

Antrim County, Michigan Natural Hazard Mitigation Plan

2023

ASAP

ACKNOWLEDGEMENTS

The Antrim County Natural Hazard Mitigation Plan is prepared for Antrim County, Michigan and all the jurisdictions within it. Each jurisdiction is invited to be a continuing participant in future regular review and updates of the Plan. This plan is the culmination of an interdisciplinary and interagency planning effort that required the time, technical assistance and expertise of individuals within the following agencies and organizations:

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	Melissa Zelenak	Executive Director
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	Mike Merriwether	Forester
	Wendy Warren	District Manager
Antrim County 911 Dispatch	Mike Gank	911 Administrative Sergeant
Antrim County Administration/Planning	Jeremy Scott	Deputy County Administrator
	Peter Garwood	County Administrator
Antrim County Board of Commissioners	Terry VanAlstine	Chair
	Dawn Lavanway	Commissioner representing Warner, Echo, Jordan & Chestonia Twps.
	Jason Helwig	Commissioner representing Mancelona Twp & Village
	Ed Boetcher	Commissioner representing Elk Rapids Twp & Village
	Judy Parliament	Director
Antrim County Commission on Aging	Amy Tate	
Antrim County Dams/Drain Commissioner	Mark Stone	Operator of Dams
	Scott Kleinhuizen	Assistant Operator of Dams
Antrim County Emergency Services	Leslie Meyers	Emergency Operations Director
Antrim County Equalization	Julie Weston	GIS Analyst
Antrim County Planning Commission	James Gurr	Helena Township
	Gary Lockwood	Helena Township
	Barbra Bradford	Kearney Township
	Ron Tschudy	Echo Township
	Richard Friske Jr.	Banks Township
	Kenny Provost	Central Lake Township
	Peter Stumm	Superintendent
Antrim County Road Commission	Dan Bean	Sheriff
Antrim County Sheriff	Donna Heeres	Clerk
Banks Township	Sue Palmisano	Executive Director
Bellaire Chamber of Commerce	Christine Wilhelm	
Bellaire Family Health Center	Bonnie Robbins	Trustee
Helena Township	Clark "Butch" Peebles	Supervisor
Kearney Township	Ed Niepoth	Supervisor
MI Dept. of Health & Human Services	Bob Bush	

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MI EGLE Remediation and Redevelopment Division
Michigan State Police
Milton Township
NW MI Health Dept
Three Lakes Assn.
Schuss Mtn. Ski Patrol/Kearney Twp.
Torch Lake Fire Dept.
Village of Bellaire
Village of Elk Rapids
Village of Ellsworth

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I. INTRODUCTION

Hazard mitigation is defined as any action taken before, during, or after a disaster or emergency to permanently eliminate or reduce the long-term risk to human life and property from natural, technological and human-related hazards. Mitigation is an essential element of emergency management, along with preparedness, response and recovery.

Mitigation allows repairs and reconstruction to be completed after an incident occurs in such a way that does not just restore the damaged property as quickly as possible to pre-disaster conditions. It also ensures that such cycles are broken, that post-disaster repairs and reconstruction take place after damages are analyzed, and that sounder, less vulnerable conditions are produced. Through a combination of regulatory, administrative, and engineering approaches, losses can be limited by reducing susceptibility to damage. When successful, hazard mitigation will lessen the impact of a disaster on people, property, the environment and economy, and continuity of services through the coordination of available resources, programs, initiatives, and authorities.

A *hazard*, in the context of this plan, is an event or physical condition that has potential to cause fatalities; injuries; damage to personal property, infrastructure, or the environment; agricultural product loss; or interruption of business or civic life. The Antrim County Natural Hazard Mitigation Plan focuses on *natural* hazards such as heat, drought, wildfires, flooding, shoreline erosion, thunderstorm, high winds, hail, extreme winter weather, and invasive species. An exception is that it will also consider these technological and human-related hazards: dam failure and public illness outbreak.

The main objective of the Antrim County Natural Hazard Mitigation Plan is to permanently eliminate or reduce long-term risks to people and property from natural hazards so that county assets such as transportation, infrastructure, commerce, and tourism can be sustained and strengthened. This can be accomplished through collaborative efforts/activities amongst agencies within the county to protect the health, safety, and economic interests of the residents and businesses through planning, awareness, and implementation.

Through this Plan, a broad perspective was taken in examining multiple natural hazard mitigation activities and opportunities in Antrim County. Each natural hazard was analyzed from a historical perspective, evaluated for potential risk, and considered for possible mitigation.

Since the 2016 plan's adoption period, the county and municipalities have achieved the following key endeavors to address their priority mitigation strategies; a detailed list is included in the Appendix.

- FLOODING &/OR EROSION
 - In 2022, the United State Army Corps of Engineers (USACE) finished a 2-year long hydrology study of the Antrim County Chain of Lakes. The data that the USACE hydrologists gathered was studied and used to develop a computer model of the Elk River Chain of Lakes Watershed. The model will be used to study behavior patterns of the water flow and to predict lake water levels under different storm scenarios, including flood events. The findings of the study were presented to the public in June 2022.
 - Partnerships with other local municipalities and non-profits to conserve parkland/undeveloped land.
 - Commissioning the creation of a new county-wide Soil Erosion and Sedimentation Control ordinance
 - Increased standards for County construction permit approval - elevation certificates and compliance with NFIP required.
 - Collaboration with The Watershed Center Grand Traverse Bay, Antrim Conservation District and Tip of the Mitt Watershed Council resulted in an inventory of shoreline erosion sites and culverts for road/stream crossings throughout the County.
- OTHER
 - Implemented the "Rave" brand mass alert notification software that enables information sharing across multiple channels, whether through mobile in the form of SMS alert (Short Message Service), email, desktop or social media, or audibly through voice calls, sirens or long-range acoustic devices (LRADs).
 - All fire departments in the county are equipped to be used as secondary emergency shelters if needed.

Section VI of this plan provides a list of hazard mitigation strategies for each natural hazard identified. Strategies were developed based on discussions with local officials and a review of FEMA best practices for hazard mitigation. Appendix C provides a review of mitigation strategies included in the 2016 plan and their current status. Mitigation strategies are intended to be action items completed during the 5-year timeframe in which the plan is active.

Recognizing the importance of reducing community vulnerability to natural hazards, Antrim County is actively addressing the issue through the development and implementation of this plan. This process will help ensure that Antrim County remains a vibrant, safe, enjoyable place in which to live, raise a family, continue to conduct business, and maintain a tourist base. The Plan serves as the foundation for natural hazard mitigation activities and actions within Antrim County, and will be a resource for building coordination and cooperation within the community for local control of future mitigation and community preparedness around the following:

Figure 1: Planning Goals

Natural Hazards Mitigation Planning Goals for Antrim County
Goal 1: Increase local awareness and participation in natural hazards mitigation
Goal 2: Integrate natural hazards mitigation considerations into the County's comprehensive planning process
Goal 3: Utilize available resources and apply for additional funding for natural hazards mitigation projects
Goal 4: Develop and complete natural hazards mitigation projects in a timely manner

II. PLANNING PROCESS

The Stafford Act, as amended by the Disaster Mitigation Act of 2000, shifted the Federal Emergency Management Agency's (FEMA) scope of work to promoting and supporting prevention, or what is referred to as hazard mitigation planning. FEMA requires government entities to have a natural hazards mitigation plan in place and updated on a 5-year cycle as a condition for applying for grant funding related to natural hazard mitigation and remediation. Antrim County has a history of mitigation planning and adopted past Natural Hazard Mitigation Plans in 2007 and 2016. The adoption of the 2022 plan will reaffirm the eligibility of the county, as well as those local municipalities who participated in the planning process and adopted the county's plan, for federal funding.

The update of the County's plan was led by the Natural Hazards Task Force comprised of the County's Local Emergency Planning Committee (LEPC). Team members consist of first responders and local, regional, and state public entities that ensure the readiness of County entities by recommending equipment purchases, training and exercises, and public education on preparedness issues. Networks Northwest staff assisted with the creation of the updated plan by providing meeting facilitation, conducting an online survey, and writing the plan. The Task Force generally met on a quarterly basis virtually via Zoom, with one in-person field trip meeting. All meetings were open to the public, some in person and some via Zoom. The following is an outline of events for the development of the 2022 Antrim County Natural Hazard Mitigation Plan:

- An online public survey was made available from October 25, 2021 to January 28, 2022 to obtain input on community experience, concerns and priorities regarding natural hazard mitigation in Antrim County. The following table indicates who participated in the survey:

Survey Participant	Representative (if indicated in the survey)
Banks Township	Donna Heeres, Clerk
Central Lake Township	
Chestonia Township	
Custer Township	
Echo Township	
Elk Rapids Township	
Forest Home Twp	
Helena Township	Mike Robinson, Planning Commissioner
Jordan Township	
Kearney Township	Dick Jacques, Planning Commissioner
Mancelona Township	
Milton Township	Joe Renis, Planning Commissioner; Brett Pharo, Trustee; Jeremy Ball, Fire Dept.
Star Township	
Torch Lake Township	Jerry Kulka, Planning Commissioner; Mike Robinson, S. Torch Lake F.D.
Warner Township	
Village of Bellaire	Nicole Essad, Clerk/Zoning Administrator
Village of Central Lake	
Village of Elk Rapids	Laura Schumate; Kerri Esterley, Planning/Zoning & Community Development
Village of Ellsworth	Lynn Aldrich Spearing, President Pro Tem
Village of Mancelona	
Antrim County Emergency Management Coordinator	Leslie Meyers
Antrim County 911	Mike Gank

- LEPC meetings where the Natural Hazard Mitigation Plan update work was discussed:
 - August 10, 2021
 - September 1, 2021
 - November 9, 2021
 - February 8, 2022
 - March 16, 2022 (Special Community input meeting)
 - August 30, 2022
 - December 13, 2022
- June 14, 2022 – Field Trip to visit key hazard sites in the County
- Antrim County Emergency Management attendance at the Antrim County Planning Commission Meeting on September 6, 2022 and October 4, 2022 to explain the Hazard Mitigation Plan progress to date and obtain feedback on ideas for goals and strategies.

Additionally, county and regional agencies that share borders with Antrim County were invited to participate in the planning meetings and sent a copy of the plan in its draft form and again the approved plan. Those agency staff members are:

- Gregg Bird, Emergency Management Coordinator, Grand Traverse County
- Mike Thompson, Emergency Management Coordinator, Kalkaska County
- Jon Deming, Emergency Management Director, Otsego County
- Sienna L. Wenz, Emergency Management Coordinator, Charlevoix County
- Doug Pratt, Emergency Manager, Crawford County
- Jolanda Murphy, Public Safety Department 2 Manager and Emergency Manager, Grand Traverse Band of Ottawa and Chippewa Indians
- Robert Carson, Regional Director of Community Development, Networks Northwest

During development of the plan, all Antrim County municipalities were provided the opportunity to participate in the online community survey as well as comment on plan drafts and other related materials. The draft plan was published openly on the Antrim County Emergency Services website, as well as the project page on Networks Northwest’s website. The public was encouraged to review the draft plan and invited to submit suggestions and ideas for updates, changes to be considered during updates. All meetings where the plan was discussed were openly published for public and other jurisdiction/municipality participation as well. While no formal written comments were received, county staff (particularly the county Emergency Manager) received feedback via other informal means. This feedback took the form of phone calls, emails and conversations that occurred at various non-mitigation related meetings throughout the county. This information was provided and used in development of the plan, including the risk assessment and community profile sections.

Additionally, the public was notified through a published notice in the *Antrim Review* on ###, 2023 that the County’s draft Natural Hazard Mitigation Plan and the opportunity to provide feedback at the public hearing held on _____.

Below are images of the websites for the available draft plan and a copy of the published notice to the public.

Website Image

Source: Antrim County Emergency Services webpage DATE

Networks Northwest Image

Source: Networks Northwest webpage DATE

III. COMMUNITY PROFILE

Land Use/ Land Cover

Antrim County is located in Northwest Lower Michigan, and is bordered by Charlevoix County to the north, Otsego County to the east, Crawford County to the southwest, Kalkaska and Grand Traverse Counties to the south, and Grand Traverse Bay/Lake Michigan to the west/northwest. Refer to Figure ___ for a map of the county's main roads, water bodies and jurisdictions.

The county consists of 475.7 square miles of land area and is the 76th largest county in Michigan by total area.¹ 10% of the county area includes 47.5 square miles of water.

With the exception of the US-131 corridor, which has predominantly level topography, most of the county is covered with a rolling terrain with of forest (private and State-owned), lakes, rivers, agricultural fields, five villages and some hamlets. There are 76 inland lakes in Antrim County, 264 miles in length of streams, and with more than 25 miles of Great Lakes shoreline.

The 2018 Antrim County Master Plan indicates that based on an evaluation of land use changes from 1978 to 1998, the county gained 113 acres of water acreage and 130 acres of wetland acreage. Antrim County has more than 31,000 acres of inland water area (lakes, rivers and streams), and more than 6,500 acres of wetlands. Because of the relatively small size of these acre changes, it is suspected the gain in acreage may reflect a higher water table in 1998 compared to 1978.

A key natural resource in the western half of Antrim County is the Elk River Chain of Lakes (ERCOL). ERCOL covers over 500 square miles, including over 200 miles of shoreline and almost 60 square miles of water. This continual connection of inland waterbodies embraces 14 lakes and interconnecting rivers. The 14 lakes are listed in their order of hydraulic flow: Beals, Scotts, Six Mile, St. Clair, Ellsworth, Wilson, Benway, Hanley, Intermediate, Bellaire, Clam, Torch, Skegemog, and Elk. The Chain of Lakes is a designated water trail and flows through the Villages of Ellsworth, Central Lake, Bellaire, and Elk Rapids. The Chain of Lakes is the largest sub-watershed in the Grand Traverse Bay Watershed, which comprises 72% of the county.

The Cedar River, a "Blue Ribbon Trout Stream," flows mostly westward through Antrim County into the Intermediate River in Bellaire. The Cedar River originates in southwest Chestonia Township, near the boundary with Mancelona Township.

The headwater for the Jordan River is in Chestonia Township and it flows to the north/northwest, all but two miles, in Antrim County. Over 30,000 acres of state forestlands border this river.

The mainstream of the Upper Manistee River watershed is approximately 78 miles long and originates in southeast Antrim County (approximately six miles from the hamlet of Alba), at an elevation of 1,250 feet.

The largest concentration of people and businesses is located in the Village of Mancelona, in the southeast corner of the county on US-131.

According to the 2017 Census of Agriculture, the county had 55,565 acres of land in farms for a total of 333 farms. This represents a 20% and 13% drop in the number of farms and acreage of farms, respectively, since the 2012 USDA Census of Agriculture.

About 82% of the market value of agricultural products sold in the county is from crops. Fruits, tree nuts, and berries had the highest market value of agriculture products sold at \$16,071,000. Antrim County ranks 10th in the State of Michigan for the sale of fruits, tree nuts, and berries overall. The county also ranks 10th in the State for the sale of cultivated Christmas trees and short rotation woody crops (\$965,000 in sales). Livestock, poultry and other animal products comprised about 18% of the market value of agricultural products sold.

The predominant land cover type is "forested" followed by the combined types of land cover classified as "___" (Table 1). Developed land cover is found predominantly in and around the villages of Mancelona, Bellaire, Central Lake, Ellsworth, and Elk Rapids.

¹ <https://data.census.gov/cedsci/profile?q=0500000US26009>

Table 1: Land Cover by Type

Classification	Acres	Percent
Developed (High Intensity)		
Developed (Med. Intensity)		
Developed (Low Intensity)		
Developed (Open Space)		
Agriculture		
Forested		
Wetlands		
Grassland, Pasture, Shrub/Scrub		
Barren		
Open Water		
TOTAL		

Source: Networks Northwest

The 2016 Hazard Mitigation Plan indicated that 180,281 acres, or 59%, of the county was comprised of forested lands. Current data shows a fractional decrease. While growth in the county has remained steady, it has been noted that the type of growth is changing. Office and industrial development has largely stopped, commercial development has slowed, but residential development is occurring as quickly as plans can be approved. Housing of all types and prices is in demand, but many communities desire smaller units and multiple family units. This type of housing is especially important for the senior and low to moderate income populations and will likely be in demand for many years. The Environmental Features Map in Appendix ___ shows the intensity of development in the county as well as natural features.

Population

Antrim County is the 6th most populated county in the ten county region of Northwest Lower Michigan (Table 2) and is ranked 61 out of 83 counties in the state for population.² The 2019 American Community Survey (ACS) estimated the county population to be 23,206 people. A comparison of the 2010 and 2019 ACS data indicates a downward county population growth trend with a 3.2% decrease from 2010, when the population was an estimated 23,975 persons (Table 3). The 2019 population per square mile is approximately 44.2 people.

Antrim County is comprised of fifteen (15) townships and five (5) villages. All communities - with the exception of Chestonia, Echo, Helena, Milton and Star Townships, and the Villages of Bellaire and Mancelona - experienced population decline between 2010 and 2019 (shown in red, Table 3). The most populated community is Mancelona Township, which contains the Village of Mancelona, part of highway US-131 and is located in the southeast portion of the county, at an estimated 4,350 persons.

The second most populated community, at an estimated 2,575 persons is Elk Rapids Township, located in the southwest portion of the county. The township contains the Village of Elk Rapids and is bordered by the Grand Traverse Bay to the west, Elk Lake to the east and contains part of the US-31 highway corridor.

The third most populated community is Milton Township, at 2,545 persons, located in the southwest portion of the county. Milton Township is bordered by Torch Lake, Elk Lake, Grand Traverse Bay and also contains part of the US-31 highway corridor. Milton Township grew by an estimated 23.1% between 2010 and 2019.

² https://www.michigan-demographics.com/counties_by_population

Table 2: 2019 Estimated Regional Population by County, State

Jurisdiction	Population
Missaukee County	15,028
Kalkaska County	17,585
Benzie County	17,615
Leelanau County	21,652
Antrim County	23,206
Manistee County	24,457
Charlevoix County	26,188
Emmet County	33,104
Wexford County	33,256
Grand Traverse County	92,181
State of Michigan	9,965,265

Source: US Census, 2019 ACS Estimate

Table 3: Population Change by Municipality, 2010, 2019

Municipality	2010 Estimated Population	2019 Estimated Population	Numeric Change	Percent Change	Jurisdiction Status*
Antrim County	23,975	23,206	-769	-3.2%	2
Village of Bellaire	1,014	1,015	1	0%	
Village of Central Lake	1,046	953	-93	-8.9%	
Village of Elk Rapids	1,864	1,494	-370	-19.8%	
Village of Ellsworth	412	339	-73	-17.7%	
Village of Mancelona	1,478	1,574	96	6.5%	
Banks Township	1,686	1,604	-82	-4.9%	
Central Lake Township	2,447	1,976	-471	-19.2%	
Chestonia Township	344	433	89	25.9%	
Custer Township	1,103	949	-154	-14.0%	
Echo Township	839	846	7	0.8%	
Elk Rapids Township	2,703	2,575	-128	-4.7%	
Forest Home Township	1,949	1,594	-355	-18.2%	
Helena Township	964	1,024	60	6.2%	
Jordan Township	953	929	-24	-2.5%	
Kearney Township	1,918	1,882	-36	-1.9%	
Mancelona Township	4,442	4,350	-92	-2.1%	
Milton Township	2,068	2,545	477	23.1%	
Star Township	842	929	87	10.3%	
Torch Lake Township	1,331	1,208	-123	-9.2%	
Warner Township	386	362	-24	-6.2%	

Source: US Census, 2019 ACS Estimate

* 2022 Hazard Mitigation Plan Participation Status: 1. A new participant; 2. A continuing participant, and 3. A non-participant

Like many northwest Michigan communities, Antrim County experiences an influx of seasonal residents and tourists during the summer months. However, the decennial Census and the American Community Survey only consistently and comprehensively track the permanent population. The *Northwest Michigan Seasonal Population Analysis*, a 2014 report by the Michigan State University Land Policy Institute, analyzed the 2012 seasonal population for ten counties in northwest Michigan. The data collected for Monthly Permanent, Seasonal and Transient Residents by County estimates the population of Antrim County increases by: 40% in June (from 23,406 to 38,733) and by 42% in the months of July (from 23,406 to 43,212) and August (from 23,406 to 40,306). All ten counties in the Networks Northwest service area were included in the study: Antrim, Benzie, Charlevoix, Emmet, Grand Traverse, Kalkaska, Leelanau, Manistee, Missaukee, and Wexford.

Although the data in this report is several years old, anecdotally, the influx of seasonal residents and tourists has not decreased. While the population staying in overnight accommodations such as motels, hotels, and bed and breakfasts was considered, the boom of short-term rental accommodations changed the overnight stay market considerably. The implications of seasonal and short-term rental accommodations on hazard mitigation planning are included in discussions throughout this plan. For future reference, an updated *Northwest Michigan Seasonal Population Study* is expected to be available from Networks Northwest in 2023.

Age, Race & Disability

Understanding the age distribution and median age of Grand Traverse County can help identify social, economic, and public service needs in the community. The county's total 2019 population is broken into age cohorts (analyzing which proportions of a municipality's population are in which stages of life). This gives a nuanced view of the makeup of a community. Figure 2 indicates the cohort group with the largest population is the 45 to 64 year old group. As shown in Figure 3, the median age (the midpoint where half the population is younger and half the population is older) of Antrim County is older (51.3 years) than the State (39.7 years). The youngest community in the county is Mancelona Township with a median age of 38.5 years; the oldest community in the county is Helena Township with a median age of 60.9 years (Figure 4).

Figure 2: Antrim County Population by Age Cohort, 2019

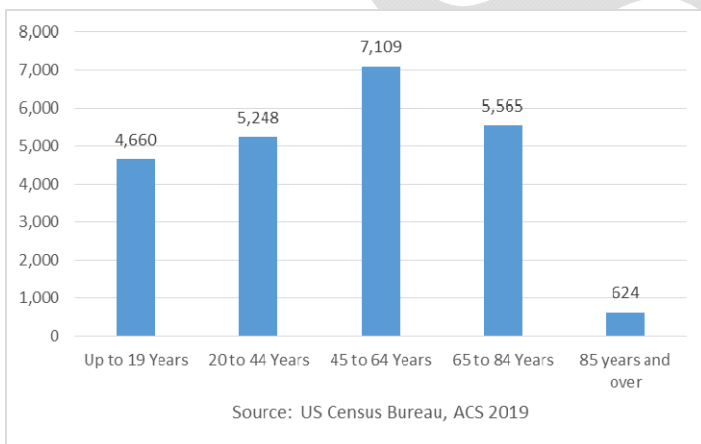


Figure 3: Median Age Trend, 2000, 2010, and 2019

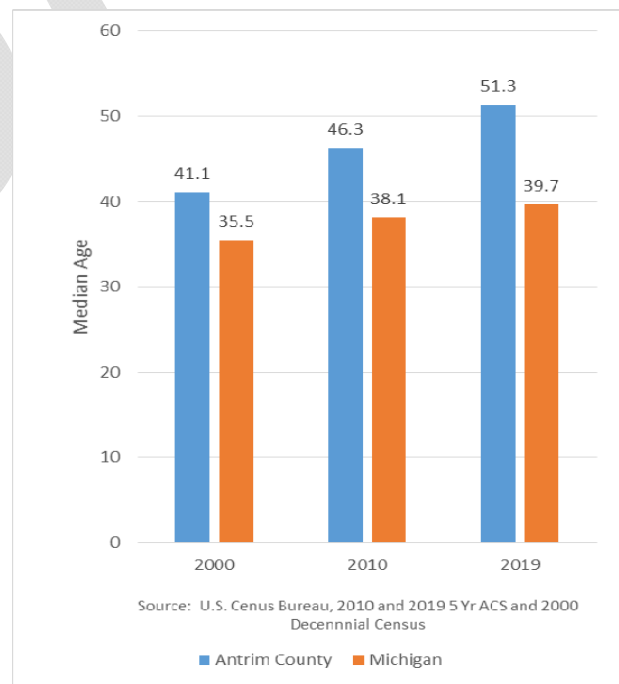
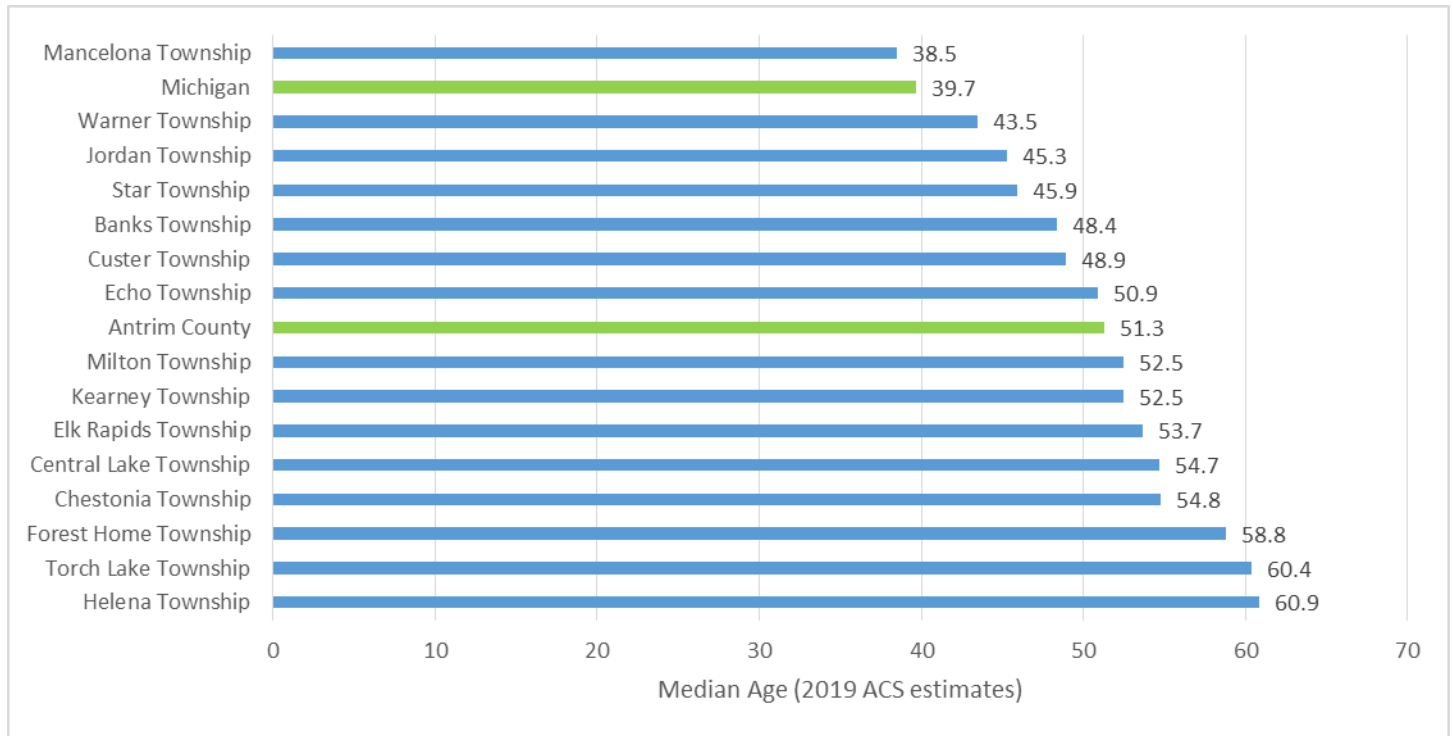


Figure 4: Median Age by Antrim County Municipality, 2019



Source: U.S. Census, 2019 ACS Estimate

The racial makeup of Antrim County is predominantly white (94.7%). 2.3% of the population is Hispanic or Latino; 1.5% consists of two or more races; 0.7% is American Indian and Alaska Native; 0.4% is Black or African American; 0.3% is Asian; and 0.1% is of some other race.

Table 5 represents the number of persons with a disability by age group. An estimated 3,733 (16.2%) of Antrim County residents have one or more type of disability. An estimated 30.3% of persons aged 65 years and over have a disability.

Table 5: Persons with a Disability, 2019

Total Civilian Noninstitutionalized Population	23,031
With one or more disability	3,733
Age 0-17 with a disability	207
18 to 64 years with a disability	1,686
65 years and over with a disability	1,840

Source: US Census, 2019 ACS Estimate

Housing Characteristics and Development Trends

The average household size for County residents is 2.32 persons, which is slightly lower than the State's average of 2.46. Antrim County has an estimated 9,899 total households (also referred to as housing units) as reported in the 2019 ACS 5-Year Estimates (Table 6). The Census defines a household as all the people who occupy a single housing unit, regardless of their relationship to one another. In 2019, an estimated 54.8% of those housing units were occupied (indicating physically occupied, principal residence housing units; Table 8). Mancelona Township has the largest percentage of housing units of all municipalities in the county (14.2%). The 2019 ACS also estimates that 88.1% (8,721) of the county's household units are 1-unit, detached structures, which are commonly referred to as single-family homes. Over 55% of residential units were built after 1980 (Table 7).

Table 6: Housing Units by Municipality, 2019

Municipality	2019 Housing Units (ACS)	Percent of 2019 Total*
Antrim County	18,069	
Village of Elk Rapids	1,179	
Village of Mancelona	647	
Village of Central Lake	590	
Village of Bellaire	550	
Village of Ellsworth	166	
Mancelona Township	2,564	14.2%
Milton Township	1,934	10.7%
Elk Rapids Township	1,918	10.6%
Central Lake Township	1,637	9.1%
Forest Home Township	1,536	8.5%
Kearney Township	1,409	7.8%
Torch Lake Township	1,399	7.7%
Custer Township	1,161	6.4%
Banks Township	1,002	5.5%
Helena Township	962	5.3%
Star Township	848	4.7%
Echo Township	601	3.3%
Jordan Township	552	3.1%
Chestonia Township	349	1.9%
Warner Township	197	1.1%

Source: US Census, 2019 ACS Estimates;

* The number of housing units for each village is incorporated into the totals for the respective township in which each village is located.

Table 7: Year Structure Built, 2019

Year Built	Housing Units	Percentage of Units
Built 2010 or later	343	1.9
Built 2000 to 2009	2,055	11.4
Built 1980 to 1999	5,733	31.7
Built 1960 to 1979	5,526	30.6
Built 1940 to 1959	2,332	12.9
Built 1939 or earlier	2,080	11.5
Total Housing Units	18,069	

Source: US Census, 2019 ACS Estimates

Housing Tenure, Table 8, summarizes the status of housing units, whether occupied or vacant, as well as the median housing value (\$160,500) and the median gross rent (\$752). Of the 18,069 total housing units, 9,899 (54.8%) are occupied.

Table 8: Housing Tenure, 2019

Total housing units	18,069	%
Occupied housing units	9,899	54.8%
Owner-occupied	8,621	87.1%
Median Housing Value	\$160,500	
Renter-occupied	1,278	12.9%
Median Gross Rent	\$752	
Vacant housing units	8,170	45.2%

Source: US Census, 2019 ACS Estimate

Economic Profile

The *2021 Comprehensive Economic Development Strategy (CEDS)* prepared by Networks Northwest is the product of a locally-based, regionally-driven economic development planning process to identify strategies for economic prosperity. The plan was prepared for the ten county region of northwest Lower Michigan. Table 8 provides a comparison of annual average wage for each county in the CEDS planning area for 2018. Kalkaska County has the highest average annual wage with \$ 50,971 followed by Grand Traverse County at \$44,562. Antrim County has the lowest average annual wage at \$33,081. As their northern neighbor, it is not unexpected to have residents of Antrim County travel to Grand Traverse County or Kalkaska County for work.

Table 8: Average Annual Wage by County, 2018

County	Average Annual Wage
Antrim	\$33,081
Manistee	\$33,821
Benzie	\$33,908
Missaukee	\$35,917
Wexford	\$35,917
Leelanau	\$36,833
Emmet	\$40,258
Charlevoix	\$44,558
Grand Traverse	\$44,562
Kalkaska	\$50,971

Source: 2021 Comprehensive Economic Development Strategy (CEDS) prepared by Networks Northwest

The Economic Profile of Antrim County is further described in Table 9. The table provides the county's industry makeup divided into 20 different North American Industry Classification Sectors (NAICS) as well as industry's establishments, jobs, percent distribution, and annual average wage. The industry with the largest percent distribution is **"Other (includes private, management of business, and unallocated)"** at 19.0% of jobs, followed by **"Accommodation and Food Service"** at 17.4%, and **"Manufacturing"** at 17.1%. The annual average wage for "Other" is not available; for "Accommodation and Food Services" is \$18,169; and for "Manufacturing" is \$41,194. **"Retail Trade"** is the fourth largest industry with 11.3% of jobs in the county, at an annual average wage of \$24,557. The industry with the highest annual average wage is "Wholesale Trade" at \$50,125, followed by "Transportation, Warehousing" at \$49,224.

Table 9: Antrim County Economic Distribution by Industry, 2018

Industry Description	Establishments	Jobs	Percent Distribution	Annual Average Wage
Total Covered Employment	525	5,304	100.00%	\$33,081
Agriculture, forestry, hunting	19	D	D	D
Mining	1	D	D	D
Construction	83	447	8.30%	\$37,231
Manufacturing	38	918	17.10%	\$41,194
Wholesale trade	13	52	1.00%	\$50,125
Retail trade	68	604	11.30%	\$24,557
Transportation, warehousing	22	35	0.70%	\$49,224
Utilities	2	D	D	D
Information	10	84	1.60%	\$17,289
Finance and Insurance	19	92	1.70%	\$47,852
Real Estate, rental, leasing	24	86	1.60%	\$28,150
Professional, technical services	26	124	2.30%	\$29,719
Administrative, waste services	23	70	1.30%	\$39,194
Educational services	11	D	D	D
Health care, social assistance	36	218	4.10%	\$41,637
Arts, Entertainment, recreation	10	144	2.70%	\$27,163
Accommodation and food services	41	932	17.40%	\$18,169
Other services, exc. Public admin.	52	214	4.00%	\$29,489
Public administration	24	317	5.90%	\$33,958
Other (includes private, management of business, and unallocated)	3	967	19.00%	N/A

Source: 2021 Comprehensive Economic Development Strategy, Networks Northwest

*D means limited industries of a sector that would disclose confidential information

According to the 2016 Economic Profile for Antrim County by the Northern Lakes Economic Alliance (Table 10), major employers for Antrim County are primarily located in or near the Villages of Mancelona, Bellaire, Elk Rapids, Central Lake and Ellsworth. The largest employer is Shanty Creek Resort, with around 600 employees in Kearney Twp, near the Village of Bellaire.

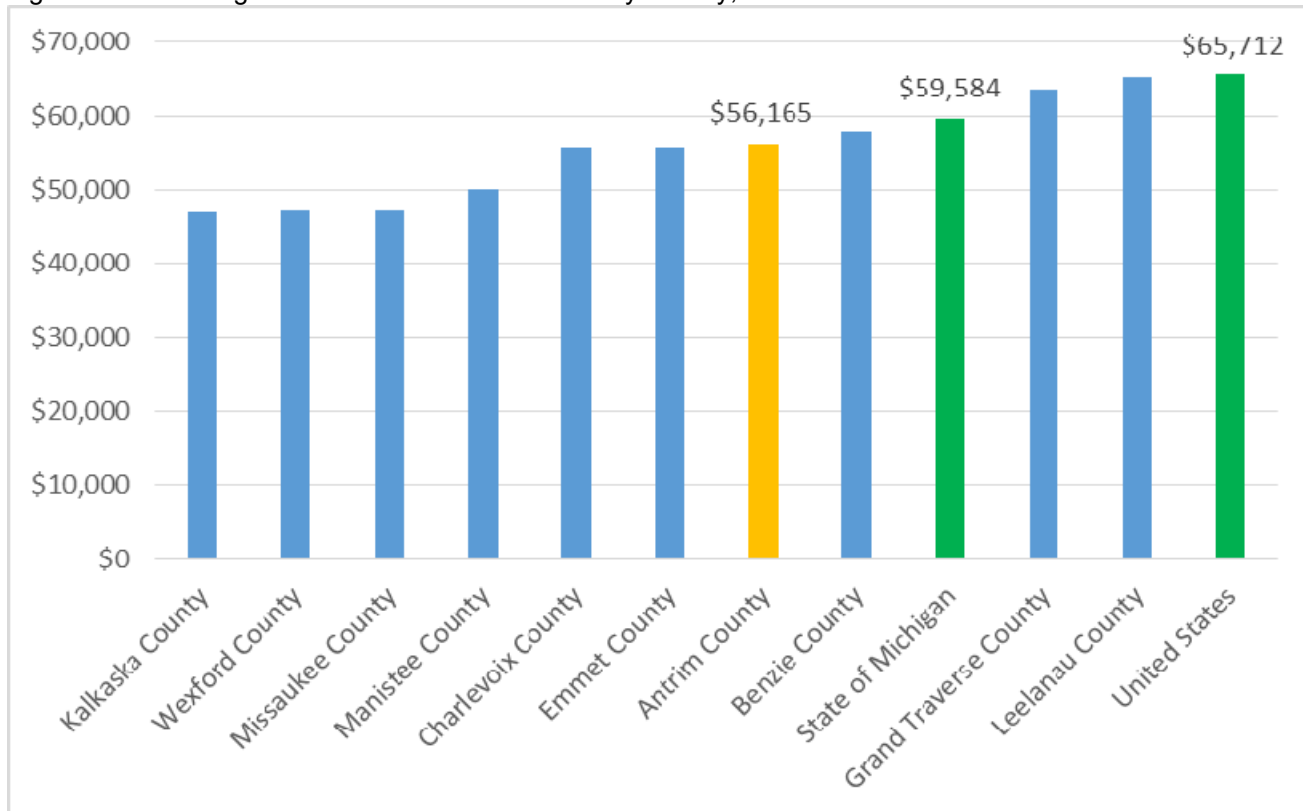
Table 10. Major Antrim County Employers

Company Name	Location	# Emp	Industry/Product
Shanty Creek Resort	Bellaire	600	Traveler Accommodation
Great Lakes Packing	Kewadin	300	Frozen Food Processors
County of Antrim	Bellaire	200	All County Departments
Elk Rapids School District	Elk Rapids	180	Elementary/Secondary School
Anchor Lamina	Bellaire	160	Plating (mfg); Electroplating, anodizing, and coloring
Cherry Ke, Inc.	Kewadin	150 Seasonal	Misc. Crop Farming
Meadowbrook Medical Care	Bellaire	150+	Nursing Care Facilities
Shorts Brewing	Bellaire/E.R.	74	Beverage Manufacturing
Burnette Foods Inc.	Elk Rapids	70	Canning; Fruit & Vegetable
Central Lake Public School	Central Lake	67	Public School
Bellaire Public School	Bellaire	55	Public School
Mancelona School District	Mancelona	50	Public School
Family Fare	Bellaire	50	Supermarket
Burt Moeke & Son Hardwoods/Fahl Forest Products	Mancelona	45	Logging
Ellsworth Farmers Exchange	Ellsworth	37	Feeds, LP Gas, Service
Traverse Bay Manufacturing	Elk Rapids	35	Sewing Contractors; Textile Products
Kitchen Farms	Elmira	35	Growing, Bagging and Shipping Potatoes
Wooden Hammer	Elk Rapids	35	Manufacturer Custom Wood Prod.
Elk Rapids Engineering	Elk Rapids	35	Engineering
Snyder Industries	Mancelona	29	Mnfg. Bulk Handling Containers
Specialty Silicone Fabricators	Elk Rapids	27	Mnfg. Custom Silicone Components
Antrim Machine Products	Mancelona	18	Machinery/Machine Tools
45th Parallel Furniture	Elk Rapids	13	Furniture Manufacturing
Echo Quality Grinding	Central Lake Twp.	12	Hardware Manufacturing

Figures 5 and 6 present a comparison of the median household income (MHI) across the ten county region, the State of Michigan, and local jurisdictions. Antrim County has the fourth highest median household income (\$56,165) in the region, just slightly ahead of Emmet County (\$55,829). The economic profile can be further described by considering the cost of housing, transportation, and other goods and services. The budgeting rule of thumb has been that a household should spend no more than 30 percent of its income on housing costs. Considering the MHI of Antrim County over twelve months, a household is earning \$4,680 per month. The US Census 2016-2020 5-year ACS estimates that the median gross monthly rent is \$761 in Antrim County.

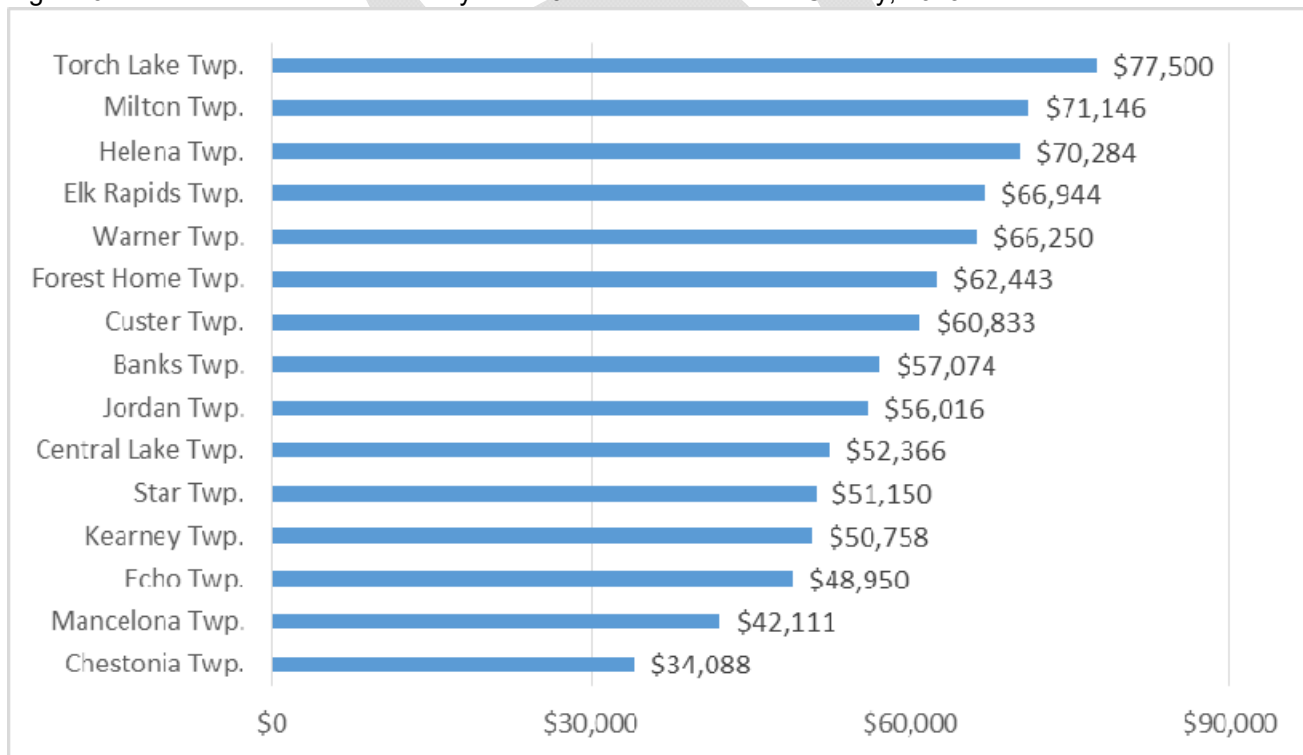
However, according to the 2019 Northwest Michigan Target Market Analysis (conducted by LandUseUSA on behalf of Housing North and Networks Northwest), rents are far higher in Antrim County than what many renters can afford. While the affordable rent for a renter earning the mean wage is \$700, the affordable rent for a full-time minimum wage worker is \$491. And anecdotally, the demand for housing is driving prices higher still. Home prices are also increasing where the cost to purchase a home is often as much as \$200/square foot or more.

Figure 5: NW Michigan Median Household Income by County, 2019



Source: US Census, 2019 ACS Estimate

Figure 6: Median Household Income by Local Jurisdiction in Antrim County, 2019



Source: US Census, 2019 ACS Estimate

The following tables describe the population with the lowest incomes. It is estimated, in 2019, that 11% of all persons in the county lived at or below the poverty level (Table 11). The Census describes poverty thresholds differently based on the size of the family and the number of related children living together, as illustrated in Table 10 below.

Table 10: 2019 Federal Poverty Level Guidelines

Persons in family/household	Poverty guideline
1	\$12,490
2	\$16,910
3	\$21,330
4	\$25,750
5	\$30,170
6	\$34,590
7	\$39,010
8*	\$43,430

*For families/households with more than 8 persons, add \$4,420 for each additional person.

Table 11: Antrim County Poverty Estimates, 2019

Poverty	Statistics
All families in poverty	7.7% (534)
Families with related children under age 18, in poverty	13.1% (298)
All persons in poverty	11% (2,527)

Source: US Census, 2019 ACS Estimate

Financial hardship is further described in the United Ways of Michigan report entitled *ALICE in Michigan: A Financial Hardship Study*. ALICE, which is an acronym for Asset Limited, Income Constrained, Employed, are those households with income above the Federal Poverty Level, but below the basic cost of modern living, such as housing, child care, food, health care, technology and transportation. The ALICE threshold is described as, “*the average income that a household needs to afford the basic necessities... for each county in Michigan. Households earning below the ALICE Threshold include both ALICE and poverty-level households*” (ALICE, 2019). Table 12 identifies the number and percentage of households that are estimated to be below ALICE and poverty thresholds for the each municipality and the County. These households likely would not have reserve savings to cover an emergency, such as impacts from a natural hazard event.

Table 12: United Ways of Michigan ALICE Report Findings, 2019³

County Subdivision	HH Below ALICE and Poverty Thresholds		
	Total Households	Percentage	Number
Mancelona Township	1,637	47%	769
Central Lake Township	913	39%	356
Elk Rapids Township	1,142	29%	331
Kearney Township	754	40%	302
Milton Township	1,068	24%	256
Forest Home Township	765	28%	214
Banks Township	679	28%	190
Torch Lake Township	584	30%	175
Echo Township	349	41%	143
Star Township	397	32%	127
Custer Township	406	30%	122
Jordan Township	367	33%	121
Chestonia Township	201	59%	119
Helena Township	493	24%	118
Warner Township	144	34%	49
Totals	9,899	34.5%	3,393

³ Michigan Association of United Ways. *ALICE in Michigan: A Financial Hardship Study*. 2021. <https://www.uwmich.org/alice-report>

IV. Hazard Identification and Assessments

Vulnerability Assessment

Natural hazard impact on the community can be understood by evaluating vulnerabilities for commonly agreed upon assets. A community's assets are defined broadly to include anything that is important to the character and function of a community and can be described very generally in the following categories:

- People
- Economy
- Built environment
- Natural environment

Vulnerable populations include the economically disadvantaged, elderly, homeless, and persons with a disability. Those that live unsheltered or in homeless encampments, assisted living facilities, mobile homes, or isolated residences are more susceptible to hazardous events. Vulnerable populations are represented on the *Vulnerable Populations and Hazard Areas Map* in Appendix A. There may be additional locations of vulnerable populations that are not listed.

The natural environment is the primary reason residents choose to live and vacation northwest Michigan. Antrim County is home to plentiful forest lands, vast inland lakes and streams, Lake Michigan shoreline and all of the wildlife within them that are integral to the identity of the community. While natural resources are abundant, they are also vulnerable to all types of hazards. Northwest Michigan has many sensitive wildlife and plant populations that require specific climates and habitats to survive. Altered or destroyed natural environments may decrease the chances for certain species' survival.

Additionally, countywide critical infrastructure is represented on the Critical Infrastructure Map, shown in Appx. A. Task Force members and community stakeholders identified the critical facilities and infrastructure on the base map; Networks Northwest updated GIS shapefiles for mapping purposes. Table 11 lists key critical infrastructure points in Antrim County.

Table 11: Critical Facilities and Infrastructure

24	Healthcare Facilities <ul style="list-style-type: none"> • 13 Extended Health Care Fac. • 5 Public Health Care Fac. • 4 Health Practitioner Office or Clinic • 2 Health Supporting Fac.
23	Emergency Services Facilities <ul style="list-style-type: none"> • Antrim County Emergency Services – Bellaire • 3 EMS Services – Mancelona, Eastport, Bellaire • 13 Fire and Emergency Services • 6 Law Enforcement Offices
17	Communications Facilities <ul style="list-style-type: none"> • Antrim County 911 • 1 Satellite Comm. • 5 Wired Comm. • 10 Wireless Comm.
14	Government Facilities <ul style="list-style-type: none"> • 7 Public Water Districts (18.6% public system or private company) • 5 Public Sewer Districts (18.6% public sewer) • 3 Dams – Elk Rapids Dam, Bellaire Dam and Cedar River Dam
8	Transportation Facilities <ul style="list-style-type: none"> • 4 Airports • 3 Antrim County Road Commission Facilities (Kewadin, Central Lake, Mancelona) • Antrim County Public Transportation (Bellaire)
6	Commercial Facilities (Agricultural/Food Products)
4	Industry <ul style="list-style-type: none"> • EJ Foundry (Elmira) • Anchor Lamina (Bellaire) • Jordan River Fish Hatchery (Star Twp./Elmira) • Lambda Energy Pipeline (main facility located in Kalkaska County)

Source: Antrim County Emergency Services

Historical Analysis

The Historical Analysis of Antrim County weather-related hazards uses information on impacts and losses from previous hazard events to predict potential impacts and losses during a similar event. Because of the frequency of these events, communities are more likely to have experience with and data on impacts and losses. Additionally, there have been five federal-or state-declared disaster events that have involved Antrim County (Table 12). These events are included in the hazard analysis for individual event types.

Table 12: Presidential and Governor Declared Disasters for Antrim County

Date Declaration	Type of Incident	Affected Area	Type of Declaration/ Fed ID #
3/1/2020	COVID-19; COVID-19 Pandemic	Statewide & National	State of Emergency, National Emergency (3455), and Governor and Presidential Declared Major Disaster (4494)
1/29/2019	Extreme Cold	Statewide	Governor Declared Emergency
9/4/2005 and 9/7/2005	Hurricane (Katrina) Evacuation	Statewide (Declared due to the emergency conditions in the State of Michigan, resulting from the influx of evacuees from states impacted by Hurricane Katrina beginning on August 29, 2005.)	Governor Declared Disaster and Presidential Declared Emergency (3225)
1/26-27/1978	Blizzard, Snowstorm	Statewide	Presidential Declared Emergency (3057); Governor Declared Disaster
3/2/1977	Drought	Antrim and 43 other counties	Presidential Declared Emergency (3035)

Sources: FEMA <https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties> and Michigan State Police [2019 Michigan Hazard Analysis \(MHA\) pub. 103](#)

Hazard Descriptions

Antrim County is vulnerable to a wide range of natural hazards. Hazard events have the potential to impact local residents, economic drivers in the community, critical infrastructure and the built environment, and the natural environment. The Antrim County Emergency Services Department is challenged with managing these threats to protect life and property. This plan includes a profile for each natural hazard event the county is likely to face. Each profile includes the location, extent, previous occurrences, probability of future events, and vulnerability assessment.

- Location is the geographic areas within the planning area that are affected by the hazard, such as a floodplain. The entire planning area may be uniformly affected by some hazards, such as drought or winter storm. Location may be described in narrative and or through map illustrations.
- Extent is the strength, severity, or magnitude of the hazard. Extent can be described in a combination of ways depending on the hazard.
- Previous occurrences describe the history of previous hazard events within the county. This information helps estimate the likelihood of future events and predict potential impacts. The extent of historic events may be included when the data is available. Data is collected from the National Oceanic and Atmospheric Administration's (NOAA's) National Centers for Environmental Information (NCEI) online storm events database.
- Probability of future events is the likelihood of the hazard occurring in the future and can be described in a variety of ways. Probability may be defined using historical event frequencies or statistical probabilities.
- Vulnerability assessment accounts for the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas and provides an estimate of the dollar losses to vulnerable assets identified. Historical records of property damage, crop damage, injuries and deaths are evaluated.

Data for natural hazard events in Antrim County was compiled from several different sources. Weather event data was collected primarily from the National Centers for Environmental Information through the National Oceanic and Atmospheric Administration's (NOAA) website utilizing the following sections:

- Climate <https://www.weather.gov/wrh/Climate?wfo=apx> – Historical local observed weather data; Climate prediction and variability; local high impact event summaries
- NOAA Storm Event Database <https://www.ncdc.noaa.gov/stormevents/> - Data on record from 1950 to May 31, 2022; however, information for various events is limited and non-contiguous throughout the decades. The database provides local storm reports, damage reports, and recorded event descriptions. The event types on record for Antrim County include: Drought (*Drought*); Heat (*Heat*); Flooding (*Flash Flood*); Hail (*Hail*); Extreme Winter Weather (*Blizzard, Extreme Cold/Wind Chill, Frost/Freeze, Heavy Snow, Ice Storm, Lake-effect Snow, Winter Storm, Winter Weather*); Tornado (*Tornado*); Thunderstorm and High Wind (*Thunderstorm Wind, Lightning, High Wind, Strong Wind*).

The [Michigan Hazard Analysis](#) report by the Michigan Department of State Police in 2019 was used to collect data on wildfires that occurred on State of Michigan owned land between 1981 and 2018. The websites for the [National Inventory of Dams](#) and [MI-EGLE's Michigan Dam Inventory](#) were used to collect information on dams in the county.

The NOAA storm events database search results indicate a total of 300 severe weather events were reported between 01/01/1950 and 05/31/2022 in Antrim County. These events were screened for missing qualitative data, such as recorded wind speed, or a lack of temporal continuity in recorded data. The remaining events, as well as the State and Federal emergency declarations, result in a total of 291 events in the hazard analysis, as illustrated in Table 13.

Lightning incidents are those that resulted in a reported fatality, injury, and/or property or crop damage.

The Episode/Event Narratives for these historical severe weather events in Antrim County is included in the Appendix.

Table 13: Reported Antrim County Event by Type

Type of Event	# of Events	Event Location	Time Interval/ Year Event Recorded
Wildfire	256	MDNR lands	1981 - 2018
Extreme Winter Weather	162	Region, County or Statewide	1978*, 1997-May 2022
Thunderstorm/Wind; High Wind; Strong Wind	72	Countywide	July 1995-May 2022
Hail	34	Countywide	1996-May 2022
Tornado	11	Countywide; Elk Rapids, Torch Lake, Alden, Kewadin, Alba	1958, 1974, 1977, 1985, 1990, 1995, 1998, 2007, 2017, 2018, 2022
Flash Flood	3	Elk Rapids, Alden, Bellaire	1999, 2021
Extreme Cold / Wind Chill	2	Region or Statewide	2007, 2019*
Drought	2	Region	1977*, 2001
Heat/Excessive Heat	2	Region	2001, 2018
Lightning	2	Region/Ellsworth	2000, 2012
Invasive Species	Ongoing	Countywide	Ongoing
Public Health Emergency (COVID-19 Pandemic)	1	Statewide/Nationwide	2020*
Coastal Hazards: Flooding, Recession, Rip Current, Seiche	0	Banks, Torch Lake, Milton, Elk Rapids, and Village of Elk Rapids	1950-2022

Sources: NOAA National Centers for Environmental Information Storm Events Database; MDNR; Michigan State Police-Dept. of Homeland Security; FEMA.

Note: * indicates a state or federal event designation

Economic Impact Analysis

The estimated economic impact of the previously described Antrim County natural hazard events that were *reported* to NOAA is \$2,304,700 in property damages and \$11,030,000 in crop damages (Table 14). It should be noted that many events, such as hail, likely cause numerous small amounts in property damage, but such damages often go unreported. The total reported Damaging Events' Costs recorded with NOAA for Antrim County are as follows:

Table 14: Damage Estimates by Event Type

Antrim County	Property Damage Estimate	Crop Damage Estimate
Extreme Winter Weather	\$270,000 (2007, 2012, 2019)	\$10,000,000 (April 2012 Frost/Freeze)
Thunderstorms with Wind; Severe/High Winds; Lightning	\$1,050,500	\$0
Hail	\$95,000 (2016, 2022)	\$1,030,000 (2006, 2016)
Tornado	\$564,280	\$0
Flash Flood	\$325,000 (Alden, 2021) (VERIFY)	\$0
Extreme Cold / Wind Chill	\$0	\$0
Drought	\$0	\$0
Heat/Excessive Heat	\$0	\$0
Public Health Emergency (Pandemic)	N/A	N/A
TOTAL	\$2,304,780	\$11,030,000

Source: NOAA's National Centers for Environmental Information

Table 15 provides an overview of each potential hazard's impact on the permanent population and the estimated impact on the State Equalized Values (SEV) for real and personal property (residential and commercial). Population data is collected from the US Census, 2019 ACS data. According to the 2014 Northwest Michigan Season Population Analysis, assume a 42% increase to account for the highest estimated annual average seasonal population within the county (which occurs in July and August).

Table 15: Geographic Economic Impact by Event (Need Environmental Features Map to be Created)

Hazard Event	Geography	Population Estimates	State Equalized Value
Extreme Winter Weather, Thunderstorm, Wind, Hail, Lightning, Tornado, Extreme Temperatures, Drought, Public Health Emergency	Antrim County	23,206	
	Chain of Lakes communities; (Echo, Kearney, Custer, Banks, Central Lake, Forest Home, Torch Lake, Milton, Helena, and Elk Rapids Townships; Villages of Elk Rapids, Central Lake, Ellsworth, and Bellaire);	16,203	
	Jordan River Valley communities (Jordan, Echo, Star and Chestonia Twps.)	3,137	
Urban Flooding	Villages of Elk Rapids, Central Lake, Bellaire, Mancelona, Ellsworth	5,375	
Coastal Erosion/Flooding	Banks, Torch Lake, Milton and Elk Rapids Townships; Village of Elk Rapids	7,932	
Wildfire	Areas with Jack Pine forest		

Sources: 2019 ACS Estimates from the U.S. Census Bureau; Antrim County Equalization

Extreme Winter Weather

National Weather Service defined as: *phenomenon (such as snow, sleet, ice, wind chill) that impacts public safety, transportation, and/or commerce.* The Extreme Winter Weather category includes the following subcategories: winter weather, winter storm, ice storm, heavy snow, blizzard, frost/freeze, and lake effect snow. Blizzards are the most perilous snowstorms and are characterized by low temperatures, strong winds, and enormous amounts of fine, powdery snow. Snowstorms have the potential to reduce visibility, cause property damage, and loss of life.

According to the 2019 Michigan Hazard Analysis, Michigan has 360 snowstorms with 0.1 average annual deaths, 0.1 average annual injuries, and \$1.9 million in average annual property and crop damage. Michigan experiences large differences in snowfall over short distances due to the Great Lakes. The average annual snowfall accumulation ranges from 30 to 200 inches with the highest accumulations in the northern and western parts of the Upper Peninsula. In Lower Michigan, the highest snowfall accumulations occur near Lake Michigan and in the higher elevations of northern Lower Michigan. For example, the average snowfall ranges from 141 inches in the Gaylord area to 101 inches in Traverse City in the northwest region of the Lower Peninsula.

Ice and Sleet Storms are storms that generate sufficient quantities of ice or sleet that result in hazardous conditions and/or property damage. Ice storms occur when cold rain freezes on contact with the surface and coats the ground, trees, buildings, and overhead wires with ice. Often times, ice storms are accompanied by snowfall, which sometimes causes extensive damage, treacherous conditions, and power loss. On the other hand, sleet storms are small ice pellets that bounce when hitting the ground or other objects. It does not stick to trees or wires, but can cause hazardous driving conditions. When electric lines are down, households are inconvenienced, and communities experience economic loss and the disruption of essential services.

According to the 2019 Michigan Hazard Mitigation Plan, Michigan has 16 average annual ice and sleet storm events with 0.2 average annual deaths, 0.5 average annual injuries, and \$11.4 million in average annual property and crop damage.

Location

Extreme winter weather events are regional events that are not confined to geographic boundaries and can affect several areas at one time with varying severity depending on factors such as elevation and wind patterns. All of Antrim County is at risk to the occurrence and impacts from extreme winter weather; the county is more susceptible to lake-effect snow due to proximity to Lake Michigan.

One of the highest-impact snowstorms in recent memory pounded Northern Michigan on the night of March 2, 2012. Low pressure tracked from Missouri, to southern Lower Michigan, and on to eastern Canada, while rapidly strengthening. Precipitation surged northward into the region on the evening of the 2nd. This was primarily snow, except in parts of east central Lower Michigan (especially near Lake Huron), where temperatures were mild enough for rain. Snow wound down on the morning of the 3rd, and though somewhat blustery winds occurred behind the system on the 3rd, blowing snow was limited because the snowfall was so wet. Snow totals ranged from 6 to 14 inches across most of Northern Michigan. Higher amounts fell near and west of Grand Traverse Bay, with a maximum amount of 20 inches near Lake Ann. With relatively warm temperatures, the snow was very wet; Traverse City saw around a foot of snow during the night, with a low temperature of 33 degrees. The snow stuck to everything, with the weight of the snow downing many, many trees and power lines. Power outages were widespread, with an outright majority of Northern Michigan residents losing power at some time during or after the storm. In Benzie County, 95 percent of residents lost power. Outages lasted up to a week in some spots. Great Lakes Energy described it as the worst snowstorm (in regards to power outages) in 30 years. A number of counties and communities opened shelters to aid those without power or heat. Also included in the tree damage was substantial damage to fruit trees in the Grand Traverse Bay region, particularly cherry trees. This event accounts for \$600,000 in reported damages.

The frost/freeze event on listed in Table 17 took place on April 27, 2012 across Northwest Lower Michigan, but especially in the Traverse City region. A killing freeze caused extreme damage to agriculture, particularly in the fruit belt of Northwest Lower Michigan. Traverse City saw low temperatures of 25 degrees on the 27th, 31 degrees on the 28th, and 26 degrees on the 29th. These values were not exceptionally colder than normal lows, which are in the middle 30s. Ultimately, the main culprit was a stretch of unprecedented warmth in mid-March, which included five consecutive 80-degree days (17th-21st). This caused fruit trees to bud out far, far ahead of schedule, and left them vulnerable to even relatively normal weather as the spring progressed. The tart cherry crop was a total loss, while other orchard fruits such as sweet cherries, apples, pears, and peaches saw losses in excess of 90% of the expected crop. Total crop losses for the region were estimated at ten million dollars.

Extent

Snowstorms can be measured based on snowfall accumulations or damages. According to the Antrim County Road Commission's annual snowfall records dating back to the 1938-39 season, the average annual snowfall in Antrim County is 149.5 inches. The March 2, 2012 heavy snow event resulted in an estimated \$250,000 in property damages. A November 2007 winter storm caused \$5,000 in property damages. The December 20, 2012 winter storm caused an estimated \$12,000 in property damages and the blizzard in February 2019 caused \$3,000 in property damages.

Extreme winter weather events in total caused \$270,000 in property damages and \$10,000,000 in crop damages on record with NOAA.

Previous Occurrences

Since 1997, and including the 1978 Presidential-declared Emergency and Governor-declared disaster for a blizzard/snowstorm, there have been 162 extreme winter weather events. These include the following types of events reported in Antrim County (Table 17): Heavy Snow, Blizzard, Winter Storm, Ice Storm, Lake-Effect Snow, Winter Weather and Frost/Freeze. In recent years, the more common events are winter storms with moderate snowfall of 5-10 inches; heavy snow, blizzards, and lake-effect snow events have been less common. Nonetheless, extreme winter weather events are the most frequently recorded extreme weather event with the potential to impact the entire county and cause widespread damage. With combined property and crop damages, winter weather events are also the most costly events to occur in the county.

Table 17: Antrim County Extreme Winter Weather Previous Occurrences

Event Type	Number of Events	Property Damage	Crop Damage	Event Year(s)
Winter Storm	64	\$ 17,000	\$ -	1997-2022
Heavy Snow	60	\$ 250,000	\$ -	1996-2020
Lake-Effect Snow	27	\$ -	\$ -	2006-2019
Blizzard	6	\$ 3,000	\$ -	1978*, 1997-2019
Ice Storm	3	\$ -	\$ -	2001, 2005, 2008
Frost/Freeze	1	\$ -	\$ 10,000,000	April 2012
Winter Weather	1	\$ -	\$ -	2006
TOTAL	162	\$ 270,000	\$ 10,000,000	

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

Since 1997, Antrim County has had 161 extreme winter weather events. This averages to about to about 6.3 events every year. The probability of an extreme winter weather event occurring in future years is 100 percent. Heavy snow events have the potential of shutting down towns and businesses for a significant period of time. Blowing and drifting snow with blizzard conditions cause driving hazards. Ice damage may occur when high winds push lake water and ice past the shoreline, causing damage to public infrastructure and residential property. Antrim County remains a leading producer of fruits, tree nuts, and berries with over \$16 million in these products sold (2017 USDA Census of Agriculture). A frost/freeze event of the magnitude in 2012 would decimate more than three quarters of the products sold today. This would be a huge blow to an economy that is also heavily reliant on agriculture and agri-tourism (wineries, orchards, etc.).

During the winter months, the population is largely made up of the base permanent residents. However, there is increasing demand from seasonal residents to purchase property and retire or work remotely from highly desirable northern and coastal communities like those in Antrim County. Many aspects of Antrim County, including natural wooded areas and proximity to lakes/rivers, are attractive to prospective buyers and the permanent population is expected to continue to grow. New residents, especially those locating in remote areas, increase the chance of risk to life and property. Winter-related events cause difficult driving conditions and in the event of an emergency, can make travel increasingly difficult for emergency personnel who may be more frequently dispatched to rural areas.

Thunderstorms and Severe Winds

The National Weather Service defines a “Thunderstorm Wind” event as having winds, arising from convection (occurring within 30 minutes of lightning being observed or detected), with speeds of at least 50 knots (58 mph), or winds of any speed (non-severe thunderstorm winds below 50 knots) producing a fatality, injury, or damage. These storms can also produce lightning, heavy rain (that could cause flash flooding), hail (at least 3/4” diameter), or tornadoes. Severe thunderstorms can occur at any time in Michigan, although they are most frequent during the warm spring and summer months from May through September.

“Strong Wind” and “High Wind” events on record with the NWS are considered severe wind events. Strong Winds are non-convective winds gusting less than 50 knots (58 mph), or sustained winds less than 35 knots (40 mph), resulting in a fatality, injury, or damage. High Winds are sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer, or gusts of 50 knots (58 mph) or greater for any duration (or otherwise locally/regionally defined).

Long-lived wind events associated with fast-moving severe thunderstorms are known as a *derecho* (pronounced similar to "deh-REY-cho"). According to the National Weather Service, a derecho is a widespread, long-lived wind storm that is associated with a band of rapidly moving showers or thunderstorms. Although a derecho can produce destruction similar to the strength of tornadoes, the damage typically is directed in one direction along a relatively straight swath. As a result, the term "*straight-line wind damage*" sometimes is used to describe derecho damage. By definition, if the wind damage swath extends more than 240 miles (about 400 kilometers) and includes wind gusts of at least 58 mph (93 km/h) or greater along most of its length, then the event may be classified as a derecho. A derecho often occurs during the spring or summer; however, it can occur any time of the year.

Severe windstorms can cause damage to homes and businesses, power lines, trees and agricultural crops, and may require temporary sheltering of individuals without power for extended periods of time.

Location

Thunderstorms and severe wind are regional events that are not confined to geographic boundaries and can affect several areas at one time with varying severity depending on factors such as elevation and wind patterns. All of Antrim County is at risk to the occurrence and impacts from thunderstorms and severe winds.

The most damaging event occurred on August 2, 2015. A historic severe weather outbreak in northern Michigan, as multiple waves of severe thunderstorms crossed the region. A passing cold front would finally end the activity during the evening hours. This episode featured widespread straight-line wind damage in parts of northwest lower Michigan, and the largest hail on record in northern Michigan in Ogemaw County. This event resulted in \$600,000 in property damages.

Extent

Thunderstorms can be measured based on wind speed or damages. The average wind speed for events in Antrim is 51.5 knots. Antrim County had a reported \$970,500 in property damages caused by thunderstorms and severe winds since 1995.

Previous Occurrences

Since 1995, there have been a total of 72 thunderstorm/wind and high wind events reported in Antrim County. This is the second-most frequently occurring type of severe weather event in the county.

Table 18: Antrim County Thunderstorm and Wind Events Previous Occurrences

Event Type	Number of Events	Property Damage	Crop Damage	Event Year(s)
Thunderstorm Wind	59	\$ 900,500	\$ -	1995-May 2022
High Wind	12	\$ 70,000	\$ -	1998, 2001, 2003, 2005, 2010, 2015, 2020, 2021
Strong Wind	1	\$ -	\$ -	2001
TOTAL	72	\$970,500	\$ -	

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

Since 1995, Antrim County has had 72 thunderstorm/wind and high wind events. This averages to 2.7 events every year. The probability of an event occurring in future years is 100 percent. Damage from straight line winds usually affects multiple counties through the loss of electricity from trees/tree limbs downing power lines; causing widespread property damage; and potentially exposing the public to severe injury or fatality due to flying debris. The magnitude and severity depend on the county population, seasonal activity, and the spread of development. During the warm or summer months, the base population expands by an estimated 42% to include both the seasonal short-term population. Residents and visitors are attracted to both rural, sparsely populated rural areas and village centers. Mobile home parks, campgrounds, institutions (schools, places of worship, etc.), and numerous annual events that draw a large number of tourists to outdoor recreation areas were identified as specific areas of concern.

ASAP

Hail

Hailstorms occur when a severe thunderstorm produces hail that falls to the ground. Hail is formed when the updrafts of the storm carries water droplets above the freezing level, where they form into rounded or irregular lumps of ice that range from the size of a pea to the size of a grapefruit. When the weight of the hail is no longer supported by the air, it falls to the ground and has the potential to batter crops, dent automobiles, and injure people and wildlife. Sometimes, large hail appears before a tornado since it is formed in the area of a thunderstorm that tornadoes are most likely to form.

According to the 2019 Michigan Hazard Mitigation Plan, Michigan has on average 191 hail storms, an expected annual statewide loss of about \$16.6 million, no deaths, and approximately 1 injury per year. Despite damaging hail occurring in every part of Michigan, the areas of the state most prone to severe thunderstorms (e.g. the Southern half of the Lower Peninsula) are also most prone to large and damaging hail. The majority of the hailstorms occur during the growing season from May through August when crops have the greatest potential to be damaged by hail.

According to the 2012 Michigan Hazard Analysis, the National Weather Service began recording hail activity in Michigan in 1967. The National Weather Service issues forecasts for severe thunderstorms with sufficient warning time to allow residents to take appropriate action to reduce the effects of hail damage to vehicles and some property. However, little can be done to prevent damage to crops. For example, during September 26-27, 1998, a line of severe thunderstorms moved across northern Lower Michigan producing hail up to 2" in diameter, destroying an estimated 30,000-35,000 bushels of apples at area farms, and damaging several homes and vehicles.

Location

Hailstorms are regional events that frequently accompany thunderstorms, and are not confined to geographic boundaries. The severity of hailstorms may range across the affected areas. All of Antrim County is at risk to the occurrence and impacts from hailstorms. According to the National Weather Service, Antrim County is in an area of the United States that has on average two days of hailstorm events per year.

During one particularly strong event on July 17, 2006, hail damage was significant within Antrim County and the region. A strong cold front ran headlong into warm and humid air in place over Michigan. Thunderstorms ignited by midday in Eastern Upper Michigan, and became widespread by late afternoon in Northern Lower Michigan. A large number of storms became severe, as this became the largest severe weather outbreak in Northern Michigan in several years. Millions of pounds of fruit crops were destroyed by hail and wind. The reported hail size in Kewadin was one inch, roughly the size of a quarter.

Extent

According to the NOAA National Centers for Environmental Information, the approximate size of hail is described as follows in Table 19. If a thunderstorm produces hail that is 1 inch in diameter (quarter size) or larger, it is considered to be a severe thunderstorm.

Table 19: NOAA Hail Size Description

Diameter	Size Description
1/4"	Pea Size
1/2"	Mothball Size
3/4"	Penny Size
7/8"	Nickel Size
1" (Severe Criteria)	Quarter Size
1 1/4"	Half Dollar Size
1 1/2"	Walnut or Ping Pong Ball Size
1 3/4"	Golf Ball Size
2"	Hen Egg Size
2 1/2"	Tennis Ball Size
2 3/4"	Baseball Size
3"	Teacup Size
4"	Grapefruit Size
4 1/2"	Softball Size

The greatest extent hail reported in Antrim County was 3 inches on July 8, 2016 in Central Lake. According to the scale, hailstones of this size are equivalent to a tea cup. Numerous vehicles in Central Lake were dented by very large hail, and

some windows were broken. Area fruit crops sustained considerable damage. Approximately 60 percent of the cherry crop in northwest lower Michigan was damaged by the severe thunderstorms with hail in the region that day.

Previous Occurrences

Between 1996 and May 2022, Antrim County had 34 hailstorms reported to NOAA (Table 20). Property damages totaling \$65,000 were reported for the 2016 3” diameter hailstorm event in 2016; the May 2022 event in Alba caused \$30,000 in property damages. A total of \$1,030,000 in crop damages were reported during events in 2006 in Kewadin and 2016 in the Central Lake area. There are no reported injuries or deaths attributed to hail.

Table 20: Antrim County Hail Events, 1996-2021

Location	Date	Magnitude	Property Damage	Crop Damage
EASTPORT	7/8/1996	1.5		
ELK RAPIDS	6/24/1998	0.75		
MANCELONA	6/9/2000	0.75		
KEWADIN	5/15/2001	0.75		
EASTPORT	5/15/2001	0.75		
KEWADIN	5/15/2001	0.75		
CENTRAL LAKE	8/9/2004	0.88		
MANCELONA	6/27/2005	0.88		
KEWADIN	7/17/2006	1		\$30,000
MANCELONA	7/17/2006	1.25		
ELLSWORTH	3/26/2007	0.75		
MANCELONA	10/18/2007	0.75		
ALBA	10/18/2007	1.5		
MANCELONA	6/27/2008	0.88		
CHESTONIA	7/15/2008	0.75		
ALBA	6/8/2011	0.75		
ELLSWORTH	6/8/2011	0.75		
ATWOOD	6/8/2011	1.25		
KEWADIN	6/8/2011	1.5		
BELLAIRE	6/8/2011	0.75		
CENTRAL LAKE	5/20/2012	1		
CLAM RIVER	5/20/2013	0.75		
BELLAIRE	5/20/2013	1		
CHESTONIA	5/30/2013	1		
ANTRIM	9/1/2013	1		
ELK RAPIDS	8/2/2015	1		
TORCH LAKE	8/2/2015	1		
CENTRAL LAKE	7/8/2016	1		\$200,000
CENTRAL LAKE	7/8/2016	3	\$65,000	\$800,000
ALDEN	7/10/2019	1		
MANCELONA MUNI ARPT	6/9/2021	0.75		
ALBA	5/20/2022	1.75		
ALBA	5/20/2022	2.5	\$30,000	
ALBA	5/20/2022	1		
TOTAL			\$95,000	\$1,030,000

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

With 34 hail events reported between 1996 and 2022, Antrim County has a probability of 1.3 hailstorm events in a given year. All existing and future buildings, exposed infrastructure, and populations are at risk from hailstorms since hail causes damage to roofs, brick walls, glass, landscaping, crops, and cars. Manufactured homes and campground populations located throughout the county and are more susceptible to hail damage. Hail can also damage roads, sidewalks, bridges, and above ground utilities. Hail has the potential to cause injury and death, and populations are advised to take shelter when an event occurs.

Riverine and Urban Flooding

Riverine flooding occurs when rivers, streams, and lakes overflow into adjacent floodplains due to prolonged, intense rainfall, rapid snowmelt or ice jams. Flooding can damage or destroy property, disable utilities, destroy crops and agricultural lands, make roads and bridges impassable, and cause public health and safety concerns. Floods occur in the early spring, but also occur in the winter due to ice jams, and during the summer or fall from severe thunderstorms. Flooding caused by severe thunderstorms has a greater impact on watercourses with smaller drainage areas.

Urban flooding occurs when water flows into low-lying areas because it does not have a place to go. This flooding occurs from a combination of excessive rainfall, snowmelt, saturated ground, and inadequate drainage, and is becoming more common in Michigan. Since development is occurring in floodplains, the natural landscape is unable to properly disperse the water. Urban flooding also has the potential to overflow onto docks or other structures with electricity running to them, which increases the risk for an electric shock drowning. Additionally, storm and sanitary sewers are unable to handle the water flows associated with storm events, which can result in sewer overflows and affect the water quality of nearby lakes and rivers, as well as structures with basements or shallow groundwater tables.

According to the 2019 Michigan Hazard Analysis, the most damaging hazard in Michigan, based upon estimated physical damages and known response/recovery costs, appears to be floods. The MSP reports that flooding events have a statewide expected annual loss estimated at more than \$100 million (\$25.69 million had previously been estimated in the 2014 Michigan Hazard Mitigation Plan, but Federal Disaster 4195 confirmed a higher magnitude more in line with earlier MDEQ estimates, as that Metro Detroit flood event was quite similar to Federal Disaster 1346 during the previous decade).

The MSP's 2019 Michigan Hazard Analysis indicates that the Northern Lower Peninsula averages 0.3 annual flooding events, with average annual property and crop damages of \$2,591,244 due to flooding.

Location

The Villages of Bellaire, Central Lake, Elk Rapids, and Ellsworth are at risk for riverine and urban flooding, due to their locations along the Chain of Lakes watershed. One of the three flash flooding events on record with NOAA occurred in the Village of Elk Rapids. Not only does the Village have a fair amount of impervious surface coverage, but the Chain of Lakes waterway outlet connects to Lake Michigan just past the Elk Rapids hydropower dam.

The Chain of Lakes hydrology network begins in Echo Township and continues through Banks Township, the Village of Ellsworth, Central Lake Township, the Village of Central Lake, Forest Home and Kearney Townships, the Village of Bellaire, Custer Township, Helena Township, Torch Lake Township, Milton Township, Elk Rapids Township and the Village of Elk Rapids. These townships and villages are likely to experience riverine flooding from the Chain of Lakes and their tributaries. Other flooding may involve low-lying areas that collect runoff waters; flaws or shortcomings in existing sewer infrastructure; undersized or poorly designed storm water control practices; collective effects of land use and development trends; illegal diversion of water, or actions that interfere with system function.

If the Elk Rapids Dam failed, the immediate impact would be to Dexter Street and adjoining recreation, residential and commercial land uses in the Village of Elk Rapids. If the Bellaire Dam or Cedar Dam failed, immediate impacts would be to adjoining roads and commercial, residential and recreation properties within the Village of Bellaire. Additionally, other roads that cross the Chain of Lakes waterway system often act as dams. Those locations, along with floodplain areas and any nearby development, could be impacted by an upstream dam breach.

Extent/Previous Occurrences

On July 5, 1999, flash flooding occurred after numerous thunderstorms moved across the region with isolated severe wind reports. Training echoes (thunderstorms continuously moving over the same general area) over the Lake Michigan shoreline counties in northwest lower Michigan caused up to 4 inches of rainfall within a few hours. In the Village of Elk Rapids, secondary roads were flooded with 4-6 inches of water.

On August 11, 2021, flash flooding occurred in multiple locations after heavy rain occurred parts of NW lower Michigan. A bridge on Alden highway completely washed out near Comfort Rd, in Helena Township. Two vehicles fell into this road wash out, causing injury to 1 person. Property damages are estimated at \$325,000. Multiple other road sections washed throughout county. A flash flood also occurred in Bellaire as a result of this heavy rain event, with water over M-88 in multiple places.

Probability of Future Events and Vulnerability Assessment

Floods can damage or destroy public and private property, disable utilities, make roads and bridges impassable, destroy crops and agricultural lands, cause disruption to emergency services, and result in fatalities. People may be stranded in their homes for several days without power or heat, or they may be unable to reach their homes at all. Long-term collateral dangers include the outbreak of disease, widespread animal death, broken water or sewer lines causing water supply pollution, downed power lines, broken gas lines, fires, and the release of hazardous materials.

Since 1999, Antrim County has had three flash flood events, which equates to a 7.7% chance that a flash flood would occur in a given year. The magnitude and severity of a heavy rainfall event also depends on the population densities, seasonal activity, and the spread of development. During the warm or summer months, the population expands to include both the permanent resident base population and the seasonal short- and long-term population. The seasonal population is attracted to both rural, sparsely populated rural areas and urban activity centers. Villages are the where many seasonal special events take place, drawing large crowds of people. Additionally, the Cedar River Dam and the Bellaire Dam are categorized as “high hazard potential” dams. The Elk Rapids hydropower dam is a “low hazard potential” dam.

Antrim County has partnered with the US Army Corps of Engineers (USACE) to complete a hydrology study for the Elk Rapids Chain of Lakes watershed. Conducted from 2020-2022, the study consists of two computer models: one that simulates the hydrology of the ERCOL watershed and one that simulates the hydraulics of the ERCOL lakes and connecting rivers. The two models work together to simulate certain types of future rain events. The hydraulic model calculates how high the lake levels will be, and how long it will take the water levels to recede. The report also contains the results of the 100-year storm analysis, along with the results of three scenarios: the impact of the Ellsworth culverts on lake levels upstream; dredging the Intermediate River between Intermediate Lake and the Bellaire Dam; and dredging the Torch River. This new model will serve as an important tool for future hazard preparedness.

Specific flood hazard areas were identified during public meetings and are identified on the Hazard Areas Map provided in Appendix A. Flood hazard information may be obtained from the Flood Rate Insurance Maps (FIRM) available for jurisdictions. In order to delineate potential flood plain areas (seasonal floodplains) for each jurisdiction, Networks Northwest overlaid wetland, soils, and elevation data to determine the most likely flood prone areas. Once overlaid; isolated polygons (areas) were deleted in order to show a more accurate representation of potential flood prone areas along lakes, rivers, and streams. Sources: Temporary/Seasonally Flooded Areas data are from the National Wetland Inventory of the US Fish and Wildlife Service; Hydric soils data are from the county digital soil surveys (were available); and Digital Elevation Model data are from the Center for Geographic Information, Michigan Department of Information Technology.

NFIP Participation Status

FEMA’s online National Flood Hazard Layer (NFHL) is a geospatial database that contains current effective flood hazard data, which support the National Flood Insurance Program. Flood Insurance Rate Maps, or FIRMs, can be viewed for participating areas in the U.S. through the NFHL. The FIRMs aid in better understanding a property’s level of flood risk and type of flooding in the area. The maps show the delineation of the 1% Annual Chance Floodplain Boundary (the “100-Year Flood Boundary”) and the 0.2% Annual Chance Floodplain Boundary (the “500-Year Flood Boundary”).

For a particular river, USGS collects river streamflow data over time, determines the largest flood in each year, and then calculate statistical data for that river. The more years of data available, the more accurate the estimates for the various flood quantiles. As more years of data become available, the estimates become more refined, which can result in revisions to the quantiles and thus revised floodplain boundaries.⁴ Urban development and installation of flood controls can also result in changes in streamflow data over time.

Antrim County participating communities are scheduled to receive updated digital flood maps by the end of 2022 or in 2023. According to the National Flood Insurance Program, there are no residential properties in the county that have suffered repetitive flood losses.

Additionally, Antrim County, in conjunction with the US Army Corps of Engineers (USACE) just completed a Hydrology Study and Model for a major portion of the Elk River Chain of Lakes Watershed. It is anticipated that additional changes to flood maps will be made FEMA late 2024.

⁴ <https://www.usgs.gov/faqs/why-do-values-100-year-flood-seem-change-every-flood>

Table 22: NFIP Participation

Municipality	NFIP	FIRM	Effective	Number
Banks Township	Y	Y	9/1/1988	2606430004B
Central Lake Township		N		
Chestonia Township		N		
Custer Township		N		
Echo Township		N		
Elk Rapids Township	Y	N		
Forest Home Township		N		
Helena Township		N		
Jordan Township		N		
Kearney Township		N		
Mancelona Township		N		
Milton Township	Y	Y	2/2/1983	2606370020B
Star Township		N		
Torch Lake Township	Y	Y	1/17/1997	2604140025B
Warner Township		N		
Village of Bellaire		N		
Village of Central Lake		N		
Village of Elk Rapids	Y	Y	9/30/1988	2606990005C
Village of Ellsworth		N		
Village of Mancelona		N		

Source: FEMA Community Status Book Report

Lightning

Lightning is a random and unpredictable discharge of electricity in the atmosphere between the clouds, air, or ground to equalize the charged regions in the atmosphere. It is still being debated how the electrical charges build up in the clouds. Lightning generally occurs during thunderstorms; however, it can occur without a thunderstorm, such as during intense forest fires and heavy snowstorms. Lightning that occurs without nearby rain is most likely to cause forest fires.

Location

Lightning is not confined to geographic boundaries and is a regional event. Since lightning occurs randomly, it is impossible to predict where lightning will occur and how severe it will be. All of Antrim County is at risk to the occurrence and impacts from lightning.

Extent/Previous Occurrences

There have been two lightning events reported to NOAA for Antrim County. There were no injuries or fatalities.

On September 1, 2000 a series of evening thunderstorms across the region produced lightning that was nearly continuous. One man was killed by the lightning (not in Antrim County) when he and his 9 year old son climbed a small hill behind a shopping mall to view the approaching lightning. The 40 year old father was struck and killed by a lightning bolt. His son was thrown to the ground, but only sustained minor injuries. Lightning that Friday night also disrupted numerous high school football games. Many games were cancelled or postponed until the following Saturday morning. Many of the schools which began play had lengthy delays and many waited an hour or more before fans and players could return to the field. This was widely covered by area newspapers and television stations. The cost of postponed games is not known.

On June 18, 2012, lightning struck a home in Banks Township, Antrim County, igniting a fire that destroyed the home. Property damages were estimated at \$80,000.

Probability of Future Events and Vulnerability Assessment

Since there have been two lightning events that have occurred on record in the last 22 years, there is a 9% chance a damaging lightning event would occur every year. However, not all lightning events may have been reported since events with injuries, deaths, and extensive damages tend to be the only ones reported. Therefore, the number of lightning events and damages are likely higher.

All existing and future buildings, exposed infrastructure, and populations are at risk from lightning events since it may cause structural and wildland fires, loss of electrical and telecommunications equipment, and damage to buildings or vehicles from falling trees struck by lightning. People that work outside or participate in outdoor recreation activities are at a higher risk to be struck by lightning.

Tornado

A tornado is a violently rotating column of air that extends from a thunderstorm to the ground, and can occur anytime during the day and throughout the year. It can only be seen if water droplets, dust, and debris form a funnel. The funnel cloud can have winds that reach up to 300 miles per hour with an interior air pressure that is 10-20% below the surrounding atmosphere's pressure. The length of a tornado path has been reported up to 200 miles. Tornado path widths are generally less than one-quarter mile wide. These storms are the most violent of the atmospheric storms since they have the potential to destroy buildings, uproot trees, hurl objects, and cause loss of life.

According to the National Oceanic and Atmospheric Administration/National Weather Service's Storm Prediction Center, tornadoes cause approximately 60 deaths and hundreds of millions of dollars in property damage each year. According to the 2019 Michigan Hazards Plan, Michigan is located on the northern fringe of the nation's tornado belt and has a statewide expected annual loss of about \$19.6 million due to tornadoes. Michigan also has an average of 18 tornadoes, approximately 4 deaths, and approximately 50 injuries per year. Between 1999 and 2019, Michigan has had 314 reported tornado events with 52.9% as EF0 (weak) or EF1 (moderate), 38.9% reported as F0 or F1 (weak), 6.7% as EF2 (significant) or EF3 (severe), and 1.6% as F2 (strong). In Northern Michigan, tornados are most likely in the summer months, although some have occurred in the spring and fall.

Location

Tornadoes are a regional event that are not confined to geographic boundaries and can affect several areas at one time. Also, the magnitude of tornadoes may range across the affected areas. All of Antrim County is at risk to the occurrence and impacts from tornadoes. It should be noted that it is impossible to predict where and with what magnitude a tornado will touchdown.

The 11 tornadoes described in Table _ have impacted different communities in Antrim County. The first reported tornado first touched down in Long Lake Township and headed northeast into Leelanau County. The second reported tornado began in Acme Township, headed east into Whitewater Township, and continued into Kalkaska County. The third tornado began in Peninsula Township and headed northeast into Antrim County. The fourth and last reported tornado in Grand Traverse County began in western Garfield Township and headed at a sharp northeast angle through the City of Traverse City and into Peninsula Township.

Extent

The Fujita Scale (Table 24) categorizes tornado severity based on observed damage. The six-step scale ranges from F0 (light damage) to F5 (incredible damage). As of February 2007, the National Weather Service uses the Enhanced Fujita Scale (EF Scale). This new scale ranges from EF0 to EF5. Based on the Fujita Scale, Grand Traverse County's most damaging tornado occurred on April 3, 1956 with winds ranging from 210-261 mph. It caused no injuries or deaths, but \$ 250,000 in property damages.

Table 24: Fujita and Enhanced Fujita Scale Comparison

Fujita Scale		EF Scale	
Fujita Scale	3-Second Gust Speed (mph)	EF Scale	3-Second Gust Speed (mph)
F0	45-78	EF0	65-85
F1	79-117	EF1	86-109
F2	118-161	EF2	110-137
F3	162-209	EF3	138-167
F4	210-261	EF4	168-199
F5	262-317	EF5	200-234

Source: FEMA

Previous Occurrences

Between 1950 and May 2022, Antrim County has had eleven reported tornadoes, causing \$564,280 in property damage and two deaths (Table 25). The most destructive tornado was a category F3 in 1974 that caused \$250,000 in property damages and two injuries. The second-most destructive tornado occurred recently, in May 2022. It was an EF1 that began near Alba in Start Township and caused \$175,000 in property damage. This tornado continued in a northeasterly direction into Otsego County, amplifying to an F3 tornado when it hit Gaylord.

Table 25: Tornado Events, 1950- May 2022

Begin Location	End Location	Date	Deaths	Injuries	Scale	Property Damage	Crop Damage
Kearney Twp., S. end of Intermediate Lake		7/16/1958			F1	\$30	
Jordan Twp, near Lilak Creek and M-66	Elmira Twp. (Otsego County)	7/3/1974		2	F3	\$250,000	
Central Lake Twp., M-88 and Sunset Hill Rd.	Warner Twp., North of M-32, west of Tebo School Rd.	7/31/1977			F2	\$250	
Jordan Twp., M-66 south of Old State Rd.	Jordan Twp., Pinney Bridge Rd., N. of the Jordan R.	9/7/1985			F1	\$0	
Milton Twp., east of Chippewa Trail, between Rex Terrace and Miller Rds.	Helena Twp. on Clam Lake, N. of Green Street	7/8/1990			F1	\$0	
Elk Rapids Twp., 3 miles north of Elk Rapids		8/4/1995			F0	\$0	
Torch Lake Twp. on lake MI, between Bay Harbor Club Dr., and San Marino Trail		5/31/1998			F0	\$0	
Helena Twp., SE of Walling Rd. and SE Torch Lake Drive		7/10/2007			EF0	\$4,000	
Elk Rapids Twp., south end of Birch Lake	Elk Rapids Twp., S. of Williams Rd.	8/3/2017			EF0	\$55,000	
Mancelona Twp., west of Dry Lake Rd., north of Wetzel Lake Rd.	Star Twp., NW of Primrose and Eastcott Rds.	8/28/2018			EF0	\$80,000	
Star Twp., north of Olds Rd and west of Keystone Ln.	Star Twp., Old Alba Rd., west of Alba Hwy.	5/20/2022			EF1	\$175,000	
TOTAL		11		2		\$ 564,280	\$ 0

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

Since there have been eleven tornado events reported in the last 71.42 years, this indicates a 15.4% chance a tornado would occur in a given year. While the chance for a tornado is low, if an event occurs, there is potential for a higher magnitude tornado to touch down. Many of the reported historic events have caused property damage.

The county utilizes the “Rave” mass notification system for notification of tornado warnings and watches, along with other severe weather alerts. The system notifies a participant via their mobile or land-line phone. The National Weather Service may concurrently utilize their notification system when deemed necessary in severe weather event situations to send phone notifications to all users within signal of a cellular tower. Additionally, there is one manual emergency siren located in the Village of Mancelona.

Antrim County Emergency Management Department maintains contracts with seven of the eleven local fire stations in the county so that they may be utilized as temporary shelters in the event of an emergency. Those seven are: Torch Lake

Township, Central Lake Township, Mancelona Township, Elk Rapids Township, South Torch Lake Fire District and Milton Township. A full list of temporary shelter locations is included in the Mitigation Strategies section of this plan.

The American Red Cross can set up temporary shelters within 12-24 hours after an emergency event occurs; usually this is done within an existing structure. The two Antrim County Senior Centers in Mancelona and Bellaire, as well as local libraries, have been utilized during regular hours for temporary shelters to be used during the day.

There are no homeless shelters located within Antrim County.

ASAP

Extreme Temperatures

Prolonged periods of very high or very low temperatures are often accompanied by other extreme meteorological conditions, such as high humidity, drought, heavy snowfall, or high winds. Extreme heat or extreme cold primarily affect the most vulnerable segments of the population, such as the elderly, children, impoverished individuals, and people in poor health.

Nationwide, there have been approximately 175 deaths per year that are attributable to extreme heat according to the 2019 Michigan Hazard Analysis. The threats from extreme heat are heatstroke, sunstroke, muscle cramps, heat exhaustion, and fatigue. It is hazardous to livestock and agricultural crops, causes water shortages, exacerbates fire hazards, exacerbates respiratory problems, prompts excessive electrical energy demands, and causes infrastructure failures. Urban areas experience the most serious extreme heat with the combined high temperatures and high humidity that produce a heat-island effect.

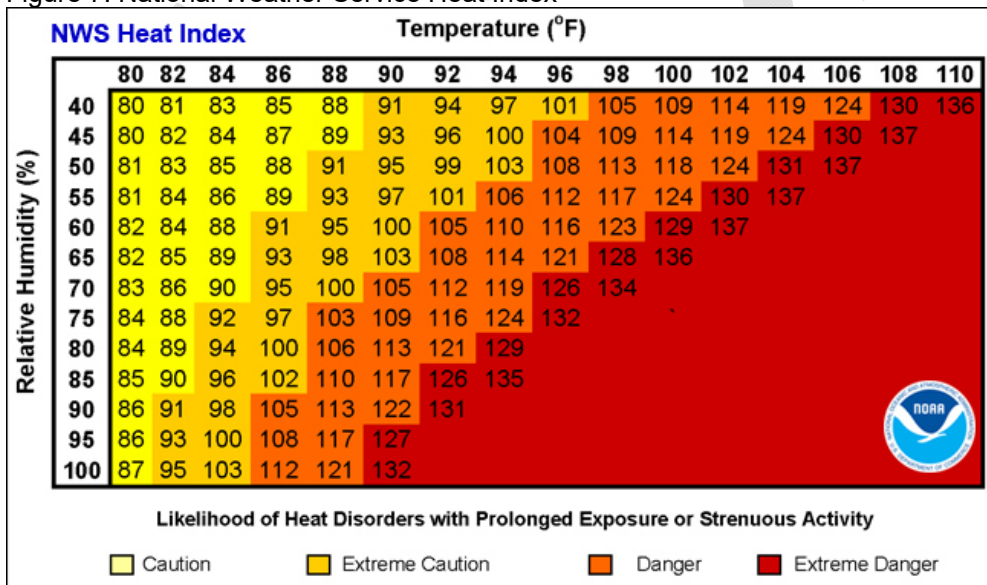
According to the 2019 Michigan Hazard Mitigation Plan, Michigan has 11 average annual extreme heat events with 0.4 average annual deaths and 41 average annual injuries.

In the United States, approximately 700 people die each year as a result of severe cold temperature-related causes according to the 2019 Michigan Hazard Analysis, with a significant number of deaths occurring due to illnesses or disease that are negatively impacted by severe cold weather, such as stroke, heart disease, and pneumonia. Exposure to extreme cold temperatures can be life threatening and can cause hypothermia and frostbite. According to the 2019 Michigan Hazard Mitigation Plan, Michigan has 35 average annual extreme cold events with 1 death, 9.4 average annual injuries, and \$6.4 million in average annual property and crop damage. Extreme cold affects transportation modes and power utilities, resulting in dead vehicle batteries and loss of power/heat.

Measuring Extreme Temperatures (Extreme Heat and Extreme Cold)

Extreme heat is measured with the National Weather Service’s Heat Index Chart (Figure 7). The chart uses relative humidity and air temperature to determine the likelihood of heat disorders with prolonged exposure or strenuous activity. Individuals are unable to shed excess heat from their bodies when they experience prolonged exposure to hot temperatures, which results in heat disorders.

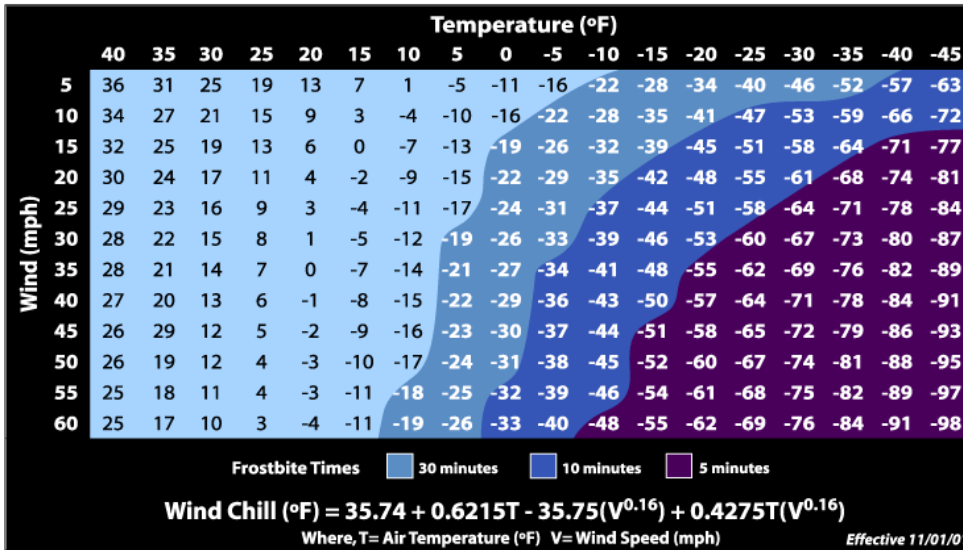
Figure 7: National Weather Service Heat Index



Source: National Weather Service

Extreme cold is measured with the wind chill index, which is a measure of the rate of heat loss from exposed skin caused by the combined effects of wind and cold. As the wind increases, heat is carried away from the body and reduces the external and internal body temperatures. Figure 8 shows the NOAA Wind Chill Chart as it corresponds to various temperatures and wind speeds.

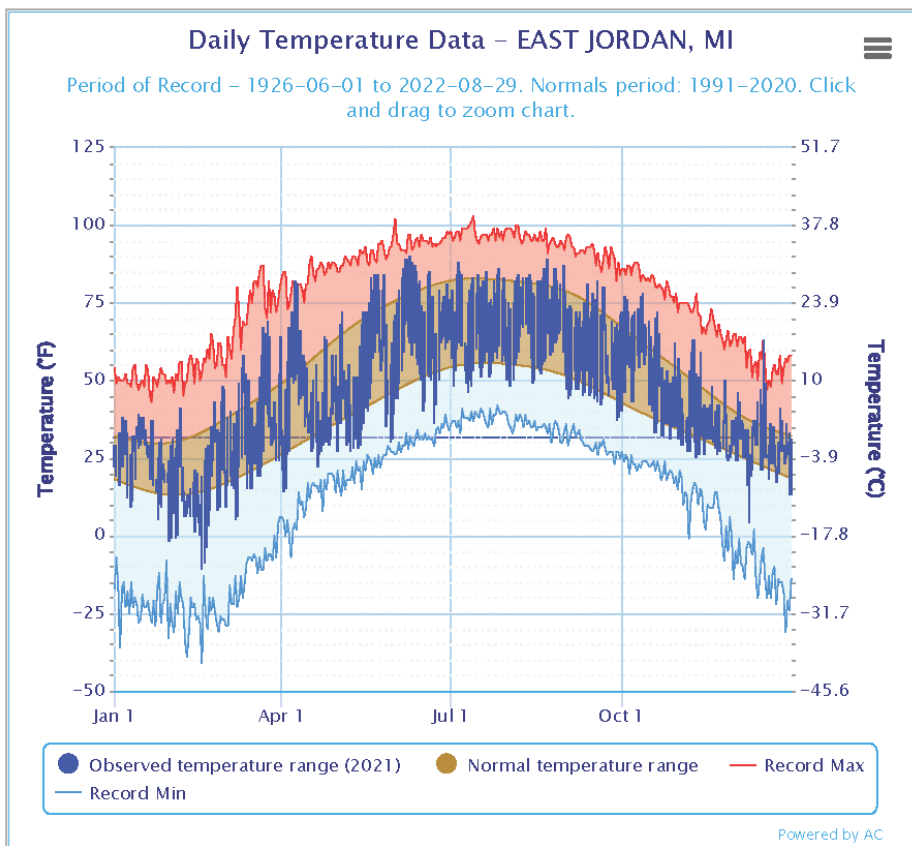
Figure 8: National Weather Service Wind Chill Chart



Source: National Weather Service

Figure 9 are the observed temperatures at East Jordan (in Charlevoix County, adjoining Antrim County to the north) for 2021. The dark blue line shows temperatures recorded between January 1, 2021 and December 21, 2021. The red line above shows record high temperatures for that day, and the light blue line below indicates record low temperatures for that day. Note that maximum record high temperatures were reached in 2021 on April 8 (82 degrees F), April 9 (81 degrees F), and on December 16, 2021 (63 degrees F).

Figure 9: Daily Temperature Data:



Source: NOAA Climate Data Online

Location, Extent and Previous Occurrences

Extreme temperatures are a regional event that are not confined to geographic boundaries and range in severity across the affected areas. All of Antrim County is at risk to the occurrence and impacts from extreme temperatures.

Antrim County has had two extreme heat events in 2001 and 2018. The events did not have any deaths, injuries, or property/crop damages. The heat events consisted of hot and humid conditions that caused outdoor events to be modified and attendance at outdoor events to be lower than normal.

The first instance of reported excessive heat occurred on August 1, 2001. Excessive Heat was also a problem the first two weeks in August across all of northern Michigan. Temperatures reach the mid to upper 90s, on average, a few days each year; however, for a 5 day (8/5 - 8/9) stretch overnight low temperatures failed to fall below the lower 70s in most areas. This very humid air mass was unusual for northern Michigan, an area which typically sees cool nighttime temperatures and for this reason has very few homes with air conditioners. No heat related deaths or injuries were reported; however, most outdoor events were modified due to the forecasts of hot and humid conditions. County fairs sent animals home, yet still there were livestock losses at fairs in Otsego and Alcona counties. Attendance at county fairs was well below normal and this was attributed to the heat. This period of excessive heat also brought on a drought event at the same time.

The second instance of reported excessive heat occurred on June 30, 2018. The month of June closed with one of the hottest days in recent memory. Highs were well into the 90s, including 99 at Alpena, and 98 at Traverse City and Gaylord. The National Weather Service office near Gaylord also hit 98; that was (by several degrees) the warmest reading recorded at that location since observations began there in the late 1990s. Heat indices exceeded 105 degrees across most of northern lower Michigan, and some locations exceed 110. The warmest reported heat index on the day was 114 near Indian River. There were estimated to be between 25 and 30 individuals who visited local hospitals due to heat-related illnesses.

There have been two extreme cold events on record with NOAA for Antrim County. However, it should be noted that since cold temperatures typically occur during winter months, many events may have gone unrecorded. The first reported event occurred on February 4, 2007. Exceptionally cold air surged into Northern Michigan. High temperatures on the 4th (Super Bowl Sunday) were around zero, with low temperatures that night from five to ten below zero. Gusty northwest winds

produced hazardous wind chills of 20 to 30 below zero, along with blowing and drifting snow. Many area schools closed on the 5th, due to the extreme cold and poor road conditions.

The second instance of extreme cold was the Governor Declared Emergency that occurred on January 29, 2019. Wind chills of 15 to 30 below zero were common in northern lower Michigan. Wind chills were much colder in eastern upper Michigan, including -51 at Kinross, and -42 at Sault Ste Marie and Mackinac Island. The low temperatures caused schools to close.

Probability of Future Events and Vulnerability Assessment

There have been two extreme heat events on record with NOAA in Antrim County over the past 20.4 years: one in 2001 and one 2018. This indicates that there is 10.2% chance of another extreme heat occurring in a given year.

There have been two extreme cold events on record with NOAA in Antrim County over the past 14.4 years: one in 2007 and one in 2019. This indicates that there is a 14% chance of another extreme cold event occurring in a given year. Since extreme cold events tend to occur during the winter months and are coupled with blustery winds and snowstorms, these events may have been reported as other hazards or not at all, which means there may have been more extreme cold events in the county.

Extreme heat and cold events are more likely to impact unsheltered populations (i.e., people at campgrounds, outdoor events, and the homeless) as well as the elderly or disabled.

Antrim County Emergency Management Department maintains contracts with seven of the eleven local fire stations in the county so that they may be utilized as temporary shelters in the event of an emergency. Those seven are: Torch Lake Township, Central Lake Township, Mancelona Township, Elk Rapids Township, South Torch Lake Fire District and Milton Township. A full list of temporary shelter locations is included in the Mitigation Strategies section of this plan.

The American Red Cross can set up temporary shelters within 12-24 hours after an emergency event occurs; usually this is done within an existing structure. The two Antrim County Senior Centers in Mancelona and Bellaire, as well as local libraries, have been utilized during regular hours for temporary shelters to be used during the day.

There are no homeless shelters located within Antrim County.

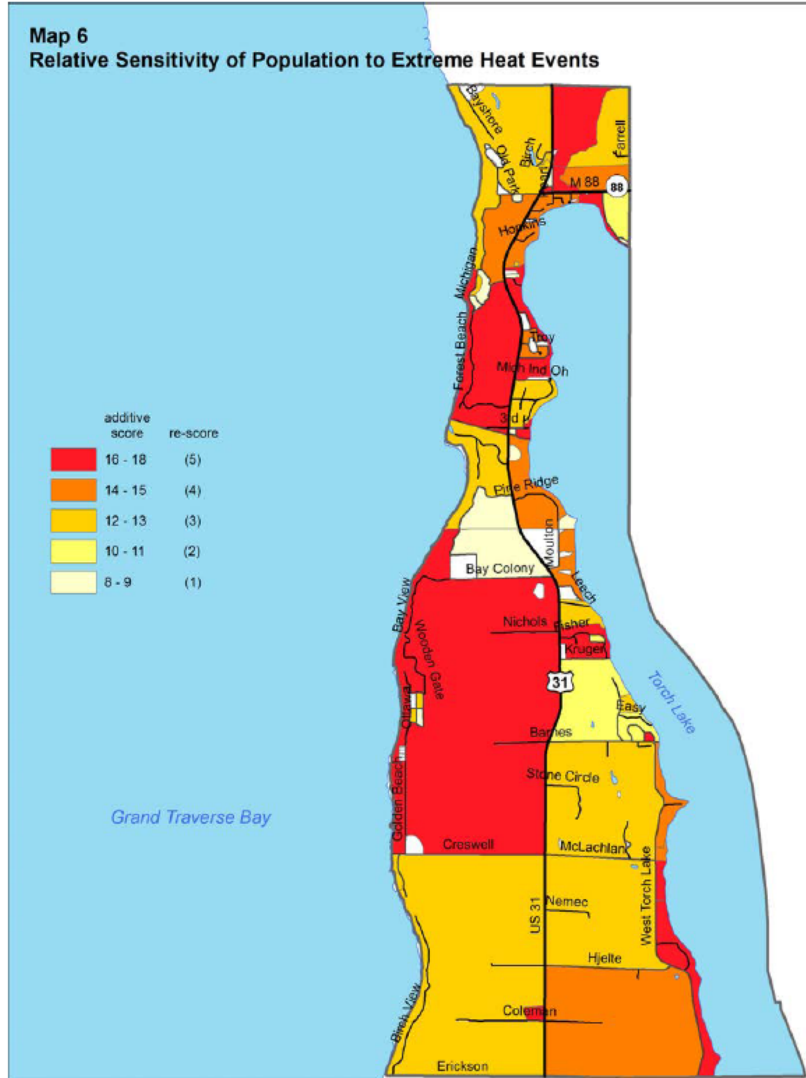
The *Northwest Lower Michigan Coastal Resilience Atlas* written by the Land Information Access Association (LIAA) completed a Heat Vulnerability Assessment⁵ of coastal communities. A community's vulnerability is their exposure to the hazard (determined by tree canopy and impervious surface coverage) + their sensitivity. Sensitivity is determined by the following factors:

- Persons > 65 years
- Persons living alone
- Minority (non-white) persons
- Persons living below the poverty threshold
- People > age 25 with less than a high school education
- Disability status (i.e., ambulatory difficulty, mental disability)

Torch Lake Township has the second highest median age (60.4 years) of all Antrim County communities. Their relative sensitivity to extreme heat events is pictured in Figure 10. Other Lake Michigan shoreline communities in Antrim County consist of Banks Township, Milton Township, Elk Rapids Township and the Village of Elk Rapids. The Heat Vulnerability maps for those communities can be found in pages 804-843.

Figure 10: Torch Lake Township Relative Sensitivity of Population to Extreme Heat Events

⁵ Land Information Access Association. (2019). *Northwest Lower Michigan Coastal Resilience Atlas*. http://www.resilientmichigan.org/nw_atlas.asp



Source: LIAA Northwest Lower Michigan Coastal Resilience Atlas

Drought

Drought is a normal part of the climate cycle. It is a slow-moving hazard, which causes people to underestimate the damage it can do, but losses from drought are as substantial as those from hurricanes, tornadoes and other faster-moving disasters. Drought causes losses to agriculture; affects domestic water supply, energy production, public health, and wildlife; and contributes to wildfire, to name a few of its effects.

Location

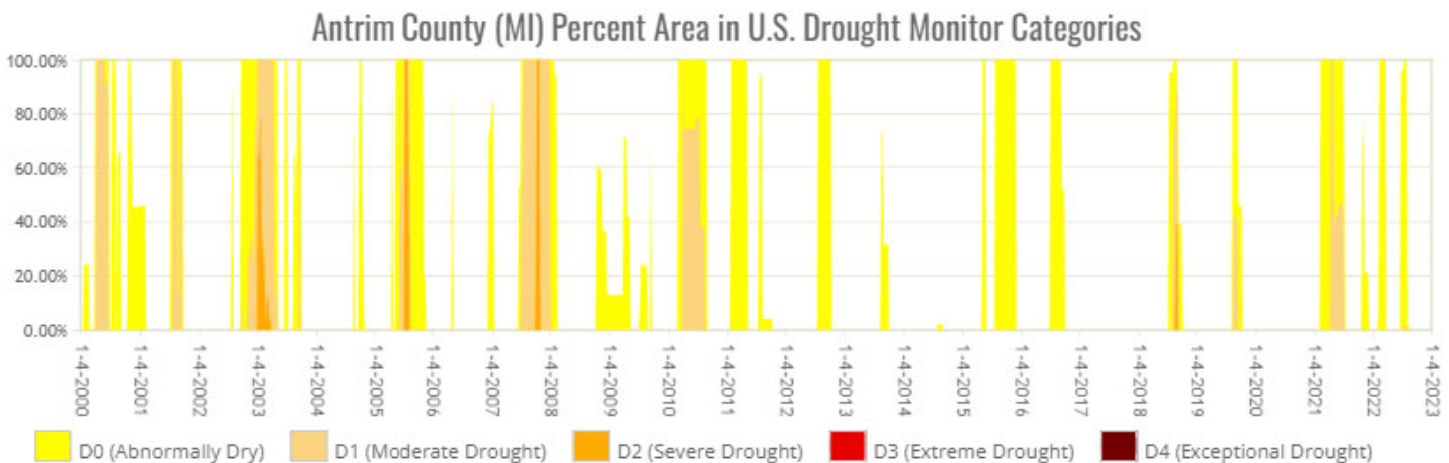
Drought is a regional event that is not confined to geographic boundaries and range in severity across the affected areas. All of Antrim County is at risk to the occurrence and impacts from drought.

Extent

The Palmer Drought Severity Index (PDSI) uses readily available temperature and precipitation data to estimate relative dryness. It is a standardized index that generally spans -10 (dry) to +10 (wet). Maps of operational agencies like NOAA typically show a range of -4 to +4, but more extreme values are possible. The PDSI has been reasonably successful at quantifying long-term drought.

The U.S. Drought Monitor (Figure 11) combines several input sources including the PDSI and the Standardized Precipitation Index to prepare a weekly map showing parts of the U.S. that are in drought. The map uses five classifications: abnormally dry (D0), showing areas that may be going into or are coming out of drought, and four levels of drought: moderate (D1), severe (D2), extreme (D3) and exceptional (D4) (Figure 12).

Figure 11: Antrim County Historical Drought Levels



Source: [US Drought Monitor](#)

Figure 12: U.S. Drought Categories and Historically Observed Impacts

Michigan

Category	Historically observed impacts
D0	Grass fires increase
	Lawns are brown; landscape and gardens are watered more frequently
D1	Most crops and vegetation are stressed; farmed Christmas trees are stressed
	Well levels decline
D2	Corn and soybean yields are low
	Mature trees are stressed
	Streamflow is extremely low, potentially too low to irrigate

Source: [US Drought Monitor](#)

Previous Occurrences

There have been two instances of drought in Antrim County. The first was a Presidential Declared Emergency for drought problems in the State was enacted in 1977 and included Antrim County. The second occurred on August 1, 2001. It was preceded by a warmer than usual July 2001 with less than an inch of rainfall recorded in some areas. This lack of rain and warm conditions became serious during the first two weeks of August when little if any rain fell and temperatures jumped into the 90s. The stress on the crops was most noted in northern Michigan corn, but also hit hay crops to a lesser extent. As a result of the drought, the U.S.D.A. declared several counties disaster areas and granted farmers in counties where the crop losses were 30% or greater, special low interest loans.

Probability of Future Events and Vulnerability Assessment

Between 1977 and May 2022 (45.4 years), there have been two drought events on record. This equates to a 4.4% annual chance for a drought event in Antrim County. In Northern Michigan's forested regions, drought can adversely impact timber production and some tourism and recreational enterprises. This can also cause a drop in income, which impacts other economic sectors. Drought conditions also increase the risk for wildfire. Many portions of Antrim County are heavily forested and can be vulnerable to drought-related wildfire threats. Additionally, the threat to water sources should also be considered. Many county residents rely on ground water wells for drinking water. Even drought events in category D1 experience water well level decline. Drought events combined with excessive heat can have severe impacts on vulnerable populations, such as the elderly and lower income populations.

ASAP

Wildfire

A wildfire is an unplanned, uncontrolled fire in grassland, brushland, or forested areas. Wildfires can occur in any forest or grassland type under dry conditions; however, some forest types are more susceptible to wildland fires. For example, jack and red pine forest stands have a high risk for wildfires, as they depend on fire to provide all the right conditions for regeneration, while aspen and white pine forest stands have a moderate risk. The primary cause of wildfires is from human activities, specifically burning outdoor debris. Wildfires cause destruction to property and timber resources, and injuries or loss of life to wildlife and persons living or recreating in wildfire prone areas. Long-term effects include scorched and barren land, soil erosion, landslides/mudflows, water sedimentation, and loss of recreational opportunities.

Approximately 55% (20.4 million acres) of Michigan's total land area is forest cover. The vast forests provide Michigan with the largest state-owned forest system in the United States. In addition, Michigan has the fifth largest quantity of timberland acreage, with 19.3 million acres (including hardwoods and softwoods). That vast forest cover is a boon for both industry and recreation, and these areas have been gradually increasing in recent years. However, it also means that many areas of Michigan are vulnerable to wildfires.

Michigan's fire season starts in early spring, when leaves and grasses remain dry from fall and winter and trees are not yet green. Wildfires are often accompanied by drought where dry conditions increase the potential to burn. Often a thunderstorm will roll through and lightning will strike causing sparking of dry leaves and dead wood. High winds can then spread wildfire. Wildfires can become unpredictable in windy conditions or when the wind changes direction suddenly. Cooler nighttime temperatures often help suppress wildfires and the potential for wildfire; however Michigan has had several major fire events.

According to MDNR and U.S. Forest Service records, between 1910 and 1949, over 5.8 million acres of forest were burned, an average of 145,000 acres per year. By comparison, it was reported that between 1950 and 1996, the MDNR and U.S. Forest Service were involved in suppressing over 46,100 wildfires that burned 390,000 acres of forest, which averages only 8,300 acres burned per year. This drastic reduction in the acres of timber burned was largely the result of (1) increased use of specialized equipment to suppress the fires, and (2) intensified efforts toward fire prevention.

However, lightning strikes are not the primary cause of wildfires in Michigan. Recently, only about 4% of all wildfire in Michigan were caused by lightning strikes, and most other causes have been attributed to human activity. Outdoor debris burning is the leading cause of wildfires in Michigan. Most Michigan wildfires occur close to where people live and recreate, which puts both people and property at risk. The immediate danger from wildfires is the destruction of property, timber, wildlife, and injury or loss of life of persons who live in the affected area or who are using recreational facilities in the area.

Location

All of the county's communities and developed areas are vulnerable to wildfires since the community centers and rural residential developments interface with the high risk forest types (e.g. Red Pine, Eastern White Pine, and Jack Pine). Approximately ___ acres or ___% of Antrim County is forested. Jack Pine forests make up ___ acres of forested land. As shown on the Environmental Features Map in Appendix A , Pine forests are located primarily in _____. These townships and villages are located in the _ area of the county where it is heavily forested and are highly susceptible to wildfire events.

Extent and Previous Occurrences

Extent can be measured by the number of acres burned and the cost of property damage. Between 1981 and 2018 there were 256 reported wildfires on lands under MDNR jurisdiction. This resulted in 285 total acres burned, or an average of 7.5 acres burned/6.7 wildfires per year. No property damages were recorded.

Probability of Future Events and Vulnerability Assessment

There is a 100% chance there will be a wildfire on MDNR lands in a given year, and a small chance there will be a wildfire on lands outside of MDNR jurisdiction. Forest types (Red Pine, Eastern White Pine, and Jack Pine) within Antrim County are susceptible to wildfires. Additional factors that increase fire risk include dead or dying Ash trees as a result of disease/invasive species, lightning strikes, and human factors such as the number of persons residing, camping, or traveling through the County. Historically, Michigan's landscape has been shaped by wildfire; however, over the last several decades, the current landscape has transformed from wildland to residential development. With the increase in residential development in and around rural areas prone to wildfires, there is an increase in the potential for loss of life and property damage. Unfortunately, rural areas do not have enough fire suppression forces available to protect every structure from wildfires. Residential development in rural Antrim County is often isolated from town centers and

emergency services. Those subdivisions that are located in rural areas near Jack Pine forests are identified on the Vulnerable Populations and Hazard Areas Map in Appendix A.

Shoreline Hazards (Coastal Flooding and Coastal Recession)

Shoreline hazards include coastal flooding and coastal recession. Coastal recession (subsidence) is the wearing away of land, such as loss of riverbank, beach, shoreline, or dune material. It is measured as the rate of change in the position or displacement of a riverbank or shoreline over a period of time. Short-term erosion typically results from periodic natural events, such as flooding, hurricanes, storm surge, and windstorms, but may be intensified by human activities. Long-term erosion is a result of multi-year impacts such as repetitive flooding, wave action, sea level rise, sediment loss, subsidence, and climate change. Death and injury are not typically associated with erosion; however, it can destroy buildings and infrastructure. Waters of the Great Lakes may cause shoreline hazards to occur making the entire northwest Michigan coastline is susceptible to shoreline hazards. As indicated in Figure , large portions of the Lake Michigan shoreline throughout west Michigan are identified as “High Risk Erosion Areas in 2019.”

Figure : Great Lakes Shorelines with High Risk Erosion Areas, 2019



Shoreline flooding results when water levels rise and push inland or during rainfall or snowmelt accumulates and is not able to drain properly. Shoreline flooding may also be caused during storms and wind events with high-energy waves. In developing the *Northwest Lower Michigan Coastal Resilience Atlas*, scenario planning was used to determine the potential impact of three differing levels of storms combined with high waters. The three scenarios are described as follows:

The first scenario, **“Lucky” Future**: Under the Lucky Climate Future, Great Lakes water levels will continue to stay relatively low. Although there will be wave and wind action, major storm events and wave impacts will not encroach on properties landward of current beaches. A Lucky Future projection, indicating the land areas that would be affected by high-energy waves along the shoreline and/or adjacent riverine flooding under these conditions, is shown in green on the maps.

“Expected” Future: Under the Expected Climate Future, Great Lakes water levels will continue to fluctuate according to long-term decadal patterns, including recent extreme storm events incorporated into the ongoing Great Lakes Coast Flood Study being conducted by the Federal Emergency Management Agency (FEMA). Given those ongoing fluctuations, this Climate Future accounts for periods when Great Lakes still-water elevations are closer to the long-term average. In addition, this Climate Future anticipates the so-called “100-year storm event” (or 1% storm) becoming more like a 20- or 50-year storm event (i.e., an expected storm within the normal community planning time horizon) because of increased storminess. The Expected Future projection is shown in yellow on the maps.

“Perfect Storm” Future: Under the Perfect Storm Climate Future, Great Lakes water levels will continue to fluctuate according to decadal patterns, consistent with assumptions made for the Expected Future. However, for this Perfect Storm Climate Future, the estimated still-water elevation is set higher than the long-term average and closer to the long-term high (583 feet). In addition, this Climate Future anticipates the occurrence of a so-called “500-year storm event” (or 0.2% storm) occurring within the planning time horizon while lake levels are high. The Perfect Storm Future projection is shown in red on the maps.

Location

To reference the *Northwest Lower Michigan Coastal Resilience Atlas*, “Climate scientists predict that northwest Lower Michigan can expect more frequent storms of increasing severity in the decades ahead. The total amount of rainfall per year is also likely to increase. The potential for substantially larger rain events and severe storms raises concerns of harm to human health and damage to buildings and infrastructure, especially for areas along the Lake Michigan coastline.”

The following Antrim County jurisdictions are located on the Lake Michigan coast (Grand Traverse Bay) and are impacted by shoreline hazards: Banks Township, Torch Lake Township, Milton Township, Village of Elk Rapids and Elk Rapids Township. LIAA documented potential shoreline hazards for these communities in the *Northwest Lower Michigan Coastal Resilience Atlas*. Specific areas of shoreline hazards were identified during public input sessions. These are marked as a hazard area on the Hazard Area Map in Appendix A.

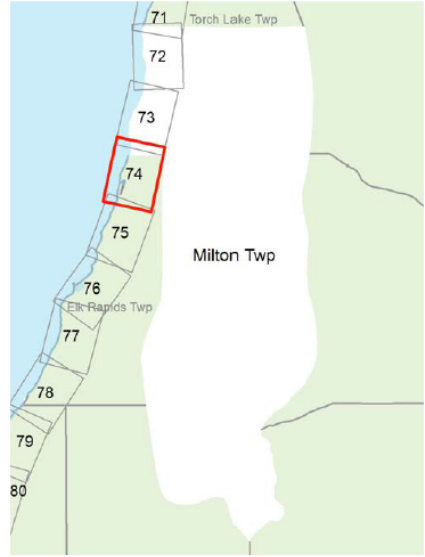
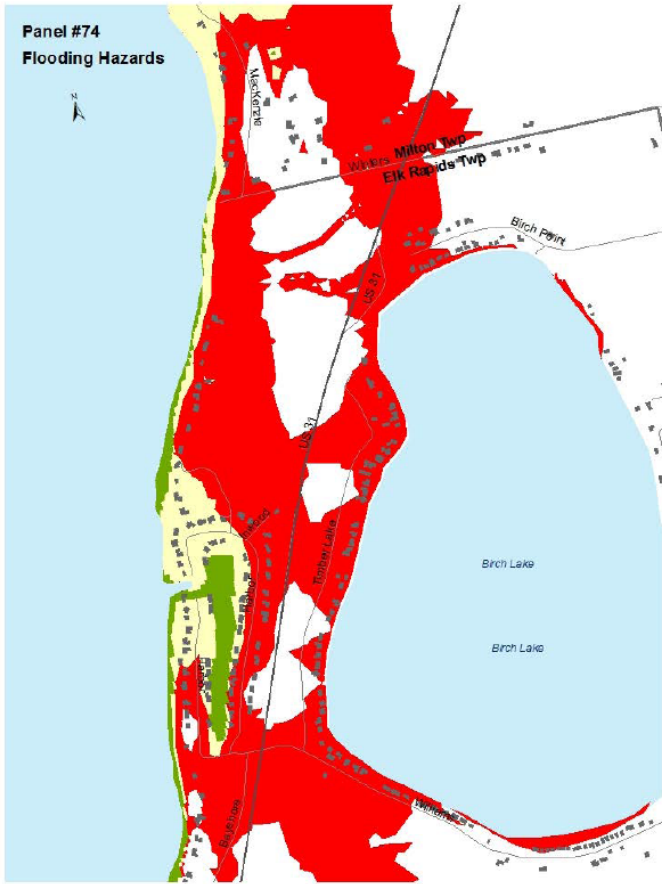
Antrim County



Source: LIAA, Northwest Lower Michigan Coastal Resilience Atlas

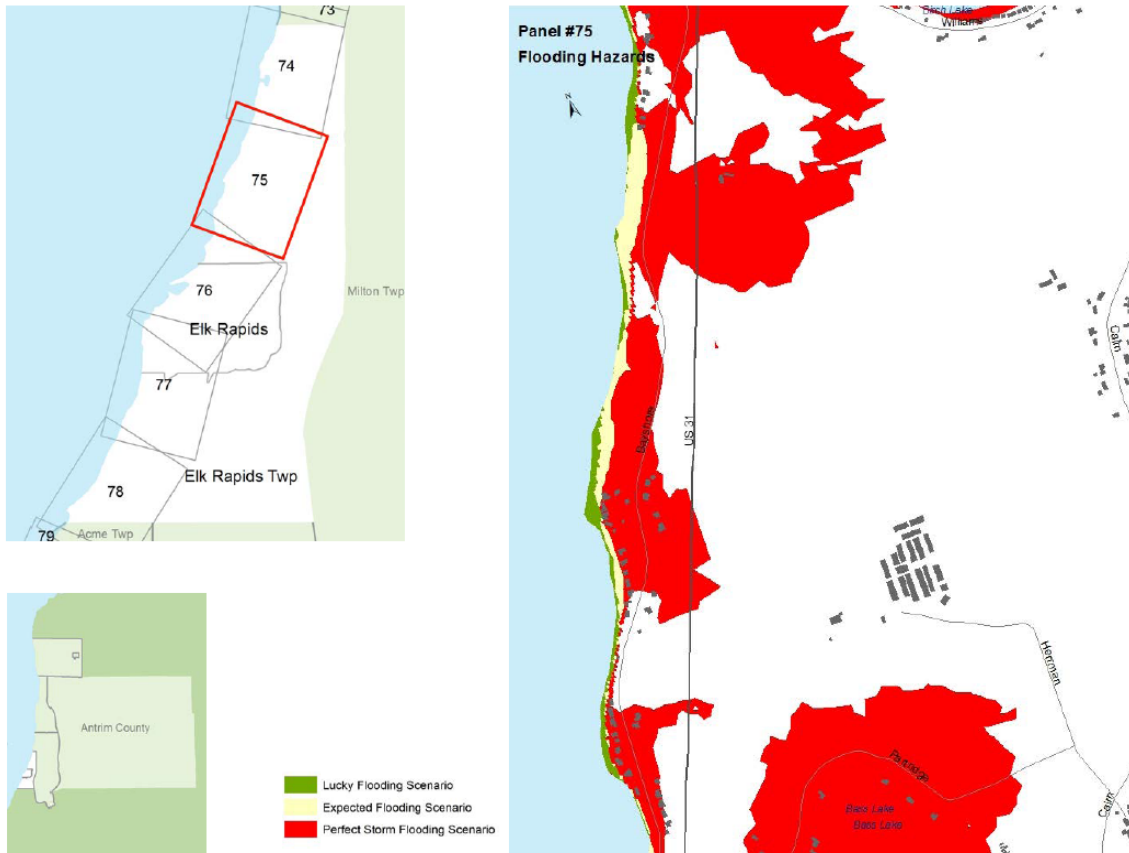
Figure 13 - 15 illustrate the three potential flooding scenarios at Elk Rapids Village/Elk Rapids Township. “Lucky” scenario flooding is shown in green, “Expected” flooding scenario is shown in yellow, and “Perfect Storm” future scenario is shown in red. These communities would bear the greatest impact out of all Antrim county coastal communities in a “Perfect Storm” flooding scenario.

Figures 13 -15: Panels #74 and #75 Coastal Flooding Scenario, Elk Rapids Township/Village of Elk Rapids



- Lucky Flooding Scenario
- Expected Flooding Scenario
- Perfect Storm Flooding Scenario

AS



Coastal recession or erosion to Lake Michigan communities is a constant, but very small wearing away of the shoreline. The Great Lakes are estimated to lose one foot of shoreline per year to normal wave and wind activity. However, storms and increased wave activity have caused increased coastal recession to varying degrees in Antrim County's coastal communities.

Chapter 4 of the *Northwest Lower Michigan Coastal Resilience Atlas* describes bluffline recession since its recorded shoreline in 1938. The blue line indicates the shoreline in 1938, the green line indicates the bluffline in 1938, the yellow line is the bluffline in 2016, and the red line is the predicted 30 year bluffline. The overall shoreline recession areas are shown in Figure 14 for Banks Township. Detailed maps of shoreline recession boundaries for all Antrim County coastal communities are appended.

Figure 14: Shoreline Recession, Banks Township

Banks Twp.



- Shoreline 1938
- Bluffline 1938
- Bluffline 2016
- Predicted 30yr Bluffline

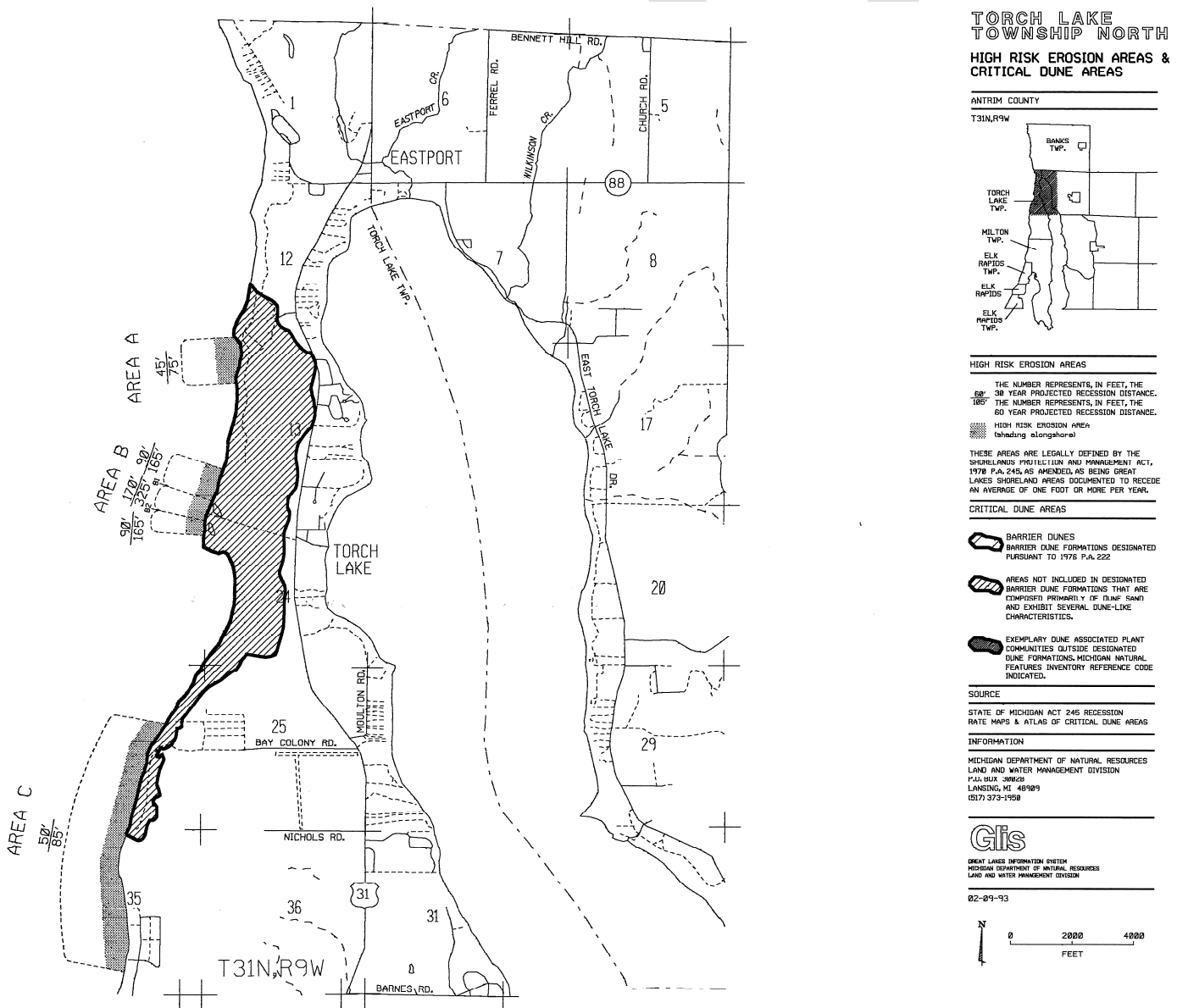


Source: LIAA, Northwest Lower Michigan Coastal Resilience Atlas

Additionally, all of the coastal communities in Antrim County contain several areas of "High Risk Erosion Areas", as designated by the State of Michigan's EGLE. Figure _ illustrates one of the maps from that report, for Torch Lake Township. Torch Lake Township also contains State-designated "Critical Dune Areas", which are areas not included in the designated Barrier Dune Formations that are composed primarily of dune sand and exhibit several dune-like characteristics.

High risk erosion areas are those shorelands of the Great Lakes where recession of the landward edge of active erosion has been occurring at a long-term average rate of one foot or more per year, over a minimum period of 15 years. EGLE staff conducted the initial recession rate research of coastal counties between 1980 and 1986; during that time they identified high risk erosion areas in 36 of 41 coastal counties. An EGLE permit is required prior to construction on a parcel in a high risk erosion area regardless of where the structure is proposed on the parcel. Any person or local governmental agency proposing to erect, install, move, or enlarge a permanent structure on a parcel must obtain a permit prior to the commencement of construction.

Figure __. EGLE's Map of High Risk Erosion Areas and Critical Dune Areas for Torch Lake Twp. (North)

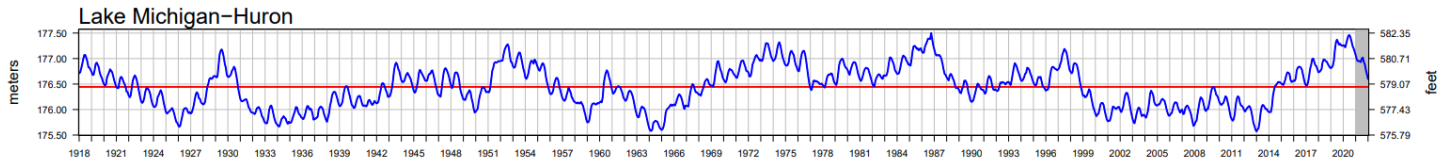


Extent

Shoreline recession can be measured by feet of bluffline retreat and property damages. Bluffline retreat distances vary across the county, and there are no reported damages from bluffline recession. Shoreline flooding can be measured by flood water levels, inches of rainfall, lake water levels (shown in Figure 15), and damages.

In recent years, the swings in water levels have been unprecedented. In January 2013, Lake Michigan-Huron set an all-time record low of 576.02 feet, and seven years later in July of 2020 Lake Michigan-Huron reached a monthly record high of 582.22, only second to the October 1986 monthly record high of 582.35.

Figure 15: Lake Michigan-Huron Historic Water Levels, 1918-2021



LAKES MICHIGAN-HURON

2021	580.94	580.68	580.54	580.54	580.54	580.48	580.71	580.77	580.48	580.41	579.95	579.69	580.48
Mean	578.48	578.44	578.48	578.77	579.07	579.30	579.40	579.33	579.17	578.94	578.77	578.61	578.90
Max	581.56	581.53	581.43	581.69	581.96	582.19	582.22	582.09	581.96	582.35	581.96	581.56	
	2020	2020	2020	2020	2020	2020	2020	2020	1986	1986	1986	1986	
Min	576.02	576.08	576.05	576.15	576.57	576.64	576.71	576.67	576.64	576.44	576.28	576.15	
	2013	1964	1964	1964	1964	1964	1964	1964	1964	1964	1964	2012	

Source: US Army Corps of Engineers

Previous Occurrences

The Great Lakes experienced record high lake levels in 1985-86, and again in 1997-98. As of 2021, Lake Michigan is at a higher than average level, retreating from the record high levels of 2020. The recent high lake levels have contributed many areas of coastal erosion as well as backups of rivers and tributaries, causing infrastructure damage and failures throughout Antrim County and many other areas in Michigan.

Probability of Future Events and Vulnerability Assessment

While there are no records of shoreline flooding or erosion (subsidence) on record with NOAA for Antrim County, that does not mean there is 0% risk of such an event occurring in the future. Shoreline or soil erosion hazards involve the loss of property or necessitate the relocation of homes as sand or soil is removed by flowing water (lake, river, etc.) and carried away over time. The foundation of a structure, or underground utility pipes in the area, may become fully exposed and vulnerable to weather, extreme temperatures, water damage, or other sources of risk. Shoreline banks that support roadways may erode and cause the road surface to crack, become unstable, or more prone to deposits of sand, snow, water, and ice. This hazard is especially relevant to those municipalities that contain residential and commercial development along Grand Traverse Bay (Banks Township, Torch Lake Township, Milton Township, Village of Elk Rapids and Elk Rapids Township) that experience seasonal shifts in water levels and possible ice erosion hazards.

As lake water levels fluctuate and increased storminess occurs, shoreline recession and flooding will continue. In 2021 the levels of Lake Michigan-Huron began to decline, however, as historic data shows us, the water will begin to rise again. Those communities that have already faced shoreline hazards are likely to experience issues in the future. Changes in land use practices and improvements to the shoreline such as natural vegetation plantings or shoreline armoring may reinforce the shoreline for a period of time, but is likely not a permanent solution.

Storm Surges (Seiches) and Rip Currents

Seiches are typically caused when strong winds and rapid changes in atmospheric pressure push water from one end of a body of water to the other. When the wind stops, the water rebounds to the other side of the enclosed area. The water then continues to oscillate back and forth for hours or even days. In a similar fashion, earthquakes, tsunamis, or severe storm fronts may also cause seiches. A seiche may occur in any semi- or fully enclosed body of water.

Rip currents are powerful, channeled currents of water flowing away from shore. They typically extend from the shoreline through the surf zone, and past the line of breaking waves. Typically, they form at breaks in sandbars, and also near structures, such as jetties and piers, as well as cliffs that jut into the water. Rip currents are common and can be found on most surf beaches, including the Great Lakes.

Nearby Leelanau County has a history of Seiche events and Benzie, Emmet, Leelanau, and Manistee Counties have a history of rip current events. Each county has a recorded death due to a rip current event.

There is a possibility of a storm surges (seiches) and rip current event in Antrim County; however, the likelihood of an event is very small. There are no seiche or rip current events listed in the NCEI database for Antrim County. There also have not been any reported coastal hazard (rip current) incidents along Antrim County's Lake Michigan shoreline according to the [Great Lakes Current Incident Database](#). Therefore, seiches and rip currents have been removed from the hazard analysis.

Public Health Emergency (Infectious Disease)

Public health emergencies occur when there is a widespread and/or severe epidemic, contamination incident, bioterrorist attacks, or other situation that negatively impacts the health and welfare of the public. These emergencies include disease epidemics, large-scale food or water contamination incidents, extended periods without adequate water and sewer services, harmful exposure to chemical, radiological or biological agents, and large-scale infestations of disease-carrying insects or rodents. A common characteristic of public health emergencies is that they impact or have the potential to impact a large number of people either statewide, regionally, or locally in scope and magnitude. These health emergencies can occur as primary events or as secondary events from another hazard or emergency (e.g. flood, tornado, or hazardous material incident).

Location

Public Health Emergency can be a worldwide, national, state or regional event that is not confined to geographic boundaries and range in severity across the affected areas. All of Antrim County is at risk to the occurrence and impacts from an infectious disease. Depending on the type of disease, different populations are more susceptible.

Extent

The extent of a public health emergency can be determined by the number of cases and deaths, and the amount of money spent to prepare for and respond to public health threats. In Antrim County, the Health Department of Northwest MI works with local, state, and federal agencies to prepare for and respond to public health threats. It developed a comprehensive emergency preparedness program capable of responding to a variety of emergency situations with funds from the Centers for Disease Control. The State of Michigan reports, as of January 3, 2023, there are 5,201 cumulative cases of COVID-19 and 76 deaths. Those 80 years and older have the most deaths of any age range at 28 deaths.

Previous Occurrences

Throughout the years, there have been many pandemics. For example, there was an outbreak of severe acute respiratory syndrome (SARS) in 2003. This virus was a new coronavirus that resulted in over 8,000 illnesses worldwide. Of these, 774 died. Since 2012, Middle East respiratory syndrome (MERS), a coronavirus, has been reported in 27 countries where there have been approximately 2,494 people infected and 858 deaths. In 2017, the World Health Organization (WHO) put SARS and MERS on its priority pathogen list to spur further research into coronaviruses. More recently in 2020, a Presidential and Governor Emergency was declared for COVID-19 Pandemic in Michigan.

Probability of Future Events and Vulnerability Assessment

Naturally occurring pandemics may result in widespread precautions around the world. The Antrim County Health Department created a pandemic plan that serves as a template for responding to a large-scale outbreak of influenza and other highly infectious respiratory diseases. That plan is being tested currently since COVID-19 appeared in January 2020. The response is ongoing to this pandemic. The elderly, immune-compromised, and low income populations are most vulnerable to public health emergencies.

Invasive Species (Add Autumn Olive)

The National Invasive Species Council defines an invasive species as, "A species that is not native and whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health." The Council was formed under Presidential Executive Orders 13112 and 13751 to prevent the introduction and spread of invasive species, and to support efforts to eradicate and control invasive species that are established throughout the United States. NOAA's National Ocean Service identifies invasive species as "capable of causing extinctions of native plants and animals, reducing biodiversity, competing with native organisms for limited resources, and altering habitats." Invasive species harmful to Michigan and Antrim County may be either terrestrial invasive species (TIS) or aquatic invasive species (AIS).

Terrestrial invasive include non-native, land-based plants, insects, animals and diseases that harm Michigan's environment, economy, and human health. Aquatic invasive (water-dwelling) species include non-native plants, animals, and other organisms that have evolved to live primarily in water (aquatic habitats) rather than on land. Aquatic habitats are habitats that are covered with water all or part of every year. Michigan State Departments cooperated to prepare the Terrestrial Invasive Species State Management Plan and the 2013 Aquatic Invasive Species State Management Plan Update: *Prevention, Detection, and Management in Michigan Waters*. Each plan outlines a statewide strategy to reduce the environmental and economic damages caused by either TIS or AIS.

Location

Combined, terrestrial and aquatic invasive species may be present in Antrim County forest, wetland, farmland, grassland, aquatic, shoreline, and urban environments. "A Field Guide to Invasive Plants of Aquatic and Wetland Habitats for Michigan" (Campbell, Higman, Slaughter, Schools) identifies the Lake Michigan coastline as particularly vulnerable. "Lake-moderated climates along the Lake Michigan shoreline, Saginaw Bay, the Thumb, Lake St. Clair, and western Lake Erie are much milder than those in the state's interior... These areas have the potential to harbor species typically found far south of Michigan."

Extent

According to the 2013 Aquatic Invasive Species State Management Plan, "Since the 1800s, at least 182 nonindigenous aquatic organisms have colonized habitats of the Great Lakes ecosystem. These species include: algae (27), vascular plants (55), invertebrates (66), fish (28), and bacteria and viruses (6) (National Oceanic and Atmospheric Administration 2011). Roughly 55% of these species are native to Eurasia; 13% are native to the Atlantic Coast." The Great Lakes Regional Collaboration estimates that a new aquatic invasive species arrives in the Great Lakes at a rate of one every eight months. The State estimates that \$24 million per year is spent to control aquatic plants in Michigan, including Eurasian Watermilfoil. Additionally, an estimated \$200 million per year is lost by the Great Lakes region due to the effects of ship-born invasive species on sport fishing, commercial fishing, wildlife watching, and raw water usage.

Previous Occurrences

Non-native terrestrial and aquatic species are introduced to Michigan and the Great Lakes both intentionally and unintentionally. Aquatic invasive species are the result of unwanted fish and aquatic plants released from home aquariums, travelled across the ocean in ballast water carried by freighters, or entered from the ocean through human-built channels such as the Welland Canal. There are 32 AIS specifically listed in the State Management Plan. The State TIS Management Plan lists fourteen species including insects, mollusks, plants, mammals, a shrub, and a bird. Top priority plants in the region include garlic mustard, Japanese knotweed, invasive phragmites, and Oriental bittersweet.

Probability of Future Events and Vulnerability Assessment

The Great Lakes and connecting channels and rivers form the largest surface freshwater system in the world. This freshwater system, along with Michigan's inland lakes, streams, rivers, and wetlands represent an invaluable resource and are therefore justifiably a top natural resource management priority. The State of Michigan estimates 42% of threatened or endangered species are considered at risk due to non-native species. The Michigan Department of Environment, Great Lakes, and Energy produced the "Michigan Watch List Aquatic Invasive Plants: A Guide for Identification" for those species that have been identified as posing an immediate or potential threat to Michigan's economy, environment, or human health. Included in the watch list are ten species that have been found in limited parts of Michigan and surrounding states. The State TIS Management Plan provides a list of eleven terrestrial species on the watch list.

The Charlevoix, Antrim, Kalkaska, and Emmet Cooperative Invasive Species Management Area (CAKE CISMA) was established in 2015 as a joint effort between local conservation districts and various non-profits. Their mission is to protect the natural resources, economy, and human health of Northern Lower Michigan through collaborative outreach and management of invasive species. They partner with many other organizations, such as the Antrim Conservation District, Tip of the Mitt Watershed Council, and Grand Traverse Regional Land Conservancy.

Impacts from Climate Change

Climate describes the average weather conditions for a particular location and over a long period of time. The changing climate impacts society and ecosystems in a broad variety of ways. For example, climate change can alter rainfall, influence crop yields, affect human health, cause changes to forests and other ecosystems, and even impact our energy supply. Climate-related impacts are occurring across the country by increasing the severity of storms and weather-related events. Natural disasters then have a direct impact on our economy.

According to a new comprehensive report from the World Meteorological Organization (WMO), “A disaster related to a weather, climate or water hazard occurred every day on average over the past 50 years – killing 115 people and causing \$202 million (US \$) in losses daily. The number of disasters has increased by a factor of five over the 50-year period, driven by climate change, more extreme weather and improved reporting. But, thanks to improved early warnings and disaster management, the number of deaths decreased almost three-fold⁶” (World Meteorological Organization, 2021).

The impacts of climate change already are, and continue to be, deep and widespread in the Great Lakes Region and Michigan as a whole. The National Climate Assessment (NCA) assesses the science of climate change and variability and its impacts across the United States, now and throughout this century. Chapter 21 of the NCA *Fourth National Climate Assessment Volume II: Impacts Risks, and Adaptation in the United States reports*, the Great Lakes influence regional weather and climate conditions and impact climate variability and change across the region. The lakes influence daily weather by:

- 1) Moderating maximum and minimum temperatures of the region in all seasons,
- 2) Increasing cloud cover and precipitation over and just downwind of the lakes during winter, and
- 3) Decreasing summertime convective clouds and rainfall over the lakes.

The Great Lakes Integrated Sciences and Assessments (GLISA) is one of 11 NOAA Regional Integrated Sciences and Assessments teams that focus on helping the nation prepare for and adapt to climate variability and change. A summary of findings from NCA and the GLISA report, *Climate Change in the Great Lakes Region*⁷, are provided to show the impacts of climate change throughout the state of Michigan.

Temperature

Warm-season temperatures are projected to increase more in the Midwest than any other region of the United States.⁸ Since 1951, annual average air temperatures have increased by 2.3°F (1.3°C) in the U.S., Great Lakes region. By mid-century (2050), average air temperatures are projected to increase by 3°F to 6°F (1.7°C to 3.3°C). By end of century (2100), average air temperatures are projected to increase by 6°F to 11°F (3.3°C to 6.1°C).

The frost-free season is projected to increase 10 days by early this century (2016–2045), 20 days by mid-century (2036–2065), and possibly a month by late century (2070–2099) compared to the period 1976–2005 according to the higher scenario (RCP8.5).⁹

Precipitation

Since 1951, total annual precipitation has increased by 14% in the U.S., Great Lakes Region. Future projections suggest more precipitation on average, but not necessarily during all seasons (summer to be drier) and not for all locations depending on which model is used. Reduced lake ice cover and enhanced evaporation may lead to increased lake-effect snowfall in the near-term, but rising temperatures will cause more winter precipitation to fall as rain as opposed to snow across the region by late century.

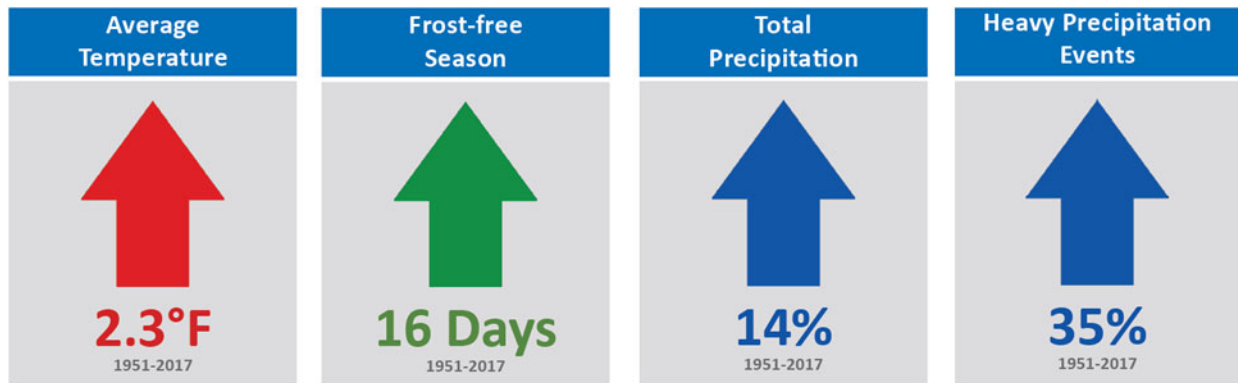
⁶ World Meteorological Organization. (2021, August 31). Retrieved from Weather-related disasters increase over past 50 years, causing more damage but fewer deaths: <https://public.wmo.int/en/media/press-release/weather-related-disasters-increase-over-past-50-years-causing-more-damage-fewer>

⁷ (2019, February 14). Retrieved from Climate Change in the Great Lakes Region: <https://glisa.umich.edu/wp-content/uploads/2021/04/GLISA-2-Pager.pdf>

⁸ Vose, R. S., D. R. Easterling, K. E. Kunkel, A. N. LeGrande, and M. F. Wehner, 2017: Temperature Changes in the United States. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Wuebbles, D. J., D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, Eds., U.S. Global Change Research Program, Washington, DC, USA, 185–206. doi:[10.7930/J0N29V45](https://doi.org/10.7930/J0N29V45).

⁹ Hibbard, K. A., F. M. Hoffman, D. Huntzinger, and T. O. West, 2017: Changes in Land Cover and Terrestrial Biogeochemistry. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Wuebbles, D. J., D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, Eds., U.S. Global Change Research Program, Washington, DC, USA, 277–302. doi:[10.7930/J0416V6X](https://doi.org/10.7930/J0416V6X).

From 1951-2017, the United States, Great Lakes Region, overall, has seen increases in average temperature, frost-free season, total precipitation, and heavy precipitation events.



Snow, Ice Cover and Lake Temperature

Summer lake surface temperatures have been increasing faster than the surrounding air temperatures, with Lake Superior increasing by 4.5°F between 1979 and 2006. Annual average ice cover on the Great Lakes shifted from higher amounts prior to the 1990s to lower amounts in recent decades. There remains strong year-to-year variability, and high ice years are still possible. Lake-effect snowfall has increased in northern areas and may continue to increase through mid-century.

Extreme Weather

The frequency and intensity of severe storms has increased. This trend will likely continue as the effects of climate change become more pronounced. The amount of precipitation falling in the heaviest 1% of storms increased by 35% in the U.S. Great Lakes region from 1951 through 2017. More severe storms may have a negative economic impact due to resulting damages and increased costs of preparation, clean up, and business disruption.

The NCA *Fourth National Climate Assessment Volume II: Impacts Risks, and Adaptation in the United States* states, “Climate change is transforming where and how we live and presents growing challenges to human health and quality of life, the economy, and the natural systems that support us. Risks posed by climate variability and change vary by region and sector and by the vulnerability of people experiencing impacts. Social, economic, and geographic factors shape the exposure of people and communities to climate-related impacts and their capacity to respond. Risks are often highest for those that are already vulnerable, including low-income communities, some communities of color, children, and the elderly” ([Ch. 14: Human Health, KM 2](#); [Ch. 15: Tribes, KM 1–3](#); [Ch. 28: Adaptation, Introduction](#)).

A vulnerability assessment can be found in the two-page report: *Climate Change in the Great Lakes Region* by GLISA. The report identifies key challenges from climate change such as:

- **Public Health**
 - Increased risk of heat waves and increased humidity may amplify the number of heat-related deaths and illnesses.
 - More storm activity and flooding, resulting in increased point- and non-point source pollution, will likely increase watershed contamination and water-borne illnesses, while warmer surface waters amplify the risk of toxic algal blooms and fish contamination.
- **Tourism and Recreation**
 - *Winter recreation/tourism are likely to suffer* due to reduced snow cover and shorter winters. Reduced lake ice cover and enhanced evaporation may lead to increased lake-effect snowfall in the near-term, but rising temperatures will cause more winter precipitation to fall as rain as opposed to snow across the region by late century.
 - Increasing temperatures and a longer summer season may *increase the demand for lake and beach use*.
 - Overall, *summer tourism may grow before temperature rise becomes unfavorable* for outdoor recreation.
 - *The fishing industry* (commercial and recreation) is likely to be impacted by the *decline of coldwater species of fish, such as lake trout and whitefish*.
- **Natural Environment**

- Despite increasing precipitation, land surfaces in the region are expected to become drier overall due to increasing temperatures and evaporation rates.
- More frequent summer droughts could affect soil moisture, surface water, and groundwater supply.
- Increased evaporation rates and sustained levels of high or low water levels may change wetland areas in the region.
- The rate of warming may *outpace the rate at which ecosystems are able to migrate and adapt*.
- *Wildlife populations better adapted to cold temperatures will continue to decline* as competing species migrate into the region with rising air and surface water temperatures.
- *Forest productivity will likely increase in the short term*, until other impacts of climate change such as increased drought, fire and invasive species present additional stressors to forests.

The full two-page report can be found [here](#).

Climate Change has impacted Antrim County in the following ways:

- Residents have reported more water in their basements and crawl spaces in recent years, where they never had issues previously.
- The culvert in Ellsworth between Lake Ellsworth and Lake St. Clair has been determined to be a “chokepoint” according to the USACE Hydrology Study. Areas located above this chokepoint experience very high water levels during and after heavy rain events.
- A section of Rushton Road between Benway Lake and Wilson Lakes in Central Lake Township has deteriorated recently. The Road Commission has put caution signs out alerting drivers of bumps in the roadway. The Road Commission is working to crush, shape and re-pave this portion of this road in 2022.
- The intense rainstorm event in August 2021 blew out the Alden Highway culvert over Finch Creek, which was replaced/rebuilt in the Fall of 2021.

Climate Change is expected to impact Antrim County in the following ways:

- It is anticipated that the County’s population will grow as the northern Michigan region becomes more of a destination to live and visit, as it will comparatively have cooler summers than other southern areas of the State and nation, as well as plentiful groundwater and surface water resources.

Antrim County and partner agencies are preparing for Climate Change using the following:

- Development of a Natural Hazard Mitigation plan which identifies specific community-driven strategies
- Prepared 2023 Elk River Chain of Lakes Hydrology Study
- Currently the Antrim County Conservation District is re-evaluating and revising their Soil Erosion Ordinance to provide better permitting procedures so that surface water resources are protected from land development activities.
- Road/Stream Crossing Inventory underway (status/details?)
- The problematic Ellsworth culvert on the Chain of Lakes should be replaced with a free span bridge in the future.

V. Goals and Objectives

The mission of the Antrim County Natural Hazards Mitigation Plan is to protect the health and safety of the public and property in the County which includes prevention of injury, loss of life, property damage, breakdown in vital services like transportation and infrastructure, economic slumps, maintain tourist base, and liability issues. This is done by taking action to permanently eliminate or reduce the long-term risks from natural hazards.

Specific goals and objectives have been established based upon the community's natural hazards analysis, as well as input from the Task Force participants and the public through meetings, request for comments on the draft plan, and the presentation of the plan to the Local Emergency Planning Team.

Goal 1: Increase local awareness and participation in natural hazards mitigation strategies

- Encourage cooperation and communication between planning and emergency management officials
 - a. Develop partnerships and procedures with adjoining county Emergency Managers to coordinate resources in the event of an emergency; for example, identifying long-term and short-term shelter sites for a large amount of displaced people (i.e., campgrounds, hotels, community centers, special event spaces).
- Encourage additional local governmental agencies to participate in the natural hazards mitigation process
- Encourage public and private organizations to participate, including organizations who advocate for individuals with functional or access needs (vulnerable populations)

Goal 2: Integrate natural hazards mitigation considerations into the community's comprehensive planning process

- Enforce and/or incorporate natural hazards mitigation provisions in building code standards, ordinances, and procedures; and into the county's comprehensive master plan
- Update zoning ordinances to reflect building codes, shoreline protection rules, etc.
- Incorporate natural hazards mitigation into basic land use regulation mechanisms
- Improve hazard preparedness and mitigation through increased community education and promotion of public warning systems
- Strengthen the role of the Local Emergency Planning Committee in the land development process
- Integrate natural hazards mitigation into the capital improvement planning process so that public infrastructure does not lead to development in natural hazards areas
- Encourage county agencies to assess local roads, bridges, dams, and related transportation infrastructure for natural hazards vulnerability

Goal 3: Utilize available resources and apply for additional funding for natural hazards mitigation

- Provide a list of desired community mitigation measures to the State for possible future funding
- Encourage the application for project funding from diverse entities

Goal 4: Develop and complete natural hazards mitigation projects in a timely manner

- Encourage public and business involvement in natural hazards mitigation projects

VI. Mitigation Strategies and Priorities

Types of Mitigation Strategies

The mitigation planning regulations requires that each participating jurisdiction identify and analyze a comprehensive range of specific mitigation actions and projects to reduce the impacts of the hazards identified in the risk assessment. The emphasis is on the impacts or vulnerabilities identified in the risk assessment, not on the hazards themselves. The types of mitigation actions can be classified into the following types:

- Local Plans and Regulations
- Building and Infrastructure Projects
- Natural Systems Protection
- Education and Awareness Programs

Furthermore, a set of evaluation criteria was developed to determine which mitigation strategies were best suited to address the identified problems in Antrim County.

- The measure must be technically feasible.
- The measure must be financially feasible.
- The measure must be environmentally sound and not cause any permanent, significant environmental concerns.
- The measure must be acceptable to those participating in the strategy and/or primarily affected by the strategy.

By anticipating future problems, the County can reduce potential injury, structure losses, loss of utility services such as electric and internet connectivity, and prevent wasteful public and private expenditures. The County Infrastructure, Vulnerability, and Hazard Maps in Appendix A can assist with the determining future problem areas.

Emergency Warning System Coverage

Integrated Public Alert & Warning System (IPAWS): FEMA's national system for local alerting that provides authenticated emergency and life-saving information to the public through mobile phones using Wireless Emergency Alerts, to radio and television via the Emergency Alert System, and on the National Oceanic and Atmospheric Administration's Weather Radio.

Mobile warning system: Antrim County uses the *Rave* Emergency Communications Network, which is an electronic high-speed outbound notification service available to the general public. The system notifies a participant via their mobile or land-line phone. The National Weather Service may concurrently utilize their mobile warning notification system when deemed necessary in severe weather event situations to send phone notifications to all users within signal of a cellular tower.

Radio warning system: Antrim County uses **radio channels 580 AM and 103.5 FM for emergency weather alerts.**

Tornado/Severe Weather Systems: The mobile warning systems indicated previously are primarily used in the event of a potential or current severe weather event. A manual siren is located in the Village of Mancelona.

Flood warning system: **For dam failures/flooding downstream an active warning system is pre-determined utilizing geographic boundary information and the *Rave* Emergency Communications Network and IPAWS alerts.**

Antrim County Emergency Management Department maintains contracts with seven of the eleven local fire stations in the county so that they may be utilized as temporary shelters in the event of an emergency. Those seven are: Torch Lake Township, Central Lake Township, Mancelona Township, Elk Rapids Township, South Torch Lake Fire District and Milton Township. A list of municipalities or departments and addresses are provided.

Temporary Shelter Locations in Antrim County	
Banks Twp Fire	6520 Center St. Ellsworth 49729
Bellaire Fire	735 E Broad Bellaire 49615
Central Lake Fire	1924 S Main St. Central Lake 49622
East Jordan Fire	201 Main St. East Jordan 49727
Elk Rapids Fire	209 N. Bridge Elk Rapids 49629
Elmira Warner Fire	2035 Mt. Jack Rd. Elmira 49730
Mancelona Fire	8587 W. State St. Mancelona 49659
Mancelona Fire #2	8062 Pineview Dr. Mancelona 49659
Milton Twp Fire	7015 Cairn Hwy. Kewadin 49648
Milton Twp Fire #2	12105 Cherry Ave. Rapid City 49676
South Torch Fire	8665 Cedar River Rd. Alden 49612
Star Twp Fire	6775 Alba Hwy. Alba 49730
Torch Lake Fire	2355 N US 31 Eastport 49627
Banks Township Hall	6520 Center Street, Ellsworth, MI 49729
Central Lake Township Hall	1622 North M-88, Central Lake, MI 49622
Custer Township Hall	2949 Alden Highway, Mancelona, MI 49659
Echo Township Hall	2021 Finkton Road, East Jordan, MI 49727
Elk Rapids Township Hall	315 Bridge Street, Elk Rapids, MI 49629
Forest Home Township Hall	321 North Bridge, Street Bellaire, MI 49615
Helena Township Hall	8751 Helena Road, Alden, MI 49612
Jordan Township Hall	574 North M-66, Mancelona, MI 49629
Kearney Township Hall	4820 Aero Park Drive, Bellaire, MI 49615
Mancelona Township Hall	9610 South M-88, Mancelona, MI 49659
Milton Township Hall	7023 Cherry Street, Kewadin, MI 49648
Star Township Hall	6775 Alba Highway, Elmira, MI 49730
Torch Lake Township Hall	2355 North US 31, Kewadin, MI 49648

Hazard Mitigation Strategies are grouped according to type. Types include: Awareness & Preparation, Shelters, Building & Development, Utilities & Technology, and Environment & Natural Resources. The table also includes: a description of each strategy; what natural hazards they address; where the strategy applies; who is responsible for implementing the strategy; how the strategy will be implemented (what resources are available to apply the strategy); when the strategy could feasibly begin; the level of priority; and what type of strategy it is.

The resources for how the strategies may be implemented are listed below:

ID	Resource	Description	Website	Hazard Type
A	Midwest Agriculture Climate Team	MAC-T members are Extension specialists and state climatologists from many of the states represented in the Midwest Climate Hub, and NOAA NWS climate and weather specialists. The goal of this team is to share expertise regionally, discuss impacts and opportunities as it relates to agriculture and outlooks, and maintain an open line of communication so when weather/climate events do occur, the Midwest agriculture community is set to respond. The team meets monthly during the growing season regularly, and as needed during the winter season.	https://www.climatehub.usda.gov/hubs/midwest/topic/midwest-agriculture-climate-team-mac-t	Drought, Extreme Temperatures, Flooding, Severe Winter Weather, High Winds, Hail
B	NWS Climate Prediction Center	The U.S. Drought Monitor is a map released every Thursday, showing parts of the U.S. that are in drought. The map uses five classifications: abnormally dry (D0), showing areas that may be going into or are coming out of drought, and four levels of drought: moderate (D1), severe (D2), extreme (D3) and exceptional (D4).	https://www.cpc.ncep.noaa.gov/products/Drought/	Drought
C	National Fire Protection Association	Firewise USA Program: Each applicant must create a board/committee, complete a community wildfire risk assessment with a 3-year action plan to reduce ignition risk to homes, and complete annual educational and risk reduction actions identified in the plan.	https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Firewise-USA	Wildfire, Drought
D	National Fire Protection Association	Training on Assessing Structure Ignition Potential from Wildfire	https://www.nfpa.org/Training-and-Events/By-topic/Home-Ignition-Zone	Wildfire, Drought
E	Consumer's Energy Utility Service	Consumers Energy electrical and natural gas utility service. Energy through renewable energy sources is available. A power outage map is available to track outage locations.	https://www.consumersenergy.com/outagemap	Severe winter weather; Thunderstorm, High Winds, Hail, Tornado, Lightning; Flooding; Extreme Temperatures
F	Consumer's Energy Hydro Planning	Information on planning processes and documents related to the future of hydropower dams in Michigan.	www.consumersenergy.com/hydrofuture	Inland Flooding
G	Great Lakes Shoreviewer Tool	View aerial imagery of Lake MI shoreline and associated risk levels for coastline, infrastructure/roads, and buildings.	http://www.greatlakesshoreviewer.org/	Shoreline flooding and erosion
H	Land Information Access Association's Northwest Lower Michigan Coastal Resilience Atlas	Mapped coastal flooding and coastal erosion based on three future climate scenarios for communities adjoining Lake MI; areas of the shoreline population, by census tract, that are most vulnerable to extreme heat events.	http://www.resilientmichigan.org/nw_atlas.asp	Shoreline flooding and erosion, Extreme Heat
I	State-designated high-risk erosion areas: programs and maps	High risk erosion areas are those shorelands of the Great Lakes where recession of the landward edge of active erosion has been occurring at a long-term average rate of one foot or more per year, over a minimum period of 15 years.	https://www.michigan.gov/egle/about/organization/water-resources/shoreland-management/high-risk-erosion-areas	Shoreline erosion

J	State-designated Critical Dune Areas	Michigan's critical dune program protects the dune resource using alternative construction techniques to reduce the impacts of development on dunes and protects dune vegetation essential to dune preservation and stability. Earthmoving, vegetation removal, and construction activities within a critical dune area are regulated through a permit program.	https://Michigan.gov/CriticalDunes	Shoreline erosion
K	Michigan EGLE's Coastal Zone Management Program	A plethora of resources to improve coastal and climate resiliency through both planning and best management projects.	https://www.michigan.gov/egle/about/organization/water-resources/coastal-management	Shoreline flooding and erosion
L	Resilient Lakeshore Heritage Program	This grant program is administered by the Michigan State Historic Preservation Office. Funding for the program is provided by the Paul Bruhn Historic Revitalization Grant from the National Park Service to support the preservation of historic buildings in rural communities located along the Great Lakes statewide.		Shoreline flooding and erosion
M	Great Lakes Water Safety Consortium	A nonprofit community of BEST practice, connecting and serving safety experts & water enthusiasts, educating the public on safer ways to enjoy the water, and encouraging leaders to take bold action to make their shoreline safer for residents and visitors.	https://www.greatlakeswatersafety.org/	Coastal Hazards - rip currents
N	FEMA Floodplain Management Resources for Local Government Officials	How to participate with the NFIP and tools and resources to provide higher standards for floodplain management.	https://www.fema.gov/floodplain-management/manage-risk/local	Inland and coastal flooding
O	FEMA Hazard Mitigation Assistance (HMA) Grants: Flood Mitigation Assistance (FMA) and Pre-Disaster Mitigation (PDM) Grant	FMA is a competitive grant program that provides funding to states, local communities, federally recognized tribes. Funds can be used for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the National Flood Insurance Program. PDM is a competitive grant program that provides funding to states, local communities, federally recognized tribes to plan for and implement sustainable cost-effective measures designed to reduce the risk to individuals and property from future natural hazards, while also reducing reliance on federal funding from future disasters. The program is authorized by Section 203 of the Stafford Act.	https://www.fema.gov/grants/mitigation/floods	Inland and coastal flooding
P	FEMA Hazard Mitigation Assistance (HMA) Grants: Building Resilient Infrastructure and Communities (BRIC)	Best for proposed projects that help a community reduce risks from future disasters and natural hazards. Administered by the Michigan State Police on behalf of the Federal Emergency Management Agency (FEMA). BRIC provides funds on an annual basis for hazard mitigation planning and the implementation of mitigation projects prior to a disaster. The BRIC program guiding principles are supporting communities through capability- and capacity-building; encouraging and enabling innovation; promoting partnerships; enabling large projects; maintaining flexibility; and providing consistency.	https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	All hazards

Q	Michigan Invasive Species Grant Program	The Departments of Natural Resources, Environmental Quality and Agriculture and Rural Development work together to address strategic issues of prevention, detection, eradication, and control for both terrestrial and aquatic invasive species in Michigan. This program is designed to address strategic issues of prevention, detection, eradication and control for both terrestrial invasive species (TIS) and aquatic invasive species (AIS) in Michigan.	www.michigan.gov/invasives/grants/misgp	Invasive Species
R	Clean Boats, Clean Waters Program	Funding from the Michigan Department of Environment, Great Lakes, and Energy and the Great Lakes Restoration Initiative has enabled Clean Boats, Clean Waters to grow into a comprehensive aquatic invasive species boater outreach program. The program's mission is to prevent new aquatic invasive species introductions and limit their dispersal from water recreation activities through outreach and engagement. The program promotes understanding of boat cleaning practices and regulations through the distribution of educational materials, an online resource library, boat washing demonstrations, grants and partnerships.	www.canr.msu.edu/clean_boats_clean_waters/index	Invasive Species
S	EGLE's "NotMISpecies" webinar series	This webinar series explores how agencies, universities and locally led organizations are working together to protect Michigan's natural resources through the Michigan Invasive Species Program. If you are concerned about the impacts of invasive species or interested in the techniques used to control them, join us as we examine species-specific actions, innovations in research and technology, and programs designed to help communities prevent and manage harmful invasive species.	https://www.michigan.gov/invasives/take-action	Invasive Species
T	State of MI: Resources and Best Practices to prevent and manage invasive species	Prevention tips and action steps to control or remove invasive species.	https://www.michigan.gov/invasives/take-action	Invasive Species
U	Northern Michigan Community Action Association (NMCAA)	Weatherization Assistance Program and Emergency Home Repair Program for low- to moderate- income households.	https://www.nmcaa.net	Severe winter weather; Thunderstorm, High Winds, Hail, Tornado, Lightning; Flooding; Extreme Temperatures; Public Health Emergency
V	"MI HOPE" Grants (Michigan Housing Opportunities Promoting Energy Efficiency)	Program for up to \$25K to repair or replace roofs, doors, windows, insulation, heating/cooling systems, water heaters, security lighting, Energy Star appliances and electrical systems for eligible low-income residents.	www.michigan.gov/mi-hope	Severe winter weather; Thunderstorm, High Winds, Hail, Tornado, Lightning; Flooding; Extreme Temperatures; Public Health Emergency

W	Health Department of Northwest Michigan (HDNW)	Provide programs and services such as: immunizations; community clinics; school health services; permitting processes for proper location and installation of water wells and septic systems; education about cleaning, monitoring and maintaining septic systems; septic or well repair financial assistance, and the inspection and licensing of food service establishments.	https://www.nwhealth.org/	Severe winter weather; Thunderstorm, High Winds, Hail, Tornado, Lightning; Flooding; Extreme Temperatures; Public Health Emergency
X	Michigan State University Extension	Resources available for: training elected and appointed officials, agriculture and food support programs, and natural resources protections.	https://www.canr.msu.edu/outreach/	Inland flooding, shoreline erosion; Invasive Species; Public Health Emergency
Y	MSU Michigan Inland Lakes Partnership	The purpose of the Michigan Inland Lakes Partnership (Partnership) is to engage state and local agencies, Native American Nations, outreach institutions (universities and other educational institutions), non-governmental organizations (NGOs), businesses, industries and citizens in a collaborative effort to ensure the quality, sustainability and ecological diversity of lakes, while considering society's needs. The Partnership will promote communication and cooperation between partners, communities and citizens interested in the management of Michigan's inland lakes, educating leaders, and strengthening stewardship efforts.	https://www.canr.msu.edu/michiganlakes/convention/	Inland flooding, shoreline erosion; Invasive Species
Z	USDA Natural Resources Conservation Service	The NRCS helps America's farmers, ranchers, and landowners conserve our nation's resources through voluntary programs and science-based solutions.	https://www.nrcs.usda.gov/	Drought; Extreme Temperatures; Invasive Species; Public Health Emergency
AA	Antrim County staff	Antrim County staff as appropriate		All hazards
BB	Local government staff	All local units of government		All hazards
CC	Local Emergency Services and Fire Departments			Severe winter weather; Thunderstorm, High Winds, Hail, Tornado, Lightning; Wildfire; Flooding; Extreme Temperatures; Public Health Emergency
DD	Antrim Conservation District	Our mission is to promote the exploration and conservation of Antrim County's natural resources. Our current programs include forestry, water quality and soil erosion, invasive species, and recycling/household hazardous waste. Our partners include: Michigan Agriculture Environmental Assurance Program (MAEAP), CAKE-CISMA, USDA-NRCS, MI On-Farm Produce Safety program, and several local recreation advocacy groups.	https://www.antrimcd.com/	Flooding, shoreline erosion; Invasive Species; wildfire; drought

EE	Antrim County Commission on Aging	The Antrim County Commission on Aging helps seniors and their families by answering questions, finding specific products and services, and by providing guidance on how to access a variety of programs and agencies available to residents of our County. Services include: Home-Delivered Meals " Congregate Meals " Dining Out Program " Senior Project Fresh " Personal Care " Respite Care " Homemaker Program " Snow Removal Program " Medical Transportation " Flu Immunizations " Medicare/Medicaid Assistance Program " Volunteer Opportunities " Loan Closet for Durable Medical Equipment " Tax Assistance " Monthly Newsletter " Project Lifesaver " Information & Assistance " Assistance w/Unmet Needs	https://www.antrimcounty.org/departments_services_/commission_on_aging/index.php	Severe winter weather; Thunderstorm, High Winds, Hail, Tornado, Lightning; Flooding; Extreme Temperatures; Public Health Emergency
FF	EGLE's Michigan Oil, and Gas and Minerals Division Data Explorer	Interactive mapping tool to search for oil and gas well facilities and associated records throughout Michigan.	https://www.egle.state.mi.us/dataminer/	Flooding, Lightning, Tornado, Severe Winter Weather, High Winds
FF	EGLE's list of oil and gas well types and status codes.		https://www.michigan.gov/egle/about/organization/oil-and-gas/oil-and-gas-well-type-and-status	
GG	Otsego-Antrim Habitat for Humanity	<i>Critical Home Repair</i> and <i>Aging in Place</i> Programs. Habitat selects partner families based on income, need and willingness to partner. They also help elderly persons preserve their independence by providing critical repairs to their house so they can safely stay in their home longer than they might have been able to without the repairs. Habitat affiliates use volunteer labor and donated materials to keep their costs low and take no profit for their services.	https://www.otsegoantrinhabitat.org/critical-home-repairs	Flooding, Thunderstorms, Hail, High Winds, Severe Winter Weather, Lightning, Extreme Temperatures, Public Health Emergency
HH	EGLE's Wetlands Map Viewer	The WMV application was created for the Department of Environment, Great Lakes, and Energy to provide the public with quick and easy access to wetland spatial data.	https://www.mcgi.state.mi.us/wetlands/mcgiMap.html	Flooding, Drought, Extreme Temperatures
II	Charlevoix-Antrim-Kalkaska-Emmet Cooperative Invasive Species Management Association			
JJ	The Watershed Center of Grand Traverse Bay			
KK	Tip of the Mitt Watershed Council			
LL	Torch Lake Protection Alliance			
MM	Three Lakes Association			
NN	Intermediate Lake			

	Association			
OO	Elk Skegemog Lakes Association			
PP	Healthy Lakes Landscaping Program	The ACD's Program to help lakeshore residents learn what they can do to help protect their property value and the health of the lake on which they live by protecting, stabilizing and beautifying their shorelines with nature-based solutions.	https://www.antrimcd.com/healthy-lakes-landscaping.html	Flooding, erosion, invasive species
QQ	ARPA	The Coronavirus State and Local Fiscal Recovery Funds (SLFRF) program, a part of the American Rescue Plan	https://home.treasury.gov/policy-issues/coronavirus/assistance-for-state-local-and-tribal-governments/state-and-local-fiscal-recovery-funds	All hazards

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