Leelanau County, Michigan
Natural Hazard Mitigation Plan

2023

FEMA LETTER OF APPROVAL

ACKNOWLEDGEMENTS

The Leelanau County Natural Hazard Mitigation Plan is prepared for Leelanau 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:

Agency	Name	Title/Role
Leelanau County Board of Commissioners		
Leelanau County	Chet Janik	Administrator
	Matt Ansorge	Emergency Management Director
	Kelly LaCross	Deputy Director
	Trudy Galla	Planning & Community Development Director
	Rob Herman	GIS Analyst
	Lt. Jim Kiessel	Undersheriff
	Brendan Mullane	Manager Leelanau County Road Commission
	Jim Calhoun	Road Commissioner
Grand Traverse Band of Ottawa and Chippewa Indians (GTB)	Becky Oien	Tribal Manager
	Jolanda Murphy	Public Safety Department 2 Manager and Emergency Manager
	Garrett Fairchild	Fire Chief
	Lori Savaso	Director of Risk Management and Safety
	Joe Huhn	Department of Public Works
	Nicki Basch	Housing Director
	Courtney Hessell	NRD Environmental Spec.
City of Traverse City	Jim Tuller	Fire Chief
Bingham Township	Jim Porter	Fire Chief
	Capt. Mark Bowen	Fire and Rescue
Centerville Township	Jim Schwantes	Supervisor
	Joe Mosher	Planning Commissioner
Cleveland Township		
Elmwood Township	Keith Tampa	Fire Chief
Empire Township		
Glen Arbor Township		
Kasson Twp.	Dana Boomer	Clerk
Leelanau Twp.		
Leland Township	Clint Mitchell	
	Dan Besson	Fire Chief
Solon Twp.	Kelly Claar	
Suttons Bay Township	Jim Porter	Fire Chief

	Capt. Mark Bowen	Fire and Rescue
Village of Empire	Maggie Bacon	Trustee
Village of Leland	Stephanie Long	
Village of Northport	Hugh Cook	Fire Chief
Village of Northport	Daniel Caudill	Planning Commissioner
Village of Suttons Bay		
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Benzie County	Rebecca Hubers	Emergency Management Coordinator
Benzie-Leelanau Health Dept.	Chloe Willetts	
Benzie-Leelanau Health Dept.	Bobbi Scott	
Cedar Area Fire and Rescue Chief	Andy Doornbos	
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Leelanau Conservancy	Gayle Egeler	
MI EGLE - RRD Cadillact District	Brian Flickinger	
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Michigan State Police	Tpr. Jason Tropf	
Michigan State Police	F/Lt. Travis House	
Michigan State Police EMHSD	Lt. Michael deCastro	
Mobile Medical Rescue	Amy Fairchild	
National Park Service	Andy Blake	Ranger

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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 Leelanau 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 Leelanau 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 Leelanau 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 strategy areas; a detailed list is included in the Appendix.

- Public and private coordination for shoreline flooding and erosion mitigation
- Utilities perform emergency and preventative tree work
- Leelanau Conservancy acquisition of land for open space designation

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, Leelanau County is actively addressing the issue through the development and implementation of this plan. This process will help ensure that Leelanau 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 Leelanau County, and will be a resource for building coordination and cooperation within the community for local control of future mitigation and community preparedness around the following:

Figure 1: Planning Goals

To be discussed

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. Leelanau County has a history of mitigation planning and adopted past Natural Hazard Mitigation Plans in 2007 and 2016. The adoption of the 2022 plan will reaffirm the eligibility of the county, as well as those local municipalities who participated in the planning process and adopted the county's plan, for federal funding.

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

- On July 1, 2021, Matt Ansorge attended a project kick off meeting with county and tribal emergency managers.
- On October 21, 2021 Networks Northwest attended a LPT meeting, provided an introduction and timeline for the project, and presented the community profile information.
- An online public survey was made available from October 4, 2021 to February 4, 2022 to obtain input on community experience, concerns and priorities regarding natural hazard mitigation in Leelanau County.
- On February 10, 2022 Networks Northwest presented the hazard analysis and provided a summary of survey results.
- On April 14, 2022 a joint community meeting was held between GTB Tribal officials and representatives from Leelanau County to discuss potential hazards. The meeting was held at the Leelanau County Government Center.
- On October 13, 2022 Networks Northwest presented the partial draft plan, goals and objectives, and hazard mitigation strategies.

Additionally, county and regional agencies that share borders with Leelanau 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
- Jolanda Murphy, Public Safety Department 2 Manager and Emergency Manager, Grand Traverse Band of Ottawa and Chippewa Indians
- Rebecca Hubers, Emergency Management Coordinator, Benzie County
- Robert Carson, Regional Director of Community Development, Networks Northwest

During development of the plan, all Leelanau 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 Leelanau County Emergency Management webpage, 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 Managers) 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. Specifically… …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 *Leelanau Enterprise* on ###, 2023 that the County's draft Natural Hazard Mitigation Plan and the opportunity to provide feedback at the public hearing held on _____.

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

Website Images
Source: Leelanau County Emergency Management webpage DATE

Source: Networks Northwest webpage DATE

III. COMMUNITY PROFILE

Land Use/ Land Cover

Leelanau County is located in Northwest Lower Michigan, and is bordered by Lake Michigan to the north and west, the West Arm of Grand Traverse Bay to the east, and Grand Traverse County and Benzie County to the south. North Manitou Island (part of Leland Township) and South Manitou Island (part of Glen Arbor Township.) are located west of the mainland in Lake Michigan. Leelanau Township also includes two offshore islands, South Fox Island and North Fox Island, located 15-20 miles northwest of the mainland. The county is approximately 375.5 acres, or 240,334.1 square miles in area. __% of the county area includes __ square miles of water. Additionally, the County has 151 miles of Great Lakes shoreline.

The 1995 *Leelanau General* Plan, last amended in 2019, describes the major land features of the county as high dune and glacial ridges, which generally run north to south. There are small pocket valleys between the ridges, as well as broad slightly rolling plateaus in the center of the county. High points on the ridges are landmarks because of the striking views they provide to the inland lakes, Lake Michigan, and Grand Traverse Bay. The area north of Northport is flat compared to the rest of the county**,** with large open fields and large conifer plantations. Sleeping Bear Dunes National Lakeshore is located along the southwest coast of the county, near Empire, and includes the North and South Manitou Islands. The National Lakeshore extends south into adjoining Benzie County.

Most of the County is a checkerboard of woodlots, pastures or meadows, active crop fields, orchards and water. There are few routes where forest borders the roads for more than a half mile, nor where open fields stretch for more than a mile without encountering another woodlot. There is more wooded landscape than open fields.

According to the 2017 Census of Agriculture, the county had 50,053 acres of land in farms for a total of 470 farms. This represents a 5% and 16% drop in the number of farms and acreage of farms, respectively, since the 2012 USDA Census of Agriculture. About 93.7% 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 $35,292,000. Leelanau County ranks 5th in the State of Michigan for the sale of fruits, tree nuts, and berries overall.

Big and Little Glen Lakes and Lake Leelanau are the largest lakes in the county. Numerous smaller lakes and streams, usually associated with wetlands, are scattered throughout the county.

The predominant land cover type is "____" followed by the combined types of land cover classified as "___" (Table 1). Developed land cover is found predominantly in and around the villages and settlements of Greilickville, Suttons Bay, Glen Arbor, Empire, Leland, Northport, Peshawbestown and Lake Leelanau.

Table 1: Land Cover by Type

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

Source: Networks Northwest

The 2016 Hazard Mitigation Plan indicated that 126,900 acres, or 44.4%, of the county was comprised of forested lands. Current data shows ____ acres or ___% of Leelanau County is forested. While development in the county has remained

fairly steady in the past decade, it has been noted that the type of new development 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 population and will likely be in demand for many years. The Environmental Features Map in Appendix __ shows the intensity of development in the county as well as natural features.

Population

Leelanau County is the 7th most populated county in the ten county region of Northwest Lower Michigan (Table 2) and is the ranked 63 out of 83 counties in the state for population.[1] The 2019 American Community Survey (ACS) estimated the county population to be 21,652 people. A comparison of the 2010 and 2019 ACS data indicates a 0.5% decrease in county population from 2010, when the population was an estimated 27,057 persons (Table 3). The estimated 2019 population per square mile is approximately 11.1 people.

Leelanau County is comprised of eleven (11) townships, three (3) villages, and a small part of the City of Traverse City. The communities of Suttons Bay Township, Bingham Township, Leland Township, Kasson Township, and Glen Arbor Township experienced population decline between 2010 and 2019 (Table 3). The most populated community is Elmwood Charter Township, located in the southeast portion of the county, with an estimated 4,497 persons. The population estimates for the villages are shown separately for informational purposes; however, those population count estimates are incorporated into the totals presented for the township in which they are located. The second most populated community, at an estimated 2,985 persons is Suttons Bay Township, which contains the Village of Suttons Bay. The third most populated community is Bingham Township, at 2,496 persons.

Table 2: Population by County, State, 2019

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 5-Year Estimates

[1] https://www.michigan-demographics.com/counties_by_population

Table 3: Population Change by Municipality, 2010 & 2019

Municipality	2010 Estimated Population	2019 Estimated Population	Numeric Change	Percent Change	Jurisdiction Status*
Village of Suttons Bay	607	544	-63	-63.0%	
Village of Northport	411	457	46	46.0%	
Village of Empire	260	263	3	3.0%	
Leelanau County	**21,757**	**21,652**	**-105**	**-0.5%**	
Elmwood Charter Twp.	4,493	4,497	4	0.1%	
Suttons Bay Township	2,999	2,985	-14	-0.5%	
Bingham Township	2,574	2,496	-78	-3.0%	
Leelanau Township	1,843	2,007	164	8.9%	
Leland Township	2,280	1,756	-524	-23.0%	
Solon Township	1,490	1,747	257	17.2%	
Kasson Township	1,639	1,457	-182	-11.1%	
Centerville Township	1,289	1,449	160	12.4%	
Cleveland Township	1,113	1,197	84	7.5%	
Empire Township	1,101	1,161	60	5.4%	
Glen Arbor Township	772	668	-104	-13.5%	
City of Traverse City	164	232	68	41.5%	

Source: US Census, 2010 and 2019 5-Year ACS Estimates
* 2022 Hazard Mitigation Plan Participation Status: 1. A new participant; 2. A continuing participant, and 3. A non-participant

Like many northwest Michigan communities, Leelanau County experiences an influx of seasonal residents and tourists during the summer months. However, the decennial Census and the American Community Survey only consistently and comprehensively track the permanent population. The *Northwest Michigan Seasonal Population Analysis*, a 2014 report by the Michigan State University Land Policy Institute, analyzed the 2012 seasonal population for ten counties in northwest Michigan. The data collected for Monthly Permanent, Seasonal and Transient Residents by County estimates the population of Leelanau County increases by: 36% in June (from 21,652 to 29,447) and by 40% in the months of July and August (from 21,652 to 30,313). All ten counties in the Networks Northwest service area were included in the study: Leelanau, Benzie, Charlevoix, Emmet, Grand Traverse, Kalkaska, Leelanau, Manistee, Missaukee, and Wexford.

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

Age, Race & Disability

Understanding the age distribution and median age of Leelanau County can help identify social, economic, and public service needs in the community. The county's total estimated 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, followed by those in 65-84 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 Leelanau County is older (54.1 years) than the State (39.7 years). The youngest community in the county is Traverse City with a median age of 44.7 years; the oldest community in the county is Glen Arbor Township with a median age of 65.5 years (Figure 4).

Figure 2: Leelanau County Population by Age Cohort, 2019

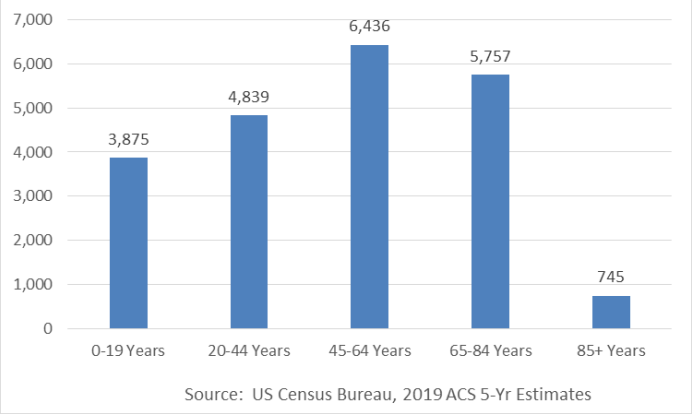
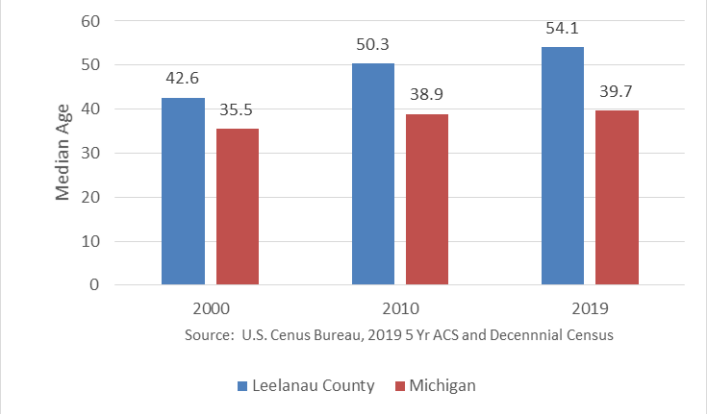
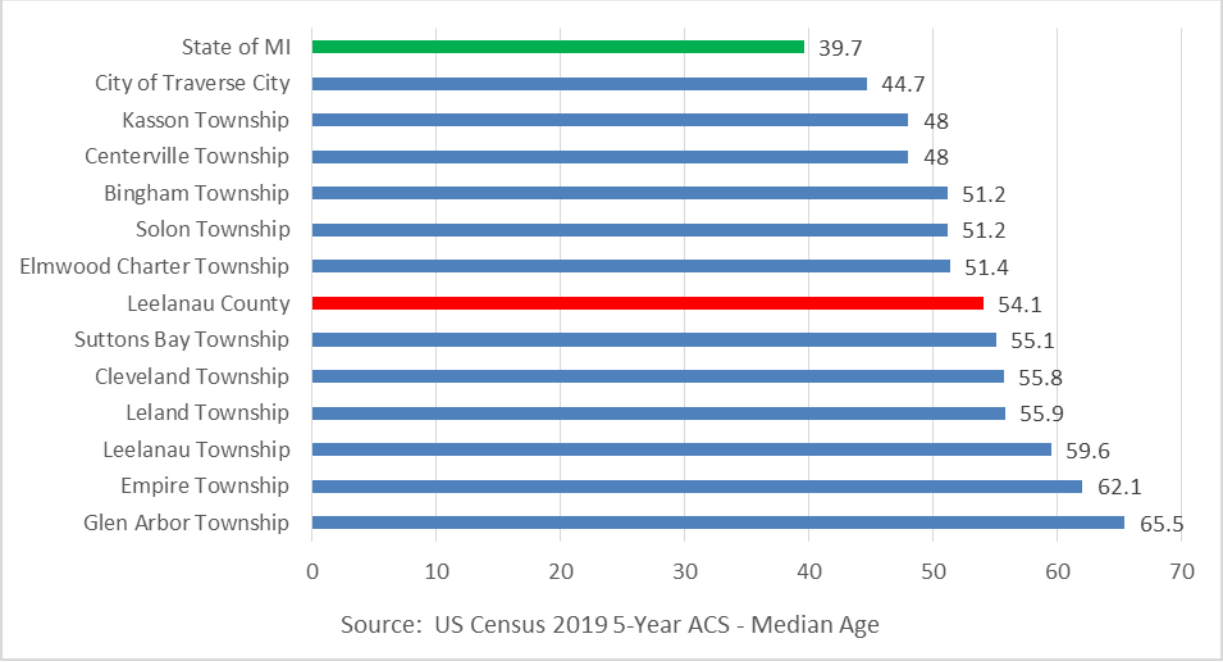


Figure 3: Median Age Trend, 2000, 2010, and 2019



Source: US Census, 2010 and 2019 5-Year ACS Estimates

Figure 4: Median Age Comparison, 2019



Source: US Census, 2010 and 2019 5-Year ACS Estimates

The racial makeup of Leelanau County is predominantly white (94.7%) (Table 5). 4.3% of the population is American Indian or Alaskan Native; this is quite higher than representation in the State as a whole. 4.4% of the population is Hispanic or Latino; 1.2% is Black; 1.5% consists of two or more races; 0.9% is Asian; 0.9% is of some other race; and 0.1% is Native Hawaiian or Other Pacific Islander.

Table 5: Racial Composition, 2019

	White	Black	American Indian or Alaskan Native	Asian	Hispanic or Latino	Native Hawaiian or Other Pacific Islander	Some Other Race	Two or More Races
Leelanau County	94.7%	1.2%	4.3%	0.9%	4.4%	0.1%	0.9%	1.5%
Michigan	75.0%	13.6%	0.5%	3.1%	5.1%	0.1%	0.1%	2.5%

Source: US Census 2019 5-Year ACS Estimates

Table 6 represents the number of persons with a disability by age group. An estimated 2,806 (13.1%) of Leelanau County residents have one or more type of disability. An estimated 53.8% of those with one or more disabilities are aged 65 years or older.

Table 6: Persons with a Disability, 2019

Total Civilian Noninstitutionalized Population	**21,495**
With one or more disability	2,806
Age 0-17 with a disability	95
18 to 64 years with a disability	1,081
65 years and over with a disability	1,630

Source: US Census 2019 5-Year ACS Estimates

Housing Characteristics and Development Trends

The average household size for Leelanau County residents is 2.32 persons, which is slightly lower than the State's average of 2.46. Leelanau County has an estimated 15,638 total households 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.

Leelanau County has an estimated 15,638 housing units. Leelanau Township has the largest percentage of housing units of all municipalities in the county, 2,113 or 13.5%, followed by Elmwood Charter Township, 2,084 or 13.3%. Over 43% of residential units were built before 1980 (Table 8). The 2019 ACS also estimates that 86% (13,445) of the county's household units are 1-unit, detached structures, which are commonly referred to as single-family homes. The number of housing units for each village is incorporated into the totals for the respective township in which each village is located.

Table 7: Housing Units by Municipality, 2019

	Total Housing Units	% of Total
Leelanau County	**15,638**	
Village of Northport	247	1.6%
Village of Suttons Bay	239	1.5%
Village of Empire	141	0.9%
Leelanau Township	2,113	13.5%
Elmwood Charter Township	2,084	13.3%
Leland Township	1,776	11.4%
Glen Arbor Township	1,766	11.3%
Suttons Bay Township	1,711	10.9%
Bingham Township	1,427	9.1%
Empire Township	1,191	7.6%
Cleveland Township	926	5.9%
Centerville Township	925	5.9%
Solon Township	849	5.4%
Kasson Township	772	4.9%
City of Traverse City	98	0.6%

Source: US Census, 2019 ACS Estimates

Table 8: Year Structure Built, 2019

Housing Units	Number	% of Total
Built 2010 or later	632	4.0%
Built 2000-2009	2,408	15.4%
Built 1980-1999	5,837	37.3%
Built 1960-1979	3,470	22.2%
Built 1940-1959	1,398	8.9%
Built 1939 or earlier	1,893	12.1%
Total Housing Units	**15,638**	

Source: US Census, 2019 ACS 5-Year Estimates

Housing Tenure, Table 9, summarizes the status of housing units, whether occupied or vacant, as well as the median housing value of owner-occupied units ($268,400) and the median gross rent ($959). Of the 15,638 total housing units, 9,139 (58.4%) are occupied (indicating physically occupied, principal residence housing units).

Table 9: Housing Tenure, 2019

Total housing units	15,638	%
Occupied housing units	9,139	58.4%
Owner-occupied	8,071	88.3%
Median Housing Value	$268,400	
Renter-occupied	1,068	11.7%
Median Gross Monthly Rent	$959	
Vacant housing units	6,499	41.6%

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. Leelanau County has the 5th highest average annual wage at $36,833. As their northern/northwestern neighbor, it is not unexpected to have residents of Leelanau County travel to Grand Traverse 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
Wexford	$35,917
Leelanau	**$36,833**
Emmet	$40,258
Charlevoix	$44,558
Grand Traverse	$44,562
Kalkaska	$50,971

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

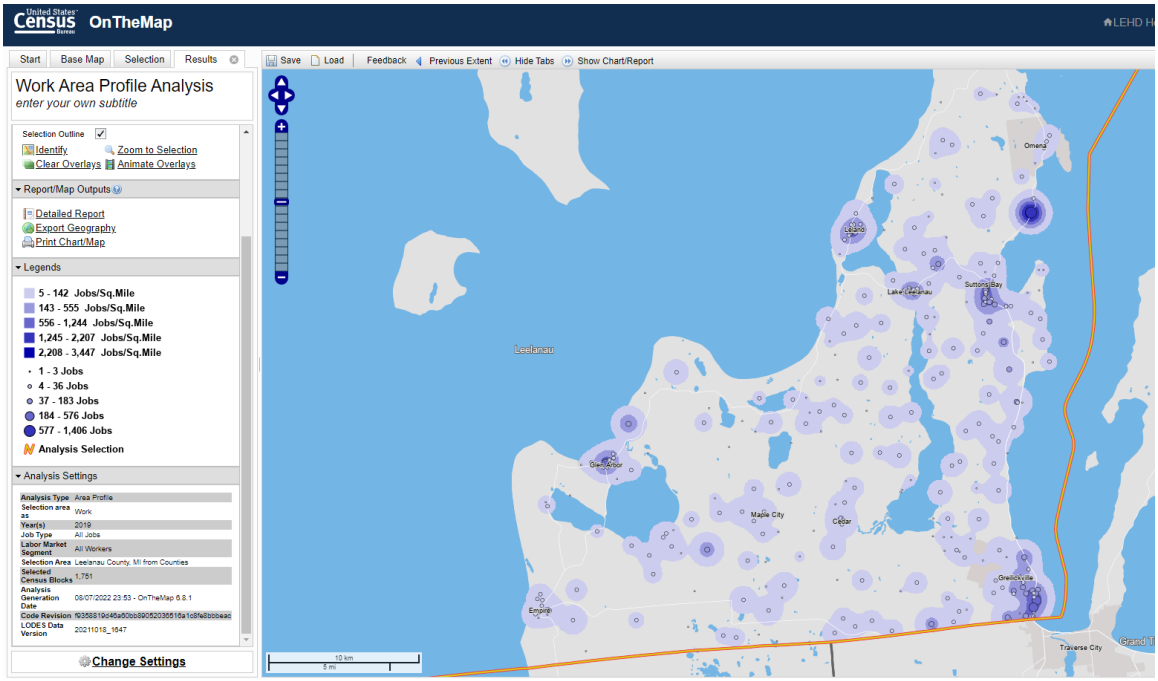
The Economic Profile of Leelanau County is further described in Table 11. The table provides the county's industry makeup divided into 20 different North American Industry Classification Sectors (NAICS) as well as industry's establishments, jobs, percent distribution, and annual average wage. The industry with the largest percent distribution is "**Other (includes private, management of business, and unallocated)**" at 19.6% of jobs, followed by "**Accommodation and Food Service**" at 13.7%, and "**Construction**" at 9.1%. The annual average wage for "Other" is not available; for "Accommodation and Food Services" is $24,207; and for "Construction" is $43,924. "**Retail Trade"** is the fourth largest industry with 8.9% of jobs in the county, at an annual average wage of $22,325. The industry with the highest annual average wage is "**Finance and Insurance**" at $77,656, followed by "**Health care, social assistance**" at $55,148.

Table 11: Leelanau County Economic Distribution by Industry, 2018

Industry	Establishments (2018)	Jobs (2018)	% Distribution of Jobs	Annual Average Wage
Total Covered Employment	682	6,454	100.00%	$36,833
Agri., forestry, hunting	41	D	D	D
Mining	4	D	D	D
Construction	109	586	9.10%	$43,924
Manufacturing	39	495	7.70%	$30,100
Wholesale trade	13	265	4.10%	$27,582
Retail trade	97	574	8.90%	$22,325
Transportation, warehousing	17	84	1.30%	$41,934
Information	13	54	0.80%	$31,478
Finance and Insurance	19	137	2.10%	$77,656
Real Estate, rental, leasing	25	90	1.40%	$35,371
Professional, technical services	48	D	D	D
Administrative, waste services	38	197	3.10%	$39,317
Educational services	10	427	6.60%	$42,386
Health care, social assistance	35	477	7.40%	$55,148
Arts, entertainment, recreation	24	244	3.80%	$34,571
Accommodation and food services	75	886	13.70%	$24,207
Other services (except for Public admin.)	52	158	2.40%	$32,748
Public administration	18	517	8.00%	$44,445
Other Includes (private, utilities, management of business, and unallocated)	5	1,263	19.60%	N/A

Source: 2021 Comprehensive Economic Development Strategy, Networks Northwest
**D means limited industries of a sector that would disclose confidential information*

Additionally, OnTheMap, an online interactive tool available from the US Census Bureau, allows for viewing of estimated job density within the county. This website is useful for emergency preparedness planning as related to response and potential impact to local economic activity areas. It appears the greatest density of jobs are located within the Traverse City/Greilickville and Peshawbestown areas. Other key areas of employment are in the Villages of Northport, Empire, and Suttons Bay, as well as Lake Leelanau, Leland, the Leelanau County Campus, Glen Arbor, Cedar, and Maple City. Below are screenshots of the interactive map when completing an area profile analysis for all workers in all jobs in the county in 2019.

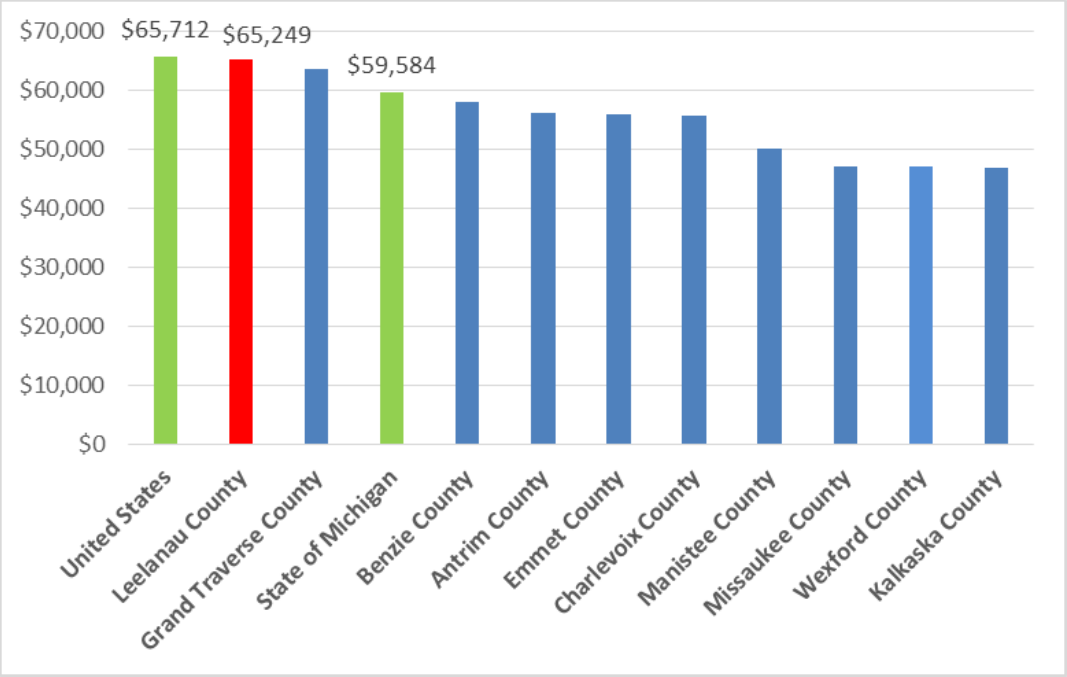


Source: https://onthemap.ces.census.gov/.

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. Leelanau County has the highest median household income ($65,249) in the region, which is also above that of the State. The county's 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 Leelanau County over twelve months, a household is earning $5,437 per month. Leelanau County households should spend no more than $1,631 on housing costs. The US Census 2019 5-year ACS estimates that the median gross monthly rent is $959 in Leelanau County.

However, according to the 2019 Northwest Michigan Target Market Analysis[2] (conducted by LandUseUSA on behalf of Housing North and Networks Northwest), rents are far higher in Leelanau County than what many renters can afford. While the affordable rent for a renter earning the mean wage in the county is $796, the affordable rent for a full-time minimum wage worker is $491. And anecdotally, the demand for housing is driving prices higher still. Home prices are also increasing where the cost to purchase a home is often as much as $200/square foot or more.

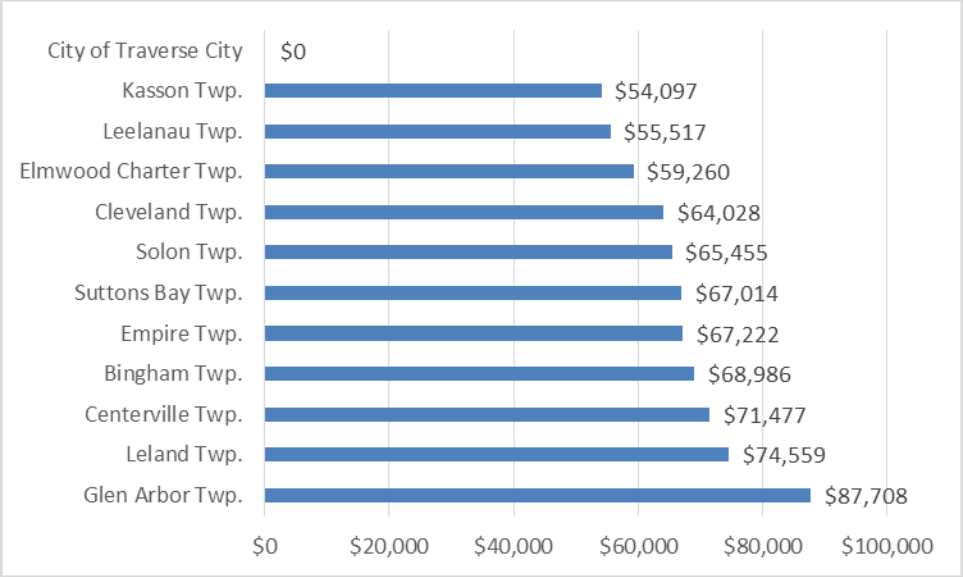
Figure 5: NW Michigan Median Household Income by County, 2019



Source: US Census, 2019 ACS Estimate

[2] https://www.housingnorth.org/target-market-analysis

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



Source: US Census, 2019 ACS Estimates
Note: no data available for the City of Traverse City within Leelanau County

The following tables describe the population with the lowest incomes. It is estimated, in 2019, that 2.6% of all people in the county lived at or below the poverty level (Table 13). 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 12 below.

Table 12: 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 13: Leelanau County Poverty Estimates, 2019

Poverty	Statistics
All families living below the poverty level	2.6% (163)
Families with related children under age 18, in poverty	3.9% (72)
All persons living below the poverty level	6.1% (1,310)

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 14 identifies the number of ALICE and poverty households for the county and each municipality. These households likely would not have reserve savings to cover an emergency, such as impacts from a natural hazard event.

Table 14: ALICE Report Findings, 2019[3]

Leelanau County Jurisdiction	Total Households	% of all HH that are in Poverty and ALICE
LEELANAU COUNTY	9,179	37% (State Avg. is 25%)
Bingham Twp.	1,078	38%
Centerville Twp.	587	40%
Cleveland Twp.	513	45%
Elmwood Charter Twp.	1,839	46%
Empire Twp.	572	43%
Glen Arbor Twp.	323	23%
Kasson Twp.	593	52%
Leelanau Twp.	938	50%
Leland Twp.	756	34%
Solon Twp.	676	43%
Suttons Bay Twp.	1,180	43%

Source: United Ways of Michigan

[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 home parks, or isolated subdivisions are more susceptible to hazardous events. Vulnerable populations are represented on the *Vulnerable Populations and Hazard Areas Map* in Appendix A. Those locations included on the map were specifically discussed during public input sessions. There may be additional locations of vulnerable populations that are not listed.

The natural environment is the primary feature residents choose to live in northwest Michigan and the primary feature visitors choose to vacation in northwest Michigan. Leelanau County is home to forest lands, inland lakes and streams, unique sand dune areas, Lake Michigan shoreline and all of the wildlife within that are integral to the identity of the community. While natural resources are abundant they are vulnerable to all types of hazards. Northwest Lower Michigan is also home to many sensitive wildlife populations that require specific climates and habitats to survive. Damaged, destroyed, or changing natural environments may decrease the chances for certain species' survival.

Additionally, countywide critical infrastructure is represented on the Critical Infrastructure Map, shown below. Task Force members and community stakeholders identified the critical facilities and infrastructure on the base map and provided updated GIS shape files for mapping purposes. The Critical Infrastructure Points Map is in Appendix A. Table 15 is a summary of critical infrastructure points in Leelanau County:

Table 15: Critical Facilities and Infrastructure

No. of Facilities (TOTAL)	FACILITY TYPE
23	**Communications** • Wireless Communications Facilities (22) • Satellite Communications Facility (1)
14	**Emergency Services** • Law enforcement (3) – (County Jail, Sheriff's Office, GTB Police) • Fire and emergency medical services (10) • Emergency Management (1) – Leelanau County EM/911
18	**Energy** • Electricity
14	**Government Facilities** • Water and waste water treatment (6) • Municipal facilities (3) • Dams (5)
15	**Healthcare** • Extended care facilities (9) • Ambulatory, public health or health supporting facilities (6)
1	**Industry** • Hazardous Chemical Storage/Stockpile/Utilization/Distribution
24	**Transportation** • Airport (1) • Airfields/Airstrips (5) • Bays (8) • Marinas (10)

Source: Leelanau County Emergency Services

Historical Analysis

The Historical Analysis of Leelanau 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 seven (7) federal-or state-declared disaster incidents that have involved Leelanau County (Table 16). These are included in the hazard analysis for individual event types.

Table 16: Presidential and Governor Declared Disasters for Leelanau County

Date of Declaration	Type of Incident	Affected Area	Type of Declaration/ Fed ID#
March 2020	COVID-19; Pandemic	Statewide & National	State of Emergency, National Emergency (3455), and Governor and Presidential Declared Major Disaster (4494)
1/29/2019	Extreme Cold	Statewide	Governor Declared Emergency
8/2/2015	Thunderstorms	Grand Traverse County and Leelanau County	Governor Declared Disaster
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	Leelanau and 43 other counties	Presidential Declared Emergency (3035)
4/5/1956	Tornado	4 Counties: Benzie, Leelanau, Manistee and Ottawa	Presidential Declared Major Disaster (53)

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

Leelanau 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 Leelanau 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 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 National Centers for Environmental Information data center (NOAA).
- **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 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 potential dollar losses to vulnerable assets identified.

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

- Climate https://www.weather.gov/wrh/Climate?wfo=apx – Historical local observed weather data; Climate prediction and variability; local high impact event summaries

- NOAA Storm Event Database https://www.ncdc.noaa.gov/stormevents/ - Data on record from 1950 to 2021; however, information for various events is limited and non-contiguous. The database provides local storm reports, damage reports, and recorded event descriptions. The event types researched for Leelanau County include: Drought (Drought); Flooding (Flash Flood, Flood); Shoreline (Lakeshore) Flood; Hail (Hail); Extreme Winter Weather (Blizzard, Extreme Cold/Wind Chill, Freezing Fog, Frost/Freeze, Heavy Snow, Ice Storm, Lake-effect Snow, Sleet, Winter Storm, Winter Weather); Rip Current; Seiche; Tornado (Tornado, Funnel Cloud); Thunderstorm and High Wind (Heavy Rain, High Wind, Lightning, Strong Wind, Thunderstorm Wind); and Wildfire (Wildfire).

The Great Lakes Current Incident Database was referenced for information about dangerous currents and current-related drownings or rescues, going back to 2002. https://www.michiganseagrant.org/dcd/dcdsearch.php

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

The 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 , but as events occur the database will change. Thus, additional events will be added in subsequent years. 255 events were reported between 01/01/1950 and 6/30/2022 (26,479 days). There were a total of 212 days with an event, 2 days with event and death, 2 days with an event and death or injury, 35 days with event and property damage, and 6 days with event and crop damage. Those events as well as the emergency declaration events are included in the hazard analysis. The hazard analysis groups the events into the following categories:

Table 17: Reported Event by Type

Type of Event	# of Events	Event Location	Time Interval/ Year Event Recorded
Extreme Winter Weather	137	County and Region	1978*; 1996-2022
Thunderstorm/Wind and Severe Winds	65	Statewide; Region	1995-2021; 1998-2021
Hail	35	County and Region	1955-2022
Coastal Hazards (Lakeshore Flooding, Seiche, Rip Current)	5	Leelanau County coastline	2012, 2019 (3), 2020
Flash Flood	4	Countywide; Empire; Solon	1999, 2000, 2021 (2)
Tornado	3	Countywide	1977, 1978, 2011
Extreme Temperatures (Cold / Heat)	3 / 2	Region; Statewide	2007, 2008; 2019* / 2001, 2018
Drought	2	Region	1977*, 2001
Lightning	2	County/Region; Greilickville	2000, 2007
Wildfire	60	MDNR Lands	1981-2018
Public Health Emergency (COVID-19 Pandemic)	1	Statewide/National	March 2020

Sources: NOAA National Centers for Environmental Information Storm Events Database; MDNR; Michigan State Police-Dept. of Homeland Security; FEMA;
Note: * indicates a state or federal event designation

Economic Impact Analysis

Table presents the *reported* deaths, injuries, property damages, and crop damages of storm events in Leelanau County from 1950-2021. There were two deaths and zero injuries. One death occurred from an extreme cold event on February 10, 2008, and the other death occurred from a rip current on August 30, 2012The estimated economic impact of the previously described Leelanau County natural hazard events that were *reported* to NOAA is $25,576,000 in property damages and $53,563,000 in crop damages (Table 18). It should be noted that many events likely cause numerous small amounts in property damage, but this often goes unreported. The total reported Damaging Events' Costs recorded with NOAA for Leelanau County are as follows:

Table 18: Damage Estimates by Event Type

Leelanau County	Death / Injury	Property Damage Estimate	Crop Damage Estimate
Thunderstorm/Wind; High Winds	0 / 0	$24,269,000	$8,000
Extreme Winter Weather	0 / 0	$832,000	$50,500,000
Hail	0 / 0	$85,000	$3,055,000
Coastal Hazards (Lakeshore Flooding, Seiche, Rip Current)	1 / 0	$184,000	$0
Flash Flood		$50,000	$0
Tornadoes	0 / 0	$295,000	$0
Extreme Temperatures (Cold / Heat)	1 / 0	$0	$0
Drought	0 / 0	$0	$0
Lightning	0 / 0	$40,000	$0
Wildfire	0 / 0	$0	$0
Public Health Emergency (COVID-19 Pandemic)	*	n/a	n/a
TOTALS:	**2 / 0**	**$25,576,000**	**$53,563,000**

Source: NOAA's National Centers for Environmental Information
*More information is provided in the hazard analysis

Table 15 provides an overview of each potential hazard's impact on the permanent population and the estimated impact on the State Equalized Values (SEV) for real and personal property (residential and commercial). Population data is collected from the US Census, 2019 ACS data. According to the 2014 Northwest Michigan Season Population Analysis, assume a 40% increase to account for the highest estimated annual average seasonal population within the county (which occurs in July and August).

Table15: Geographic Economic Impact by Event (Need Environmental Features Map to be Created)

Hazard Event	Geography	Population Estimates	State Equalized Value
Extreme Winter Weather, Thunderstorm, Wind, Hail, Lightning, Tornado, Extreme Temperatures, Drought, Public Health Emergency	Leelanau County	21,652	
Riverine Flooding	Cedar River and Lake Leelanau: Solon Twp & Elmwood Twp.		
Urban Flooding	Greilickville area and Traverse City area of Elmwood Township; Village of Suttons Bay; Village of Northport, Leland area.		
Coastal Erosion/Flooding & other Coastal Hazards	All Townships except Kasson Twp. and Solon Twp.		
Wildfire	Areas with Jack Pine forest/Sand Dunes		

Sources: 2019 ACS Estimates from the U.S. Census Bureau; Leelanau 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 Leelanau 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.

Extent
Snowstorms can be measured based on snowfall accumulations or damages. Leelanau County receives the most snowfall in January with a normal amount of 26.3 inches followed by December with 21.2 inches, and February with 19 inches. Snowfall in March, April, and November are each 12.6 inches or less.

Table is a summary of winter weather events. Extreme winter weather events in total caused $653,000 in property damages and $50,500,000 in crop damages on record with NOAA.

Table 13: Extreme Winter Weather Previous Occurrences

Event Type	Number of Events	Property Damage	Crop Damage	Event Year(s)
Winter Weather	1	$ 0	$ 0	2006
Winter Storm	53	$ 3,000	$ 0	1997-2022
Ice Storm	4	$ 0	$ 0	2001, 2002, 2005, 2008
Heavy Snow	51	$ 650,000	$ 13,000,000	1996-2020
Blizzard	6	$ 0	$ 0	1978*, 1997, 1998, 1999, 2002, 2019
Frost/Freeze	1	$ 0	$ 37,500,000	2012
Lake-Effect Snow	21	$ 0	$ 0	2006-2019
TOTAL	**137**	**$ 653,000**	**$ 50,500,000**	

Source: NOAA: National Centers for Environmental Information

Previous Occurrences
Since 1996, there have been 137 extreme winter weather events, including heavy snowstorms, ice storms, frost/freeze, blizzards, and winter storms reported in Leelanau County (Table 17). Additionally, in 1978, Leelanau County, along with

the rest of the state of Michigan, received a Presidential Emergency Declaration for a snowstorm and blizzard. In recent years, the more common events are winter storms with moderate snowfall of 5-10 inches. Heavy snow, blizzards, and lake-effect snows 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.

One of the highest-impact snowstorms in recent memory pounded Northern Michigan on the night of March 2, 2012. *Low pressure tracked from Missouri, to southern Lower Michigan, and on to eastern Canada, while rapidly strengthening. Precipitation surged northward into the region on the evening of the 2nd. This was primarily snow, except in parts of east central Lower Michigan (especially near Lake Huron), where temperatures were mild enough for rain. Snow wound down on the morning of the 3rd, and though somewhat blustery winds occurred behind the system on the 3rd, blowing snow was limited because the snowfall was so wet. Snow totals ranged from 6 to 14 inches across most of Northern Michigan. Higher amounts fell near and west of Grand Traverse Bay, with a maximum amount of 20 inches near Lake Ann. With relatively warm temperatures, the snow was very wet; Traverse City saw around a foot of snow during the night, with a low temperature of 33 degrees. The snow stuck to everything, with the weight of the snow downing many, many trees and power lines. Power outages were widespread, with an outright majority of Northern Michigan residents losing power at some time during or after the storm. In Benzie County, 95 percent of residents lost power. Outages lasted up to a week in some spots. Great Lakes Energy described it as the worst snowstorm (in regards to power outages) in 30 years. A number of counties and communities opened shelters to aid those without power or heat. Also included in the tree damage was substantial damage to fruit trees in the Grand Traverse Bay region, particularly cherry trees.* This event accounts for $650,000 in reported property damages and $13,000,000 in reported crop 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*. In Leelanau County, $37,500,000 in crop damages were reported.

Probability of Future Events and Vulnerability Assessment

Since 1996, Leelanau County has had 137 extreme winter weather events. This averages to about to about five 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. Leelanau 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 Leelanau County. Many aspects of Leelanau 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.

Comments from input session

- Ice dams along rivers/lakes can damage adjoining properties
- Food pantry can lose their supplies if the power is out.
- Agricultural products (vineyards, cropland) can be impacted if there is a late spring heavy frost, ice or hail storm. This can negatively impact the local agriculture economy and people's personal property.
- People who aren't aware of storm damage to their seasonal homes and return in the spring/summer to find and report damaged property (perhaps they had a roof leak or water lines that froze)
- More vulnerable residents whose homes are not well insulated could have more problems with roof damage and frozen pipes.
- 2012 storms left businesses, government and roads closed for 5 days

- Have a lack of community shelters
- Winds and ice can pull electrical lines down
- Increased potential for car accidents
- Gas stations down if they don't have back up power
- Cell towers down causes challenges with communications
- Many people rely on wood/propane fuel to heat their homes and often live in rural areas that are difficult to access in an emergency to provide their fuel source if needed.
- Population stranded on rural properties; can't be accessed by emergency vehicles with heavy/drifting snow or ice.
- Erratic winter weather patterns recently – less consistent.
- Extra burden and cost placed on the Road Commission and emergency services.
- 1977 Blizzard MSP/Corp of Engineers – road closures
- GTB Tribe added generators since the 2012 winter storms

Thunderstorms and Severe Winds

Severe thunderstorms are weather systems accompanied by strong winds (at least 56mph), 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.

High wind events are included in this category. 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 Leelanau County is at risk to the occurrence and impacts from thunderstorms and severe winds.

Extent
Thunderstorms can be measured based on wind speed or damages. The average wind speed for events in Leelanau is 52 knots. There have been a total of $24,269,000 in property damages and $8,000 in reported crop damages.

Table 14: Thunderstorm and Wind Events Previous Occurrences

Event Type	Number of Events	Property Damage	Crop Damage	Event Year(s)
Thunderstorm Wind	50	$ 24,200,000	$ 8,000	1975-2022
High Wind	12	$ 47,000	$ 0	1998-2021
Strong Wind	3	$ 22,000	$ 0	2001, 2007, 2007
TOTAL	**65**	**$ 24,269,000**	**$ 8,000**	

Source: NOAA: National Centers for Environmental Information

Previous Occurrences
Since 1955, there have been a total of 65 thunderstorm/wind and high wind events reported in Leelanau County. This is the second most frequently occurring type of severe weather event in the county.

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.* Winds speeds during this event were reported to be 78 knots. This event resulted in $18,800,000 in property damages.

Probability of Future Events and Vulnerability Assessment
Since 1955, Leelanau County has had 65 thunderstorm/wind and high wind events. This averages to .97 events every year. The probability of an event occurring in future years is 97 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.

Comments from input session

- Power outages, trees down, wires down
    - Gas stations are closed; impacts commerce. Gas is needed to fuel generators!
    - Road closures due to downed trees, etc. prohibits EMS timely response to incidents; people can be stuck in their homes/neighborhoods. Also impacts local commerce if the roads are not able to be used to transport goods and services.
    - People living on oxygen or who have a low food supply or primarily perishable food supply are directly impacted
    - Glen Arbor, Peshawbestown and other areas of the County in 2015 – 5-day stretch without power after a thunderstorm. GTB had downed lines (they have a lot of overhead lines). Their sewer stations had pump failures at the main lift and had to supply generators to power them. Many negative impacts to commerce and transportation. Debris management is a cost to the county and to contract out at the State level.
    - Only have 1 power company in the County, which limits their ability to respond quickly to all outages in a wide-spread event.
    - Power outages are costly to emergency services and residents.
- Can result in big floods
- Lightning strikes can cause fires, impacting homes, woodlands
- Money and time spent on the extreme demand placed on local responders – pay overtime for increased manpower
- Leelanau County receives 1-2 events per year that meet the criteria of a severe thunderstorm, windstorm, hail, lightning, tornado… Given our seasonal influx of tourists and the high potential for these storms at the same time of the year this could have devastating impacts to the economy, infrastructure and environment.

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 Leelanau County is at risk to the occurrence and impacts from hailstorms. According to the National Weather Service, Leelanau County is in an area of the United States that has on average two days of hailstorm events per year.

Extent
Hailstorms are categorized using the TORRO Hailstorm Intensity Scale, which ranges from H0 (Hard Hail) to H10 (Super Hailstorms) (Table 15). According to the NOAA National Centers for Environmental Information, the approximate size of hail is described as follows. If a thunderstorm produces hail that is 1 inch in diameter (quarter size) or larger, it is considered to be a severe thunderstorm.

Table 19: NOAA Hail Size Description

Appearance	Approximate Size in Inches
Pea	0.25-0.5 inch
Penny	0.75 inch
Nickel	0.88 inch
Quarter	1.00 inch (Severe)
Walnut/Ping Pong	1.50 inch
Golf Ball	1.75 inch
Hen Egg	2.00 inch
Tennis Ball	2.50 inch
Baseball	2.75 inch
Tea Cup	3.00 inch
Grapefruit	4.00 inch
Softball	4.50 inch

The greatest extent hail reported in Leelanau County was 3 inches on July 8, 2016 in Empire. According to the scale, hailstones of this size are equivalent to a tea cup. Hail can damage aircraft, homes and cars, and can be deadly to livestock and people. Hailstorms have caused no deaths or injuries, $85,000 in property damages and $3,055,000 in crop damages.

Previous Occurrences
Between 1955 and 2022, Leelanau County had 35 hailstorms reported to NOAA (Table 20).

Table 20: Leelanau County Hail Events

BEGIN LOCATION	BEGIN DATE	MAGNITUDE
SUTTONS BAY	6/24/1998	0.75
LELAND	5/12/2000	1
SUTTONS BAY	5/12/2000	1
MAPLE CITY	5/12/2000	1
NORTHPORT	6/9/2000	0.88
LELAND	5/15/2001	1
SUTTONS BAY	5/15/2001	1.75
SUTTONS BAY	5/15/2001	1
LELAND	5/30/2002	0.75
GREILICKVILLE	8/28/2003	0.88
LELAND	6/13/2004	1
GLEN HAVEN	8/9/2004	0.75
CEDAR	9/7/2005	0.88
LELAND	7/17/2006	1
EMPIRE ARPT	10/18/2007	1
EMPIRE	6/15/2008	0.88
HATCHS	6/15/2008	1
CEDAR	7/2/2008	0.88
SUTTONS BAY	**7/2/2008**	**0.75**
LELAND	9/7/2008	0.88
SUTTONS BAY	4/25/2009	0.75
MAPLE CITY	4/10/2011	0.88
EMPIRE	4/10/2011	1
MAPLE CITY	4/10/2011	1
LAKE LEELANAU	6/8/2011	1
SUTTONS BAY	6/8/2011	0.88
GREILICKVILLE	5/20/2013	1
NORTHPORT	5/20/2013	1
NORTHPORT	8/30/2013	1.5
LAKE LEELANAU	8/2/2015	1
EMPIRE	7/8/2016	3
BOCUS	7/8/2016	1.5
SUTTONS BAY	7/8/2016	1
LELAND	4/10/2017	0.88
GREILICKVILLE	8/10/2021	0.75

Source: NOAA: National Centers for Environmental Information

During one particularly strong event on July 17, 2006, hail damage was significant within Leelanau 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 1", roughly the size of a quarter.

Another strong event occurred on July 8, 2016 near Empire. Powerful thunderstorms developed over Lake Michigan late in morning of the 8th, ahead of an incoming cold front. These storms produced very large hail, and some damaging winds, as they swept across northern Michigan. Approximately 60 percent of the cherry crop in northwest lower Michigan was damaged by the severe thunderstorms. Golfball-sized hail was reported in Empire, and up to three inches in diameter in Glen Arbor. Some vehicles were damaged, and a few homes lost windows and skylights. Considerable damage was done to orchards and vineyards in the area.

Probability of Future Events and Vulnerability Assessment
With 35 events reported in the past 67 years, Leelanau County has a 52% chance of a major hailstorm every year. All existing and future buildings, exposed infrastructure, and populations are at risk from hailstorms since hail causes damage to roofs, brick walls, glass, landscaping, crops, and cars. Manufactured homes and campground populations located throughout the county and are more susceptible to hail damage. Hail can also damage roads, sidewalks, bridges, and above ground utilities. Hail has the potential to cause injury and death, and populations are advised to take shelter when an event occurs.

Riverine and Urban Flooding

Fluvial, or 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.

Pluvial, or *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.

Dam failure is also a potential source of flooding. Infrastructure in the state is aging and costly to maintain. FEMA provides Federal Guidelines for Dam Safety. These guidelines encourage strict safety standards in the practices and procedures employed by federal agencies or required of dam owners regulated by the federal agencies (2004). The National Inventory of Dams provides a catalogue of dams in the nation with a profile of each. Each profile lists the Hazard Potential Classification. This is a system that categorizes dams according to the degree of adverse incremental consequences of a failure or mis-operation of a dam. The hazard potential classification does not reflect in any way on the current condition of the dam. Dam condition…

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

Urbanized areas or areas with higher concentrations of impervious surface and low –lying areas are most likely to flood in Leelanau County. Heavy rainfall can oftentimes overwhelm a city stormwater system causing backups and ponding or flooding. The Village of Suttons Bay and the Village of Northport have experienced significant flooding in the past. The County's hilly terrain will cause water to cascade oftentimes bringing sediment with it. Water and sediment will congregate in the low lying areas. Enough rain will cause erosion of the road bed and eventually cause road washouts. Cherry Bend Rd, Tumble Rd, and N West Bay Shore Dr have been known to flood.

Extent

Flood extent can be measured by the amount of property damage and accumulation of rainfall. In total, flood and flash flood events have caused $50,000 in property damages, no crop damages, and no deaths or injuries. Since 2000, the average annual precipitation is 34.18 inches. October is historically the wettest month with an average of 4.27 inches.

Table 17: Leelanau County Fluvial and Pluvial Flood Events

LOCATION	DATE	EVENT TYPE	PROPERTY DAMAGE	CROP DAMAGE	FLOOD CAUSE
COUNTYWIDE	7/6/1999	Flash Flood	$ 0	$ 0	Heavy Rain
COUNTYWIDE	9/1/2000	Flash Flood	$50,000	$ 0	Heavy Rain
EMPIRE	8/10/2021	Flash Flood	$ 0	$ 0	Heavy Rain
SOLON	8/10/2021	Flash Flood	$ 0	$ 0	Heavy Rain

Source: NOAA: National Centers for Environmental Information

Previous Occurrences
Leelanau County has experienced four flash flood events. The event narrative for the flash flood event on September 1, 2000 is as follows:

Thunderstorms formed along a warm front that stretched across northern Lower Michigan. The first thunderstorms began in Leelanau County around 400 pm and intensified quickly over the next hour. One thunderstorm intensified west of Traverse City and quickly moved over the downtown area. As the storm moved east of the city, a 60 MPH wind gust was reported, followed by a report of one inch diameter hail. Meanwhile, more storms producing very heavy rainfall formed over Lake Michigan and continued to dump rain over Leelanau county, mainly to the south of Leland and Suttons Bay, as well as over the Traverse City metropolitan area. The rain lasted over these locations from 600 pm to 1130 pm. Another area of thunderstorms formed over northern Benzie county around 700 pm. These also moved into the Traverse City metropolitan area. As with the storms over Leelanau county, these storms persisted until 1130 pm, continually affecting the same areas. Over the 4 to 5 hour period of rainfall, much of Leelanau county reported rainfall amounts ranging from 4 to 8 inches, while amounts ranged from 2 to 6 inches in Benzie and Grand Traverse counties.

These storms led to flooding across Leelanau county as well as the northern half of Benzie and Grand Traverse counties. Many secondary roadways across the central and western sections of Leelanau county were washed out. Sections of M-22 running near Suttons Bay received significant damage due to the force of the running water. Several businesses within the town of Glen Arbor were flooded. Many city streets around Traverse City became inundated with as much as 4 feet of standing water. Intense lightning also occurred with these storms. The lightning caused power outages to hundreds of homes and businesses in the Traverse City area.

Probability of Future Events and Vulnerability Assessment
Since 1996, Leelanau County has had 4 flooding events. There is a 14.8% chance of an annual flood. The magnitude and severity depend on the county population, 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. Downtown Traverse City is also the epicenter for festivals and events such as the National Cherry Festival which takes place mid-summer over the Fourth of July holiday. While Downtown and much of the city is located in Grand Traverse County, many visitors stay in Leelanau County and commute to the city for events.

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 sewer lines causing water supply pollution, downed power lines, broken gas lines, fires, and the release of hazardous materials.

The seasonal nature of flooding will continue to occur. Years with exceptional snowfall levels will likely result in flooding events from snowmelt. Lake Michigan water temperatures will create more active storm systems and heavier rainfalls. Lake Michigan water levels will also increase flooding events inland as the water table rises. Furthermore, increased development, reduction in green space, and subsequent soil erosion cause sedimentation to accumulate in river and lake beds reduce the amount of water flow. Rivers and lakes with sedimentation buildup will experience water backups and flooding events unless mitigated.

Members of the task force identified the following sites for concern:

- The Belanger Creek Dam (at the end of Belanger Creek at the intx. with M-22)
- Belanger Creek, located southeast of Stallman Road to the outlet in the Bay – potential for overflow
- Stallman Road near the intersection with Belanger Creek, located SW of Strongheart Way.

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

NFIP Participation Status

Leelanau County participating communities received updated digital flood maps in 2018.

Word on updated digital flood maps?

Table 22: NFIP Participation

Municipality NFIP	FIRM	Effective
City of Traverse City	12/15/1982	08/28/18
Village of Empire	No	
Village of Northport	03/02/89	08/28/18
Village of Suttons Bay	06/01/77	08/28/18
Bingham Township	08/28/18	08/28/18
Centerville Township	02/01/86	08/28/18
Cleveland Township	09/01/86	08/28/18
Elmwood Charter Township	02/02/83	08/28/18
Empire Township	08/28/18	08/28/18
Glen Arbor Township	09/01/86	08/28/18
Kasson Township	No	
Leelanau Township	04/02/86	08/28/18
Leland Township	08/28/18	08/28/18
Solon Township	08/28/18	08/28/18
Suttons Bay Township	08/28/18	08/28/18

Source: FEMA Community Status Book Report

The county has __ property(ies) that has been identified by the National Flood Insurance Program as having suffered repetitive flood losses….This property should be prioritized for flood mitigation activities, in order to prevent or reduce such losses in the future.

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 Leelanau County is at risk to the occurrence and impacts from lightning.

Extent
Lightning can be measured by damages-caused including deaths, injuries, property damages, and/or crop damages. Since 1996, two lightning events have been reported to NOAA in Leelanau County. Those events have caused $40,000 in property damage, no crop damages, no injuries, and no fatalities.

Previous Occurrences
There have been two lightning strikes reported to NOAA since 1996. There have been no fatalities. There have been no other reports of damages or injuries from lightning. Table 18 is a record of lightning events in Leelanau County.

The event narrative of August 12, 2007 is as follows:

A small cluster of thunderstorms produced severe weather in Leelanau County. A lightning strike ignited a fire, which destroyed a three-car garage and a boat that was inside, and melted vinyl siding on an adjacent home.

Lightning from the event on September 1, 2000 caused a fatality and an injury in Grand Traverse County. A man and his son were struck by lightning when they climbed a hill to view the approaching lightning. Lightning also caused delays in numerous high school football games.

Table 23: Lightning Events

LOCATION	DATE	DEATHS	INJURIES	PROPERTY DAMAGE
County/Region	9/1/2000	0	0	$0
Solon Township	8/12/2007	0	0	$40,000
TOTAL		**0**	**0**	**$40,000**

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment
Since there have been two lightning events reported in the last 27 years, the data shows that there is a 7% chance a lightning strike 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 may be higher.

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

Tornado

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

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

Location

Tornadoes are a regional event that are not confined to geographic boundaries and can affect several areas at one time. Also, the magnitude of tornadoes may range across the affected areas. All of Leelanau 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.

Extent

The Fujita Scale (Table 24) categorizes tornado severity based on observed damage. The six-step scale ranges from F0 (light damage) to F5 (incredible damage). As of February 2007, the National Weather Service uses the Enhanced Fujita Scale (EF Scale). This new scale ranges from EF0 to EF5. Based on the Fujita Scale, Leelanau County's most damaging tornado occurred on August 15, 1978; wind speeds are unknown. It caused no injuries or deaths, but $ 250,000 in property damages.

Table 20: 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 1951 and 2021, Leelanau County has had four reported tornadoes touchdown, causing a reported $ 295,000 in property damage (Table). As a result of these tornadoes, there were no deaths, no injuries, and no reported crop damage. The tornado event on August 15, 1978 caused $250,000 in damage, the most destructive of the three. The tornado touched down in Suttons Bay Township and proceeded northeast into Peshawbestown across E. McKeese Road.

The event narrative is as follows:

A tornado touched down on M-22, south of Leland, and skipped ENE damaging four homes and two mobile homes and blocking roads with felled trees. Most of the damaged homes were on Dumas Road. Many small boats on Lake Leelanau broke loose from their moorings with several sail boats capsizing.

Table 19: Tornado Events

BEGIN LOCATION	DATE	MAGNITUDE	DEATHS	INJURIES	PROPERTY DAMAGE
Countywide	4/5/1956				
Glen Arbor Township	7/31/1977	F1	0	0	$25,000
Suttons Bay Township	8/15/1978		0	0	$250,000
Leland Township	6/22/2011	EF0	0	0	$20,000
TOTAL			**0**	**0**	**$295,000**

Source: NOAA: National Centers for Environmental Information

Probability of Future Events and Vulnerability Assessment

Since there have been four tornadoes events reported in the last 71 years, the data shows that there is a 5.6% chance a tornado would occur every year. While the chance for a tornado is low, if an event occurs, there is potential for a higher magnitude tornado to touch down. All reported historic events have caused significant property damage. Due to increased residential growth in the county, the chances of a tornado touching down and causing residential damage is very high, especially inTraverse City and surrounding townships where population densities are highest.

Sirens and shelters…###

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.

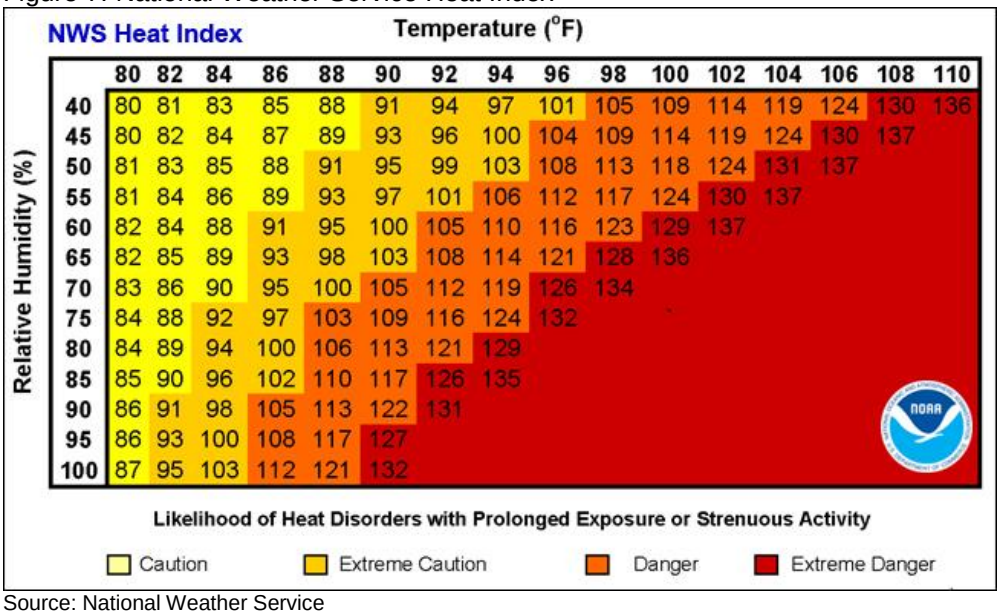
Nationwide, there have been approximately 175 deaths per year that are attributable to extreme heat according to the 2019 Michigan Hazard Analysis. The threats from extreme heat are heatstroke, sunstroke, muscle cramps, heat exhaustion, and fatigue. It is hazardous to livestock and agricultural crops,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

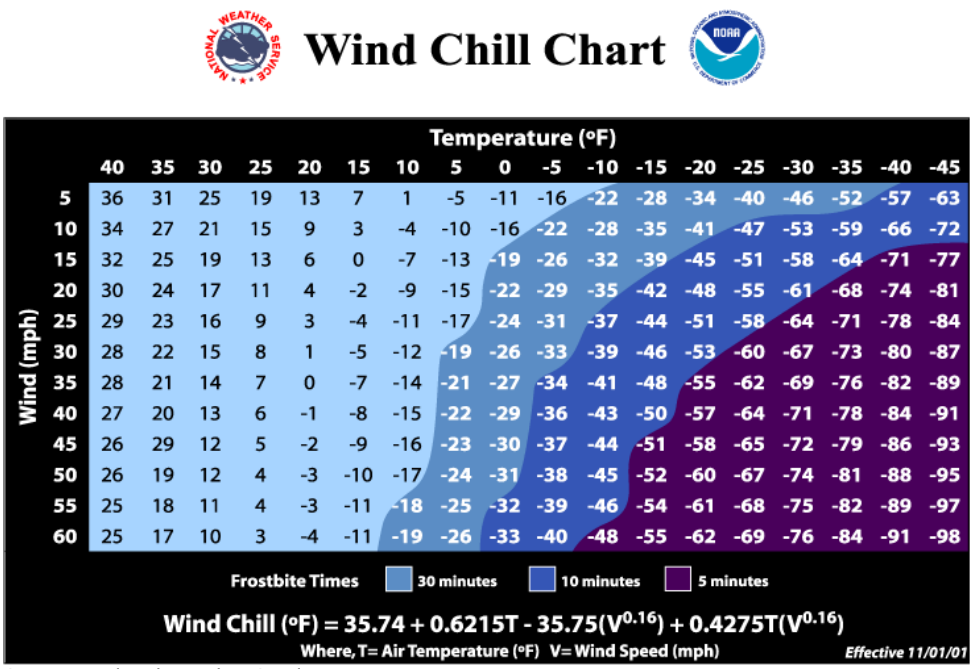
Figure 7: National Weather Service Heat Index



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 Chill Chart

Wind (mph) \ Temperature (°F)	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

Frostbite Times: 30 minutes | 10 minutes | 5 minutes

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

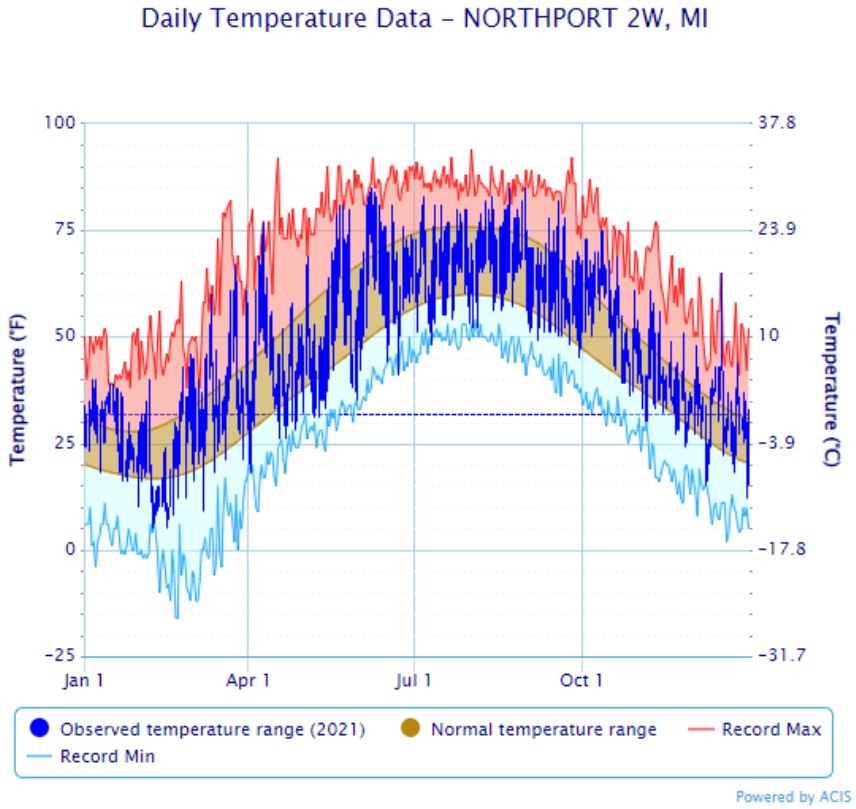
Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: National Weather Service

Figure 9 are the observed temperatures in Northport 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.

Figure 9: Daily Temperature Data:



Source: NOAA Climate Data Online

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

Previous Occurrences
Leelanau County has had two extreme heat events in 2001 and 2018 (Table 26). The events did not have any deaths, injuries, or property/crop damages. The events consisted of hot and humid conditions that caused outdoor events to be modified and attendance at outdoor events to be lower than normal.

Table 26: Heat Related Events

	DATE	EVENT TYPE	INJURIES, DEATHS, DAMAGES	EVENT DESCRIPTION
LEELANAU (ZONE)	8/1/2001	Heat	0	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.
LEELANAU (ZONE)	6/30/2018	Excessive Heat	0	Highs were well into the 90s, including 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.

Source: NOAA: National Centers for Environmental Information

Since 2000, there have been three extreme cold events reported in Leelanau County. There was one death, no injuries, and no property/crop damages. The low temperatures caused schools to close. However, since cold temperatures typically occur during winter months, many events may have gone unrecorded.

Governor Declared Emergency for extreme cold in the State was enacted in 2019 and included Leelanau County.

Table 27: Cold Related Events

	DATE	EVENT TYPE	INJURIES, DEATHS, DAMAGES	EVENT DESCRIPTION
LEELANAU (ZONE)	2/4/2007	Extreme Cold/wind chill	0	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.
LEELANAU (ZONE)	2/10/2008	Extreme Cold/wind chill	1	Polar air surged into the region behind the departing system, dropping temperatures to around zero. Lake effect and lake enhanced snow quickly developed, with a widespread two to five inches in the snowbelts. There were isolated higher amounts of seven inches in Gaylord, nearly nine inches south of Traverse City, and eight inches near Trout Lake. Wind gusts up to 45 mph, when combined with falling and blowing snow, produced outright blizzard conditions in the open country of central Chippewa County, and near blizzard conditions at times across much of the rest of Northern Michigan. In Leland, an 87-year-old male Alzheimers patient was found dead five blocks from his home on the morning of the 10th. Local law enforcement stated he died of exposure to the cold. A number of area schools were closed on the 11th (Monday) as the clean-up was still underway..
LEELANAU (ZONE)	1/29/2019	Extreme Cold/wind chill	0	Governor Declared Emergency – 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.

Source: NOAA: National Centers for Environmental Information

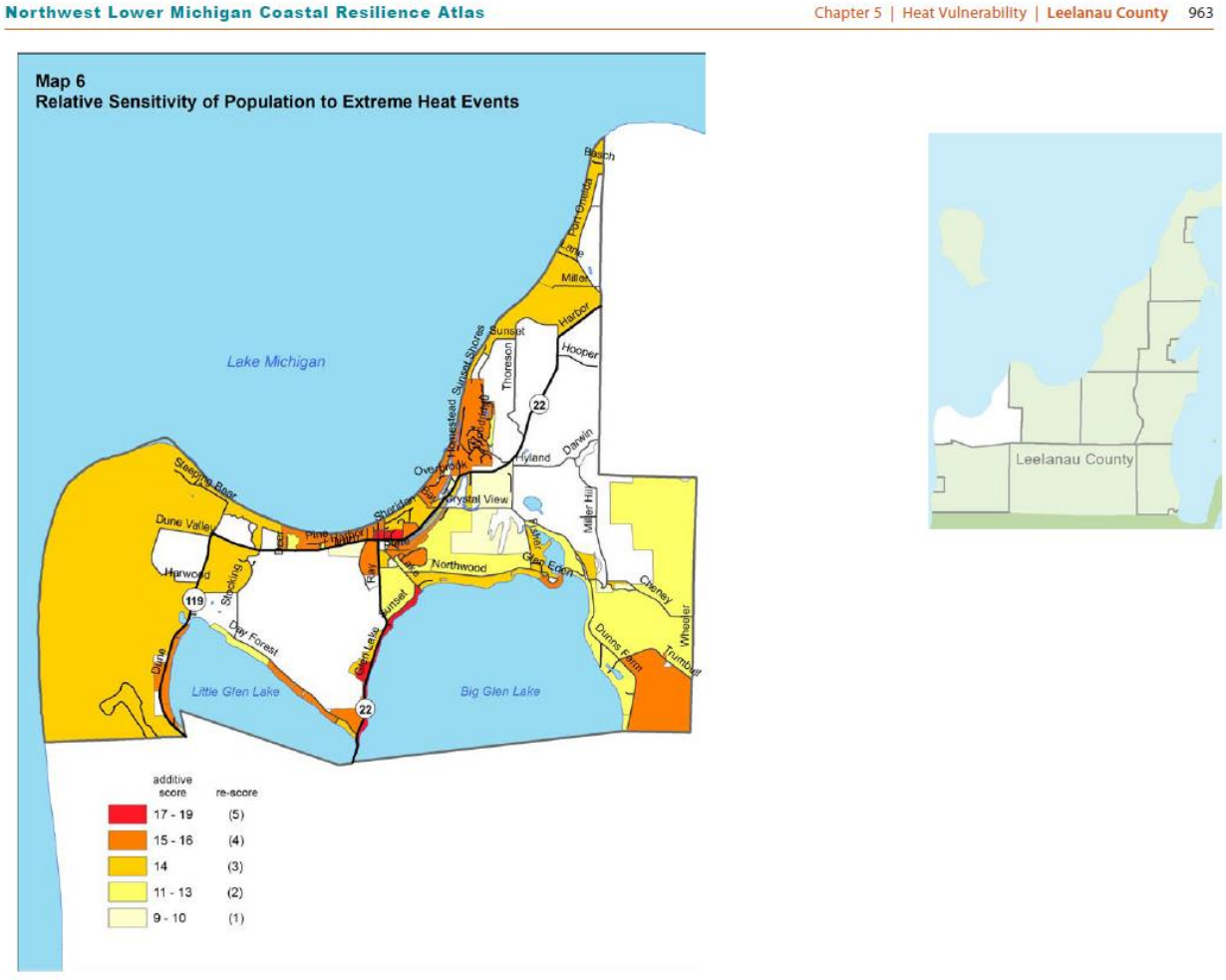
Probability of Future Events and Vulnerability Assessment
Since 1999, there have been two extreme heat events in Leelanau County. This data shows approximately one extreme heat event would occur every 12 years. Since 2000, there have been three extreme cold events in Leelanau County. This data shows approximately one event would occur every 7 years. 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. Traverse City's homeless population is especially vulnerable. Seasonal Emergency Shelters such as Safe Harbor are essential services for the community. The *Northwest Lower Michigan Coastal Resilience Atlas* written by the Land Information Access Association completed a Heat Vulnerability Assessment[4] 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)

Glen Arbor Township has the highest median age (65.5) of all Leelanau County communities. Their relative sensitivity to extreme heat events is pictured in Figure 10.

Figure 10: Glen Arbor Township Relative Sensitivity of Population to Extreme Heat Events



Source: LIAA *Northwest Lower Michigan Coastal Resilience Atlas*

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

Drought

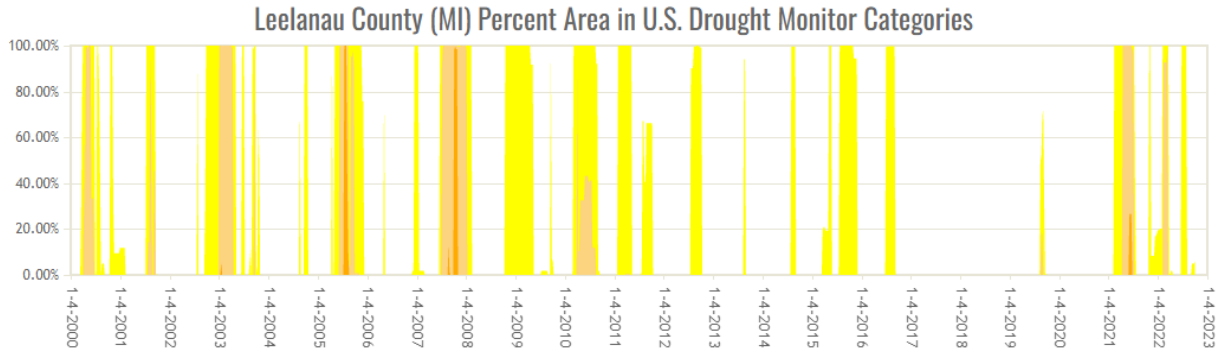
Drought is a normal part of the climate cycle. It is a slow-moving hazard, which causes people to underestimate the damage it can do, but losses from drought are as substantial as those from hurricanes, tornadoes and other faster-moving disasters. Drought causes losses to agriculture; affects domestic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



Source: US Drought Monitor

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

Michigan

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

Source: US Drought Monitor

Previous Occurrences
There have been two instances of drought in Leelanau County. The first event was a Presidential Declared Emergency enacted in 1977 for drought problems in the State and included Leelanau, Lake, Mason, Oceana, and Wexford Counties. The second event occurred on August 1, 2001. No deaths, injuries, or damages are associated with these drought events.

The August 1, 2001 event narrative is as follows:

After a cool beginning, the last half of July 2001 was characterized by warmer than normal and drier than normal weather. Less than an inch of rainfall was recorded in some areas for the month of July. 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
There is a 4% annual chance for a drought event in Leelanau County. Drought can adversely impact residential water sources when well levels decline, agriculture including both crops and livestock, and some tourism and recreational enterprises This can also cause a drop in income, which impacts other economic sectors. The biggest problem drought presents, however, is the increased threat of wildfire. Western and southern portions of Leelanau County are heavily forested and are therefore highly vulnerable to drought-related wildfire threats. Additionally, the threat to water sources should also be considered. Many county residents rely on ground water wells for drinking water. Even drought events in category D1 experience water well level decline. Drought events combined with excessive heat can have severe impacts on elderly and low income people.

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 thunderstorm will roll through and lightning will strike causing sparking of dry leaves and dead wood. High winds can then spread wildfire. Wildfires can become unpredictable in windy conditions or when the wind changes direction suddenly. Cooler nighttime temperatures often help suppress wildfires and the potential for wildfire; however Michigan has had several major fire events.

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

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

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

Extent and Previous Occurrences
Extent can be measured by the number of acres burned and the cost of property damage. Between 1996 and 2017 there were no wildfires reported outside of MDNR lands in Leelanau County. Between 1981 and 2018 there were 60 reported fires on lands under MDNR jurisdiction. This resulted in 267.6 acres burned and 7 acres burned 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 MDRN lands, and a small chance there will be a wildfire on lands outside of MDNR jurisdiction. Forest types (Red Pine, Eastern White Pine, and Jack Pine) within Leelanau County are susceptible to wildfires. Additional factors that increase fire risk include dead or dying Ash trees as a result of disease/invasive species, lightning strikes, and human factors such as the number of persons residing, camping, or traveling through the County. Historically, Michigan's landscape has been shaped by wildfire; however, over the last several decades, the current landscape has transformed from wildland to residential development. With the increase in residential development in and around rural areas prone to wildfires, there is an increase in the potential for loss of life and property damage. Unfortunately, rural areas do not have enough fire suppression forces available to protect every structure from wildfires. Residential development in rural Leelanau 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.

Rip Currents

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.

It is important to note the difference between a rip current and an undertow. An undertow is a term used to describe the current beneath the surface when waves are breaking upon the shore. Tides are very long-period waves that move through the ocean in response to the forces of the moon and sun. While tides can be a factor in rip current development, there is no phenomenon specifically called a “rip tide”.

Rip currents carry swimmers into deeper water, where they may not be able to get their footing. These currents rarely extend far out, and will not pull a swimmer underwater. Rip currents vary in size from very narrow to more than 50 yards wide. Speeds can also vary. The average speed is 1-2 per second, but they have been measured as fast as 8 feet per second. In Michigan, since 2001, there have been 34 deaths and 15 injuries due to rip current events.

Location
Rip currents are a coastal event that is not confined to geographic boundaries and may occur anywhere in Lake Michigan waters. All coastal areas are at risk to the occurrence and impacts from rip currents.

Extent
The National Weather Service provides a Surf Zone Forecast to measure the risk level associated with rip current hazards. Surf Zone Forecasts contain three levels of Rip Current Outlooks:

- Low Risk: The risk for rip currents is low, however, life threatening rip currents often occur in the vicinity of groins, jetties, reefs, and piers.
- Moderate Risk: Life threatening rip currents are possible in the surf zone.
- High Risk: Life threatening rip currents are likely in the surf zone.

Rip currents can be measured by damages-caused including deaths and injuries. There has been one significant rip current event in Leelanau County, and one death was reported.

Previous Occurrences
Leelanau County has had one reported fatality from a rip current event. The event occurred on August 30, 2012. The event narrative is as follows:

Southwest winds of 20 to 30 mph producing significant wave action and strong currents along the Lake Michigan coast. Three individuals were caught in rip currents near Van's Beach in Leland. One was rescued via kayak; a second managed to escape and swim back to shore. Unfortunately, the third, a teenaged male from Lake Leelanau, went under and disappeared. His body was found by searchers the next day, in about six feet of water.

Table 27: Rip Current Events

Date	Fatalities	Rescues	Beach Name	Location	Type Of Current	Wave Direction	Wave Height (ft)
8/30/2012	1	2	Van’s Beach	Leland Township	Classic Rip	S	5 TO 6

Source: Great Lakes Current Incident Database https://www.michiganseagrant.org/dcd/dcdsearch.php

It is likely that more rip current events have occurred and gone reported. There are instances of fatalities from rip currents in nearby coastal counties including Benzie, Emmet, and Manistee Counties.

Probability of Future Events and Vulnerability Assessment
One rip current event has occurred in the past 21 years. There is a 4.7% of a rip current event happening every year. Rip current events are likely to occur more frequently, but go unreported as injuries and deaths do not occur. Rip currents are dangerous to all swimmers, especially those who are unprepared to be swept up in the current. Many Lake Michigan beaches do not have a lifeguard on duty who may identify potential hazardous swimming conditions. Swimmers who are caught unaware may panic when caught up in the fast-moving water, tire as they try to swim against the current, and drown.

Seiche

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.

Seiches are usually limited to partially or fully enclosed basins, such as Lake Erie. Lake Erie is known for seiches, especially when strong winds blow from southwest to northeast. In 1844, a 22-foot seiche breached a 14-foot-high sea wall killing 78 people and damming the ice to the extent that Niagara Falls temporarily stopped flowing. As recently as 2008, strong winds created waves 12 to 16 feet high in Lake Erie, leading to flooding near Buffalo, New York.

In some of the Great Lakes and other large bodies of water, the time period between the "high" and "low" of a seiche can be as much as four to seven hours. This is very similar to the time period between a high and low tide in the oceans, and is often mistaken as a tide.

In Michigan, since 1998, there have been 15 seiche events. There are no deaths, no injuries, and $31,000 in property damages due to seiche events.

Location
Seiches are a coastal event that is not confined to geographic boundaries and may occur anywhere in Lake Michigan waters. All coastal areas are at risk to the occurrence and impacts from a seiche.

Extent
Seiche events can be measured by damages-caused including deaths, injuries, and property damages. There has been one significant seiche event in Leelanau County, and no deaths or injuries were reported.

Previous Occurrences
Leelanau County has had one seiche event. The event occurred on May 9, 2019, and caused $5,000 in property damages. The event narrative is as follows:

The sudden relaxation of a gusty east wind, and quick transition to a northwest wind, resulted in a seiche on Lake Michigan. With very high water levels already in place on all of the Great Lakes, localized flooding developed. Water entered some of the historic fishing shanties in the Fishtown section of Leland. Sandbags and other methods were deployed to attempt to keep the water out.

Probability of Future Events and Vulnerability Assessment
One seiche event has occurred in the past 25 years. There is a 4% of a seiche event happening every year. Seiche events are likely to occur more frequently, but go unreported as injuries, deaths, or damages do not occur. As noted in the May 9, 2019 event and others, persons and property along the lake shore are also vulnerable to high waves caused by a seiche. Seiche events are also dangerous to all swimmers, especially those who are unprepared to be swept up in the current. Many Lake Michigan beaches do not have a lifeguard on duty who may identify potential hazardous swimming conditions.

Shoreline Hazards (Coastal Flooding and Coastal Recession)

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

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

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."

Jurisdictions located on the Lake Michigan coast (Grand Traverse Bay) are impacted by shoreline hazards: City of Traverse City, Village of Empire, Village or Northport, Village of Suttons Bay, and the following coastal townships: Elmwood, Bingham, Suttons Bay, Leelanau, Leland, Centerville, Cleveland, Glen Arbor, and Empire. The Land Information Access Association 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.

Leelanau County

Coastal Flooding Scenario Impacts

Leelanau County			
Total SEV	Lucky	Expected	Perfect Storm
$ 3,402,236,245.00	$ 114,536,520.00	$ 255,435,310.00	$ 585,910,250.00

Source: LIAA, Northwest Lower Michigan Coastal Resilience Atlas

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

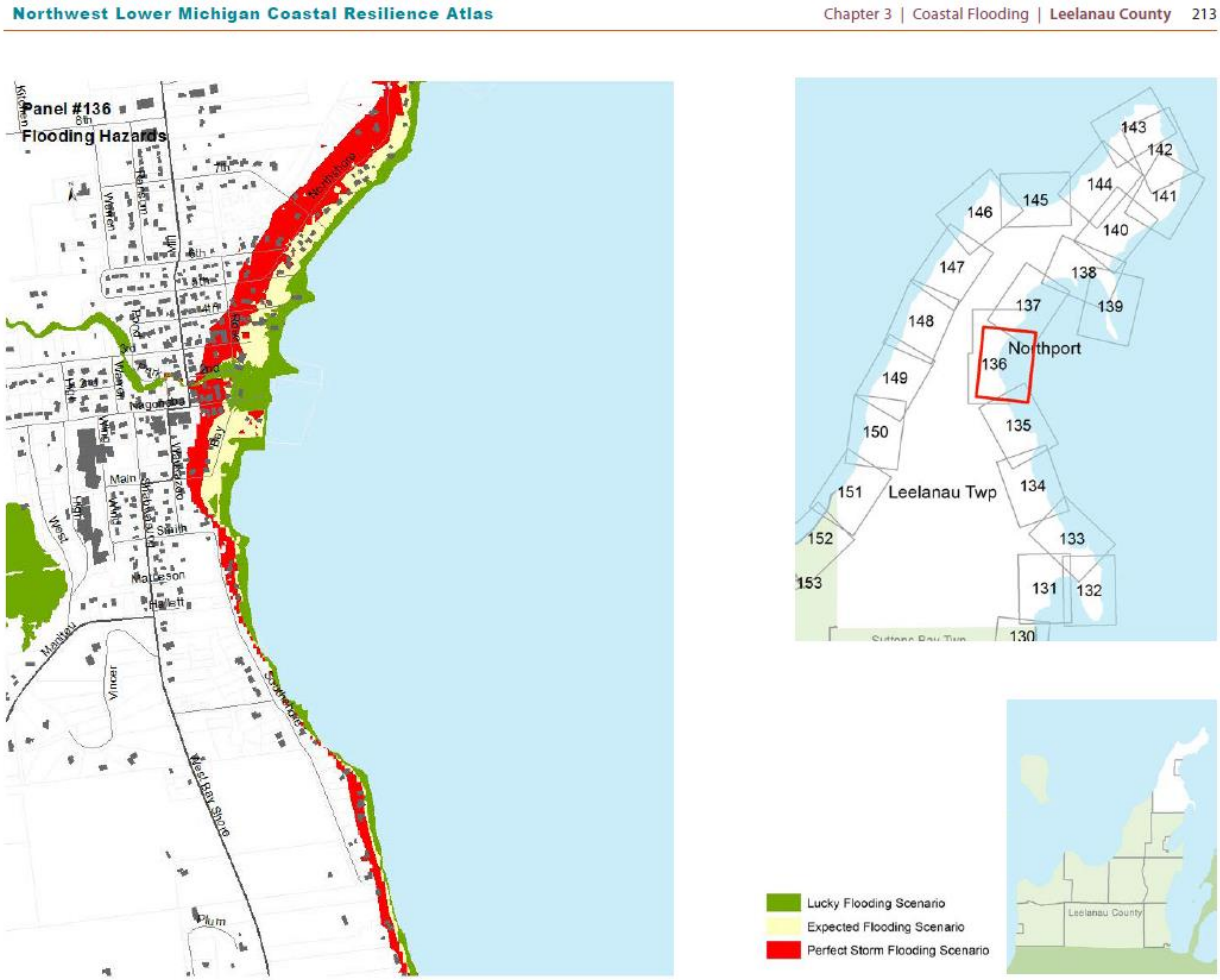
The first scenario, **"Lucky" Future:** Under the Lucky Climate Future, Great Lakes water levels will continue to stay relatively low. Although there will be wave and wind action, major storm events and wave impacts will not encroach on properties landward of current beaches. A Lucky Future projection, indicating the land areas that would be affected by high-energy waves along the 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.

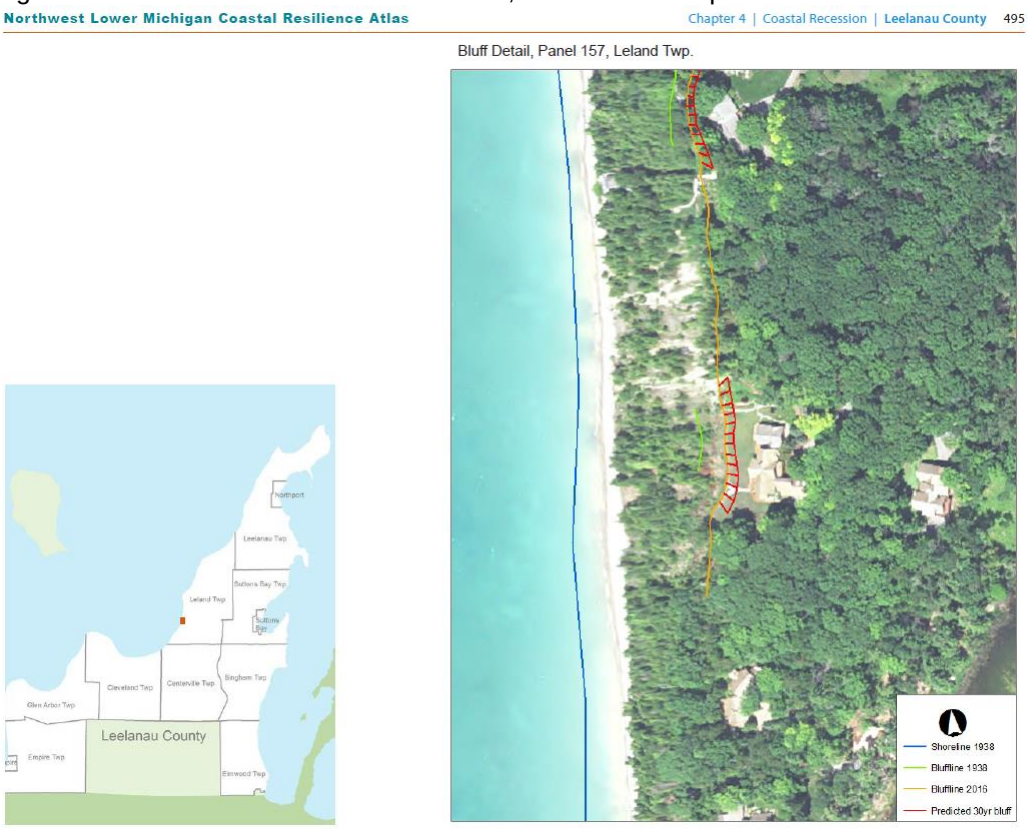
"Perfect Storm" Future: Under the Perfect Storm Climate Future, Great Lakes water levels will continue to fluctuate according to decadal patterns, consistent with assumptions made for the Expected Future. However, for this Perfect Storm Climate Future, the estimated still-water elevation is set higher 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.

Figure 13: Panel #136 Flooding Hazard, Northport and Leelanau 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 Leelanau 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 varying lines are shown in Figure 14 depicting the recession of the bluffline in Acme Township near the LochenHeath Golf Club.

Figure 14: Panel #157 Shoreline Recession, Leland Township



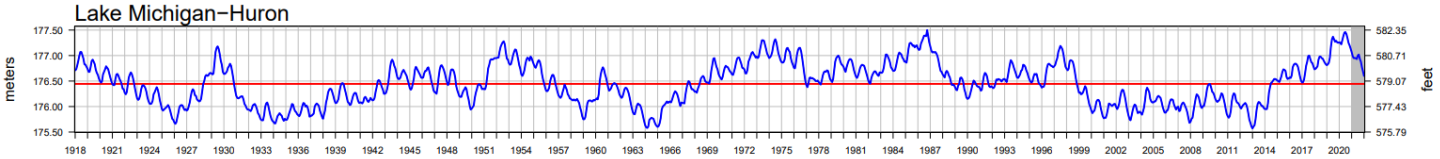
Source: LIAA, Northwest Lower Michigan Coastal Resilience Atlas

Extent

Shoreline recession can be measured by feet of bluffline retreat and property damages. Bluffline retreat distances vary across the county, and there are no reported damages from bluffline recession. Shoreline flooding can be measured by flood water levels, inches of rainfall, lake water levels (shown in Figure 15), and damages. The lakeshore flooding events in 2019 and 2020 caused $179,000 in property damages.

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

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



LAKES MICHIGAN-HURON

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

Source: US Army Corps of Engineers

Previous Occurrences
The Great Lakes experienced record high lake levels in 1985-86, again in 1997-98, and again in 2019-20. Many cases of erosion are present and high lake levels causing rivers and tributaries to back up have caused infrastructure damage and failures throughout Leelanau County and many other areas in Michigan. More specifically, three incidents have been reported. The first occurred on October 16, 2019, the second occurred on October 21, 2019, and the third occurred on April 13, 2020.

The narrative of the event on October 16, 2019 is as follows:

Northwest to north winds produced high waves and elevated water levels along the northwest lower Michigan coastline. With Great Lakes water levels at near-record levels, significant coastal flooding and beach erosion resulted. The parking lot of the Grand Traverse Yacht Club was flooded.

The second event occurred on October 21, 2019. *Strong northerly to easterly winds resulted in another round of substantial coastal flooding and beach erosion, this time on both Lake Michigan and Lake Huron, for the 21st into the 22nd. In Northport on the 21st, a dock was damaged and a boat house was flooded. Water levels rose over the docks at Northport Marina. On the 22nd in Empire, a part of the break wall at Empire Beach was destroyed. In Glen Haven, restoration efforts from flooding earlier in the month were eliminated, and shoreline fences were destroyed at Glen Haven Beach.*

Probability of Future Events and Vulnerability Assessment
Michigan lakeshore flood events began being recorded in 2014. Over the nine years, three events have occurred. This is a 33% chance of shoreline flooding and an equal chance erosion will cause shoreline damages. The shoreline hazards of 2019 and 202 occurred under unique circumstances when the Great Lakes water levels were above average. Based on past water level measurements, similar levels are not likely to occur for some time. On the contrary, the Great Lakes may experience low water levels with the ebb and flow of the lakes.

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 Lake Michigan and the Grand Traverse Bay (City of Traverse City, Village of Empire, Village or Northport, Village of Suttons Bay, and the following coastal townships: Elmwood, Bingham, Suttons Bay, Leelanau, Leland, Centerville, Cleveland, Glen Arbor, and Empire) 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. The following is an excerpt from the *Leelanau County Plan, Amended 2019.*

Seemingly endless shorelines and monumental dunal formations epitomize the grandeur of the area. While these resources serve as critical components of the County's tourism and recreation industry, they are particularly vulnerable to wind and wave action, as well as to any land use and development activities which disturb the stability of the dunes. The clearing of vegetation along shorelines and dunes seriously increases their susceptibility to erosion, shifting, and demise. Disturbance of their natural character by land use activities heightens their vulnerability to winds and waves, and other climatic forces. Many of the County's shoreline areas and dunal formations are considered "high risk erosion areas." The significance of these areas is highlighted by their inclusion for protection under the Michigan Natural Resources Act 451. This Act serves to protect designated "critical dune areas", including Sleeping Bear Dunes and Empire Bluffs as well as less prominent dune areas.

The Lake Michigan shoreline and dunal formations harbor yet another sensitive environmental resource - threatened and endangered plant and animal species. Inventories by the Michigan Department of Natural Resources have identified numerous unique plant and animal species in the County which rely largely upon shoreline and dune areas for their survival. Other threatened species which rely upon a more inland environment have also been identified. The fact that these plant and animal species are already considered unique due to their threatened survival emphasizes the need to prevent disturbances in the ecosystem in which they thrive.

Shorelines of inland lakes are also sensitive natural resources. The calmer waters and areas of interface between the land and water are particularly important habitats for wildlife and plant life. Understandably, these areas are also actively sought for development and recreational use. The resulting threat to these environments through soil erosion and sedimentation, disturbance of the natural shoreline and vegetation, and leachate from faulty septic systems is a concern today and will become more significant as the County's population grows.

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 Leelanau 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 Leelanau County, the Benzie-Leelanau Health Department works with local, state, and federal agencies to prepare for and respond to public health threats. It developed a comprehensive emergency preparedness program capable of responding to a variety of emergency situations with funds from the Centers for Disease Control. The State of Michigan reports, as of October 4, 2022, there are 4,173 cumulative cases of COVID-19 and 63 deaths in Leelanau County. Those 80 years and older have the most deaths of any age range at 31 deaths.

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

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

Invasive Species

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

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

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

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

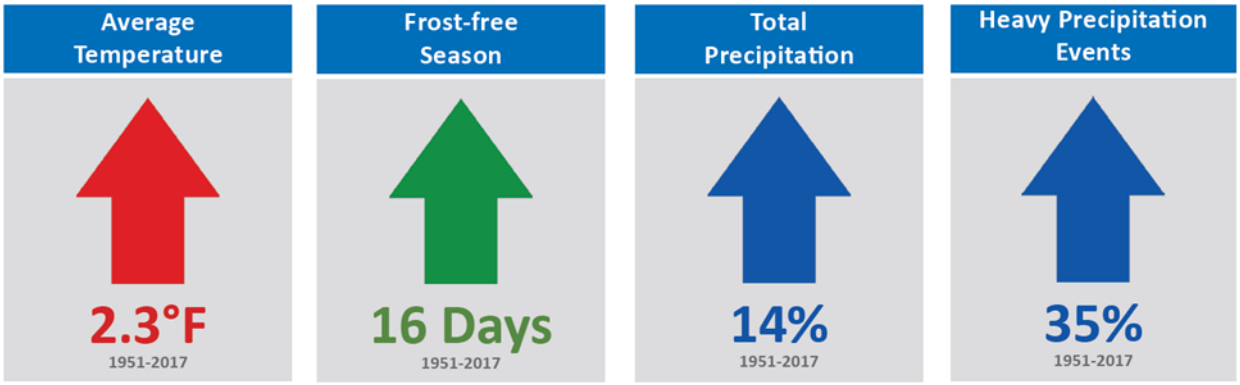
Previous Occurrences
Non-native terrestrial and aquatic species are introduced to Michigan and the Great Lakes both intentionally and unintentionally. Aquatic invasive species are the result of unwanted fish and aquatic plants released from home aquariums, travelled across the ocean in ballast water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

Probability of Future Events and Vulnerability Assessment
The Great Lakes and connecting channels and rivers form the largest surface freshwater system in the world. This freshwater system, along with Michigan’s inland lakes, streams, rivers, and wetlands represent an invaluable resource and are therefore justifiably a top natural resource management priority. The State of Michigan estimates 42% of threatened or endangered species are considered at risk due to non-native species. The Michigan Department of Environment, Great Lakes, and Energy produced the “Michigan Watch List Aquatic Invasive Plants: A Guide for Identification” for those species that have been identified as posing an immediate or potential threat to Michigan’s economy, environment, or human health. Included in the watch list are ten species that have been found in limited parts of Michigan and surrounding states. The State TIS Management Plan provides a list of eleven terrestrial species on the watch list. The Northwest Michigan Invasive Species Network and Leelanau Conservation District and other partners “protect, enhance, and promote Northwest Michigan’s natural communities through terrestrial invasive plant management and outreach.”

Impacts from Climate Change
Climate describes the average weather conditions for a particular location and over a long period of time.

According to the World Meteorological Organization, "A disaster related to a weather, climate or water hazard occurred every day [in the United States? Globally?] on average over the past 50 years – killing 115 people and causing $202 million (US $) in losses daily, according to a comprehensive new report from the World Meteorological Organization (WMO). 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." (source)

The impacts of climate change already are, and continue to be, deep and widespread in the Great Lakes region. Rising temperatures and CO_2 levels, increasing precipitation and extreme weather events, and longer frost-free seasons are already affecting agriculture, infrastructure, natural resources, public health, and vulnerable populations. 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. GLISA summarized the impacts of climate change in the Great Lakes region in a two-page Executive Summary factsheet, reiterated below. The findings come from peer-reviewed publications.



Temperature
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).

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.

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 increased frequency of severe storms, flooding, drought and extreme heat can have the following impacts on public health, the built environment, economy and natural environment:

- **Public Health**
  - Increased heat waves and 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*.
- Warmer surface waters amplify the risk of *toxic algal blooms and fish contamination.*

- **Built Environment**
  - The seasonal distribution of the water cycle will likely change. Warmer temperatures may lead *to more winter rain and earlier peak streamflows*. This can *impact stormwater and road/bridge infrastructure, along with any structures located within a floodplain*.
  - More extreme heat may increase the risk of *heat damage to pavement and railroads*.
  - More extreme precipitation may *compromise transportation routes and damage infrastructure*.
  - Reduced summer water availability may *interfere with some industrial operations (i.e., hydropower, thermoelectric and nuclear plant cooling*.)
  - Warmer temperature and more frequent heat waves will likely *increase electricity demands, particularly in urban areas and during summer months*.
  - Projected increases in droughts, severe storms, and flooding events may *amplify the risk of erosion, sewage overflow, interference with transportation, and flood damage*.

- **Economy**
  - *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*.
  - *Shipping lanes* will likely be *open earlier and longer* due to reduced ice cover on the Great Lakes.
  - Low lake levels can affect navigation channels and *reduce the maximum loads carried by vessels, which amount to substantial monetary losses per transit*.
  - In the *near-term*, a longer growing season and higher CO_2 concentrations will likely have a *positive effect on crop and forest productivity*. In the *long-term*, the *negative effects* of increasing storm activity, flooding, extreme heat, summer drought risks, and pests may *outweigh the benefits of a warmer climate*.
  - *More severe storms* may have a negative economic impact due to *resulting damages and increased costs of preparation, clean up and business disruption.*

- **Natural Environment**
  - Warmer surface water temperatures increase stratification of the lakes and decrease vertical mixing, leading to *hypoxic conditions that will further stress biomass productivity in lakes and wetlands*.
  - With stronger storms, the presence of impervious surfaces increase runoff and nutrient loading to surface water bodies; combined sewer overflows and agricultural fertilizers are major contributors to high nutrient loads. This contributes to the formation of harmful *algal blooms and hypoxic dead zones* that can *degrade shoreline water quality and coastal ecosystem health*.
  - The coupling of climate change and land use change (i.e., *more impervious surface area) could result in even greater impacts on water quality*.

  - Increasing variability in Great Lakes water level fluctuations.
  - 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.

  - 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.

How has Climate Change impacted Leelanau County?

How will Climate Change impact Leelanau County?

What is or should the County be doing to prepare for Climate Change?

V. Goals and Objectives

The mission of the Leelanau 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 whole community participation, strategies, and initiatives in natural hazardsmitigation

- Encourage cooperation and communication between planning and emergency management officials
- Encourage additional local governmental agencies to participate in the hazard mitigation process
- Encourage public and private organizations to participate, including organizations who advocate for individuals with functional or access needs
- Encourage use of the "Firewise Communities Program" (www.firewise.org) which offers both workshopsand web-based interactive training geared toward homeowners, forestry professionals, firefighters and others on a variety of wildfire safety topics.

Goal 2: Integrate hazard mitigation considerations into the community'scomprehensive planning process:

- Enforce and/or incorporate hazard mitigation provisions in building code standards, ordinances, and procedures; and into the county's comprehensive master plan
- Create or update zoning ordinances to reflect any new regulations
- Incorporate hazard mitigation into basic land use regulation mechanisms
- Incorporate hazard area classifications into standard zoning classifications
- Develop community education and warning systems
- Integrate hazard mitigation into the capital improvement planning process so that public infrastructure does not lead to development in hazard areas
- Encourage county agencies to review local roads, bridges, dams, and related transportation infrastructure for hazard vulnerability

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

Strategies

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

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

Strategies

- Encourage public and business involvement in natural hazards mitigation projects

VI. Mitigation Strategies and Priorities

Types of Mitigation Actions

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
- Structure 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 Leelanau 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 power, such as electric and gas, 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

Mobile warning system: Leelanau County uses the Emergency Communications Network, which is an electronic high-speed outbound notification service available to the general public.

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

Tornado/Severe Weather Systems: Manual sirens are located at fire departments. Automatic sirens. Weather alert radios were purchased and distributed to

Flood warning system: For dam failures/flooding

There are warning sirens located at each Fire Station (Suttons Bay, Leland, Elmwood, Northport, Cedar, and Glen Lake) and one warning siren located in Peshawbestown at the Pow Wow Grounds on Stallman Road forthe Grand Traverse Band of Ottawa and Chippewa Indians.