Antrim County, Michigan
Natural Hazard Mitigation Plan

2023

DRAFT 2/28/2023

FEMA LETTER OF APPROVAL

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:

Participating Entity	Representative	Title
Antrim County Board of Commissioners	Bill Hefferan	District 1 (Milton Township, Elk Rapids Township, Village of Elk Rapids)
	Terry VanAlstine	Board Chair, District 3 (Village of Bellaire; Forest Home, Helena and Kearney Townships; part of Custer Township)
	Jason Helwig	Vice Chair, District 4 Commissioner representing the Village of Mancelona, the west half of Mancelona Township, and part of Custer Township
	Dawn LaVanway	District 5 Commissioner representing the Townships of Warner, Echo, Jordan, Chestonia, Star and the east half of Mancelona Township
	Ed Boetcher	Former Commissioner representing Elk Rapids Township & Village of Elk Rapids
Antrim County Planning Commission	Bill Hefferan	Planning Commissioner
	James Gurr	Planning Commissioner
	Gary Lockwood	Planning Commissioner
	Barbara Bradford	Planning Commissioner
	Ron Tschudy	Planning Commissioner
	Richard Friske Jr.	Planning Commissioner
	Leslie Elrod	Planning Commissioner
	Kenny Provost	Planning Commissioner (former)
Antrim County	Jeremy Scott	County Administrator / Deputy County Administrator (former)
	Janet Koch	Deputy County Administrator
	Peter Garwood	County Administrator (former)
	Matthew Adamek	Emergency Operations Director
	Leslie Meyers	Emergency Operations Director (former) / Operator of Dams
	Mike Gank	911 Administrative Sergeant
	Mark Stone	Operator of Dams (former)
	Scott Kleinhuizen	Assistant Operator of Dams
	Julie Weston	GIS Technician
	Alan Shumaker	Meadow Brook County Health Care Facility – Director of Maintenance
	Kevin Hoch	County Sheriff's Office
	Daniel Bean	Sheriff
Village of Bellaire	Nicole Essad	Clerk/Zoning Administrator
	Dave Gadja	Treasurer/ Bellaire DDA member
Village of Central Lake	Andrew Smith	Treasurer/Clerk (former)
Village of Elk Rapids	David Centala	Chief of Police
	Kevin Lane	DPW Supervisor
	Kerri Esterly	Treasurer/Planning/Zoning/Community Development
	Laura Schumate	Trustee
	Bill Hefferan	County Commissioner, District 1

Village of Ellsworth	Lynn Aldrich Spearing	Village of Ellsworth President Pro Tem
Village of Mancelona	Jason Helwig	County Commissioner, District 4
	Michael Allison	Village President
Banks Township	Richard Friske Jr.	County Planning Commissioner
	Donna Heeres	Clerk
Central Lake Township	Judith Kosloski	Clerk
Chestonia Township	Dawn LaVanway	County Commissioner, District 5
Custer Township	Roxann Flake	Supervisor
	Terry VanAlstine	Board Chair, District 3
	Jason Helwig	Vice Chair, District 4
Echo Township	Ron Tschudy	County Planning Commissioner
Elk Rapids Township	Bill Hefferan	County Commissioner, District 1
Forest Home Township	Terry Smith	Supervisor
	Bonnie Robbins	Trustee
	Stephen C. Barnard	Zoning Administrator
	Paul Trumbler	Planning Commission Chair
Helena Township	James Gurr	County Planning Commissioner
	Gary Lockwood	County Planning Commissioner
	Bonnie Robbins	Trustee
	Clark "Butch" Peeples	Supervisor
Jordan Township	Dawn LaVanway	County Commissioner, District 5
Kearney Township	Barbara Bradford	County Planning Commissioner
	Ed Niepoth	Supervisor
	Dick Jacques	Township Planning Commissioner
Mancelona Township	Jason Helwig	County Commissioner, District 4
	Dawn LaVanway	County Commissioner, District 5
Milton Township	Bill Hefferan	Township Planning Commission Chair
	Jeremy Ball	Milton Township Fire Chief
	Joe Renis	Planning Commissioner
	Brett Pharo	Trustee
Star Township	Dawn LaVanway	County Commissioner, District 5
	Robert Marsh	Supervisor
Torch Lake Township	Ted Schroeder	Assistant Fire Chief
	Jerry Kulka	Planning Commissioner (former)
	Mike Robinson	S. Torch Lake F.D.
	Sara Kopriva	Zoning Administrator
Warner Township	Dawn LaVanway	County Commissioner, District 5
Antrim County Road Commission	Peter Stumm	Superintendent
	Burt Thompson	Engineer/Manager
Antrim Commission on Aging	Judy Parliament	Director
	Amy Tate	Clerk I, Office Manager
Antrim Conservation District	Melissa Zelenak	Executive Director
	Kyle Williams	Soil Erosion Officer
	Mike Meriwether	Forester
	Heidi Shafer	Soil Erosion Officer (former)
	Wendy Warren	Executive Director (former)
Charlevoix, Antrim, Kalkaska, &	Lindsey Bona-	Program Coordinator

Emmet – Cooperative Invasive Species Management Area (CAKE CISMA)	Eggeman	
Three Lakes Association	Fred Sittel	President
The Watershed Center Grand Traverse Bay	Heather Smith	Grand Traverse Baykeeper
Bellaire Chamber of Commerce	Sue Palmisano	Executive Director
American Red Cross	Darlene Windish	Disaster Assistant Volunteer
Health Department of Northwest Michigan	Chloe Capaldi	Emergency Preparedness Coordinator
Bellaire Family Health Center	Christine Wilhelm	HR Director
Michigan Department of Health and Human Services	Bob Bush	
Michigan State Police – Emergency Management & Homeland Security Division	Lt. Mike deCastro	District 7 District Coordinator
	Mike Sobocinski	Hazard Mitigation Planning Analyst
Michigan Department of Environment, Great Lakes and Energy (EGLE) -Remediation and Redevelopment Division	Brian Flickinger	Project Manager

Prepared for: Antrim County Board of Commissioners

Prepared by: Antrim County Office of Emergency Management and the Antrim County Local Emergency Planning Committee with assistance from:

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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 (ongoing).
    - Commissioning the creation of a new county-wide Soil Erosion and Sedimentation Control ordinance (currently in development).
    - Increased standards for County construction permit approval - elevation certificates and compliance with NFIP required. (year accomplished?)
    - Collaboration with The Watershed Center Grand Traverse Bay, Antrim Conservation District and the Tip of the Mitt Watershed Council resulted in an inventory of shoreline erosion sites and culverts for road/stream crossings throughout the County. (year accomplished?)
- 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:

Natural Hazards Mitigation Planning Goals and Objectives

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

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 2023 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. The following is an outline of events for the development of the 2023 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. Table 1 indicates who participated in the survey. A copy of the survey results are included in Appendix B.

Table 1: Community Survey Participation

Community/Organization	Completed Survey?	Representative and Title (if indicated in the survey)
Banks Township	Yes	Donna Heeres, Township Clerk
Central Lake Township	Yes	Judith Kosloski, Township Clerk; citizen; summer resident
Chestonia Township	No	
Custer Township	Yes	Citizen
Echo Township	No	
Elk Rapids Township	No	
Forest Home Twp.	Yes	Stephen C. Barnard, Zoning Administrator
		Paul Trumbler, Planning Commission Chair
Helena Township	Yes	Mike Robinson, Planning Commissioner and Lt. of S. Torch Lake Fire Dept.
Jordan Township	No	
Kearney Township	Yes	Dick Jacques, Planning Commissioner
		Elected Official
Mancelona Township	Yes	County Community Emergency Response Team member
		Citizens (2)
Milton Township	Yes	Joe Renis, Planning Commissioner
		Brett Pharo, Trustee
		Jeremy Ball, Fire Chief
		Planning Commission members (2)
Star Township	Yes	Robert Marsh, Supervisor
Torch Lake Township	Yes	Jerry Kulka, Planning Commissioner (former)
		Mike Robinson, S. Torch Lake F.D.
		Sara Kopriva, Zoning Administrator
Warner Township	No	
Village of Bellaire	Yes	Nicole Essad, Clerk/Zoning Administrator
Village of Central Lake	Yes	Andrew Smith, Clerk/Treasurer (former)
		Citizen
Village of Elk Rapids	Yes	Laura Schumate, Village Council Trustee
		Kerri Esterley, Treasurer; Planning/Zoning/Community Dev.

		Elected Official
Village of Ellsworth	Yes	Lynn Aldrich Spearing, President Pro Tem
Village of Mancelona	Yes	Michael Allison, Village President
Antrim County Government	Yes	Leslie Meyers, Emergency Management Coordinator (former)
		Mike Gank, 911 Manager
		Deputy Assessor
		EDC Board Member
		Elected Officials (3)
		County Government Employees (2)
Antrim County Road Commission	Yes	Burt Thompson, Engineer/Manager

- 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
  - January 10, 2023

- June 14, 2022 – Field Trip to visit key hazard sites in the County

- The Antrim County Emergency Manager attended the Antrim County Planning Commission Meeting on September 6, 2022, October 4, 2022, and January 10, 2023 to explain the Hazard Mitigation Plan progress to date and obtain feedback on ideas for goals and strategies.

- On March 7, 2023, a public hearing was held regarding the draft Hazard Mitigation Plan at the Antrim County Planning Commission meeting. The Planning Commission members then recommended that the draft plan be submitted to Michigan State Police/FEMA for their review and approval.

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:

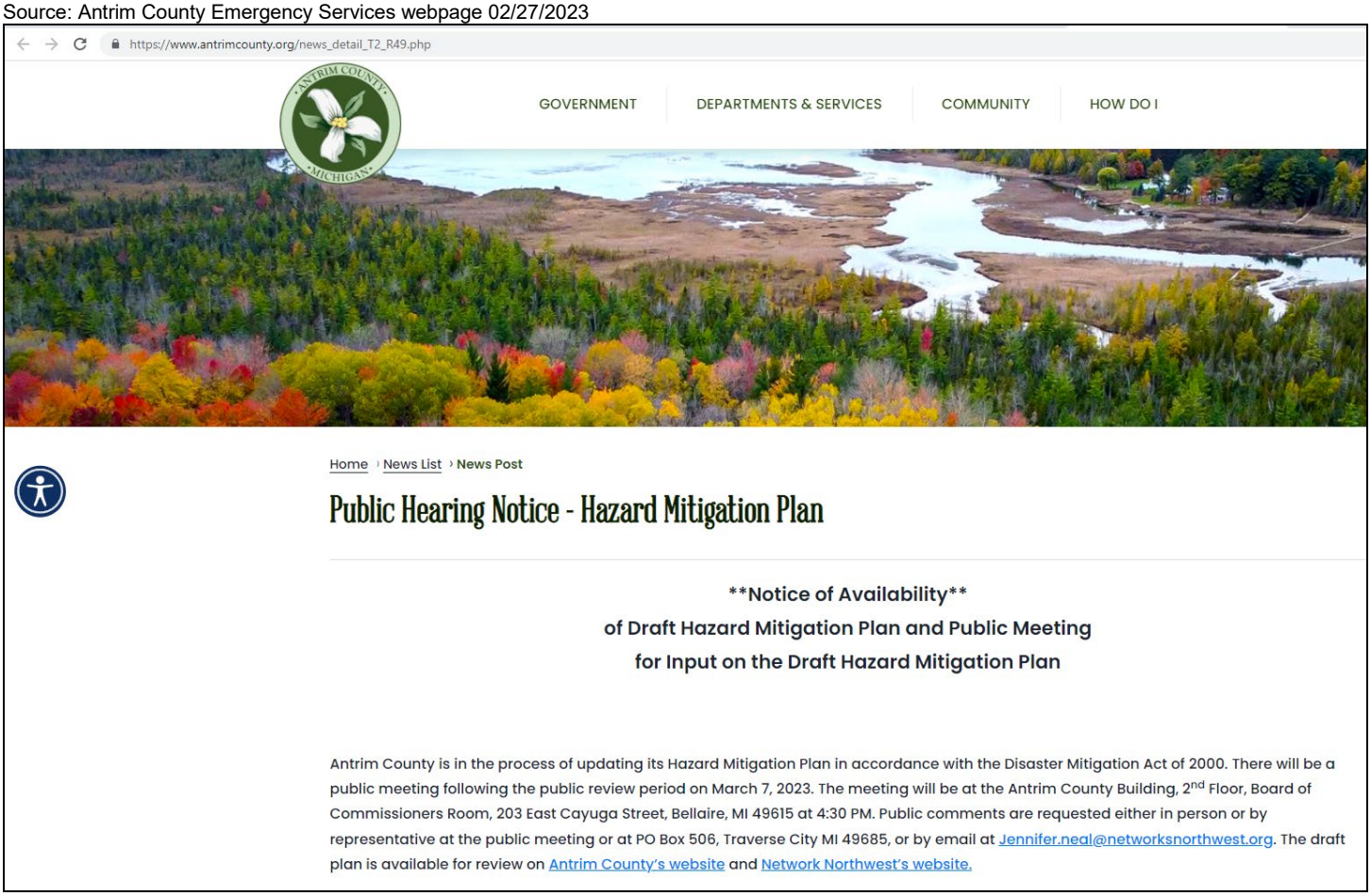
- Gregg Bird, Emergency Management Coordinator, Grand Traverse County
- Mike Thompson, Emergency Management Coordinator, Kalkaska County
- Jon Deming, Emergency Management Director, Otsego County
- Sienna L. Wenz, Emergency Management Coordinator, Charlevoix County
- Doug Pratt, Emergency Manager, Crawford 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 March 7, 2023.

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

Website Image
Source: Antrim County Emergency Services webpage 02/27/2023



Networks Northwest Image
Source: Networks Northwest webpage 2/27/2023

-mitigation/antrim-county.html

ANTRIM COUNTY

Notice of Availability of Draft Hazard Mitigation Plan and Public Meeting for Input on the Draft Hazard Mitigation Plan

A public hearing for the plan will be held on March 7, 2023 at 4:30 PM as part of the Antrim County Planning Commission Meeting. The meeting location is in the Antrim County Building, 2nd Floor, Board of Commissioners Room at 203 East Cayuga Street, Bellaire, MI. Upon review of the plan, Planning Commission shall recommend it be sent to Michigan State Police Homeland Security Division for review/preliminary approval and then on to FEMA for their review and approval. Once FEMA has approved the plan, it will be brought before all local government boards for adoption.

Public comments are requested either in person or by representative at the public meeting or at PO Box 506, Traverse City MI 49685, or by email at Jennifer.neal@networksnorthwest.org.

2023 Antrim County Hazard Mitigation Plan Current Drafts for Review:

2/3/2023 Draft Plan and **Strategies Table**

Full Size Hazard Maps (Appx. A of the plan)

- **Hazard Areas**
- **Vulnerable Populations and Hazard Areas**
- **Environmental Features**
- **Infrastructure**

Meetings and Documentation

Natural Hazard work-related meeting dates, times, and presentation materials will be posted here as they become available. All meetings are open to the public and are held via Zoom, unless otherwise stated. Please contact the Antrim County Emerency Operations Director for a Zoom link if you would like to attend!

Antrim County LEPC/LPT Meetings, 10:00 AM
09/01/2021
11/09/2021
02/08/2022
03/16/22 *Public Input via Zoom to ID Natural Hazard Concern Areas for: Coastal Communities & Inland Communities 3/16/22 Notes and Hazard ID Map
06/14/2022 Field Trip to Hazard Concern Sites
8/30/22 LEPC/LPT
10/4/22 and 10/5/22 Public Input Sessions on Draft Via Zoom
01/10/23 LEPC/LPT

Update Process

Phase I: Data collection and community survey

An online survey was available from 10/25/2021 to 1/28/2022 to obtain input on past projects, hazard events, and potential mitigation strategies. The survey results are summarized here.

Phase II: Hazard identification and risk assessment

Phase III: Review and update hazard mitigation goals, priority areas, and implementation strategies.

Phase IV: Draft plan public comment period. Post the plan electronically and meet with the public for comments. Incorporate feedback from the public review period and make final edits to the plan.

Phase V: Plan Adoption. Facilitate the plan adoption process with the County Board of Commissioners and local officials.

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 southeast, Kalkaska and Grand Traverse Counties to the south, and Grand Traverse Bay/Lake Michigan to the west/northwest. Refer to the county maps in Appendix A for locations of main roads, water bodies, other natural features, 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.

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,” a combination of deciduous forest, evergreen forest, and mixed forest. The second most prevalent land cover type is “Agriculture,” a combination of “cultivated crops and hay/pasture.” Developed land cover is found predominantly in and around the villages of Mancelona, Bellaire, Central Lake, Ellsworth, and Elk Rapids. The largest concentration of people and businesses is located in the Village of Mancelona, in the southeast corner of the county on US-131.

[1] https://data.census.gov/cedsci/profile?g=0500000US26009

Table 2: Land Cover by Type

Classification	Acres	Percent
Developed (High Intensity)	178.37	0.1%
Developed (Med. Intensity)	933.79	0.3%
Developed (Low Intensity)	6,936.23	2.2%
Developed (Open Space)	16,563.63	5.2%
Agriculture (Cultivated Crops, Hay/Pasture)	52,481.56	16.5%
Forested (Deciduous, Evergreen and Mixed Forest)	157,722.49	49.5%
Herbaceous & Shrub/Scrub	39,898.25	12.5%
Wetlands	28,201.74	8.9%
Barren Land	1,363.13	0.4%
Open Water	14,244.66	4.5%
TOTAL	**318,523.85**	

Source: Networks Northwest

The 2016 Hazard Mitigation Plan indicated that 180,821 acres, or 57%, of the county was comprised of forested lands; compared to current data, there has been a 12% decrease in forested areas. 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 A 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 3) and is the 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 Table 4).

Figure 1 illustrates the difference in population levels for each township in the County. 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, and 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 3: 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

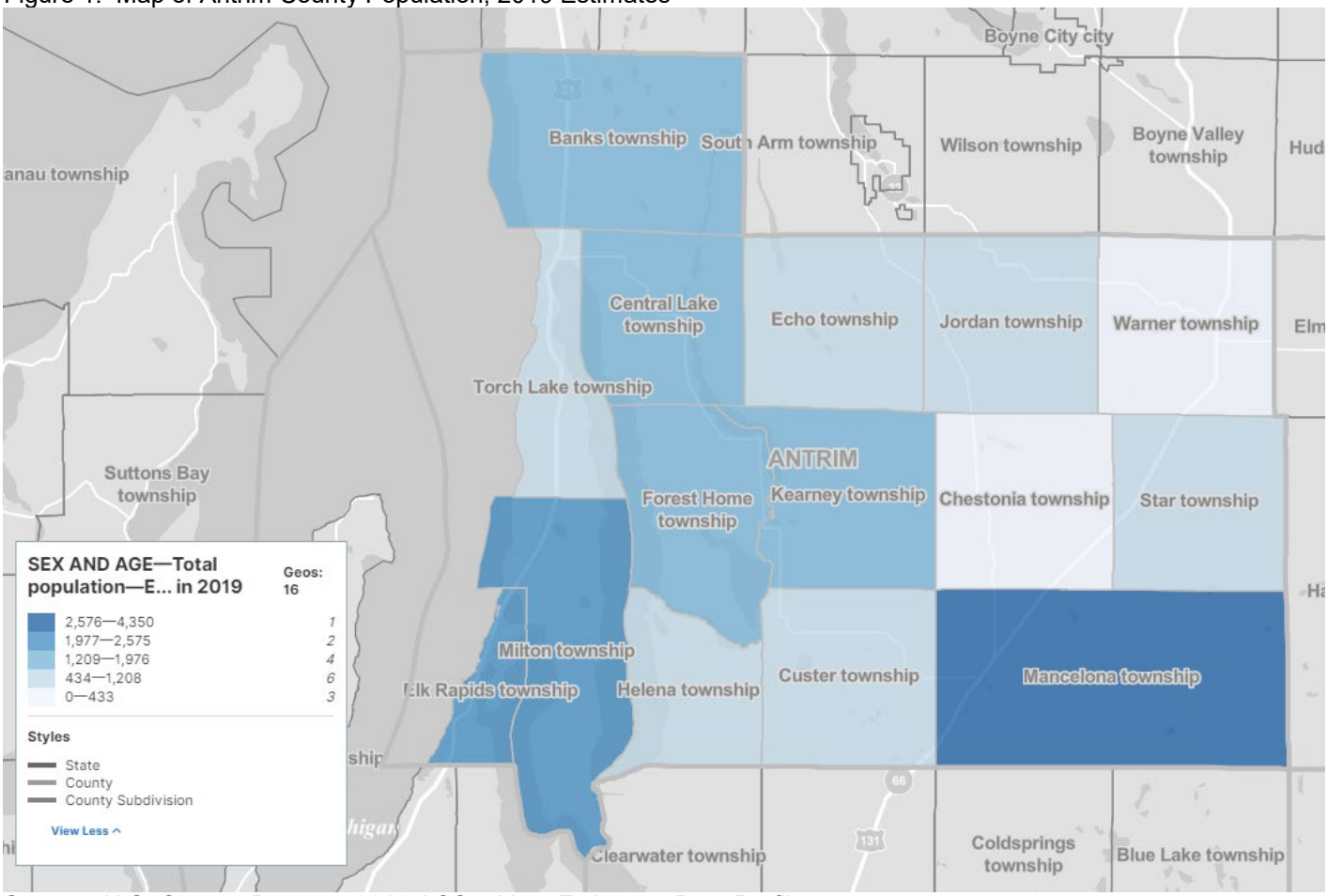
Source: US Census, 2019 ACS Estimate

Table 4: Population by Municipality, 2010, 2019

Municipality	2010 Estimated Population	2019 Estimated Population	Numeric Change	Percent Change
Antrim County	**23,975**	**23,206**	**-769**	**-3.2%**
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

Figure 1: Map of Antrim County Population, 2019 Estimates



Source: U.S. Census Bureau - 2019 ACS 5-Year Estimates Data Profile

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 2022 *Seasonal Population Study for Northwest Lower Michigan*, analyzed the 2020 seasonal population for ten counties in northwest Michigan. The study collected data for permanent and part-time residents and overnight visitors in accommodations and short-term rentals by County. Northwest Lower Michigan's permanent base population is 310,802 and expands to its largest seasonal population of 676,052 in July, 118% increase. Antrim County's combined population increases by as much as 92% from its combined population in January (30,991) to July (59,352). On average, the population grows by 75% or 17,599 people throughout the year. 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.

Table 5: Antrim County Seasonal Population by Month

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.	Region
Permanent Population	23,431	23,431	23,431	23,431	23,431	23,431	23,431	23,431	23,431	23,431	23,431	23,431	23,431	310,802
Combined Population	30,991	31,104	30,860	31,701	42,680	57,446	59,352	59,237	43,462	38,615	33,397	33,519	41,030	676,052
Difference	7,560	7,673	7,429	8,270	19,249	34,015	35,921	35,806	20,031	15,184	9,966	10,088	17,599	365,250
Percent Change	**32%**	**33%**	**32%**	**35%**	**82%**	**145%**	**153%**	**153%**	**85%**	**65%**	**43%**	**43%**	**75%**	

Age, Race & Disability

Understanding the age distribution and median age of Antrim 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 is Mancelona Village with a median age of 28.7 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

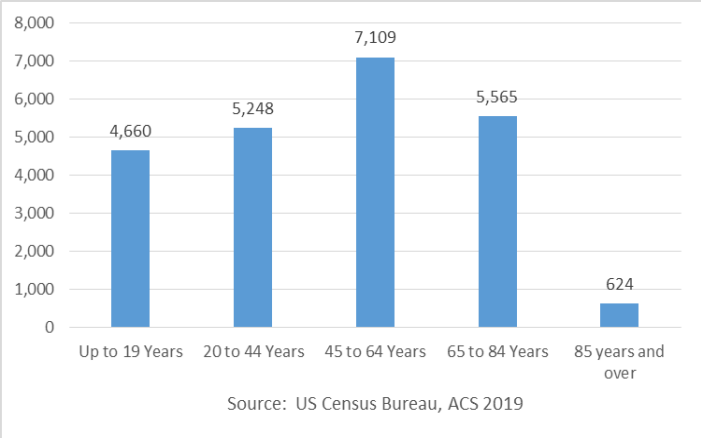


Figure 3: Median Age Trend, 2000, 2010, and 2019

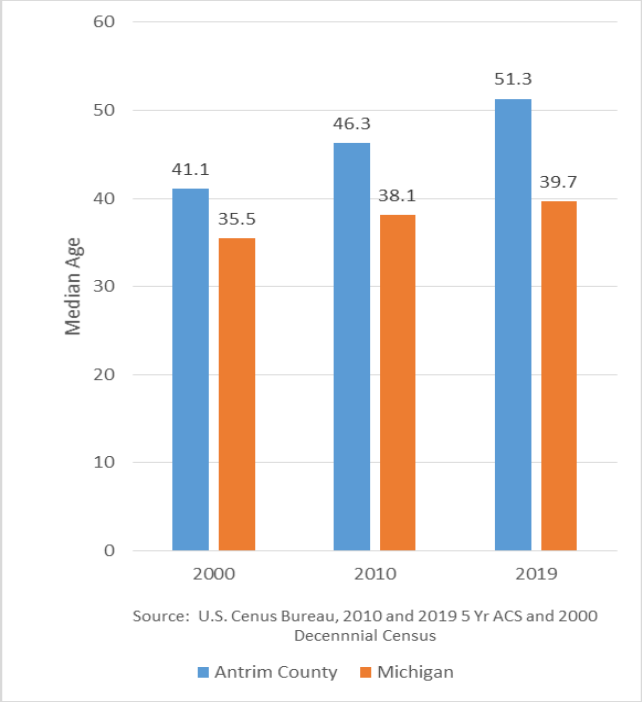
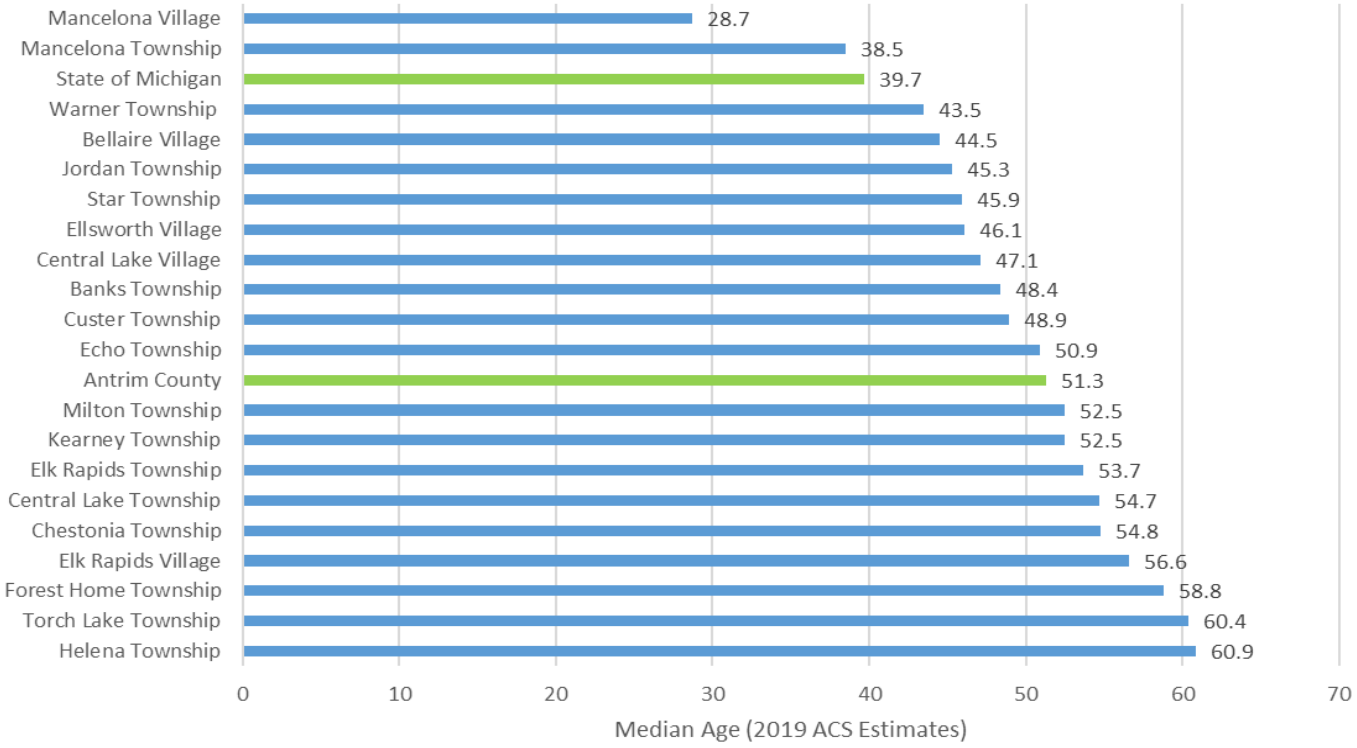


Figure 4: Median Age by Antrim County Municipality, 2019



Source: U.S. Cenus, 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 6 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 6: 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 Estimates

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 7). 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 8).

Table 7: Housing Units by Municipality, 2019

Municipality	2019 Housing Units (ACS)	Percent of 2019 Total
Antrim County	18,069	
Village of Elk Rapids	1,179	6.5%
Village of Mancelona	647	3.6%
Village of Central Lake	590	3.3%
Village of Bellaire	550	3.0%
Village of Ellsworth	166	0.9%
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

Table 8: 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 9, 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 9: 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 10 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 10: Average Annual Wage by County, 2018

County	Average Annual Wage
Antrim	**$33,081**
Manistee	$33,821
Benzie	$33,908
Missaukee	$35,917
Leelanau	$36,833
Emmet	$40,258
Wexford	$40,586
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 11. 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 11: 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 12), 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 Township, near the Village of Bellaire.

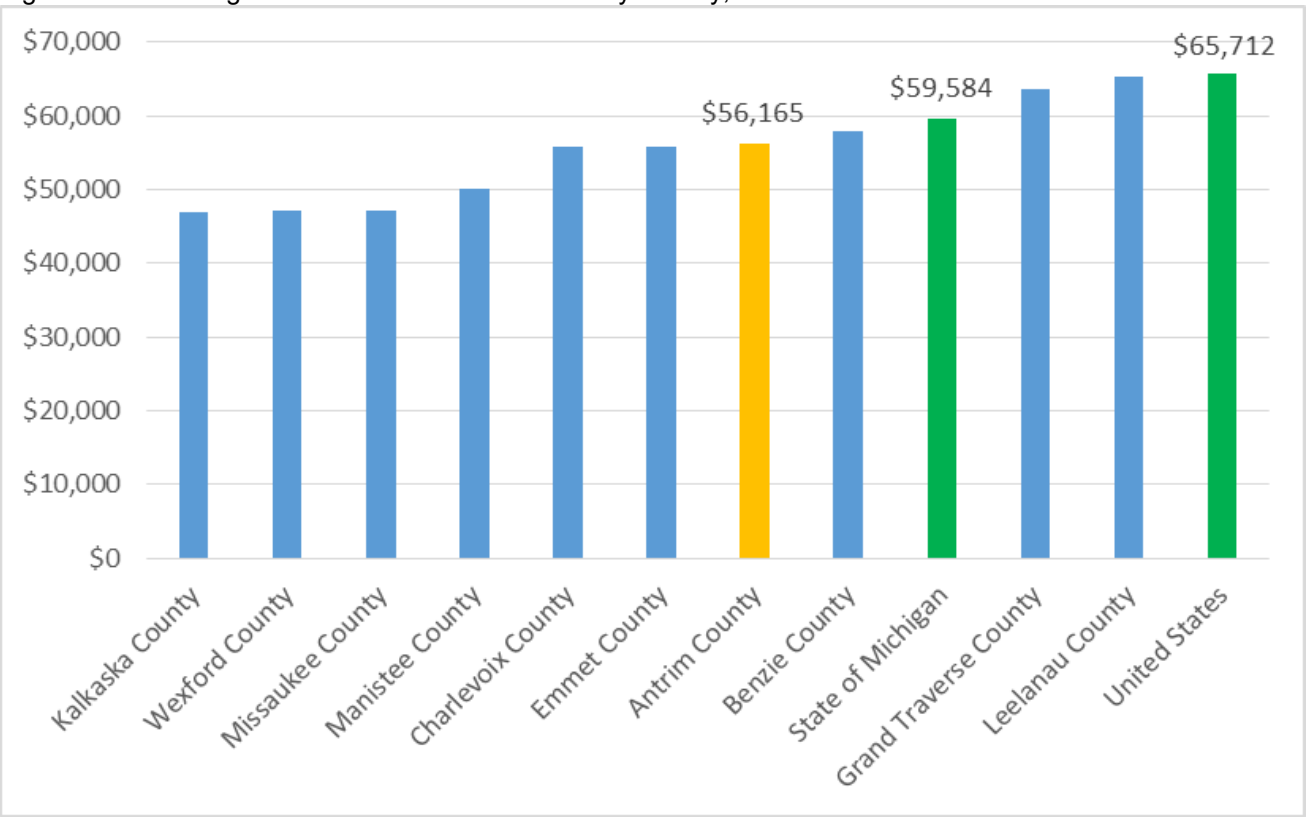
Table 12. Major Antrim County Employers

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). Chestonia Township has the lowest MHI at $34,088, and Torch Lake Township has the highest MHI at $77,500. 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.

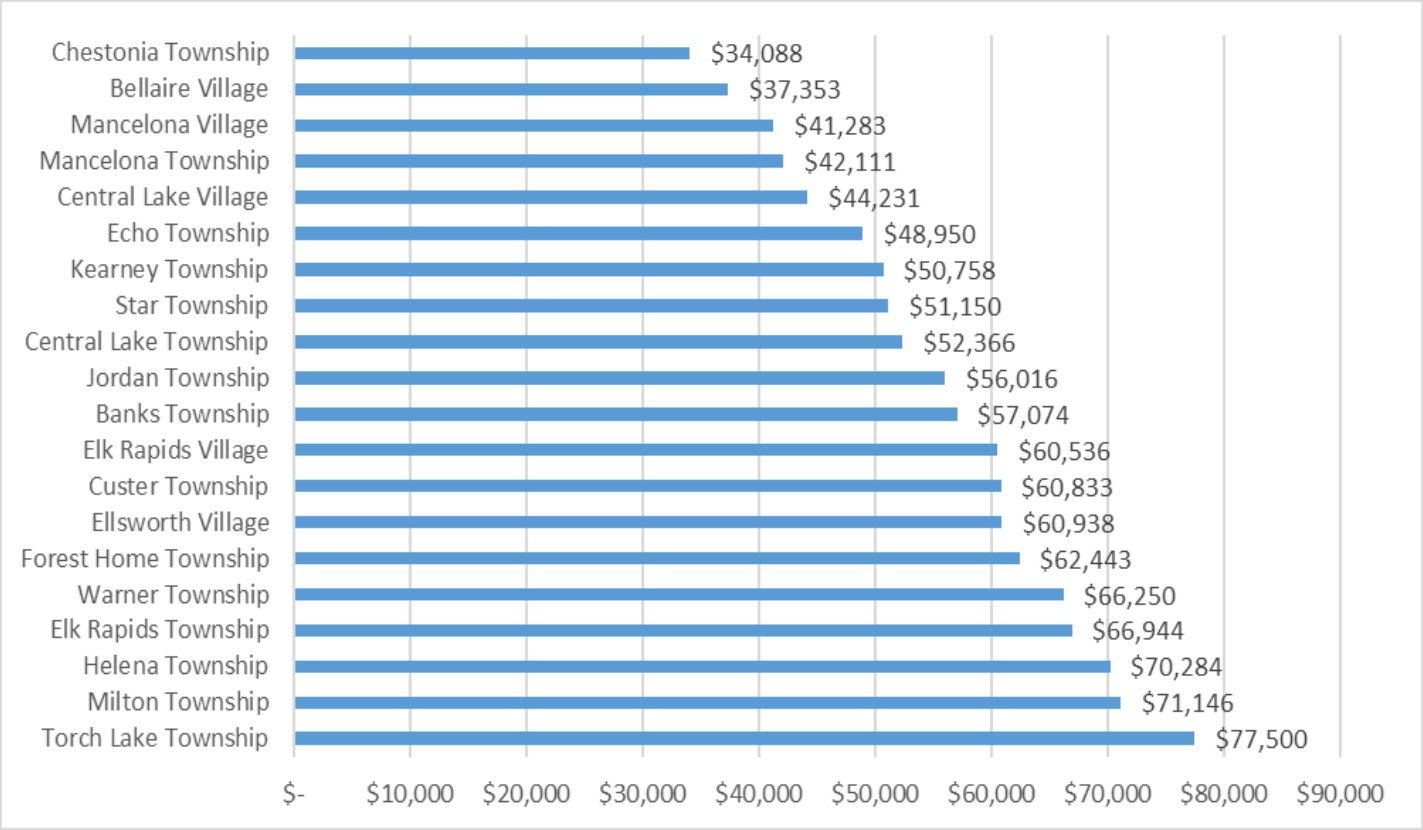
However, according to the 2019 Northwest Michigan Target Market Analysis (conducted by LandUseUSA on behalf of Housing North and Networks Northwest), rents are far higher in Antrim County than what many renters can afford. While the affordable rent for a renter earning the mean wage is $700, the affordable 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 Estimates

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



Source: US Census, 2019 ACS Estimates

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 14). 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 13 below.

Table 13: 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 14: 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 15 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. Note that ALICE data is not available for villages in Antrim County.

Table 15: United Ways of Michigan ALICE Report Findings, 2019[3]

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

[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 Appendix 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 16 lists key critical infrastructure points in Antrim County.

Table 16: Critical Facilities and Infrastructure

24	**Healthcare Facilities** • 13 Extended Health Care Fac. • 5 Public Health Care Fac. • 4 Health Practitioner Office or Clinic • 2 Health Supporting Fac.
24	**Emergency Services Facilities** • Antrim County Emergency Services – Bellaire • 3 EMS Services – Mancelona, Eastport, Bellaire • 14 Fire and Emergency Services • 6 Law Enforcement Offices
17	**Communications Facilities** • Antrim County 911 • 1 Satellite Comm. • 5 Wired Comm. • 10 Wireless Comm.
14	**Government Facilities** • 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** • 4 Airports • 3 Antrim County Road Commission Facilities (Kewadin, Central Lake, Mancelona) • Antrim County Public Transportation (Bellaire)
6	**Commercial Facilities (**Agricultural/Food Products)
3	**Industry** • EJ Foundry (Elmira) • Anchor Lamina (Bellaire) • Jordan River Fish Hatchery (Star Twp./Elmira)

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 17). These events are included in the hazard analysis for individual event types.

Table 17: 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; Pandemic COVID-19	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. All data sources include:

- FEMA's webpage on Disaster Declarations for States and Counties was referenced for the most up-to-date data on Presidential- and Governor-Declared emergencies and disasters pertaining to Antrim County (Table 17).

- 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 November 30, 2022. The database provides local storm reports, damage reports, and recorded event descriptions. Flood (Flash Flood, Flood), Shoreline (Lakeshore) Flood, Hail (Hail), Extreme Winter Weather (Blizzard, Freezing Fog, Frost/Freeze, Heavy Snow, Ice Storm, Lake-effect Snow, Sleet, Winter Storm, Winter Weather), Extreme Temperatures (Cold/Wind Chill/Heat/Extreme Heat), Tornado (Tornado, Funnel Cloud), Dense Fog (Dense Fog), Thunderstorm and High Wind (Heavy Rain, High Wind, Lightning, Strong Wind, Thunderstorm Wind), Wildfire (Wildfire), Rip Current (Rip Current).

- The *Michigan Hazard Analysis*, completed by the Michigan Department of State Police in 2019, was referenced to collect data on wildfires that occurred on State of Michigan owned land between 1981 and 2018 (as reported by the MDNR).

- 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 Great Lakes Current Incident Database https://www.michiganseagrant.org/dcd/dcdsearch.php provided by the National Weather Service and Michigan Sea Grant provides a list of all types of dangerous current incidents on the Great Lakes from 2002 to 2020.

The NOAA Storm Events Database is updated on a rolling basis, and thus the database is always being added to. The most up to date information was added to Table 18, but as events occur the database will change. Thus, 2022 is only partially represented through November 30, 2022, with 302 events reported since 01/01/1950 (26,632 days). There were a total of 252 days with an event, 3 days with event and death or injury, 44 days with event and property damage, and 3 days with event and crop damage. Those events, as well as any wildfires on MDNR land, and State and Federal emergency or disaster declarations, are included in the hazard analysis.

Table 18: Number of Hazard Events in Antrim County by Type

Type of Event	# of Events	Event Location	Time Interval/ Year Event Recorded
Wildfire	256	MDNR lands	1981 - 2018
Extreme Winter Weather	164	Region, County or Statewide	1978*, 1996 - November 2022
Thunderstorm/Wind; High Wind; Strong Wind	83	Countywide	1965 - 2022
Hail	36	Countywide	1979 - 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
Total	**563**		

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 emergency or disaster event designation

Economic Impact Analysis

The estimated economic impact of the previously described Antrim County natural hazard events that were *reported* to NOAA is $2,304,780 in property damages and $11,030,000 in crop damages (Table 19). 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 damage estimates, injuries/illness, and deaths for Antrim County hazard events are as follows:

Table 19: Cost Estimates by Event Type

Event Type	Property Damage Estimate	Crop Damage Estimate	Injuries/ Illness	Deaths
Extreme Winter Weather	$270,000	$10,000,000		
Thunderstorms with Wind; Severe/High Winds	$970,500	$0	1	
Hail	$95,000	$1,030,000		
Lightning	$80,000	$0		
Tornado	$564,280	$0	2	
Flash Flood	$325,000	$0	1	
Extreme Cold / Wind Chill	$0	$0		
Drought	$0	$0		
Heat/Excessive Heat	$0	$0		
Public Health Emergency (COVID-19)	N/A	N/A	5,244	76
Invasive Species	N/A	N/A		
TOTAL	**$2,304,780**	**$11,030,000**	**5,248**	**76**

Sources: NOAA's National Centers for Environmental Information; https://www.michigan.gov/coronavirus/stats

Table 20 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). The SEV is equal to half the true value of the property. Population data is collected from the US Census, 2019 ACS data. Based on data from the 2022 report, *Seasonal Population Study for Northwest Lower Michigan*, assume a 153% increase from the base population permanent residents in July and August to account for the highest estimated seasonal population in the County during the year.

Table 20: Geographic Economic Impact by Event

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	$2,686,829,990.00
Inland Flooding	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); and Jordan River Valley communities (Chestonia, Jordan, Mancelona, Star, and Warner Townships; Village of Mancelona)	16,203 7,003	$82,761,805.40
Coastal Hazards: Flooding and Shoreline Erosion	Banks, Torch Lake, Milton and Elk Rapids Townships; Village of Elk Rapids	7,932	$11,244,039.40
Tree Damage from High Winds	Forest Home Township (Glacial Hills Preserve area)	1,594	$8,781,430.05
Wildfire	Scattered Pine Forest Areas (White, Red, and Jack Pine) are present in portions of every community. However,	23,206	$206,332,648.20
	Wildfire is considered a major hazard of concern for Mancelona Township, due to the concentration of pine forest present.	4,350 (of which 1,574 estimated persons are in the Village of Mancelona)	$131,447,697.99

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 events 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 1996, and including the 1978 Presidential-declared Emergency and Governor-declared disaster for a blizzard/snowstorm, there have been 164 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 21: Extreme Winter Weather Events; Damages; Years

Hazard Event	Number of Events	Property Damage	Crop Damage	Time Interval/ Year Event Recorded
Winter Storm	66	$ 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	**164**	**$ 270,000**	**$ 10,000,000**	

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment
Since 1996, Antrim County has had 163 extreme winter weather events. This averages to about to about 6 extreme winter weather 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 measured wind gusts for thunderstorm/wind and high wind / strong wind events in Antrim County ranges from 50 to 70 knots. Antrim County had a reported $970,500 in property damages caused by thunderstorms and severe winds since 1965.

One (1) injury has been recorded in association with a thunderstorm/wind event. On June 11, 2005, a female hiker was struck by a falling tree in the Landslide Creek area in Chestonia Township. Her injuries were not serious.

Previous Occurrences
Since 1965, there have been a total of 83 thunderstorm/wind and high wind events reported in Antrim County (Table 22). This is the third-most frequently occurring type of severe weather event in the county.

Table 22: Thunderstorm and Wind Events; Damages; Years

Hazard Event	Number of Events	Property Damage	Crop Damage	Time Interval/ Year Event Recorded
Thunderstorm Wind	70	$ 900,500	$ -	1965 - 2022
High Wind	12	$ 70,000	$ -	1998, 2001, 2003, 2005, 2010, 2015, 2020, 2021
Strong Wind	1	$ -	$ -	2001
TOTAL	**83**	**$970,500**	**$ -**	

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

Since 1965, Antrim County has had 83 thunderstorm/wind and high wind or strong wind events. This averages to 1.4 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. The locations of mobile homes and campgrounds are identified on the Vulnerable Populations and Hazard Areas Map in Appendix A. These structures/facilities are more vulnerable to impacts from thunderstorms and severe winds.

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.

Extent
According to the NOAA National Centers for Environmental Information, the approximate size of hail is described as follows in Table 23. If a thunderstorm is considered severe if it produces hail that is 1 inch in diameter or greater.

Table 23: 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 diameter hail reported in Antrim County was 3 inches (teacup size) on July 8, 2016 in Central Lake. 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 1979 and 2022, Antrim County had 36 hailstorms reported to NOAA (Table 24). 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 24: Hail Events, 1979-2021

Location	Date	Magnitude	Property Damage	Crop Damage
-	6/20/1979	1		
-	10/15/1989	0.75		
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 36 hail events reported between 1979 and 2022, Antrim County has an 82% chance for a hailstorm event 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; the locations of these are identified on the Vulnerable Populations and Hazard Areas Map in Appendix A.

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 Elk River Chain of Lakes (ERCOL) watershed 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.

There are many various sized culverts at road/stream crossings throughout the ERCOL watershed. These vary in size and age; many are undersized and cannot accommodate the high volumes of storm water produced from the intense rainfall events that are occurring more frequently. Additionally, road/stream crossings that are improperly designed or installed, structurally failing, or no longer accommodate current stream conditions affect stream health. They can affect stream hydrology, prevent fish and other aquatic organisms from reaching up-and downstream reaches, increase water temperatures, and are sources of nutrients, sediments, bacteria, heavy metals, and other nonpoint source pollutants. In Northern Michigan, sediments pose the greatest threat to rivers and streams. Sedimentation can adversely impact fish and aquatic organisms by degrading their habitat and reducing water quality.

There are three major dams in Antrim County, as described in Table 25.

Table 25: Major Dams in Antrim County

Dam Name	Location	Hazard Potential Classification	EAP on File	EAP Last Revised	Last Inspected	Condition Assessment	Owner
Cedar River Dam	Village of Bellaire	High	Yes	1/27/1999	10/9/2021	Fair; meets applicable hydrologic and seismic regulatory criteria	Village of Bellaire
Bellaire Dam	Village of Bellaire	High	Yes	N/A	11/1/2018	Fair	Antrim County Board of Public Works
Elk Rapids Hydroelectric Dam	Village of Elk Rapids	Low	Yes	3/4/2020	7/26/2017	N/A	Antrim County

Sources: State of Michigan Dam Inventory; National Inventory of Dams

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 (Table 25).

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 and downstream properties in adjoining Kearney Township and/or Forest Home Township. 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.

Additionally, Antrim County is located downstream of a high hazard potential dam - the Rugg Pond Dam - located on the Rapid River in southerly adjoining Rapid River Township, Kalkaska County. The dam is owned by Kalkaska County and has been given a “Fair” condition rating by the EGLE Dam Safety Unit. The Kalkaska County Board of Commissioners is currently in the process of evaluating options of whether to repair the dam and remove accumulated sediment behind the dam, or remove the dam and accumulated sediment entirely. If this dam were to fail, floodwaters would impact property along the Rapid River in Kalkaska County, which terminates at the Torch River, just south of Torch Lake, near Milton Township in Antrim County. It is recommended that Antrim County stay regularly informed about the current status of action associated with this dam in Kalkaska County.

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. Specific road/stream crossing concerns related to flooding that was noted by participants during the plan development include the following; quoted text was obtained from online survey results:

- Village of Ellsworth: severely undersized culvert on Bridge Street that is "impeding the flow of water from the upper chain of lakes"; sediment deposits around the culvert make it very difficult to navigate the waterway in a non-motorized watercraft. There is evidence of erosion/overflow/undercutting where the bridge structure meets the stream. Additionally, the Lake Street (C-48) crossing over Skinner Creek, near the Tapawingo restaurant, was noted to have flooding concerns and structural deficiencies due to aging. It is a stone culvert – allegedly the oldest in the county. Not much sediment deposit noted in the stream, but the surface edge of road on the upstream side is degrading/eroding.

- Village of Ellsworth/Banks Township (on the border of both communities): an undersized and deteriorated culvert on a main trunkline (East Jordan Road/Lake Street/C-48) that is in need of replacement. If it fails, traffic in and out of Ellsworth on the north side of Six Mile Lake will be severely impeded; private residences are also located near this problematic road/stream crossing.

- Village of Bellaire: "two dams in proximity…that could cause some issues." "There are three bridges in the Village, and two dams within the Village." Craven Pond (Blair Lake) in Bellaire almost overflowed during storm events in October 2020 and August 2021; if this were to happen the dam would have been breached. The Intermediate River has filled with sediment and become very shallow.

- Village of Central Lake: State Street Bridge (aging) over the Intermediate River. There is a USGS water level monitoring station on the bridge – the only one in the county. Need to ask the Road Commission if work is scheduled on bridge soon – a potential area of water constriction/erosion concern?

- Village of Elk Rapids: "I think that our infrastructure is aging – and there are significant pieces within our jurisdiction – but I also know that there are plans in place to inspect and maintain them. We need to monitor this to make sure that there is follow-through." "We have a dam and a bridge (the bridge is not in the best of shape either). There is an undersized road/stream crossing on Cedar Street over the Elk River; concerns with the structural condition of the Dexter Street Bridge just south of the Elk Rapids Dam; flooding issues on Lake Street on the south side of Bass Lake. Flood would most likely have the largest impact on the community with "lots of waterfront and low-lying areas."

- Central Lake Township: Mohrmann Road Bridge - timbers on bridge structure. Increased sedimentation over the years makes the river/lakes wider and shallower. Floods go down and around the bridge, not over. This bridge is the only way to cross the lakes between the Villages of Ellsworth and Central Lake. It is not on Road Commission's agenda for applying for funding. It is rated as being in "Fair" condition. Road Commission will complete some work on it as needed with their crews at minimal expense.

- Helena Township: "…two consecutive years of parts of town [hamlet of Alden] and homes that have flooded." The Alden Highway bridge over Finch Creek washed out in an August 2021 major rainstorm; this has since been reconstructed by the Antrim County Road Commission. There are many undersized culverts at road/stream crossings that result in flooding. The Road Commission is pursuing funding for local bridge funds for FY 2025 for preventative maintenance work at the Clam River Bridge in both Helena Township and Forest Home Township. The road at this location acts like a dam and restricts water flows from Clam Lake to Torch Lake.

- Forest Home Township: General concern about private dams and culverts. Also, the Intermediate River has filled with sediment and become very shallow.

- Kearney Township: Dams and bridges; "We only have one bridge that is connected to the one dam that we have our Township, this was last renovated about 20 – 25 years ago." "With heavy rains, we have concerns with road culverts not being able to handle the increase water flow and possibly causing erosion of the road bed and banks" (primarily along cottage Drive near Lake Bellaire and Clam Lake. Also, the Intermediate River has filled with sediment and become very shallow.

- Custer Township: "Flooding with bridges."

- Milton Township: "We have concerns to the bridge in our area – Torch River Bridge – as well as utilities and the potential for weather related events." The Road Commission is pursuing funding for local bridge funds for FY 2025 for preventative maintenance work where there has been flooding along the Torch River in Milton Township/Kalkaska County.

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.

Banks Township, Elk Rapids Township, Milton Township, Torch Lake Township, and the Village of Elk Rapids are the only Antrim County communities participating in the National Flood Insurance Program (Table 26). Their FIRM effective dates range from 1983 to 1988. In light of the changing flood potential in surrounding counties and Antrim County, Antrim County officials are in contact with FEMA to review existing flood concerns in the county. Community input and coordination with FEMA will determine the extent of future mapped flood areas.

FEMA defines a "repetitive loss property" as any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period since 1978 (the year at which consistent claims data collection began). County officials have not identified any properties that are defined by the National Flood Insurance Program as having suffered repetitive flood losses. FEMA officials were contacted in July 2022 with a request to provide documentation of NFIP data. The documentation was not provided prior to the completion of this plan. FEMA officials have indicated to Antrim County that updated digital flood maps for NFIP participating communities may not be available until 2024.

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 FIRMs that incorporate data from this model will be made by FEMA in 2024.

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

Table 26: 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	NSFHA	
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. The locations of campgrounds are identified on the Vulnerable Populations and Hazard Areas Map in Appendix A.

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. Approximate trajectories of recorded tornadoes with NOAA are illustrated on the Vulnerable Populations and Hazard Areas Map in Appendix A.

Extent

The Fujita Scale (Table 27) 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, Antrim County's most damaging tornado was an F3 on July 3, 1974 with winds ranging from 138-167 mph.

Table 27: 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 injuries (Table 28). The most destructive tornado was a category F3 in 1974 that caused $250,000 in property damages and the reported two injuries. The second-most destructive tornado occurred recently, in May 2022. It was an EF1 that began near Alba in Star 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.

The event narrative for the 1974 tornado is as follows:

> "Touched down near M66. Skipped through woods, continuous swath several miles west of Elmira. Two girls injured when chicken house carried 100 ft. through air. Industrial building at U.S. 131 and M32 destroyed and both highways covered by debris. Other small buildings destroyed. 350 acres of trees destroyed along track east of Elmira."

The event narrative for the 2022 tornado is as follows:

> "The tornado formed 4 miles east of Alba in a location on Olds Rd 0.5 miles east of the Alba Rd intersection. It tracked east northeast for about 1.75 miles before exiting Antrim county 200 yards southeast of the Alba Rd/Old Alba Rd intersection. The tornado continued in Otsego county for almost 16 additional miles before dissipating at 1457 EST. In Antrim county, no injuries or fatalities were reported. Several homes were damaged along with numerous softwood trees snapped at their trunks (DI 28, DOD 4) along Patterson Rd. While the highest rating of EF1 in Antrim county was assigned at this location, the tornado was rated EF3 in Otsego county. The maximum path width in Antrim county was 200 yards."

Table 28: Tornado Events, Year, Damages

Event #	Beginning Location	End Location	Date	Deaths	Injuries	Scale	Property Damage	Crop Damage
1	Kearney Twp., South end of Intermediate Lake		7/16/1958			F1	$30	
2	Jordan Township	Elmira Township (Otsego County)	7/3/1974		2	F3	$250,000	
3	Central Lake Township	Warner Township	7/31/1977			F2	$250	
4	Jordan Township	Chestonia Township	9/7/1985			F1	$0	
5	Milton Township	Clam Lake, between Forest Home and Helena Townships	7/8/1990			F1	$0	
6	Lake Michigan, near Elk Rapids/Elk Rapids Township		8/4/1995			F0	$0	
7	Lake Michigan, near Torch Lake Township		5/31/1998			F0	$0	
8	Torch Lake	South of the hamlet of Alden, in Helena Township	7/10/2007			EF0	$4,000	
9	Birch Lake, Milton Township, near the hamlet of Kewadin	Williams Road south of Birch Lake, near the hamlet of Kewadin	8/3/2017			EF0	$55,000	
10	Southwest of the hamlet of Alba, Mancelona Township	Northwest of Primrose and Eastcott Roads, Star Township	8/28/2018			EF0	$80,000	
11	4 miles east of Alba in a location on Olds Rd 0.5 miles east of the Alba Rd intersection, Star Township	Old Alba Road near the Otsego County Line, Star Township	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.

Similar to thunderstorms and severe wind events, populations without access to permanent, sturdy shelter are most vulnerable to tornado events. This includes mobile home parks, campgrounds, recreation areas, and large outdoor gatherings. The locations of mobile homes and campgrounds are identified on the Vulnerable Populations and Hazard Areas Map in Appendix A.

Persons with a disability or elderly persons are also more vulnerable. Tornados can occur suddenly with very little warning, and it may be difficult for these populations to find adequate shelter in a hurry.

The county currently 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 that is operable for tornado warnings. Input received as part of the hazard mitigation planning process indicated an interest in investigating potential funding opportunities for additional manual tornado sirens to be installed in the other four villages in the County.

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. Additionally, 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.

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.

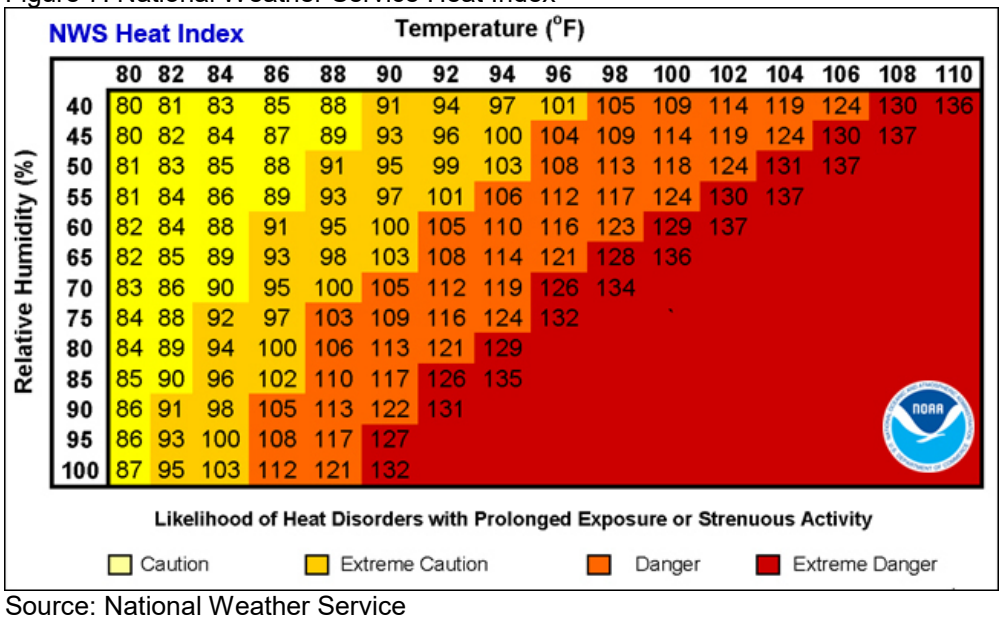
Nationwide, there have been approximately 175 deaths per year that are attributable to extreme heat according to the 2019 Michigan Hazard Analysis. The threats from extreme heat are heatstroke, sunstroke, muscle cramps, heat exhaustion, and fatigue. It is hazardous to livestock and agricultural crops, 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.

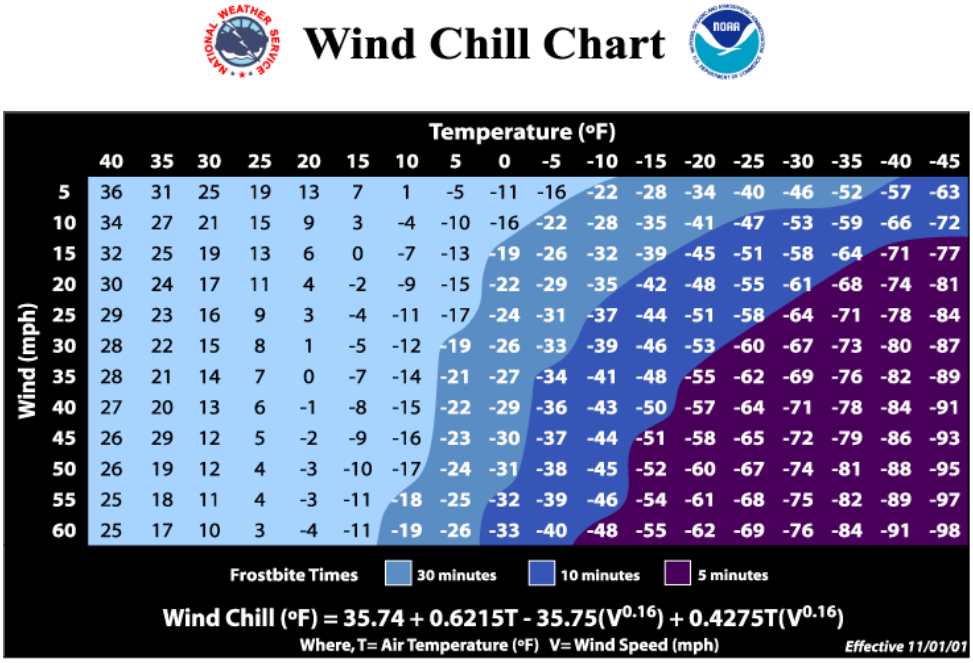
Figure 7: National Weather Service Heat Index



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

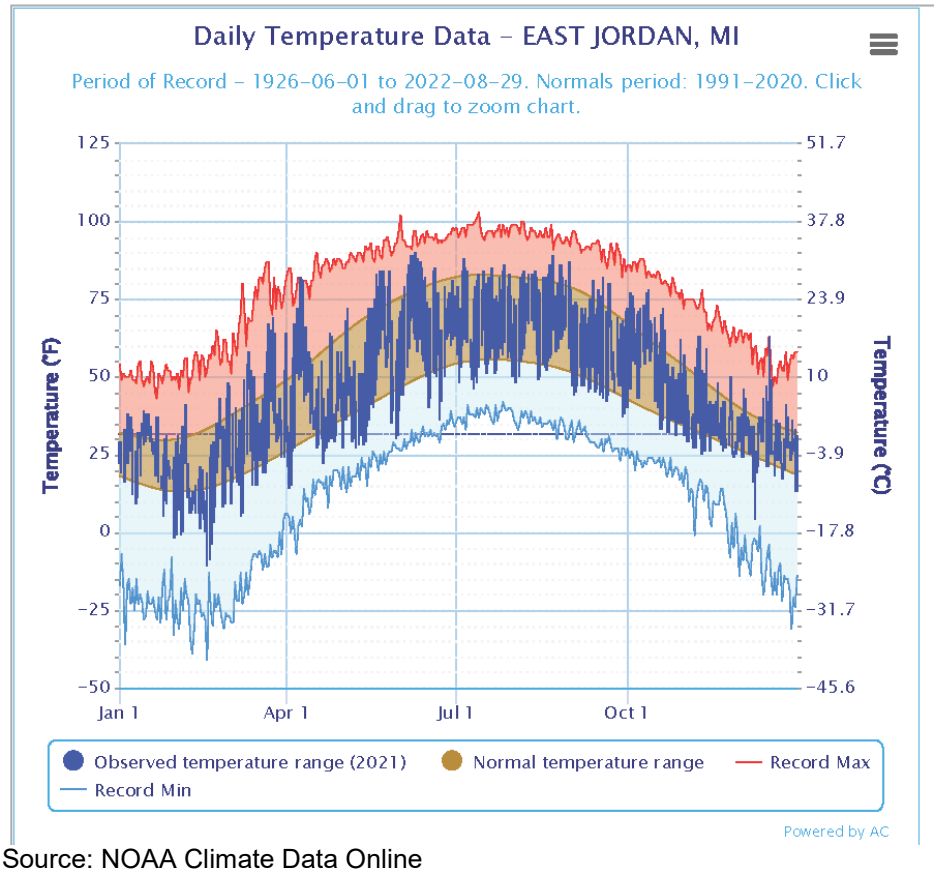


Wind (mph)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29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

Source: National Weather Service

Figure 9 illustrates 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

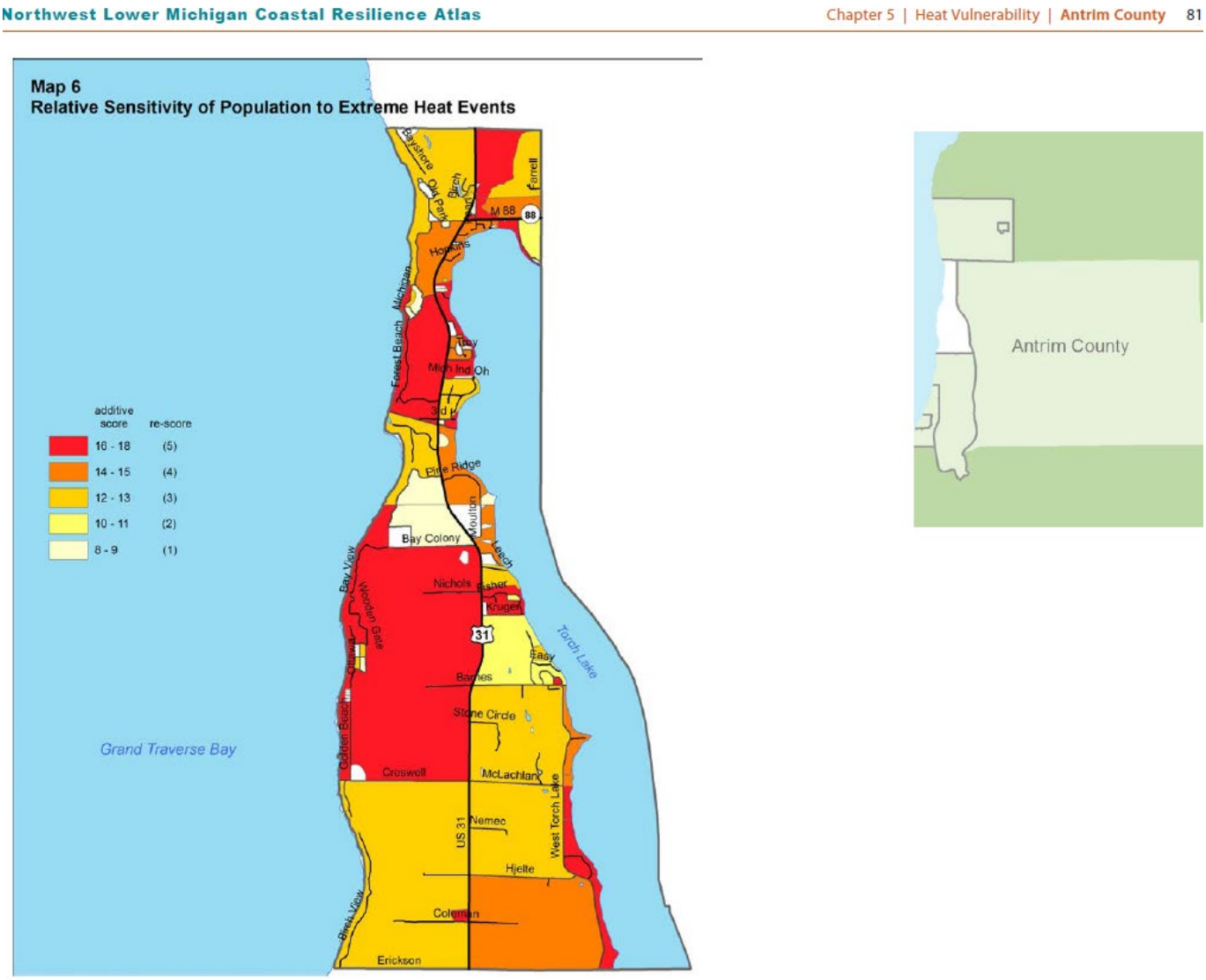
libraries, have been utilized during regular hours for temporary shelters to be used during the day. There are no homeless shelters located within Antrim County.

The *Northwest Lower Michigan Coastal Resilience Atlas* written by the Land Information Access Association (LIAA) completed a Heat Vulnerability Assessment[5] 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 folowing 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



Source: LIAA *Northwest Lower Michigan Coastal Resilience Atlas*

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

Drought

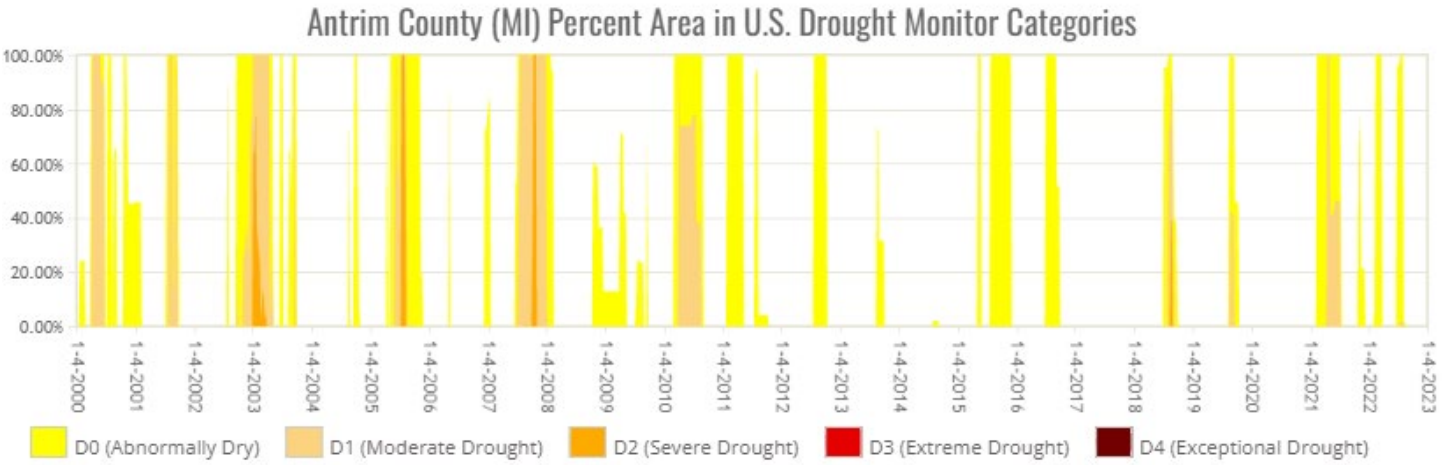
Drought is a normal part of the climate cycle. It is a slow-moving hazard, which causes people to underestimate the damage it can do, but losses from drought are as substantial as those from hurricanes, tornadoes and other faster-moving disasters. Drought causes losses to agriculture; affects domestic 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: Historical Drought Levels, Years



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. Almost half of Antrim County is forested, and cultivated crop land cover accounts for 13.7% of the county's land cover. These land uses may be most at risk for impacts from drought.

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.

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 dependent 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 lightning strike will 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 can 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 USFS 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.

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 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 157,723 acres or 49.5% of Antrim County is forested. Jack pine trees, which are considered the most flammable, comprise 1,568 acres, or 0.8%, of the predominant tree species. Red pine comprises 23,997 acres, or 11.6%, and white pine comprises 167 acres, or 0.1%. The Environmental Features Map in Appendix A shows pine forests in various places throughout every community. However, the largest groupings of pine forest are in the southeast portion of the county, in Mancelona Township and parts of Star, Chestonia and Custer Townships. These areas are highly susceptible to wildfire, as are tree farms in Banks, Central Lake, and Helena Townships (shown on the Vulnerable Populations & Hazard Areas Map in Appendix A.)

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 land in a given year, and a small chance there will be a wildfire on lands outside of MDNR jurisdiction. Red Pine, Eastern White Pine, and Jack Pine forests within Antrim County are most susceptible to wildfires. Additional factors that increase fire risk include dead or dying 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, areas of the current landscape have transformed into residential development. With this land use change, 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 12, large portions of the Lake Michigan shoreline throughout west Michigan are identified as “High Risk Erosion Areas in 2019.”

Figure 12: 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 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 shorefront 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 in 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.

Figure 13: Lake Michigan Coastal Communities in Antrim County

Source: LIAA, Northwest Lower Michigan Coastal Resilience Atlas

Figures 14 - 15 illustrate the three potential flooding scenarios in Milton and Elk Rapids Townships. "Lucky" scenario flooding is shown in green, "Expected" flooding scenario is shown in yellow, and "Perfect Storm" future scenario is shown in red. The locations of existing roads and structures are overlaid on these hazard scenario maps.
Figures 14: Panel #74 Coastal Flooding Scenarios, Milton Township and Elk Rapids Township

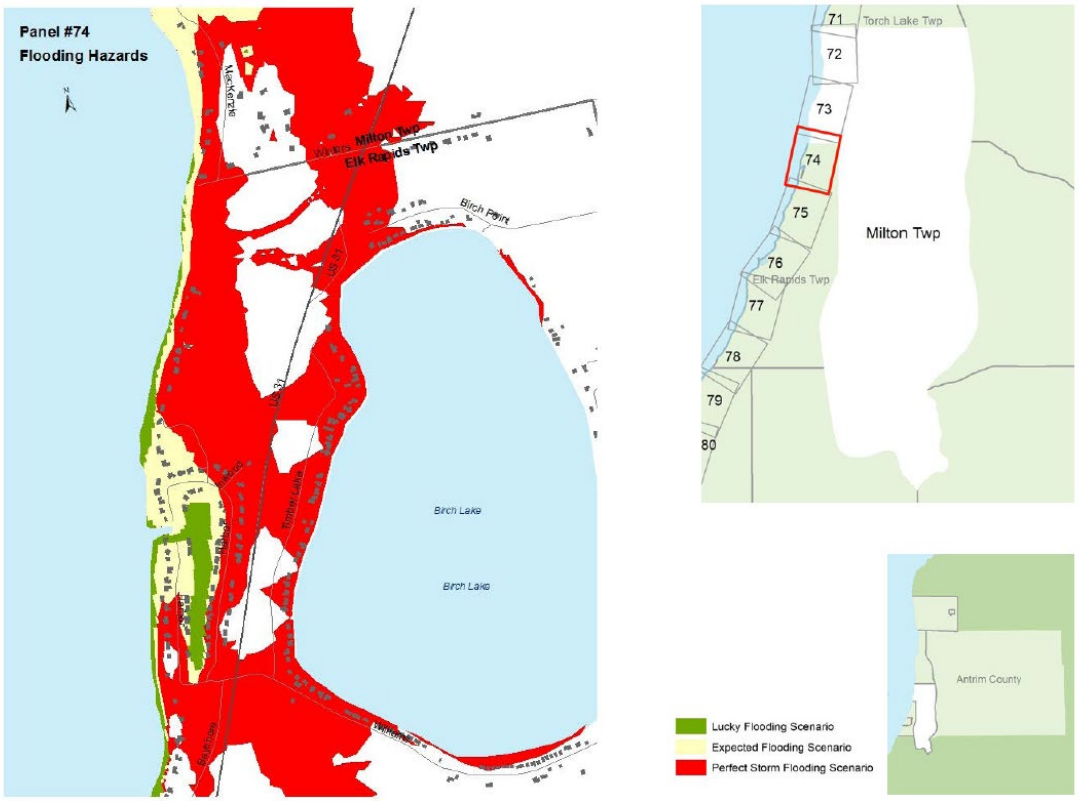


Figure 15: Panel #75 Coastal Flooding Scenorios, Elk Rapids Township

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 16 for Banks Township. Detailed maps of shoreline recession boundaries for all Antrim County coastal communities are appended.

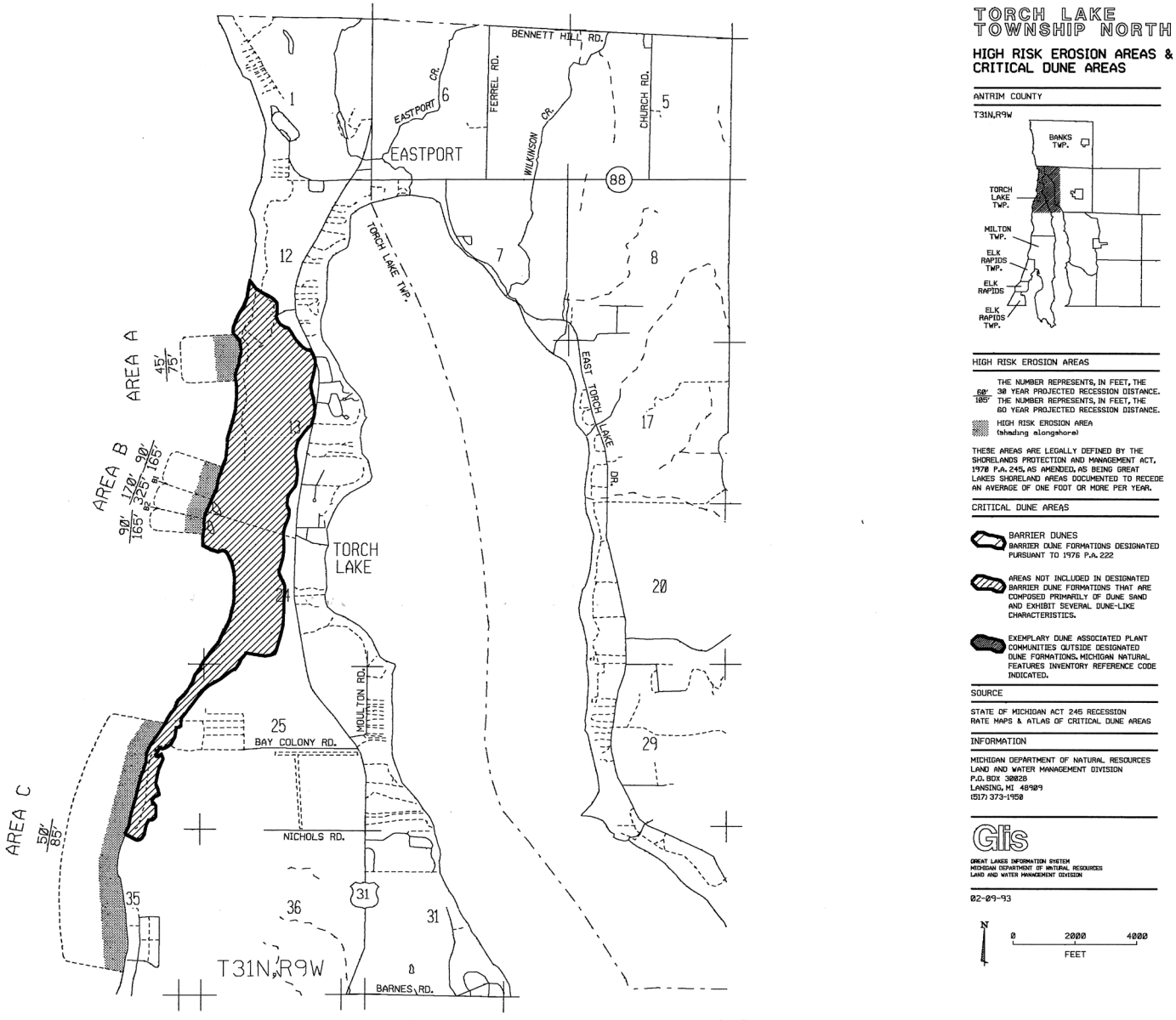
Figure 16: Shoreline/Bluffline Recession, Banks Township

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 17 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.

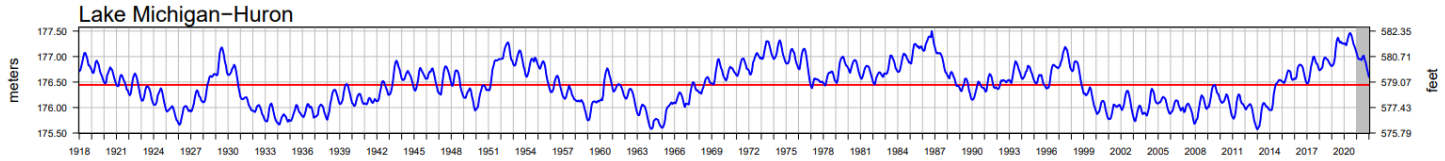
Figure 17. EGLE's Map of High Risk Erosion Areas and Critical Dune Areas for Torch Lake Township (North)



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 18), 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 18: 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 of these counties has recorded death(s) and/or rescue(s) 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 Michigan 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[6], as of January 31, 2023, there are 5,244 cases and 76 deaths (confirmed and probable for COVID-19) in Antrim County. Those 80 years and older have the most deaths of any age range at 35 deaths; there are 15 deaths reported in the county for those aged 70-79 years and 15 deaths reported in the county for those aged 60-69 years. [7]

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. These emergency declarations are still in effect at the time of development of this Hazard Mitigation Plan.

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.

[6] https://www.michigan.gov/coronavirus/stats
[7] The sum of the deaths for individual categories may be fewer than the total number of deaths due to data suppression.

Invasive Species

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." There are a wide variety of species considered invasive. Known and monitored species include:

- Mammals
- Birds
- Insects
- Fish
- Crustaceans
- Mollusks
- Worms
- Plants
- Diseases

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 include non-native, water-dwelling 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.

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[8]. 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.

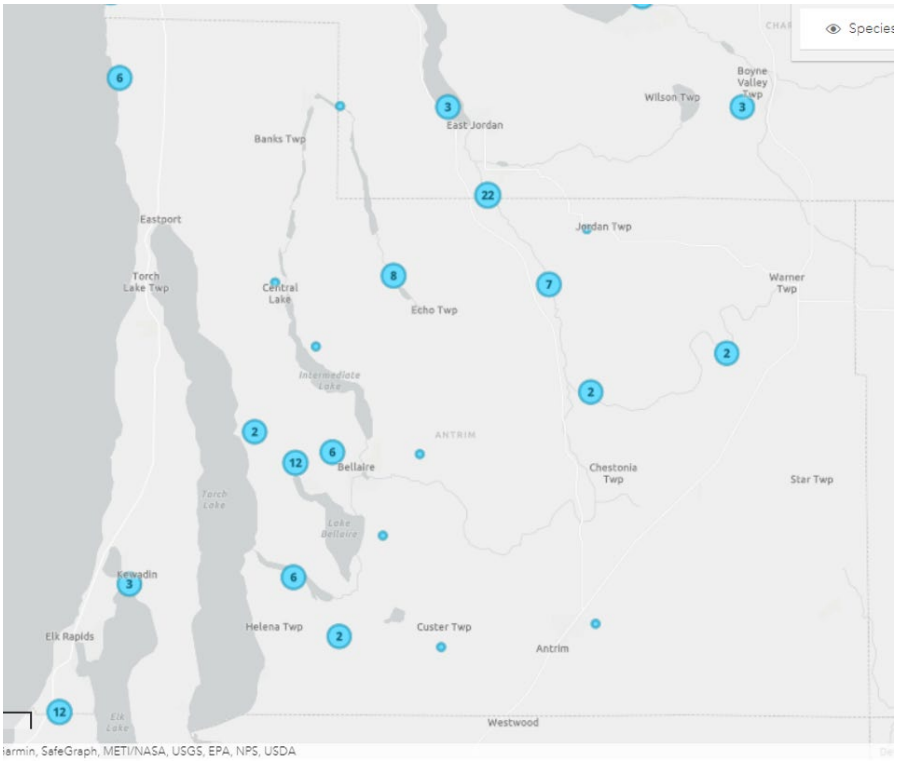
The Midwest Invasive Species Network (MISIN) is a regional effort to develop and provide early detection and response resources for invasive species. Among many tools and resources, the website (misin.msu.edu) provides a catalog of species information and a report of occurrences submitted within each state. Animals, plants, and diseases are included in the catalog. The top five reported species in Michigan are: phragmites (invasive) with 63,018, garlic mustard with 18,368, autumn olive with 16,042, spotted knapweed with 15,436, and brown marmorated stink bug with 13,351.

Location

Terrestrial and aquatic invasive species threaten sensitive ecosystems and 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. TIS and AIS designation generally applies, however, several upland species appear to be spreading to wetland and aquatic areas. Regular monitoring and reporting introductions detected is the only way to know where an invasive species has infested. The MISIN Species Observations shares reported detections by species name (common and scientific) and family type. Figure 19 identifies reported MISIN Autumn Olive cases throughout Antrim County and in some adjoining counties.

[8] The Welland Canal is a ship canal in Ontario, Canada, connecting Lake Ontario and Lake Erie.

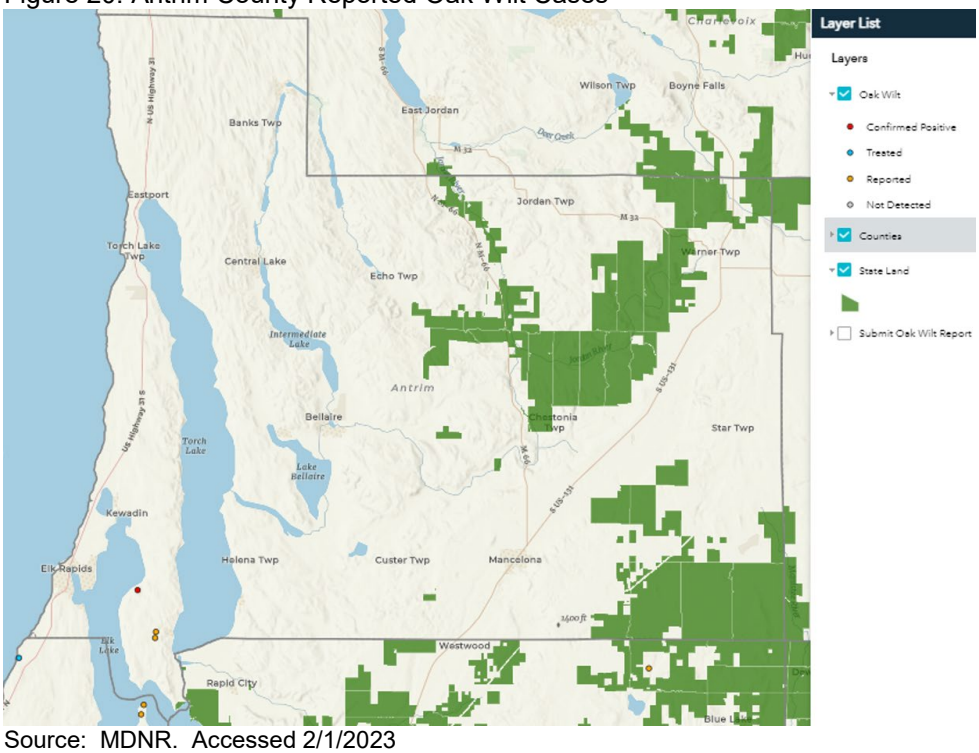
Figure 19: Antrim County Autumn Olive Reported Cases



Source: Midwest Invasive Species Information Network Accessed 2/1/23.

Figure 20 illustrates the MDNR interactive mapping resource “Look for Oak Wilt,” which allows users to submit an Oak Wilt Report throughout Michigan. Three Oak Wilt cases have been reported in the southwest portion of Antrim County, in Milton Township. These include trees confirmed positive for the disease and trees that are reported cases.

Figure 20: Antrim County Reported Oak Wilt Cases



Source: MDNR. Accessed 2/1/2023

Extent

Invasive species impact on the county can be measured by its damaging effects. TIS cause billions of dollars in damage annually, are extremely costly to control, and often have irreversible ecological effects. Native habitats, agriculture lands and livestock, and the outdoor recreation economy are threatened or damaged by invasive species. *Michigan's Terrestrial Invasive Species State Management Plan* lists these state impacts:

- The State of Michigan estimates 42% of threatened or endangered species are considered at risk due to non-native species.
- Visitors spent over $22 billion dollars in Michigan in 2014, supporting nearly 327,000 jobs (Tourism Economics 2014). Invasive species impact the use and beauty of Michigan's shorelines, trails and parks, which may result in a reduction in visitor spending and citizen enjoyment
- Michigan's Forest Products Industry supports 96,000 jobs and contributes more than $20 billion to the state's economy each year (Michigan DNR 2015). Invasive forest pests including emerald ash borer, oak wilt and beech bark disease kill trees and significantly impact the value of urban properties, forests and timber resources. The estimated cost of treating or removing dead ash within developed land in Michigan's communities due to emerald ash borer was $230 million in 2009[9]. A map of oak wilt cases in Antrim County is shown as Figure _.

Previous Occurrences
The Department of Environment, Great Lakes, and Energy oversees invasive species programs for the State. The State has produced prohibited and restricted species lists, watch lists, and state management plans for terrestrial and aquatic species. Many of the species listed in this plan are also listed as a prohibited or restricted species: it is unlawful to possess, introduce, import, sell, or offer that species for sale as a live organism, except under certain circumstances. A full list of prohibited and restricted species can be found at Michigan.gov/invasives.

The Cooperative Invasive Species Management Area serving Charlevoix, Antrim, Kalkaska, and Emmet counties (CAKE CISMA) and Antrim Conservation District are focused on habitat-specific management: planning to manage for the resource (aka that natural area) and restoration therefore will remove and control anything that is not supposed to be there. Natural areas for consideration are high-quality natural areas in Charlevoix, Antrim, Kalkaska, and Emmet Counties such as around coastal dunes (e.g. Lake Michigan) and waterways & riparian areas (i.e., the Elk River Chain of Lakes (ERCOL) Watershed). Many of these invasive species are detrimental to local property values if they degrade the quality of and access to valued natural resources.

One of our most beloved evergreens, the eastern hemlock (*Tsuga canadensis*) is also a critical part of our local ecosystems. Often found along ravines, hillsides, and stream banks, eastern hemlock offer habitat for wildlife and provide shade for streams, effectively lowering stream temperatures and increasing oxygen for fish and other aquatic species. Hemlocks provide aesthetic value and are loved by homeowners. It is estimated that Michigan is home to 170 million eastern hemlock trees. Unfortunately, this beautiful tree is now threatened by an invasive species: hemlock woolly adelgid (*Adelges tsugae*).

CAKE CISMA began conducting grant-funded surveys of hemlock trees within 5 miles of the Lake Michigan shoreline lakeshore for Hemlock Wooly Adelgid in the winter of 2023. The area within 5 miles of the Lake Michigan shoreline is the most probable area for new infestations. The adelgids tend to favor the temperatures and conditions found near the lake more than those inland.

Phragmites (non-native) and Purple loosestrife (described below) are two other invasive, riparian plants that grow quickly in and near rivers, lakes and streams. CAKE CISMA, in cooperation with landowners, treats these species along the Elk River Chain-of-Lakes, the Lake Michigan coast and other wet areas throughout the county in order to improve fish and wildlife habitat, as well as biodiversity.

The following terrestrial species are causing significant harm:

- Japanese knotweed, Giant knotweed and Bohemian knotweed, *Polygonaceae,* can be a concern to homeowners, and municipalities because of these plants' ability to grow into a structure's foundation, through sidewalks and road surfaces. These plants can also be spread by root fragments and stem sections. It can create monocultures that shade out desirable vegetation, creating poor habitats for native species. This is of particular concern along water bodies and has been shown to be extremely detrimental to waterways in the Eastern US.

[9] Kovacs, K.F., R.G. Haight, D.G. McCullough, R.J. Mercader, N.W. Siegert and A.M. Liebhold. 2010. Cost of potential emerald ash borer damage in U.S. communities, 2009−2019. Ecological Economics 69: 569-578.

- (Invasive) Phragmites is a large-scale clonal grass that rapidly colonizes wetlands. Phragmites crowds out native plants and alters habitat for native fauna. In doing so, Phragmites also alters human access to water resources and has adverse economic effects, including decreasing property value, inhibiting recreational use, and limiting populations of game species. It can become a fire hazard when it dries down
- Cypress spurge is an erect, herbaceous to semi-woody perennial with bright yellow-green flowers that turn to purple-red as they mature. Cypress Spurge is toxic to horses and cows.
- Black Swallow Wort is a rapidly growing, herbaceous perennial in the Milkweed family. However, Black Swallow Wort is toxic to animals and the monarch butterfly.
- Oriental bittersweet is a vine plant that can strangle a tree and causes tree mortality. This impacts ecosystem health and economic health that is associated with trees' health.
- Autumn olive is very widespread in Michigan. It is spread by birds and is recolonizing old farm fields. Its value to wildlife is relatively low (low in protein and other nutrients compared to our natives). It also is known for its nitrogen-fixing abilities.
- Oak wilt is an infectious vascular disease that can affect all species of oak. Red oaks get the disease more often and succumb more readily than white oak. The disease spreads via root grafts and sap-feeding beetles.
- Beech bark disease is caused by the combination of the *Neonectria* fungus and beech scale. Beech scales are yellow, soft-bodied insects that are 0.5 to 1.0 mm long as adults. The insects, found on the tree trunk and branches, feed on sap in the inner bark. The minute wounds caused by the scale insects eventually enable the Nectria fungus to enter the tree. The Nectria kills areas of woody tissue.

The following aquatic species are causing significant harm:

- Didymo or “rock snot” is an aquatic diatom that is brown, tan, or yellow in color. Unlike most algae, it feels like wet cotton and is not slimy. Grows in rivers, streams, and lakes. It occurs particularly in cool, oligotrophic, clear water
- Purple loosestrife is an herbaceous wetland perennial reaching 5 feet with reddish-purple flowers with five to seven petals are held in dense terminal cluster. Grows in moist soils, in wet meadows and prairies, shallow marsh, ditches, waste areas, and along lakes, ponds, streams, and rivers.
- Garlic mustard is an aquatic, herbaceous biennial, up to 4 feet in height. Forms round basal rosette the first year, flowers the second year and dies. Grows in forests, particularly floodplain forest, open wetlands, parking lots, campgrounds, paths, and roadsides.
- Eurasian water-milfoil is a submergent, aquatic perennial that reached 3-10 feet or more in length. Grows in ponds, lakes, and low-energy zones in rivers and streams.
- New Zealand mudsnail is an aquatic mollusk with an elongated shell 1/8 inch long with 7-8 whorls. Shell color varies from gray and dark brown to light brown. Grows in flowing freshwater with silt/sand to very brackish rivers; lives in water as deep as 60 feet in lakes or reservoirs.
- Red swamp crayfish is an aquatic crustacean with a dark red body and claws with spiky, bright red bumps, and black wedge-shaped stripe on underside. Grows in flowing to non-flowing freshwater or salt water; permanent ponds; areas of streams and ditches with organic debris; agricultural areas; wetlands.
- Zebra mussel is an aquatic mollusk with striped shells or dark or light shells with no stripes. They attach to objects (pipe, boats, etc.) causing major damage as colonies can block pipes, affecting power and water-treatment plants.

Many of the species listed above are monitored and managed by CAKE-CISMA. However, the list of all invasive species impacting the county is extensive and many established species are treated on a case-by-case basis. Other species of concern include:

- Honeysuckle (non-native)
- Glossy buckthorn
- Common buckthorn
- Wild parsnip
- Multiflora rose
- Periwinkle

Probability of Future Events and Vulnerability Assessment

The State TIS Management Plan provides a list of eleven terrestrial species on the watch list, provided below. These are priority species that have been identified as posing an immediate and significant threat to Michigan’s natural resources. These species have either not been confirmed in Michigan, have very limited distribution, or are localized. Early detection and timely reporting of occurrences of these species is crucial for increasing the likelihood of stopping an invasion and limiting negative ecological and economic impacts. This list is reviewed and updated periodically, and the most current list is available at www.michigan.gov/invasives.

Common Name - Scientific Name - Category

1. Asian longhorned beetle *Anoplophora glabripenni* Insect
2. Asiatic sand sedge *Carex kobomugi* Plant
3. Balsam woolly adelgid *Adelges piceae* Insect
4. Chinese yam* *Dioscorea oppositifolia* Plant
5. Hemlock woolly adelgid* *Adelges tsugae* Insect
6. Himalayan balsam* *Impatiens glandulifera* Plant
7. Japanese stiltgrass* *Microstegium vimineum* Plant
8. Kudzu* *Pueraria montana* Plant
9. Mile-a-minute weed *Persicaria perfoliata* Plant
10. Nutria *Myocastor coypus* Mammal
11. Thousand Cankers Disease *Geosmithia morbida Pityophthorus juglandis* Tree Disease

The Michigan Watch List: Aquatic Invasive Plants and CAKE CISMA are also monitoring for additional species:

- Spotted lantern fly which impacts fruit and winery production. Winery and fruit production issues can impact agri-tourism.
- Hydrilla is an aquatic, perennial plant that forms dense mats in slow-moving water of lakes, ponds, stream, and rivers.
- European frog-bit is an aquatic, floating, herbaceous annual that forms large colonies, creating dense mats. Grows in open, still waters.
- Parrot feather water-milfoil is an aquatic, herbaceous perennial that can grow 6.5-16.5 feet in length and forms monotypic stands. Grows in lakes, ponds, slow streams, and mudflats, where the emergent form is found.
- Starry stonewort is an aquatic microalga which forms dense mats that cover lake bottoms. Grows in still or slow moving waters.
- Asian Carp (bighead, black, grass, and silver carp) are in direct competition with native aquatic species for food and habitat. Their rapid population increase is disrupting the ecology and food web of the large rivers of the Midwest.
- Beech leaf disease causes dark stripes or banding between leaf veins. A nematode (microscopic worm) is associated with symptoms. Ongoing research is investigating the possibility of other contributing microorganisms.

Potential impact from the species listed on watch lists could be catastrophic for Antrim County's natural resources, agriculture, recreation, tourism, and economy.

CAKE CISMA, Antrim Conservation District, and other land and water management partners protect, enhance, and promote Northwest Michigan's natural communities through terrestrial and/or aquatic invasive plant management, education, and outreach. Antrim County's natural resources are highly vulnerable to invasive animals, plants, and diseases. Significant natural features include forested areas such as Glacial Hills Pathway and Natural Area in Forest Home Township; the Mackinaw State Forest in the northeast portion of the county which includes the Jordan River, Jordan River National Fish Hatchery, Jordan River Pathway, Warner Creek Pathway and MDNR campgrounds; the Mackinaw State Forest lands in the southeast port of the county, and of course the Elk River Chain of Lakes Watershed in the western half of the county. Additionally, Lake Skegemog is part of the ERCOL Chain of Lakes in Milton Township, but is also present in Kalkaska County community of Clearwater Township. The Elk-Skegemog Lakes Association works with CAKE CISMA to combat problematic invasive species such as purple loosestrife and phragmites.

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-fold[10]" (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*[11], 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.[12] 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).[13]

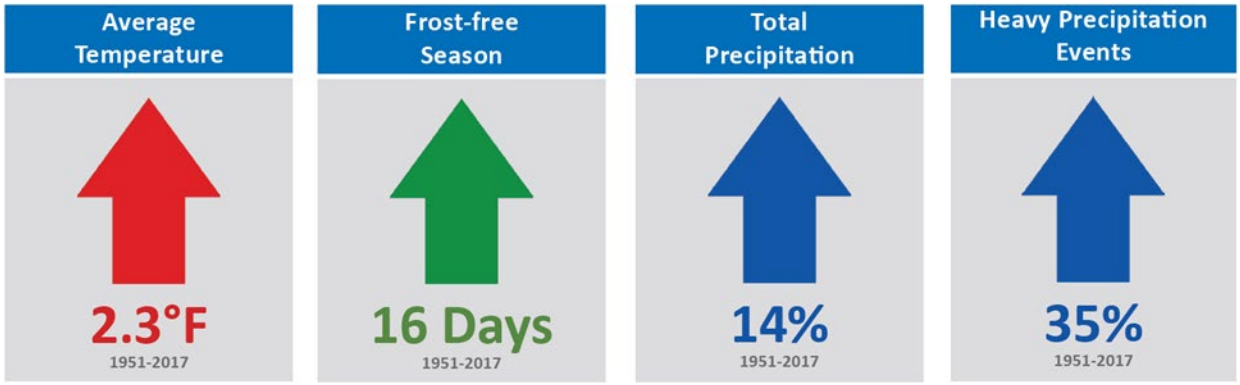
Precipitation
Since 1951, total annual precipitation has increased by 14% in the U.S., Great Lakes Region. Future projections suggest more precipitation on average, but not necessarily during all seasons (summer to be drier) and not for all locations depending on which model is used. Reduced lake ice 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.

[10] *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

[11] (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

[12] 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.
[13] 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.

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* reports, "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
- Utilizing and expanding on the 2022 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
- 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. An operable tornado 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.

Table 29: Temporary Shelter Locations in Antrim County

Banks Township 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 Township Fire	7015 Cairn Hwy. Kewadin 49648
Milton Township Fire #2	12105 Cherry Ave. Rapid City 49676
South Torch Fire	8665 Cedar River Rd. Alden 49612
Star Township 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

Source: Antrim County Department of Emergency Management

The Hazard Mitigation Strategies for Antrim County are provided in the following pages and are grouped according to theme: 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.

VII. Implementation

Hazard mitigation is any action taken before, during, or after a disaster to permanently eliminate or reduce the long-term risk to human life and property from natural and technological hazards. Mitigation is an essential element of emergency management, along with preparedness, response, and recovery. Emergency management includes four phases: actions to mitigate a disaster, a community prepares for a disaster; responds when it occurs; and then there is a transition into the recovery process. The process is cyclical and mitigation measures are evaluated and adopted constantly. The evaluation improves the preparedness posture of the County for the next incident, and so on. When successful, mitigation will lessen the impacts of natural hazards to such a degree that succeeding incidents will remain incidents and not become disasters.

Plan Review, Monitoring, and Evaluation

This Plan is intended to be a resource for building coordination and cooperation within a community for local control of future mitigation and community preparedness. The County Board will lead the implementation of the Natural Hazards Mitigation Plan with assistance from the Emergency Services Coordinator and the Administration. The LPT is an inter-agency partnership and will collaborate to accomplish the goals and objectives of the Plan. The LPT meets on a regular basis to carry out its duties and has expanded its role to function as the Natural Hazards Task Force. The Natural Hazards Task Force will be responsible for monitoring and implementing the mitigation plan. Staff support will be provided by the Antrim County Emergency Services Coordinator and will coordinate with the County Board of Commissioners.

The Natural Hazards Task Force will perform an annual review of the Antrim County Hazard Mitigation Plan and consider the list of mitigation strategies identified in the plan. The Task Force will identify projects that have been completed and identify new projects to be completed. The following agencies have been encouraged to actively participate in revising, updating, and maintaining the plan.

- Antrim County Government Staff
- Townships and Villages
- Antrim County Conservation District
- Antrim County Drain Commissioner
- Antrim County Road Commission
- Grand Traverse Band of Ottawa and Chippewa Indians
- Grand Traverse Regional Land Conservancy
- Charlevoix, Antrim, Emmet and Kalkaska – Cooperative Invasive Species Management Area
- The Watershed Center Grand Traverse Bay
- Tip of the Mitt Watershed Council
- Networks Northwest
- Health Department of Northwest Michigan
- Michigan State University Extension
- Michigan Department of Environment, Great Lakes, and Energy
- Michigan Department of Natural Resources
- U.S. Environmental Protection Agency
- U.S. Army Corps of Engineers
- U.S. Department of Agriculture Natural Resources Conservation Service
- Insurance Companies
- Real Estate Companies

In addition, the townships and villages (whether or not they have their own zoning) have indicated to the county emergency manager that they will follow the county's lead in identifying mitigation projects and developing grant applications to fund those projects. Land use issues associated with those projects (where applicable) will be handled by each jurisdiction that have an adopted Master Plan and regulate zoning in the project area.

Community planning services are provided by the professional staff of each municipality within the county. The respective planners assist communities in developing plans and zoning ordinances, provides resource information and technical assistance, and convenes communities to address land use issues of common interest.

Building permits are issued by the Antrim County Construction Code Department. Soil erosion permits are issued by the Antrim Conservation District. Permits related to water well and septic systems are issued by the Health Department of Northwest Michigan.

Funding the Implementation of the Plan
To assist with the funding of the proposed natural hazards mitigation strategies, the following is a list of potential financial assistance entities to help fund the implementation projects of the Plan.

- Federal Emergency Management Administration – Hazard Mitigation Grant and Building Resilient Infrastructure and Communities Programs
- U.S. Environmental Protection Agency
- U.S. Department of Agriculture Natural Resources Conservation Service
- U.S. Department of Agriculture Rural Development: Rural broadband opportunity – high speed telecommunication funding from the Public Telecommunications Facilities Planning and Construction grants
- U.S. Department of Housing and Urban Development
- Michigan Department of Environment, Great Lakes, and Energy
- Michigan Department of Natural Resources
- National Oceanic and Atmospheric Administration
- Community, Regional Foundations
- Businesses

Plan Integration
All townships and villages in Antrim County, and local and state agencies will consider integrating information from the hazard mitigation plan into their comprehensive and operations plans. All communities - except for the Townships of Central Lake, Chestonia, Custer, Echo, Jordan, Mancelona, Star and Warner - administer zoning. As part of the education and outreach aspect of the hazard mitigation effort, the other townships and villages will be encouraged to adopt zoning regulations to minimize the effect of hazards.

All natural hazards mitigation planning could be pursued using Michigan Public Act 226 of 2003, the Joint Municipal Planning Act. This Act provides for joint land use planning by cities, villages, and townships, and allows two or more municipalities' legislative bodies to create a single joint planning commission to address planning issues. This tool helps with planning for the "big picture" issues such as natural hazards that cross jurisdictional boundaries.

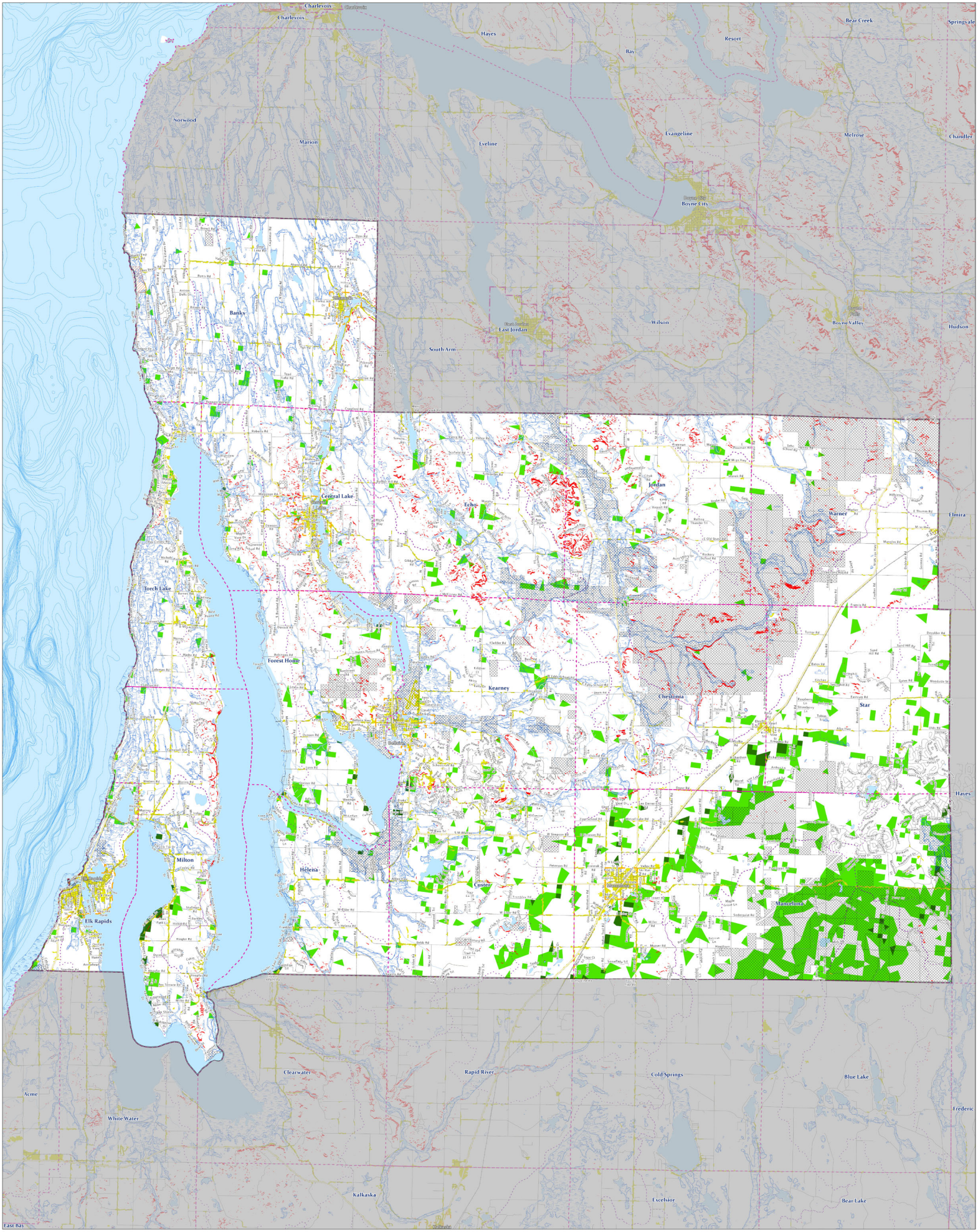
The intent of this legislation is for local governments to consider the following:

- Individual units of government modifying their ordinances simultaneously to include language that would incorporate aspects of protection
- Developing an overlay zoning district that would cross jurisdictional boundaries which would be incorporated into existing independent units of government's zoning ordinances
- Forming a new joint (multi-jurisdictional) planning commission or zoning board
- Sharing zoning administration and enforcement activities

Five Year Plan Review and Update
The Stafford Act, as amended by the Disaster Mitigation Act of 2000, requires the Antrim County Hazard Mitigation Plan to be updated, adopted, and re-submitted for Federal Emergency Management Agency (FEMA) approval every five years. The plan will be reviewed by the Natural Hazards Task Force every five years in alignment with federal regulations. The update will include determining changes in the county, such as changes in development, an increase in exposure to hazards, an increase or decrease in the communities' capability to address hazards, addition and/or removal of mitigation actions and strategies, reviewing goals, and a change in federal or state legislation. Upon plan review and update completion, the plan will be sent to the State Hazard Mitigation Officer at the Michigan State Police for final review and approval in coordination with FEMA. When the plan has received an "approved pending adoption" status from FEMA, the Antrim County Board of Commissioners can review, approve, and adopt the plan, along with individual local units of government. In order to properly update the plan in the future, Antrim County will need to seek funding from appropriate state and/or federal agencies.

Continued Public Involvement
Antrim County is committed to keeping the public involved in the implementation and update of the Hazard Mitigation Plan. Copies of the plan will be available at the county libraries, county clerk's office, and all township offices, and will be posted on the community websites and/or regional planning agency website. The Emergency Management Office will be responsible for keeping a record of public comments on the plan.

APPENDIX A – Hazard Maps



Antrim County Environmental Features

2023 Hazard Mitigation Plan

Legend

- Highways
- Roads
- Railroad
- Rivers/Streams
- Water Bodies
- Part 303 Wetlands
- Lake MI Bathymetric
- Watershed Boundary 12 Digit
- High Risk Erosion Zones
- Critical Dune Areas
- Slope 30% or Greater
- Developed Land
  - High, Medium & Low Intensity
- Pine Forest
  - Jack Pine
  - Red Pine; Eastern White Pine
- Public Land
- Villages
- Cities
- Township Boundaries
- Antrim County
- Adjacent Counties

Note:
FEMA Floodplain Data is not available in a digital shapefile format for Antrim County. Available Floodplain Maps are by FIRM Panel as an image and are unable to be displayed in the GIS Maps prepared for this planning process.

0 2,500 5,000 10,000 15,000 20,000 Feet

0 0.63 1.25 1.88 2.5 5 7.5 10 Miles

N W E S

Antrim County Hazard Mitigation Planning Process.
Map produced by Networks Northwest Community Development 2023.
Map data sources: State of Michigan, ESRI, NRCS, USDA, USGS

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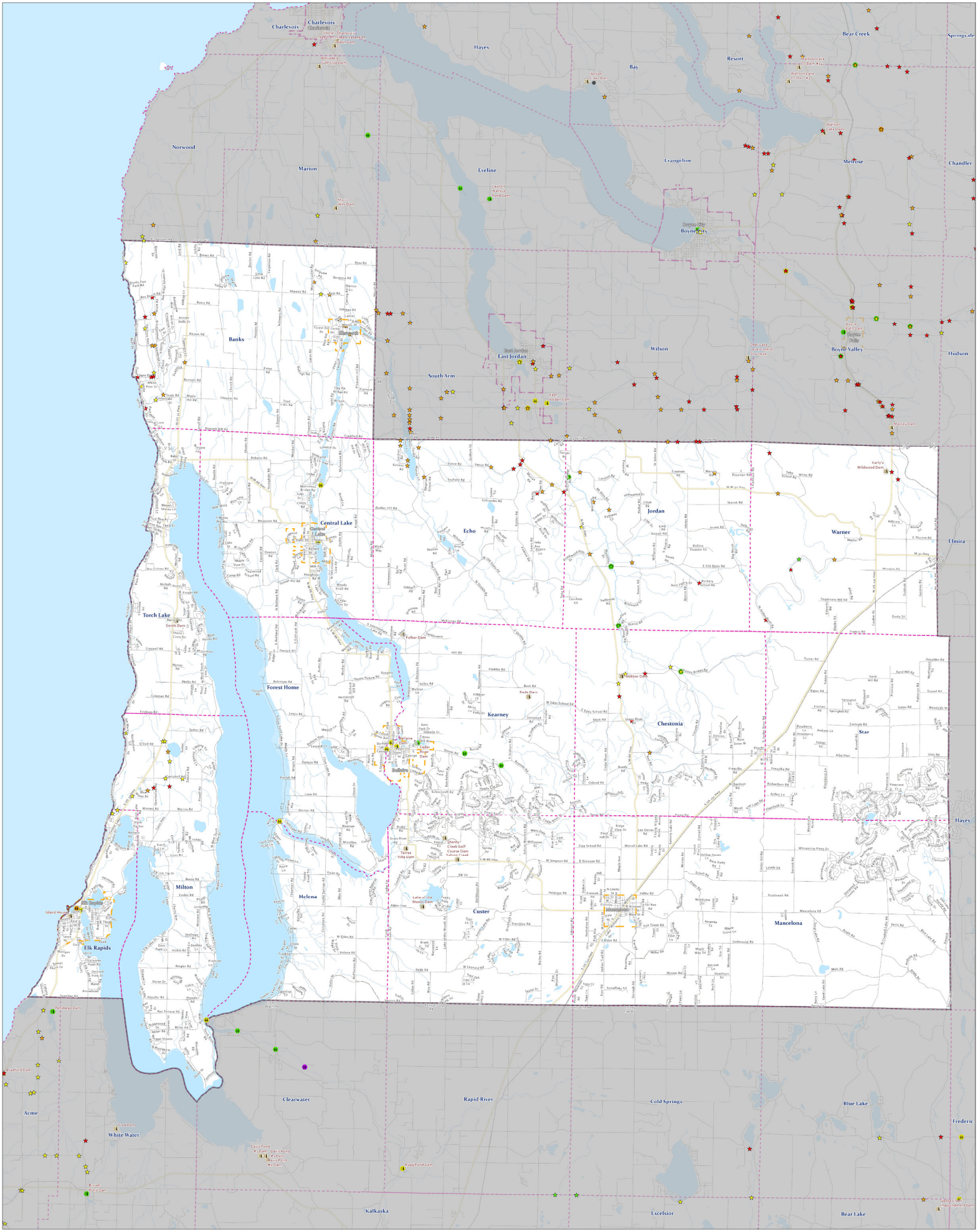

Legend

Antrim County Infrastructure

2023 Hazard Mitigation Plan

Railroad
Roads
Highways
Rivers/Streams
Water Bodies

Stream Crossings (CRA)
Severity
Restored
Minor
Moderate
Severe
Unknown

Bridge Condition
Rating
Good
Fair
Poor
Serious
Critical
Closed

MI Dam Inventory
Condition
Satisfactory
Fair
Poor
Unsatisfactory
Not Rated

Villages
Cities
Township Boundaries
Antrim County
Adjacent Counties

0 2,500 5,000 10,000 15,000 20,000 Feet
0 0.63 1.25 1.88 2.5 5 7.5 10 Miles

N
W E
S

Antrim County Hazard Mitigation Planning Process.
Map produced by Networks Northwest Community Development 2023.
Map data sources: State of Michigan, ESRI, NRCS, USDA, USGS, CRA, MDOT

Networks Northwest
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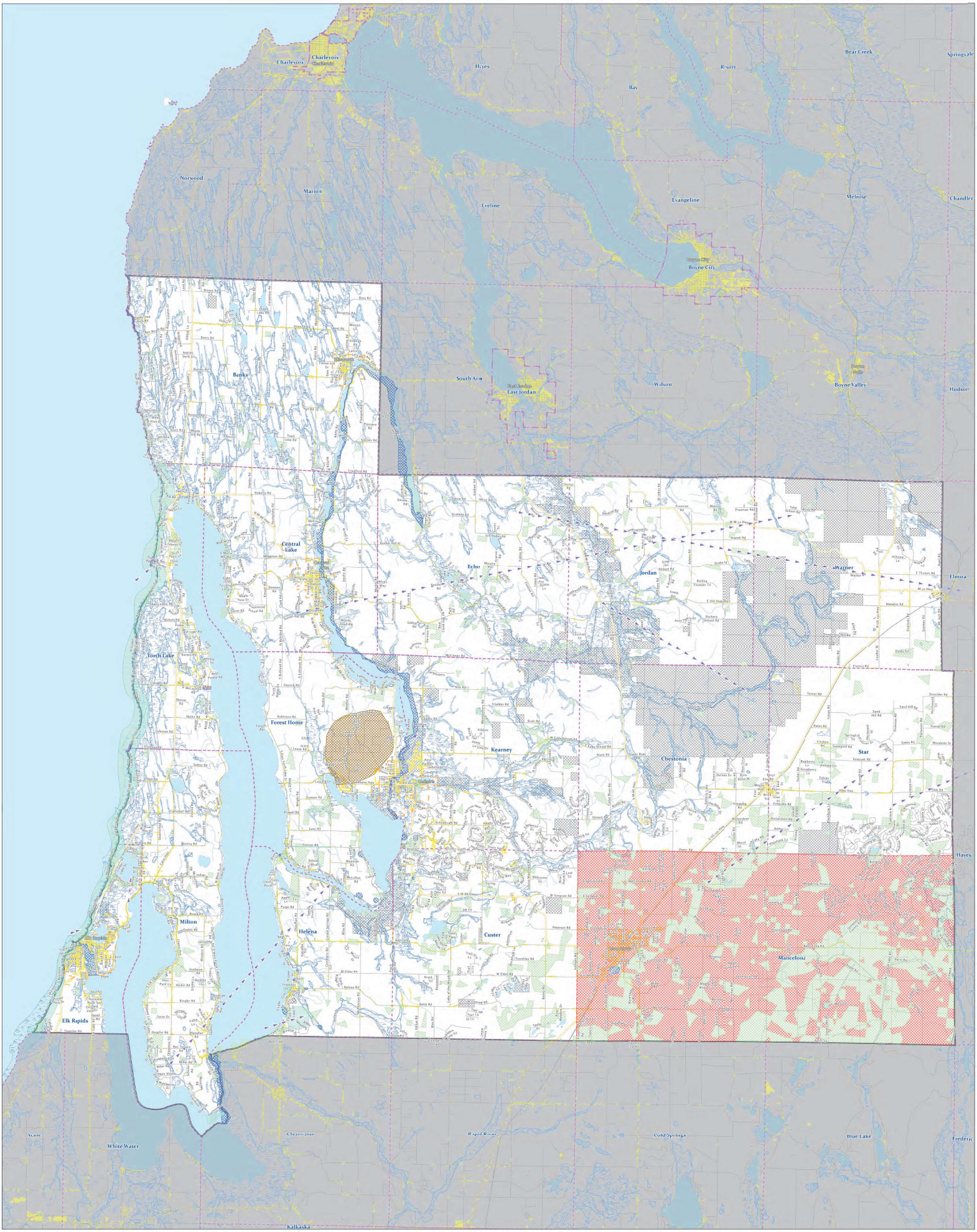

Antrim County Hazard Areas

2023 Hazard Mitigation Plan

Legend

Hazard Areas

Type
- Flood
- Shoreline Erosion
- Fire
- Wind Tree Damage
- Pine Forest
- Invasive Species
- Tornado Path

- Highways
- Roads
- Railroad

- Rivers/Streams
- Water Bodies
- Part 303 Wetlands

- Public Land

Developed Land
- High, Medium & Low Intensity

- Villages
- Cities
- Township Boundaries
- Antrim County
- Adjacent Counties

0 2,500 5,000 10,000 15,000 20,000 Feet

0 0.63 1.25 2.5 5 7.5 10 Miles

N W E S

Antrim County Hazard Mitigation Planning Process.
Map produced by Networks Northwest Community Development 2023.
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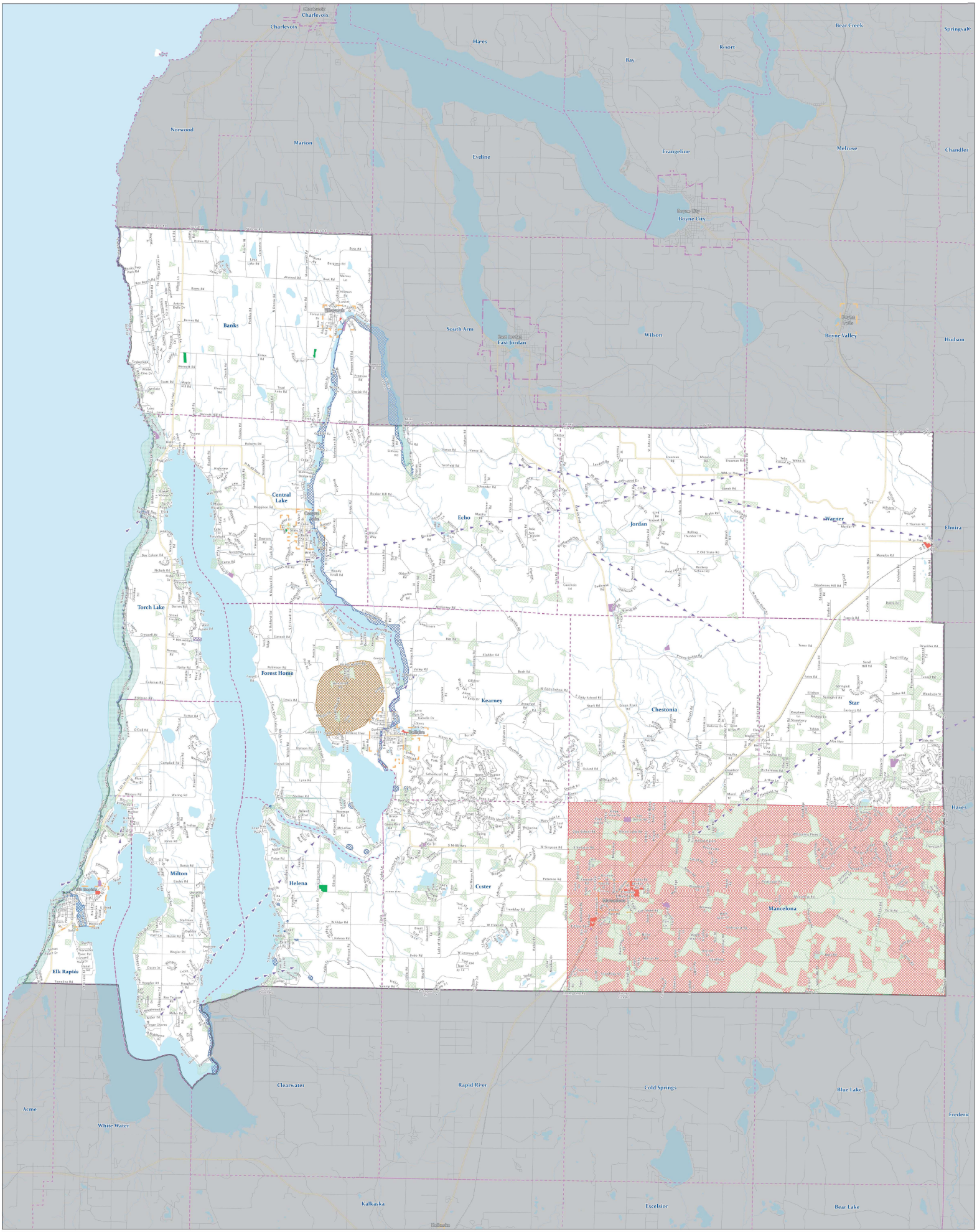


Antrim County Hazard Areas & Vulnerable Populations

2023 Hazard Mitigation Plan

Legend

Vulnerable Populations
Type
- Campground
- Mobile Home
- Tree Farm

Hazard Areas
Type
- Flood
- Shoreline Erosion
- Fire
- Wind Tree Damage
- Pine Forest
- Invasive Species
- Tornado Path

- Highways
- Roads
- Railroad
- Rivers/Streams
- Water Bodies
- Township Boundaries
- Villages
- Cities
- Antrim County
- Adjacent Counties

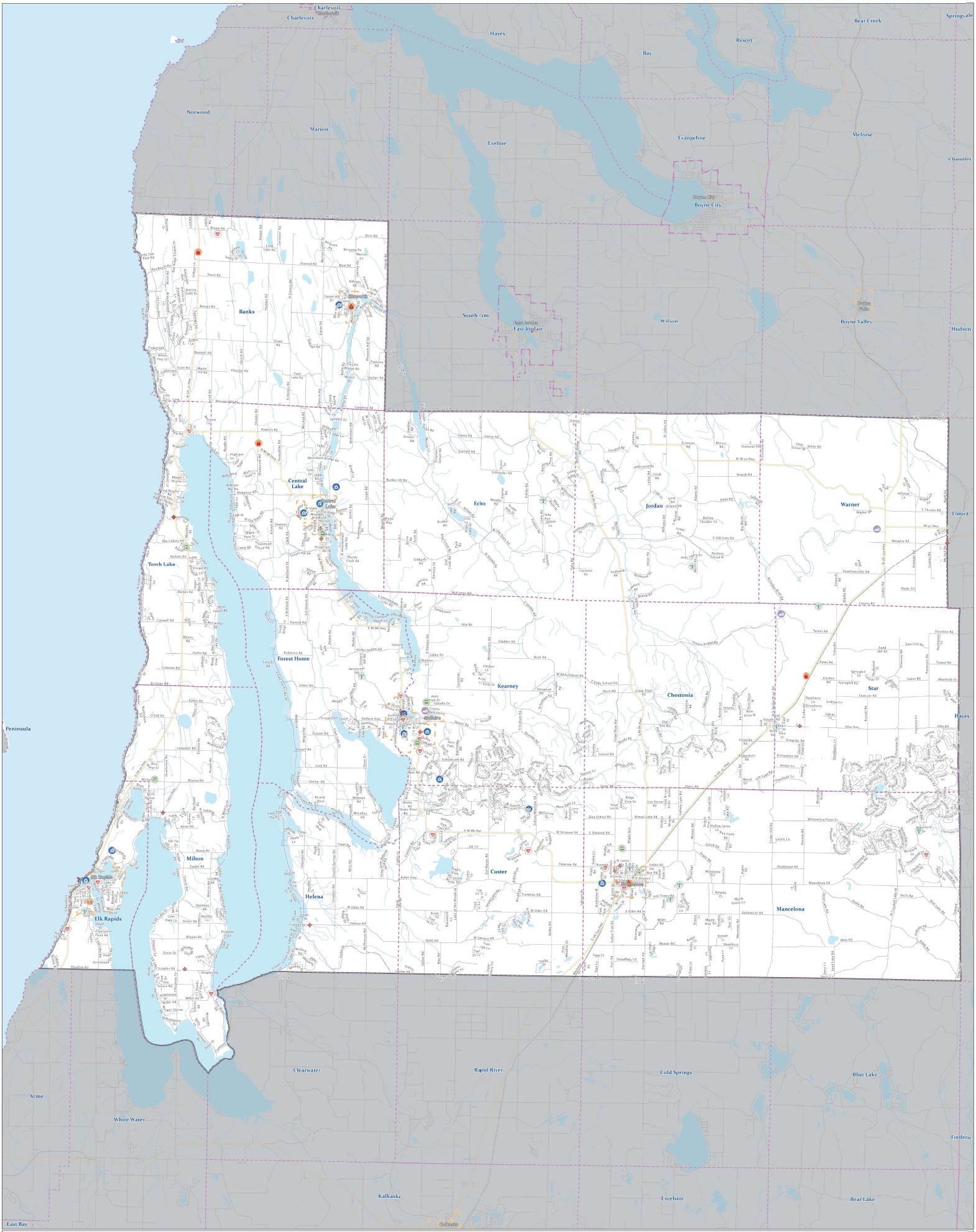
0 2,500 5,000 10,000 15,000 20,000 Feet

0 0.63 1.25 1.88 2.5 5 7.5 10 Miles

N W E S

Antrim County Hazard Mitigation Planning Process.
Map produced by Networks Northwest Community Development 2023.
Map data sources: State of Michigan, ESRI, NRCS, USDA, USGS, CRA, MDOT
Antrim County Emergency Management

Networks Northwest
Town / Business / Community



Antrim County Critical Infrastructure Points

2023 Hazard Mitigation Plan

Legend

Critical Infrastructure Points

Sector
- Commercial
- Communications
- Emergency Services
- Government Facility

Sector
- Transportation
- Healthcare
- Industry

Highways
Roads
Railroad
Rivers/Streams
Water Bodies

Villages
Cities
Township Boundaries
Antrim County
Adjacent Counties

0 2,500 5,000 10,000 15,000 20,000 Feet

0 0.63 1.25 2.5 5 7.5 10 Miles

W E S

Antrim County Hazard Mitigation Planning Process.
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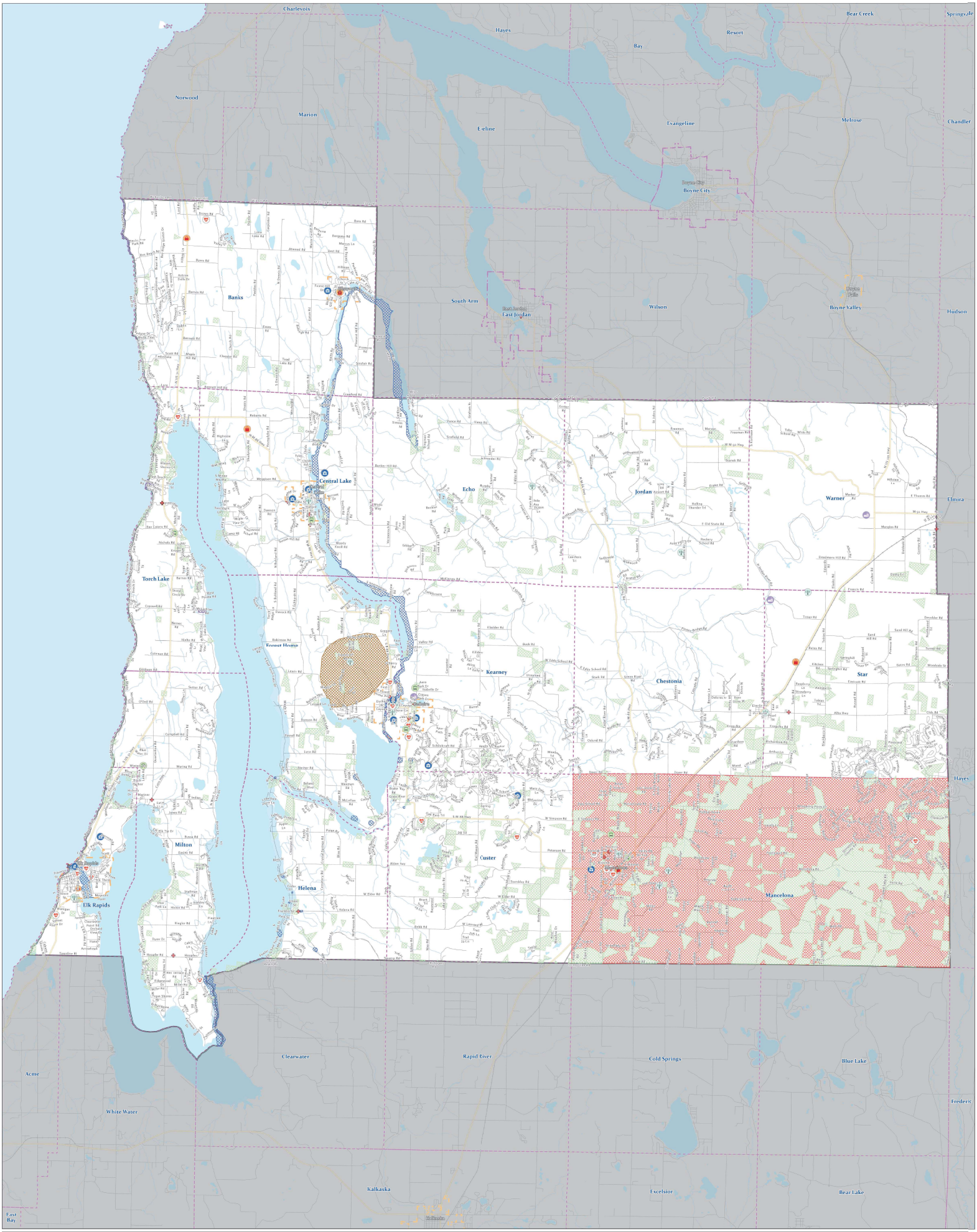
Networks Northwest
Talent / Business / Community



Antrim County Critical Infrastructure Points & Hazard Areas

2023 Hazard Mitigation Plan

Legend

Critical Infrastructure Points

Hazard Areas

Type
- Flood
- Shoreline Erosion
- Fire
- Wind Tree Damage
- Pine Forest

Sector
- Commercial
- Communications
- Emergency Services
- Government Facility

Sector
- Transportation
- Healthcare
- Industry

- Highways
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- Villages
- Cities
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- Antrim County
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0 2,500 5,000 10,000 15,000 20,000 Feet

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Networks Northwest
Talent / Business / Community

APPENDIX B – Community Survey Results

APPENDIX C – 2016 Natural Hazards Mitigation Plan Strategies and Comments

APPENDIX D - Meeting Documentation