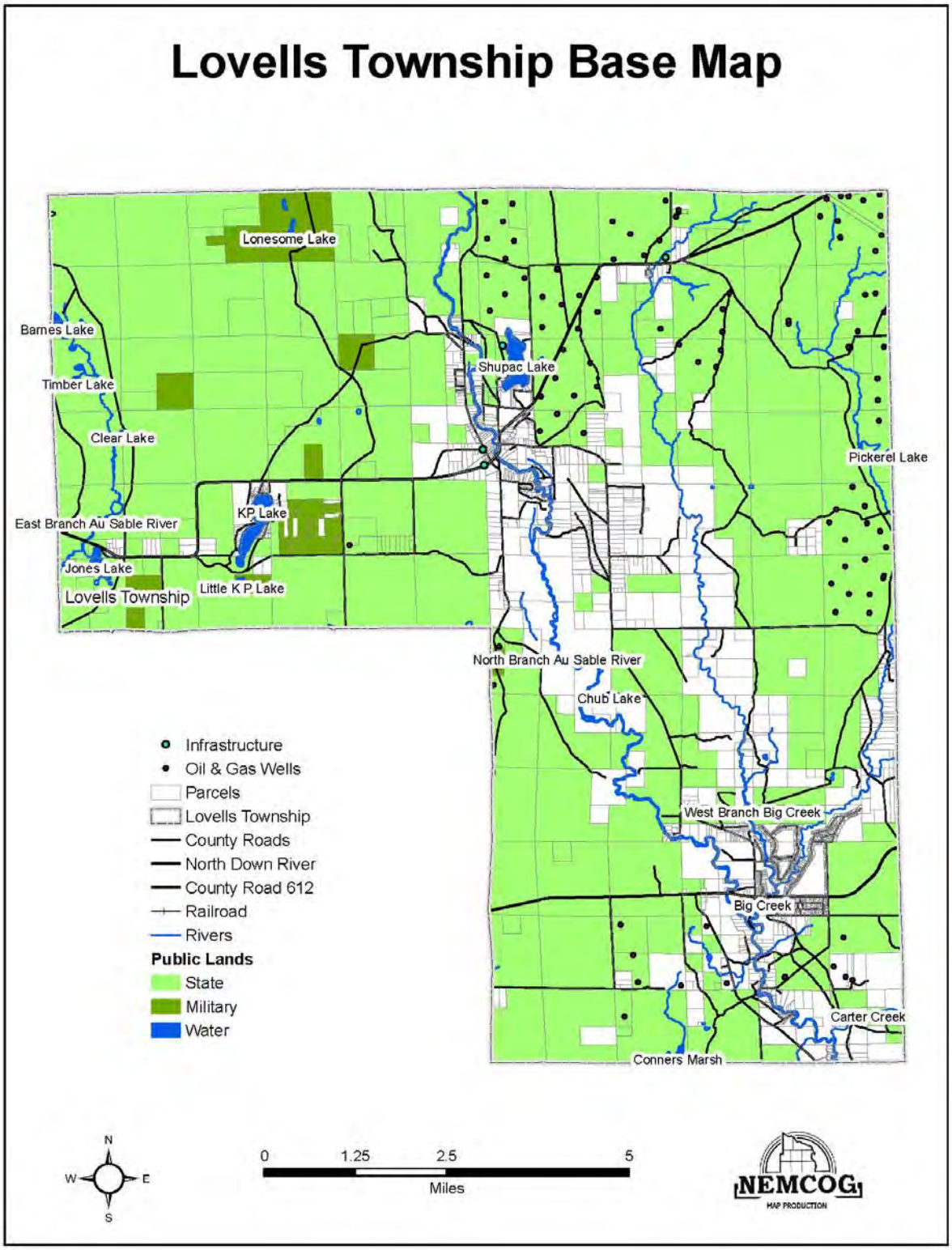
Grayling Township
Grayling
Lake Margrethe

Figure 6-16


Lovells Township Base Map
Lonesome Lake
Barnes Lake
Timber Lake
Clear Lake
Shupac Lake
Pickerel Lake
KP Lake
East Branch Au Sable River
Jones Lake
Little K P Lake
Lovells Township
North Branch Au Sable River
Chub Lake
West Branch Big Creek
Big Creek
Carter Creek
Conners Marsh
Infrastructure
Oil & Gas Wells
Parcels
Lovells Township
County Roads
North Down River
County Road 612
Railroad
Rivers
Public Lands
State
Military
Water
N
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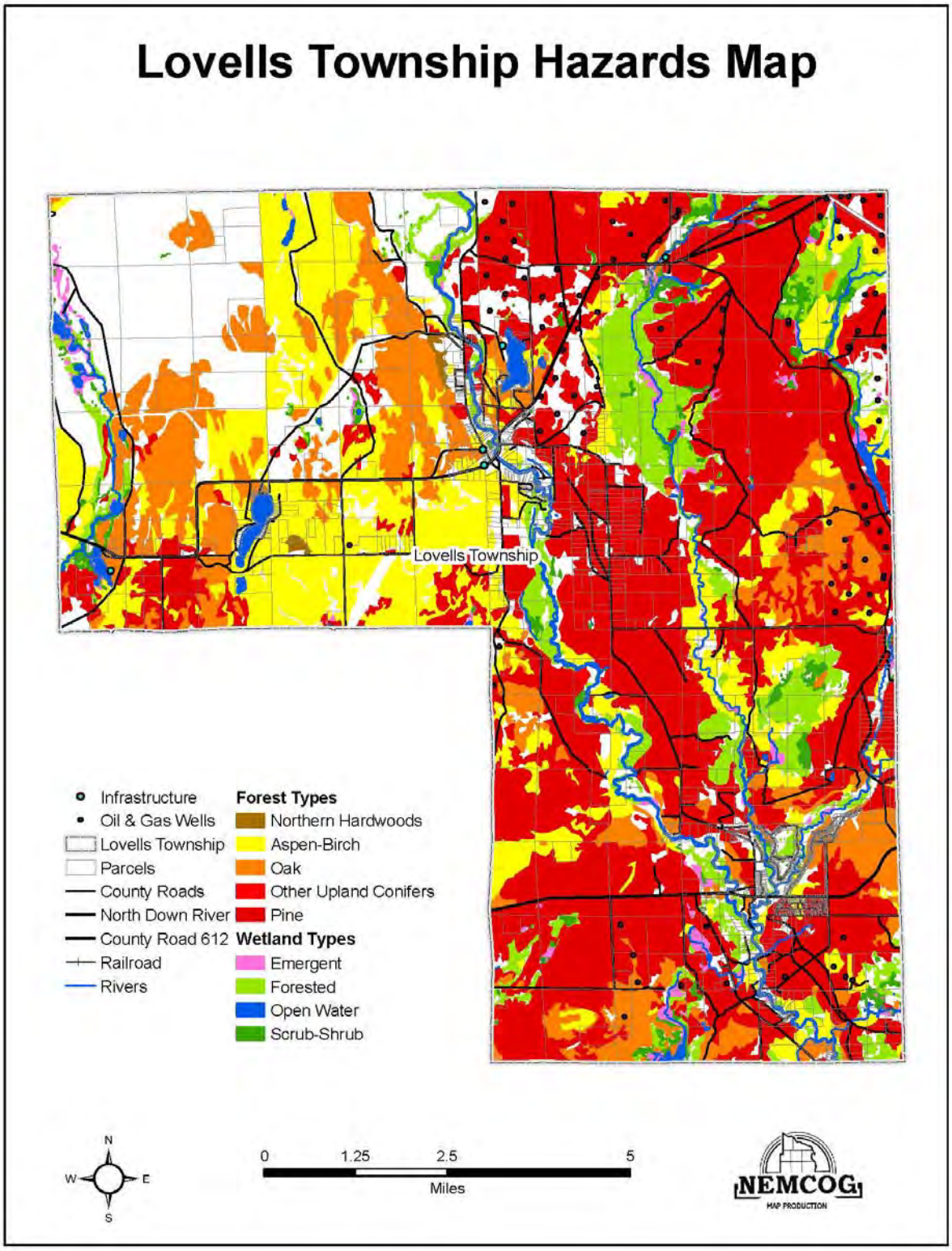
1.25
2.5
5
Miles
NEMCOG
MAP PRODUCTION

Figure 6-17


Lovells Township Hazards Map
Lovells Township
Infrastructure
Oil & Gas Wells
Lovells Township
Parcels
County Roads
North Down River
County Road 612
Railroad
Rivers
Forest Types
Northern Hardwoods
Aspen-Birch
Oak
Other Upland Conifers
Pine
Wetland Types
Emergent
Forested
Open Water
Scrub-Shrub
N
W
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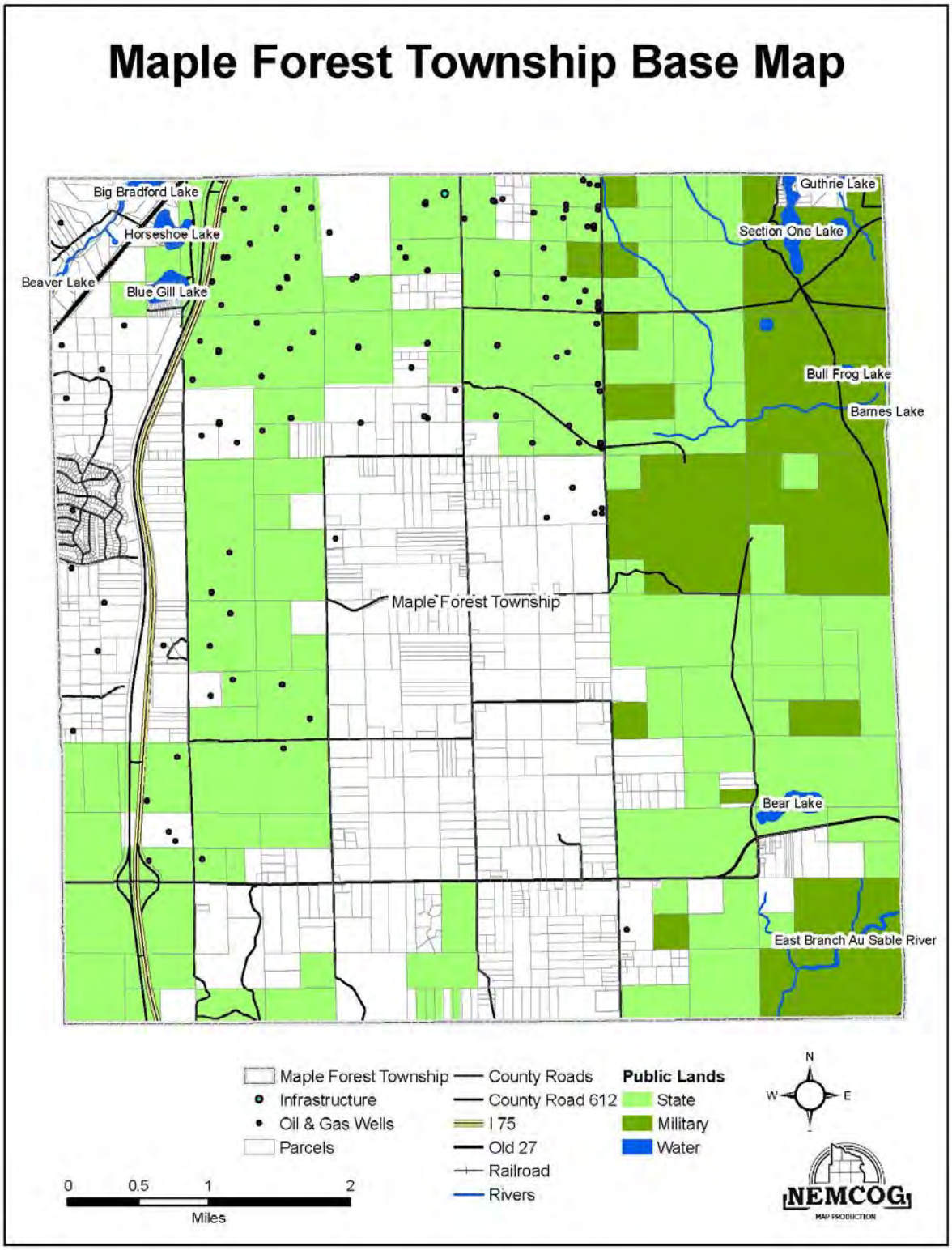
0
1.25
2.5
5
Miles
NEMCOG
MAP PRODUCTION

Figure 6-18


Maple Forest Township Base Map
Big Bradford Lake
Horseshoe Lake
Beaver Lake
Blue Gill Lake
Guthrie Lake
Section One Lake
Bull Frog Lake
Barnes Lake
Maple Forest Township
Bear Lake
East Branch Au Sable River
Maple Forest Township
Infrastructure
Oil & Gas Wells
Parcels
County Roads
County Road 612
I 75
Old 27
Railroad
Rivers
Public Lands
State
Military
Water
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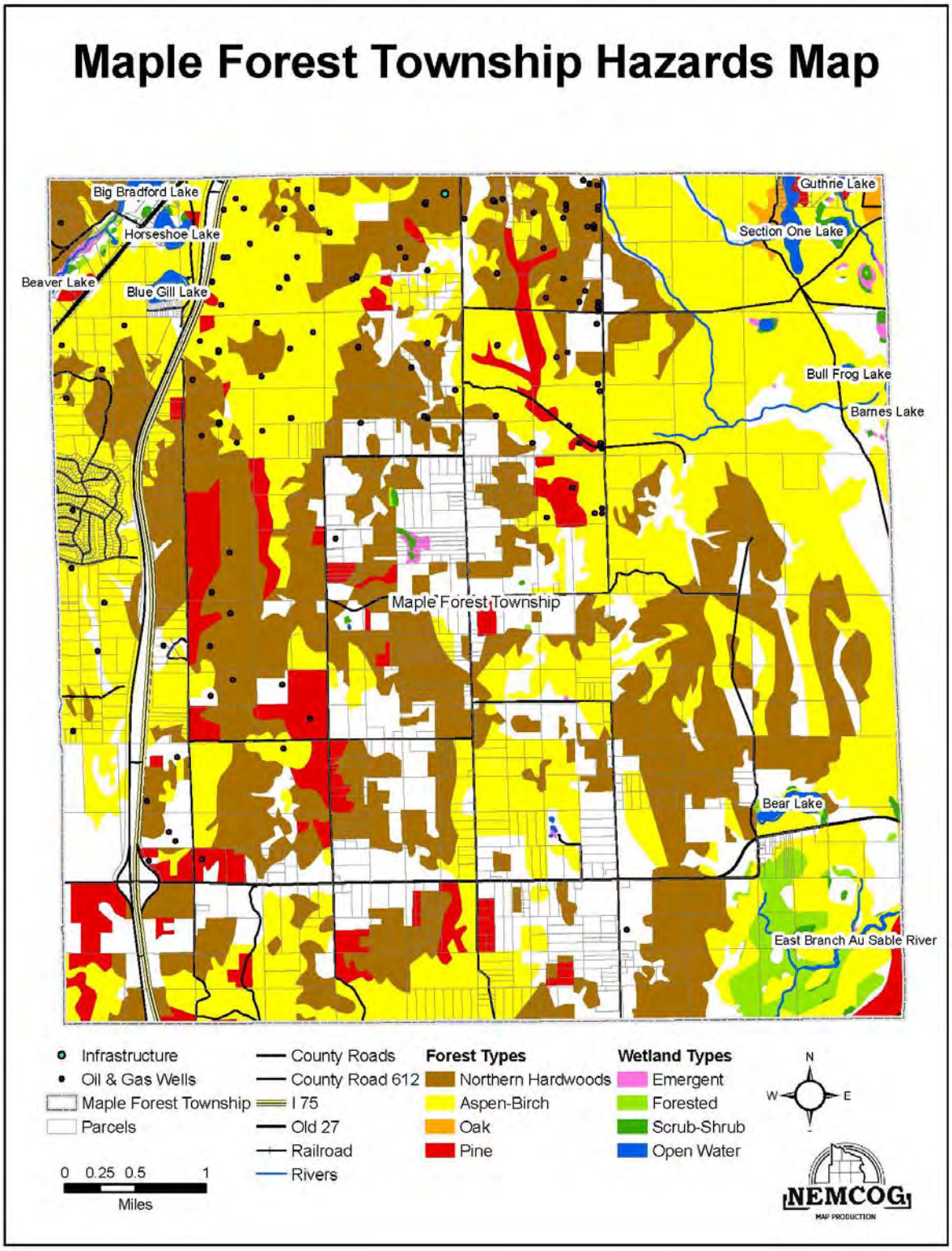
Miles
NEMCOG
MAP PRODUCTION

Figure 6-19


Maple Forest Township Hazards Map
Big Bradford Lake
Horseshoe Lake
Beaver Lake
Blue Gill Lake
Guthrie Lake
Section One Lake
Bull Frog Lake
Barnes Lake
Maple Forest Township
Bear Lake
East Branch Au Sable River
Infrastructure
Oil & Gas Wells
Maple Forest Township
Parcels
County Roads
County Road 612
I 75
Old 27
Railroad
Rivers
Forest Types
Northern Hardwoods
Aspen-Birch
Oak
Pine
Wetland Types
Emergent
Forested
Scrub-Shrub
Open Water
0 0.25 0.5 1
Miles
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W
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NEMCOG
MAP PRODUCTION

Figure 6-20

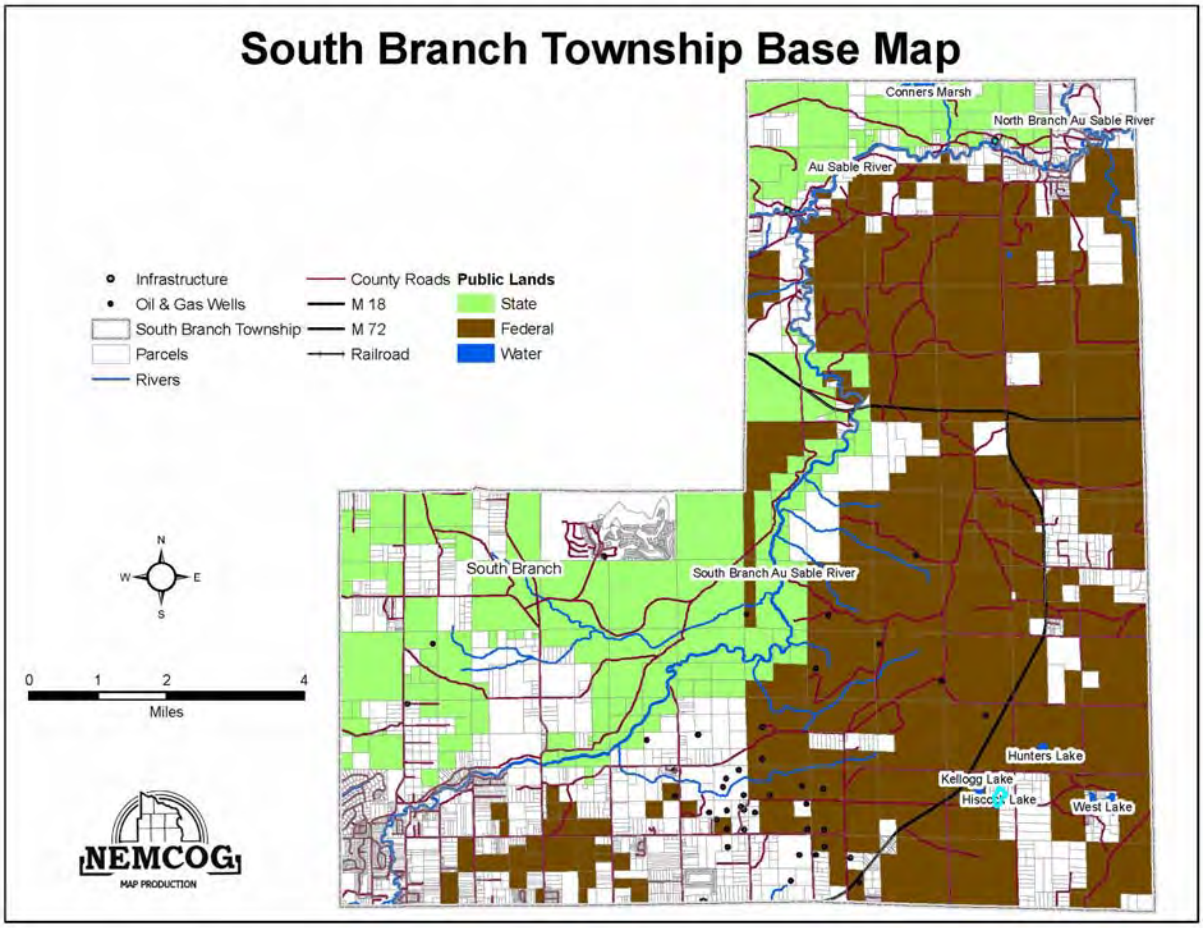
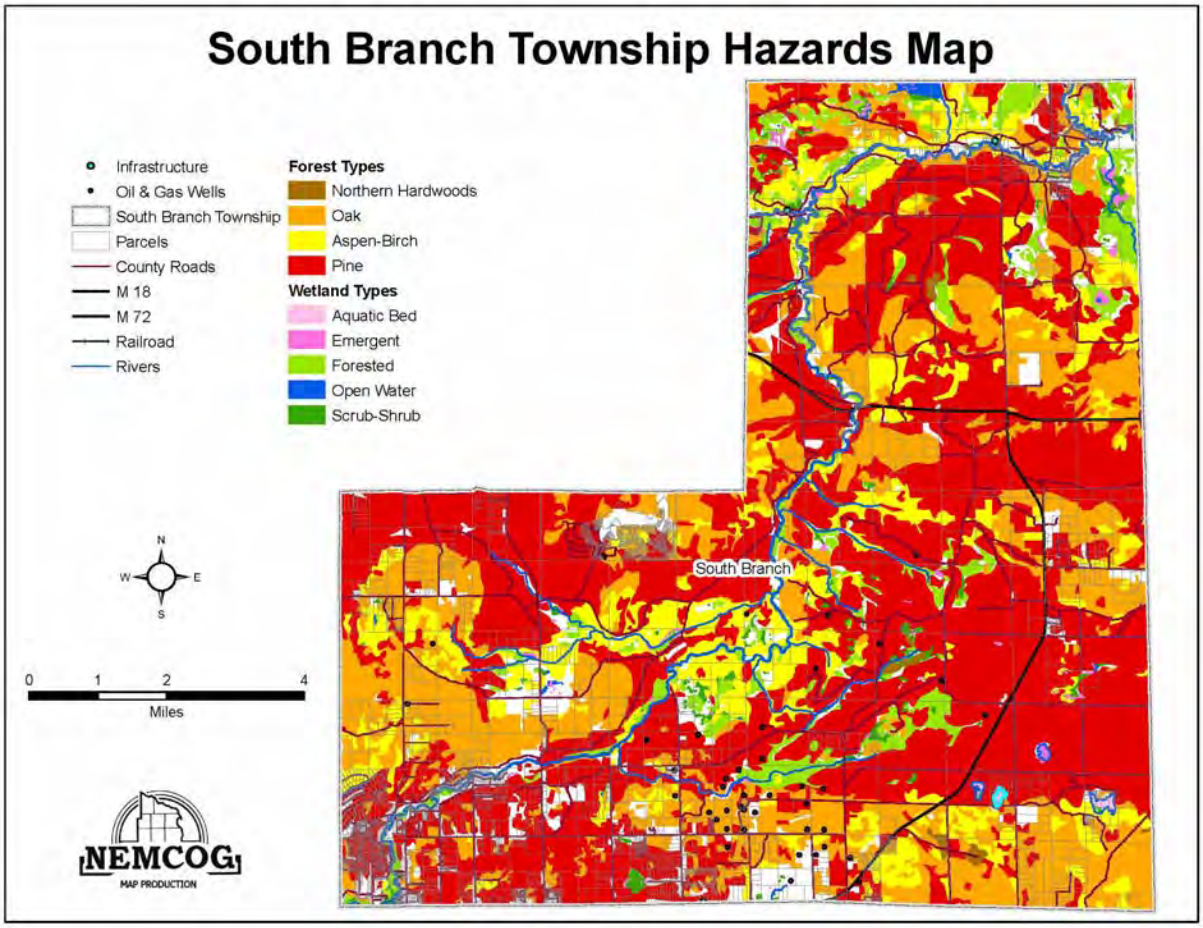

South Branch Township Base Map
Conners Marsh
North Branch Au Sable River
Au Sable River
Infrastructure
Oil & Gas Wells
South Branch Township
Parcels
Rivers
County Roads
M 18
M 72
Railroad
Public Lands
State
Federal
Water
South Branch
South Branch Au Sable River
N
W
E
S
0
1
2
4
Miles
Hunters Lake
Kellogg Lake
Hisco Lake
West Lake
NEMCOG
MAP PRODUCTION

Figure 6-21


South Branch Township Hazards Map
Infrastructure
Oil & Gas Wells
South Branch Township
Parcels
County Roads
M 18
M 72
Railroad
Rivers
Forest Types
Northern Hardwoods
Oak
Aspen-Birch
Pine
Wetland Types
Aquatic Bed
Emergent
Forested
Open Water
Scrub-Shrub
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Miles
NEMCOG
MAP PRODUCTION
South Branch