# Ottawa County Hazards Analysis Report



# Introduction

Ottawa County is vulnerable to a wide range of natural hazards. Periodic disasters resulting from floods, high winds, winter storms and other similar events cause injuries and loss of life, disruption of services, significant property damage and disruption of the stability of the local economy.

The following document is a comprehensive study of the natural hazards that have confronted Ottawa County, as well as those that have the potential to occur in the future. Some of these hazards pose a greater threat to the community than others, and some hazards will impact one sector or region of the society greater than they may impact another. Records of the National Weather Service, Federal Emergency Management Agency, Michigan Department of State Police Emergency Management Division, newspapers, and numerous other federal, state, and local agencies and private organizations were used as sources for the data presented.

The document format consists of a narrative description in the following three areas: 1) a Community Profile of Ottawa County; 2) a Hazard Identification and Assessment for Ottawa County; and 3) a Hazard Profile and Evaluation.

The Community Profile of Ottawa County provides geographic, economic, social and land use information that is relevant to how Ottawa County is affected by, and responds to, natural hazard events. The Hazard Identification and Assessment describes in detail the natural hazards that have the potential to occur in Ottawa County. This section is divided by hazard, and contains the following information for each hazard: 1) a hazard description; 2) historically significant hazard related events in Ottawa County; 3) state, federal or other organizational programs and initiatives that exist to mitigate the hazard threat; and 4) a summary of potential impacts from the hazard. The Hazard Profile and Evaluation is a risk assessment that involves the evaluation of the County's natural hazards using objective measures that evaluate such factors as exposure, frequency, and scope of impact. Following the evaluation, the hazards are ranked according to their potential severity of impact on the residents, businesses and communities in Ottawa County.

The end of the document contains resources where interested parties can obtain further information on the topics listed in this Hazard Analysis.

# **Community Profile of Ottawa County**

Ottawa County is located in the southwest of Michigan's lower peninsula, 174 miles west of Detroit and 150 miles northeast of Chicago. A 30-mile span of beach and duneland along the Lake Michigan shore from Holland to Spring Lake forms the western boundary. The eastern boundary is about 20 miles inland and lies adjacent to the Grand Rapids metropolitan area. Total land area of the County is 565 square miles. Ottawa County is composed of 17 townships, six cities, and one village.

Ottawa County residents enjoy a high quality of life due to the County's naturally occurring scenic beauty, strong social fabric, and diversified and expanding economy. The residents of the County enjoy sandy beaches on Lake Michigan, multiple recreational opportunities, low crime rates, and limited government. Moreover, the labor force is well educated and has a strong work ethic. The local economy is diversified and has strong manufacturing, retail and service components in addition to having the largest and most profitable agricultural production rate in Michigan. The County also has attained the lowest county millage rate in the state.

These attributes have attracted not only many visitors, but also a large number of permanent residents to the County. In fact, so much growth has occurred in Ottawa County that it is now the ninth largest county in Michigan and the fastest growing of all counties with populations over 200,000. Ottawa County's estimated population is currently 224,357 and is expected to reach 271,016 by the year 2010 and 338,450 by the year 2020. Furthermore, this growth is not occurring around one central urban area, but in three urbanized areas (Holland/Zeeland, Muskegon/Tri-Cities, Grand Rapids) and one emerging urbanized area (Allendale). This fact makes Ottawa County's growth all the more challenging since it is originating from multiple locations in or near the County.

# The History of Ottawa County

Ottawa County was named for the Ottawa Indians who occupied this area in the middle of the 17th century. The word "Ottawa" means "trader". The Ottawa Indians were hunters and fishermen who also grew and harvested wild rice in the swamps along the Grand River. In 1754 a Frenchman named Charles Langlade came to this area to recruit Indians to fight against Braddock and Washington in the French and Indian War. For his part in the defeat of Braddock, Langlade was given the fur trade rights throughout the entire Grand River Valley. On December 29, 1837, the Michigan legislature enacted a law that created Ottawa as a county of Michigan.

Ottawa County was primarily settled by Dutch immigrants and today 45 percent of the population still claim Dutch ancestry. Persons of German ancestry are the next largest group, comprising 26 percent of the population. Today the County also boasts a substantial population of persons of Mexican-American descent.

# **Geography of Ottawa County**

Ottawa County is one of the most diverse counties in Michigan. In addition to the healthy and diverse economy, the County enjoys a beautiful array of natural features including the Lake Michigan shoreline, the Grand River, and forested areas that contribute to the County's outstanding quality of life.

Ottawa County contains wetlands, floodplains, woodlands, and rolling terrain. In addition to the aesthetic and recreational value of the natural features, these resources provide a clean water supply, a base for tourism, and exceptional agricultural land. The following is a brief description of the natural features that occur in Ottawa County.

# Soils

Twelve soil associations exist in Ottawa County. A soil association is an area of land that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil. The soils in one association may occur in another, but in a different pattern. The soil survey of Ottawa County shows that primarily sandy soils dominate the land. 47 percent of acreage in the County consists of predominantly sandy soil. Loamy soil makes up another 29 percent of the County soil, followed by sandy-loamy mix with 17 percent, bottomland solids and organic matter mix with 4 percent, and 3 percent a gravel sand mix. The small amount of bottomland solids and organic matter stretch from Jenison to Zeeland along an old glacial drainage way.[1] This fertile area makes for excellent farming of celery, onions, carrots, and other vegetable crops.

# Topography

Topography is fairly uniform within the County. The elevation at the shore of Lake Michigan is approximately 580 feet, and the highest elevation in the County is slightly more than 800 feet. Local differences in elevation exceed 150 feet in only a few places in the County. Steep banks exist only along the Grand River in eastern Ottawa County, and along the shoreline dunes. The presence of surface features are, for the most part, the result of glacial action.

Three well defined topographic divisions are recognized in the County. The first division is a broad, low-lying sandy plain found in the western half of the County. Next, a gently sloping to hilly upland exists in the southeastern portion of the County, and finally a gently sloping to rolling upland plain occupies the northeastern corner.[1]

# Sand Dunes

The most dramatic topographic feature in the County is the sand dunes. Ottawa County hosts a significant band of dunes extending almost the entire Lake Michigan shoreline. The widest areas of dunes are north of Lake Macatawa, in or near the Holland State Park and around Port Sheldon. Another significant area of dunes begins north of Lake Michigan Drive and extends to the north County line. There are approximately 3,750 acres of dunes in the County. Some of the dunes are 200 feet high. Besides their aesthetic value, the dunes provide benefits by providing homes for numerous varieties of birds and other wildlife.

# Surface Water

Water features abound in Ottawa County. Besides Lake Michigan along its western boundary, many inland lakes, rivers and streams are located in the County. Many of the County's waters are popular fishing resources, supporting several varieties of game fish. Interesting views and the tranquility of flowing water are all part of the natural ambiance created by rivers and lakes. The Michigan Department of Natural Resources has identified 3,941 acres of rivers and 4,106 acres of lakes in the County. This 8,047 acres represents just over two percent of the county's total area. Spring Lake, Lake Macatawa, Pigeon Lake, Crockery Lake, the Grand River and its numerous bayous, the Black River, and the Pigeon River are the primary water formations in the County.

# Floodplains

Several areas of 100-year floodplain exist in Ottawa County. The Grand River and its tributaries make up the largest area of floodplain, with a wide swath along the entire length of the river. Parts of the Grand River floodplain in Georgetown and in the Spring Lake area are up to one mile wide. The Lake Macatawa and Black River floodplains extend through Park Township into Holland Township, and the tributaries of this waterway has tributaries with floodplains that extend into the City of Holland and Zeeland Township. Except for a large area near the south center of Park Township, the floodplain is fairly narrow. The Crockery and Rio Grande Creeks in Chester Townships also have floodplain areas. These areas are also fairly narrow, except for one large pocket at the south branch of Crockery Creek. Another significant floodplain is located along Rush Creek in Georgetown Township and the City of Hudsonville.

#### Groundwater

Almost one half of the Michigan's population uses groundwater as their source of drinking water. Ottawa County's groundwater usage closely parallels that of the State.

#### Wetlands

"Wetland" is the collective term for marshes, swamps, bogs, and similar areas often found between open water and upland areas. Wet areas and hydric soils exist in virtually every part of the County. According to the Grand Valley State University Water Resources Institute, the total wetland acreage in Ottawa County is 5,772.5 acres, or 1.6 % of the County's land area.

The largest areas of wetlands lie in the northern portion of the County, along the Grand River. Crockery, Robinson, Grand Haven and Spring Lake Townships hold most of these wetland areas. Other areas of significant wetlands exist along the Grand River in Allendale Township, near the eastern boarder of the County along the Grand River, along Crockery Creek in Crockery Township, along the Pigeon River in Port Sheldon Township, and along the Black River in Holland Township.

# Woodlands

Much of the woodlands in the County are grouped in small parcels, usually left from agricultural clearing. Logging, tree farming, and firewood production have historically been significant industries in the County, and still represent a section of the economy today. According to 1991 calculations, Ottawa County contains 83,335 acres of forest land. This accounts for slightly more than 22 percent of the total land area.[1]

# **Climate of Ottawa County**

The lake effect on the Ottawa County climate is quite strong throughout much of the year, especially for those communities located near the lakeshore. This lake effect is produced by prevailing westerly winds that pass over Lake Michigan. The lake effect typically increases cloudiness and snowfall during the fall and winter, and moderates the temperature throughout most of the year. This modification of the climate is partially responsible for the diversified agriculture that occurs in western Michigan. Because the day-to-day weather is controlled by the movement of pressure systems across the Nation, the County seldom experiences prolonged periods of hot, humid weather in the summer or extreme cold during the winter.

Average annual rainfall	31 inches
Average annual snowfall	75 inches
Average January low temperature	19 degrees F
Average July high temperature	79 degrees F
Average Growing Season	173 days
Prevailing wind	Southwesterly, averaging 10 miles per hour
Relative humidity	May: 53 %, December: 75 %, Average: 64 %
Average percent possible sunshine	July: 64 %, December: 21%, Average: 45 %
Annual thunderstorm occurrence	39 days

The following is a list of weather averages for Ottawa County:

(Source: Michigan State University Climatology Program)

# **Ottawa County Population Trends**

Ottawa County has experienced exceptional growth during the past 30 years. From 1970 to 1980, its population increased 22.6 percent; and from 1980 to 1990 the County grew by another 19.5 percent. Between 1990 and 1998, the growth rate stayed steady at 19.5 percent. Estimates suggest that the County's population will reach 276,467 by the year 2010 and 330,347 by the year 2020.

Year	Population	Percent Change
1900	39,667	
1910	45,301	14.2 %
1920	47,660	5.2 %
1930	54,858	15.1 %
1940	59,660	8.8 %
1950	73,751	23.6 %
1960	98,719	33.9 %
1970	128,181	29.8 %
1980	157,174	22.6 %
1990	187,768	19.5 %
1991	193,323	3.0 %
1992	197,043	1.9 %
1993	200,827	1.9 %
1994	204,988	2.1 %
1995	210,060	2.5 %
1996	215,379	2.5 %
1997	219,940	2.1 %
1998	224,357	2.0 %
1990-1998		19.5 %

Population levels for Ottawa County, 1900-1998

(Source: US Census Bureau)

Population increases can have a tremendous impact on how natural hazards impact a community. Population increases typically are responsible for the rise in disaster losses when a natural hazard hits a community. Not only are there more people and structures to be affected than when there were fewer people, but sometimes the development actually increases the severity of the hazard. Such is the case with flooding. This is because there are fewer pervious surfaces like fields, wetlands, and forested areas to absorb water from rain and snow in a severe weather event. More impervious surfaces covering the ground create more stormwater runoff. In some communities the stormwater drainage systems capacity was designed to meet the populations of 50 years ago or more. The correlation between population change and increased losses from severe weather events will be discussed in further detail in the hazard analysis sections that follow.

Although every community in Ottawa County has grown in recent years, some areas are increasing at a much greater rate than others. As is indicated by the table below, between 1990 and 1998 the community with the greatest population change (as a percent) was Holland Township. The community with the smallest change in population was the City of Grand Haven. However, it is important to note the absolute change in population as well. Actual changes in the number of people, and not just the percent change, can have a tremendous impact on how a community develops.

The following are population levels and increases from 1990 to 1998 for each jurisdiction in Ottawa County:

Township/City/Village	<b>1990 Population</b>	1998 Population	Percent Change	Amount Change
Allendale Township	8,022	10,516	31.1	2,494
Blendon Township	4,740	5,740	21.1	1,000
Chester Township	2,133	2,294	7.5	161
Coopersville City	3,421	3,883	13.5	462
Crockery Township	3,599	3,881	7.9	282
Ferrysburg City	2,919	3,192	9.4	273
Georgetown Township	32,672	40,739	24.7	8,067
Grand Haven City	11,951	11,982	0.3	31
Grand Haven Township	9,710	11,932	22.9	2,222
Holland City	25,086	26,549	5.8	1,463
Holland Township	17,523	25,136	43.4	7,613
Hudsonville City	6,170	6,893	11.7	723
Jamestown Township	4,059	4,799	18.2	740
Olive Township	2,866	3,157	10.2	291
Park Township	13,541	16,723	23.5	3,182
Polkton Township	2,277	2,475	23.5	198
Port Sheldon Township	2,929	3,538	20.8	609
Robinson Township	3,925	5,540	41.1	1,615
Spring Lake Township	8,214	10,203	24.4	1,989
Spring Lake Village	2,537	2,592	2.2	55
Tallmadge Township	6,300	7,089	12.5	789
Wright Township	3,285	3,531	7.5	246
Zeeland City	5,417	6,066	12	649
Zeeland Township	4,472	5,907	32.1	1,435

(Source: US Census Bureau)

# **Economic Activity in Ottawa County**

Economic diversification, a skilled and dedicated labor force, and pro-business attitude are factors which make Ottawa County one of the fastest growing counties in Michigan. These factors have also helped to boost the County's state equalized value to over \$5.5 billion.

Manufacturing is the primary economic activity in Ottawa County. With approximately 700 manufacturing facilities located in the County, this sector employs over 40,000 people, or almost 30 percent of the County's jobs. Manufacturing, services and retail trade provide jobs for 2 of every 3 workers in the County. A number of these businesses produce office furniture, accessories for the automotive industry, or food products. Major local manufacturing employers include Johnson Controls, Donnelly Corporation, Sara Lee Refrigerated Foods (Bil-Mar Foods), Delphi Automotive, Meridian, Herman Miller, Haworth, Lifesavers.

Agriculture is another major economic activity in Ottawa County. The County's moderate climate and favorable soils yield agricultural products that have the highest market value of any sold in Michigan. In 1997 the County ranked first in Michigan for the total value of agricultural products sold, the value of crops including nursery, and in the value of livestock and poultry. Ottawa County leads all other Michigan counties in the value of sales of nursery and greenhouse

crops, as well as in the production of turkeys, layers and pullets, and blueberries. The community of Hudsonville has the designation as "Michigan's Salad Bowl" for its production of vegetable crops such as lettuce, celery, and onions.. Other principal crops include corn, wheat, and oats.

Tourism and recreation are also economically significant to the area. Each year Ottawa County welcomes millions of visitors to the vacation playground. The area's natural features and mild summer climate have helped the County develop into a popular destination for sportsmen and vacationers. The shoreline of Lake Michigan, the Grand and Pigeon rivers and Lake Macatawa offer many opportunities for marinas, fishing, boating, swimming, and waterfront lodging. All together, there are 307 miles of rivers and streams and numerous lakes to add to vacationers' pleasure. In addition, a number of annual festivals attract tourists from across the nation, as do County's other unique natural resources and attractive downtown districts. Attractions such as festivals and scenic beauty attract tourists that support the County's strong service sector.

In Holland, over a million people come from around the world to the Tulip Time Festival each May. This festival is ranked as one of the top ten festivals in North America and is the fourth largest flower festival in the United States. In the City of Grand Haven, each summer the annual Coast Guard Festival brings thousands of visitors to the area to enjoy ten days of parades, music, food and the parade of boats. Another Grand Haven event is the Great Lakes Kite Festival. One of the nations largest kite festivals, this event attracted over 65,000 spectators in 1998.

The County is home to 9 County operated parks, as well as numerous city, township and state recreation areas.

Full-time and Part-time Employment by Industry in Ottawa County, 1993 and 1997							
# Jobs in 1993	Percent	# Jobs in 1997	Percent				
3,944	3.46	3,837	2.77				
1,450	1.27	1,840	1.33				
90	0.08	106	0.08				
6,218	5.45	8,387	6.06				
33,106	29.03	40,972	29.62				
3,227	2.83	3,674	2.66				
4,079	3.56	5,030	3.64				
17,596	15.43	21,222	15.34				
5,678	4.98	7,165	5.18				
27,202	23.86	33,176	23.99				
11,453	10.04	12,899	9.33				
114,043	100	138,308	100				
	# Jobs in 1993 3,944 1,450 90 6,218 33,106 3,227 4,079 17,596 5,678 27,202 11,453	# Jobs in 1993 Percent   3,944 3.46   1,450 1.27   90 0.08   6,218 5.45   33,106 29.03   3,227 2.83   4,079 3.56   17,596 15.43   5,678 4.98   27,202 23.86   11,453 10.04	# Jobs in 1993Percent# Jobs in 1997 $3,944$ $3.46$ $3,837$ $1,450$ $1.27$ $1,840$ 90 $0.08$ $106$ $6,218$ $5.45$ $8,387$ $33,106$ $29.03$ $40,972$ $3,227$ $2.83$ $3,674$ $4,079$ $3.56$ $5,030$ $17,596$ $15.43$ $21,222$ $5,678$ $4.98$ $7,165$ $27,202$ $23.86$ $33,176$ $11,453$ $10.04$ $12,899$				

Full-time and Part-time Employment by Industry in Ottawa County, 1993 and 1997

(Source: US Department of Commerce, Bureau of Economic Analysis, Regional Accounts Data)

In 1996, 119,575 people out of an average civilian labor force of 123,500 were employed, for an unemployment rate of 3.2 percent. The record low unemployment rate for Ottawa County came in 1998, when levels reached 2.5 percent. In 1999, Ottawa County's unemployment rate averaged 2.7 percent. Compared to the other 82 counties in Michigan, Ottawa County had the sixth lowest unemployment rate in 1999.[1]

# Land Use Patterns

The primary land use in Ottawa County is agriculture. Although the acreage of land in farms dropped from 176,305 acres in 1992 to 170,627 acres in 1997, farmland still comprises over 46 percent of total land area in the County.[1] Agriculture is followed by forested areas and urban development. The rapid growth in recent years has created many challenges in the effort to preserve area natural resources and agricultural lands. County and local governments are currently researching means of maintaining the rural character of Ottawa County while still allowing for managed growth.

As mentioned earlier, how land is used and developed can have a tremendous impact on how natural hazards affect a community during a disaster, as well as how a community is able to respond to and recover from a hazard. For example, communities that have more people moving into forested areas are more likely to experience wildfire, since the leading cause of wildfires in Michigan is burning of debris.

	Ottawa Coun	ty Lanu Use m	Acres, 1770 and	u 1//1	
Land Use	Year: 1978	% of County	Year: 1991	% of County	% Change
Urban	43,792.5	11.9	56,422.5	15.3	28.8
Agriculture	201,757.5	54.7	173,810	47.1	-13.9
Open Field	23,505	6.4	40,745	11	73.3
Forest	85,595	23	83,335	22.6	-2.6
Wetlands	5,770	1.6	5,772.5	1.6	0
Water	8,072.5	2.2	8,465	2.3	4.9
Barren	605	0.2	547.5	0.1	-9.5
Total	369,097.5	100	369,097.5	100	

Ottawa County Land Use in Acres, 1978 and 1991

(Source: Water Resources Institute, Grand Valley State University, November 1998)

Unlike most counties which contend with growth issues from a single urban center, Ottawa County contends with the growth issues in three metropolitan centers (Grand Rapids, Holland/Zeeland, Muskegon/Tri Cities) as well as one significant and emerging urbanized center (Allendale).

# **Transportation Network of Ottawa County**

# **Major Transportation Corridors and Trucklines**

Within Ottawa County there are approximately 35 miles of freeway consisting of segments of Interstate 96 and Interstate 196. Future plans for US-31 may include upgrading it to a freeway type facility. US-31, M-45, M-11 and M-104 are the at-grade trucklines that provide the through route system. Most of US-31 and M-11 is developed in a four-lane boulevard-type cross section. M-45 and M-104 vary from two to five lanes cross sections. These roadways carry significant local traffic volumes, as well as regional or commuter traffic.

# Airports

Residents of Ottawa County have access to commercial air passenger service in neighboring counties at the Gerald R. Ford/Kent County International Airport in Grand Rapids, the Muskegon County Airport, and the Kalamazoo County Airport. There are also six smaller airports within Ottawa County that serve corporate and recreational pilots. Grand Haven Memorial Airpark,

Park Township Airport, and Tulip City Airport (owned by the City of Holland) are public aviation airports, while the remaining three, Jablonski Airport, Riverview Airport, and Ottawa Executive Airport, are all private airports.

#### **Ports and Marinas**

Ottawa County has 9 ports and 17 recreational marinas:

U.S. Coast Guard: the U.S. Coast Guard occupies a port on the Grand River in Grand Haven.

<u>Grand Haven Materials Terminal</u>: This privately owned company operates a port along the Grand River in Grand Haven. Approximately 140,000 tons of cement and fertilizer are shipped from this terminal each year.

Standard Sand: This sand receiving dock located in Ferrysburg has been in operation for seventy years.

<u>Verplank Trucking Company (2 docks)</u>: This company imports natural materials such as sand, gravel, and halite (rock salt). One port is located along the Grand River in Grand Haven, and the second is at the eastern end of Lake Macatawa in Holland.

<u>Grand Haven Board of Light and Power</u>: Owned and operated by the City of Grand Haven, this port is located along the Grand River and receives approximately 180,000 tons of coal annually.

<u>Brewer's City Dock, Inc</u>.: Located at the uppermost portion of Lake Macatawa, this port receives approximately 200,000 tons of sand, slag and stone annually.

<u>Holland Board of Public Works</u>: The City of Holland operates this Lake Macatawa port to receive shipment of coal for the James DeYoung power plant. Approximately 140,000 tons of coal are shipped from Cleveland, Ohio to this port annually.

<u>Macatawa Bay Dock & Terminal Company</u>: Padnos Iron and Materials operates this port on Lake Macatawa to receive shipments of scrap iron.

#### **Passenger Rail Service**

Budget cuts threatened to eliminate Amtrak rail service to Grand Rapids and Holland in 1994, but an annual subsidy from MDOT has allowed the Pere Marquette line to continue operations. Ridership on the Pere Marquette line, which travels from Grand Rapids to Chicago, increased from 101,883 in FY 1994-95 to 104,480 the following year, with peak travel times during the winter holidays and the month of August.

#### Local Transit Services

<u>Harbor Transit</u>. Harbor Transit bus service is owned and operated by the City of Grand Haven, with participation of the neighboring communities of Ferrysburg and Spring Lake Township. Harbor Transit operates 15 vehicles on a demand-response basis. Included in its fleet Harbor Transit has 11 buses that are lift equipped, each with a capacity of 14 individual seats and room for 2 wheelchairs. Harbor Transit also provides three trolleys that are in service between Memorial Day weekend and Labor Day.

<u>Macatawa Area Express (MAX)</u>. In 1999, the Dial-A-Ride became the Macatawa Area Express (MAX). The MAX system includes three fixed, scheduled routes in Holland and Holland Township: one crossing Holland from north and south into Holland Township and two crossing

the city east and west. MAX also includes a demand-response service similar to the previous Dial-A-Ride. The transit system is owned by the City of Holland which contracts with a private firm for operation of the service. Holland Dial-A-Ride maintained eleven vehicles each having a capacity for twenty-two passengers. MAX has added several more buses to the service. All of the new buses, plus five of the Dial-a-Ride buses are lift equipped.

<u>Georgetown Senior Bus Service</u>. The Georgetown Senior Bus Service is a demand-response service operated from the Senior Citizen Center in Georgetown Township. The primary intended users of this service are senior citizens and physically challenged individuals. Seniors residing in Georgetown Township, Hudsonville, Jamestown Township, Allendale Township and Coopersville have access to this service that will transport them within a sixty mile radius of Georgetown Township. The Georgetown Senior Bus Service maintains 3 lift-equipped vans.

<u>Greyhound.</u> Two Greyhound bus line routes pass through Ottawa County and have local stops in the cities of Grand Haven and Holland. The route that travels along I-96 and it connects Grand Rapids with Grand Haven and Muskegon consists of two daily runs. The other Greyhound route through Ottawa County also begins in Grand Rapids. Buses travel I-96 to the Holland area and then on to Chicago.

<u>School Buses</u>. Each school district within Ottawa County operates its own school bus system intended for student transportation.

# Condition of Roads, Bridges, and Other Transportation Infrastructure

The Michigan Department of Transportation (MDOT) rates the condition of federal and state highways and trucklines based on surface, base, capacity, and accidents. The condition of each facility is rated as good, fair, or poor. The following is the 1992 rating of major roads in Ottawa County:

- US-31 from Allegan Co. line to Chicago Ave.: GOOD
- US-31 from Chicago Ave. to M-45: POOR
- US-31 from M-45 to Muskegon Co. line: FAIR
- Chicago Ave. from US-31 to 32nd St.: FAIR
- Chicago Ave. from 32nd St. to Kent Co. line: GOOD
- I-196 throughout entire Co. POOR
- M-45 from US-31 to 78th Ave.: GOOD
- M-45 from 78th Ave. to 56th Ave.: POOR
- M-45 from 56th Ave. to Kent Co. line: FAIR
- I-96 from Muskegon Co. line to Kent Co. line: GOOD
- M-104 from Spring Lake to I-96: GOOD

# DROUGHT

"A water shortage caused by a deficiency of rainfall, generally lasting for an extended period of time."[1]

# Hazard Description

Drought is the consequence of a reduction in the amount of precipitation that was 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.

A drought can cause many severe hardships for communities and regions. Probably one of the most common and severe impacts to a community like Ottawa County would be a drop in the quantity and quality of agricultural crops. Other negative impacts that can be attributed to a drought include water shortages for human consumption, industrial, business and agricultural uses, recreation and navigation; declines in water quality in lakes, streams and other natural bodies of water; malnourishment of wildlife and livestock; increases in fires and wildfire related losses to timber, homes, and other property; increases in wind erosion; and declines in tourism in areas dependent on water-related activities.

These direct impacts can further result in indirect impacts to a community, such as reduced revenue due to income losses in agriculture, retail, tourism and other economic sectors; declines in land values due to physical damage from the drought conditions and decreased functional use of the property; and possible loss of human life due to extreme heat, fire, and other heat-related problems.

Two common measurement tools of dry weather conditions are the Palmer Drought Indices (including the Palmer Drought Severity Index and the Palmer Hydrological Drought Index) and the Crop Moisture Index. The Palmer Drought Severity Index is good long-term drought monitoring tool. It is a monthly index that indicates the severity of a wet or dry spell. This index is based on average temperature and rainfall information for a particular location in a formula to determine dryness. It uses a value of 0 as normal or the baseline, and drought is shown in terms of negative numbers; for example, minus 2 is moderate drought, minus 3 is severe drought, and minus 4 is extreme drought. This index can be used for indicating lake levels and surface water supply abnormalities but is not all that good for monitoring climatic impacts on vegetation, especially crops.[1]

The Crop Moisture Index (CMI) evaluates short-term moisture conditions across crop producing regions. The CMI measures how much moisture is in the plant root zone of the soil. This index is based on the mean temperature and total precipitation that occurs each week, as well as the CMI from the previous week. The CMI changes as quickly as the weather changes. A heavy rainstorm can dramatically change the CMI for a region. Since this index changes so quickly and in response to a single weather event, the CMI is not considered a good long-term drought measurement tool.

# Historically Significant Droughts/Drought Related Events in Ottawa County

# Summer of 1871

One of the first recorded catastrophic fires in Michigan occurred as a result of the prolonged drought of 1871. Much of the Great Lakes region was impacted by this dry spell. The lack of

rain left logging debris dry, leading to the break out of fires around the region. This drought was responsible for the Holland fire that destroyed half the of the city, and more notable the Great Chicago Fire. During 1871, more than 200 people were killed in Michigan by fires attributed to the drought.

#### 1904

1904 is one of the driest years on record for Ottawa County. That year only 23.97 inches of rain fell in Grand Haven.

#### 1931

According to the Palmer Drought Severity Index, which contains records from 1895 to the present, the most severe drought to impact southwest Michigan occurred in the year 1931.

#### June 1-September 21, 1996

Ottawa County was granted a disaster declaration for drought by the U.S. Secretary of Agriculture in 1996. Because of this declaration, area farmers became eligible for low interest rate federal loans.

#### January 1-September 30, 1998

During the spring and summer of 1998 Ottawa County received less than 2 inches of rain from mid-April through the end of July, with the most rain anywhere being about 1 inch in Coopersville. Area farmers unofficially reported that this was the driest period since 1987. Because of the drought, Ottawa County farmers became eligible for low-interest emergency loan assistance under a disaster declaration from the U.S. Department of Agriculture. (Please refer to U. S. Department of Agriculture section below for more information on federal disaster assistance).

# **Programs and Initiatives**

No one federal or state agency monitors drought. Rather, a number of agencies have programs and initiatives in place designed to identify, monitor, analyze, and respond to drought. The U.S. Army Corps of Engineers (USACE), Institute for Water Resources, has developed and maintains the <u>National Drought Atlas</u>, which provides information on the magnitude and frequency of minimum precipitation and stream flow in the United States.

#### U.S. Geological Survey

The U.S. Geological Survey (USGS) is the primary federal agency that collects and analyzes streamflow data, another good index of the relative severity of drought. The USGS Hydro-Climatic Data Network is composed of 1,659 streamflow stations in all 50 states and U.S. Territories. These stations have recorded streamflows for 20 years or more. The USGS, in cooperation with over 600 other government agencies, operates some 7,300 stream gauges for data collection. In addition to streamflow data, the USGS collects data on water quality, reservoir levels and contents, and groundwater levels for each state. For Michigan, this data can be found in the annual <u>Water Resources Data for Michigan</u> document.

#### National Weather Service

The National Weather Service (NWS) is the primary Federal agency that collects and publishes precipitation data. The NWS publishes precipitation data from approximately 9,100 non-recording and 2,100 recording stations in the United States. This data is published monthly, by

state, in the <u>Climatological Data and Hourly Precipitation Data</u>. A drop from normal precipitation levels is a commonly-used index to determine drought severity.

#### U.S. Department of Agriculture

The U.S. Department of Agriculture (USDA) has a variety of programs designed to provide federal assistance to farmers and other agricultural enterprises that have suffered a loss due to a natural disasters - including drought. Some assistance programs require that either the President of the United States or Secretary of Agriculture make a disaster declaration before assistance is made available. The USDA Farm Service Agency (FSA) can provide emergency loans to farmers, ranchers, and agriculture operators under one or more of the following programs:

• The Emergency Conservation Program (ECP)

The ECP shares with agricultural producers the cost of rehabilitating eligible farmlands damaged by natural disaster. During severe drought, ECP also provides emergency water assistance, both for livestock and for existing irrigation systems for orchards and vineyards. ECP assistance may be made available without a Presidential or Secretarial emergency disaster designation.

• The Noninsured Crop Disaster Assistance Program (NAP)

NAP is for crops for which insurance is not available. It provides assistance to farmers who grow these crops, which limits their losses from natural disaster and helps to manage their overall business risk. NAP assistance may be made available without a Presidential or Secretarial emergency disaster designation.

• Emergency Loan Assistance (EM)

Low interest EM loan assistance is provided to eligible farmers to help cover production and physical losses in counties declared as disaster by the President or designated by the Secretary of Agriculture. The FSA Administrator my also authorize EM loan assistance to cover physical losses only.

• Emergency Haying and Grazing Assistance

Emergency having and grazing of certain Conservation Reserve Program acreage may be made available in areas suffering from weather-related disaster. Requests for assistance are granted on a county-by-county basis. If approved, harvesting of hay and/or livestock grazing is allowed on cropland that has been removed from production of annual crop programs.

In some instances, applicants affected by disaster in counties contiguous to areas that have received a Presidential disaster declaration, or those that have been specifically designated in a Secretary of Agriculture disaster declaration may also qualify for assistance.

The USDA Natural Resources Conservation Service (NRCS) can provide technical and financial assistance to farmers and agriculture operators for land and water conservation-related efforts aimed at recovering from the adverse impacts of drought and other natural disasters.

#### National Drought Mitigation Center

The National Drought Mitigation Center (NDMC), located at the University of Nebraska-Lincoln, is a major research and information center with the mission to help people and institutions in the United States develop and implement measures to reduce communities' vulnerability to drought. The NDMC, through its various programs and initiatives, stresses prevention and risk management rather than crisis management. The NDMC builds on the work of the International Drought Information Center (IDIC), also at the University of Nebraska-Lincoln, which takes a worldwide perspective in its research and mitigation work related to the hazard of drought. The NDMC and IDIC are both clearinghouses for drought-related research studies, policy and planning assistance, training and educational initiatives, and information sharing. These

organizations are the central coordinating points, worldwide, for drought-related programs and initiatives.

#### State of Michigan

In Michigan, drought identification and monitoring is a multi-agency, collaborative effort that may involve the Departments of Agriculture, Environmental Quality, Natural Resources, Community Health, and the State Police Emergency Management Division. When a drought occurs in Michigan, other agencies, such as the Office of Services to the Aging and the Family Independence Agency, may also become involved to monitor the impact of the drought conditions on individuals and families. Depending on the nature and extent of the situation, a state-level task force may be set up to promote cooperation, coordination, and good information flow among participating agencies. In extreme cases, the State Emergency Operations Center may be activated and staffed for the duration of the event.

# **Summary of Potential Impacts**

Because much of the economy of Ottawa County is based upon agriculture and industry, a drought could negatively alter the quantity and quality of crops, livestock and other agricultural activities, resulting in severe economic and social hardships throughout the County.

Although Ottawa County did not receive a Governor's or Presidential disaster declaration, the County's dry weather in the summer of 1998 did have a significant impact on the County's agricultural sector. The lack of rain affected somewhere between 80 and 90 percent of the County's corn crop. Corn which should have been 6 or 7 feet high reached only 2 to 5 feet. Fruit trees and bushes were also under stress. Area blueberry bushes produced berries about half the size of those produced the year before in 1997. Although not entirely caused by the drought (poor pollination and frost damage in May also contributed), in 1998 blueberry yields for the state of Michigan fell sharply from 1997 levels. In 1997, 72 million pounds of blueberries were produced in Michigan. In 1998 blueberry production dropped to 49 million pounds.[1] In addition, the decrease of rain led to a lack of natural food in the wild, causing deer and birds to eat the blueberry crops.[1]

Drought also increases the threat of wildfire, especially in forested and vegetated areas like those found in Ottawa County. A drought-impacted landscape can quickly turn a small fire into a raging, out of control blaze. Uncontrolled wildfires could potentially destroy homes, business, and other property located in Ottawa County's rural residential areas.

# EARTHQUAKES

"A shaking or trembling of the crust of the earth caused by the breaking and shifting of rock beneath the surface." [1]

# Hazard Description

Earthquakes range in intensity from slight tremors to great shocks. They may last from a few seconds to several minutes, or come as a series of tremors over a period of several days. The energy of earthquakes is released in seismic waves, usually occurring without warning. Earthquakes tend to occur along fault lines, which are formed when large plates of the earth's crust below the surface push and move against one another.

Fortunately, Michigan is not located in an area subject to major earthquake activity. Although there are fault lines in the bedrock of Michigan, they are now considered relatively stable. To date, no destructive earthquake has ever been document in Ottawa County, although several minor tremors have been reported and experienced in Michigan. The most recent of these tremors was in the summer of 1997.

According to the U.S. Geological Survey, although Michigan is in an area in which there is a low probability of earthquake occurrence, portions of Michigan, including southern portions of Ottawa County, fall into the area that could be affected by distant earthquakes which could occur in the New Madrid Seismic Zone.

# **Historically Significant Earthquakes in Ottawa County**

There have been no significant earthquake events in Ottawa County.

# **Programs and Initiatives**

The Federal government has several programs and initiatives in place to help reduce the earthquake threat, two of which impact Michigan. The most recent, and perhaps most prominent, is the development of the Federal Response Plan (FRP) to coordinate federal assistance to a catastrophic earthquake or other similar disaster. Coordinated through the Federal Emergency Management Agency (FEMA), the FRP outlines the responsibilities of 27 federal agencies with a role in disaster response and/or recovery. Should a catastrophic earthquake ever impact Michigan, federal response and recovery assistance would be coordinated under the provisions set forth in the FRP.

In January 1990, Executive Order (EO) 12699, Seismic Safety of Federal and Federally-Assisted or Regulated New Building Construction, was signed into law. This EO requires that appropriate seismic design and construction standards and practices be adopted for any new construction or replacement of a federal building or federally-regulated building receiving federal assistance. The purpose of this EO is to reduce risks from failure of federal buildings during or after an earthquake.

# **Summary of Potential Impacts**

Although the chances are slight, we cannot assume that an earthquake will never impact Michigan or Ottawa County. Based on recent studies, southern Ottawa County could be expected to receive minor damage is an earthquake were to occur along the New Madrid fault. Damage to property would probably be negligible in well-designed and constructed buildings. However, poorly designed, constructed, or older dilapidated buildings could suffer considerable damage.

The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Most casualties result from falling objects and debris. Disruption of communications systems, electrical power, and gas, sewer and water mains can be expected. In addition, water supplies can become contaminated by seepage around water mains. Damage to roadways and other transportation systems may create food and other resource shortages if transportation is interrupted. In addition, earthquakes may trigger other emergency situations such as fires and hazardous material spills, thereby compounding the situation.

# **EXTREME TEMPERATURES**

"Prolonged periods of very high or very low temperatures, often accompanied by other extreme meteorological conditions."[1]

# **Hazard Description**

Prolonged periods of extreme temperatures, whether extreme summer heat or extreme winter cold, can pose severe and often life-threatening problems for residents of Ottawa County. Although radically different in terms of conditions and impacts, the two hazards share a commonality in that they both primarily affect the most vulnerable segments of society: the elderly, children, impoverished individuals, and people in poor health. Extreme temperatures can also negatively impact livestock, crops, and wildlife.

	Hellend		Grand	·	Grand	
Month	Holland Maximum	Minimum	Haven Maximum	Minimum	Rapids Maximum	Minimum
January	30.6	17.6	30.7	18.8	29.0	14.9
February	33.6	18.0	32.8	19.4	31.7	15.7
March	43.1	25.9	41.9	26.8	41.5	24.6
April	57.4	36.7	55.1	37.3	56.7	35.6
May	69.3	46.2	66.4	46.7	69.2	45.6
June	78.6	55.4	75.4	56.1	78.7	55.5
July	82.3	59.7	79.0	61.7	82.6	59.9
August	80.7	58.4	77.7	60.8	80.9	58.2
September	74.0	52.1	71.6	54.0	73.1	50.7
October	62.4	42.4	60.9	44.5	61.2	40.5
November	47.6	32.8	47.0	34.4	46.1	30.9
December	35.5	22.6	35.7	24.1	33.9	20.7
Annual Average	57.9	39.0	56.2	40.4	57.1	37.7

# Daily Average Temperatures in Ottawa and Kent County 1951-1980 (degrees F)

(Source: MSU Climatology Program)

#### Extreme Heat

Extreme heat is characterized by a combination of very high temperatures and very high humidity. When these conditions persist over a prolonged period of time, it is known as a heat wave.

Several health conditions can be caused by exposure to extreme heat. *Heat cramps* are muscular pains that are caused by an imbalance of fluids in the body because of dehydration from heavy sweating. These cramps usually involve the legs or abdominal muscles. *Heat exhaustion* is often the result of exercise or heavy work in a hot place. Physical exertion causes a person to loose fluids through heavy sweating. Blood flow to the skin increase, causing blood flow to vital organs to decrease, creating a mild form of shock. Symptoms include dizziness, weakness, and fatigue. Heat exhaustion can usually be treated by drinking fluids and staying in a cool place until the body temperature and fluids return to normal. *Heatstroke* is a life-threatening condition that results when a person's temperature control system, which produces sweating to cool the body, stops working. When this happens, the body temperature can rise so high that brain damage and death may result if the body is not cooled quickly.

A heat index is often used in the summer to express the possible dangers of extreme heat. The heat index is designed to show how hot it really *feels*, based upon the combination of heat and humidity. Exposure to full sunshine can increase the heat index by another 15 degrees F.

Effect of humidity on apparent temperature									
Air Temperature (degrees Fahrenheit)									
Relative									
Humidity	70	75	80	85	90	95	100	105	110
0 %	64	69	73	78	83	87	91	95	99
10 %	65	70	75	80	85	90	95	100	105
20 %	66	72	77	82	87	93	99	105	112
30 %	67	73	78	84	90	96	104	113	123
40 %	68	74	79	86	93	101	110	123	137
50 %	69	75	81	88	96	107	120	135	150
60 %	70	76	82	90	100	114	132	149	
70 %	70	77	85	93	106	124	144		
80 %	71	78	86	97	113	136			
90 %	71	79	88	102	122	150			
100 %	72	80	91	108	133				

Heat Index

- 00

(Source: Kentucky Division of Emergency Management)

# Extreme Cold

Extreme cold is characterized by temperatures well below freezing, often accompanied by high winds. The longer these cold spells last, the more significant the negative impacts. Unseasonably low temperatures, such as nights that drop below freezing in the late spring or summer months, may also be considered extreme cold.

Like extreme heat, exposure to extreme cold can also create significant health problems. On average, each year 700 people in the United States die as a result of extreme cold-related causes. However, most cold-related deaths are not the direct result of freezing, but rather the result of

preexisting illness and disease that are exacerbated by the extreme temperatures. These illnesses include stroke, heart disease, and pneumonia.

Still, there are some health conditions that are the direct result of extreme cold temperatures. *Frostbite* is the freezing or partial freezing of some part of the body, usually occurring in the extremities such as toes, fingers, ears or nose. Frostbite rarely results in death, but does damage the tissue that has been frozen and in extreme cases can require amputation. A loss of feeling and a white or pale appearance in body parts are symptoms of frostbite. *Hypothermia* is a condition brought on when body temperature drops drastically because of exposure to cold. Hypothermia becomes serious when body temperature drops to below 95 degrees F. When body temperature falls below 90 degrees, the normal body shivering reaction stops, and emergency treatment is necessary. Symptoms of hypothermia include uncontrollable shivering (when the body temperature is above 90 degrees F.), slow speech, memory lapses, frequent stumbling, drowsiness, and exhaustion. If left untreated, or treated improperly, hypothermia will lead to death.

Unlike frostbite, hypothermia can occur to a person who is exposed to only moderate indoor cold stress, typically over a prolonged period of time. Infants, the elderly, or people with conditions that do not allow their bodies to heat normally are most susceptible to this form of onset of hypothermia.

Extreme cold temperatures that occur during the spring and summer months can also harm or destroy agricultural crops. Freezing temperatures drastically can reduce crop yield, which in turn can lead to economic hardship for farmers.

Like the heat index, the wind chill index expresses how weather conditions *feel*. The wind chill index is an air temperature index that measures heat loss from exposed skin surfaces.

Air Temperature (degrees Fahrenheit)									
Wind Speed			Temper				/		
(MPH)	50	40	30	20	10	0	-10	-20	-30
Calm	50	40	30	20	10	0	-10	-20	-30
5	48	37	27	16	6	-5	-15	-26	-36
10	40	28	16	3	-9	-22	-34	-46	-58
15	36	23	9	-5	-18	-31	-45	-58	-72
20	32	19	4	-10	-24	-39	-53	-67	-81
25	30	16	1	-15	-29	-44	-59	-74	-88
30	28	13	-2	-18	-33	-49	-64	-79	-93
35	27	12	-4	-20	-35	-52	-67	-82	-97
40	26	11	-5	-21	-37	-53	-69	-84	-100

#### **Wind Chill Index**[1] Effect of wind speed (mph) on apparent temperature

		45		10	-6	-22	-38	-54	-70	-85	-102
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(Source: The Weather Channel and Kentucky Division of Emergency Management)

# **Historically Significant Extreme Temperature Events in Ottawa County**

<b>Extreme Heat</b>		Extreme Cold	
Temperatures	Date	Temperature	Date
105	July 4, 1921	-24	February 3, 1912
102	July 21, 1934	-21	January 1, 1964
102	July 13, 1947	-21	December 15, 1917
101	July 23, 1934	-18	January 11, 1979
101	June 20, 1953	-16	January 16, 1972

#### **Record Temperatures for the City of Holland 1900-1999 (degrees F)**

(Source: MSU Climatology Program)

# Extreme Heat

#### July 4, 1921

July 4, 1921 holds the record for the hottest day in Holland since 1900. On this day, temperatures rose to 105 degrees.

#### July 18-26, 1934

During the summer of 1934, the entire country suffered a heat wave and drought. On July 18, the temperature rose to 90 degrees in Holland. Temperatures stayed above 90 for an entire week, reaching a high of 102 on July 21, and 101 on July 23. Temperatures began to cool with rain and breezes on July 26.

# July 1936

Once again, a heat wave swept across the country, affecting all areas of Michigan, including Ottawa County. In Holland, daily high temperatures were above 90 from July 6-14, with a reading of 98 on July 11, and 99 on July 13. Nationally, the death toll from this heat wave surpassed 3000.

#### Summer 1988

This summer ranks as one of the hottest in the history of Holland. From May to August, 25 temperature records were set. These records ranged from 86 degrees in May to 100 degrees on July 7. Then again in August, temperatures reached 91 to 97 degrees on the 2-9, and 90 to 96 degrees on the 12-18. On the night of August 16-17, Holland recorded the warmest low temperature ever recorded in Michigan. This night the low fell to only 82 degrees.

#### July 30, 1999

July 30 was the hottest day in 1999. Temperatures peaked at 97 degrees in Ottawa County, with a heat index of 113 degrees.

<u>Extreme Cold</u> February 3, 1912 The February 3, 1912 temperature of 24 degrees below zero marks the day of the all time record low in the City of Holland.

#### December 15, 1917

Almost matching the record low, temperatures in Holland fell to 21 degrees below zero on December 15, 1917.

#### December 31, 1963-January 1, 1964

On December 31, 1963 the temperature dropped to 16 degrees below zero in the City of Holland. Then the next day the temperature dropped even further to 21 degrees below zero. This counts as the coldest two-night stretch in the history of Holland.[1]

#### February 17, 1969

This day temperatures fell to 16 degrees below zero.

#### January 16, 1972

Like three years earlier, temperatures fell to 16 degrees below zero.

#### January 11, 1979

Temperatures fell to 18 degrees below zero in Holland.

#### December 9-10, 1995

A cold wave passed through lower Michigan on December 9-10, 1995. Winds averaging 20 to 25 mph combined with afternoon temperatures in the single digits to produce wind chills of 30 to 35 degrees below zero.

# April 6-10, 1997

A U.S. Department of Agriculture disaster declaration was granted to Ottawa County for extreme cold temperatures that occurred over this five day stretch.

#### June 1-9, 1998

Severe crop damage occurred, and area farmers became eligible for federal disaster assistance, following a cold snap in early June 1998. During this week long spell, night time temperatures dropped below freezing. This is quite a bit lower than the average June low temperature of 55 degrees. Because of these freezing temperatures, Ottawa County received a U.S. Department of Agriculture Disaster Declaration.

# **Programs and Initiatives**

#### Extreme Heat

Heat waves severe enough to threaten health do not occur every year in West Michigan, and several mild summers may intervene between major heat waves. This erratic occurrence hinders effective planning and prevention efforts. The problem is further complicated by the fact that long-term weather forecasts cannot reliably predict prolonged periods of extreme heat. Short-term forecasts of hot weather are more accurate, but often leave little time for mobilizing the effort needed to effectively combat the hazard.

In the aftermath of extreme summer heat events of 1980 and the early 1990s', many cities are beginning to develop contingency plans for addressing heat-related hazards. The primary elements of these plans include: 1) enhanced weather monitoring to better predict periods of

extreme heat; 2) increased outreach to the elderly and other vulnerable individuals; 3) establishment of "cooling centers" for those who do not have air conditioned homes and are affected by the heat; and 4) enhanced public information campaigns to inform people of the dangers of extreme summer heat and the resources available to them.

#### Extreme Cold

Since illness and death from hypothermia are not only seen in association with prolonged periods of extreme outdoor cold temperatures, efforts to prevent hypothermia must be ongoing throughout the winter. Because elderly people are particularly vulnerable to hypothermia, intentional prevention efforts must be directed to them. Family, friends, neighbors, local governmental and voluntary agencies can help ensure that all elderly persons' homes are properly heated. This may require that a regular outreach program be established specifically for this purpose. In Ottawa County, the Community Action Agency administers a weatherization program that inspects and repairs homes of low-income County residents. This program helps to ensure that the homes of these residents, many of whom are elderly, are sufficiently heated during the winter.

Local communities should also have adequate housing codes that require dwellings to have furnaces capable of maintaining sufficient room temperature for the winter conditions that will normally be expected. Governmental authorities, voluntary agencies and utilities can also assist those elderly people that cannot pay all or part of their heating bills by providing financial assistance and/or making special arrangements for payment. Most utility companies have special payment programs for the elderly or low income customers who have difficulty making payment for heating related utility use.

Finally, government and voluntary agencies should, in conjunction with local media, continue to address the dangers associated with cold temperatures through regular public information and awareness campaigns. The combination of all these activities certainly will not prevent all cold temperature-related injuries and deaths, but it will go a long way toward preventing a large share.

# **Summary of Potential Impacts**

The "lake effect" on Ottawa County's climate is quite strong throughout much of the year, especially for those communities located along the shoreline. The prevailing westerly winds, in combination with Lake Michigan to the west, produce this lake effect. The lake effect moderates the temperature in the County through all four seasons. Because the day-to-day weather is controlled by the movement of pressure systems across the nation, Ottawa County seldom experiences prolonged periods of hot, humid weather in the summer or extreme cold during the winter.[1] However, days of extreme cold and heat do periodically occur, and therefore residents of Ottawa County must be aware of the dangers and prepared to respond when extreme temperatures strike.

# Extreme Heat

Extra health precautions are necessary during a heatwave. Exposure to extreme heat may result in: heat cramps, heat exhaustion, and heat stroke. Prolonged high temperatures, when not accompanied by rain, may also lead to drought conditions. This can have a significant negative impact on the County's agricultural sector. (Please refer to the *Drought* section for more information on this topic).

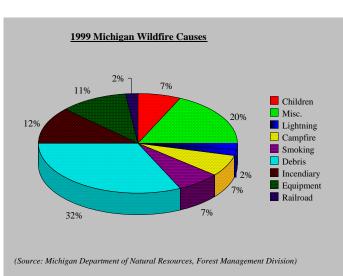
Extreme Cold

Extreme cold often accompanies a winter storm. As mentioned earlier, prolonged exposure to cold can cause frostbite or hypothermia and become life-threatening. Infants and elderly people are most susceptible, but so are those people who take part in outdoor activities during extreme cold events. Insufficient home heating and/or insulation may create health problems, especially for the elderly, ill, infants. Also, poorly insulated homes may have water pipes freeze and burst resulting in damage to the home. People with mobility limitations may find it especially difficult to leave home and become more dependent on outside assistance.

Non-health related problems can also be cause by extreme cold. Extreme cold temperatures that occur during the growing season for local agricultural products may lead to crop failure. This in turn could cause economic hardship for County farmers. In the winter and spring months, extreme cold may cause ice jams on local rivers and lead to flooding. (Please refer to the "Riverine and Urban Flooding" section for more information on ice jams.)

# FIRES: WILDFIRES

"An uncontrolled fire in grasslands, brushlands or forested areas." [1]



debris burning was responsible for 32 percent of the

wildfires in Michigan in 1999. Incendiary, or intentional,

**Hazard Description** 

According to 1991 calculations, Ottawa County contains 83,335 acres of forested land. This

accounts for slightly more than 22 percent of the total land Area.[1] In addition, there are long stretches of dune land covered by grasses and shrubbery. Both the forested areas and the dunes contain vegetation that, given the appropriate conditions, can be highly flammable.

Contrary to popular belief, lightning strikes are not a leading cause of wildfires in Michigan. Today, only 2 percent of all wildfires are caused by lightning, and the rest are caused by human activity. Outdoor burning is the leading cause of wildfires in Michigan. As you can see from the chart below.

Upon examination of the causes of fire, it becomes apparent that most Michigan fires accounted for another 12 percent of the total wildfires. wildfires occur close to where people live and recreate, which puts both people and

property at risk. The immediate danger from uncontrolled wildfires is the destruction of timber, structures, other property, wildlife, and injury or loss of life to people who live in the affected area or who are using recreational facilities in the area.

# Historically Significant Wildfires in Ottawa County

Although there have been no devastating wildfires in recent years in Ottawa County, each year there are hundreds of small fires. (Refer to the Analysis and Impact section for more information on the annual number of wildfires in Ottawa County). Given the appropriate weather, fuels (dry and dead grasses, tree debris, etc.) and topography, any fire can develop into a significant wildfire.

# **Programs and Initiatives**

Michigan Department of Natural Resources, Forest Management Division

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

#### Michigan Forest Fire Experiment Station

A string of disastrous wildfires in the early part of the 20th century led to the creation of the Michigan Forest Fire Experiment Station in 1929. This Station, established by the Michigan Department of Conservation (now Natural Resources) and located in Roscommon, is designed to investigate how wildfires behave, how to properly manage forest fuels, and how to use mechanized equipment to fight wildfires. Its research efforts have been invaluable in helping to prevent, contain and suppress wildfires in Michigan and across the country.

#### Michigan State Police Fire Marshal Division

The services provided by this office are many and varied, ranging from their primary mission of fire/arson investigation, the collection and analysis of data, public education, and training and certification of fire service personnel through the Fire Fighters Training Council.

#### Michigan Interagency Wildland Fire Protection Association

Because the vast majority of wildfires are caused by human activity, the Michigan Interagency Wildfire Prevention Group was established in 1981 by the Michigan Department of Natural Resources. This was the first such group in the nation promoting wildfire prevention and awareness that had 100 percent involvement of the state's fire agencies. By 1993, the Michigan Interagency Wildfire Prevention Group had expanded to form the Michigan Interagency Wildland Fire Protection Association (MIWFPA). The MIWFPA promotes interagency cooperation in fire prevention, training, fire technology, and fire fighting operations. Members of the MIWFPA include: 1) DNR Forest Management Division; 2) USDI Forest Service: Huron-Manistee, Hiawatha, and Ottawa National Forests; 3) USDI National Park Service: Pictured Rocks and Sleeping Bear Dunes National Lakeshores; 4) SDI Fish and Wildlife Service: Seney National Wildlife Refuge; 5) USDI Bureau of Indian Affairs; 6) Michigan Department of State Police, Fire Marshal Division; 7) Michigan State Firemen's Association; and 8) Michigan Fire Chief's Association.

# Michigan Natural Resources and Environmental Protection Act

The Michigan Natural Resources and Environmental Protection Act (451 P.A. 1994), Part 515, assigns responsibility for the prevention and suppression of forest fires to the Director of the Michigan Department of Natural Resources. The Act also establishes requirements for burning permits, allows the Governor to issue prohibitions against the use of fire during extreme fire hazard conditions, and allows the DNR Director to enter into forest fire assistance agreements with other states and the federal government to control forest fires. These measures contribute to forest fire mitigation by preventing forest fires from starting in the first place, or lessening the spread of fires when they do start.

# Solid Waste Management Act

The Michigan Solid Waste Management Act (264 P.A. 1990) prohibits the burning of leaves and grass clippings in municipalities over 7,500 in population, unless a municipality has an ordinance expressly allowing such burning activities. When properly applied and enforced, this law helps prevent some wildfires, since roughly one-quarter of all wildfires are started by small residential waste fires that get out of control.

#### Great Lakes Forest Fire Compact

The DNR Forest Management Division is a member of the Great Lakes Forest Fire Compact. The Compact is a partnership between the states of Michigan, Wisconsin and Minnesota, and the Canadian provinces of Ontario and Manitoba. Its purpose is to promote effective prevention, presuppression, and control of wildfire in the Great Lakes region through mutual aid and cooperation. Initiatives are implemented by committees comprised of members of the Compact. An example of an activity the Compact has undertaken is the development of a fire hazard assessment for the region. Michigan took the lead on this project, and it has proven to be an extremely beneficial educational tool for communities and property owners in assessing their fire hazard potential.

The efforts of the Compact to build coordination and cooperation are based on the understanding that wildfires are multi-jurisdictional, and that suppression of fires usually requires the efforts of many groups and jurisdictions.

# National Fire Incident Reporting System

The National Fire Incident Reporting System (NFIRS) was established by the National Fire Data Center in order to carryout the intentions of the Federal Fire Prevention and Control Act of 1974 (P.L. 93-498). This Act authorizes the National Fire Data Center of the United States Fire Administration (USFA) to gather and analyze national information on fires. The Act further authorizes the USFA to develop uniform data reporting methods, and to encourage and assist state agencies in developing and reporting data.

The most recent version of NFIRS, version 5.0, was released in January 1999. This software has been designed as a tool for fire departments to report and maintain computerized records of fires and other fire department incidents in a uniformed manner. Not only does NFIRS 5.0 help State and local government develop fire reporting and analysis capability for their own use, and to obtain data that can be used to more accurately assess and subsequently combat the fire problem at a national level, it expands the collection of data beyond fires to include the full range of fire department activity on a national scale. It is a true all-incident reporting system.

As of January 1, 1999 Michigan required that all fire incidents be reported with NFIRS 5.0. This includes those fires suppressed by both the DNR and local fire departments. However, as of January 2000 the system still had some glitches and was not fully operational.

# Summary of Potential Impacts

According to the Great Lakes Forest Fire Compact, three-quarters of all wildfires are caused by people being careless. There is no excuse for these fires. With appropriate fire safety education and more attention to the dangers and causes of wildfires, these fires can be prevented.[1]

Between 1981 and 1996, 103 wildfires in Ottawa County were suppressed by Michigan Department of Natural Resources (DNR) personnel. These fires occurred on state lands where the DNR has jurisdiction (such as state parks), and burned a total of 399 acres. None of these wildfire events was considered a "significant" wildfire. The most recent reports from the DNR indicate that in 1999 the DNR responded to 5 wildfires in Ottawa County. Three of these fires were ignited by the burning of debris, 1 was incendiary, and 1 was accidentally caused by a child. These fires ranged from 3/10 of an acre to 17.1 acres in size.[1]

In 1998, local fire departments reported suppressing 206 wildfires in Ottawa County.[1] Examining these statistics, it becomes apparent that the dry summer months can have a dramatic influence on the number of fires. In July of 1998, following an uncommonly dry spring and early summer, there were 67 wildfires reported in Ottawa County, and 39 wildfires reported the month before. This is compared to 1 fire in January, and 3 fires in December. The number of fires is probably also higher in the summer months for two reasons. First, the summer is when there are more outdoor vacationers participating in activities that can easily lead to wildfires. Second, more burning of debris on private property occurs in the summer. There were also 11 fires in November. This may correlate to people camping and hunting, as well as people burning fall debris.

Currently, fire suppression activities of the DNR and local fire departments are tracked by separate reporting systems. However, following the transformation to the National Fire Incident Reporting System (NFIRS), most fire suppression activities that occur in Ottawa County will be logged in a uniform manner under one system. The NFIRS will be a useful tool for analyzing wildfire activity at a time when Ottawa County is developing at such a rapid pace.

With more people living in rural areas, their activity leads to more wildfires. Debris burning accounts for over one-third of the fire starts in Michigan. These fires, by their very nature, occur in close proximity to homes and other structures.[1] This increases the potential for loss of life and property from fire. Properties that have not been properly fire-protected, by clearing leaf and tree debris and planting fire resistant vegetation an appropriate distance from structures, increase the fire hazard.[1] Carelessness and not keeping a close watch on a debris fire can also allow a contained fire to get out of hand.

Fires in rural dune and woodlands areas are also hard to control, and create special accessibility challenges. Not only do the brush, dry grasses and tree debris create more fuel for the fire, but usually structures are not close to fire stations, and tend to be difficult to access with fire suppression equipment. Also, an inadequate supply of water can impede fire suppression. While urban fire fighters usually have access to water mains and fire hydrants, rural departments often must protect remote and rural areas with water they transport themselves.

Planning for rural fire suppression is a multi-step process. The four steps that must be considered are: 1) how much water is needed; 2) where are available water supplies; 3) what are the advantages of a dry hydrant system; and 4) how is water moved to the fire.[1] Strategic placement of dry hydrants can be a successful methods for ensuring an accessible water supply in rural areas. Property owners, developers and local fire departments should consider the installation of dry hydrants at plentiful water supplies such as ponds and streams. When appropriately placed with sufficient vehicle access, a dry hydrant can allow more water to be distributed in less time.

Unless residents in rural and urbanizing areas of Ottawa County take the necessary precautions to ensure that their homes are located, constructed, and maintained to minimize the risk of ignition, and that all measures are in place to suppress a fire that does ignite, then it is anticipated that the number of wildfires in the County and the property damage associated with these fires, will increase as the rural areas continue to become more populated in the coming years.

# **FLOODING: DAM FAILURES**

"The collapse or failure of an impoundment resulting in downstream flooding."[1]

# **Hazard Description**

A dam failure can result in loss of life and extensive property or natural resource damage for miles downstream from the dam. Dam failures occur not only during flood events, which may cause overtopping of a dam, but also as a result of misoperation, lack of maintenance and repair, and vandalism. A common form of dam failure occurs when tree roots disrupt the integrity of an earthen dam. Water can pass through the dam where the soil has been broken apart by the roots.

In Ottawa County there are 6 publicly owned dams that fall under the jurisdiction of the Ottawa County Drain Commission. In addition, there are numerous privately owned dams scattered throughout the County. Many privately owned dams are located in Zeeland Township where soil types and ravines allow for the easy construction of earthen dams.

In Michigan, all dams over 6 feet high that create an impoundment with a surface area of more than 5 acres are regulated by Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act (451 P.A. 1994), as amended. This statute requires the Michigan Department of Environmental Quality (DEQ) to rate each dam as either a *low*, *significant*, or *high* hazard potential. This rating system is based solely on the potential downstream impact if the dam were to fail, and is not according to the physical condition of the dam.

The potential downstream impact is figured by assessing the population concentration and economic activities located downstream from the dam. Dams assigned the *low* hazard potential rating are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property. Dams assigned the *significant* hazard potential rating are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure. Dams assigned the *high* hazard potential classification are those where failure or misoperation will probably cause loss of human life.

Dam owners are required to maintain an emergency action plan (EAP) for *significant* and *high* hazard potential dams. Owners are also required to coordinate with local emergency management officials to assure consistency with local emergency operations plans.

# Historically Significant Dam Failures in Ottawa County

Although there are earthen dams that require maintenance or dams that have had water seepage, there have been no outright dam failures in Ottawa County.

# May 20-21, 1996

After several inches of rain fell in the southern portion of the County on May 20, officials were concerned about the Timmer Dam, which is located south of Quincy Street between 48th and 56th Avenue in Zeeland Township. According to reports, at one point water to a depth of 15 inches flowed over the emergency spillway of the dam. Residents living downstream of the dam were put on alert, however water levels dropped and no significant damage occurred.[1] (Please refer to the *Analysis and Impact* section for more information on potential dam failure problems in Ottawa County.)

# **Programs and Initiatives**

Both the Michigan Department of Environmental Quality (DEQ) and the Federal Energy Regulatory Commission (FERC) classify and regulate dams in Michigan.

The current Dam Safety Act was passed following a September 1986 flood in central Lower Michigan. During this event, 11 dams failed and 19 others were threatened with failure, resulting in about 1500 people being evacuated from downstream of the dams. The Dam Safety Act is meant to ensure that dams are built and maintained with the necessary engineering and inspections for safety of the public and the environment.

The DEQ Dam Safety Program administers the provisions of Part 307 and Part 315 of The Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Part 315, Dam Safety, provides for the inspection of dams. This statute requires the DEQ to rate each dam as either *low*, *significant*, or *high* hazard potential, according to the potential downstream impact if the dam were to fail. Dams over 6 feet in height that create an impoundment with a surface area of more than 5 acres are regulated by this statute. Statewide, the DEQ has identified and rated over 2,400 dams. Dam owners are required to maintain an emergency action plans (EAP) for *significant* and *high* hazard potential dams. Owners of these dams are also required to coordinate with local emergency management officials to assure consistency with local emergency operations plans. Approximately 240 dams in Michigan come under state regulations requiring EAPs.

Part 307 of The Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, regulates the construction and maintenance of dams specifically as they relate to inland lakes.

The FERC licenses water power projects (including dams) that are developed by non-federal entities, including individuals, private firms, states and municipalities. Under provisions of the Federal Power Act and federal regulations, the licensee of the project must prepare an EAP. This plan must include a description of actions to be taken by the licensee in case of an emergency. Inundation maps showing approximate expected inundation areas must also be prepared. Licensees must conduct a functional exercise at certain projects, in cooperation with local emergency management officials. However, there are no dams regulated by FERC in Ottawa County.

# **Summary of Potential Impacts**

According to the Michigan Department of Environmental Quality Dam Safety Division, only one dam in Ottawa County is classified as a *significant* hazard, and there are no dams categorized as a *high* hazard potential. The *significant* hazard dam is the Black Creek Watershed Structure 1A, commonly known as Berens Dam. This dam is owned by the Ottawa County Drain Commission and is located along the Black River in the southeast corner of Blendon Township. This dam was build in 1993 by the Ottawa County Drain Commission as a stormwater detention basin dam and does not hold a permanent body of water.[1]

Several dams in the County do not hold bodies of water most of the time. Those dams operated by the Ottawa County Drain Commission have serve 3 primary functions: 1) stormwater control during heavy rain; 2) water quality improvements (such as sediment entrapment); and 3) wildlife habitat.

Timmer Dam, located in Zeeland Township, has not outright failed but does require maintenance (although this structure was receiving maintenance at the time of writing this analysis). Timmer Dam holds a permanent water body that forms an 11 acre lake. Although not classified as a significant or high hazard potential by the DEQ, local officials believe that if this dam were to fail, it could disrupt traffic along Quincy Street, M-21 (Chicago) and the CSX rail line, cause property damage in the vicinity, and possibly even lead to loss of life.

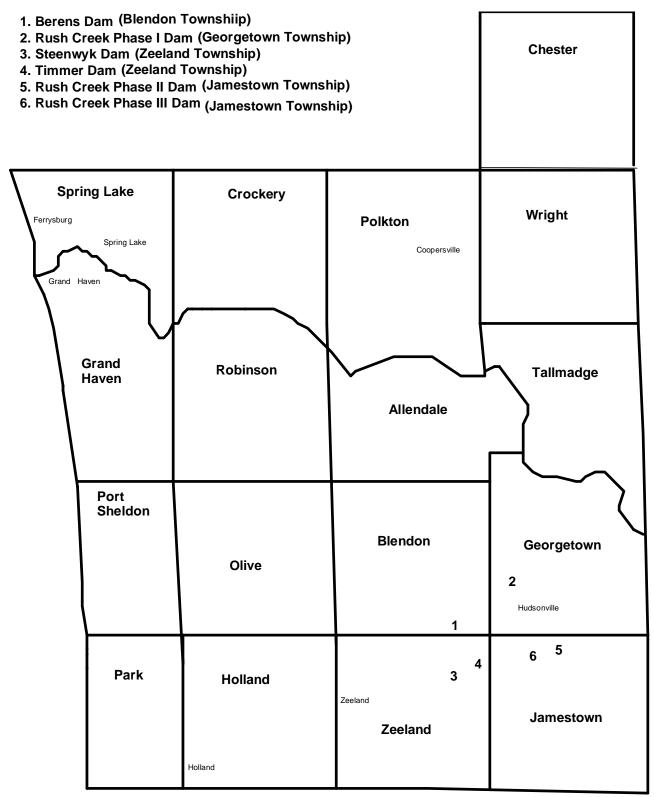
Several privately owned earthen dams in the County also have the potential to fail and cause flooding problems. One example is the Motman dam, located in Tallmadge Township. This dam has not failed, but has caused some concern for County officials. It is an earthen embankment across a small ravine and tree roots growing in the dam have created leaks in the dam. M-45 is located downstream of this structure, so if this dam were to fail, it could disrupt traffic on M-45 and possibly inundate homes located in the vicinity. It is important to note that this is just one example of many privately owned and operated dams in the County. There are several other dams that could be in a similar position.

Failure of dams located in contiguous counties could impact Ottawa County as well. One example is Ottagon Dam, located just south of the Ottawa-Allegan County boarder in Laketown Township. Located directly south of Ottagon Street (32nd Street), near Old Orchard Avenue in the City of Holland, this dam was recently installed to help combat flooding problems in the neighborhood near Ottagon Street. If the dam were to fail, it could potentially flood an area from Ottagon Street north to Lake Macatawa. This is a residential neighborhood where flooding could cause extensive property damage. So although this dam is physically located in Allegan County, if the dam were to fail, almost all of the damage would occur in Ottawa County.

Development of an emergency management plan for each dam in the County might help to lessen the risk of dam failure. Development of effective emergency plans requires accurate prediction of water levels and times at a given location. A *Breach Inundation Study* has been performed for several dams in the County. This study examines the potential downstream impacts were a dam to fail. Such studies are crucial to characterizing and reducing threats due to potential dam failures.

Since the hazard level of dams is based upon the potential downstream impacts if the dam were to fail, it is possible for the hazard status of a dam to change over time. As Ottawa County becomes more developed, and there are more people and businesses located downstream from dams, the potential human and economic impact from a dam failure is increased.

# Ottawa County Publicly Owned Dams Ottawa County Drain Commission



# FLOODING: RIVERINE & URBAN

"The overflow of rivers, streams, drains and lakes due to excessive rainfall, rapid snowmelt or ice."[1]

# **Hazard Description**

Every year, more homes in the United States are damaged by floods than any other natural disaster. These floods costs homeowners more than \$2 billion in property damage.

Several areas of Ottawa County are considered high risk locations for *riverine flooding*; this is especially true along the Grand River. Riverine flooding occurs when there is an increased amount of water in a stream or river channel, and the river overflows its banks onto the floodplain. (A *floodplain* is the area of land adjoining a lake, river or other watercourse which will be inundated by a flood.) The Pigeon River, Rush Creek, and waterways in the Lake Macatawa watersheds are additional flood threats, to name a few. Much riverine flooding occurs in the early spring as a result of excessive rainfall and/or the combination of rainfall and snowmelt. Ice jams also can create riverine flooding problems in winter and early spring.

However, flooding does not only occur when a river or lake overflows its banks. Most urban flooding is simply the combination of excessive rainfall and/or snowmelt, saturated ground, and inadequate drainage. To illustrate this point, the National Flood Insurance Program (NFIP) reports that almost 25 percent of all flood insurance claims come from properties that are *not* located in a "special flood hazard area," also known as the 100-year floodplain. The 100-year floodplain is "an area of land that would be inundated by a flood having a 1 percent chance of occurring in any given Year." [1] Most 100-year floodplains are located along rivers and lakes. In Ottawa County, several heavy summer rains have resulted in significant culvert and drain flooding, especially in the cities of Holland and Zeeland.

	1900	
Month	Holland	Grand Haven
January	2.28	2.06
February	1.48	1.29
March	2.45	2.2
April	3.59	2.98
May	2.8	2.91
June	3.91	3.09
July	3.17	2.61
August	3.32	3.01
September	3.39	3.27
October	3.13	2.83
November	3.13	2.67
December	3.03	2.36

#### Monthly Mean Precipitation (liquid equivalent in inches) in Ottawa County 1951-1080

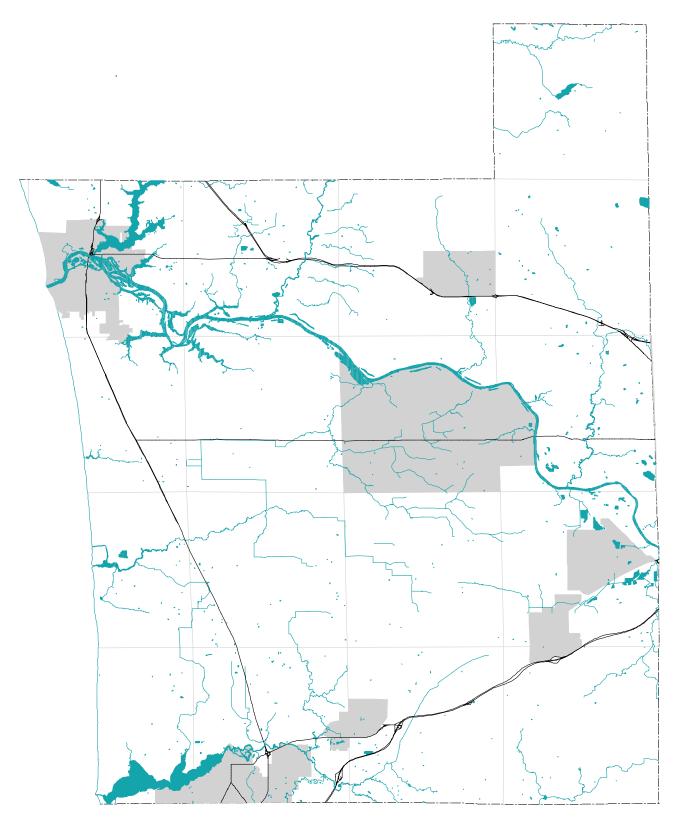
Annual Average	35.68	31.28

(Source: MSU Climatology Program)

# Ice Jams

Cold winters like those we experience in Ottawa County can produce thick river ice and the potential for ice jams. An ice jam develops when pieces of snow and ice build up along a river. As the ice buildup increases, water passes slowly, and flooding develops behind the dam of ice. Water levels can also rise rapidly when temperatures rise and result in snowmelt runoff or rain, thus adding more water to the river behind an ice jam.

In the spring, or when temperatures rise, the ice buildup will thaw and break up, and may unleash all of the damned up water in a short period of time. When this occurs, flooding can rapidly result downstream from the ice jam. The combination of ice, debris, and water released from the ice jam can cause tremendous physical damage to homes, docks, and other structures.



# Historically Significant Flooding in Ottawa County

# **Record Rainfall Events in the City of Holland 1900-1999**

Rain Amount	Date
11.0 inches	July 17-18, 1982

7.7 inches	May 20-21, 1996
4.71 inches	June 16, 1972
4.16 inches	June 7, 1967
4.1 inches	June 21, 1997

(Source: The Holland Sentinel, "Holland's extremes of the century," January 1, 2000)

Two regions in Ottawa County have historically experienced the most flooding. Almost annually, flooding occurs along the Grand River, especially in Robinson Township, where homes have been built in the 100-year floodplain. Minor flooding in past years has caused road blockages and inundation of homes in the spring and early fall, depending on the weather and level of the river. Major flooding of the Grand River occurred in 1994, 1996, and 1998 in Robinson Township. Besides the Grand River region, flooding also occurs periodically in the southern half of Ottawa County, espcially near Holland, Zeeland and Georgetown Townships. The following is a description of some of the more significant flooding events that have occurred in Ottawa County over the past 30 years.

# April 1975

A series of intense thunderstorms passed through southern Lower Michigan during the last two weeks of April, 1975, spawning several tornadoes and causing widespread flooding over a 21-county area. Total private and public damage in the regions was nearly \$58 million. A Presidential Major Disaster Declaration was granted for Ottawa County, as well as 20 other affected counties.

# August-September 1975

During the last week of August and first week of September in 1975, intense thunderstorms and severe winds pounded west-central and central Lower Michigan. The heavy rainfall accompanying these storms caused widespread flooding, resulting in nearly \$3 million in public and private damage. A Presidential Major Disaster Declaration was granted for the 16 affected counties, including Ottawa County.

# May 10-11, 1981

Over 5 inches of rain fell during this two day period of May 10-11, 1981, leading to flooded and washed out roads throughout the southern portion of Ottawa County.

In the City of Holland and Holland Township, flooded roads included: 24th Street between Waverly Road and Country Club Road; Pine Avenue in front of the Power Plant; Van Bragt Park near River Avenue; US-31 at New Holland, Quincy, and Riley Street Some sections of Quincy Street and Greenly Street were under 6 inches to 1 foot of water. In addition, the Paw Paw bridge over Macatawa River was damaged by high water.

The City of Zeeland and Zeeland Township also dealt with problems from high waters. Paw Paw Drive between Chicago Drive and 104th Avenue was flooded, and 96th Avenue at and Quincy Street was under 2 feet of water. Zeeland Public and Christain schools were closed, and Zeeland High School sustained \$2,000 to \$3,000 damage. A Zeeland sewer lift station that could not handle the large capacity of water flooded, resulting in numerous flooded basements. And streets were flooded and water entered homes in the vicinity 104th Avenue and Alice Street along Noordeloos Creek.

In other parts of the County the Macatawa River flooded Chicago Drive from Zeeland to Hudsonville, and Rush Creek flooded Chicago Drive at Port Sheldon Road in Georgetown Township.

# July 17-18, 1982

An 11 inch deluge on July 17-18, 1982 left most major thoroughfares leading out of the Holland area impassable because of flooding. At one point, US-31 northbound, which was closed south of 32nd Street, was the only major roadway out of town. By July 19, several streets in the area were still closed due to damage and high water.

In addition, this storm cause property damage all around Holland. In the city, water flooded all the home basements along 24th Street between Lincoln and Fairbanks, causing 3 gas leaks. Heavy rain caused the roof to cave in at Montgomery Wards, and sewer backups occurred when power was knocked out at the lift station on 8th Street near Chicago Drive. Flood waters also left the intersection of Chicago Drive and 8th Street in pieces.

Lightning and wind associated with the storm knocked out power out all over the area. One report estimated that 20 percent of the Holland area population was with out power for an extended period of time. Several Holland BPW substations were knocked out, as well as primary and secondary power lines. Consumers Power representatives estimated that 21,000 of their customers were left without power.

#### September 10, 1986

On September 10, 1986, a slow moving storm system moved across the middle of the Lower Peninsula. In a 24 hour period, this storm produced rainfall amounts ranging from 8 to 17 inches over an area 60 miles wide and 180 miles long. In Ottawa County, emergency spillways were destroyed at 2 Drainage District dams in the Rush Creek watershed. Around the state, flooding from the storm caused thousands of people to be evacuated and caused over \$30 million in damage. At the time, it was considered the worst flood in Michigan in 50 years. Thirty counties, including Ottawa County, were included in a Governor's Disaster Declaration and Presidential Major Disaster Declaration.

#### May 29, 1989

Several residences flooded along the Rose Drain at M-21 (Rich Street) in the City of Zeeland when 5 inches of rain fell in 24 hours.

# October 17, 1992 and October 17, 1993

Occurring exactly one year apart, these two heavy rain events of 3 to 4 inches in 24 hours caused water to flow over a significant stretch of Kenowa Avenue in the vicinity of 44th Street in Georgetown Township. Homes were reported to have flooded during these events and cars stalled in the high water in the roads. Because of the high water, residents of the Brookmeadow Apartments had difficulty accessing their complex. Flooding from both these events was localized in the southeastern quarter of the County

#### February 24-March 5, 1994

In February 1994, mild temperatures led to a rapid snowmelt in Ottawa County. Because the ground was still frozen, water from the snowmelt was not absorbed. On February 24, extensive water runoff caused the Grand River to go out of its banks behind a mile and a half long ice jam in Robinson Township. On this day, water levels on the Grand River rose approximately 5 feet in 45 minutes. By February 25, the Grand River had risen 5 feet above bankfull, and forced the evacuation of 125 people from 41 homes located along the river. Small boats were used to

evacuate families whose homes were quickly flooded. The high water level did not return to below bankfull until noon on March 5. During this 10-day period, floodwaters damaged 45 homes and 3 businesses, causing at least \$260,000 worth of private property damage.

Public damage from this flood included damage to sections of 3 County roads and Riverside County park. The County formally requested a Governor's Disaster Declaration, but was denied. However, the Governor did request and receive a Small Business Administration Disaster Declaration which made available low-interest disaster loans to those home and business owners that suffered uninsured losses in the flood. It is estimated that total damage from this flood was \$500,000.

#### July 5, 1994

A slow moving storm system dropped 2 to 4 inches of rain in northern Ottawa, Kent, and Ionia Counties during the early morning hours on July 5, 1994. This heavy rain resulted in moderate, but widespread flooding in low spots and underpasses. The waterway most affected in Ottawa County was Crockery Creek in Chester Township, which crested at 2 feet above bankfull. Although there was no significant damage as a result of this flood event (most flooding occurred in rural, less populated areas), the heavy rain did necessitate the dumping of more than 4.2 million gallons of untreated, but diluted sewage into the Grand River at Grand Rapids.

#### May 18, 1996

3.5 to 5.5 inches of rain fell in a 24 hour period on May 18, 1996. The heaviest rains fell in the townships of Zeeland, Jamestown, and Georgetown. Ottawa County Flooding events associated with this storm occurred at the intersection of 44th Street and Kenowa Avenue in Georgetown Township, and water flowed into the spillway at Timmer Dam in Zeeland Township.

#### May 20-21, 1996

From May 20 to 21, 1996 rains of 3.5 to 4.5 inches led to extensive flooding in the City of Holland and surrounding rural areas. Early in the afternoon on May 20, police closed US-31 between Lincoln and 32nd Street where a half mile portion of the highway was covered with water under the railroad overpass near 40th Street. Later in the evening, police also closed US-31 at Washington Avenue. The high point of flooding occurred between 8:00 and 9:0 PM on May 20. The flooding also caused a partial washout of the 32nd Street bridge over the Tulip Intercounty Drain.

In the City of Zeeland, Noordeloos Creek overflowed its banks and flooded streets and yards near 104th Avenue and Alice Street. Chicago Drive from east of the City of Zeeland to Hudsonville was also under water for a period of time.

In addition to causing widespread property damage to homes that received flooded basements, one vehicle slid off the road into a tributary to the Black River along Adams Street near 80th Avenue in Zeeland Township where high water covered the road. When the driver abandoned his vehicle, he was swept away by the current under the bridge. The driver was forced to cling to a tree above the rushing water until rescuers arrived.

Property damage caused by this flood was reported at \$100,000 by the National Climatic Data Center.

#### June 18, 1996

On June 18, 1996, the Holland area experienced the heaviest rainstorm since 1982. Widespread flooding occurred around Holland as previously rain soaked areas received several more heavy showers throughout the day. The total rainfall for June 18 was 4.41 inches, with an additional

3.46 inches having fallen on the previous day. Once again numerous roads were closed for a time, including US-31 near Lincoln Avenue. Some motorists were stranded in up to 5 feet of water near this particular intersection. Pine Avenue in the City of Holland was also closed due to high water overwhelming city storm sewers. Dozens of homes and businesses were flooded, mostly located in the areas of 16th Street and Lincoln, College Avenue and 19th in the City of Holland, and along the Pine Creek in Holland Township. In the City of Zeeland, Alice Street between 103rd Avenue and 104th Avenue was turned into a wading pond. According to the National Climatic Data Center, property damage caused by this flood event was estimated at \$100,000.

No major injuries were associated with this storm, however an 8 year old girl was swept into a culvert near Washington Street in Holland from a rush of water and was rescued at a service manhole more than 200 feet away with only minor injuries.

#### Winter 1996

This 1996 flood along the Grand River was caused by an ice jam and forced several families from their homes in Robinson Township.

#### May 1-June 16, 1997

Ottawa County received a disaster declaration from the U.S. Department of Agriculture for heavy rains and flooding. With this declaration, area farmers became eligible for low interest rate federal disaster loans.

#### June 20-21, 1997

Beginning on June 20, 1997, severe thunderstorms moved through Ottawa County. Notable rainfall totals for June 20 included: 5.47 inches for the City of Holland, 9.16 inches at Holland State Park, and an unofficial reading of 13 inches in the Zeeland area. As a result of these storms, flash flooding occurred along creeks and rivers in the cities of Holland and Zeeland, and the townships of Holland, Zeeland, Jamestown, Wright, and Chester. Six bridges and/or road culverts were destroyed, and approximately 44 roads in the County were flooded and impassible during the storm, including US-31. Forty of these roads were deemed impassable due to washouts. Zeeland officials reported 15-20 percent of the city's streets were flooded during the storm.

During the peak of flooding, many motorists became stranded in high water. A U.S. Coast Guard helicopter rescued a total of 12 people from stranded vehicles; 4 of these people were rescued off an overturned car at 80th Avenue and Adams Street in Zeeland Township.

Like has occurred in many other severe storms, numerous powerlines were knocked out. Consumers Energy reported that approximately 11,000 customers were without power in Allegan and Ottawa Counties, and Holland BPW reported scattered outages throughout the Holland area. An area of road near 25th and Washington was closed where a transformer burned itself off the utility pole and fell into the street.

Other problems caused by the storm included Damage to a sewage lift station located in the City of Zeeland. This resulted in flooding and sewage backups to 30 city residences and Township 40 residences. By the end of the storm, approximately 150 homes and 11 businesses were damaged altogether, most of the damage occurring in flooded basements.

By June 21, many high waters had receded, but 2 boys received minor injuries when their raft overturned in the swollen north branch of the Black River in Holland.

It was estimated that this storm event caused \$700,000 in public damage, and total property damage from the flooding exceeded \$1 million. On June 23, Ottawa County officials declared a local State of Emergency. Damage and costs associated with this storm were so severe that the County also requested a Governor's Disaster Declaration, which was issued on June 27.

#### March 22-25, 1998

Rain and warm temperatures caused existing snow to melt from March 18 to 19, 1998. Luckily, temperatures dropped below freezing on March 20, which greatly reduced the snowmelt and minimized the flooding. However, flooding still did occur along the Grand River in Kent and Ottawa Counties during the period of March 22-25. The Grand River in Robinson Township crested at its flood stage of 13.3 feet on March 22, and held at this level until March 25. No property damage was reported, and only minor flooding occurred.

#### April 22-23, 1999

Heavy rains fell countywide as 3.75 inches fell in 24 hours.

### **Programs and Initiatives**

#### National Weather Service Doppler Radar

The National Weather Service has completed a major modernization program designed to improve the quality and reliability of weather forecasting. The keystone of this improvement is Doppler Weather Surveillance Radar, which can more easily detect severe weather events that threaten life and property – including weather events that can lead to flooding. Most important, the lead-time and accuracy of warnings for severe weather have improved significantly.

#### National Weather Service Flood Watches and Warnings

The National Weather Service issues *flood watches* and *flood warnings* when conditions are right for flooding. A flood watch indicates meteorological conditions are conducive to flooding. People in the watch area are instructed to stay tuned to local radio or television stations for updates on flooding and weather conditions. When flooding is imminent, a flood warning is issued. The warning will identify the anticipated time, level and duration of flooding. People in areas that will be flooded are instructed to take appropriate protective actions, which can include evacuation of family members and removal or elevation of valuable personal property.

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

#### Severe Weather Awareness Week

Each spring, the Department of State Police Emergency Management Division, in conjunction with the Michigan Severe Weather Awareness Committee, sponsors a Severe Weather Awareness Week. This public information campaign focuses on severe weather hazards such as tornadoes, thunderstorms, lightning, hail, high winds, and flooding. Informational materials on flooding and the other severe weather hazards are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

#### Michigan Flood Hazard Regulatory Authorities

#### Subdivisions of Land Act, 288 P.A. 1967, as amended.

The Subdivisions of Land Act governs the subdivision of land in Michigan. The Act requires review at the local, county and state levels to ensure the land being subdivided is suitable for development. From a flood hazards viewpoint, a proposed subdivision is reviewed by the County Drain Commissioner for proper drainage and to manage stormwater runoff, and for floodplain impacts by the Department of Environmental Quality, Land and Water Management Division.

Provisions of the Act and its Administrative Rules require that the floodplain limits be defined and prescribe minimum standards for new developments for residential purposes and occupancy, within or *affected by* a floodplain. Restrictive deed covenants are filed with the final plat which stipulate that any building used, or capable of being used, for residential purposes and occupancy, within or affected by the floodplain, shall meet the following conditions (R 560.304 Buildings with areas affected by floodplains):

- 1. Be located on a lot having a minimum buildable site of 3,000 square feet of its area at its natural grade above the elevation line defining the floodplain limit. The buildable site shall exclude all setbacks and easements. (This requirement may be waived if the building site is to be filled and the lowest floor, including the basement, is to be constructed above the floodplain elevation.)
- 2. Be served by streets within the proposed subdivision having surfaces not lower than one foot below the elevation defining the floodplain limits.
- 3. Have lower floors, excluding basements, not lower than the elevation defining the floodplain limits.
- 4. Have openings into the basement not lower than the elevation defining the floodplain limits.
- 5. Have basement walls and floors, if below the elevation defining the floodplain limits, watertight and designed to withstand hydrostatic pressures.
- 6. Be equipped with a positive means of preventing sewer backup from sewer lines and drains which serve the building.
- 7. Be properly anchored to prevent flotation.

# Floodplain Regulatory Authority, found in Water Resources, Part 31 of the Natural Resources and Environmental Act, 451 P.A. 1994, as amended.

The floodplain regulatory portion of Act 451 restricts residential occupation of high risk flood hazard areas and ensures that other occupations do not obstruct flood flows. A permit is required from the Department of Environmental Quality for any occupation or alteration of the 100-year floodplain. In general, construction and fill may be permitted in the portions of the floodplain that are not floodway, provided local ordinances and building standards are met. (A floodway is the channel of a river or stream and those portions of the floodplain adjoining the channel which are reasonably required to carry and discharge a 100-year flood. These are areas of moving water during floods.) New residential construction is specifically prohibited in the floodway. Non-residential construction may be permitted in the floodway, although a hydraulic analysis may be required to demonstrate that the proposed construction will not harmfully affect the stage-discharge characteristics of the watercourse.

The Act does not apply to watersheds that have a drainage area of less than two square miles. Those small watersheds are considered to be local drainage systems, and do not fall under the Floodplain Regulatory Authority.

# Soil Erosion and Sedimentation Control, Part 91 of the Natural Resources and Environmental Protection Act, 451 P.A. 1994, as amended.

This portion of the Act seeks to control soil erosion and protect the waters of the state from sedimentation. A permit is required for all earth changes that disturb one or more acres of land, as well as those earth changes that are within 500 feet of a lake or stream. The Act itself does not specifically address flood hazards, however, if sedimentation is not controlled, it can clog streams, block culverts, and result in continual flooding and drain maintenance problems. In Ottawa County, the enforcing agent is located in the Drain Commissioners office.

# Inland Lakes and Streams, Part 301 of the Natural Resources and Environmental Protection Act, 451 P.A. 1994, as amended.

This portion of the Act regulates all construction, excavation, and commercial marina operations on the State's inland waters. It ensures that proposed actions do not adversely affect inland lakes, streams, connecting waters and the uses of all such waters. Structures are prohibited that interfere with the navigation and/or natural flow of an inland lake or stream. Though reduction of flooding is not a specific goal of this Act, minimizing restrictions on a stream can help to reduce flooding conditions.

# Wetlands Protection, Part 303 of the Natural Resources and Environmental Protection Act, 451 P.A. 1994, as amended.

This portion of the Act requires a permit from the Department of Environmental Quality for any dredging, filling, draining or alteration of a wetland. This permitting process helps preserve, manage, and protect wetlands and the public functions they provide – including flood and storm water runoff control. The hydrologic absorption and storage capacity of the wetland allows wetlands to serve as natural floodwater and sedimentation storage areas. The Act recognizes that the elimination of wetland areas can result in increased downstream flood discharges and an increase in flood damage. Permits for wetland alterations are generally not issued unless there is no feasible alternative and the applicant can demonstrate that the proposal would not have a detrimental impact upon the wetland functions.

# Natural Rivers Program, Part 305 of the Natural Resources and Environmental Protection Act, 451 P.A. 1994, as amended.

The Natural Rivers Act was originally passed in 1970, and has been incorporated as Part 305 of the Natural Resources and Environmental Protection Act. The purpose of this program is to establish and maintain a system of outstanding rivers in Michigan, and to preserve, protect, and enhance their multi-faceted values. Through the natural rivers designation process, a Natural River District is established (typically 400 feet either side of the riverbank) and a zoning ordinance is adopted. Within the Natural River District, permits are required for building construction, land alteration, platting of lots, cutting of vegetation, and bridge construction. Not all of the zoning ordinances on the natural rivers have the same requirements, but they all have building setback and vegetative strip requirements. Although the purpose is not specifically to reduce flood losses, by requiring building setbacks (in many cases prohibiting construction in the 100-year floodplain), flood hazard mitigation benefits can be realized.

TheDrainCode,40P.A.1956,asamended.The Drain Code of 1956, commonly known as Act 40, establishes laws relating to the laying out<br/>and consolidation of drainage districts, and the maintenance of drains, sewers, pumping<br/>equipment, bridges, culverts, fords, and other structures and mechanical devices to ensure that the<br/>drains function properly. The Drain Code also provides for the development of flood control and

water management projects, the creation of water management districts and subdistricts, and for flood control and drainage projects within drainage districts. As a means to obtain funding for drain and water management projects, this Act provides for the assessment and collection of taxes, the investment of funds, and the deposit of funds for future maintenance of drains. Also, it authorizes public corporations to impose taxes for the payment of assessments in anticipation of which bonds are issued, provides for the issuance of bonds by drainage districts and for the pledge of the full faith and credit of counties for payment of the bonds; it authorizes counties to impose taxes when necessary to pay principal and interest on bonds for which full faith and credit is pledged, validates certain acts and bonds, and prescribes penalties.

Drainage districts and drains are established by petition of the affected landowners and/or municipalities. County drains, with a special assessment district entirely within the County, are administered by the locally elected County Drain Commissioner. Inter-county drains, with a special assessment district in more than one county, are administered by a drainage board which consists of the drain commissioners of the affected counties, and is chaired by the Director of the Michigan Department of Agriculture (MDA) or an MDA Deputy Director.

#### Manufactured Housing Commission Act, 96 P.A. 1987, as amended.

The Michigan Manufactured Housing Commission Act and its implementing Administrative Rules provide regulation on the placement of manufactured homes and establishes construction criteria. Manufactured homes are prohibited from being placed within a floodway, as determined by the Department of Environmental Quality. In addition, manufactured homes sited within a floodplain must install an approved anchoring system to prevent the home from being moved from the site by floodwaters (or high winds), and be elevated above the 100 year flood elevation.

#### Local River Management Act, 253 P.A. 1964.

Enacted in 1964, the Local River Management Act provides for the coordination of planning between local units of government in order to carry out a coordinated water management program. Implementation of the water management program occurs via the establishment of watershed councils. These councils conduct studies on watershed problems, water quality, and the types of land uses occurring within the watershed. Watershed councils have the authority to develop River Management Districts for the purpose of acquisition, construction, operation and the financing of water storage and other river control facilities necessary for river management. The provision to allow acquisition of land adjacent to the river for the purpose of management aids in regulating development of land prone to flooding.

#### Floodplain Service Program

The need to identify a flood hazard area before construction is essential to the goal of flood hazard mitigation. The Department of Environmental Quality regularly provides floodplain information to public and private interests as part of its Floodplain Service Program under the Land and Water Management Division. The goal of the program is to provide 100-year floodplain information to interested parties so that informed purchase or development decisions can be made. In addition to providing floodplain information, the DEQ will provide information on land and water "interface" permit requirements and on building requirements relating to construction in flood hazard areas.

#### National Flood Insurance Program

For many years, the response to reducing flood damages followed a structural approach of building dams and levees and making channel modifications. However, this approach did not slow the rising cost of flood damage, nor could individuals purchase insurance to protect themselves from flood damage costs. It became apparent that a different approach was needed.

The National Flood Insurance Program (NFIP) was instituted in 1968 to make flood insurance available in those communities agreeing to regulate future floodplain development. As a participant in the NFIP, a community must adopt regulations that: 1) require any new residential construction within the 100-year floodplain to have the lowest floor, including the basement, elevated above the 100-year flood elevation; 2) allow non-residential structures to be elevated or dry floodproofed (the floodproofing must be certified by a registered professional engineer or architect); and 3) require anchoring of manufactured homes in floodprone areas. The community must also maintain a record of all lowest floor elevations or the elevations to which buildings in flood hazard areas have been floodproofed. In return for adopting floodplain management regulations, the federal government makes flood insurance available to the citizens of the community. In 1973, the NFIP was amended to mandate the purchase of flood insurance as a condition of any federally regulated, supervised or insured loan on any construction or building within the 100-year floodplain.

Currently, there are about 26,582 flood insurance policies in force in Michigan, which amounts to approximately \$2.4 billion worth of coverage. About 18,604 (69.9 percent) of these policies are within an identified flood hazard area, and the remainder are for properties located outside flood hazard areas. Officials from FEMA and the DEQ estimate that only 15 percent of all floodprone structures in Michigan eligible to purchase flood insurance actually have flood insurance.

All local governments in Ottawa County participate in the NFIP, and therefore all residents and business owners in Ottawa County are eligible to purchase flood insurance through the NFIP. Ottawa was the first county in Michigan to have 100 percent participation in the NFIP. However, currently there are only 339 flood insurance policy holders in the County. Please see Appendix 2 for a list of the date of entry to the NFIP of each community in Ottawa County.

#### Flood Mitigation Assistance Program

With the passage of the National Flood Insurance Reform Act of 1994, Congress authorized the establishment of a federal grant program to provide financial assistance to states and local communities for flood mitigation planning and activities. The Federal Emergency Management Agency (FEMA) has designated this the Flood Mitigation Assistance Program (FMAP). The FMAP funds can be used to fund activities that reduce the risk of flood damage to structures insurable under the National Flood Insurance Program. The FMAP is administered jointly by the Department of State Police and the Department of Environmental Quality, and cost-shared on a 75 percent federal, 25 percent local basis.

Three types of FMAP grants are available: 1) *planning grants* to assist local communities in developing flood mitigation plans; 2) *project grants* to fund eligible flood mitigation projects, with emphasis on repetitively or substantially-damaged structures insured under the NFIP; and 3) *technical assistance grants* to assist the State in providing technical assistance to applicants in applying for the program or implementing approved projects.

#### Flood Management and Mitigation Education

The DEQ Land and Water Management Division, has developed guidance documents aimed at local officials involved in floodplain management and flood hazard mitigation. These guidebooks are used as textbooks in training workshops and as a reference for day-to-day

activities. One of these publications, *Floodplain Management for Local Officials*, covers topics including floodplain construction and building code requirements, the duties and responsibilities of the building code inspector under the NFIP and the Construction Code Act, and flood-resistant building techniques and materials. This publication is available by contacting Land and Water Management Division.

The Emergency Management Division, Department of State Police, has developed the *Local Hazard Mitigation Planning Workbook* for local officials. This guidance document provides an overview of a planning process that communities can follow to help reduce their vulnerability to a wide array of natural, technological and human-made hazards – including riverine flooding.

Both the Land and Water Management Division and Emergency Management Division regularly conduct floodplain management and flood hazard mitigation training courses and workshops for state and local officials. The Land and Water Management Division also conducts regular community assistance visits as part of its administrative duties under the National Flood Insurance Program. Such visits are a form of training aimed at improving a community's implementation of floodplain management practices. In addition, the Land and Water Management Division continuously conducts flood hazard workshops for lenders, Realtors, building officials, engineers, citizens and any other interested parties.

#### Road Infrastructure Flood Mitigation Committee

Following the September, 1986 floods, the Michigan Department of Transportation (MDOT) formed a flood mitigation committee to determine ways to lessen damage to road infrastructure caused by riverine flooding. The committee consisted of representatives from the County Road Association of Michigan, the Federal Highway Administration, the Department of Environmental Quality, and MDOT. One of the primary purposes of the committee was to identify reasons for failed stream crossings and damaged roads during a flood event, and make recommendations for achieving more flood-resistant stream crossings. The committee published its findings and recommendations in a report that is used today as a reference guide for officials involved in road infrastructure design and maintenance.

As a result of one of the committee's recommendations, the Department of Environmental Quality regularly sponsors workshops and seminars on stream crossing design and erosion control practices. These workshops are geared toward design engineers at the state, county and local levels, in addition to private consultants and county drain commissioners.

#### State and Federally-Assisted Relocation of Floodprone Properties

The State of Michigan has been very pro-active in its initiation and participation in the acquisition and relocation of floodprone properties, in both pre- and post-disaster situations. Typically properties are purchased by the local unit of government using federal Hazard Mitigation Grant Program (HMGP) and Flood Mitigation Assistance Program funds. In Michigan, the HMGP is administered by the Michigan State Police Emergency Management Division.

#### Other State and Federally-Assisted Flood Hazard Mitigation Projects

The State of Michigan has used a variety of federal funding sources to assist in the implementation of flood hazard mitigation projects. Those funding sources have included: 1) the Hazard Mitigation Grant Program (HMGP); 2) the Flood Mitigation Assistance Program (FMAP); 3) the Public Assistance Grant Program (PAGP); 4) the Individual and Family Grant Program (IFGP); 5) Community Development Block Grants (CDBG); and 6) Farmers Home Administration (FmHA) loans. State and local funds have been used to match these federal sources of funding.

### **Summary of Potential Impacts**

Across the country, and throughout much of Ottawa County, flooding is the most common form of natural hazard. According to National Flood Insurance Program (NFIP), the risk of flood is much greater than the risk of fire. For structures located in the 100-year floodplain, there is a 26 percent chance of experiencing a flood during the life of a 30 year mortgage compared to a 4 percent chance of experiencing a fire. The chance of flooding is greater even for structures located in the 500-year floodplain, a 6 percent chance of flood compared to a 4 percent chance of fire.

One reason flooding is so common is because flooding is a natural occurrence. Flooding does not become a disaster until people put themselves and objects of value into the way of this natural processes. When left undisturbed, the land that surrounds a waterway serves as natural flood and erosion control system by providing temporary storage of floodwaters, reducing the velocity of the water, and minimizing the amount of sediment that can accumulate downstream. Floodplains also help maintain water quality by filtering nutrients and impurities from stormwater runoff. However, many Ottawa County floodplains contain rich soils and are farmed, and therefore have typical pitfalls including semistabilized ground and agricultural waste disposal. When these areas flood, they can lower the water quality in the nearby bodies of water.

In Ottawa County, there are 32,413 acres of land in the 100-year floodplain, most of which are located along the Grand River and its tributaries. Significant floodplains are found from Georgetown to Spring Lake, reaching up to one mile in width. Although there may not be homes and business in all of this floodplain, any other alteration of the natural terrain and vegetation can affect how and entire region responds to a heavy rains or snowmelt.

However, as the statistics above show, even a home or business that is not in a 100-year floodplain or even near a lake or river can be flooded. Many floods are caused by rain storms, melting snow, and water backup due to inadequate or overloaded drainage systems and sewer lift system failure, or a combination of theses events. No matter the cause, the solution to flooding is not an easy one. It is not as simple as building drains to direct all the water into rivers and lakes. The more the land is altered to deal with flooding, the more the natural flood protection measures are disturbed.

#### **Causes of Flooding**

#### Riverbank Overflow

Nationally, riverine flooding is the most common form of flooding. Many flood events in Ottawa County are also caused by high river levels, especially in the areas along the Grand River and the Macatawa watershed.

In the spring, the overflow of waterways is typically the result of rapid snowmelt. This problem is compounded when the snowmelt is accompanied by rainfall. Snowmelt runoff is especially dangerous where the ground beneath the snow is still frozen and therefore cannot absorb the water from the melting snow. During the winter and spring months, ice jams can be a primary cause of flood concern, both for communities located upstream of the dam and those that may experience flooding downstream when the dam breaks loose. In the summer, rivers typically overflow following extended periods of heavy rain or following extreme rainfall amounts in a short period of time. Covering the ground with streets, buildings, parking lots and other impervious surfaces also increases riverine flooding by increasing stormwater runoff. Because the impervious covered ground does not absorb the stormwater, more water flows directly into nearby rivers. These impacts can be mitigated by proper stormwater management.

#### Storm Sewer/Drain Overflow

In the Cities of Holland and Zeeland, flooding has often occurred with overflowing storm sewers and drains. This flooding has been caused by design standards, financial limitations, or even flaws, and increased quantities of water in the cities' storm sewer systems. Several neighborhoods in the core city of Holland have experienced flooding with almost every major rainstorm, dating back more than 20 years. One flood-causing flaw was a sanitary sewer line that crossed in front of a storm drain pipe, blocking the path of flowing water. Flooding also occurred in a neighborhood that was located at the low end of a 847 acre watershed that emptied into Lake Macatawa through a major sewer trunk. The water outlet in the lake was under water and lacked the pressure to carry the storm water into the lake, causing water to back up during times of heavy rain.[1]

#### Sanitary Sewer Flooding Problems

In the City of Zeeland, numerous homes and businesses have sustained flood damage when the local sanitary sewer lift stations have not been able to handle the large quantity of water that enters the system during heaving rain events. When this happens, water and sewage backs up in to homes though the sewer lines. Power outages have also caused the lift stations to fail, resulting in similar backups.

Similarly, in Zeeland Township the Maple Lake condominium residents experienced sanitary sewer backups when the Rose Drain at flood stage entered an available sanitary sewer manhole. Also, Holland Township residents near Quincy Street and 142nd Avenue received wet basements when during the June 1997 flood a local resident popped off a sanitary sewer manhole to relieve yard flooding near Pine Creek. Water then flooded the sanitary sewer system and entered nearby homes.

#### Design of Detention/Retention Ponds and Other Man-made Lakes

Another potential cause of flooding is caused by the design or construction of man-made lakes and retention ponds. Such lakes are quite popular in many new residential developments. A man-made lake at a development in Holland Township led many resident to loose up to 15 feet of their back yard, and fear that their homes would be flooded when heavy rains fell. The cause of the problem turned out to be that a culvert connecting the lake and a nearby stream needed a backflow device. The culvert allowed water to flow back and forth between the lake and stream, but a backflow device would only allow water to drain from the lake into the stream, and would not allow excess stream water to flow into the lake. Luckily, the cause of the problem was detected, and remedied, before any damage to homes occurred.

#### The Impact of Land Development

Continued development both in the 100-year floodplain and surrounding areas increases the potential for flood damage to homes, business and infrastructure. Flooding has become especially significant in portions of Ottawa County where development, some of which occurred prior to knowledge and implementation of stormwater management techniques, has disrupted the ability of natural land areas such as open fields, woodlands, marshes and wetlands to absorb water, and the drainage infrastructure to properly carry and disperse water flow. Developed areas have more impermeable surfaces and other land uses that generate high volumes of stormwater

runoff. As a result, rivers rise to higher levels and the impact of flooding becomes more severe. For example, the damage due to flooding in the Macatawa watershed has become more evident because of increased human activity along the floodway. The proximity of structures and inhabitants to flood waters increases the potential for personal injury and property damage during floods.[1]

It is widely accepted that controlling floodplain development is the key to reducing flood-related damages. Although there are state and local floodplain regulations designed to manage new development in flood prone areas, floodplain development in many communities continues to increase, resulting in corresponding increases in potential flood-related damages. The ability to mitigate flood hazards rests primarily with local units of government, since they control the direction of land development through the master plan, zoning ordinance, and building codes. Proper land use management and strict enforcement of zoning ordinances and building codes can make communities safer from flood hazards and help reduce the high costs of flood losses.

#### **Current Flood Mitigation Activities in Ottawa County**

Communities have several options for reducing damage to property in flood hazard areas. The general categories for these options are: 1) *Regulations*, including zoning, subdivision regulations and building codes that limit the construction of structures in flood hazard areas; 2) *Acquisition*, or purchasing land and removing the hazard-prone structures; 3) *Flood warning systems and evacuation plans*, whereby people remove themselves and portable belongings from home and business when flooding is anticipated; and 4) *Engineering measures*, such as levees and drains. Of these options, floodplain regulations are often the most effective way to reduce future flood loss. Such regulations can keep people from locating in dangerous areas and require safer building designs for flood prone areas.[1]

Since the occurrence of the significant flooding events listed previously in this chapter, residents, local units of government and the County have taken a variety of actions to reduce flooding problems across the County. The following are just a few examples of mitigation activities around the County.

In Robinson Township, several homes in the VanLopik and Limberlost subdivisions along the Grand River have been elevated to lower their chances of future flooding. In addition, in the fall of 1999 Robinson Township officials agreed to participate with the Michigan Department of Environmental Quality and Michigan State Police Emergency Management Division (MSP-EMD) to secure Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program funding to purchase several repetitive flood loss properties in the area.

In the Summer of 1999, the City of Holland undertook a \$2.4 million reconstruction of 12th Street. As part of the project, the city installed several new storm drain pipes and constructed a relief drain that now empties into Lake Macatawa off 12th Street. These improvement projects should eliminate much of the flooding in the City's downtown residential neighborhoods.

Also in 1999, the MSP-EMD assisted the Maplewood Intercounty Drain Board and the City of Holland in obtaining more than \$100,000 in FEMA funding to purchase two flood prone homes located on Lincoln Avenue along the Maplewood drain. City officials decided to purchase the two homes after learning that improvements to the Maplewood drain in the surrounding area could not guarantee that the homes would not flood in a rainstorm of more than 4.5 inches. One of these structures, located at 401 Lincoln, had sustained major damage in a July 1982 downpour when water that filled the entire basement caused a basement wall to collapse.[1] This home also

suffered structural damage in June 1996 after more than 7" of rainfall caused the Maplewood drain to be filled beyond maximum capacity. Once again, a wave of water broke through a basement wall.[1] By early 2000, residents had moved out of both homes and the City planned to demolish the structures and turn the area into greenspace.

In the Zeeland area, activities have been undertaken to reduce the amount of stormwater that entered the sanitary sewer system and causes the sanitary system to be overwhelmed and back up into homes. Some projects included: the installation of better seals on sanitary sewer manholes; raising the height of the sanitary sewer manhole above the level of possible floodwaters; and covering the openings to sanitary sewer lines in open basements in new construction.

The Ottawa County Drain Commission has also been actively involved in reducing flooding threats throughout the County. Some of their recent projects include:

- Improvements along Bliss Creek in Georgetown Township to alleviate flooding near the intersection of 44th Street and Kenowa Avenue.
- Construction of a relief drain at the Rose Drain in the City of Zeeland. The Drainage District receive funding through the Hazard Mitigation Grant Program to assist with the cost of this project.
- Construction of a flood control berm near Pine Creek to protect a home from flooding in Holland Township.
- Installation of new culverts at US-31 and New Holland Street, Quincy Street, and Riley Street.
- Improvements to Berens Dam, Steenwyk Dam, and Timmer Dam in the Black Creek Watershed.

#### What More Can Be Done?

For decades, the national philosophy of how to limit flood damage was limited to the construction of flood-control projects, such as dams and levees. However, this approach did not eliminate flood damage, nor did it discourage unwise development and land use practices.

The above mentioned flood mitigation activities should significantly reduce flooding in a few locations around Ottawa County. But most flood mitigation activities are very site specific, so even though a few neighborhoods will now be more flood resistant, others are still at risk from flooding. Therefore a variety of mitigation measures are still needed.

The best way to limit flood losses is to avoid building in flood hazard areas. Unfortunately, this is not always an easy or viable option, especially when economic and political pressures make development in floodplains attractive for some communities. Methods must be found to mitigate the impacts of development and reduce flood losses while still allowing property owners some reasonable use of their land. Flood protections can involve a variety of changes to a structure and property. These changes can vary in complexity and cost. A few of these changes, as well as other mitigation and protection options are listed below.

#### Consider Purchasing National Flood Insurance

Because almost no property is 100 percent safe from flooding, residents of Ottawa County should consider purchasing flood insurance from the National Flood Insurance Program (NFIP). This is especially necessary for those homes and businesses located in a flood hazard area. Most homeowners and business insurance policies will not cover losses in the event of a flood. That

means that most often all cleanup, replacement and repair costs will be out-of-pocket expenses for the flood victim.

Often people who own a home or business in a flood hazard area assume that if their property suffers damage from a flood, the federal government will provide financial assistance to recover from the flood. However, this is not entirely true. Before a community is eligible for federal disaster assistance, it must be declared a federal disaster area. Federal disaster assistance declarations are issued in less than 50 percent of flooding incidents. Also, federal disaster assistance is typically provide in the form of a loan that must be repaid with interest. Flood insurance pays even if a disaster is not declared. The premium for an NFIP policy, averaging a little more than \$300 a year, is usually less expensive than interest on federal disaster loans. Furthermore, if a property owner in the 100-year floodplain is uninsured and receives federal disaster assistance after a flood, he *must purchase flood insurance to remain eligible for future disaster relief.* 

This stipulation is outlined in The National Flood Insurance Reform Act. The Act requires individuals who have a home or business in the 100-year floodplain, who have received federal disaster assistance for flood disaster losses to real or personal property, to purchase and maintain flood insurance coverage for as long as they occupy the building. If flood insurance is not purchased and maintained, future disaster assistance *will be denied*. If the structure is sold, the current owner is required to notify the buyer of the property of the need to purchase and maintain flood insurance. If the buyer is not notified, suffers uninsured flood losses, and receives disaster assistance, the seller may be required to repay the federal government any federal disaster assistance the buyer received.[1]

The Flood Disaster Protection Act of 1973 and the National Flood Insurance Reform Act of 1994 also mandate the purchase of flood insurance as a condition of federal or federally related financial assistance for acquisition and/or construction of buildings in the 100-year flood plain of *any* community. The Act prohibits federal agency lenders, such as the Small Business Administration (SBA), Federal Housing Administration (FHA), Veterans Administration (VA) or Government-Sponsored Enterprises for Housing (Freddie Mac and Fannie Mae) from making, guaranteeing, or purchasing a loan secured by improved real estate or mobile homes in the 100-year floodplain, unless flood insurance has been purchased, and is maintained during the term of the loan.

Local units of government should work with insurance companies to inform their residents of the benefits and needs of NFIP.

#### Update/Complete/Create Flood Insurance Rate Maps for All Communities

Flood Insurance Rate Maps (FIRMS) are developed by FEMA and illustrate the extent of flood hazard in a community. Using engineering studies that analyze records of streamflow and rainfall, topography, hydrologic and hydraulic data, and other information gathered from the community (such as what areas have a history of flooding), FEMA is able to determine the 100-year floodplain boundaries and elevations. These maps are called "rate maps" because they are used by the National NFIP to determine the premium that will be paid by a property owner. Properties located in high flood risk areas are subject to higher premium rates than those properties that are located outside of the 100-year floodplain. This differential rate structure provides significant financial incentive to builders and homeowners locate structures in less hazardous areas.

It is important for communities to have accurate, up to date FIRMs for several reasons. Most importantly, FIRM help planners determine what areas of the community are at risk of flooding, and what potential impacts from flooding could be. This knowledge provide communities with clear boundaries and guidelines upon which to base floodplain management ordinances. Another reason FIRMs are important is that they allow property owners and potential property buyers to determine whether or not a property is located in a high risk flood area. When a property owner is aware of the potential flood hazard and high cost of flood insurance, they may be less inclined to development the property in a hazardous manner. Finally, until a community has official FIRMs it cannot fully participate in the NFIP. This initial phase of a community's participation in the NFIP is known as the Emergency Phase. During this phase, communities are only eligible for limited flood insurance coverage.

Unfortunately, significant areas of Ottawa County are not currently mapped. So although every community in the County participates in the National Flood Insurance Program, and therefore all property owners and residents in the County are eligible to purchase flood insurance, 8 communities in Ottawa County are in the Emergency Phase of the NFIP. These communities are Blendon Township, Crockery Township, Jamestown Township, Olive Township, Polkton Township, Robinson Township, City of Zeeland, and Zeeland Township.

Also, FIRMs when developed do not necessarily document all floodplains. Floodplains along smaller waterbodies, both lakes and streams, are not always mapped. Significant floodplain exists, and extensive flooding has occurred along streams which FIRMs show no related floodplain. Since no other mapping is currently available for Ottawa County (except to a limited extent the Ottawa County Drain Commissioner Master Drainage Map), FIRMs are extensively utilized by the decision makers working for/with local units of government. Because some of these maps are incomplete, local units of government or property owners are given the false impression that floodplains do not exist in those areas. This is one reason why floodplains have been, and still are being, filled or occupied by structures. More extensive floodplain mapping is needed to assist local units and property owners.

In addition, it is important to keep the FIRMs up to date because as a community grows, and more openspace is converted to developed land, flood hazard areas will change.

#### Enforce NFIP standards/Community Floodplain Regulations

According to the Department of Environmental Quality Land and Water Management Division, voluntary community participation in the National Flood Insurance Program (NFIP) has had a positive impact on floodplain management activities in Michigan. This is partly because in order for a community to participate in the NFIP, the community must agree to enforce certain types of land use regulations. These regulations must:

- (a) Require that new construction and substantial improvements in flood prone areas be designed and anchored to prevent floatation, collapses or lateral movement, be constructed with materials and utility equipment resistant to flood damage, and be constructed by methods and practices that minimize flood damages.
- (b) Require, where flood elevation data are available, that:
  - b) All new construction and substantial improvements of residential structures located in mapped floodplain areas have the lowest floor (including basement) elevated to or above the 100-year flood level.
  - c) All new construction and substantial improvements of nonresidential structures in flood hazard areas have the lowest floor (including basement) elevated or

floodproofed to or above the 100-year flood level. Floodproofing must be certified by a registered professional engineering or architect.

- (a) Require anchoring of mobile homes in flood prone areas.
- (b) Maintain a record of all lowest floor elevations or the elevations to which buildings have been floodproofed when the building is located in a mapped flood hazard area.[1]

Probably the best way to integrate these regulations into a community land use plan and manage floodplain development is through the zoning ordinance and the establishment of a *floodplain zoning district*. This district may be an established zoning district or may be used as an overlay zone. The objectives of this regulation should be:

- To control filling, grading, dredging and other development which may increase flood damage;
- To prevent the removal of vegetation in the floodplain;
- To prevent the unnatural diversion of flood waters or increase flood hazards;
- To slow stormwater runoff;
- To preserve wetland areas and prevent excessive sedimentation; and
- To prevent the encroachment of development on stream and river channels.[1]

Permitted uses in the floodplain should not obstruct flood flows or have a high damage potential; for example recreational and agricultural uses, private drives, lawns and open spaces, or public rights-of-way.

It must be remembered that these requirements are of no value in reducing flood losses if the local office or department responsible inspecting and enforcing the floodplain regulations for the communities in the County does not enforce them.

#### Limit Impervious Surfaces/Maintain Greenspace

Flooding is becoming significant in portions of Ottawa County where development has outstripped the ability of natural land areas such as open fields, woodlands, marshes and wetlands to absorb water, and the drainage infrastructure and to properly carry and disperse water flow. Limiting of impervious surfaces can be regulated though the floodplain management regulations and/or zoning ordinances.

#### Elevate Flood Prone Structures

When structures are already located in flood hazard areas, elevating these structures above the reach of floodwaters is a technique often used to reduce flood damage. Elevation of structures, if done properly and in appropriate sites, can be a useful option for flood loss reduction.

#### Purchase Flood Prone Structures and Property

Like the City of Holland and Robinson Township, communities may opt to purchase homes or business that have suffered repetitive flood losses. When funds are available, communities may receive Federal Hazard Mitigation Grant assistance to cover 75 percent of the purchase price of the property. Under the requirements of this grant, structures must be removed, and the acquired properties must be maintained as open space. The property acquisition option may be the best solution to a situation that could be considered "no win." Although a home or business owner may not want to leave their home or property, other mitigation measures may be cost prohibitive or may not significantly reduce flood damage.

With property acquisition, land can be purchased and structures can either be relocated off the high risk flood areas or the structures may be demolished. The acquired lands may then be used for public recreation or greenspace.

#### Install or Maintain Stream Buffers

Buffer areas are the lands next to a river, lake or other body of water that are covered with trees, shrubs, or other vegetation and groundcover. Buffer areas are an important element in flood control because the vegetation reduces and filters runoff through interception and detention. Plants and trees also help to slow down runoff, enabling water be absorbed into the ground more easily. When less runoff reaches the river or lake, the volume of water that contributes to the flood is also reduced. Buffer areas also stabilize stream slopes to help prevent erosion.

A recent study of the Macatawa watershed indicated that 70 percent of the riverfront is not currently buffered in any way.[1] Zoning ordinances are a tool that can be used to ensure that riverine areas are properly buffered from development.

#### Install Sewer Backflow Devices

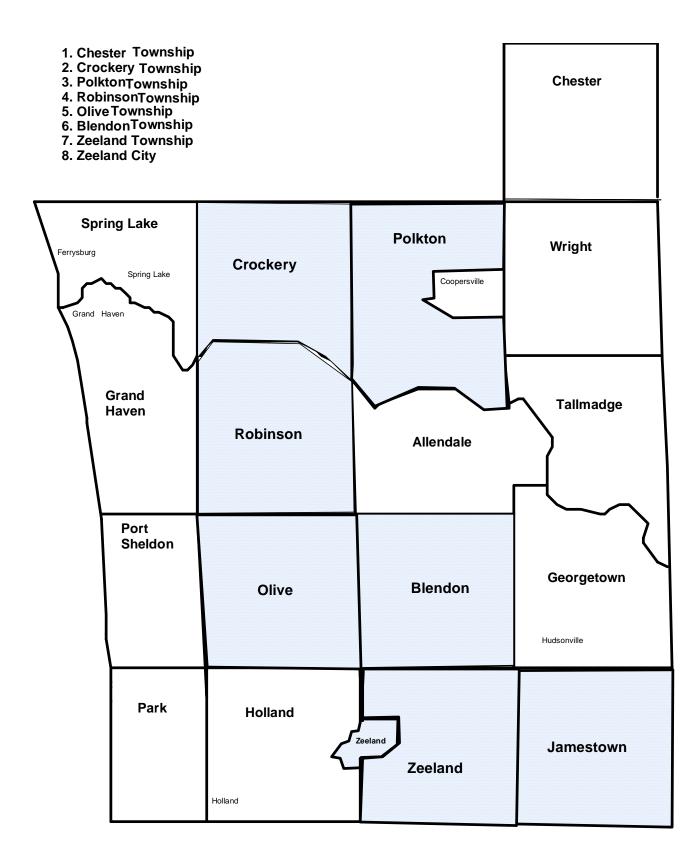
For structures that have experienced sewer backflow problems in the past, or new buildings in neighborhoods that have a history of sewer lift station failure, owners may wish to consider the installation of a sewer backflow devise. A good way to protect homes from sewage backups is to install backflow valves, which are designed to block drain pipes temporarily and prevent flow into the house. Backflow valves are available in a variety of designs that range from simple to complex. One of the more complex designs is a *gate valve*. This type of valve provides a strong seal, but must be activated by hand. This means that someone must be available and able to shut the valve at the time of need. A more simple type of valve is a *flap* or *check valve*. This valve opens to allow flow out of the house, but closes when the flow reverses. This form of valve incorporate the advantages of both flap and gate valves into a single design.

Valves should be installed on all pipes that leave the house or that are connected to equipment that is below the potential flood level. Having a plumber or contractor install one backflow valve will cost about \$525 for a combined gate and flap valve, or about \$375 for a flap valve.[1] These figures include the cost of excavation and backfilling.

#### Ensure that Detention/Retention Ponds and Man-made Lakes are Properly Designed

Neighborhood developments with waterfront homes have popped up all over Ottawa County in recent years. And if properly designed, these homes on man-made lakes can provide scenic beauty and recreation. But in some cases these lakes can create a new flooding problem where none existed before. Flooding to homes on these lakes could result in thousands of dollars in damage to the homes and belongings. Strict oversight and engineering must be ensured when developing a community on a natural or man-made lake.

Finally, if unsure whether or not a home or business is at risk from flooding, the local unit of government or the Michigan Department of Environmental Quality Land and Water Management Division Floodplain Management Office may be able to provide assistance.



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# **FLOODING: SHORELINE FLOODING & EROSION**

The flooding and erosion of shoreline areas caused by fluctuating Great Lakes water levels, storm surges, or winds.

#### **Hazard Description**

With a 30 mile span of beach and duneland along the Lake Michigan shore from Holland to just north of Grand Haven, Ottawa County is subject to shoreline flooding and erosion. Shoreline flooding and erosion is a natural process and can occur at normal, high and even low Great Lakes water levels.

Seasonal and Long-term

variations in precipitation evaporation

fluctuation of Great Lakes

water levels. The lakes are generally at their

lowest level in the winter

months. In the fall and

early winter, the air above the lakes is usually cold

and dry, and the lake

resulting in evaporation.

With more water leaving than entering the lake, the

water level drops. Then

as snow melts in the spring, water runoff to the

evaporation rate is also

low because the air above

is

year,

warm,

At this

the

to

rates

the

and

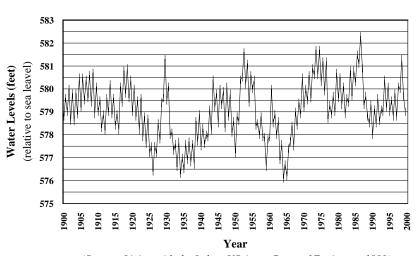
contribute

temperature

lakes increases.

of

time



Lake Michigan Monthly Mean Water Levels

(Source: Living with the Lakes, US Army Corps of Engineers, 1999)

However, during periods of high water, storms, wind, and ice, flooding and erosion are more frequent, causing serious damage to homes and businesses, roads, and other structures along the coast. Homes located in Ottawa County have sustained damage due to shoreline erosion.

the lakes is warm and moist. Lake levels typically are at the highest in the early summer months.

Long-term fluctuations occur over periods of several years. The hydrograph above illustrates the long-term variations in Lake Michigan water levels since 1900. Several relatively wet and cold years in a row will cause water levels to rise. Conversely, consecutive warm and dry years will cause lake levels to drop.

Record high lake levels in 1985 and 1986 culminated in a Governor's Disaster Declaration for Ottawa County and 16 other shoreline counties. After this event, the State of Michigan implemented three shoreline flooding and erosion mitigation programs aimed at reducing future flood impacts on shoreline communities and homeowners.

#### Historically Significant Shoreline Flooding and Erosion in Ottawa County

February 21, 1986

Governor's Disaster Declaration for Ottawa and 16 other Counties in Michigan for Great Lakes flooding and wave action.

#### April 1997

An intense low pressure system passed though Lower Michigan, including Ottawa County, on April 6, 1997. With this storm came wind gust up to 70 miles per hour and wave heights of 10 to 15 feet on Lake Michigan near the shoreline. Widespread wind damage and lake shore beach erosion was reported across the area.

#### November 10-11, 1998

Strong winds sustained over a two day period generated 15-20 foot waves on Lake Michigan. These waves caused considerable beach erosion.

#### Other

Although listed in the flooding section, shoreline erosion is a more immediate and common threat than shoreline flooding in Ottawa County. Several sections of Ottawa County Lake Michigan coast are classified as *high risk erosion areas*. Please refer to the *Programs and Initiatives* and *Analysis and Impact* sections for more information on shoreline erosion in the County.

#### **Programs and Initiatives**

#### Michigan Shoreline Flood and Erosion Hazard Regulatory Authority

# Shorelands Protection and Management, Part 323 of the Natural Resources and Environmental Protection Act, 451 P.A. 1994, as amended.

Part 323 is designed to provide protection to Michigan's Great Lakes shoreline. While these fragile and dynamic shorelines are desirable vacation and recreational areas, they also present inherent hazards to development. Part 323 gives the Michigan Department of Environmental Quality (DEQ) responsibility to identify hazardous and fragile coastal areas and establish regulations designed to minimize the impact of development on these areas, and to minimize the hazard facing development. The three types of coastal areas to be identified include: 1) *high risk erosion areas* – those shorelines identified as receding at an average long-term rate of one foot per year; 2) *flood risk areas* – those Great Lakes coastal areas or connecting waterways that are within an identified 100-year floodplain; and 3) *environmental areas* – those portions of the Great Lakes shorelands which have been determined to be necessary for the preservation and maintenance of fish and wildlife.

Mechanisms provided in the law to accomplish protection are state-developed zoning ordinances, special studies, plans, and remedies for violation of rules. The Act gives the DEQ the authority to regulate high risk erosion, flood, and environmental areas using setbacks, zoning, and building code standards.

#### High Risk Erosion Areas

Through the enforcement of setbacks, Part 323 of Act 451 ensures the protection of high risk erosion area and personal property. Two different setbacks, a projected 30-year period and a 60-year period, have been identified for permanent structures (two different types of permanent structures are defined in the law). Depending upon the type of structure, a landowner must either conform to the 30-year, or the 60-year, established setback.

Permits are required for construction of new permanent structures or enlargement of existing structures in high risk erosion or flood areas. Permits are also required for alterations such as dredging, filling, grading, or placement of a permanent structure in an environmental area.

Local units of government may adopt a zoning ordinance for high risk erosion areas, which replaces the need for the state high risk erosion area permit. The community can base the regulation of these areas upon state established setback distances, or a single setback distance may be adopted for the entire shoreline. This setback distance must be approved by the DEQ and meet or exceed the largest setback distance of any shoreline segment within the community. In Ottawa County, the Port Sheldon Township Planning Commission has developed a *High Risk Erosion Area Overly Zone*, Article XI, in the local zoning ordinance. This article establishes required setbacks for six high risk erosion area zones; A, B, C-1, C-2, C-3, and C-4. The setback requirement is broken down further by the type of structure.

#### Flood Risk Areas

In flood risk areas, the Administrative Rules for Part 323 of PA 451 require: 1) residential structures must have the lowest portion of all floor joists elevated to, or above, the 100 year flood elevation; and 2) any additions to existing structures must be elevated above the 100 year flood elevation.

#### Environmental Areas

Environmental area designation establishes a review process whereby the affected property owner must receive a permit from the DEQ for any construction or placement of permanent structures, dredging, filling, grading, or other alteration of soil, vegetation, and natural drainage. Activities which do not require a permit include: maintenance of existing dikes; farming, if specific provisions are complied with; and timber harvest if outside a colonial bird nesting area.

#### National Flood Insurance Program

The National Flood Insurance Program (NFIP) was instituted in 1968 to make flood insurance available to those communities agreeing to regulate future floodplain development. As a participant in the NFIP, a community must adopt regulations that: 1) require any new residential construction within the 100-year floodplain to have the lowest floor, including the basement, elevated above the 100-year flood elevation; 2) allow non-residential structures to be elevated or dry floodproofed (the floodproofing must be certified by a registered professional engineer or architect); and 3) require anchoring of manufactured homes in floodprone areas. The community must also maintain a record of all lowest floor elevations or the elevations to which buildings in flood hazard areas have been floodproofed. In return for adopting floodplain management regulations, the federal government makes flood insurance available to the citizens of the community. In 1973, the NFIP was amended to mandate the purchase of flood insurance as a condition of any federally regulated, supervised or insured loan on any construction or building within the 100-year floodplain.

#### **Community Education**

The DEQ periodically holds workshops for lenders, realtors, insurance agencies, citizens and any other interested parties. The workshops provide a wide variety of information tailored to the specific group(s). Topics typically include building code requirements, other state and federal regulations, floodplain management programs, and responsibilities of involved parties such as local governments, lending institutions, citizens, etc. Staff from the DEQ will also meet with property owners on site to discuss shoreline flooding and erosion problems and possible solutions based on the specifics of the property.

#### USACE Advance Measures Program

The Army Corps of Engineers (USACE) Advance Measures Program can be implemented to assist a state or local government in mitigating the potential damage and impact caused by

flooding. Under the Advance Measures Program, USACE the may provide "self-help" materials (i.e., sandbags, sand, and plastic sheeting) at 100 percent federal cost, to participating units of government for use in direct pre-flood mitigation activities. An example of a self-help project would be the construction of temporary sandbag dikes. The Advance Measures Program also has a construction component under which the Corps can provide assistance with permanent construction projects designed to mitigate potential flood damages. Such projects are funded on a 75 percent federal and 25 percent local cost-share basis. Construction projects require a written cooperation agreement between the Corps and the participating jurisdiction. The jurisdiction must agree to furnish all land, easements and rights-of-way, agree to operate and maintain the project for 25 years, pay the 25 percent project cost-share, and provide interior drainage. Examples of construction projects that could potentially be funded under this component of the program include earthen levees, rock and/or sand-filled cribs, and concrete and/or steel sheetpile seawalls.

The Advance Measures Program and its predecessor, Operation Foresight, has been implemented during the last three high water periods on the Great Lakes. Over 100 flood mitigation projects have been funded under these programs in Michigan and other Great Lakes states over the last three decades. In the most recent high water period of 1997-1998, in response to a request by the Governor, the USACE provided approximately 1 million self-help sandbags, and is currently working with seven communities to complete eight Advance Measures construction projects. Those projects are located on or adjacent to Lake Erie, Lake St. Clair, and Saginaw Bay.

#### Lake Michigan Potential Damages Study

The U.S. Army Corps of Engineers (USACE) Detroit District and cooperating organizations have initiated and are currently conducting the *Lake Michigan Potential Damages Study* (LMPDS). This study will provide an extensive assessment of potential shoreline damages due to changes in Lake Michigan water levels over the next 50 years. Initiated in October 1996, the LMPDS is anticipated to be the first in a series of similar assessments of potential damages for all US Great Lakes' shorelines. Lake Michigan has been chosen as a pilot study because it has severe erosion problems and experienced the most damage during the high water periods of the 1970s and 1980s. Ottawa and Allegan Counties have been selected as the pilot study communities in Michigan.

The objective of the LMPDS is to create a modeling procedure for estimating economic effects of lake level changes and related social, environmental, and cultural impacts. Economic effects will be assessed for residential, commercial, industrial, institutional uses, and will include recreational boating, municipal water supply and wastewater treatment, and navigation. The environmental consequences of lake level fluctuations are also expected to be addressed. These include impacts to fisheries, habitat diversity, endangered and threatened species and archaeological and special natural features.

The LMPDS modeling approaches are expected to be the framework for economic assessments for each of the other Great Lakes. The LMPDS is also intended to be a forum for information system development between international, federal, state, county, township and municipal governance about the commonly shared resource base.[1]

#### **Summary of Potential Impacts**

Shoreline Flooding

Luckily, Ottawa County does not suffer from chronic shoreline flooding problems. According to National Flood Insurance Program studies, the 100-year flood elevation along Lake Michigan in the County is 584 feet. Army Corps of Engineer lake level studies indicate that the highest monthly mean water level for Lake Michigan is 582.6 feet, recorded in 1886. The highest monthly mean water level in recent years was approximately 582.4 feet in 1987.

Therefore no communities in Ottawa County have been designated as Great Lakes Flood Risk Areas in the Administrative Rules for Great Lakes Shorelands. This does not mean that shoreline flooding will not ever occur in the County, it just means that no area in the County has a history of flooding, nor does the regional topography indicate that there is a high risk for flooding.

#### Shoreline Erosion

Shoreline erosion, on the other hand, is a significant problem in Ottawa County. Over 75 percent of the Lake Michigan shoreline in Ottawa County has been designated a high risk erosion area. Many homes and structures have been destroyed along areas of the Great Lakes subject to shore erosion processes. This destruction has resulted in severe financial loss to property owners. Structures threatened by erosion must either be set back away from the shore, protected by shore protection measures, or lost.

In the spring of 1999, Lake Michigan water levels were at a low they hadn't reached since 1990. The average monthly water level in March 1999 was 20 inches below what they were in 1998, and 5 inches below the long-term monthly mean measured from 1918 to 1998. These low water levels have been the result of low rainfall levels, as well as below normal snowfall.[1] Shoreline manages fear that the several years of low water levels will lull property owners into a false sense of security. Even though shoreline erosion can occur at any water level, most severe short-term damage occurs at high water levels and during storms. With the low water levels in the past couple of years, the DEQ has received more requests to build closer to the shoreline than in years past.

Although erosion is caused by natural wind and water processes, its rate and severity can be intensified by human activity. Pedestrian and vehicle traffic destroy vegetation, degrade dunes, and weaken bluffs and banks. Docks, jetties, and other structures interrupt the natural shoreline movement of water and redirect erosive forces, possibly in undesirable directions. Inappropriate building practices in high bluff areas can seriously reduce bluff stability. In particular, drainage patterns from new building construction can cause infiltration of runoff directly into a bluff and can weaken its normal cohesive forces. Wise management of shoreline construction and land uses can significantly reduce economic losses due to erosion.[1]Dredging and bulldozing dunes remove natural protection against wind and waves.

Within the high risk erosion area, or areas where erosion studies have indicated the erosion hazard line is receding at an average of one foot or more per year over a minimum 15 year period, any new permanent structure must comply with building setback regulations that require a minimum distance between the existing erosion hazard line and the structure.

# 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." [1]

## **Hazard Description**

Public health emergencies can take many forms: wide-spread incidents of food or water contamination, large-scale infestations of disease-carrying insects or rodents, communicable diseased epidemics, extended periods without proper sewer or water service, and harmful exposure to chemicals or other toxins, to name a few. The common characteristic of most public health emergencies is that they have the potential to adversely impact a large number of people, either nationwide, regional, statewide, or localized in scope and magnitude. The following information describes of some of the more common or serious illnesses that possibly could develop into a public health emergency in Ottawa County.

#### Food-borne Illness

There are approximately 250 known food-borne illnesses. They can be caused by many different bacteria, viruses, parasites, and natural or man-made chemicals. People contract these agents by the ingestion of contaminated food, with or without subsequent spread from person to person by the fecal-oral route. Below are just a few of the more common food-borne illness that have the potential to result in a wide-spread outbreak.

#### Salmonellosis

Salmonellosis is an infection with a bacteria called *Salmonella*. The Salmonella germ is actually a group of bacteria that can cause diarrheal illness in humans. Every year, approximately 40,000 cases of salmonellosis are reported in the United States. Because many mild cases are not diagnosed or reported, the actual number of infections may be twenty or more times greater. Medical costs and lost wages associated with this illness have been estimated to be \$1 billion per year nationally.[1]

Salmonellosis is more common in the summer than winter. Children are the most likely to get salmonellosis, and young children, the elderly, and the immunocompromised are the most likely to have severe infections. It is estimated that approximately 1,000 people die each year with acute salmonellosis. Most people infected with Salmonella develop diarrhea, fever, and abdominal cramps within 12 to 72 hours after ingestion. The illness usually lasts 4 to 7 days, and most people recover without treatment. However, for some people the diarrhea may be so severe that the patient must be hospitalized. In these patients, the Salmonella infection may spread from the intestines to the blood stream, and then to other parts of the body and can cause death unless the person is treated promptly with antibiotics.

Salmonella live in the intestinal tracts of humans and other animals. Salmonella are usually transmitted to humans by eating foods contaminated with animal feces. Contaminated foods typically are animal products, such as beef, poultry, milk, or eggs, but all foods may become contaminated. Many raw foods of animal origin are frequently contaminated, but thorough cooking kills Salmonella. Food may also become contaminated by the hands of an infected food handler, who did not wash his or her hands with soap after using the bathroom. Salmonella may also be spread by pets, especially those with diarrhea, and people can become infected if they do

not wash their hands after contact with these feces. Reptiles are particularly likely to harbor Salmonella and people should always wash their hands immediately after handling a reptile, even if the reptile is healthy.

#### Escheria coli 0157:H7 (E. coli)

*Escherichia coli O157:H7*, commonly known as *E. coli*, is an relatively new cause of food-borne illness. An estimated 10,000 to 20,000 cases of infection occur in the United States each year. Infection often leads to bloody diarrhea, and occasionally to kidney failure.

Most illness has been associated with eating undercooked, contaminated ground beef. Infection can also occur after drinking unpasteurized milk, or from swimming in or drinking sewage-contaminated water. Because E. coli bacteria is present in the stool of those infected, person-to-person contact in families and child care centers is another mode of transmission. Although the number of organisms required to cause illness is not known, it is suspected to be very small.

Meat can become contaminated during slaughter, and organisms can be thoroughly mixed into beef when it is ground. Bacteria present on the cow's udders or on equipment may get into raw milk. Because the organism lives in the intestines of healthy cattle, preventive measures on cattle farms and during meat processing are being investigated.

Young children typically shed the organism in their feces for a week or two after their illness resolves. E. coli infection often causes severe bloody diarrhea and abdominal cramps; however sometimes the infection causes nonbloody diarrhea or no symptoms. Usually little or no fever is present, and the illness resolves in 5 to 10 days.

In some people, especially children under 5 years old and the elderly, the infection can cause a complication called *hemolytic uremic syndrome*, in which the red blood cells are destroyed and the kidneys fail. About 2 to 7 percent of E. coli infections lead to this complication. In the United States, hemolytic uremic syndrome is the principal cause of acute kidney failure in children, and most cases of hemolytic uremic syndrome are caused by E. coli.

People can help prevent E. coli infection by thoroughly cooking ground beef, avoiding unpasteurized milk, and washing hands carefully.

#### Listeriosis

Listeriosis, a serious infection caused by eating food contaminated with the bacterium *Listeria monocytogenes*, has recently been identified as an important public health problem in the United States. Each year, an estimated 1,100 people in the United States become seriously ill with listeriosis. Of the ill, 250 die. The disease affects primarily pregnant women, newborns, and adults with weakened immune systems. Babies can be born with listeriosis if their mothers eat contaminated food during pregnancy. Healthy adults and children occasionally may consume contaminated foods and get infected with Listeria, but they rarely become seriously ill.

Listeria monocytogenes is found in soil and water. Vegetables can become contaminated from the soil or from manure used as fertilizer. Animals can carry the bacterium without appearing ill and can contaminate foods such as meats and dairy products. The bacterium has been found in a variety of raw foods, such as uncooked meats and vegetables, as well as in processed foods that become contaminated after processing, such as soft cheeses and cold cuts. Unpasteurized milk or foods made from raw milk may contain the bacterium.

Listeria is killed by pasteurization, and other heating procedures used to prepare ready-to-eat

processed meats should be sufficient to kill the bacterium; however, unless good manufacturing practices are followed, contamination can occur after processing. People at risk can prevent Listeria infection by avoiding certain high risk foods and by handling food properly.

A multi-state outbreak of Listeriosis that occurred from August 1998 to February 1999 had its origin at the Bil-Mar Foods meat processing plant in Zeeland Township. Health officials identified hot dogs and deli meats produced at the plant as the carriers of the bacteria. The exact source of the contamination has not been determined. A total of 21 deaths and 100 illnesses nationwide were linked to the contaminated meats. In December 1998, 35 million pounds of hot dogs and deli meats were voluntarily recalled by Bil- Mar Foods. This was the largest recall in U.S. History. The Zeeland plant was allowed to resume meat production in March 1999 after more stringent food safety procedures were implemented.

#### Botulism

Botulism is a rare but serious paralytic illness caused by a nerve toxin that is produced by the bacterium *Clostridium botulinum*. In the United States an average of 110 cases of botulism are reported each year. Of these, approximately 25 percent are foodborne. Foodborne botulism is caused by eating foods that contain the botulism toxin. All forms of botulism can be fatal and are considered medical emergencies. Foodborne botulism can be especially dangerous because many people can be poisoned by eating a contaminated food. Because the amount of toxin required to paralyze a person is so low, the potential for a very large scale botulism outbreak always exists.

Outbreaks of foodborne botulism involving two or more people occur almost every year, and usually are caused by eating contaminated home-canned foods. In 1977, one of the largest outbreaks of foodborne botulism ever to occur in North America was linked to home canned jalapeno peppers served by an Oakland County restaurant. Reportedly 59 people became ill from the peppers; many of these people required intensive care treatment and the horse serum botulism antitoxin.

#### Hepatitis A

Hepatitis A is a virus that harms the liver and causes fever, loss of appetite, nausea, abdominal pain, and jaundice. It is transmitted through the fecal/oral route or by consuming food or water contaminated by an infected food handler. Hepatitis A infection is usually a mild and self-limiting illness. It is rarely fatal and can be prevented through post-exposure immune globulin or by pre-exposure vaccination.

Hepatitis A can occur in situations ranging from isolated cases to widespread epidemics. Nationally, it is estimated that there are between 125,000 and 200,000 infections per year. In Ottawa County, between 1987-1997 the annual average was 5.79 reported cases per 100,000 population. This is slightly higher than the Michigan average of 4.78 reported cases per 100,000 per year. Nationally, Hepatitis A costs the \$200 million per year in medical care and work loss.

In the spring of 1997, almost 300 cases of hepatitis A occurred in at least four Michigan school districts. An epidemiological investigation linked the outbreak to frozen strawberries distributed through the national school lunch program.

#### Arthropod-borne Illness

Antropod-borne illnesses are those caused by viruses that are transmitted between susceptible vertebrate hosts (people, birds, and other animals) by blood feeding arthropods, such as mosquitoes and ticks.

#### Encephalitis

Encephalitis is an illness characterized by the swelling of the brain. An outbreak of the *West Nile encephalitis* occurred in the New York City metropolitan area in the summer of 1999. This particular strain of encephalitis had never before been reported in the Western Hemisphere, and resulted in 56 reported cases of the illness, including 7 deaths. Birds were believed to be the carriers of this strain of encephalitis. The virus was transmitted to humans by mosquitoes that had previously fed on the infected birds. There is no evidence that a person can get the virus from handling live or dead infected birds. Although this outbreak was localized in New York, given the mobility of humans and birds, it had the potential to be transported to other regions of the country.

*St. Louis encephalitis* is a more common strain of encephalitis in the United States. Since 1964 there have been 4,478 reported human cases of St. Louis encephalitis, with an average of 128 cases reported annually. People also contract St. Louis encephalitis by the bite of a carrier mosquito.

Mild encephalitis infections are most common and include fever, headache, and body aches, often with skin rash and swollen lymph glands. More severe infection is marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, paralysis, and on rare occasions, death.

The risk of these and other antropod-borne illnesses is greatly reduced due to the effectiveness of mosquito control and public education programs.

#### Water-borne Pathogenic Illness

#### Cryptosporidiosis

Cryptosporidiosis is contamination by a microscopic parasite *Cryptosporidium*, that can live in the intestines of humans and animals. This parasite is protected by an outer shell that allows it to survive outside the body for long periods of time and makes it very resistant to chlorine disinfection. Normally, healthy people can effectively fight the parasite on their own and have no symptoms. However, for people with preexisting health conditions, infection with Cryptosporidium can be life threatening.

Cryptosporidium is present in approximately 97 percent of surface water, and 39 percent of drinking water supplies in the United States. Cryptosporidiosis can be contracted by ingesting anything that has come in contact with the stool of a person or animal with the parasite. This includes swallowing water from swimming pools, hot tubs, Jacuzzis, lakes, rivers, springs, ponds, or streams contaminated with sewage or feces from humans or animals, or by eating uncooked food contaminated with Cryptosporidium.

Symptoms of Cryptosporidiosis generally begin 2 to 10 day after being infected and include diarrhea, stomach cramps, upset stomach, and a slight fever. These symptoms tend to last about 2 weeks. Once the symptoms are gone, a carrier continues to pass Cryptosporidium in his stool for up to 2 months. During this 2 month period, the infection can be spread to others. People should avoid swimming in pools for at least 2 weeks after the symptoms stop if they have had Cryptosporidiosis. Infected swimmers have caused several outbreaks of Cryptosporidiosis among pool users because the parasite can survive in chlorinated pools for several days.

To prevent the spread of Cryptosporidium, wash your hands with soap and water after using the toilet, changing diapers, and before eating or preparing food. Also, avoid water or food that may be contaminated: this includes avoiding drinking water from lakes, rivers, springs, ponds, or streams unless it has been filtered and chemically treated. During community-wide outbreaks caused by contaminated drinking water, boil drinking water for 1 minute to kill the crypto parasite and make the water safe to drink.

A severe Cryptosporidium outbreak occurred in Milwaukee, Wisconsin in April of 1993. On April 5, thousands of city residents suddenly became ill with a gastrointestinal disorder. Followup investigations identified the largest water-borne disease outbreak in U.S. history as being caused by Cryptosporidium in the city's water supply. Engineering studies indicated the need for more than \$90 million in improvements to Milwaukee's water supply and treatment system. During this outbreak more than 400,000 people were infected with the parasite, and over 4,000 victims required hospitalization. In addition, over 100 people in the Milwaukee area with compromised immune systems are believed to have died prematurely after being infected with Cryptosporidium during the outbreak.

# Other Communicable Diseases

#### Influenza

Influenza, commonly called "the flu," is caused by the influenza virus, which infects the respiratory tract. The virus is typically spread from person-to-person when an infected person coughs or sneezes the virus into the air. Compared with other viral respiratory infections such as the common cold, influenza infection can cause severe illness and also precipitate serious and life-threatening complications in all age groups. Flu is a major cause of sickness and death in the U.S., leading to approximately 20,000 deaths and greater than 110,000 hospitalizations each year. In Michigan, during a typical flu season, 200 to 500 people will die from flu related illness.

Typical symptoms of flu include fever, dry cough, sore throat, runny or stuffy nose, headache, muscle aches, and extreme fatigue. Children may experience nausea, vomiting, and diarrhea, but such symptoms are not common in adults. Some medical complications brought on by flu include bacterial pneumonia, dehydration, and worsening of preexisting chronic conditions, such as congestive heart failure and asthma. Complications occur most often in people who are particularly vulnerable, such as the elderly and people of any age with certain chronic health conditions.

In the United States, flu outbreaks typically occur during the winter months from late December through March. The start, peak period, duration and total hospitalizations and deaths of the flu season vary considerably from year to year.

By far, the most important preventive measure against the flu is for individuals, especially those at high risk for complications, to get vaccinated in the fall prior to the onset of the flu season. The effectiveness of flu vaccine in protecting individuals against illness or serious complications of flu depends on primarily: 1) the age and physical condition of the person receiving the vaccine and 2) the similarity or "match" between the virus strains in the vaccine and those in circulation. When the "match" between vaccine and circulating strain is close, the flu vaccine prevents illness in 70 to 90 percent of healthy people younger than age 65 years.

## Historically Significant Public Health Emergencies in Ottawa County

No significant public health emergencies have occurred in Ottawa County.

### **Programs and Initiatives**

The Michigan Department of Community Health and local and district health departments across the state have a number of programs and initiatives in place to protect the health, safety and well being of Michigan's residents. These programs and initiatives, such as providing immunizations, have been very successful in preventing, or limiting the scope and magnitude of, the types of public health emergencies described above. However, because the nature of the threats to our public health is always changing, and because the population is becoming larger and more mobile, the possibility always exists for a local, regional or statewide public health emergency to occur.

The Director of the Department of Community Health, and local public health officers, have the authority (under the Michigan Public Health Code) to take those steps deemed necessary and prudent to prevent epidemics and the spread of hazardous communicable diseases, or to effectively mitigate other conditions or practices that constitute a menace to public health. The Director and local public health officers can issue written orders to that effect, and those orders can be enforced through the imposition of civil and criminal penalties for failure to comply.

At the national level, the U.S. Centers for Disease Control and Prevention (CDC), a branch of the Department of Health and Human Services located in Atlanta, Georgia, has the responsibility and authority to investigate public health emergencies to determine their cause, probable extent of impact, and appropriate mitigative measures. The CDC can also assist state and local public health officials in establishing health surveillance and monitoring systems/programs, and in disseminating information on prevention and treatment to the general public.

One example of a CDC program is PulseNet. In 1998 the CDC launched this collaborative interagency initiative that uses DNA fingerprinting to better detect food-borne illness. With this program, more than 35 laboratories across the country can identify E. coli in less than 24 hours, whereas the process used to take days or weeks.

(Note: For information on specific programs and initiatives aimed at mitigating water and sewer system failures, refer to the Infrastructure Failures section.)

### **Summary of Potential Impacts**

There are numerous pathogens that could potentially create a public health emergencies in Ottawa County. New and unique causes of illness are emerging, and familiar ones are growing resistant to treatment. And although Michigan has had several large-scale public health emergencies in recent history, fortunately none of these emergencies has caused injury or death in Ottawa County.

Foodborne illnesses are one of the more common causes of public health emergencies in the United States. Although the nation's food supply is one of the safest in the world, food contamination is a constant threat. Since 1942, the number of known foodborne pathogens has increased more than five-fold. Two reasons for the spread and increase in foodborne illness in recent years is that consumers eat out more, and eat more processed food than ever before. This increases one's chance for contact with disease-producing food-handling errors.

Food safety related recalls occur almost every month in the United States. From October 1999 through January 2000, there were the following 4 food recalls in the United States: 1) In October, over 52,000 pounds of beef frankfurters were recalled because they were suspected of being contaminated with Listeria monocytogenes; 2) in December and again in January, there was a recall of a variety of smoked fish products because they had the potential of being contaminated with Listeria monocytogenes; 3) in January a North Carolina poultry processor recalled 146,000 pounds of turkey breasts because some may have been under cooked; and 4) in January a multistate outbreak of at least 49 Shigell sonnei infections led to the recall of several brands of 5 layer chip dip that were the cause of the infections.[1]

Keeping up to date on food recalls can help one avoid foodborne illness. Consumers need to educate themselves on the potential dangers of foodborne pathogens as well as how to protect themselves against illness.

Although no area in Michigan is immune to public health emergencies, areas with high population concentrations will be more vulnerable to the threat. In addition, like with most hazards, the more vulnerable members of society - the elderly, children, the poor and people in poor health - are at more risk than the general population. That is why it is so important to ensure that people in these high risk categories are properly immunized against preventable pathogens, such as the flu.

Michigan is fortunate in that it has an excellent public health system that constantly monitors the threats that could lead to a widespread or significant public health emergency. However, even the best monitoring and surveillance programs cannot always prevent such incidents from occurring.

# THUNDERSTORM HAZARDS

## **Hazard Description**

Severe thunderstorms are weather systems accompanied by strong winds, lightning, heavy rain, and possibly hail and tornadoes. The following section will address hail and lightning. Because of their severity, tornadoes and severe winds are discussed as separate sections, and heavy rain is covered in the flooding section.

#### Hailstorms

"A condition where atmospheric water particles from thunderstorms form into rounded or irregular lumps of ice that fall to the earth." [1]

Hail is a possible by-product of strong 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. As one of these thunderstorms passes over, hail usually falls near the center of the storm, along with the heaviest rain. Most hail stones range in size from a pea to a golf ball, but hailstones larger than baseballs have been reported.

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

#### Lightning

"The discharge of electricity resulting from the buildup of positive and negative charges from within a Thunderstorm." [1]

Most direct impacts from lightening are relatively site specific in scope, and therefore do not have a tremendous impact on the community as a whole. With the temperature of a bolt of lightning approaching 50,000 degrees Fahrenheit in a split second, the most common damage from lightning is fire. The most common indirect effect of lightning is power outages. This indirect effect can have an impact on a much larger segment of the community, leaving hundreds and sometimes thousands of homes without electricity.

The following are some notable thunderstorm related events that have occurred in Ottawa County in recent years.

#### Historically Significant Thunderstorm Related Events in Ottawa County

#### April 15, 1994

Lightning struck a television antenna and caused an attic fire at a residence in Holland. There were no injuries, but the cost of damages was estimated at \$5,000.

#### June 13, 1994

Lightning hit a tree next to a home in Park Township destroyed electrical equipment and appliances in the home, and caused minor injuries to a child who suffered burns from her braces. The estimated cost of damages was \$50,000.

#### July 5, 1994

Two homes in Allendale were struck by lightning, causing \$50,000 in damages, but no injuries.

#### July 4, 1995

Lightning struck a home in Holland and ignited an attic fire that also caused smoke damage to other parts of the house. Damages were estimated at \$15,000.

#### April 12, 1996

A storm spotter reported hail stones of .75" covering the ground near Adams Street and 80th Avenue in Zeeland Township.

#### May 5, 1997

A line of strong thunderstorms moved through the Lower Peninsula in the afternoon and evening. Considerable hail was reported in Jenison, Zeeland, and Grand Haven. No injuries or significant property damage occurred, however there was much crop damage, although damage estimates were not available.

#### June 20-24, 1997

A hail storm that passed through the area caused severe crop damage and resulted in a disaster declaration from U.S. Department of Agriculture. With this declaration, Ottawa County farmers became eligible for low interest rate federal loans.

#### September 19, 1997

A strong storm passed through southern Michigan, depositing .75" to 1.25" hail in Ottawa County near Grand Haven, Hudsonville, and Jenison.

#### April 21, 1998

Lightning striking the roof of a house in Nunica caused a house fire that resulted in \$45,000 damage to the house and \$15,000 to the families belongings.

#### May 6, 1998

A 34 year old male was critically injured when struck by lightning at Spring Grove Park near Jamestown. The Ottawa County Parks employee suffered led and chest injuries. On this same day, 1" hail reportedly broke the windows of a home in Ferrysburg.

#### July 21, 1998

A three bedroom house in Georgetown Township was mostly destroyed by fire that started when the home was struck by lightning.

#### July 28, 1999

On the evening of July 28, 1999 thunderstorms produced numerous reports of large hail ranging in size of 0.75" to 2" in Allendale, Grand Haven, and Port Sheldon. The 60 to 70 mph winds that accompanied this storm also downed trees, limbs and powerlines, and caused minor damage to homes.

#### **Programs and Initiatives**

Many of the programs and initiatives in place to mitigate against, prepare for, respond to, and recover from other severe thunderstorms hazards (severe winds and tornadoes) have the dual purpose of also protecting against hail and lightning. Unfortunately, lightning prevention or

protection, in an absolute sense, is impossible. However, the consequences of lightning strikes have been diminished (both in terms of deaths and injuries and property damage) through the implementation of the following programs and special initiatives:

#### National Weather Service Doppler Radar

The National Weather Service (NWS) Doppler Weather Surveillance Radar can detect severe weather events that threaten life and property, including storms that are likely to produce damaging hail and lightning. Most important, thanks to the Doppler Radar the lead time and specificity of warnings for severe weather have improved significantly. Doppler technology calculates both the speed and the direction of severe storms. By providing data on the wind patterns within developing storms, the new system allows forecasters to better identify the conditions leading to severe weather such as tornadoes, strong winds, lightning and damaging hail. This means early detection of the precursors to severe storms, as well as information on the direction and speed of storms once they form.

#### National Weather Service Watches/Warnings

The National Weather Service issues *severe thunderstorm watches* for areas when the meteorological conditions are conducive to the development of a severe thunderstorm. People in the watch area are instructed to stay tuned to local radio or television stations for weather updates, and watch for developing storms. Once radar or a trained Skywarn spotter detects the existence of a severe thunderstorm, the National Weather Service will issue a *severe thunderstorm warning*. The warning will identify where the storm is located, the direction in which it is moving, and the time frame during which the storm is expected to be in the area. People in the warning area are instructed to seek shelter immediately.

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

The National Weather Service also has an extensive public information program aimed at educating citizens about the dangers of lightning and other severe weather and ways to prevent weather-related deaths and injuries.

#### Severe Weather Awareness Week

Each spring, the Michigan Department of State Police Emergency Management Division, in conjunction with the Michigan Committee on Severe Weather Awareness, sponsors Severe Weather Awareness Week. This annual public information and education campaign focuses on such severe weather events as tornadoes, thunderstorms, lightning, high winds, flooding and hail. Informational materials on hail and other thunderstorm hazards are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

#### Lightning Protection for Structures

The National Lightning Safety Institute (NLSI) has identified a systematic lightning hazard mitigation approach that can be followed to protect structures from lightning damage. That approach attempts to mitigate both the direct and indirect effects of lightning strikes through the application of appropriate structural safety improvements, as identified in a comprehensive

lightning safety analysis. Full details of this mitigation approach can be obtained by contacting the NLSI or visiting the NLSI Web Page.

#### National Lightning Detection Network

Despite advancements in electric power system design and equipment, lightning continues to be the single largest cause of outages on electrical distribution and transmission lines. To help combat that problem, the National Lightning Detection Network (NLDN), a technologically advanced lightning location system operated by a private company in Phoenix, Arizona, was invented. The NLDN helps electric utilities make effective decisions regarding line maintenance priorities, crew dispatch, and future design and placement of utility transmission lines and lightning protection. NLDN lightning data is available in both real-time and archival format (1989-present). The lightning information from NLDN can lead to significant savings to utility maintenance and construction budgets, improved design and placement of future transmission and distribution infrastructure, and reduced outages due to lightning-related damage. Data from the NLDN can also be used to improve the safety of participants at outdoor events such as golf tournaments, air shows, fairs and festivals, and sporting events and concerts, and other events at outdoor venues.

## **Summary of Potential Impacts**

Annually, thunderstorms will occur on an average of 39 days in Ottawa County.[1] Because nothing can be done to prevent the hail and lightning that often accompanies these storms, the best defense against these hazards is public education and awareness of the dangers posed by these natural hazards.

Lighting is a major health threat during a thunderstorm. In the United States, between 75 and 100 people are hit and killed by lightning each year. Studies reveal the following about lightning fatalities and injuries in Michigan and the United States:

Location of Lightning Strike injuries and Deaths							
Location	Michigan [1] (lightning injury)	Michigan[1] (lightning death)	U (lig				
Open field and recreation areas (not golf course)	34 percent	27 percent					
Under a tree (not on a golf course)	15 percent	28 percent					
On or near water: boating, swimming, fishing, etc.	4 percent	12 percent					
Golf course	5 percent	11 percent					
On or near equipment and machinery	3 percent	2 percent					
At telephone	3 percent	2 percent					
Other or unspecified	36 percent	18 percent					

#### Location of Lightning Strike Injuries and Deaths

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

# TORNADOES

"An intense column of wind that extends from the base of a severe thunderstorm to the ground." [1]

### Hazard Description

Tornadoes in Michigan are most frequent in spring and early summer when warm, moist air from the Gulf of Mexico collides with cold air from the polar regions to generate severe thunderstorms. These thunderstorms often produce tornadoes. A tornado may have winds up to 300 miles per hour and an interior air pressure that is 10 to 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, up to 200 miles, have been reported. Tornado path widths are generally less than one-quarter mile wide. Historically, tornadoes have resulted in tremendous loss of life, with an average of 111 deaths nationally per year. Property damage from tornadoes is in the hundreds of millions of dollars every year in the United States.

#### Tornado Intensity

Tornado intensity is measured on the Fujita Scale, which examines the damage caused by a tornado on homes, commercial buildings, and other man-made structures. The Fujita Scale rates the intensity of a tornado based on damaged caused, not by its size. It is important to remember that the size of a tornado is not necessarily an indication of its intensity. Large tornadoes can be weak, and small tornadoes can be extremely strong. It is very difficult to judge the intensity and power of a tornado while it is occurring. Generally, that can only be done after the tornado has passed.

F-Scale Number	Intensity Description	Wind Speed (mph)	Type/Intensity of Damage
F0	Gale tornado	40-72	Light damage. Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1	Moderate tornado	73-112	Moderate damage. The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	Significant tornado	113-157	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	Severe damage. Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown.
F4	Devastating tornado	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	Incredible tornado	261-318	Incredible damage. Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile- sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged; incredible phenomena will occur.
F6	Inconceivable tornado	319-379	These winds are very unlikely. The area of damage they might produce would be unrecognizable.

## The Fujita Scale of Tornado Intensity

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

*NOTE:* When describing tornadoes, meteorologists often classify the storms as follows: F0 and F1 - weak tornado; F2 and F3 - strong tornado; F4 and F5 - violent tornado

Michigan lies at the northeastern edge of the nation's tornado belt. Although tornadoes appear to be more frequent in the southern part of the state, between 1950 and 1997, 16 tornadoes were reported in Ottawa County. In the past 20 years, there has been no significant damage or loss of life from tornadoes in the County.

Tornado Occurrences in Ottawa County, 1950-1997							
Date	Magnitude	# Deaths	<b># Injuries</b>	\$ Damage			
03/06/1956	F2	0	0	50,000			
04/03/1956	F5	14	200	1,000,000			
06/22/1957	F2	0	0	50,000			
09/22/1961	F2	0	1	50,000			
04/11/1965	F4	5	142	5,000,000			
09/04/1965	F2	0	0	50,000			
07/12/1966	F2	0	0	50,000			
06/17/1975	F0	0	0	50,000			
03/12/1976	F1	0	1	500,000			
05/13/1978	F0	0	0	0			
08/09/1979	F1	0	0	500,000			
08/09/1979	F1	0	0	50,000			
08/09/1979	F0	0	0	5,000			
07/09/1987	F0	0	0	5,000			
05/30/1991	F1	0	0	5,000			
06/17/1992	F0	0	0	0			
	Total	19	344	7,365,000			

#### Historically Significant Tornadoes in Ottawa County 1950 to Present

(Source: NOAA National Climatic Data Center and The Tornado Project)

#### March 6, 1956

A tornado passed through central Ottawa County, approximately 10 miles north of Holland on March 6, 1956. The most severe damage occurred near the North Blendon and Bauer area where barns were flattened, trees uprooted, and power lines downed.

#### April 3, 1956

On April 3, 1956 a violent tornado swept through Ottawa County. To date, this was the deadliest tornado to strike in the County since 1950. Damage from the tornado stretched from Hudsonville to Graafschap and Saugatuck in Allegan County. Hudsonville by far suffered the most damage. 80 to 90 houses were damaged by the storm, 30 of these were completely leveled. Estimates were given that 800 people were left homeless in Hudsonville and Standale (located just over the boarder into Kent County). According to the Red Cross, a total of 69 homes were destroyed, 300 homes were damaged, and 186 other building were "wrecked" by this tornado.

So many injuries occurred as a result of this event that hospitals and emergency centers in the area were overflowing. The Hudsonville firehouse was set up as a temporary morgue for the 12 people who were killed in the Hudsonville area.

#### April 11, 1965

Ottawa County was one of the 14 Michigan counties affected by the April 11, 1965 Palm Sunday tornado outbreak. A total of 23 tornadoes touched down in Michigan, resulting in 53 fatalities, 798 injuries, and \$51 million in damage to public and private property. The one tornado reported in Ottawa County was rated as an F4, or "devastating tornado," with wind speeds ranging from 207 to 260 miles per hour. Reports of deaths associated with this tornado vary by source. One source has stated that only 2 people in the County were injured, both in Marne, and none were killed. Another report has listed 5 dead and 142 injured. County damage reports from this tornado also vary. One report has stated that damage was estimated at \$175,000, the other report lists damage at over \$5 million.

#### August 9, 1979

Wind gusts up to 70 miles per hour cut a path from Marne eastward to the Peach Ridge area of Kent County on August 9, 1979. Numerous trees were uprooted and toppled from the 50 mph gusts that were reported in the Holland area, along with 2 inches of rain. Damage from the storm included: roofs torn off 12 homes and a church at the corner of M-104 and 136th Avenue in Crockery Township; downed trees blocked M-104 from Fruitport Road in Spring Lake Township to Nunica in Crockery Township; and 35 to 40 power lines were down in Holland Township. Estimated cost of damages to homes and property located along M-104 west of Spring Lake amounted to \$300,000.

## **Programs and Initiatives**

Note: Many of the programs and initiatives designed to mitigate against, prepare for, respond to, and recover from severe winds have the dual purpose of also protecting against tornadoes. As a result, there is some overlap in the narrative programs and initiatives descriptions for each respective hazard.

#### National Weather Service Doppler Radar

Doppler Weather Surveillance Radar can assist in the detection of severe weather events that threaten life and property, including tornadoes and the severe storms that spawn them. With this technology the lead time and specificity of warnings for severe weather have improved significantly over previous methods of weather detection. Doppler technology calculates both the speed and the direction of motion of severe storms. By providing data on the wind patterns within developing storms, the new system allows forecasters to better identify the conditions leading to severe weather such as tornadoes. This means early detection of the precursors to severe storms, as well as information on the direction and speed of storms once they form.

## National Weather Service Watches/Warnings

The National Weather Service issues *tornado watches* for areas when the meteorological conditions are conducive to the development of a tornado. People in the watch area are instructed to stay tuned to local radio or television stations for weather updates, and watch for developing storms. Once a tornado has been sighted and its existence is confirmed, or Doppler Radar shows strong probability of the development or occurrence of a tornado, the National Weather Service

will issue a *tornado warning*. The warning will identify where the tornado was sighted, the direction in which it is moving, and the time frame during which the tornado is expected to be in the area. People in the warning area are instructed to seek shelter immediately.

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

#### Public Warning Systems

Numerous communities in Michigan have outdoor warning siren systems in place to warn the public about impending tornadoes and other hazards. Most of these systems were originally purchased as civil defense sirens to warn residents of a nuclear attack, but that purpose was later expanded to include severe weather hazards as well. These systems can be very effective at saving lives in densely populated areas where the siren warning tone is most audible. In more sparsely populated areas where warning sirens are not as effective, communities are turning to NOAA weather alert warning systems to supplement or supplant outdoor warning siren systems. Unfortunately, a large number of communities across the state, including parts of Ottawa County, do not have adequate public warning systems in place to warn their residents of severe weather or other hazards. Several communities in the County do not have warning sirens, nor is the entire County covered by the NOAA weather radio broadcast area.

The following is a list of communities in Ottawa County that have operational warning siren systems:

**City of Coopersville**: The City of Coopersvilles has an independent siren system that covers most of the downtown and in town area, but does not extend to neighborhoods on the outskirts of town. Recently the city received Hazard Mitigation Grant funding to install one early warning siren with a generator, and 2 generators at existing sites.

**Crockery Township**: Crockery Township has a system that is mostly dysfunctional.

## **City of Ferrysburg:**

**Georgetown Township**: After receiving federal grant money, Georgetown Township is in the process of expanding their existing sire system. This system can only be activated by the township.

**City of Grand Haven**: The City of Grand Haven siren system covers all of the city's geographic area. This system can be activated by Ottawa County Central Dispatch, and the Emergency Operations Center at the County Fillmore Street Complex.

**Grand Valley State University-Allendale:** Grand Valley State University has one tornado warning siren located west of the fieldhouse on campus. This siren is toned with the Ottawa County system, and is tested at the same time the as the other County activated systems.

**City of Holland**: The City of Holland has a slightly dated, but adequate siren system that covers the majority of the geographic area of the city. These civil defense sirens can be sounded from

the Holland Police Department, the department's supervisor's car, Ottawa County Central Dispatch and the Ottawa County Emergency Services Office Emergency Operations Center at the County Fillmore Street Complex.

**City of Hudsonville**: The City of Hudsonville has a siren system that can only be activated by the local unit of government.

#### Spring Lake Township:

**City of Zeeland**: The City of Zeeland maintains a sire system that can only be activated by the city.

The State of Michigan has used federal Hazard Mitigation Grant Program (HMGP) funds to assist several communities in purchasing public warning systems. To date, a total of 8 systems have been installed, consisting of outdoor warning sirens, NOAA weather alert systems, or both. Communities were also encouraged to implement a warning education program as part of the project, to ensure that residents know what to do once they receive warning of an impending hazardous event. Because HMGP funds must be used to fund a wide variety of mitigation projects, the amount of funds available to fund warning systems is limited to a small percentage of the overall available grant funds allocated to the state. The HMGP funds are provided on a 75 percent federal, 25 percent local cost share. A Presidential Major Disaster Declaration is required to activate the HMGP funding. As a result, the funding stream may not always be available in the future. In addition, state mitigation priorities may change over time, putting public warning systems at a lower priority than other mitigation projects.

## Severe Weather Awareness Week

Each spring, the Department of State Police Emergency Management Division, in conjunction with the Michigan Severe Weather Awareness Committee, sponsors Severe Weather Awareness Week. This annual public information and education campaign focuses on severe weather events such as tornadoes, thunderstorms, lightning, hail, high winds and flooding. The purpose of the tornado portion of this campaign is to inform the public about what tornadoes are and when they usually occur, what they should do if a tornado occurs, what community warning systems exist, and to provide other pertinent tornado-related information as appropriate. Informational materials are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public. Special educational programs are often conducted during this week. In 2000, Severe Weather Awareness week was held March 26-April 1.

## Manufactured Home Anchoring

Manufactured homes are always vulnerable to tornado damage, but especially so if they are not properly anchored down. As a result, a major national effort has been initiated to encourage structural anchoring or "tie down" of manufactured homes. The Michigan Manufactured Housing Commission Administrative Rules (R 125.1602, Subsection 5) require new manufactured home installations in floodplains to be structurally anchored to a foundation. Through this requirement, the possibility of damage from wind is minimized. Although this will not protect a manufactured home from a direct hit by a tornado, it certainly will help prevent rollovers in most high-wind situations. Unfortunately, structures outside designated floodplains do not have to comply with the anchoring provision, although many owners choose to comply voluntarily. It should also be noted that local communities have the option of adopting an ordinance that requires anchoring of manufactured home installations located outside a

designated floodplain. State anchoring system standards are outlined in Administrative Rules R 125.1605 through R 125.1608.

#### Electrical Infrastructure Reliability

One of the major problems associated with the severe winds from tornadoes and thunderstorms is the loss of electric power caused by trees falling on power lines. Michigan has had numerous widespread and severe electrical power outages caused by severe wind and other weather events. Several of those outages have resulted in upwards of 500,000 electrical customers (roughly 5 percent of the State's population) being without power for several hours to several days at a time. Wind-related damage to electric power facilities and systems is a concern that is being actively addressed by utility companies across the state. Detroit Edison, Consumers Energy and other major electric utility companies have active, ongoing programs to improve system reliability and protect facilities from damage by tornadoes, severe straight-line winds, and other hazards. Typically, these programs focus on trimming trees to prevent encroachment of overhead lines, strengthening vulnerable system components, protecting equipment from lightning strikes, and placing new distribution lines underground. The Michigan Public Service Commission (MPSC) monitors power system reliability to help minimize the scope and duration of power outages.

#### Structural Bracing

One of the best ways to protect buildings from damage from severe winds associated with thunderstorms, tornadoes, or other high wind events is to install structural bracing and metal connectors (commonly called hurricane clips) at critical points of connection in the frame of the structure. Typically, this involves adding extra gable end bracing at each end of the structure, anchoring the roof rafters to the walls with metal connector straps, and properly anchoring the walls and sill plate to the foundation. This extra bracing helps ensure that the roof stays on the structure, and the structure stays anchored on its foundation. Experience in tornadoes and other high wind events has shown that once the roof begins to peel away from the walls, or the building begins to move off its foundation due to extreme lateral wind forces, major structural damage occurs. If the damage continues unabated, the building can end up being a total loss.

The Emergency Management Division, Michigan Department of State Police (EMD/MSP), and the Michigan State Housing Development Authority (MSHDA), have begun a small pilot program aimed at employing wind engineering techniques on new residential construction. This initiative is designed to show that implementing such techniques can be a relatively inexpensive way to protect buildings from damage in high wind events. While these techniques will do nothing to protect a building from damage caused by flying debris, they will help ensure that the damage does not occur from the building coming apart at critical junctures due to extreme wind forces. If this pilot program is successful, it may be expanded in the future to include retrofitting existing residential and commercial structures.

In addition, Kent County and Ottawa County Emergency Management Divisions have held joint workshops to address these issues. In March of 2000, these divisions sponsored Professor James Abernathy share a practical approach on how you can determine the "safe area" in your place of work.

#### Urban Forestry/Tree Maintenance Programs

Urban forestry programs can be very effective in minimizing storm damage caused by falling trees or tree branches. In almost every tornado or other severe wind event, falling trees and branches cause power outages and clog public roadways with debris. However, a properly designed, managed and implemented urban forestry program can help keep tree-related damage and impact to a minimum. To be most effective, an urban forestry program should address tree

maintenance in a comprehensive manner, from proper tree selection, to proper placement, to proper tree trimming and long-term care.

Every power company in Michigan has a tree trimming program in place, and numerous local communities have some type of tree maintenance program in place. The electrical utility tree trimming programs are aimed at preventing encroachment of trees and tree limbs within power line rights-of-way. Typically, professional tree management companies and utility work crews perform the trimming operations. At the local government level, only a handful of Michigan communities have actual urban forestry departments or agencies. Rather, crews from the public works agency or county road commission perform the bulk of the tree trimming work.

When proper pruning methods are employed, and when the work is done on a regular basis with the aim of reducing potential storm-related damage, these programs can be quite effective. Often, however, tree trimming work is deferred when budgets get tight or other work is deemed a higher priority. When that occurs, the problem usually manifests itself in greater storm-related tree debris management problems down the line. Although nothing will prevent tree damage from a direct tornado strike, a well planned, well managed urban forestry program can certainly reduce the scope and magnitude of the post-tornado tree debris problem.

## **Summary of Potential Impacts**

Michigan is located on the northeast fringe of the Midwest tornado belt. Most tornadoes in the state come from the southwest and travel to the northeast. The low frequency of tornadoes occurring in Michigan may be, in part, the result of the cold water of Lake Michigan during the spring and early summer months, a prime period of tornado activity. Within Michigan, tornadoes occur more frequently in the southern half of the Lower Peninsula than any other area of the state. During 1950-87, Michigan averaged 15 tornadoes each year.[1] During 1956-92, 16 tornadoes occurred within Ottawa County.

Although tornadoes are a fairly rare event in Ottawa County, a few of the tornadoes that have hit have been quite destructive and some even deadly. In general, improved surveillance and warning systems implemented by the National Weather Service and emergency management agencies, coupled with public education campaigns have been effective in keeping the death toll down in recent years. However, this is not to say that a major death toll could not occur again if a strong tornado should strike a highly populated area. History has clearly shown that tornadoes must always be considered with the utmost caution. Other initiatives, such as structural bracing, urban forestry practices, manufactured home anchoring, and strengthening electrical system components can help to reduce public and private property damage.

Like severe wind events, tornado disasters require that communities plan and prepare for the mass care or residents left without electrical power and the clearance and disposal of tree and other debris from roadways. These are two primary challenges that face all Michigan communities in such an event. The planning and preparedness effort should include the identification of mass care facilities and supplies. In Ottawa County, the local chapter of the American Red Cross maintains a list of potential shelter and evacuation sites, as well as sources of emergency supplies. Depending on the severity and location of the disaster, the Red Cross will establish a shelter in any one or a number of these sites.

Lining up potential debris removal equipment and services before a disaster strikes is also necessary. Communities should develop debris management procedures that include the identification of multiple debris storage, processing, and removal sites, so that the debris stream can be handled in the most expedient, efficient, and environmentally safe manner possible. Both FEMA and the Michigan State Police Emergency Management Division offer debris management courses to provide local, State, and Federal management personnel at all levels with an overview of issues and recommended actions necessary to plan for, respond to, and recover from a major debris generating event. Such a course would be useful for local government leaders in developing a debris management plan.

So although tornadoes cannot be predicted until almost the last moment or prevented, their potential impact on the citizens of Ottawa County can certainly be reduced with the appropriate forethought and preparation.

## WINDSTORMS

"Winds of 58 mile per hour or greater." [1]

## **Hazard Description**

Severe winds spawned by thunderstorms and other weather events can have devastating effects in terms of loss of life, injuries, and property damage. According to data compiled by the National Weather Service for the period of 1970 to August 1999, Michigan experienced nearly 9,200 severe wind events (not including tornadoes). Typically severe wind events occur most frequently in the southern part of the state. Ottawa County is in a very high risk area for severe thunderstorms and severe winds, and therefore can expect 5 to 7 high wind incidents per year. One of the major problems associated with windstorms is the loss of electrical power and associated services. Windstorms also cause property damage from falling tree limbs and other flying debris.

## Historically Significant Wind Events in Ottawa County

#### November 11, 1940

In this Veterans Day event, hurricane force winds pushed a storm across Lake Michigan, sinking two freighters and a grain carrier causing more than 70 deaths from Luddington to South Haven. This storm produced winds of 90 to 100 mph on the lake.

#### July 15-20, 1980

A Presidential Major Disaster Declaration made for 10 Michigan Counties, including Ottawa County. This same storm event resulted in a Governor's Disaster Declaration on July 21, 1980 for the City of Grand Haven and Village of Spring Lake.

## April 6, 1997

In early April a low pressure system moved across the Great Lakes and brought gale force winds to much of Lower Michigan. This storm had sustained wind speeds of 35-45 miles per hour, and wind gusts that ranged from 50 to 70 miles per hour. Not only did this windstorm cause widespread beach erosion along much of the coastline, but damage occurred inland as well. Winds downed trees and power lines and resulted in roof damage to area homes and businesses. In Holland a 70 foot tall tree was uprooted and landed on a house. In Coopersville, a section of the roof was ripped off the Owens-Corning manufacturing building, and at the Grand Haven Municipal Airport the doors were torn off of four large airplane hangers.

#### June 20-21, 1997

Although the primary damage was caused by flooding, the June 20-21, 1997 storms that resulted in a Governor's Disaster Declaration for Ottawa County also caused severe wind damage to trees and structures in the City of Zeeland, Zeeland Township, and Drenthe areas, resulting in structural damage and power outages.

#### May 31, 1998

On May 31, 1998, a line of severe thunderstorms passed through west-central Michigan, producing winds up to 130 miles per hour. These winds caused extensive damage in Ottawa County. Hundreds of homes sustained significant property damage or were destroyed. At least 45 people were evacuated from their homes, and 31 people required emergency shelter. Several

people were injured, 20 of them required hospitalization, and one utility worker was killed while repairing electrical lines. Downed power lines and damaged utilities left thousands of utility customers without power, with some townships not able to regain electrical service for several days. Numerous roads were blocked by trees and other debris. Damages and losses were concentrated in the City of Grand Haven, the northern portion of Grand Haven Township, Spring Lake Township, the Village of Spring Lake, Crockery Township, Polkton Township, and Wright Township. Other more localized damages and losses were sustained at numerous other locations within the County.

This storm had a tremendous economic impact on Ottawa County. Total public damage (to schools, parks, public utilities, etc.) from this storm was estimated at over \$4 million. Total private property damage costs were estimated at \$25 million in the City of Grand Haven and Grand Haven Township, \$5.1 million in the Village of Spring Lake, \$130 thousand in Park Township, \$182.9 thousand in the City of Zeeland, and \$20 thousand in the Holland area.[1] Local businesses also lost revenue, primarily due to power outages. According to the Association of Commerce and Industry, estimated daily economic impacts from the storm to communities in the greater Grand Haven area exceeded \$1.8 million per day.[1] In addition, crop damage reports estimated \$10 million in damage to tree fruit crops in the northern part of the County.

This storm also upset the aesthetic beauty of several communities across the County. Not only were homes and businesses damaged and destroyed, but thousands of trees, many of them quite old and large, were up rooted or snapped off.

Ottawa County was included in both a Governor's Disaster Declaration and a Presidential Major Disaster Declaration for this storm. The Presidential declaration was granted for 13 of the 15 affected 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 counties to help rebuild homes and businesses damaged in the storm.

#### November 10-11, 1998

One of the strongest storms ever recorded in the Great Lakes moved across Michigan on November 10-11, 1998. This system resulted in scattered damage to residences in the Holland and Zeeland areas. Although the wind speeds did not top 74 miles per hour, this storm was actually more severe than the May 31 storm because the high wind speeds were sustained for several hours. As a result, hundreds of trees were ripped down, power lines were cut and some county parks in Allegan and Ottawa ended up looking like "war zones" with fallen trees and other damage that would have to wait until spring to be Repaired. [1] Downed wires caused traffic problems, power outages and surges across the area. The strong winds also generated 15-20 foot waves on Lake Michigan, causing considerable beach erosion.

## May 16-17, 1999

According to the National Weather Service, wind speeds in Ottawa County reached 70 miles per hour during a storm event that moved through West Michigan on May 16-17, 1999. Jamestown Township took the brunt of the storm in the County, where the roof was blown off of a home, a pole barn was damaged, and several trees were blown down, taking power lines down in their wake. Although the NWS received several reports of funnel cloud sightings, none were confirmed touchdowns and the damage appeared to be caused by straight line winds.[1] Several portions of southern Ottawa County were without power for at least a short time during this storm.

## **Programs and Initiatives**

Note: Many of the programs and initiatives designed to mitigate against, prepare for, respond to, and recover from tornadoes have the dual purpose of also protecting against other strong winds. As a result, there is some overlap in the narrative programs and initiatives descriptions for each respective hazard. This redundancy allows each hazard section to "stand alone," eliminating the need to refer to other hazard sections for basic information.

#### National Weather Service Doppler Radar

Doppler Weather Surveillance Radar can help to detect severe weather events that threaten life and property, including severe winds. Most important, the lead time and specificity of warnings for severe weather have improved significantly. Doppler technology calculates both the speed and the direction of motion of severe storms. By providing data on the wind patterns within developing storms, the new system allows forecasters to better identify the conditions leading to severe weather such as tornadoes and severe straight-line winds. This means early detection of the precursors to severe storms, as well as information on the direction and speed of storms once they form.

## National Weather Service Watches/Warnings

The National Weather Service issues severe thunderstorm watches for areas when the meteorological conditions are conducive to the development of a severe thunderstorm. People in the watch area are instructed to stay tuned to local radio or television stations for weather updates, and watch for developing storms. Once radar or a trained Skywarn spotter detects the existence of a severe thunderstorm, the National Weather Service will issue a severe thunderstorm warning. The warning will identify where the storm is located, the direction in which it is moving, and the time frame during which the storm is expected to be in the area. People in the warning area are instructed to seek shelter immediately.

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

#### Severe Weather Awareness Week

Each spring, the Emergency Management Division, Department of State Police, in conjunction with the Michigan Severe Weather Awareness Committee, sponsors Severe Weather Awareness Week. This annual public information and education campaign focuses on severe weather events such as tornadoes, thunderstorms, lightning, hail, flooding and high winds. Informational materials on severe winds and other weather hazards are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

#### Manufactured Home Anchoring

Manufactured homes are vulnerable to wind damage if they are not properly anchored down. As a result, a major national effort has been initiated to encourage the structural anchoring or "tie down" of manufactured homes. The Michigan Manufactured Housing Commission Administrative Rules (R 125.1602, Subsection 5) require new manufactured home installations in floodplains to be structurally anchored to a foundation. Through this requirement, the possibility of damage from wind is minimized. Unfortunately, structures outside designated floodplains do

not have to comply with the anchoring provision, although many owners choose to comply voluntarily. It should also be noted that local communities have the option of adopting an ordinance that requires anchoring of manufactured home installations located outside a designated floodplain. State anchoring system standards are outlined in Administrative Rules R 125.1605 through R 125.1608.

#### Electrical Infrastructure Reliability

One of the major problems associated with severe winds is the loss of electric power. As illustrated above, Michigan has had numerous widespread and severe electrical power outages caused by severe winds, and several of those outages have resulted in upwards of 500,000 electrical customers (roughly 5 percent of the State's population) being without power for several hours to several days at a time. Wind-related damage to electric power facilities and systems is a concern that is being actively addressed by utility companies across the state. Detroit Edison, Consumers Energy and other major electric utility companies have active, ongoing programs to improve system reliability and protect facilities from damage by severe winds and other hazards. Typically, these programs focus on trimming trees to prevent encroachment of overhead lines, strengthening vulnerable system components, protecting equipment from lightning strikes, and placing new distribution lines underground. The Michigan Public Service Commission (MPSC) monitors power system reliability to help minimize the scope and duration of power outages.

## Structural Bracing

One of the best ways to protect buildings from damage from severe winds is to install structural bracing and metal connectors (commonly called hurricane clips) at critical points of connection in the frame of the structure. Typically, this involves adding extra gable end bracing at each end of the structure, anchoring the roof rafters to the walls with metal connector straps, and properly anchoring the walls and sill plate to the foundation. This extra bracing helps ensure that the roof stays on the structure, and the structure stays anchored on its foundation. Experience in high wind events has shown that once the roof begins to peel away from the walls, or the building begins to move off its foundation due to extreme lateral wind forces, major structural damage occurs. If the damage continues unabated, the building can end up being a total loss.

The Emergency Management Division, Michigan Department of State Police (EMD/MSP), and the Michigan State Housing Development Authority (MSHDA), have begun a small pilot program aimed at employing wind engineering techniques on new residential construction. This initiative is designed to show that implementing such techniques can be a relatively inexpensive way to protect buildings from damage in high wind events. While these techniques will do nothing to protect a building from damage caused by flying debris, they will help ensure that the damage does not occur from the building coming apart at critical junctures due to extreme wind forces. If this pilot program is successful, it may be expanded in the future to include retrofitting existing residential and commercial structures.

## Urban Forestry/Tree Maintenance Programs

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

Every power company in Michigan has a tree trimming program in place, and numerous local communities have some type of tree maintenance program in place. The electrical utility tree trimming programs are aimed at preventing encroachment of trees and tree limbs within power line rights-of-way. Typically, professional tree management companies and utility work crews perform the trimming operations. At the local government level, only a handful of Michigan communities have actual urban forestry departments or agencies. Rather, crews from the public works agency or county road commission perform the bulk of the tree trimming work.

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

## **Summary of Potential Impacts**

Figures from the National Weather Service indicate that severe winds occur more frequently in the southern half of the Lower Peninsula than any other area of the state. On average, severe wind events can be expected 5-7 times per year in the southern Lower Peninsula. This refers to winds from thunderstorms and other forms of severe weather, and does not include tornadoes.

National Weather Service forecasts of severe winds usually give sufficient warning time to allow residents to take appropriate action to reduce, at least to some degree, the effects of wind on structures and property. However, when these events occur during the night, or very early in the morning when people most likely are not listening to their televisions or radios, both damage and injury can be more severe.

But even with sufficient warning, little can be done to prevent damage from flying objects. Sometimes removing loose objects such as planters, lawn furniture and yard equipment from outside can keep these items from becoming airborne debris, and therefore help reduce some property damage. Also, as indicated earlier, proper structural bracing techniques can help minimize or even eliminate major damage due to the loss of the roof or movement of the building off its foundation.

In terms of response to a severe wind event, providing for the mass care and sheltering of residents left without heat or electricity, and mobilizing sufficient resources to clear and dispose of downed tree limbs and other debris from roadways, are the primary challenges facing Michigan communities. In addition, downed power lines present a public safety threat that requires close coordination of response efforts between local agencies and utility companies. Thunderstorms and severe winds can affect every Michigan community. Therefore, every community should adequately plan and prepare for this type of emergency. That planning and preparedness effort should include the identification of necessary resources such as cots, blankets, food supplies, generators, and debris removal equipment and services.

In addition, each community should develop debris management procedures (including the identification of multiple debris storage, processing and disposal sites) so that the stream of tree and construction debris can be handled in the most expedient, efficient, and environmentally safe manner possible. Both FEMA and the Michigan State Police Emergency Management Division offer debris management courses to provide local, State, and Federal management personnel at all levels with an overview of issues and recommended actions necessary to plan for, respond to, and

recover from a major debris generating event. Such a course would be useful for local government leaders in developing a debris management plan.

To mitigate against the effects of severe winds, communities can: 1) institute a comprehensive urban forestry program; 2) properly brace and strengthen vulnerable public facilities; 3) ensure compliance with manufactured home anchoring regulations; 4) coordinate with utility companies on local restoration priorities and procedures; 5) improve local warning systems; and 6) amend local codes to require structural bracing, where appropriate, in all new residential and commercial construction.

## SEVERE WINTER WEATHER

## **Hazard Description**

Severe winter weather hazards include snowstorms, blizzards, extreme cold, freezing rain and sleet. As a northern state, Michigan is vulnerable to all of these winter hazards. Most of the severe winter weather events that occur in Michigan have their origins in Canadian and Arctic cold fronts that move across the state from the west or northwest.

The following describes the forms of winter precipitation:

*Snowstorm:* A period of rapid accumulation of snow often accompanied by high winds, cold temperatures, and low Visibility.[1] *Blizzards* are the most dramatic and dangerous snowstorms, characterized by winds over 35 miles per hour and enormous amounts of snow, often reducing visibility to near zero.

*Sleet:* Rain drops that freeze into ice pellets before reaching the ground. Sleet usually bounces when hitting surfaces and does not stick to objects.[1]

*Freezing rain:* Rain that falls onto a surface with a temperature below freezing. This causes the rain to freeze to surfaces, such as cars, trees, and roads, forming a coating or glaze of Ice.[1]

January is typically the coldest month in Ottawa County, with the average maximum temperature 31 degrees F and average minimum temperature 19 degrees F. On average there are 3 days below 0 each year.

Ottawa County is in the high risk area for a large number of snowstorms because of its shoreline location. Lake effect snows have resulted in significant snowfall amounts for the County, with yearly averages ranging from 60 inches in Zeeland and Hudsonville to 75 inches in Holland, but in some years may be as much as 100 inches. Ice and sleet storms also frequently occur during January through March. Winter storms often cause disruption of land and air transportation and a loss of utilities.

Month	Holland	Grand Haven					
January	32.2	25.5					
February	18.1	12.7					
March	10.5	8.5					
April	2.4	1.3					
October	0.9	0.5					
November	8	6.6					
December	23.9	19.9					
Annual Average	96	75					

## Annual Monthly Mean Snowfall in Ottawa County (in inches) 1951-1980

(Source: MSU Climatoloty Program)

## **Record Snowfall in the City of Holland 1900-1999**

Amount of Snow	Date
27.5 inches	January 19-21, 1985

23.5 inches	January 26-27, 1967
22.0 inches	January 26-27, 1978
20.0 inches	January 26-27, 1977
17.5 inches	December 3-4, 1991

(Source: The Holland Sentinel, "Holland's extremes of the century." January 1, 2000)

## Historically Significant Severe Winter Weather Events in Ottawa County

#### January 26-27, 1967

In a 24 hour period, 23.5 inches of snow fell in Ottawa County, with drifts up to 5 feet high.

## March 2-7, 1976

During the period from March 2 to 7, 1976, an ice storm with accompanying high winds and tornadoes struck a 29-county area in the central Lower Peninsula. This storm, one of the worst to ever hit the state, caused over \$56 million in damage and widespread power outages. The storm impacts were so severe that a Presidential Major Disaster Declaration was granted for the 29 affected counties, including Ottawa County.

## January 26-30, 1977

Beginning on January 26, 1977 and lasting for several days, a severe snowstorm occurred affecting vast portions of southern Michigan, including Ottawa County. Between January 27-30, some 20 inches of snow fell in the City of Holland. Winds of blizzard proportion resulted in extensive drifting of snow, creating mounds of snow 5 to 6 feet high, blocking many roads. Many residents were isolated in rural residences. This storm was so severe that it resulted in a Governor's Disaster Declaration and a Presidential Emergency Declaration for a 15-county area.

#### January 26-27, 1978

On January 26 and 27, 1978 a severe snowstorm struck that affected the entire state. In the Holland area, over 22 inches of snow fell in a two day period. At the height of the storm it was estimated that over 50,000 miles of roadway were blocked, 104,000 vehicles were abandoned on the highways, and over 390,000 homes were without electrical power. This storm was so severe that it resulted in both a Governor's Disaster Declaration and a Presidential Emergency Declaration for the entire state of Michigan in order to provide assistance for snow clearance and removal activities.

#### January 19-21, 1985

In these few days, 27.5 inches of snow fell in Ottawa County in the Holland area. 6 to 8 inches fell on January 19, with an additional 15.5 inches on the January 20. This became Holland's all-time greatest single-day snowfall.

#### October 26, 1997

On October 26, 1997 an early season snowstorm passed through Ottawa County, dumping 2 to 8 inches of heavy, wet snow. This resulted in power outages from ripped down power lines, property damage and economic loss from downed fruit trees in the eastern part of the County. Approximately 6,500 Board of Public Works customers and 9,800 Consumers Energy customers without electricity in Ottawa and Allegan counties. It would be five days before all power was restored in the area.[1]

#### March 9-10, 1998

Despite warm temperatures in February 1998, the Holland area received 8 inches of snow March 9, 1998. In this same storm, the Zeeland area received 8.5 inches, and Grand Haven topped off with a foot of snow. Along with the snow were strong winds and temperatures that did not get above the mid-20s. The storm was too much for Ottawa Road Commission plow crews to keep up with. A full crew of 70 drivers and trucks was on the road throughout day until about 7 p.m. In the City of Holland, Street Department Superintendent Nick King said conditions were "bad all over." Holland road crews, including 13 plows, were on the road from 8:30 in the morning until about 7 p.m. [1]

#### January 1999

Early January 1999 saw a span of days in which more than 40 inches of snow fell, shutting down virtually all activities in the shoreline area of County, including schools and businesses. In Grand Haven, a record 42 inches of snow fell between January 2-6. Later in the month, on the morning of January 28th, Holland Police advised residents to limit travel, and only venture out for emergency since many roads were covered with solid ice. On February 4, Ottawa County and 27 other counties were added to the Presidential Emergency Declaration for severe winter weather that was first approved for Wayne County and the Detroit area on January 27. Ottawa County also was granted a disaster declaration from the Secretary of Agriculture for this heavy snowfall. With the USDA declaration, area farmers became eligible for low interest rate federal disaster loans.

#### February 18, 2000

An estimated 7 inches of snow fell across much of Ottawa County, causing several area schools to cancel classes for the first time this winter. The dangerous driving conditions led to more than 150 accidents reported across Ottawa and Allegan counties between 7 am and 10 pm. These calls were mostly reports of stranded motorists which had been in accidents or slid into a ditch.[1]

## **Programs and Initiatives**

## National Weather Service Doppler Radar

The National Weather Service (NWS) has completed a major modernization program designed to improve the quality and reliability of weather forecasting. The keystone of this improvement is Doppler Weather Surveillance Radar, which can assist in the detection of severe weather events that threaten life and property, including severe winter weather events such as ice and sleet storms. Most important, the lead time and specificity of warnings for severe weather have improved significantly.

## National Weather Service Watches, Warnings and Advisories

Sufficient warning can do much to reduce the damage from severe winter storms by permitting people to prepare properly. The National Weather Service uses the terms *ice storm*, *freezing rain*, and *freezing drizzle*, to warn the public when a coating of ice is expected on the ground and on other exposed surfaces. The qualifying term "heavy" is used to indicate ice coating which, because of the extra weight of the ice, could cause significant damage to trees, overhead wires, and other exposed objects.

The NWS issues winter storm watches and winter storm warnings to notify the public of severe winter weather conditions. A *winter storm watch* indicates severe winter weather conditions may affect the area, while a *winter storm warning* indicates that severe winter weather is imminent.

The NWS also issues a number of different advisories for winter weather. These advisories can be issued for snow, freezing rain, blowing snow, and wind chill, among other things. Advisories mean that conditions are expected to cause significant inconveniences and may be hazardous.

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

## Winter Hazards Awareness Week

Each fall, the Emergency Management Division, Department of State Police, in conjunction with the Michigan Severe Weather Awareness Committee, sponsors Winter Hazards Awareness Week. This annual public information and education campaign focuses on winter weather hazard events such as snowstorms, blizzards, extreme cold, and ice and sleet storms. Informational materials on winter weather hazards and safety are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

## Electrical Infrastructure Reliability

One of the major problems associated with ice storms is the loss of electric power. Michigan has had numerous widespread and severe electrical power outages caused by ice storms, several of which have resulted in a power loss to 250,000 – 500,000 electrical customers for several hours to several days at a time. Ice-related damage to electric power facilities and systems is a concern that is being actively addressed by utility companies across the state. Most major electric utility companies have active, ongoing programs to improve system reliability and protect facilities from damage by ice, severe winds, and other hazards. Typically, these programs focus on trimming trees to prevent encroachment of overhead lines, strengthening vulnerable system components, protecting equipment from lightning strikes, and placing new distribution lines underground. The Michigan Public Service Commission (MPSC) monitors power system reliability to help minimize the scope and duration of power outages.

## Urban Forestry/Tree Maintenance Programs

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

Every power company in Michigan has a tree trimming program in place, and numerous local communities have some type of tree maintenance program in place. The electrical utility tree trimming programs are aimed at preventing encroachment of trees and tree limbs within power line rights-of-way. Typically, professional tree management companies and utility work crews perform the trimming operations. At the local government level, only a handful of Michigan communities have actual urban forestry departments or agencies. Rather, crews from the public works agency or county road commission perform the bulk of the tree trimming work.

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

#### **Summary of Potential Impacts**

Severe snow and ice storms could have a significant impact anywhere in the County. In communities along the lakeshore, the lake effect increases cloudiness and snowfall during the fall and winter.

Severe winter weather can create high infrastructure costs for local units of government, the County, and other service providers. Strong winds and heavy snow can knock down utility poles, break tree limbs or destroy entire trees, and take out power lines. Heavy snow can isolate rural areas and collapse buildings. The cost of snow removal, repairing damages, and loss of business can have a large economic impact on cities and towns. Even small amounts can cause severe hazard to motorists and pedestrians. Ice, or a severe freeze during growing season for local farmers can also severely damage crops. This crop damage can mean millions of dollars in lost revenue for farmers in Ottawa County.

Winter storms are know as "deceptive killers" because most deaths are indirectly related to the storm: people die in traffic accidents on icy roads; people die of heart attacks while shoveling snow; people die of hypothermia from prolonged exposure to cold.

Winter death statistics: *Ice & Snow* 70 percent occur in automobiles 25 percent are people caught in the storm Most are males over 40 years old

*Exposure to cold* 50 percent are people over 50 75 percent are males 20 percent occur in the home

The best protection against severe winter weather is to stay inside and to dress warmly by wearing loose-fitting, layered, lightweight clothing.

## Hazard Profile and Evaluation

## **Evaluation Measures and Benchmark Factors**

The Ottawa County Hazard Profile and Evaluation uses a set of 12 evaluation measures 48 corresponding benchmark factors to evaluate each hazard facing the community. The following is a description of these measures and benchmark factors used in this analysis.

## **Historical Occurrence**

Historical occurrence measures the frequency with which a particular hazard occurs in Ottawa County. The more frequently a hazard event occurs, the more potential there is for damage and negative impact on the community. The specific benchmark factors used in the historical occurrence analysis are:

*Excessive Occurrence*, indicating the hazard event is likely to occur 4 or more times per year; *High Occurrence*, indicating the hazard event is likely to occur 2-3 times per year; *Medium Occurrence*, indicating the hazard event is likely to occur 1 time per year; *Low Occurrence*, indicating the hazard event occurs less than once per year.

## Affected Area

Each hazard affects a geographical area. For example, a blizzard might affect the entire County, while a flood might only affect a portion of a community. Although size of the affected area is not always indicative of the destructive potential of the hazard, generally the larger the affected area, the more problematic the hazard event is on a community. The specific benchmark factors used in the affected area analysis are:

*Large Area*, if a hazard event has the potential to impact 3 or more townships or communities; *Small Area*, if the hazard event could impact 1 or 2 townships or communities;

*Multiple Sites*, if the hazard event could impact more than one area within a township or community;

Single Site, if the hazard event is likely to only impact a small area within a township or community.

## Speed of Onset

Speed of onset refers to the amount of time it typically takes for a hazard event to develop. Speed of onset is an important evaluation measure because the faster an event develops, the less time local governments have to warn the potentially impacted population of appropriate protective actions. The specific benchmark factors used in the speed of onset analysis are:

*Minimal or No Warning*, indicating the hazard event could occur without any advanced notice or warning;

Less than 12 Hours, indicating the hazard event usually allows less than 12 hours advance notice before occurring;

12-24 Hours, indicating the hazard event generally allows 12-24 hours advanced notice before occurring;

*Greater than 24 Hours*, indicating the hazard event generally allows more than 24 hours advance notice before occurring.

## **Population Impact**

Population impact refers to the number of casualties (deaths and injuries) that can be expected if a particular hazard event occurs. Specific benchmark factors used in the population impact analysis are:

*High Impact*, indicating 10 or more casualties can be expected; *Medium Impact*, indicating 6-10 casualties can be expected; *Low Impact*, indicating 1-5 casualties can be expected; *No Impact (none)*, indicating that no casualties can be expected.

## **Seriously Affected Population**

Seriously affected population refers to the number of people in the County who can expect to be directly affected by a particular hazard event, either because they receive physical injury, property damage, economic hardship, or their day to day activities are severely disrupted because of severe damage to their community of residence or work. Specific benchmark factors used in the severely affected population impact analysis are:

*Significant Population Affected*, indicating more than 100,000 people are likely to be affected by the hazard event;

*High Population Affected*, indicating 50,000 to 100,000 people are likely to be affected by the hazard event;

*Medium Population Affected*, indicating 10,000 to 50,000 people are likely to be affected by the hazard event;

Low Population Affected, indicating fewer than 10,000 people are likely to be affected by the hazard event.

## **Economic Effects**

Economic effects are the monetary damages incurred from a hazard event, and include both public and private damage. Direct physical damage costs, as well as indirect impact costs such as lost business and tax revenue, are included as part of the total monetary damages. Specific benchmark factors used in the economic impact analysis are:

*Significant Effects*, indicating over \$100,000 in monetary damages incurred; *Medium Effects*, indicating \$50,000 to \$100,000 in monetary damages incurred; *Low Effects*, indicating \$10,000 to \$50,000 in monetary damages incurred; *Minimal Effects*, indicating less than \$10,000 in monetary damages incurred.

## Duration

Duration refers to the time period the hazard event is actively present and causing damage (often referred to as the "time on the ground"). Duration is not always indicative of the damage potential of a hazard event, however, in most cases the longer an event is "active" and causing damage, the greater the total damages will be. Specific benchmark factors used in the duration analysis are:

*Long Duration*, indicating the hazard event is likely to last longer than 1 week; *Medium Duration*, indicating the hazard event is likely to last from 1 day to 1 week; *Short Duration*, indicating the hazard event is likely to last from 12 to 24 hours; *Minimal Duration*, indicating the hazard event is likely to last less than 12 hours.

## Seasonal Pattern

Seasonal pattern refers to the time of the year in which a particular hazard event can reasonably be expected to occur. Some hazard events can occur at any time of the year, while others occur

primarily during one particular season. Oftentimes, hazard patterns coincide with peak tourism seasons and other times of temporary population increases, greatly increasing the vulnerability of the population to the negative impacts of certain hazard events. The specific benchmark factors used in the seasonal pattern analysis are:

Year-round Occurrence, indicating the hazard event can occur at any time of the year;

*Three Season Occurrence*, indicating the hazard event can realistically occur during 3 seasons of the year;

*Two Season Occurrence*, indicating the hazard event can realistically occur during 2 seasons of the year;

One Season Occurrence, indicating the hazard event realistically occurs during only 1 season of the year.

#### Predictability

Predictability refers to the ease with which a particular hazard event can be predicted, in terms of time of occurrence, location, and magnitude. Predictability is important because the more predictable a hazard event is, the more likely it is a community will be able to warn the potentially impacted population and take other preventative measures to minimize loss of life and property. The specific benchmark factors used in the predictability analysis are:

Unpredictable, indicating the hazard is extremely difficult, if not impossible, to predict.

*Somewhat Predicable*, indicating the time of occurrence, location, and magnitude of the hazard can be predicted with less than 50 % accuracy.

*Predicable,* indicating the time of occurrence, location, and magnitude of the hazard can be predicted at 50 % or greater accuracy;

*Highly Predictable*, indicating the time of occurrence, location, and magnitude of the hazard is predicable virtually 100 % of the time.

## **Collateral Damage**

Collateral Damage refers to the possibility of a particular hazard event causing secondary damage and impacts. For example, blizzards and ice storms cause power outages, which can cause loss of heat, which can lead to hypothermia and possible death or serious injury. Generally, the more collateral damage a hazard event causes, the more serious a threat the hazard is to a community. The specific benchmark factors used in the collateral damage analysis are:

*High Possibility*, indicating there is a great likelihood (76 % chance or greater) that the hazard event will cause secondary hazard events and damage;

*Good Possibility*, indicating there is a higher than average likelihood (50 to 75 % chance) that the hazard event will cause secondary hazard events and damage;

*Some Possibility*, indicating there is a less than average likelihood (less than 50 % chance) that a hazard event will cause secondary hazard events and damage;

*No Possibility*, indicating there is virtually no likelihood (0 % chance) that a particular hazard event will cause secondary hazard events and damage.

## Availability of Warnings

Availability of warnings indicates the ease with which the public can be warned of a hazard. This measure **does not** address the availability of warning systems in a community. Rather, it looks at the overall availability of warning in general for a particular hazard event. For example, a community might receive warning that a flood will occur with 24 hours, but receive no warning when a large fire occurs. Generally, hazards that have little or no availability of warning tend to

be more problematic for a community from a population protection and response standpoint. The specific benchmark factors used in the availability of warning analysis are:

*Warning Available*, indicating that the nature of the hazard is such that warning of the hazard event is always available (100 %) and received in a timely manner;

*Warning Sometimes Available*, indicating that the nature of the hazard is such that warning of the hazard event is available most of the time (50 to 99 %) and received in a timely manner;

*Warning Generally Not Available*, indicating that the nature of the hazard is such that warning of the hazard event is generally not available (less than 50 %) and generally not received in a timely manner;

*Warning Unavailable*, indicating that the nature of the hazard is such that warning of the hazard event is not available.

#### Mitigative Potential

Mitigative potential refers to the relative ease with which a particular hazard event can be mitigated against through the application of structural or non-structural (or both) mitigation measures. Generally, the easier a hazard event is to mitigate against, the less of a future threat it may pose to a community in terms of loss of life and property. The specific benchmark factors for the mitigative potential analysis are:

*Easy to Mitigate*, indicating there are a wide variety of structural and non-structural measures that can be reasonably and economically applied to lessen or eliminate future vulnerability;

*Possible to Mitigate*, indicating there are some structural and non-structural measures that can be applied, but not all can be applied in an economic manner or are completely effective to lessen or eliminate future vulnerability;

*Difficult to Mitigate*, indicating that there are very limited choices for mitigating, and not all measures may prove effective in lessening the vulnerability to the hazard;

*Impossible to Mitigate*, indicating that the nature of the hazard is such that it is virtually impossible to effectively apply mitigation measures to lessen or eliminate future vulnerability.

By their very nature, each natural hazard event is unique and will vary in intensity and impact. Therefore a range of benchmark factors have been assigned more accurately reflect the potential impact of these hazards. The *Ottawa County Hazards Profile and Evaluation: 2000* table displays which benchmark factors correspond to each hazard in Ottawa County.

# Ottawa County Hazard Profile and Evaluation

HAZARD	Historical Occurrence	Affected Area	Speed of Onset	Population Impact (casualties)	Seriously Affected Population	Economic Effects	Duration	Seasonal Pattern	Predict- ability	Collateral Damage	Availability of Warnings	Mitigative Potential
Drought	Low Occurrence (once every 5 to 10 years)	Large Area (entire County)	Several weeks to months warning.	No Impact	Up to 10,000 People Affected	Significant Effects (> \$100,000 in damage)	Long Duration (by definition, will last for months)	Two to Three Season Occurrences (spring, summer, fall)	Highly Predictable (nearly 100%)	Some Possibility (< 50% chance; economic effects, health impacts)	Warning Available (about 100% of the time)	Difficult to Impossible to Mitigate.
Earthquakes	Very Low Occurrence (has not occurred)	Large Area (southern 1/3 of County)	Minimal or No Warning	No to High Impact (0 to more than 10 casualties possible)	< 10,000 People Affected	Significant Effects (> \$100,000 in damage)	Minimal Duration (> 12 hours)	Year-round Occurrences	Unpredictable	High Possibility (> 75% chance; utility and infrastructure damage, health impacts, economic effects)	Warning Unavailable	Difficult to Mitigate
Extreme Temperature	Medium Occurrence (once every 5 to 10 years)	Large Area (entire County)	Greater than 24 Hours	No to High Impact (0 to more than 10 casualties possible)	Up to 5,000 People Affected	Minimal Effects (<\$10,000 in damage)	Medium Duration (1 day to 1 week)	Two Season Occurrences (Winter & Summer)	Predictable to Highly Predictable (> 50% accuracy)	Good Possibility (50-75% chance; utility and infrastructure damage, health impacts)	Warning Available (about 100% of the time)	Impossible to Mitigate
Fire: Wildfires	Excessive Occurrence (more than 206 wildfires in County in 1998)	Single Site (fire will generally impact 1 site at a time)	Minimal or No Warning	No to Medium Impact (0-10 casualties possible)	50 to 300 People Affected per Year	Minimal to Significant Effects (\$100 to >\$100,000 in damage)	Minimal to Medium Duration (< 12 hours to 1 week)	Three Season Occurrences (spring, summer, fall, on rare occasion in winter)	Unpredictable Predictable	Good Possibility (50-75% chance; utility and infrastructure damage, health impacts, economic effects)	Generally Not Available (<50 % of the time)	Possible to Mitigate
Flooding: Dam Failure	Low Occurrence (threat is less than once per year)	Single Site (only 1 site, city, or township)	12-24 Hours Warning	No to Low Impact (0-5 casualties)	50 to 1,000 People Affected	Low to Significant Effects (\$10,000 to > \$100,000 in damage)	Medium Duration (1 day to 1 week)	Year-round Occurrences	Somewhat Predictable to Predictable (< 50% to 50% accuracy)	Good Possibility (50-75% chance; utility and infrastructure	Warning Sometimes Available (50-99% of the time)	Possible to Mitigate

Flooding: River & Urban	High Occurrence (more than once per year somewhere in County)	Small Area (1 or 2 townships to ¼ of County)	Less than 12 Hours Warning	No to Low Impact (usually no casualties, but up to 5 casualties possible)	10,000 to 50,000 People Affected	Medium to Significant Effects (> \$50,000 in damage)	Medium Duration (1 day to 1 week)	Three Season Occurrence (winter, spring, summer, typically not in the fall)	Somewhat Predictable (< 50% accuracy)	damage, health impacts, economic effects) High Possibility (> 75% chance; utility and infrastructure damage, health impacts, economic	Warning Sometimes Available (50-99% of the time)	Possible to Easy to Mitigate
Flooding: Shoreline Flooding & Erosion	Low Occurrence (once every 10 years)	Large Area (3 or more townships)	Weeks to Months Warning (unless caused by a storm event)	No Impact (no casualties expected)	Less than \$10,000 People Affected	Significant Effects (> \$100,000)	Long Duration (likely to last longer than 1 week)	Year-round Occurrences	Highly Predictable (nearly 100% accuracy)	effects) Some Possibility (< 50% chance; utility and infrastructure damage, health impacts, economic effects)	Warning Sometimes Available (50-99% of the time)	Possible to Mitigate
Public Health Emergencies	Low Occurrence (less than once per year)	Large Area (3 or more townships)	Greater than 24 Hours (usually several days or weeks)	High Impact (by definition, more than 10 casualties expected)	10 to 1000 People Affected	Medium to Significant Effect (including cost of treatment and potential lost wages)	Long Duration (usually longer than one week)	Year-round Occurrences	Somewhat Predictable (< 50 % accuracy)	No Possibility	Warning Sometimes Available (50-99% of the time)	Difficult to Mitigate
Thunderstorm Hail & Lightening	Excessive Occurrence (more than once per year)	Small Area or Multiple Sites (single sites to more than 1 township )	Usually 12 to 24 Hours Warning	No to Low Impact (usually no casualties expected, 1-5 casualties possible)	1 to 1,000 People Affected	Low to Significant Effects (\$10,000 or more for fire damage from lightning, but hail could cause extensive crop and property damage)	Minimal Duration (< 12 hours)	Three Season Occurrences (spring, summer, fall; typically not much hail or lightning in winter)	Predictable to Highly Predictable (usually can predict severe storm that may bring hail or lightning, 50% to 100% accuracy)	Good Possibility (50-75% chance; utility and infrastructure damage, economic effects, health impacts)	Warning Sometimes Available (50-99% of the time)	Difficult to Impossible to Mitigate
Tornadoes	Low Occurrence	Small Area (1 to 2	Minimal or No Warning	Low to High Impact	10,000 to 50,000	Significant Effects	Minimal Duration	Three Season Occurrences	Unpredictable to Somewhat	High Possibility	Warning Sometimes	Difficult to Impossible

	(Once every 5 years)	townships)		(usually at least a few casualties, possibly more than 10)	People Affected	(> \$100,000 in damage)	(< 12 hours)	(spring, summer, fall; typically not in winter)	Predictable (0 to < 50% accuracy)	(> 75% chance; utility and infrastructure damage, economic effects, health impacts)	Available (50-99 % of the time)	to Mitigate
Windstorms	Medium to High Occurrence (at least 1 event per year)	Single site to Large Area (single site to much of County)	No Warning or Less than 12 Hours	No to High Impact (usually no casualties expected, but more than 10 casualties possible)	10 to 100,000 People Affected	Minimal to Significant Effects (<\$10,000 to >\$100,000)	Minimal Duration (< 12 hours)	Year-round Occurrences	Unpredictable to Somewhat Predictable. (0 to < 50% accuracy)	High Possibility (> 75% chance; utility and infrastructure damage, economic effects, health impacts)	Warning Generally Not Available (> 50% of the time)	Possible to Difficult to Mitigate
Severe Winter Weather	High Occurrence (2 to 3 times per year)	Large Area (up to entire County)	> 12 Hours Warning	No to Medium Impact (usually no casualties, but up to 10 casualties possible)	Up to 200,000 People Affected	Low to Medium to Significant Effects (\$50,000 to >\$100,000 in lost revenue to businesses and/or property damage, etc.)	Medium Duration (1 day to 1 week)	One to Two Season Occurrence (winter, on occasion spring or fall)	Predictable to Highly Predictable (nearly 50 % to 100 % accuracy)	Good Possibility (50-75 % chance; utility and infrastructure damage, economic effects, health impacts, traffic accidents)	Warning Sometimes Available (50-99% of the time)	Difficult to Impossible to Mitigate hazard, but some impacts can be mitigated (such as health impacts)

## Hazard Scoring

In order to rank the hazards from most severe threat to least threat to Ottawa County, each corresponding benchmark factor has been assigned a specific point value of 10, 7, 4, or 1 point, based on each factor's relative severity and negative impacts. The more severe the potential impact from a hazard event, the more points that hazard will receive.

Next, each evaluation measure was assigned a "weight." The purpose of weighing the 12 measures is to stress which measures are deemed most important. The weighing has been done for all 12 measures, with the most important measure receiving a weight of 12, and the least important measure receiving a weight of 1. When the point value of a particular benchmark factor is multiplied by the weight, the measure receives more emphasis (points) than the other measures that are not assigned such a high weight. This way, the resulting quantitative analysis accurately reflects those areas deemed most important. The following is a list of the measures and their assigned weight:

Historical Occurrence: 12 Seriously Affected Population: 11 Collateral Damage: 10 Population Impact: 9 Economic Effects: 8 Affected Area: 7 Duration: 6 Availability of Warning: 5 Speed of Onset: 4 Seasonal Pattern: 3 Predictability: 2 Mitigative Potential: 1

The quantitative result (score) for each hazard is obtained by multiplying each measure's benchmark factor point value by the weight. That gives the total score for that particular measure. Then the points for all the measures are summed for each hazard, giving each natural hazard a total hazard score.

## Hazard Ranking

The total hazard scores are compared to determine the hazard ranking. The hazard that receives the highest score has been determined to be the greatest threat to the most people in Ottawa County. The following is a summary of the total hazard score results and the hazard rankings.

RANK	NATURAL HAZARD	HAZARD SCORE			
1	Severe Winter Weather	496			
2	Flooding: Riverine & Urban	491			
3	Windstorms	479			
4	Tornadoes	459			
5	Earthquakes*	459			
6	Fires: Wildfires	428			
7	Public Health Emergencies	392			
8	Thunderstorm Hazards	372			
9	Flooding: Shoreline Flooding & Erosion	342			

## 10

10	Extreme Temperatures	331
11	Drought	319
12	Flooding: Dam Failure	300

The ranking process is not intended to discount the threat of any particular hazard. All hazards elaborated upon in the *Ottawa County Natural Hazard Analysis* are real threats to Ottawa County. Rather, the hazard ranking process allows us to objectively compare the hazards to each other, to determine which hazards are the greatest threats to the greatest number of people in the County as a whole. This means that the hazards which have the potential to injure or kill the most people in the County have received the highest ranking. For example, shoreline flooding and erosion is a serious threat to the homes and businesses located along the lakeshore, but do not directly affect people living in the eastern side of the County. On the other hand, severe winter weather such as a blizzard would typically have a greater possibility of directly affect most communities in the County.

[i] The Holland Sentinel. "Holland's extremes of the century," 01/01/00.

[i]MSU Climatology Program, http://climate.geo.msu.edu

[i]Grand Valley State University Water Resources Institute, November 1998.

[1] Planning for Water Supply and Distribution in the Wildland/Urban Interface. National Fire Protection Association. p. 4.

[1] *A Hydrologic Study of the Macatawa River Watershed*. Michigan Department of Environmental Quality, Land and Water Management Division, Water Management Section, Hydrologic Studies Unit. 01/07/00.

<sup>[1]</sup> US Department of Agriculture-Soil Conservation Service, Soil Survey of Ottawa County, Michigan, 1972.

<sup>[1]</sup> US Department of Agriculture-Soil Conservation Service, Soil Survey of Ottawa County, Michigan, 1972.

<sup>[1]</sup> Grand Valley State University Water Resources Institute, November 1998.

<sup>[</sup>i] The Holland Sentinel. "Local unemployment rates at near-record low" 01/28/00.

<sup>[1]</sup> US Department of Agriculture-Michigan Agricultural Statistics Service, 1997 Census of Agriculture County Profile.

<sup>[1]</sup> Michigan Hazard Analysis, 1998. p. 13

<sup>[</sup>i]Correspondence with Dr. Fred Nurnberger, Michigan State Climatologist, 01/31/00.

<sup>[1]</sup> Michigan Agricultural Statistics 1998-99. U.S. Department of Agriculture and Michigan Department of Agriculture.

<sup>[</sup>i] The Holland Sentinel. "Drought turning into disaster," 07/30/98.

<sup>[1]</sup> Michigan Hazard Analysis, 1998. p. 17

<sup>[</sup>i] Michigan Hazard Analysis, 1998. p. 19

<sup>[1]</sup>Some experts debate the reliability of the wind chill index. In May 2000, the American Meteorological will discuss several alternative indexes that have been devised.

<sup>[1]</sup> Michigan Hazard Analysis, 1998. p. 39

<sup>[1]</sup> Wildfire: Are You and Your Home Prepared?

<sup>[1]</sup>Phone conversation with Kim DuFresne, Michigan Department of Natural Resources, Fire supervisor for Southwest Michigan, 01/31/00.

<sup>[1]</sup> Michigan State Police, State Fire Marshal Office.

<sup>[1]</sup> Protecting Life and Property from Wildfire, p. 1

<sup>[</sup>i] Wildfire: Are You and Your Home Prepared?

<sup>[</sup>i] Michigan Hazard Analysis, 1998. p. 49

<sup>[</sup>i] The Holland Sentinel, May 21, 1996.

<sup>[1]</sup> Phone conversation with Jim Hayes, DEQ LUMD Dam Safety Unit

<sup>[</sup>i] Michigan Hazard Analysis, 1998. p. 52

<sup>[1]</sup> Answers to Questions About the National Flood Insurance Program, p. 2

<sup>[1]</sup> The Holland Sentinel. "Work starts of flooding solution" 10/13/98

[1] *Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials*. Federal Emergency Management Agency, February 1987.

[i] The Holland Sentinel. 7/12/82. p. A-5.

[1] The Holland Sentinel. "City may buy flood-damaged house" 8/18/99

[1] Answers to Questions About the National Flood Insurance Program, p. 19

[1] Floodplain Management for Local Officials. George Hosek. Michigan Department of Environmental Quality, Land and Water Management Division. August 1999. p. 39.

[1] The Ottawa County Rural Character and Farmland Preservation Guidebook. Ottawa County Planning Commission, January 1999. p. 30.

[1] A Hydrologic Study of the Macatawa River Watershed. Michigan Department of Environmental Quality, Land and Water Management Division, Water Management Section, Hydrologic Studies Unit. 01/07/00. p. 18.

[1] Protecting Your Property From Flooding: Install Sewer Backflow Valves information sheet. Federal Emergency Management Agency.

[1] Lake Michigan Potential Damages Study, Progress Report on Activities 1999 - Draft, U.S. Army Corps of Engineers, Detroit District, November 1999.

[1] The Holland Sentinel. "Flooding, erosion focus of new study" 04/28/99

[1] *Living with the Lakes*, US Army Corps of Engineers, 1999. p.30

[1] Michigan Hazard Analysis, 1998. p. 114

[1]Centers for Disease Control and Prevention

[1] Federal Consumer Information Center.

[1] Michigan Hazard Analysis, 1998. p. 131

[1] Thunderstorms and Lightning Fact Sheet, Federal Emergency Management Agency, 1993.

[1] Climate of Holland Narrative Summary and Climate of Grand Haven Narrative Summary, Michigan State University Climatology Program.

[1] Michigan Hazard Analysis, 1999. p. 150. Statistics for 1959-1997.

[1] Michigan Hazard Analysis, 1999. P. 149. Statistics for 1959-1997.

1 National Oceanic and Atmospheric Administration and the National Lightning Safety Institute. Statistics for 1959-1994.

[i] Michigan Hazard Analysis, 1998. p. 143

[1] Climate of Holland Narrative Summary, Michigan State University Climatology Program.

[i] Michigan Hazard Analysis, 1998. p. 137

[1] National Climatic Data Center report Ottawa County impacts of the wind event of May 31, 1998.

[1] Fax from Association of Commerce and Industry to local units of government, 06/03/98.

[1] *The Holland Sentinel.* "Weather took center stage in '98," 12/30/98

[i] The Holland Sentinel. "Strong storms hit the area for a second straight day," 05/18/99.

[i] Michigan Hazard Analysis, 1998. p. 168

[i] "Winter Storms. . . the Deceptive Killer" brochure. USDC, NOAA, ARC, FEMA

[1] "Winter Storms. . .the Deceptive Killer" brochure. USDC, NOAA, ARC, FEMA

[i] The Holland Sentinel. "Weather '97: Wait a minute and it will change" 12/28/97

[1] The Holland Sentinel. "Spring gets whited out" 03/10/98

[1] The Holland Sentinel. "Storm yields season's first snow day for area schools" 02/19/00.