SECTION 2:
RISK ANALYSIS

2.1 RISK ANALYSIS OVERVIEW

The State of Ohio is prone to many natural, manmade, and technological hazards. Ohio has experienced thousands of hazard events, resulting in millions of dollars in losses and casualties, and 51 Presidential disaster declarations. The Risk Analysis (RA) in Section 2 of this plan draws data and analysis from many different sources in order to analyze and mitigate impacts from the state's highest risk hazards.

In order to meet FEMA state mitigation planning requirements in 44 CFR 201.4(c) (2) and (d), a state mitigation plan risk assessment must:

- Include an overview of the type and location of all natural hazards that can affect the state,
- Provide an overview of the probabilities of future hazard events,
- Address the vulnerability of state assets located in hazard areas and estimate the potential dollar losses to these assets,
- Include an overview and analysis of the vulnerability of jurisdictions to the identified hazards and the potential losses to vulnerable structures, and
- Reflect changes in development

NATIONAL RISK INDEX

The State of Ohio has chosen to use FEMA's National Risk Index (NRI) as a primary source for determining the vulnerability and performing loss estimation for certain natural hazards in the SOHMP. All methodologies for determining risk and performing loss estimation have limitations and the NRI is no different but the advantages of the NRI significantly outweigh any limitations. The advantages of using the NRI is a consistent data set which has been downscaled to the census tract level, the use of national recognized data sets in well documented methodologies and the inclusion of future conditions data. The NRI limitations include an over reliance on Expected Annual Loss calculations, which can lead to an over representation of high-density population areas in risk calculations and a lack of integration of data from local and state level hazard mitigation plans. The technical documentation for the NRI is located in Appendix J.

The NRI data will be used for the vulnerability analysis and lost estimation for those hazards which data is available this includes:

- Flooding
- Tornado
- Winter Storms
- Landslide
- Wildfire
- Seiche/Coastal Flooding
- Earthquake
- Severe Summer Storms
- Extreme Heat (Heatwave)

The NRI does not encompass all the natural hazard addressed in SOHMP, the below hazards will use an alternative method described in each hazard's section to determine the vulnerability and perform any loss estimation related to each hazard:

- Dam/Levee Failure
- Drought
- Coastal Erosion
- Invasive Species
- Land Subsidence
- Future Conditions

The National Risk Index provides three different types of results for Risk and each component used to derive Risk: EAL, Social Vulnerability, and Community Resilience:

- Values. Values for Risk and EAL are in units of dollars, representing the community's average economic loss from natural hazards each year. For Social Vulnerability and Community Resilience, values are the index values for the community provided by the source data sets.
- Scores. Scores represent the national percentile ranking of the community's component value compared to all other communities at the same level (county or Census tract).
- Ratings. Ratings are provided in one of five qualitative categories describing the community's component value in comparison to all other communities at the same level. Rating categories range from "Very Low" to "Very High."

In the risk equation, each component is represented by a score that represents a community's national percentile ranking relative to all other communities at the same level (county or Census tract). The composite Risk Index score is calculated to measure a community's risk to all 18 hazard types. The Risk Index score is a community's national percentile ranking in risk compared to all other communities at the same level. The Risk Index score and EAL score are provided as both composite scores from the summation of all 18 hazard types, as well as scores where each specific hazard type is considered separately.

HAZARD IDENTIFICATION

The State of Ohio Hazard Identification and Risk Analysis (HIRA) provides an overview of the type and location of all natural hazards that can affect the state (see Appendix H). The HIRA is maintained by the Ohio EMA Plans Branch and is the authoritative source of hazard identification and analysis that informs all state plans related to emergency management. However, the SOHMP does not include an in-depth analysis of all hazards listed in the HIRA for several reasons some of which include:

- The hazard is human-caused or technological and the impacts of the hazard are more appropriately addressed in preparedness or law enforcement plans,
- The hazard probability is so low that an in-depth analysis is not justified or the data to conduct the analysis does not exist, and
- The State of Ohio has decided to focus limited mitigation resources on the hazards that will have the highest probability and greatest documented impact to people and property.

To support the hazards selected for a detailed analysis in the SOHMP, the state has applied multiple risk analysis models that use different methodologies. The results of these analyses can be found in the 2019 SOHMP. All of the risk analysis models used in the SOHMP concurred that flooding, tornado/windstorms, and winter storms are the highest threat hazards in Ohio. In the 2024 SOHMP update, the following hazards are analyzed in detail:

- Flooding (includes riverine and flash flooding)
- Tornado
- Severe Winter Storms (includes snow, ice, and extreme cold)
- Landslide (includes mudslides)
- Dam/Levee Failure
- Wildfire
- Seiche / Coastal Flooding
- Earthquake
- Coastal Erosion
- Drought
- Summer Storms (includes high-winds and hail)

- Invasive Species
- Land Subsidence (includes abandoned mines)
- Extreme Heat (newly added)
- Future Potential Areas of Risk (includes future growth, climate change, hydraulic fracturing, and Harmful Algal Blooms (HAB)

Each hazard identified in this section includes an overview of the hazard and the probability of future hazard events. Each section also addresses, where appropriate, the vulnerability of state assets located in hazard areas and estimates the potential dollar losses to these assets. The methodology for estimating losses to state-owned critical facilities is different based on the characteristics of the hazard and data available to conduct the vulnerability analysis. The methodology used for each hazard is discussed in that section of the plan. Each section also contains an overview and analysis of the vulnerability of jurisdictions to the identified hazards and the potential losses to vulnerable structures based on analysis of data in local hazard mitigation plans.

STATE OF OHIO MITIGATION INFORMATION PORTAL HAZARD RANKINGS

The Mitigation Information Portal (MIP) serves as a repository for previous, current, and future versions of all LHMPs and mitigation projects in Ohio. As local hazard mitigation plans are updated, they are uploaded onto the MIP. There are seven factors for each hazard: Frequency, Response, Onset, Impact (magnitude), Impact on business, Impact on people, and Impact on Property. This allows for an integration of local risks and priorities into SOHMP.

For the 2024 SOHMP update, the risk assessment data from local county hazard mitigation plans were assessed where 79 local hazard mitigation plans were reviewed as part of this analysis. These 79 plans were the plans that were approved, or were the last approved plans of a county, as of June 2023. The remaining 9 county plans are either currently in development, or were not contractually obligated to enter the plan onto the MIP. Table 2.1.a shows the ranking of the SOHMP Hazards based on local priorities. For more information regarding the Local Hazard Mitigation Planning Integration in the MIP, see Section 4.3.

Table 2.1.a

Hazard	Frequency (1.5)	Response (1.5)	Onset (1.25)	Magnitude (1)	Impact on Business (1)	Impact on Humans (1)	Impact on Property (1)	Cumulative Score	Hazard Rank (2024)
Flooding	5.41	4.80	3.18	2.35	2.12	1.97	2.30	22.13	1
Tornado	3.82	4.09	4.52	1.85	2.00	2.32	1.82	20.41	2
Winter Storms	4.65	3.84	2.43	3.17	1.53	1.70	1.83	19.14	3
Severe Summer Storm	4.41	3.54	3.34	2.73	1.33	1.56	1.88	18.78	4
Earthquake	1.99	3.25	4.22	1.79	1.58	1.72	1.57	16.13	5
Dam/Levee Failure	1.77	4.08	2.85	1.76	1.84	1.75	1.87	15.92	6
Drought	2.68	4.31	1.51	2.52	1.55	1.21	1.52	15.30	7
Wildfire	1.41	3.41	4.00	1.40	1.35	1.45	1.30	14.32	8
Mud/Landslide	1.33	3.33	3.79	1.28	1.47	1.31	1.34	13.85	9
Invasive Species	1.35	4.65	1.49	2.19	1.23	1.03	1.77	13.71	10
Land Subsidence	1.18	3.04	3.32	1.23	1.43	1.14	1.37	12.71	11
Coastal Erosion	0.32	2.10	1.25	1.00	1.00	1.00	1.20	7.87	12

The 2024 SOHMP also assessed a new hazard that wasn’t assessed in the 2019 plan: Extreme Heat. Due to this hazard not having enough local planning scores, extreme heat does not yet have a ranking. Coastal flooding is another hazard that does not have a rank, due to most counties that border Lake Erie typically combining their coastal flooding assessments into a general “Flooding” section.

ASSESSING VULNERABILITY OF STATE FACILITIES

44 CFR 201.4 (c) (2) (ii) – The risk assessment shall include "an overview and analysis of the state's vulnerability to the hazards described in this paragraph (c) (2), based on estimates provided in local risk assessments. State-owned or operated critical facilities located in the identified hazard areas shall be addressed." The methodology for this section varies by hazard due to available data and their attributes, and is more thoroughly discussed below.

The State of Ohio Department of Administrative Services (DAS) Risk Management Section currently maintains a listing of state-owned and state-leased facilities. Both the state-owned and state-leased facility datasets are attributed and contain a geo-referenced point for each facility. The data includes facilities ranging from small salt buildings owned by the Department of Transportation (ODOT) to multi-story office buildings owned by DAS. Additionally, the state leases nearly 400 facilities around the state, and a significant percentage of those are critical in nature. Therefore, it was deemed necessary to evaluate all state-owned and state-leased structures, and parse out those that are critical in nature.

A critical facility is defined as any facility whose services are necessary to the response and/or recovery operations following a disaster. Such facilities include (but are not limited to) administration office buildings, transportation facilities, highway patrol posts, armories, radio antenna towers etc. Also, numerous facilities exist at correctional institute complexes that are used for sheltering purposes immediately following a disaster, and such facilities include structures appurtenant and necessary to their function.

The state-owned and state-leased datasets are sufficient for vulnerability assessments, the state-owned dataset included estimated values for building and contents replacements and the state-leased dataset include estimated values for contents replacement. The quality of the dataset has significantly improved since the previous plan iteration, the data is now very robust including all the relevant building data and other specific data sets listed below:

- First floor elevation
- Latitude and longitude
- Flood zone
- Distance to water source
- Historic Status
- Backup Generator
- General insurance exposure information

This data was in part funded by a 7% planning project under DR-4360. This improved data set, along with NRI data allows the state to perform an improved vulnerability assessment for the state owned and leased critical facilities.

An additional dataset was acquired from the National Geospatial-Intelligence Agency in cooperation with FEMA. During DR-4002 recovery efforts, Ohio EMA worked with FEMA to gain access to the Homeland Security Infrastructure Program (HSIP) Gold Dataset 2011. The datasets are the products of collaborative efforts of various stakeholders in the Defense, Intelligence, and Homeland Security Communities. The data provides national critical infrastructure sectors as defined by Homeland Security. Much of the data is populated in major metropolitan areas, but gaps exist between highly populated areas. Additionally, replacement costs are not provided for various facilities, limiting the discussion on vulnerability in terms of dollars. The datasets are used to supplement the data obtained from DAS, especially for non-geographic hazards.

ESTIMATING POTENTIAL LOSSES OF STATE FACILITIES

44 CFR 201.4 (c) (2) (iii) – The risk assessment shall include "an overview and analysis of potential losses to identified structures, based on estimates provided in local risk assessments. The state shall estimate the potential dollar losses to state-owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas."

A summary of the state-owned and state-leased facilities by county and agency is provided in Appendix C. It should be noted that facility specifics (i.e., facility name, location, etc.) are not listed in this plan due to increased security. Further information can be obtained from the Ohio DAS-Risk Management Section.

Tables 2.1.b – 2.1.d lists state-owned and leased critical and non-critical facility numbers and replacement values within each county. Currently, there are a total of 7,401 state-owned and leased facilities (3,768 critical) throughout Ohio worth an estimated $10.7 billion. For Region 1, there are a total of 1711 state-owned and leased facilities and 852 critical facilities worth approximately $1.5 billion and $1.2 billion, respectively. The county with the largest dollar exposure of state-owned and leased facilities is Lucas County with $331 million. Lucas County also has the highest dollar exposure of critical facilities at $274 million.

In Region 2, there are a total of 2,784 state-owned and leased facilities and 1684 critical facilities worth approximately $6.8 billion and $5.7 billion, respectively. As would be expected, Franklin County, which contains the state capital, represents the majority of the dollar value with $3.1 billion in state-owned and leased facilities that include 190 critical in nature, worth approximately $2.3 billion. In Region 3 there are total of 2,935 state-owned facilities and 1232 critical facilities worth approximately $2.3 billion and $1.9 billion, respectively. Ross County has the highest dollar exposure of any county in the region ($534 million and 510 million).

Table 2.1.b – Region 1

COUNTY	# of Facilities	Replacement Cost of All Facilities	# of Critical Facilities	Replacement Cost of Critical Facilities
ALLEN	111	$ 176,595,214	99	$ 148,535,104
AUGLAIZE	101	$ 24,057,189	18	$ 6,542,813
CHAMPAIGN	62	$ 13,683,511	21	$ 9,246,093
CLARK	89	$ 19,907,821	27	$ 9,650,921
CRAWFORD	12	$ 11,520,704	12	$ 11,520,704
DARKE	29	$ 18,041,002	27	$ 17,992,950
DEFIANCE	26	$ 13,611,631	15	$ 12,622,416
ERIE	98	$ 171,945,123	55	$ 150,149,608
FULTON	59	$ 15,120,842	12	$ 9,821,964
HANCOCK	49	$ 22,615,955	20	$ 12,221,847
HARDIN	20	$ 7,121,726	18	$ 6,825,758
HENRY	40	$ 17,950,511	16	$ 4,250,244
HURON	25	$ 11,074,234	22	$ 10,837,347
LOGAN	82	$ 25,047,926	21	$ 9,389,923
LUCAS	134	$ 331,076,997	52	$ 274,497,738
MARION	71	$ 250,819,651	59	$ 237,054,145
MERCER	35	$ 9,839,505	27	$ 9,141,077
MIAMI	49	$ 26,951,521	30	$ 20,994,660

OTTAWA	151	$ 74,137,997	52	$ 42,237,937
PAULDING	11	$ 8,375,637	11	$ 8,375,637
PREBLE	136	$ 54,615,162	28	$ 7,555,862
PUTNAM	19	$ 4,857,269	19	$ 4,857,269
SANDUSKY	26	$ 14,154,795	14	$ 8,633,501
SENECA	50	$ 47,575,038	47	$ 47,263,740
SHELBY	69	$ 35,778,743	35	$ 32,329,713
VAN WERT	30	$ 9,258,457	16	$ 7,772,807
WILLIAMS	22	$ 9,484,348	17	$ 7,837,080
WOOD	58	$ 74,637,716	40	$ 68,292,566
WYANDOT	47	$ 12,022,745	22	$ 6,729,705
REGION 1 TOTAL	**1711**	**$ 1,511,878,970**	**852**	**$ 1,203,181,127**

Table 2.1.c – Region 2

COUNTY	# of Facilities	Replacement Cost of All Facilities	# of Critical Facilities	Replacement Cost of Critical Facilities
ASHLAND	146	$ 103,558,863	145	$ 103,491,091
BUTLER	49	$ 22,772,578	29	$ 17,200,278
CLINTON	95	$ 21,714,415	31	$ 13,450,515
CUYAHOGA	123	$ 405,493,715	106	$ 389,621,908
DELAWARE	117	$ 92,971,857	33	$ 61,002,573
FAIRFIELD	79	$ 96,444,985	67	$ 94,557,543
FAYETTE	25	$ 12,145,010	23	$ 11,052,410
FRANKLIN	408	$ 3,130,227,269	190	$ 2,336,963,045
GEAUGA	92	$ 35,544,708	27	$ 12,064,728
GREENE	55	$ 39,432,526	21	$ 17,560,307
HAMILTON	46	$ 199,948,908	41	$ 113,316,790
KNOX	44	$ 76,788,713	41	$ 76,691,482
LAKE	52	$ 18,824,775	21	$ 12,988,101
LICKING	106	$ 202,938,657	67	$ 186,741,453
LORAIN	118	$ 217,354,441	83	$ 212,390,581
MADISON	134	$ 403,894,872	104	$ 398,511,572
MEDINA	27	$ 17,421,263	17	$ 16,239,797
MONTGOMERY	87	$ 196,246,858	72	$ 187,896,794
MORROW	31	$ 14,222,961	19	$ 12,996,574
PICKAWAY	249	$ 394,514,941	137	$ 346,622,641
PORTAGE	96	$ 34,935,210	25	$ 17,793,583
RICHLAND	121	$ 246,681,238	77	$ 236,998,425
STARK	63	$ 152,870,281	57	$ 148,641,582
SUMMIT	120	$ 213,595,305	65	$ 197,956,468
UNION	60	$ 169,787,946	55	$ 169,438,472
WARREN	209	$ 342,267,387	109	$ 323,719,448
WAYNE	32	$ 16,078,800	22	$ 12,202,802
REGION 2 TOTAL	**2784**	**$ 6,878,678,486**	**1684**	**$ 5,728,110,964**

Table 2.1.d – Region 3

COUNTY	# of Facilities	Replacement Cost of All Facilities	# of Critical Facilities	Replacement Cost of Critical Facilities
ADAMS	39	$ 14,377,906	30	$ 12,672,306
ASHTABULA	233	$ 44,610,508	72	$ 25,195,275
ATHENS	73	$ 60,203,941	35	$ 53,251,615
BELMONT	114	$ 158,196,525	70	$ 153,564,291
BROWN	43	$ 37,980,934	31	$ 35,387,446
CARROLL	19	$ 6,125,581	18	$ 5,220,360
CLERMONT	109	$ 42,632,118	51	$ 32,967,768
COLUMBIANA	88	$ 27,522,238	36	$ 14,981,756
COSHOCTON	34	$ 18,718,378	21	$ 16,813,037
GALLIA	72	$ 51,657,606	61	$ 49,786,218
GUERNSEY	203	$ 142,953,189	50	$ 58,733,741
HARRISON	40	$ 12,130,563	24	$ 9,202,403
HIGHLAND	71	$ 15,015,632	11	$ 6,701,555
HOCKING	178	$ 52,274,554	27	$ 7,590,231
HOLMES	31	$ 9,274,758	29	$ 9,188,433
JACKSON	47	$ 15,550,708	21	$ 10,211,085
JEFFERSON	63	$ 18,695,727	34	$ 14,685,898
LAWRENCE	33	$ 9,873,739	26	$ 9,167,439
MAHONING	83	$ 126,976,227	58	$ 109,678,167
MEIGS	62	$ 11,250,427	24	$ 9,369,001
MONROE	16	$ 4,039,998	12	$ 3,933,796
MORGAN	123	$ 34,433,864	15	$ 7,945,305
MUSKINGUM	133	$ 38,260,781	36	$ 14,169,870
NOBLE	58	$ 73,351,998	32	$ 65,273,141
PERRY	12	$ 7,815,190	9	$ 7,167,121
PIKE	79	$ 19,851,169	12	$ 8,643,712
ROSS	294	$ 534,940,057	129	$ 510,798,521
SCIOTO	140	$ 510,358,597	66	$ 478,434,987
TRUMBULL	118	$ 102,818,055	69	$ 97,032,569
TUSCARAWAS	107	$ 62,140,101	54	$ 50,576,265
VINTON	152	$ 45,000,597	19	$ 14,102,427
WASHINGTON	68	$ 53,428,703	50	$ 36,699,000
REGION 3 TOTAL	**2935**	**$ 2,362,460,369**	**1232**	**$ 1,939,144,738**

2.2 FLOOD

Floods are natural and beneficial functions of stream and lacustrine systems. Floods occur when streams or lakes overflow their banks and spill onto the adjoining land area, which is called a floodplain. Loss of life and property can result when people build structures and develop in flood hazard areas. Numerous factors can cause or exacerbate flooding in Ohio including: heavy and/or prolonged periods of rainfall, snowmelt, soil saturation, ground freeze, severe wind events, and inadequate drainage systems. Floods damage private and public property and infrastructure in Ohio every year. Flooding is the most frequently occurring natural disaster in Ohio and the United States.

The two major drainage basins in Ohio are the Lake Erie and Ohio River basins. Streams in the northern third of the state flow into Lake Erie and eventually into the Atlantic Ocean. Streams in the southern two-thirds of the state flow into the Ohio River and eventually into the Gulf of Mexico.

There are many types of flooding that occur in Ohio including: riverine, flash flooding, coastal flooding, and shallow flooding. Riverine flooding is generally characterized by slower rising water, which allows for increased warning time, but has the potential to last for longer periods of time. Ohio communities experience riverine flooding on both large basins and smaller tributary streams throughout the state. Major sources of riverine flooding in Ohio include the Ohio River, Scioto River, Great Miami River, Muskingum River, Hocking River, Maumee River, Blanchard River, Sandusky River, Cuyahoga River, Grand River, Little Miami River, the Mahoning River and their larger tributaries.

Flash flooding can occur when a severe storm produces large amounts of rainfall in a short time. Flash flooding is generally characterized by high-velocity water that rises and recedes quickly allowing little or no warning time to evacuate. Ohio’s Appalachian Region is particularly vulnerable to flash flooding because of the steep terrain and narrow stream valleys. Ohio’s urban areas also experience flash flooding that may be attributed to inadequate or poorly maintained stormwater infrastructure, increased impervious area, and lost wetland areas. The U.S. Geological Survey (USGS) has concluded that urbanization generally increases the size and frequency of floods and may increase a community’s flood risk.

Coastal flooding generally occurs in the counties that border Lake Erie. Flooding in coastal areas can be caused by stream overflow, wave run-up caused by strong winds, and higher than normal lake levels. Annual fluctuations in Lake Erie water levels are the result of seasonal changes and the amount of water flowing into and out of the lake. In-flow for Lake Erie includes drainage from the upper portion of the Great Lakes basin through the Detroit River, water from streams flowing directly into the lake, groundwater, and precipitation falling directly into the lake. Out-flow includes discharge into Lake Ontario through the Niagara River, evaporation, and any diversion or other withdrawals. Lake Erie levels also exhibit a wide range of long-term fluctuations that are the result of prolonged and persistent deviation from average climatic conditions.

Shallow flooding occurs in flat areas with inadequate channels that prevent water from draining easily. There are four types of shallow flooding: sheet flow, ponding, urban drainage, and rural drainage. Sheet flow flooding occurs in areas where channels are not defined. Sheet flow flooding moves downhill and covers a large area under a relatively uniform depth.

Ponding occurs in flat areas where runoff collects in depressions and cannot drain. Ponding can occur where glaciers carved out depressions in the landscape, and where man-made features such as roads have blocked drainage outlets.

Urban drainage systems can include combinations of ditches, storm sewers, detention ponds, house gutters, and yard swales. When a rainfall event exceeds the design capacity of the drainage system, it can result in the system's back-up and overflowing ditches. Basements are highly susceptible to flood damage caused by overloaded sewer and drainage systems. Urban drainage flooding can also occur behind levees when rainfall amounts exceed the capacity of pumps or other man-made systems designed to drain the landward side of the levees.

Rural drainage flooding in northwest Ohio is similar to urban drainage flooding in Ohio's cities and villages. Most of northwest Ohio was covered by a large swamp prior to European settlement that was subsequently drained for agriculture. The flat topography of this area is drained by an extensive system of ditches, swales, and small meandering streams. Rural drainage flooding occurs when rainfall exceeds the design capacity of the drainage system.

Ohio's river systems offer many benefits that have contributed to the development of the state such as: transportation, waste disposal, energy, commerce, recreation, and water supply. As a result, most major communities include development in flood hazard areas. Wetland areas have been developed, streamside forests have been removed, and streams have been straightened and channelized resulting in faster and increased runoff. After two centuries, these development patterns have drastically changed Ohio's riparian ecosystems, and resulted in escalating flood damages.

Historically, efforts to manage flooding can be divided into three major eras according to the Federal Interagency Floodplain Management Task Force. The Frontier Era (Pre-1917) is characterized by limited federal involvement in flood control or relief. During this time, many federal policies and programs encouraged land development with the common goal being "to conquer the wild landscape and to promote productive use of the land." Flood hazards were the problem of the individual property owner or dealt with cooperatively at the local level.

The Structural Era (1917-1959) is characterized by attempts to modify and control floodwater and move water off the land as quickly as possible. The federal government began assuming the costs to construct dams, levees, reservoirs, and other large structural flood control projects. As this era came to an end, resource managers began to realize that flood control projects were not eliminating flood damage and may be harming the environment.

During the Stewardship Era (1960-present), people began to recognize the important benefits and natural functions provided by floodplain areas such as natural flood and erosion control, water quality maintenance, groundwater recharge, recreation, wildlife habitat, agricultural production, and many others. The responsibility of floodplain management began to shift from the federal government to the local level again. The federal government began to focus on providing financial assistance to reduce and recover from the impacts of flooding. Congress created the National Flood Insurance Program (NFIP) in 1968 as a response to mounting flood losses and increasing disaster relief costs. The intent of the program is to reduce future flood damage through community floodplain management regulations, and provide a federally-subsidized insurance alternative to federal disaster relief.

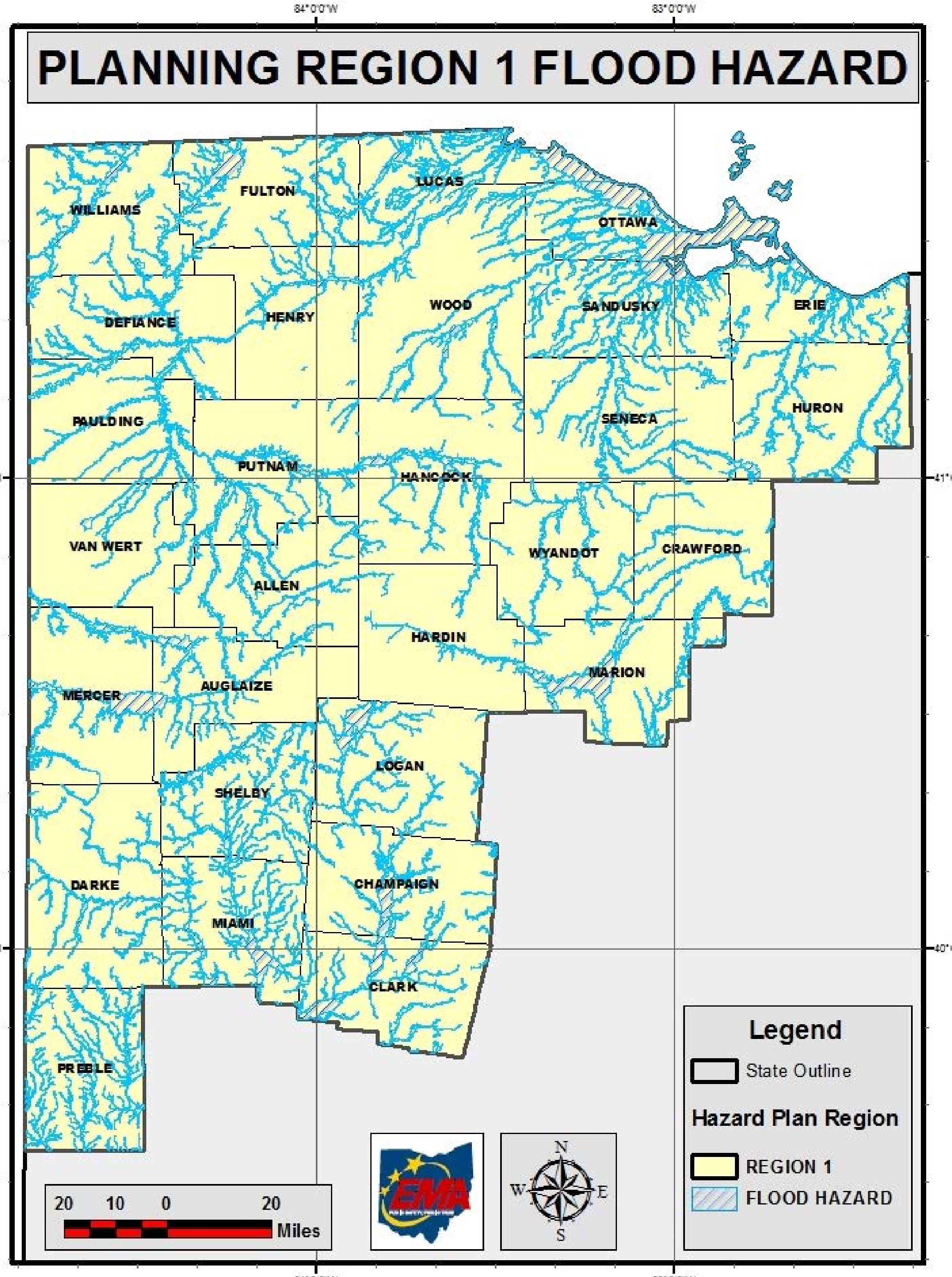
The political jurisdictions in Ohio that are eligible to participate in the NFIP include cities, villages, and unincorporated areas (through the county government). As of the 2020 Census, there are 250 cities, 676 villages, and 88 counties in Ohio. There are 754 Ohio communities that participate in the NFIP. FEMA has identified flood hazard areas in every county in the state. As of January 18, 2023, there were 23,661 flood insurance policies in effect for $4,446,946,000 in coverage statewide. Since 1978, the NFIP has paid 27,756 claims totaling $355,169,727.

LOCATION

The four sources of information used to determine the location of flooding in Ohio are: FEMA flood maps and studies, NOAA data, information provided by the Ohio Department of Natural Resources - Division of Water Resources, and HAZUS analyses. Flood maps generated by FEMA to support the NFIP are the primary source of information on the location of special flood hazard areas (SFHAs) in the state. There are two main types of flood maps: the Flood Hazard Boundary Map (FHBM) and the Flood Insurance Rate Map (FIRM). The FHBM identifies approximate SFHAs based on the best available data at the time the map was created.

Generally, Flood Insurance Studies (FISs) and FIRMs are issued by FEMA following a detailed engineering analysis of flood hazard areas in participating communities. The FIS and FIRM identify 1%-annual-chance flood elevations and boundaries for selected stream reaches in the community. The FIRM will contain flood elevation information for various flood frequencies and may also delineate floodway boundaries. Flooding occurs in every county in Ohio. There are over 60,000 miles of named, unnamed, and intermittent streams in Ohio. FEMA has mapped approximately 2,777 square miles of flood hazard area in the state. Maps 2.2.a -2.2.c display FEMAs identified SFHAs in the State of Ohio for the designated Regions.

Map 2.2.a


PLANNING REGION 1 FLOOD HAZARD
84°0'0"W
83°0'0"W
41°0'0"N
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WILLIAMS
FULTON
LUCAS
OTTAWA
DEFIANCE
HENRY
WOOD
SANDUSKY
ERIE
PAULDING
SENECA
HURON
PUTNAM
HANCOCK
VAN WERT
WYANDOT
CRAWFORD
ALLEN
HARDIN
MARION
MERCER
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CLARK
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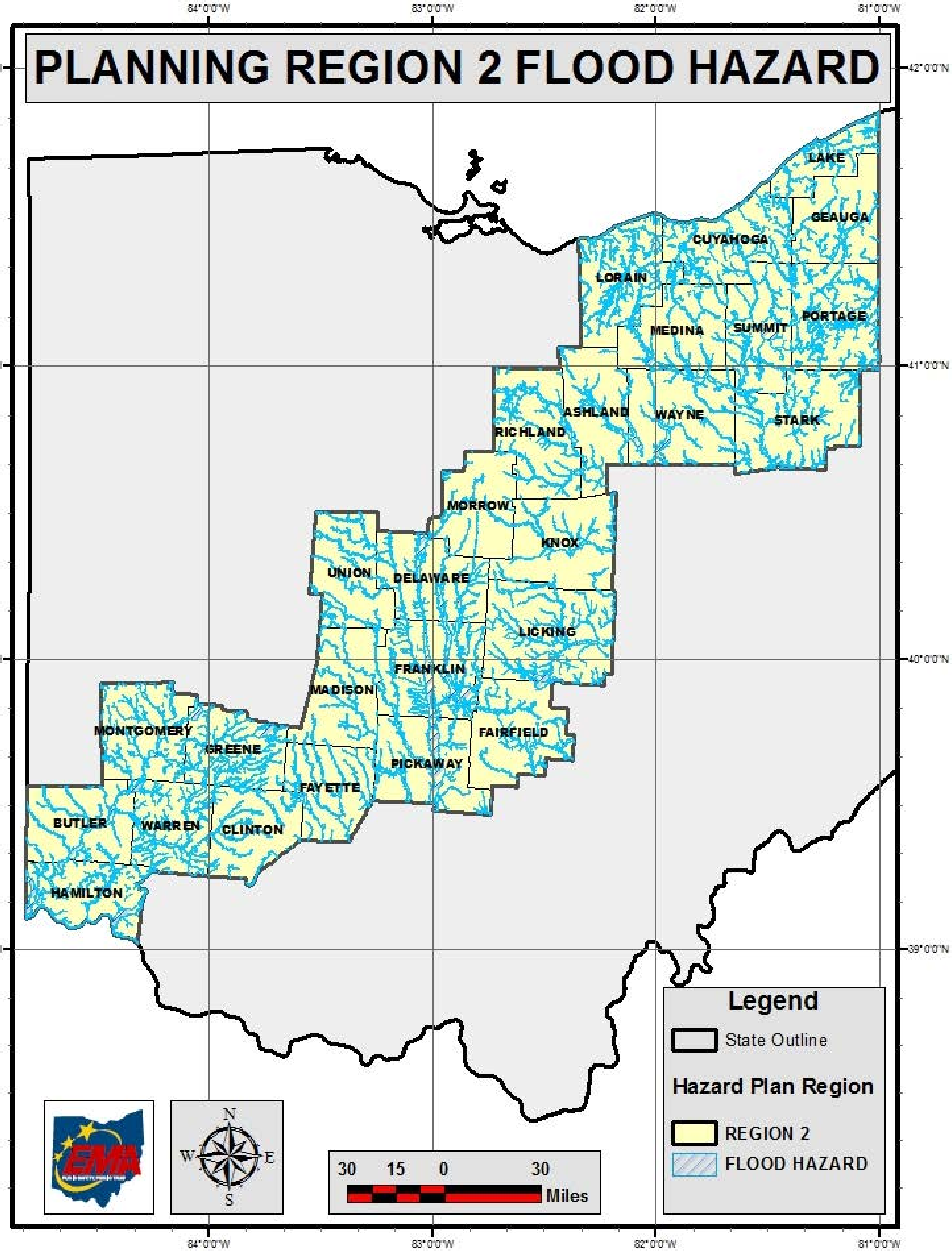
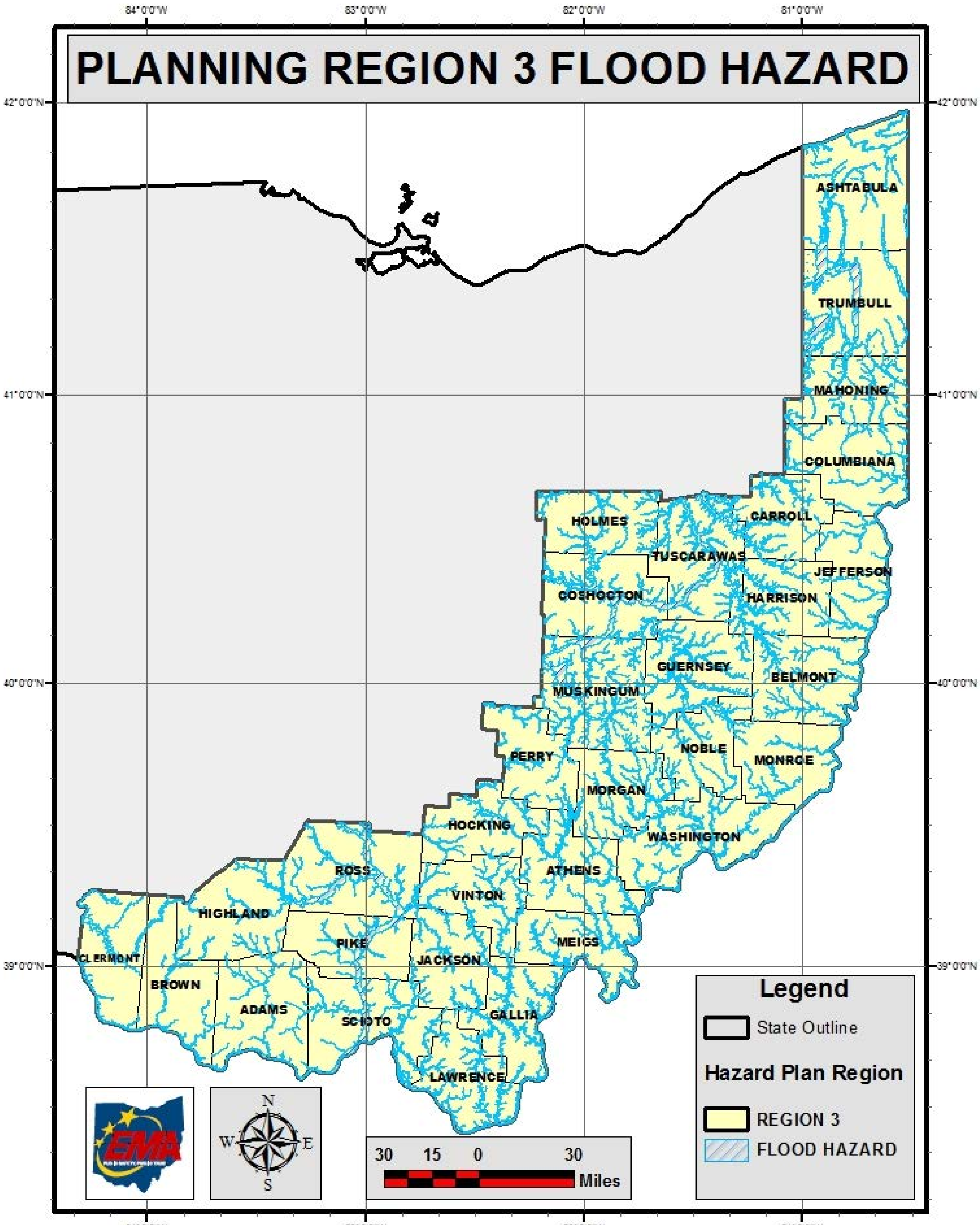
Map 2.2.b


PLANNING REGION 2 FLOOD HAZARD
84°0'0"W
83°0'0"W
82°0'0"W
81°0'0"W
42°0'0"N
41°0'0"N
40°0'0"N
39°0'0"N
LAKE
GEAUGA
CUYAHOGA
LORAIN
MEDINA
SUMMIT
PORTAGE
ASHLAND
WAYNE
STARK
RICHLAND
MORROW
KNOX
UNION
DELAWARE
LICKING
FRANKLIN
MADISON
MONTGOMERY
GREENE
FAIRFIELD
PICKAWAY
FAYETTE
BUTLER
WARREN
CLINTON
HAMILTON
Legend
State Outline
Hazard Plan Region
REGION 2
FLOOD HAZARD
30 15 0 30
Miles
N
S
E
W

Map 2.2.c


PLANNING REGION 3 FLOOD HAZARD
84°0'0"W
83°0'0"W
82°0'0"W
81°0'0"W
42°0'0"N
41°0'0"N
40°0'0"N
39°0'0"N
ASHTABULA
TRUMBULL
MAHONING
COLUMBIANA
HOLMES
CARROLL
TUSCARAWAS
JEFFERSON
COSHOCTON
HARRISON
GUERNSEY
BELMONT
MUSKINGUM
NOBLE
PERRY
MONROE
MORGAN
HOCKING
WASHINGTON
ROSS
ATHENS
VINTON
HIGHLAND
PIKE
MEIGS
CLERMONT
JACKSON
BROWN
ADAMS
SCIOTO
GALLIA
LAWRENCE
Legend
State Outline
Hazard Plan Region
REGION 3
FLOOD HAZARD
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The NOAA's National Climate Data Center (NCDC) Storm Events Database contains information on the location of flood events in Ohio. The database can be searched by county and includes a written description of the location of flood events reported in the state. The database also contains latitude and longitude values for some events and contains information on reported deaths, injuries, and estimated property and crop damage. The database can be found on the NCDC website.

The Ohio Department of Natural Resources, Division of Water Resources is mandated to be a state repository for flood hazard information (Ohio Revised Code Section 1521.13(C)(2)). The Floodplain Management Program maintains copies of flood hazard data generated by various federal, state, local, and private entities.

PAST OCCURRENCES

Profiling past occurrences of flooding at the state level involves gathering and compiling data from many different sources. The data sources used to profile the past occurrences of flooding include FEMA, the ODNR, the Ohio EMA, the NOAA, and the book Thunder in the Heartland by Thomas W. and Jeanne Applehans-Schmidlin, 1996. Table 2.2.a displays a summary of historic flooding information from 1860 to 1990 based on the chronicle Thunder in the Heartland: A Chronicle of Outstanding Weather Events in Ohio. More specific information on these events as well as events post 1990 can be found in the narrative of this section.

Table 2.2.a

Summary of Historic Flood Events 1860-1990			
Date of Event	**Affected Area(s)**	**Water Bodies Affected**	**Event Description**
8/12/1861	Columbiana County, Elkton, Lisbon	Beaver Creek, Elk Run	Every home in Elkton was damaged and four persons drowned when one home was washed off its foundation.
2/17/1867	Toledo, Maumee	N/A	Ice jams destroyed one bridge and damaged several others. Flooding in downtown Toledo.
2/11/1881	Toledo, Grand Rapids, Columbus, Findlay	Maumee River, Scioto River, Blanchard River	Four bridges were damaged by ice jams and debris in Toledo. Flooding in downtown Toledo.
2/1883	Statewide	Auglaize, Blanchard, Maumee, Portage, and Sandusky Rivers	A combination of snowmelt, ice jams, frozen ground and heavy rains caused flooding statewide.
2/14/1884	Statewide	Ohio, Hocking, Maumee, and Muskingum Rivers	Second highest stage on the Ohio River in Cincinnati. Thousands were evacuated and 3000 buildings were submerged.
5/12/1886	Xenia	Shawnee Creek	Flash flooding washed away several homes killing 21 people and destroying one bridge.
1/23/1904	Lorain, Toledo, Waverly	Black, Scioto, Mahoning and Maumee Rivers	Ships, bridges, and structures were damaged by ice jams and flooding.
3/14-18/1907	Ohio River Watershed	Southern 2/3 of Ohio	Large scale flooding in the Ohio River Watershed resulted in 32 casualties, hundreds of flooded structures, utility and infrastructure damage.
3/23-27/1913	Statewide	Statewide	Described as "Ohio's Greatest Weather Disaster". Four days of heavy rain on saturated soils resulted in 467 casualties, over 2,200 homes destroyed, over 40,000 damaged, and over $2.5 Billion damage in 2003 dollars.
7/16/1914	Cambridge	Wills Creek Watershed	Over 7.09 inches of rain in 1.5 hours causing flash flooding.
8/16/1920	Toledo	Maumee River	Flash flooding in downtown Toledo damaged homes, businesses and infrastructure.
2/26/1929	Cleveland, Dayton, Mt. Vernon, Bridgeport, Springfield	Little Miami, Maumee, Miami, Rocky, Mad, and Kokosing Rivers, Wheeling and Buck Creeks	Two to three inches of rain, melting snow, and ice jams caused widespread flooding.
3/21/1933	Cincinnati and Southern Ohio	Ohio River	Two periods of heavy rain cause widespread minor flooding.
8/7/1935	Coshocton and surrounding counties	Tuscarawas Watershed	Heavy rain on saturated soils saturated soils caused flash flooding.
3/19/1936	Ohio River Communities from Pittsburgh to Steubenville	Upper Ohio River	Snowmelt and heavy rains in Penn. and W. Virginia caused the Ohio River to rise 20 feet in two days.

Table 2.2.a (Continued)

Summary of Historic Flood Events 1860-1990			
Date of Event	**Affected Area(s)**	**Water Bodies Affected**	**Event Description**
1/26/1937	All Ohio River Communities	Ohio River	Described as the "Greatest Flood on the Ohio River". Record levels on the Ohio River from Gallipolis to the confluence with the Mississippi.
7/7/1943	Akron and Steubenville	Cuyahoga River, Cross and Wills Creeks	Six to seven inches of rain in several hours caused flash flooding and landslides.
6/16/1946	Wayne and Holmes Counties	Killbuck and Salt Creeks	Heavy rain caused flash flooding resulting in one death, a train wreck destroying 5 bridges and seriously damaging 55 others.
6/8/1947	Adams, Lawrence and Scioto Counties	South Fork of Scioto Brush Creek and other small tributaries to the south emptying into the Ohio River	Flash flooding damaged many homes, bridges, roads, and crops.
3/21/1948	Counties in the Lake Erie Watershed	Lake Erie Watershed	The most severe damage was reported in along the Chagrin River in Cleveland. Twenty buildings were destroyed and 153 were damaged.
6/16/1950	Crooksville, Roseville	Moxahala Creek Watershed	One of the most intense rainfalls ever known in Ohio caused severe flood damages to homes and businesses.
1/21/1959	Statewide	Statewide	Rainfall in January 1959 ranging from 3-6 inches on snow-covered, frozen ground caused the most severe statewide flooding since 1913. Streams reached flood stage from January 21-24 killing 16 people, forcing 49,000 people from their homes, and causing extensive damage to homes, businesses and infrastructure.
6/5/1963	Guernsey County	Wills Creek Watershed	Official records indicate 7.95 inches of rainfall in 16- hours in Cambridge. One railroad bridge was destroyed, all major highways were inundated, and water supplies were polluted.
3/10/1964	Southern and Central Ohio	All Streams in Southern and Central Ohio	Two periods of heavy rain cause widespread flooding resulting in eight deaths, thousands evacuated, 84 homes destroyed, and 8,200 damaged.
7/21/1964	Akron	Ohio Canal and Little Cuyahoga River	Official records indicate 3.05 inches of rain in 75 minutes, but rain distribution was variable. The resulting flooding caused a sewer line to collapse a large section of road killing 3 people.
4/27/1966	Communities Along Lake Erie's Western Basin	Lake Erie's Western Basin	Several hours of winds up to 55 mph from the northeast pushed the western end of Lake Erie to flood stage. Fifteen hundred were evacuated, hundreds of homes were damaged, and utility services were interrupted.
7/12/1966	Erie, Ottawa, and Huron Counties	Sandusky and Huron River Watersheds	Rainfall totals ranging from 9-12 inches of rainfall over and approximately one-day period. Total damages exceed $27 million in 2003 dollars, including damages to 12,000 homes and businesses in Sandusky.
5/23-27/1968	Central and Southern Ohio	Hocking, Scioto, Little Miami	Two periods of heavy rain within 5 days on already saturated soils caused flooding on many streams. Four deaths have been attributed to this event.
7/4/1969	Northern Ohio	Lake Erie Watershed	Severe thunderstorms moved from Lake Erie into Ohio’s coastal communities on July 4, 1969. Flooding combined with strong wind and tornadoes caused 41 deaths and injured 559 people. Loss estimates for this event totaled $65 million dollars in 1969, or over $328 billion in 2003 dollars.
11/14/1972	Coastal communities from Toledo to Cedar Point	Lake Erie	Northeast wind setup caused Lake Erie to rise 3 feet at Toledo and fall 4 feet at Buffalo resulting in coastal flooding. Total damages were estimated at $22 million in 1972 dollars.
4/9/1973	Coastal communities from Toledo to Port Clinton	Lake Erie	Northeast winds caused 8 to 10 foot waves and flooding.
9/14/1979	Southeastern half of the state	N/A	The remains of Hurricane Frederic brought six inches of rain in a band from Cincinnati to Youngstown causing widespread flooding.
3/12/1982	Communities in the Maumee River Watershed	Maumee River Watershed	Two inches of rainfall on snow covered, frozen ground caused flooding. Loss estimates totaled $11 million in 1982 dollars with Defiance County being the hardest hit.
6/14/1990	Shadyside in Belmont County	Pipe Creek and Wegee Creek	Twenty-six people died in a flash flood near Shadyside. Approximately 80 homes were destroyed and 250 were damaged. An estimated that 3-4 inches of rain fell in a little over an hour.
12/31/1990	Widespread	Widespread	The wettest year on record ended with extensive flooding on New Year's Eve causing $50 million (1990 dollars) in damages.

Historically, significant floods in Ohio occurred in 1913, 1937, 1959, and 1969. Heavy rain on saturated soils caused flooding throughout Ohio during March 23rd to 27th, 1913, killing 467 people, destroying 2,200 homes, and flooding 40,637 residences. Losses were totaled at $113 million in 1913 (approximately $3.5 billion in 2023 dollars), including: $78 million to buildings and personal property, $12 million to roads and bridges, $12 million to railroad property, which includes lost profit, $6 million to the agricultural industry, and $4 million dollars to machinery. This flood set record water levels on many Ohio streams. The Miami River Watershed experienced the highest casualties and damages during this event.

The flood of record for the Ohio River occurred the last two weeks in January 1937. Normal January precipitation in Ohio is 2-3 inches. The statewide average rainfall in January 1937 was 9.57 inches, with some stations recording over 14 inches. Ohio River levels on January 26th and 27th were the highest ever recorded from Gallipolis, Ohio to the confluence with the Mississippi River. Every Ohio community along the river was flooded resulting in 10 casualties, 16 injuries, thousands of damaged structures, and over 54,000 evacuations statewide.

Rainfall in January 1959, ranging from 3-6 inches on snow-covered, frozen ground, caused the most severe statewide flooding since 1913. Streams reached flood stage from January 21-24, killing 16 people, forcing 49,000 people from their homes, and causing extensive damage to homes, businesses, and infrastructure. Loss estimates for this event totaled $100 million in 1959, or over $1.04 billion in 2023 dollars. Some of the factors that reduced casualties and damages from the 1913 flood include: less intense rainfall amounts, the construction of flood-control reservoirs built after 1913, and improved emergency management procedures and capabilities.

Severe thunderstorms moved from Lake Erie into Ohio’s coastal communities on July 4th, 1969. This line of storms became nearly stationary for more than eight hours, aligned from Toledo southeast to Wooster. Official records indicate over 10 inches of precipitation lasting over a two-day period. Flooding combined with strong winds and tornadoes caused 41 deaths and injured 559 people. Loss estimates for this event totaled $65 million dollars in 1969, or over $539 million in 2023 dollars. This flood caused extensive damage to homes, businesses, infrastructure, utilities, boats, and automobiles.

Twenty-six people died in a flash flood near Shadyside, Ohio on June 14th, 1990. The National Weather Service estimated that 3-4 inches of rain fell in a little over an hour near Pipe Creek and Wegee Creek. Total rainfall is estimated at 5.5 inches in three hours. The saturated soils and narrow, steep-sided valleys caused the water to drain quickly into the creeks. Flash flooding began at 9:30 PM and was over in 30 minutes. During that time, a wall of water six feet high (reported to be 20 feet in some areas) rushed through the valley at seven to ten miles-per-hour. Approximately 80 homes were destroyed and 250 were damaged.

Storms that produced heavy rains during March 1st and 2nd, 1997, resulted in severe flooding in southern Ohio. The largest accumulations of rainfall were recorded in southern Adams and Brown Counties and ranged from 10-12 inches over the two-day period. Generally, rainfall amounts of four or more inches fell on most of the counties along or near the southern border of Ohio. Widespread damages to private and public property occurred throughout the area. Preliminary loss estimates totaled nearly $180 million in 1997, or over $341 million in 2023 dollars. Approximately 20,000 people were evacuated and 6,500 residences and 833 businesses were affected. Five deaths were attributed to flooding; all of the fatalities were the result of attempts to drive through flooded roads.

Storms during June 26th through 30th, 1998, resulted in flooding and widespread damage throughout much of central, east-central and southeastern Ohio. More than 10 inches of rain fell during a four-day period in parts of southeast Ohio. Twelve storm or flood-related fatalities were reported and infrastructure and utilities were heavily impacted. Loss estimates totaled nearly $178 million in 1998, or over $446 million in 2023 dollars.

PRESIDENTIAL DISASTER DECLARATION DATA

Flood vulnerability can also be expressed as historic expenditures on disaster recovery for flood events. Total expenditures for programs triggered by a Presidential Disaster Declarations are tracked and summarized by Ohio EMA (Appendix A). Between the 2005 and 2024 plan updates, eight flood events resulted in Presidential disaster declarations.

DR-1651-OH declared July 2, 2006: Severe thunderstorms and tornado touchdowns caused two deaths and widespread damage in northern Ohio from June 21st and 23rd, 2006. The primary causes of damage in this event were flash flooding, which overwhelmed urban stormwater infrastructure, and riverine flooding. Huron County and the City of Brecksville were especially impacted. The communities of Toledo, Norwalk, Valley View, and Independence also experienced significant flooding. The USGS estimated flood recurrence intervals for gaged streams based on flood stage for this event. The flooding on the Vermilion River was estimated to be a 50-year event. The flooding on the Cuyahoga River and Tinkers Creek were estimated to be 25 to 50-year events.

DR-1656-OH declared August 1, 2006: Two separate weather systems produced storms resulting in more than 11 inches of rain in parts of Lake County, Ohio on July 27th and 28th, 2006. As a result of the storms and ensuing flooding, the counties of Lake, Geauga, and Ashtabula were declared Federal Disaster Areas. The flooding caused one fatality and 600 evacuations in Lake County. Over all of Lake County, 100 homes and businesses were destroyed and an additional 731 homes and businesses were damaged. Flooding destroyed five bridges in Lake County and closed 13 roads. The City of Painesville experienced heavy damages. The USGS streamflow-gaging station at the Grand River near Painesville, Ohio had record peak stream flow and peak stage. The recurrence interval for this event was estimated to be 500 years (Ebner, A.D.; Sherwood, J.M.; Astifan, Brian; and Lombardy, Kirk, 2007, Flood of July 27-31, 2006, on the Grand River near Painesville, Ohio: U.S. Geological Survey Open-File Report 2007-1164).

DR-1720-OH declared August 26, 2007: Heavy rainfall inundated multiple communities across northern Ohio during a two-day period. The rain developed along a nearly stationary frontal boundary that was oriented from west to east across north central Ohio. Moisture from the Gulf of Mexico, as well as the remnants of Tropical Depression Erin, was drawn northward resulting in tropical downpours. The heaviest rains redeveloped each night, starting Sunday night August 19th, 2007, into Monday morning and then again on Monday night into the early morning hours of Tuesday, August 21st, 2007.
Stream gage reports from four locations in the affected area indicated that 24-hour rainfall totals ending at 8 AM on August 21st, 2007, exceeded the 1,000 year/24-hour rainfall frequency. Peak flood stage of the Blanchard River in the City of Findlay was 0.04 less than the flood of record in 1913 (National Weather Service Forecast Office in Cleveland, Ohio). Communities in the Blanchard, Sandusky, and Mohican River watersheds were heavily impacted. There were approximately 2,500 flooded structures in the City of Findlay. The communities of Ottawa, Bucyrus, Shelby, Lima, Carey, and Bluffton also had many flooded structures.

DR-4002-OH declared July 13, 2011: Heavy rains and thunderstorms moved through the state on February 27th, 2011, as 3-4 inches of rain accumulated over a 24-hour period in already saturated areas across northern Ohio. This system exited the state and a second wave of precipitation moved through Southern Ohio. Warm temperatures, heavy snow pack, and snow melt resulted in moderate to major flooding in many areas of the state. The State monitored river crests and falling temperatures over a 48-hour period for impacts, including potential issues with debris, wastewater, sewage, and shelters. Major to moderate flood river levels were recorded in Northern Ohio. The Cuyahoga River reached near-record flood levels.

In March and April, much of Ohio continued to experience heavy rain, severe storms, flooding, and flash flooding across the southern portion of the state. The cumulative effect of these conditions, coupled with flooding in neighboring states along the Ohio and Mississippi Rivers, resulted in dangerous conditions and damages which affected the health, safety, and welfare in 21 southern Ohio counties. More severe storms moved across the south-central part of the state in May, producing heavy rain and high winds. These conditions further intensified the previously affected citizens in Gallia, Jackson, Lawrence, Pike, Ross, Scioto, and Vinton Counties. During this time, the Governor had issued two proclamations and requested a Presidentially-declared disaster for 13 counties along the Ohio River and 8 adjacent counties.

DR-4098-OH declared January 3, 2013: Hurricane Sandy brought heavy rainfall and significant flooding to northern portions of Ohio on October 29th and 30th, 2012. The flooding was the result of three consecutive weather events; a cold front, hurricane Sandy remnants, and lake enhanced showers. Rain started on October 26th as a slow-moving cold front moved into the Ohio Valley. This front brought widespread 0.75 to 2.0 inches of rainfall to northern Ohio, highest near the lake. By Monday, the remnants of Hurricane Sandy moved into Pennsylvania, and the pressure gradient between it and high pressure over Missouri produced storm force winds over Lake Erie. Moisture from Sandy moved into the region producing an additional rainfall of 2 to 3 inches by Tuesday the 30th. Rain continued at a rate averaging 0.10 inches per hour for the day, but increased to 0.75 inches per hour overnight and early Wednesday morning. This band of heavier rain caused the rivers which were receding to once again rise. Areal flooding was limited to more northern counties; however, some small streams and creeks came out of their banks as far south as Ashland County. Numerous roads were closed due to flooding in Cuyahoga, Lake, and Medina Counties. In Ashtabula County, docks were damaged at the Port of Ashtabula due to severe wind and violent wave actions on Lake Erie, and marinas had to be dredged at the Port Authority of Conneaut. A flood watch was in effect for the lakefront counties and flood advisories were issued during the event.

A few dozen homes and businesses were impacted as water inundated basements or first floors. A number of homes affected were located in the floodplain of the rivers or along the shoreline where the raised lake level combined with the increased stream flows to produce flooding in areas not typically affected. Two rivers along the lakeshore reached major flood stage (based on NWS stage categories), the Cuyahoga and the Huron Rivers. The rest of the Lake Erie tributaries saw minor or moderate flooding. Many basements flooded further inland as sump pumps failed due to power outages. As the result of Hurricane Sandy, an estimated $17.8 Million in public assistance funds has been awarded to this point.

DR-4360-OH declared April 17, 2018: Beginning on February 14, 2018, and continuing through February 25, 2018, a persistent band of moderate to severe storms moved across Region V impacting Illinois, Indiana, Michigan, Ohio, and Wisconsin. While precipitation levels and storm-related damages varied, Ohio experienced a significant amount of flooding and subsequent damage along the southern portion of the state. The snowmelt and continued rain throughout the incident period, combined with the frozen soils, led to flooding along area streams, rivers, and low-lying areas. Numerous flood gauges in this area rose to moderate flood stage, and rainfall totals in the impacted areas during the incident period ranged from a total of five to nine inches. Following these storms, there were several road closures as well as reports of inaccessible areas throughout southern Ohio due to standing water. Widespread flooding culminated February 26, 2018, when the Ohio River at Cincinnati rain gauge showed a crest of 60.53 feet, 8 feet above flood stage and the highest crest since 1997. Communities near the river and its tributaries incurred damages to roads, bridges, and public buildings, as well as basement flooding and sewage backup. According to the Governor, preventative steps on the part of state and local agencies, such as Ohio EMA, shielded the area from the worst possible damage. The SEOC was partially activated with Emergency Support Functions (ESFs). A FEMA Region V Liaison Officer was deployed to the SEOC from February 25, 2018, through February 27, 2018, and the SEOC returned to normal operations on February 27, 2018.

There were several local evacuations due to flooding and the American Red Cross opened three shelters in the impacted areas. There was one confirmed fatality (Shelby County) as a result of this event, and at its peak, there were 10,449 customers without power statewide. On March 6, the Governor requested a joint preliminary damage assessment (PDA) conducted by local, state, and federal emergency management officials. The joint PDA resulted in documentation of approximately $44 million worth of damages to county, village and township roads, bridges, and public buildings. On March 26, the Governor requested a Presidential Disaster Declaration. On April 17, 2018, a disaster was declared for the State of Ohio, due to severe storms, flooding, and landslides that occurred during the incident period of February 14, 2018, through February 25, 2018. As a result of that declaration, Public Assistance has been made available for Adams, Athens, Belmont, Brown, Columbiana, Gallia, Hamilton, Jackson, Lawrence, Meigs, Monroe, Muskingum, Noble, Perry, Pike, Scioto, Vinton, and Washington Counties. The Disaster impact data is fluid as only half of the Public Assistance projects have been awarded as of January 2019.

DR-4424-OH declared April 8, 2019: Beginning February 5 and lasting through February 13, severe storms and excessive rainfall created dangerous and damaging conditions affecting the health, safety and welfare of the citizens of Ohio. Ohio Governor Mike DeWine declared a state of emergency on March 11, 2019 for 20 Ohio counties including: Adams, Athens, Brown, Gallia, Guernsey, Hocking, Jackson, Jefferson, Lawrence, Meigs, Monroe, Morgan, Muskingum, Noble, Perry, Pike, Ross, Scioto, Vinton and Washington. The counties suffered from significant infrastructure damage as heavy rains poured down on already-saturated soils, damaging public infrastructure like roads and culverts. On April 8, 2019, A Presidential Disaster Declaration was made that ordered Federal assistance to supplement State and local recovery efforts in the areas affected by severe storms, flooding, and landslides. Joint preliminary damage assessments conducted by local, state, and federal emergency management officials during the second week of March documented damages to critical infrastructure, such as county roads, bridges, culverts, and public buildings totaling $41.4 million.

DR-4447-OH declared June 18, 2019: Following the Memorial Day tornadoes that touched down in parts of western Ohio and brought rain and flooding impact across the state, the federal government declared a federal major disaster on June 18, 2019. Officially, this is the Ohio Severe Storms, Straight-line Winds, Tornadoes, Flooding, Landslides, and Mudslide (DR-4447). The federal disaster area includes households and business owners in Auglaize, Darke, Greene, Hocking, Mercer, Miami, Montgomery, Muskingum, Perry, and Pickaway counties. This list later included Mahoning and Columbiana counties in the eastern part of the state. In the June 27 request to the FEMA, Ohio Emergency Management Agency Executive Director Sima Merick included a preliminary damage assessment of about $18.1 million in eligible costs, of which two-thirds, or about $12 million, was debris removal.

NOAA DATA SUMMARY

Table 2.2.b lists the number of reported floods in Ohio since the year 1996, and associated loss totals according to the NOAA's NCDC Storm Events Database. The information in this database comes from NWS, who receives their data from a variety of sources including: county, state, and federal emergency management officials, local law enforcement officials, weather spotters, NWS damage surveys, newspaper clipping service, and the insurance industry and the public. An effort is made to use the best available information, but because of time and resource constraints, information from these sources may be unverified by the NWS.

Table 2.2.b

Ohio Flood Data Summary from the National Climatic Data Center [1]					
Year	Number of Reported Flood Events [2]	Deaths [3]	Injuries [4]	Recorded Property Damage [5]	Recorded Crop Damage [5]
1996	71	3	None Reported	$43,412,850	$863,850
1997	51	5	5	$125,449,400	$1,862,000
1998	50	9	None Reported	$204,678,980	$134,593,250
1999	30	2	1	$1,644,040	None Reported
2000	45	4	2	$16,113,580	None Reported
2001	35	3	1	$21,850,880	None Reported
2002	38	1	None Reported	$3,848,800	None Reported
2003	64	4	None Reported	$526,955,380	$4,399,000
2004	44	2	None Reported	$205,637,540	$1,450,700
2005	41	3	None Reported	$96,869,800	None Reported
2006	34	4	1	$835,633,376	$57,532,000
2007	23	None Reported	None Reported	$374,280,550	$24,587,980
2008	26	2	None Reported	$7,883,590	$64,350
2009	20	1	None Reported	$6,467,890	$75,790
2010	23	5	4	$18,827,550	$1,390
2011	51	3	None Reported	$61,623,285	$239,750
2012	22	1	2	$1,875,300	None Reported
2013	36	2	None Reported	$55,264,970	$131,000
2014	31	None Reported	None Reported	$90,021,360	$98,040
2015	37	5	3	$34,532,010	$354,750
2016	26	None Reported	None Reported	$5,887,720	None Reported
2017	39	None Reported	None Reported	$23,264,880	$1,860,000
2018	70	2	None Reported	$7,014,390	$1,220
2019	62	3	2	$106,447,020	$182,400
2020	45	4	None Reported	$22,293,765	$2,340
2021	36	None Reported	None Reported	$2,940,550	None Reported
2022	36	None Reported	None Reported	$8,736,604	None Reported
Total:	1086	68	21	$2,909,456,060	$228,299,810

1 - Figures include Flood and Flash Flooding events as recorded on the NOAA Storm Events Database.
2 - Figures of Flood and Flash Flood events were calculated as days with events.
3 - Figures include both direct and indirect deaths.
4 - Figures include both direct and indirect injuries.
5 - Damage figures were converted to 2023 U.S. Dollars from the amount recorded of year.

PROBABILITY OF FUTURE EVENTS

The probability of occurrence of flooding is the likelihood that a specific event will happen. The likelihood of a flood event happening is usually expressed in terms of frequency. The NFIP provides maps and studies that use the 1 percent annual chance floodplain area (area inundated during a 100-year flood) as the national standard for regulating floodplain development. It is critical to establish the probability of occurrence for flooding so that the state and local communities can make informed decisions about the sustainability of future development, and determine the feasibility of proposed mitigation projects.

The primary sources of data for determining the probability of occurrence of flooding are the FEMA FISs and FIRMs. Nearly every community that participates in the NFIP has a map that identifies at least some area of flood hazard in the community that has a 1 percent annual chance of being equaled or exceeded in any given year. This area is referred to as the 1%-annual-chance floodplain, or the 100-year floodplain, and is graphically represented on a FIRM or FHBM.

Communities that do not have FISs, usually have an FHBM or FIRM that shows the approximate area that would be inundated by the 1%-annual-chance flood. An FHBM was intended for interim use in most communities, until a FIS could be completed. FHBMs are still being used in some Ohio communities where a detailed FIS has yet to be produced.

Approximately 81 percent of Ohio communities that participate in the NFIP have a portion of their flood hazard areas identified in a FIS. The purpose of a FIS is to investigate the existence and severity of flood hazards in a certain geographic area. The information in a FIS is used to establish actuarial flood insurance rates and assist the community in its efforts to regulate flood hazard areas. A FIS contains data on: historical flood events, the area and flood sources studied, and the engineering methods employed to generate the flood hazard data. A FIS will have flood elevation profiles for the 100-year recurrence probability flood, and usually the 10-, 50-, and/or 500-year floods. It may also contain tables summarizing floodway data and other flood hazard information; however, it does not usually contain data for every flood hazard area in a community. The remaining areas may have approximate flood hazard data, or none at all.

There are several other possible data sources for determining the area affected by a particular probability flood event. The Ohio Department of Natural Resources, Division of Water Resources, is the state repository for flood hazard information and has copies of flood hazard information generated by various federal, state, local and private entities. The Floodplain Management Program maintains current copies of all FEMA FIS and flood maps in the state.

Probability by County								
Region 1			Region 2			Region 3		
County	Days with Event	Annual Probability	County	Days with Event	Annual Probability	County	Days with Event	Annual Probability
Allen	13	49%	Ashland	43	161%	Adams	82	304%
Auglaize	52	193%	Butler	71	263%	Ashtabula	41	152%
Champaign	39	146%	Clinton	47	176%	Athens	85	315%
Clark	57	214%	Cuyahoga	73	273%	Belmont	94	349%
Crawford	30	112%	Delaware	48	178%	Brown	67	248%
Darke	57	223%	Fairfield	54	203%	Carroll	49	182%
Defiance	14	55%	Fayette	33	129%	Clermont	97	360%
Erie	48	179%	Franklin	95	352%	Columbiana	53	197%
Fulton	11	41%	Geauga	27	101%	Coshocton	81	300%
Hancock	39	146%	Greene	59	221%	Gallia	81	300%
Hardin	38	154%	Hamilton	141	523%	Guernsey	58	215%
Henry	14	54%	Knox	26	97%	Harrison	38	141%
Huron	29	109%	Lake	37	137%	Highland	49	182%
Logan	58	227%	Licking	71	277%	Hocking	68	256%
Lucas	40	150%	Lorain	60	225%	Holmes	36	135%
Marion	56	208%	Madison	27	105%	Jackson	44	163%
Mercer	62	230%	Medina	43	161%	Jefferson	39	145%
Miami	44	165%	Montgomery	67	248%	Lawrence	76	282%
Ottawa	18	67%	Morrow	22	82%	Mahoning	32	119%
Paulding	16	60%	Pickaway	53	196%	Meigs	85	315%
Preble	45	169%	Portage	28	105%	Monroe	52	193%
Putnam	17	66%	Richland	45	168%	Morgan	36	139%
Sandusky	32	119%	Stark	61	229%	Muskingum	55	204%
Seneca	27	101%	Summit	39	146%	Noble	60	222%
Shelby	53	214%	Union	41	154%	Perry	45	169%
Van Wert	17	63%	Warren	85	318%	Pike	59	219%
Williams	6	23%	Wayne	26	97%	Ross	66	245%
Wood	33	124%				Scioto	97	360%
Wyandot	29	109%				Trumbull	60	224%
						Tuscarawas	65	241%
						Vinton	66	245%
						Washington	106	393%

LHMP DATA

As stated at the beginning of Section 2, integration of LHMP data into the state HIRA is an ongoing effort. As local plans continue to expire and jurisdictions update their plans, vulnerability information and loss estimation are collected and assembled. Highlighted below is some of the more notable jurisdictional plan information that has been assembled and integrated into the state flood risk analysis.

Cuyahoga County - The 2022 Cuyahoga County Hazard Mitigation Plan utilized two methodologies to estimate potential losses to flooding. In the first approach, they estimated the number of structures within the Special Flood Hazard Area. In which, it was estimated that there were 647 structures within the SFHA, and 9 critical facilities. Of which, the village of Valley View had the most with 161 structures, and the City of North Olmstead had the second most with 145 structures. The second methodology utilized HAZUS-MH to estimate that their flood vulnerabilities. In a 100-year flood assessment, they estimated that there are $33,789,380,000 in building exposure to a potential 100-year flood event. There were 977 essential facilities (fire stations, hospitals, police stations, and schools) at risk with three schools and one fire station expected to be damaged in the scenario event. The scenario also estimated that there would be $302 million in building losses, $490 million in content losses, and $19.73 million in inventory loss.

Hancock County - The 2019 Hancock County Hazard Mitigation Plan utilize GIS Mapping to estimate their vulnerabilities to flooding. The plan assessed the properties within the City of Findlay and assigned damage curves to whether they were situated within the floodway (75% damage curve) or the floodplain (25% damage curve). It was estimated that there were 414 properties within the floodway that would potentially have $75 million dollars in damages according to the damage curves. In the floodplain, there were 2,295 properties that would potentially have $50 million dollars in damages

Washington County - The Washington County 2021 Hazard Mitigation Plan used HAZUS-MH to estimate that their flood vulnerabilities. In a 100-year flood assessment, they estimated that there are $2,134,385,000 in building exposure to a potential 100-year flood event. There were 34 essential facilities (fire stations, hospitals, police stations, and schools) at risk with none expected to be damaged in the scenario event. The scenario also estimated that there would be $115 million in building losses, $106 million in content losses, and $3.34 million in inventory loss.

MIP LHMP HIRA ASSESSMENT

Flood ranks highly amongst local hazard mitigation plans. It ranks first in frequency, response time, and impact on business and property. Overall, it ranks first in cumulative scoring.

FLOOD MIP LHMP HIRA ASSESSMENT

	Hazard Frequency	Response Time	Onset Time	Magnitude	Impact on Business	Impact on Humans	Impact on Property	Cumulative Score
Ranking	1	1	7	4	1	2	1	1
Criteria Score	5.41	4.8	3.18	2.35	2.12	1.97	2.3	22.13

VULNERABILITY ANALYSIS

Flooding vulnerability is the likelihood of something to be damaged in a flood. A vulnerability analysis is a measurement of a community's flood risk. Vulnerability can be measured using many different methods. The method selected is highly dependent on the type and format of available data. If site-specific information on flood elevation, lowest floor elevation, structure type, and replacement value exist, a detailed vulnerability analysis can be performed using flood damage curves. The State of Ohio, and most communities in the state lack all or a component of the data required for a detailed analysis and must use more simplified methods. Several different data sources are utilized in this discussion to help develop a clearer picture of Ohio's flood vulnerability including: HAZUS-MH analyses, the statewide Structure Inventory, NFIP repetitive loss data, and local data uploaded into Mitigation Information Portal (MIP).

NFIP REPETITIVE LOSS PROPERTIES

The NFIP has identified a subset of structures covered by flood insurance policies that are referred to as "repetitive loss" and "severe repetitive loss" (see Appendix B). For this analysis, a repetitive loss (RL) structure is any property covered under an NFIP flood insurance policy with two or more losses of more than $1,000 each, in any 10-year rolling period, and at least two losses that are more than 10 days apart.

Severe repetitive loss (SRL) structures are defined as residential structures that are covered under an NFIP flood insurance policy and a) that have at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amounts of such claims payments exceed $20,000; or b) for which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building. For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart.

NFIP repetitive loss data can be used to identify some of the structures vulnerable to flooding throughout the state. In Ohio, the number of NFIP flood insurance policies are declining. The two main reasons for this include the rising costs of flood insurance, and the increasing availability of private flood insurance. Other reasons include: misinformation about flood insurance as a mitigation option; no requirement for structures to be covered by flood insurance if there is no current mortgage; lack of resources to purchase coverage; and lack of enforcement by the mortgage holder.

Recent legislation is focused on reducing the number of repetitive loss structures by offering mitigation options to the owners. FEMA mitigation grant programs have also prioritized the mitigation of repetitive loss structures including: HMGP and FMA. The repetitive loss data should be used to identify areas that are repetitively flooded in a community. Given the current prioritization of repetitive loss structures, these structures should be considered when developing mitigation projects that utilize FEMA funding. As part of the State mitigation strategy, Goal #4 includes the elimination of repetitive loss flood-prone structures. One of the three objectives under this Goal is to prioritize repetitive loss properties for available funds from FEMA mitigation programs. As opportunities for mitigation funding have developed, Ohio has worked with local jurisdictions, counties and FEMA to address repetitive loss and other issues to reduce loss or disaster impact. Ohio continues to be very active in accomplishing the objectives set forth in the mitigation strategy regarding repetitive loss structures. Still, there are counties where there have been few or no mitigated repetitive loss structures. Ultimately, mitigation occurs at the local level. There are many reasons why a particular community has not yet addressed identified repetitive loss structures including: lack of property owner interest, the targeted structure cannot meet benefit-cost analysis requirements, lack of grant match dollars, etc. As demonstrated by the number of successful mitigation projects, the Ohio EMA Mitigation Branch is committed to working with Ohio communities to overcome these obstacles and support local mitigation efforts.

The State of Ohio strives to promote sustainable communities and development (Goal #2, Objective 4). The ODNR Floodplain Management Program's effort to promote sound floodplain management statewide is one example of the state's commitment. Ohio EMA's promotion of mitigation planning through the Mitigation Information Portal (MIP) also demonstrates the state's commitment to promoting community sustainability principles. The mitigation priorities identified in the State of Ohio Hazard Mitigation Plan align well with the identified risk in the state. In partnership with the Federal government and local communities, the State of Ohio will continue to develop, implement and administer mitigation grant programs that reduce risk to repetitive loss properties. These mitigation planning and project activities will continue to decrease the burden of repetitively flood damaged structures on the Disaster Relief Fund and the National Flood Insurance Fund.

The Ohio EMA Mitigation Branch examined repetitive flood loss data for all 88 counties and their affected communities. Data was compiled and analyzed for the entire state. The 15 counties with the greatest number of total losses are summarized in Table 2.2.c. The "Total Paid" column is the sum of building and content payments. Appendix B lists the RL/SRL properties for the entire state. As of November 2023, there are 2,573 repetitive and severe repetitive loss (RL/SRL) structures in Ohio with a total of 7,283 losses and $152,478,285 dollars paid. This estimate does not include structures and losses from properties that have already been mitigated. For a list of RL/SRL properties summarized for each county, refer to Appendix B.

Table 2.2.c

Repetitive and Severe Repetitive Loss Structures in Ohio as of November 2023 [1]						
County	**OEMA Region**	**Repetitive Loss Structures**	**Severe Repetitive Loss Structures**	**Total RL/SRL Structures**	**Total Losses**	**Total Paid**
HANCOCK COUNTY	1	161	25	186	550	$ 11,832,474.94
OTTAWA COUNTY	1	130	4	134	403	$ 4,023,889.67
ERIE COUNTY	1	76	16	92	322	$ 3,446,452.25
LUCAS COUNTY	1	76	8	84	239	$ 2,975,499.14
REGION 1 TOTAL		**443**	**53**	**496**	**1,514**	**$ 22,278,316.00**
CUYAHOGA COUNTY	2	112	25	137	470	$ 21,647,739.63
HAMILTON COUNTY	2	129	25	154	489	$ 16,721,206.78
SUMMIT COUNTY	2	83	10	93	242	$ 6,019,187.69
LAKE COUNTY	2	76	7	83	245	$ 3,926,915.81
FRANKLIN COUNTY	2	99	5	104	273	$ 3,727,765.50
LORAIN COUNTY	2	54	6	60	166	$ 3,417,320.08
REGION 2 TOTAL		**553**	**78**	**631**	**1,885**	**$ 55,460,135.49**
WASHINGTON COUNTY	3	174	24	198	513	$ 12,069,519.87
BELMONT COUNTY	3	63	2	65	161	$ 2,914,188.51
TRUMBULL COUNTY	3	40	4	44	125	$ 2,181,164.46
ATHENS COUNTY	3	45	5	50	151	$ 2,166,791.99
LAWRENCE COUNTY	3	36	7	43	131	$ 1,664,408.60
REGION 3 TOTAL		**358**	**42**	**400**	**1,081**	**$ 20,996,073.43**
STATEWIDE TOTAL		**1,354**	**173**	**1,527**	**4,480**	**$ 98,734,524.92**

1 – Does not include already mitigated properties.

Region 1 is identified as having the second highest number of RL/SRL structures in the State. As a whole Region 1 has 496 RL/SRL structures identified, with the total of contents replacements and total payments equaling $22,278,316 in paid claims. Within Region 1 the most significant concentration of repetitive loss structures is located in the City of Findlay (Hancock County), which is along the Blanchard River. In total, Findlay has 168 RL/SRL structures identified with 505 losses, which have paid a total of $11,053,618 for structure repairs and content replacement.

Region 2 has the highest number of RL/SRL structures identified in the state at 631 structures, including 78 severe repetitive loss structures. The amount paid out for repair of these structures through November 2023 is $55,460,135 for structure repairs and contents replacement. There are two areas of significant loss identified within the region: The City of Independence (Cuyahoga County) has 21 identified repetitive loss structures with 130 claims for a total of $14,020,812. The second area is the City of Cincinnati (Hamilton County) is located in the southwestern portion of the state on the Ohio River and have 60 repetitive loss structures with 198 claims for $10,110,024.

Region 3 is third in the state for all statistics regarding repetitive loss structures. In total, there are 358 RL/SRL structures with 1,081 losses totaling $20,996,073 in repairs and contents paid. The City of Marietta (Washington County) has 121 repetitive loss structures with 306 reported claims representing $8,228,525 in repairs and contents replacements.

NFIP COMMUNITY RATING SYSTEMS (CRS) PROGRAM

According to the October 2018 NFIP Flood Insurance Manual, the Community Rating System (CRS) is a voluntary program for communities participating in the National Flood Insurance Program (NFIP). The CRS offers flood insurance policy premium discounts in communities that develop and execute extra measures beyond minimum floodplain management requirements to provide protection from flooding. A community's eligibility for the CRS depends upon participating in the Regular Program and maintaining full compliance with the NFIP. CRS flood insurance policy premium discounts range from 0 percent to 45 percent depending on the community's floodplain management measures and activities.

The CRS recognizes measures for flood protection and flood loss reduction. The four main activity categories include Public Information, Mapping and Regulation, Flood Damage Reduction, and Flood Preparedness.

In order to participate in the CRS, a community must complete and submit an application to FEMA. Subsequently, FEMA reviews the community's floodplain management efforts and assigns the appropriate CRS classification based on credit points earned for various activities. A community's classification may change depending on the level of continued floodplain management efforts. Classifications range from one to ten and determine the premium discount for eligible flood insurance policies. All community assignments begin at Class 10 with no premium discount. Communities with a Class 1 designation receive the maximum 45 percent premium discount.

The table below highlights the available CRS premium discounts organized by class and flood zone. In addition to the Rate Class of the, the discount amount also varies depending on whether the insured property is in a Special Flood Hazard Area (SFHA), or not.

CRS Premium Discounts by Class and Flood Zone

Rate Class	Discount for SFHA*	Discount for Non-SFHA**	Credit Points Required
1	45%	10%	4,500 +
2	40%	10%	4,000–4,499
3	35%	10%	3,500–3,999
4	30%	10%	3,500–3,499
5	25%	10%	3,000–2,999
6	20%	10%	2,500–2,499
7	15%	5%	1,500–1,999
8	10%	5%	1,000–1,499
9	5%	5%	500–999
10	0	0	0–499

* Special Flood Hazard Area

** Preferred Risk Policies are available only in B, C, and X Zones for properties that are shown to have a minimal risk of flood damage. The Preferred Risk Policy does not receive premium rate credits under the CRS because it already has a lower premium than other policies. Although they are in SFHAs, Zones AR and A99 are limited to a 5% discount. Premium reductions are subject to change.

Source: 2018 National Flood Insurance Program (NFIP) Community Rating System (CRS): A Local Official's Guide to Saving Lives, Preventing Property Damage, Reducing the Cost of Flood Insurance

Table 2.2.d: CRS Eligible Communities in Ohio, October 1, 2023 Effective Date

Community Number	Community Name	CRS Entry Date	Current Effective Date	Class	% Discount
390412	Kettering, City of	10/1/1995	10/1/2000	8	10%
390328	Licking County	10/1/1993	5/1/2009	7	15%
390378	Medina County	5/1/2007	4/1/2023	9	5%
390432	Ottawa County	10/1/1992	10/1/1992	9	5%
390472	Ottawa, Village of	10/1/1995	10/1/1995	9	5%
390460	Preble County	10/1/1998	10/1/1998	9	5%
390479	Shelby, City of	10/1/1992	4/1/2023	7	15%
390419	West Carrollton, City of	5/1/2002	4/1/2023	7	15%

As of October 2023, only eight communities in Ohio participate in the CRS program. This is a decrease from October 2018, where there were 13 communities that participated in NFIP. In addition, Medina County was lowered to Class 8, a 5% discount, whereas before they were at Class 9, qualifying for a 10% discount. There was one improvement, where the City of West Carrollton was upgraded to a Class 7, now qualifying a 15% discount on flood insurance premiums. Ohio community participation in the CRS has been declining due to numerous factors:

1. The amount of time/work necessary to apply for and maintain CRS certification
   a. Most communities want to see a cost savings from CRS that would equate to or exceed the cost to maintain a local CRS program.
   b. There is an overall decline in NFIP flood insurance policies, therefore the cost/benefit to the community is reduced.
2. To be eligible for CRS participation, communities must complete a Community Assistance Visit (CAV) with no known violations (even from decades ago). Many communities do not want to invite an audit of their floodplain management program since the process may reveal floodplain development permitting violations from the past that the community will be required to remedy.

3. Ohio communities are not required to adopt/enforce floodplain management standards that exceed the minimum NFIP criteria.
4. Most communities are operating on reduced staffing resources and do not want to assume additional responsibilities.

To encourage and support CRS participation in Ohio, the FMP responds to requests for information about the program, participates in community educational events, and promotes the program to communities when possible. To increase FMP capabilities, FMP staff acquired additional training in CRS requirements, activities, and procedures in 2024. In the upcoming year, staff will be performing quarterly webinars and other outreach in an effort to generate community interest in the program. The FMP also works with CRS-participating communities to ensure locally adopted floodplain management regulations and higher standards are aligned with community goals and meet NFIP/CRS requirements. These actions to support CRS participation around the state is listed in the mitigation strategy as actions #22, 40, and 71.

Substantial Damage (SD) Assessment

Communities that are participating in the National Flood Insurance Program (NFIP) are required to adopt and enforce regulations and codes that apply to new development in Special Flood Hazard Areas (SFHAs). These local floodplain management regulations must contain, at a minimum, NFIP requirements and standards that apply not only to new structures, but also to existing structures which are Substantially Improved (SI), or Substantially Damaged (SD) from any cause, whether natural or human-induced hazards.

According to 44 CFR 59.1, Substantial improvement means any reconstruction, rehabilitation, addition or other improvement to a structure, the total cost of which equals or exceeds 50 percent of the market value of the structure before the start of construction of the improvement. Likewise, substantial damage means damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred. SI/SD requirements are also triggered when any combination of costs to repair and improvements to a structure in an SFHA equals or exceeds 50 percent of the structure's market value (excluding land value).

$$\frac{(Cost\ to\ Repair) + (Cost\ of\ Improvements)}{Market\ Value\ of\ Structure} \geq 50\ Percent$$

Enforcing the SI/SD requirements is a very important part of a community's floodplain management responsibilities. The purpose of the SI/SD requirements is to protect the property owner's investment and safety, and, over time, to reduce the total number of buildings that are exposed to flood damage, thus reducing the burden on taxpayers through the payment of disaster assistance. SD/SI requirements are enforced by the local floodplain administrator and monitored by the Ohio Department of Natural Resources (ODNR) Floodplain Management Program during Community Assistance Visits. If a local floodplain administrator is overwhelmed by the number of SD/SI inspections after a large event, ODNR has developed a network of building code officials that are trained in conducting SD/SI field determinations. Help with SD/SI inspections can be requested through the county emergency management agency director.

ODNR's Floodplain Management Program (FMP) monitors and seeks information about communities experiencing structural damage from severe weather events. When impacted communities are identified, the FMP performs outreach to communities, responds to requests for assistance, provides guidance on substantial damage requirements, interpretation and application of locally adopted floodplain management regulations as well as tools and other potential resources for damage assessment. The FMP also participates in briefings, agency coordination, and reporting.

When communities request assistance with damage assessment, the FMP can provide training or assist in coordinating skilled help from the Ohio Building Officials Association (OBOA) Damage Assessment Response Team (DART). ODNR will monitor progress on damage assessment and share information with the County and State EMA accordingly. This is listed in the mitigation strategy as action #62.

Risk MAP

Not only is flooding one of the most common and costly disasters, flood risk can also change over time because of new building and development, weather patterns and other factors. Although the frequency or severity of impacts cannot be changed, FEMA is working with federal, state, and local partners across the nation to identify flood risk and promote informed planning and development practices to help reduce that risk through the Risk Mapping, Assessment and Planning (Risk MAP) program

Risk MAP provides high quality flood maps and information, tools to better assess the risk from flooding and planning and outreach support to communities to help them take action to reduce or mitigate flood risk. Each Risk MAP flood risk project is tailored to the needs of each community and may involve different products and services.

Risk MAP outreach and discovery meetings in Ohio

FEMA, ODNR, Ohio EMA and the Strategic Alliance for Risk Reduction hosted outreach and discovery meetings with local officials and the public to discuss floodplain mapping needs and potential mitigation projects on the following dates.

County Name	Date
Fairfield County (Rush and Raccoon Creek PMR) CCO	6/26/2018
Scioto County (Portsmouth and New Boston PMR)	6/26/2018
Paulding, Van Wert, and Defiance Counties Workmap meeting	6/28/2018
Lucas County (Lake Erie) CCO and Open House	9/20/2018
Defiance County CCO	10/1/2019
Clinton County (Little Miami Watershed) CCO and Open House	11/19/2019
Highland County (Little Miami Watershed) CCO and Open House	11/19/2019
Greene County CCO and Open House	11/20/2019
Erie County (Lake Erie) CCO	1/15/2020
Upper Scioto Workmap Meetings	8/5 to 8/14/2020
Lower Great Miami Flood Risk Review Meetings	11/16 to 11/20/2020
Van Wert County CCO Meeting	1/21/2021
Montgomery County (Little Miami Watershed) CCO	2/4/2021
Van Wert County Open House Meeting	3/4/2021
Paulding County CCO	3/9/2021
Allen County CCO	3/10/2021
Montgomery County (Little Miami Watershed) Open House	3/16/2021
Ottawa County CCO	3/23/2021
Allen County Open House	3/24/2021
Warren County (Little Miami Watershed) Open House	4/20/2021
Ottawa County Open House	4/22/2021
Paulding County Open House	5/5/2021
Warren County (Little Miami Watershed) CCO	6/9/2021
Hamilton County (Little Miami Watershed) CCO	6/10/2021
Hamilton County (Little Miami Watershed) Open House	6/30/2021
Athens County (Hocking River PMR)- Revised PMR CCO	2/28/2022
Port Clinton- Lake Erie Tabletop Exercise	4/5/2022
Athens County (Hocking River PMR)- Revised PMR Open House	4/9/2022
Crawford County (Upper Scioto Watershed) CCO and Open House	4/26/2022
Union County (Upper Scioto Watershed) CCO	5/6/2022
Preble County (Lower Great Miami Watershed) Meetings	5/9 to 5/10/2022
Madison County (Upper Scioto Watershed) CCO	5/24/2022
Union County (Upper Scioto Watershed) Open House	6/1/2022
Delaware County (Upper Scioto Watershed) CCO	6/7/2022
Marion County (Upper Scioto Watershed) CCO	6/7/2022
Madison County (Upper Scioto Watershed) Open House	6/8/2022
Marion County (Upper Scioto Watershed) Open House	6/8/2022
Delaware County (Upper Scioto Watershed) Open House	6/14/2022
Licking County (Upper Scioto Watershed) CCO and Open House	6/28/2022
Ross County (Chillicothe Levee PMR) CCO	7/22/2022
Morrow County (Upper Scioto Watershed) CCO and Open House	7/25/2022
Ross County (Chillicothe Levee PMR) Open House	7/26/2022
Williams County Discovery Meeting	8/9/2022
Henry County- Discovery Meeting	8/9/2022
Wyandot County- Discovery Meeting	8/10/2022
Fayette County Discovery Meeting	8/11/2022
Vinton County Discovery meeting	8/11/2022
Hardin County (Upper Scioto Watershed) CCO	11/9/2022
Hardin County (Upper Scioto Watershed) Open House	12/5/2022
Fairfield County (Upper Scioto Watershed) CCO and Open House	12/19/2022
Hamilton County (Lower Great Miami Watershed) CCO and Open House	5/23/2023
Warren County (Lower Great Miami Watershed) CCO and Open House	5/24/2023
Wyandot County- Discovery Workshop	8/11/2023
Henry County- Discovery Workshop	8/12/2023
Vinton County Discovery workshop	8/13/2023
Fayette County Discovery workshop	8/13/2023
Auglaize County CCO and Open House	9/20/2023

USACE-OEMA HAZUS-MH LEVEL 2 FLOOD ANALYSIS

From November 2022 to December 2023, Ohio EMA coordinated with the US Army Corps of Engineers (USACE) to undertake a HAZUS analysis project under the USACE's Silver Jackets program. In this project, the USACE completed Level 2 flood analysis for 25 counties: Ashland, Ashtabula, Butler, Cuyahoga, Delaware, Fairfield, Franklin, Geauga, Greene, Hamilton, Knox, Lake, Licking, Lorain, Mahoning, Medina, Montgomery, Pickaway, Portage, Richland, Stark, Summit, Trumbull, Warren, and Wayne. This analysis assessed 25 and 100-year Flood Event Scenarios and utilized refined property inventory and values from the National Structure Inventory (NSI) developed by the US Army Corp of Engineers. For Ashtabula, Lake, Cuyahoga, and Lorain Counties, coastal flooding was also assessed and are included in the loss estimates. While it is a considerable enhancement from HAZUS-MH Level 1 Assessments, it is important to remember all the information reported via the state's HAZUS-MH analyses is an estimate and cannot be interpreted as precise losses.

RESULTS

Table 2.2.e

USACE-OEMA HAZUS-MH Level 2 Scenario Analysis, 100-Year Flood Event												
			Percent Damage						Estimated Building Interuption		
County	2020 Population	Building Exposure Value ($1,000)	1-10% Damage Count	11-20% Damage Count	21-30% Damage Count	31-40% Damage Count	41-50% Damage Count	>50% Damage Count	Building Loss	Content Loss	Inventory Loss
Ashland	52,447	$ 1,786,016	31	68	57	33	29	74	$ 27,462,740	$ 50,388,642	$ 17,852,898
Ashtabula	97,574	$ 3,643,344	31	110	53	37	21	38	$ 19,939,706	$ 34,675,439	$ 7,873,924
Butler	390,357	$ 8,676,740	256	701	763	429	235	270	$ 236,333,798	$ 484,932,872	$ 52,986,063
Cuyahoga	1,264,817	$ 16,268,693	97	296	184	102	74	81	$ 110,148,410	$ 222,970,401	$ 50,484,705
Delaware	214,124	$ 4,605,739	31	63	55	50	96	200	$ 59,947,876	$ 71,221,313	$ 14,222,396
Fairfield	158,921	$ 4,876,227	104	244	241	185	125	180	$ 83,947,013	$ 140,004,516	$ 26,315,536
Franklin	1,323,807	$ 22,711,477	391	1245	849	424	202	140	$ 205,452,090	$ 360,984,631	$ 52,799,748
Geauga	95,397	$ 2,394,681	23	26	15	7	1	3	$ 3,779,520	$ 2,387,798	$ 387,155
Greene	167,966	$ 3,847,505	45	89	69	51	29	23	$ 25,902,724	$ 54,337,409	$ 11,646,306
Hamilton	830,639	$ 14,035,544	229	446	534	471	346	393	$ 260,672,817	$ 522,711,416	$ 125,950,224
Knox	62,721	$ 3,035,442	111	178	153	52	27	28	$ 24,522,874	$ 41,375,025	$ 8,131,340
Lake	232,603	$ 5,311,483	257	184	130	75	35	24	$ 44,122,438	$ 79,301,434	$ 17,613,802
Licking	178,519	$ 7,430,274	160	600	513	268	148	152	$ 139,207,415	$ 203,643,604	$ 77,905,295
Lorain	312,964	$ 9,936,457	78	523	177	66	65	37	$ 69,008,624	$ 82,233,163	$ 11,753,947
Mahoning	228,614	$ 3,234,470	24	27	22	9	10	6	$ 27,791,110	$ 59,808,946	$ 12,493,156
Medina	182,470	$ 3,587,560	33	43	37	12	8	18	$ 9,751,739	$ 12,456,129	$ 4,203,784
Montgomery	537,309	$ 9,433,776	369	847	970	382	190	140	$ 185,681,990	$ 313,380,060	$ 43,916,675
Pickaway	58,539	$ 2,231,664	9	17	12	7	6	15	$ 8,207,035	$ 18,729,370	$ 5,579,817
Portage	161,791	$ 3,436,926	14	39	37	26	23	19	$ 12,034,305	$ 13,531,471	$ 1,517,746
Richland	124,936	$ 2,447,972	54	114	107	70	28	20	$ 48,955,311	$ 122,777,488	$ 24,396,653
Stark	374,853	$ 6,972,526	147	284	255	150	77	77	$ 87,069,885	$ 166,595,976	$ 29,080,510
Summit	540,428	$ 8,604,422	124	243	188	121	82	49	$ 92,633,342	$ 213,287,593	$ 37,610,013
Trumbull	201,977	$ 5,686,303	103	218	213	96	55	47	$ 57,033,857	$ 103,635,138	$ 29,768,583
Warren	242,337	$ 7,232,933	164	313	365	259	192	388	$ 169,573,015	$ 209,941,822	$ 39,354,218
Wayne	116,894	$ 2,506,200	40	39	55	17	19	65	$ 15,989,241	$ 28,071,829	$ 5,359,223

Table 2.2.f

USACE-OEMA HAZUS-MH Level 2 Scenario Analysis, 25-Year Flood Event											
			Percent Damage						Estimated Building Interuption		
County	2020 Population	Building Exposure Value ($1,000)	1-10% Damage Count	11-20% Damage Count	21-30% Damage Count	31-40% Damage Count	41-50% Damage Count	>50% Damage Count	Building Loss	Content Loss	Inventory Loss
Ashland	52,447	$ 1,695,478	32	57	39	33	27	59	$ 23,288,697	$ 44,058,069	$ 15,181,274
Ashtabula	97,574	$ 3,418,081	35	77	41	32	17	27	$ 15,402,842	$ 27,391,231	$ 6,041,745
Butler	390,357	$ 8,363,347	305	692	676	322	185	174	$ 190,817,572	$ 399,163,626	$ 40,899,521
Cuyahoga	1,264,817	$ 14,419,866	79	200	128	69	54	54	$ 72,911,583	$ 148,085,340	$ 26,833,852
Delaware	214,124	$ 4,316,934	33	45	49	51	125	149	$ 47,326,486	$ 57,079,850	$ 12,380,390
Fairfield	158,921	$ 4,757,527	96	237	226	160	77	147	$ 66,022,137	$ 101,170,214	$ 21,417,755
Franklin	1,323,807	$ 21,918,863	338	1086	679	297	144	82	$ 158,994,206	$ 271,413,567	$ 42,865,767
Geauga	95,397	$ 2,328,381	20	23	15	4	0	2	$ 2,886,568	$ 1,782,382	$ 170,157
Greene	167,966	$ 3,566,605	43	78	67	34	22	16	$ 19,947,065	$ 42,247,485	$ 8,719,237
Hamilton	830,639	$ 12,249,209	221	378	449	339	216	232	$ 168,632,561	$ 321,475,400	$ 65,978,019
Knox	62,721	$ 2,852,888	84	115	67	31	14	21	$ 14,537,298	$ 27,164,521	$ 5,279,994
Lake	232,603	$ 5,237,565	215	140	84	44	21	15	$ 27,387,287	$ 49,823,911	$ 11,973,759
Licking	178,519	$ 7,012,362	139	509	343	202	95	86	$ 99,801,480	$ 154,369,200	$ 69,384,279
Lorain	312,964	$ 9,433,866	77	454	144	57	46	24	$ 54,451,730	$ 62,459,316	$ 9,560,832
Mahoning	228,614	$ 3,098,374	22	25	9	8	6	4	$ 18,736,709	$ 37,648,703	$ 8,311,469
Medina	182,470	$ 3,244,067	19	33	21	8	5	16	$ 6,730,158	$ 9,101,297	$ 3,570,124
Montgomery	537,309	$ 8,857,241	370	799	809	292	111	119	$ 150,860,931	$ 244,693,166	$ 33,740,875
Pickaway	58,539	$ 1,868,437	13	13	9	6	6	11	$ 6,908,945	$ 16,095,996	$ 4,330,285
Portage	161,791	$ 3,390,137	9	36	37	26	19	9	$ 10,169,772	$ 11,340,557	$ 1,255,748
Richland	124,936	$ 2,309,819	60	98	89	37	18	13	$ 37,693,936	$ 91,195,046	$ 18,025,391
Stark	374,853	$ 6,494,442	147	266	229	101	61	63	$ 69,154,224	$ 136,862,487	$ 23,281,666
Summit	540,428	$ 7,640,781	97	166	166	101	44	34	$ 75,047,116	$ 179,628,379	$ 32,798,450
Trumbull	201,977	$ 5,481,407	97	202	166	73	36	32	$ 43,751,882	$ 79,223,992	$ 22,842,122
Warren	242,337	$ 7,044,205	200	311	361	211	152	316	$ 143,920,200	$ 177,865,171	$ 32,813,459
Wayne	116,894	$ 2,115,292	35	37	41	20	10	61	$ 12,266,426	$ 19,848,576	$ 3,464,242

FEMA NATIONAL RISK INDEX: RIVERINE FLOODING

The FEMA National Risk Index (NRI) is a dataset and online tool to help illustrate the United States communities most at risk for 18 natural hazards. For Riverine Flooding, the Expected Annual Loss was determined by multiplying the frequency, exposure, and the historical loss ratio. This equation was calculated to determine population, agriculture, and building losses. For more information on current methods and data, refer to section 17 of the National Risk Index Technical Manual.

RESULTS

In Region 1, Lucas, Hancock, Erie, and Mercer counties are estimated to experience the most damages from flooding.

- Lucas County, which has a small coastline to Lake Erie and has the largest population in the region, is estimated to experience $4 million in expected annual loss. This is mainly from building damage and population equivalence at $2 million each.
- Hancock County, which has less than a fifth of the population of Lucas County but historically have flooding issues, is also estimated to experience $4 million in expected annual loss. The vast majority of this estimate comes from building damages at $3.7 million.

In Region 2, Franklin County is estimated to experience the most damages from flooding, followed by Summit and Cuyahoga Counties.

- Franklin County, located in central Ohio and have the most people per county in the state, is estimated to experience over $8.5 million in expected annual loss. The vast majority of this estimate comes from population equivalence at $8.2 million.
- Summit and Cuyahoga Counties are neighboring counties and both located in northeastern Ohio. Summit County, with less than half the number of people as Cuyahoga County, is estimated to experience slightly more damage at roughly $7 million in expected annual loss with a majority of that coming from building damages. Cuyahoga County, which borders Lake Erie, has an expected annual loss of $6.5 million.

In Region 3, Trumbull County is estimated to experience the most damages from flooding, followed by Scioto and Washington Counties.

- Trumbull County, located in the northeast border of the state, does not border Lake Erie but is one of the larger counties in the region, is estimated to experience over $6.9 million in expected annual loss. The vast majority of this estimate comes from population equivalence at $6.5 million.
- Scioto and Washington Counties are both in southern Ohio along the Ohio River. Both counties are estimated to experience over $3.4 million in expected annual loss. For Scioto County, this estimate heavily comes from population equivalence, while for Washington County’s estimate heavily comes from building damage.

Table 2.2.g

FEMA National Risk Index Riverine Flood Analysis, October 2023, OEMA Region 1								
County	2020 Population	Exposure (Population)	Exposure (Agriculture)	Exposure (Buildings)	Expected Annual Loss (Pop. Equivalence)	Expected Annual Loss (Agriculture)	Expected Annual Loss (Buildings)	Expected Annual Loss (Total)
Allen	102,206	2,045	$ 8,949,368	$ 353,580,418	$ 90,337	$ 37,465	$ 27,434	$ 155,236
Auglaize	46,422	751	$ 7,892,493	$ 236,066,119	$ 169,121	$ 43,063	$ 57,703	$ 269,887
Champaign	38,714	883	$ 11,106,109	$ 191,822,919	$ 324,570	$ 162,729	$ 13,764	$ 501,063
Clark	136,001	3,016	$ 11,655,277	$ 804,382,892	$ 361,248	$ 52	$ 45,534	$ 406,834
Crawford	42,025	584	$ 11,098,057	$ 109,868,056	$ 72,257	$ 188,779	$ 277,064	$ 538,100
Darke	51,881	1,064	$ 43,955,080	$ 268,799,155	$ 258,503	$ 1,012,064	$ 32,007	$ 1,302,574
Defiance	38,286	828	$ 4,617,930	$ 166,876,981	$ 51,199	$ 297	$ 18,244	$ 69,740
Erie	75,622	3,943	$ 3,395,931	$ 1,682,841,074	$ 818,688	$ 88,791	$ 2,154,421	$ 3,061,900
Fulton	42,713	927	$ 15,412,986	$ 139,260,735	$ 40,963	$ 77,370	$ 7,120	$ 125,454
Hancock	74,920	4,718	$ 7,779,824	$ 1,046,790,703	$ 138,868	$ 158,350	$ 3,673,247	$ 3,970,465
Hardin	30,696	480	$ 3,282,819	$ 75,749,809	$ 74,284	$ 48,101	$ 5,555	$ 127,939
Henry	27,662	469	$ 2,743,891	$ 98,625,522	$ 24,881	$ 5,276	$ 13,148	$ 43,305
Huron	58,565	679	$ 5,718,715	$ 143,118,027	$ 156,815	$ 94,534	$ 499,996	$ 751,345
Logan	46,150	1,648	$ 7,074,663	$ 504,035,938	$ 385,892	$ 156,970	$ 224,567	$ 767,429
Lucas	431,279	11,530	$ 8,150,558	$ 2,433,226,443	$ 2,037,496	$ 899	$ 2,011,568	$ 4,049,964
Marion	65,359	1,762	$ 24,311,710	$ 356,362,227	$ 396,913	$ 7,550	$ 206,572	$ 611,034
Mercer	42,528	998	$ 66,407,200	$ 587,556,670	$ 251,250	$ 1,584,624	$ 1,104,933	$ 2,940,807
Miami	108,774	2,316	$ 8,231,977	$ 526,798,417	$ 450,120	$ 151,633	$ 72,286	$ 674,039
Ottawa	40,364	5,943	$ 13,883,405	$ 2,894,513,142	$ 472,560	$ 105,202	$ 528,775	$ 1,106,537
Paulding [1]	18,806	0	$ 490	$ -	$ -	$ 1	$ -	$ 1
Preble	40,999	1,293	$ 6,977,453	$ 274,554,341	$ 62,731	$ 113,919	$ 43,513	$ 220,164
Putnam	34,451	1,793	$ 34,390,907	$ 329,943,915	$ 183,744	$ 9,327	$ 30,099	$ 223,170
Sandusky	58,896	1,557	$ 10,762,551	$ 411,174,665	$ 220,070	$ 184,562	$ 485,525	$ 890,157
Seneca	55,069	1,348	$ 6,071,147	$ 254,877,154	$ 186,622	$ 61,368	$ 174,741	$ 422,731
Shelby	48,230	1,425	$ 14,428,880	$ 346,097,712	$ 295,882	$ 283,901	$ 40,870	$ 620,652
Van Wert [1]	28,931	66	$ 9,419	$ 12,297,010	$ 4,112	$ 55	$ 8,613	$ 12,780
Williams	37,102	722	$ 5,972,113	$ 226,302,228	$ 19,143	$ 9,824	$ 216,039	$ 245,006
Wood	132,248	2,209	$ 6,362,731	$ 545,810,789	$ 302,494	$ 7,689	$ 191,949	$ 502,131
Wyandot	21,900	747	$ 4,775,853	$ 202,339,733	$ 106,392	$ 60,986	$ 37,643	$ 205,021

1 – Paulding and Van Wert Counties were missing effective flood mapping data during the development of the National Risk Index (March 2023 Version) which resulted in significantly lower results. Due to this, the NRI Expected Annual Loss estimates for Paulding and Van Wert Counties are not indicative of their actual risk.

Table 2.2.h

FEMA National Risk Index Riverine Flood Analysis, October 2023, OEMA Region 2								
County	2020 Population	Exposure (Population)	Exposure (Agriculture)	Exposure (Buildings)	Expected Annual Loss (Pop. Equivalence)	Expected Annual Loss (Agriculture)	Expected Annual Loss (Buildings)	Expected Annual Loss (Total)
Ashland	52,447	862	$ 5,272,502	$ 293,982,482	$ 156,137	$ 113,381	$ 762,855	$ 1,032,373
Butler	390,357	5,808	$ 4,660,867	$ 1,374,603,007	$ 302,149	$ 124,877	$ 244,716	$ 671,742
Clinton	42,018	1,047	$ 5,729,071	$ 208,945,715	$ 279,700	$ 58	$ 6,702	$ 286,460
Cuyahoga	1,264,817	5,037	$ 341,905	$ 1,768,484,362	$ 1,535,292	$ 9,876	$ 4,965,690	$ 6,510,858
Delaware	214,124	1,213	$ 2,774,950	$ 398,390,058	$ 224,977	$ 48,791	$ 26,752	$ 300,520
Fairfield	158,921	5,383	$ 6,886,956	$ 1,249,739,367	$ 686,968	$ 182	$ 97,373	$ 784,523
Fayette	28,951	651	$ 6,889,589	$ 192,473,922	$ 83,425	$ 83,643	$ 9,056	$ 176,123
Franklin	1,323,807	22,464	$ 6,414,104	$ 3,802,772,707	$ 8,236,779	$ 222,869	$ 108,078	$ 8,567,725
Geauga	95,397	346	$ 226,994	$ 67,473,007	$ 39,749	$ 992	$ 214,308	$ 255,049
Greene	167,966	2,118	$ 7,201,811	$ 724,560,733	$ 467,728	$ 150,747	$ 10,316	$ 628,791
Hamilton	830,639	10,262	$ 10,390,421	$ 4,714,157,320	$ 1,143,254	$ 569,824	$ 1,522,550	$ 3,235,627
Knox	62,721	2,500	$ 5,468,371	$ 589,675,526	$ 265,101	$ 60,115	$ 895,678	$ 1,220,894
Lake	232,603	2,495	$ 781,206	$ 623,630,441	$ 192,400	$ 18,134	$ 1,870,706	$ 2,081,240
Licking	178,519	6,069	$ 12,574,534	$ 1,446,106,673	$ 1,501,346	$ 294,792	$ 206,105	$ 2,002,244
Lorain	312,964	4,662	$ 5,066,614	$ 959,971,572	$ 678,419	$ 150,651	$ 1,535,824	$ 2,364,894
Madison	43,824	495	$ 6,753,783	$ 79,808,918	$ 52,445	$ 67,857	$ 16,019	$ 136,322
Medina	182,470	1,091	$ 3,371,400	$ 286,759,660	$ 183,095	$ 66,753	$ 1,390,922	$ 1,640,771
Montgomery	537,309	8,613	$ 4,031,073	$ 1,899,861,648	$ 2,206,871	$ 97,878	$ 40,499	$ 2,345,248
Morrow	34,950	369	$ 1,962,038	$ 135,501,534	$ 32,632	$ 21,186	$ 302,026	$ 355,844
Pickaway	58,539	1,401	$ 16,406,753	$ 376,664,009	$ 309,545	$ 343,423	$ 126,758	$ 779,725
Portage	161,791	1,671	$ 598,277	$ 335,647,365	$ 184,571	$ 882	$ 826,732	$ 1,012,184
Richland	124,936	1,442	$ 7,354,428	$ 596,214,363	$ 250,071	$ 165,585	$ 2,271,450	$ 2,687,107
Stark	374,853	3,799	$ 3,065,599	$ 1,178,621,629	$ 922,954	$ 19,207	$ 4,492,105	$ 5,434,266
Summit	540,428	4,411	$ 478,157	$ 1,251,315,064	$ 880,340	$ 3,933	$ 6,082,620	$ 6,966,893
Union	62,784	685	$ 13,622,477	$ 193,256,009	$ 108,936	$ 205,303	$ 245,531	$ 559,769
Warren	242,337	5,172	$ 4,068,433	$ 1,142,560,905	$ 652,262	$ 129,442	$ 265,430	$ 1,047,134
Wayne	116,894	1,659	$ 20,692,437	$ 586,704,766	$ 175,877	$ 2,092	$ 743,260	$ 921,229

Table 2.2.i

National Risk Index Riverine Flood Analysis, October 2023, OEMA Region 3								
County	2020 Population	Exposure (Population)	Exposure (Agriculture)	Exposure (Buildings)	Expected Annual Loss (Pop. Equivalence)	Expected Annual Loss (Agriculture)	Expected Annual Loss (Buildings)	Expected Annual Loss (Total)
Adams	27,477	988	$ 1,246,457	$ 275,112,308	$ 646,458	$ 37,049	$ 2,137,052	$ 2,820,558
Ashtabula	97,574	753	$ 817,071	$ 156,847,041	$ 129,758	$ 15,916	$ 724,260	$ 869,934
Athens	62,431	12,739	$ 4,178,187	$ 3,880,321,617	$ 255,295	$ 122,440	$ 1,689,880	$ 2,067,615
Belmont	66,497	2,947	$ 673,615	$ 1,069,990,936	$ 740,680	$ 33,735	$ 3,375,181	$ 4,149,595
Brown	43,676	1,170	$ 1,542,643	$ 357,156,104	$ 1,001,963	$ 39,394	$ 1,010,155	$ 2,051,512
Carroll	26,721	977	$ 2,427,809	$ 271,676,540	$ 211,584	$ 49,802	$ 160,530	$ 421,917
Clermont	208,601	3,038	$ 658,824	$ 1,118,439,889	$ 839,703	$ 24,547	$ 743,541	$ 1,607,790
Columbiana	101,877	1,737	$ 3,040,980	$ 464,769,728	$ 406,638	$ 52	$ 566,643	$ 973,333
Coshocton	36,612	760	$ 15,417,214	$ 375,009,313	$ 265,255	$ 639,574	$ 784,910	$ 1,689,739
Gallia	29,220	2,418	$ 6,685,198	$ 848,632,705	$ 215,527	$ 198,705	$ 468,765	$ 882,997
Guernsey	38,438	1,634	$ 6,176,522	$ 620,903,789	$ 389,838	$ 200,700	$ 546,428	$ 1,136,965
Harrison	14,483	457	$ 1,619,683	$ 96,839,498	$ 70,719	$ 34,457	$ 77,905	$ 183,081
Highland	43,317	160	$ 2,982,231	$ 65,087,562	$ 32,501	$ 57,430	$ 56,292	$ 146,223
Hocking	28,050	2,438	$ 2,109,424	$ 806,616,606	$ 635,381	$ 52,102	$ 450,406	$ 1,137,889
Holmes	44,223	969	$ 11,688,377	$ 362,192,466	$ 145,514	$ 74,495	$ 1,542,011	$ 1,762,021
Jackson	32,653	868	$ 1,028,893	$ 340,527,211	$ 160,965	$ 18,091	$ 1,054,775	$ 1,233,831
Jefferson	65,249	2,493	$ 450,261	$ 972,299,958	$ 407,437	$ 6,974	$ 1,856,738	$ 2,271,149
Lawrence	58,240	5,274	$ 2,729,127	$ 945,547,113	$ 482,385	$ 31,348	$ 1,382,238	$ 1,895,971
Mahoning	228,614	450	$ 967,428	$ 402,595,945	$ 55,704	$ 11,340	$ 1,488,066	$ 1,555,110
Meigs	22,210	3,096	$ 3,876,003	$ 757,188,786	$ 644,789	$ 111,962	$ 813,010	$ 1,569,760
Monroe	13,385	459	$ 4,057,955	$ 132,439,713	$ 249,659	$ 122,890	$ 961,457	$ 1,334,006
Morgan	13,802	785	$ 1,920,176	$ 216,333,314	$ 421,295	$ 24,116	$ 313,636	$ 759,046
Muskingum	86,410	1,226	$ 10,271,570	$ 329,205,630	$ 270,896	$ 317,917	$ 947,625	$ 1,536,438
Noble	14,115	296	$ 1,506,697	$ 133,893,195	$ 262,351	$ 49,786	$ 877,889	$ 1,190,027
Perry	35,408	1,496	$ 2,265,859	$ 341,428,715	$ 264,435	$ 37,943	$ 471,726	$ 774,104
Pike	27,088	1,430	$ 15,194,603	$ 538,030,206	$ 599,102	$ 324,411	$ 357,297	$ 1,280,809
Ross	77,093	1,572	$ 15,053,796	$ 547,986,729	$ 499,955	$ 365,519	$ 293,714	$ 1,159,188
Scioto	74,008	3,976	$ 9,810,586	$ 685,522,763	$ 2,144,233	$ 369,635	$ 964,075	$ 3,477,943
Trumbull	201,977	3,296	$ 1,560,720	$ 1,096,784,245	$ 299,479	$ 35,936	$ 6,591,168	$ 6,926,583
Tuscarawas	93,263	3,159	$ 15,726,979	$ 970,055,225	$ 227,185	$ 32	$ 1,666,799	$ 1,894,017
Vinton	12,800	354	$ 1,602,354	$ 47,999,129	$ 90,791	$ 38,907	$ 199,604	$ 329,301
Washington	59,771	6,028	$ 7,277,149	$ 2,342,726,275	$ 275,909	$ 258,950	$ 2,897,121	$ 3,431,980

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

Utilizing the dataset of critical facilities in Appendix C, state-owned and state-leased critical facilities were assessed based on their coordinates to determine if they were in a flood zone. Those in flood zones AE and AH were further assessed to determine their first-floor elevations (FFE) and base flood elevations (BFE). These FFEs and BFEs, along with each structures' square footage and replacement values were plugged into FEMA's BCA Tool and DFA depth-damage curves to estimate building and content damages for each structure. The data for each state agency, by county, is summarized in table 2.2.j below. Structures that returned zero building damages and contents indicate that while they are in a flood zone, their first-floor elevations were above the base flood elevation.

Table 2.2.j

State-owned and State-leased Critical Facilities in Flood Zones AE and AH				
County Department	**OEMA Region**	**# of Critical Facilities**	**Building Damages**	**Content Damages**
OTTAWA	**1**	**36**	**$ 16,981,249**	**$ 9,882,530**
ADJUTANT GENERAL		36	$ 16,981,249	$ 9,882,530
CLARK	**1**	**9**	**$ 175,992**	**$ 98,654**
DEPARTMENT OF TRANSPORTATION		9	$ 175,992	$ 98,654
PICKAWAY	**2**	**20**	**$ 5,695,920**	**$ 3,332,675**
DEPARTMENT OF YOUTH SERVICES		20	$ 5,695,920	$ 3,332,675
CUYAHOGA	**2**	**8**	**$ 448,325**	**$ 263,238**
DEPARTMENT OF PUBLIC SAFETY		1	$ -	$ -
DEPARTMENT OF TRANSPORTATION		7	$ 448,325	$ 263,238
KNOX	**2**	**1**	**$ 133,884**	**$ 78,777**
DEPARTMENT OF ADMINISTRATIVE SERVICES		1	$ 133,884	$ 78,777
WARREN	**2**	**7**	**$ 40,681**	**$ 23,555**
DEPARTMENT OF REHABILITATION AND CORRECTION		7	$ 40,681	$ 23,555
ATHENS	**3**	**20**	**$ 1,769,127**	**$ 1,031,265**
DEPARTMENT OF MENTAL HEALTH AND ADDICTION SERVICES		10	$ 4,471	$ 2,635
DEPARTMENT OF TRANSPORTATION		10	$ 1,764,656	$ 1,028,630
SCIOTO	**3**	**9**	**$ 331,462**	**$ 192,000**
DEPARTMENT OF TRANSPORTATION		9	$ 331,462	$ 192,000
MONROE	**3**	**3**	**$ 257,159**	**$ 151,460**
DEPARTMENT OF TRANSPORTATION		3	$ 257,159	$ 151,460
JEFFERSON	**3**	**5**	**$ 67,830**	**$ 34,138**
DEPARTMENT OF TRANSPORTATION		5	$ 67,830	$ 34,138
BELMONT	**3**	**8**	**$ -**	**$ -**
DEPARTMENT OF PUBLIC SAFETY		1	$ -	$ -
DEPARTMENT OF TRANSPORTATION		7	$ -	$ -
TUSCARAWAS	**3**	**4**	**$ -**	**$ -**
DEPARTMENT OF TRANSPORTATION		4	$ -	$ -
TOTAL		130	$ 25,901,629	$ 15,088,292

2.3 TORNADO

The National Oceanic Atmospheric Association (NOAA) defines a tornado as a narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground. Because wind is invisible, it is hard to see a tornado unless it forms a condensation funnel made up of water droplets, dust and debris. Tornadoes are the most violent of all atmospheric storms, and the most hazardous when they occur in populated areas. Tornadoes can topple mobile homes, lift cars, snap trees, and turn objects into destructive missiles. Among the most unpredictable of weather phenomena, tornadoes can occur at any time of day, in any state in the union, and in any season. While the majority of tornadoes cause little or no damage, some are capable of tremendous destruction, reaching wind speeds of 200 mph or more.

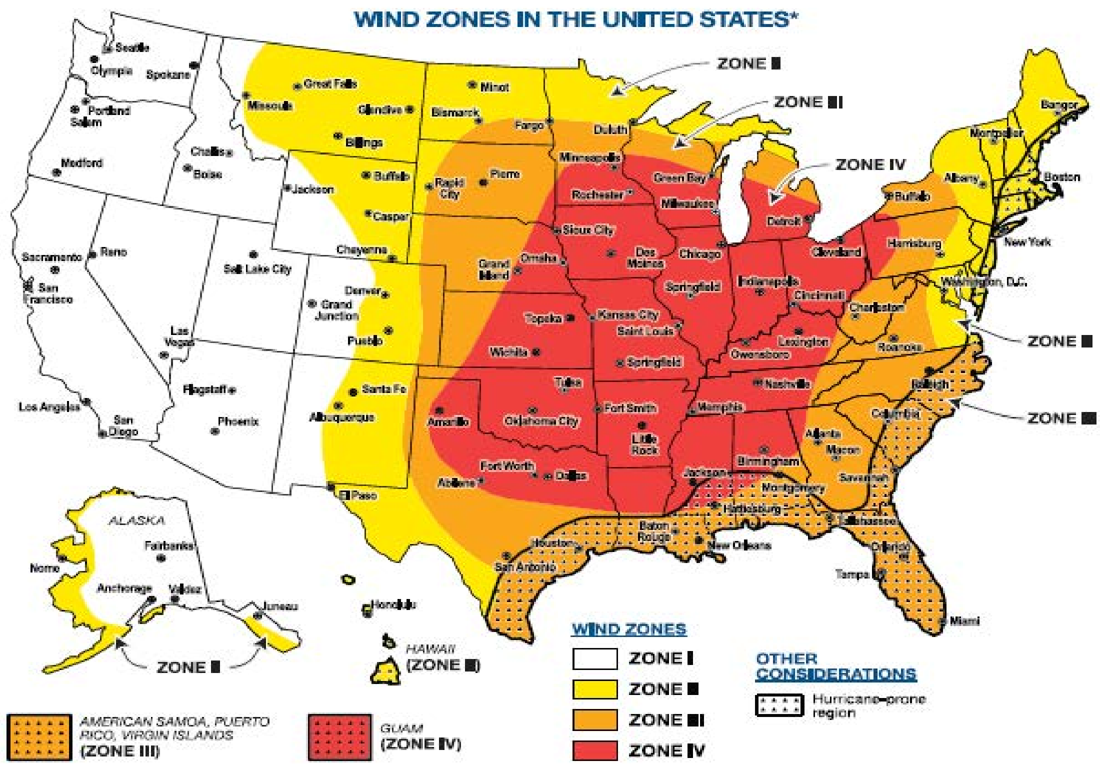


Figure 2-7: Wind Zones in the United States*

* If you are uncertain of your location because of the level of detail and size of the map, or if you live on or very near one of the delineation lines, use the highest adjacent wind zone.

Map 2.3.a

Tornadoes are non-spatial hazards; therefore, it is often difficult to profile tornadoes and determine the exact risk. However, estimations can be developed by analyzing historic occurrences and past declarations. While Ohio does not rank among the top states for the number of tornado events, it does rank within the top 20 states for fatalities, injuries, and dollar losses, indicating that it has a relatively high likelihood for damages resulting from tornadoes. Tornadoes are measured by damage scale based on their winds, with greater damage equating to greater wind speed. The original Fujita-scale (F-scale) was developed without considering a structure's integrity or condition as it relates to the wind speed necessary to damage it. The process of rating the damage was subjective with the original F-scale and arbitrary judgments were the norm. In order to reduce this subjectivity, the Enhanced F-scale (EF- scale) took effect February 1, 2007.

The Enhanced F-scale uses the original F-scale (i.e., F0-F5) and classifies tornado damage across 28 different types of damage indicators, which mostly involve building/structure type, and these are assessed at eight damage levels (1-8). Therefore, construction types and their strengths and weaknesses are incorporated into the EF classification given to a particular tornado. The most intense damage within the tornado path will generally determine the EF-scale given the tornado. Table 2.3.a. lists the classifications under the EF- and F-scale. It should be noted the wind speeds listed are estimates based on damage rather than measurements. Also, there are no plans by National Oceanic Atmospheric Administration or the National Weather Service to re- evaluate the historical tornado data using the Enhanced scale.

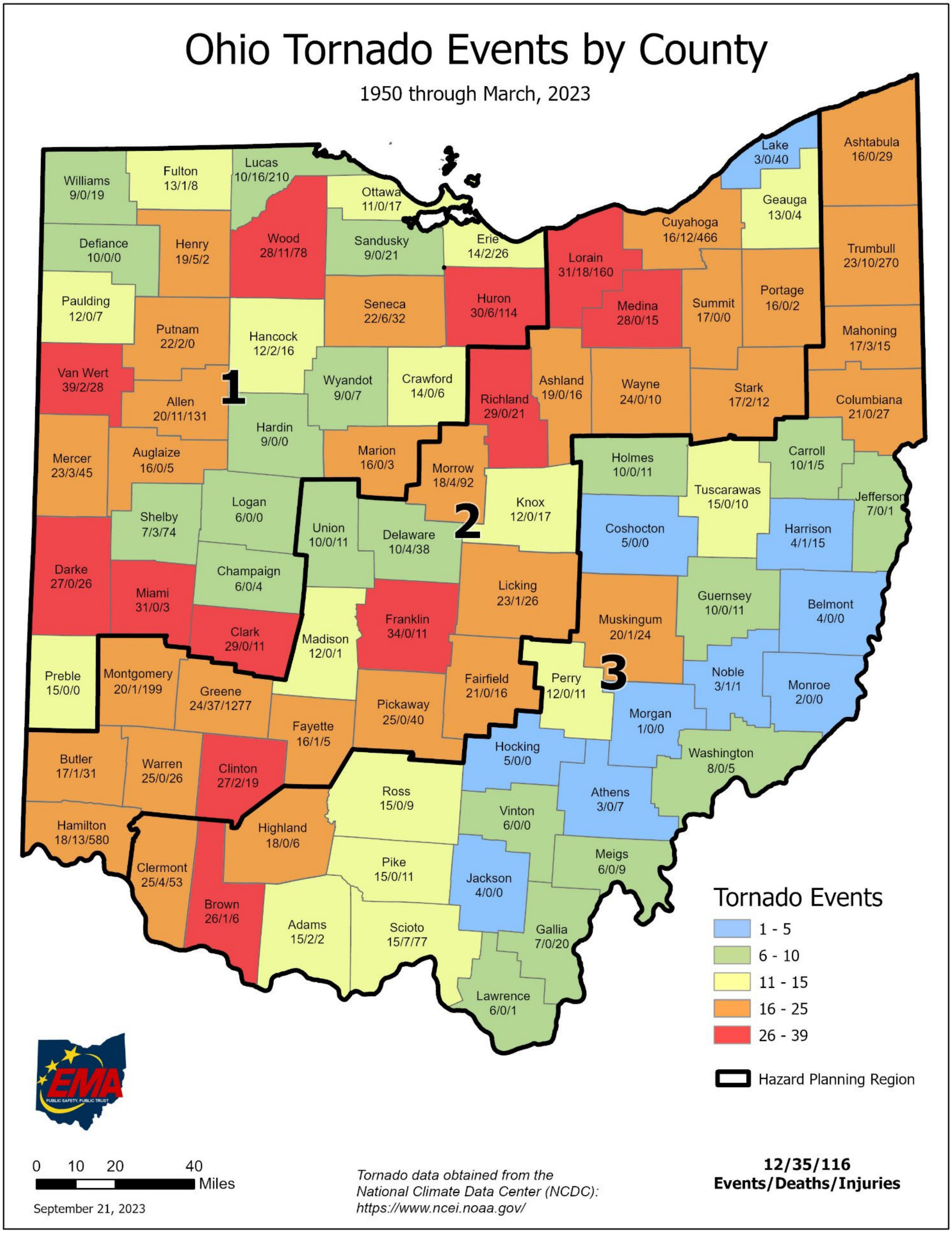
Fujita Scale 3-Second Gust (mph)		Damage Levels	Enhanced Fujita Scale 3-Second Gust (mph)	
F-0	45-78	Light - tree branches down	EF-0	65-85
F-1	79-117	Moderate - roof damage	EF-1	86-110
F-2	118-161	Considerable - houses damaged	EF-2	111-135
F-3	162-209	Severe - buildings damaged	EF-3	136-165
F-4	210-261	Devastating - structures leveled	EF-4	166-200
F-5	262-317	Incredible - whole towns destroyed	EF-5	Over 200

Table 2.3.a - Source: http://www.spc.noaa.gov/faq/tornado/ef-scale.html

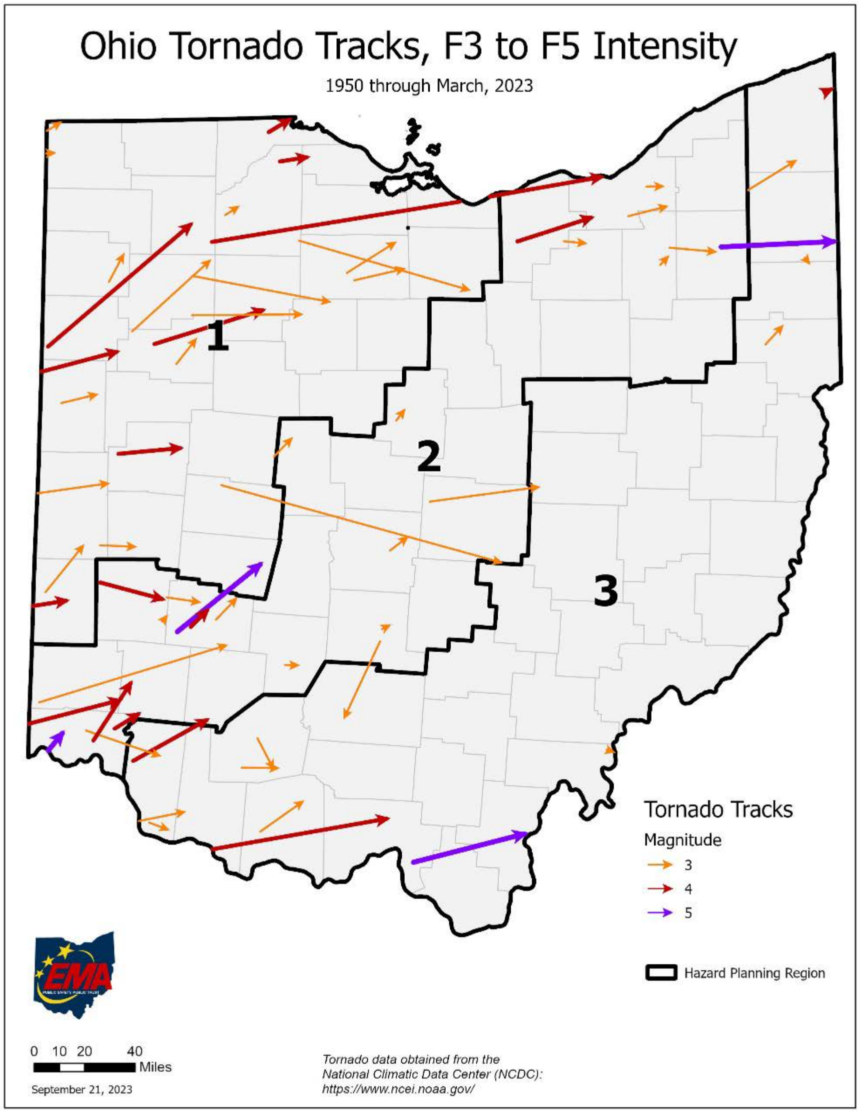
RISK ASSESSMENT

LOCATION

The wind zones in the United States map (Map 2.3.a) indicate that the entire state falls within the 250 mile per hour zone, but the frequency in which Tornadoes occurs varies greatly depending on which county you are located. Ohio has a significant history of past tornado events. Map 2.3.b depicts the touchdowns of 1414 tornadoes that struck the State between 1950 and 2023. The counties in red have the greatest number of tornadoes touchdowns in that time period. In order, those counties are: Van Wert (39), Franklin (34), Lorain (31), Miami (31) and Huron (30). When looking at a regional perspective Region 1 (488) and Region 2 (525) have had significantly more Tornadoes than Region 3 (354). Much of the variance in the number of Tornadoes between Region 1 and 2, and Region 3 is due to the topography of Region 3.


Ohio Tornado Events by County
1950 through March, 2023
Williams 9/0/19
Fulton 13/1/8
Lucas 10/16/210
Ottawa 11/0/17
Lake 3/0/40
Ashtabula 16/0/29
Defiance 10/0/0
Henry 19/5/2
Wood 28/11/78
Sandusky 9/0/21
Erie 14/2/26
Lorain 31/18/160
Cuyahoga 16/12/466
Geauga 13/0/4
Trumbull 23/10/270
Paulding 12/0/7
Putnam 22/2/0
Hancock 12/2/16
Seneca 22/6/32
Huron 30/6/114
Medina 28/0/15
Summit 17/0/0
Portage 16/0/2
Mahoning 17/3/15
Van Wert 39/2/28
Allen 20/11/131
Wyandot 9/0/7
Crawford 14/0/6
Richland 29/0/21
Ashland 19/0/16
Wayne 24/0/10
Stark 17/2/12
Columbiana 21/0/27
Mercer 23/3/45
Auglaize 16/0/5
Hardin 9/0/0
Marion 16/0/3
Morrow 18/4/92
Holmes 10/0/11
Carroll 10/1/5
Tuscarawas 15/0/10
Jefferson 7/0/1
Shelby 7/3/74
Logan 6/0/0
Union 10/0/11
Delaware 10/4/38
Knox 12/0/17
Coshocton 5/0/0
Harrison 4/1/15
Darke 27/0/26
Miami 31/0/3
Champaign 6/0/4
Licking 23/1/26
Guernsey 10/0/11
Belmont 4/0/0
Muskingum 20/1/24
Clark 29/0/11
Madison 12/0/1
Franklin 34/0/11
Preble 15/0/0
Montgomery 20/1/199
Greene 24/37/1277
Fayette 16/1/5
Pickaway 25/0/40
Fairfield 21/0/16
Perry 12/0/11
Noble 3/1/1
Monroe 2/0/0
Morgan 1/0/0
Hocking 5/0/0
Washington 8/0/5
Butler 17/1/31
Warren 25/0/26
Clinton 27/2/19
Ross 15/0/9
Athens 3/0/7
Vinton 6/0/0
Hamilton 18/13/580
Highland 18/0/6
Clermont 25/4/53
Pike 15/0/11
Jackson 4/0/0
Meigs 6/0/9
Brown 26/1/6
Adams 15/2/2
Scioto 15/7/77
Gallia 7/0/20
Lawrence 6/0/1
1
2
3
Tornado Events
1 - 5
6 - 10
11 - 15
16 - 25
26 - 39
Hazard Planning Region
EMA
PUBLIC SAFETY PUBLIC TRUST
0 10 20 40
Miles
September 21, 2023
Tornado data obtained from the National Climate Data Center (NCDC): https://www.ncei.noaa.gov/
12/35/116
Events/Deaths/Injuries

Map 2.3.b – Source - NOAA Storm Database



Map 2.3.c indicates the tracks of the F 3 or greater Tornadoes that have occurred in the state from 1950-2023. The tracks of these high intensity Tornadoes are generally spread throughout the state with the exception of the southern and eastern portions of Region 3. The highest intensity or F5 Tornadoes tracks are indicated in purple and have occurred in all of the regions in the state. Only one F5 tornado has occurred in Region 1, even though a large number of F 3 and F4 Tornadoes occurred within that Region.

Map 2.3.c – Source - NOAA Storm Database

LHMP DATA

CLERMONT COUNTY

There were two events in 2012 that caused significant damages. The first was on March 2, 2012, and this tornado was categorized as an EF3. The Village of Moscow, parts of Franklin, Washington, & Tate Townships were all in the direct path, resulting in 353 structures damaged and 18 residential structures destroyed causing roughly $3,700,000 in damages with three lives lost and 13 injured. The second tornado event occurred on September 8, 2012. The Village of Moscow was hit the hardest with 2 homes destroyed. The location, frequency and impacts of tornadoes cannot be accurately predicted. However, an analysis of historic events can provide a reasonable understanding of expected future risks. Clermont County has had 26 tornadoes in 20 unique years since 1953, and they have sustained total losses of approximately

$15.3 million. The annual chance of occurrence for a tornado is 23%. The annualized risk is approximately $190,883 with 1 injury and 3% chance of life loss.

GREENE COUNTY

Greene County has been directly impacted by 24 tornadoes. The County has been part of 3 federal disaster declarations relating to tornadoes. Two resulted in public assistance, and one has resulted in Individual Assistance.

The April 3rd, 1974 tornado measured by any metric, the worst tornado that Greene County has ever experienced was part of a Super Outbreak. Striking at 4:40 in the afternoon, the tornado was the most powerful on the old Fujita Scale, an F5. It tore straight through Xenia, destroying much of the city, killing 36, and injuring 1,150 others. Total damages were estimated at $250 million.

On Sept. 20th, 2000, a violent tornado that moved at 65 mph hit the town of Xenia for the second time in 26 years damaging some of the same areas that were hit in 1974. Along the path of the tornado, around 250 homes were either damaged or destroyed, over 40 businesses were damaged or destroyed including the local Wal Mart, Kroger, and Tire Discounters, and 6 churches were damaged. A strip mall was nearly destroyed, cars were thrown from the Highway 35 bypass into ditches, 4 semi-trailers were thrown up to 400 yards, and most of the buildings were damaged or destroyed at the Greene County fairgrounds. In Sugarcreek Township, which is to the southwest of Xenia, an additional 14 houses and 3 barns were damaged and some crops were destroyed on a narrow path. Over 10,000 residents were without power for at least 1 day.

Greene County also suffered impacts from the 2019 Memorial Weekend Tornado Outbreak (DR 4447), the tornado first touched down in Riverside in far eastern Montgomery County at 10:12 PM before quickly moving into western Greene County at 10:13 PM. The tornado continued to move east across western and central Greene County before lifting along U.S. 68, about 5 miles north of Xenia. There were two locations along the track of this tornado in the Beavercreek area where damage was indicative of EF3 intensity. The first was in the vicinity of I-675 and Grange Hall Road. Several homes along Rushton Drive had entire roofs lifted, as well as the collapse of several exterior walls with only interior walls left standing. Additional homes along Gardenview and Wendover Drives experienced high-end EF2 damage with windows shattered, garage doors collapsed and entire roof structures removed.

Additional EF3 damage occurred in Beavercreek near Anna Laura Lane. In this area, some buildings of an apartment complex had large sections of roofs removed and exterior walls on upper levels collapsed, leaving just interior walls standing. Most of the damage from near Grange Hall Road eastward to businesses near North Fairfield Road was EF2 to EF1 type damage, where some concrete block businesses had partially collapsed walls and roof lift off.

CUYAHOGA COUNTY

The Cuyahoga County All-Hazards Mitigation Plan (2022) provides a comprehensive history of the tornado events that have occurred within Cuyahoga County from 1950-2021 including a tornado track map. According to the Cuyahoga County LHMP, sixteen tornadoes were reported in between 1950 and 2021. These tornadoes caused 12 deaths, 466 injuries and over $426 million dollars of damage in 2022 dollars. The Cuyahoga County LHMP states, while all county assets are considered at risk from this hazard, a particular tornado would only cause damages along its specific track. A high-magnitude tornado sweeping through densely-populated portions of the County would have extensive injuries, deaths, and economic losses. There is no way to be sure how many people would be injured or killed due to the difference that time of day and year can make, but property values can provide an estimate of economic losses.

VAN WERT COUNTY

Per the 2021 Van Wert County LHMP, Van Wert County has the highest occurrences of Tornadoes in the state. The most devastating event in recent history occurred on November 10, 2002, when a F4 tornado struck the City of Van Wert, killing 2 people and causing over $50 million dollars in damages and other economic losses. This event is ranked among the top 10 Tornadoes to ever hit the northeastern United States. While Tornadoes can cause significant damage to structural assets, it is almost impossible to predict vulnerability and damages due to the inherent characteristics of how and when Tornadoes develop. Based on past events, some events are relatively minor and losses to the County have been negligible, limited primarily to vehicles and minor structural damages. However, other events are quite significant with considerable losses to buildings and equipment, and in some cases injuries and even deaths have occurred

Using HAZUS property values as estimates and the potential building exposure for the county with those assumptions, Van Wert County has a total exposure of 4,957 structures valued at $ 1,440,265,000

PAST OCCURRENCES

XENIA – 1974

According to a Dayton Daily News article (April 2011), on April 3, 1974 an F-5 tornado tore through the heart of Xenia, killing 36 people and injuring more than 1,300 others. It bulldozed a path more than a half-mile wide, destroying or damaging more than 1,400 buildings, including 1,200 homes, dozens of businesses, 10 churches, and several schools. By the time it lifted into the sky near Cedarville, it left behind more than $100 million of damage in Greene County. The Xenia tornado was part of a super outbreak, when 148 twisters swept across several states, killing 335 people in a 16-hour period on April 3-4, 1974. It still ranks as one of the largest natural disasters in American history, with Xenia the hardest hit community.

Photograph 2.3.a – source - NWS

The Xenia subdivision of “Arrowhead” was especially hard-hit, the tornado leaving it in ruins. The 4-year-old subdivision on the city’s southwest side lost more than 300 homes, many on concrete slabs with no basements. Greene Memorial Hospital in northeast Xenia narrowly escaped the tornado’s wrath, but lost its power and telephone service and its water quality was suspect. About 500 people were treated there in the first 24 hours, 34 of them being admitted with a number transferred to hospitals in nearby Dayton for treatment.

XENIA - 2000

Twenty-six years later another tornado (an F-4) struck at an unusual time – early autumn and after dark – on September 20, 2000. The tornado would follow an eerily familiar path of destruction through Xenia, killing one man and destroying or damaging more than 300 homes and 30 businesses.

Photograph 2.3.b – source - Dayton Daily News

MAY TORNADO OUTBREAK - 1985

Per the NWS, on May 31, 1985, twenty-one tornadoes tracked across Northeast Ohio and Northwest Pennsylvania during that evening. Of these 21, one was rated an F5, and six were rated F4's. Tragically, these tornadoes killed 76 people in Ohio and Pennsylvania. In Ohio, this was the worst event since the April 3-4th, 1974 outbreak that killed 37 in Xenia.

The strongest of the tornadoes touched down at the Ravenna Arsenal in eastern Portage County around 6:35 p.m. The tornado intensified to an F5 as it tracked east across southern Trumbull County, devastating the communities of Newton Falls and Niles. Nine people were killed in the business district of Niles.

Photograph 2.3.c – Source - NWS

Photograph 2.3.d – Source - NWS

The residents of Ohio will long remember May 31st, 1985. Rarely has such an outbreak of tornadoes been seen in this county and never before in this area. This day serves as a reminder that devastating tornadoes can occur in any month of the year at any time of the day and at any location in the country.

BLUE ASH TORNADO - 1999

Another notable tornado occurred in April 1999 in the counties of Clinton, Hamilton, and Warren. The tornadoes killed four people, injured 42, and damaged or destroyed 400 structures, causing about $82 million in losses (Ohio EMA 16). It was a lone supercell thunderstorm that produced this F4 tornado, with winds between 207 and 260 mph.

Photograph 2.3.e – Source - Cincinnati Enquirer

DR-1444 - 2002 & DR-1484 - 2003

In more recent years, there have been two disaster declarations: DR-1444, which was for tornado-related damage, and DR-1484, which covered tornado and flood related damage. DR-1444 was in November 2002 and affected several counties throughout the state. Many of the residents of the impacted counties were left homeless or were trapped in debris, damage to commercial structures created localized unemployment, hundreds of injuries were reported, and multiple lives were lost.

Photograph 2.3.F – Source - OSHP

DR-1484 occurred in August 2003 and was the most recent declaration that included tornadic damage. The tornado was confirmed as an F-1 and affected part of the City of Youngstown and parts of the unincorporated areas of the County. The tornado was 50-100 yards wide and eight miles long. Sixty homes received major damage and 20 received minor damage. The estimated loss from this tornado was $900,000 and approximately 33% of the structures were insured.

2010 TORNADOES

The first event occurred in June 5 - 6, when a major tornado outbreak affected the Midwestern United States and Great Lakes Region. At least 46 tornadoes were confirmed from Iowa to southern Ontario and Ohio as well as northern New England. Tornadoes moved through northern Ohio affecting Fulton, Lucas, Wood, Ottawa, Richland, Holmes and Tuscarawas Counties. While all counties sustained heavy structural damage, the event resulted in seven people dead in Wood County. The Governor of Ohio issued an Emergency Proclamation for the event and requested a Presidential Declaration for the area, however, none was granted. Regardless, tornadoes ranged from EF-0 northeast of Lucas, Ohio in Richland County, to an EF-4 tornado that resulted in 78 homes with major damage and 97 with minor damage. The total residential loss was approximately $7,545,300. Thirty-two businesses had major damage and three had minor damage resulting in $4,661,000 in losses. The Counties experienced a total of $1,263,858 in infrastructure damage.

The second event occurred when severe weather and tornadoes swept across the state in the afternoon of September 16th. The National Weather Service confirmed 11 tornadoes in Wayne, Holmes, Fairfield, Athens, Perry, Meigs, Delaware and Tuscarawas Counties. The tornadoes ranged from EF-0 to EF-3, and Athens, Meigs, Pickaway, Perry and Wayne Counties declared a local state of emergency. Thirteen people were injured in Athens County, while six were injured in Meigs County. State and county teams assessed the damaged structures to be 62 destroyed, 77 with major damage, 113 with minor damage and 373 structures as affected. Residential loss equated to 2,227 claims amounting in $11,400,000, while business losses included 287 claims amounting in $4,700,000.

MOSCOW TORNADO - 2012

In March 2012, Brown and Clermont Counties experienced a devastating EF-3 tornado that came up from Kentucky and into Ohio. Thunderstorms developed during the afternoon in a high wind shear environment ahead of a strengthening low-pressure system. Many of these storms became severe, with large hail, damaging thunderstorm winds, and tornadoes all being the main threats. The tornado traveled seven miles in the Kentucky counties of Campbell and Pendleton. The tornado then moved into Clermont County, Ohio at 4:46 pm, where it hit the town of Moscow. It continued on the ground across Clermont County, crossing into Brown County around 4:58 pm. It then lifted south of Hamersville in western Brown County. This tornado caused extensive damage to structures and trees along its entire path on both sides of the Ohio River. Numerous homes were very heavily damaged or destroyed. Many homes lost their roofs, having complete exterior wall failure. Some modular homes were completely removed from their foundations, lifted, and thrown in excess of 100 yards where they were destroyed. The damage in Ohio from this tornado was consistent with maximum winds estimated at 160 miles per hour in Clermont County, and 100 miles per hour in Brown County. Clermont County experienced three deaths from the tornado. One fatality occurred in Moscow in Clermont County, while two others occurred in Bethel. Thirteen injuries were reported resulting from this storm. Property damage was estimated at $5,660,000.

Photograph 2.3.g – Source - OEMA

As this same system moved into Adams County it caused an additional fatality. A tornado touched down just east of Highway 41, about 2 miles northeast of West Union. The tornado then traveled northeast for just over 11 miles, destroying at least 5 mobile homes and damaging two other houses. One of these homes was built of brick. A 99 year old woman was in her mobile home in Tiffin Township when the tornado struck. She was injured from this tornado and passed away several days later. Two other people were also injured from this tornado. A dozen cattle were killed and major power transmission poles were knocked over. Numerous trees were snapped or uprooted. Based on the damage surveyed, the maximum estimated wind speed of this tornado was 125 miles per hour and caused an estimated $2 million in damage. The path of the tornado continued east into Pike and Scioto Counties causing an additional estimated $230,000 in damage, but no other fatalities or injuries were reported.

CEDARVILLE TORNADO - 2014

A narrow but intense tornado ripped through Greene County on May 14, 2014, while sparing the nearby town of Cedarville. The NWS in Wilmington confirmed an EF3 tornado hit the area, packing winds as high as 145 mph. Cedarville is nine miles northeast of Xenia, the site of a massive F5 tornado that killed dozens during the Super outbreak of April 4, 1974. The NWS says two people were injured and several homes were hit by the tornado. This includes completely destroying two homes and causing over $500,000 in damage.

Photograph 2.3.h - Source - NWS

MEMORIAL DAY WEEKEND - 2019

The devastating tornadoes started shortly after 10 p.m. in Mercer County, just west of the City of Celina. The final confirmed tornado was reported in Roseville, Perry County, at 2:30 a.m. on May 28. National Weather Service teams in the region counted 21 tornadoes on May 27-28, 2019, based on damage surveys, photographs, and videos. At least 166 people were injured in Ohio, and more than 500 homes were damaged or destroyed. The total damage was estimated at around $1 billion. Various tornadoes struck the western half of Ohio

Photograph 2.3.i - Source - NWS

A strong EF3 tornado (150 mph) turned deadly in Celina with 150 mph winds, claiming the life of an 82-year-old man when an unoccupied car was tossed into his home.

Photograph 2.3.j - Source - NWS

A violent EF4 tornado that touched down west of Brookville, in Montgomery County, traveled 20 miles through Trotwood, Dayton, and Riverside.

Photograph 2.3.k - Source - NWS

Two additional EF3 tornadoes (136 to 165 mph) were confirmed in Darke-Miami counties beginning near West Milton, and in eastern Montgomery-western Greene counties, where a tornado traveled 14 miles through Beavercreek shortly after 11 p.m., damaging or destroying more than 100 homes. Three tornadoes touched down in Pickaway and Hocking counties. The strongest reached EF2 intensity near Laurelville. The nighttime aspect of this historic tornado outbreak — between 10 p.m. on May 27 and 2 a.m. on May 28 — made the situation all the more frightening, since tornado spotting at night is nearly impossible unless revealed by lightning flashes.

PAST OCCURRENCES

Between 1950-2023, Ohio has experienced 1,414 tornadoes, an average of 19.36 tornadoes annually. The majority of Tornadoes that have occurred in the state have been between an EF-0 and EF-2 (92.2%). Table 2.3.b give a breakdown of the various EF tornado events that have occurred in the state from 1950-2023.

Year	F0	F1	F2	F3	F4	F5	Total
1950	0	1	1	1	0	0	3
1951	0	1	2	0	0	0	3
1952	0	2	0	0	0	0	2
1953	0	1	1	0	6	0	8
1954	6	5	2	0	0	0	13
1955	0	2	2	2	0	0	6
1956	1	2	5	2	0	0	10
1957	0	1	3	0	0	0	4
1958	1	5	6	0	0	0	12
1959	5	2	2	1	0	0	10
1960	1	4	2	0	0	0	7
1961	6	6	4	3	1	0	20
1962	1	1	2	0	0	0	4
1963	5	8	6	0	0	0	19
1964	3	2	4	0	0	0	9
1965	2	14	12	3	8	0	39
1966	0	1	1	1	0	0	3
1967	0	3	3	0	0	0	6

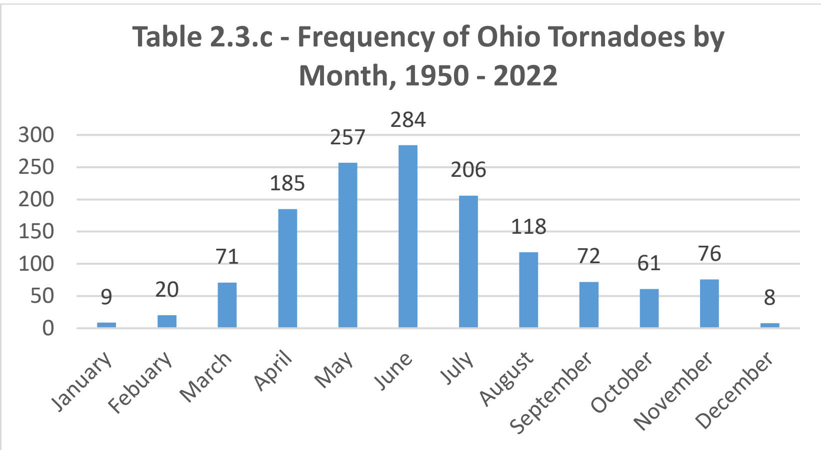
1968	1	7	4	0	5	3	20
1969	1	11	1	8	0	0	21
1970	6	7	9	1	0	0	23
1971	1	3	7	4	0	0	15
1972	1	7	2	0	0	0	10
1973	17	17	11	10	0	0	55
1974	3	11	4	2	2	3	25
1975	2	6	4	0	0	0	12
1976	7	3	2	0	0	0	12
1977	5	15	3	1	0	0	24
1978	4	15	2	1	0	0	22
1979	1	2	1	0	0	0	4
1980	1	30	6	0	0	0	37
1981	6	14	6	1	0	0	27
1982	0	7	3	0	0	0	10
1983	0	6	2	2	0	0	10
1984	0	2	0	0	0	0	2
1985	2	11	5	4	2	3	27
1986	3	13	11	0	0	0	27
1987	2	3	1	0	0	0	6
1988	0	0	0	0	0	0	0
1989	4	11	4	0	0	0	19
1990	13	8	7	0	4	0	32
1991	6	2	0	1	0	0	9
1992	26	20	12	4	1	0	63
1993	2	3	0	0	0	0	5
1994	4	5	0	0	0	0	9
1995	6	2	0	0	0	0	8

1996	6	4	0	0	0	0	10
1997	7	6	1	1	0	0	15
1998	17	6	3	0	0	0	26
1999	10	9	1	1	1	0	22
2000	9	10	7	0	1	0	27
2001	4	2	2	1	0	0	9
2002	8	12	8	5	1	0	34
2003	7	4	2	0	0	0	13
2004	4	5	0	0	0	0	9
2005	2	2	0	0	0	0	4
2006	22	11	4	0	0	0	37
2007	8	5	0	0	0	0	13
2008	12	2	1	0	0	0	15
2009	10	3	0	0	0	0	13
2010	20	23	5	2	1	0	51
2011	24	14	2	0	0	0	40
2012	11	2	1	1	0	0	15
2013	20	14	3	0	0	0	37
2014	16	4	0	1	0	0	21
2015	5	2	0	0	0	0	7
2016	16	7	3	0	0	0	26
2017	16	21	7	0	0	0	44
2018	8	11	0	0	0	0	19
2019	28	22	4	3	1	0	58
2020	20	4	0	0	0	0	24
2021	15	14	4	0	0	0	33
2022	14	16	3	0	0	0	33
2023	31	13	3	0	0	0	47

Total	**525**	550	229	67	34	9	1414

Table 2.3.b – Source - NOAA Storm Database

Considering more tornadoes have formed in June than any other month, there is approximately a 20.7 percent chance of a tornado on any day in June. The likelihood of a tornado is lower during the winter and higher during the summer, as indicated in Graph 2.3.a.



Graph 2.3.a – Source NOAA Storm Database

Every County in the state of Ohio has experienced at least one tornado from 1950-2023, and six counties have each recorded at least 30 tornadoes (see table 2.3.d). Van Wert and Franklin Counties have had the most Tornadoes with 39 and 34 respectively. Note that prior to 1900 Tornadoes were not documented and rarely reported.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHODOLOGY

In the National Risk Index, a tornado risk index score and rating represent a community's relative risk for Tornadoes when compared to the rest of the United States. A tornado expected annual loss score and rating represent a community's relative level of expected building and population loss each year due to Tornadoes when compared to the rest of the United States. The National Risk Index – Technical Documentation (Appendix J) describes in greater detail the methodology used to perform the risk analysis for Tornadoes. Generally, the tornado exposure value represents a community's building value (in dollars) and population (in both people and population equivalence), and agriculture value (in dollars) exposed to Tornadoes.

County	Exposure (Buildings)	Exposure (Population)	Exposure (Agriculture)
Adams	$ 7,250,020,475	27463	$ 46,001,867
Allen	$ 22,716,708,588	102191	$ 160,496,256
Ashland	$ 13,803,678,610	52443	$ 130,487,461
Ashtabula	$ 20,560,536,719	97518	$ 66,415,498
Athens	$ 11,699,628,860	62393	$ 13,104,471

Auglaize	$ 9,860,532,402	46399	$ 237,335,321
Belmont	$ 13,488,466,636	66461	$ 29,087,217
Brown	$ 8,791,650,830	43652	$ 82,277,263
Butler	$ 75,012,204,432	390244	$ 62,955,865
Carroll	$ 5,326,823,085	26701	$ 55,775,343
Champaign	$ 7,667,577,552	38673	$ 137,134,143
Clark	$ 26,184,456,652	135980	$ 145,090,222
Clermont	$ 36,078,126,867	208527	$ 36,442,863
Clinton	$ 10,400,046,542	41956	$ 134,061,383
Columbiana	$ 21,193,341,284	101872	$ 122,355,264
Coshocton	$ 7,743,404,536	36580	$ 113,678,424
Crawford	$ 7,313,887,213	42015	**$ 268,368,664**
Cuyahoga	**$ 244,271,620,347**	**1264334**	$ 7,139,284
Darke	$ 14,009,129,640	51868	**$ 592,046,670**
Defiance	$ 8,087,444,704	38229	$ 123,028,714
Delaware	$ 54,674,879,512	213208	$ 99,598,499
Erie	$ 17,826,579,068	75596	$ 108,040,692
Fairfield	$ 29,693,562,383	158878	$ 114,416,499
Fayette	$ 7,200,569,590	28951	$ 145,919,280
Franklin	**$ 236,422,365,963**	**1323446**	$ 59,817,357
Fulton	$ 9,458,090,692	42713	$ 198,555,183
Gallia	$ 5,985,030,900	29179	$ 21,771,339
Geauga	$ 21,951,348,661	95397	$ 41,416,609
Greene	$ 32,904,572,507	167939	$ 111,374,164
Guernsey	$ 8,571,916,308	38372	$ 30,718,163
Hamilton	**$ 153,888,698,740**	**830623**	$ 26,421,546
Hancock	$ 15,955,317,386	74885	$ 155,722,617
Hardin	$ 5,771,780,125	30690	**$ 255,601,798**

Harrison	$ 2,837,123,823	14475	$ 21,371,245
Henry	$ 6,671,430,216	27662	$ 153,003,310
Highland	$ 10,507,328,303	43282	$ 140,989,067
Hocking	$ 6,751,958,435	28040	$ 5,834,953
Holmes	$ 11,951,498,604	44196	$ 208,850,782
Huron	$ 12,267,907,773	58532	$ 229,320,807
Jackson	$ 6,971,680,704	32646	$ 12,654,530
Jefferson	$ 15,713,558,690	65187	$ 10,548,230
Knox	$ 14,262,973,508	62691	$ 155,013,155
Lake	$ 45,763,676,596	232492	$ 84,443,953
Lawrence	$ 9,823,219,144	58183	$ 4,625,383
Licking	$ 37,618,983,655	178382	$ 212,638,122
Logan	$ 13,072,529,195	45835	$ 139,648,149
Lorain	$ 63,415,048,848	312902	$ 153,571,419
Lucas	$ 84,065,358,995	431225	$ 58,114,456
Madison	$ 8,575,780,568	43789	$ 182,647,724
Mahoning	$ 48,322,567,878	228579	$ 78,699,686
Marion	$ 12,618,822,391	65349	$ 155,912,944
Medina	$ 38,977,305,363	182378	$ 59,097,992
Meigs	$ 4,709,053,511	22183	$ 19,054,372
Mercer	$ 13,482,838,954	42522	**$ 724,437,877**
Miami	$ 24,042,809,985	108774	$ 122,404,090
Monroe	$ 4,269,411,186	13379	$ 16,020,912
Montgomery	**$ 99,451,730,751**	**537193**	$ 90,263,913
Morgan	$ 2,734,311,820	13787	$ 20,660,347
Morrow	$ 6,740,057,169	34943	$ 96,569,984
Muskingum	$ 18,106,752,065	86374	$ 80,370,075
Noble	$ 4,120,330,194	14107	$ 8,365,126

Ottawa	$ 13,873,314,133	40343	$ 67,919,699
Paulding	$ 5,212,443,329	18790	$ 198,980,415
Perry	$ 5,607,927,097	35327	$ 38,807,640
Pickaway	$ 12,399,763,844	58527	$ 186,562,233
Pike	$ 6,578,325,422	27037	$ 63,156,277
Portage	$ 32,692,818,126	161780	$ 39,552,855
Preble	$ 8,365,928,677	40984	$ 167,747,600
Putnam	$ 6,676,187,095	34443	$ 246,010,331
Richland	$ 24,198,309,075	124906	$ 155,034,818
Ross	$ 13,696,889,502	77071	$ 89,156,257
Sandusky	$ 13,863,139,112	58813	$ 115,856,168
Scioto	$ 11,861,302,547	73911	$ 20,459,899
Seneca	$ 11,329,882,913	55063	$ 161,581,658
Shelby	$ 14,107,369,217	48215	$ 204,457,715
Stark	$ 76,095,235,247	374812	$ 109,916,533
Summit	**$ 108,471,919,232**	**540333**	$ 14,459,158
Trumbull	$ 42,033,156,468	201961	$ 64,314,882
Tuscarawas	$ 19,321,270,818	93231	$ 143,573,861
Union	$ 13,980,628,662	62265	$ 240,069,701
Van Wert	$ 5,627,990,573	28929	$ 219,408,525
Vinton	$ 2,259,117,031	12767	$ 6,529,618
Warren	$ 49,577,843,084	242269	$ 54,672,546
Washington	$ 11,589,652,639	59732	$ 48,217,160
Wayne	$ 24,062,125,634	116847	**$ 376,044,644**
Williams	$ 9,168,323,113	37098	$ 140,850,996
Wood	$ 34,370,108,616	132182	$ 182,623,882
Wyandot	$ 4,936,442,754	21893	$ 180,432,174
Grand Total	**$2,381,567,460,093**	**11793992**	**$ 10,714,185,787**

Table 2.3.c

A tornado annualized frequency value represents the average number of recorded tornado hazard occurrences (events) per year over the period of record (34 years). The Expected Annual Loss represents the relative level of building, population and agriculture value loss each year due to Tornadoes.

County	EAL (Buildings)	EAL (Population Equivalence)	EAL (Agriculture)	EAL (Total)
Adams	$ 560,945.28	$ 174,986.73	$ 380.16	$ 736,312.17
Allen	$ 2,212,794.70	$ 389,954.48	$ 1,216.08	$ 2,603,965.27
Ashland	$ 1,093,273.68	$ 284,230.45	$ 847.19	$ 1,378,351.32
Ashtabula	$ 1,357,664.99	$ 1,439,157.69	$ 942.58	$ 2,797,765.27
Athens	$ 441,074.70	$ 174,713.77	$ 71.97	$ 615,860.44
Auglaize	$ 1,186,504.88	$ 420,138.67	$ 1,871.48	$ 1,608,515.03
Belmont	$ 585,740.09	$ 519,287.01	$ 427.54	$ 1,105,454.64
Brown	$ 777,533.57	$ 318,898.91	$ 591.13	$ 1,097,023.60
Butler	**$ 14,813,609.80**	**$ 9,908,728.78**	$ 708.35	**$ 24,723,046.94**
Carroll	$ 202,435.84	$ 147,949.42	$ 923.06	$ 351,308.32
Champaign	$ 829,982.48	$ 309,097.85	$ 1,212.90	$ 1,140,293.24
Clark	$ 2,352,486.39	$ 1,055,878.48	$ 683.09	$ 3,409,047.95
Clermont	$ 3,018,082.84	$ 2,192,618.03	$ 310.25	$ 5,211,011.12
Clinton	$ 1,061,113.12	$ 329,922.34	$ 1,024.33	$ 1,392,059.79
Columbiana	$ 1,021,514.63	$ 971,779.87	$ 2,212.04	$ 1,995,506.54
Coshocton	$ 483,601.12	$ 168,456.99	$ 980.83	$ 653,038.94
Crawford	$ 331,146.81	$ 547,425.46	$ 1,674.00	$ 880,246.27
Cuyahoga	**$ 15,861,766.04**	**$ 12,474,229.37**	$ 41.41	**$ 28,336,036.82**
Darke	$ 3,013,680.71	$ 1,441,069.87	**$ 3,938.91**	$ 4,458,689.49
Defiance	$ 1,379,020.39	$ 777,368.11	$ 3,037.46	$ 2,159,425.95
Delaware	$ 5,018,228.75	$ 1,431,603.62	$ 829.00	$ 6,450,661.37
Erie	$ 1,877,044.38	$ 1,087,341.53	$ 609.47	$ 2,964,995.39
Fairfield	$ 2,068,318.34	$ 828,937.51	$ 795.24	$ 2,898,051.09
Fayette	$ 701,915.72	$ 241,659.94	$ 576.27	$ 944,151.93

Franklin	**$ 16,964,075.28**	**$ 8,424,863.31**	$ 447.31	**$ 25,389,385.90**
Fulton	$ 1,554,829.50	$ 787,732.53	**$ 4,814.36**	$ 2,347,376.39
Gallia	$ 188,994.26	$ 68,124.89	$ 78.26	$ 257,197.41
Geauga	$ 889,893.90	$ 541,943.75	$ 194.32	$ 1,432,031.97
Greene	$ 3,148,976.47	$ 1,287,681.50	$ 990.60	$ 4,437,648.57
Guernsey	$ 373,098.26	$ 143,097.88	$ 181.79	$ 516,377.93
Hamilton	**$ 26,206,184.50**	**$ 21,075,837.06**	$ 300.14	**$ 47,282,321.70**
Hancock	$ 1,686,552.20	$ 1,773,200.83	$ 1,096.66	$ 3,460,849.69
Hardin	$ 588,275.47	$ 219,038.09	$ 1,921.44	$ 809,235.00
Harrison	$ 98,471.26	$ 46,646.73	$ 328.66	$ 145,446.65
Henry	$ 831,867.28	$ 451,393.87	$ 1,062.34	$ 1,284,323.49
Highland	$ 957,653.64	$ 318,726.39	$ 1,010.88	$ 1,277,390.91
Hocking	$ 405,619.52	$ 124,662.89	$ 54.47	$ 530,336.88
Holmes	$ 843,614.29	$ 254,082.46	$ 1,464.55	$ 1,099,161.31
Huron	$ 1,256,059.58	$ 768,469.49	$ 1,466.07	$ 2,025,995.14
Jackson	$ 298,510.46	$ 105,126.56	$ 57.18	$ 403,694.20
Jefferson	$ 625,662.58	$ 336,906.51	$ 168.71	$ 962,737.80
Knox	$ 1,190,822.93	$ 361,368.17	$ 1,192.27	$ 1,553,383.37
Lake	$ 1,937,373.61	$ 1,163,998.29	$ 294.00	$ 3,101,665.90
Lawrence	$ 304,887.85	$ 648,827.24	$ 46.01	$ 953,761.10
Licking	$ 928,659.31	$ 960,870.10	$ 1,851.99	$ 1,891,381.40
Logan	$ 1,384,593.88	$ 371,444.11	$ 1,287.90	$ 1,757,325.89
Lorain	$ 4,492,399.52	$ 2,656,067.86	$ 916.94	$ 7,149,384.32
Lucas	**$ 8,862,877.93**	**$ 6,633,781.87**	$ 383.25	**$ 15,497,043.06**
Madison	$ 840,108.32	$ 316,114.99	$ 835.23	$ 1,157,058.54
Mahoning	$ 2,865,534.10	$ 2,890,943.59	$ 1,398.81	$ 5,757,876.50
Marion	$ 1,101,547.11	$ 434,912.18	$ 1,122.88	$ 1,537,582.17
Medina	$ 3,705,558.61	$ 1,879,238.95	$ 379.53	$ 5,585,177.10

Meigs	$ 166,397.12	$ 55,390.15	$ 99.99	$ 221,887.26
Mercer	$ 2,683,122.70	$ 873,184.21	**$ 7,291.39**	$ 3,563,598.30
Miami	$ 2,694,266.44	$ 938,748.30	$ 960.72	$ 3,633,975.46
Monroe	$ 133,867.69	$ 77,108.24	$ 197.09	$ 211,173.02
Montgomery	$ 3,203,839.35	$ 4,318,356.60	$ 779.74	$ 7,522,975.69
Morgan	$ 111,636.83	$ 41,563.87	$ 127.50	$ 153,328.20
Morrow	$ 606,344.57	$ 210,834.43	$ 663.58	$ 817,842.58
Muskingum	$ 948,981.18	$ 382,885.30	$ 518.62	$ 1,332,385.10
Noble	$ 157,686.67	$ 101,974.90	$ 116.13	$ 259,777.70
Ottawa	$ 1,739,954.83	$ 838,731.61	$ 414.35	$ 2,579,100.79
Paulding	$ 881,959.61	$ 380,078.88	**$ 4,820.52**	$ 1,266,859.01
Perry	$ 328,900.46	$ 152,608.38	$ 241.25	$ 481,750.09
Pickaway	$ 983,517.01	$ 343,605.84	$ 1,421.83	$ 1,328,544.68
Pike	$ 385,611.07	$ 136,764.67	$ 509.45	$ 522,885.18
Portage	$ 1,766,953.49	$ 882,776.22	$ 171.05	$ 2,649,900.76
Preble	$ 1,916,782.89	$ 1,209,010.22	$ 1,864.92	$ 3,127,658.04
Putnam	$ 834,436.82	$ 531,136.84	$ 1,482.03	$ 1,367,055.69
Richland	$ 968,261.18	$ 684,323.18	$ 1,099.56	$ 1,653,683.92
Ross	$ 815,998.56	$ 436,197.00	$ 941.23	$ 1,253,136.79
Sandusky	$ 1,471,041.47	$ 959,251.01	$ 708.48	$ 2,431,000.96
Scioto	$ 553,304.41	$ 299,404.57	$ 124.42	$ 852,833.41
Seneca	$ 1,033,103.07	$ 530,510.92	$ 1,031.42	$ 1,564,645.42
Shelby	$ 1,561,193.42	$ 412,105.37	$ 1,609.88	$ 1,974,908.67
Stark	$ 3,981,170.13	$ 1,831,508.12	$ 425.46	$ 5,813,103.72
Summit	$ 4,304,401.81	$ 2,719,678.42	$ 63.89	$ 7,024,144.12
Trumbull	$ 2,571,319.72	$ 3,061,775.76	$ 1,104.35	$ 5,634,199.83
Tuscarawas	$ 545,426.31	$ 205,304.02	$ 630.04	$ 751,360.37
Union	$ 1,454,273.75	$ 481,904.35	$ 2,022.49	$ 1,938,200.58

Van Wert	$ 782,436.10	$ 416,425.31	$ 1,728.40	$ 1,200,589.81
Vinton	$ 122,656.85	$ 48,787.36	$ 72.50	$ 171,516.71
Warren	$ 4,741,126.64	$ 2,119,898.48	$ 276.60	$ 6,861,301.73
Washington	$ 365,776.86	$ 132,639.15	$ 212.48	$ 498,628.49
Wayne	$ 2,153,391.39	$ 469,496.62	$ 2,260.77	$ 2,625,148.77
Williams	$ 1,601,827.01	$ 779,705.63	**$ 3,542.33**	$ 2,385,074.97
Wood	$ 4,132,421.08	$ 2,033,609.80	$ 1,333.27	$ 6,167,364.14
Wyandot	$ 621,938.45	$ 370,976.24	$ 1,378.33	$ 994,293.02
Grand Total	**$ 200,107,507.89**	**$ 122,148,796.90**	**$ 93,497.35**	**$ 322,349,802.14**

Table 2.3.d

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

The state-owned and state-leased critical facilities datasets were used to perform an analysis based upon the spatial location of each critical facility, the replacement cost of that facility and Tornado Risk Index score and rating from the NRI at the census tract level (Appendix J).

Hamilton County has the greatest number of critical facilities (36) in the Relatively High risk rating, followed by Shelby (31), Darke (25), Miami (24) and Butler (24). Mercer County have the greatest number of critical facilities (6) in the Very High-risk rating, followed by Butler (4), Hamilton (1) and Preble (1).

	Very Low		Relatively Low		Relatively Moderate		Relatively High		Very High	
County	**# of CF**	**Replacement Cost**	**# of CF**	**Replacement Cost**	**# of CF**	**Replacement Cost**	**# of CF**	**Replacement Cost**	**# of CF**	**Replacement Cost**
ADAMS	0	$ -	0	$ -	18	$ 3,809,451	12	$ 8,862,854	0	$ -
ALLEN	0	$ -	19	$ 6,347,063	**80**	**$ 142,188,041**	0	$ -	0	$ -
ASHLAND	0	$ -	1	$ 23,670	**144**	**$ 103,467,432**	0	$ -	0	$ -
ASHTABULA	0	$ -	0	$ -	**69**	**$ 24,530,807**	3	$ 664,471	0	$ -
ATHENS	0	$ -	35	$ 53,251,614	0	$ -	0	$ -	0	$ -
AUGLAIZE	0	$ -	0	$ -	17	$ 6,220,319	1	$ 322,500	0	$ -
BELMONT	0	$ -	46	$ 147,324,460	24	$ 6,239,839	0	$ -	0	$ -
BROWN	0	$ -	0	$ -	18	$ 6,359,988	13	$ 29,027,458	0	$ -
BUTLER	0	$ -	0	$ -	1	$ 547,500	**24**	**$ 11,979,606**	**4**	**$ 4,673,173**
CARROLL	0	$ -	3	$ 1,408,948	15	$ 3,811,413	0	$ -	0	$ -
CHAMPAIGN	0	$ -	0	$ -	16	$ 8,259,993	5	$ 986,100	0	$ -
CLARK	0	$ -	1	$ 572,100	26	$ 9,078,822	0	$ -	0	$ -
CLERMONT	0	$ -	2	$ 897,300	27	$ 9,518,724	22	$ 22,551,744	0	$ -
CLINTON	0	$ -	0	$ -	17	$ 3,232,917	14	$ 10,217,600	0	$ -
COLUMBIANA	0	$ -	4	$ 2,975,574	32	$ 12,006,183	0	$ -	0	$ -
COSHOCTON	0	$ -	4	$ 1,291,947	17	$ 15,521,094	0	$ -	0	$ -
CRAWFORD	0	$ -	3	$ 544,326	9	$ 10,976,380	0	$ -	0	$ -
CUYAHOGA	0	$ -	43	$ 54,796,849	57	$ 178,377,456	6	$ 156,447,618	0	$ -
DARKE	0	$ -	0	$ -	2	$ 661,640	**25**	**$ 17,331,315**	0	$ -
DEFIANCE	0	$ -	0	$ -	0	$ -	15	$ 12,622,421	0	$ -
DELAWARE	0	$ -	2	$ 555,369	22	$ 58,645,808	9	$ 1,801,404	0	$ -
ERIE	0	$ -	0	$ -	46	$ 145,033,394	9	$ 5,116,214	0	$ -
FAIRFIELD	0	$ -	55	$ 89,983,799	12	$ 4,573,750	0	$ -	0	$ -
FAYETTE	0	$ -	0	$ -	22	$ 11,026,797	1	$ 25,613	0	$ -
FRANKLIN	0	$ -	53	$ 205,062,745	**127**	**$ 1,541,889,731**	10	$ 590,010,580	0	$ -
FULTON	0	$ -	0	$ -	2	$ 765,977	10	$ 9,055,986	0	$ -
GALLIA	0	$ -	**61**	**$ 49,786,218**	0	$ -	0	$ -	0	$ -
GEAUGA	0	$ -	10	$ 2,599,882	17	$ 9,464,846	0	$ -	0	$ -
GREENE	0	$ -	1	$ 226,721	20	$ 17,333,591	0	$ -	0	$ -
GUERNSEY	0	$ -	37	$ 31,438,512	13	$ 27,295,230	0	$ -	0	$ -

HAMILTON	0	$ -	1	$ 303,200	3	$ 649,003	**36**	**$ 112,320,077**	**1**	**$ 44,509**
HANCOCK	0	$ -	0	$ -	0	$ -	20	$ 12,221,849	0	$ -
HARDIN	0	$ -	0	$ -	11	$ 3,099,615	7	$ 3,726,143	0	$ -
HARRISON	0	$ -	24	$ 9,202,405	0	$ -	0	$ -	0	$ -
HENRY	0	$ -	0	$ -	15	$ 4,226,196	1	$ 24,050	0	$ -
HIGHLAND	0	$ -	0	$ -	8	$ 5,699,900	3	$ 1,001,655	0	$ -
HOCKING	0	$ -	17	$ 4,416,450	10	$ 3,173,780	0	$ -	0	$ -
HOLMES	0	$ -	0	$ -	27	$ 8,358,433	2	$ 830,000	0	$ -
HURON	0	$ -	0	$ -	19	$ 10,199,563	3	$ 637,787	0	$ -
JACKSON	0	$ -	16	$ 8,805,760	5	$ 1,405,325	0	$ -	0	$ -
JEFFERSON	0	$ -	33	$ 14,646,395	1	$ 39,502	0	$ -	0	$ -
KNOX	0	$ -	11	$ 5,958,280	30	$ 70,733,206	0	$ -	0	$ -
LAKE	0	$ -	17	$ 12,497,023	4	$ 491,079	0	$ -	0	$ -
LAWRENCE	0	$ -	25	$ 7,406,239	1	$ 1,761,200	0	$ -	0	$ -
LICKING	**2**	**$ 1,643,248**	52	$ 169,171,906	13	$ 15,926,302	0	$ -	0	$ -
LOGAN	0	$ -	0	$ -	15	$ 7,792,950	6	$ 1,596,980	0	$ -
LORAIN	0	$ -	38	$ 85,528,152	45	$ 126,862,437	0	$ -	0	$ -
LUCAS	0	$ -	1	$ 36,748	41	$ 254,321,996	10	$ 20,139,002	0	$ -
MADISON	0	$ -	**68**	**$ 374,054,248**	30	$ 16,311,025	6	$ 8,146,300	0	$ -
MAHONING	0	$ -	3	$ 272,366	55	$ 109,405,808	0	$ -	0	$ -
MARION	0	$ -	48	$ 230,139,872	1	$ 516,311	10	$ 6,397,971	0	$ -
MEDINA	0	$ -	2	$ 1,368,843	13	$ 7,238,567	2	$ 7,632,389	0	$ -
MEIGS	0	$ -	24	$ 9,369,001	0	$ -	0	$ -	0	$ -
MERCER	0	$ -	0	$ -	7	$ 1,079,195	14	$ 7,233,279	**6**	**$ 828,612**
MIAMI	0	$ -	0	$ -	6	$ 5,300,425	24	**$ 15,694,241**	0	$ -
MONROE	0	$ -	12	$ 3,933,797	0	$ -	0	$ -	0	$ -
MONTGOMERY	0	$ -	51	$ 156,013,600	21	$ 31,883,216	0	$ -	0	$ -
MORGAN	0	$ -	15	$ 7,945,308	0	$ -	0	$ -	0	$ -
MORROW	0	$ -	1	$ 364,042	18	$ 12,632,534	0	$ -	0	$ -
MUSKINGUM	0	$ -	18	$ 8,465,278	18	$ 5,704,597	0	$ -	0	$ -
NOBLE	0	$ -	26	$ 63,588,248	6	$ 1,684,895	0	$ -	0	$ -

OTTAWA	0	$	-	36	$	34,797,636	10	$	5,930,316	6	$	1,509,983	0	$	-
PAULDING	0	$	-	0	$	-	0	$	-	11	$	8,375,639	0	$	-
PERRY	0	$	-	4	$	985,911	5	$	6,181,210	0	$	-	0	$	-
PICKAWAY	0	$	-	**99**	**$**	**284,332,631**	38	$	62,290,013	0	$	-	0	$	-
PIKE	0	$	-	4	$	1,338,100	1	$	24,716	7	$	7,280,896	0	$	-
PORTAGE	0	$	-	23	$	17,615,244	2	$	178,336	0	$	-	0	$	-
PREBLE	0	$	-	0	$	-	7	$	1,011,740	20	$	6,521,892	**1**	**$**	**22,231**
PUTNAM	0	$	-	0	$	-	16	$	3,879,569	3	$	977,700	0	$	-
RICHLAND	0	$	-	23	$	8,545,628	54	$	228,452,819	0	$	-	0	$	-
ROSS	0	$	-	4	$	1,264,694	**124**	**$**	**508,377,826**	1	$	1,156,000	0	$	-
SANDUSKY	0	$	-	0	$	-	10	$	7,325,322	4	$	1,308,180	0	$	-
SCIOTO	0	$	-	**64**	**$**	**478,241,655**	2	$	193,331	0	$	-	0	$	-
SENECA	0	$	-	0	$	-	47	$	47,263,743	0	$	-	0	$	-
SHELBY	0	$	-	0	$	-	4	$	709,072	**31**	**$**	**31,620,653**	0	$	-
STARK	0	$	-	24	$	22,690,539	33	$	125,951,046	0	$	-	0	$	-
SUMMIT	0	$	-	45	$	65,858,556	20	$	132,097,918	0	$	-	0	$	-
TRUMBULL	0	$	-	4	$	894,688	54	$	82,196,685	11	$	13,941,198	0	$	-
TUSCARAWAS	**10**	**$**	**1,065,899**	44	$	49,510,366	0	$	-	0	$	-	0	$	-
UNION	0	$	-	0	$	-	55	$	169,438,472	0	$	-	0	$	-
VAN WERT	0	$	-	0	$	-	16	$	7,772,814	0	$	-	0	$	-
VINTON	0	$	-	8	$	1,631,300	11	$	12,471,127	0	$	-	0	$	-
WARREN	0	$	-	**89**	**$**	**308,295,722**	6	$	3,137,066	14	$	12,286,660	0	$	-
WASHINGTON	**4**	**$**	**1,426,900**	46	$	35,272,100	0	$	-	0	$	-	0	$	-
WAYNE	0	$	-	7	$	1,548,476	7	$	4,181,399	8	$	6,472,928	0	$	-
WILLIAMS	0	$	-	0	$	-	1	$	496,549	16	$	7,340,531	0	$	-
WOOD	0	$	-	0	$	-	18	$	11,814,763	22	$	56,477,802	0	$	-
WYANDOT	0	$	-	0	$	-	2	$	1,235,382	20	$	5,494,328	0	$	-
Grand Total	**16**	**$**	**4,136,047**	**1,407**	**$**	**3,135,397,504**	**1,836**	**$**	**4,489,945,417**	**497**	**$**	**1,235,389,597**	**12**	**$**	**5,568,525**

Table 2.3.e

REGIONS

Region 3 has the greatest number (300) critical facilities in the both the in the Relatively High and Very High Risk categories. Region 2 has the highest replacement cost of critical facilities in the Relatively High and Very High Risk categories at just over 920 million dollars in replacement costs.

	Very Low		Relatively Low		Relatively Moderate	
	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost
Region 1	0	$ -	108	$ 272,437,745	444	$ 697,160,087
Region 2	2	$ 1,643,248	716	$ 1,867,395,125	831	$ 2,937,014,266
Region 3	14	$ 2,492,799	583	$ 995,564,634	561	$ 855,771,064

	Relatively High		Very High	
	# of CF	Replacement Cost	# of CF	Replacement Cost
Region 1	293	$ 232,732,546	7	$ 850,843
Region 2	130	$ 917,340,775	5	$ 4,717,682
Region 3	74	$ 85,316,276	0	$ -

Table 2.3.f

2.4 WINTER STORMS (WEATHER)

For the purpose of this plan, *Winter Storms* is a risk assessment that is encompasses multiple hazards: *Blizzards, Extreme Cold and Windchill*, *Frost and Freeze*, *Heavy Snow, Ice Storms, Winter Storms, and Winter Weather* events as reported and defined by the National Weather Service Instruction 10-1605.

Winter Storms are winter weather events that has more than one significant hazard (i.e., heavy snow and blowing snow; snow and ice; snow and sleet; sleet and ice; or snow, sleet and ice) and meets or exceeds locally/regionally defined 12- and/or 24-hour warning criteria for at least one of the precipitation elements. Normally, a Winter Storm would pose a threat to life or property.

Blizzard conditions occur when the following conditions last three hours or longer:

- 35 mph or greater wind speeds,
- Considerable snowfall and blowing snow bringing visibility below ¼ mile.
- Severe blizzards have wind speeds exceeding 45 mph, visibility near zero, and temperatures of 10º F or lower.

Extreme Cold and Wind Chill events are defined as A period of extremely low temperatures or wind chill temperatures reaching or exceeds locally/regionally defined warning criteria. Normally these conditions should cause significant human and/or economic impact. The NWS issues windchill alerts for:

- Advisories when windchills are expected to be 10°F to -25°F for at least 3 hours,
- Warnings when -25°F or colder with wind speeds 5 mph or greater for at least 3 hours.
- These criteria are, for the most part, uniformed across all Ohio NWS office, with the exception of Northern Indiana where their windchill advisories are issued at -15° F to -29° F.

Canadian and Arctic cold fronts that push cold temperatures, ice, and snow into the State generally cause winter storms, blizzards, and ice storms. Severe winter weather in Ohio consists of freezing temperatures and heavy precipitation, usually in the form of snow, freezing rain, or sleet. Severe winter weather affects all parts of the State.

Snow and strong easterly wind conditions ahead of a warm front usually cause ice storms. The snow, however, changes temporarily to sleet and then to rain that freezes when it hits the ground, covering exposed surfaces with a layer of ice. Local accumulations of ice may be heavy if the storm halts over a region for extended periods of time. Ice storms lasting more than 12 hours usually produce ice accumulations several inches thick and affect an area that may range from a few square miles to areas covering several states. The typical ice storm swath is 30 miles wide and 300 miles long.

While Ohio residents and governments are accustomed to handling winter storm events, occasional extreme events can make conditions dangerous and disruptive. Heavy snow volume makes snow removal difficult. Trees, cars, roads, and other surfaces develop a coating of ice, making even small accumulations of ice extremely hazardous to motorists and pedestrians. The most prevalent impacts of heavy accumulations of ice are slippery roads and walkways that lead to vehicle and pedestrian accidents; collapsed roofs from fallen trees and limbs from heavy ice and snow loads; and felled trees, telephone poles and lines, electrical wires, and communication towers. As a result of severe ice storms, telecommunications and power can be disrupted for days.

The northeastern portion of Ohio near the Great Lakes experiences what is known as “lake-effect snow” As cold air passes over the relatively warm waters of the large lakes, the weather system absorbs moisture and heat, and releases this in the form of snow. Lake effect snowfall intensity is affected by:

- The contrast between the lake and air temperatures,
- The distance air has traveled over water, known as the fetch, and
- The regional weather conditions-- a snow storm’s maximum penetration inland will generally be greatest during late autumn/early winter and shortest during the late winter.

Lake-effect snowstorms have been known to cause continuous snowfall for as long as 48 hours over a sharply defined region. One single, intense local storm cell can yield as much as 48 inches of light-density snow in 24 hours or less. Consequently, snowfalls can vary greatly, with areas of deep snowfall adjacent to areas with relatively little snow.

Figure 2.4.a

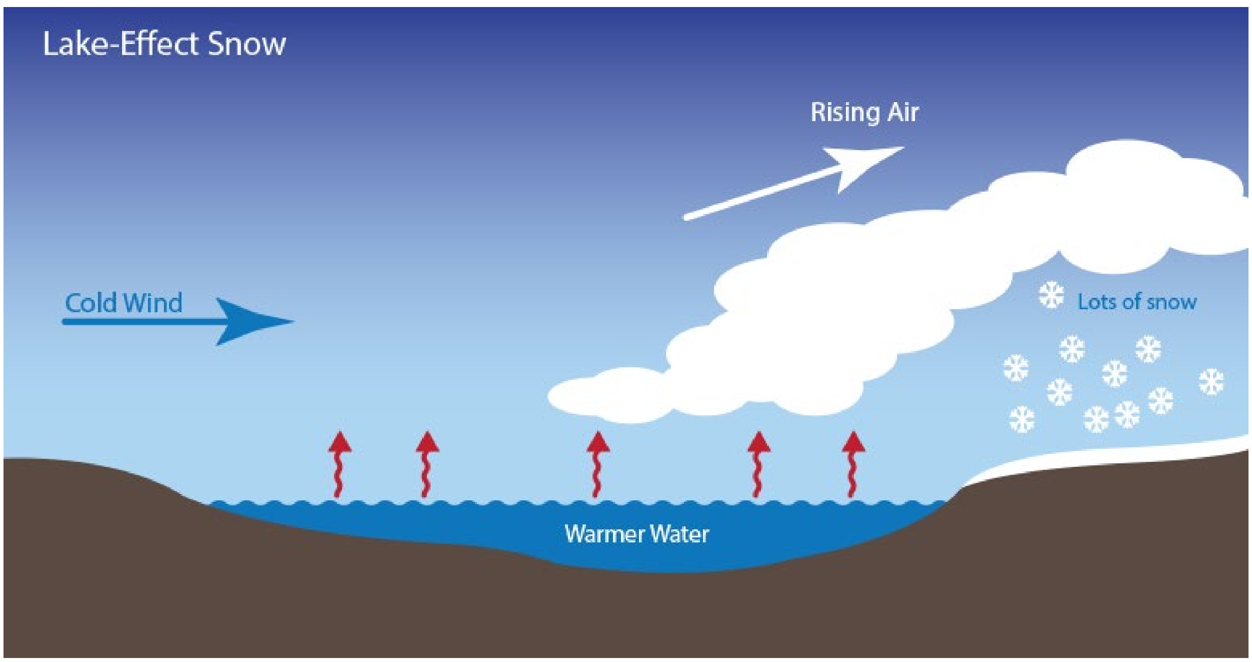
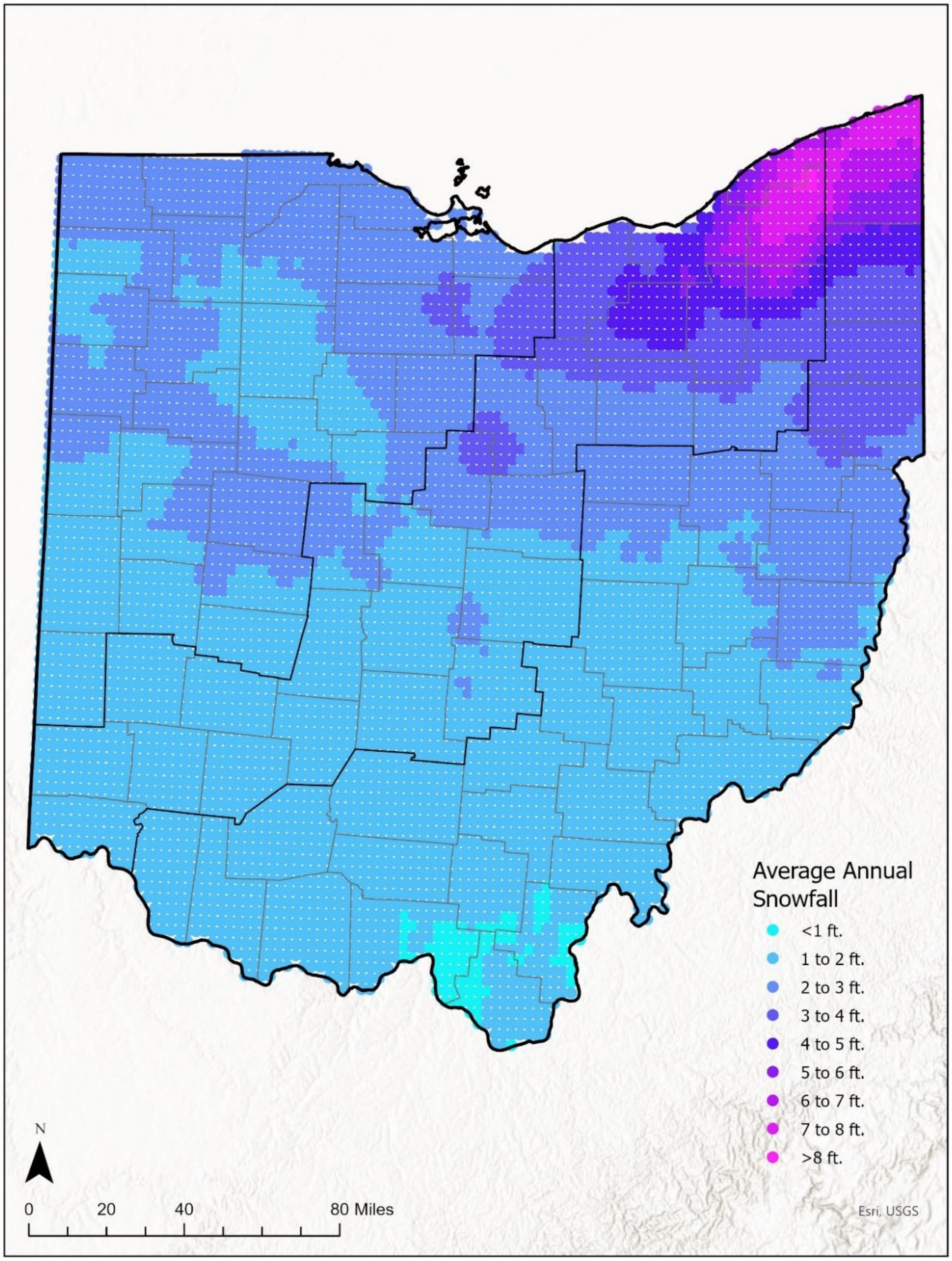


Figure 2.4.a: Generation of Lake Effect Snow
Source: [NOAA SciJinks]

LOCATION

Winter Storms events are not spatially-specific hazards but affects all parts of the State; therefore, it is difficult to determine the actual location of the damage that may result from a winter storm event. In an effort to address this limitation, the mean annual snow depth from 2017 to 2022 was mapped.

Figure 2.4b: State of Ohio Annual Mean Snowfall, 2017-2022



Source: Annual data compiled from the NOAA National Gridded Snowfall Analysis; *https://www.nohrsc.noaa.gov/snowfall/*

PAST OCCURANCES AND PROBABILITY OF FUTURE EVENTS

According to the NCDC Storm Database, there has been 367 Winter Storms events from January 1, 2003 to January 1, 2023 statewide. From these events, about $737,247,674 (Inflation-adjusted value 2023) in property and crop damages have been reported and have resulted in 27 deaths and 99 injuries. Table 2.4.a depicts the reported events by county, as well as the estimated annual probability based on reported data. Past occurrences are reported based as *Days with Event*. When a county reports multiple hazard events on the same day, it is calculated as a single event for that day. When multiple counties report one or more *Winter storm* event(s) on the same day, it's reported as a single event in the statewide count.

Based on these figures, Ohio with has a 100% chance events of occurring in any given year. However, the probability and severity of snowfall vary greatly by location. The higher snowfall totals and probability for the northeastern portion of Ohio can be attributed to the lake effect snows caused by the area's proximity to Lake Erie. Lake, Geauga, and Ashtabula counties can see greater than eight feet of snowfall in a given year. This trend tapers off as the level of snowfall generally decreases as you move closer to the south and southwestern counties where average snow depths are one to two feet. Global climate change may have an impact on the probability of future events; however, it is unclear as to the extent of this impact. Several storms were notable and since 1964, two involved federal declarations.

Table 2.4.a

Severe Winter Storms Past Occurrences and Probability Assessment by County

Region 1				
County	Total Deaths	Total Injuries	Days with Event [1, 2]	Est. Annual Probability [3]
Allen	0	0	65	3.1
Auglaize	0	0	103	4.9
Champaign	0	0	101	4.8
Clark	0	0	108	5.1
Crawford	0	0	26	1.3
Darke	0	0	112	5.3
Defiance	0	0	68	3.2
Erie	0	0	33	1.6
Fulton	1	0	60	2.9
Hancock	0	0	26	1.2
Hardin	0	0	76	3.6
Henry	0	0	64	3.0
Huron	0	0	32	1.7
Logan	0	0	116	5.5
Lucas	0	0	34	1.6
Marion	0	0	22	1.1
Mercer	0	0	93	4.4
Miami	1	0	103	4.9
Ottawa	0	0	29	1.4
Paulding	1	0	74	3.5
Preble	0	0	110	5.2
Putnam	0	0	70	3.3
Sandusky	0	0	29	1.4
Seneca	0	0	24	1.1
Shelby	0	0	102	4.8
Van Wert	2	0	71	3.4
Williams	0	0	60	2.9
Wood	0	0	32	1.5
Wyandot	0	0	21	1.0

Region 2				
County	Total Deaths	Total Injuries	Days with Event [1, 2]	Est. Annual Probability [3]
Ashland	0	0	41	1.9
Butler	3	0	113	5.3
Clinton	0	0	122	5.8
Cuyahoga	3	0	81	3.8
Delaware	0	4	104	4.9
Fairfield	0	0	102	4.8
Fayette	0	0	95	4.5
Franklin	0	4	127	6.0
Geauga	0	0	108	5.1
Greene	1	0	107	5.1
Hamilton	2	32	114	5.4
Knox	0	0	25	1.2
Lake	0	4	73	3.5
Licking	0	0	100	4.8
Lorain	1	0	45	2.1
Madison	1	0	87	4.1
Medina	1	0	49	2.3
Montgomery	2	0	132	6.3
Morrow	0	0	23	1.1
Pickaway	0	0	97	4.6
Portage	0	0	51	2.5
Richland	0	0	39	1.9
Stark	0	0	30	1.4
Summit	1	40	54	2.6
Union	0	1	98	4.6
Warren	0	10	114	5.4
Wayne	0	0	32	1.6

Region 3				
County	Total Deaths	Total Injuries	Days with Event [1, 2]	Est. Annual Probability [3]
Adams	0	0	102	4.8
Ashtabula	0	0	104	4.9
Athens	2	0	52	2.5
Belmont	0	0	38	1.8
Brown	0	0	103	4.9
Carroll	0	0	43	2.0
Clermont	1	1	105	5.0
Columbiana	3	0	59	2.8
Coshocton	0	0	36	1.7
Gallia	0	0	41	1.9
Guernsey	0	0	35	1.7
Harrison	0	0	33	1.6
Highland	0	0	93	4.4
Hocking	0	0	86	4.1
Holmes	0	0	30	1.4
Jackson	1	0	45	2.1
Jefferson	0	0	45	2.1
Lawrence	0	0	38	1.8
Mahoning	0	3	36	1.7
Meigs	0	0	47	2.2
Monroe	0	0	29	1.4
Morgan	0	0	50	2.4
Muskingum	0	0	41	1.9
Noble	0	0	25	1.2
Perry	0	0	54	2.6
Pike	0	0	82	3.9
Ross	0	0	95	4.5
Scioto	0	0	96	4.5
Trumbull	0	0	52	2.6
Tuscarawas	0	0	50	2.4
Vinton	0	0	48	2.3
Washington	0	0	50	2.4

1- Count includes blizzards, extreme cold and windchill, frost/freeze, heavy snow, ice storms, winter storms, and winter weather events as reported by the National Weather Service.

2- Events are counted as days with events, where multiple events per day is counted as one event.

3- Due to the reason above, estimated annual probability is the probability of an event day occurring in a given year.

The Great Blizzard of 1978, January 1978 (EM-3055): Homes and businesses were closed for one week and caused the deaths of 51 people. Wind gusts reached 70 mph and caused blowing and drifting snow. The worst winter storm in Ohio history struck before dawn on Thursday, January 26th, 1978. The Blizzard of '78 continued through Thursday and into Friday. Transportation, business, industry, and schools were closed statewide for two days with the normal pace of society not returning to the state for five days. Atmospheric pressure fell to 28.28 inches at Cleveland, the lowest ever recorded in Ohio, as the center of the blizzard crossed Ohio. This rapidly intensifying storm pulled bitterly cold air across Ohio on winds of 50 to 70 mph. These conditions, combined with heavy snow and blowing of deep snow already on the ground, caused extreme blizzard conditions all across Ohio. Enormous snowdrifts covered cars and houses, blocked highways and railways, and closed all airports for two days. More than 5,000 members of the Ohio National Guard were called to duty and were pressed into long hours of work with heavy equipment clearing roads, assisting electric utility crews, rescuing stranded persons, and transporting doctors and nurses to hospitals. Forty-five National Guard helicopters flew 2,700 missions across Ohio rescuing thousands of stranded persons, many in dire medical emergencies. Thousands of volunteers with snowmobiles and four-wheel drive vehicles responded to pleas from police statewide to deliver medicine and transport doctors and nurses to hospitals. The death toll of 51 made this one of the deadliest winter storms in Ohio history. As a result of this event, Ohio counties received a total of $3,546,669 in public assistance funds.

Severe Winter Storm, February 2003 (DR-1453): Prior to this event, a several series of low-pressure systems tracked through the Ohio River valley, producing up to four inches of snow across west central Ohio all through the month of January. The main event happened when a warm front ahead of low-pressure passing through the Tennessee Valley brought abundant moisture to the Ohio Valley on east-southeast winds. Cold air was already in place on the surface and conditions were right for snow accumulation of 6 to 8 inches to occur over much of the region north of the Ohio River. Counties closest to the Ohio River saw some ice accumulations to a quarter or a half inch, but the majority of the weather associated with this system was heavy snow along the I-70 corridor. Fayette, Franklin, Greene, Guernsey, Monroe, and Muskingum counties received record snowfall from this event. Adams, Gallia, Lawrence, Meigs, and Scioto Counties had severe ice accumulation in addition to snow that downed trees and power lines. Loss of power to water treatment and sewage systems resulted in the loss of water pressure to customers. For those who had some water, boil alerts were issued. In Gallia County, most of the water customers lost service and needed generators to restore service. Booster station in the affected areas did not have full power until a week after the storm hit the region. At one time more than an estimated 12,000 customers were without water. As a result of this event, thirty Ohio counties received a total of $15,761,979.42 in public assistance funds.

Severe Winter Storms, Flooding and Mudslides, December 2004 – January 2005 (DR-1580): A low-pressure system moved into the northeast across the Ohio Valley. Cold west to northwest winds behind the low caused lake effect snow showers to develop in Northeast Ohio. This activity began during the predawn hours of the 16th and continued through midday on the 17th. The heaviest fell during the late afternoon and evening hours of the 16th when visibilities at times were near zero. Accumulations ranged from 6 to 8 inches in Geauga, southern Ashtabula, and eastern Cuyahoga Counties. This storm system affected four additional counties to the previous storm and caused an approximate $106,901,000 in property damage. As a result of this event, Ohio counties received a total of $7,948,685.48 in public assistance funds.

Snow Event, January - February 2005 (EM-3198): An Alberta Clipper passed to the north of Lake Erie during the evening hours of November 23rd. An arctic cold front trailing this low swept east across Ohio by the early morning hours of the 24th. Cold northwest winds behind this front caused lake effect snow showers to develop just before daybreak on the 24th. These bands quickly intensified and by mid-morning, visibilities in some areas were less than one-quarter mile. Northwest winds gusting in excess of 30 mph accompanied the snow and caused considerable blowing and drifting. The snow showers tapered to flurries during the early evening hours. Snowfall totals of 6 to 9 inches were reported in both Geauga and inland Ashtabula Counties by sunset on the 24th. Then, after midnight on the 25th, an upper-level disturbance rotated through the region. This caused a new round of lake effect snow showers to develop. This activity diminished during the afternoon of the 25th after another 6 to 9 inches of snow had fallen. Two-day totals for this event exceed a foot of snow in many locations.

A peak of 15.6 inches was measured in Hambden Township (Geauga County) with 14 inches at Hartsgrove (Ashtabula County). This storm system affected four additional counties to the previous storm and caused an approximate $5,475,000 in property damage. As a result of this event, Ohio counties received a total of $1,447,217.85 in public assistance funds.

Blizzard Event, March 2008 (EM-3286): On the morning of March 7th, snow spread into the region during the morning and afternoon hours, then tapered off during the evening and overnight into the 8th. Snow intensified across the area as low-pressure moved north into the Carolinas by the morning of the 8th. Snow persisted across much of the area but did mix with sleet and freezing rain at times across far eastern Ohio. By the evening hours of the 8th, snow began tapering off from west to east. Any areas of mixed precipitation across far eastern Ohio changed back to snow before ending. The low-pressure continued intensifying as it moved into New England by the morning hours of the 9th. Some light snow and flurries persisted overnight, mainly from around Cleveland and points east, but by midday on the 9th the snow tapered off across the entire area. Throughout this event, locations across northwest Ohio picked up between 5 and 10 inches. Those locations experienced a rather steep gradient for snowfall totals. In eastern Ohio, snowfall amounts were slightly lower as sleet and freezing rain mixed in at times causing reduced snowfall amounts. Locations across northeast and north-central Ohio saw the greatest snowfall amounts with 21.5 inches in Broadview Heights in Cuyahoga County, and 21.0 inches in Galion located in Crawford County. As a result of this event, Ohio counties received a total of $1,709,668.49 in public assistance funds.

LHMP DATA

Cuyahoga County: The Countywide All Natural Hazards Mitigation Plan of 2022 states that severe winter storm hazards most often impact driving conditions, electric infrastructure, and community or business functions. Losses may be as small as lost productivity and wages when workers are unable to travel or as large as sustained roof damage or building collapse. According to the National Climatic Data Center website, between January 1996 and March 2021, Cuyahoga County has been impacted by 87 severe winter weather events that have accounted for $34,685,000 in damages and 10 casualties.

Lake County: The Lake County Hazard Mitigation Plan of 2022 indicates there have been 114 severe winter storms from 1950 to 2021 causing $30,587,000 in damages with an average of $268,307 per event. These types of storms are known to cause utility, infrastructure, structural damage. They can also cause severe transportation problems and exposure threats for residents. This hazard is noted as a high frequency event with a total of 47 injuries and business disruptions ranging from days to weeks for the county.

Ashtabula County: The HIRA of the Ashtabula County Countywide All Natural Hazards Mitigation Plan of August 2019 examines subcategories of winter storms: blizzards, ice storms, lake effect snow on the southeastern Lake Erie Snow Belt, and extreme cold. From 1993 to 2019, there was a total of $33,281,00 of damages with an average event causing $180,875 of damage, and the worst single event causing $5,000,000.

MIP LHMP HIRA ASSESSMENT

Winter storms ranked third in cumulative scoring when scored amongst all local hazard mitigation plans. It has fallen for second place in the 2019 SOHMP.

WINTER STORMS MIP LHMP HIRA ASSESSMENT								
Ranking	**2**	**6**	**9**	**1**	**6**	**5**	**4**	**3**
Criteria Score	**4.65**	**3.84**	**2.43**	**3.17**	**1.53**	**1.70**	**1.83**	**19.14**
	Hazard Frequency	Response Time	Onset Time	Magnitude	Impact on Business	Impact on Humans	Impact on Property	Cumulative Score

VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHODOLOGY

To determine the estimated annual damage at the county level, a historical analysis was done first for each county. The 20-year (January 2003 to January 2023) reported damages of was adjusted to 2023 dollars and summed up to for each respective county. This was then divided by 20 for the number of years assessed. The resulted in the average annual damage for each county.

In order to offset under-reporting in the state, the sum of the twenty-year reported damages across the state was divided by 20 to determine the average estimated annual loss. This figure was then divided by the State-wide Taxable Value of Real Estate to determine the Statewide percentage of annual damage relative to real estate, 0.0121%. A corresponding calculation was also done for each county within the state. These percentages were used to determine the counties that reported less than average damages relative to their value of taxable real property; whichever county that falls below the Statewide percentage of damage relative to real estate threshold, their respective countywide percentage of damage relative to real estate gets replaced with the statewide value. Annual estimated losses for each of these counties would then be calculated by multiplying their respective Countywide Taxable Value of Real Estate.

RESULTS- Table 2.4.b

In Region 1, it is estimated that Hancock County has the highest county-wide damage per year at $1,569,680. However, the county with the highest per-capita cost is Wyandot at $33.58 dollars per person. Region 1 has a higher estimated annual damage at $13,040,719, which is much more than Region 3 but also much less than Region 2.

In Region 2, it is estimated that Franklin County will have the highest county-wide damage per year at $4,364,277. Close behind is Cuyahoga County at $4,056,703. The county with the highest per-capita cost is Ashland County at $28.62 dollars per person.

In Region 3, it is estimated that Ashtabula County will have the highest county-wide damage per year by far at $2,168,190. The second highest is Holmes County at $1,001,468. Holmes County had the highest at $22.65 per person and Ashtabula County had the second highest per-capita cost at $22.22 dollars per person.

Table 2.4.b

Estimate of Potential Losses to Severe Winter Storms by Region

Region 1

County	Population Census 2020	Est. Damage Per Year	Annual Damage per Capita
Allen	102,206	$ 265,779	$ 2.60
Auglaize	46,422	$ 143,078	$ 3.08
Champaign	38,714	$ 133,267	$ 3.44
Clark	136,001	$ 360,490	$ 2.65
Crawford	42,025	$ 1,265,145	$ 30.10
Darke	51,881	$ 154,731	$ 2.98
Defiance	38,286	$ 102,666	$ 2.68
Erie	75,622	$ 600,375	$ 7.94
Fulton	42,713	$ 123,918	$ 2.90
Hancock	74,920	$ 1,569,680	$ 20.95
Hardin	30,696	$ 71,611	$ 2.33
Henry	27,662	$ 84,761	$ 3.06
Huron	58,565	$ 989,600	$ 16.90
Logan	46,150	$ 201,326	$ 4.36
Lucas	431,279	$ 1,037,610	$ 2.41
Marion	65,359	$ 1,131,335	$ 17.31
Mercer	42,528	$ 142,590	$ 3.35
Miami	108,774	$ 374,275	$ 3.44
Ottawa	40,364	$ 434,858	$ 10.77
Paulding	18,806	$ 60,555	$ 3.22
Preble	40,999	$ 111,938	$ 2.73
Putnam	34,451	$ 109,466	$ 3.18
Sandusky	58,896	$ 496,795	$ 8.44
Seneca	55,069	$ 980,565	$ 17.81
Shelby	48,230	$ 148,816	$ 3.09
Van Wert	28,931	$ 76,547	$ 2.65
Williams	37,102	$ 101,015	$ 2.72
Wood	132,248	$ 1,032,570	$ 7.81
Wyandot	21,900	$ 735,358	$ 33.58
Total	1,976,799	$ 13,040,719	$ 6.60

Region 2

County	Population Census 2020	Est. Damage Per Year	Annual Damage per Capita
Ashland	52,447	$ 1,500,915	$ 28.62
Butler	390,357	$ 1,136,382	$ 2.91
Clinton	42,018	$ 124,564	$ 2.96
Cuyahoga	1,264,817	$ 4,056,703	$ 3.21
Delaware	214,124	$ 1,143,814	$ 5.34
Fairfield	158,921	$ 649,020	$ 4.08
Fayette	28,951	$ 86,812	$ 3.00
Franklin	1,323,807	$ 4,364,277	$ 3.30
Geauga	95,397	$ 1,467,368	$ 15.38
Greene	167,966	$ 569,857	$ 3.39
Hamilton	830,639	$ 2,562,039	$ 3.08
Knox	62,721	$ 1,221,042	$ 19.47
Lake	232,603	$ 2,312,930	$ 9.94
Licking	178,519	$ 631,019	$ 3.53
Lorain	312,964	$ 1,305,725	$ 4.17
Madison	43,824	$ 147,753	$ 3.37
Medina	182,470	$ 1,226,788	$ 6.72
Montgomery	537,309	$ 1,271,752	$ 2.37
Morrow	34,950	$ 853,300	$ 24.41
Pickaway	58,539	$ 171,580	$ 2.93
Portage	161,791	$ 599,053	$ 3.70
Richland	124,936	$ 2,742,270	$ 21.95
Stark	374,853	$ 1,425,660	$ 3.80
Summit	540,428	$ 1,695,957	$ 3.14
Union	62,784	$ 311,442	$ 4.96
Warren	242,337	$ 1,106,844	$ 4.57
Wayne	116,894	$ 1,121,883	$ 9.60
Total	7,837,366	$ 35,806,747	$ 4.57

Region 3

County	Population Census 2020	Est. Damage Per Year	Annual Damage per Capita
Adams	27,477	$ 59,842	$ 2.18
Ashtabula	97,574	$ 2,168,190	$ 22.22
Athens	62,431	$ 132,882	$ 2.13
Belmont	66,497	$ 213,481	$ 3.21
Brown	43,676	$ 113,837	$ 2.61
Carroll	26,721	$ 99,924	$ 3.74
Clermont	208,601	$ 608,159	$ 2.92
Columbiana	101,877	$ 261,942	$ 2.57
Coshocton	36,612	$ 88,651	$ 2.42
Gallia	29,220	$ 178,150	$ 6.10
Guernsey	38,438	$ 113,795	$ 2.96
Harrison	14,483	$ 61,939	$ 4.28
Highland	43,317	$ 107,551	$ 2.48
Hocking	28,050	$ 106,011	$ 3.78
Holmes	44,223	$ 1,001,468	$ 22.65
Jackson	32,653	$ 70,590	$ 2.16
Jefferson	65,249	$ 161,779	$ 2.48
Lawrence	58,240	$ 140,103	$ 2.41
Mahoning	228,614	$ 814,465	$ 3.56
Meigs	22,210	$ 217,588	$ 9.80
Monroe	13,385	$ 69,328	$ 5.18
Morgan	13,802	$ 33,587	$ 2.43
Muskingum	86,410	$ 228,751	$ 2.65
Noble	14,115	$ 38,439	$ 2.72
Perry	35,408	$ 77,111	$ 2.18
Pike	27,088	$ 53,885	$ 1.99
Ross	77,093	$ 197,686	$ 2.56
Scioto	74,008	$ 143,463	$ 1.94
Trumbull	201,977	$ 832,520	$ 4.12
Tuscarawas	93,263	$ 284,517	$ 3.05
Vinton	12,800	$ 26,684	$ 2.08
Washington	59,771	$ 186,875	$ 3.13
Total	1,985,283	$ 8,893,193	$ 4.48

Statewide

County	Population	Est. Damage Per Year	Annual Damage per Capita
All 88	11,799,448	$ 57,740,658	$ 4.89

FEMA National Risk Index

In the National Risk Index, a cold wave, ice storm, and winter weather hazard risk index score/rating represent a community's relative risk for those hazards when compared to the rest of the United States. Generally, the exposure value represents a community's agriculture and building values (in dollars), and population (in both people and population equivalence) exposed to cold waves, ice storms, and winter weather. The Expected Annual Loss (EAL) represents the relative level of agriculture, building, and population loss each year. For more information on current methodology and data, refer to Sections 8 (Cold Wave), 14 (Ice Storms), and 23 (Winter Weather) of the National Risk Index Technical Manual.

Table 2.4.c

FEMA National Risk Index Ice Storm Analysis by Region

Region 1		
County	EAL (Buildings)	EAL (Pop Equiv.)
Allen	$11,882	$530
Auglaize	$5,043	$18,410
Champaign	$301,960	$15,956
Clark	$1,415,468	$75,878
Crawford	$115,098	$90
Darke	$8,576	$54,837
Defiance	$2,799	$1,470
Erie	$366,839	$300
Fulton	$6,395	$1,651
Hancock	$867,639	$593
Hardin	$86,042	$96
Henry	$10,856	$252
Huron	$358,972	$237
Logan	$487,801	$17,616
Lucas	$226,692	$3,758
Marion	$213,675	$117
Mercer	$6,857	$36,753
Miami	$16,732	$58,643
Ottawa	$92,783	$277
Paulding	$5,030	$711
Preble	$5,797	$48,141
Putnam	$4,453	$269
Sandusky	$144,002	$428
Seneca	$538,525	$360
Shelby	$7,055	$18,647
Van Wert	$3,214	$658
Williams	$49,370	$1,563
Wood	$234,223	$1,142
Wyandot	$117,781	$80
Total	$5,711,561	$359,463

Region 2		
County	EAL (Buildings)	EAL (Pop Equiv.)
Ashland	$386,989	$176
Butler	$56,922	$497,190
Clinton	$623,232	$25,962
Cuyahoga	$103,461	$9,842
Delaware	$1,595,821	$64,116
Fairfield	$1,279,104	$70,659
Fayette	$412,016	$17,267
Franklin	$208,386	$6,578
Geauga	$46,521	$605
Greene	$1,907,019	$100,512
Hamilton	$190,932	$5,737
Knox	$325,413	$149
Lake	$48,940	$1,422
Licking	$878,455	$42,923
Lorain	$514,670	$1,753
Madison	$415,268	$21,756
Medina	$590,976	$793
Montgomery	$77,890	$325,321
Morrow	$109,739	$71
Pickaway	$529,431	$25,804
Portage	$93,422	$896
Richland	$429,969	$284
Stark	$134,469	$1,220
Summit	$152,691	$2,250
Union	$498,315	$22,942
Warren	$39,665	$149,896
Wayne	$664,909	$390
Total	$12,314,624	$1,396,511

Region 3		
County	EAL (Buildings)	EAL (Pop Equiv.)
Adams	$80,582	$10,805
Ashtabula	$49,098	$90,385
Athens	$404,845	$22,398
Belmont	$379,239	$24,174
Brown	$111,970	$19,495
Carroll	$177	$6,295
Clermont	$23,663	$167,050
Columbiana	$319	$37,795
Coshocton	$228	$7,078
Gallia	$53,964	$6,607
Guernsey	$160,717	$7,413
Harrison	$1,939	$2,817
Highland	$173,693	$24,875
Hocking	$292,278	$12,534
Holmes	$242,619	$116
Jackson	$96,568	$10,554
Jefferson	$21,578	$25,575
Lawrence	$92,280	$16,964
Mahoning	$161,054	$106,181
Meigs	$149,207	$7,258
Monroe	$96,205	$4,172
Morgan	$110,347	$5,745
Muskingum	$714	$18,103
Noble	$123,025	$6,101
Perry	$579	$15,456
Pike	$65,055	$9,497
Ross	$587,031	$34,127
Scioto	$92,742	$19,948
Trumbull	$129,113	$128,536
Tuscarawas	$19,677	$239
Vinton	$96,450	$5,628
Washington	$266,802	$14,722
Total	$4,083,757	$868,645

Statewide		
County	EAL (Buildings)	EAL (Pop Equiv.)
All 88	$22,109,942	$2,624,619

Table 2.4.d

FEMA National Risk Index Coldwave Analysis by Region

Region 1

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Allen	$ 4,393	$ 17,725	$ 1,022
Auglaize	$ 2,469	$ 6,615	$ 32,330
Champaign	$ 2,204	$ 5,513	$ 32,631
Clark	$ 2,332	$ 19,386	$ 29,807
Crawford	$ 2,077	$ 18,686	$ 1,175
Darke	$ 4,098	$ 49,530	$ 45,221
Defiance	$ 1,369	$ 139,926	$ 40,061
Erie	$ 5,490	$ 33,234	$ 473
Fulton	$ 1,601	$ 156,338	$ 64,654
Hancock	$ 3,898	$ 32,921	$ 682
Hardin	$ 1,833	$ 4,375	$ 2,650
Henry	$ 1,129	$ 15,477	$ 852
Huron	$ 3,813	$ 28,399	$ 1,095
Logan	$ 3,799	$ 6,459	$ 40,281
Lucas	$ 13,270	$ 191,788	$ 254
Marion	$ 3,915	$ 7,883	$ 683
Mercer	$ 3,292	$ 40,605	$ 28,722
Miami	$ 2,838	$ 15,507	$ 32,626
Ottawa	$ 4,406	$ 17,943	$ 297
Paulding	$ 1,008	$ 78,600	$ 74,048
Preble	$ 2,010	$ 33,115	$ 31,114
Putnam	$ 1,210	$ 20,648	$ 1,469
Sandusky	$ 2,978	$ 26,157	$ 507
Seneca	$ 3,349	$ 24,489	$ 707
Shelby	$ 3,653	$ 6,795	$ 35,944
Van Wert	$ 1,088	$ 33,608	$ 220,466
Williams	$ 1,552	$ 135,786	$ 45,864
Wood	$ 6,094	$ 58,788	$ 799
Wyandot	$ 1,427	$ 9,625	$ 790
Total	$ 92,594	$ 1,235,923	$ 767,223

Region 2

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Ashland	$ 4,338	$ 6,822	$ 623
Butler	$ 3,532	$ 493,689	$ 29,741
Clinton	$ 2,310	$ 2,761	$ 35,116
Cuyahoga	$ 15,774	$ 3,634,092	$ 28
Delaware	$ 3,358	$ 28,058	$ 32,918
Fairfield	$ 2,284	$ 12,196	$ 27,948
Fayette	$ 1,761	$ 2,540	$ 32,467
Franklin	$ 17,400	$ 2,411,494	$ 41,783
Geauga	$ 5,973	$ 34,315	$ 148
Greene	$ 2,570	$ 38,822	$ 33,805
Hamilton	$ 7,980	$ 860,405	$ 14,387
Knox	$ 3,291	$ 8,250	$ 740
Lake	$ 6,878	$ 156,829	$ 304
Licking	$ 2,783	$ 17,606	$ 31,711
Lorain	$ 18,031	$ 221,314	$ 672
Madison	$ 2,181	$ 5,282	$ 30,464
Medina	$ 11,434	$ 81,113	$ 259
Montgomery	$ 14,712	$ 64,803	$ 42,564
Morrow	$ 1,992	$ 4,215	$ 423
Pickaway	$ 2,598	$ 4,493	$ 33,997
Portage	$ 8,599	$ 65,411	$ 157
Richland	$ 7,368	$ 16,248	$ 740
Stark	$ 13,074	$ 151,544	$ 437
Summit	$ 28,238	$ 218,468	$ 58
Union	$ 3,707	$ 8,775	$ 40,179
Warren	$ 4,554	$ 15,941	$ 26,470
Wayne	$ 4,032	$ 51,968	$ 1,646
Total	$ 200,751	$ 8,617,455	$ 459,788

Region 3

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Adams	$ 811	$ 1,807	$ 11,781
Ashtabula	$ 2,293	$ 1,669,590	$ 12,357
Athens	$ 480	$ 1,353	$ 972
Belmont	$ 1,100	$ 139,121	$ 2,706
Brown	$ 996	$ 1,915	$ 15,921
Carroll	$ 718	$ 97,812	$ 9,081
Clermont	$ 1,278	$ 9,147	$ 9,684
Columbiana	$ 2,858	$ 373,181	$ 19,921
Coshocton	$ 954	$ 2,379	$ 25,286
Gallia	$ 123	$ 316	$ 807
Guernsey	$ 704	$ 1,664	$ 4,555
Harrison	$ 219	$ 30,300	$ 1,988
Highland	$ 1,599	$ 1,899	$ 23,536
Hocking	$ 693	$ 1,538	$ 1,534
Holmes	$ 3,145	$ 5,331	$ 914
Jackson	$ 143	$ 354	$ 469
Jefferson	$ 1,211	$ 136,454	$ 981
Lawrence	$ 134	$ 28,215	$ 327
Mahoning	$ 10,840	$ 1,210,152	$ 18,304
Meigs	$ 97	$ 240	$ 706
Monroe	$ 348	$ 28,006	$ 1,490
Morgan	$ 168	$ 448	$ 2,298
Muskingum	$ 2,230	$ 5,618	$ 17,877
Noble	$ 336	$ 29,530	$ 778
Perry	$ 575	$ 1,915	$ 7,193
Pike	$ 748	$ 1,779	$ 14,320
Ross	$ 1,649	$ 4,508	$ 21,725
Scioto	$ 1,437	$ 2,432	$ 2,275
Trumbull	$ 5,158	$ 1,832,997	$ 14,961
Tuscarawas	$ 2,233	$ 6,064	$ 343
Vinton	$ 93	$ 277	$ 484
Washington	$ 623	$ 1,310	$ 3,575
Total	$ 45,993	$ 5,627,652	$ 249,151

Statewide

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
All 88	$ 339,338	$ 15,481,031	$ 1,476,162

Table 2.4.e

FEMA National Risk Index Winter Weather Analysis by Region

Region 1

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Allen	$ 3,781	$ 77,982	$ 506
Auglaize	$ 32,807	$ 36,436	$ 748
Champaign	$ 54,093	$ 31,749	$ 452
Clark	$ 52,402	$ 111,636	$ 478
Crawford	$ 483,733	$ 38,677	$ 712
Darke	$ 52,234	$ 73,938	$ 2,206
Defiance	$ 8,558	$ 19,379	$ 370
Erie	$ 522,396	$ 65,735	$ 302
Fulton	$ 11,676	$ 25,260	$ 697
Hancock	$ 458,283	$ 61,645	$ 402
Hardin	$ 3,296	$ 23,419	$ 806
Henry	$ 6,891	$ 19,670	$ 450
Huron	$ 712,439	$ 53,923	$ 625
Logan	$ 4,635	$ 35,993	$ 440
Lucas	$ 288,091	$ 84,621	$ 158
Marion	$ 718,026	$ 58,078	$ 425
Mercer	$ 45,230	$ 51,290	$ 2,284
Miami	$ 60,203	$ 226,526	$ 412
Ottawa	$ 388,153	$ 37,629	$ 185
Paulding	$ 5,016	$ 9,978	$ 627
Preble	$ 29,644	$ 52,805	$ 565
Putnam	$ 3,768	$ 25,089	$ 741
Sandusky	$ 390,618	$ 51,960	$ 307
Seneca	$ 410,713	$ 48,944	$ 417
Shelby	$ 6,809	$ 37,862	$ 645
Van Wert	$ 3,841	$ 15,014	$ 676
Williams	$ 11,319	$ 21,940	$ 495
Wood	$ 62,228	$ 82,015	$ 458
Wyandot	$ 313,037	$ 18,369	$ 466
Total	$ 5,143,918	$ 1,497,560	$ 18,056

Region 2

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Ashland	$ 1,027,427	$ 52,608	$ 402
Butler	$ 61,003	$ 599,086	$ 253
Clinton	$ 70,994	$ 41,184	$ 528
Cuyahoga	$ 1,106,533	$ 70,116	$ 68
Delaware	$ 68,463	$ 167,427	$ 314
Fairfield	$ 56,341	$ 153,119	$ 443
Fayette	$ 84,198	$ 28,935	$ 586
Franklin	$ 98,699	$ 184,551	$ 176
Geauga	$ 597,818	$ 71,995	$ 534
Greene	$ 53,341	$ 131,879	$ 351
Hamilton	$ 126,089	$ 452,759	$ 102
Knox	$ 414,859	$ 56,011	$ 411
Lake	$ 462,684	$ 19,189	$ 982
Licking	$ 59,785	$ 130,528	$ 625
Lorain	$ 820,976	$ 94,383	$ 594
Madison	$ 61,068	$ 46,589	$ 563
Medina	$ 927,135	$ 102,308	$ 263
Montgomery	$ 49,778	$ 415,222	$ 304
Morrow	$ 563,698	$ 30,403	$ 242
Pickaway	$ 72,253	$ 58,494	$ 749
Portage	$ 411,761	$ 66,300	$ 210
Richland	$ 1,206,934	$ 81,471	$ 433
Stark	$ 570,728	$ 82,200	$ 315
Summit	$ 918,721	$ 215,952	$ 74
Union	$ 4,241	$ 52,229	$ 809
Warren	$ 164,436	$ 372,905	$ 223
Wayne	$ 858,384	$ 83,702	$ 1,024
Total	$ 10,918,343	$ 3,861,546	$ 11,578

Region 3

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Adams	$ 81,010	$ 22,546	$ 152
Ashtabula	$ 278,896	$ 31,070	$ 940
Athens	$ 12,033	$ 11,242	$ 1
Belmont	$ 872	$ 5,684	$ 1
Brown	$ 65,054	$ 39,732	$ 301
Carroll	$ 800	$ 3,007	$ 3
Clermont	$ 54,836	$ 59,487	$ 136
Columbiana	$ 881	$ 12,166	$ 307
Coshocton	$ 997	$ 19,586	$ 244
Gallia	$ 5,262	$ 15,623	$ 47
Guernsey	$ 823	$ 3,534	$ 1
Harrison	$ 814	$ 1,531	$ 1
Highland	$ 106,433	$ 40,168	$ 525
Hocking	$ 76,137	$ 26,523	$ 22
Holmes	$ 1,043,234	$ 42,056	$ 569
Jackson	$ 7,046	$ 18,644	$ 29
Jefferson	$ 972	$ 7,118	$ 0
Lawrence	$ 6,844	$ 84,497	$ 10
Mahoning	$ 426,000	$ 67,516	$ 259
Meigs	$ 7,757	$ 2,116	$ 1
Monroe	$ 1,437	$ 968	$ 1
Morgan	$ 1,273	$ 1,497	$ 1
Muskingum	$ 969	$ 8,239	$ 3
Noble	$ 1,543	$ 974	$ 0
Perry	$ 5,642	$ 26,481	$ 117
Pike	$ 66,561	$ 21,232	$ 199
Ross	$ 56,763	$ 70,151	$ 326
Scioto	$ 128,403	$ 60,679	$ 67
Trumbull	$ 203,784	$ 26,541	$ 397
Tuscarawas	$ 904	$ 10,180	$ 7
Vinton	$ 6,407	$ 7,747	$ 16
Washington	$ 6,318	$ 6,680	$ 2
Total	$ 2,656,705	$ 755,214	$ 4,684

Statewide

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
All 88	$ 18,718,966	$ 6,114,320	$ 34,318

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHODOLOGY

The methodology for analyzing vulnerabilities of state-owned and state-leased critical facilities to Winter Storms is extended from the methodology of countywide vulnerabilities in the previous pages. The adjusted Countywide Percentages of Damage Relative to Real Estate are multiplied with their respective county's value of state-owned and state-leased critical facilities to determine an estimated annual damage to state-owned and state-leased critical facilities for that county. Table 2.4.c depicts the estimated annual damage to State-owned and State-leased critical facilities by county.

RESULTS

Within Region 1, Lucas County has the highest value of State-owned and State-leased critical facilities. However, because they reported zero dollars in property damages to the various hazards under *Winter Storms* from 2003 to 2023, it's only estimated annual damage to critical facilities are $33,253 - the fourth highest in region 1. Marion County with almost the number and value of critical facilities compared to Lucas County, had the highest estimated damage at $195,704 dollars per year. Overall, Region 1 has second highest total estimated damage amongst the three regions at $428,365 per year.

In Region 2, Franklin County by far had the highest number and value of critical facilities, and but only had the second highest estimated annual damage to State-owned and State-leased critical facilities at $283,103. Richland County had the highest estimated damage at $307,358 to 77 critical facilities. This may be due to two recorded events that together estimated over $50 million in damages, which is higher than other counties relative to their typical taxable value of real estate. With the most number and value of critical facilities of all the regions, Region 2 has the highest total estimated damage at $1,181,599 per year.

In Region 3, there is a total estimated annual damage of $297,370 regionwide- the lowest amongst the three regions. Ross County has the highest estimated annual damage per capita at $61,879. Scioto County had the second highest estimated damage at $57,958 per year.

Table 2.4.c

Estimated Annual Damage to State-owned and State-leased Critical Facilities- Winter Storms

Region 1

County	Number of Crit. Fac.	Value of Crit. Fac.	Est. Damage Per Year
Allen	99	$ 148,535,104	$ 17,994
Auglaize	18	$ 6,542,813	$ 793
Champaign	21	$ 9,246,093	$ 1,120
Clark	27	$ 9,650,921	$ 1,169
Crawford	12	$ 11,520,704	$ 1,396
Darke	27	$ 17,992,950	$ 2,180
Defiance	15	$ 12,622,416	$ 1,529
Erie	55	$ 150,149,608	$ 18,189
Fulton	12	$ 9,821,964	$ 1,190
Hancock	20	$ 12,221,847	$ 1,481
Hardin	18	$ 6,825,758	$ 827
Henry	16	$ 4,250,244	$ 515
Huron	22	$ 10,837,347	$ 1,313
Logan	21	$ 9,389,923	$ 1,138
Lucas	52	$ 274,497,738	$ 33,253
Marion	59	$ 237,054,145	$ 28,717
Mercer	27	$ 9,141,077	$ 1,107
Miami	30	$ 20,994,660	$ 2,543
Ottawa	52	$ 42,237,937	$ 5,117
Paulding	11	$ 8,375,637	$ 2,514
Preble	28	$ 7,555,862	$ 1,937
Putnam	19	$ 4,857,269	$ 1,822
Sandusky	14	$ 8,633,501	$ 1,693
Seneca	47	$ 47,263,740	$ 38,357
Shelby	35	$ 32,329,713	$ 26,690
Van Wert	16	$ 7,772,807	$ 7,174
Williams	17	$ 7,837,080	$ 5,221
Wood	40	$ 68,292,566	$ 116,921
Wyandot	22	$ 6,729,705	$ 8,186
Total	852	$ 1,203,181,127	$ 332,084

Region 2

County	Number of Crit. Fac.	Value of Crit. Fac.	Est. Damage Per Year
Ashland	145	$ 103,491,091	$ 12,537
Butler	29	$ 17,200,278	$ 2,084
Clinton	31	$ 13,450,515	$ 1,629
Cuyahoga	106	$ 389,621,908	$ 47,199
Delaware	33	$ 61,002,573	$ 7,390
Fairfield	67	$ 94,557,543	$ 11,455
Fayette	23	$ 11,052,410	$ 1,339
Franklin	190	$ 2,336,963,045	$ 283,103
Geauga	27	$ 12,064,728	$ 1,462
Greene	21	$ 17,560,307	$ 2,127
Hamilton	41	$ 113,316,790	$ 13,727
Knox	41	$ 76,691,482	$ 9,291
Lake	21	$ 12,988,101	$ 1,792
Licking	67	$ 186,741,453	$ 28,821
Lorain	83	$ 212,390,581	$ 25,729
Madison	104	$ 398,511,572	$ 61,584
Medina	17	$ 16,239,797	$ 1,967
Montgomery	72	$ 187,896,794	$ 22,762
Morrow	19	$ 12,996,574	$ 1,574
Pickaway	137	$ 346,622,641	$ 58,764
Portage	25	$ 17,793,583	$ 7,096
Richland	77	$ 236,998,425	$ 78,276
Stark	57	$ 148,641,582	$ 62,245
Summit	65	$ 197,956,468	$ 156,751
Union	55	$ 169,438,472	$ 219,741
Warren	109	$ 323,719,448	$ 312,011
Wayne	22	$ 12,202,802	$ 16,081
Total	1,684	$ 5,728,110,964	$ 1,448,538

Region 3

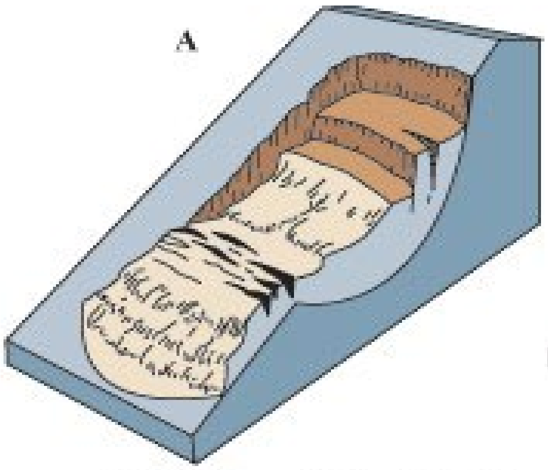
County	Number of Crit. Fac.	Value of Crit. Fac.	Est. Damage Per Year
Adams	30	$ 12,672,306	$ 1,535
Ashtabula	72	$ 25,195,275	$ 3,052
Athens	35	$ 53,251,615	$ 6,451
Belmont	70	$ 153,564,291	$ 18,603
Brown	31	$ 35,387,446	$ 4,287
Carroll	18	$ 5,220,360	$ 632
Clermont	51	$ 32,967,768	$ 3,994
Columbiana	36	$ 14,981,756	$ 1,926
Coshocton	21	$ 16,813,037	$ 2,037
Gallia	61	$ 49,786,218	$ 6,031
Guernsey	50	$ 58,733,741	$ 7,115
Harrison	24	$ 9,202,403	$ 1,115
Highland	11	$ 6,701,555	$ 812
Hocking	27	$ 7,590,231	$ 919
Holmes	29	$ 9,188,433	$ 1,113
Jackson	21	$ 10,211,085	$ 1,237
Jefferson	34	$ 14,685,898	$ 1,779
Lawrence	26	$ 9,167,439	$ 1,111
Mahoning	58	$ 109,678,167	$ 13,287
Meigs	24	$ 9,369,001	$ 2,838
Monroe	12	$ 3,933,796	$ 477
Morgan	15	$ 7,945,305	$ 963
Muskingum	36	$ 14,169,870	$ 1,717
Noble	32	$ 65,273,141	$ 35,271
Perry	9	$ 7,167,121	$ 868
Pike	12	$ 8,643,712	$ 1,047
Ross	129	$ 510,798,521	$ 61,879
Scioto	66	$ 478,434,987	$ 57,958
Trumbull	69	$ 97,032,569	$ 17,872
Tuscarawas	54	$ 50,576,265	$ 12,042
Vinton	19	$ 14,102,427	$ 9,690
Washington	50	$ 36,699,000	$ 42,232
Total	1,232	$ 1,939,144,738	$ 321,889

Statewide

County	Number of Crit. Fac.	Value of Crit. Fac.	Est. Damage Per Year
All 88	3,768	$ 8,870,436,830	$ 2,102,512

2.5 LANDSLIDE

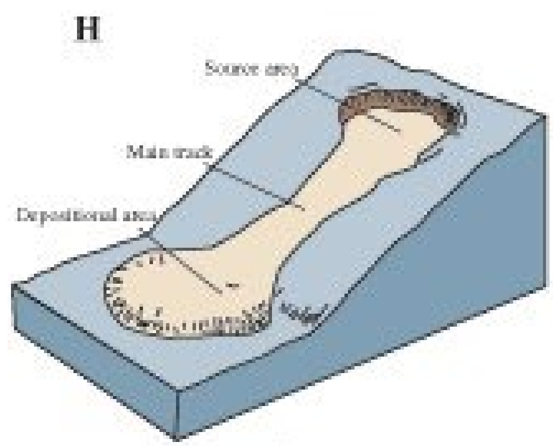
Per the Ohio Department of Natural Resources – Division of Geological Survey GeoFacts publication, a landslide is the downward and outward movement of soil and rock material on slopes. There are three main types of landslides that occur in Ohio. (https://ohiodnr.gov/discover-and-learn/safety-conservation/geologic-hazards/landslides)



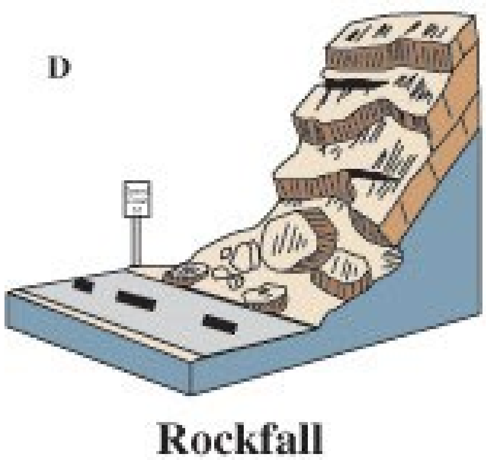
Rotational landslide

Rotational Slump: the movement of a mass of weak rock or sediment as a block unit along a curved slip plane. In Ohio, these types of slides commonly involve hundreds of thousands of cubic yards of material and extend for hundreds of feet. The crown or head, located in the upper section of the ground surface, consists of one or more rupture zones (scarps) that form a stair-step pattern of displaced blocks. The surfaces of these blocks are commonly rotated backward (reverse slope) and form depressions where water may accumulate, creating small ponds or swampy areas. Trees on these blocks may be inclined upslope, toward the top of the hill. The lower, downslope end (toe) of a rotational slump is a fan-shaped, bulging mass of material characterized by radial ridges and cracks. Trees on this portion of the landslide may be inclined at strange angles, giving rise to the descriptive terms "drunken" or "staggering" forest. Rotational slumps may develop comparatively slowly and commonly require several months or even years to reach stability; however, on occasion, they may move rapidly, achieving stability in only a few hours.

Earthflow: involves rock, sediment, or weathered surface materials moving downslope in a mass. The most common form of earth movement in Ohio, earthflow involves a smaller area than a rotational slump and forms a hummocky topography of ridges and swales. Trees may be inclined at odd angles throughout the length of an earthflow. Earthflows are most common in weathered surface materials, do not necessarily indicate weak rock, and are also common in unconsolidated glacial sediments. The rate of movement of an earthflow is generally quite slow.



Earthflow



Rockfall: an extremely rapid, potentially dangerous downslope movement of earth materials. Large blocks of massive bedrock suddenly become detached from a cliff or steep hillside and free fall in a rolling, bounding, or sliding manner downslope. Most rockfalls in Ohio involve massive beds of sandstone or limestone. Surface water seeps into joints or cracks in the rock, increasing its weight and causing expansion of joints in freezing temperatures, thus prying blocks of rock away from the main cliff. Weak and easily eroded clay or shale beneath the massive bed is an important contributing factor to rockfall. All illustrations were provided by the USGS.

One or more of the following conditions contribute to the occurrence of landslide events:

- ***Steep slope:*** All landslides move downslope under the influence of gravity. Therefore, steep slopes, cliffs, or bluffs are a required element leading to a landslide, especially in conjunction with one or more of the conditions listed below.
- ***Jointed rocks:*** Fractures in rocks allow surface moisture to penetrate and weaken it. When the moisture freezes, it pries the rock masses apart at the joint.
- ***Fine-grained, permeable rock or sediment:*** Fine rock particles are particularly conducive to landslide development because large amounts of moisture can enter them easily, increasing the material's weight, reducing the bonding strength of individual grains, and dissolving grain-cementing materials.
- ***Clay or shale units subject to lubrication***: Groundwater penetration of clay or shale can lead to a loss of binding strength between individual mineral grains and subsequent failure.
- ***Large amounts of water:*** Periods of heavy rainfall, excess snowmelt, or other events where water is accumulated saturate the zone above the normal water table and cause a landslide.

In addition to the conditions noted above, a landslide requires a triggering mechanism to initiate downslope movement. Several events or circumstances, many of them human-caused, can trigger landslides, including:

- ***Vibrations*** such as those from human-causes like blasting, the passing of a heavy truck, or from natural events like earthquakes, although no such occurrence has been documented in Ohio.
- ***Over steepened slopes*** caused by undercutting by stream or wave erosion, by human construction activities, or by the addition of fill material to the upper portion of a slope, disturb the equilibrium of a stable slope and cause the angle of stability to be exceeded.
- ***Increased weight on a slope*** caused by the addition of large amounts of fill, the construction of a building or other structure, or an unusual increase in precipitation, either from heavy rains or from artificial alteration of drainage patterns.
- ***Removal of vegetation and trees*** because of the loss of roots, which tend to hold the rock or sediment in place and soak up excess moisture.

RISK ASSESSMENT

LOCATION

Areas in southern and eastern Ohio have several conditions that can lead to the occurrence of landslide events. Thick deposits of broken and weathered bedrock fragments called colluvium, and lake silts, create slopes that are vulnerable to failure (among other geological factors). In addition, redbeds, soft shales that weather rapidly and slip, slide, and flow to form gentle contours that are quickly grassed over, have long presented landslide conditions in the Appalachian Plateau.

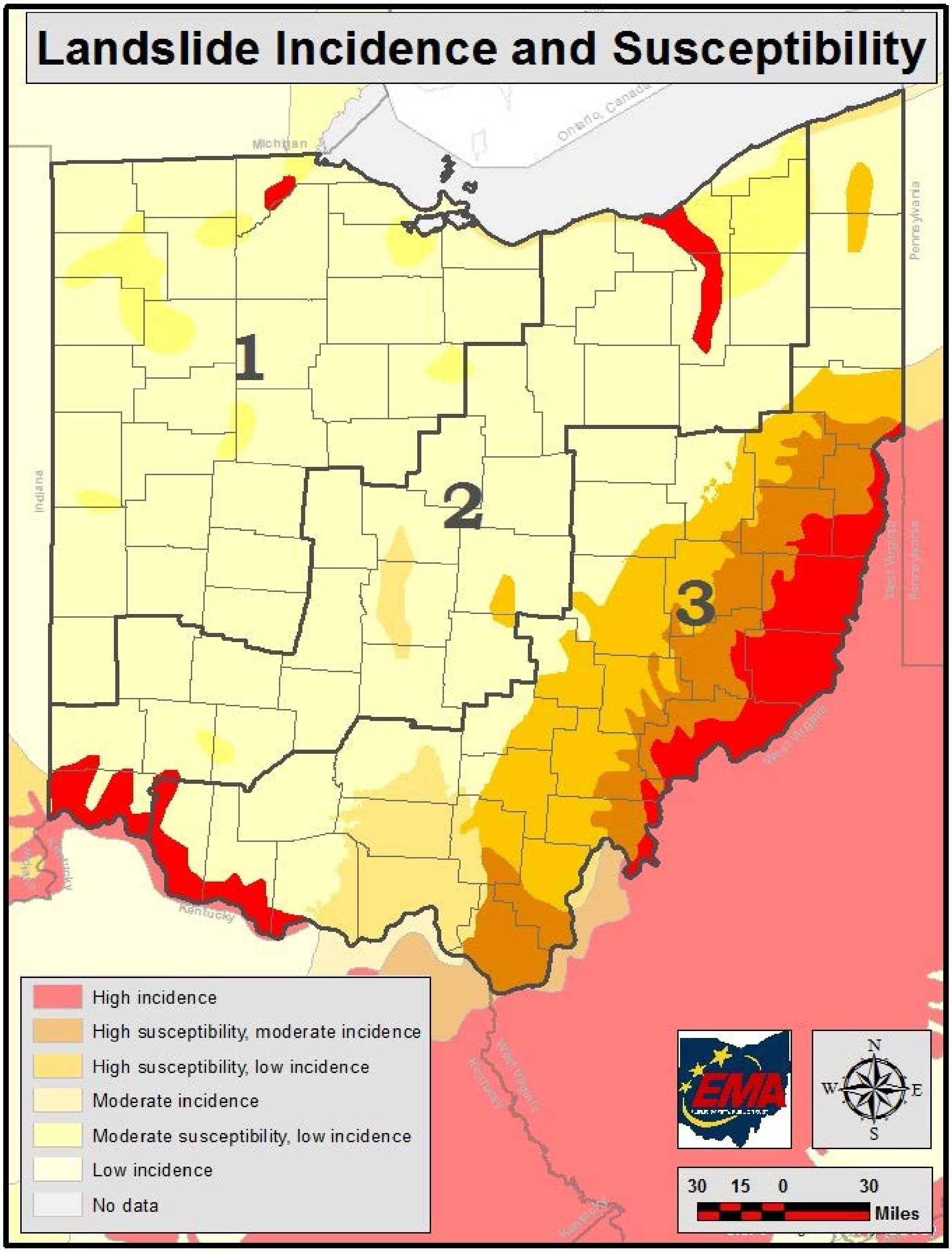
Per the USGS, (https://geochange.er.usgs.gov/sw/impacts/geology/landslides/) the Landslide incidence and susceptibility map (2.5.a) was digitized from the original stable-base manuscripts from USGS Professional Paper 1183. The map displays both the incidence of landslides and susceptibility of the land surface to landslides. Briefly, the map was constructed by evaluating geologic units shown on the geologic map of the United States (King and Beikman, 1974) and classifying them as having high, medium, or low landslide incidence based on number of known landslides, and as having the high, medium, or low susceptibility to landslide. High incidence was assigned to map units (indicated in red on the map) having more than 15 percent of their area involved in landslide; moderate incidence (in tan) to those having between 15 and 1.5 percent; and low incidence (in yellow) to those having less than 1.5 percent.

The largely subjective susceptibility indicators were defined as the probable degree of response of the rocks and soils at the surface to natural or artificial cutting or loading of slopes, or to anomalously high precipitation. The same percentages used to delimit landslide incidence were applied to the three categories of susceptibility. For example, a high susceptibility area would exhibit some movement over 15 percent or more of its surface area in response to widespread artificial cutting or high precipitation. The three susceptibility categories classified were: (1) high susceptibility with moderate incidence of landslide (dark brown); (2) high susceptibility combined with low landslide incidence (in gold); and (3) moderate susceptibility combined with low landslide incidence (in yellow/green).

Full weight could not be given to the important factors of slope angle and precipitation because no adequate slope or precipitation maps at the appropriate scale existed at the time the map was produced in 1982. A more detailed description about the construction of the map is given in the original U.S Geological Survey Professional Paper 1183

Region 1 primarily has a low landslide incidence. The most notable exception to this is Lucas and Wood Counties, which are reported to have a high landslide incidence. (Map 2.5.a). Along with Region 1, Region 2 also has a primarily low landslide incidence. Within Region 2, Butler, Hamilton, Warren, Cuyahoga, and Summit are all identified as having a high landslide incidence, which does not reflect the regional trend. Region 3 is identified as having the most area susceptible to landslide (i.e., the Appalachian Plateau). The largest part of the region has a high susceptibility with a low or moderate incidence. However, most of Belmont and Monroe counties have a high landslide incidence with parts of Columbiana, Jefferson, Harrison, Washington, Athens, Meigs, Adams, Brown, and Clermont Counties having a high incidence as well.

Map 2.5.a



LHMP DATA

Hamilton County – While Region 3 and parts of Region 2 have potentially high susceptibility and incidence to landslides. Hamilton County and the City of Cincinnati has some of the highest cost per capita in the United States for historical landslide damages. The 2023 Hamilton County Multi-Hazard Mitigation plan included a landslide assessment performed by the University of Cincinnati which is summarized in Table 2.5.a.

Building Type	Number of Buildings	Estimated Losses/Exposure
Residential	1,346	$279,851,500
Non-Residential	610	$19,740,730
Critical Facilities	10	$2,150,000
Totals	1,966	$301,742,230

Table 2.5.a

Landslides are a significant problem in several areas of Ohio. Hamilton County and the Cincinnati area has one of the highest per-capita costs due to landslide damage of any city in the United States. Landslide occurrences have significantly increased since 2011, especially along the Columbia Parkway. For example, in 2009, there were three reports to the City's Customer Service system of landslides, and one in 2010. By comparison, there were 18 reports of landslides affecting the Columbia Parkway in 2011. Additionally, record rainfalls led to multiple landslides in January and May 2012. On April 17, 2018, the State received a disaster declaration (DR-4360) due to the severe storms, flooding, mudslides, and landslides that struck the southern and southeastern counties of Ohio in February, including Hamilton County. Public assistance grants obligated totaled $66,595,216.18.

Monroe County – The 2023 Monroe County Hazard Mitigation Plan indicates that landslides are, unfortunately, common in Monroe County. According to the Ohio Department of Transportation (ODOT), Monroe County has had more than 1,187 landslides that affect roadways (ODOT, 2020). ODOT releases weekly updates regarding State Route closures in Ohio. In January of 2020, two sites on State Route 536 were restricted due to emergency slip repairs. Sites on State Route 255 were also restricted during that same timeframe. Prior to the January 28, 2020 status update, each report in December of 2019 indicated land slips and sinks along State Routes 255 and 536. In addition to state routes, county roads have also experienced numerous slips. According to the 2019 County Engineer Report, 10 Monroe County roads were scheduled for slip removal during the 2019 fiscal year.

PAST OCCURRENCES

Ohio has had a long history of damage from landslides; for example, geologists at the University of Cincinnati report that the Cincinnati metropolitan area has one of the highest per capita costs of landslide damage of any metropolitan area in the United States. Accounts of landslide concerns date back to the 1970s. A 1980 U.S Geological survey report estimated Hamilton County likely had the highest annual per capita landslide damage costs in the country. Within Hamilton County, Cincinnati alone was spending about $500,000 annually on emergency landslide repairs. Despite the chronic problem, no long-term plan currently exists to permanently provide a solution. While landslides have been problematic in Cincinnati since the early to mid-1800s, documentation is limited. As the city began to expand and infrastructure was improved in the early 1900s, landslide hazards became better documented.

The University of Cincinnati report found that landslide damages in Hamilton County, primarily due to public road construction, averaged more than $5 million each year between 1973 and 1978. Well-publicized landslides that occurred in the 1970s included those along Columbia Parkway, Hillside Avenue, Delhi Pike, and Huffman Court. Mt. Adams (Cincinnati, Ohio) is the most prominent topographic feature in Cincinnati. It is also home to one of the most expensive landslide remediation projects in the history of the U.S. The cost of remediation was $44.5 million in 2005 dollars. A normal retaining wall for this slide could not be used because the failure surface was too deep.

Rockfalls have also caused dangerous conditions. Ohio DNR reports that on Christmas Eve in 1986, an individual traveling in an automobile was killed by falling rock along U.S. Route 52 in Lawrence County in southern Ohio. In 2017, ODOT reported several large boulders fell in Lawrence County blocking all four lanes of State Route 7 for several days. The westbound lanes of State Route 7 didn't reopen for nearly a month. The photograph was provided by ODOT District 9.

Landslides can be triggered by heavy rainfall and flooding, leading to multiple disasters in the same location. An example is from April of 2018 when the State received a disaster declaration (DR- 4360) due to the severe storms, flooding, mudslides, and landslides that struck the southern and southeastern counties of Ohio. Federal funding also was available to State and eligible local governments on a cost-sharing basis for the repair or replacement of public facilities damaged by the severe storms, flooding, mudslides, and landslides in the counties of Adams, Athens, Belmont, Brown, Columbiana, Gallia, Hamilton, Harrison, Jackson, Jefferson, Lawrence, Meigs, Monroe, Morgan, Muskingum, Noble, Perry, Pike, Scioto, Vinton, and Washington Counties. The photograph was provided by ODOT.

A similar incident occurred in February of 2019, when much of southern Ohio was impacted by very high periods of rainfall, which led to soil saturation and triggered several landsides. when the State received a disaster declaration (DR- 4424) due to the severe storms, flooding, mudslides, and landslides that struck the southern and southeastern counties of Ohio. Federal funding also was available to State and eligible local governments on a cost-sharing basis for the repair or replacement of public facilities damaged by the severe storms, flooding, mudslides, and landslides in the counties of Adams, Athens, Belmont, Brown, Gallia, Guernsey, Hocking, Jackson, Jefferson, Lawrence, Meigs, Monroe, Morgan, Muskingum, Noble, Perry, Pike, Ross, Scioto, Vinton and Washington.

The impact of most if not all landslide and rockfall events in Ohio are directly tied to rainfall events, therefore more damage data related to such events in captured under flood related damages for the purposes of FEMA's public assistance program. Additionally, the State has seen a recent increase in request for Hazard Mitigation Assistance funding to address landslide and erosion hazards. This would include nearly $7.4 million in federal funding including over $5.4 million for a project in Zanesville, Ohio.

OHIO DEPARTMENT OF TRANSPORTATION LANDSLIDE AND ROCKFALL INVENTORIES

The Landslide (01/2022) and Rockfall (10/2022) manuals prepared the ODOT Office of Geotechnical Engineering (OGE), provide a rational approach to manage the unsafe or failed slopes/embankments and rockfalls. The manuals include a systematic process for collecting the information needed for decision making.

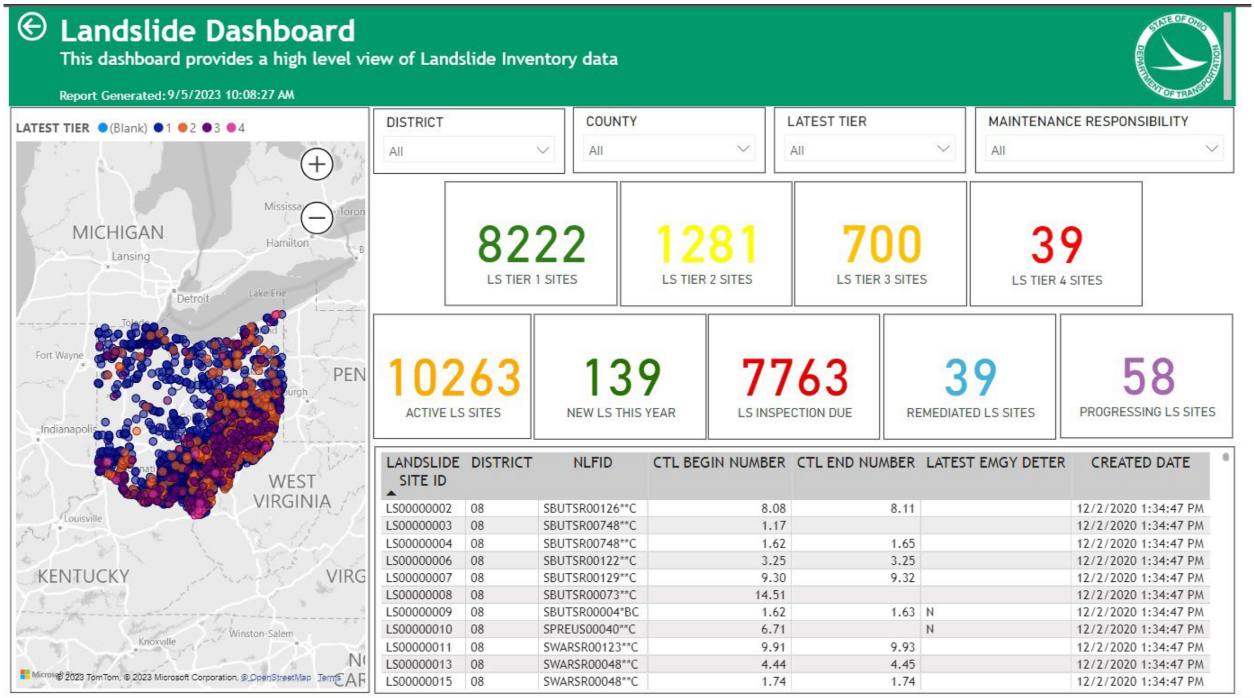
LANDSLIDE MANUAL (https://www.transportation.ohio.gov/working/engineering/geotechnical/asset-management/landslide-inventory)

This manual was developed by ODOT OGE to inventory soil slopes, to identify potential hazardous slopes, to assess relative risk for those slopes, to determine degree of monitoring required, and to allow for actions to be taken to reduce, minimize, or eliminate the risk to the public's safety and to protect the highway system. The intent of this manual is to facilitate the creation of a statewide landslide inventory process through the development of a statewide inventory procedure and the establishment of office and field methods. These methods should be used during the initial population of the inventory, inventory of new sites following the initial population, and for maintenance and monitoring of the sites. The data collected from the SdAD inventory process will be stored within the Geologic Hazard Management System (GHMS) and other related components of the ODOT GeoMS.

Essentially, this manual provides information about the following:

- procedure for landslide data collection;
- landside hazard assessment using the ODOT rating matrix; and
- guidance on the use of a global positioning system (GPS) and an internet website for the ODOT landslide database.

The Preliminary Rating will segregate the lower priority sites from the groups that will receive detailed data collection efforts. This Manual will outline a tiered data collection methodology which will allow landslides within Ohio to be rated for relative risk of slope instability to the public and Ohio's highway system. The dashboard (2.5.b) was created by the Office of Geotechnical Engineering (OGE) and represents the number of landslides by county that are currently impacting the State's highway system. The dashboard indicates the number of landslides by tiers 1,2,3,4 and 5 sites throughout the entire state. The counties with the most currently impacted roadways are Monroe (1159), Morgan (1028) and Athens (835).



LANDSLIDE SITE ID	DISTRICT	NLFID	CTL BEGIN NUMBER	CTL END NUMBER	LATEST EMGY DETER	CREATED DATE
LS00000002	08	SBUTSR00126**C	8.08	8.11		12/2/2020 1:34:47 PM
LS00000003	08	SBUTSR00748**C	1.17			12/2/2020 1:34:47 PM
LS00000004	08	SBUTSR00748**C	1.62	1.65		12/2/2020 1:34:47 PM
LS00000006	08	SBUTSR00122**C	3.25	3.25		12/2/2020 1:34:47 PM
LS00000007	08	SBUTSR00129**C	9.30	9.32		12/2/2020 1:34:47 PM
LS00000008	08	SBUTSR00073**C	14.51			12/2/2020 1:34:47 PM
LS00000009	08	SBUTSR00004*BC	1.62	1.63	N	12/2/2020 1:34:47 PM
LS00000010	08	SPREUS00040**C	6.71		N	12/2/2020 1:34:47 PM
LS00000011	08	SWARSR00123**C	9.91	9.93		12/2/2020 1:34:47 PM
LS00000013	08	SWARSR00048**C	4.44	4.45		12/2/2020 1:34:47 PM
LS00000015	08	SWARSR00048**C	1.74	1.74		12/2/2020 1:34:47 PM

Table 2.5.b

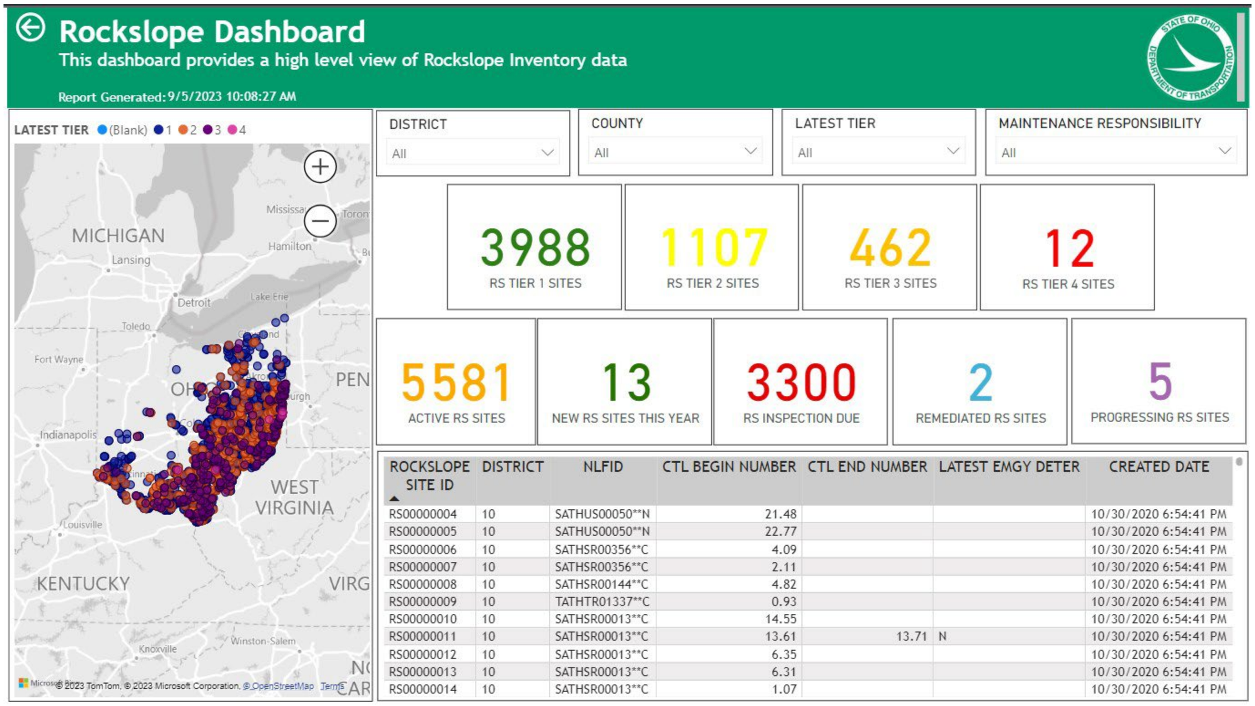
ROCKFALL MANUAL

http://www.dot.state.oh.us/Divisions/Engineering/Geotechnical/Geotechnical_Documents/Manual%20for%20Rockfall%20Inventory.pdf

Rockfalls can constitute a major hazard along Ohio roadways, posing a risk to life, property, and traffic safety. As a result of rockfalls, maintenance problems are constantly occurring, resulting in a strain on the Ohio Department of Transportation (ODOT) funds and manpower. A rockfall inventory was performed for the state highway system as noted in ODOT's policy on geohazards. This inventory included all natural and man-made slopes with exposed bedrock.

The data collection procedures are grouped into four (4) primary sections with subsections:

- Site Inventory and Preliminary Rating
- Tier 1 Site Rating
- Tier 2 Site Rating
- Tier 3 and Tier 4 Site Rating



ROCKSLOPE SITE ID	DISTRICT	NLFID	CTL BEGIN NUMBER	CTL END NUMBER	LATEST EMGY DETER	CREATED DATE
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RS00000005	10	SATHUS00050**N	22.77			10/30/2020 6:54:41 PM
RS00000006	10	SATHSR00356**C	4.09			10/30/2020 6:54:41 PM
RS00000007	10	SATHSR00356**C	2.11			10/30/2020 6:54:41 PM
RS00000008	10	SATHSR00144**C	4.82			10/30/2020 6:54:41 PM
RS00000009	10	TATHTR01337**C	0.93			10/30/2020 6:54:41 PM
RS00000010	10	SATHSR00013**C	14.55			10/30/2020 6:54:41 PM
RS00000011	10	SATHSR00013**C	13.61	13.71	N	10/30/2020 6:54:41 PM
RS00000012	10	SATHSR00013**C	6.35			10/30/2020 6:54:41 PM
RS00000013	10	SATHSR00013**C	6.31			10/30/2020 6:54:41 PM
RS00000014	10	SATHSR00013**C	1.07			10/30/2020 6:54:41 PM

Table 2.5.c

This Manual outlines a tiered data collection methodology which allows rock slopes within Ohio to be rated for relative rockfall risk to the public and Ohio's highway system. The data collected from each site is incorporated into an Enterprise Database and integrated into a GIS system. The inventory consists of identifying and locating Inventory Sites within the rock slopes situated along Ohio's highway system. Generally, this inventory is concerned with rock slopes located above the roadway, unless a rockfall event below the road could result in adverse impacts to the highway system.

PROBABILITY OF FUTURE EVENTS

Landslide probability is highly site-specific, and cannot be accurately characterized on a statewide basis, except in the most general sense. Statewide analyses for potential landslides have been performed by the US Geological Survey (USGS). The possible landslide incidence and susceptibility was discussed earlier in this chapter and illustrated on Map 2.5.a.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHODOLOGY

In the National Risk Index, a landslide risk index score and rating represent a community's relative risk for landslides when compared to the rest of the United States. A landslide expected annual loss score and rating represent a community's relative level of expected building and population loss each year due to landslides when compared to the rest of the United States. The National Risk Index – Technical Documentation (Appendix J) describes in greater detail the methodology used to perform the risk analysis for landslides. Generally, the landslide exposure value represents a community's building value (in dollars) and population (in both people and population equivalence) exposed to landslides. A landslides annualized frequency value represents the average number of recorded landslide hazard occurrences (events) per year over the period of record (11.8 years). The Expected Annual Loss represents the relative level of building and population loss each year due to landslides.

RESULTS

County	Exposure (Sq. Mi)	Exposure (Buildings)	Exposure (Population)	EAL* (Buildings)	EAL* (Population Equivalence)	EAL* (Total)
Adams	9.50	$3,452,859,752	12782	$4,500	17400	$21,900
Allen	1.29	$696,355,435	3033	$4,500	17400	$21,900
Ashland	5.35	$2,542,108,044	8478	$4,500	17400	$21,900
Ashtabula	8.85	$5,664,938,817	26831	$105,000	17400	$122,400
Athens	17.44	$9,565,434,138	50651	$158,080	27137	$185,217
Auglaize	0.67	$248,084,544	1502	$4,500	17400	$21,900
Belmont	18.96	$8,926,772,868	44938	**$505,744**	**78978**	**$584,722**
Brown	6.07	$2,116,114,968	9606	$25,182	**99261**	$124,442
Butler	15.59	$11,265,861,944	61981	$105,000	17400	$122,400
Carroll	14.47	$4,074,596,364	21086	$4,500	17400	$21,900
Champaign	1.91	$577,843,864	3151	$4,500	17400	$21,900
Clark	4.73	$3,126,643,510	15694	$4,500	17400	$21,900
Clermont	14.76	$8,955,171,944	44553	**$281,495**	42467	**$323,962**
Clinton	1.89	$789,540,757	2986	$4,500	17400	$21,900
Columbiana	21.75	$10,451,769,075	51668	$138,053	26965	$165,018
Coshocton	11.33	$4,255,410,632	19798	$4,500	17400	$21,900
Crawford	0.23	$39,382,443	300	$1,969	17400	$19,369
Cuyahoga	33.57	**$39,192,910,283**	**189582**	$174,152	20666	$194,817
Darke	1.19	$532,559,402	2092	$4,500	17400	$21,900
Defiance	0.63	$398,840,536	1738	$4,500	17400	$21,900
Delaware	2.33	$1,877,031,890	6979	$4,500	17400	$21,900
Erie	1.97	$1,103,308,276	4073	$4,500	17400	$21,900
Fairfield	14.96	$7,880,446,179	45753	$105,000	17400	$122,400
Fayette	0.10	$33,427,074	148	$1,671	8590	$10,262
Franklin	9.64	**$13,882,694,469**	**65461**	$105,000	17400	$122,400
Fulton	0.09	$14,768,535	112	$738	6489	$7,227
Gallia	12.58	$3,973,498,128	20191	$4,500	17400	$21,900
Geauga	8.73	$4,691,636,830	20150	$4,500	17400	$21,900
Greene	6.76	$4,660,494,500	22677	$4,500	17400	$21,900
Guernsey	16.46	$6,155,218,716	27499	$105,000	17400	$122,400
Hamilton	52.50	**$52,441,671,477**	**274992**	**$383,750**	47362	**$431,112**
Hancock	1.55	$1,141,895,588	3556	$4,500	17400	$21,900
Hardin	0.48	$125,821,917	629	$4,500	17400	$21,900
Harrison	8.35	$2,190,197,005	11483	$10,323	47349	$57,672
Henry	0.11	$53,244,841	162	$2,662	9414	$12,077
Highland	6.56	$2,435,932,388	10477	$4,500	17400	$21,900

Hocking	10.77	$5,272,102,861	22170	$259,436	39500	$298,935
Holmes	12.55	$5,697,381,784	21897	$105,000	17400	$122,400
Huron	1.18	$496,327,424	3031	$4,500	17400	$21,900
Jackson	10.83	$3,941,590,597	20538	$18,961	**65853**	$84,814
Jefferson	18.76	$12,539,534,879	49813	**$398,132**	65511	**$463,643**
Knox	11.01	$4,303,806,392	20573	$4,500	17400	$21,900
Lake	11.27	$7,923,164,389	43341	$105,000	17400	$122,400
Lawrence	16.63	$6,188,126,906	38828	**$860,817**	**151141**	**$1,011,958**
Licking	20.35	$10,712,805,626	52933	$105,000	17400	$122,400
Logan	2.34	$959,459,034	4164	$4,500	17400	$21,900
Lorain	4.52	$3,290,141,793	15352	$4,500	17400	$21,900
Lucas	2.27	$2,131,914,743	7210	$4,500	17400	$21,900
Madison	0.09	$42,283,680	153	$2,114	8853	$10,967
Mahoning	9.41	$6,461,861,706	25101	$206,266	33917	$240,183
Marion	0.29	$163,776,015	482	$4,500	17400	$21,900
Medina	7.49	$4,247,662,643	19522	$4,500	17400	$21,900
Meigs	11.10	$3,763,456,711	17469	$20,030	**74802**	$94,832
Mercer	0.22	$86,835,690	254	$4,342	14750	$19,092
Miami	1.61	$845,508,297	4239	$4,500	17400	$21,900
Monroe	9.06	$3,542,350,553	9857	$4,500	17400	$21,900
Montgomery	14.90	$11,448,976,543	65199	$105,000	17400	$122,400
Morgan	8.00	$2,277,973,531	11158	$4,500	17400	$21,900
Morrow	1.62	$596,675,133	2857	$4,500	17400	$21,900
Muskingum	23.53	$10,474,708,502	51796	$105,000	17400	$122,400
Noble	5.86	$2,680,188,017	10120	$4,500	17400	$21,900
Ottawa	0.90	$809,716,169	1292	$4,500	17400	$21,900
Paulding	0.07	$28,612,510	70	$1,431	4044	$5,474
Perry	11.43	$3,511,770,990	23170	$4,500	17400	$21,900
Pickaway	2.07	$1,055,627,389	6863	$4,500	17400	$21,900
Pike	8.41	$3,358,215,468	14882	$16,381	41392	$57,773
Portage	12.07	$6,754,463,596	35153	$105,000	17400	$122,400
Preble	3.61	$1,311,200,826	6966	$4,500	17400	$21,900
Putnam	0.11	$24,550,162	71	$1,228	4089	$5,317
Richland	11.14	$4,763,749,701	27318	$4,500	17400	$21,900
Ross	14.72	$7,075,354,032	35049	$166,038	33836	$199,874
Sandusky	0.76	$609,429,457	2343	$4,500	17400	$21,900
Scioto	21.93	$7,088,723,306	49369	$142,882	25449	$168,331
Seneca	0.76	$308,986,882	872	$4,500	17400	$21,900
Shelby	3.25	$2,236,773,626	12326	$4,500	17400	$21,900
Stark	35.81	**$22,556,094,485**	**107469**	$105,000	17400	$122,400
Summit	34.83	**$27,749,690,100**	**144124**	$160,170	19171	$179,341
Trumbull	4.27	$2,491,320,418	10933	$4,500	17400	$21,900
Tuscarawas	23.48	$10,186,664,450	48879	$160,194	26300	$186,494

Union	0.11	$42,174,550	163	$6,845	24917	$31,762
Van Wert	0.28	$176,617,718	902	$4,500	17400	$21,900
Vinton	5.98	$1,722,187,556	9808	$15,105	63415	$78,520
Warren	10.03	$5,815,738,155	29033	$105,000	17400	$122,400
Washington	20.67	$7,042,584,817	38636	$149,696	25908	$175,603
Wayne	11.10	$5,425,147,570	27048	$105,000	17400	$122,400
Williams	0.51	$178,722,598	651	$4,500	17400	$21,900
Wood	1.72	$1,511,653,447	5561	$4,500	17400	$21,900
Wyandot	0.87	$290,082,232	1470	$4,500	17400	$21,900
Grand Total	**789.93**	**$453,748,952,793**	**2245269**	**$5,941,884**	**2164125**	**$8,106,009**

*Expected Annual Loss
Chart 2.5.a

STATE OWNED AND STATE LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHODOLOGY

The state-owned and state-leased critical facilities datasets were used to perform an analysis based upon the spatial location of each critical facility, the replacement cost of that facility and Landslide Risk Index score and rating from the NRI at the census tract level (Appendix J).

	Very Low		Relatively Low		Relatively Moderate		Relatively High		Very High	
County	**# of CF**	**Replacement Cost**	**# of CF**	**Replacement Cost**	**# of CF**	**Replacement Cost**	**# of CF**	**Replacement Cost**	**# of CF**	**Replacement Cost**
ADAMS	0	$ -	0	$ -	16	$ 3,135,451.00	12	$ 8,862,854.00	2	$ 674,000.00
ALLEN	0	$ -	11	$ 1,797,850.00	72	$ 140,738,961.00	0	$ -	0	$ -
ASHLAND	16	$ 48,123,413.00	3	$ 1,253,854.00	18	$ 27,397,852.00	107	$ 26,692,313.00	0	$ -
ASHTABULA	0	$ -	27	$ 6,128,401.00	32	$ 6,991,711.00	13	$ 12,075,166.00	0	$ -
ATHENS	0	$ -	0	$ -	4	$ 704,050.00	25	$ 51,430,178.00	6	$ 1,117,386.00
AUGLAIZE	0	$ -	0	$ -	10	$ 5,299,001.00	0	$ -	0	$ -
BELMONT	0	$ -	0	$ -	44	$ 146,285,132.00	5	$ 3,388,643.00	21	$ 3,890,524.00
BROWN	0	$ -	10	$ 1,944,400.00	20	$ 33,389,995.00	0	$ -	0	$ -
BUTLER	8	$ 914,192.00	4	$ 3,492,825.00	6	$ 5,067,067.00	2	$ 588,095.00	0	$ -
CARROLL	0	$ -	0	$ -	18	$ 5,220,361.00	0	$ -	0	$ -
CHAMPAIGN	0	$ -	13	$ 7,720,300.00	8	$ 1,525,793.00	0	$ -	0	$ -
CLARK	1	$ 20,517.00	25	$ 9,363,438.00	1	$ 266,967.00	0	$ -	0	$ -
CLERMONT	0	$ -	0	$ -	12	$ 5,870,500.00	32	$ 26,297,482.00	6	$ 771,250.00
CLINTON	1	$ 292,820.00	2	$ 610,600.00	26	$ 12,113,709.00	1	$ 395,063.00	0	$ -
COLUMBIANA	0	$ -	0	$ -	13	$ 4,989,755.00	23	$ 9,992,002.00	0	$ -
COSHOCTON	0	$ -	1	$ 23,237.00	20	$ 16,789,804.00	0	$ -	0	$ -
CRAWFORD	0	$ -	10	$ 11,001,610.00	0	$ -	2	$ 519,096.00	0	$ -
CUYAHOGA	0	$ -	61	$ 163,185,697.00	20	$ 181,890,442.00	0	$ -	0	$ -
DARKE	0	$ -	12	$ 2,790,496.00	2	$ 401,720.00	2	$ 639,568.00	0	$ -
DEFIANCE	0	$ -	0	$ -	0	$ -	12	$ 11,003,684.00	0	$ -
DELAWARE	1	$ 16,126,450.00	4	$ 1,547,674.00	1	$ 46,125.00	0	$ -	0	$ -
ERIE	0	$ -	1	$ 611,697.00	1	$ 271,672.00	8	$ 3,786,119.00	0	$ -
FAIRFIELD	2	$ 799,074.00	5	$ 876,198.00	50	$ 89,107,601.00	9	$ 3,731,330.00	0	$ -
FAYETTE	2	$ 462,600.00	0	$ -	1	$ 25,613.00	0	$ -	0	$ -
FRANKLIN	11	$ 3,796,523.00	57	$ 492,003,551.00	14	$ 274,537,016.00	15	$ 1,231,839,826.00	0	$ -
FULTON	0	$ -	0	$ -	9	$ 8,164,053.00	0	$ -	0	$ -
GALLIA	0	$ -	0	$ -	61	$ 49,786,218.00	0	$ -	0	$ -
GEAUGA	4	$ 979,295.00	12	$ 3,338,308.00	11	$ 7,747,125.00	0	$ -	0	$ -

GREENE	8	$ 12,563,703.00	11	$ 4,167,609.00	0	$ -	0	$ -	0	$ -
GUERNSEY	0	$ -	0	$ -	0	$ -	50	$ 58,733,742.00	0	$ -
HAMILTON	2	$ 617,363.00	29	$ 90,941,503.00	8	$ 21,357,812.00	2	$ 400,111.00	0	$ -
HANCOCK	0	$ -	2	$ 47,101.00	0	$ -	14	$ 6,550,107.00	0	$ -
HARDIN	0	$ -	0	$ -	18	$ 6,825,758.00	0	$ -	0	$ -
HARRISON	0	$ -	0	$ -	17	$ 6,917,039.00	7	$ 2,285,366.00	0	$ -
HENRY	0	$ -	2	$ 585,529.00	13	$ 3,640,667.00	0	$ -	0	$ -
HIGHLAND	0	$ -	2	$ 966,600.00	9	$ 5,734,955.00	0	$ -	0	$ -
HOCKING	0	$ -	0	$ -	1	$ 499,702.00	26	$ 7,090,528.00	0	$ -
HOLMES	0	$ -	0	$ -	2	$ 633,134.00	27	$ 8,555,299.00	0	$ -
HURON	0	$ -	19	$ 8,361,487.00	0	$ -	3	$ 2,475,863.00	0	$ -
JACKSON	0	$ -	0	$ -	15	$ 8,543,360.00	5	$ 1,405,325.00	1	$ 262,400.00
JEFFERSON	0	$ -	0	$ -	25	$ 12,245,048.00	7	$ 2,101,449.00	2	$ 339,400.00
KNOX	0	$ -	36	$ 75,700,422.00	5	$ 991,064.00	0	$ -	0	$ -
LAKE	8	$ 9,262,306.00	8	$ 3,199,726.00	4	$ 491,079.00	1	$ 34,991.00	0	$ -
LAWRENCE	0	$ -	1	$ 28,111.00	3	$ 992,200.00	12	$ 5,734,528.00	10	$ 2,412,600.00
LICKING	1	$ 416,470.00	6	$ 1,819,033.00	37	$ 43,897,507.00	2	$ 561,259.00	0	$ -
LOGAN	0	$ -	11	$ 6,888,938.00	0	$ -	5	$ 1,573,265.00	0	$ -
LORAIN	2	$ 3,623,098.00	66	$ 201,705,925.00	0	$ -	0	$ -	0	$ -
LUCAS	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
MADISON	0	$ -	10	$ 8,662,800.00	0	$ -	2	$ 1,503,700.00	0	$ -
MAHONING	0	$ -	12	$ 6,705,376.00	41	$ 102,301,939.00	1	$ 75,264.00	1	$ 323,229.00
MARION	0	$ -	47	$ 230,110,009.00	0	$ -	10	$ 6,397,971.00	0	$ -
MEDINA	1	$ 7,618,116.00	14	$ 8,564,124.00	0	$ -	0	$ -	0	$ -
MEIGS	0	$ -	0	$ -	22	$ 8,496,701.00	0	$ -	2	$ 872,300.00
MERCER	0	$ -	13	$ 1,907,807.00	12	$ 6,145,781.00	0	$ -	0	$ -
MIAMI	0	$ -	12	$ 5,980,656.00	5	$ 5,266,628.00	0	$ -	0	$ -
MONROE	0	$ -	0	$ -	9	$ 3,207,128.00	3	$ 726,669.00	0	$ -
MONTGOMERY	2	$ 1,118,575.00	39	$ 138,970,092.00	10	$ 27,380,197.00	0	$ -	0	$ -
MORGAN	0	$ -	0	$ -	4	$ 1,724,577.00	11	$ 6,220,731.00	0	$ -
MORROW	0	$ -	8	$ 6,031,104.00	2	$ 880,049.00	9	$ 6,085,423.00	0	$ -

MUSKINGUM	0	$ -	0	$ -	20	$ 8,539,636.00	16	$ 5,630,239.00	0	$ -
NOBLE	0	$ -	0	$ -	26	$ 63,588,248.00	6	$ 1,684,895.00	0	$ -
OTTAWA	36	$ 34,797,636.00	1	$ 383,775.00	5	$ 1,126,208.00	0	$ -	0	$ -
PAULDING	0	$ -	1	$ 747,985.00	0	$ -	0	$ -	0	$ -
PERRY	0	$ -	0	$ -	4	$ 985,911.00	5	$ 6,181,210.00	0	$ -
PICKAWAY	2	$ 859,800.00	4	$ 916,031.00	34	$ 60,874,713.00	96	$ 283,935,598.00	0	$ -
PIKE	0	$ -	0	$ -	5	$ 1,362,816.00	7	$ 7,280,896.00	0	$ -
PORTAGE	0	$ -	10	$ 3,272,186.00	15	$ 14,521,394.00	0	$ -	0	$ -
PREBLE	1	$ 22,231.00	25	$ 6,894,679.00	1	$ 620,813.00	0	$ -	0	$ -
PUTNAM	0	$ -	4	$ 1,435,662.00	0	$ -	0	$ -	0	$ -
RICHLAND	1	$ 216,613.00	54	$ 229,450,873.00	10	$ 3,578,900.00	0	$ -	0	$ -
ROSS	0	$ -	0	$ -	100	$ 485,209,772.00	29	$ 25,588,748.00	0	$ -
SANDUSKY	1	$ 902,538.00	0	$ -	0	$ -	4	$ 1,308,180.00	0	$ -
SCIOTO	0	$ -	0	$ -	22	$ 76,900,775.00	42	$ 400,971,611.00	2	$ 562,600.00
SENECA	0	$ -	37	$ 39,140,884.00	8	$ 6,139,561.00	0	$ -	0	$ -
SHELBY	5	$ 1,548,217.00	4	$ 709,072.00	26	$ 30,072,436.00	0	$ -	0	$ -
STARK	0	$ -	34	$ 134,633,408.00	13	$ 8,386,147.00	0	$ -	0	$ -
SUMMIT	0	$ -	33	$ 174,060,902.00	18	$ 10,552,127.00	13	$ 5,792,638.00	0	$ -
TRUMBULL	33	$ 87,371,476.00	22	$ 3,828,910.00	5	$ 1,259,932.00	0	$ -	0	$ -
TUSCARAWAS	0	$ -	0	$ -	32	$ 6,367,390.00	13	$ 42,851,727.00	9	$ 1,357,148.00
UNION	0	$ -	0	$ -	9	$ 8,450,630.00	0	$ -	0	$ -
VAN WERT	0	$ -	12	$ 6,943,539.00	2	$ 785,260.00	0	$ -	0	$ -
VINTON	0	$ -	0	$ -	8	$ 1,631,300.00	7	$ 11,138,727.00	4	$ 1,332,400.00
WARREN	1	$ 1,558,000.00	88	$ 308,271,672.00	15	$ 12,613,969.00	2	$ 1,195,500.00	0	$ -
WASHINGTON	0	$ -	0	$ -	18	$ 19,171,090.00	30	$ 16,687,410.00	2	$ 840,500.00
WAYNE	0	$ -	3	$ 550,094.00	11	$ 5,179,781.00	8	$ 6,472,928.00	0	$ -
WILLIAMS	0	$ -	0	$ -	15	$ 7,424,175.00	1	$ 387,624.00	0	$ -
WOOD	6	$ 5,692,411.00	9	$ 16,021,184.00	3	$ 8,105,660.00	0	$ -	0	$ -
WYANDOT	0	$ -	6	$ 1,899,686.00	2	$ 1,235,382.00	14	$ 3,594,642.00	0	$ -
Grand Total	**156**	**$ 239,703,437.00**	**953**	**$ 2,438,194,630.00**	**1,179**	**$ 2,140,620,045.00**	**758**	**$ 2,330,455,583.00**	**68**	**$ 14,755,737.00**

Chart 2.5.b

REGIONS

Region 3 has the greatest number (482) critical facilities in the both the in the Relatively High and Very High Risk categories. Region 2 has the highest replacement cost of critical facilities in the Relatively High and Very High Risk categories at just over 1.5 billion dollars in replacement costs.

	Very Low		Relatively Low		Relatively Moderate	
	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost
Region1	50	$ 42,983,550	277	$ 361,343,384	213	$ 234,056,496
Region 2	73	$ 109,348,411	601	$ 2,057,226,211	338	$ 817,087,919
Region 3	33	$ 87,371,476	75	$ 19,625,035	628	$ 1,089,475,630

	Relatively High		Very High	
	# of CF	Replacement Cost	# of CF	Replacement Cost
Region1	75	$ 38,236,119	0	$ -
Region 2	269	$ 1,569,228,775	0	$ -
Region 3	414	$ 722,990,689	68	$ 14,755,737

Chart 2.5.c

2.6 DAM/LEVEE FAILURE

DAM FAILURE

A dam is defined as an artificial barrier that does or may impound water or other liquefied material. Upground reservoirs and lagoons are considered dams per Ohio Administrative Code (OAC) 1501:21-3-01. Most commonly, a dam is constructed across a stream channel to impound water for recreation, flood control, or other uses. Upground reservoirs and lagoons are common for drinking water supply and water treatment. Some flood control dams, often referred to as “dry dams”, only impound water during wet or flooding conditions. A dam failure is defined as an uncontrolled release of impounded water. The most common causes of dam failures include dam overtopping, excessive seepage, and structural failure of a component. Despite efforts to provide sufficient structural integrity and to perform inspection and maintenance, problems can develop that can lead to failure. While most dams have storage volumes small enough that failures would have little or no consequences, dams with large storage amounts could cause significant flooding downstream.

Dam failures can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding;
- Inadequate spillway capacity, resulting in excess overtopping flows;
- Internal erosion caused by embankment or foundation leakage or piping;
- Improper maintenance, including failure to remove trees, repair internal seepage problems, replace lost material from the cross section of the dam and abutments, or maintain gates, valves, and other operational components;
- Improper design, including the use of improper construction materials and construction practices;
- Improper operation, including the failure to remove or open gates or valves during high flow periods;
- Failure of upstream dams on the same waterway that release water to a downstream dam;
- Earthquakes, which typically cause longitudinal cracks at the tops of the embankments that can weaken entire structures.

In terms of emergency management and planning, dam failures are analyzed as either sunny day failures or flood condition failures. Sunny day failures occur during a non- flooding situation with the reservoir near normal pool level. Flood condition failures usually involve periods of heavy rainfall and high river flows, which can exacerbate inadequate spillway capacity. Improper design of a spillway or operation of gates during high flows can lead to excessive water pressure and subsequent failure as well. Even though both types of failures can be disastrous, it can be assumed that a sunny day failure would be more catastrophic due to its unanticipated occurrence and the lack of time to warn residents downstream.

Dams are complicated structures, and it can be difficult to predict how a structure will respond to distress “… the modes and causes of failure are varied, multiple, and often complex and interrelated, i.e., often the triggering cause may not truly have resulted in failure had the dam not had a secondary weakness. These causes illustrate the need for careful, critical review of all facets of a dam” (Safety of Existing Dams, 1983).

LEVEE FAILURE

A levee is any artificial barrier together with appurtenant works that will divert or restrain the flow of a stream or other body of water for the purpose of protecting an area from inundation by flood waters. Generally, a levee is subjected to water loading during a few days or weeks each year; unlike most dams that retain water most of the time.

A levee breach results when a portion of the levee breaks away, providing an opening for water to flood the landward side of the structure. Such breaches can be caused by surface erosion due to water velocities, or they can be the result of subsurface actions. Subsurface actions usually involve sand boils whereby the upward pressure of water flowing through porous soil under the levee exceeds the static pressure of the soil weight above it (i.e., under-seepage). These boils can indicate instability of the levee foundation given the liquefied substrate below it, leading the way to breaching. Levee overtopping is similar to dam overtopping in that the flood waters simply exceed the design capacity of the structure, thus flowing over the lowest crest of the system. Such overtopping can lead to erosion on the landward side which, subsequently, can lead to breaching. In order to prevent this type landward erosion, many levees are reinforced or armored with rocks or concrete.

AUTHORITY AND RESPONSIBILITY

The Ohio Department of Natural Resources, Division of Water Resources - Dam Safety Program (DSP) has the responsibility to ensure that human life, health and property are protected from dam and levee failures. The program achieves its core purpose by performing the following main functions:

- Emergency response – Assessing the conditions of dams during severe floods and emergency's, taking action to correct dams that pose an immediate threat to public safety, providing timely and best-available information to other agencies and the public during disasters, and supporting mandate Ohio Revised Code (ORC) Section 1521.062;
- Construction permits – Ensuring that dams and levees are designed and constructed in accordance with proper engineering standards and Ohio Administrative Code (OAC) Rules 1501:21-1-01 through 1501:21-23-01, reviewing construction plans and specifications, performing calculations and investigations, issuing permits, and monitoring/approving construction;
- Repairs and modifications -- Ensuring that dams and levees are repaired in accordance with proper engineering standards and OAC rules, reviewing construction plans and specifications, performing calculations and investigations, issuing permits, and monitoring/approving construction, and supporting mandate ORC Section 1521.062;
- Periodic safety inspections –Inspecting Class I-III dams once every five years, monitoring the overall condition of Ohio's dams, providing data for the National Inventory of Dams (NID), and supporting mandate ORC Section 1521.062;
- Emergency Action Plans – Requiring all Class I, II, and III dam owners to develop an Emergency Action Plan (EAP). Class I dams are required to have an inundation study preformed evaluating dam failure, typically during a probable maximum flood event, 100- year flood, and during a sunny dam failure per OAC 1501:21-15-07;
- Enforcement – Requiring dam and levee owners to improve safety when efforts for voluntary compliance have been unsuccessful (OAC 1501:21-23) and focusing on Class I dams with dense populations downstream; and

- Public information – Providing data security for Ohio EMA, US Army Corps of Engineers (USACE), the National Guard, Ohio EPA, as well as the state and federal legislatures, providing dam and levee owners and engineers with technical information and access to division files, educating the public about dam safety and providing quality data, and giving presentations for EPA, Water Management Association of Ohio (WMAO), and the Ohio Lake Communities Association (OLCA). However, some data regarding the safety of infrastructure (such as inundation maps and EAPs) cannot be distributed to unauthorized personnel per ORC 149.433(a).

The ORC provides the authority for the program to regulate dam and levee safety, and dictates the responsibilities of the program as well as the responsibilities of the dam and levee owners. The program has jurisdiction over approximately 2,474 dams in Ohio, of which 366 are Class I (highest hazard); DSP does not have jurisdiction over Federal dams. USACE presides over most of those Federal dams in Ohio, and ensures they are operated and maintained properly.

Many levees in Ohio are owned and maintained by local communities, with a few levees being owned and maintained by the USACE. While a federal inventory of levees is complete, the methodology for evaluating the effects of levees on flood hazards is in flux. This will be discussed later in this section.

RISK ASSESSMENT

DAMS—CLASSIFICATION

In Ohio, there are 5,753 known existing structures that retain or detain water, and these are included in ODNR's inventory of dams (DSP data, December 2023). Many of the structures in that count have been properly abandoned, are exempt from DSP jurisdiction, or are proposed dams. As such the focus of this section will include dams that are under the jurisdiction of the DSP. The ODNR DSP classifies dams as Class I, Class II, Class III, and Class IV dams, with generally Class I being the highest risk and Class IV the lowest risk (see Table 2.6.a). The classification of a dam is based on three factors: the dam's height, storage capacity, and potential downstream hazard. The height of the dam is the vertical distance from the crest to the downstream toe. The storage capacity is the volume of water that the dam can impound at the top of dam (crest) elevation. The downstream hazard consists of roads, buildings, homes, and other structures that would be damaged in the event of a dam failure. Potential for loss of life is also evaluated.

The USACE's National Inventory of Dams (NID) compiles information about dams from a variety of agencies with an inventory of dams. Some of the partners that contribute data to the NID include ODNR DSP, Department of the Interior (National Park Service and Mine Safety and Health), USDA (Forest Service and Natural Resources Conservation Service), USACE, and Federal Energy Regulatory Commission. For a dam to be included in the NID it must meet at least one of the following criteria. 1) High hazard potential classification - loss of human life is likely if the dam fails; 2) Significant hazard potential classification - no probable loss of human life but can cause economic loss; environmental damage, disruption of lifeline facilities, or impact other concerns; 3) Equal or exceed 25 feet in height and exceed 15 acre-feet in storage; 4) Equal or exceed 50 acre-feet storage and exceed 6 feet in height. In addition to specifying the ODNR Classification System, Table 2.6.a summarizes how the ODNR DSP classification corresponds with the hazard class in the NID.

Table 2.6.a

Ohio and Federal Dam Classification Systems				
Ohio Dam Classification	**Hazard Description**	**Height (ft)**	**Storage (ac-ft)**	**Corresponding NID Classification**
Class I	Probable loss of life, serious hazard to health, structural damage to high value property (i.e., homes, industries, major public utilities)	>60	>5,000	High
Class II	Flood water damage to homes, businesses, industrial structures (no loss of life envisioned), damage to state and interstate highways, railroads, only access to residential areas	>40	>500	Significant
Class III	Damage to low value non- residential structures, local roads, agricultural crops and livestock	>25	>50	Low
Class IV	Losses restricted mainly to the dam	£25	£50	Other
Exempt	N/A	< 6	15 ac-ft. OR <10 ft & ≤50 ac-ft.	N/A

Source: Ohio Department of Natural Resources, Division of Water Resources, Dam Safety Program

When assessing risk for dams, various dam failure scenarios must be considered, and they include failures when the dam is at normal pool level (sunny day) and failures during significant flood events (rainy day). Each of the three factors is evaluated, and the final classification of the dam is based on the highest individual factor. The classification of a dam can change based on future development along the downstream channel. It is important to note all classes are required to have Emergency Action Plans (EAPs) and Class I dams are required to include dam failure inundation mapping. This update will focus on Class I dams as they are deemed as having the most potential for loss of life, greatest hazards to health, and causing the most structural damage should any of them fail. Classes II and III also will be evaluated to a slight degree since their failure would most likely result in damages to homes, businesses, infrastructure, but no loss of life is likely.

LOCATION— DAMS

There are 366 Class I dams, 561 Class II, 438 Class III, and 1,034 Class IV dams regulated by ODNR DSP in Ohio. Region 1 has many fewer dams than regions 2 and 3. This may be largely due to the topography as Region 1 is relatively flatter than Regions 2 and 3.

- Region 1 has a total of 381 dams consisting of 81 Class I, 85 Class II, 64 III, and 161 Class IV.
- Region 2 has a total of 1,148 dams consisting of 169 Class I, 239 Class II, 250 Class III, and 448 Class IV dams.
- Region 3 has a total of 1,048 dams consisting of 172 Class I, 255 Class II, 222 Class III, and 399 Class IV dams.
- Additionally, there are approximately 3,354 "other" structures throughout the state that are proposed, unclassified, exempt, and/or abandoned.

The ODNR DSP maintains an online Dam Locator to assist the public, local officials, and other partners to view basic information about dams in the State of Ohio. Table 2.6.b summaries the distribution of the various classes of dams by region and further by county. See Map 2.6.a displays the location of Class I dams in Ohio.

Table 2.6.b

Dam Inventory by County and Dam Classification

Region 1

County	Class I	Class II	Class III and IV	Total
Allen	5	3	15	23
Auglaize	1	1	3	5
Champaign	1	7	8	16
Clark	2	3	11	16
Crawford	5	2	18	25
Darke	0	3	8	11
Defiance	2	5	9	16
Erie	0	0	6	6
Fulton	5	3	1	9
Hancock	9	3	2	14
Hardin	0	1	8	9
Henry	0	1	1	2
Huron	10	5	18	33
Logan	3	5	16	24
Lucas	2	4	0	6
Marion	0	2	5	7
Mercer	2	4	2	8
Miami	3	3	11	17
Ottawa	0	2	3	5
Paulding	1	1	6	8
Preble	5	3	24	32
Putnam	1	2	3	6
Sandusky	1	0	2	3
Seneca	2	5	5	12
Shelby	2	3	12	17
Van Wert	3	0	1	4
Williams	1	5	17	23
Wood	5	4	0	9
Wyandot	0	5	10	15
Total	**71**	**85**	**225**	**381**

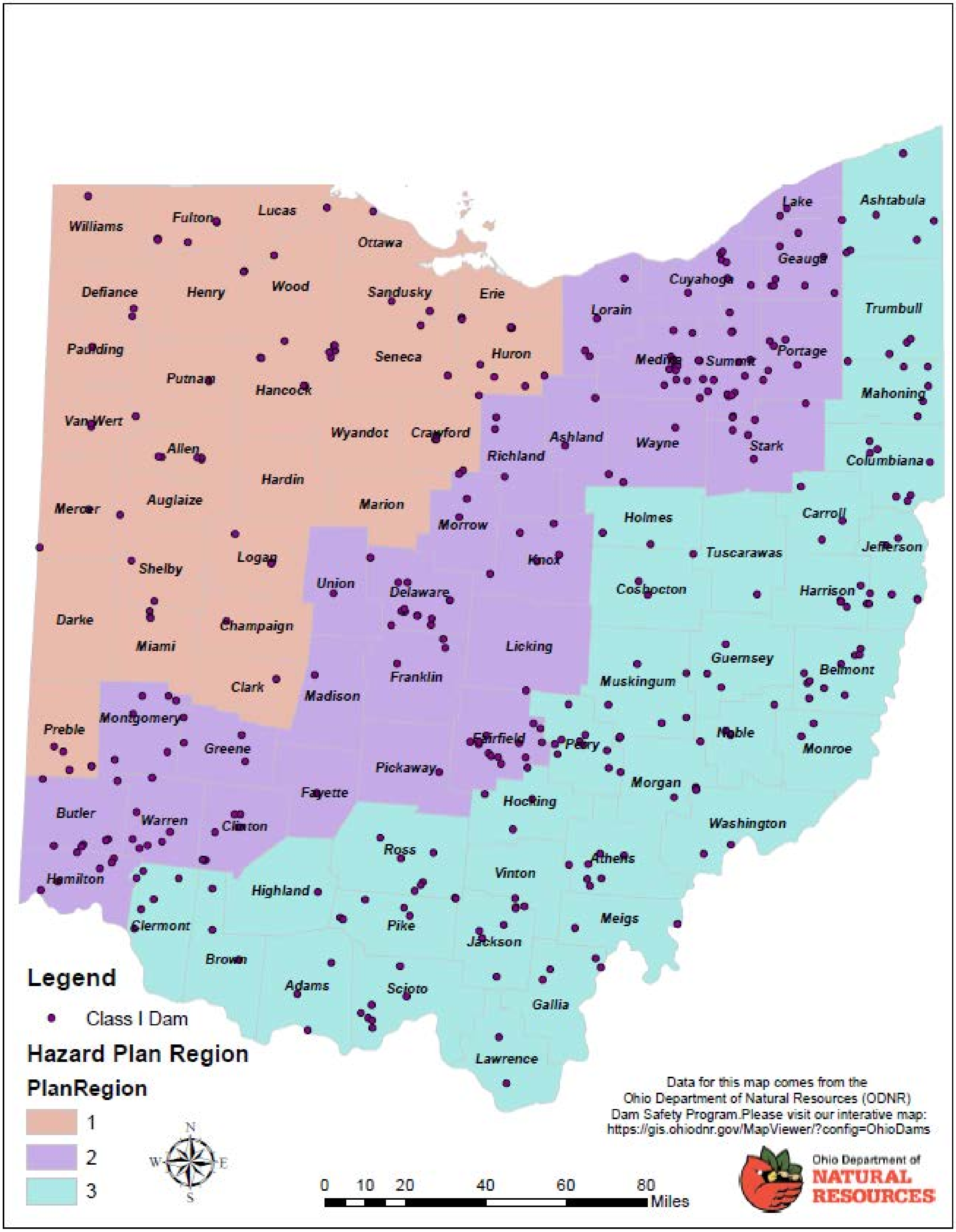
Region 2

County	Class I	Class II	Class III and IV	Total
Ashland	5	8	31	44
Butler	7	7	35	49
Clinton	8	10	15	33
Cuyahoga	7	8	9	24
Delaware	16	5	29	50
Fairfield	14	16	35	65
Fayette	1	1	3	5
Franklin	5	13	16	34
Geauga	9	11	35	55
Greene	4	5	20	29
Hamilton	8	18	23	49
Knox	6	7	14	27
Lake	1	3	13	17
Licking	2	8	49	59
Lorain	4	6	36	46
Madison	1	2	2	5
Medina	14	26	89	129
Montgomery	6	2	11	19
Morrow	3	8	22	33
Pickaway	2	3	20	25
Portage	8	7	37	52
Richland	3	5	18	26
Stark	4	20	42	66
Summit	18	15	40	73
Union	1	4	5	10
Warren	12	15	67	94
Wayne	2	6	22	30
Total	**171**	**239**	**738**	**1148**

Region 3

County	Class I	Class II	Class III and IV	Total
Adams	3	7	14	24
Ashtabula	6	13	37	56
Athens	7	2	12	21
Belmont	11	4	34	49
Brown	3	10	24	37
Carroll	3	7	38	48
Clermont	8	20	34	62
Columbiana	9	22	34	65
Coshocton	4	5	22	31
Gallia	4	5	8	17
Guernsey	6	13	27	46
Harrison	9	9	25	43
Highland	3	5	12	20
Hocking	4	8	15	27
Holmes	2	2	12	16
Jackson	5	8	17	30
Jefferson	7	14	25	46
Lawrence	4	4	5	13
Mahoning	6	6	23	35
Meigs	2	5	8	15
Monroe	2	6	11	19
Morgan	1	10	15	26
Muskingum	6	14	40	60
Noble	3	5	9	17
Perry	12	12	16	40
Pike	8	1	8	17
Ross	6	9	14	29
Scioto	9	4	7	20
Trumbull	5	8	23	36
Tuscarawas	6	5	26	37
Vinton	3	3	12	18
Washington	5	9	14	28
Total	**172**	**255**	**621**	**1048**

Map 2.6.a — Class I Dam Locations in Ohio



LOCATION— LEVEES

There are two primary sources of levee data for the State of Ohio- The US Army Corp of Engineers National Levee Database (NLD) and the Ohio Department of Natural Resources Dam Safety Program. Section 2.6, Dam and Levee Failure, will be utilizing NLD Data for assessing levee and levee risks in Ohio. Although the National Levee Database is dynamic in nature, it provides static information regarding levee location and potential consequences, which can aid in decision making and better flood risk management. As of June 2023, the database identifies 149 levee system in Ohio.

For the most current list of levees and their protected areas in Ohio, refer to the National Levee Database.

Table 2.6.c

Levee Inventory and Potential Consequences							
County	OEMA Region	Levee Systems	Levee Miles	Leveed Area (mi^2)	Population at Risk	Buildings at Risk	Property Value
Butler	2	7	13.07	4.34	14,225	3,615	$ 2,933,448,936
Carroll and Stark	3 and 2	1	0.91	0.11	380	142	$ 88,900,000
Columbiana	3	1	2.85	0.45	1,868	1,113	$ 250,209,774
Cuyahoga	2	1	0.28	0.01	148	32	$ 10,259,040
Erie	1	2	1.72	0.62	410	234	$ 51,282,636
Fairfield	2	2	2.48	0.83	1,050	330	$ 224,765,426
Franklin	2	3	9.51	4.83	15,250	4,688	$ 2,409,064,347
Guernsey	3	2	1.87	0.24	979	162	$ 190,824,338
Hamilton	2	9	9.70	5.22	14,814	1,742	$ 2,769,832,530
Hocking	3	1	0.27	0.03	90	47	$ 35,009,336
Knox	2	6	5.26	1.06	3,780	1,100	$ 1,048,146,246
Lake	2	1	0.22	0.03	217	105	$ 30,574,370
Lawrence	3	2	6.83	2.35	9,377	4,943	$ 1,306,517,060
Licking	2	1	1.23	0.16	671	283	$ 63,380,640
Lorain	2	1	0.98	0.25	0	0	$ -
Lucas	1	3	13.26	3.97	3,598	1,770	$ 588,477,420
Lucas and Ottawa	1	1	3.60	0.42	0	0	$ -
Marion	1	1	0.96	0.23	234	234	$ 121,000,000
Miami	1	6	5.89	1.98	46,533	10,715	$ 9,659,934,425
Montgomery	2	18	35.39	11.36	134,760	24,312	$ 28,204,735,676
Muskingum and Perry	3	1	1.16	0.11	384	324	$ 85,748,340
Ottawa	1	60	64.73	8.79	33,391	7,602	$ 7,496,620,584
Ottawa and Sandusky	1	1	1.87	0.12	3	1	$ 498,778
Perry	3	1	0.64	0.19	1,053	302	$ 201,182,764
Pike	3	4	5.12	1.81	192	10	$ 580,805,876
Richland	2	1	0.19	0.02	0	1	$ -
Ross	3	1	3.80	2.15	9,407	3,999	$ 2,051,408,100
Sandusky	1	3	5.53	1.30	2,756	1,342	$ 477,547,495
Scioto	3	1	7.83	2.99	11,062	4,717	$ 2,652,305,730
Stark	2	3	5.14	0.83	2,321	704	$ 435,490,930
Tuscarawas	3	1	0.76	0.11	124	68	$ 71,300,000
Warren	2	3	3.30	0.38	2,325	695	$ 424,852,893
Grand Total		**149**	**216.35**	**57.32**	**311,402**	**75,332**	**$ 64,464,123,691**

Source: USACE National Levee Database

The USACE NLD classifies levee risk characteristics in their Levee Safety Action Classification Table (LSAC). The LSAC is a classification system designed to take into account the probability of the levees being loaded (Hazard), existing condition of the levee, the current and future maintenance of the levee (Performance), and the Consequences if a levee were to fail or be overwhelmed. In Ohio, there are no levee systems rated as Very High, only *one* levee system is rated High, *six* as Moderate, *18* as low, and the remaining were not screened. See Table 2.6.d for the LSAC classifications, and table 2.6.e for a list of Moderate and High LSAC Rated Levee systems in Ohio.

Table 2.6.d

USACE Levee Safety Action Classification Table[1], EC 1165-2-218			
Risk		Risk Characteristics of this Class	Actions for Levee Systems and Leveed Areas in this Class ***(Adapt actions to specific levee system conditions.)***
Very High (1)		Likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in very high risk.	Based on risk drivers, take immediate action to implement interim risk reduction measures. Increase frequency of levee monitoring, communicate risk characteristics to the community within an expedited timeframe; verify emergency plans and flood inundation maps are current; ensure community is aware of flood warning systems and evacuation procedures; and, recommend purchase of flood insurance. Support risk reduction actions as very high priority.
High (2)		Likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in high risk.	Based on risk drivers, implement interim risk reduction measures. Increase frequency of levee monitoring; communicate risk characteristics to the community within an expedited timeframe; verify emergency plans and flood inundation maps are current; ensure community is aware of flood warning and evacuation procedures; and, recommend purchase of flood insurance. Support risk reduction actions as high priority.
Moderate (3)		Likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in moderate risk.	Based on risk drivers, implement interim risk reduction measures as appropriate. Verify risk information is current and implement routine monitoring program; assure O&M is up to date; communicate risk characteristics to the community in a timely manner; verify emergency plans and flood inundation maps are current; ensure community is aware of flood warning and evacuation procedures; and, recommend purchase of flood insurance. Support risk reduction actions as a priority.
Low (4)		Likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in low risk.	Verify risk information is current and implement routine monitoring program and interim risk reduction measures if appropriate; assure O&M is up to date; communicate risk characteristics to the community as appropriate; verify emergency plans and flood inundation maps are current; ensure community is aware of flood warning and evacuation procedures; and, recommend purchase of flood insurance. Support risk reduction actions to further reduce risk to as low as practicable.
Very Low (5)		Likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in very low risk.	Continue to implement routine levee monitoring program, including operation and maintenance, inspections, and monitoring of risk. Communicate risk characteristics to the community as appropriate; verify emergency plans and flood inundation maps are current; ensure community is aware of flood warning and evacuation procedures; and recommend purchase of flood insurance.
No Verdict		Not enough information is available to assign an LSAC.	

1- Levee risk is the risk that exists due to the presence of the levee system and this is the risk used to inform the decision on the LSAC assignment. The information presented in this table does not reflect the overtopping without breach risk associated with the presence or operation of the levee system. Source: USACE Levee Safety Action Classification

Table 2.6.e

Moderate and High LSAC Rated Levee Systems in Ohio								
LSAC Rating	System Name	County	Region	Levee Miles	Leveed Area (mi^2)	Population at Risk	Buildings at Risk	Property Value
High	Portsmouth-New Boston, OH, LPP	Scioto	3	7.83	2.99	11,062	4,717	$ 2,652,305,730
Moderate	Cincinnati Levee System	Hamilton	2	1.39	3.41	12,163	1,500	$ 2,090,491,260
Moderate	Chillicothe, OH, LPP	Ross	3	3.80	2.15	9,407	3,999	$ 2,051,408,100
Moderate	West Columbus, OH, LPP	Franklin	2	7.14	4.55	13,684	4,680	$ 2,032,031,550
Moderate	Ironton LPP	Lawrence	3	5.05	1.90	7,904	4,180	$ 1,193,727,950
Moderate	Wellsville, OH	Columbiana	3	2.85	0.45	1,868	1,113	$ 250,209,774
Moderate	Massillon, OH, LPP - East	Stark	2	2.18	0.31	1,166	349	$ 170,001,290
				30.24	15.76	57,254	20,538	$ 10,440,175,654

LOCAL HAZARD MITIGATION PLAN DATA

As counties update their LHMP, ODNR DSP is available to provide up to date dam information for their counties. Part of a dam participating in the High Hazard Potential Dam Grant requires counties to update their LHMP to address all dam risk, which ODNR DSP plays a key role. Below is a high-level overview of some of the counties dam risk sections.

STARK COUNTY: According to flood studies on file with the Stark County EMA, many communities in the county could be affected by a dam failure event. In an event that the Dover and Bolivar dams are at the emergency spillway, back up flooding along the Tuscarawas River through Stark County would significantly impact the Village of Navarre, as well as affect the cities of Massillon and Canal Fulton. Flooding in Navarre would far surpass 500-year flood levels, placing much of the village's downtown under water. Similar studies for Atwood Lake and the Beach City Dam, on file with the county EMA, indicate similar concerns. After an extensive examination of spreadsheet calculations, vulnerability assessments show that 28,288 structures could be damaged with an estimated loss of $1,019,132,000.

DELAWARE COUNTY: Dam failure is a significant concern for Delaware County. As of June 2018, there are 88 dams and reservoirs located within the county that could result in significant losses if they were to fail or become overtopped. These include 16 Class I dams, 13 Class II and III dams, and 24 Class IV dams. The Hoover Dam structure is located within Blendon Township in Franklin County, but a significant portion of its reservoir exists within Delaware County and should be considered a potential hazard to Delaware County residents (see Section 2.2). The Dams located within Delaware County are regulated by the U.S. Army Corp of Engineers (USACE), Ohio Department of Natural Resources (Division of Water) (ODNR) and Federal Energy Regulatory Commission (FERC).

For the 2013 Delaware County Hazard Mitigation Plan, local GIS inundation maps for all of the dams, except for the Sunbury and Ashley reservoirs, were overlaid onto the Auditor's parcel data and this determined the number of structures at-risk within each jurisdiction. Delaware, Powell, and Shawnee Hills are the only cities or villages that contain at-risk populations or structures due to their proximity to crucial rivers and reservoirs. Delaware City contains a staggering 1,458 vulnerable structures valued at over $300 million because the densely populated city lies directly south of the dam, in the direct pathway of the water's direction. In addition, there are over 2,000 vulnerable structures that lie outside of the county's municipalities, particularly since the majority of the dams and reservoirs are a sizeable distance from them. The 2013 Delaware County Multi-Hazard Mitigation Plan estimates that a total of 3,734 structures could be damaged with an estimated loss of $909,122,500.

PAST OCCURRENCES

The 2008 State Hazard Mitigation Plan Update referenced "The National Performance of Dams Partnership," a cooperative effort of engineers and dam safety professionals in the U.S. who retrieve, archive, and disseminate information on dam performance in order to list dam incidents and failures throughout the state. According to this database, Ohio experienced 273 dam incidents from 1882 to 2001. Because dam classification can be dynamic, a more complete database was developed by DSP for a span of years ranging from 1852 to 2014. (Please note the DSP data list incidents/failures dating back to 1852, However, the DSP was not created until 1963. Therefore, not all data provided to Ohio EMA were collected by DSP). Table 2.6.f lists the dam failures and incidents for Class I and II dams throughout the state. Due to limitations in data, incidents since 2014 could not be obtained when updating the 2023 State Hazard Mitigation Plan.

There has been little property damage that has resulted from a dam failure alone, as dam failures are few in Ohio. However, there has been property damage due to a combination of downstream flooding from excessive precipitation and dam failure. Unfortunately, it is difficult to assess which property damage was a direct result of the dam failure and which damage was a result of downstream flooding due to excessive precipitation. There has been some infrastructure loss in terms of roads washing away, but there has been no loss of critical facilities due to dam failure to date. It should be noted that DSP does not have much data showing property damages and losses; such data are generally unavailable as there has not been a large dam failure in Ohio for many years. The comments associated with each incident or failure in Table 2.6.f rarely contains such loss information.

There are no documented instances of levee breaches whereby structures or properties were damaged in Ohio as such data are generally unavailable and undocumented. This does not mean there is minimal risk behind these levees; it means more effort needs to be exerted in the collection of such data. However, according to DSP records, in 1997 the Green Acres Levee (Pike County) was overtopped by a flood estimated to be a 100-year event. Several homes were flooded as a result, but no specific damage data could be found for this update.

Table 2.6.f

Ohio High Hazard Dam Incidents/Failures From 1852 to 2014

County	OEMA Region	DSP Class	Dam Name	Incident Year	Incident Description
Sandusky	1	I	BALLVILLE DAM	1913	Dam failed with 1913 flood; no damage downstream reported.
Huron	1	I	NORWALK LOWER RESERVOIR	1969	Dam failed; no damage downstream noted. Dam was rebuilt with berm and drainage.
Huron	1	I	GREENWICH RESERVOIR DAM	1969	Dam partially failed; no damage downstream noted.
Lucas	1	II	SWANTON UPGROUND RESERVOIR	1970	Dam failure in 1970, but was repaired.
Defiance	1	II	INDEPENDENCE DAM	1982	Left abutment was overtopped and damaged.
Seneca	1	II	MOHAWK LAKE DAM	1910, 1963	Dam failure in 1910 resulted in replacement; dam failure in 1963 resulted in repairs. No damage downstream reported.
Williams	1	I	LAKE SENECA DAM	1973, 1996	Overflow spillway failed in 1973 and 1996; no damage downstream reported.

County	OEMA Region	DSP Class	Dam Name	Incident Year	Incident Description
Wyandot	1	I	KILLDEER UPGROUND RESERVOIR	1979, 2004	Leak and slide indicated in 1979, and multiple slides indicated in 2004.
Huron	1	I	HOLIDAY LAKE DAM	1982, 2007	Left sidewall failed in 1982. A shallow slide was noted in 2007.
Stark	2	II	WILLOWDALE LAKE DAM	1923	Original dam failed and was rebuilt in 1924, with multiple repairs through the present.
Geauga	2	II	PAW PAW LAKE DAM	1941	Dam failed and was rebuilt in 1941; no damage downstream was reported.
Knox	2	I	KNOX LAKE DAM	1950	Seepage was noted and spillway failed.
Licking	2	II	NEWARK LOW HEAD DAM	1959	Dam washed out in 1959, but was rebuilt.
Medina	2	I	RAVENS WOOD LAKE DAM	1973	Original dam failed and was rebuilt in 1973.
Summit	2	I	LAKE LITCHFIELD DAM	1973	Embankment failed during construction.
Wayne	2	I	CHIPPEWA CREEK STRUCTURE VII-C	1973	Foundation failure during construction; no damage indicated downstream.
Cuyahoga	2	II	MARSHFIELD LAKE DAM	1973	Dam breached under order; no damages reported; rebuilt in 1977.
Portage	2	I	BRIMFIELD LAKE DAM	1979	Dam nearly failed due to overtopping; no damage downstream reported.
Geauga	2	I	TANGLEWOOD LAKE DAM	1981	Spillway partially failed, but was repaired; no damage downstream noted.
Fairfield	2	I	RUSHCREEK STRUCTURE NO. VI-A	1982	An abutment leakage was noted and repaired.
Hamilton	2	II	HERMITAGE CLUB LAKE DAM	1982	Intense storm resulted in dam overtopping; no damage downstream reported.
Franklin	2	II	TIMBERLAKE NO. 1 DAM	1984	Drain pipe failed, but was repaired.
Lake	2	I	BRIGHTWOOD LAKE DAM	1985	A resident near the emergency spillway stated the dam overtopped; no damage downstream reported.
Portage	2	II	AURORA POND DAM	1985	Dam failed and was rebuilt around 1985.
Delaware	2	I	LEXINGTON GLEN DAM	1987	Dam failed due to erosion on the emergency spillway and four erosion rills on the downstream slope.
Licking	2	II	GOSS LAKE DAM	1990	Floodwaters caused partial failure of principal spillway; no damage downstream noted.
Warren	2	II	WATER'S EDGE DAM	1993	Dam was rebuilt in 1993 after failure.
Morrow	2	I	CANDLEWOOD LAKE DAM	1998	Approximately 3-4' noted in the emergency spillway.
Medina	2	II	RPM LAKE DAM	1998	Principal spillway failure; repairs made in 1998.
Medina	2	I	PISCHIERI POND DAM	1999	Dam was breached in controlled manner due to detection of void in dam; no damage downstream.
Richland	2	I	SHELBY UPGROUND RESERVOIR NO. 2	2001	Seepage was noted through reservoir due to field tile; repairs were made accordingly.
Warren	2	I	PINE HILL LAKE DAM	2001	Emergency spillway flowed; no damage downstream reported.
Stark	2	II	MORELLI POND DAM	2003	Causeway breached due to a compromise in left end of dam; no damage downstream reported.
Summit	2	II	VIRGINIA KENDALL PARK DAM	2003	Dam failure in late 1970s, and was overtopped in 2003; no damage downstream noted.
Summit	2	II	LAKE FOREST DAM	2003	Dam experienced a flood of record in 2003; no damage downstream reported.
Summit	2	II	CITY OF HUDSON UPPER LAKE DAM	2003	Dam overtopped; no downstream damage noted.
Summit	2	II	CITY OF HUDSON LOWER LAKE DAM	2003	Dam overtopped; no downstream damage noted.
Cuyahoga	2	I	BRIAR HILL LAKE DAM	2006	Dam possibly overtopped; no damage downstream noted.

County	OEMA Region	DSP Class	Dam Name	Incident Year	Incident Description
Geauga	2	I	MONT-MERE LAKE DAM	2006	Water was 1-1.5' below top of dam; dam never overtopped.
Lake	2	I	HOOSE ROAD RETENTION DAM	2006	Water was 1-2' above emergency spillway elevation.
Summit	2	II	CAMP JULIA CROWELL LAKE DAM	2006	Severe erosion was noted on the left side of the emergency spillway.
Lorain	2	II	BRENTWOOD LAKE DAM	2009	Spillway failed. ODNR issued an order for the dam to be repaired or breached. The dam was breached.
Geauga	2	II	KENSTON LAKE DAM	2010	Spillway clogged and the dam overtopped. ODNR issued an order for the dam to be repaired or breached. The dam was breached. Pipe jacked and bored through the dam, eliminating the reservoir and making the dam a roadway embankment.
Summit	2	II	THE MEADOWS DAM	2012	Spillway failed. ODNR issued an order for the dam to be repaired or breached. The dam was breached.
Fairfield	2	I	PINE LAKE ESTATES DAM	2013	Spillway failure
Delaware	2	I	SUNBURY UPGROUND RESERVOIR NO. 1	1960s	Dam overtopped; no downstream damage noted.
Geauga	2	II	KENSTON LAKE DAM	1970s	Downstream face slipped.
Geauga	2	II	BURTON LAKE DAM	1970s, 1997	Dam breached in the 1970s, and seepage boils were noted in 1997.
Medina	2	I	RUSTIC HILLS LAKE DAM	1980, 2003	Dam failed in 1980, and emergency spillway failed in 2003 which caused overtopping; no damage downstream reported.
Columbiana	3	I	GUILFORD LAKE DAM	1852	Dam breached; no downstream damage noted.
Jackson	3	I	WELLSTON RESERVOIR DAM	1937	A slide was noted.
Hocking	3	I	LAKE LOGAN DAM	1950	Dam was breached upon initial filling; no damage downstream noted. Dam was redesigned in 1952 and rebuilt in 1954.
Morgan	3	I	CROOKSVILLE RESERVOIR NO. 1 DAM	1950	Dam noted as probably overtopping; no damage downstream indicated.
Muskingum	3	II	MUSKINGUM RIVER LOCK AND DAM NO. 10	1951	Dam failed in 1951; no damage downstream reported.
Morgan	3	II	MUSKINGUM RIVER LOCK AND DAM NO. 7	1959	Dam failed in 1959; no damage downstream reported.
Columbiana	3	II	SLATES LAKE DAM	1965	Dam failed during initial filling of lake due to seepage around spillway pipe; no damage downstream indicated.
Perry	3	II	MERKLE DAM	1972	Dam washed out but was rebuilt in 1972.
Athens	3	I	ATHENS FISH AND GAME CLUB LAKE DAM	1975	Dam was deemed unsafe due to seepage and a slide and was breached; no downstream damage reported. It was reconstructed in 1978.
Carroll	3	II	ROHR DAM	1975	Failure indicated at right end of dam; no damage downstream reported.
Guernsey	3	I	LUBURGH LAKE DAM	1979	A downstream slope slide was noted and repaired.
Ross	3	I	KNOLES POND DAM	1979	Lake was drained for repairs.
Athens	3	II	RAINBOW LAKE DAM	1979	Slide was noted in the downstream slope near right abutment, and was fixed.
Ashtabula	3	II	ELKEM FLUID WASTE POND 3A	1980	Slide was noted in the downstream slope, and was fixed.
Belmont	3	I	ST. CLAIRSVILLE RESERVOIR NO. 2 DAM	1980	A sinkhole was noted in the upstream slope.
Scioto	3	II	ELKS COUNTRY CLUB LAKE DAM	1980	33' long slide on the downstream slope; repaired, but slipped again.
Morgan	3	I	CROOKSVILLE RESERVOIR NO. 2 DAM	1984	Slide was noted in the downstream slope, and was fixed.
Carroll	3	II	BOY SCOUT DAM	1984	Upstream slope failed during construction.

County	OEMA Region	DSP Class	Dam Name	Incident Year	Incident Description
Jackson	3	I	OAK HILL UPGROUND RESERVOIR	1986	Multiple slides were noted.
Trumbull	3	II	NEWTON FALLS LOW HEAD DAM	1988	Hole was noted in spillway.
Harrison	3	II	SELESKI LAKE NO. 2 DAM	1989	Dam overtopped at left end; no damage downstream reported.
Lawrence	3	II	SMITH HOLLOW DAM	1989	Spillway failed; no damage downstream reported.
Perry	3	I	SHELTON LAKE DAM	1990	Dam overtopped; no downstream damage noted.
Perry	3	II	TECUMSEH LAKE DAM	1990	Dam was overtopped by 1-2'; no damage downstream was reported.
Jefferson	3	II	LAKE HENRY DAM	1993	Original principal spillway was blocked.
Ross	3	I	CALDWELL LAKE DAM	1994	Sink hole was noted and repaired.
Washington	3	II	CHOPPER'S LAKE DAM	1994	Dam breached due to heavy rainfall with erosion of earth adjacent to spillway; no downstream damage noted.
Brown	3	I	RUSSELLVILLE RESERVOIR DAM	1997	Dam was overtopped; no damage noted downstream.
Scioto	3	I	ROOSEVELT LAKE DAM	1997	Dam overtopped; no downstream damage noted.
Scioto	3	II	LAKE MARGARET DAM	1997	Dam overtopped in 1997, but repaired in 2002. No damage downstream noted.
Guernsey	3	I	SALT FORK LAKE DAM	1998	Dam overtopped; no downstream damage noted.
Clermont	3	II	BECKJORD ASH POND C DAM	1999	Elbow of pipe and riser collapsed.
Columbiana	3	II	WOODLAND LAKE DAM	2003	Dam overtopped; no downstream damage noted.
Belmont	3	I	MEIGS-PHILLIPS I NO. 1 DAM	2004	Severe erosion was noted in the emergency spillway.
Jefferson	3	I	JEFFERSON LAKE DAM	2004	Dam was within 0.5' of overtopping two times in one year.
Jefferson	3	I	WILLIAMS LAKE DAM	2004	Dam overtopped twice in same year; no damage downstream reported.
Perry	3	I	ALTIERS LAKE DAM	2004	Flood event resulted in pool being 3-4' above normal; dam did not overtop.
Belmont	3	I	BARNESVILLE LAKE DAM	2005	A shallow slide was noted on the downstream slope.
Columbiana	3	I	Buckeye Water District Reservoir	2008	N/A
Tuscarawas	3	I	SUGARCREEK SPORTSMAN CLUB Dam	2010	Seepage.
Ashtabula	3	II	GERLAT LAKE DAM	2011	Spillway failed. ODNR issued an order for the dam to be repaired or breached. The dam was breached.
Hocking	3	I	LAKE OF THE FOUR SEASONS DAM	2013	Upstream slope earth slide.
Columbiana	3	II	SEVAKEEN COUNTRY CLUB LAKE DAM	1930s	Dam breached and rebuilt; no downstream damage noted.
Pike	3	I	LAKE WHITE DAM	1964, 1994	Dam overtopped in 1964 and 1994; no damage downstream reported.
Columbiana	3	II	WESTVILLE LAKE DAM	1980, 1982, 1994	Breach in the south dike indicated in 1980; another breach indicated in 1982; portion of replacement spillway washed out during construction in 1994. No damage downstream was reported.

Source: ODNR—Division of Water Resources, Dam Safety Program, Dam Inventory Data.

PROBABILITY OF OCCURRENCE

From 1852 to 2014, there were 103 documented Class I and II dam incidents/failures that were generally minor and resulted in little property damage (Table 2.6.f). Based on these past events, there is seemingly a 64% (103 incidents/162 years observed) annual chance of Class I/II dam incident/failure in any given year. However, from a dam safety perspective, past occurrences of incidents/failure are not a predictor of future failures.

There are no documented instances of levee breaches whereby structures or properties were damaged in Ohio as such data are generally unavailable and undocumented. This does not mean that there is a zero percent chance of levee failure within the state, but more effort needs to be exerted in the collection of such data in order to produce a more accurate probability statement.

For reasons previously mentioned, and some of which are uncontrollable by humans, it is possible a dam or levee can fail at any time, given the right circumstances. However, the probability of future occurrence is reduced due to proactive preventative action on the part of ODNR, DSP and individual dam and levee owners. As previously discussed in this section, the DSP provides oversight to dam/levee repairs, oversees and issues construction permits, enforces safety standards and mandates, conducts periodic safety inspections, and provides public information to levee owners, engineers, and the general public. This proactive approach to managing dam and levee safety in Ohio reduces the number of losses to property and life as a result of dam or levee failures or near failures.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

DAMS – METHODOLOGY

Ideally all dams in the State of Ohio would have inundation mapping performed so dam safety officials, local officials, and first responders would be aware of the risk. Per Ohio Administrative Code 1501:21-15-07 all Class I dam owners must provide an inundation study and map along with their EAP. While voluntary compliance is not at 100%, the DSP has a relative idea of the impacts of dam failure and many of these dams do have an approved EAP complete with inundation mapping.

Under Ohio Revised Code 149.433(a) Class I dams are considered infrastructure and information regarding the safety of infrastructure cannot be distributed to unauthorized personnel due to security concerns. This means inundation maps and EAPs cannot be widely distributed, However, local EMAs and DSP are copy holders of the EAPs for all dams.

In an ongoing effort, ODNR DSP is utilizing Decision Support System for Water Infrastructure Security (DSS-WISE) Lite (https://dsswiseweb.ncche.olemiss.edu/userpages/about.php) to develop inundation areas for Class I Dams, initially focusing on dams that do not have an approved EAP. As part of this analysis, daytime and nighttime PAR are calculated to help planners and responders understand the differing impacts that a dam failure may have dependent on if people are out of their residence at a place of employment or at school (daytime) or at their residence, likely sleeping (nighttime).

ODNR DSP helps the United States Army Corps of Engineers update the National Inventory of Dams (NID) yearly. This information can be found on the NID website: https://nid.sec.usace.army.mil/#/. See Table 2.6.g for a listing of Class I Dams and their EAP Status. As of December 2023, over 265 Class I Dams with EAPs have inundation studies and inundation maps to help identify downstream risk.

Table 2.6.g

Ohio Class I Dam with EAP Status				
NID Number	**Name**	**County**	**OEMA Region**	**EAP Status**
OH03174	WILLIAMS RESERVOIR	ALLEN	1	Approved
OH00525	BRESLER UPGROUND RESERVOIR	ALLEN	1	Approved
OH00522	LOST CREEK UPGROUND RESERVOIR	ALLEN	1	Approved
OH00520	FERGUSON UPGROUND RESERVOIR	ALLEN	1	Approved
OH00521	METZGER UPGROUND RESERVOIR	ALLEN	1	Approved
OH00581	GRAND LAKE ST. MARYS - EAST EMBANKMENT	AUGLAIZE	1	Approved
OH00077	STROMAN LAKE DAM	CHAMPAIGN	1	Approved
OH00444	CLARK LAKE DAM	CLARK	1	Approved
OH00153	BUCYRUS RESERVOIR NO. 3 DAM	CRAWFORD	1	Approved
OH00150	POWERS UPGROUND RESERVOIR	CRAWFORD	1	Cursory
OH01467	BUCYRUS UPGROUND RESERVOIR NO. 4	CRAWFORD	1	Approved
OH00704	CELERYVILLE UPGROUND RESERVOIR	CRAWFORD	1	Cursory
OH00151	BUCYRUS RESERVOIR NO. 1 DAM	CRAWFORD	1	Approved
OH00385	DEFIANCE POWER DAM	DEFIANCE	1	Approved
OH03143	DEFIANCE UPGROUND RESERVOIR	DEFIANCE	1	Approved
OH00791	ARCHBOLD UPGROUND RESERVOIR NO. 1	FULTON	1	Approved
OH00420	DELTA RESERVOIR NO. 1	FULTON	1	Not Approved
OH01592	DELTA UPGROUND RESERVOIR NO. 2	FULTON	1	Not Approved
OH00789	WAUSEON UPGROUND RESERVOIR NO. 2	FULTON	1	Approved
OH00792	ARCHBOLD UPGROUND RESERVOIR NO. 2	FULTON	1	Approved
OH00788	FOSTORIA UPGROUND RESERVOIR NO. 5	HANCOCK	1	Approved
OH00783	McCOMB UPGROUND RESERVOIR NO. 1	HANCOCK	1	Approved
OH01089	McCOMB UPGROUND RESERVOIR NO. 2	HANCOCK	1	Approved
OH00785	LAKE LAMBERJACK UPGROUND RESERVOIR	HANCOCK	1	Approved
OH00787	LAKE MOTTRAM UPGROUND RESERVOIR	HANCOCK	1	Approved
OH00784	LAKE MOSIER UPGROUND RESERVOIR	HANCOCK	1	Approved
OH02730	VETERANS MEMORIAL RESERVOIR	HANCOCK	1	Cursory
OH00758	FINDLAY UPGROUND RESERVOIR NO. 1	HANCOCK	1	Approved
OH00782	FINDLAY UPGROUND RESERVOIR NO. 2	HANCOCK	1	Approved
OH00222	HOLIDAY LAKE DAM	HURON	1	Approved
OH00217	GREENWICH RESERVOIR DAM	HURON	1	Approved
OH00952	NEW LONDON RESERVOIR	HURON	1	Approved
OH00804	BELLEVUE UPGROUND RESERVOIR NO. 1	HURON	1	Approved
OH00805	BELLEVUE UPGROUND RESERVOIR NO. 3	HURON	1	Approved
OH00806	BELLEVUE UPGROUND RESERVOIR NO. 4	HURON	1	Approved
OH00761	NORWALK MEMORIAL RESERVOIR	HURON	1	Approved
OH00762	NORWALK UPPER RESERVOIR	HURON	1	Approved
OH00763	NORWALK LOWER RESERVOIR	HURON	1	Approved
OH00775	WILLARD CITY UPGROUND RESERVOIR	HURON	1	Approved
OH01944	PINE LAKE DAM	LOGAN	1	Not Approved
OH00980	BRIARWOOD SPORTSMAN'S CLUB NO. 11 DAM	LOGAN	1	Not Approved
OH00596	INDIAN LAKE DAM	LOGAN	1	Cursory
OH01977	COLLINS PARK WTP SLUDGE LAGOONS B & C	LUCAS	1	Approved
OH03218	HOWARD FARM DAM	LUCAS	1	Approved
OH00579	UPPER WABASH STRUCTURE NO. 3 DAM	MERCER	1	Approved
OH00580	GRAND LAKE ST. MARYS - WEST EMBANKMENT	MERCER	1	Approved
OH02103	ECHO LAKE DAM	MIAMI	1	Approved
OH02104	FRANZ POND DAM	MIAMI	1	Approved
OH00515	SWIFT RUN LAKE DAM	MIAMI	1	Approved
OH00476	PAULDING UPGROUND RESERVOIR	PAULDING	1	Cursory
OH00154	PARADISE LAKES - NORTH LAKE DAM	PREBLE	1	Cursory
OH00155	PARADISE LAKES - SOUTH LAKE DAM	PREBLE	1	Cursory
OH00159	FOUR EAGLES LAKE DAM	PREBLE	1	Approved
OH00434	RUSH RUN LAKE DAM	PREBLE	1	Approved
OH00156	LAKE LAKENGREN DAM	PREBLE	1	Cursory
OH01058	OTTAWA UPGROUND RESERVOIR	PUTNAM	1	Approved
OH03201	FREMONT UPGROUND RESERVOIR	SANDUSKY	1	Approved
OH00754	RACCOON CREEK UPGROUND RESERVOIR	SANDUSKY	1	Approved
OH00469	BEAVER CREEK UPGROUND RESERVOIR	SENECA	1	Approved
OH03137	ATTICA UPGROUND RESERVOIR #2	SENECA	1	Approved
OH00391	LOCKINGTON DAM	SHELBY	1	Approved
OH00442	LAKE LORAMIE DAM	SHELBY	1	Approved
OH03148	DELPHOS RESERVOIR DAM	VAN WERT	1	Approved
OH00768	VAN WERT UPGROUND RESERVOIR NO. 1	VAN WERT	1	Cursory
OH03144	VAN WERT UPGROUND RESERVOIR NO. 3	VAN WERT	1	Approved
OH00382	LAKE SENECA DAM	WILLIAMS	1	Cursory

NID Number	Name	County	OEMA Region	EAP Status
OH02768	PROVIDENCE DAM	WOOD	1	Approved
OH02769	GRAND RAPIDS DAM	WOOD	1	Approved
OH02767	BOWLING GREEN UPGROUND RES & SLUDGE LGNS	WOOD	1	Approved
OH00777	NORTH BALTIMORE UG RES NO. 1 & 2	WOOD	1	Approved
OH01144	ARTESIAN LAKE DAM	ASHLAND	2	Not Approved
OH00095	CINNAMON LAKE DAM	ASHLAND	2	Approved
OH01292	STONEGATE POND DAM	BUTLER	2	Cursory
OH02911	FAIRFIELD DETENTION "A" DAM	BUTLER	2	Approved
OH02920	FAIRFIELD DETENTION "C" DAM	BUTLER	2	Approved
OH01294	SWAN LAKE DAM	BUTLER	2	Approved
OH00177	CHARYLIE'S LAKE DAM	BUTLER	2	Not Approved
OH00174	ROSS TRAILS LAKE DAM	BUTLER	2	Approved
OH00575	ACTON LAKE DAM	BUTLER	2	Approved
OH01013	CLINTON COUNTY TRIBUTARY NO. 4 DAM	CLINTON	2	Approved
OH01014	CLINTON COUNTY TRIBUTARY NO. 1 DAM	CLINTON	2	Approved
OH00967	BLANCHESTER RESERVOIR NO. 3 DAM	CLINTON	2	Approved
OH03109	BLANCHESTER RESERVOIR NO. 6 DAM	CLINTON	2	Approved
OH00781	BLANCHESTER RESERVOIR NO. 4 DAM	CLINTON	2	Not Approved
OH00764	WILMINGTON UPGROUND RESERVOIR NO. 1	CLINTON	2	Approved
OH00765	WILMINGTON UPGROUND RESERVOIR NO. 2	CLINTON	2	Approved
OH00500	COWAN LAKE DAM	CLINTON	2	Approved
OH00352	LOWER SHAKER LAKE DAM	CUYAHOGA	2	Approved
OH00353	UPPER SHAKER LAKE DAM	CUYAHOGA	2	Approved
OH02943	KERRUISH STORMWATER CONTROL FACILITY DAM	CUYAHOGA	2	Approved
OH00918	FOREST HILL PARK DAM NO. 2	CUYAHOGA	2	Cursory
OH00945	LAKEVIEW CEMETERY FLOOD CONTROL DAM	CUYAHOGA	2	Approved
OH01483	BRIAR HILL LAKE DAM	CUYAHOGA	2	Cursory
OH01487	HOLLENBECK LAKE DAM	CUYAHOGA	2	Approved
OH03191	JOHN R. DOUTT UPGROUND RESERVOIR	DELAWARE	2	Approved
OH01522	HORACE TROOP POND DAM	DELAWARE	2	Not Approved
OH03173	TIMBER LAKE LIBERTY DAM	DELAWARE	2	Cursory
OH02737	LEXINGTON GLEN DAM	DELAWARE	2	Cursory
OH01513	DEL-CO UPLAND STORAGE RESERVOIR NO. 2	DELAWARE	2	Approved
OH02882	DEL-CO UPLAND STORAGE RESERVOIR NO. 3	DELAWARE	2	Approved
OH02886	DEL-CO UPLAND STORAGE RESERVOIR NO. 4	DELAWARE	2	Approved
OH00812	SUNBURY UPGROUND RESERVOIR NO. 1	DELAWARE	2	Approved
OH00747	SUNBURY UPGROUND RESERVOIR NO. 2	DELAWARE	2	Approved
OH03066	DEL-CO UPLAND STORAGE RESERVOIR NO. 5	DELAWARE	2	Approved
OH00748	WESTERVILLE RESERVOIR DAM	DELAWARE	2	Approved
OH00752	CAMP GREENWOOD LAKE DAM	DELAWARE	2	Approved
OH03129	ALUM CREEK UPGROUND RESERVOIR NO. 2	DELAWARE	2	Approved
OH02905	ALUM CREEK UPGROUND RESERVOIR	DELAWARE	2	Approved
OH00751	O'SHAUGHNESSY RESERVOIR DAM	DELAWARE	2	Approved
OH02899	HUNTERS RUN STRUCTURE R-42	FAIRFIELD	2	Approved
OH00725	RUSHCREEK STRUCTURE NO. V-C	FAIRFIELD	2	Approved
OH02848	TARHE DRY DAM	FAIRFIELD	2	Approved
OH00716	HUNTERS RUN STRUCTURE NO. 1	FAIRFIELD	2	Approved
OH00719	HUNTERS RUN STRUCTURE NO. 4	FAIRFIELD	2	Approved
OH00718	HUNTERS RUN STRUCTURE NO. 3	FAIRFIELD	2	Cursory
OH00721	HUNTERS RUN STRUCTURE NO. 6	FAIRFIELD	2	Cursory
OH00722	HUNTERS RUN STRUCTURE NO. 8	FAIRFIELD	2	Approved
OH00714	HUNTERS RUN STRUCTURE NO. 9	FAIRFIELD	2	Approved
OH00727	RUSHCREEK STRUCTURE NO. VII-E	FAIRFIELD	2	Cursory
OH01077	RUSHCREEK STRUCTURE NO. VI-D	FAIRFIELD	2	Cursory
OH02679	RUSHCREEK STRUCTURE NO. VII-A	FAIRFIELD	2	Cursory
OH01564	RUSHCREEK STRUCTURE NO. VI-A	FAIRFIELD	2	Cursory
OH00948	PINE LAKE ESTATES DAM	FAIRFIELD	2	Approved
OH00627	WASHINGTON COURT HOUSE UG NO. 1 DAM	FAYETTE	2	Cursory
OH00736	THOREAU POND DAM	FRANKLIN	2	Approved
OH00740	JULIAN GRIGGS DAM	FRANKLIN	2	Approved
OH00737	HOOVER DAM	FRANKLIN	2	Approved
OH01005	SCHLOSS POND DAM	GEAUGA	2	Cursory
OH00365	MONT-MERE LAKE DAM	GEAUGA	2	Approved
OH01621	LAKE-IN-THE-WOODS DAM	GEAUGA	2	Cursory
OH01629	SHADOW HILL LAKE DAM	GEAUGA	2	Not Approved
OH00358	LAKE LUCERNE DAM	GEAUGA	2	Approved
OH00359	TANGLEWOOD LAKE DAM	GEAUGA	2	Not Approved
OH01622	LOECY POND DAM	GEAUGA	2	Approved
OH00755	EAST BRANCH RESERVOIR DAM	GEAUGA	2	Approved

NID Number	Name	County	OEMA Region	EAP Status
OH00756	BRIDGE CREEK DAM	GEAUGA	2	Approved
OH00426	HUFFMAN DAM	GREENE	2	Approved
OH01648	DOMINICK LOFINO PARK LAKE DAM	GREENE	2	Cursory
OH00807	CEDARVILLE UPGROUND RESERVOIR	GREENE	2	Not Approved
OH00206	LAKE SHAWNEE DAM	GREENE	2	Approved
OH00936	CHATEAU LAKES NO. 1 DAM	HAMILTON	2	Approved
OH02907	WRIGHT FARM WEST DETENTION BASIN DAM	HAMILTON	2	Cursory
OH00991	SHARONVILLE RETENTION DAM	HAMILTON	2	Approved
OH03050	ASTON OAKS LAKE DAM	HAMILTON	2	Approved
OH01703	LINCOLN HEIGHTS UPGROUND RESERVOIR	HAMILTON	2	Approved
OH00191	KREIS DAM	HAMILTON	2	Approved
OH00346	LAKE VIERING DAM	KNOX	2	Not Approved
OH03205	LAKE DAMASCUS DAM	KNOX	2	Cursory
OH01856	KNOX CATTLE COMPANY DAM	KNOX	2	Not Approved
OH00638	KNOX LAKE DAM	KNOX	2	Approved
OH00345	APPLE VALLEY LAKE DAM	KNOX	2	Approved
OH02833	HOOSE ROAD RETENTION DAM	LAKE	2	Approved
OH00474	BUCKEYE LAKE DAM	LICKING	2	Approved
OH00472	DAWES ARBORETUM LAKE DAM	LICKING	2	Not Approved
OH00438	FINDLEY LAKE DAM	LORAIN	2	Approved
OH02990	WILLOWAY UPGROUND NO. 5 DAM	LORAIN	2	Approved
OH00112	OBERLIN UPGROUND RESERVOIR	LORAIN	2	Approved
OH00774	WELLINGTON UPGROUND RESERVOIR	LORAIN	2	Approved
OH00068	LAKE CHOCTAW DAM	MADISON	2	Approved
OH02010	CHIPPEWA CREEK STRUCTURE III-A	MEDINA	2	Approved
OH01085	CHIPPEWA CREEK STRUCTURE VIII-C	MEDINA	2	Approved
OH00616	SIEDEL LAKE DAM	MEDINA	2	Approved
OH01081	BLUE HERON LAKE NO. 1 DAM	MEDINA	2	Cursory
OH00614	BLUE HERON LAKE NO. 5 DAM	MEDINA	2	Cursory
OH02713	RIDGEWOOD LAKE DAM	MEDINA	2	Not Approved
OH00622	LAKE MEDINA DAM	MEDINA	2	Approved
OH00607	RUSTIC HILLS LAKE DAM	MEDINA	2	Approved
OH03057	BRYE LAKE DAM	MEDINA	2	Not Approved
OH00621	HINCKLEY LAKE DAM	MEDINA	2	Approved
OH00623	LAKE BRUNSWICK DAM	MEDINA	2	Approved
OH00600	RAVENS WOOD LAKE DAM	MEDINA	2	Approved
OH02086	LAKE HAVEN DAM	MEDINA	2	Not Approved
OH00615	SEVEN SPRINGS LAKE DAM	MEDINA	2	Approved
OH00425	GERMANTOWN DAM	MONTGOMERY	2	Approved
OH00427	TAYLORSVILLE DAM	MONTGOMERY	2	Approved
OH00431	ENGLEWOOD DAM	MONTGOMERY	2	Approved
OH02129	NEWFIELDS DEVELOPMENT LAKE DAM	MONTGOMERY	2	Approved
OH00423	LAKE MARINOLE DAM	MONTGOMERY	2	Approved
OH00428	SPRING LAKE DAM	MONTGOMERY	2	Not Approved
OH00689	MOUNT GILEAD LOWER LAKE DAM	MORROW	2	Approved
OH00686	AMICKS UPGROUND RESERVOIR	MORROW	2	Cursory
OH00688	CANDLEWOOD LAKE DAM	MORROW	2	Approved
OH00643	HARGUS LAKE DAM	PICKAWAY	2	Approved
OH00670	TUCAWAY LAKE DAM	PORTAGE	2	Not Approved
OH02729	HICKORY HILLS PARK LAKE DAM	PORTAGE	2	Not Approved
OH03217	CAMP SPELMAN LAKE DAM	PORTAGE	2	Approved
OH02286	BRIMFIELD LAKE DAM	PORTAGE	2	Approved
OH00665	MOGADORE RESERVOIR DAM	PORTAGE	2	Approved
OH00668	LAKE ROCKWELL DAM	PORTAGE	2	Approved
OH02853	SHELBY UPGROUND RESERVOIR NO. 3	RICHLAND	2	Approved
OH00778	CLEAR FORK RESERVOIR DAM	RICHLAND	2	Approved
OH00455	SHELBY UPGROUND RESERVOIR NO. 2	RICHLAND	2	Approved
OH03146	MARATHON BRINE POND DAM	STARK	2	Approved
OH02437	LORDS LAKE DAM	STARK	2	Approved
OH00241	DALE WALBORN RESERVOIR DAM	STARK	2	Approved
OH03146	MARATHON BRINE POND DAM	STARK	2	Approved
OH00236	LAKE CABLE DAM	STARK	2	Approved
OH00481	GORGE PLANT DAM	SUMMIT	2	Approved
OH02471	SILVER CREEK LAKE DAM	SUMMIT	2	Approved
OH03185	ZIMBER DITCH DETENTION BASIN B	SUMMIT	2	Approved
OH00479	COMET LAKE DAM	SUMMIT	2	Approved
OH02472	STEEPLECHASE LAKE DAM	SUMMIT	2	Approved
OH00489	LAKE BUTLER DAM	SUMMIT	2	Approved
OH00933	LAKE LITCHFIELD DAM	SUMMIT	2	Approved

NID Number	Name	County	OEMA Region	EAP Status
OH02854	SWAN LAKE DAM	SUMMIT	2	Not Approved
OH00487	LOYAL OAK LAKE DAM	SUMMIT	2	Approved
OH03044	CHARBONNEAU LAKE DAM	SUMMIT	2	Approved
OH02470	RESERVOIR PARK UPGROUND	SUMMIT	2	Cursory
OH00485	TUSCARAWAS RIVER DIVERSION DAM	SUMMIT	2	Approved
OH00584	NIMISILA RESERVOIR DAM	SUMMIT	2	Approved
OH00486	LAKE DOROTHY DAM	SUMMIT	2	Approved
OH00588	EAST RESERVOIR DAM	SUMMIT	2	Approved
OH00587	NORTH RESERVOIR DAM	SUMMIT	2	Approved
OH00585	WEST RESERVOIR DAM	SUMMIT	2	Approved
OH00483	WOLF CREEK DAM	SUMMIT	2	Approved
OH03166	MARYSVILLE UPGROUND RESERVOIR	UNION	2	Approved
OH00553	SHAKER RUN DAM	WARREN	2	Approved
OH00547	LILLEY LAKE DAM	WARREN	2	Not Approved
OH00532	CLASSICWAY FARM LAKE DAM	WARREN	2	Not Approved
OH00542	PINE HILL LAKE DAM	WARREN	2	Approved
OH00540	LANDEN FARM LAKE DAM	WARREN	2	Approved
OH02594	REMICK LAKE DAM	WARREN	2	Approved
OH00533	SUNRISE LAKE DAM	WARREN	2	Approved
OH00926	CHIPPEWA CREEK STRUCTURE VII-C	WAYNE	2	Approved
OH00436	SHREVE LAKE DAM	WAYNE	2	Approved
OH00254	MINERAL SPRINGS RESORT LAKE DAM	ADAMS	3	Approved
OH00259	ADAMS LAKE DAM	ADAMS	3	Approved
OH01127	KILLEN STATION ASH DISPOSAL DIKE	ADAMS	3	Cursory
OH00392	LOWER JEFFCO LAKE DAM	ASHTABULA	3	Not Approved
OH00396	CAMP WHITEWOOD LAKE DAM	ASHTABULA	3	Not Approved
OH00938	HOLIDAY CAMPLANDS LAKE DAM	ASHTABULA	3	Approved
OH01191	NAJI LAKE DAM	ASHTABULA	3	Not Approved
OH00407	ASHTABULA COUNTY OUTDOOR CLUB LAKE DAM	ASHTABULA	3	Approved
OH00397	ROAMING ROCK SHORES LAKE DAM	ASHTABULA	3	Approved
OH00084	MARGARET CREEK STRUCTURE NO. 4	ATHENS	3	Approved
OH00086	DOW LAKE DAM	ATHENS	3	Approved
OH00960	MARGARET CREEK STRUCTURE NO. 1	ATHENS	3	Approved
OH00081	NESBITT POND DAM	ATHENS	3	Not Approved
OH00706	MARGARET CREEK STRUCTURE NO. 6	ATHENS	3	Approved
OH00083	MARGARET CREEK STRUCTURE NO. 2	ATHENS	3	Not Approved
OH01218	BELMONT HILLS COUNTRY CLUB LAKE DAM	BELMONT	3	Approved
OH00300	BARNESVILLE RESERVOIR NO. 2 DAM	BELMONT	3	Approved
OH00299	BARNESVILLE RESERVOIR NO. 1 DAM	BELMONT	3	Approved
OH00793	ST. CLAIRSVILLE RESERVOIR NO. 1 DAM	BELMONT	3	Approved
OH01229	MEIGS-PHILLIPS I NO. 1 DAM	BELMONT	3	Approved
OH00877	BARNESVILLE LAKE DAM	BELMONT	3	Approved
OH00753	BARNESVILLE RESERVOIR NO. 3 DAM	BELMONT	3	Approved
OH00794	ST. CLAIRSVILLE RESERVOIR NO. 2 DAM	BELMONT	3	Approved
OH00292	BELMONT LAKE DAM	BELMONT	3	Approved
OH01099	THE OHIO VALLEY COAL SLURRY DISPOSAL DAM	BELMONT	3	Approved
OH00293	BETHESDA RESERVOIR DAM	BELMONT	3	Approved
OH01002	MOUNT ORAB UPGROUND RESERVOIR NO. 2	BROWN	3	Approved
OH01249	FAYETTEVILLE HIGH SCHOOL LAKE DAM	BROWN	3	Not Approved
OH00162	LAKE WAYNOKA DAM	BROWN	3	Approved
OH00462	PUSKARICH LAKE DAM	CARROLL	3	Cursory
OH00459	VO-ASH LAKE DAM	CARROLL	3	Approved
OH00467	LAKE MOHAWK DAM	CARROLL	3	Approved
OH01358	GALLEY HILL LAKE DAM	CLERMONT	3	Approved
OH03032	EQUINUS (LEGENDARY RUN) LAKE DAM	CLERMONT	3	Approved
OH00271	CLERMONT GOLF LIMITED LAKE DAM	CLERMONT	3	Cursory
OH03006	MARGE SCHOTT LAKE DAM	CLERMONT	3	Approved
OH01391	WILLOWBROOK LAKE DAM	CLERMONT	3	Approved
OH00269	STONELICK LAKE DAM	CLERMONT	3	Approved
OH00315	LAKE TOMAHAWK DAM	COLUMBIANA	3	Approved
OH03145	BUCKEYE WATER DISTRICT RESERVOIR	COLUMBIANA	3	Approved
OH00321	SALEM RESERVOIR (SOUTH EMBANKMENT)	COLUMBIANA	3	Approved
OH00307	WELLSVILLE RESERVOIR DAM	COLUMBIANA	3	Approved
OH00322	SPRING VALLEY PARK LAKE DAM	COLUMBIANA	3	Approved
OH00635	HIGHLANDTOWN LAKE DAM	COLUMBIANA	3	Approved
OH00636	GUILFORD LAKE DAM	COLUMBIANA	3	Approved
OH00310	BIBBEE'S LITTLE ROCK LAKE DAM	COLUMBIANA	3	Not Approved
OH03216	BUCKEYE WATER DISTRICT RESERVOIR II	COLUMBIANA	3	Approved
OH00038	SUNSET LAKE DAM	COSHOCTON	3	Approved

NID Number	Name	County	OEMA Region	EAP Status
OH00285	RIO GRANDE RESERVOIR	GALLIA	3	Approved
OH00283	TYCOON LAKE DAM	GALLIA	3	Approved
OH00971	GAVIN BOTTOM ASH POND	GALLIA	3	Cursory
OH00919	STINGY RUN FLY ASH DAM	GALLIA	3	Cursory
OH00051	INDIAN LAKES REC. AREA LOWER LAKE DAM	GUERNSEY	3	Cursory
OH00053	LUBURGH LAKE DAM	GUERNSEY	3	Approved
OH00433	SALT FORK LAKE DAM	GUERNSEY	3	Approved
OH00879	STEVENS LAKE DAM	HARRISON	3	Not Approved
OH00896	VARKONY POND DAM	HARRISON	3	Not Approved
OH00141	SALLY BUFFALO PARK LAKE DAM	HARRISON	3	Approved
OH01736	SALLY BUFFALO PARK LAKE NO. 4 DAM	HARRISON	3	Approved
OH01111	SALLY BUFFALO PARK LAKE NO. 2 DAM	HARRISON	3	Approved
OH00129	GEORGETOWN PLANT FRESHWATER DAM	HARRISON	3	Not Approved
OH00302	ROCKY FORK LAKE DAM	HIGHLAND	3	Approved
OH01764	HOLIDAY HAVEN LAKE DAM I	HOCKING	3	Cursory
OH00251	LAKE OF THE FOUR SEASONS DAM	HOCKING	3	Cursory
OH00260	LAKE LOGAN DAM	HOCKING	3	Approved
OH00249	OLD MAN'S CAVE LAKE DAM	HOCKING	3	Approved
OH00065	BETHANY LAKE DAM	HOLMES	3	Cursory
OH00063	LAKE BUCKHORN DAM	HOLMES	3	Approved
OH01807	FAIRGREENS GOLF CLUB DAM	JACKSON	3	Not Approved
OH00813	WELLSTON RESERVOIR DAM	JACKSON	3	Cursory
OH00510	LAKE KATHARINE LAKE DAM	JACKSON	3	Approved
OH00642	JACKSON LAKE DAM	JACKSON	3	Approved
OH00508	JISCO LAKE DAM	JACKSON	3	Approved
OH00507	HAMMERTOWN LAKE DAM	JACKSON	3	Approved
OH00920	CARDINAL FLY ASH NO. 1 DAM	JEFFERSON	3	Approved
OH00123	FRIENDSHIP PARK LAKE DAM	JEFFERSON	3	Approved
OH00121	PINE VALLEY SPORTSMEN'S LAKE NO. 4 DAM	JEFFERSON	3	Not Approved
OH00497	JEFFERSON LAKE DAM	JEFFERSON	3	Approved
OH00862	BASICH LAKE DAM	JEFFERSON	3	Cursory
OH01826	CARDINAL FLY ASH NO. 2 DAM	JEFFERSON	3	Approved
OH00707	LAKE AUSTIN DAM	JEFFERSON	3	Approved
OH00953	IZAAK WALTON LAKE DAM	LAWRENCE	3	Cursory
OH00145	WALLER LAKE DAM	LAWRENCE	3	Cursory
OH00632	PINE LAKE DAM	MAHONING	3	Approved
OH03105	YOUNGSTOWN UPGROUND RESERVOIR	MAHONING	3	Approved
OH00629	LAKE HAMILTON DAM	MAHONING	3	Approved
OH00628	McKELVEY LAKE DAM	MAHONING	3	Approved
OH00631	EVANS LAKE DAM	MAHONING	3	Approved
OH00419	LAKE MILTON DAM	MAHONING	3	Approved
OH00440	FORKED RUN LAKE DAM	MEIGS	3	Approved
OH02094	MEIGS MINE NO. 1 SLURRY IMPOUNDMENT	MEIGS	3	Cursory
OH00441	MONROE LAKE DAM	MONROE	3	Approved
OH03177	WOODSFIELD RESERVOIR DAM NO. 3	MONROE	3	Not Approved
OH00696	MUSKINGUM RIVER LOCK AND DAM NO. 6	MORGAN	3	Approved
OH02226	ZANESVILLE STATE NURSERY LAKE DAM	MUSKINGUM	3	Approved
OH00055	DEER LAKE DAM	MUSKINGUM	3	Not Approved
OH02190	MUSKINGUM COLLEGE LAKE DAM	MUSKINGUM	3	Approved
OH00841	INTERNATIONAL ANIMAL PRESERVE POND DAM #10	MUSKINGUM	3	Approved
OH00061	BLUE ROCK LAKE DAM	MUSKINGUM	3	Approved
OH03060	CLINE LAKE DAM	NOBLE	3	Approved
OH00708	CALDWELL LAKE DAM	NOBLE	3	Approved
OH00437	WOLF RUN LAKE DAM	NOBLE	3	Approved
OH00654	ESSINGTON LAKE DAM	PERRY	3	Cursory
OH02243	ALLEN NO. 1 DAM	PERRY	3	Not Approved
OH02844	RUSHCREEK STRUCTURE NO. II	PERRY	3	Approved
OH00660	RUSHCREEK STRUCTURE NO. III-A	PERRY	3	Cursory
OH02254	RUSHCREEK STRUCTURE NO. IV-C	PERRY	3	Cursory
OH03076	RUSHCREEK STRUCTURE NO. III-C	PERRY	3	Cursory
OH00649	ALTIERS LAKE DAM	PERRY	3	Not Approved
OH00648	SAN TOY DAM	PERRY	3	Approved
OH00661	GLASS ROCK LAKE DAM	PERRY	3	Cursory
OH00655	PERRY RECLAMATION DAM NO. 3	PERRY	3	Approved
OH00653	RUSH CREEK STRUCTURE NO. 1-B	PERRY	3	Cursory
OH00798	NEW LEXINGTON RESERVOIR DAM	PERRY	3	Not Approved
OH00198	LONG'S RETREAT LAKE DAM	PIKE	3	Approved
OH00446	LAKE WHITE DAM	PIKE	3	Approved
OH00200	PIKE LAKE DAM	PIKE	3	Approved

NID Number	Name	County	OEMA Region	EAP Status
OH02277	ARNETT LAKE DAM	PIKE	3	Not Approved
OH00197	CAVE LAKE DAM	PIKE	3	Approved
OH02356	BROWN & HASKINS LAKE DAM	ROSS	3	Cursory
OH00025	WHITE TURKEY LAKE DAM	ROSS	3	Approved
OH00443	ROSS LAKE DAM	ROSS	3	Approved
OH00766	SOUTHERN SILICA POND NO. 1 DAM	ROSS	3	Cursory
OH00767	SOUTHERN SILICA POND NO. 2 DAM	ROSS	3	Not Approved
OH00023	CALDWELL LAKE DAM	ROSS	3	Approved
OH00498	BEAR CREEK LAKE DAM	SCIOTO	3	Approved
OH02376	KINSKEY LAKE DAM	SCIOTO	3	Not Approved
OH02390	WOLFDEN LAKE DAM	SCIOTO	3	Approved
OH02385	POND LICK LAKE DAM	SCIOTO	3	Approved
OH00291	BIG BEAR LAKE DAM	SCIOTO	3	Not Approved
OH00644	TURKEY CREEK LAKE DAM	SCIOTO	3	Approved
OH00286	ROOSEVELT LAKE DAM	SCIOTO	3	Approved
OH02380	LAKE EMMA	SCIOTO	3	Not Approved
OH00336	PLEASANT VALLEY LAKE DAM	TRUMBULL	3	Not Approved
OH00634	UPPER GIRARD LAKE DAM	TRUMBULL	3	Approved
OH00337	MINERAL RIDGE DAM	TRUMBULL	3	Approved
OH00334	COALBURG LAKE DAM	TRUMBULL	3	Cursory
OH02525	SUGARCREEK SPORTSMAN CLUB LAKE DAM	TUSCARAWAS	3	Not Approved
OH00074	LAKE ALMA DAM	VINTON	3	Approved
OH00073	LAKE RUPERT DAM	VINTON	3	Approved
OH02839	SANDS HILL SLURRY IMPOUNDMENT DAM	VINTON	3	Not Approved
OH00445	VETO LAKE DAM	WASHINGTON	3	Approved
OH00973	MUSKINGUM RIVER LOWER FLY ASH DAM	WASHINGTON	3	Approved
OH00972	MUSKINGUM RIVER MIDDLE FLY ASH DAM	WASHINGTON	3	Approved
OH01100	ERAMET WASTE RETENTION DAM	WASHINGTON	3	Approved
OH00989	MUSKINGUM RIVER UPPER FLY ASH DAM	WASHINGTON	3	Approved

Source: Ohio Department of Natural Resources Dam Safety Program, December 2023.

Assessing the hazard that a dam poses to downstream areas can be divided into three analyses: (1) analysis of an uncontrolled release of the reservoir, (2) analysis of the inundation from the uncontrolled release, and (3) analysis of the consequence of the release. In other words, a dam fails, the failure causes flooding downstream, and the flooding has negative impacts on people or property. Each of these analyses includes substantial uncertainty. Legitimate estimates of discharge from a breach can differ by over 200%. Discharge from a dam breach is usually several times the one percent-annual-chance flood, and, therefore, typical flood studies are of limited use in estimating the extent of flooding. Dam failure inundation studies require specialized hydraulic modeling software and experience. Determining the impact of flooding is also difficult to accomplish, especially for estimating loss of life. Loss of life is a function of the time of day, warning time, awareness of those affected, and failure scenario. Many dam safety agencies have used “population at risk” (PAR), a more quantifiable measurement of the impact to human life, rather than “loss of life.” PAR is the number of people in structures within the inundation area that would be subject to significant, personal danger, if they took no action to evacuate.

Another factor in assessing the hazard that a dam poses is the dam’s condition. Assessing the condition of a dam can be an extensive and expensive process. ODNR’s Dam Safety Program inspects all regulated dams once every 5 years. As part of that inspection, the dam’s history is reviewed including original construction plans, previous inspection reports, investigations and studies, “Operation, Maintenance, and Inspection Manuals”, “Emergency Action Plans”, calculations, and any other available information. During the inspection, an assessment of the downstream area is made to verify the classification of the dam. If the inspection, combined with the dam’s history and potential downstream impacts, reveals concerns with the dam’s condition, the DSP takes enforcement action through the Ohio Attorney General’s office as needed.

As mentioned at the beginning of this section, emergency managers usually categorize dam failures as either sunny-day failures or rainy-day failures. Sunny day failures occur during a non-flooding situation with the reservoir near normal pool level. Rainy day failures usually involve periods of rainfall and flooding. Improper design of a spillway or careless operation of gates during high flows can lead to dam overtopping, excessive water pressure, and subsequent failure. Even though both types of failures can be disastrous, it can be assumed that a sunny day failure would be more catastrophic due to its unanticipated occurrence and the lack of time to warn residents downstream. The impacts of a dam failure are contingent on many factors and, therefore, cannot be concisely described.

In the mid the 2000's the DSP program incorporated an assessment to estimate a dam's risk to infrastructure and population at risk. The assessment looks at sunny day and rainy-day failures to categorize if infrastructure (roads, structures, water treatment facilities, etc.) would be damaged. This assessment is revisited when a dam is inspected as part of the 5-year inspection cycle. Table 2.6.h contains rough estimates of the downstream impacts of dam failures for the Class I dams that have an estimated Sunny Day People-at-Risk (PAR) greater than 50.

Infrastructure damage categorization is as follows:

- "Low" 1-3 impacted,
- "Medium" 10-50 impacted,
- "High" 51-150 impacted, and
- "Very high" over 150 impacted.

PAR is categorized in the following way:

- "Low" is less than 100 people,
- "Medium" is 101-200 people, and
- "High" is more than 200 people.

The condition of the dams in table 2.6.h is not a factor of the estimated damage or PAR levels. Because of the uncertainty of determining precisely who and what will be impacted by a dam failure, a scale was developed by the DSP to categorize dams based on their estimated impact to lives and structures downstream. The "Very high, high, medium, and low" scale is based on the PAR and was developed using experience with flood modeling, aerial photographs, field observations, and engineering judgment. The Damage and PAR levels are periodically updated by DSP staff as new data is obtained.

DAMS – RESULTS

Table 2.6.h

Class I Dams, Estimated Downstream Damage Level and Estimated Population At-Risk (PAR) by County						
County	OEMA Region	Dam Name	Sunny Day Infrastructure Damage Level	Sunny Day PAR Level	Rainy Day Infrastructure Damage Level	Rainy Day PAR Level
Allen	1	Ferguson Upground Reservoir	High	Medium	Very High	Medium
Allen	1	Metzger Upground Reservoir	Medium	Medium	Very High	Medium
Allen	1	Lost Creek Upground Reservoir	Medium	Low	Medium	Low
Crawford	1	Bucyrus Reservoir No. 1 Dam	Medium	Low	Medium	Low
Hancock	1	Veterans Memorial Reservoir	Medium	Low	Medium	Low
Huron	1	Willard City Upground Reservoir	Medium	Low	Medium	Low
Huron	1	Norwalk Memorial Reservoir	High	Low	High	Low
Huron	1	Norwalk Upper Reservoir	High	Low	High	Low

County	OEMA Region	Dam Name	Sunny Day Infrastructure Damage Level	Sunny Day PAR Level	Rainy Day Infrastructure Damage Level	Rainy Day PAR Level
Huron	1	Norwalk Lower Reservoir	High	Low	High	Low
Shelby	1	Lockington Dam	--	Low	Very High	Medium
Shelby	1	Lake Loramie Dam	Medium	Low	Medium	Low
Butler	2	Fairfield Detention "A" Dam	--	Low	Medium	Low
Butler	2	Fairfield Detention "C" Dam	--	Low	Medium	Low
Butler	2	Acton Lake Dam	High	Low	High	Low
Clinton	2	Wilmington Upground Reservoir No. 2	Medium	Low	Medium	Low
Cuyahoga	2	Lakeview Cemetery Flood Control Dam	--	Low	High	Medium
Delaware	2	Alum Creek Upground Reservoir	High	Low	High	Low
Delaware	2	O'Shaughnessy Reservoir Dam	Very High	Low	Very High	Low
Franklin	2	Hoover Dam	Very High	High	Very High	High
Franklin	2	Julian Griggs Dam	High	Low	High	Low
Geauga	2	Bridge Creek Dam	Very High	Medium	Very High	Medium
Greene	2	Huffman Dam	--	Low	Very High	Medium
Knox	2	Apple Valley Lake Dam	High	Low	High	Low
Licking	2	Buckeye Lake Dam	Very High	High	Very High	Medium
Montgomery	2	Germantown Dam	--	Low	Very High	Medium
Montgomery	2	Taylorsville Dam	--	Low	Very High	Medium
Montgomery	2	Englewood Dam	--	Low	Very High	High
Portage	2	Mogadore Reservoir Dam	High	Medium	High	Medium
Portage	2	Lake Rockwell Dam	High	Medium	Very High	Medium
Richland	2	Clear Fork Reservoir Dam	Medium	Low	High	Medium
Summit	2	West Reservoir Dam	High	Low	High	Low
Summit	2	Wolf Creek Dam	Very High	High	Very High	High
Summit	2	Tuscarawas River Diversion Dam	Medium	Low	High	Low
Summit	2	North Reservoir Dam	Medium	Low	Medium	Low
Summit	2	East Reservoir Dam	Medium	Low	Medium	Low
Summit	2	Lake Dorothy Dam	Medium	Low	High	Low
Ashtabula	3	Roaming Rock Shores Lake Dam	High	Medium	High	Medium
Belmont	3	Belmont Lake Dam	Medium	Low	High	Medium
Clermont	3	Stonelick Lake Dam	High	Medium	Medium	Low
Columbiana	3	Guilford Lake Dam	High	Medium	Medium	Low
Gallia	3	Gavin Bottom Ash Pond	Medium	Low	Medium	Low
Gallia	3	Stingy Run Fly Ash Dam	Very High	Medium	Very High	High
Guernsey	3	Salt Fork Lake Dam	Very High	Medium	Very High	Medium
Highland	3	Rocky Fork Lake Dam	Very High	High	Very High	High
Holmes	3	Lake Buckhorn Dam	Medium	Low	Medium	Low
Jefferson	3	Cardinal Fly Ash No. 2 Dam	Very High	Low	Very High	Low
Jefferson	3	Lake Austin Dam	High	Low	High	Low
Mahoning	3	Evans Lake Dam	High	Medium	Very High	Medium
Mahoning	3	McKelvey Lake Dam	High	Medium	High	Medium
Mahoning	3	Lake Hamilton Dam	Medium	Low	High	Low
Mahoning	3	Lake Milton Dam	Very High	High	Very High	High
Noble	3	Wolf Run Lake Dam	Very High	Medium	Very High	Medium
Noble	3	Caldwell Lake Dam	High	Medium	High	Medium
Scioto	3	Turkey Creek Lake Dam	High	Medium	Medium	Low
Trumbull	3	Mineral Ridge Dam	Very High	High	Very High	High
Washington	3	Eramet Waste Retention Dam	High	Medium	High	Medium

Source: Ohio Department of Natural Resources Dam Safety Program, “Population at Risk” Evaluation

LEVEES – METHODOLOGY

Levee vulnerability was included as "Risk Characteristics" for each Levee system in the US Army Corp of Engineers National Levee Database (NLD). A risk classification was not assessed for every levee, however there are no levee systems rated as Very High, only one levee system is rated High, six as Moderate, 18 as low, and the remaining were not screened. The Risk Characteristics for each levee system was assessed to estimate the number of people and buildings at risk, as well as the property value exposed. The risk characteristics are as summarized in table 2.6.c and 2.6.e above.

LEVEES – RESULTS

Statewide, there are 149 levee systems in the National Levee Database that protect an area of approximately 57.32 mi^2. Within this area resides an estimated 311,402 people and 75,332 structures, and an estimated property value of $64,464,123,691.

- In Region 1, there are 77 levee systems that protect an area of approximately 17.43 mi^2. Within this area resides an estimated 86,925 people and 21,898 structures, and an estimated property value of $18,395,361,338. One of these levee systems extend into Monroe County which is in Region 3.
- In Region 2, there are 56 levee systems that protect an area of approximately 29.34 mi^2. Within this area resides an estimated 189,561 people, 37,607 structures, and an estimated property value of $38,554,551,035.
- In Region 3, there are 11 levee systems that protect an area of approximately 10.58 mi^2. Within this area resides an estimated 34,916 people, 15,827 structures, and an estimated property value of $7,514,211,318. One of these levee systems extend into Stark County which is in Region 2.

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

DAM VULNERABILITY METHODOLOGY

As discussed in Section 2.1, the Department of Administrative Services maintains a database of all state-owned and state-leased facilities. These data were obtained for this enhanced plan update, and facilities were categorized based on their critical and non-critical nature (per the definition provided in Section 2.1). For dam failures, inundation mapping for Class I dams owned and operated by the USACE were available. This mapping was coupled with the coordinates of state-owned and state-leased facilities to determine the state properties are at risk given a dam failure that matches the assumptions made during the inundation analyses.

This methodology was used for assessing state-owned and state-leased facilities vulnerable to Class I dams owned and operated by the USACE. Specifically, the inundation areas of 16 dams were analyzed.

RESULTS

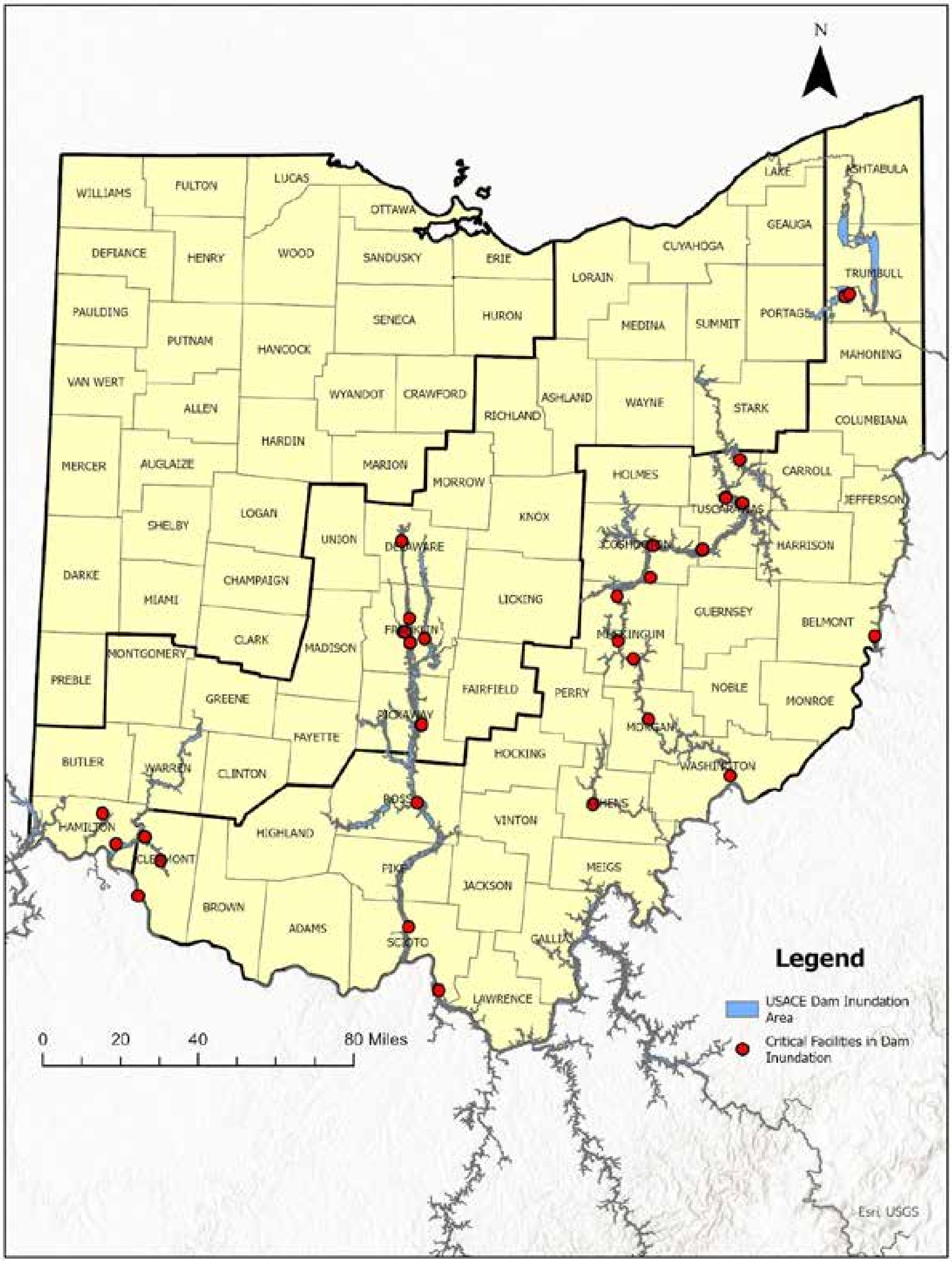
Table 2.6.j shows the numbers of state-owned and state-leased facilities potentially affected by an event equivalent to the spillway design flood with dam failure, and their replacement costs. There are a total of 148 critical facilities within the inundation areas of listed USACE dams.

Region 2 has 48 critical facilities with a total replacement cost of $262,329,722. Region 3 has 100 facilities with a total replacement cost of $154,634,166. Region 1 did not have any critical facilities within these inundation areas.

Table 2.6.j— State-owned and State-leased Critical Facilities within USACE Dam Inundation Areas

USACE DAM County	OEMA Region	Number of CF	Replacement Costs
ALUM CREEK DAM			
FRANKLIN	2	2	$ 55,525,979
BLUESTONE DAM			
SCIOTO	3	4	$ 47,247,200
BOLIVAR DAM			
COSHOCTON	3	8	$ 9,400,669
MORGAN	3	1	$ 34,340
MUSKINGUM	3	1	$ 258,017
TUSCARAWAS	3	15	$ 41,598,780
DELAWARE DAM			
DELAWARE	2	1	$ 45,665
FRANKLIN	2	24	$ 152,230,767
PICKAWAY	2	17	$ 37,146,600
SCIOTO	3	1	$ 657,000
DOVER DAM			
TUSCARAWAS	3	21	$ 1,876,140
WASHINGTON	3	3	$ 5,827,804
KINZUA DAM			
BELMONT	3	8	$ 794,717
MICHAEL J KIRWAN DAM			
TRUMBULL	3	3	$ 412,970
MOHAWK DAM			
COSHOCTON	3	1	$ 568,568
MUSKINGUM	3	6	$ 1,091,427
TUSCARAWAS	3	1	$ 45,150
PAINT CREEK DAM			
ROSS	3	7	$ 1,338,100
TOM JENKINS DAM			
ATHENS	3	10	$ 40,515,100
WEST FORK OF MILL CREEK LAKE DAM			
HAMILTON	2	3	$ 17,349,071
WILLIAM H HARSHA LAKE DAM			
CLERMONT	3	10	$ 2,968,184
HAMILTON	2	1	$ 31,640
Grand Total		**148**	**$ 416,963,888**

Map 2.6.b— State-owned and State-leased Critical Facilities within USACE Dam Inundation Areas



STATE OWNED DAMS

In addition to State owned critical facilities that may be impacted by dam failures, the State of Ohio, Department of Natural Resources also owns and maintains 57 Class I Dams. Of these 57 dams, 56 have EAPs complete with inundation maps while 1 has a cursory EAP that contains some level of downstream hazard map. Please see Map 2.6.c which depicts the location of these dams throughout the state followed by table 2.6.k for the name of the dam and the NID number of the ODNR Dams. Future updates to this plan will include analysis of these maps in coordination with the ODNR using the same methodology described previously.

Map 2.6.c — State Owned Class I Dams

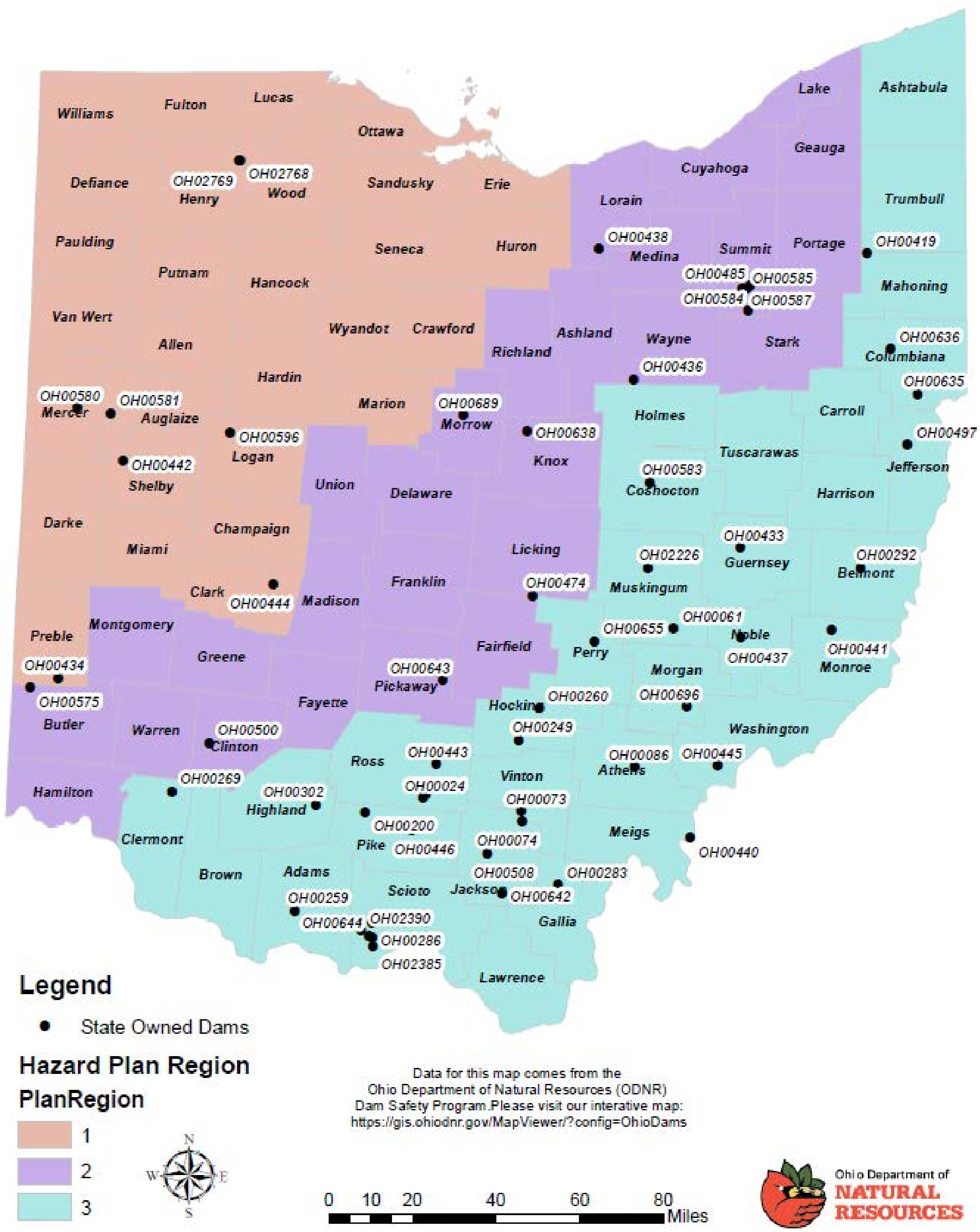


Table 2.6.k — State Owned Class I Dams

NID Number	NAME	County	OEMA Region
OH00575	ACTON LAKE DAM	BUTLER	2
OH00259	ADAMS LAKE DAM	ADAMS	1
OH00498	BEAR CREEK LAKE DAM	SCIOTO	3
OH00292	BELMONT LAKE DAM	BELMONT	3
OH00061	BLUE ROCK LAKE DAM	MUSKINGUM	3
OH00474	BUCKEYE LAKE DAM	LICKING	2
OH00023	CALDWELL LAKE DAM	ROSS	3
OH00444	CLARK LAKE DAM	CLARK	1
OH00500	COWAN LAKE DAM	CLINTON	2
OH00086	DOW LAKE DAM	ATHENS	3
OH00588	EAST RESERVOIR DAM	SUMMIT	2
OH00654	ESSINGTON LAKE DAM	PERRY	3
OH00438	FINDLEY LAKE DAM	LORAIN	2
OH00440	FORKED RUN LAKE DAM	MEIGS	3
OH00159	FOUR EAGLES LAKE DAM	PREBLE	1
OH00581	GRAND LAKE ST. MARYS - EAST EMBANKMENT	AUGLAIZE	1
OH00580	GRAND LAKE ST. MARYS - WEST EMBANKMENT	MERCER	1
OH02769	GRAND RAPIDS DAM	WOOD	1
OH00636	GUILFORD LAKE DAM	COLUMBIANA	3
OH00643	HARGUS LAKE DAM	PICKAWAY	2
OH00635	HIGHLANDTOWN LAKE DAM	COLUMBIANA	3
OH00596	INDIAN LAKE DAM	LOGAN	1
OH00642	JACKSON LAKE DAM	JACKSON	3
OH00497	JEFFERSON LAKE DAM	JEFFERSON	3
OH00638	KNOX LAKE DAM	KNOX	2
OH00074	LAKE ALMA DAM	VINTON	3
OH00510	LAKE KATHARINE LAKE DAM	JACKSON	3
OH00260	LAKE LOGAN DAM	HOCKING	3
OH00442	LAKE LORAMIE DAM	SHELBY	1
OH00419	LAKE MILTON DAM	MAHONING	3
OH00073	LAKE RUPERT DAM	VINTON	3
OH00446	LAKE WHITE DAM	PIKE	3
OH00441	MONROE LAKE DAM	MONROE	3
OH00689	MOUNT GILEAD LOWER LAKE DAM	MORROW	2
OH00696	MUSKINGUM RIVER LOCK AND DAM NO. 6	MORGAN	3
OH00584	NIMISILA RESERVOIR DAM	SUMMIT	2
OH00587	NORTH RESERVOIR DAM	SUMMIT	2
OH00249	OLD MAN'S CAVE LAKE DAM	HOCKING	3
OH00655	PERRY RECLAMATION DAM NO. 3	PERRY	3
OH00200	PIKE LAKE DAM	PIKE	3
OH02385	POND LICK LAKE DAM	SCIOTO	3
OH02768	PROVIDENCE DAM	WOOD	1
OH00302	ROCKY FORK LAKE DAM	HIGHLAND	3
OH00286	ROOSEVELT LAKE DAM	SCIOTO	3
OH00443	ROSS LAKE DAM	ROSS	3
OH00434	RUSH RUN LAKE DAM	PREBLE	1
OH00433	SALT FORK LAKE DAM	GUERNSEY	3
OH00436	SHREVE LAKE DAM	WAYNE	2
OH00269	STONELICK LAKE DAM	CLERMONT	3
OH00644	TURKEY CREEK LAKE DAM	SCIOTO	3
OH00485	TUSCARAWAS RIVER DIVERSION DAM	SUMMIT	2
OH00283	TYCOON LAKE DAM	GALLIA	3
OH00445	VETO LAKE DAM	WASHINGTON	3
OH00585	WEST RESERVOIR DAM	SUMMIT	2
OH00437	WOLF RUN LAKE DAM	NOBLE	3
OH02390	WOLFDEN LAKE DAM	SCIOTO	3
OH02226	ZANESVILLE STATE NURSERY LAKE DAM	MUSKINGUM	3

Source: Ohio Department of Natural Resources Dam Safety Program

LEVEE VULNERABILITY METHODOLOGY

As referenced in Table 2.6.c, the National Levee Database lists 149 levee systems in Ohio. Each one of these levees protects a defined area. Each of these leveed areas were used to intersect with the list of State-owned and State-leased critical facilities in Ohio.

RESULTS

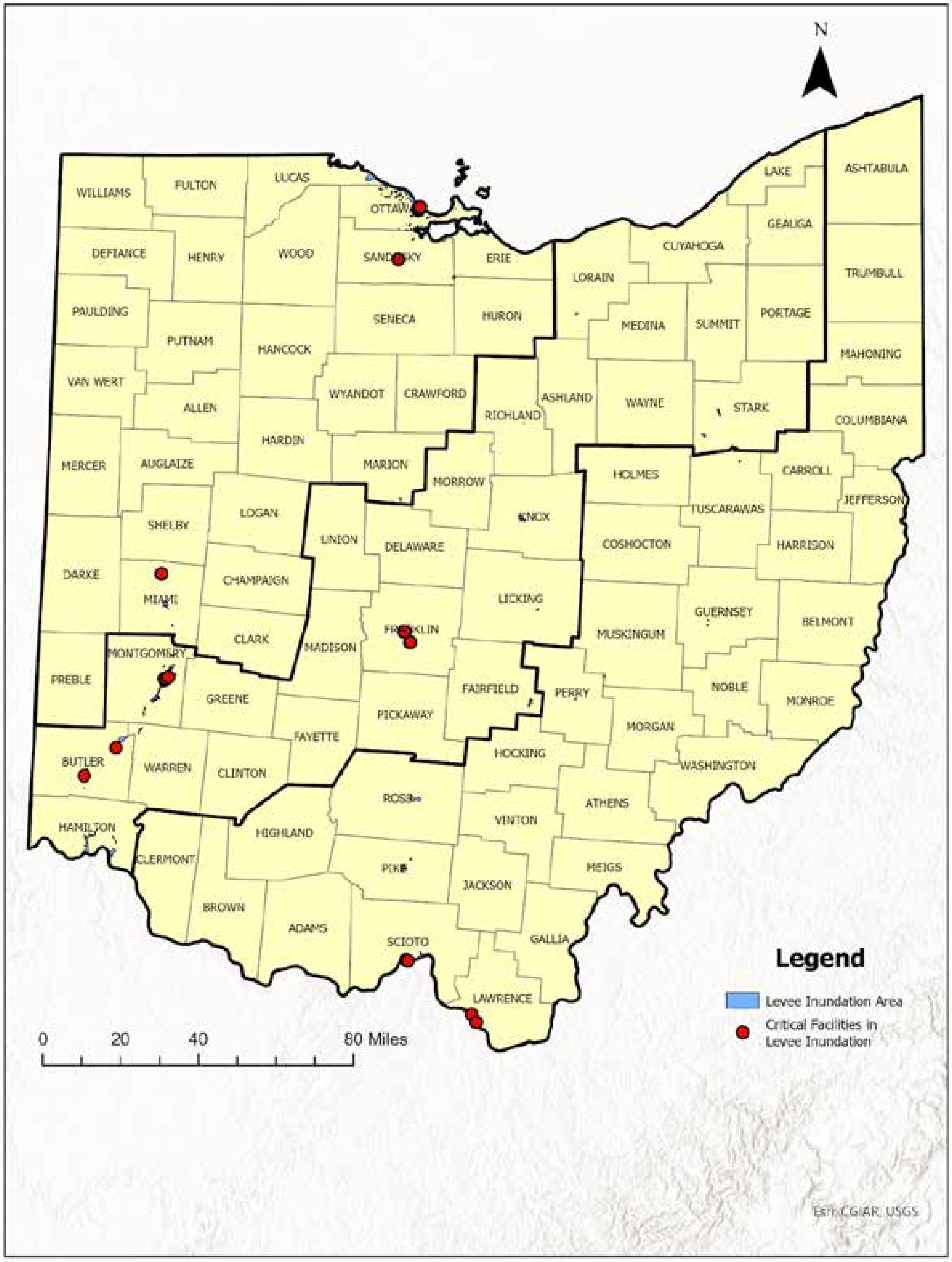
Table 2.6.m shows that there are 80 State-owned and State-leased critical facilities in Ohio that are protected by levees listed in the National Levee Database. The total value of these structures amount to approximately $198 million.

- Region 1 has 40 state-owned and state-leased critical facilities with a total replacement cost of $38,766,857.
- Region 2 has 29 state-owned and state-leased critical facilities with a total replacement cost of $156,431,312. The vast majority of this is in Franklin County with 23 facilities at $152,147,643.
- Region 3 has 11 state-owned and state-leased critical facilities with a total replacement cost of $3,529,142.

Table 2.6.l

State-owned and State-leased Critical Facilities in Levee-Protected Areas			
USACE DAM County	**OEMA Region**	**Number of CF**	**Replacement Costs**
Camp Perry 7			
OTTAWA	1	36	$ 34,797,636
City of Dayton Levee 10			
MONTGOMERY	2	3	$ 871,658
Hamilton Local Flood Protection (HAML5)			
BUTLER	2	1	$ 166,486
Ironton LPP			
LAWRENCE	3	9	$ 3,335,811
Middletown Local Flood Protection			
BUTLER	2	2	$ 3,245,525
Piqua Local Flood Protection (PIQR1)			
MIAMI	1	3	$ 3,941,499
Portsmouth-New Boston, OH, LPP			
SCIOTO	3	2	$ 193,331
Sandusky River - Fremont - Left Bank			
SANDUSKY	1	1	$ 27,722
West Columbus, OH, LPP			
FRANKLIN	2	23	$ 152,147,643
Grand Total		**80**	**$ 198,727,311**

Map 2.6.d — State-owned and State-leased Critical Facilities in Levee-Protected Areas



2.7 WILDFIRE

A wildfire is an uncontrolled fire that burns an area of combustible vegetation and typically occurs in rural areas. Each year in Ohio, an average of 450 wildfires burn 1500 acres of forest and grassland within ODNR Division of Forestry's Wildfire Protection Area (Map 2.7.a). The protection area includes all 200,000+ acres of Ohio's 24 State Forests, as well as all privately owned lands within the district boundaries. The forest fire protection district corresponds mostly to the state's unglaciated hill country (southern and eastern Ohio), and also encompasses a section of northwest Ohio (Maumee State Forest area). According to the Ohio Department of Natural Resources, Ohio's wildfire seasons occur primarily in the spring (March, April and May) before vegetation has "greened-up", and the fall (October and November) when leaf drop occurs. During these times and especially when weather conditions are warm, windy and with low humidity, cured vegetation is particularly susceptible to burning. Fuel (vegetation, woody debris), weather (wind, temperature, humidity) and topography (hills and valleys) when combined present an unpredictable danger to unwary civilians and firefighters in the path of a wildfire. Open burning is regulated by state laws and local burning ordinances, which may vary from one jurisdiction to another. Outside municipal limits, burning is prohibited from 6 am to 6 pm during the months of March, April, May, October and November. It is during these times of the year and day that wildfires are most likely to occur and are the most difficult to control.

While Ohio government agencies and local fire departments are accustomed to handling seasonal wildfires, occasional extreme events can make conditions dangerous and disruptive. Heavy fuel accumulations oftentimes make wildfire suppression extremely difficult due to more intense blazes. Occasionally, heavy fuel loadings and topography create problems in limiting access to fires, and lead to heavy equipment use for suppression. Prolonged drought may cause an exceptionally long or active wildfire season, as well as contribute to extreme wildfire behavior or burning conditions. Multiple concurrent fires can tax resources and quickly create a lack of manpower and other resources and retard the ability to suppress fires rapidly and safely.

The Wildland Urban Interface (WUI) conditions may create a serious issue of concern in Ohio. The WUI is defined as the situation where homes, residences, and structures are in close proximity to forested lands and grasslands prone to wildfire. This creates a situation where, in the event of a wildfire, personal and property safety are put in jeopardy. Additionally, WUI situations force fire departments to shift focus from fire suppression to structure protection, consequently increasing exposure time and risk. WUI situations are most effectively addressed prior to wildfire occurrence by individual homeowners. Mitigation strategies include reducing flammable vegetation and debris within 30 feet of the structure, choosing less flammable landscape species, using fire resistant building materials, and practicing safe open burning techniques. Currently in Ohio, there are numerous codes in place that regulate buildings and fire safety. The Ohio Fire Code 1301: 7-7 establishes regulations affecting or relating to structures, processes, premises and safeguards regarding:

1. The hazard of fire and explosion arising from the storage, handling or use of structures, materials or devices.
2. Conditions hazardous to life, property or public welfare in the occupancy of structures or premises.
3. Fire hazards in the structure or on the premises from occupancy or operation.

4. Matters related to the construction, extension, repair, alteration or removal of fire protection systems.
5. Conditions affecting the safety of fire fighters and emergency responders during emergency operations.

Because nearly all wildfire occurrences in Ohio are human caused, wildfire prevention through community outreach, education, and local fire department cooperation are critical to decreasing wildfire occurrence and minimizing damage. When local fire departments take the lead on community safety, chances for success are greater because of the leadership and trust that local responders have with community members. The ODNR Division of Forestry supports local fire departments by providing educational materials, brochures, and wildfire prevention handouts for events. The Division of Forestry also supports local Fire Departments by providing wildfire suppression training, grant opportunities, and other capacity-building programs.

Open burning (burning of yard waste or debris) is regulated by state laws and local burning ordinances, which may vary from one jurisdiction to another. ORC addresses kindled fires regulations, and states that outside municipal limits, open burning is prohibited from 6 am to 6 pm during the months of March, April, May, October and November. It is during these times of the year and days that wildfires are most likely to occur and are the most difficult to control. Additionally, the Ohio EPA enforces OAC 3745.19, which regulates materials that may or may not be incinerated through open burning. Prohibited substances include petroleum-based materials, food waste, and animal carcasses. To ensure compliance with all regulations, residents should contact their local fire official with jurisdiction for the applicable laws.

RISK ASSESSMENT

LOCATION

Wildfires in Ohio occur most frequently in the southern, southeastern, and eastern parts of the state. This area is predominantly unglaciated, hilly country, and varies in land cover type, including abundant forests and grasslands. The ODNR Division of Forestry is responsible for wildland fire protection on all state and private lands within this area. Additionally, ODNR Division of Forestry has wildfire protection responsibility in a disjoined area in northwest Ohio surrounding Maumee State Forest. Local and volunteer fire departments across these parts of Ohio typically provide initial response wildfire suppression service within their respective jurisdictions. Following response to a wildfire event, local fire departments within the ODNR Division of Forestry wildfire protection area are encouraged to file a wildfire report to ODNR Division of Forestry. Wildfire reports contain information such as date, time, location, size, etc. Filing wildfire reports to ODNR Division of Forestry is not mandatory, but is highly encouraged.

On February 9, 2019, the Ohio Department of Natural Resources announced the expansion of the ODNR Division of Forestry's Forest Fire Protection Area. This new boundary now includes the entirety of Ashland, Columbiana, Fulton, Henry, Highland, Holmes, Knox, Licking, Lucas, Richland, Fairfield, Ross, and Stark Counties whereas in the previously they were each only partially within the area. In addition, entire counties are wholly incorporated including: Ashtabula, Brown, Clermont, Geauga, Mahoning, Portage, and Trumbull Counties whereas before they were entirely outside of the boundary.

Map 2.7a

ODNR Division of Forestry's Expanded Forest Fire Protection Area

The ODNR Division of Forestry does not collect wildfire occurrence data from outside the ODNR Forestry protection area. Parts of Ohio that are outside of the protection area experience occasional wildfire events, but due to land use and land cover type (agricultural, developed urban/suburban) are generally of lower wildfire risk and occurrence. However certain parts of western Ohio have scattered Conservation Reserve Program (CRP) grasslands, which are a very volatile wildland fire fuel type. Since fire departments outside of the ODNR Forestry wildfire protection area do not file wildfire reports within the ODNR database, ODNR Division of Forestry does not have a dataset for wildfire occurrence in these areas.

For the remaining parts of the state outside of the ODNR wildfire protection area, data obtained from the National Fire Incident Reporting System (NFIRS), established by the US Fire Administration, will be used for the purpose of research in this part of the plan. Per their website, NFIRS is a reporting standard that fire departments use to uniformly report on the full range of their activities. It is the largest national database of fire incident information and claims to comprise of about 75% of all reported fires that occur annually. For Ohio, the data is maintained and compiled by the Ohio Department of Commerce Division of State Fire Marshal and reports the compiled data to the US Fire Administration.

Region 1: ODNR Division of Forestry collects wildfire data from fire departments in Lucas, Henry, and Fulton counties in Region 1, as these counties contain parts of Maumee State Forest. ODNR Division of Forestry does not collect wildfire report data in the remainder of Region 1 counties. Land cover type in Region 1 is predominantly agricultural land, and generally unforested; therefore, wildfire occurrence and risk are not as great as Region 3 where the topography provides abundant sources of natural combustible fuel.

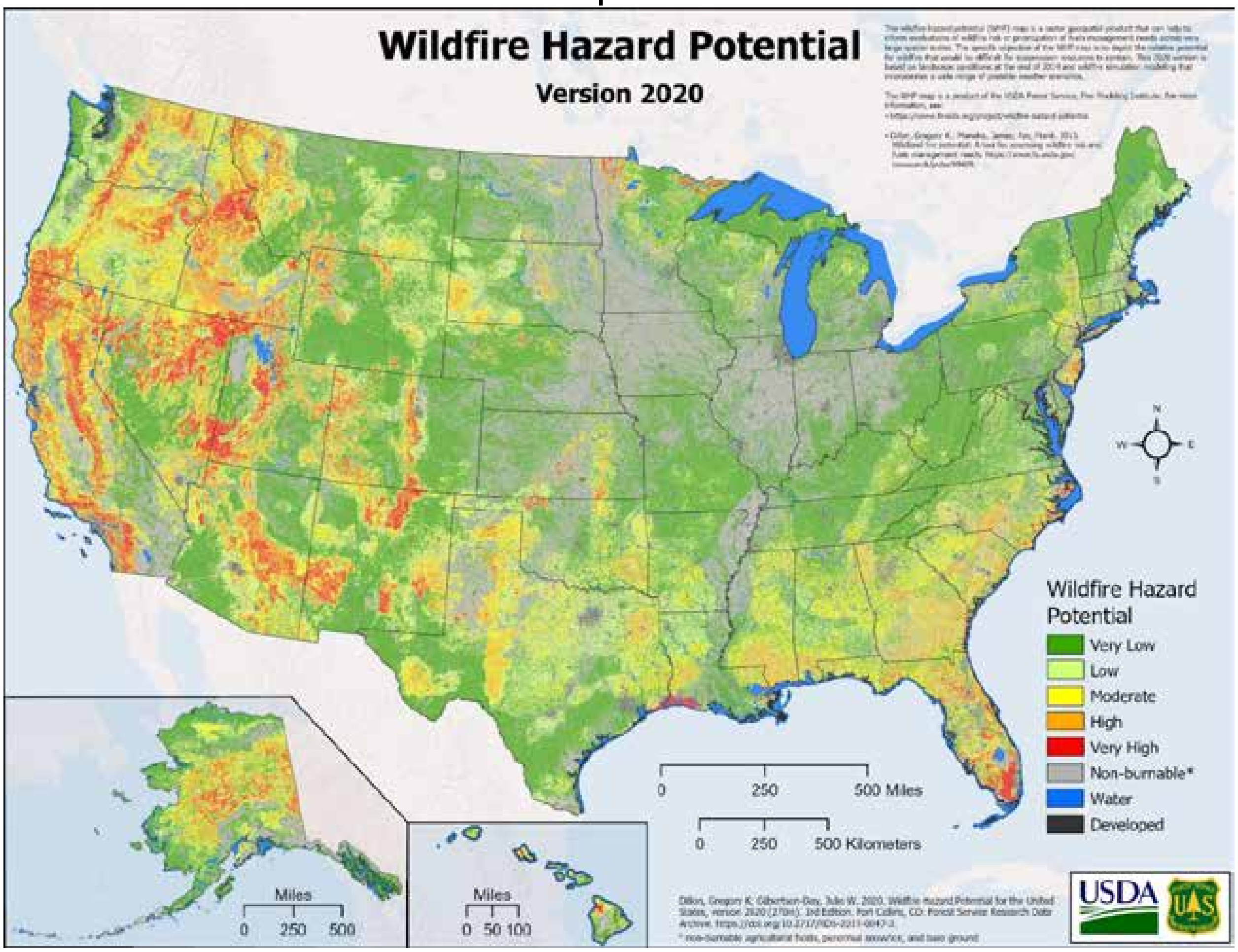
Region 2: The majority of Region 2 lies outside of the ODNR Division of Forestry wildfire protection area – eight counties in the wildfire protection area boundary are included in Region 2: Geauga, Portage, Stark, Ashland, Richland, Knox, Licking and Fairfield. Ashland County contains Mohican State Forest, which is located in Region 2. Region 2 contains Ohio's most developed metropolitan hubs, as well as areas of highest population density. Wildland fuel types (woodland, grasslands) are not as abundant. One notable location for potential large scale and damaging wildfire in Region 2 is the Mentor Marsh in Lake County, east of Cleveland. Mentor Marsh is a 691 acre nature preserve that has converted to nearly a monoculture of 8-12 foot high non-native Phragmites grass. This area is highly flammable, especially in spring with high winds coming off Lake Erie. Mentor Marsh has experienced 10 wildfire events since 1979, four of these being extremely noteworthy: May 1982 – 200 acres, May 1987 – 120 acres, May 1992 – 400 acres, April 2003 – 375 acres. All of these large-scale events were determined to be arson caused. Many homes, businesses, and high valued property are at risk from wildfire events in Mentor Marsh.

Region 3: The ODNR Division of Forestry collects wildfire data from fire departments in all counties of Region 3. Counties within Region 3 represent areas of highest wildfire risk and hazard in the State of Ohio. The vast majority of wildfires in Ohio occur in Region 3 due in part to abundant forested lands and grasslands. Population distribution and regional socio-cultural aspects contribute to higher wildfire occurrence, as well. Topography in Region 3 has more variety with numerous ridges and hollows, as opposed to flatter areas in western and central Ohio, which contributes to more complex wildfire behavior.

Wildfire Hazard Profile

Per the US Forest Service, the Wildfire Hazard Potential (WHP) map is a raster geospatial product produced by the USDA Forest Service, Fire Modeling Institute that can help to inform evaluations of wildfire risk or prioritization of fuels management needs across very large landscapes (millions of acres). It was produced for all of the conterminous United States at a 270-meter resolution. Areas mapped with higher WHP values represent fuels with a higher probability of experiencing torching, crowning, and other forms of extreme fire behavior under conducive weather conditions, based primarily on landscape conditions at the end of 2014 and wildfire simulation modeling that incorporates a wide range of possible weather scenarios. On its own, WHP is not an explicit map of wildfire threat or risk, but when paired with spatial data depicting highly valued resources and assets such as communities, structures, or powerlines, it can approximate relative wildfire risk to those resources and assets. WHP is also not a forecast or wildfire outlook for any particular season, as it does not include any information on current or forecasted weather or fuel moisture conditions. It is instead intended for long-term strategic planning and fuels management.

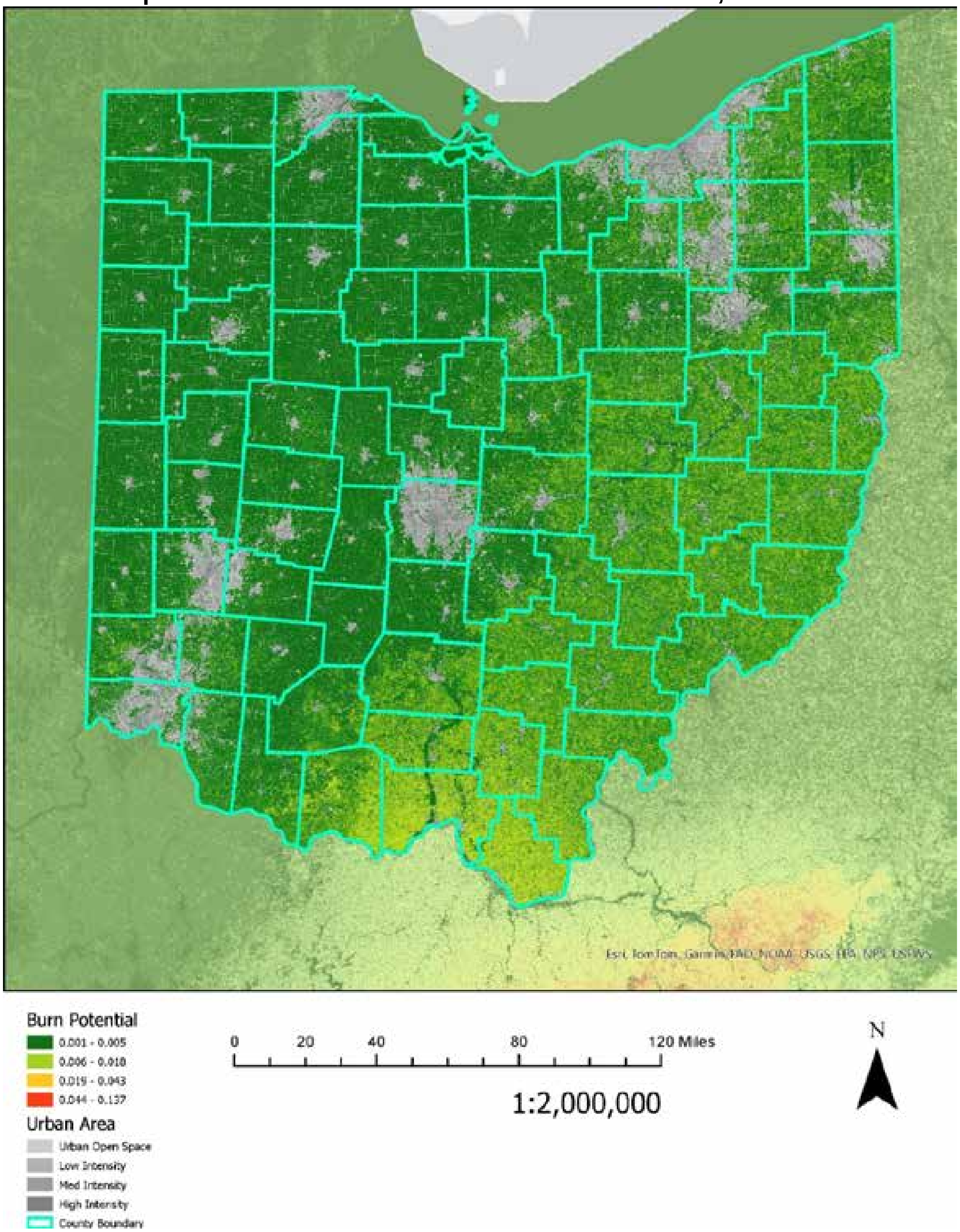
Map 2.7.b



Dillon, G.K.; J. Menakis; and F. Fay. 2015. Wildland Fire Potential: A Tool for Assessing Wildfire Risk and Fuels Management Needs. pp 60-76 In Keane, R. E.; Jolly, M.; Parsons, R.; and Riley, K. Proceedings of the large wildland fires conference; May 19-23, 2014; Missoula, MT. Proc. RMRS-P-73. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 345 p.

Based on the WHP 2020 map, Ohio consists of areas of non-burnable to moderate wildfire potential. Most of the wildfire potential and risk exists in the south eastern portion of the state which is also where the ODNR Division of Forestry primarily designates as wildfire protection area. While the vast majority of the state does not have a high potential of wildfire, the potential exists statewide. Refer to the following section, probability of future events, for a closer look at the USDA Wildfire Hazard Potential assessment for Ohio.

Map 2.7.c— USDA Forest Service Wildfire Hazard Potential, Ohio Extent

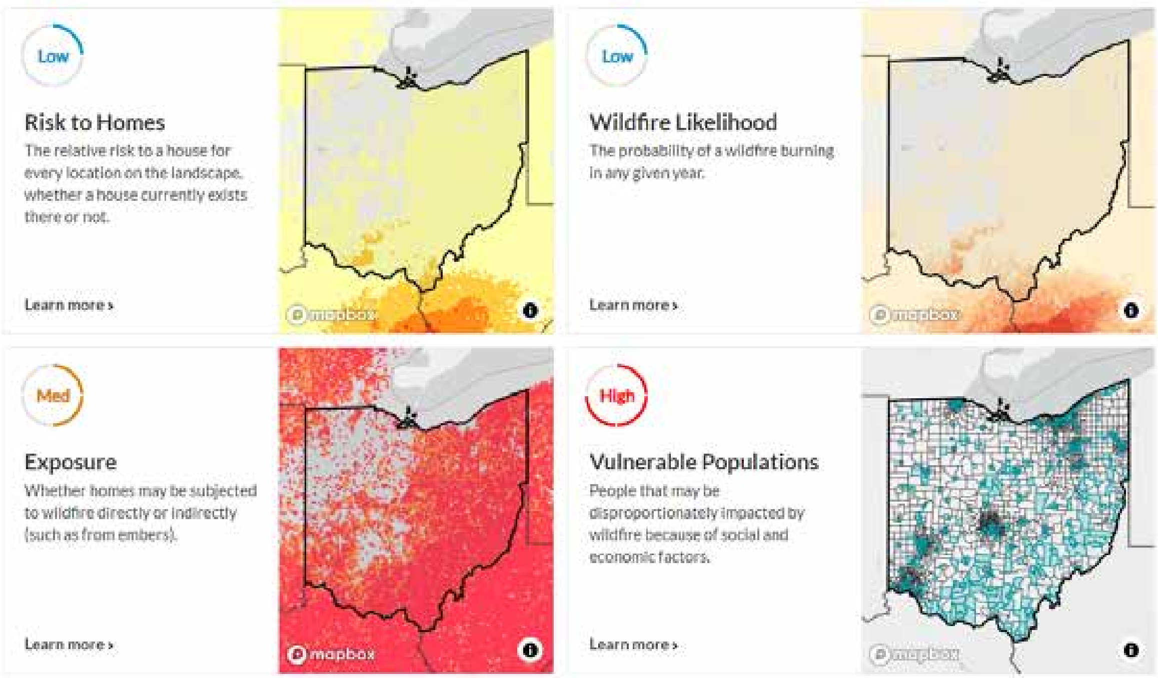


USDA Forest Service Wildfire Risks to Communities Platform

The USDA Forest Service Wildfire Risk to Communities is a free, easy-to-use website with interactive maps, charts, and data to help communities in the United States understand, explore, and reduce wildfire risk. Maps and data are available at the community, county, and state levels. It provides information about communities' relative wildfire risk profile, the nature and effects of wildfire risk, and actions communities can take. For example, information can be used to:

- Prioritize mitigation efforts among communities in a state or county with the greatest wildfire risk.
- Identify communities where localized wildfire hazard mitigation and planning efforts are most needed.
- Find resources, partners, and solutions to help manage, mitigate, and reduce risk.

Maps 2.7.d



According to ODNR Forestry, while the assessment was national in scope, some of the results *do not completely align* with their years of local experience and observations – an example of this is the elevated wildfire likelihood shown in Highland, Brown and Clermont Counties. ODNR Forestry's experience and data collection shows that counties with historically higher wildfire occurrence tend to maintain that pattern and can be reasonable assumed to have higher likelihood of wildfire occurrence in the future. Counties that are included in ODNR Forestry's prediction of having higher likelihood of wildfire occurrence cluster around central southern Ohio: Pike, Adams, Scioto, Lawrence, and Gallia counties.

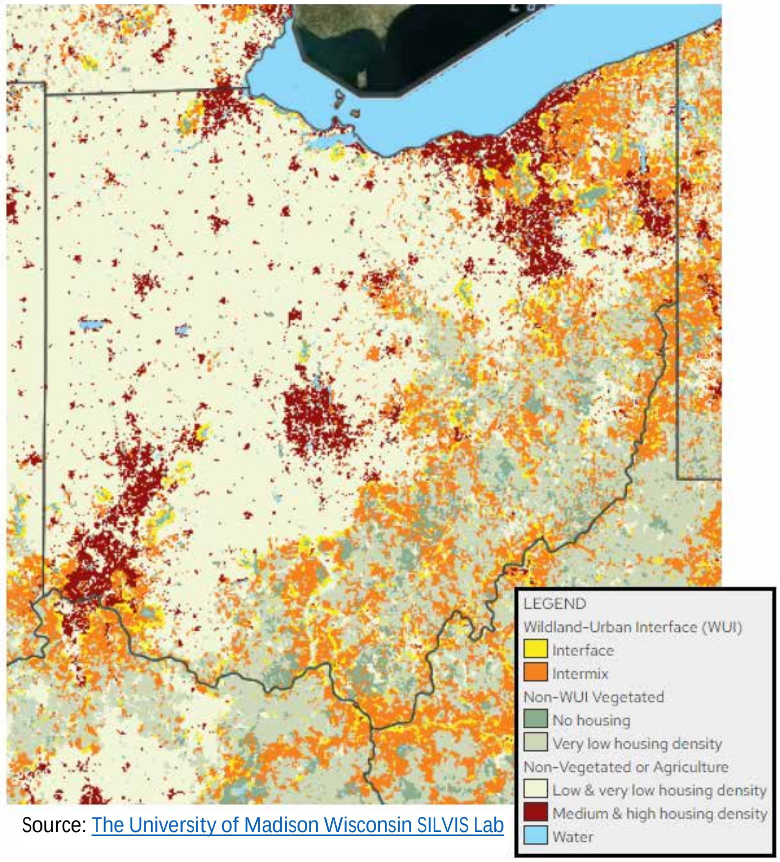
Nearly all wildfires in Ohio are human caused and result from accidents associated with deliberate activities, the main cause being escaped debris burning. ODNR Forestry works hard to promote fire prevention, awareness and outdoor fire safety, especially in these counties; however, activities that have been traditionally practiced by populations in certain parts of Ohio (such as debris burning in these southern Ohio counties) seem to continue despite prevention and education efforts. As a result, past wildfire occurrence is a fairly accurate indicator of where future wildfires are likely to occur.

Wildland-Urban Interface (WUI) Change 1990-2020, University of Madison Wisconsin SILVIS Lab

The University of Madison Wisconsin SILVIS Lab publishes research the Wildland-Urban Interface (WUI) Change 1990-2020. Related publications include: Rapid growth of the US wildland-urban interface raises wildfire risk.

WUI maps are intended to illustrate where the WUI was located in 1990, 2000, 2010, and 2020. There are types of WUI: intermix and interface. Intermix WUI are areas where housing and vegetation intermingle; interface WUI are areas with housing in the vicinity of contiguous wildland vegetation. WUI GIS data were designed to provide a spatially detailed national assessment of the Wildland Urban Interface (WUI) across the conterminous U.S. to support inquiries into the effects of housing growth on the environment, and to inform both national policy and local land management concerning the WUI and associated issues.

Maps 2.7.e – Wildland-Urban Interface (WUI) 2020



Source: The University of Madison Wisconsin SILVIS Lab

HOUSING UNITS	Intermix WUI			
STATE	**1990**	**2000**	**2010**	**2020**
Ohio	306,258	322,787	350,337	346,389
Conterminous U.S.	12,212,669	13,254,402	15,108,293	15,579,050
	Interface WUI			
STATE	**1990**	**2000**	**2010**	**2020**
Ohio	368,800	414,764	439,913	441,323
Conterminous U.S.	17,778,032	21,910,181	26,255,965	28,390,711
	WUI (total)			
STATE	**1990**	**2000**	**2010**	**2020**
Ohio	675,058	737,551	790,250	787,712
Conterminous U.S.	29,990,701	35,164,583	41,364,258	43,969,761

Source: Statewide WUI Totals, The University of Madison Wisconsin SILVIS Lab

The research also estimates the number of housing units within intermix and interface WUIs. The estimates are available in reference years 1990, 2000, 2010, and 2020.

According to these estimates, as of 2020, in Ohio there are 346,389 housing units in the intermix WUI, and 441,323 housing units in the interface WUI.

According the ODNR Forest Service, of note here is the majority of WUI occurs within the ODNR Forestry wildfire protection area. WUI presents a complex hazard when conducting wildfire suppression. Because of the nature of wildfire ignition in Ohio (human caused), the majority of wildfires are within the WUI, or at minimum contain WUI type exposures (homes, buildings, infrastructure, etc.).

PAST OCCURRENCES

Weather is the primary factor that determines the severity of fall and spring wildfire seasons in Ohio. Drought condition, combined with windy days create red flag, or extreme high fire danger. Consequently, the past fire occurrence record can be closely linked to historical weather data. Weather conditions leading up to and in 1930 resulted in the worst year to date for wildfires in Ohio, as 15,400 acres were recorded as burning over the course of the year.

Extreme drought in 1950 that continued for the next several years provided for very active wildfire seasons as well. March 27, 1950 is considered the worst day in Ohio fire control history – 65 fires burned a total of 5,900 acres. In 1952, continued summer drought spurred a record fall fire season in Ohio and neighboring states. ODNR Division of Parks and Division of Wildlife employees assisted in suppression efforts, and the Ohio National Guard also provided assistance. A total of 680 wildfires burned 22,445 acres in the fall of 1952.

Drought conditions in 1963 required placing on alert the ODNR Division of Forestry's pilots, 2000 fire wardens, 150 ODNR Division of Forestry employees, as well as several thousand volunteer firefighters and the Ohio National Guard. One or more fires were reported every day from September 17 through November 29, and October showed a record number of fires for that month.

1988 was another severe wildfire year, as drought conditions required that Civilian Conservation Corps crews be mobilized, as well as all other trained Division employees. More recently, 1999 proved to be a busy year for wildfire in Ohio, as an above average 7,836 acres were burned by nearly 1,500 wildfires.

As previously mentioned, there are two main datasets used to record wildfire incidents: The Ohio Wildfire Reporting System, and the National Fire Incident Reporting System (NFIRS). For the 2024 State of Ohio Hazard Mitigation Plan, the use of the ODNR database was expanded to reflect the 2019 expanded boundaries of the ODNR Forest Fire Protection Area. Counties that previously utilized NFIRS data and are now completely within the ODNR, will now either fully utilize ODNR data or a combination of the two datasets depending on available data.

Tables 2.7.a/b/c below summarizes the wildfire incidents as recorded from both databases. Between the five-year period of 1/1/2018 and 12/31/2022, Ohio has experienced 4,885 wildfires that have burned 11,057 acres within the ODNR Division of Forestry Wildfire Protection Area. It can be safely assumed that less than 100% of all wildfires on state and public land are reported; consequently, actual total occurrence and acres burned are suspected to be higher than data indicate.

Table 2.7.a – Wildfire Incidents Reported, OEMA Region 1

Wildfire Incidents Reported, 2018 to 2022										
County	Data Source	Reported Incidents	Annual Probability	Injuries	Deaths	Structures Threatened	Structures Destroyed	Acres Burned Average	Acres Burned Max	Acres Burned Total
Allen	NFIRS	1	18%	N/A	N/A	0	0	0.00	0	0
Auglaize	NFIRS	0	No Data	N/A	N/A	0	0	0.00	0	0
Champaign	NFIRS	15	≥100%	N/A	N/A	0	0	1.69	10	25
Clark	NFIRS	36	≥100%	N/A	N/A	1	0	8.98	200	323
Crawford	NFIRS	3	≥100%	N/A	N/A	0	0	0.53	1	2
Darke	NFIRS	41	≥100%	N/A	N/A	2	0	3.23	50	133
Defiance	NFIRS	5	88%	N/A	N/A	1	0	3.04	10	15
Erie	NFIRS	8	≥100%	N/A	N/A	3	0	4.61	17	37
Fulton	COMBINED	39	≥100%	0	0	9	0	3.13	50	122
Hancock	NFIRS	24	≥100%	N/A	N/A	2	0	1.45	15	35
Hardin	NFIRS	34	≥100%	N/A	N/A	0	0	1.82	15	62
Henry	COMBINED	46	≥100%	1	0	7	0	2.97	58	137
Huron	NFIRS	10	≥100%	N/A	N/A	0	0	0.43	2	4
Logan	NFIRS	24	≥100%	N/A	N/A	0	1	2.24	35	54
Lucas	COMBINED	31	≥100%	1	0	1	0	1.70	25	53
Marion	NFIRS	79	≥100%	N/A	N/A	0	0	15.44	100	1219 [1]
Mercer	NFIRS	2	34%	N/A	N/A	0	0	1.00	1	2
Miami	NFIRS	1	65%	N/A	N/A	0	0	1.00	1	1
Ottawa	NFIRS	22	≥100%	N/A	N/A	0	0	4.76	20	105
Paulding	NFIRS	23	≥100%	N/A	N/A	0	0	1.15	5	26
Preble	NFIRS	6	≥100%	N/A	N/A	0	0	5.02	25	30
Putnam	NFIRS	11	≥100%	N/A	N/A	0	0	1.84	5	20
Sandusky	NFIRS	18	≥100%	N/A	N/A	1	1	0.40	2	7
Seneca	NFIRS	5	≥100%	N/A	N/A	0	0	0.62	1	3
Shelby	NFIRS	1	21%	N/A	N/A	0	0	0.25	0	0
Van Wert	NFIRS	1	30%	N/A	N/A	0	0	2.00	2	2
Williams	NFIRS	4	≥100%	N/A	N/A	0	0	2.00	5	8
Wood	NFIRS	47	≥100%	N/A	N/A	0	0	0.94	6	44
Wyandot	NFIRS	15	≥100%	N/A	N/A	0	0	1.32	7	20
Grand Total		**552**	**≥100%**	**2**	**0**	**27**	**2**			**2,490**

1- From 2021-2022, there were 7 records of wildfire events that claimed 700 acres burned in Marion County and is possibly inaccurate. This county not known for wildfires or burn potential.

Table 2.7.b – Wildfire Incidents Reported, OEMA Region 2

Wildfire Incidents Reported, 2018 to 2022, OEMA Region 2										
County	Data Source [2]	Reported Incidents	Annual Probability	Injuries [1]	Deaths [1]	Structures Threatened	Structures Destroyed	Acres Burned Average	Acres Burned Max	Acres Burned Total
Ashland	ODNR	103	≥100%	1	0	2	1	1.34	20	139
Butler	NFIRS	170	≥100%	N/A	N/A	4	0	0.06	1	10
Clinton	NFIRS	85	≥100%	N/A	N/A	0	0	3.73	100	317
Cuyahoga	NFIRS	232	≥100%	N/A	N/A	0	0	0.14	1	32
Delaware	NFIRS	38	≥100%	N/A	N/A	1	0	0.50	5	19
Fairfield	COMBINED	98	≥100%	0	0	12	0	1.37	25	134
Fayette	NFIRS	16	≥100%	N/A	N/A	0	0	2.10	25	34
Franklin	NFIRS	187	≥100%	N/A	N/A	0	0	1.15	100	215
Geauga	COMBINED	23	≥100%	0	0	1	0	0.95	4	22
Greene	NFIRS	75	≥100%	N/A	N/A	0	0	2.78	80	208
Hamilton	NFIRS	50	≥100%	N/A	N/A	4	0	0.75	20	38
Knox	COMBINED	80	≥100%	0	0	17	0	0.70	10	56
Lake	NFIRS	6	≥100%	N/A	N/A	0	0	0.95	3	6
Licking	ODNR	38	≥100%	1	0	4	0	2.26	25	86
Lorain	NFIRS	22	≥100%	N/A	N/A	0	0	1.94	12	43
Madison	NFIRS	14	≥100%	N/A	N/A	0	0	0.62	2	9
Medina	NFIRS	13	≥100%	N/A	N/A	0	0	0.35	1	5
Montgomery	NFIRS	26	≥100%	N/A	N/A	0	0	0.94	6	24
Morrow	NFIRS	16	≥100%	N/A	N/A	0	0	0.91	3	15
Pickaway	NFIRS	38	≥100%	N/A	N/A	0	0	5.51	75	209
Portage	COMBINED	41	≥100%	0	0	4	1	0.92	9	38
Richland	ODNR	33	≥100%	0	0	8	0	2.28	20	75
Stark	ODNR	14	≥100%	1	0	5	0	4.98	45	70
Summit	NFIRS	56	≥100%	N/A	N/A	3	0	0.61	9	34
Union	NFIRS	131	≥100%	N/A	N/A	0	0	2.17	40	284
Warren	NFIRS	697	≥100%	N/A	N/A	0	0	0.17	40	118
Wayne	NFIRS	2	66%	N/A	N/A	0	0	0.75	1	2
Grand Total		**2,304**	**≥100%**	**1**	**0**	**65**	**2**			**2,239**

Table 2.7.c – Wildfire Incidents Reported, OEMA Region 3

Wildfire Incidents Reported, 2018 to 2022										
County	**Data Source**	**Reported Incidents**	**Annual Probability**	**Injuries**	**Deaths**	**Structures Threatened**	**Structures Destroyed**	**Acres Burned Average**	**Acres Burned Max**	**Acres Burned Total**
Adams	ODNR	72	≥100%	2	0	24	2	4.05	125	292
Ashtabula	COMBINED	72	≥100%	0	0	0	0	5.19	90	374
Athens	ODNR	69	≥100%	0	0	22	0	1.50	20	104
Belmont	ODNR	60	≥100%	0	0	3	0	3.35	100	201
Brown	COMBINED	35	≥100%	0	0	7	0	1.94	50	68
Carroll	ODNR	30	≥100%	0	0	2	0	2.38	10	71
Clermont	ODNR	55	≥100%	0	0	3	1	0.52	5	29
Columbiana	COMBINED	79	≥100%	1	0	5	1	1.70	20	134
Coshocton	ODNR	55	≥100%	2	0	6	2	1.77	14	97
Gallia	ODNR	96	≥100%	0	0	11	0	3.36	50	323
Guernsey	ODNR	69	≥100%	0	0	31	0	1.14	10	78
Harrison	ODNR	30	≥100%	0	0	8	0	2.16	11	65
Highland	ODNR	16	≥100%	0	0	2	0	1.40	5	22
Hocking	ODNR	73	≥100%	0	0	16	1	1.06	5	77
Holmes	ODNR	44	≥100%	1	0	6	0	1.47	10	65
Jackson	ODNR	38	≥100%	0	0	19	0	3.53	25	134
Jefferson	ODNR	21	≥100%	0	0	0	0	2.06	12	43
Lawrence	ODNR	109	≥100%	0	0	53	2	10.07	450	1,098
Mahoning	ODNR	25	≥100%	0	0	2	0	1.47	10	37
Meigs	ODNR	70	≥100%	2	0	14	0	1.37	10	96
Monroe	ODNR	20	≥100%	0	0	0	0	1.46	5	29
Morgan	ODNR	23	≥100%	0	0	2	1	2.69	10	62
Muskingum	ODNR	135	≥100%	1	0	16	1	1.40	20	189
Noble	ODNR	40	≥100%	3	0	0	0	3.09	60	124
Perry	ODNR	83	≥100%	0	0	15	1	1.48	20	123
Pike	ODNR	134	≥100%	1	0	13	1	2.89	50	388
Ross	ODNR	98	≥100%	5	0	22	0	4.57	100	448
Scioto	ODNR	145	≥100%	4	0	18	0	7.15	250	1,037
Trumbull	COMBINED	66	≥100%	0	0	12	0	2.82	45	186
Tuscarawas	ODNR	75	≥100%	1	0	7	1	1.60	18	120
Vinton	ODNR	48	≥100%	0	0	11	1	2.06	10	99
Washington	ODNR	44	≥100%	1	0	4	1	2.72	50	120
Grand Total		**2,029**	**≥100%**	**24**	**0**	**354**	**16**			**6,329**

PROBABILITY OF FUTURE EVENTS

Based on reported historical events from January 2018 to December 2022, there is a 100% probability that a wildfire will occur in the majority of counties in Ohio in any given year. However, the severity of these events will depend on many factors. According to research and the historical record, wildfires have occurred every spring and fall in the hardwood forests and grasslands of southern, southeastern, and eastern Ohio for hundreds of years, and will continue to do so. The number of occurrences, size of wildfires, and severity of burn fluctuate annually in response to a variety of factors including:

- Weather – daily, monthly, seasonal, annual, and long-term trends in:
  - Precipitation
  - Relative Humidity
  - Temperature
  - Wind
- Fuels – condition of 1, 10, 100, 1000 hour fuels in terms of:
  - Moisture content
  - Arrangement
  - Accumulation level
  - Availability
  - See Map 2.7.b for The Wildfire Hazard Potential in Ohio, developed by the USDA Forest Service. It is a represention of fuels with a higher probability of experiencing extreme fire behavior under conducive weather conditions, based primarily on landscape.
- Ignitions – presence or absence of wildfire starts:
  - Human caused
    - Debris burning – compliance with ORC 1503.18, and safe debris burning techniques
    - Incendiary – arsonists at large
    - Wildfire prevention and awareness efforts
- Suppression Response – Capability and timeliness of initial attack:
  - Quickness of response to the incident
  - Local / Volunteer fire department capability
  - Availability of state and local resources
    - Number of concurrent wildfires

In an effort to anticipate severity and probability of future wildfire occurrences, the Ohio Division of Forestry closely monitors current and predicted weather conditions, as well as seasonal trends, to determine periods of elevated wildfire danger. Resources that assist with this include:

- Remote Automatic Weather Stations (RAWS) – The Division of Forestry maintains 7 RAWS units in southern and eastern Ohio.
- National Weather Service - The Division of Forestry works in cooperation with NWS offices in the interpretation of weather data, as well as issuance of fire weather warnings, hazardous weather statements, and Red Flag warnings.

- Easter Area Coordination Center (EACC) Predictive Services group – EACC provides regional fire weather and fuels analysis and modeling products that are helpful in identifying potentially problematic fire weather and likelihood of receptive fuels.
- Interagency Cooperation – The Ohio Division of Forestry works cooperatively with the Wayne National Forest to monitor local fire weather, ignition/occurrence patterns, fuels conditions, and other locally specific data pertaining to wildland fire.

VULNERABILITY ANALYSIS & LOSS ESTIMATION METHODOLOGY

The FEMA National Risk Index (NRI) is a dataset and online tool to help illustrate the United States communities most at risk for 18 natural hazards. For wildfire, the Expected Annual Loss was determined by multiplying the frequency, exposure, and the historical loss ratio. This equation was calculated to determine population, agriculture, and building losses. For more information on current methods and data, refer to section 23 of the National Risk Index Technical Manual.

Table 2.7.d

FEMA National Risk Index Wildfire Analysis, OEMA Region 1								
County	Exposure (Sq. Mi)	Exposure (Buildings)	Exposure (Population)	Exposure (Agriculture)	Expected Annual Loss (Buildings)	Expected Annual Loss (Population Equivalence)	Expected Annual Loss (Agriculture)	Expected Annual Loss (Total)
Allen	16.41	$ 1,398,712,984.41	6,867	$ 8,496,673	$ 6,075.73	$ 527.71	$ 1.60	$ 6,605.04
Auglaize	25.96	$ 1,211,804,555.75	5,609	$ 19,961,496	$ 4,969.62	$ 409.47	$ 3.29	$ 5,382.38
Champaign	21.64	$ 754,088,150.98	4,342	$ 7,898,795	$ 3,411.21	$ 345.39	$ 1.28	$ 3,757.87
Clark	54.66	$ 6,105,803,143.32	29,562	$ 24,238,252	$ 24,504.34	$ 2,076.79	$ 3.30	$ 26,584.43
Crawford	4.85	$ 177,610,938.65	1,146	$ 5,495,515	$ 2,358.92	$ 272.72	$ 2.65	$ 2,634.29
Darke	69.47	$ 3,334,185,550.41	12,967	$ 165,276,315	$ 13,336.74	$ 909.04	$ 22.44	$ 14,268.23
Defiance	58.43	$ 1,924,586,320.83	10,032	$ 26,973,809	$ 7,698.35	$ 703.24	$ 3.66	$ 8,405.24
Erie	35.02	$ 3,934,525,011.36	17,176	$ 20,015,485	$ 15,738.10	$ 1,204.04	$ 2.72	$ 16,944.86
Fulton	43.51	$ 2,191,537,664.60	11,784	$ 36,106,039	$ 8,766.15	$ 826.05	$ 4.90	$ 9,597.11
Hancock	7.71	$ 411,023,590.57	2,128	$ 2,851,964	$ 2,316.80	$ 209.39	$ 0.69	$ 2,526.88
Hardin	5.27	$ 115,818,939.46	521	$ 4,816,425	$ 1,117.96	$ 98.84	$ 4.06	$ 1,220.86
Henry	26.29	$ 1,033,256,683.95	4,707	$ 14,046,901	$ 4,133.03	$ 330.00	$ 1.91	$ 4,464.93
Huron	47.46	$ 2,468,366,221.77	13,217	$ 32,150,803	$ 10,035.49	$ 941.26	$ 4.49	$ 10,981.24
Logan	9.76	$ 506,657,596.63	1,840	$ 3,780,384	$ 4,770.13	$ 298.95	$ 1.52	$ 5,070.60
Lucas	42.49	$ 14,722,221,549.75	71,122	$ 10,657,452	$ 58,888.88	$ 4,985.81	$ 1.45	$ 63,876.14
Marion	3.55	$ 145,844,699.84	777	$ 2,370,496	$ 2,218.63	$ 179.47	$ 2.03	$ 2,400.13
Mercer	45.91	$ 2,852,671,139.05	8,661	$ 169,538,699	$ 11,410.68	$ 607.12	$ 23.02	$ 12,040.83
Miami	70.10	$ 6,847,422,870.30	29,993	$ 25,444,581	$ 27,389.69	$ 2,102.59	$ 3.46	$ 29,495.74
Ottawa	27.16	$ 3,753,368,533.20	10,410	$ 9,610,350	$ 15,024.37	$ 730.42	$ 1.31	$ 15,756.10
Paulding	35.32	$ 1,168,121,858.46	4,335	$ 50,655,175	$ 4,672.49	$ 303.93	$ 6.88	$ 4,983.29
Preble	67.01	$ 3,055,667,543.15	15,658	$ 38,145,272	$ 12,224.99	$ 1,097.65	$ 5.18	$ 13,327.82
Putnam	22.53	$ 712,301,977.97	3,780	$ 29,181,566	$ 2,849.21	$ 264.96	$ 4.03	$ 3,118.20
Sandusky	20.04	$ 1,207,999,204.92	4,856	$ 7,069,176	$ 4,935.17	$ 346.46	$ 1.03	$ 5,282.66
Seneca	10.37	$ 353,534,717.17	1,555	$ 3,811,994	$ 1,999.03	$ 149.56	$ 0.80	$ 2,149.39
Shelby	36.19	$ 2,211,591,542.48	7,604	$ 36,450,790	$ 8,945.85	$ 541.11	$ 5.04	$ 9,492.01
Van Wert	27.83	$ 1,027,254,500.37	5,027	$ 25,756,252	$ 4,109.02	$ 352.38	$ 3.50	$ 4,464.90
Williams	85.28	$ 2,767,731,941.46	10,698	$ 40,696,299	$ 11,070.93	$ 749.94	$ 5.53	$ 11,826.39
Wood	38.81	$ 5,634,747,444.91	21,219	$ 16,426,543	$ 22,575.53	$ 1,490.30	$ 2.32	$ 24,068.15
Wyandot	2.93	$ 62,614,097.31	314	$ 2,477,757	$ 924.12	$ 63.60	$ 2.65	$ 990.37

Table 2.7.e

FEMA National Risk Index Wildfire Analysis, OEMA Region 2								
County	Exposure (Sq. Mi)	Exposure (Buildings)	Exposure (Population)	Exposure (Agriculture)	Expected Annual Loss (Buildings)	Expected Annual Loss (Population Equivalence)	Expected Annual Loss (Agriculture)	Expected Annual Loss (Total)
Ashland	114.62	$ 6,613,424,974.67	24,745	$ 58,171,406	$ 26,455.37	$ 1,734.80	$ 7.90	$ 28,198.07
Butler	55.76	$ 10,865,501,458.62	59,771	$ 9,976,474	$ 89,353.59	$ 8,997.01	$ 8.40	$ 98,359.00
Clinton	26.50	$ 1,654,093,743.42	7,688	$ 9,218,330	$ 6,987.26	$ 570.72	$ 1.32	$ 7,559.31
Cuyahoga	43.05	$ 37,661,752,312.22	179,830	$ 2,661,526	$ 150,647.01	$ 12,606.51	$ 0.36	$ 163,253.88
Delaware	14.07	$ 2,560,422,905.11	10,749	$ 3,642,937	$ 56,018.41	$ 4,046.02	$ 3.02	$ 60,067.45
Fairfield	23.92	$ 2,051,140,435.42	13,074	$ 6,702,029	$ 34,002.57	$ 3,420.95	$ 2.92	$ 37,426.44
Fayette	7.99	$ 389,468,196.45	1,150	$ 3,197,117	$ 5,052.92	$ 240.49	$ 2.10	$ 5,295.51
Franklin	11.50	$ 5,794,630,719.97	33,352	$ 2,454,292	$ 30,395.24	$ 2,858.36	$ 0.88	$ 33,254.48
Geauga	53.70	$ 7,913,011,602.34	35,739	$ 15,336,619	$ 31,701.59	$ 2,512.65	$ 2.09	$ 34,216.33
Greene	77.90	$ 11,885,849,502.07	59,031	$ 23,439,913	$ 47,543.40	$ 4,138.20	$ 3.18	$ 51,684.78
Hamilton	39.85	$ 23,097,426,388.13	134,820	$ 6,010,341	$ 105,238.56	$ 10,707.23	$ 2.30	$ 115,948.09
Knox	124.51	$ 6,218,127,419.52	28,843	$ 60,720,281	$ 24,876.20	$ 2,022.44	$ 8.25	$ 26,906.89
Lake	24.72	$ 8,918,281,576.40	44,001	$ 38,560,403	$ 35,719.03	$ 3,087.33	$ 5.27	$ 38,811.63
Licking	133.77	$ 11,250,117,296.92	54,934	$ 76,010,144	$ 46,688.46	$ 4,007.22	$ 10.52	$ 50,706.21
Lorain	92.16	$ 17,388,581,056.89	83,911	$ 43,266,044	$ 69,849.54	$ 5,903.32	$ 5.94	$ 75,758.80
Madison	13.84	$ 572,095,827.04	3,377	$ 6,405,181	$ 2,310.86	$ 238.42	$ 0.94	$ 2,550.22
Medina	104.58	$ 14,250,331,399.38	66,579	$ 23,306,457	$ 57,031.76	$ 4,670.08	$ 3.17	$ 61,705.01
Montgomery	93.44	$ 21,494,547,747.13	107,081	$ 28,433,882	$ 85,978.19	$ 7,506.63	$ 3.86	$ 93,488.68
Morrow	42.74	$ 1,331,615,901.91	7,998	$ 13,875,287	$ 11,483.65	$ 1,030.44	$ 3.01	$ 12,517.09
Pickaway	11.75	$ 552,897,056.44	2,750	$ 4,185,366	$ 21,246.90	$ 1,862.71	$ 5.35	$ 23,114.96
Portage	82.63	$ 9,767,986,449.13	50,426	$ 14,336,237	$ 39,140.24	$ 3,542.86	$ 1.95	$ 42,685.06
Richland	81.80	$ 7,034,418,226.90	39,801	$ 50,614,334	$ 28,596.49	$ 2,847.50	$ 7.21	$ 31,451.20
Stark	160.69	$ 23,433,526,787.19	121,199	$ 55,318,881	$ 93,737.08	$ 8,496.43	$ 7.51	$ 102,241.03
Summit	57.36	$ 26,500,244,791.45	130,102	$ 7,066,053	$ 106,012.67	$ 9,121.76	$ 0.96	$ 115,135.40
Union	5.60	$ 343,002,107.15	1,613	$ 4,046,468	$ 4,911.44	$ 464.42	$ 2.14	$ 5,378.01
Warren	111.34	$ 21,940,671,609.88	109,131	$ 19,865,370	$ 87,998.55	$ 7,676.15	$ 2.73	$ 95,677.43
Wayne	179.40	$ 10,350,391,261.44	53,596	$ 181,413,621	$ 41,401.56	$ 3,757.21	$ 24.63	$ 45,183.41

Table 2.7.f

FEMA National Risk Index Wildfire Analysis, OEMA Region 3								
County	Exposure (Sq. Mi)	Exposure (Buildings)	Exposure (Population)	Exposure (Agriculture)	Expected Annual Loss (Buildings)	Expected Annual Loss (Population Equivalence)	Expected Annual Loss (Agriculture)	Expected Annual Loss (Total)
Adams	35.11	$ 1,213,149,844.07	4,786	$ 8,103,641	$ 296,360.63	$ 41,927.38	$ 96.82	$ 338,384.83
Ashtabula	93.17	$ 5,913,533,021.21	29,439	$ 20,870,946	$ 23,669.19	$ 2,066.10	$ 2.84	$ 25,738.13
Athens	32.81	$ 2,398,387,036.74	13,245	$ 3,324,457	$ 10,151.61	$ 1,004.37	$ 0.54	$ 11,156.53
Belmont	160.46	$ 6,988,184,409.44	36,398	$ 26,756,889	$ 27,952.74	$ 2,551.57	$ 3.63	$ 30,507.94
Brown	34.87	$ 1,339,051,119.45	6,857	$ 7,077,846	$ 208,993.44	$ 39,302.21	$ 54.08	$ 248,349.73
Carroll	118.37	$ 3,327,867,397.24	17,594	$ 41,179,144	$ 13,311.47	$ 1,233.36	$ 5.59	$ 14,550.42
Clermont	32.65	$ 7,414,270,495.51	41,816	$ 3,674,092	$ 87,761.87	$ 20,542.62	$ 5.83	$ 108,310.32
Columbiana	145.33	$ 9,860,532,191.16	49,680	$ 71,815,987	$ 39,442.13	$ 3,482.70	$ 9.75	$ 42,934.58
Coshocton	129.29	$ 3,697,403,359.66	18,827	$ 73,279,532	$ 14,789.61	$ 1,319.82	$ 9.95	$ 16,119.39
Gallia	9.77	$ 290,097,650.05	1,766	$ 1,495,178	$ 35,383.08	$ 7,636.70	$ 6.93	$ 43,026.72
Guernsey	133.92	$ 4,814,685,093.17	22,475	$ 23,774,175	$ 19,258.74	$ 1,575.51	$ 3.23	$ 20,837.48
Harrison	103.53	$ 1,861,716,657.89	9,820	$ 16,582,719	$ 7,446.87	$ 688.42	$ 2.25	$ 8,137.54
Highland	41.51	$ 1,515,202,461.49	6,751	$ 13,835,748	$ 256,642.27	$ 39,343.43	$ 82.79	$ 296,068.48
Hocking	17.41	$ 1,925,454,188.53	8,178	$ 1,019,448	$ 8,399.30	$ 619.37	$ 0.20	$ 9,018.88
Holmes	165.00	$ 7,984,102,273.85	31,699	$ 145,378,653	$ 31,936.41	$ 2,222.18	$ 19.74	$ 34,178.32
Jackson	6.34	$ 261,181,724.65	1,525	$ 629,225	$ 11,273.31	$ 2,156.77	$ 1.62	$ 13,431.70
Jefferson	92.10	$ 6,781,059,829.03	30,636	$ 8,898,956	$ 27,124.24	$ 2,147.69	$ 1.21	$ 29,273.13
Lawrence	6.98	$ 519,681,520.65	3,409	$ 358,934	$ 138,813.59	$ 33,323.70	$ 3.25	$ 172,140.54
Mahoning	84.31	$ 13,200,790,141.50	60,460	$ 36,307,276	$ 52,893.48	$ 4,246.98	$ 4.94	$ 57,145.40
Meigs	14.86	$ 688,998,323.60	3,196	$ 2,202,982	$ 2,969.84	$ 243.97	$ 0.48	$ 3,214.30
Monroe	74.10	$ 2,470,882,641.15	10,140	$ 12,898,409	$ 9,883.53	$ 710.84	$ 1.75	$ 10,596.13
Morgan	64.46	$ 1,504,852,763.38	8,183	$ 13,109,766	$ 6,019.78	$ 573.72	$ 1.78	$ 6,595.28
Muskingum	159.03	$ 8,577,985,067.71	42,050	$ 52,321,325	$ 34,322.09	$ 2,948.99	$ 7.11	$ 37,278.19
Noble	77.99	$ 3,145,658,665.33	9,410	$ 7,338,644	$ 12,582.63	$ 659.67	$ 1.00	$ 13,243.30
Perry	44.87	$ 1,784,047,417.99	12,045	$ 10,181,225	$ 7,406.74	$ 856.57	$ 1.44	$ 8,264.75
Pike	7.55	$ 226,037,397.06	1,328	$ 3,926,044	$ 19,944.08	$ 4,314.96	$ 20.43	$ 24,279.47
Ross	29.80	$ 1,078,962,051.30	6,665	$ 5,956,354	$ 118,808.21	$ 12,625.46	$ 22.74	$ 131,456.41
Scioto	7.09	$ 385,529,336.08	2,873	$ 660,263	$ 34,924.88	$ 9,285.63	$ 1.91	$ 44,212.42
Trumbull	74.65	$ 10,123,014,391.18	49,284	$ 17,684,913	$ 40,620.21	$ 3,465.63	$ 2.42	$ 44,088.26
Tuscarawas	143.21	$ 7,650,604,250.17	41,022	$ 101,568,266	$ 30,602.42	$ 2,875.71	$ 13.79	$ 33,491.92
Vinton	5.08	$ 212,429,692.12	1,102	$ 420,298	$ 1,434.02	$ 143.93	$ 0.12	$ 1,578.06
Washington	122.60	$ 4,845,247,118.52	31,602	$ 32,192,313	$ 19,380.99	$ 2,215.35	$ 4.37	$ 21,600.71

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHODOLOGY

The state-owned and state-leased critical facilities datasets were used to perform an analysis based upon the spatial location of each critical facility, the replacement cost of that facility, and FEMA National Risk Index Wildfire Hazard Risk Index score/rating from the NRI at the census tract level. For more information on current methodology and data, refer to section 22 of the National Risk Index Technical Manual.

Table 2.15.g – State Owned and State Leased Critical Facilities by County and NRI Hazard Risk Rating, OEMA Region 1

	No Rating		Very Low		Relatively Low		Relatively Moderate		Relatively High		Very High	
County	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost
ALLEN	0	$ -	99	$ 148,535,104.00	0	$ -	0	$ -	0	$ -	0	$ -
AUGLAIZE	0	$ -	11	$ 5,621,501.00	7	$ 921,318.00	0	$ -	0	$ -	0	$ -
CHAMPAIGN	0	$ -	13	$ 7,720,300.00	8	$ 1,525,793.00	0	$ -	0	$ -	0	$ -
CLARK	0	$ -	2	$ 592,617.00	25	$ 9,058,305.00	0	$ -	0	$ -	0	$ -
CRAWFORD	0	$ -	12	$ 11,520,706.00	0	$ -	0	$ -	0	$ -	0	$ -
DARKE	0	$ -	0	$ -	27	$ 17,992,955.00	0	$ -	0	$ -	0	$ -
DEFIANCE	0	$ -	0	$ -	15	$ 12,622,421.00	0	$ -	0	$ -	0	$ -
ERIE	1	$ 38,551.00	0	$ -	54	$ 150,111,057.00	0	$ -	0	$ -	0	$ -
FULTON	0	$ -	0	$ -	12	$ 9,821,963.00	0	$ -	0	$ -	0	$ -
HANCOCK	0	$ -	18	$ 12,174,748.00	2	$ 47,101.00	0	$ -	0	$ -	0	$ -
HARDIN	0	$ -	11	$ 3,099,615.00	7	$ 3,726,143.00	0	$ -	0	$ -	0	$ -
HENRY	0	$ -	2	$ 585,529.00	14	$ 3,664,717.00	0	$ -	0	$ -	0	$ -
HURON	0	$ -	0	$ -	22	$ 10,837,350.00	0	$ -	0	$ -	0	$ -
LOGAN	0	$ -	7	$ 1,477,752.00	14	$ 7,912,178.00	0	$ -	0	$ -	0	$ -
LUCAS	5	$ 969,594.00	4	$ 13,244,891.00	43	$ 260,283,261.00	0	$ -	0	$ -	0	$ -
MARION	1	$ 29,863.00	58	$ 237,024,291.00	0	$ -	0	$ -	0	$ -	0	$ -
MERCER	0	$ -	0	$ -	27	$ 9,141,086.00	0	$ -	0	$ -	0	$ -
MIAMI	0	$ -	3	$ 3,941,499.00	27	$ 17,053,167.00	0	$ -	0	$ -	0	$ -
OTTAWA	0	$ -	1	$ 37,059.00	51	$ 42,200,876.00	0	$ -	0	$ -	0	$ -
PAULDING	0	$ -	0	$ -	11	$ 8,375,639.00	0	$ -	0	$ -	0	$ -
PREBLE	0	$ -	0	$ -	28	$ 7,555,863.00	0	$ -	0	$ -	0	$ -
PUTNAM	0	$ -	15	$ 3,421,607.00	4	$ 1,435,662.00	0	$ -	0	$ -	0	$ -
SANDUSKY	0	$ -	1	$ 27,722.00	13	$ 8,605,780.00	0	$ -	0	$ -	0	$ -
SENECA	0	$ -	47	$ 47,263,743.00	0	$ -	0	$ -	0	$ -	0	$ -
SHELBY	0	$ -	0	$ -	35	$ 32,329,725.00	0	$ -	0	$ -	0	$ -
VAN WERT	0	$ -	2	$ 44,015.00	14	$ 7,728,799.00	0	$ -	0	$ -	0	$ -
WILLIAMS	0	$ -	0	$ -	17	$ 7,837,080.00	0	$ -	0	$ -	0	$ -
WOOD	0	$ -	5	$ 13,428,519.00	35	$ 54,864,046.00	0	$ -	0	$ -	0	$ -
WYANDOT	0	$ -	22	$ 6,729,710.00	0	$ -	0	$ -	0	$ -	0	$ -
Grand Total	**7**	**$ 1,038,008.00**	**333**	**$ 516,490,928.00**	**512**	**$ 685,652,285.00**	**0**	**$ -**	**0**	**$ -**	**0**	**$ -**

Table 2.15.h – State Owned and State Leased Critical Facilities by County and NRI Hazard Risk Rating, OEMA Region 2

	No Rating		Very Low		Relatively Low		Relatively Moderate		Relatively High		Very High	
County	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost
ASHLAND	0	$ -	1	$ 23,670.00	144	$ 103,467,432.00	0	$ -	0	$ -	0	$ -
BUTLER	0	$ -	0	$ -	29	$ 17,200,279.00	0	$ -	0	$ -	0	$ -
CLINTON	0	$ -	4	$ 941,745.00	27	$ 12,508,772.00	0	$ -	0	$ -	0	$ -
CUYAHOGA	30	$ 195,431,106.00	22	$ 32,092,106.00	54	$ 162,098,711.00	0	$ -	0	$ -	0	$ -
DELAWARE	2	$ 91,790.00	3	$ 16,681,819.00	28	$ 44,228,972.00	0	$ -	0	$ -	0	$ -
FAIRFIELD	0	$ -	12	$ 4,447,243.00	55	$ 90,110,306.00	0	$ -	0	$ -	0	$ -
FAYETTE	0	$ -	6	$ 8,209,189.00	17	$ 2,843,221.00	0	$ -	0	$ -	0	$ -
FRANKLIN	37	$ 1,319,103,707.00	116	$ 900,824,388.00	37	$ 117,034,961.00	0	$ -	0	$ -	0	$ -
GEAUGA	0	$ -	0	$ -	27	$ 12,064,728.00	0	$ -	0	$ -	0	$ -
GREENE	0	$ -	0	$ -	21	$ 17,560,312.00	0	$ -	0	$ -	0	$ -
HAMILTON	3	$ 476,442.00	9	$ 21,389,452.00	29	$ 91,450,895.00	0	$ -	0	$ -	0	$ -
KNOX	0	$ -	0	$ -	41	$ 76,691,486.00	0	$ -	0	$ -	0	$ -
LAKE	0	$ -	10	$ 10,284,888.00	11	$ 2,703,214.00	0	$ -	0	$ -	0	$ -
LICKING	0	$ -	5	$ 14,273,506.00	62	$ 172,467,950.00	0	$ -	0	$ -	0	$ -
LORAIN	0	$ -	3	$ 2,198,821.00	80	$ 210,191,768.00	0	$ -	0	$ -	0	$ -
MADISON	0	$ -	86	$ 389,068,715.00	18	$ 9,442,858.00	0	$ -	0	$ -	0	$ -
MEDINA	0	$ -	0	$ -	17	$ 16,239,799.00	0	$ -	0	$ -	0	$ -
MONTGOMERY	3	$ 871,658.00	2	$ 2,816,160.00	67	$ 184,208,998.00	0	$ -	0	$ -	0	$ -
MORROW	0	$ -	0	$ -	19	$ 12,996,576.00	0	$ -	0	$ -	0	$ -
PICKAWAY	1	$ 36,502.00	98	$ 284,296,129.00	38	$ 62,290,013.00	0	$ -	0	$ -	0	$ -
PORTAGE	0	$ -	1	$ 130,120.00	24	$ 17,663,460.00	0	$ -	0	$ -	0	$ -
RICHLAND	0	$ -	2	$ 265,172.00	75	$ 236,733,275.00	0	$ -	0	$ -	0	$ -
STARK	3	$ 1,796,245.00	2	$ 766,984.00	52	$ 146,078,356.00	0	$ -	0	$ -	0	$ -
SUMMIT	0	$ -	5	$ 5,190,784.00	60	$ 192,765,690.00	0	$ -	0	$ -	0	$ -
UNION	0	$ -	48	$ 166,248,757.00	7	$ 3,189,715.00	0	$ -	0	$ -	0	$ -
WARREN	0	$ -	88	$ 308,271,672.00	21	$ 15,447,776.00	0	$ -	0	$ -	0	$ -
WAYNE	0	$ -	1	$ 22,422.00	21	$ 12,180,381.00	0	$ -	0	$ -	0	$ -
Grand Total	**79**	**$ 1,517,807,450.00**	**524**	**$ 2,168,443,742.00**	**1,081**	**$ 2,041,859,904.00**	**0**	**$ -**	**0**	**$ -**	**0**	**$ -**

Table 2.15.i – State Owned and State Leased Critical Facilities by County and NRI Hazard Risk Rating, OEMA Region 3

	No Rating		Very Low		Relatively Low		Relatively Moderate		Relatively High		Very High	
County	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost	# of CF	Replacement Cost
ADAMS	0	$ -	0	$ -	27	$ 11,652,213.00	2	$ 674,000.00	1	$ 346,092.00	0	$ -
ASHTABULA	0	$ -	0	$ -	72	$ 25,195,278.00	0	$ -	0	$ -	0	$ -
ATHENS	0	$ -	11	$ 40,591,259.00	24	$ 12,660,355.00	0	$ -	0	$ -	0	$ -
BELMONT	0	$ -	0	$ -	70	$ 153,564,299.00	0	$ -	0	$ -	0	$ -
BROWN	0	$ -	0	$ -	1	$ 53,051.00	30	$ 35,334,395.00	0	$ -	0	$ -
CARROLL	0	$ -	0	$ -	18	$ 5,220,361.00	0	$ -	0	$ -	0	$ -
CLERMONT	0	$ -	0	$ -	51	$ 32,967,768.00	0	$ -	0	$ -	0	$ -
COLUMBIANA	0	$ -	0	$ -	36	$ 14,981,757.00	0	$ -	0	$ -	0	$ -
COSHOCTON	0	$ -	1	$ 23,237.00	20	$ 16,789,804.00	0	$ -	0	$ -	0	$ -
GALLIA	0	$ -	0	$ -	42	$ 40,526,483.00	19	$ 9,259,735.00	0	$ -	0	$ -
GUERNSEY	0	$ -	0	$ -	50	$ 58,733,742.00	0	$ -	0	$ -	0	$ -
HARRISON	0	$ -	0	$ -	24	$ 9,202,405.00	0	$ -	0	$ -	0	$ -
HIGHLAND	0	$ -	0	$ -	0	$ -	11	$ 6,701,555.00	0	$ -	0	$ -
HOCKING	0	$ -	0	$ -	27	$ 7,590,230.00	0	$ -	0	$ -	0	$ -
HOLMES	0	$ -	0	$ -	29	$ 9,188,433.00	0	$ -	0	$ -	0	$ -
JACKSON	0	$ -	9	$ 3,591,935.00	11	$ 6,356,750.00	1	$ 262,400.00	0	$ -	0	$ -
JEFFERSON	0	$ -	1	$ 21,541.00	33	$ 14,664,356.00	0	$ -	0	$ -	0	$ -
LAWRENCE	9	$ 3,335,811.00	0	$ -	4	$ 2,753,400.00	13	$ 3,078,228.00	0	$ -	0	$ -
MAHONING	0	$ -	5	$ 670,859.00	53	$ 109,007,315.00	0	$ -	0	$ -	0	$ -
MEIGS	0	$ -	2	$ 872,300.00	22	$ 8,496,701.00	0	$ -	0	$ -	0	$ -
MONROE	0	$ -	0	$ -	12	$ 3,933,797.00	0	$ -	0	$ -	0	$ -
MORGAN	0	$ -	0	$ -	15	$ 7,945,308.00	0	$ -	0	$ -	0	$ -
MUSKINGUM	0	$ -	0	$ -	36	$ 14,169,875.00	0	$ -	0	$ -	0	$ -
NOBLE	0	$ -	0	$ -	32	$ 65,273,143.00	0	$ -	0	$ -	0	$ -
PERRY	0	$ -	0	$ -	9	$ 7,167,121.00	0	$ -	0	$ -	0	$ -
PIKE	0	$ -	0	$ -	10	$ 7,756,112.00	2	$ 887,600.00	0	$ -	0	$ -
ROSS	0	$ -	20	$ 16,922,739.00	13	$ 10,351,796.00	96	$ 483,523,985.00	0	$ -	0	$ -
SCIOTO	2	$ 193,331.00	1	$ 456,000.00	63	$ 477,785,655.00	0	$ -	0	$ -	0	$ -
TRUMBULL	1	$ 61,323.00	2	$ 383,945.00	66	$ 96,587,303.00	0	$ -	0	$ -	0	$ -
TUSCARAWAS	0	$ -	0	$ -	54	$ 50,576,265.00	0	$ -	0	$ -	0	$ -
VINTON	0	$ -	0	$ -	19	$ 14,102,427.00	0	$ -	0	$ -	0	$ -
WASHINGTON	0	$ -	1	$ 563,590.00	49	$ 36,135,410.00	0	$ -	0	$ -	0	$ -
Grand Total	**12**	**$ 3,590,465.00**	**53**	**$ 64,097,405.00**	**992**	**$ 1,331,388,913.00**	**174**	**$ 539,721,898.00**	**1**	**$ 346,092.00**	**0**	**$ -**

2.8 STORM SURGE / SEICHE / COASTAL FLOODING

When a storm system moves across a lake, typically the temperature drops and the wind changes direction. This disturbs the water in the lake and causes it to move in the same direction the storm is moving. The magnitude of storm surge events is dependent on a number of factors. Wind velocity and barometric pressure are the most obvious contributors to the size of an event. The orientation of the lake with respect to the direction the storm is moving is critical to the wind fetch distance over the lake which in turn increases wave heights and storm surges. Lake Erie is oriented southwest to northeast, and the lake is shallowest near Toledo. Therefore, storms moving northeast to southwest have the potential to produce higher storm surges.

Seiche can be defined as a standing wave in an enclosed or partially enclosed body of water which can result in coastal flooding. The most common cause of seiches in Ohio is a strong, constant wind blowing over the surface of the water forcing it to accumulate at the down-wind shore. When the wind diminishes the water level will begin to return to its original equilibrium though a series of broad oscillations across the entire body. Often referred to as the bathtub effect, seiches cause the water levels to rise and fall along the shorelines repeatedly until equilibrium is restored. Other causes of seiches include earthquakes, changes in barometric pressure or any of a variety of atmospheric changes.

The United States Army Corps of Engineers office in Detroit Michigan developed a profile of seiche as part of a larger work analyzing water levels for the Great Lakes. Figure 2.8.a displays the static impact storm surge has on a body of water with water levels rising on the downwind shore and falling along the upwind shore.

Figure 2.8.a

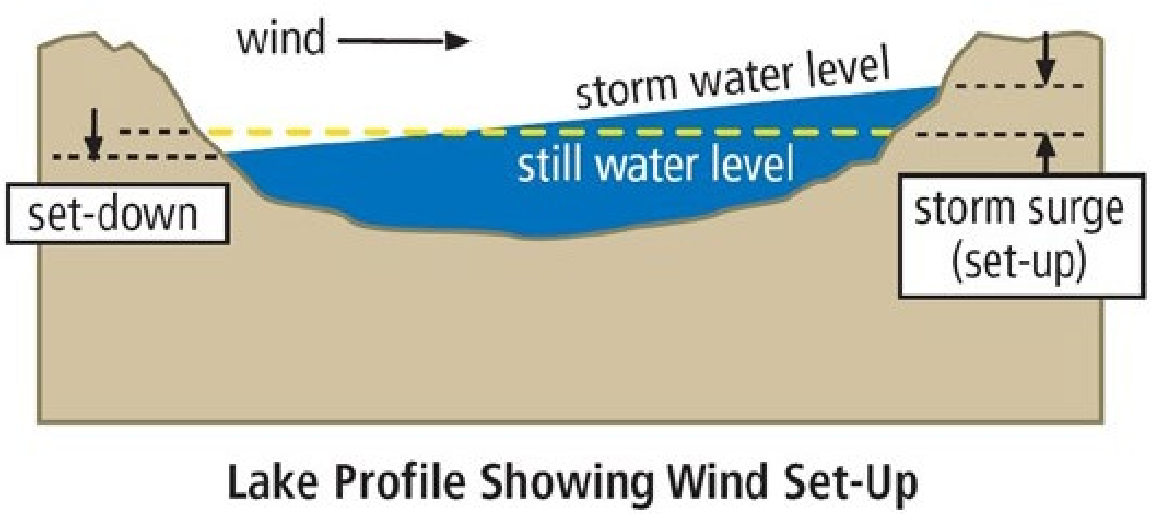


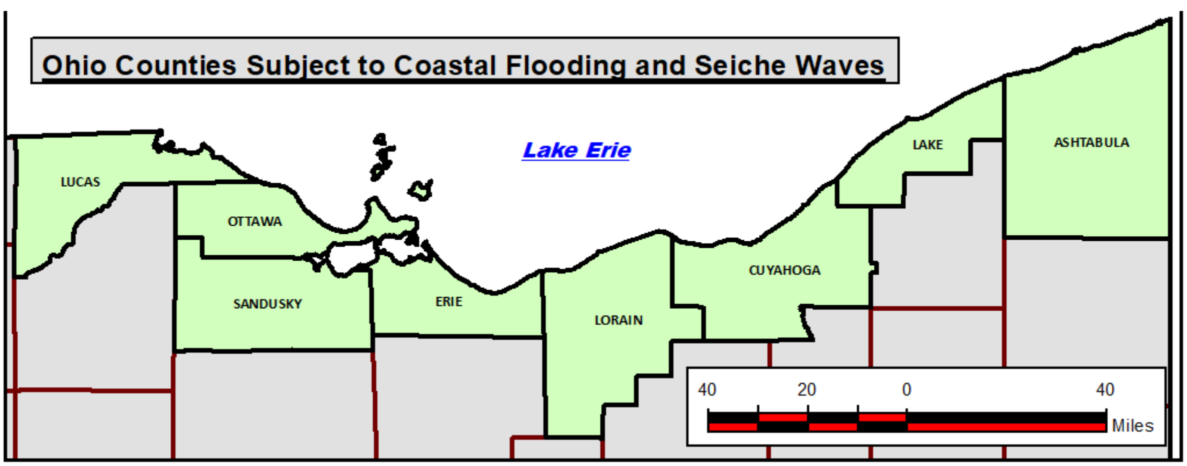
Figure 2.8.b provides a depiction of the combined effect of wind and wave actions. The base water level for the lake is marked as the SWL, or still water level. The position marked R is for run-up, the elevation a wave rises to as it spills on the shore or a structure. When winds are generated by severe storms the potential for wave action increases greatly.

Figure 2.8.b

RISK ASSESSMENT

LOCATION

Lake Erie is the most notable water body impacted by storm surge and seiches in Ohio. Although Lake Erie has 9,940 square miles of surface area implying a large body of water, it is relatively shallow with an average depth of 62 feet. Broken into what is generally referred to as the eastern, central and western basins, Lake Erie's susceptibility to storm surge and seiches varies greatly. The central basin, encompassing the area from Ohio's eastern border to Lorain, ranges from 45 to 65 feet deep with a shoreline that is mostly developed and armored. The western basin is much shallower with a depth averaging about 24 feet. The shorelines in the western basin are former coastal wetlands, many of which have been armored. One of the un-protected areas are the islands off of Ottawa County.



The seiche / coastal flooding hazard exposure is limited to counties adjacent to the south shore of Lake Erie. Region 1 counties impacted by seiche include: Lucas, Ottawa, Sandusky and Erie. Region 2 counties impacted by seiche include: Lorain, Cuyahoga, and Lake. Ashtabula is the only county impacted in Region 3.

PAST OCCURRENCES

The NCDC history of hazardous weather events currently lists only one seiche event which occurred on November 10, 1998 impacting Erie, Lorain, Lucas and Ottawa counties. The event consisted of southwest storm force winds gusting to 69 miles per hour that pushed water away from the western end of Lake Erie towards the state of New York and Ontario Canada. As the water level fell to four feet below normal, boats and ferries were left stranded in the mud in marinas from the Maumee River east to the lagoons in Vermilion, while freighters were forced to drop anchor outside Sandusky Bay near Port Clinton. There were no estimates provided for property or other economic losses. Prolonged SW storm events create navigational hazards in the western basin due to the low water level. Put-in-Bay harbor has been near-emptied in this type of event, exposing rock and making the harbor non-navigable.

The earliest recorded seiche wave in Ohio history occurred on the morning of June 23, 1882 when an eight-foot wall of water suddenly crashed into the 9th Street Pier in Cleveland. This wave damaged or destroyed several boats and created a novel fishing experience as it propelled hundreds of fish farther inland from the docks. One fatality resulted from this event as a homeless person was sleeping near the shore and drowned. Other events occurred in May 1942, 1944 and 1948 with waves being recorded anywhere from six to 20 feet high. Seiche waves continued to oscillate from several hours to days.

The NCDC database also contains six days with events described as storm surge. The six descriptions cover a period of nearly record high water level. Lake water level is the most important factor in producing storm surges that cause wave damage and coastal flooding. The NE storms happen every year, but flooding and damage occur when there is high water.

March 13, 1997 Storm Surge - Gale force east winds to 35 knots caused the water level at the west end of Lake Erie to rise to 79 inches above low water datum, around 35 inches above the recent average lake level. Flooding and considerable beach erosion occurred along the lakeshores of Lucas, Ottawa, Sandusky and Erie Counties. In Toledo (Lucas County), roads and a parking lot were inundated, including Monroe and Second Streets, and at Point Place on Maumee Bay. Water also overtopped a road in Jerusalem Township. In Ottawa County, roads were flooded in Port Clinton and sandbagging was performed at some local businesses. Also, on Catawba Island, waves were recorded as overtopping at least one road. At Bayview (Sandusky County), County Road 259 was flooded. Losses approached $50,000 from this coastal event.

June 1, 1997 Storm Surge - Businesses and homes were flooded when strong northeasterly winds and near record high lake levels produced waves of six to eight feet, aggravating shoreline erosion and slowing discharge of stream outflow into Lake Erie. In Erie County, an estimated 75 to 100 families evacuated near the Vermilion and Huron Rivers, while those on Mudbrook Road moved to their second floors to escape the flood waters. Also in Erie County, Riverside Avenue residents were evacuated as well as those in Franklin Flats, Rye Beach and White's Landing. Roads along the shoreline were flooded and covered with so much sand and debris that they had to be cleared with snow plows in Port Clinton and Marblehead. On Catawba Island, rising water flooded buildings and cars were submerged. Charter services cancelled trips and hundreds of travelers were stranded on South Bass Island when most ferry trips were also cancelled. In Erie County, the north end of Jackson Pier collapsed. As the water receded, a large number of fish were left behind in people’s yards. Losses were estimated at $525,000 from the event which encompassed Erie, Lorain, Lucas, Ottawa and Sandusky Counties.

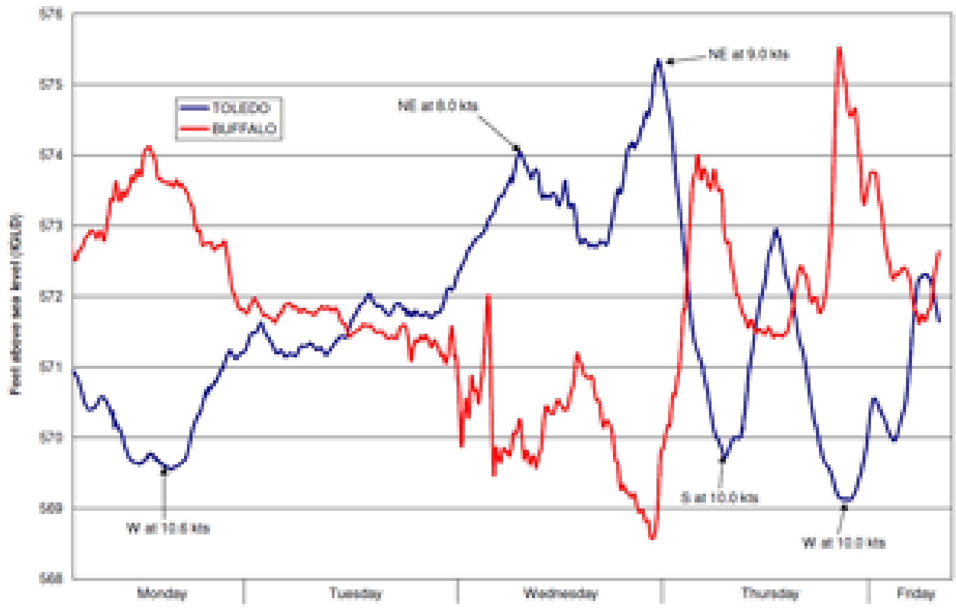
February 4, 1998 Storm Surge - Northeast winds up to 35 miles per hour caused flooding of the immediate lakeshore and beach erosion in Lucas, Erie, and Ottawa Counties. Losses were estimated at $75,000 from the event.

February 17, 1998 Storm Surge - Northeast winds up to 40 miles per hour increased the water level at the Toledo Coast Guard Station (Lucas County) to around seven feet above low water datum. Waves of seven to ten feet caused major flooding and beach erosion along the western shoreline of Lake Erie, particularly at Crystal Rock and Whites Landing (Erie County), where homes and yards were flooded. Losses were estimated at $700,000 from the event which impacted Erie, Lucas and Ottawa Counties.

March 20, 1998 Storm Surge - North to northeast gales of 35 knots, with higher gusts, produced 11-to-14-foot waves on Lake Erie. Also, the water level at Toledo (Lucas County) was seven feet above low water datum. This combination resulted in major flooding and beach erosion. Many streets were flooded around Sandusky Bay (Ottawa, Sandusky, and Erie Counties) and Maumee Bay (Lucas County) and flooding had progressed further inland in some areas. In Sandusky and Huron (Erie County), several streets were flooded. At Beachwood Cove in Huron, the 30-foot-high break wall was destroyed and just a few feet of land separated the homes from the lake. Losses were estimated at $400,000 from the event which impacted Sandusky, Lorain, Ottawa, Erie and Lucas counties.

April 9, 1998 Storm Surge - Northeast gales of 35 knots and water levels that peaked just below 100 inches above low water datum produced 10-to-14-foot waves which caused major damage along the lakeshore. Many lakeshore roads were not only flooded, but also covered with rocks and other debris that, in some places, had to be removed by bulldozers. In Ottawa County, ten houses were destroyed and over 200 others were damaged, streets in downtown Port Clinton were flooded and the dike system and gravel roads in the Ottawa National Wildlife Refuge were badly damaged. Some evacuations took place at Whites Landing in Erie and Sandusky Counties and also at Wightmans Grove and Memory Marina in Sandusky County. A State of Emergency was declared and standing flood water persisted for several days in some areas. Losses were estimated at $3,700,000 from the event which impacted Erie, Ottawa, Lucas and Sandusky Counties.

October 17 to 21, 2011 Seiche Event - The graph below traces a recent Lake Erie seiche. From October 17 to 21, 2011, the wind shifted widely, from out of the west to out of the northeast, and to eventually out of the west again. The lines on the graph show the response of the water levels at Buffalo (red) and Toledo (blue) to these shifts. The greatest difference in water level was about 7 feet, and as the up-and-down swings of the lines show, the lake never settled to an equilibrium state over these several days.



Source: Ohio Dept. of Natural Resources, Division of Geological Survey

April 15, 2018 Storm Surge – High water, strong NE winds and rain combine to cause storm surge and flooding in Lucas, Ottawa, Erie and Sandusky Counties. Water levels within 6 inches of 1985's all-time record high, hours of 40-plus knot gale force winds from the east and 1 ½ inches of rain combined resulting in 13–15-foot waves. The municipalities of Marblehead, Port Clinton, Oak Harbor, Bayshore, Woodville, Toledo, Curtice, Point Place and Luna Pier (MI) were issued flood warnings. Damage was reported to structures in Port Clinton. Flooding inundated many farms, roads, businesses and homes on the west end of Lake Erie. State Route 2 was closed between S.R. 590 and Camp Perry, along with many other state routes along the north shore. The high water and waves caused $10-11 Million in damages to outer dikes protecting several of Lake Erie's marshes at Ottawa National Wildlife Refuge, Magee Wildlife Area, and Metzger's Marsh. There was also damage to docks and fishing piers in the area.

PROBABILITY OF FUTURE EVENTS

It is clear storm surge, coastal flooding, and seiche waves have a significant impact in Ohio. Based on the event profiles, it is possible for these events to occur between two and five times in a given year. Based on twelve events over 136 years, there is an 8.82% chance of a storm surge event significant enough to cause coastal flooding happening on any given year. The only seasonal limitation to events on Lake Erie would be during the height of winter when portions of the water surface can be covered by ice. It should be noted that ice coverage on Lake Erie varies from year to year, making it impossible to indicate any definitive time period when events cannot occur.

LHMP DATA

Cuyahoga County – Seiche. The Countywide All Natural Hazards Mitigation Plan states their northern coastline has a high frequency of seiche with a moderate vulnerability. The roads and highways along the coast can become flooded due to seiche waves. Most damage caused by seiche involves boat docks, low-lying areas along the lake shore, and river inlets to Lake Erie. The most severe seiche that hit the Cleveland area was an eight-foot seiche in the early 1990s.

Lucas County – Coastal Flooding. The Plan states that lake surges (also referred to as storm surges) are associated with extreme weather events and are responsible for coastal flooding and erosion (along

Lake Erie within Lucas County). The storms that generate large waves and lake surges can develop year-round, however within Lucas County, these events have typically occurred in the early spring and late fall months. Storm surges inundate coastal floodplains by dune over wash, the rise in water levels in inland bays and harbors, and backwater flooding through river mouths. Storm systems also generate large waves that run up and flood coastal beaches. The problem of lake surges and associated inland flooding is compounded by adjacent low-lying floodplains. The plan's history provides information that lake surges cause coastal flooding in the cities of Toledo, Oregon, the Village of Harbor View and the unincorporated Jerusalem Township. The total damages attributed to lake surges are $665,981.92, which equates to approximately $110,996.99 per event. There are limited data to calculate the probability of occurrence; however, records indicate multiple occurrences during the early spring and late fall months. It is fair to assume that future events would likely result in localized property damage to only specific areas within Lucas County, and that there is only a small potential for future events to result in injuries or deaths.

MIP LHMP HIRA ASSESSMENT

Due to most counties that border Lake Erie typically combining their coastal flooding assessments into a general "Flooding" section, and the MIP not having a default hazard entry field for coastal flooding, the hazard does not have its own rank in the MIP. Across only the Ohio counties that border Lake Erie, the flooding scores are typically much higher than flooding than when assessed throughout the state.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHODOLOGY

Loss estimates for Ohio's coastal flooding hazard were developed using FEMA's hazard analysis and loss estimation software HAZUS-MH MR3 coastal flooding application within the flood module. This application was updated in HAZUS-MH MR3 to reflect the unique issues associated with the Great Lakes. Still water lake elevations for each county were taken from the US Army Corps of Engineers report *Revised Report on Great Lakes Open-Coast Flood Levels* published April 1988.

HAZUS-MH MR3 analysis was run for each county bordering Lake Erie based on a 100-year return event. Each run was specifically adjusted to take into consideration the type of shoreline associated with each county. Sandusky County could not be analyzed due to the software failing to recognize any coastal exposure. Upon closer review, the exposure which does exist within the county was assessed as part of the two neighboring county evaluations.

RESULTS

Region 1 exposure to coastal flooding is limited to the coastal counties of Erie, Lucas, Ottawa and Sandusky. The total building exposure is estimated at $8,743,489,700. The numbers of impacted structures by percent of the structure damaged are estimated to be: 1 to 10 percent damaged at 455, 11 to 20 percent damaged at 2,184, 21 to 30 percent damaged at 1,476, 31 to 40 percent damaged at 1,059, 41 to 50 percent damaged at 309 and substantially damaged at 914. There are an estimated 4 essential facilities, which will experience at least moderate damage. According to Table 2.8.a, estimates for business interruption and building losses are $8,560,000 and $974,880,000, respectively.

Table 2.8.a

Estimate of Potential Losses to Coastal Flooding Region 1										
County	Population	Building Exposure Value	1-10% Damage Count	11-20 % Damage Count	21-30% Damage Count	31-40% Damage Count	41-50% Damage Count	Substantial Damage Count	Essential Facilities Count	Estimated Business Interrupt	Estimated Property Loss
Erie	79,321	$4,150,287,000	159	372	175	28	5	40	1	$2,070,000	$132,210,000
Lucas	454,029	$2,545,448,000	113	395	840	932	227	189	3	$3,260,000	$548,900,000
Ottawa	41,036	$2,047,754,700	183	1,417	461	99	77	685	0	$3,230,000	$293,770,000
TOTAL	**574,386**	**$8,743,489,700**	**455**	**2,184**	**1,476**	**1,059**	**309**	**914**	**4**	**$8,560,000**	**$974,880,000**

The majority of building loss is associated with Lucas County as a result of inland backup flooding of the Maumee River. HAZUS-MH MR3 profiles for the remaining counties do not indicate riverine backup flooding to a significant extent.

Region 2 exposure to coastal flooding is limited to the coastal counties of Cuyahoga, Lake and Lorain. The total building exposure is estimated at $2,396,004,000. The numbers of impacted structures by percent of the structure damaged are estimated to be: 1 to 10 percent damaged at 82, 11 to 20 percent damaged at 260, 21 to 30 percent damaged at 278, 31 to 40 percent damaged at 91, and 41 to 50 percent damaged at 20 and substantially damaged at 12. There are no essential facilities estimated as impacted. Estimates for business interruption and building loss are $500,000 and $82,690,000 respectively (see Table 2.8.b).

Table 2.8.b

Estimate of Potential Losses to Coastal Flooding Region 2										
County	Population	Building Exposure Value	1-10% Damage Count	11-20 % Damage Count	21-30% Damage Count	31-40% Damage Count	41-50% Damage Count	Substantial Damage Count	Essential Facilities Count	Estimated Business Interrupt	Estimated Property Loss
Cuyahoga	1,384,252	$1,033,868,000	2	19	16	0	2	0	0	$110,000	$10,410,000
Lake	227,324	$671,888,000	55	159	206	89	12	12	0	$240,000	$43,840,000
Lorain	285,798	$450,219,000	25	82	56	2	6	0	0	$150,000	$28,710,000
TOTAL	**1,897,374**	**$2,396,004,000**	**82**	**260**	**278**	**91**	**20**	**12**	**0**	**$500,000**	**$82,960,000**

Region 3 exposure to coastal flooding is limited to the coastal county of Ashtabula. The total building exposure is estimated at $240,290. The numbers of impacted structures by percent of the structure damaged are estimated to be: 1 to 10 percent damaged at 3, 11 to 20 percent damaged at 12, 21 to 30 percent damaged at 8, 31 to 40 percent damaged at 1, and 41 to 50 percent damaged at 0 and substantially damaged at 1. There are no essential facilities estimated as impacted. Estimates for business interruption and building loss are $80,000 and $5,280,000 respectively (see Table 2.8.c).

Table 2.8.c

Estimate of Potential Losses to Coastal Flooding Region 3										
County	Population	Building Exposure Value	1-10% Damage Count	11-20 % Damage Count	21-30% Damage Count	31-40% Damage Count	41-50% Damage Count	Substantial Damage Count	Essential Facilities s Count	Estimated Business Interrupt	Estimated Property Loss
Ashtabula	102,729	$240,029,000	3	12	8	1	0	1	0	$80,000	$5,280,000

GREAT LAKES COASTAL FLOOD STUDY

The FEMA has initiated a coastal analysis and mapping study to produce updated Digital Flood Insurance Rate Maps (DFIRMs) for coastal counties around the Great Lakes. This storm surge study is one of the most extensive coastal storm surge analyses to date, encompassing coastal floodplains in eight states. Ultimately, the study will update the coastal storm surge elevations for all of the U.S. shoreline of the Great Lakes. This new coastal flood hazard analyses will utilize updated 1-percent-annual chance stillwater elevations obtained from a comprehensive storm surge study conducted by the U.S. Army Corps of Engineers.

The effort to produce these maps for all the Great Lakes states began in 2012 and is expected to be completed in Ohio in 2020. The resulting DFIRMs will introduce VE Zones to Ohio and the Great Lakes Region. A VE Zone is used on a DFIRM to differentiate coastal high hazard areas from the rest of the 1%-annual-chance flood hazard area (100-year floodplain). The Zone VE designation indicates that during the 1%-chance-annual flood, wave hazards are expected to be particularly strong and have the potential to cause structural damage.

Zone VE is mapped for areas that meet one of more of the following criteria:

1. Wave runup depth exceeds 3 feet relative to the ground,
2. Wave overtopping rate exceeds 1cfs/ft.,
3. Wave heights exceed 3 feet in areas of overland wave propagation, or
4. The primary frontal dune.

Figure 2.8c illustrates wave runup and overtopping as well as overland wave propagation.

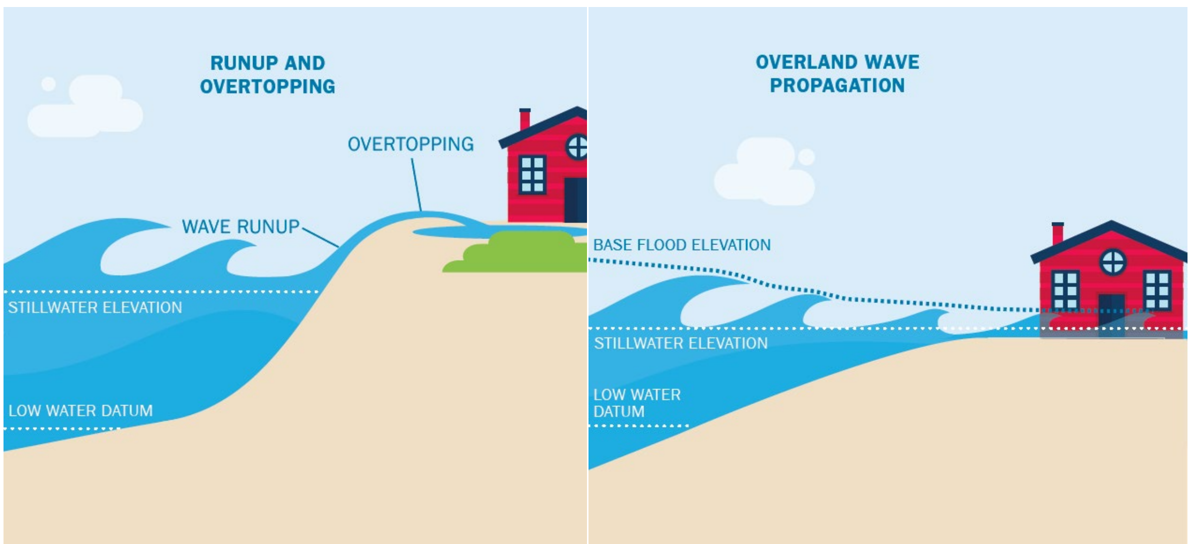


Figure 2.8d illustrates how the VE Zone designations on the FIRM relate to the wave risk.

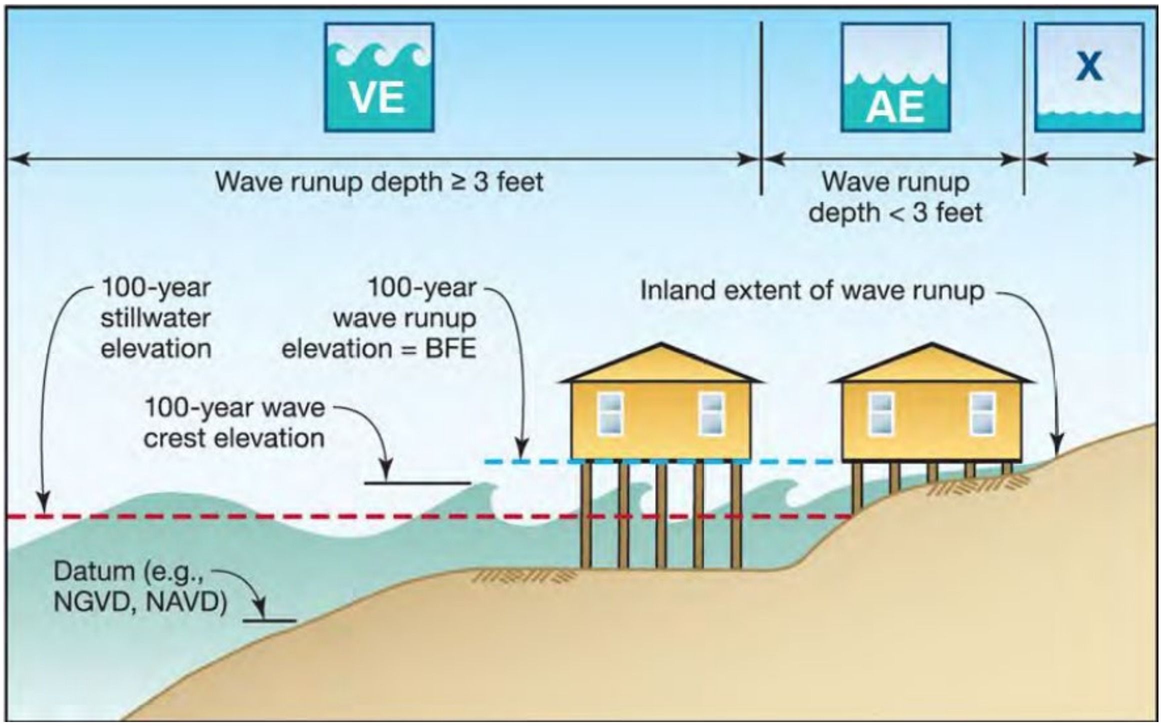


Table 2.8c summarizes building exposure based on analysis performed by the ODNR Office of Coastal Management using Preliminary DFIRM data and county auditor data. The results of this analysis will change as the Preliminary DFIRMs are reviewed and undergo the appeals period.

Table 2.8.c

County	Total Coastal Parcels	Parcels in V-Zone	Parcels with Buildings in V-Zone
Lucas	590	333	1
Ottawa	2,511	1,675	111
Erie	1,982	1,212	20
Lorain	962	1,019	28
Cuyahoga	899	875	24
Lake	1,111	1,070	20
Ashtabula	792	818	29
Total	8847	7002	233

* Sandusky County does not have identified V Zones

FEMA NATIONAL RISK INDEX: COASTAL FLOODING

The FEMA National Risk Index (NRI) is a dataset and online tool to help illustrate the United States communities most at risk for 18 natural hazards. For Coastal Flooding, the Expected Annual Loss was determined by multiplying the frequency, exposure, and the historical loss ratio. Agricultural losses were not assessed. This equation was calculated to determine population and building losses. For more information on current methods and data, refer to section 7 of the National Risk Index Technical Manual.

Table 2.2.j

FEMA National Risk Index Coastal Flood Analysis, October 2023								
County	2020 Population	Exposure (Population)	Exposure (Agriculture)	Exposure (Buildings)	Expected Annual Loss (Pop. Equivalence)	Expected Annual Loss (Agriculture)	Expected Annual Loss (Buildings)	Expected Annual Loss (Total)
Ashtabula	97,574	280	N/A	$ 78,503,225	$ 69	N/A	$ 14,620	$ 14,690
Cuyahoga	1,264,817	438	N/A	$ 139,084,941	$ 99	N/A	$ 23,874	$ 23,973
Erie	75,622	2,589	N/A	$ 1,454,140,494	$ 645	N/A	$ 282,595	$ 283,240
Lake	232,603	1,205	N/A	$ 284,392,853	$ 306	N/A	$ 51,464	$ 51,770
Lorain	312,964	1,569	N/A	$ 332,291,859	$ 334	N/A	$ 53,730	$ 54,064
Lucas	431,279	4,468	N/A	$ 658,094,972	$ 691	N/A	$ 85,150	$ 85,841
Ottawa [1]	40,364	0	N/A	$ -	$ -	N/A	$ -	$ -
Sandusky	58,896	480	N/A	$ 134,233,025	$ 111	N/A	$ 22,602	$ 22,713

1 – Despite having 94 miles of coastline along Lake Erie, the NRI results for Ottawa County to Coastal Flooding was zero. Due to this, the NRI Expected Annual Loss estimates for Ottawa County are not indicative of their actual risk to Coastal Flooding.

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

Using HAZUS-MH MR3 results and the FIRMs for the coastal counties, state- owned and state-leased facilities were evaluated for their involvement with seiche/coastal hazards. While all eight coastal counties were evaluated, only three of those contained facilities that could be at risk of flooding via seiche or coastal flooding, and all three are in Region 1. Table 2.8.d lists the results of this analysis.

One state-owned critical facility was located in the hazard area in Lucas County, which represents $153,000 at risk. While this facility is operated by the ODNR, it is a watercraft office that would be crucial to immediate response and rescue necessities. In terms of non-critical facilities, over 90 percent of those identified are located in Lucas County, and the majority of those involve state park facilities. Only one state-leased non-critical facility was noted to be at risk, and it is located in the City of Sandusky, Erie County, representing over $80,000 in annual rent at risk. It should be noted that no state-leased critical facilities were determined to be at risk to this hazard.

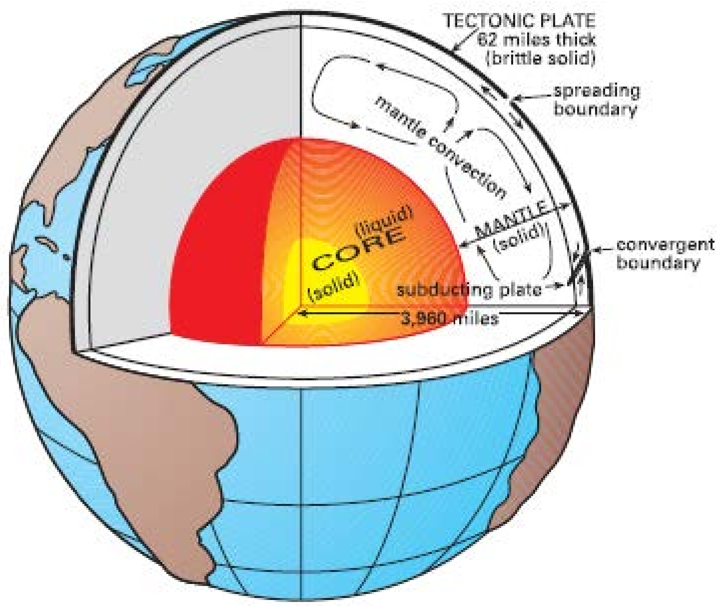
Table 2.8.d

Estimated Losses from Coastal Flooding for State-Owned and State-Leased Facilities						
County	State-Owned Critical Facility Count	State-Owned Critical Facility Value	State-Owned Non-Critical Facility Count	State-Owned Non-Critical Facility Value	State-Leased Non-Critical Facility Count	State-Leased Non-Critical Facility Rent
Erie	0	$0	5	$674,495	1	$82,131
Lucas	1	$153,000	33	$24,256,560	0	$0
Ottawa	0	$0	0	$0	0	$0
Sandusky	0	$0	6	$799,680	0	$0
TOTAL	**1**	**$153,000**	**44**	**$25,730,735**	**1**	**$82,131**

2.9 EARTHQUAKE

Earthquakes occur as a result of the constant motion of the earth. Current science describes the earth in three major regions: the core, mantle and crust. Figure 2.9a provides a three dimensional representation of the earth's regions. The core is hot and consists of two subsections. The very center of the planet's core is hottest and solid. Surrounding the solid center is a liquid (i.e. molten material/magma) layer. The mantle is cooler than the core and although solid, circulates with the consistency of malleable plastic. Through convection, the portion of the mantle closest to the core heats and subsequently rises in the same manner as the air in the earth's atmosphere. Conversely, the upper portion of the mantle transfers its heat to the crust, cools and descends back toward the core.

Figure 2.9a



Interior zones of Earth (figure modified from Washington Division of Geology and Earth Resources, Information Circular No. 85, 1988). Earth's crust consists of great plates that slowly move across the surface of Earth in response to convection cells in the mantle. Most earthquakes occur where plates meet, such as at spreading or convergent boundaries.

Source: Educational Leaflet No. 9 Revised Edition 2020 Division of Geological Survey

The crust is also solid; however, unlike the mantle it is rigid and brittle. The crust consists of a number of individual plates, each in constant motion, resting on the mantle. The boundaries where plates meet are the locations where new crust develops (spreading boundary) and alternately existing crust material returns to the mantle (convergent boundary).

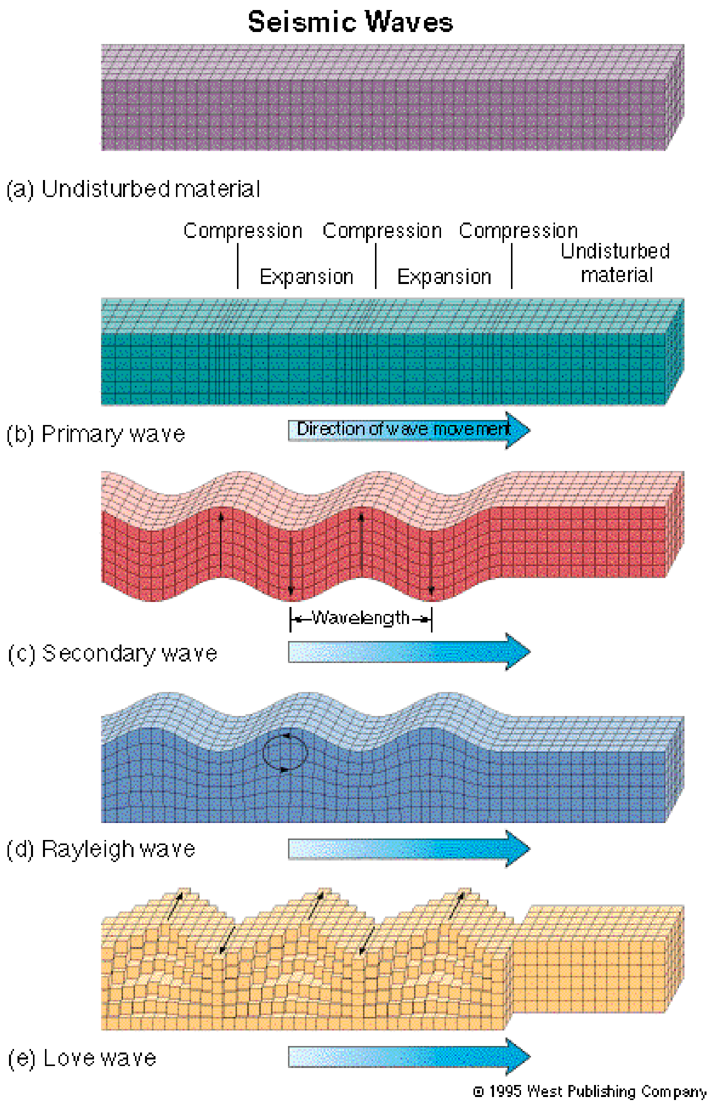
Understanding the composition of the earth is crucial because earthquakes are often associated with boundaries where the plates slide against, rise over or sink under each other. The movement at many of the plate boundaries is not smooth and consistent, but rather grinds and jerks. As entire plates move the boundaries become locked together and enormous amounts of tension build until a sudden release occurs, realigning the plate edges and creating the observed earthquake.

The locations where the crust is fractured and sliding are called faults. California has several famous faults (e.g. the San Andreas Fault), which can be clearly observed though aerial photography. In cases where the crust is pulling apart, the location is called a rift. The Reelfoot Rift and associated rift valley located in Missouri is one of the largest in North America. Ohio geologically contains both fault and rift zones.

Another significant source of earthquakes is associated with large bodies of magma, which are located near the earth's crust. The Hawaiian archipelago and Yellowstone National Park are examples where magma deposits are altering the crust and generating both volcanic activity and earthquakes.

Earthquake locations are recorded based on the latitude and longitude of the occurrence, called the epicenter, and the associated depth underneath the earth's surface. The energy released in earthquakes travels from the epicenter in seismic waves through the earth. The four major types of waves are often referred to as primary, secondary (body waves), Rayleigh and Love (surface waves) (Figure 2.9.b). Primary waves compress the earth's surface in front of it as they travel. Secondary waves cause the earth's surface to rise and fall perpendicular to its line of travel. Rayleigh waves travel in a circulating pattern similar to those in an ocean wave. Finally, Love waves cause the earth's surface to oscillate from side to side perpendicular to its line of travel. The primary and secondary waves travel faster than the Rayleigh and Love waves providing the initial evidence of an event.

Figure 2.9b



Source: West Publishing Company

Figure 2.9c

	Modified Mercalli Intensity
I	Detected only by sensitive instruments.
II	Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing.
III	Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly, vibrations feel like passing truck.
IV	Felt indoors by many, outdoors by few, at night some awaken; dishes, windows, doors disturbed; standing autos rock noticeably.
V	Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects.
VI	Felt by all, many frightened and run outdoors; falling plaster and chimneys, damage minor.
VII	Everybody runs outdoors; damage to buildings varies depending on quality of construction; noticed by drivers of autos.
VIII	Panel walls thrown out of frames; walls, monuments, and chimneys fall; sand and mud ejected; drivers of autos disturbed.
IX	Buildings shifted off foundations, cracked, or thrown out of plumb; ground cracked; underground pipes broken.
X	Most masonry and frame structures destroyed; ground cracked; rails bent; landslides.
XI	Few structures remain standing; bridges destroyed; fissures in ground, pipes broken; landslides; rails bent.
XII	Damage total; waves seen on ground surface, lines of sight and level distorted; objects thrown up into air.

Magni-tude: 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8

Scale showing general relationship between epicentral Modified Mercalli Intensities and magnitude. Intensities can be highly variable, depending on local geologic conditions. Modified from D. W. Steeples, 1978, Earthquakes: *Kansas Geological Survey pamphlet.*

Source: [*Educational Leaflet No. 9 Revised Edition 2020 Division of Geological Survey*]

Each wave affects structures differently. For example, secondary waves have much greater impact in tall structures. Additionally, each wave has unique characteristics. The secondary wave, for example, cannot travel through fluids, including the molten outer core.

Location of earthquake events has the added dimension of land / crust composition. Within the United States, areas like southern California are primarily young, hot rock that is broken by mountain ranges. Under these conditions seismic waves are somewhat limited in their ability to travel (attenuation) reducing the overall area of impact. Conversely, seismic zones in the central and eastern United States have flat-lying, cold, brittle rocks with much thicker deposits of soil and sediments. Loosely consolidated materials such as sand and soil cause seismic waves to amplify ground motion.

When seismic waves travel through unconsolidated materials it can have the effect of turning solid land into quicksand. When this phenomenon, called liquefaction, occurs, any object located in the affected area may slide over or sink into the soil. Entire buildings, roadways and bridges may be significantly damaged. One factor which greatly determines the extent of damage from an event is duration. Events can last anywhere from a few seconds to minutes. The longer the event is promulgating seismic waves the greater the opportunity for damage.

According to the US Geological Survey, The Modified Mercalli Intensity Scale (MMI) (Figure 2.9.c) was developed in 1931 and is currently used to evaluate the effects of earthquakes. It is composed of increasing levels of intensity that does not have a mathematical basis—only an arbitrary ranking based on observed effects.

RISK ASSESSMENT

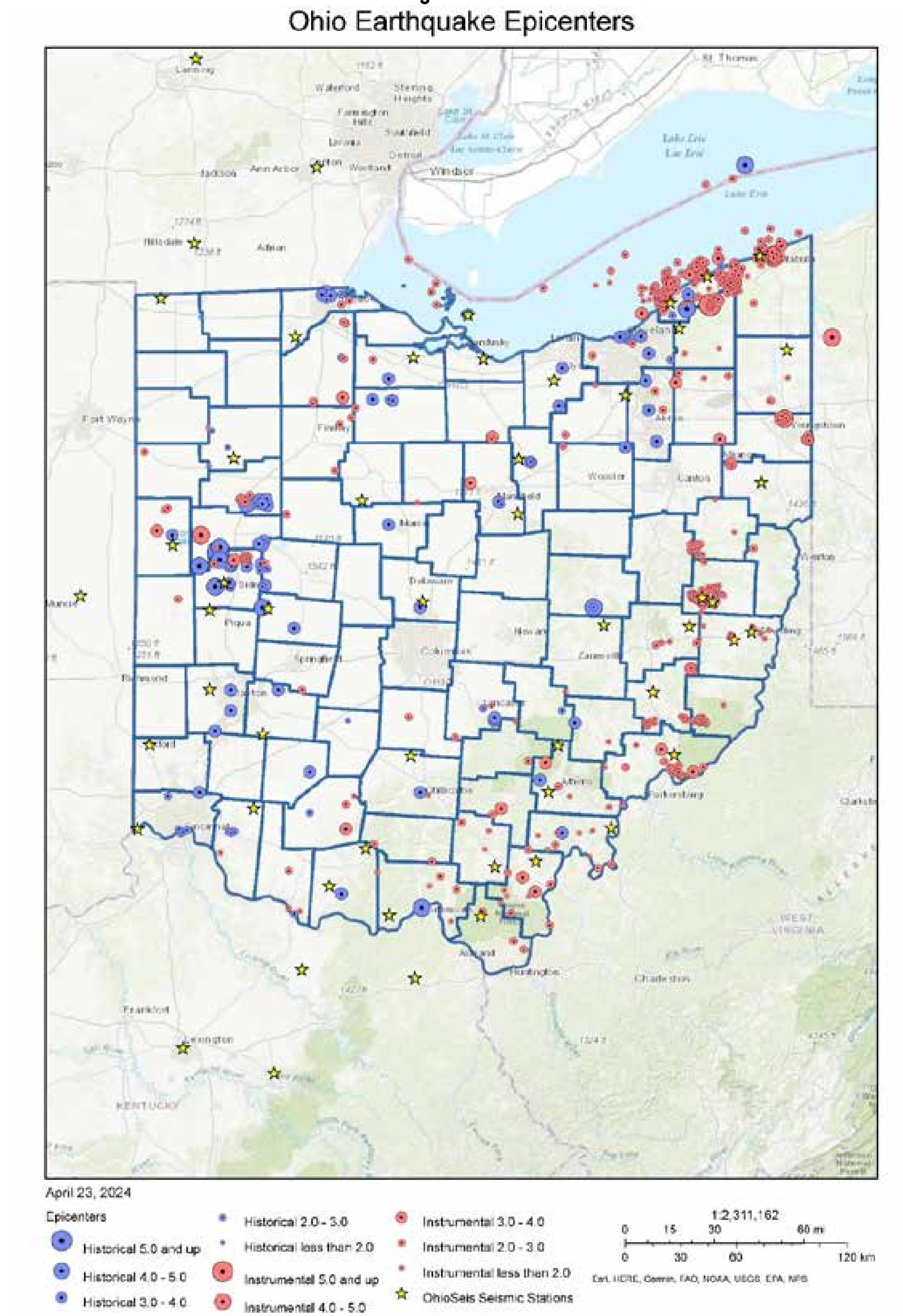
LOCATION

Earthquakes in Ohio are primarily located in the northeast and far west- central portions of the state and historically have not exceeded 5.4 magnitude (Figure 2.9.d). The map of historical epicenters lists all the events with magnitudes greater than 2.0. The size of the location marker increases with the magnitude of the event. Red circles represent instrumentally recorded events. Blue circles represent non-instrument recorded.

The epicenter map clearly identifies the northeast Ohio counties of Ashtabula, Geauga and Lake as one of the most earthquake-prone areas. Similarly, another earthquake-prone area is located in the west-central Counties of Auglaize, Champaign, Logan, Mercer, and Shelby. Although there are clear clusters of activity, a limited number of events have occurred and are spread over a large portion of the state.

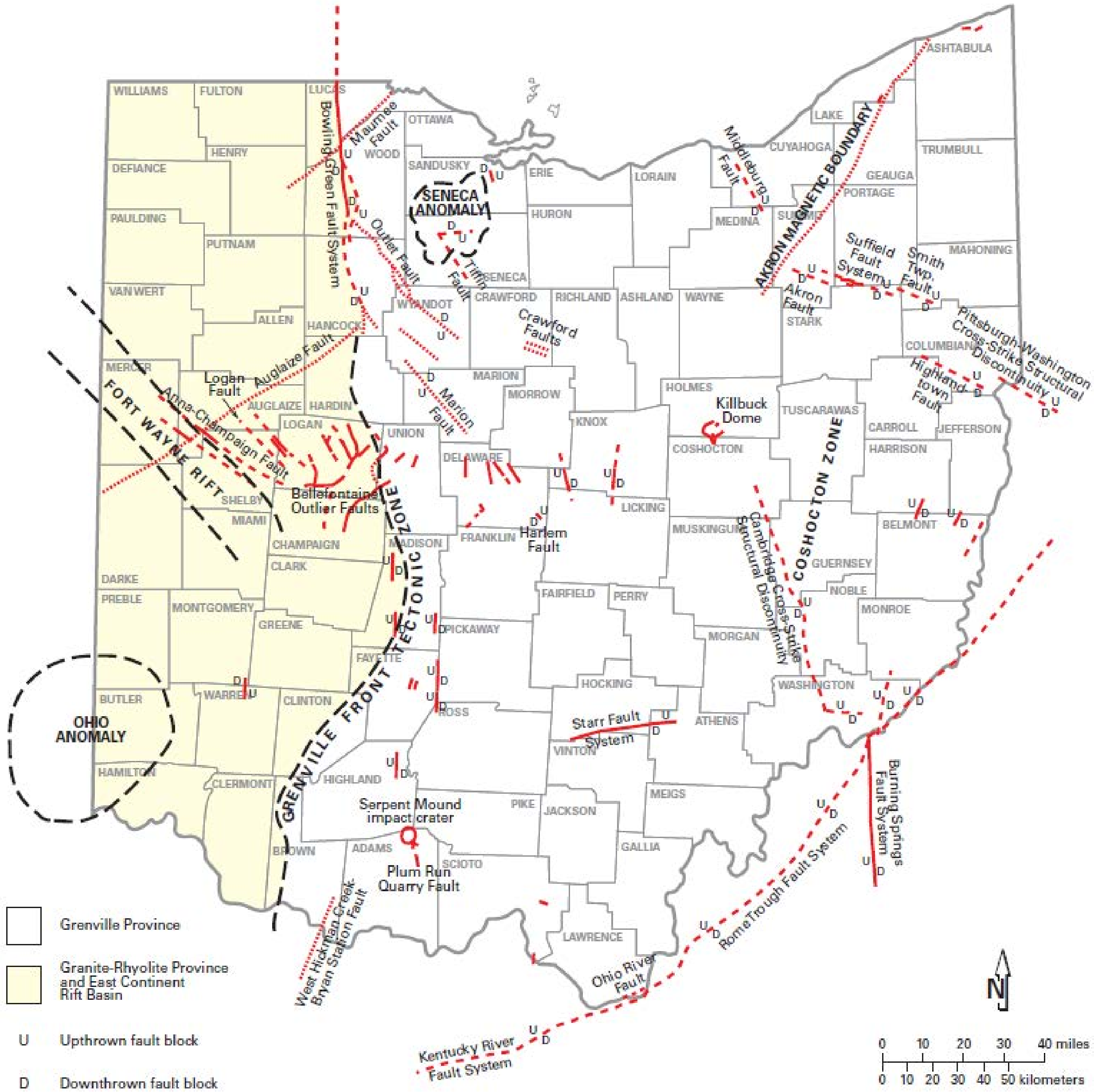
According to information published by the ODNR Division of Geological Survey, the origins of Ohio earthquakes, as with earthquakes throughout the eastern United States, are poorly understood at this time. Those in Ohio appear to be associated with ancient zones of weakness in the Earth's crust that formed during continental collision and mountain-building events about one billion years ago. These zones are characterized by deeply buried and poorly known faults, some of which serve as the sites for periodic release of strain that is constantly building up in the North American continental plate due to continuous movement of the tectonic plates that make up the Earth's crust.

Figure 2.9.d



Source: *[Educational Leaflet No. 9 Revised Edition 2020 Division of Geological Survey]*

Figure 2.9.e



Basement structures in Ohio (modified from Baranoski, 2013). This map portrays a number of deep faults and other structures that have been identified by a variety of geologic studies. Some faults are well known, whereas others are speculative. Very few of them are visible at the surface. The Fort Wayne (Anna) rift in western Ohio is the site of numerous historic earthquakes.

Source: [Educational Leaflet No. 9 Revised Edition 2020 Division of Geological Survey]

The Division of Geological Survey has developed a map of geologic features, referred to as basement structures, which lie far below the earth's surface (see Figure 2.9.e). Several geologists have speculated the Akron Magnetic boundary is a fracture zone in crystalline rocks lying more than 6,000 feet below the surface. The Fort Wayne Rift along with the Anna-Champaign, Logan and Auglaize faults, though still poorly understood, can be evaluated using the existing understanding of how these structures behave.

LHMP DATA

Of the 858 earthquakes documented by the Ohio Department of Natural Resources, Lake, Ashtabula, and Shelby had the most occurrences of all counties in the state.

The Shelby County Hazards 2022 Mitigation Plan states utilized HAZUS to model a 5.0 magnitude event with an epicenter in the City of Sidney. During such an event, damages to water, natural gas, electric, and communications systems could be as high as $1.5 billion.

The Ashtabula Hazard 2019 Mitigation Plan ranked earthquake low amongst their other assessed hazards. While they assessed the hazard to have a high probability, the severity was deemed as limited. The plan utilized HAZUS to estimate damages of $646.52 million dollars in income and capital stock losses.

The Lake County Multi-Jurisdictional 2022 Hazard Mitigation Plan summarized public sentiment to earthquakes that was obtained through surveys. The majority (215, 57.70%) of respondents felt that they were not at all concerned with earthquakes. 149 respondents (37%) felt only somewhat concerned.

MIP LHMP HIRA ASSESSMENT

Earthquake ranked 5th amongst local hazard mitigation plans. It ranks first in frequency, response time, and impact on business and property. Overall, it ranks first in cumulative scoring.

Table 2.9.a -- Earthquake MIP LHMP HIRA ASSESSMENT								
Ranking	**6**	**10**	**2**	**7**	**4**	**4**	**5**	**1**
Criteria Score	**1.99**	**3.25**	**4.22**	**1.79**	**1.58**	**1.72**	**1.57**	**16.13**
	Hazard Frequency	Response Time	Onset Time	Magnitude	Impact on Business	Impact on Humans	Impact on Property	Cumulative Score

NATIONAL LEVEL EXERCISE, 2011 (NLE-11)

In September 2010, Ohio EMA's Mitigation Section was consulted to provide HAZUS runs for an earthquake tabletop exercise scenario. The scenario was designed for selected counties in southwest Ohio in preparation for NLE-11 (National Level Exercise 2011). The purpose is to test critical resource logistics and catastrophic planning in conjunction with FEMA Region V and participating States. HAZUS runs were produced for Hamilton, Butler, Clermont, Darke, Scioto and Warren Counties with a 5.7 moment magnitude scale epicenter in downtown Cincinnati to a depth of 10 kilometers.

The aggregate HAZUS runs resulted in 79,070 buildings with moderate damage and 4,418 buildings beyond repair. Four hundred eighty-seven (487) essential facilities would be less than 50% functional. One thousand four hundred sixty-eight (1,468) transportation systems and 201 utility systems would be damaged. Destruction is projected to produce 3.513 million tons of debris and 93 fire ignitions resulting 13,490 people displaced from their residences with $1,248,000,000 in damage. The social impact estimates 179 fatalities, 123 people with life-threatening injuries, 901 people would have to be hospitalized and 3,871 would have to be treated with first aid or at an aid station. Eight thousand eight hundred six (8,806) people would seek temporary shelter. The economic impact is projected to result in $10,828,490,000 in lost income and, $2,050,500,000 in capital stock loss. It is estimated to take 15 years for economic recovery from this event.

PAST OCCURENCES

Earthquakes are a continuously occurring hazard in Ohio. Data are available for events dating back almost 250 years. Most of Ohio's earthquake events are small, registering between 2 and 4 magnitudes. Significant events are discussed in Geological Survey document Educational Leaflet No. 9, which follows. The Ohio Department of Natural Resources have documented 795 earthquakes that have occurred since 1776.

September 19, 1884: An earthquake in the vicinity of Lima (Allen County) had an epicentral Modified Mercalli Intensity Scale (MMI) of VI. There were reports of fallen ceiling plaster as far away as Zanesville (Muskingum County) and Parkersburg, West Virginia. On the basis of area feeling the earthquake (140,000 square miles), it is estimated to have had a magnitude of 4.8. Workmen on top of the Washington Monument in Washington, D.C., reported feeling this earthquake.

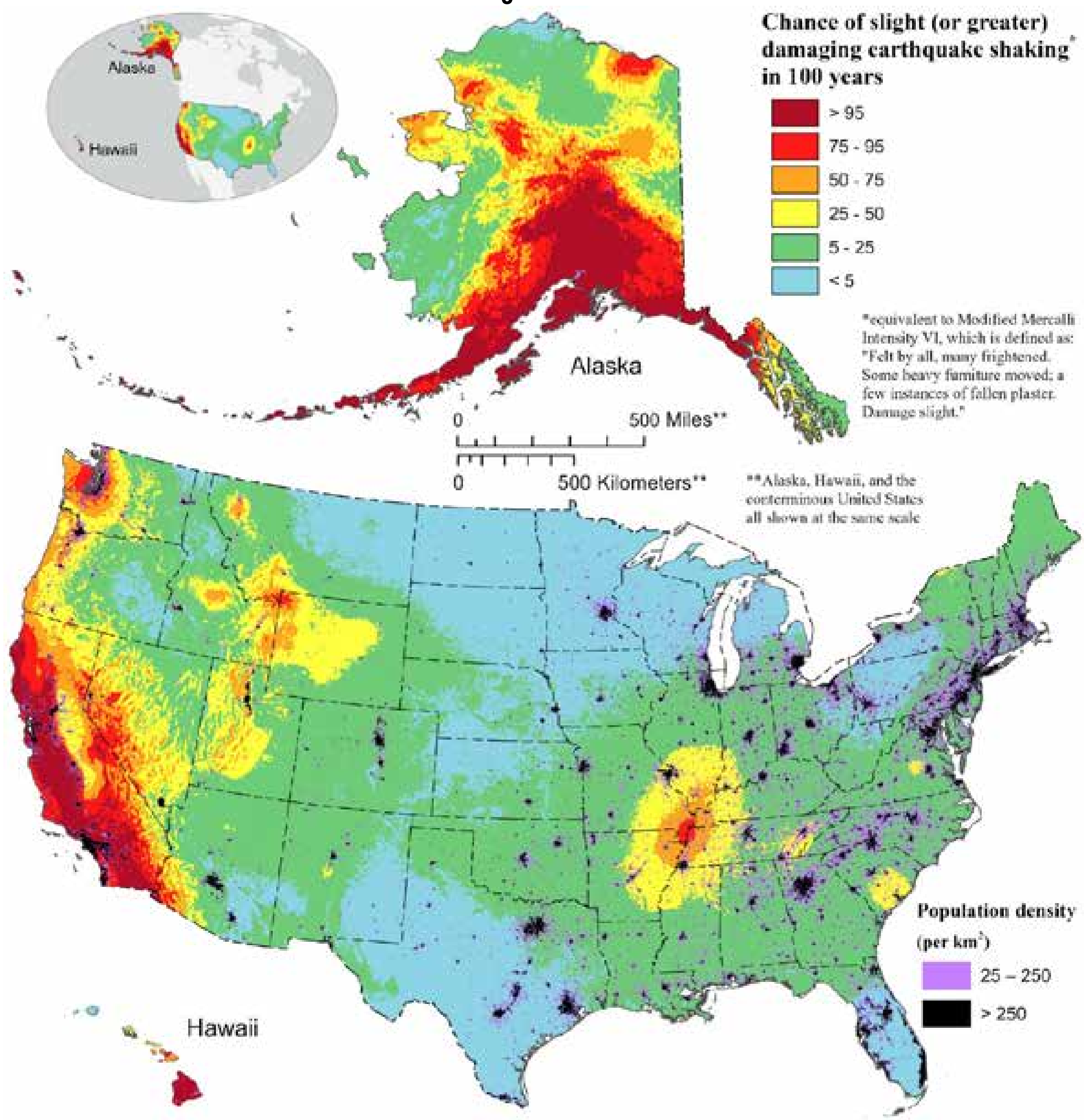
September 20, 1931: In this event, Anna and Sidney in Shelby County experienced toppled chimneys and cracked plaster. Store merchandise and crockery were knocked off shelves, and stones were jarred loose from the foundation of the Lutheran church in Anna. A ceiling collapsed in a school at Botkins, north of Anna. An MMI of VII and a magnitude of 4.7 have been assigned to this earthquake.

March 2 and 9, 1937: These two earthquakes are the most damaging to have struck Ohio. Maximum intensities were experienced at Anna (Shelby County), where an MMI of VII was associated with the March 2 event and an MMI of VIII with the March 9 event. In Anna, chimneys were toppled, organ pipes were twisted in the Lutheran church, the masonry school building was so badly cracked that it was razed, water wells were disturbed, and cemetery monuments were rotated. Both earthquakes were felt throughout a multi-state area—plaster was cracked as far away as Fort Wayne, Indiana. The March 9th event was felt throughout an area of about 150,000 square miles. Analysis of seismograms from these earthquakes by the U.S. Geological Survey (Stover and Coffman, 1993) assigned magnitudes of 4.7 and 4.9, respectively, to these events. On the basis of felt area, these earthquakes have been assigned magnitudes of 4.9 and 5.4, respectively.

January 31, 1986: This earthquake, which had a magnitude of 5.0 and an MMI in the high VI range, occurred in Lake County, east of Cleveland, in the general vicinity of a 1943 event with 4.5 magnitude. The 1986 earthquake cracked plaster and masonry, broke windows, and caused changes in water wells. The epicenter was only a few miles from the Perry nuclear power plant. It is the most intensively studied earthquake in Ohio and was the subject of several scientific reports (i.e., Nicholson and others, 1988).

PROBABILITY OF FUTURE EVENTS

Figure 2.9.f



Source: https://pubs.usgs.gov/of/2002/ofr-02-420/USpga500v3-508.pdf

Earthquakes have affected Ohio as early in history as written and oral records exist. There is clear precedence to expect Ohio will continue to experience seismic events for the foreseeable future. Probabilities of future events have been developed and mapped by the USGS (Figure 2.9.f). The measurement used in this estimation is based on the chance of ground shaking (e.g. peak ground acceleration) as a percentage of the natural force of gravity over time. In this analysis the extreme southwestern portion of Ohio has one in ten-chance of experiencing an earthquake equal in force to three percent of the earth's gravity in the next 50 years due to its proximity to the New Madrid seismic zone. When accounting for all earthquakes of any magnitude, an earthquake is likely to occur in any of the three regions in any given year.

From January 1950 to April 2024 (74 years), Ohio experienced 775 earthquakes. West of Interstate I-71, there had been fewer earthquakes with most of the seismicity is concentrated within the Anna Seismic Zone of Shelby, Auglaize, and Logan County. The average magnitude for this part of the state is 1.81 ML. More earthquakes have been experienced (historically and currently) east of I-71 where the average magnitude for the area is 2.60 ML and most of the seismicity is localized in Lake and Ashtabula counties. Although future earthquake events are highly likely to occur in Ohio, fortunately the state has not experienced any recorded loss of life due to earthquakes. Damages are commonly limited to poorly built structures.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHODOLOGY

Loss estimates for Ohio's earthquake hazard were developed using FEMA's hazard analysis and loss estimation software HAZUS-MH 6.0 and its ability to simulate arbitrary events. HAZUS has been used successfully for over a decade in California's earthquake preparation and response efforts. Results should be interpreted as estimates and cannot be considered precise losses.

There were two methods used in analyzing the vulnerabilities and loss estimates of all counties across Ohio: HAZUS 6.0 Earthquake Scenarios (Method 1), and the FEMA National Risk Index (Method 2).

METHOD 1: HAZUS 6.0 Earthquake Scenarios

The first method assessed historical hotspots of seismic activity. Shelby County had experienced Ohio's strongest earthquake to date at 5.4 magnitude while Lake County had experienced the state's second strongest at 5.0 magnitude. Based on this information, HAZUS was used to simulate similar events in a Lake County in Northeast Ohio, and Shelby County in Western Ohio. Historic parameters of the events were used to re-model the events if they were to happen today: Location (of epicenter), magnitude, and depth. It is expected that losses will expand outward contiguously to other counties across the state. The cost of the damage is to the surrounding area will vary greatly on which county the earthquake is located.

There are four damage classifications used for each HAZUS run: Slight, Moderate, Extensive, and Complete. The descriptions for each would vary depending on the type of building damaged. For the complete definitions for different types of building category, refer to section 7.7.1 of the HAZUS Earthquake Model User Guidance.

RESULTS

Figure 2.9.g – Method 1, Scenario A: Shelby County 5.4 ML EQ Event (40.47°, -84.28°), 3 km-Depth, (x$1,000)

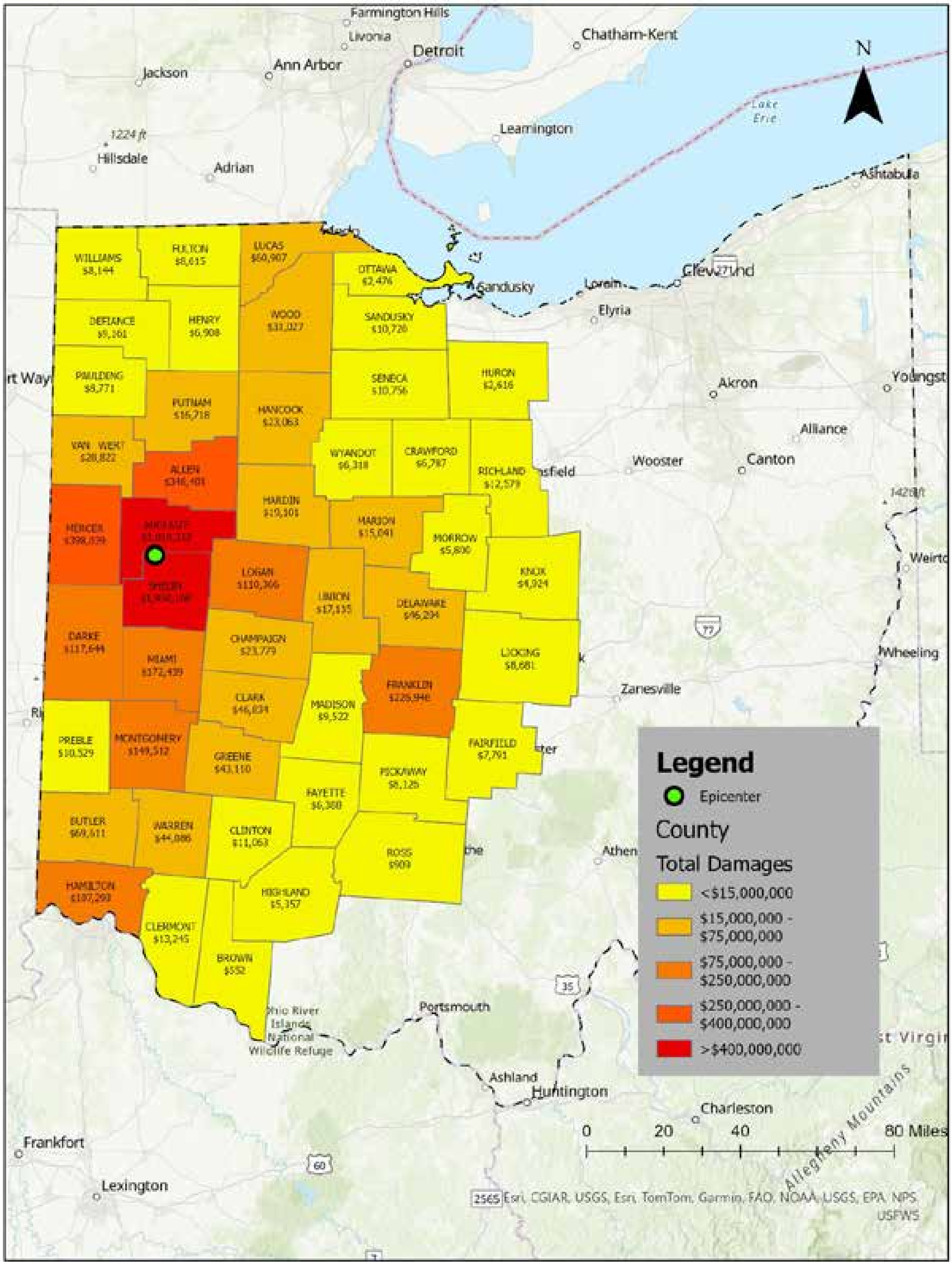


Table 2.9.b

HAZUS 6.0 Estimated Losses to Earthquake							
Shelby County 5.4 Magnitude Earthquake Event (40.47°, -84.28°)							
County	**Slight Damage Count**	**Moderate Damage Count**	**Extensive Damage Count**	**Complete Damage Count**	**Income Losses [1]**	**Capital Stock Losses [2]**	**Total Losses**
Auglaize	5,297	3,384	1,312	497	$ 333,672,000	$ 1,476,639,000	$ 1,810,311,000
Shelby	4,761	3,055	1,212	429	$ 193,494,000	$ 1,256,673,000	$ 1,450,167,000
Mercer	3,117	1,480	329	39	$ 80,731,000	$ 317,308,000	$ 398,039,000
Allen	4,061	1,493	271	31	$ 71,404,000	$ 276,995,000	$ 348,399,000
Franklin	5,747	1,609	195	8	$ 91,079,000	$ 135,866,000	$ 226,945,000
Miami	2,700	931	156	15	$ 40,579,000	$ 131,859,000	$ 172,438,000
Montgomery	4,231	1,232	157	9	$ 55,642,000	$ 93,870,000	$ 149,512,000
Darke	1,702	666	112	9	$ 20,417,000	$ 97,227,000	$ 117,644,000
Logan	1,911	678	108	11	$ 26,411,000	$ 83,955,000	$ 110,366,000
Hamilton	2,958	917	94	3	$ 44,404,000	$ 62,888,000	$ 107,292,000
ALL OTHER COUNTIES (39)	20,150	5,849	667	22	$ 227,850,000	$ 444,423,000	$ 672,273,000
TOTAL	56,635	21,294	4,613	1,073	$ 1,185,683,000	$ 4,377,703,000	$ 5,563,386,000

1- Income Losses include: Wage, capital-related, rental, and relocation costs.
2- Capital Stock Losses include: Building (structural and non-structural), content, and inventory losses.

Due to the parameters of this scenario, HAZUS estimates that the damage area of an event like this will affect over 49 counties in the state. Not only is this event modeled on a 5.4 magnitude event, but also at a much shallower 3.0-kilometer depth as compared to the Lake County 5.0 magnitude scenario. HAZUS results for building counts indicate 56,635 slight, 21,294 moderate, 4,613 extensive and 1,073 completely impacted structures. Income losses are estimated to reach $1.18 billion and capital-stock losses are estimated at $4.37 billion. Auglaize, Shelby, Mercer, Allen, Franklin, Miami, Montgomery, Darke, Logan, and Hamilton counties are the top ten of 49 counties estimated to see damages from this event. Auglaize and Shelby had the highest losses and together accounted for 59-percent of the estimated $5.56 billion in total losses. Damage is likely to extend out to counties located in eastern Indiana.

HAZUS estimates that there will be one hospital, twelve schools, seven police station, and seven fire stations that will see at least moderate damage (>50 percent). Additionally, there will be eleven bridges, one railway facility, and one airport facility that will see at least moderate damage. On the first day, 1,890 households will be without potable water service and 17,343 households without electric power. Within one week, the numbers will drop to 0 households without water and 7,574 households without electricity.

Figure 2.9.g – Method 1, Scenario B: Lake County 5.0 ML EQ Event (41.65°, -81.162°), 5 km-Depth, (x$1,000)

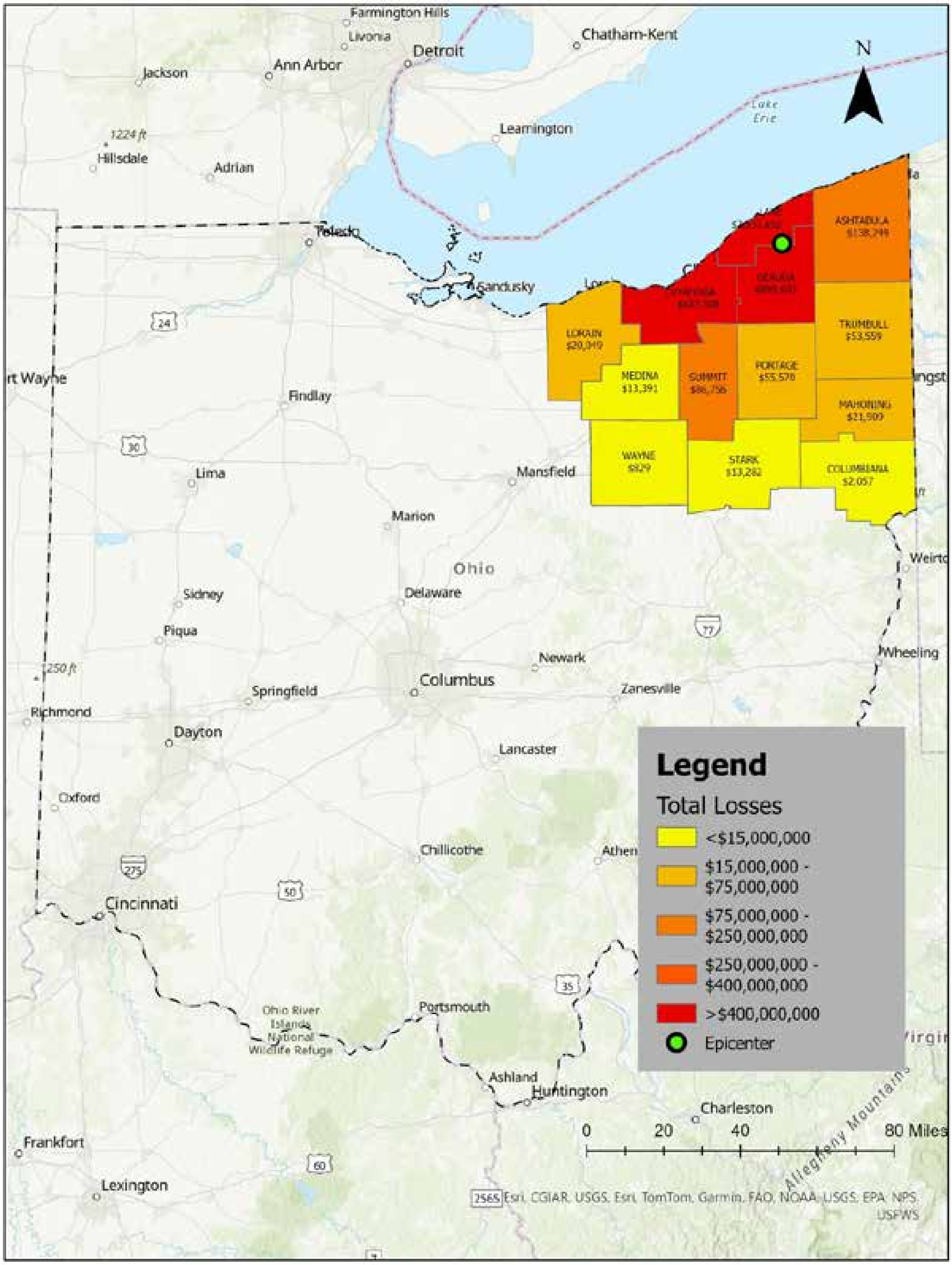


Table 2.9.c

HAZUS 6.0 Estimated Losses to Earthquake							
Lake County 5.0 ML Earthquake Event (41.65°, -81.16°)							
County	Slight Damage Count	Moderate Damage Count	Extensive Damage Count	Complete Damage Count	Income Losses [1]	Capital Stock Losses [2]	Total Losses
Lake	17,063	8,131	2,205	496	$ 399,473,000	$ 2,132,179,000	$ 2,531,652,000
Geauga	5,509	2,691	781	189	$ 149,436,000	$ 750,167,000	$ 899,603,000
Cuyahoga	12,216	3,652	534	44	$ 158,434,000	$ 475,074,000	$ 633,508,000
Ashtabula	2,389	811	130	14	$ 35,115,000	$ 103,134,000	$ 138,249,000
Summit	2,402	669	79	3	$ 27,520,000	$ 59,236,000	$ 86,756,000
Portage	1,286	391	47	2	$ 15,013,000	$ 40,557,000	$ 55,570,000
Trumbull	1,493	441	50	2	$ 16,148,000	$ 37,411,000	$ 53,559,000
Mahoning	859	235	23	0	$ 8,031,000	$ 13,878,000	$ 21,909,000
Lorain	755	201	21	0	$ 7,350,000	$ 12,699,000	$ 20,049,000
Medina	475	126	12	0	$ 4,492,000	$ 8,899,000	$ 13,391,000
ALL OTHER COUNTIES (3)	636	168	15	0	$ 6,284,000	$ 9,884,000	$ 16,168,000
TOTAL	45,083	17,516	3,897	750	$ 827,296,000	$ 3,643,118,000	$ 4,470,414,000

1- Income Losses include: Wage, capital-related, rental, and relocation costs.
2- Capital Stock Losses include: Building (structural and non-structural), content, and inventory losses.

HAZUS results for building counts indicate 45,083 slight, 17,516 moderate, 3,897 extensive and 750 completely impacted structures. The total loss of income is estimated at $827,296,000 and capital stock losses are estimated at $3,643,118,000. Lake, Geauga, Cuyahoga, Ashtabula, Summit, Portage, Trumbull, Mahoning, Lorain, and Medina counties are the top ten estimated to see damages from this event. Lake, Geauga, and Cuyahoga had the highest losses and together accounted for 91 percent of the estimated $4,470,414,000 in total losses. Damages are likely to extend out to counties located in western Pennsylvania.

Results indicated minimal losses of utility, transportation and critical facilities. HAZUS estimates that there will be no essential facilities (hospitals, schools, EOCs, Police Stations, and/or Fire Stations) that will see at least moderate damage (>50 percent). Additionally, there are no transportations systems that will see at least moderate damage. On the first day, 40 households that will be without potable water service and 39,303 households without electric power. Within one week, the numbers will drop to 0 and 14,982 households respectively. While the number of households estimated to be without power is dramatically less than the Shelby County scenario, the number of households without electricity is about double. This is likely due to the event epicenter being in a much higher populated area.

Method 2: FEMA National Risk Index

The second method utilizes the FEMA National Risk Index to assess exposure and expected annual loss (EAL). An earthquake hazard risk index score and rating represent a community's relative risk for earthquake when compared to the rest of the United States. Generally, the earthquake exposure value represents a community's building values (in dollars), and population (in both people and population equivalence) exposed to earthquakes. The Expected Annual Loss (EAL) represents the relative level of building, and population loss each year due to earthquakes. For more information on current methodology and data, refer to section 10 of the National Risk Index Technical Manual.

Figure 2.9.i – FEMA National Risk Index Expected Annual Losses for Ohio

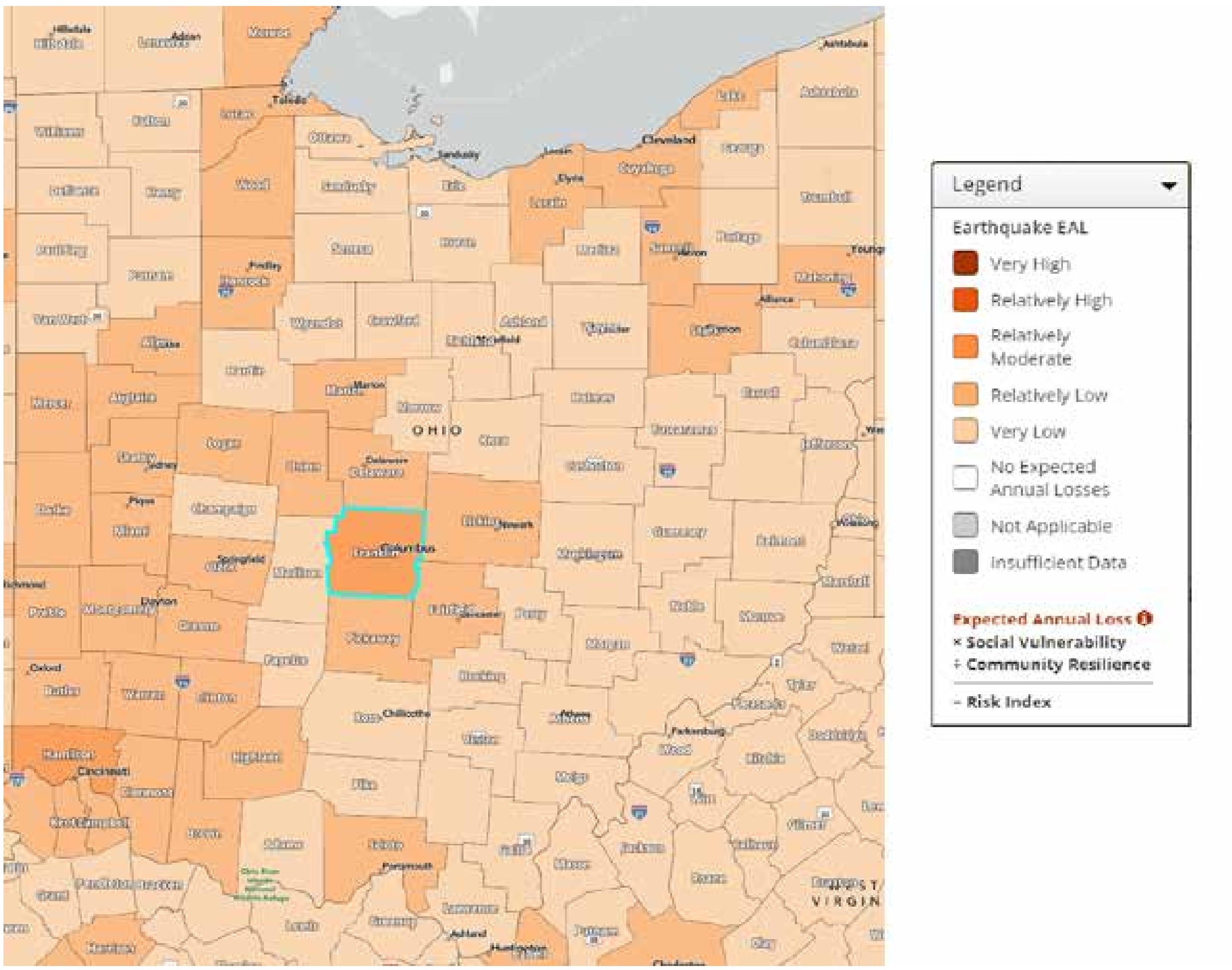


Table 2.9.d

FEMA National Risk Index Earthquake Analysis, October 2023, OEMA Region 1					
County	2020 Population	Exposure (Buildings)	EAL (Buildings)	EAL (Pop Equiv)	EAL (Total)
Allen	102,206	$ 22,716,390,000	$ 676,769	$ 149,411	$ 826,179
Auglaize	46,422	$ 9,860,406,000	$ 413,391	$ 91,924	$ 505,315
Champaign	38,714	$ 7,667,457,000	$ 187,396	$ 50,470	$ 237,865
Clark	136,001	$ 26,183,981,000	$ 613,477	$ 198,087	$ 811,565
Crawford	42,025	$ 7,313,758,000	$ 100,108	$ 26,949	$ 127,056
Darke	51,881	$ 14,008,966,000	$ 640,121	$ 183,081	$ 823,202
Defiance	38,286	$ 8,087,343,000	$ 134,968	$ 31,858	$ 166,826
Erie	75,622	$ 17,826,363,000	$ 160,459	$ 32,866	$ 193,324
Fulton	42,713	$ 9,457,982,000	$ 143,947	$ 29,585	$ 173,532
Hancock	74,920	$ 15,955,152,000	$ 285,062	$ 56,718	$ 341,781
Hardin	30,696	$ 5,771,695,000	$ 130,637	$ 37,761	$ 168,398
Henry	27,662	$ 6,671,358,000	$ 106,950	$ 24,449	$ 131,399
Huron	58,565	$ 12,267,749,000	$ 124,665	$ 33,128	$ 157,792
Logan	46,150	$ 13,072,391,000	$ 312,324	$ 56,310	$ 368,633
Lucas	431,279	$ 84,064,006,000	$ 945,215	$ 233,154	$ 1,178,369
Marion	65,359	$ 12,618,640,000	$ 234,991	$ 63,863	$ 298,855
Mercer	42,528	$ 13,482,727,000	$ 593,692	$ 140,423	$ 734,115
Miami	108,774	$ 24,042,551,000	$ 849,876	$ 224,897	$ 1,074,773
Ottawa	40,364	$ 13,873,147,000	$ 115,340	$ 19,737	$ 135,077
Paulding	18,806	$ 5,212,389,000	$ 143,593	$ 40,769	$ 184,362
Preble	40,999	$ 8,365,787,000	$ 246,950	$ 71,705	$ 318,655
Putnam	34,451	$ 6,676,094,000	$ 145,705	$ 37,328	$ 183,033
Sandusky	58,896	$ 13,862,967,000	$ 155,273	$ 33,507	$ 188,780
Seneca	55,069	$ 11,329,727,000	$ 148,902	$ 34,208	$ 183,111
Shelby	48,230	$ 14,107,251,000	$ 839,258	$ 213,653	$ 1,052,910
Van Wert	28,931	$ 5,627,905,000	$ 157,184	$ 39,908	$ 197,092
Williams	37,102	$ 9,168,213,000	$ 136,120	$ 26,116	$ 162,236
Wood	132,248	$ 34,369,777,000	$ 479,254	$ 96,972	$ 576,226
Wyandot	21,900	$ 4,936,380,000	$ 85,341	$ 22,101	$ 107,442

Table 2.9.e

FEMA National Risk Index Earthquake Analysis, October 2023, OEMA Region 2					
County	2020 Population	Exposure (Buildings)	EAL (Buildings)	EAL (Pop Equiv)	EAL (Total)
Ashland	52,447	$ 13,803,533,000	$ 91,833	$ 25,492	$ 117,325
Butler	390,357	$ 75,011,282,000	$ 1,889,953	$ 487,256	$ 2,377,209
Clinton	42,018	$ 10,399,925,000	$ 412,192	$ 152,420	$ 564,611
Cuyahoga	1,264,817	$ 244,268,216,000	$ 1,227,228	$ 306,427	$ 1,533,655
Delaware	214,124	$ 54,674,480,000	$ 643,483	$ 159,739	$ 803,223
Fairfield	158,921	$ 29,693,187,000	$ 291,581	$ 78,318	$ 369,899
Fayette	28,951	$ 7,200,490,000	$ 212,299	$ 49,656	$ 261,956
Franklin	1,323,807	$ 236,419,136,000	$ 3,627,252	$ 1,077,846	$ 4,705,098
Geauga	95,397	$ 21,951,144,000	$ 98,583	$ 20,522	$ 119,105
Greene	167,966	$ 32,904,117,000	$ 787,621	$ 265,283	$ 1,052,904
Hamilton	830,639	$ 153,886,223,000	$ 3,375,502	$ 1,056,355	$ 4,431,857
Knox	62,721	$ 14,262,798,000	$ 102,835	$ 30,323	$ 133,157
Lake	232,603	$ 45,763,174,000	$ 233,972	$ 54,183	$ 288,155
Licking	178,519	$ 37,618,491,000	$ 330,617	$ 86,049	$ 416,666
Lorain	312,964	$ 63,414,274,000	$ 488,486	$ 121,087	$ 609,573
Madison	43,824	$ 8,575,643,000	$ 205,145	$ 52,732	$ 257,877
Medina	182,470	$ 38,976,927,000	$ 160,726	$ 34,295	$ 195,021
Montgomery	537,309	$ 99,450,167,000	$ 2,329,265	$ 689,868	$ 3,019,133
Morrow	34,950	$ 6,739,957,000	$ 70,015	$ 18,501	$ 88,515
Pickaway	58,539	$ 12,399,592,000	$ 223,927	$ 57,733	$ 281,660
Portage	161,791	$ 32,692,427,000	$ 179,892	$ 47,298	$ 227,190
Richland	124,936	$ 24,197,977,000	$ 132,928	$ 28,856	$ 161,784
Stark	374,853	$ 76,094,295,000	$ 405,699	$ 100,378	$ 506,077
Summit	540,428	$ 108,470,549,000	$ 533,986	$ 120,159	$ 654,145
Union	62,784	$ 13,980,483,000	$ 274,647	$ 66,014	$ 340,661
Warren	242,337	$ 49,577,360,000	$ 1,147,271	$ 317,812	$ 1,465,083
Wayne	116,894	$ 24,061,823,000	$ 130,867	$ 28,664	$ 159,531

Table 2.9.f

FEMA National Risk Index Earthquake Analysis, October 2023, OEMA Region 3					
County	2020 Population	Exposure (Buildings)	EAL (Buildings)	EAL (Pop Equiv)	EAL (Total)
Adams	27,477	$ 7,249,941,000	$ 162,156	$ 43,940	$ 206,097
Ashtabula	97,574	$ 20,560,241,000	$ 110,324	$ 24,264	$ 134,588
Athens	62,431	$ 11,699,436,000	$ 108,956	$ 31,331	$ 140,288
Belmont	66,497	$ 13,488,212,000	$ 47,170	$ 12,654	$ 59,824
Brown	43,676	$ 8,791,535,000	$ 306,788	$ 85,802	$ 392,591
Carroll	26,721	$ 5,326,746,000	$ 18,802	$ 5,421	$ 24,222
Clermont	208,601	$ 36,077,593,000	$ 964,756	$ 292,136	$ 1,256,893
Columbiana	101,877	$ 21,193,052,000	$ 72,865	$ 22,181	$ 95,046
Coshocton	36,612	$ 7,743,292,000	$ 28,398	$ 7,175	$ 35,573
Gallia	29,220	$ 5,984,926,000	$ 78,384	$ 22,093	$ 100,477
Guernsey	38,438	$ 8,571,787,000	$ 44,273	$ 11,203	$ 55,477
Harrison	14,483	$ 2,837,065,000	$ 11,331	$ 3,188	$ 14,519
Highland	43,317	$ 10,507,219,000	$ 281,373	$ 84,736	$ 366,109
Hocking	28,050	$ 6,751,881,000	$ 54,108	$ 14,068	$ 68,176
Holmes	44,223	$ 11,951,380,000	$ 45,485	$ 9,229	$ 54,713
Jackson	32,653	$ 6,971,593,000	$ 97,467	$ 26,048	$ 123,516
Jefferson	65,249	$ 15,713,329,000	$ 43,843	$ 13,795	$ 57,638
Lawrence	58,240	$ 9,823,030,000	$ 126,030	$ 37,304	$ 163,335
Mahoning	228,614	$ 48,321,897,000	$ 222,944	$ 55,522	$ 278,466
Meigs	22,210	$ 4,708,976,000	$ 62,552	$ 22,620	$ 85,172
Monroe	13,385	$ 4,269,365,000	$ 21,201	$ 6,235	$ 27,436
Morgan	13,802	$ 2,734,268,000	$ 16,533	$ 4,886	$ 21,419
Muskingum	86,410	$ 18,106,494,000	$ 123,638	$ 37,462	$ 161,100
Noble	14,115	$ 4,120,282,000	$ 24,073	$ 9,457	$ 33,530
Perry	35,408	$ 5,607,834,000	$ 45,366	$ 15,910	$ 61,275
Pike	27,088	$ 6,578,241,000	$ 105,792	$ 24,278	$ 130,070
Ross	77,093	$ 13,696,693,000	$ 155,944	$ 44,167	$ 200,111
Scioto	74,008	$ 11,861,062,000	$ 215,625	$ 64,891	$ 280,516
Trumbull	201,977	$ 42,032,572,000	$ 200,202	$ 47,518	$ 247,720
Tuscarawas	93,263	$ 19,320,974,000	$ 97,757	$ 27,145	$ 124,902
Vinton	12,800	$ 2,259,076,000	$ 27,106	$ 9,959	$ 37,065
Washington	59,771	$ 11,589,435,000	$ 81,308	$ 22,466	$ 103,774

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

Method 2 of the Vulnerability Analysis and Loss Estimation utilized FEMA's National Risk Index to estimate values including exposures and expected annual losses. An "NRI Buildings Expected Annual Loss (EAL) to Exposure" ratio was determined by taking the (building) expected annual losses and dividing it by the exposure values for each county. To estimate the EAL for State-owned and State-leased critical facilities, the replacement costs of State-owned and State-leased Critical Facilities for each county was multiplied by the county's respective NRI EAL to Exposure ratio.

RESULTS

Region 2 had the highest estimated expected annual loss to state-owned and state-leased critical facilities due to the large presence and replacement costs of critical facilities. There is a total of $82,745 in expected annual losses across 1,684 facilities.

Region 1 and 3 were essentially tied in estimated expected annual loss to state-owned and state-leased critical facilities at $22,218 and $22,300 respectively. Region 1 had fewer critical facilities at 852, however had a greater NRI EAL to Exposure ratio. Region 3 had a greater number of critical facilities at 1,232 however due to having a smaller ratio, their expected annual losses are essentially the same as that of Region 1.

Results

Table 2.9.g

Expected Annual Loss of State-owned and State-leased Critical Facilities Earthquakes				
Region 1				
County	**Number of Critical Facilities**	**NRI Buildings EAL to Exposure Ratio**	**Replacement Cost of Critical Facilities**	**Expected Annual Loss to Critical Facilities**
Allen	99	0.0030%	$ 148,535,104	$ 4,425
Auglaize	18	0.0042%	$ 6,542,813	$ 274
Champaign	21	0.0024%	$ 9,246,093	$ 226
Clark	27	0.0023%	$ 9,650,921	$ 226
Crawford	12	0.0014%	$ 11,520,704	$ 158
Darke	27	0.0046%	$ 17,992,950	$ 822
Defiance	15	0.0017%	$ 12,622,416	$ 211
Erie	55	0.0009%	$ 150,149,608	$ 1,352
Fulton	12	0.0015%	$ 9,821,964	$ 149
Hancock	20	0.0018%	$ 12,221,847	$ 218
Hardin	18	0.0023%	$ 6,825,758	$ 154
Henry	16	0.0016%	$ 4,250,244	$ 68
Huron	22	0.0010%	$ 10,837,347	$ 110
Logan	21	0.0024%	$ 9,389,923	$ 224
Lucas	52	0.0011%	$ 274,497,738	$ 3,086
Marion	59	0.0019%	$ 237,054,145	$ 4,415
Mercer	27	0.0044%	$ 9,141,077	$ 403
Miami	30	0.0035%	$ 20,994,660	$ 742
Ottawa	52	0.0008%	$ 42,237,937	$ 351
Paulding	11	0.0028%	$ 8,375,637	$ 231
Preble	28	0.0030%	$ 7,555,862	$ 223
Putnam	19	0.0022%	$ 4,857,269	$ 106
Sandusky	14	0.0011%	$ 8,633,501	$ 97
Seneca	47	0.0013%	$ 47,263,740	$ 621
Shelby	35	0.0059%	$ 32,329,713	$ 1,923
Van Wert	16	0.0028%	$ 7,772,807	$ 217
Williams	17	0.0015%	$ 7,837,080	$ 116
Wood	40	0.0014%	$ 68,292,566	$ 952
Wyandot	22	0.0017%	$ 6,729,705	$ 116
Total	**852**	**0.0018%**	**$ 1,203,181,127**	**$ 22,218**

Table 2.9.h

Expected Annual Loss of State-owned and State-leased Critical Facilities Earthquakes				
Region 2				
County	**Number of Critical Facilities**	**NRI Buildings EAL to Exposure Ratio**	**Replacement Cost of Critical Facilities**	**Expected Annual Loss to Critical Facilities**
Ashland	145	0.0007%	$ 103,491,091	$ 689
Butler	29	0.0025%	$ 17,200,278	$ 433
Clinton	31	0.0040%	$ 13,450,515	$ 533
Cuyahoga	106	0.0005%	$ 389,621,908	$ 1,957
Delaware	33	0.0012%	$ 61,002,573	$ 718
Fairfield	67	0.0010%	$ 94,557,543	$ 929
Fayette	23	0.0029%	$ 11,052,410	$ 326
Franklin	190	0.0015%	$ 2,336,963,045	$ 35,855
Geauga	27	0.0004%	$ 12,064,728	$ 54
Greene	21	0.0024%	$ 17,560,307	$ 420
Hamilton	41	0.0022%	$ 113,316,790	$ 2,486
Knox	41	0.0007%	$ 76,691,482	$ 553
Lake	21	0.0005%	$ 12,988,101	$ 66
Licking	67	0.0009%	$ 186,741,453	$ 1,641
Lorain	83	0.0008%	$ 212,390,581	$ 1,636
Madison	104	0.0024%	$ 398,511,572	$ 9,533
Medina	17	0.0004%	$ 16,239,797	$ 67
Montgomery	72	0.0023%	$ 187,896,794	$ 4,401
Morrow	19	0.0010%	$ 12,996,574	$ 135
Pickaway	137	0.0018%	$ 346,622,641	$ 6,260
Portage	25	0.0006%	$ 17,793,583	$ 98
Richland	77	0.0005%	$ 236,998,425	$ 1,302
Stark	57	0.0005%	$ 148,641,582	$ 792
Summit	65	0.0005%	$ 197,956,468	$ 975
Union	55	0.0020%	$ 169,438,472	$ 3,329
Warren	109	0.0023%	$ 323,719,448	$ 7,491
Wayne	22	0.0005%	$ 12,202,802	$ 66
Total	**1684**	**0.0014%**	**$ 5,728,110,964**	**$ 82,745**

Table 2.9.i

Expected Annual Loss of State-owned and State-leased Critical Facilities Earthquakes				
Region 3				
County	Number of Critical Facilities	NRI Buildings EAL to Exposure Ratio	Replacement Cost of Critical Facilities	Expected Annual Loss to Critical Facilities
Adams	30	0.0022%	$ 12,672,306	$ 283
Ashtabula	72	0.0005%	$ 25,195,275	$ 135
Athens	35	0.0009%	$ 53,251,615	$ 496
Belmont	70	0.0003%	$ 153,564,291	$ 537
Brown	31	0.0035%	$ 35,387,446	$ 1,235
Carroll	18	0.0004%	$ 5,220,360	$ 18
Clermont	51	0.0027%	$ 32,967,768	$ 882
Columbiana	36	0.0003%	$ 14,981,756	$ 52
Coshocton	21	0.0004%	$ 16,813,037	$ 62
Gallia	61	0.0013%	$ 49,786,218	$ 652
Guernsey	50	0.0005%	$ 58,733,741	$ 303
Harrison	24	0.0004%	$ 9,202,403	$ 37
Highland	11	0.0027%	$ 6,701,555	$ 179
Hocking	27	0.0008%	$ 7,590,231	$ 61
Holmes	29	0.0004%	$ 9,188,433	$ 35
Jackson	21	0.0014%	$ 10,211,085	$ 143
Jefferson	34	0.0003%	$ 14,685,898	$ 41
Lawrence	26	0.0013%	$ 9,167,439	$ 118
Mahoning	58	0.0005%	$ 109,678,167	$ 506
Meigs	24	0.0013%	$ 9,369,001	$ 124
Monroe	12	0.0005%	$ 3,933,796	$ 20
Morgan	15	0.0006%	$ 7,945,305	$ 48
Muskingum	36	0.0007%	$ 14,169,870	$ 97
Noble	32	0.0006%	$ 65,273,141	$ 381
Perry	9	0.0008%	$ 7,167,121	$ 58
Pike	12	0.0016%	$ 8,643,712	$ 139
Ross	129	0.0011%	$ 510,798,521	$ 5,816
Scioto	66	0.0018%	$ 478,434,987	$ 8,698
Trumbull	69	0.0005%	$ 97,032,569	$ 462
Tuscarawas	54	0.0005%	$ 50,576,265	$ 256
Vinton	19	0.0012%	$ 14,102,427	$ 169
Washington	50	0.0007%	$ 36,699,000	$ 257
Total	**1232**	**0.0011%**	**$ 1,939,144,738**	**$ 22,300**

2.10 COASTAL EROSION

Coastal erosion is the gradual wearing away of the land by the natural forces of wind and water. The constant action of wind, waves, and ice has affected the coastline of Lake Erie. The major causes of erosion along the Ohio Lake Erie coastline are storm-generated waves and gravity or groundwater driven slides and slumps along higher relief areas of the coastline. Wave erosion causes undercutting of the bluff or bank, mass wasting including block falls, rotational slumps, and debris flows, and accelerates down cutting of cohesive lakebed materials. As materials from the bluff or bank slides into the lake, it too is eroded by the waves. As this process continues, the shoreline shifts farther landward. Many natural factors affect erosion of the coastline, including the geology and relief of the coastline, nearshore geology and bathymetry, presence or absence of beaches, shoreline orientation, lake level fluctuations, and a changing climate (increasing storm frequency and magnitude, loss of ice cover, and precipitation).

The current shape of Lake Erie was created by glacial scouring of the earth's surface during the last major glaciation. Prior to the Pleistocene Ice Age (approximately 2 million years ago), the Lake Erie region would be characterized as a low-lying basin or lowland with an east-flowing river, known as the Erigan River. The underlying bedrock geology in the basin included Silurian and Devonian carbonates (more resistant limestone and dolomite) in the western portion of the basin and less resistant Devonian shales in the eastern portion of the basin. The first of the four major glacial advances during the Pleistocene obliterated the existing river drainage system and deepened and enlarged the basin. Succeeding glaciations further deepened and enlarged the basin. Glacial ice was able to erode the less resistant shales to the east to create the central and eastern Lake Erie basins. Glacial erosion to the west was less due to the more resistant limestone and dolomite bedrock thus creating the western Lake Erie basin.

Lake Erie is the southernmost of the Great Lakes and is also the shallowest because the ice was relatively thin (therefore lacking significant erosive power) when the glacier reached its maximum southern extent. As the glaciers advanced, eroded rock and soil were transported by the flowing ice and deposited as glacial till and morainal deposits. Laminated silt and clay were also deposited in proglacial lakes that formed along the margins of the glacier. These geologic materials are now exposed in Lake Erie's coastal bluffs and banks. As the glacier gradually retreated, the proglacial lakes drained westward through the Toledo area into the Mississippi River. Upon final retreat of the glacier (out of Ohio), pro-glacial meltwater started to discharge over the Niagara escarpment (Niagara River) to the east. Over time, glacial isostatic rebound raised the Niagara escarpment and gradually increased Lake Erie water levels to the current mean water level of 571 feet above sea level.

The geology, relief, and erodibility of the shoreline vary along the Ohio Lake Erie coastline. From the Ohio/ Pennsylvania border to Huron, Ohio, the shore can be characterized as moderate to high relief bluffs, banks, and slopes composed of glaciolacustrine sands, silts, clay, till, and/or shale. From Huron, Ohio to the Marblehead peninsula (including Sandusky Bay), the shore is a low relief plain composed of glaciolacustrine sediments and till, with limestone/dolomite exposed around the Marblehead peninsula. At the mouth of Sandusky Bay, two barrier beach complexes extend from the east (Cedar Point Chaussee) and from the west (Bay Point) into the Bay. Around Marblehead Peninsula and Catawba Island, low to moderate banks/bluffs are composed of limestone/dolomite bedrock and till. West of Catawba Island, the landscape consists of low-relief lake plain and coastal wetlands (remnants of the Black Swamp). Nearshore slopes are generally gentle and are composed of the same materials in bluff or bank. Natural beaches are typically narrow (less than 50 feet wide) to non-existent along much of the shore. Manmade features have affected the longshore transport of sand trapping sand on the updrift side at harbor jetties, power plant intakes, and shore-perpendicular groins. Shore parallel structures have altered sand transport as well.

Climate affects overall physical setting in the nearshore, beach, and shore zones. Long-term and annual fluctuations in lake level are due to changes in precipitation and evaporative losses in the Great Lakes Basin. Short-term fluctuations (8 to 24 hours) in water level elevations are due to wind-driven storm surges (seiche events). The greatest storm surges occur when the wind blows parallel to the long axis of the lake. Under extreme conditions, lake levels at each end of the lake (Toledo or Buffalo) may rise or fall more than eight feet from pre-storm levels. Passage of storm systems through the Great Lakes can cause lake levels at the ends of the lake to fluctuate over a period of several days as water moves oscillates around the basin. With respect to Ohio, the most significant impacts occur along the shoreline of the western Central Basin and Western Basin shorelines. These seiche events are driven by strong winds out of the northeast resulting in a rapid short-term rise in Lake Erie water levels and large storm-generated waves (and storm surge) in the western portions of Lake Erie.

The size of wind-generated waves depends upon wind speed and duration, open-water fetch distance, and water depth. The largest waves affecting the Ohio lakeshore are those generated by storm winds from the west through the northeast. Wave energy is highest from late fall through spring; however, lake levels are lower during the winter months and shorefast ice typically forms a natural barrier that absorbs storm waves and prevents shoreline erosion. Most wave erosion occurs during early spring storms when the greatest amount of wave energy is expended on the shore. The largest waves to strike the shore are generated by onshore storms winds from the west to the northeast. Wave erosion causes undercutting of the bluff or bank, mass wasting including block falls, rotational slumps, and debris flows, and accelerates down cutting of cohesive lakebed materials. Bedrock is not as easily eroded as the cohesive glacial sediments. Although erosion of the bluff is necessary to sustain beaches, excessive erosion of the Lake Erie shoreline is considered to be a coastal hazard.

Coastal Erosion Area

A Coastal Erosion Area (CEA) is a designated area of land adjacent to Lake Erie that is anticipated to be lost to erosion in 30 years unless preventive measures are taken. Coastal erosion is measured by determining how far landward the bluff, bank, or dune has receded over time. The landward shift of the bluff, bank, or dune is called recession.

Coastal erosion area designations are a component of the Ohio Coastal Management Law passed by the Ohio Legislature in 1988 in response to the serious hazards and substantial economic losses caused by coastal erosion. The laws and rules that define the Coastal Erosion Area program are found in Ohio Revised Code Section 1506 and Ohio Administrative Code Section 1501-6. The objective of the CEA program is to identify the hazards and mitigate the economic losses of erosion-related damage.

The Ohio Department of Natural Resources (ODNR) developed standards for designating coastal erosion areas with input from geologists, engineers, local officials, and landowners. Coastal Erosion Areas are depicted on maps that are produced by ODNR. To develop coastal erosion maps, rates of recession are calculated using analytical tools, including aerial imagery and LiDAR, mathematical calculations, and field visits to verify observations. The amount of recession that is calculated is used to project recession rates for a 30-year period; areas that are projected to erode greater than a given threshold amount are designated as CEAs and shown on coastal erosion maps. The maps include data tables that show the amount of recession calculated at regular 100- foot intervals along all of Ohio’s Lake Erie coast, including the bays and islands.

ODNR has mapped Ohio's Lake Erie coast to identify coastal erosion areas since 1992. Maps showing the first CEA designations were finalized in 1998 and were based on the amount of recession that occurred between 1973 and 1990. Since then, ODNR has updated CEA designations in accordance with the laws and rules that define the CEA program. In 2010, ODNR released maps based on the amount of recession that occurred between 1990 and 2004. The 1998 and 2010 CEA maps now serve only as historical records. In January 2019, ODNR released the 2018 CEA maps, which depict the most current CEA designations based on the amount of recession that occurred between 2004 and 2015. ODNR uses these maps to determine if property is currently located within a CEA. All sets of CEA maps are available to view online at https://gis.ohiodnr.gov/MapViewer/?config=cea.

Property along Ohio's Lake Erie coast that is located within a designated CEA is subject to CEA program requirements, which address property sales and transfers and construction. Landowners selling or transferring property within a designated CEA must disclose that status on the Residential Property Disclosure Form, which is required with all residential real property transactions in Ohio. Construction within a CEA may require a CEA Permit, depending on the type and location of a structure. A permit is required to construct a new building or add 500 square feet or more (as measured at ground level) to an existing structure. This applies to residential, commercial, industrial, institutional, and agricultural buildings, and septic systems. CEA Permits are issued by ODNR through the Office of Coastal Management.

RISK ASSESSMENT

LOCATION AND SELECT HISTORICAL OCCURRENCE

Lake Erie comprises 312 miles of the northern coast of Ohio bordering Lucas, Ottawa, Sandusky (Sandusky Bay), Erie, Lorain, Cuyahoga, Lake, and Ashtabula Counties. Lake Erie, the 12th largest (area) lake in the world, is about 210 miles long, 57 miles wide, and has a shoreline length of 871 miles (including the islands). With the exclusion of government-owned park and reserve areas, the coast is highly prized for commercial and residential development. In many cases, human activity has disrupted the natural function of beach formation and aquatic habitats. According to the Ohio Geological Survey, 95 percent of Ohio's Lake Erie shoreline is subject to gradual erosion over time.

Unlike many of the other hazards affecting Ohio, the Ohio Lake Erie coastline is subject to continuous coastal erosion. Although a combination of high Lake Erie water levels and severe storm events may increase periods of (local) short-term catastrophic erosion, generally the shore continues erodes gradually (imperceptibly) every day due to the impact of continuous wave activity.

Table 2.10.a – 2004 to 2015
Ohio Lake Erie Erosion Statistics

County	Distance	Feet/year
Ashtabula	2.8	0.26
Lake	5.4	0.49
Cuyahoga	0.8	0.07
Lorain	0.3	0.02
Erie (lake)	0.3	0.03
Ottawa (lake)	0.5	0.04
Lucas	0.2	0.01
Erie (bay)	0.6	0.05
Ottawa (bay)	9.1	0.54

To monitor erosion, the net landward movement of the shore over a specific time is calculated. The position of characteristic shore features such as bluff lines can be determined from maps and aerial photographs. By analyzing the position of these features (recession lines) through time, the amount of recession can be determined, and rates of recession can be calculated. Long-term and short-term recession data have been developed for each county (see table 2.10.a).

During 1929-30, the mid-1940s, 1952, the fall of 1972, the spring of 1973, 1985, 1998 and 2012 storms and high lake levels caused property damage along the low-lying areas, such as low glacial till bluffs, low glaciolacustrine banks, and barrier beaches and eroded high glacial till or glaciolacustrine bluffs inducing mass wasting in Erie, Lake, Cuyahoga, and Ashtabula counties. The short-term and long-term rates indicate that the low-lying areas have been extremely affected.

More recently, Lake Erie experienced a gradual rise in water levels that began in 2015 and resulted in record-high water levels in 2019 and in 2020. Record-high water levels and associated storms resulted in significant erosion along both protected and unprotected reaches of the Ohio Lake Erie coastline. Record-high water levels also resulted in severe persistent flooding in low-lying coastal areas along the Ohio Lake Erie coastline. More recently, Lake Erie water levels have declined since 2020 and are now about a foot above the long-term mean (2023). The ODNR Division of Geological Survey and the ODNR Office of Coastal Management are collecting new aerial imagery and elevation (LIDAR) data to assess the impacts of the recent record-high water levels in 2019 and 2020 on the Ohio Lake Erie coastline. GeoSurvey and the Office of Coastal Management also continue to monitor ongoing coastal erosion and flooding and provide technical assistance to municipalities and coastal property owners in response to local erosion or flooding events.

LHMP DATA

The LHMPs for counties that border Lake Erie (Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa, and Sandusky) indicate that coastal erosion is a recognized hazard and ranked them either fourth or fifth for their county. Most of the plans reference the same data (Figure 2.10.a) provided by the Ohio Geological Survey. Erie County's LHMP indicated that they had completed a structural inventory in the late 1990's; but those data were not available to them at the time of writing their plan.

Ashtabula County. The HIRA of the Ashtabula County Countywide All Natural Hazards Mitigation Plan of August 2012 describes the 28 miles of Lake Erie coastline form the northern border of the County. The HIRA also explains that factors such as high lake levels, long shore currents, high winds, water runoff over cliffs, bluff recession and seasonal fluctuations are driving forces that lead to coastal erosion. The risk is classified as having a Moderate Probability and Moderate Impact. The plan's vulnerability analysis determined 2,619 structures would be affected with a loss estimate of $78,295,582.

Lake County. As part of the Lake County Planning Commission's coastal management plan, breakwalls have been constructed in Mentor and North Perry. Further, individual jurisdictions have been compiling agreements with appropriate contractors, state agencies, and local partners to ensure that response measures (such as shoring up structures and filling in eroded areas) can be implemented quickly. These jurisdictions include Fairport Harbor, Painesville Township, and North Perry. While coastal erosion is likely to remain a hazard for the foreseeable future (due to the county's proximity to Lake Erie), potential losses have been lessened since previous adoptions of this plan.

Erie County. Factors that cause shoreline erosion include bluff recession, high lake levels, high winds, and human activities. These factors may cause many problems in the coastal communities of Bay View, Sandusky, Huron, Vermilion, and Kelley's Island. Manmade shoreline structures that lie within a designated CEA along Lake Erie's coastline are susceptible to property damage over a 30-year period. Because of the large number of residential properties located within a CEA along the shoreline, property damages are expected to be high.

Based on the property damage expected from stream bank and lake erosion, the impact on the local economy and local government expenditures is considered to be high. Manmade shoreline structures built along the Lake Erie shoreline, trap sand supply, causing beachless shores. Lack of beaches may have an adverse effect upon tourism in Erie County. County roadways may be affected and in need of repair, but this repair does not typically have an adverse effect on the economy, as motorists will find an alternate route.

Lucas County. According to the Lucas County Countywide All Natural Hazards Mitigation Plan of March 2013, lake surges (also referred to as storm surges) are associated with extreme weather events and are responsible for coastal flooding and erosion along Lake Erie within Lucas County. The storms that generate the large waves of lake surges can develop year-round, however within Lucas County, these events have typically occurred in the early spring and late fall months. Storm surges inundate coastal floodplains, the rise in water levels in inland bays and harbors, and backwater flooding through river mouths. Coastal erosion is generally associated with storm surges, windstorms, and flooding hazards, and may be exacerbated by human activities such as boat wakes, shoreline hardening, and dredging. Conversely, actions to supplement natural coastal processes, such as beach nourishment, dune stabilization, and construction of shore protection structures can greatly modify and reduce erosion trends within an area.

Ottawa County. Within Ottawa County, the risk for coastal erosion varies by jurisdiction. The lakeshore jurisdictions in the western portion of the county have a higher coastal erosion risk than those to the east. The coastal areas in Carroll, Erie, and Bay Township are primarily beach and marsh areas with low elevations. Structures in these coastal areas are primarily residential and include a large percentage of summer homes and seasonal cottages. Some of these areas are protected by breakwalls that reduce the impact of waves as they wash onshore.

The eastern municipalities of Marblehead, Port Clinton and Put-In-Bay and Catawba Island, Danbury, Portage, and Put-In-Bay Townships are susceptible to coastal erosion but, given their high elevation and rocky surface and sub-surface, erosion is less likely to impact structures than in other areas of the county. The high cliffs and rock ledges protect the homes, businesses, and infrastructure along the lakeshore from wind and water damage. In the city of Port Clinton, the highway and homes are several hundred feet from the coastline and not significantly susceptible to coastal erosion damage. While the county is significantly lakefront, there is not a large amount of beach across the shoreline. A large percentage of the coastal area is either marsh and wetland, or rocky ledge.

Mitigation Information Portal (MIP). See Section 4.3 for an analysis of coastal erosion data in local hazard mitigation plans.

Coastal Barrier Resources System

The Coastal Barrier Resources Act (CBRA) of 1982 and subsequent amendments established the John H. Chafee Coastal Barrier Resources System (CBRS). The CBRS consists of relatively undeveloped coastal barriers and other areas located the Atlantic, Gulf of Mexico, Great Lakes, U.S. Virgin Islands, and Puerto Rico coasts. The CBRS currently includes 585 System Units, which comprise nearly 1.4 million acres of land and associated aquatic habitat. There are also 277 "Otherwise Protected Areas," a category of coastal barriers that are mostly already held for conservation and/or recreation purposes that include an additional 2.1 million acres of land and associated aquatic habitat. The CBRS units are identified and depicted on a series of maps entitled "John H. Chafee Coastal Barrier Resources System." These maps are controlling and indicate which lands are affected by the CBRA. The maps are maintained by the Department of the Interior through the U.S. Fish and Wildlife Service and can be viewed at: https://www.fws.gov/cbra/Maps/Mapper.html.The Coastal Barrier Resources Act and its amendments prohibit most new federal expenditures that tend to encourage development or modification of coastal barriers. The laws do not restrict activities carried out with private or other non-federal funds and only apply to the areas that are within the defined CBRS. The main prohibition affecting property owners is the prohibition on federal flood insurance.

Examples of prohibited federal assistance within System units include subsidies for road construction, channel dredging, and other coastal engineering projects. Federal flood insurance through the National Flood Insurance Program is available in a CBRS unit if the subject building was constructed (or permitted and under construction) before the CBRS unit's effective date. If an existing insured structure is substantially improved or damaged, the federal flood insurance policy will not be renewed.

PROBABILITY OF FUTURE EVENTS

With shore structures increasing along the coastline, the shoreline becomes increasingly modified. Reports and studies suggest that wave erosion and mass wasting caused by Lake Erie will continue to erode the Ohio shore for the foreseeable future. Damage to the built environment is inevitable without intervention and will warrant the full understanding of coastal processes within each stretch to rehabilitate the shoreline.

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

Previous versions of this plan indicated that coastal erosion had limited potential to affect any state-owned structures or critical facilities. All state facilities near the Lake Erie Coast were evaluated for their proximity to coastal erosion areas using the DAS data within a GIS. No state-owned or state-leased facilities are located within the coastal erosion areas, which represents no change since the last plan update.

2.11 DROUGHT

Drought is a normal, recurrent feature of climate that originates from a deficiency of precipitation over an extended period of time, resulting in a water shortage for some activity, group, or environmental sector. Within the State of Ohio, drought is equally as possible to occur in one section of the state as it is in another. The effects of drought within the state vary though, based on land use (agricultural production as opposed to urban areas), economy (dependence on drought-impacted business such as farming), geology (presence of an aquifer or ground structure that limits well production), and water source (public water supply, private well, or cistern).

There are four primary types of droughts: agricultural, hydrological, meteorological, and socioeconomic. The State of Ohio is most often affected by agricultural and hydrological types of droughts, and is often affected by both simultaneously. Below, these two types of droughts are described in more detail.

Agricultural Droughts— Agricultural drought links characteristics of hydrological drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, and reduced groundwater or reservoir levels. The amount of water available for agricultural use demand depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil. A good definition of agricultural drought accounts for the variable susceptibility of crops during different stages of crop development, from emergence to maturity. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per acre and a reduction of final yield.

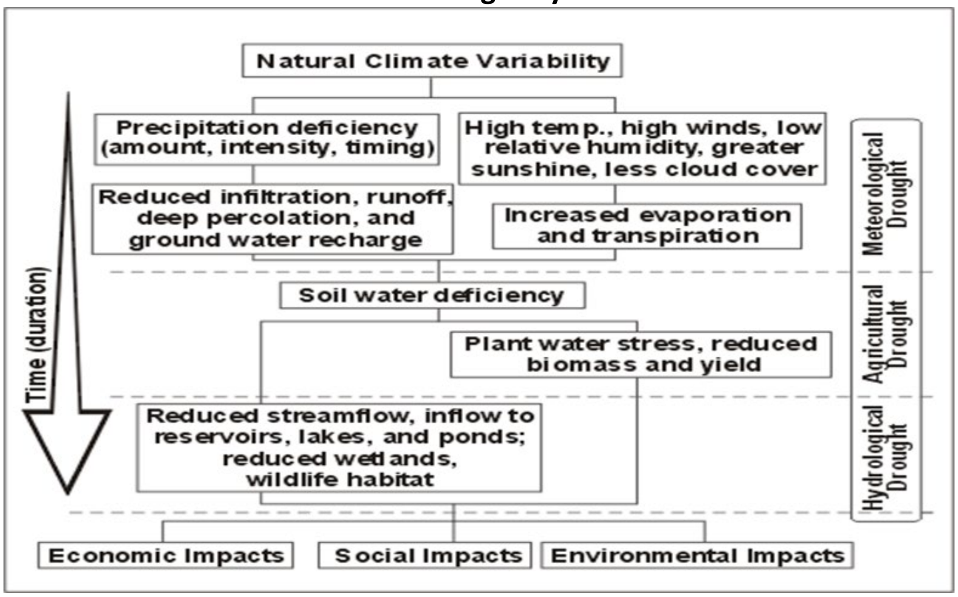
Hydrological Drought— Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on the surface or subsurface water supply – stream flow, reservoir, and lake levels and groundwater. The frequency and severity of hydrological drought are often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system.

Water in hydrologic storage systems (e.g., reservoirs, rivers) is often used for multiple and competing purposes (e.g., flood control, irrigation, recreation, navigation, hydropower, or wildlife habitat), further complicating the sequence and quantification of impacts. Competition for water in these storage systems escalates during drought and conflicts between water users increase significantly.

Although the climate is a primary contributor to hydrological drought, there are other factors such as changes in land use, deforestation, land degradation, and the construction of dams, which can all affect the hydrological characteristics of a basin. Because regions are interconnected by hydrologic systems, the impact of meteorological drought may extend well beyond the borders of the precipitation- deficient area.

The flow chart below illustrates the progression of drought and the relationship between meteorological, agricultural, and hydrological drought. Economic, social, and environmental impacts are shown at the bottom of the chart, independent of the time scale, indicating that such impacts can occur at any stage during a drought.

Figure 2.11.a
The Drought Cycle



Source: Source: National Drought Mitigation Center, University of Nebraska-Lincoln, U.S.A.
http://www.drought.unl.edu/droughtbasics/typesofdrought.aspx

MEASURING DROUGHT

The Palmer Drought Severity Index (PDSI) is a soil moisture algorithm. The PDSI was developed by W.C. Palmer in 1965. Many U.S. government agencies and states rely on the PDSI to trigger drought relief programs and responses. Most of the agency-based actions within the Ohio Emergency Operation Plan's Drought Incident Annex are triggered by the PDSI.

Figure 2.11.b

Palmer Drought Severity Index Classification	
4.0 or greater	Extremely Wet
3.0 to 3.99	Very Wet
2.0 to 2.99	Moderately Wet
1.0 to 1.99	Slightly Wet
0.5 to 0.99	Incipient Wet Spell
0.49 to -0.49	Near Normal
-0.5 to -0.99	Incipient Dry Spell
-1.0 to -1.99	Mild Drought
-2.0 to -2.99	Moderate Drought
-3.0 to -3.99	Severe Drought
-4.0 or less	Extreme Drought

The PDSI is based on the supply-and-demand concept of the water balance equation, taking into account more than just the precipitation deficit at specific locations. The objective of the PDSI is to provide standardized measurements of moisture conditions, so that comparisons using the index can be made between locations and between time periods (usually months). The PDSI is calculated based on precipitation and temperature data, as well as the local Available Water Content of the soil. The Palmer Index is designed so that a -4.0 in South Carolina has the same meaning in terms of the moisture departure from a climatological normal as a -4.0 does in Ohio.

One advantage of the PDSI is that as a strictly numeric product, PDSI values can be computed back to the beginning of the historic record. Disadvantages of the PDSI are that it is slow to detect quick-onset droughts, and does not reflect snowpack, an important component of water supply in the western United States. The Palmer was the main drought index in the United States before the *U.S. Drought Monitor.*

The *U.S. Drought Monitor (USDM)* is jointly produced by the National Oceanic and Atmospheric Administration (NOAA), the United States Department of Agriculture (USDA), and the National Drought Mitigation Center (NDMC). The weekly maps are based on measurements of climatic, hydrologic and soil conditions as well as reported impacts and observations from more than 350 contributors around the U.S. The U.S. Drought Monitor (USDM) identifies areas in drought and labels them by intensity. The map uses four categories of drought, from D1—the least intense—to D4, the most. It also highlights areas with no drought and uses the D0 category to indicate abnormally dry areas that could be entering or recovering from drought.

Figure 2.11.c

Category	None	D0	D1	D2	D3	D4
Description	Normal or wet conditions	Abnormally Dry	Moderate Drought	Severe Drought	Extreme Drought	Exceptional Drought

These categories are then summarized into one comparable index: The *Drought Severity and Coverage Index (DSCI)* is a method for converting drought levels from the U.S. Drought Monitor map to a single value for an area. DSCI values are part of the U.S. Drought Monitor data tables. Possible values of the DSCI are from 0 to 500. Zero means that none of the area is abnormally dry or in drought, and 500 means that all of the area is in D4, exceptional drought. Weekly Categorical USDM Statistics are assessed and are calculated for DSCI with the following equation: **1(D0) + 2(D1) + 3(D2) + 4(D3) + 5(D4) = DSCI**

STATE DROUGHT RESPONSE: THE STATE OF OHIO EOP, DROUGHT INCIDENT ANNEX

Once a D2 drought is determined for any part of Ohio, the Executive Director of Ohio EMA will activate and will appoint a chair for the Drought Assessment Committee (DAC). DAC will consist of one-or-more representatives from the following agencies:

- Ohio Department of Natural Resources (ODNR), Division of Soil and Water Resources
- Ohio Environmental Protection Agency (OEPA), Division of Drinking and Ground Waters
- Ohio Department of Agriculture (ODA)
- Ohio Emergency Management Agency (OEMA)
- Ohio Department of Commerce, Division of State Fire Marshal
- Ohio State University Extension
- State Climate Office of Ohio (SCOO)
- National Weather Services (NWS) (Wilmington)
- United States Department of Agriculture, Farm Service Agency (USDA-FSA)
- Public Utilities Commission of Ohio (PUCO)
- United States Army Corps of Engineers
- Ohio Department of Health (ODH)

The tasks to be carried out by the State DAC includes monitoring, issuing of information, make recommendations relating to proposed State actions, including the activation of Impact Task Forces. There are six state-level Drought Impact Task Forces. When activated, Drought Impact Task Forces will coordinate and facilitate individual agency actions and oversee cooperative efforts of agencies with assigned responsibilities under each Task Force. The following agencies are lead state agencies for the six impact task forces:

- Impact Task Force #1 – Agriculture: Ohio Department of Agriculture
- Impact Task Force #2 – Wildfire: Ohio Department of Natural Resources, Division of Forestry
- Impact Task Force #3 – Fish and Wildlife: Department of Natural Resources, Division of Wildlife
- Impact Task Force #4 – Recreation and Tourism: Ohio Department of Natural Resources, Division of Parks and Recreation
- Impact Task Force #5 – Public and Private Water Supply: Ohio Environmental Protection Agency, Division of Drinking and Ground Waters
- Impact Task Force #6 – Economic: Office of Budget and Management

As drought conditions worsens into USDM classifications D3-D4, the Governor can activate the Drought Executive Committee (DEC). The DEC will be chaired by the Executive Director of Ohio EMA and will meet regularly to direct, facilitate and coordinate drought emergency response in Ohio. A Drought Emergency may be declared when the U.S. Monitor has reached a D3 or D4 (extreme to exceptional) category in all or a portion of the State of Ohio. This indicates that precipitation, stream flows, reservoir levels, and ground-water levels have and will continue to decline, and/or that Emergency Response Actions are required. An Emergency Declaration will provide:

- Adequate response to water shortages, and the implementation of emergency programs and actions as provided in the Ohio Revised Code.
- Short- and long-term drought response recommendations as they relate to agricultural concerns and the protection and support of public and private water supplies. The DEC's recommendations and responses will be based upon input from the DAC.

A Drought Emergency may be canceled when conditions improve and precipitation levels, stream flows, reservoir levels, and ground-water levels increase. Extended forecasts should also indicate that normal conditions over a four-week period can be expected before a Drought Emergency is canceled.

RISK ASSESSMENT

LOCATION

The National Drought Mitigation Center (NDMC) has calculated values showing the spatial extent of drought based on historical Palmer Drought Severity Index (PDSI) data. The table 2.11.b lists the number of years that the United States has had a severe or extreme drought in the 100 years from 1896 to 1995, based on the Palmer Drought Severity Index (PDSI). The data is divided and analyzed based on NOAA river basins. The chart shows that some part of the United States has experienced a severe or extreme drought in each year from 1896 to 1995, and that in 72 years, droughts covered more than 10% of the country.

Table 2.11.a

Number of Years with Severe or Extreme Drought between 1896 and 1995									
% area of basin/region	>0%	>10%	>25%	>33%	>50%	>66%	>75%	>90%	100%
United States	100	72	27	13	1	0	0	0	0
Upper Mississippi	77	55	43	30	19	12	9	3	1
Mid-Atlantic	69	49	32	24	12	5	4	0	0
South Atlantic/Gulf	79	47	25	15	9	3	3	0	0
Ohio	67	51	34	28	16	12	9	4	3
Missouri	90	70	43	33	17	10	4	3	0
Pacific Northwest	86	61	42	33	23	14	9	1	0
California	53	45	40	30	14	9	5	3	3
Great Basin	71	65	43	37	19	6	3	1	1
Lower Colorado	56	54	35	28	16	11	10	4	3
Upper Colorado	50	50	42	34	27	25	16	9	8
Rio Grande	58	47	32	24	15	8	5	2	2
Texas Gulf Coast	49	48	38	26	22	13	10	9	7
Arkansas–White–Red	65	48	27	23	14	7	4	0	0
Lower Mississippi	56	38	19	15	4	1	0	0	0
Souris–Red–Rainy	66	57	38	29	19	10	8	5	2
Great Lakes	73	58	32	23	9	3	2	2	0
Tennessee	31	31	27	24	21	16	13	5	5
New England	56	44	27	13	8	5	4	0	0

Source: National Climatic Data Center, Understanding Your Risk and Impacts – A Comparison of Droughts, Floods, and Hurricanes in the United States. http://www.drought.unl.edu/risk/us/compare.html.

The table(s) below estimates weekly the extent of areas affected by drought, and the associated DSCI score calculated from those estimates. The years assessed are those of the 2002-2003, 2007-2008, and 2012-2013 drought years that impacted Ohio.

Table 2.11.b

Percentage of Area in Drought (2002 to 2003)									
Week of	Year	Area Not in Drought	Area Abnormally Dry (D0)	Area in Moderate Drought (D1)	Area in Severe Drought (D2)	Area in Extreme Drought (D3)	Area in Exceptional Drought (D4)	Area in Moderate (D1) to Exceptional (D4) Drought	DSCI Index[1]
July 23	2002	11%	70%	19%	0%	0%	0%	19%	107
July 30	2002	27%	24%	49%	0%	0%	0%	49%	122
August 6	2002	8%	38%	43%	11%	0%	0%	54%	158
August 13	2002	0%	13%	59%	28%	0%	0%	87%	215
August 20	2002	0%	34%	66%	0%	0%	0%	66%	166
August 27	2002	4%	31%	65%	0%	0%	0%	65%	162
September 3	2002	0%	15%	42%	43%	0%	0%	85%	227
September 10	2002	0%	2%	49%	49%	0%	0%	98%	246
September 17	2002	0%	2%	55%	43%	0%	0%	98%	240
September 24	2002	0%	6%	53%	41%	0%	0%	94%	235
October 1	2002	12%	51%	36%	0%	0%	0%	36%	124
October 8	2002	29%	43%	28%	0%	0%	0%	28%	99
October 15	2002	30%	39%	31%	0%	0%	0%	31%	101
October 22	2002	41%	29%	31%	0%	0%	0%	31%	90
October 29	2002	40%	30%	30%	0%	0%	0%	30%	91
November 5	2002	40%	28%	32%	0%	0%	0%	32%	92
November 12	2002	52%	27%	21%	0%	0%	0%	21%	69
November 19	2002	53%	25%	22%	0%	0%	0%	22%	70

Source: U.S. Drought Monitor, a partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture and the National Oceanic and Atmospheric Administration.

1- Weeks displayed are those above the median weekly DSCI Index Value from January 2000 to December 2023. The median DSCI index from that timeframe was 66.

Table 2.11.c

Percentage of Area in Drought (2007 to 2008)									
Week of	Year	Area Not in Drought	Area Abnormally Dry (D0)	Area in Moderate Drought (D1)	Area in Severe Drought (D2)	Area in Extreme Drought (D3)	Area in Exceptional Drought (D4)	Area in Moderate (D1) to Exceptional (D4) Drought	DSCI Index[1]
June 5	2007	23%	51%	26%	0%	0%	0%	26%	103
June 12	2007	27%	41%	32%	0%	0%	0%	32%	105
June 19	2007	1%	49%	46%	4%	0%	0%	50%	153
June 26	2007	0%	52%	38%	9%	0%	0%	48%	157
July 3	2007	0%	65%	31%	4%	0%	0%	35%	139
July 10	2007	0%	27%	69%	4%	0%	0%	73%	178
July 17	2007	0%	18%	76%	6%	0%	0%	82%	188
July 24	2007	0%	20%	75%	6%	0%	0%	80%	186
July 31	2007	0%	39%	55%	6%	0%	0%	61%	167
August 7	2007	0%	41%	54%	5%	0%	0%	59%	165
August 14	2007	22%	32%	32%	14%	0%	0%	46%	138
August 21	2007	45%	18%	26%	11%	0%	0%	37%	103
August 28	2007	52%	19%	11%	9%	9%	0%	29%	103
September 4	2007	54%	12%	11%	11%	11%	0%	33%	113
September 11	2007	59%	13%	9%	10%	10%	0%	28%	98
September 18	2007	70%	6%	5%	10%	10%	0%	24%	83
September 25	2007	66%	8%	5%	11%	11%	0%	27%	93
October 2	2007	71%	6%	9%	9%	5%	0%	23%	70

Source: U.S. Drought Monitor, a partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture and the National Oceanic and Atmospheric Administration.

1- Weeks displayed are those above the median weekly DSCI Index Value from January 2000 to December 2023. The median DSCI index from that timeframe was 66.

Table 2.11.d

Percentage of Area in Drought (2012 to 2013)									
Week of	Year	Area Not in Drought	Area Abnormally Dry (D0)	Area in Moderate Drought (D1)	Area in Severe Drought (D2)	Area in Extreme Drought (D3)	Area in Exceptional Drought (D4)	Area in Moderate (D1) to Exceptional (D4) Drought	DSCI Index[1]
June 19	2012	9%	72%	16%	3%	0%	0%	19%	114
June 26	2012	8%	56%	33%	3%	0%	0%	36%	132
July 3	2012	5%	29%	62%	3%	0%	0%	66%	164
July 10	2012	0%	22%	68%	10%	0%	0%	78%	188
July 17	2012	0%	2%	85%	13%	0%	0%	98%	211
July 24	2012	0%	2%	85%	13%	0%	0%	98%	211
July 31	2012	2%	14%	68%	16%	0%	0%	84%	197
August 7	2012	9%	18%	61%	11%	1%	0%	73%	177
August 14	2012	15%	23%	59%	3%	1%	0%	62%	151
August 21	2012	15%	24%	57%	4%	0%	0%	61%	150
August 28	2012	7%	28%	58%	6%	2%	0%	65%	168
September 4	2012	7%	37%	48%	8%	0%	0%	56%	156
September 11	2012	14%	38%	41%	7%	0%	0%	48%	142
September 18	2012	14%	38%	43%	6%	0%	0%	48%	140
September 25	2012	29%	29%	31%	11%	0%	0%	42%	124
October 2	2012	29%	28%	35%	7%	0%	0%	42%	120
October 9	2012	34%	32%	27%	7%	0%	0%	34%	106
October 16	2012	35%	37%	24%	5%	0%	0%	29%	99
October 23	2012	36%	37%	23%	5%	0%	0%	27%	96

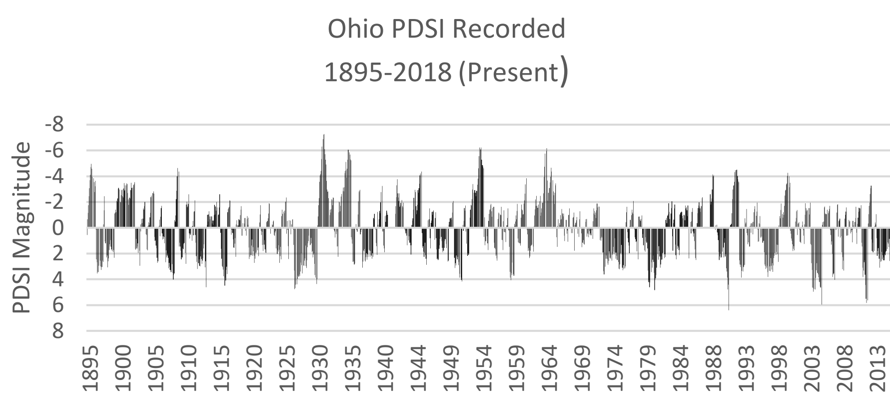
Source: U.S. Drought Monitor, a partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture and the National Oceanic and Atmospheric Administration.

1- Weeks displayed are those above the median weekly DSCI Index Value from January 2000 to December 2023. The median DSCI index from that timeframe was 66.

PAST OCCURRENCES

The NOAA National Climatic Data Center has calculated values showing the spatial extent of drought based on historical Palmer Drought Severity Index (PDSI) data. The period of record is from 1895 through the latest month (February 2018). Data was derived from area-weighted averages from interpolated estimates across the United States. Figure 2.11.d tabulates the PDSI in Ohio since from January 1985 to February 2018 by month.

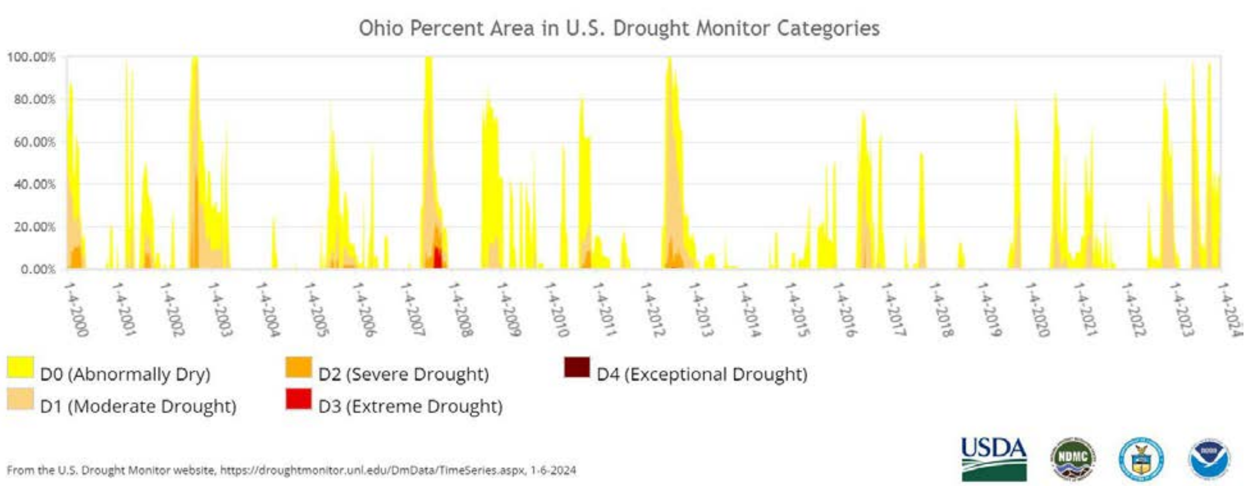
Figure 2.11.d



Source: Monthly Palmer Drought Severity Index for States and Climate Divisions; NOAA National Climatic Data Center
https://www.drought.gov/drought/data/noaa-national-climatic-data-center/monthly-palmer-drought-severity-index-states-and-climate

As mentioned earlier, the U.S. Drought Monitor (USDM) index identifies areas in drought and labels them by intensity of drought, from D1—the least intense—to D4, the most. Figure 2.11.e below compares the last 23 years for Ohio relative to percent area affected.

Figure 2.11.e

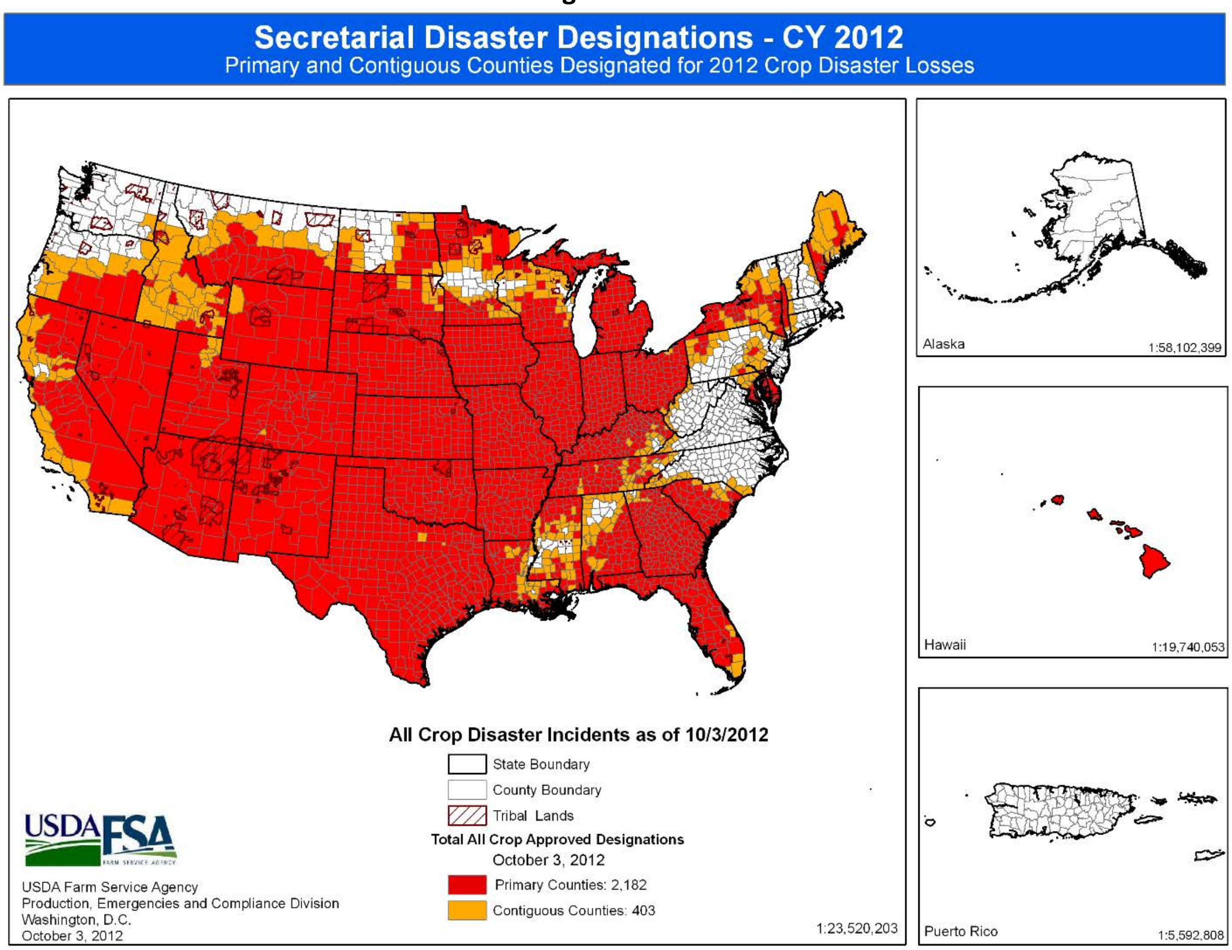


2012 NORTH AMERICAN DROUGHT

The 2012-2013 North American Drought was an expansion of the 2010-2012 United States Drought which began in the spring of 2012 when the lack of snow caused very little meltwater to absorb into the soil. The drought included most of the United States and all of Ohio. Several counties in the state were designated with moderate drought conditions by mid-June of 2012. Its effects were equal to similar droughts which occurred in the 1930s and 1950s, but the 2012 event did not last as long. Nonetheless, the 2012 North American Drought inflicted catastrophic economic ramifications on the state. In most measures, the 2012 drought exceeded the 1988-1989 North American Drought, which was the most recent comparable drought.

On July 30th, 2012, the Governor of Ohio sent a memorandum to the U.S. Department of Agriculture State Executive Director requesting primary county natural disaster designations for eligible counties due to agricultural losses caused by drought during the 2012 crop year. The USDA reviewed the Loss Assessment Reports and determined that there were sufficient production losses in 85 counties to warrant a Secretarial disaster designation on September 5th, 2012. By December 2012, all 88 counties received such a designation.

Figure 2.11.f



The USDA – National Agricultural Statistics Service (NASS) Annual Statistical Bulletins were used to compare a regular crop production period (Crop Year 2010) and the affected crop production period during drought conditions. Commodities were selected and compared. Table 2.11.e shows the difference in crop production in Ohio.

Table 2.11.e

Ohio Agriculture Outputs: 2010 and 2012											
CROP	Unit	Yield per Acre Thousands			Production Thousands			Price Per Unit[1]	Value of Production[1] Thousand Dollars		
		2010	2012	Difference	2010	2012	Difference		2010	2012	Difference
Corn for Grain	Bu.	163	123	-25%	533,010	448,950	-16%	$ 7.71	$ 4,111,906	$ 3,463,425	-16%
Soybeans	Bu.	48	45	-6%	220,320	206,100	-6%	$ 16.40	$ 3,613,689	$ 3,380,452	-6%
Winter Wheat	Bu.	61	69	13%	45,750	31,050	-32%	$ 7.23	$ 330,681	$ 224,429	-32%
All Wheat	Bu.	61	69	13%	45,750	31,050	-32%	$ 7.23	$ 330,681	$ 224,429	-32%
Oats	Bu.	70	56	-20%	3,500	2,576	-26%	$ 4.10	$ 14,352	$ 10,563	-26%
Tobacco - Burley	Lb.	2,050	2,100	2%	5,125	3,990	-22%	$ 2.27	$ 11,612	$ 9,040	-22%
All Hay	Ton	3	2	-18%	2,871	2,330	-19%	$ 155.68	$ 446,957	$ 362,734	-19%
Alfalfa Hay	Ton	3	3	-15%	1,287	980	-24%	$ 200.16	$ 257,606	$ 196,157	-24%
All Other Hay	Ton	2	2	-18%	1,584	1,350	-15%	$ 113.98	$ 180,544	$ 153,873	-15%
Strawberries	Cwt	48	42	-13%	35	28	-20%	$ 378.08	$ 13,233	$ 10,586	-20%
Apples	Lb.	13,200	8,250	-38%	83	33	-60%	$ 0.52	$ 43	$ 17	-60%
Peaches	Ton	5	4	-32%	6	5	-17%	$ 2,196.20	$ 13,177	$ 10,981	-17%
Grapes	Ton	2	3	54%	3	5	71%	$ 988.29	$ 3,064	$ 5,238	71%
Fresh Market Bell Peppers	Cwt	245	183	-25%	686	567	-17%	$ 33.36	$ 22,885	$ 18,915	-17%
Cabbage	Cwt	280	369	32%	336	480	43%	$ 35.58	$ 11,956	$ 17,080	43%
Pumpkins	Cwt	160	240	50%	1,104	1,742	58%	$ 20.99	$ 23,172	$ 36,563	58%
Squash	Cwt	160	180	13%	272	304	12%	$ 49.07	$ 13,346	$ 14,916	12%
Sweet Corn	Cwt	90	105	17%	1,224	1,586	30%	$ 34.19	$ 41,853	$ 54,232	30%
Tomatoes	Cwt	270	170	-37%	1,269	697	-45%	$ 51.29	$ 65,088	$ 35,750	-45%
Processing Tomatoes	Ton	27	27	-1%	158	157	-1%	$ 136.64	$ 21,630	$ 21,397	-1%
Cucumbers	Ton	11	4	-59%	22	31	45%	$ 625.50	$ 13,511	$ 19,578	45%
TOTAL									**$ 9,542,996**	**$ 8,272,369**	**-13.31%**

Source: U. S. Department of Agriculture - National Agricultural Statistics Service, Ohio Field Office Annual Statistical Bulletin(s)

1- Based on crop values, January 2011, adjusted to 2023 dollars

PROBABILITY OF FUTURE EVENTS

The probability of future occurrences of drought in Ohio is difficult to predict; however, there are two factors that may influence future drought conditions: The El Niño–Southern Oscillation (ENSO), and climate change.

EL NINO AND LA NINA SOUTHERN OSCILLATION

A great deal of research has been conducted in recent years on the role of interacting systems, or teleconnections, in explaining regional and even global patterns of climatic variability. These patterns tend to recur periodically with enough frequency and with similar characteristics over a sufficient length of time that they offer opportunities to improve our ability for long-range climate prediction, particularly in the tropics.

Every 2 to 7 years, off the western coast of South America, ocean currents and winds shift, bringing warm water westward, displacing the nutrient-rich cold water that normally wells up from deep in the ocean. The invasion of warm water disrupts both the marine food chain and the economies of coastal communities that are based on fishing and related industries. Because the phenomenon peaks around the Christmas season, the fishermen who first observed it named it El Niño (“the Christ Child”). In recent decades, scientists have recognized that El Niño is linked with other shifts in global weather patterns. The intensity and duration of an ENSO event is varied and hard to predict. Typically, it lasts anywhere from 14-to-22 months, but it can be much longer or shorter. El Niño often begins early in the year and peaks between the following November.

During an El Niño–Southern Oscillation (ENSO) event, the Southern Oscillation is reversed. Generally, when pressure is high over the Pacific Ocean, it tends to be low in the eastern Indian Ocean, and vice versa. It is measured by gauging sea-level pressure in the east (at Tahiti) and west (at Darwin, Australia) and calculating the difference. El Niño and Southern Oscillation often occur together, but also happen separately. High positive values of the SOI indicate a La Niña, or "cold event". La Niña is the counterpart of El Niño and represents the other extreme of the ENSO cycle. La Niña years often (but not always) follow El Niño years.

Understanding the connections between ENSO (and La Niña) events and weather anomalies around the globe can help in forecasting droughts, floods, tropical storms, and hurricanes. NOAA estimates that the economic impacts of the 1982–83 El Niño, perhaps the strongest event in recorded history, conservatively exceeded $8 billion worldwide, from droughts, fires, flooding, and hurricanes. This event and its associated disasters have been blamed for 1,000 to 2,000 deaths. In addition, the extreme drought in the United States' Midwest during 1988 has been linked to the "cold event", or La Niña, of 1988 that followed the ENSO event of 1986–87.

It is possible that the direct impacts of climate change on water resources might be hidden beneath natural climate variability. With a warmer climate, droughts, and floods could become more frequent, severe, and longer-lasting. The potential increase in these hazards is a great concern given the stresses being placed on water resources and the high costs resulting from recent hazards. The drought of the late 1980s showed what the impacts might be if climate change leads to a change in the frequency and intensity of droughts across the United States. From 1987 to 1989, losses from drought in the United States totaled $39 billion. More frequent extreme events such as droughts and floods could end up being more cause for concern than the long-term change in temperature and precipitation averages.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

Drought risk is based on a combination of the frequency, severity, and spatial extent of drought and the degree to which a population or activity is vulnerable to the effects of drought. The degree of a region's vulnerability depends on the environmental and social characteristics of the region and is measured by the ability to anticipate, cope with, resist, and recover from a drought.

Society's vulnerability to drought is determined by a wide range of factors, both physical and social, such as demographic trends and geographic characteristics. People and activities will be affected in different ways by different hazards.

There is a sequence of impacts associated with meteorological, agricultural, and hydrological droughts in Ohio. When drought begins, the agricultural sector is usually the first to be affected because of its heavy dependence on stored soil water, which can be rapidly depleted during extended dry periods. If precipitation deficiencies continue, then people dependent on other sources of water will begin to feel the effects of the shortage. Those who rely on surface water (reservoirs and lakes) and subsurface water (groundwater) are usually the last to be affected. A short-term drought that persists for 3 to 6 months may have little impact on these sectors, depending on the characteristics of the hydrologic system and water use requirements.

When precipitation returns to normal and meteorological drought conditions have abated, the sequence is repeated for the recovery of surface and subsurface water supplies. Soil water reserves are replenished first, followed by stream flow, reservoirs and lakes, and groundwater. Drought impacts may diminish rapidly in the agricultural sector because of its reliance on soil water, but linger for months or even years in other sectors, dependent on stored surface or subsurface supplies. Groundwater users, often the last to be affected by drought during its onset, may be last to experience a return to normal water levels. The length of the recovery period is a function of the intensity of the drought, its duration, and the quantity of precipitation received as the episode terminates.

Socioeconomic definitions of drought associate the supply and demand of some economic goods with elements of meteorological, hydrological, and agricultural drought. It differs from the other types of drought because its occurrence depends on the time and space processes of supply and demand to identify or classify droughts. The supply of many economic goods, such as water, forage, food grains, fish, and hydroelectric power, depends on the weather. Socioeconomic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply.

FEMA estimated in 1995 that drought costs the United States $6– 8 billion annually. Other studies have indicated that drought losses average $200 million to $1.24 billion annually in the Great Plains. This range is based on crop losses and other direct and indirect losses. According to NOAA's National Climatic Data Center, in 1999, a drought that affected twenty-eight Ohio counties caused $200 million in crop damages.

The Dust Bowl years of the 1930s and the drought of 1988–89 are both contenders for the worst drought on record in the United States. Economic losses are often hard to calculate and compare for a variety of reasons: lack of historical records and economic models, and past and present costs that are often based on different criteria. Today, many different types of losses are often included in an economic analysis, such as energy losses, ecosystem losses, and consumer purchasing losses, but they were not typically included in previous analyses and are difficult to assess in retrospect.

While crop production may not show the full picture of the impacts of a drought, and droughts aren't the only factor in crop production, the Yield Per Acre columns in Table 2.11.e above indicates that despite the acres of a crop harvested, the annual yield per acre for the majority of crops in 2012 were significantly less compared to a more favorable year such as 2010. This means that despite the number of acres planted of a type of crop, less quantities were able to be harvested and produced. Tables 2.11.f, g, and h displays the vulnerable croplands and crop cash receipts for each county, then estimates the expected loss from an event modeled on statewide losses from the 2012 drought event.

Table 2.11.f

Agricultural Cash Receipts and Scenario Losses, OEMA Region 1				
County	**2020 Population**	**Cropland [1] (Acres)**	**Crop Cash Receipts [1] (2023 Dollars)**	**Expected Losses 2012 Drought Scenario (2023 Dollars)**
Darke	51,881	316,123	$ 201,767,500	$ 26,864,850
Putnam	34,451	291,173	$ 174,300,000	$ 23,207,619
Huron	58,565	213,866	$ 168,625,000	$ 22,452,007
Wood	132,248	253,839	$ 158,022,500	$ 21,040,310
Van Wert	28,931	240,762	$ 154,375,000	$ 20,554,654
Mercer	42,528	248,544	$ 154,137,500	$ 20,523,032
Fulton	42,713	182,198	$ 153,665,000	$ 20,460,119
Henry	27,662	225,208	$ 146,193,750	$ 19,465,341
Crawford	42,025	220,942	$ 145,161,250	$ 19,327,866
Seneca	55,069	242,837	$ 144,415,000	$ 19,228,505
Hancock	74,920	226,730	$ 135,948,750	$ 18,101,244
Hardin	30,696	243,997	$ 134,025,000	$ 17,845,101
Clark	136,001	151,402	$ 125,208,750	$ 16,671,239
Champaign	38,714	168,701	$ 123,945,000	$ 16,502,974
Preble	40,999	188,287	$ 122,708,750	$ 16,338,370
Auglaize	46,422	194,575	$ 122,511,250	$ 16,312,074
Wyandot	21,900	205,093	$ 121,931,250	$ 16,234,848
Shelby	48,230	197,251	$ 115,888,750	$ 15,430,304
Miami	108,774	158,306	$ 115,007,500	$ 15,312,968
Sandusky	58,896	166,414	$ 114,746,250	$ 15,278,183
Erie	75,622	77,112	$ 108,686,250	$ 14,471,309
Marion	65,359	190,282	$ 107,846,250	$ 14,359,465
Logan	46,150	183,851	$ 107,646,250	$ 14,332,835
Allen	102,206	172,699	$ 107,297,500	$ 14,286,400
Williams	37,102	189,883	$ 101,392,500	$ 13,500,164
Paulding	18,806	208,175	$ 100,471,250	$ 13,377,502
Defiance	38,286	205,771	$ 100,297,500	$ 13,354,367
Ottawa	40,364	115,059	$ 68,795,000	$ 9,159,886
Lucas	431,279	61,938	$ 58,977,500	$ 7,852,710
TOTAL	**1,976,799**	**5,741,018**	**$ 3,693,993,750**	**$ 491,846,246**

Source: U. S. Department of Agriculture - National Agricultural Statistics Service, Agricultural Census and Quick Stats

1- Values obtained from the 2017 Ohio Agricultural Census and reflect 2017 amounts. Dollar amounts were adjusted to 2023 dollars.

Situated in the Northwestern part of the state, the majority of Region 1 was repeatedly inundated by glaciers and is generally flat with glacial sediments conducive to agriculture. Due to this, Region 1 largely driven by its agriculture industry and has the most cropland in the state. Crop Cash Receipts from this region is estimated to be much greater than Regions 2 and 3.

Table 2.11.g

Agricultural Cash Receipts and Scenario Losses, OEMA Region 2				
County	**2020 Population**	**Cropland [1] (Acres)**	**Crop Cash Receipts [1] (2023 Dollars)**	**Expected Losses 2012 Drought Scenario (2023 Dollars)**
Pickaway	58,539	274,958	$ 185,742,500	$ 24,731,160
Madison	43,824	235,321	$ 156,803,750	$ 20,878,036
Lorain	312,964	105,149	$ 145,776,250	$ 19,409,752
Clinton	42,018	190,717	$ 134,591,250	$ 17,920,496
Fayette	28,951	189,877	$ 132,518,750	$ 17,644,548
Union	62,784	196,063	$ 129,333,750	$ 17,220,473
Greene	167,966	149,590	$ 110,146,250	$ 14,665,704
Licking	178,519	160,705	$ 104,497,500	$ 13,913,587
Wayne	116,894	204,037	$ 101,696,250	$ 13,540,607
Delaware	214,124	117,539	$ 96,805,000	$ 12,889,349
Fairfield	158,921	153,607	$ 96,743,750	$ 12,881,194
Lake	232,603	8,267	$ 90,803,750	$ 12,090,298
Montgomery	537,309	91,369	$ 86,631,250	$ 11,534,739
Knox	62,721	139,999	$ 77,757,500	$ 10,353,221
Morrow	34,950	139,079	$ 76,906,250	$ 10,239,879
Richland	124,936	113,080	$ 62,605,000	$ 8,335,703
Warren	242,337	71,243	$ 55,897,500	$ 7,442,616
Franklin	1,323,807	45,000	$ 55,501,250	$ 7,389,856
Ashland	52,447	120,812	$ 55,251,250	$ 7,356,569
Butler	390,357	92,146	$ 50,993,750	$ 6,789,693
Stark	374,853	101,697	$ 50,757,500	$ 6,758,237
Medina	182,470	78,627	$ 47,753,750	$ 6,358,295
Portage	161,791	59,464	$ 30,591,250	$ 4,073,150
Geauga	95,397	33,577	$ 21,841,250	$ 2,908,109
Hamilton	830,639	8,405	$ 17,501,250	$ 2,330,249
Summit	540,428	10,653	$ 10,788,750	$ 1,436,496
Cuyahoga	1,264,817	639	$ 7,672,500	$ 1,021,575
TOTAL	**7,837,366**	**3,091,620**	**$ 2,193,908,750**	**$ 292,113,592**

Source: U. S. Department of Agriculture - National Agricultural Statistics Service, Agricultural Census and Quick Stats

1- Values obtained from the 2017 Ohio Agricultural Census and reflect 2017 amounts. Dollar amounts were adjusted to 2023 dollars.

Table 2.11.h

Agricultural Cash Receipts and Scenario Losses, OEMA Region 3				
County	**2020 Population**	**Cropland [1] (Acres)**	**Crop Cash Receipts [1] (2023 Dollars)**	**Expected Losses 2012 Drought Scenario (2023 Dollars)**
Highland	43,317	224,722	$ 118,371,250	$ 15,760,843
Ross	77,093	168,173	$ 83,430,000	$ 11,108,501
Brown	43,676	154,673	$ 78,921,250	$ 10,508,172
Ashtabula	97,574	101,081	$ 47,880,000	$ 6,375,105
Trumbull	201,977	82,006	$ 45,147,500	$ 6,011,279
Columbiana	101,877	95,927	$ 43,180,000	$ 5,749,312
Holmes	44,223	104,215	$ 41,833,750	$ 5,570,062
Coshocton	36,612	97,155	$ 41,582,500	$ 5,536,608
Muskingum	86,410	88,133	$ 35,962,500	$ 4,788,319
Clermont	208,601	65,529	$ 35,556,250	$ 4,734,228
Adams	27,477	89,226	$ 31,352,500	$ 4,174,509
Mahoning	228,614	56,429	$ 30,678,750	$ 4,084,801
Washington	59,771	56,999	$ 29,150,000	$ 3,881,251
Perry	35,408	58,863	$ 28,898,750	$ 3,847,798
Pike	27,088	54,339	$ 28,350,000	$ 3,774,733
Tuscarawas	93,263	80,075	$ 26,881,250	$ 3,579,173
Carroll	26,721	64,345	$ 23,677,500	$ 3,152,601
Scioto	74,008	45,142	$ 17,422,500	$ 2,319,763
Meigs	22,210	31,354	$ 13,397,500	$ 1,783,844
Guernsey	38,438	59,132	$ 13,265,000	$ 1,766,202
Gallia	29,220	37,576	$ 11,620,000	$ 1,547,175
Harrison	14,483	41,043	$ 9,788,750	$ 1,303,348
Morgan	13,802	40,318	$ 8,947,500	$ 1,191,338
Belmont	66,497	41,431	$ 7,358,750	$ 979,800
Athens	62,431	30,432	$ 7,197,500	$ 958,330
Jackson	32,653	27,257	$ 6,498,750	$ 865,293
Monroe	13,385	31,103	$ 6,115,000	$ 814,197
Vinton	12,800	14,006	$ 5,715,000	$ 760,938
Jefferson	65,249	32,970	$ 5,285,000	$ 703,685
Hocking	28,050	14,069	$ 5,126,250	$ 682,548
Noble	14,115	24,365	$ 3,311,250	$ 440,885
Lawrence	58,240	15,978	$ 3,016,250	$ 401,606
TOTAL	**1,985,283**	**2,128,066**	**$ 894,918,750**	**$ 119,156,246**

Source: U. S. Department of Agriculture - National Agricultural Statistics Service, Agricultural Census and Quick Stats

1- Values obtained from the 2017 Ohio Agricultural Census and reflect 2017 amounts. Dollar amounts were adjusted to 2023 dollars.

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

Drought does not pose a specific threat to state-owned or state-leased facilities. The larger threat from drought would be based on the agricultural and drinking water demands with a limited supply. Additionally, drought can play a major role in occurrences of wildfires throughout the state (Section 2.7).

2.12 SEVERE SUMMER STORMS

For the purpose of this plan, Severe Summer Storms is an assessment of multiple hazards: thunderstorm- and high- winds, hail, and lightning events.

Severe summer storms traditionally precede an approaching cold air mass. In the northern hemisphere, the spin of the earth naturally produces weather patterns affecting North America, which travel from west to east across the continent. Key components to the formation of storms are a low-pressure zone, high-pressure zone and the jet stream.

The troposphere is the lowest portion of Earth's atmosphere containing approximately 75% of the atmosphere's mass and almost all of its water vapor. Air at this level is acted upon by the earth surface (land and water) and the heating cycle associated with sunlight. Unlike other portions of the atmosphere which are largely homogenous, at the surface discrete areas or bubbles exist of differing temperature, water vapor content and pressure. Warm areas (low pressure) tend to rise, pressing on the borders of surrounding cool areas (high pressure). It is where the pressure zones interface that temperature changes cause water vapor in the air to condense creating precipitation. The warmer the overall temperature of the atmosphere and the greater the volume of water vapor present, the larger the associated perception event.

Jet streams are fast flowing, relatively narrow air currents found in the atmosphere around 11 kilometers (36,000 ft.) above the surface of the Earth. They form at the boundaries of adjacent air masses with significant differences in temperature, such as of the polar region and the warmer air toward the equator. These air currents migrate north and south in a snakelike pattern changing their relative location as the planet’s axis tilts with each passing year. These winds act on the high- and low-pressure zone moving them across the continent and shifting them north and south.

Summer storms are considered *high wind* events by the National Climactic Data Center when surface winds meet or exceed 50 knots or 57.6 miles per hour. It is possible for winds in strong storms to exceed 100 miles per hour, with gusts even stronger. On the occasion that a *high wind* event occurs on a convective line without lightning and embedded within an area with a tight surface pressure gradient, it is then classified as a *thunderstorm wind* event.

Figure 2.12a

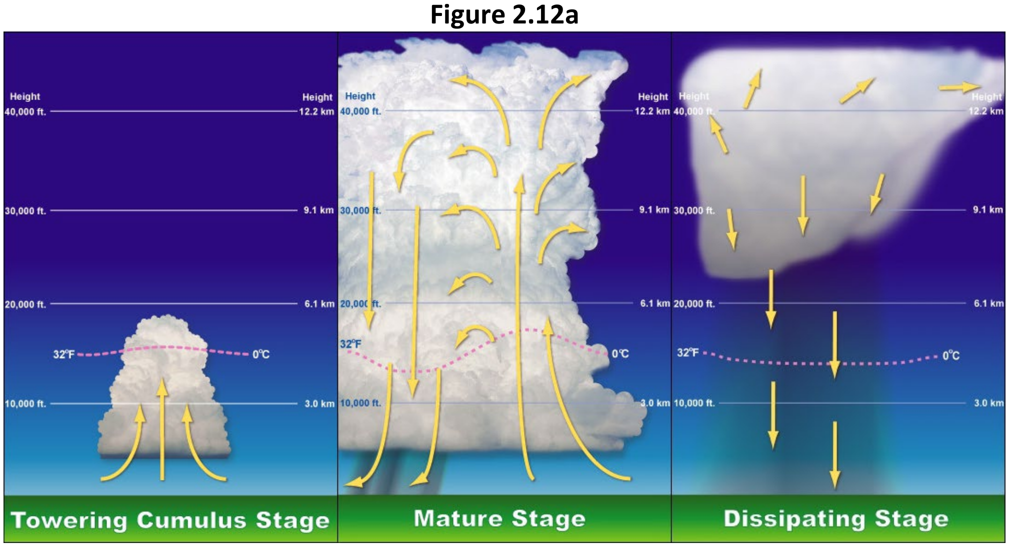


Figure 2.12.a: Stages of a Thunderstorm’s Life
Source: [Wikipedia]

Figure 2.12.b: Tennis ball sized hail from June 8, 2007, Summit County

Source: National Weather Service, Cleveland. Photo courtesy of Dale Dailey

Thunderstorms develop when large differences exist between adjacent zones combined with significant water vapor. As warm air begins to lift, it eventually starts to cool and condensation takes place. When the moisture condenses, heat is released which further aids in the lifting process. If enough instability is present in the atmosphere, this process will continue long enough for cumulonimbus clouds to form, which supports lightning and thunder (see Diagram 2.12a). As water droplets rise into the colder air, they can freeze. When the velocity of wind becomes great enough, the ice pellets are repeatedly lifted and dropped in the storm adding layers of ice with each cycle. Once the wind cannot support the weight of the ice pellet it falls the ground in the form of *hail*.

Figure 2.12.c: Lightning event at Temescal Valley, CA

Source: National Weather Service, Photo courtesy of Willi Wilkens

One key component to a thunderstorm is lightning, an atmospheric discharge of electricity. High speed videos (examined frame-by frame) show that most lightning strikes are made up of multiple individual strokes. A typical strike is made of 3 to 4 strokes. The sudden increase in pressure and temperature from lightning produces rapid expansion of the air surrounding and within a bolt of lightning. In turn, this expansion of air produces a sonic shock wave which produces the sound of thunder. Lightning, other storm components, often seeks a path though the tallest object available. Trees, utility line/poles, tall buildings and even humans can be sought as a pathway for the discharging electricity.

According to the National Weather Service, lightning is a major cause of storm related deaths in the U.S. A lightning strike can result in a cardiac arrest (heart stopping) at the time of the injury, although some victims may appear to have a delayed death a few days later if they are resuscitated but have suffered irreversible brain damage. Over the last 30 years (1989-2018) the U.S. has averaged 43 reported lightning fatalities per year. Only about 10% of people who are struck by lightning are killed, leaving 90% with various degrees of disability. More recently, in the last 10 years (2009-2018), the U.S. has averaged 27 lightning fatalities.

RISK ASSESSMENT

LOCATION

Severe summer storms and associated thunderstorm/high winds, lightning, and hail events are common throughout Ohio and reported hundreds of times each year. Each of these hazards are not spatially-limited and are state-wide hazards. For thunderstorm wind and hail events, past occurrences will be reported based on days with events. For lightning, each reported event will be counted as a single event.

PAST OCCURRENCES AND PROBABILITY OF FUTURE EVENTS (TABLE 2.12.a/b/c)

HIGH- AND THUNDERSTORM- WINDS

According to the NCDC Storm Database, there has been *972 High- and Thunderstorm- Wind* events from January 1, 2003 to January 1, 2023. From these events, about *$1,550,716,970* (*Inflation-adjusted value 2023*) in property and crop damages have been reported and have resulted in *26* deaths and *153* injuries. Based on these figures, *High- and Thunderstorm- Winds* are the most prevalent natural hazard events in Ohio with having a *100%* chance events of occurring in any given year. The costliest high wind event happened on September 14, 2008 as a result of Hurricane Ike. High winds affected most parts of the state. The NCDC Storm Database reports that $771,955,000 had been caused in property and crop damage.

Table 2.12.a

High- and Thunderstorm- Winds Past Occurrences and Probability Assessment by County														
Region 1					Region 2					Region 3				
County	Total Deaths	Total Injuries	Days with Event [1,2]	Est. Annual Probability [3]	County	Total Deaths	Total Injuries	Days with Event [1,2]	Est. Annual Probability [3]	County	Total Deaths	Total Injuries	Days with Event [1,2]	Est. Annual Probability [3]
Allen	0	3	76	3.8	Ashland	0	1	110	5.4	Adams	0	0	76	3.8
Auglaize	0	2	82	4.1	Butler	0	0	107	5.3	Ashtabula	0	0	120	5.9
Champaign	0	1	73	3.6	Clinton	0	0	102	5.0	Athens	0	6	76	3.8
Clark	0	0	106	5.2	Cuyahoga	0	6	182	8.9	Belmont	0	0	83	4.1
Crawford	0	0	97	4.8	Delaware	1	5	88	4.4	Brown	0	0	103	5.1
Darke	0	0	104	5.1	Fairfield	1	1	104	5.1	Carroll	0	0	100	5.0
Defiance	0	0	64	3.2	Fayette	0	1	74	3.7	Clermont	0	1	139	7.0
Erie	0	1	96	4.7	Franklin	0	10	144	7.2	Columbiana	0	3	127	6.2
Fulton	0	0	63	3.2	Geauga	1	0	115	5.6	Coshocton	0	0	98	4.9
Hancock	0	0	120	5.9	Greene	1	0	121	6.0	Gallia	0	0	55	2.9
Hardin	0	0	49	2.4	Hamilton	3	4	144	7.2	Guernsey	0	0	88	4.3
Henry	0	1	80	4.0	Knox	0	1	117	5.8	Harrison	2	0	83	4.1
Huron	0	0	113	5.6	Lake	0	2	108	5.3	Highland	0	1	90	4.5
Logan	0	0	84	4.2	Licking	2	4	115	5.7	Hocking	0	0	71	3.5
Lucas	2	0	123	6.1	Lorain	1	3	154	7.6	Holmes	0	0	101	5.0
Marion	1	4	103	5.1	Madison	1	3	67	3.3	Jackson	0	1	61	3.2
Mercer	0	3	78	3.9	Medina	1	3	112	5.5	Jefferson	1	2	102	5.1
Miami	0	3	98	4.8	Montgomery	1	2	141	7.0	Lawrence	0	1	71	3.5
Ottawa	0	5	101	5.0	Morrow	0	0	82	4.1	Mahoning	1	0	111	5.5
Paulding	0	0	56	2.8	Pickaway	0	2	68	3.4	Meigs	0	0	43	2.3
Preble	2	0	75	3.7	Portage	0	2	126	6.3	Monroe	0	0	54	2.7
Putnam	0	2	60	3.0	Richland	0	2	135	6.7	Morgan	0	0	55	2.8
Sandusky	0	2	100	4.9	Stark	1	1	122	6.1	Muskingum	1	1	98	4.9
Seneca	0	1	109	5.4	Summit	0	1	134	6.6	Noble	0	0	54	2.7
Shelby	0	1	86	4.3	Union	0	0	69	3.4	Perry	1	0	78	3.9
Van Wert	1	0	83	4.2	Warren	0	4	127	6.3	Pike	0	5	69	3.5
Williams	1	2	59	2.9	Wayne	0	2	122	6.0	Ross	0	0	87	4.3
Wood	0	1	118	5.8						Scioto	1	2	123	6.1
Wyandot	0	0	69	3.4						Trumbull	0	40	152	7.5
										Tuscarawas	0	0	127	6.3
										Vinton	0	0	57	3.0
										Washington	0	0	65	3.2

1- Count includes both high winds, and thunderstorm wind events as reported by the National Weather Service.

2- Events are counted as days with events, where multiple events per day is counted as one event.

3- Due to the reason above, estimated annual probability is the probability of an event day occurring in a given year.

HAIL

For *hail* during the same timeframe, there were *673* days with events that resulted in *$1,264,550,867* in property and crop damage and have resulted in *0* deaths and *3* injuries. Based on these figures, Hail events also have a *100%* chance of occurring in any given year. The costliest hail event from happened on May 25, 2012, affecting Hancock County and had reported *$85 million (approximately $116.5 million Inflation-adjusted value 2023*) in damages. The event had produced hail as large as baseballs. The western half of the city of Findlay was especially hard hit. As many as 4,000 homes and business in this area may have been damaged by the hail. Thousands of automobiles also sustained damage from the hail. This event could end up being one of costliest hail storms in Ohio history.

Table 2.12.b

Hail Past Occurrences and Probability Assessment by County														
Region 1					Region 2					Region 3				
County	Total Deaths	Total Injuries	Days with Event [1, 2]	Est. Events Per Year	County	Total Deaths	Total Injuries	Days with Event [1, 2]	Est. Events Per Year	County	Total Deaths	Total Injuries	Days with Event [1, 2]	Est. Events Per Year
Allen	0	0	24	1.2	Ashland	0	0	48	2.4	Adams	0	0	29	1.4
Auglaize	0	0	40	2.0	Butler	0	0	49	2.4	Ashtabula	0	0	35	1.7
Champaign	0	0	21	1.1	Clinton	0	0	36	1.8	Athens	0	0	31	1.5
Clark	0	0	35	1.7	Cuyahoga	0	0	68	3.4	Belmont	0	0	30	1.5
Crawford	0	0	35	1.7	Delaware	0	0	28	1.4	Brown	0	0	33	1.6
Darke	0	0	34	1.7	Fairfield	0	0	41	2.0	Carroll	0	0	18	0.9
Defiance	0	0	22	1.1	Fayette	0	0	30	1.5	Clermont	0	0	49	2.4
Erie	0	0	40	2.0	Franklin	0	0	70	3.5	Columbiana	0	0	46	2.3
Fulton	0	0	14	0.7	Geauga	0	0	36	1.8	Coshocton	0	0	25	1.3
Hancock	0	0	39	1.9	Greene	0	0	45	2.2	Gallia	0	0	28	1.4
Hardin	0	0	20	1.0	Hamilton	0	0	58	2.9	Guernsey	0	0	30	1.5
Henry	0	0	13	0.7	Knox	0	0	30	1.5	Harrison	0	0	15	0.7
Huron	0	0	48	2.4	Lake	0	0	37	1.9	Highland	0	0	23	1.1
Logan	0	0	25	1.3	Licking	0	1	45	2.2	Hocking	0	0	19	0.9
Lucas	0	0	48	2.4	Lorain	0	0	64	3.2	Holmes	0	0	32	1.6
Marion	0	0	40	2.0	Madison	0	0	20	1.0	Jackson	0	0	23	1.2
Mercer	0	0	31	1.5	Medina	0	0	57	2.8	Jefferson	0	0	29	1.5
Miami	0	0	30	1.5	Montgomery	0	2	63	3.1	Lawrence	0	0	36	1.8
Ottawa	0	0	43	2.2	Morrow	0	0	26	1.4	Mahoning	0	0	43	2.1
Paulding	0	0	25	1.3	Pickaway	0	0	21	1.0	Meigs	0	0	24	1.2
Preble	0	0	23	1.1	Portage	0	0	61	3.0	Monroe	0	0	19	1.0
Putnam	0	0	31	1.5	Richland	0	0	65	3.2	Morgan	0	0	15	0.8
Sandusky	0	0	40	2.0	Stark	0	0	67	3.3	Muskingum	0	0	33	1.7
Seneca	0	0	51	2.5	Summit	0	0	88	4.4	Noble	0	0	12	0.6
Shelby	0	0	36	1.8	Union	0	0	27	1.3	Perry	0	0	31	1.6
Van Wert	0	0	14	0.7	Warren	0	0	49	2.4	Pike	0	0	16	1.0
Williams	0	0	13	0.6	Wayne	0	0	49	2.4	Ross	0	0	33	1.7
Wood	0	0	53	2.6						Scioto	0	0	44	2.2
Wyandot	0	0	23	1.1						Trumbull	0	0	57	2.8
										Tuscarawas	0	0	34	1.7
										Vinton	0	0	8	0.5
										Washington	0	0	33	1.6

1- Count includes both high winds, and thunderstorm wind events as reported by the National Weather Service.
2- Events are counted as days with events, where multiple events per day is counted as one event.
3- Due to the reason above, estimated annual probability is the probability of an event day occurring in a given year.

LIGHTNING

Within the same period, there were 39 counties that reported 65 lightning events and resulted in $2,547,080 dollars in reported property and crop damages, *15* deaths, and *62* injuries. These figures are the reported events on the NCDC Storm Events Database within the observed period. However, it does not mean that these were the only events nor that there weren't any lightning events other counties. It could also be assumed from these figures that events were not recorded unless resulting in death, injuries, or damages to crops and/or property.

According to the National Weather Service, lightning detecting systems in the United States monitor an average of 25 million strokes of lightning per year, and the odds of being a lightning victim in the U.S. in any given year is about one in 1,222,000. The odds of being struck within a lifetime of 80 years, is one in 15,300.

Table 2.12.c

Lightning Past Occurrences by County					
County	**Region**	**Total Deaths**	**Total Injuries**	**Reported Events [1]**	**Reported Damages [2] 1/1/2003 to 1/1/2023**
Allen	1	0	0	3	$ 304,000
Clark	1	0	1	1	*None Reported*
Darke	1	0	0	1	$ 27,800
Fulton	1	0	0	1	$ 65,500
Hardin	1	1	0	1	*None Reported*
Huron	1	1	1	1	*None Reported*
Logan	1	0	1	1	*None Reported*
Miami	1	0	3	2	$ 4,800
Van Wert	1	0	0	1	$ 96,850
Wood	1	0	1	2	$ 60,000
Butler	2	1	2	3	$ 6,100
Cuyahoga	2	0	1	2	$ 126,400
Fairfield	2	0	1	1	*None Reported*
Franklin	2	2	4	4	$ 1,170
Hamilton	2	2	1	3	$ 36,200
Lorain	2	0	0	2	$ 181,700
Medina	2	0	1	2	$ 118,500
Montgomery	2	0	1	1	*None Reported*
Morrow	2	0	0	1	$ 23,700
Stark	2	1	1	5	$ 252,800
Summit	2	0	9	1	*None Reported*
Warren	2	1	2	4	$ 695,000
Wayne	2	0	0	1	$ 76,000
Ashtabula	3	0	1	2	$ 158,000
Athens	3	0	0	3	$ 17,050
Belmont	3	1	5	1	*None Reported*
Carroll	3	0	6	1	*None Reported*
Coshocton	3	1	0	1	*None Reported*
Gallia	3	0	1	1	*None Reported*
Hocking	3	0	10	1	*None Reported*
Lawrence	3	0	3	2	$ 34,250
Mahoning	3	1	0	1	*None Reported*
Meigs	3	0	0	1	$ 26,600
Monroe	3	1	0	1	*None Reported*
Muskingum	3	1	0	1	*None Reported*
Ross	3	1	5	1	*None Reported*
Trumbull	3	0	0	2	$ 229,700
Vinton	3	0	1	1	*None Reported*
Washington	3	0	0	1	$ 4,960
Total		**15**	**62**	**65**	**$ 2,547,080**

1- NCDC Storm Events Database only produces lightning events resulting in death, injuries, or damages to crops and/or property.

HURRICANES AND TROPICAL STORMS

In more recent years, a number of disaster declarations for Ohio was declared in result of remnants from hurricanes and tropical storms. Notably, wind events caused by remnants of Hurricane IKE in September 2008 had resulted in large damages across Ohio. High winds, rain, and flooding events from Hurricane SANDY, 2012, followed through to portions of Ohio.

STATEWIDE HIGH WINDS – SEPTEMBER 2008 (FEMA DR-1805-OH)
Usually, tropical storms and hurricanes directly affecting other states result in extended rainfall in Ohio. NOAA Operational Significant Event Imagery shows that the windstorms of 2008 were a legacy from Hurricane IKE, which arced clockwise from the Gulf of Mexico to the western basin of Lake Erie and the Saint Lawrence Seaway. Ohio was affected from Hamilton County in southwest Ohio to the northeastern counties of Ashland, Carroll and Summit. Unlike other secondary effects of a diminishing hurricane, high winds in excess of 65 miles per hour were primarily the cause of damage for many counties, causing power outages across these portions of the state. It was reported that winds equal to a Category 1 hurricane (winds up to 74 miles per hour) caused at least $1.255 billion in insured losses.

SEVERE STORMS, FLOODING AND LANDSLIDES – APRIL & MAY 2011 (FEMA DR- 4002-OH)
The impact of this event was widespread and costly due to the prolonged and record-setting spring rainfall during the months of March, April and May. According to the National Weather Service (NWS), a persistent upper valley weather channel over the eastern U.S. led to an active storm track over the Ohio Valley. During the month of April and into mid-May, the local NWS offices serving Ohio issued flood watches, flood warnings, flash flood watches and advisories and/or special weather statements for the Ohio River Watershed and Drainage Basin for 31 of the 44 days. Eighty-one percent of the watches, warnings and advisories were issued directly for the impacted counties, however, all of the counties had high stream levels on their watersheds. Also, during this time period, there were road closures almost every day due to flooding and/or high water. A notable incident was a small plane crashed near Ravenna, Ohio with three injuries due to saturated soil absorbing much of the impact. According to the Highway Patrol, had it not been for soft, soaked earth and mud, all three on board would have perished upon impact. Other incidents included 7,630 customers in power outages, trees uprooted, parts of buildings sustaining moderate damage and the loss of a countywide 911 system. As a result, the 21 affected Ohio counties received $44,506,071 in public assistance funds.

SEVERE STORMS AND STRAIGHT-LINE WINDS – JUNE 2012 (FEMA DR-4077-OH)
An anomalously strong storm ridge centered across the Southeast and brought record heat to the Upper Ohio Valley with the area in a flow on the northern edge of the ridge. A weak frontal boundary extended from northern Indiana into western Pennsylvania. Abundant moisture, strong instability, moderate shear, and a short wave just south of the boundary provided the ingredients for a long-tracked mesoscale convective system, classified by the Storm Prediction Center as a derecho, to track all the way from northern Indiana across eastern Ohio, southwestern Pennsylvania, northern WV, and western Maryland. As the system crossed the area, widespread wind damage was reported across areas primarily south and west of Pittsburgh. There were several reports of structural damage and damage led to a fatality when a barn collapsed in Muskingum County. Power outages were widespread with up to 130,000 outages reported immediately after the storms passage, most of which, were in Ohio. Muskingum and Guernsey counties sustained $712,000 and $500,000 in damages respectively. This also became one of the costliest disasters to hit Ohio, right behind Hurricane Ike in 2008. Two fatalities and eight injuries occurred during this event with $40,440,000 in property damage and $105,000 in damage to crops. As a result, of this event, 37 affected Ohio counties received $22,538,519 in public assistance funds.

HURRICANE SANDY – OCTOBER 2012 (FEMA DR-4098-OH)

On October 29, 2012, Hurricane Sandy made landfall near Atlantic City, New Jersey, however, the storm continued to produce significant wind, storm surge, rainfall and inland-flooding hazards across the Northeastern United States. High wind warnings as well as flood and flash flood watches and warnings for portions of Ohio and Indiana. The National Weather Service reported winds up to 80 miles per hour during the height of the storm system. First Energy Nuclear Operating Company reported sirens without AC power near Perry Nuclear Power Plant (Lake County-15 sirens, Geauga County-1 siren, Ashtabula-1siren) and Beaver Valley Power Station (Beaver County, PA-1siren). In Cuyahoga County, 80 people with functional needs were evacuated to a high school in Cleveland Heights, while another 11 shelters were being opened. The storm delivered a blow to Ashtabula County, but it wasn't the big uppercut some people had feared. As expected, strong wind toppled trees and dropped power lines, causing power outages across the county. Incessant rain toppled trees and flooded some thoroughfares in the area. Some of the hardest-hit areas were along the lakeshore, including Conneaut, North Kingsville, and Saybrook Township. Outages were reported in every city, village and township in the county, according to Illuminating Company information. Trees and limbs that collapsed on power lines were a big culprit, officials said. Lake County had residents from 142 homes near the mouth of the Chagrin River evacuated to the Mentor Community Center with another 70 evacuated to a shelter in Painesville. First Energy reported 55,516 customers without power in northeast Ohio. No fatalities were reported, however there was one injury that occurred. Property damage was estimated at $55,234,000 with no damage to crops. As a result, of this event, 37 affected Ohio counties received $17,810,815 in public assistance funds.

SEVERE STORMS, LANDSLIDES, AND MUDSLIDES – FEBRUARY 2018 (FEMA DR-4360-OH)

Beginning on February 14, 2018, and continuing through February 25, 2018, a persistent band of moderate to severe storms moved across Region V impacting Illinois, Indiana, Michigan, Ohio, and Wisconsin. While precipitation levels and storm-related damages varied, Ohio experienced a significant amount of flooding and subsequent damage along the southern portion of the state. The snowmelt and continued rain throughout the incident period, combined with the frozen soils, led to flooding along area streams, rivers, and low-lying areas. Numerous flood gauges in this area rose to moderate flood stage, and rainfall totals in the impacted areas during the incident period ranged from a total of five to nine inches. Following these storms, there were several road closures as well as reports of inaccessible areas throughout southern Ohio due to standing water.

On March 26, the Governor requested a Presidential Disaster Declaration. On April 17, 2018, a disaster was declared for the State of Ohio, due to severe storms, flooding, and landslides that occurred during the incident period of February 14, 2018, through February 25, 2018. As a result of that declaration, Public Assistance has been made available for Adams, Athens, Belmont, Brown, Columbiana, Gallia, Hamilton, Jackson, Lawrence, Meigs, Monroe, Muskingum, Noble, Perry, Pike, Scioto, Vinton, and Washington Counties. The Disaster impact data is fluid as only half of the Public Assistance projects have been awarded as of January 2019.

SEVERE STORMS, FLOODING, AND LANDSLIDES – APRIL 2019 (FEMA DR-4424-OH)

Beginning February 5 and lasting through February 13, created dangerous and damaging conditions affecting the health, safety and welfare of the citizens of Ohio. Ohio Governor Mike DeWine declared a state of emergency on March 11, 2019 for 20 Ohio counties including: Adams, Athens, Brown, Gallia, Guernsey, Hocking, Jackson, Jefferson, Lawrence, Meigs, Monroe, Morgan, Muskingum, Noble, Perry, Pike, Ross, Scioto, Vinton and Washington. The counties suffered from significant infrastructure damage as heavy rains poured down on already-saturated soils, damaging public infrastructure like roads and culverts. On April 8, 2019, A Presidential Disaster Declaration was made that ordered Federal assistance to supplement State and local recovery efforts in the areas affected by severe storms, flooding, and landslides. Joint preliminary damage assessments conducted by local, state, and federal emergency management officials during the second week of March documented damages to critical infrastructure, such as county roads, bridges, culverts, and public buildings totaling $41.4 million.

SEVERE STORMS, STRAIGHT-LINE WINDS, TORNADOES, FLOODING, AND MORE– APRIL 2019 (FEMA DR-4447-OH)

Following the Memorial Day tornadoes that touched down in parts of western Ohio and brought rain and flooding impact across the state, the federal government declared a federal major disaster on June 18, 2019. Officially, this is the Ohio Severe Storms, Straight-line Winds, Tornadoes, Flooding, Landslides, and Mudslide (DR-4447). The federal disaster area includes households and business owners in Auglaize, Darke, Greene, Hocking, Mercer, Miami, Montgomery, Muskingum, Perry, and Pickaway counties. This list later included Mahoning and Columbiana counties in the eastern part of the state. In the June 27 request to the FEMA, Ohio Emergency Management Agency Executive Director Sima Merick included a preliminary damage assessment of about $18.1 million in eligible costs, of which two-thirds, or about $12 million, was debris removal.

LHMP DATA

HENRY COUNTY: The County's Hazard Mitigation Plan of 2018 states that from January of 1950 to June of 2017 in Henry County. These events have caused two injuries, over $800,000 in property damage, $600,000 in crop damage, and no deaths. Based on historical information, Henry County can expect to endure at least three severe storms in any given year.

DARKE COUNTY: The 2011 Updated Hazard Mitigation Plan cites that there has been a total of 2 lightning events, 64 hail events, and 148 thunderstorm/wind events in Darke County from June 9, 1958 through December 31, 2010. Based on NCDC data, Darke County can expect at least four severe summer storm events each year along with smaller events. Some of the significant events are described in the following paragraphs.

FAIRFIELD COUNTY: The 2016 Fairfield County Natural Hazards Mitigation Plan references 219 severe thunderstorm events from 1968 to 2016. From the period of 1961 to 2016, the County experienced 58 Hail events creating $52,000.00 in property damages. No deaths or injuries as a result of Hail storms.

MIP LHMP HIRA ASSESSMENT

Overall, Severe summer storms ranked fourth in cumulative scoring amongst the other hazards, falling from third in the 2019 SOHMP.

Table 2.12.d

FLOOD MIP LHMP HIRA ASSESSMENT								
Ranking	3	7	5	2	10	6	2	4
Criteria Score	4.41	3.54	3.34	2.73	1.33	1.56	1.88	3.54
	Hazard Frequency	Response Time	Onset Time	Magnitude	Impact on Business	Impact on Humans	Impact on Property	Cumulative Score

VULNERABILITY ANALYSIS AND LOSS ESTIMATION

METHDOLOGY

In the National Risk Index, a hail, lightning, and strong winds hazard risk index score/rating represent a community's relative risk for those hazards when compared to the rest of the United States. The Expected Annual Loss (EAL) represents the relative level of agriculture, building, and population loss each year. For more information on current methodology and data, refer to Sections 11 (Hail), 16 (Lightning), and 18 (Strong Winds) of the National Risk Index Technical Manual

RESULTS

HAIL

The FEMA NRI estimates expected annual losses (EAL) will more heavily impact buildings than people. For county-specific estimates for lightning in Ohio, refer to table 2.12.e.

- Region 1 is estimated to have an expected annual loss of $7,851,253: $7,156,835 in building loss, $116,768 in population equivalence, and $577,650 in agriculture loss.
- Region 2 is estimated to have an expected annual loss of $39,640,581: $7,156,835 in building loss, $667,635 in population equivalence, and $263,035 in agriculture loss.
- Region 3 is estimated to have an expected annual loss of $7,244,652: $6,805,557 in building loss, $245,583 in population equivalence, and $193,512 in agriculture loss.

LIGHTNING

The FEMA NRI estimates expected annual losses (EAL) will more heavily impact people than buildings, and does not estimate EAL for agriculture. For county-specific estimates for lightning in Ohio, refer to table 2.12.f.

- Region 1 is estimated to have an expected annual loss of $3,013,923: $2,557,163 in population equivalence and $456,760 in building loss.
- Region 2 is estimated to have an expected annual loss of $12,112,966: $11,334,731 in population equivalence and $778,235 in building loss.
- Region 3 is estimated to have an expected annual loss of $3,013,923- $2,557,163 in population equivalence and $456,760 in building loss.

STRONG (HIGH AND THUNDERSTORM) WINDS

The FEMA NRI estimates expected annual losses (EAL) will more heavily impact buildings than people. For county-specific estimates for lightning in Ohio, refer to table 2.12.g.

- Region 1 is estimated to have an expected annual loss of $22,229,867: $14,419,400 in building loss, $7,406,297 in population equivalence, and $404,170 in agriculture loss.
- Region 2 is estimated to have an expected annual loss of $30,517,458: $23,665,793 in building loss, $6,753,214 in population equivalence, and $98,450 in agriculture loss.
- Region 3 is estimated to have an expected annual loss of $9,933,268: $7,014,647 in building loss, $2,877,856 in population equivalence, and $40,764 in agriculture loss.

Table 2.12.e

FEMA National Risk Index Hail Analysis by Region

Region 1

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Allen	$ 1,118,144	$ 1,471	$ 8,477
Auglaize	$ 5,358	$ 696	$ 628
Champaign	$ 17,592	$ 1,792	$ 15,604
Clark	$ 8,153	$ 6,337	$ 16,829
Crawford	$ 67,531	$ 6,409	$ 4,446
Darke	$ 12,575	$ 851	$ 74,524
Defiance	$ 505,188	$ 1,760	$ 30,411
Erie	$ 224,048	$ 10,762	$ 5,921
Fulton	$ 416,638	$ 1,932	$ 64,456
Hancock	$ 1,542,012	$ 10,280	$ 2,762
Hardin	$ 3,013	$ 1,434	$ 14,038
Henry	$ 410,301	$ 1,253	$ 2,843
Huron	$ 29,630	$ 8,961	$ 4,753
Logan	$ 18,239	$ 2,053	$ 15,775
Lucas	$ 173,837	$ 19,128	$ 1,293
Marion	$ 197,528	$ 3,185	$ 14,359
Mercer	$ 7,913	$ 661	$ 85,624
Miami	$ 5,955	$ 1,622	$ 14,270
Ottawa	$ 212,916	$ 5,532	$ 4,933
Paulding	$ 325,122	$ 864	$ 49,110
Preble	$ 395	$ 678	$ 21,209
Putnam	$ 411,068	$ 1,564	$ 13,029
Sandusky	$ 258,946	$ 8,119	$ 1,923
Seneca	$ 81,581	$ 7,612	$ 6,188
Shelby	$ 9,296	$ 683	$ 22,593
Van Wert	$ 271,963	$ 409	$ 23,754
Williams	$ 355	$ 1,704	$ 34,416
Wood	$ 501,960	$ 5,893	$ 13,489
Wyandot	$ 319,576	$ 3,124	$ 9,992
Total	$ 7,156,835	$ 116,768	$ 577,650

Region 2

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Ashland	$ 68,418	$ 2,860	$ 4,078
Butler	$ 8,856	$ 6,022	$ 7,700
Clinton	$ 80,650	$ 1,926	$ 15,322
Cuyahoga	$ 75,575	$ 97,304	$ 400
Delaware	$ 4,129,357	$ 9,328	$ 11,037
Fairfield	$ 10,572	$ 6,106	$ 10,881
Fayette	$ 61,818	$ 1,325	$ 16,565
Franklin	$ 6,808,896	$ 87,668	$ 6,173
Geauga	$ 111,669	$ 22,624	$ 4,124
Greene	$ 16,819	$ 7,934	$ 12,866
Hamilton	$ 450,330	$ 60,033	$ 3,145
Knox	$ 72,260	$ 3,307	$ 13,423
Lake	$ 102,218	$ 25,351	$ 821
Licking	$ 2,407,612	$ 13,115	$ 23,112
Lorain	$ 93,433	$ 44,531	$ 4,803
Madison	$ 13,257	$ 2,010	$ 20,962
Medina	$ 78,572	$ 29,416	$ 1,963
Montgomery	$ 7,919,778	$ 15,390	$ 10,910
Morrow	$ 69,515	$ 1,717	$ 1,331
Pickaway	$ 23,938	$ 2,371	$ 19,004
Portage	$ 1,080,173	$ 26,648	$ 3,522
Richland	$ 40,038	$ 11,876	$ 12,781
Stark	$ 6,815,319	$ 70,489	$ 5,869
Summit	$ 7,331,417	$ 91,855	$ 1,010
Union	$ 9,121	$ 2,915	$ 28,237
Warren	$ 628,844	$ 3,571	$ 6,264
Wayne	$ 201,456	$ 19,942	$ 16,733
Total	$ 38,709,911	$ 667,635	$ 263,035

Region 3

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Adams	$ 260,713	$ 1,174	$ 4,903
Ashtabula	$ 56,064	$ 10,191	$ 14,314
Athens	$ 79,461	$ 2,379	$ 1,254
Belmont	$ 800,338	$ 42,528	$ 3,891
Brown	$ 9,246	$ 1,907	$ 2,602
Carroll	$ 38	$ 4,204	$ 10,313
Clermont	$ 221,852	$ 2,953	$ 5,854
Columbiana	$ 1,097,925	$ 16,562	$ 39,594
Coshocton	$ 368,992	$ 1,702	$ 13,970
Gallia	$ 290,312	$ 1,108	$ 2,080
Guernsey	$ 514,574	$ 1,623	$ 3,224
Harrison	$ 131,065	$ 2,104	$ 3,615
Highland	$ 27,699	$ 1,959	$ 849
Hocking	$ 14,093	$ 1,042	$ 549
Holmes	$ 117,978	$ 2,437	$ 4,221
Jackson	$ 99,904	$ 1,282	$ 1,240
Jefferson	$ 687,625	$ 8,996	$ 1,774
Lawrence	$ 133,567	$ 38,014	$ 1,915
Mahoning	$ 70,607	$ 36,005	$ 25,366
Meigs	$ 31,735	$ 849	$ 1,810
Monroe	$ 209,646	$ 7,322	$ 1,875
Morgan	$ 381	$ 488	$ 1,820
Muskingum	$ 1,081,180	$ 3,635	$ 8,417
Noble	$ 212,888	$ 7,809	$ 979
Perry	$ 10,615	$ 1,291	$ 3,562
Pike	$ 10,567	$ 1,115	$ 6,461
Ross	$ 18,461	$ 3,328	$ 9,613
Scioto	$ 7,500	$ 2,936	$ 2,028
Trumbull	$ 139,379	$ 31,024	$ 1,413
Tuscarawas	$ 1,541	$ 5,080	$ 9,166
Vinton	$ 91,115	$ 500	$ 636
Washington	$ 8,494	$ 2,042	$ 4,202
Total	$ 6,805,557	$ 245,583	$ 193,512

Statewide

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
All 88	$ 52,672,303	$ 1,029,986	$ 1,034,197

Table 2.12.f

FEMA National Risk Index Lightning Analysis by Region

Region 1

County	EAL (Buildings)	EAL (Pop Equiv.)
Allen	$ 17,466	$ 100,491
Auglaize	$ 10,379	$ 47,860
Champaign	$ 5,927	$ 127,924
Clark	$ 21,601	$ 150,521
Crawford	$ 5,099	$ 93,756
Darke	$ 2,458	$ 47,860
Defiance	$ 15,855	$ 88,798
Erie	$ 53,017	$ 52,028
Fulton	$ 4,400	$ 83,660
Hancock	$ 52,378	$ 165,845
Hardin	$ 3,791	$ 94,170
Henry	$ 12,025	$ 58,725
Huron	$ 12,857	$ 196,723
Logan	$ 8,121	$ 50,588
Lucas	$ 15,202	$ 48,721
Marion	$ 9,226	$ 159,989
Mercer	$ 25,952	$ 48,875
Miami	$ 3,064	$ 263,715
Ottawa	$ 12,828	$ 81,640
Paulding	$ 10,144	$ 43,263
Preble	$ 15,457	$ 43,777
Putnam	$ 13,549	$ 82,047
Sandusky	$ 379	$ 121,949
Seneca	$ 8,258	$ 50,745
Shelby	$ 18,132	$ 50,973
Van Wert	$ 6,553	$ 31,081
Williams	$ 16,618	$ 76,713
Wood	$ 57,786	$ 51,844
Wyandot	$ 18,239	$ 42,881
Total	$ 456,760	$ 2,557,163

Region 2

County	EAL (Buildings)	EAL (Pop Equiv.)
Ashland	$ 9,722	$ 106,375
Butler	$ 108,998	$ 947,889
Clinton	$ 12,423	$ 129,360
Cuyahoga	$ 22,413	$ 1,479,777
Delaware	$ 52,574	$ 568,191
Fairfield	$ 25,041	$ 55,287
Fayette	$ 5,847	$ 85,197
Franklin	$ 2,063	$ 1,825,352
Geauga	$ 16,699	$ 104,458
Greene	$ 26,920	$ 498,296
Hamilton	$ 58,101	$ 1,454,180
Knox	$ 13,348	$ 147,689
Lake	$ 5,597	$ 252,216
Licking	$ 5,535	$ 461,502
Lorain	$ 111,991	$ 162,834
Madison	$ 7,960	$ 115,872
Medina	$ 10,836	$ 102,770
Montgomery	$ 9,496	$ 504,060
Morrow	$ 4,389	$ 50,849
Pickaway	$ 7,650	$ 161,715
Portage	$ 19,179	$ 101,998
Richland	$ 2,942	$ 50,975
Stark	$ 81,039	$ 606,774
Summit	$ 21,282	$ 462,132
Union	$ 9,762	$ 155,873
Warren	$ 58,353	$ 528,913
Wayne	$ 68,077	$ 214,197
Total	$ 778,235	$ 11,334,731

Region 3

County	EAL (Buildings)	EAL (Pop Equiv.)
Adams	$ 6,300	$ 85,807
Ashtabula	$ 13,557	$ 205,257
Athens	$ 6,275	$ 169,821
Belmont	$ 41,861	$ 575,670
Brown	$ 7,831	$ 141,346
Carroll	$ 2,386	$ 168,325
Clermont	$ 7,397	$ 263,896
Columbiana	$ 1,263	$ 795,781
Coshocton	$ 276	$ 126,536
Gallia	$ 4,783	$ 48,691
Guernsey	$ 5,698	$ 91,972
Harrison	$ 1,420	$ 66,052
Highland	$ 5,141	$ 129,801
Hocking	$ 5,471	$ 116,584
Holmes	$ 1,690	$ 87,465
Jackson	$ 5,888	$ 100,033
Jefferson	$ 7,287	$ 276,680
Lawrence	$ 3,369	$ 138,464
Mahoning	$ 3,414	$ 1,078,258
Meigs	$ 2,477	$ 60,687
Monroe	$ 14,154	$ 94,166
Morgan	$ 1,841	$ 33,914
Muskingum	$ 12,228	$ 316,256
Noble	$ 13,170	$ 70,396
Perry	$ 4,147	$ 94,009
Pike	$ 3,934	$ 83,078
Ross	$ 9,839	$ 400,620
Scioto	$ 10,255	$ 230,625
Trumbull	$ 13,977	$ 1,392,884
Tuscarawas	$ 9,560	$ 52,399
Vinton	$ 1,813	$ 37,352
Washington	$ 13,682	$ 100,235
Total	$ 242,384	$ 7,633,061

Statewide

County	EAL (Buildings)	EAL (Pop Equiv.)
All 88	$ 1,477,379	$ 21,524,955

Table 2.12.g

FEMA National Risk Index Strong Winds Analysis by Region

Region 1

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Allen	$ 585,424	$ 218,858	$ 108
Auglaize	$ 438,656	$ 95,324	$ 337
Champaign	$ 314,418	$ 37,021	$ 5,160
Clark	$ 835,540	$ 23,169	$ 1,133
Crawford	$ 229,227	$ 58,979	$ 22,520
Darke	$ 614,541	$ 518,020	$ 752
Defiance	$ 184,188	$ 484,770	$ 2,321
Erie	$ 528,674	$ 21,687	$ 19,667
Fulton	$ 391,771	$ 599,116	$ 29,900
Hancock	$ 736,591	$ 29,974	$ 37,108
Hardin	$ 231,413	$ 92,804	$ 10,494
Henry	$ 138,447	$ 119,168	$ 17,062
Huron	$ 337,152	$ 110,491	$ 22,799
Logan	$ 544,270	$ 58,697	$ 5,372
Lucas	$ 942,435	$ 1,087,806	$ 9,512
Marion	$ 458,726	$ 176,564	$ 8,512
Mercer	$ 652,885	$ 540,474	$ 552
Miami	$ 740,658	$ 313,076	$ 71
Ottawa	$ 643,186	$ 143,544	$ 22,032
Paulding	$ 344,887	$ 198,901	$ 21,468
Preble	$ 407,549	$ 543,588	$ 119
Putnam	$ 353,928	$ 248,238	$ 22,719
Sandusky	$ 686,954	$ 111,456	$ 34,496
Seneca	$ 445,590	$ 25,023	$ 28,467
Shelby	$ 533,696	$ 114,653	$ 125
Van Wert	$ 209,851	$ 411,033	$ 174
Williams	$ 272,618	$ 903,686	$ 18,472
Wood	$ 1,401,314	$ 69,569	$ 24,782
Wyandot	$ 214,811	$ 50,605	$ 37,936
Total	$ 14,419,400	$ 7,406,297	$ 404,170

Region 2

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Ashland	$ 372,528	$ 33,799	$ 6,321
Butler	$ 2,192,159	$ 307,424	$ 35
Clinton	$ 395,720	$ 79,170	$ 4,430
Cuyahoga	$ 1,446,471	$ 1,056,654	$ 1,017
Delaware	$ 1,236,008	$ 121,616	$ 2,845
Fairfield	$ 625,716	$ 199,157	$ 380
Fayette	$ 272,930	$ 76,959	$ 190
Franklin	$ 2,685,017	$ 527,699	$ 1,650
Geauga	$ 203,479	$ 157,517	$ 1,279
Greene	$ 1,014,288	$ 284,475	$ 3,864
Hamilton	$ 2,785,708	$ 1,106,455	$ 8
Knox	$ 350,437	$ 129,368	$ 7,066
Lake	$ 296,778	$ 273,775	$ 496
Licking	$ 818,036	$ 316,893	$ 5,314
Lorain	$ 690,103	$ 263,061	$ 10,313
Madison	$ 329,165	$ 110,795	$ 1,138
Medina	$ 616,737	$ 344,250	$ 8,701
Montgomery	$ 2,589,340	$ 361,156	$ 2
Morrow	$ 226,127	$ 61,103	$ 4,575
Pickaway	$ 392,494	$ 62,203	$ 101
Portage	$ 329,910	$ 60,549	$ 1,391
Richland	$ 503,358	$ 37,742	$ 7,502
Stark	$ 367,726	$ 186,631	$ 4,211
Summit	$ 902,078	$ 327,479	$ 456
Union	$ 515,980	$ 23,979	$ 8,649
Warren	$ 1,181,475	$ 81,779	$ 26
Wayne	$ 326,026	$ 161,527	$ 16,491
Total	$ 23,665,793	$ 6,753,214	$ 98,450

Region 3

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
Adams	$ 382,754	$ 64,140	$ 1,810
Ashtabula	$ 155,380	$ 136,568	$ 1,368
Athens	$ 215,912	$ 101,781	$ 148
Belmont	$ 66,666	$ 206,222	$ 383
Brown	$ 435,294	$ 109,026	$ 3,398
Carroll	$ 68,161	$ 44,507	$ 1,150
Clermont	$ 1,109,820	$ 300,740	$ 24
Columbiana	$ 185,369	$ 36,955	$ 2,763
Coshocton	$ 93,984	$ 49,706	$ 4,848
Gallia	$ 110,924	$ 25,516	$ 360
Guernsey	$ 123,614	$ 52,955	$ 416
Harrison	$ 34,838	$ 21,912	$ 397
Highland	$ 431,363	$ 29,013	$ 150
Hocking	$ 158,126	$ 33,313	$ 122
Holmes	$ 338,004	$ 18,393	$ 9,141
Jackson	$ 167,937	$ 25,801	$ 252
Jefferson	$ 129,377	$ 132,450	$ 200
Lawrence	$ 265,076	$ 40,533	$ 227
Mahoning	$ 373,049	$ 294,261	$ 2,512
Meigs	$ 94,205	$ 20,485	$ 446
Monroe	$ 64,109	$ 32,204	$ 107
Morgan	$ 47,221	$ 13,344	$ 226
Muskingum	$ 111,216	$ 132,862	$ 1,136
Noble	$ 83,799	$ 35,573	$ 91
Perry	$ 113,785	$ 40,865	$ 807
Pike	$ 232,223	$ 57,550	$ 1,728
Ross	$ 388,210	$ 121,405	$ 607
Scioto	$ 322,250	$ 132,271	$ 549
Trumbull	$ 363,942	$ 405,928	$ 1,989
Tuscarawas	$ 131,785	$ 73,093	$ 2,789
Vinton	$ 46,880	$ 14,719	$ 132
Washington	$ 169,377	$ 73,766	$ 489
Total	$ 7,014,647	$ 2,877,856	$ 40,764

Statewide

County	EAL (Buildings)	EAL (Pop Equiv.)	EAL (Agriculture)
All 88	$ 45,099,841	$ 17,037,367	$ 543,385

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHDOLOGY

The Vulnerability Analysis and Loss Estimation methodology above utilized FEMA's National Risk Index to estimate values including exposures and expected annual losses. To estimate the Expected Annual Losses (EAL) for state-owned and state-leased critical facilities, an *NRI Building EAL to Exposure* ratio was determined by taking each county's expected annual losses (for buildings) and dividing it by that county's total building exposure value. This ratio was then multiplied by the total replacement costs for critical facilities in each county to estimate the expected annual loss for state-owned and State-leased critical facilities.

RESULTS

The 3,678 state-owned and state-leased critical facilities are estimated to experience about the same amount of damage annually from hail and strong winds. They're expected to experience $180,210 from hail, $178,266 from strong winds, and $5,339 annually from lightning.

In Region 1, the 852 state-owned and state-leased critical facilities are estimated to experience:

- $20,146 in damages from hail
- $1,254 in damages from lightning
- $35,750 in damages from strong (high and thunderstorm) winds

In Region 2, the 1,684 state-owned and state-leased critical facilities are estimated to experience:

- $134,270 in damages from hail
- $2,245 in damages from lightning
- $100,951 in damages from strong (high and thunderstorm) winds

In Region 3, the 1,232 state-owned and state-leased critical facilities are estimated to experience:

- $25,795 in damages from hail
- $1,840 in damages from lightning
- $41,564 in damages from strong (high and thunderstorm) winds

Table 2.12.h — Hail

Expected Annual Loss of State-owned and State-leased Critical Facilities by Region
Hail

Region 1

County	# of CF	NRI Building EAL:EXP Ratio	Replacement Cost of Critical Facilities	EAL of CF
Allen	99	0.0049%	$ 148,535,104	$ 7,311
Auglaize	18	0.0001%	$ 6,542,813	$ 4
Champaign	21	0.0002%	$ 9,246,093	$ 21
Clark	27	0.0000%	$ 9,650,921	$ 3
Crawford	12	0.0009%	$ 11,520,704	$ 106
Darke	27	0.0001%	$ 17,992,950	$ 16
Defiance	15	0.0062%	$ 12,622,416	$ 788
Erie	55	0.0013%	$ 150,149,608	$ 1,887
Fulton	12	0.0044%	$ 9,821,964	$ 433
Hancock	20	0.0097%	$ 12,221,847	$ 1,181
Hardin	18	0.0001%	$ 6,825,758	$ 4
Henry	16	0.0062%	$ 4,250,244	$ 261
Huron	22	0.0002%	$ 10,837,347	$ 26
Logan	21	0.0001%	$ 9,389,923	$ 13
Lucas	52	0.0002%	$ 274,497,738	$ 568
Marion	59	0.0016%	$ 237,054,145	$ 3,711
Mercer	27	0.0001%	$ 9,141,077	$ 5
Miami	30	0.0000%	$ 20,994,660	$ 5
Ottawa	52	0.0015%	$ 42,237,937	$ 648
Paulding	11	0.0062%	$ 8,375,637	$ 522
Preble	28	0.0000%	$ 7,555,862	$ 0
Putnam	19	0.0062%	$ 4,857,269	$ 299
Sandusky	14	0.0019%	$ 8,633,501	$ 161
Seneca	47	0.0007%	$ 47,263,740	$ 340
Shelby	35	0.0001%	$ 32,329,713	$ 21
Van Wert	16	0.0048%	$ 7,772,807	$ 376
Williams	17	0.0000%	$ 7,837,080	$ 0
Wood	40	0.0015%	$ 68,292,566	$ 997
Wyandot	22	0.0065%	$ 6,729,705	$ 436
Total	**852**	**0.0016%**	**$ 1,203,181,127**	**$ 20,146**

Region 2

County	# of CF	NRI Building EAL:EXP Ratio	Replacement Cost of Critical Facilities	EAL CF
Ashland	145	0.0005%	$ 103,491,091	$ 513
Butler	29	0.0000%	$ 17,200,278	$ 2
Clinton	31	0.0008%	$ 13,450,515	$ 104
Cuyahoga	106	0.0000%	$ 389,621,908	$ 121
Delaware	33	0.0076%	$ 61,002,573	$ 4,607
Fairfield	67	0.0000%	$ 94,557,543	$ 34
Fayette	23	0.0009%	$ 11,052,410	$ 95
Franklin	190	0.0029%	$ 2,336,963,045	$ 67,304
Geauga	27	0.0005%	$ 12,064,728	$ 61
Greene	21	0.0001%	$ 17,560,307	$ 9
Hamilton	41	0.0003%	$ 113,316,790	$ 332
Knox	41	0.0005%	$ 76,691,482	$ 389
Lake	21	0.0002%	$ 12,988,101	$ 29
Licking	67	0.0064%	$ 186,741,453	$ 11,951
Lorain	83	0.0001%	$ 212,390,581	$ 313
Madison	104	0.0002%	$ 398,511,572	$ 616
Medina	17	0.0002%	$ 16,239,797	$ 33
Montgomery	72	0.0080%	$ 187,896,794	$ 14,963
Morrow	19	0.0010%	$ 12,996,574	$ 134
Pickaway	137	0.0002%	$ 346,622,641	$ 669
Portage	25	0.0033%	$ 17,793,583	$ 588
Richland	77	0.0002%	$ 236,998,425	$ 392
Stark	57	0.0090%	$ 148,641,582	$ 13,313
Summit	65	0.0068%	$ 197,956,468	$ 13,380
Union	55	0.0001%	$ 169,438,472	$ 111
Warren	109	0.0013%	$ 323,719,448	$ 4,106
Wayne	22	0.0008%	$ 12,202,802	$ 102
Total	**1,684**	**0.0012%**	**$ 5,728,110,964**	**$ 134,270**

Region 3

County	# of CF	NRI Building EAL:EXP Ratio	Replacement Cost of Critical Facilities	EAL CF
Adams	30	0.0036%	$ 12,672,306	$ 456
Ashtabula	72	0.0003%	$ 25,195,275	$ 69
Athens	35	0.0007%	$ 53,251,615	$ 362
Belmont	70	0.0059%	$ 153,564,291	$ 9,112
Brown	31	0.0001%	$ 35,387,446	$ 37
Carroll	18	0.0000%	$ 5,220,360	$ 0
Clermont	51	0.0006%	$ 32,967,768	$ 203
Columbiana	36	0.0052%	$ 14,981,756	$ 776
Coshocton	21	0.0048%	$ 16,813,037	$ 801
Gallia	61	0.0049%	$ 49,786,218	$ 2,415
Guernsey	50	0.0060%	$ 58,733,741	$ 3,526
Harrison	24	0.0046%	$ 9,202,403	$ 425
Highland	11	0.0003%	$ 6,701,555	$ 18
Hocking	27	0.0002%	$ 7,590,231	$ 16
Holmes	29	0.0010%	$ 9,188,433	$ 91
Jackson	21	0.0014%	$ 10,211,085	$ 146
Jefferson	34	0.0044%	$ 14,685,898	$ 643
Lawrence	26	0.0014%	$ 9,167,439	$ 125
Mahoning	58	0.0001%	$ 109,678,167	$ 160
Meigs	24	0.0007%	$ 9,369,001	$ 63
Monroe	12	0.0049%	$ 3,933,796	$ 193
Morgan	15	0.0000%	$ 7,945,305	$ 1
Muskingum	36	0.0060%	$ 14,169,870	$ 846
Noble	32	0.0052%	$ 65,273,141	$ 3,373
Perry	9	0.0002%	$ 7,167,121	$ 14
Pike	12	0.0002%	$ 8,643,712	$ 14
Ross	129	0.0001%	$ 510,798,521	$ 688
Scioto	66	0.0001%	$ 478,434,987	$ 303
Trumbull	69	0.0003%	$ 97,032,569	$ 322
Tuscarawas	54	0.0000%	$ 50,576,265	$ 4
Vinton	19	0.0040%	$ 14,102,427	$ 569
Washington	50	0.0001%	$ 36,699,000	$ 27
Total	**1,232**	**0.0017%**	**$ 1,939,144,738**	**$ 25,795**

Table 2.12.i — Lightning

Expected Annual Loss of State-owned and State-leased Critical Facilities by Region
Lightning

Region 1

County	# of CF	NRI Building EAL:EXP Ratio	Replacement Cost of Critical Facilities	EAL of Critical Facilities
Allen	99	0.0001%	$ 148,535,104	$ 114
Auglaize	18	0.0001%	$ 6,542,813	$ 7
Champaign	21	0.0001%	$ 9,246,093	$ 7
Clark	27	0.0001%	$ 9,650,921	$ 8
Crawford	12	0.0001%	$ 11,520,704	$ 8
Darke	27	0.0000%	$ 17,992,950	$ 3
Defiance	15	0.0002%	$ 12,622,416	$ 25
Erie	55	0.0003%	$ 150,149,608	$ 447
Fulton	12	0.0000%	$ 9,821,964	$ 5
Hancock	20	0.0003%	$ 12,221,847	$ 40
Hardin	18	0.0001%	$ 6,825,758	$ 4
Henry	16	0.0002%	$ 4,250,244	$ 8
Huron	22	0.0001%	$ 10,837,347	$ 11
Logan	21	0.0001%	$ 9,389,923	$ 6
Lucas	52	0.0000%	$ 274,497,738	$ 50
Marion	59	0.0001%	$ 237,054,145	$ 173
Mercer	27	0.0002%	$ 9,141,077	$ 18
Miami	30	0.0000%	$ 20,994,660	$ 3
Ottawa	52	0.0001%	$ 42,237,937	$ 39
Paulding	11	0.0002%	$ 8,375,637	$ 16
Preble	28	0.0002%	$ 7,555,862	$ 14
Putnam	19	0.0002%	$ 4,857,269	$ 10
Sandusky	14	0.0000%	$ 8,633,501	$ 0
Seneca	47	0.0001%	$ 47,263,740	$ 34
Shelby	35	0.0001%	$ 32,329,713	$ 42
Van Wert	16	0.0001%	$ 7,772,807	$ 9
Williams	17	0.0002%	$ 7,837,080	$ 14
Wood	40	0.0002%	$ 68,292,566	$ 115
Wyandot	22	0.0004%	$ 6,729,705	$ 25
Total	**852**	**0.0001%**	**$ 1,203,181,127**	**$ 1,254**

Region 2

County	# of CF	NRI Building EAL:EXP Ratio	Replacement Cost of Critical Facilities	EAL of Critical Facilities
Ashland	145	0.0001%	$ 103,491,091	$ 73
Butler	29	0.0001%	$ 17,200,278	$ 25
Clinton	31	0.0001%	$ 13,450,515	$ 16
Cuyahoga	106	0.0000%	$ 389,621,908	$ 36
Delaware	33	0.0001%	$ 61,002,573	$ 59
Fairfield	67	0.0001%	$ 94,557,543	$ 80
Fayette	23	0.0001%	$ 11,052,410	$ 9
Franklin	190	0.0000%	$ 2,336,963,045	$ 20
Geauga	27	0.0001%	$ 12,064,728	$ 9
Greene	21	0.0001%	$ 17,560,307	$ 14
Hamilton	41	0.0000%	$ 113,316,790	$ 43
Knox	41	0.0001%	$ 76,691,482	$ 72
Lake	21	0.0000%	$ 12,988,101	$ 2
Licking	67	0.0000%	$ 186,741,453	$ 27
Lorain	83	0.0002%	$ 212,390,581	$ 375
Madison	104	0.0001%	$ 398,511,572	$ 370
Medina	17	0.0000%	$ 16,239,797	$ 5
Montgomery	72	0.0000%	$ 187,896,794	$ 18
Morrow	19	0.0001%	$ 12,996,574	$ 8
Pickaway	137	0.0001%	$ 346,622,641	$ 214
Portage	25	0.0001%	$ 17,793,583	$ 10
Richland	77	0.0000%	$ 236,998,425	$ 29
Stark	57	0.0001%	$ 148,641,582	$ 158
Summit	65	0.0000%	$ 197,956,468	$ 39
Union	55	0.0001%	$ 169,438,472	$ 118
Warren	109	0.0001%	$ 323,719,448	$ 381
Wayne	22	0.0003%	$ 12,202,802	$ 35
Total	**1,684**	**0.0001%**	**$ 5,728,110,964**	**$ 2,245**

Region 3

County	# of CF	NRI Building EAL:EXP Ratio	Replacement Cost of Critical Facilities	EAL of Critical Facilities
Adams	30	0.0001%	$ 12,672,306	$ 11
Ashtabula	72	0.0001%	$ 25,195,275	$ 17
Athens	35	0.0001%	$ 53,251,615	$ 29
Belmont	70	0.0003%	$ 153,564,291	$ 477
Brown	31	0.0001%	$ 35,387,446	$ 32
Carroll	18	0.0000%	$ 5,220,360	$ 2
Clermont	51	0.0000%	$ 32,967,768	$ 7
Columbiana	36	0.0000%	$ 14,981,756	$ 1
Coshocton	21	0.0000%	$ 16,813,037	$ 1
Gallia	61	0.0001%	$ 49,786,218	$ 40
Guernsey	50	0.0001%	$ 58,733,741	$ 39
Harrison	24	0.0001%	$ 9,202,403	$ 5
Highland	11	0.0000%	$ 6,701,555	$ 3
Hocking	27	0.0001%	$ 7,590,231	$ 6
Holmes	29	0.0000%	$ 9,188,433	$ 1
Jackson	21	0.0001%	$ 10,211,085	$ 9
Jefferson	34	0.0000%	$ 14,685,898	$ 7
Lawrence	26	0.0000%	$ 9,167,439	$ 3
Mahoning	58	0.0000%	$ 109,678,167	$ 8
Meigs	24	0.0001%	$ 9,369,001	$ 5
Monroe	12	0.0003%	$ 3,933,796	$ 13
Morgan	15	0.0001%	$ 7,945,305	$ 5
Muskingum	36	0.0001%	$ 14,169,870	$ 10
Noble	32	0.0003%	$ 65,273,141	$ 209
Perry	9	0.0001%	$ 7,167,121	$ 5
Pike	12	0.0001%	$ 8,643,712	$ 5
Ross	129	0.0001%	$ 510,798,521	$ 367
Scioto	66	0.0001%	$ 478,434,987	$ 414
Trumbull	69	0.0000%	$ 97,032,569	$ 32
Tuscarawas	54	0.0000%	$ 50,576,265	$ 25
Vinton	19	0.0001%	$ 14,102,427	$ 11
Washington	50	0.0001%	$ 36,699,000	$ 43
Total	**1,232**	**0.0001%**	**$ 1,939,144,738**	**$ 1,840**

Table 2.12.j — Strong (High and Thunderstorm) Winds

Expected Annual Loss of State-owned and State-leased Critical Facilities by Region
Strong Winds

Region 1

County	# of CF	NRI Building EAL:EXP Ratio	Replacement Cost of Critical Facilities	EAL of Critical Facilities
Allen	99	0.0026%	$ 148,535,104	$ 3,828
Auglaize	18	0.0044%	$ 6,542,813	$ 291
Champaign	21	0.0041%	$ 9,246,093	$ 379
Clark	27	0.0032%	$ 9,650,921	$ 308
Crawford	12	0.0031%	$ 11,520,704	$ 361
Darke	27	0.0044%	$ 17,992,950	$ 789
Defiance	15	0.0023%	$ 12,622,416	$ 287
Erie	55	0.0030%	$ 150,149,608	$ 4,453
Fulton	12	0.0041%	$ 9,821,964	$ 407
Hancock	20	0.0046%	$ 12,221,847	$ 564
Hardin	18	0.0040%	$ 6,825,758	$ 274
Henry	16	0.0021%	$ 4,250,244	$ 88
Huron	22	0.0027%	$ 10,837,347	$ 298
Logan	21	0.0042%	$ 9,389,923	$ 391
Lucas	52	0.0011%	$ 274,497,738	$ 3,077
Marion	59	0.0036%	$ 237,054,145	$ 8,618
Mercer	27	0.0048%	$ 9,141,077	$ 443
Miami	30	0.0031%	$ 20,994,660	$ 647
Ottawa	52	0.0046%	$ 42,237,937	$ 1,958
Paulding	11	0.0066%	$ 8,375,637	$ 554
Preble	28	0.0049%	$ 7,555,862	$ 368
Putnam	19	0.0053%	$ 4,857,269	$ 258
Sandusky	14	0.0050%	$ 8,633,501	$ 428
Seneca	47	0.0039%	$ 47,263,740	$ 1,859
Shelby	35	0.0038%	$ 32,329,713	$ 1,223
Van Wert	16	0.0037%	$ 7,772,807	$ 290
Williams	17	0.0030%	$ 7,837,080	$ 233
Wood	40	0.0041%	$ 68,292,566	$ 2,784
Wyandot	22	0.0044%	$ 6,729,705	$ 293
Total	**852**	**0.0033%**	**$ 1,203,181,127**	**$ 35,750**

Region 2

County	# of CF	NRI Building EAL:EXP Ratio	Replacement Cost of Critical Facilities	EAL of Critical Facilities
Ashland	145	0.0027%	$ 103,491,091	$ 2,793
Butler	29	0.0029%	$ 17,200,278	$ 503
Clinton	31	0.0038%	$ 13,450,515	$ 512
Cuyahoga	106	0.0006%	$ 389,621,908	$ 2,307
Delaware	33	0.0023%	$ 61,002,573	$ 1,379
Fairfield	67	0.0021%	$ 94,557,543	$ 1,993
Fayette	23	0.0038%	$ 11,052,410	$ 419
Franklin	190	0.0011%	$ 2,336,963,045	$ 26,541
Geauga	27	0.0009%	$ 12,064,728	$ 112
Greene	21	0.0031%	$ 17,560,307	$ 541
Hamilton	41	0.0018%	$ 113,316,790	$ 2,051
Knox	41	0.0025%	$ 76,691,482	$ 1,884
Lake	21	0.0006%	$ 12,988,101	$ 84
Licking	67	0.0022%	$ 186,741,453	$ 4,061
Lorain	83	0.0011%	$ 212,390,581	$ 2,311
Madison	104	0.0038%	$ 398,511,572	$ 15,296
Medina	17	0.0016%	$ 16,239,797	$ 257
Montgomery	72	0.0026%	$ 187,896,794	$ 4,892
Morrow	19	0.0034%	$ 12,996,574	$ 436
Pickaway	137	0.0032%	$ 346,622,641	$ 10,972
Portage	25	0.0010%	$ 17,793,583	$ 180
Richland	77	0.0021%	$ 236,998,425	$ 4,930
Stark	57	0.0005%	$ 148,641,582	$ 718
Summit	65	0.0008%	$ 197,956,468	$ 1,646
Union	55	0.0037%	$ 169,438,472	$ 6,253
Warren	109	0.0024%	$ 323,719,448	$ 7,714
Wayne	22	0.0014%	$ 12,202,802	$ 165
Total	**1,684**	**0.0032%**	**$ 5,728,110,964**	**$ 100,951**

Region 3

County	# of CF	NRI Building EAL:EXP Ratio	Replacement Cost of Critical Facilities	EAL of Critical Facilities
Adams	30	0.0053%	$ 12,672,306	$ 669
Ashtabula	72	0.0008%	$ 25,195,275	$ 190
Athens	35	0.0018%	$ 53,251,615	$ 983
Belmont	70	0.0005%	$ 153,564,291	$ 759
Brown	31	0.0050%	$ 35,387,446	$ 1,752
Carroll	18	0.0013%	$ 5,220,360	$ 67
Clermont	51	0.0031%	$ 32,967,768	$ 1,014
Columbiana	36	0.0009%	$ 14,981,756	$ 131
Coshocton	21	0.0012%	$ 16,813,037	$ 204
Gallia	61	0.0019%	$ 49,786,218	$ 923
Guernsey	50	0.0014%	$ 58,733,741	$ 847
Harrison	24	0.0012%	$ 9,202,403	$ 113
Highland	11	0.0041%	$ 6,701,555	$ 275
Hocking	27	0.0023%	$ 7,590,231	$ 178
Holmes	29	0.0028%	$ 9,188,433	$ 260
Jackson	21	0.0024%	$ 10,211,085	$ 246
Jefferson	34	0.0008%	$ 14,685,898	$ 121
Lawrence	26	0.0027%	$ 9,167,439	$ 247
Mahoning	58	0.0008%	$ 109,678,167	$ 847
Meigs	24	0.0020%	$ 9,369,001	$ 187
Monroe	12	0.0015%	$ 3,933,796	$ 59
Morgan	15	0.0017%	$ 7,945,305	$ 137
Muskingum	36	0.0006%	$ 14,169,870	$ 87
Noble	32	0.0020%	$ 65,273,141	$ 1,328
Perry	9	0.0020%	$ 7,167,121	$ 145
Pike	12	0.0035%	$ 8,643,712	$ 305
Ross	129	0.0028%	$ 510,798,521	$ 14,478
Scioto	66	0.0027%	$ 478,434,987	$ 12,998
Trumbull	69	0.0009%	$ 97,032,569	$ 840
Tuscarawas	54	0.0007%	$ 50,576,265	$ 345
Vinton	19	0.0021%	$ 14,102,427	$ 293
Washington	50	0.0015%	$ 36,699,000	$ 536
Total	**1,232**	**0.0017%**	**$ 1,939,144,738**	**$ 41,564**

2.13 INVASIVE SPECIES

The National Wildlife Federation defines invasive species as any living organism, whether amphibian, plant, insect, fish, fungus, bacteria, or even an organism's seeds or eggs, that is not native to an ecosystem and causes harm. Invasive species can harm the environment, the economy, and even human health. In addition, species that can grow and reproduce quickly, spread aggressively, and have potential to cause harm are identified as "invasive".

According to the ODNR, Division of Natural Areas & Preserves, of the approximately 2,300 species of plants known to occur in Ohio, about 78% are native or have occurred in Ohio before the time of substantial European settlement (1750). The other 22% of species are not native to the state. Non-native plants have been introduced for erosion control, horticulture, forage crops, medicinal use, wildlife foods, or by accident. Most of these species never stray far from where they are introduced, but some become very invasive and displace native plants throughout the state.

Without natural predators or controls, invasive, non-native plants are able to spread quickly and force out native plants. Other non-native plants are impacting our wetlands by creating monocultures. Native plant diversity is important for wildlife habitat, as many animals depend on a variety of native plants for food and cover.

More information about invasive species in Ohio can be found on ODNR's website: http://ohiodnr.gov/invasivespecies, USFWS' website: https://www.fws.gov/invasives/, Early Detection & Distribution Mapping System (EDDMapS) website: https://www.eddmaps.org/, and the USDA National Invasive Species Information Center: https://www.invasivespeciesinfo.gov/index.shtml.

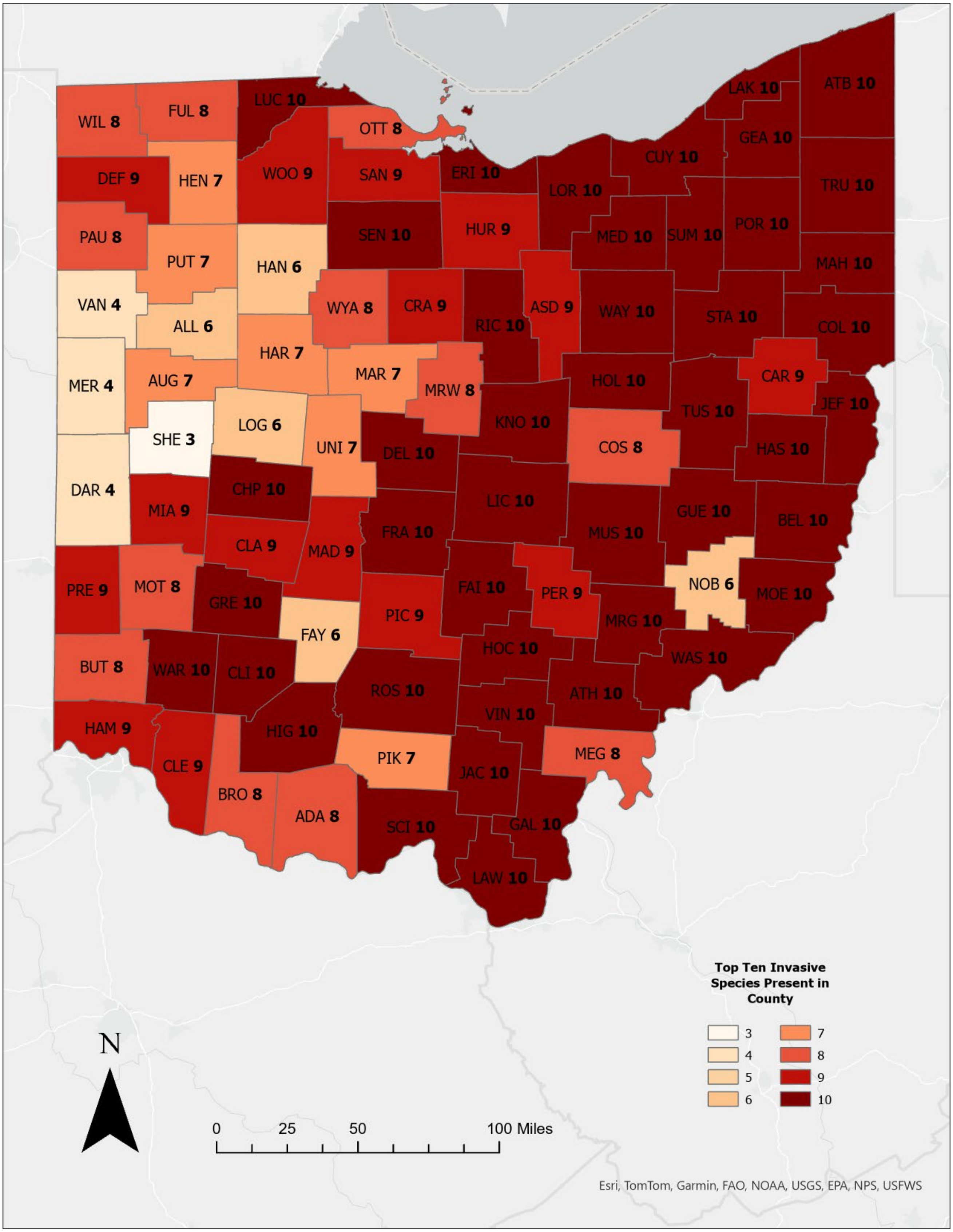
The top ten invasive plant species in Ohio are:

- Bush Honeysuckle
- Autumn – Olive
- Buckthorns
- Common Reed Grass
- Garlic Mustard
- Japanese Honeysuckle
- Japanese Knotweed
- Multiflora Rose
- Purple Loosestrife
- Reed Canary Grass

Per ODNR, aquatic invasive species (AIS) include both plants and animals that have been introduced to our waterways and have become harmful to native species and their habitats. AIS may live entirely within or partially in an aquatic habitat. Below is a list of some Ohio's top AIS threats. The list is not fully inclusive and the USGS maintains an additional list of AIS in the U.S.

Some of Ohio's top AIS are:

- Invasive Carp (Bighead Carp, Silver Carp, Black Carp, Diploid Grass Carp)
- Curlyleaf Pondweed
- Hydrilla
- Round Goby
- Ruffe
- Red Swamp Crayfish
- Sea Lamprey
- White Perch
- Zebra Mussel


WIL 8
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WOO 9
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ERI 10
LOR 10
TRU 10
PAU 8
PUT 7
HAN 6
SEN 10
HUR 9
MED 10
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POR 10
MAH 10
VAN 4
ALL 6
WYA 8
CRA 9
RIC 10
ASD 9
WAY 10
STA 10
COL 10
MER 4
AUG 7
HAR 7
MAR 7
MRW 8
HOL 10
CAR 9
JEF 10
SHE 3
LOG 6
UNI 7
DEL 10
KNO 10
TUS 10
COS 8
HAS 10
DAR 4
MIA 9
CHP 10
LIC 10
GUE 10
BEL 10
CLA 9
MAD 9
FRA 10
MUS 10
PRE 9
MOT 8
GRE 10
FAI 10
PER 9
NOB 6
MOE 10
FAY 6
PIC 9
MRG 10
BUT 8
WAR 10
CLI 10
HOC 10
WAS 10
ROS 10
ATH 10
HAM 9
HIG 10
VIN 10
CLE 9
PIK 7
MEG 8
JAC 10
BRO 8
ADA 8
SCI 10
GAL 10
LAW 10
Top Ten Invasive Species Present in County
3
4
5
6
7
8
9
10
N
0
25
50
100 Miles
Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NPS, USFWS

Per the Ohio Department of Agriculture (https://agri.ohio.gov/divisions/plant-health/invasive-pests/invasive-insects), some of Ohio's most invasive insects are:

- Asian Longhorned Beetle
- Box Tree Moth
- Emerald Ash Borer
- Hemlock Woolly Agelid
- Northern Giant Hornet
- Spotted Lanternfly
- Spongy Moth

EMERALD ASH BORER

According to the ODNR, Division of Forestry, one of the most invasive insect species in Ohio is the Emerald Ash Borer. This Asian pest is part of a group of insects known as metallic wood-boring beetles. Emerald Ash Borer affects all species of native ash found in Ohio. Because North American ash trees did not coexist in association with this pest, they have little or no resistance to its attack. This ash tree-killing insect from Asia was unintentionally introduced to southeastern Michigan several years ago. Emerald Ash Borer larvae feed on the living portion of the tree, directly beneath the bark. This eating habit restricts the tree's ability to move essential water and nutrients throughout the plant. In three to five years, even the healthiest tree is unable to survive an attack. As ash trees continue to be in a state of decline, the emerald ash borer has been responsible for the destruction of tens of millions of ash trees, and the insect has been found in 37 states. The federal domestic quarantine regulations were removed in 2021, and resources are now being allocated toward management for the pest including rearing and releasing biological control agents.

ASIAN LONGHORNED BEETLE

According to the U.S. Department of Agriculture, Division of Plant Health, other insects pose a dominant threat to forest and plant ecosystems. The Asian Longhorned Beetle (ALB) is a wood-boring beetle that is native to Asia, introduced to North America and first found in New York City in 1996. The preferred host plants of ALB in North America are maple trees, but this insect feed off of 12 genera: maples, horse-chestnuts and buckeyes, elms, willows, birches, sycamore and planetrees, poplars, mimosa, katsura, ash, golden raintree, and mountain-ash. The first infestation within Ohio was discovered in Clermont County in 2011. The manner in which trees become damaged involves the Beetle burrowing under tree bark and lays eggs. After ALB become mature adults, they chew their way out of the tree, leaving round exit holes approximately three-eighths of an inch in diameter. Signs of ALB start to show about 3 to 4 years after infestation, with tree death occurring in 10 to 15 years depending on the tree's overall health and site conditions. Infested trees do not recover, nor do they regenerate. Foresters have observed ALB-related tree deaths in every affected state.

SPOTTED LANTERN-FLY

Another insect that has recently been detected as invasive includes the Spotted Lanternfly (SLF). It feeds on a variety of woody and herbaceous plants, causing wilting and dieback and stress that can make host plants susceptible to other abiotic or biotic factors. It is a plant hopping insect native to China, India, and Vietnam, and was first discovered in southeastern Pennsylvania in 2014. In Ohio, the presence of SLF has been confirmed in Cuyahoga, Jefferson, and Lorain counties. It's preferred host plants include the non-native invasive tree-of-heaven, grapes, apples, hops, walnuts, and hardwood trees. The risks posed by SLF are not known to the fullest extent. However, the SLF has impacted vineyards. As SLF feeds on the plant, it leaves behind a sticky, sugary residue called honeydew that attracts other insects and promotes sooty mold growth which can further damage the plant. SLF can feed on more than 100 plant species, and has the potential to greatly impact the viticulture, tree fruit, nursery, and timber industries.

CALLERY PEAR

As stated by ODNR, the Callery pear is an invasive ornamental pear tree native to Asia. It was popularized in the American landscape, as it was planted by private homeowners and foresters for its aesthetic appeal. Recently, it has become unpopular as the tree has poor structure leading to branch breakage, bad smell when it blooms, and pear rust. This tree affects the growth of native forests and native plant species, and it is a threat to Ohio's ecosystem. According to the Ohio Administrative Code update in 2023, Callery pears are now illegal to sell, grow, or plant due to its invasiveness.

RISK ASSESSMENT

The area invaded by each plant species varies based on its preferred environment. Those with the fewest limitations have spread to nearly every county in Ohio.

The State Management Plan for AIS, produced by the Ohio Department of Natural Resources, prioritizes AIS into two categories based on the degree of negative impact. High-risk species are those that currently cause or could potentially cause significant harm, while medium risk species are those that have a lesser impact, but are still a cause for concern. Below are the high-risk and medium-risk AIS that are the most concerning in the United States. While not all of these AIS are currently present in the State of Ohio, there is still a potential risk for the future.

The high-risk AIS are:

- Invasive Carp
- Northern Snakehead
- Sea Lamprey
- Round & Tubenose Goby
- Zebra & Quagga Mussels

The medium-risk AIS are:

- Alewife
- River Ruffe
- Spiny & Fishhook water flea

PAST OCCURRENCES

Invasive species of plants, fish, and insects have been arriving in Ohio since the establishment of European settlers in the 1750s. With each improvement in the scale and speed of human transportation, the potential for unintended introduction of invasive species has increased. Organisms which could not survive the month-long journey from Europe or Africa to America can make the journey in a matter of hours today. Several examples of species introduction pathways follow.

The Round Goby species was introduced from Eurasia into the St. Clair River and vicinity on the Michigan-Ontario border where several collections were made in 1990 on both the U.S. and the Canadian side. Speculation exists the Goby was transported from its native Caspian Sea by way of ballast tanks on ocean-going vessels. Today, the Goby is found in all the Great Lakes and is making inroads in all contiguous state watersheds.

The Multiflora Rose was introduced to the U.S. from Japan in 1886 as an under-stock for ornamental roses. Birds are responsible for spreading the seeds, which remain viable for a number of years. In the 1930s, the Soil Conservation Services advocated the use of Multiflora Rose for erosion projects and as a way to confine livestock. Hedges of Multiflora Rose have also been used as a crash barrier and to reduce headlight glare in highway medians.

The Emerald Ash Borer was introduced into North America sometime in the 1990's. The insect is believed to have been introduced into the U.S. in wood packing material from China. It was first reported killing ash trees in the Detroit and Windsor areas in 2002. Only Ashe tree species are hosts for the beetle, which usually kill infested trees within a couple of years. Since then, infestations have been found throughout Lower Michigan, Ohio, Indiana, the Chicago area, Maryland and recently in Pennsylvania.

Considering the thousands of plants, dozens of aquatic and unknown number of insect species introduced into Ohio over the past 250 years, samples of the most often cited transfer media are provided here. Exotic species can arrive by a nearly endless number of vectors making a complete listing impossible.

PROBABILITY OF FUTURE EVENTS

Since the beginning of European colonization, non-native species have been arriving in Ohio. With the increase in global trade and travel, the probability of new and unexpected species arriving in Ohio will continue to grow. Legislation is in place around the world in an attempt to control the migration of unwanted species between ecosystems.

ODNR is currently battling the entrance of wild boars from Kentucky and West Virginia. The greatest concentration of verified populations can be found in the unglaciated region of southeastern Ohio. In addition, there are several species of carp currently migrating up the Mississippi watershed from the Gulf Coast. Per the ODNR, Division of Fish Management and Research, silver and bighead carp are already present in the upper reaches of the Ohio River system in Ohio. The state hopes to seal off all areas where the Ohio River basin and the Lake Erie basin meet. None of the species considered Invasive Carp have yet to establish themselves in the Lake Erie basin.

It is certain that new wanted and unwanted species will arrive in Ohio. The importance of controlling the integrity of existing ecosystems will require ongoing state, national and international efforts to avoid unwanted infestations. To this end, the Ohio Administrative Code has been updated in 2023 to make the sale, propagation, distribution and dissemination of 61 invasive species illegal. According to the Ohio Department of Agriculture, the species list of invasive plants are revised every 5 years by a five-person invasive plant advisory committee. The 2023 list is available at https://agri.ohio.gov/divisions/plant-health/invasive-pests/invasive-and-noxious-plants/invasive-plants.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHODOLOGY

Impacts of invasive species tend to have commercial operational impacts, as opposed to impacts on the built environment of the other hazards covered. Due to this unique situation, rather than a matrix listing loss by county, the loss estimates will be presented using historical response costs to predict future losses in unadjusted dollars.

RESULTS

From the perspective of invasive plant species, the Multiflora Rose is one of most expensive to combat in Ohio. Each individual plant’s ability to produce 500,000 seeds a year allows this invasive species to spread over large areas with incredible speed. Agricultural groups are facing the highest exposure and expense in the form of infiltration of croplands and eradication programs. According to agricultural experts associated with the Ohio State University, Ohioans are estimated to spend millions of dollars combating the Multiflora Rose. Precise dollar figures are not available due to the majority of response activities being performed by non-governmental entities.

Turning to invasive aquatic species, the Zebra Mussel is one of the most expensive to control. The mussels naturally collect on any solid surface and create significant problems for drinking water processing facilities and utilities. All in-water structures are impacted including, but not limited to, piers, break walls, vessel hulls and vessel engines cooled with external water. Estimates for controlling infestations run between $2 and $10 million per year depending on how many sources are aggregated. Should the Zebra Mussel effectively invade the river systems of Ohio, it is suggested the annual control costs could rise 10-fold.

Invasive insect species are both the direct source of damage to trees and a vector for other parasites. In the last century, the North American population of Elm trees was decimated by a fungus which arrived on infected trees shipped to an Ohio furniture company. One of the primary transport methods is though beetles which the fungus uses as a host to move from tree to tree. The beetle's ability to fly exponentially increased the number of trees impacted. Trees located in non-urban areas posed financial impact only to loggers; however, the Elm was a popular urban tree and the cost to remove them ran into the millions over the years.

Pests have the capacity to significantly de-stabilize forestry and agricultural practices. The Emerald Ash Borer, which is currently impacting the North American Ash tree, has already cost millions of dollars in attempts to identify and isolate infected trees. In Ohio alone, there are an estimated 5 billion Ash trees at risk. The continued spread of this pest threatens these resources and may permanently alter urban landscape ecosystems of the Midwest, which consists of up to 20 to 40 percent ash in some areas. Preliminary findings by U.S. Forest Service estimate that EAB's potential impact to the national urban landscape is a potential loss of between 0.5 to 2 percent of the total leaf area (30-90 million trees) and a value loss of between $20-60 billion (McPartlan et al. 2006). Although many research centers are searching for an effective means of combating the insect, the only method currently available is the use of insecticides which have to be applied annually.

Another pest that has the potential to alter the forest ecosystem and economy of Ohio includes the Asian Longhorned Beetle. Eastern and southern Ohio is dominated by hardwood forests, so the loss of these trees will impact nurseries, lumber industry, homeowners, parks and recreation, and maple syrup processors. Additionally, the state tree, the Buckeye, is threatened as it is a host for Asian Longhorned Beetle. The most recent invasive pest discovered in Ohio is the Spotted Lanternfly. It specifically affects woody and herbaceous plants that makes plants susceptible to damage. Their impact can be significant, as they feed off of more than 100 plant species, and can affect viticulture, tree fruit, nursery, and timber industries.

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

Similar to drought in Section 2.11, invasive species have a very limited impact on state-owned or state-leased facilities. The most prominent impact to state facilities relates to the maintenance of marinas in Zebra Mussel impacted areas. These mussels can clog inlets that could affect facilities, but not in the same manner as many of the other hazards. Also, the Emerald Ash Borer could result in significant increases in fuel for wildfires in Region 3, which could adversely affect state facilities.

2.14 LAND SUBSIDENCE

Subsidence is the motion of the Earth's surface as it shifts downward relative to a benchmark (often sea-level) of the surrounding terrain. There are a number of causes for this effect. In Ohio, the two primary causes are abandoned underground mines (AUMs) and karst.

Underground mining of coal began in the early 1800's and continues to current day. In the 1900s, underground salt, limestone, and gypsum mining began. All mining activities create voids under the Earth's surface. Several key factors determining the potential for these voids to collapse include depth, mining technique used, types of rock and/or soils, and development on the ground surface. Abandoned underground coal mines in Ohio have the added environmental impact of discharging acidic water. If acidic mine water is discharged into creeks or streams, it can alter the chemical composition of the water habitat and cause considerable harm to sensitive aquatic life.

Per the ODNR, Division of Geological Survey, karst is a little-known, but unique and important landform that can be found throughout the state of Ohio. Regions that contain sinkholes and other solutional features, such as caves, springs, disappearing streams, and enlarged fractures, are known as karst terrains. Sinkholes form as bedrock dissolves and surface materials erode or collapse into the resulting voids. Sinkholes are the main hazard associated with karst landforms in Ohio, and there are thousands of them in the state.

The last form of land subsidence in Ohio is associated with soils, which dramatically expand when wet and contract when dry. Structures built on these soils can experience significant shifting as the ground saturates and dries.

HAZARD PROFILE

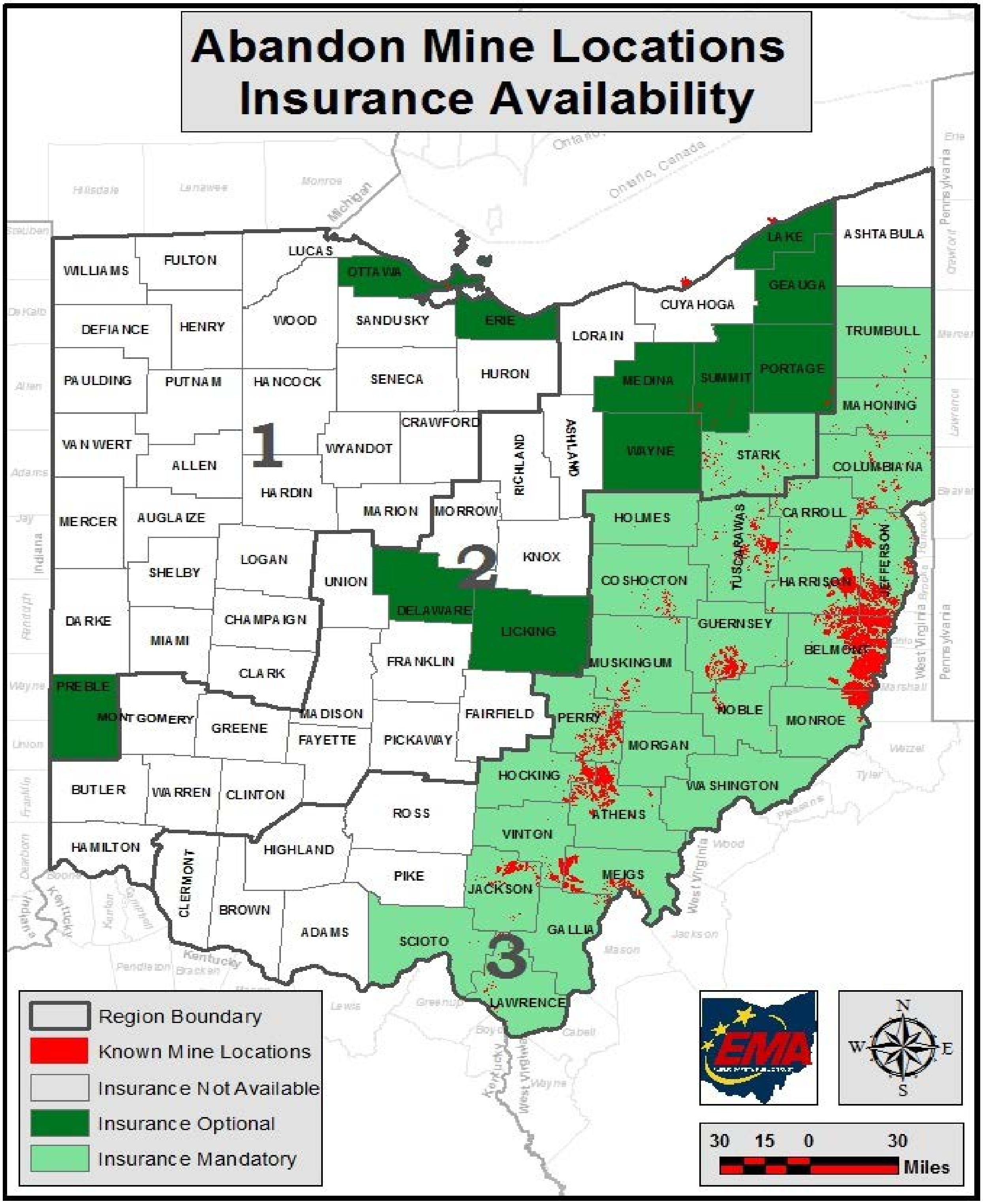
LOCATION

Beginning in the 1700s and continuing to today, there has been considerable coal mining in the Appalachian region of Ohio. In addition to coal, several salt, clay, and gypsum mines opened in counties close to Lake Erie. Finally, in central and southwestern Ohio, there are several isolated mines (Map 2.14a).

ODNR and the Ohio Department of Transportation (ODOT) actively inventories these geologic hazards and conducts risk assessments to determine the potential impact on the state's transportation infrastructure. Both mapped and unmapped underground mines pose a continued threat of subsidence to Ohio's transportation system. The statewide inventory and risk assessment of these mine sites is an ongoing process. Per the ODNR, Division of Mineral Resources Management, there are:

- 4,512 Surface Coal Mine Operation (117 active, 1,330 released, 3,065 abandoned or inactive & awaiting release)
- 19 Active Underground Coal Mines (permitted)
- 1,644 Surface IM Operations (828 active, 1080 released)
- 7 Active Underground IM Mines
- 3,425 Abandoned Underground Mines (Known)
- 6,933 Abandoned Surface Mines (based on topo maps and aerial reconnaissance)

Map 2.14a

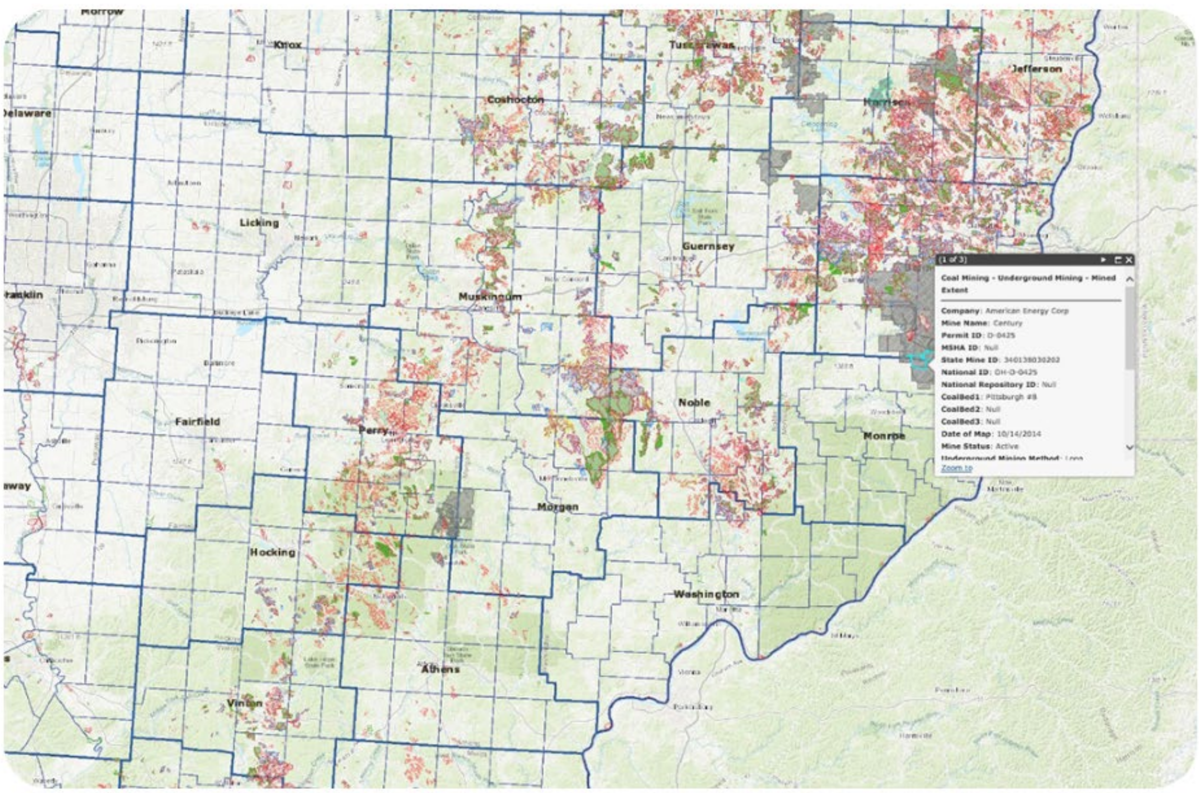


Abandon Mine Locations
Insurance Availability
WILLIAMS
FULTON
LUCAS
OTTAWA
DEFIANCE
HENRY
WOOD
SANDUSKY
ERIE
LORAIN
CUYAHOGA
LAKE
ASHTABULA
GEAUGA
TRUMBULL
PAULDING
PUTNAM
HANCOCK
SENECA
HURON
MEDINA
SUMMIT
PORTAGE
MAHONING
VAN WERT
ALLEN
HARDIN
WYANDOT
CRAWFORD
RICHLAND
ASHLAND
WAYNE
STARK
COLUMBIANA
MERCER
AUGLAIZE
MARION
MORROW
HOLMES
CARROLL
TUSCARAWAS
JEFFERSON
SHELBY
LOGAN
UNION
DELAWARE
KNOX
COSHOCTON
HARRISON
DARKE
MIAMI
CHAMPAIGN
LICKING
GUERNSEY
BELMONT
CLARK
FRANKLIN
MUSKINGUM
PREBLE
MONTGOMERY
GREENE
MADISON
FAYETTE
PICKAWAY
FAIRFIELD
PERRY
NOBLE
MONROE
MORGAN
BUTLER
WARREN
CLINTON
ROSS
HOCKING
WASHINGTON
ATHENS
HAMILTON
CLERMONT
HIGHLAND
VINTON
BROWN
ADAMS
PIKE
JACKSON
MEIGS
GALLIA
SCIOTO
LAWRENCE
1
2
3
Region Boundary
Known Mine Locations
Insurance Not Available
Insurance Optional
Insurance Mandatory
EMA
N
W
E
S
30 15 0 30
Miles

The majority of abandoned mines are located in, or directly adjacent to, Region 3, and most of these were coal mines. Coal mine depths can range from less than 100 feet below the surface to 1,000 feet or more. Deeper mines, with solid layers of rock (i.e., strata) above the void and limited soil at the surface, are less likely to fail than those closer to the surface. The ODNR, Division of Geological Survey and ODOT have developed profiles of voids, support strata composition and surface soils for a limited number mines, in order to assist in understanding the potential for subsidence events. Analysis requires experts trained in geology and significant time, which limits the number of sites assessed.

Other minerals mined include gypsum, clay and limestone, primarily in Ottawa, Preble, and Butler counties. Finally, very limited exposure to abandoned mines exists in Hamilton, Lucas, Erie, Delaware, and Licking counties, where the mineral being extracted was not available.

The ONDR Ohio Mines Locator (https://gis.ohiodnr.gov/MapViewer/?config=OhioMines), allows users to View locations and permit information on thousands of mapped surface and underground coal and minerals mines in Ohio.



The Ohio Mine Subsidence Insurance Underwriting Association provides eligible Ohio counties with mine subsidence insurance (Map 2.14a). Under the program, 26 primarily Appalachian counties (Region 3) are required to carry mine subsidence insurance at a cost of one dollar annually. Additionally, eight counties in Region 2 and three counties in Region 1 are eligible to obtain insurance at the owner's discretion at a cost of five dollars annually. The remaining 51 counties are not eligible for mine subsidence insurance.

Karst features are associated with the western third of Ohio, excluding the far northwestern counties of Williams, Fulton, and Defiance (Map 2.14b). Nearly all of Region 1 and the far western sections of Regions

2 and 3 are impacted by karst geology. The limestone, shale, and dolomite layers were deposited between 408 and 505 million years ago as the floor of an ancient sea. Later, the continental plate would rise above the existing sea level creating dry land and vast salt deposits. These sedimentary rock layers are naturally porous and dissolve into the water which passes through them.

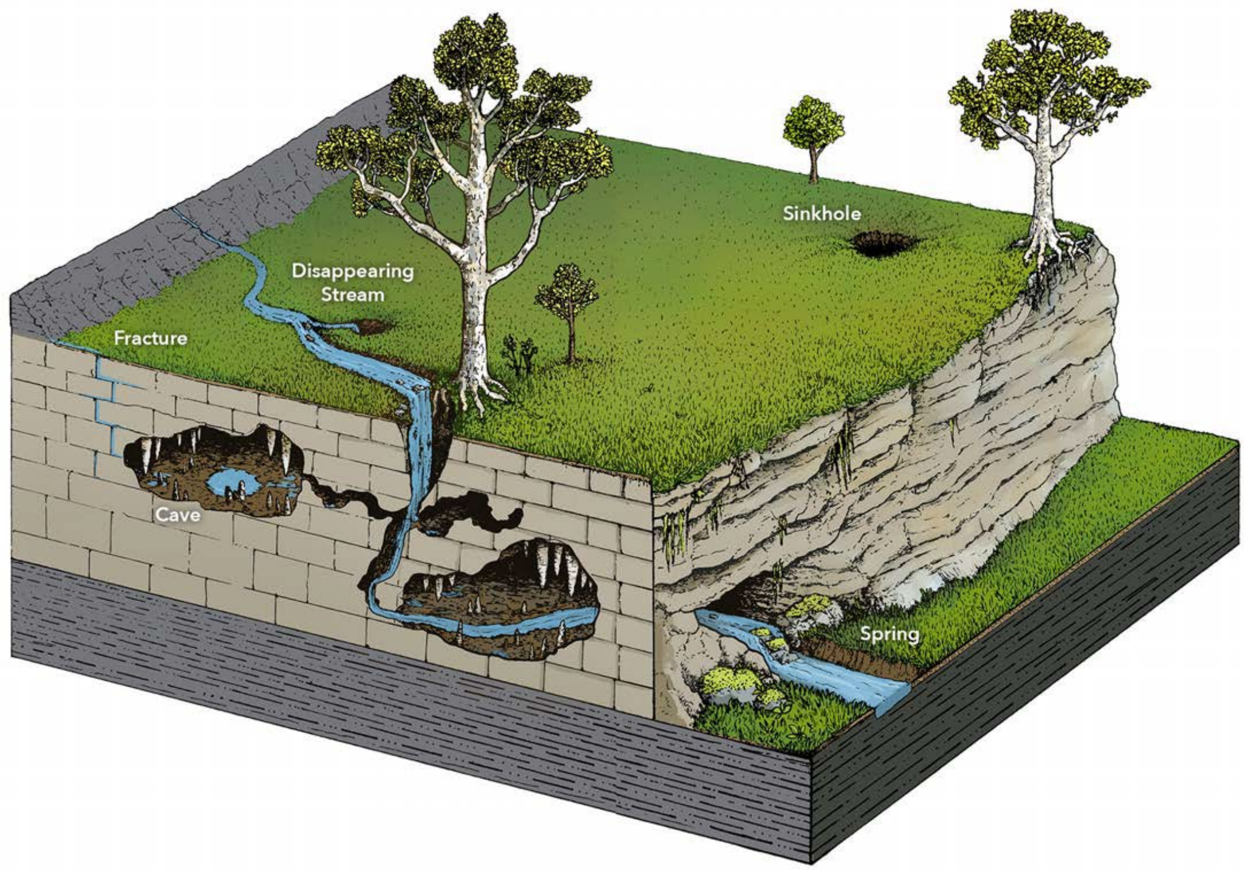
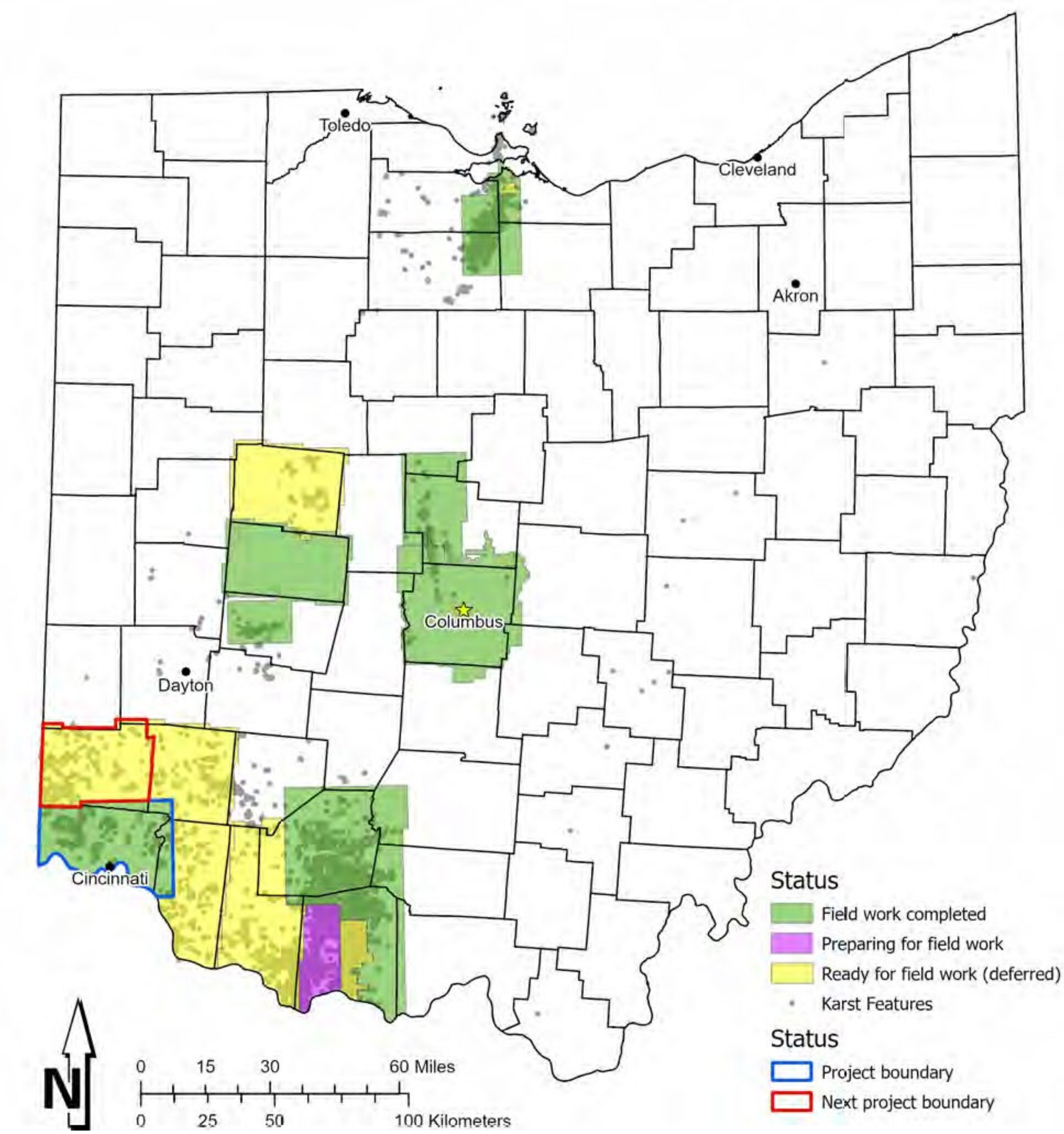


Illustration by Madison Perry.

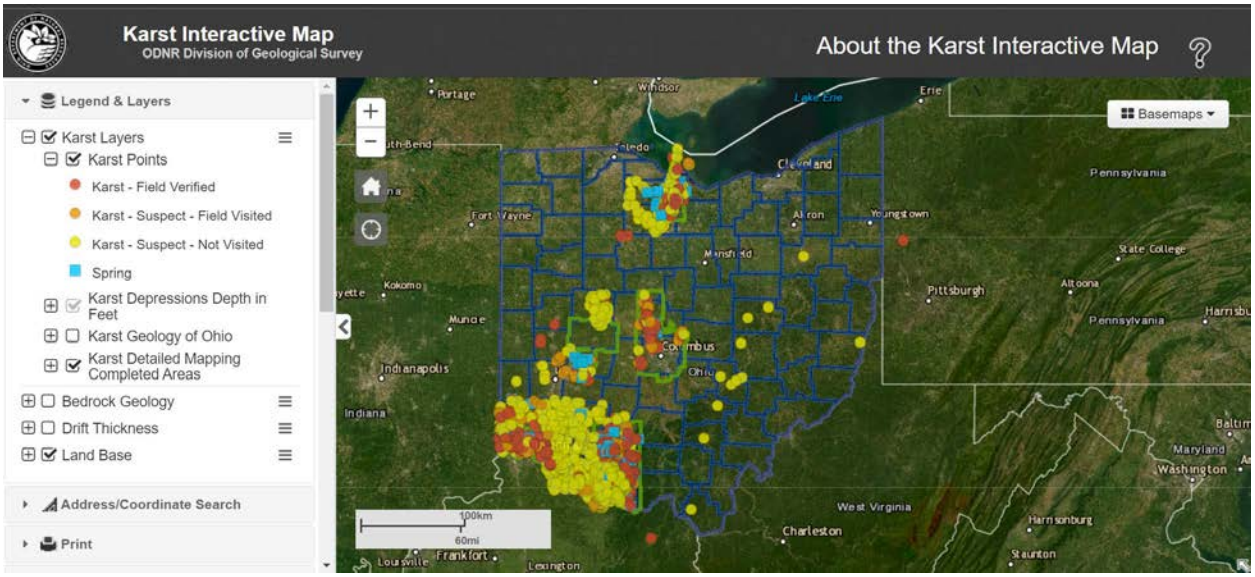
The current landscape in the karst region of Ohio was created by glaciers as they advanced from the north reaching to the Ohio River roughly 14,000 years ago. When the last glacier receded, it left behind a layer of unconsolidated material in a wide range of depths. The shallower the loose material layer, the greater the chance of water penetrating to the underlying bedrock, resulting in a void or ground deformation occurring. This is represented by the probable karst areas on the map which group into two significant clusters. In the south, the greatest impacted counties include Brown, Adams, and Highland. In the north, the greatest impacted counties include Seneca, Huron, Erie, Sandusky, and Ottawa.

ODNR – State Wide Mapping of Karst Soils

Per the 2022 Karst Annual Report produced by ODNR Division of Geological Survey, most of the known, very dense, karst areas in Ohio have been mapped in detail, apart from Adams and Brown Counties, where field work is incomplete because of the large number of features and ongoing data processing. However, there are large areas of southwestern and potentially central Ohio where remote sensing data indicates that there are hundreds of sinkholes (fig. 14). In fact, field work in Hamilton County has shown a significant occurrence of karst in the Ordovician bedrock which likely extends to surrounding counties. Field mapping will continue in the 2022–2023 field season in Butler County, where additional karst features are suspected and impacts on urban development are potentially significant. Preparation for future mapping this year included processing the DEM for Logan County and the remaining portion of Highland County

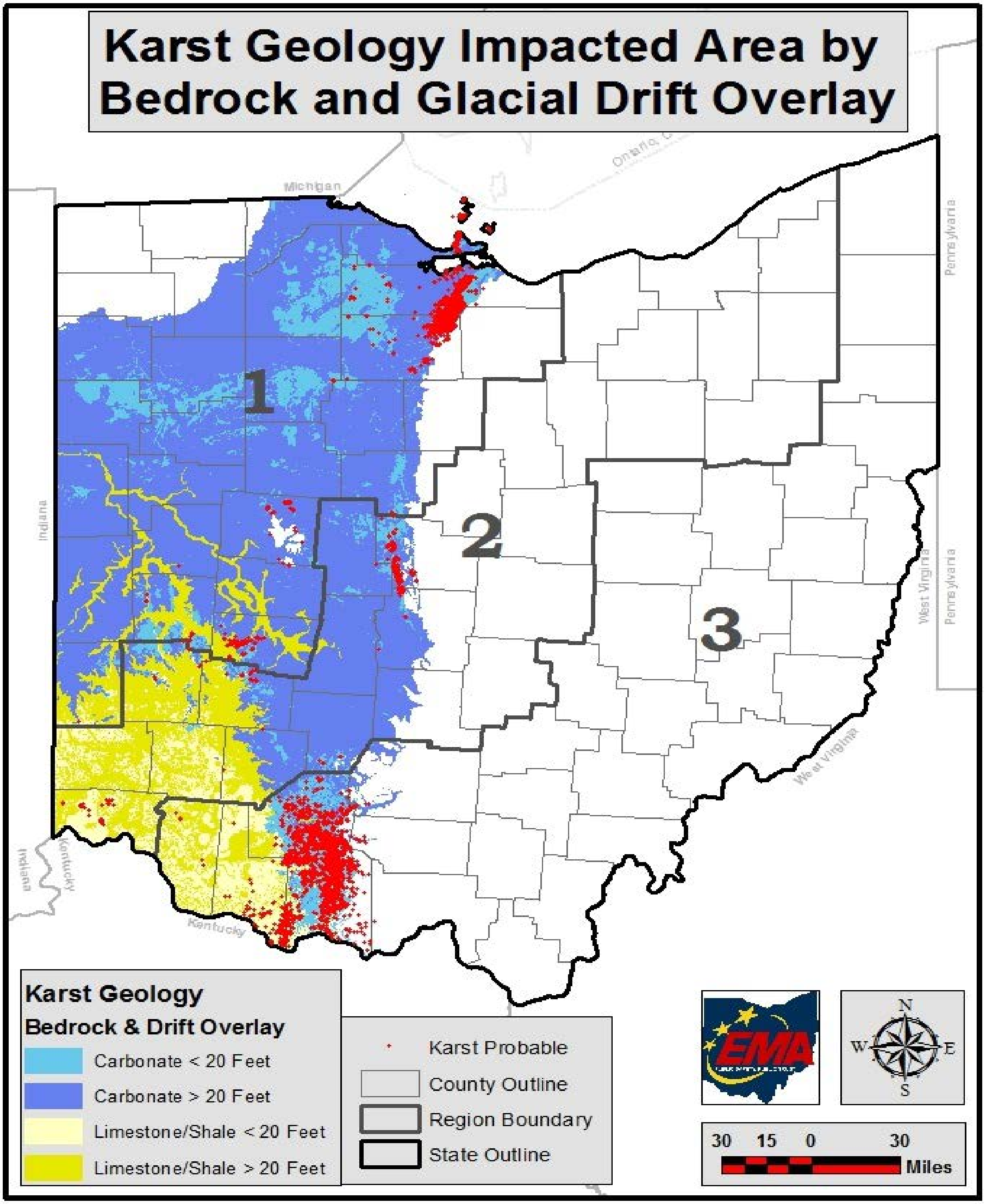


The ODNR Division of Geological Survey also released a Karst Interactive Map in 2019 (gis.ohiodnr.gov/website/dgs/karst_interactivemap/). This map is a record of karst features found throughout Ohio that is updated regularly as mapping continues. Each datapoint links to a list of information about the feature, including location; feature type; notes and comments about the location or feature; and photograph(s), if available. ODNR continues to update the Karst data statewide including new field work and related reports for Hamilton County in 2020-2022, Franklin County in 2021, Adams County in 2019 and Highland County in 2019.



Areas which are reclaimed strip mines and other type of soils poorly suited for development are often mapped by local communities and the Ohio Department of Natural Resources. Ohio’s built environment exposure to this type of hazard is very limited.

Map 2.14b



LHMP DATA

Erie County experiences impacts with flooding events due to the Karst soils in the County. In the eastern portion of the County, is primarily underlain by clastic sedimentary rocks such as sandstones and shales. The western part of the County is primarily underlain by limestones and dolomites, that form karstic landscapes. The Bellevue-Castalia Karst Plain includes parts of western Erie County and contains more sinkholes than any other karst region in Ohio. Surface drainage in this region often flows into sinkholes and continues underground. Karst is a flooding hazard for the western portion of Erie County including the Village of Bay View, the City of Bellevue, the Village of Castalia, the Village of Kelleys Island, and the City of Sandusky.

For the City of Bellevue which is located within the Bellevue-Castalia Karst Plain and resides within four counties; Erie, Huron, Sandusky, and Seneca. Three of the four counties (Huron did not) indicated that land subsidence was a hazard risk. They recognized that land subsidence, in the form of sinkholes, has a potential to occur, but also notes that there have been no incidents of land subsidence that have resulted in the damage of structures, personal injury, or loss of life. An area of concern for Sandusky County, in regards to land subsidence, is a Class I dam that is located in the southeastern portion of the county.

Sandusky, Erie, and Seneca Counties all have specific mitigation action items related to karst and land subsidence, such as to identify high-risk areas and evaluate land-use planning techniques to mitigate future events.

PAST OCCURRENCES

Abandoned underground mines in Ohio are monitored by the ODNR, Division of Mineral Resources Management, which is primarily federally funded. Within the division, two programs exist to address mine subsidence, one for emergencies and a second for non-emergencies. The emergency program gives priority to events which are directly affecting a structure (within 300 feet) or transportation route. Each year between 50 and 60 investigations are completed generating 25 to 30 projects. The time between the event and response is often within a week. Projects are undertaken to protect lives and property, and can range from simple precautions to filling the void with cement to stabilize the area affected.

Repeated emergency incidents can lead to larger non-emergency response. The City of North Canton (Region 2), Village of Cadiz (Region 3) and Village of New Lexington (Region 3) each experienced repeated emergency events culminating in area-wide engineering studies to address the problems. In each case, comprehensive mitigation activities, including the installation of in-mine support columns and the filling of voids, stabilized large areas which were subsidence-prone.

The most notable transportation-related event occurred in 1986 when an abandoned mine located in Guernsey County collapsed underneath Interstate 70 resulting in the closure of the entire interstate. Remediation included stabilizing the void and repairing the damaged roadway costing over $10 million dollars.

Underground salt mining under Lake Erie has not generated any known subsidence to date; however, solution mining in Lake, Summit and Medina Counties has. The most dramatic case in Ohio is in the Lake County community of Painesville, where an abandoned mine is responsible for a six-foot surface depression. Due to the proximity of the impacted area to Lake Erie, it is now filled with water.

Until recently, Karst events in Ohio had very little direct impact from a subsidence perspective on the built environment; however, they have been very costly in terms of pollution and flooding. Two well-documented karst-related events deal with contamination of aquifers. The oldest researched event in Ohio is associated with the Village of Bellevue, straddling the Huron / Sandusky County border. The 1961 study documents how from 1919 to 1946 the community permitted untreated wastewater injection wells and unimpeded groundwater runoff into sinkholes as an acceptable water management program. In 1946, after the groundwater was determined unfit for human consumption, the Village abandoned its last well and has since spent millions of dollars to develop a potable system based on piping water from safe sources. In February 2008, more than 200 homes experienced flooding in Bellevue when runoff from heavy snows and spring rains flooded underground karst chambers. Experts believed building pressure caused the pent-up water to surge up existing sinkholes and cracks, flooding homes and yards. A section of State Route 269 was swamped from February through June 2008.

The Village of Put-In-Bay, located on South Bass Island in Lake Erie, was the site of an extensive gastrointestinal illness outbreak in 2004. The island is a popular, warm-weather tourist destination and, at the height of the season, over 1,000 cases of digestive related maladies were documented in people who had recently vacationed there. The investigation began with the municipal systems and quickly shifted to a number of transient, non-community, public water systems used for geothermal cooling, flushing toilets, and outdoor cleaning. These systems were found interconnected to the main water system. The karst topography allowed groundwater to travel quickly between locations and is easily affected by seasonal precipitation.

The only known karst-related subsidence impact to the built environment is roadway damage. In 2007 State Route 19 was closed in Crawford County when an adjacent karst feature expanded destabilizing the road bed.

Some examples of the impact of karst during construction include U.S. Route 33 near East Liberty, where construction crews had to perform considerable back-filling and reinforcing, creating a land-bridge to make sure the highway was secure. Another example would be the construction of tunnels for sewage pipelines by the City of Dublin (Franklin County). Sinkholes, filled with clayey overburden caused the expensive rock-boring machinery to clog and break, resulting in tremendous cost overruns.

Finally, one housing development in the City of Westerville (Franklin County) contains homes, which have been dislodged and damaged by the effects of soils which dramatically expand when wet and contract when dry. Since 2000, the Ohio EMA has purchased 6 damaged homes; however, this is the only known impact from this form of land subsidence.

PROBABILITY OF FUTURE EVENTS

Mine-related land subsidence is an annual event impacting an average of five homes or roadways. Approximately 20 additional events occur each year that do not impact the built environment, yet may require remediation. Unlike mine-related events, karst events historically have manifested their impact in the form of groundwater contamination. Based on past exposure, a significant event occurs approximately each decade.

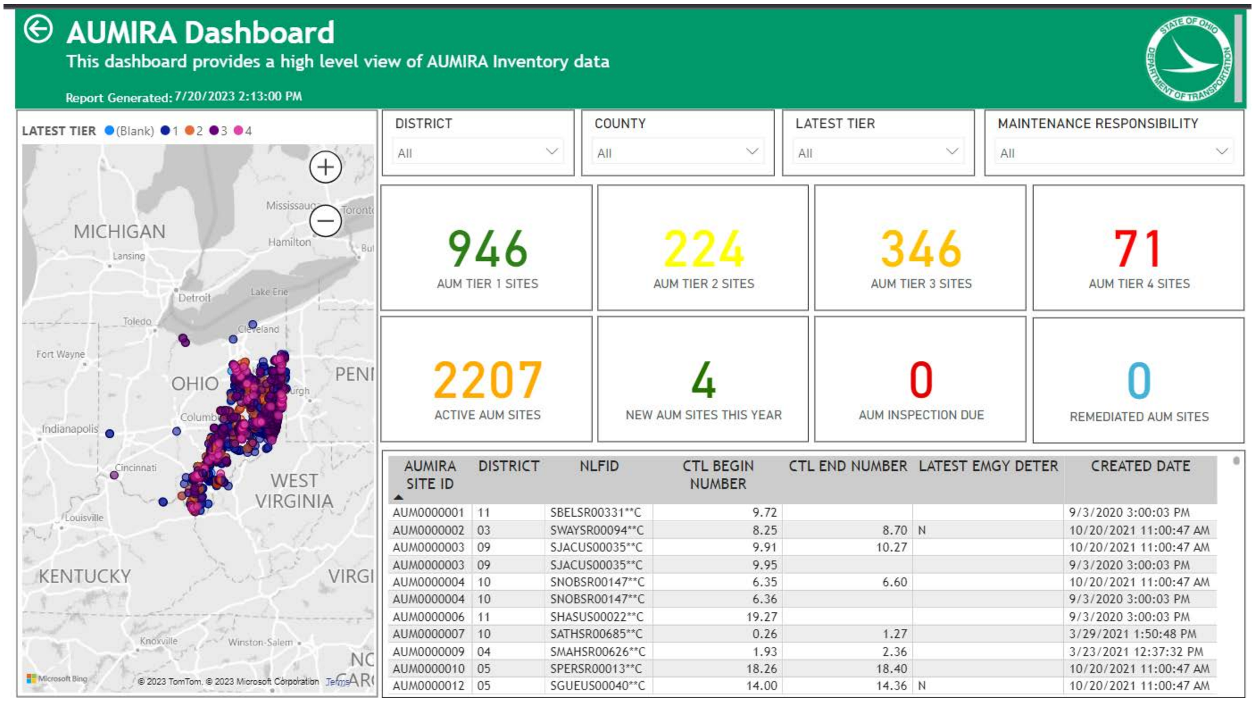
VULNERABILITY ANALYSIS & LOSS ESTIMATION

METHODOLOGY

The only predictable impact, which can be quantified for analysis, is damage to Ohio's roadways. The Ohio Department of Transportation, Office of Geotechnical Engineering has a comprehensive inventory of the federal and state routes which intersect with known and estimated abandoned mines. The location, length of each segment, potential for failure, along with a host of other data is maintained in a database (https://gis.dot.state.oh.us/tims/Map/Geotechnical) .

ODOT updated their AUM Inventory and Risk Assessment Manual in July of 2022. This new manual has an updated methodology for assessing the risk and impact of AUMs on federal and state routes. The new methodology makes use of an initial and detailed site evaluation process. This process then ranks the AUM on a 4-tier scale. More detailed information about the manual is available at https://www.transportation.ohio.gov/working/engineering/geotechnical/asset-management/aumira

ODOT also maintains the AUM dashboard at accessible via asset management website, which provides an on-the-fly view of the most current AUM data that impacts state roadways and other ODOT assets.



STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

Land subsidence is a spatial hazard, but is spatial-specific in that it would only affect very small areas given an occurrence. Therefore, this hazard has a very limited potential of affecting any state-owned or state-leased facilities. However, it should be noted that such events could impact lifelines, which could have significant effects on the functionality of various state facilities.

2.15 EXTREME/EXCESSIVE HEAT

Extreme heat, or Excessive Heat, in the general sense refers to a prolonged period of time where temperatures are much hotter and/or humid than average. As “average” is subject to factors revolving around time and location, there is not a universal temperature range used to define extreme heat and different sources may have different criteria in the recording and issuing of extreme heat events. In Ohio the five local National Weather Service (NWS) Offices maintain uniformed criteria for issuing Heat Advisories, Excessive Heat Watches, and Excessive Heat Warnings:

- **Excessive Heat Warning**: Issued when the heat index is *expected* to reach around 105°F or higher for a period of at least 2 hours. A warning would also be appropriate if heat advisory criteria are expected to be reached for 4 consecutive days.
- **Excessive Heat Watch**: Issued when there is *potential* for heat index values of 105°F or hotter within the next 24 to 48 hours.
- **Heat Advisories**: Issued for heat index of equal to 100°F and less than 105°F for a period of at least 2 hours.

The NWS utilizes the ‘Heat Index’ to measure the impact of heat experienced by individuals and to gauge potentially dangerous conditions. This table uses relative humidity and air temperature to produce the "apparent temperature" or the temperature the body "feels". While these values were devised for shady and light wind conditions, exposure to direct sunshine can increase heat index values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous as the wind adds heat to the body.

Table 2.15.a – NWS Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure and/or Strenuous Activity

Caution Extreme Caution Danger Extreme Danger

	Heat Index/Apparent Temp	Effect on the body
Caution	80°F - 89°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F -104°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	105°F-129°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	130°F or higher	Heat stroke highly likely

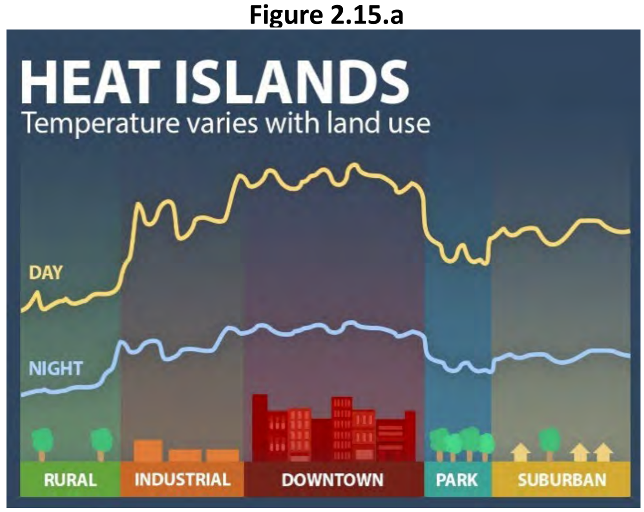
Extreme heat is responsible for the highest number of annual deaths among all weather-related hazards. Some statistical approaches estimate that more than 2,200 deaths per year in the United States are due to extreme heat- and this is expected to increase as extreme heat events (i.e., heat waves) have become more frequent in the United States in recent decades. Studies project that the frequency and intensity of extreme heat events will continue to increase as a consequence of climate change.

When people are exposed to extreme heat, they can suffer from potentially deadly heat-related illnesses such as heat exhaustion and heat stroke. Population groups that face greater risks to the effects of extreme heat include: elderly adults, infants and young children, pregnant women, impoverished households, homeless and transient populations, those with disabilities, and those with pre-existing health conditions. Tracking the rate of reported overall heat-related deaths and heat-related CVD deaths over time provides a measure of how climate change may affect human well-being.

Extreme/Excessive Heat is a statewide hazard and all areas are susceptible to Extreme Heat. Those in highly-developed urban areas face increased exposure susceptibility due to higher densities of people as well from u*rban heat island* effects. Per the National Integrated Heat Health Information System (NIHHIS), the term urban heat island (UHI) refers to the fact that cities tend to get much warmer than their surrounding rural landscapes, particularly during the summer.

This temperature difference occurs when cities' unshaded roads and buildings gain heat during the day and radiate that heat into the surrounding air. Other contributors to UHIs include lack of trees and vegetation, urban canyon effects that block wind flow, and waste heat (heat-emitting devices and vehicles). As a result, highly developed urban areas can experience mid-afternoon temperatures that are 15°F to 20°F warmer than surrounding, vegetated areas. This becomes problematic for developed areas as over 80% of Americans live in urban areas according to the U.S. Census Bureau, and the Urban Heat Island effect means that those urban areas are likely hotter than rural areas.

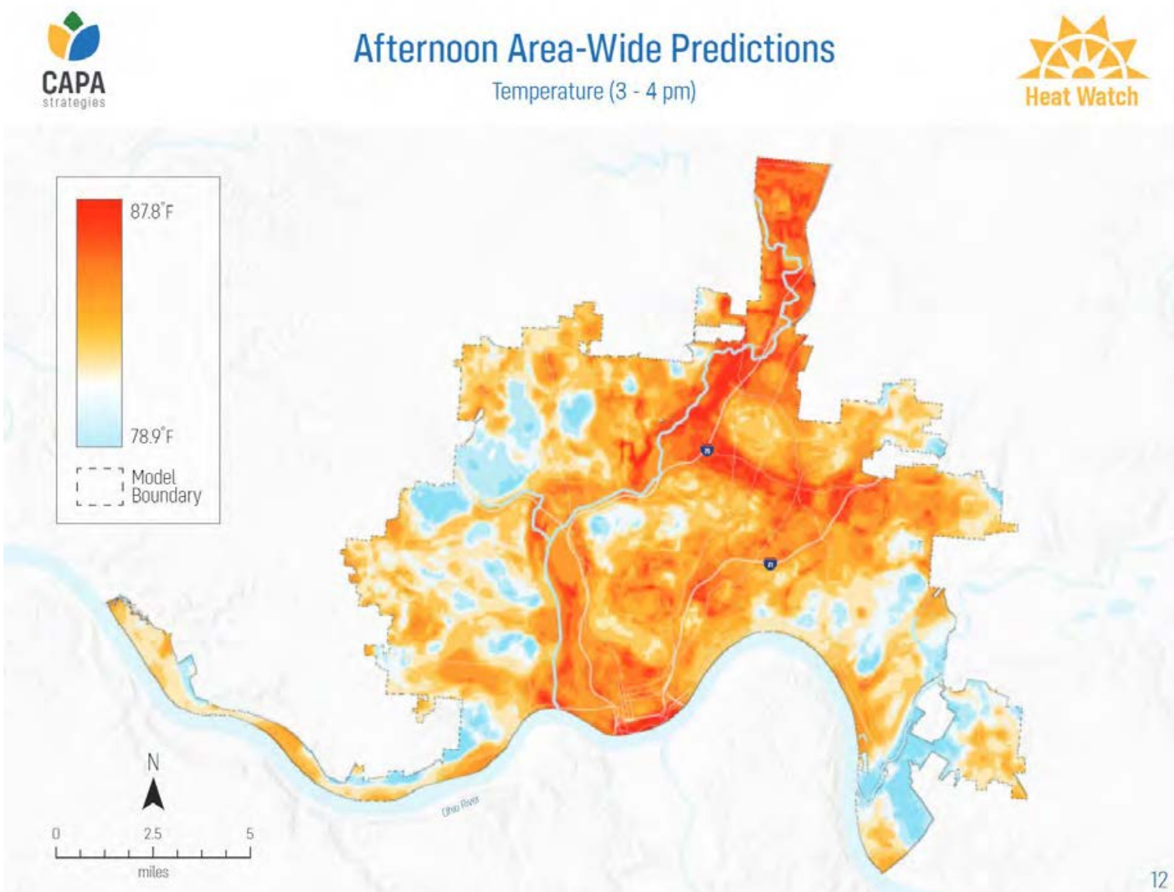
Figure 2.15.a



Source: U.S. EPA 2012, Graphic by Climate Central

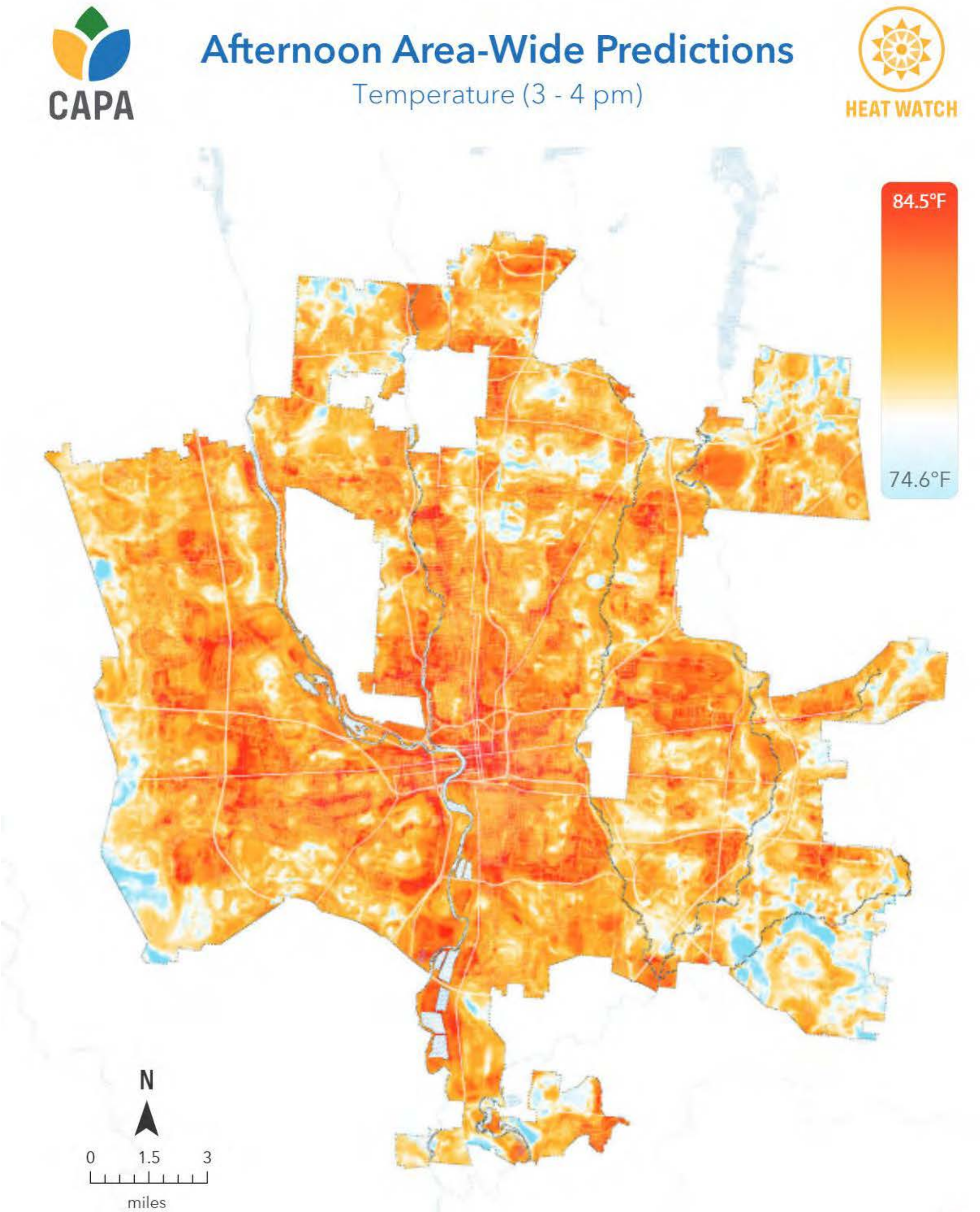
Over the past six years, NOAA (Office of Education, Climate Program Office, National Integrated Heat Health Information System (NIHHIS)) has funded CAPA Heat Watch to support 60+ communities across the United States in mapping their urban heat islands (UHI). This includes a study conducted for Cincinnati (Hamilton County) in August 2020, and Columbus (Franklin County) in August 2022. The City of Toledo (Lucas County) was selected for their 2023 UHI Mapping Campaign, however the study has yet to be published. These heat mapping studies collect thousands of temperature and humidity data points in the morning, afternoon, and evening to generate heat index predictions for different points of the day.

Figure 2.15.b – Projected Areas of Urban Heat Island Effects for Cincinnati, Ohio



Source: NOAA, NIHHIS, CAPA Heat Watch August 2020

Figure 2.15.c– Projected Areas of Urban Heat Island Effects for Columbus, Ohio



Source: NOAA, NIHHIS, CAPA Heat Watch August 2022

Urban heat islands have also been discussed in Local hazard Mitigation Plans (LHMPs) around the state. Butler and Delaware Counties, two of the five fastest growing counties in the state, shows growth in urban areas where excessive heat can also be concentrated and create UHIs. As with most developed areas, the urbanized centers of these counties both hold the highest concentrations of people, and UHI-contributing factors in their respective counties.

Figure 2.15.d – Urban Heat Severity map from the Butler County 2023 HMP

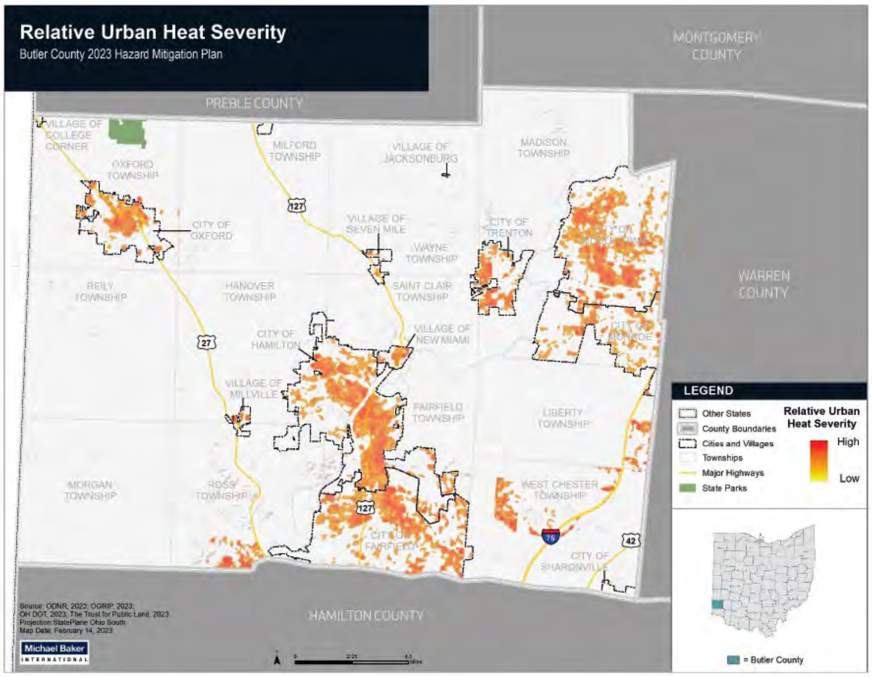
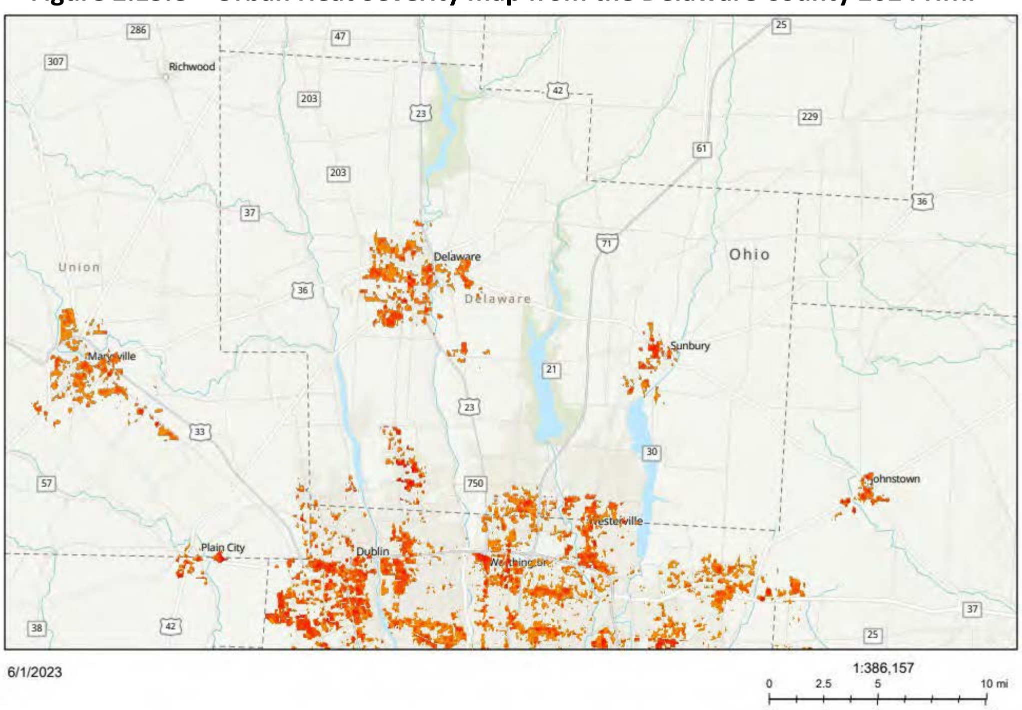


Figure 2.15.e – Urban Heat Severity map from the Delaware County 2024 HMP



PAST OCCURRENCES AND PROBABILITY OF FUTURE EVENTS

Over the 20-year period of January 2003 to January 2023, Heat and Excessive Heat events were reported on the NOAA Storm Events Database on 13 distinct days from different counties around Ohio. These events happen over large regions and are recorded as zone-based events. Based on this, it is estimated that there is approximately a 65% chance of an extreme heat event happening in a given year. This equates to 1-2 events every two years. This 65% is roughly equivalent to the estimated annual frequency rate of Heatwave of the median Ohio county, 65.02%, as estimated by the FEMA National Risk Index (table 2.15.b)

Table 2.15.b

FEMA NRI Heatwave Estimated Annual Frequency by County					
OEMA Region 1		OEMA Region 2		OEMA Region 3	
County	Annual Frequency	County	Annual Frequency	County	Annual Frequency
Allen	111.46%	Ashland	37.15%	Adams	123.84%
Auglaize	86.69%	Butler	142.41%	Ashtabula	16.82%
Champaign	80.50%	Clinton	111.46%	Athens	43.34%
Clark	80.50%	Cuyahoga	37.94%	Belmont	37.15%
Crawford	55.73%	Delaware	68.11%	Brown	130.03%
Darke	86.69%	Fairfield	86.69%	Carroll	30.96%
Defiance	105.26%	Fayette	92.88%	Clermont	148.61%
Erie	50.26%	Franklin	80.50%	Columbiana	30.96%
Fulton	99.07%	Geauga	37.15%	Coshocton	37.15%
Hancock	74.30%	Greene	86.69%	Gallia	37.15%
Hardin	80.50%	Hamilton	352.94%	Guernsey	37.15%
Henry	105.26%	Knox	37.15%	Harrison	37.15%
Huron	49.54%	Lake	30.97%	Highland	105.26%
Logan	86.69%	Licking	74.30%	Hocking	86.69%
Lucas	89.93%	Lorain	43.87%	Holmes	37.15%
Marion	55.73%	Madison	74.30%	Jackson	43.34%
Mercer	86.69%	Medina	30.96%	Jefferson	30.96%
Miami	86.69%	Montgomery	260.06%	Lawrence	37.15%
Ottawa	122.51%	Morrow	43.34%	Mahoning	24.77%
Paulding	111.46%	Pickaway	86.69%	Meigs	37.15%
Preble	99.07%	Portage	24.77%	Monroe	37.15%
Putnam	111.46%	Richland	37.15%	Morgan	43.34%
Sandusky	55.73%	Stark	37.15%	Muskingum	37.15%
Seneca	61.92%	Summit	30.96%	Noble	37.15%
Shelby	86.69%	Union	74.30%	Perry	43.34%
Van Wert	111.46%	Warren	130.03%	Pike	117.65%
Williams	99.07%	Wayne	37.15%	Ross	92.88%
Wood	74.30%			Scioto	123.84%
Wyandot	61.92%			Trumbull	24.77%
				Tuscarawas	37.15%
				Vinton	43.34%
				Washington	37.15%

CDC PROVISIONAL MORTALITY STATISTICS: HEAT-RELATED FATALITIES

The Centers for Disease Control and Prevention (CDC) WONDER is a database that provides access to statistical research data published by the CDC, as well as reference materials, reports and guidelines on health-related topics. It also allows users to query numeric data sets on CDC's computers, via "fill-in-the blank" web pages. Public-use data sets about many other topics are available for query, and the requested data are readily summarized and analyzed, with dynamically calculated statistics, charts and maps. This database was utilized to query CDC statistics on Heat-Related Fatalities:

Table 2.15.c

CDC Provisional Mortality Statistics Heat-Related Deaths [1]		
Year	**Ohio**	**United States**
2018	22	1,012
2019	14	911
2020	19	1,156
2021	16	1,602
2022	13	1,722
2023	18	2,231
TOTAL	**102**	**8,634**

Source: CDC Provisional Mortality Statistics

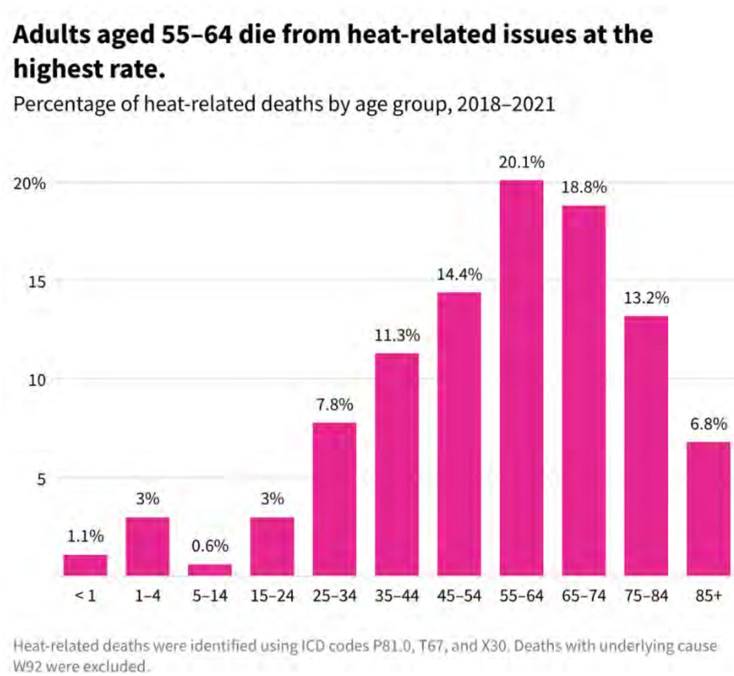
1- Statistics were queried using MCD – ICD- 10 Codes:
P81.0 (Environmental hyperthermia of newborn);
T67.0 (Heatstroke and sunstroke);
T67.1 (Heat syncope);
T67.2 (Heat cramp);
T67.3 (Heat exhaustion, anhydrotic);
T67.4 (Heat exhaustion due to salt depletion);
T67.5 (Heat exhaustion, unspecified);
T67.6 (Heat fatigue, transient);
T67.7 (Heat oedema);
T67.8 (Other effects of heat and light);
T67.9 (Effect of heat and light, unspecified);
X30 (Exposure to excessive natural heat (hyperthermia))

Over the past 6 years, CDC mortality statistics estimate that there was a total of 102 heat-related fatalities in Ohio, and 8,634 fatalities in the entire United States. This is substantially more than what was recorded in the NOAA Storm Events Database.

USAFacts is a not-for-profit, nonpartisan civic-initiative that collects, compiles, and assesses government data and statistics. Using the same Statistic Mortality Codes queried from CDC WONDER, they found that from the years 2018 to 2021, the largest age groups suffering heat-related deaths are between the ages of 55 and 64. This followed by the next age group of 65 to 74.

The CDC notes that older adults, the very young, and people with mental illness and chronic diseases are at the greatest risk for heat-related illnesses and deaths, however even young and healthy people can be affected: more than one in five heat-related deaths occur in Americans aged 15 to 44.

Figure 2.15.f



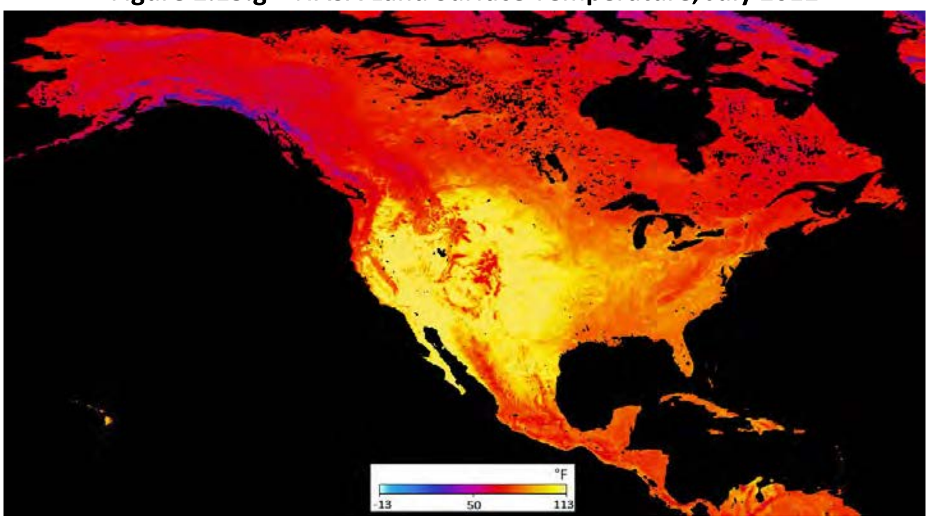
Source: CDC Provisional Mortality Statistics compiled by USAFacts

2012 NORTH AMERICAN HEAT WAVE

Not to be mistaken with the 2012 North American Drought, which happened around the same time in the Summer of 2012. That event is discussed in Section 2.11, Drought. The 2012 North American Heatwave event caused cascading impacts throughout 2012, causing increased evaporation of groundwater, lakes, reservoirs, rivers and streams.

The 2012 North American Heat Wave was one of the most severe heat waves recorded in North American history. Dubbed the "Hottest Year Ever in U.S." by the New York Times *in 2013*, the heat wave was formed when high pressure moved over Baja California, Mexico, strengthened then spread to other parts of North America throughout the Summer of 2012. Under high pressure, the air subsides toward the surface and acts like a dome that traps heat instead of allowing it to lift.

Figure 2.15.g – NASA Land Surface Temperature, July 2012



Source: NASA Earth Observations

Over the Midwest, this high pressure resulted in the warmest year for many states. The state of Ohio as a whole ended up with the warmest year on record. The contiguous United States average annual temperature of 55.3°F was 3.2°F above the 20th century average, and was the warmest year in the 1895-2012 period of record for the nation. One hundred fifty-five (155) people died as a result of extreme heat in 2012. This number is well above the 10-year average for heat related fatalities, 119. The most dangerous place to be was in a permanent home, likely with little or no air conditioning, where a reported 84 (54%) of deaths occurred. Missouri numbered the most heat victims, 34, followed closely by Illinois with 32 heat related deaths. Extreme heat most strongly affected adults aged 50+, with 117 deaths (75%). Many more males, 99 (64%), than females, 56 (36%), were killed by heat. In Ohio, three direct fatalities were reported in Licking County.

While 2012 was dubbed "Hottest Year Ever in US", that statement stood true for only another few years. The New York Times 2013 article cited the sentiment of scientists, doubting that the record would have been set without the backdrop of global warming caused by the human release of greenhouse gasses. They then warned that 2012 was "a foretaste of things to come, as continuing warming makes heat extremes more likely". This ominous prediction is proving to be true as in the following years, NASA and the NOAA declared 2016 to be the warmest year on record globally, tied that record in 2020, and most recently declared 2023 to be North America's (and the world's) warmest year on record by far.

CLIMATE PROJECTIONS

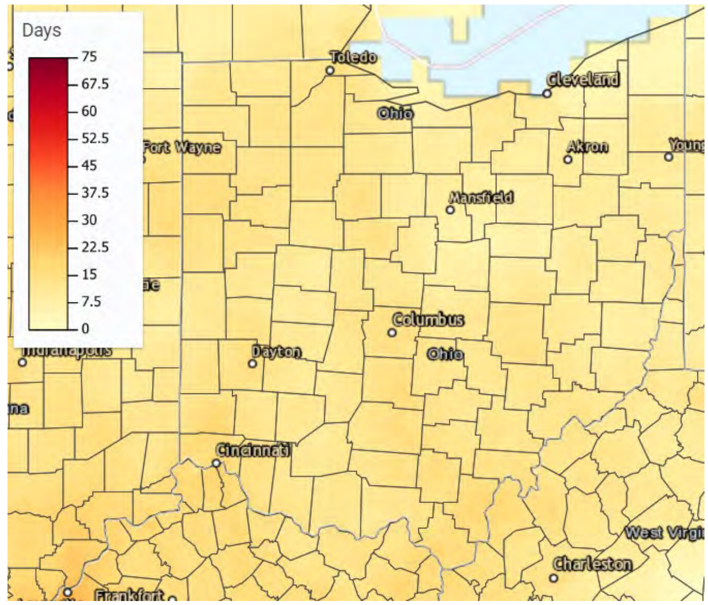
Built to accompany the U.S. Climate Resilience Toolkit, [the Climate Explorer](#) graphs projections for two possible futures: one in which humans drastically reduce and stabilize global emissions of heat-trapping gasses (labeled Lower emissions, also known as RCP4.5), and one in which we continue increasing emissions through the end of the 21st century (labeled Higher emissions, also known as RCP8.5).

The Climate Explorer allows users to view temperature and precipitation projections by county. In Ohio, these projections were disseminated for five counties based on different features and attributes: Cuyahoga, Franklin, Hamilton, Washington, and Williams. See “Features and Attributes” for tables 2.15.d/e.

Figure 2.15.h

Projected Days with Maximum Temperature > 105°F

RCP 8.5 (Higher Emissions)



Source: [The Climate Explorer](#)

By the year 2090, the Climate Explorer predicts that if humans continue to increase emissions (RCP8.5), Cuyahoga County may face upward of 9 days a year with temperatures over 105°F. For Franklin and Hamilton Counties, the projections are even worse with estimates of 15 to 18 days over 105°F annually. If humans are able to reduce global emissions (RCP 4.5), this projection would be cut down to only one to two days per year. For these larger counties, the increase in hotter days will directly impact the health of larger concentrations of people, as well as contribute to effects such as urban heat islands and increased stress onto the electric grid. Smaller counties will also face a higher number of days over 105°F which will detrimentally impact people and agricultural production.

Tables 2.15.d/e

Projected Days with Maximum Temperature > 105°F RCP 4.5 (Lower Emissions)				
County	Projected Average Number of Days by Year [1]			
	Historic [2]	2030	2060	2090
Cuyahoga [a]	0	0	0	1
Williams [b]	0	0	1	1
Franklin [c]	0	0	1	2
Washington [d]	0	0	1	1
Hamilton [e]	0	0	2	2

Projected Days with Maximum Temperature > 105°F RCP 8.5 (Higher Emissions)				
County	Projected Average Number of Days by Year [1]			
	Historic [2]	2030	2060	2090
Cuyahoga [a]	0	0	2	9
Williams [b]	0	0	3	12
Franklin [c]	0	0	4	15
Washington [d]	0	0	4	13
Hamilton [e]	0	0	5	18

1- *Weighted mean of projected days. Values rounded to nearest integer.*

2- *Based on average of weighted means from years 2005 to 2023. Values rounded to nearest integer.*

Features and Attributes

a- *Northeast Ohio - Population 1,264,817. Higher density, next to Lake Erie.*

b- *Northwest Ohio - Population 37,102. Low density, rural and agricultural.*

c- *Central Ohio- Population 1,323,807. Higher density, relatively flat with mild elevation.*

d- *Southeast Ohio - Population 59,711. Low density, rural and forested, next to Ohio River.*

e- *Southwest Ohio - Population 830,639. Higher density, mild hills, next to Ohio River.*

VULNERABILITY ANALYSIS & LOSS ESTIMATION

IMPACTS ON PROPERTY AND INFRASTRUCTURE

Extreme/Excessive Heat does not pose a direct threat to the structural integrity of buildings. However, the larger threat from extreme heat to buildings would be to their occupants, especially if they fall within a population group with increased risks. The hazard may also indirectly cause physical and economic damage to buildings in regards to maintenance of their mechanical systems such as air conditioning, plumbing, and other utilities. These impacts may be exacerbated by infrastructure failure in an event where increased stress on the electrical grid causes power outages in the form of rolling blackouts and results in losses of function.

Extreme Heat events can also cause damage to roads. Higher temperatures can cause asphalt to soften and form tire-track depressions and eventually crack. Concrete roads can "buckle" when segments expand without the spacing to support it, causing them to push up against each other and potentially raising or breaking. Not only is this damaging to the road itself but to the people and their safety, access to lifelines, and other economic activities. Statistics on road buckling due to heat isn't readily available, however it can be expected that vulnerabilities increase as infrastructure ages and extreme heat events have become more frequent. Maps of local, state, and interstate roads and average annual daily traffic counts can be obtained on the ODOT's Transportation Information Mapping System (TIMS).

Figure 2.15.i – Road Buckling due to Heat on I-77, Noble County

Source: Ohio Department of Transportation, District 10

Additionally, extreme heat can play a cascading role in occurrences and impacts from drought (section 2.11) and wildfires (section 2.7). It also contributes to urban heat island effects within higher-density communities, and the emission greenhouse gases.

IMPACTS ON PEOPLE

As mentioned earlier in this section, the most direct impacts of extreme heat are the impacts to people. Extreme heat is responsible for the highest number of annual deaths among all weather-related hazards. Some statistical approaches estimate that more than 2,200 deaths per year in the United States are due to extreme heat. That number is expected to increase as extreme heat events have become more frequent in recent decades. When people are exposed to extreme heat, they can suffer from potentially deadly heat-related illnesses such as heat exhaustion and heat stroke (see table 2.15.a). Population groups that particularly face greater risks to the effects of extreme heat include: elderly adults, infants and young children, pregnant women, impoverished households, homeless and transient populations, those with disabilities, and those with pre-existing health conditions. As shown in figure 2.15.e, approximately 39% of heat-related deaths in the United States are within the 55 to 74 age group.

Based on the past six years (table 2.15.c, there is an average of 17 heat-related deaths in Ohio annually. Similar to the methodology in the FEMA National Risk Index, population loss is monetized with a *Value of Statistical Life* approach in which each fatality is counted as $11.6 million of economic loss, which equates to an estimated annual population equivalence loss of $197,200,000. This is considered a high estimate as it utilizes CDC WONDER provisional mortality deaths, which is a different dataset from the FEMA National Risk Index which utilizes various data sources including SHELDUS loss records for their estimates seen in tables 2.15.h, i, and j.

Table 2.15.f below summarizes the estimates of people, particularly vulnerable and at-risk populations in the state of Ohio. From the year 2000 to 2020, the state population grew 4% while also gaining over 1-million people in the 55 to 74 age group, roughly 60%. Every county in the state has experienced growth in this particular age group- from Jefferson County having lost 12% of its population over this time while growing 23% specifically in the 55-74 age group. Delaware County seen a 94% growth in total population and a growing 221% in the 55-74 age group.

According to the National Alliance to End Homelessness, between 2007 and 2022, Ohio's total homeless population actually decreased by 5%. The sheltered homeless population decreased by 7%, while the unsheltered population increased by 3%. This small but considerable increase raises concern as this population group lacks access to needs such as shelter, water, and cooling.

It can be expected that impacts on people (especially to vulnerable populations) will increase as the general population grows older, more are people relocating to higher-density areas susceptible to urban heat islands effects, and extreme heat events becoming more frequent.

Table 2.15.f

Extreme Heat Populations at Risk

OEMA Region 1

County	Population Total [1]	Population Under 5	Population 55 to 74	20-year %Δ Pop 55 to 74 [2]	Est. # of Homeless [3]
Allen	102,206	5,982	25,651	48%	66
Auglaize	46,422	2,849	11,869	66%	30
Champaign	38,714	2,160	10,136	54%	25
Clark	136,001	7,719	35,251	39%	88
Crawford	42,025	2,246	11,271	32%	27
Darke	51,881	3,080	13,465	46%	34
Defiance	38,286	2,133	9,883	54%	25
Erie	75,622	3,810	22,152	51%	49
Fulton	42,713	2,438	11,104	75%	28
Hancock	74,920	4,335	18,522	69%	49
Hardin	30,696	1,854	7,039	43%	20
Henry	27,662	1,616	7,227	55%	18
Huron	58,565	3,611	14,914	63%	38
Logan	46,150	2,653	12,395	58%	30
Lucas	431,279	25,063	104,785	55%	494
Marion	65,359	3,535	16,594	53%	42
Mercer	42,528	3,204	10,680	65%	28
Miami	108,774	6,379	27,414	61%	71
Ottawa	40,364	1,710	13,271	60%	26
Paulding	18,806	1,136	4,864	45%	12
Preble	40,999	2,184	11,340	56%	27
Putnam	34,451	2,193	8,703	70%	22
Sandusky	58,896	3,158	16,127	57%	38
Seneca	55,069	2,982	14,124	50%	36
Shelby	48,230	2,994	11,962	69%	31
Van Wert	28,931	1,763	7,364	45%	19
Williams	37,102	2,046	9,781	53%	24
Wood	132,248	6,842	30,335	86%	86
Wyandot	21,900	1,265	5,833	49%	14
Total	**1,976,799**	**112,940**	**504,056**	**56%**	**1,285**

OEMA Region 2

County	Population Total [1]	Population Under 5	Population 55 to 74	20-year %Δ Pop 55 to 74 [2]	Est. # of Homeless [3]
Ashland	52,447	2,930	13,436	54%	34
Butler	390,357	22,751	87,808	86%	254
Clinton	42,018	2,445	10,834	78%	27
Cuyahoga	1,264,817	66,746	320,205	40%	1,574
Delaware	214,124	12,776	45,362	221%	139
Fairfield	158,921	9,489	37,081	97%	103
Fayette	28,951	1,643	7,380	49%	19
Franklin	1,323,807	85,902	251,996	87%	1,912
Geauga	95,397	4,952	26,881	73%	62
Greene	167,966	9,210	40,363	72%	109
Hamilton	830,639	49,503	188,316	47%	1,081
Knox	62,721	3,767	15,692	72%	41
Lake	232,603	10,995	65,166	65%	151
Licking	178,519	10,349	44,027	85%	116
Lorain	312,964	16,799	81,809	84%	203
Madison	43,824	2,271	10,613	77%	28
Medina	182,470	9,259	48,223	114%	119
Montgomery	537,309	31,034	131,086	42%	656
Morrow	34,950	1,945	9,307	79%	23
Pickaway	58,539	3,213	13,631	65%	38
Portage	161,791	7,113	40,988	81%	105
Richland	124,936	6,738	31,989	41%	81
Stark	374,853	20,211	98,537	51%	247
Summit	540,428	28,734	140,081	61%	441
Union	62,784	3,993	12,805	137%	41
Warren	242,337	13,821	55,359	161%	158
Wayne	116,894	7,376	28,569	64%	76
Total	**7,837,366**	**445,965**	**1,857,544**	**65%**	**5,094**

OEMA Region 3

County	Population Total [1]	Population Under 5	Population 55 to 74	20-year %Δ Pop 55 to 74 [2]	Est. # of Homeless [3]
Adams	27,477	1,676	7,152	49%	18
Ashtabula	97,574	5,331	26,859	52%	63
Athens	62,431	2,617	12,093	62%	41
Belmont	66,497	3,080	19,026	43%	43
Brown	43,676	2,452	11,834	77%	28
Carroll	26,721	1,363	8,043	50%	17
Clermont	208,601	11,715	52,776	115%	136
Columbiana	101,877	4,986	29,046	47%	66
Coshocton	36,612	2,370	9,566	45%	24
Gallia	29,220	1,754	7,583	35%	19
Guernsey	38,438	2,185	10,412	41%	25
Harrison	14,483	736	4,314	36%	9
Highland	43,317	2,668	10,897	55%	28
Hocking	28,050	1,507	7,701	50%	18
Holmes	44,223	3,864	8,386	68%	29
Jackson	32,653	1,965	8,159	51%	21
Jefferson	65,249	3,251	18,443	23%	42
Lawrence	58,240	2,989	15,319	31%	38
Mahoning	228,614	11,542	63,971	37%	174
Meigs	22,210	1,123	6,172	45%	14
Monroe	13,385	667	3,931	24%	9
Morgan	13,802	718	3,957	36%	9
Muskingum	86,410	4,993	21,734	53%	56
Noble	14,115	684	3,474	55%	9
Perry	35,408	2,162	9,081	73%	23
Pike	27,088	1,655	6,849	52%	18
Ross	77,093	4,215	19,354	63%	50
Scioto	74,008	3,977	18,520	32%	48
Trumbull	201,977	10,160	56,894	38%	131
Tuscarawas	93,263	5,499	24,165	54%	61
Vinton	12,800	646	3,503	62%	8
Washington	59,771	2,979	16,659	42%	39
Total	**1,797,801**	**97,905**	**479,769**	**49%**	**1,169**

1- Population estimates based on US Decennial 2020 Census
2- 20-year Percent Change in population groups based on comparison of population age groups from the 2000 and 2020 Decennial Census
3- 2022 Estimate using: U.S Department of Housing and Urban Development (HUD) PIT Data, and further curated by the National Alliance to End Homelessness.

IMPACTS ON AGRICULTURE

According to the Fourth National Climate Assessment (NCA2018), projections of mid-century yields of commodity crops show declines of 5% to over 25% below extrapolated trends broadly across the region for corn and more than 25% for soybeans in the southern half of the Midwest, with possible increases in yield in the northern half of the region. Increases in growing-season temperature in the Midwest are projected to be the largest contributing factor to declines in the productivity of U.S. agriculture. In particular, heat stress in corn during the reproductive period is projected to reduce yields in the second half of the 21st century. The NCA2018 cited *Climate Impacts on Agriculture: Implications for Crop Production* by J. L. Hatfield, K. J. Boote, B. A. Kimball, L. H. Ziska, R. C. Izaurralde, D. Ort, A. M. Thomson, D. Wolfe in which it was found that the rate of reproduction for corn begins to decrease at 35°C, or 95°F, and the photosynthetic rates declined by 50-60% at 105°F. For soybeans, the rate of reproduction begins to decrease at 102°F while the rate of grow decreases at 101°F.

In the USDA 2022 State of Ohio Agricultural Overview, Corn and Soybeans accounted for the majority of the crops planted, harvested, and the value of crop production in the State. Soybeans accounted for 5,100,000 acres (56%) planted for crops and $4,059,936,000 (40%) of the crop production value. Corn accounted for 3,400,000 (37%) of acres planted and $3,835,557,000 (38%) of crop production value. For estimates of crop cash receipts for each county, see Section 2.11, tables 2.11.f/g/h. For additional information on specific crop types and production by county, refer to the USDA Annual Statistical Bulletins. As the number of days over 105°F in Ohio are expected increase by the end of the century, it will pose a direct threat to the agricultural economy in many parts of the state.

Table 2.15.g

Crops - Planted, Harvested, Yield, Production, Price (MYA), Value of Production †
Sorted by Value of Production in Dollars

Commodity	Planted All Purpose Acres	Harvested Acres	Yield	Production	Price per Unit	Value of Production in Dollars
SOYBEANS						
SOYBEANS	5,100,000	5,080,000	55.5 BU / ACRE	281,940,000 BU	14.4 $ / BU	$4,059,936,000
CORN						
CORN	3,400,000	3,180,000	187 BU / ACRE	594,660,000 BU	6.45 $ / BU	$3,835,557,000
HAY & HAYLAGE						
HAY & HAYLAGE	N/A	880,000	2.93 TONS / ACRE, DRY BASIS	2,580,000 TONS, DRY BASIS	N/A	$418,752,000
HAY						
HAY	N/A	830,000	2.7 TONS / ACRE	2,243,000 TONS	162 $ / TON	$360,754,000
WHEAT						
WHEAT	510,000	465,000	79 BU / ACRE	36,735,000 BU	7.85 $ / BU	$292,043,000
PUMPKINS						
PUMPKINS	4,000	3,800	175 CWT / ACRE	665,000 CWT	22.4 $ / CWT	$14,791,000
OATS						
OATS	50,000	15,000	70 BU / ACRE	1,050,000 BU	5.4 $ / BU	$5,670,000

Source: U. S. Department of Agriculture - National Agricultural Statistics Service, 2022 State Agricultural Overview for Ohio

FEMA NATIONAL RISK INDEX

In the National Risk Index, a heat wave hazard risk index score and rating represent a community's relative risk for heat waves when compared to the rest of the United States. Generally, the heat wave exposure value represents a community's agriculture and building values (in dollars), and population (in both people and population equivalence) exposed to heat waves. The Expected Annual Loss (EAL) represents the relative level of agriculture, building, and population loss each year due to heat waves. For more information on current methodology and data, refer to section 12 of the National Risk Index Technical Manual.

Table 2.15.h

FEMA National Risk Index Heat Wave Analysis, October 2023, OEMA Region 1							
County	Exposure (Buildings)	Exposure (Population)	Exposure (Agriculture)	EAL (Buildings)	EAL (Pop. Equiv)	EAL (Agriculture)	EAL (Total)
Allen	$ 22,716,703,979	102,191	$ 160,496,256	$ 819	$ 49,165	$ 9,878	$ 59,861
Auglaize	$ 9,860,531,608	46,399	$ 237,335,321	$ 276	$ 17,362	$ 11,361	$ 29,000
Champaign	$ 7,667,574,489	38,673	$ 137,134,143	$ 200	$ 95,809	$ 6,096	$ 102,104
Clark	$ 26,184,414,152	135,980	$ 145,090,222	$ 682	$ 336,878	$ 6,449	$ 344,009
Crawford	$ 7,313,887,213	42,015	$ 268,368,664	$ 551	$ 47,995	$ 8,258	$ 56,804
Darke	$ 14,009,127,924	51,868	$ 592,046,670	$ 1,642	$ 19,409	$ 28,341	$ 49,392
Defiance	$ 8,087,441,978	38,229	$ 123,028,714	$ 1,151	$ 82,487	$ 7,151	$ 90,790
Erie	$ 17,826,579,068	75,596	$ 108,040,692	$ 1,045	$ 67,165	$ 2,586	$ 70,796
Fulton	$ 9,458,064,062	42,713	$ 198,555,183	$ 1,267	$ 86,741	$ 10,862	$ 98,871
Hancock	$ 15,955,315,753	74,885	$ 155,722,617	$ 1,603	$ 114,057	$ 6,389	$ 122,050
Hardin	$ 5,771,778,889	30,690	$ 255,601,798	$ 150	$ 50,639	$ 11,361	$ 62,151
Henry	$ 6,671,428,521	27,662	$ 153,003,310	$ 950	$ 59,687	$ 8,894	$ 69,530
Huron	$ 12,267,907,773	58,532	$ 229,320,807	$ 822	$ 59,433	$ 6,273	$ 66,528
Logan	$ 13,072,495,063	45,835	$ 139,648,149	$ 366	$ 122,287	$ 6,685	$ 129,338
Lucas	$ 84,065,353,547	431,225	$ 58,114,456	$ 7,744	$ 602,065	$ 2,186	$ 611,994
Marion	$ 12,618,822,345	65,349	$ 155,912,944	$ 227	$ 74,650	$ 4,798	$ 79,675
Mercer	$ 13,482,824,605	42,522	$ 724,437,877	$ 1,581	$ 15,911	$ 34,678	$ 52,170
Miami	$ 24,042,803,617	108,774	$ 122,404,090	$ 674	$ 40,703	$ 5,859	$ 47,236
Ottawa	$ 13,873,314,133	40,343	$ 67,919,699	$ 1,046	$ 46,085	$ 2,090	$ 49,220
Paulding	$ 5,212,442,255	18,790	$ 198,980,415	$ 786	$ 42,929	$ 12,246	$ 55,961
Preble	$ 8,365,924,518	40,984	$ 167,747,600	$ 1,121	$ 17,527	$ 9,177	$ 27,825
Putnam	$ 6,676,183,788	34,443	$ 246,010,331	$ 1,006	$ 78,690	$ 15,141	$ 94,837
Sandusky	$ 13,863,139,112	58,813	$ 115,856,168	$ 1,045	$ 67,183	$ 3,565	$ 71,794
Seneca	$ 11,329,882,437	55,063	$ 161,581,658	$ 949	$ 69,889	$ 5,525	$ 76,362
Shelby	$ 14,107,349,800	48,215	$ 204,457,715	$ 396	$ 18,042	$ 9,787	$ 28,224
Van Wert	$ 5,627,989,417	28,929	$ 219,408,525	$ 848	$ 13,918	$ 13,504	$ 28,270
Williams	$ 9,168,318,554	37,098	$ 140,850,996	$ 1,228	$ 75,338	$ 7,706	$ 84,273
Wood	$ 34,370,106,132	132,182	$ 182,623,882	$ 3,454	$ 201,326	$ 7,493	$ 212,273
Wyandot	$ 4,936,442,675	21,893	$ 180,432,174	$ 413	$ 27,788	$ 6,169	$ 34,370
Total	$ 438,604,147,408	1,975,890	$ 5,850,131,076	$ 34,044	$ 2,601,158	$ 270,507	$ 2,905,709

Table 2.15.i

FEMA National Risk Index Heat Wave Analysis, October 2023, OEMA Region 2							
County	Exposure (Buildings)	Exposure (Population)	Exposure (Agriculture)	EAL (Buildings)	EAL (Pop. Equiv)	EAL (Agriculture)	EAL (Total)
Ashland	$ 13,803,678,610	52,443	$ 130,487,461	$ 166	$ 39,938	$ 2,677	$ 42,781
Butler	$ 75,012,163,121	390,244	$ 62,955,865	$ 14,448	$ 239,901	$ 4,951	$ 259,300
Clinton	$ 10,400,043,228	41,956	$ 134,061,383	$ 375	$ 143,920	$ 8,251	$ 152,546
Cuyahoga	$ 244,271,620,347	1,264,334	$ 7,139,284	$ 116	$ 2,057,309	$ 146	$ 2,057,572
Delaware	$ 54,674,879,026	213,208	$ 99,598,499	$ 1,204	$ 446,942	$ 3,746	$ 451,893
Fairfield	$ 29,693,562,383	158,878	$ 114,416,499	$ 832	$ 423,884	$ 5,477	$ 430,194
Fayette	$ 7,200,569,590	28,951	$ 145,919,280	$ 216	$ 82,758	$ 7,484	$ 90,458
Franklin	$ 236,422,364,692	1,323,446	$ 59,817,357	$ 244	$ 3,375,411	$ 2,659	$ 3,378,314
Geauga	$ 21,951,348,661	95,397	$ 41,416,609	$ 1,103	$ 72,652	$ 850	$ 74,604
Greene	$ 32,904,559,550	167,939	$ 111,374,164	$ 923	$ 448,059	$ 5,331	$ 454,312
Hamilton	$ 153,888,332,381	830,621	$ 26,421,546	$ 696	$ 4,384,352	$ 5,149	$ 4,390,198
Knox	$ 14,262,973,508	62,691	$ 155,013,155	$ 171	$ 47,742	$ 3,180	$ 51,094
Lake	$ 45,763,676,596	232,492	$ 84,443,953	$ 1,916	$ 147,554	$ 1,448	$ 150,918
Licking	$ 37,618,983,655	178,382	$ 212,638,122	$ 904	$ 651,210	$ 8,725	$ 660,838
Lorain	$ 63,415,048,848	312,902	$ 153,571,419	$ 3,717	$ 278,005	$ 3,676	$ 285,398
Madison	$ 8,575,778,256	43,789	$ 182,647,724	$ 206	$ 100,139	$ 7,494	$ 107,839
Medina	$ 38,977,305,363	182,378	$ 59,097,992	$ 1,632	$ 115,741	$ 1,010	$ 118,384
Montgomery	$ 99,451,626,775	537,192	$ 90,263,913	$ 8,365	$ 794,632	$ 12,962	$ 815,959
Morrow	$ 6,740,057,169	34,943	$ 96,569,984	$ 94	$ 31,046	$ 2,311	$ 33,452
Pickaway	$ 12,399,763,844	58,527	$ 186,562,233	$ 348	$ 156,149	$ 8,930	$ 165,427
Portage	$ 32,692,818,126	161,780	$ 39,552,855	$ 1,095	$ 82,136	$ 541	$ 83,772
Richland	$ 24,198,309,075	124,906	$ 155,034,818	$ 291	$ 95,122	$ 3,181	$ 98,593
Stark	$ 76,095,235,247	374,812	$ 109,916,533	$ 3,824	$ 285,438	$ 2,255	$ 291,516
Summit	$ 108,471,919,232	540,333	$ 14,459,158	$ 4,542	$ 342,908	$ 247	$ 347,698
Union	$ 13,980,628,662	62,265	$ 240,069,700	$ 336	$ 142,390	$ 9,850	$ 152,576
Warren	$ 49,577,832,622	242,269	$ 54,672,546	$ 2,085	$ 135,983	$ 3,926	$ 141,994
Wayne	$ 24,062,125,634	116,847	$ 376,044,644	$ 1,209	$ 88,985	$ 7,715	$ 97,908
Total	$ 1,536,507,204,200	7,833,924	$ 3,144,166,696	$ 51,060	$ 15,210,306	$ 124,172	$ 15,385,538

Table 2.15.j

FEMA National Risk Index Heat Wave Analysis, October 2023, OEMA Region 3							
County	Exposure (Buildings)	Exposure (Population)	Exposure (Agriculture)	EAL (Buildings)	EAL (Pop. Equiv)	EAL (Agriculture)	EAL (Total)
Adams	$ 7,250,017,139	27,463	$ 46,001,867	$ 290	$ 104,673	$ 3,146	$ 108,109
Ashtabula	$ 20,560,536,719	97,518	$ 66,415,498	$ 317	$ 108,345	$ 667	$ 109,329
Athens	$ 11,699,628,860	62,393	$ 13,104,471	$ 164	$ 83,232	$ 314	$ 83,709
Belmont	$ 13,488,466,636	66,461	$ 29,087,217	$ 2,399	$ 231,132	$ 597	$ 234,128
Brown	$ 8,791,644,984	43,652	$ 82,277,263	$ 370	$ 174,694	$ 5,908	$ 180,972
Carroll	$ 5,326,823,085	26,701	$ 55,775,343	$ 789	$ 77,382	$ 954	$ 79,125
Clermont	$ 36,078,125,690	208,527	$ 36,442,863	$ 1,734	$ 133,765	$ 2,991	$ 138,489
Columbiana	$ 21,193,341,284	101,872	$ 122,355,264	$ 887	$ 295,235	$ 2,092	$ 298,214
Coshocton	$ 7,743,404,536	36,580	$ 113,678,424	$ 93	$ 41,826	$ 2,332	$ 44,252
Gallia	$ 5,985,030,900	29,179	$ 21,771,339	$ 72	$ 33,364	$ 447	$ 33,882
Guernsey	$ 8,571,916,308	38,372	$ 30,718,163	$ 103	$ 43,875	$ 630	$ 44,609
Harrison	$ 2,837,123,823	14,475	$ 21,371,245	$ 505	$ 50,340	$ 438	$ 51,283
Highland	$ 10,507,327,608	43,282	$ 140,989,067	$ 358	$ 140,221	$ 8,195	$ 148,773
Hocking	$ 6,751,958,435	28,040	$ 5,834,953	$ 189	$ 74,810	$ 279	$ 75,279
Holmes	$ 11,951,498,604	44,196	$ 208,850,782	$ 144	$ 33,657	$ 4,285	$ 38,086
Jackson	$ 6,971,680,704	32,646	$ 12,654,530	$ 98	$ 43,550	$ 303	$ 43,950
Jefferson	$ 15,713,558,690	65,187	$ 10,548,230	$ 2,329	$ 188,918	$ 180	$ 191,427
Lawrence	$ 9,823,219,144	58,183	$ 4,625,383	$ 494	$ 203,149	$ 95	$ 203,738
Mahoning	$ 48,322,567,878	228,579	$ 78,699,686	$ 1,619	$ 529,955	$ 1,076	$ 532,650
Meigs	$ 4,709,053,511	22,183	$ 19,054,372	$ 57	$ 25,365	$ 391	$ 25,812
Monroe	$ 4,269,411,186	13,379	$ 16,020,912	$ 759	$ 46,528	$ 329	$ 47,616
Morgan	$ 2,734,311,820	13,787	$ 20,660,347	$ 38	$ 18,392	$ 494	$ 18,925
Muskingum	$ 18,106,752,065	86,374	$ 80,370,075	$ 218	$ 98,762	$ 1,649	$ 100,628
Noble	$ 4,120,330,194	14,107	$ 8,365,126	$ 733	$ 49,060	$ 172	$ 49,964
Perry	$ 5,607,927,097	35,327	$ 38,807,640	$ 79	$ 47,126	$ 929	$ 48,133
Pike	$ 6,578,325,422	27,037	$ 63,156,277	$ 250	$ 97,897	$ 4,103	$ 102,250
Ross	$ 13,696,889,485	77,071	$ 89,156,257	$ 411	$ 220,312	$ 4,573	$ 225,296
Scioto	$ 11,861,302,547	73,911	$ 20,459,899	$ 475	$ 281,705	$ 1,399	$ 283,579
Trumbull	$ 42,033,156,468	201,961	$ 64,314,882	$ 1,408	$ 468,249	$ 880	$ 470,537
Tuscarawas	$ 19,321,270,818	93,231	$ 143,573,861	$ 232	$ 71,000	$ 2,945	$ 74,178
Vinton	$ 2,259,117,031	12,767	$ 6,529,618	$ 32	$ 17,031	$ 156	$ 17,219
Washington	$ 11,589,652,639	59,732	$ 48,217,160	$ 259	$ 69,096	$ 989	$ 70,344
Total	$ 406,455,371,310	1,984,173	$ 1,719,888,014	$ 17,904	$ 4,102,645	$ 53,936	$ 4,174,485

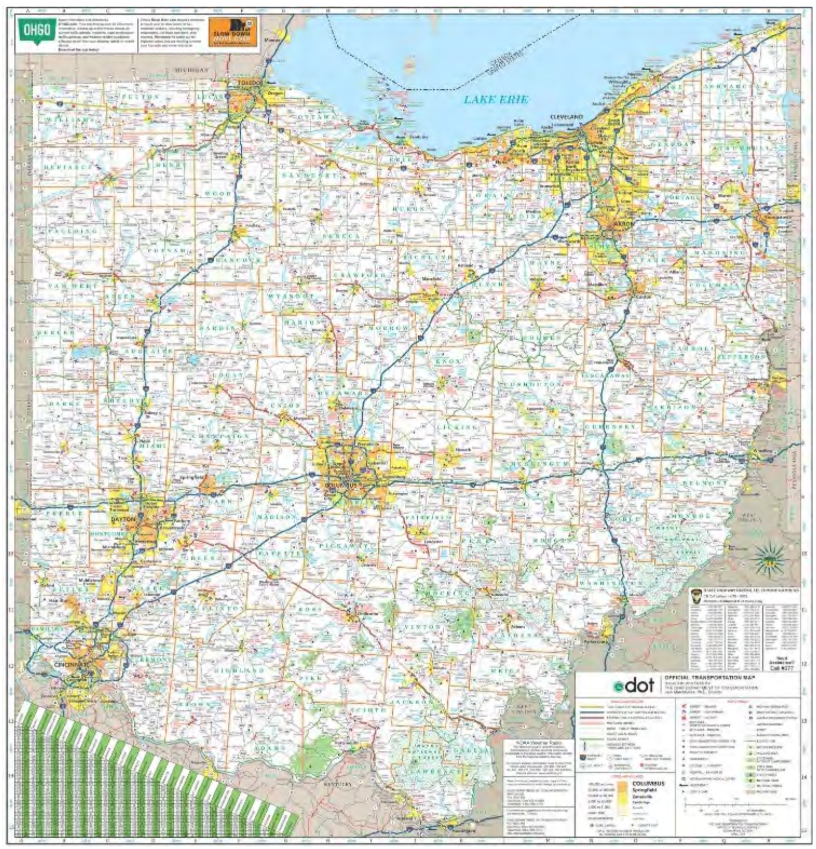
STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

As mentioned earlier in this section, extreme/excessive heat does not pose a direct threat to the structural integrity of state-owned or state-leased facilities. However, the larger threat from extreme heat to these facilities would be to their occupants, especially if they fall in a population group with increased risks. Extreme heat may also indirectly cause physical and economic damage to these facilities in regards to the maintenance of their mechanical systems such as air conditioning, plumbing, and other utilities. These impacts may be exacerbated by infrastructure failure in an event where increased stress on the electrical grid causes power outages in the form of rolling blackouts and results in losses of function. For a list of state-owned and state-leased critical facilities by county, refer to Appendix C.

Extreme heat will also impact state roads, as higher temperatures will soften and break asphalt, and cause buckling in concrete roads. Maps of local, state, and interstate roads and average annual daily traffic counts can be obtained from the Ohio Department of Transportation, and their Transportation Information Mapping System (TIMS).

Additionally, extreme heat plays a cascading role in the occurrences and impacts from drought (section 2.11) and wildfires (section 2.7). It also contributes to urban heat island effects within higher-density communities, and the emission greenhouse gases. It can be expected that vulnerabilities to state-own and state-leased facilities and infrastructure will increase as infrastructure ages and extreme heat events become more frequent.

Figure 2.15.j -- Map of select local, state, and interstate roads



Source: The Ohio Department of Transportation

2.16 FUTURE POTENTIAL AREAS OF RISK

There are several potential areas of risk which will impact the natural hazards of the state, but are not easily categorized within any of the existing natural hazards located within the Risk Assessment. The following potential areas of risk will be addressed in this section:

- Future growth
- Harmful algal bloom
- Hydraulic fracturing
- Climate change

FUTURE GROWTH

The Ohio Development Services Agency, Office of Research publishes individual county statistics evaluating the 2020 Census and the current American Community Survey (ACS) data. The county profiles cover an array of characteristics ranging from demographics to taxable land value. These county profiles and the underlying Census projections for population change were used to determine the possible future population changes for all of the counties in the state. Overall, between 2010 and 2020, the State of Ohio has seen very little change in population, showing an estimated 3 percent increase. This increase can be attributed to the significant increases in southwest and central Ohio, which include counties from Regions 2 and 3.

The projection shows significant population changes in central (Columbus Metropolitan Area) and southwest Ohio (Cincinnati Metropolitan Area). Specifically, the greatest changes in central Ohio took place in Delaware County (22.9 percent) and Union County (20 percent), and the greatest in southwest Ohio was Warren (13.9 percent) County. The dataset projections for 2020, 2030, and 2040 show that significant growth will continue to be focused in and around central Ohio, Delaware County is projected to see the greatest increase every decade.

COUNTY	Region	Projection (2020)	Projection (2030)	2020-2030 Projection %
Delaware	**2**	214,124	246,000	**14.9%**
Licking	**2**	178,519	196,570	**10.1%**
Pike	**3**	27,088	29,420	**8.6%**
Madison	**2**	43,824	47,420	**8.2%**
Fairfield	**2**	158,921	170,630	**7.4%**

By 2040, Delaware County is project to have a population of 282,160, an increase of 31.8% over the 2020 population.

COUNTY	Region	Projection (2030)	Projection (2040)	2030-2040 Projection %
Delaware	**2**	246,000	282,160	**14.7%**
Union	**2**	64,830	73,800	**13.8%**
Fairfield	**2**	170,630	186,810	**9.5%**
Licking	**2**	196,570	212,370	**8.0%**
Franklin	**2**	1,394,980	1,483,160	**6.3%**

LHMPs

Knowing this increase in population will be an impact on the hazards in the Delaware County, the county's 2023 multi-jurisdictional mitigation plan clearly describes the difficulties associated with double digit increases in population and the associated growth of the built environment. Per the 2023 Delaware County LHMP, Delaware County is the fastest growing county in Ohio according to the 2020 U.S. Census. This growth impacts every hazard analyzed in the 2023 plan update and each hazard had a Land Use and Development Trends section. An example from the flood hazard sections reads, Delaware County is increasing in population according to the 2020 U.S. Census. It is the fastest growing county in Ohio. Because of this growth development in flood zone will be a risk some are willing to take, but limiting this will also limit the amount of damages caused by floods. Also, these areas trend towards housing of the most socially vulnerable who are less likely to be resilient in times of disaster, such as a major flood. Concentrations of the most socially vulnerable are currently around urban areas in Delaware County, which are areas prone to flooding. As these areas develop socially vulnerable people may be pushed into areas which put them at even higher risk. Future practices and zoning could help mitigate some of this development.

Delaware County has a clear understanding of the problems, their implications and is working to address them through mitigation planning and educational outreach. Part of the difficulty in addressing the situation is that the growth areas are creating high-value real estate for Ohio, while the impacted areas range from manufactured home parks to older, residential structures built in or near the floodplain. Over time the size of the regulatory floodplain can be expected to increase due to development. Union County also experienced significant growth in this time period, but this growth is primarily restricted to the southwestern corner of the County. The County has included the impacts of development trends in the analysis of each hazard acknowledging that as the County grows, these development trends will continue to grow in impact to natural hazards. Franklin County also continued to experience growth but its growth was driven heavily by the increase of multi-family structures acting as in-fill or redevelopment of existing developed areas and did not have the same adverse impacts that other counties in central Ohio experienced.

As part of the 2021 Warren County Hazard Mitigation Plan, Warren County jurisdictions were asked to complete a community profile which included providing information on land use, housing trends, economic, and business and industry improvements. The Warren County Department of Economic Development was also consulted on these profiles. The profiles helped identify the developments/ trends happening in participating jurisdictions in Warren County. Each jurisdiction also competed a hazard ranking sheet, which included factoring for the 5-year land development trends as each hazard was analyzed. One of the primary mitigation goals identified in the Warren County plan was to adopt and enforce public policies to promote resilient development and enhance safe construction in high hazard areas.

Mitigation planning and associated strategies have been adequately developed at the local level to minimize adverse effects from the significant growth experienced in central and southwest Ohio and aid in community resilience.

OHIO BALANCED GROWTH STRATEGY

One of the primary strategies that the State of Ohio adopted to address future growth throughout state is the Ohio Balanced Growth Strategy (http://balancedgrowth.ohio.gov). This strategy is a voluntary, incentive-based program that provides local governments with a regional planning framework based upon watersheds and water resource protection. The fundamental principle to guide the action of state agencies is that if local governments within a watershed can agree upon areas where development is to be encouraged and which are to be conserved, Ohio will align state programs to support these locally based decisions and conversely will not utilize state programs to violate them.

The Ohio Water Resources Committee (OWRC) has implemented this initiative statewide based upon a previous program developed by the Ohio Lake Erie Commission (OLEC). The program has many elements that encourage balanced growth throughout the state, specifically:

- Focusing on land use and development planning in Ohio's watersheds. The goal is to link land use planning to the health of watersheds and major bodies of water.
- Creation of Watershed Planning Partnerships to encourage regional cooperation on the issues of land use planning and development.
- Production of Watershed Balanced Growth Plans, which will guide how growth and conservation would be promoted by both local and state policies.
- The development of model regulations to promote local land use practices that minimize development impacts on water quality.
- Align state policies, incentives and other resources to support Watershed Balanced Growth planning and implementation.

WATERSHED BALANCED GROWTH PLANS

One of the primary aspects of the Ohio Balanced Growth Strategy is the creation and adoption of a Watershed Balanced Growth Plan. These plans are intended to provide a framework for regional decision-making on growth, conservation, stormwater issues and water quality. Each of these plans is based upon the 10 guiding principles for sustainable Ohio watersheds, the guiding principles are:

- Maximize investment in existing core urban areas, transportation, and infrastructure networks to enhance the economic vitality of existing communities.
- Minimize the conversion of green space and the loss of critical habitat areas, farmland, forest, and open spaces.
- Limit any net increase in the loading of pollutants or transfer of pollution loading from one medium to another.
- To the extent feasible, protect and restore the natural hydrology of the watershed and flow characteristics of its streams, tributaries, and wetlands.
- Restore the physical habitat and chemical water quality of the watershed to protect and restore diverse and thriving plant communities and preserve rare and endangered species.
- Encourage the inclusion of all economic and environmental factors into cost / benefit accounting in land use and development decisions.
- Avoid development decisions that shift economic benefits or environmental burdens from one location within a region to another.
- Establish and maintain a safe, efficient, and accessible transportation system that integrates highway, rail, air, transit, water, and pedestrian networks to foster economic growth and personal travel.
- Encourage all new development and redevelopment initiatives to address the need to protect and preserve access to historic, cultural, and scenic resources.
- Promote public access to and enjoyment of our natural resources for all Ohioans.

These Watershed Balanced Growth plans are not intended to supersede either local comprehensive plans or local hazard mitigation plans, but to harmonize with them. Each Watershed Balanced Growth Plan must identify or include the following:

- Priority Conservation Areas (PCA), which are critical areas to protect within the watershed. This includes areas which provide flood control, are susceptible to significant natural hazards and offer areas for ecological / open space restoration in urban areas.
- Priority Development Areas (PDA), which are areas where development should be encouraged. This includes areas which will maximize development potential and efficient use of infrastructure.
- The related documentation for justifying the designation of any PCAs or PDAs.
- Plans for the implementation of any developed strategies and a description of the governance structure.
- A specific statement noting how the plan will meet the 10 guiding principles for sustainable Ohio watersheds.

STATE INCENTIVES

One of the challenges of the Balance Growth Program is that the State of Ohio is a home rule State. Therefore, all land use, zoning, and planning decisions are made solely at the local level. State agencies do, however, influence the location of development in many ways through infrastructure investments, economic development incentives, tax policies and other policies and programs. In order to encourage local watershed groups to undertake the Balanced Growth Program process, the state created an incentive package that is available to Watershed Planning Partners and their participating local jurisdictions with an endorsed plan. These are the 26 state programs that include special consideration for Balanced Growth participating communities these programs are offered by various state agencies including the OEPA, ODNR, ODSA, ODOT and several other State agencies. More information about the specific state sponsored incentives is available at https://balancedgrowth.ohio.gov/strategy.

BEST LOCAL LAND USE PRACTICES

In addition to providing incentives for the adoption of Balance Growth Plans, the State has created several best local land use practices that address the following subject matters:

- Stream, Floodplain, and Wetland Protection
- Storm Water Management/Erosion and Sediment Control
- Comprehensive Planning
- Compact Development
- Conservation Development
- Natural Areas Establishment and Management
- Source Water Protection

These best local land use practices are available for download at: https://balancedgrowth.ohio.gov/local-land-use

LOCAL ADOPTION OF WATERSHED BALANCED GROWTH PLANS

Since 2008, 12 local State endorsed Watershed Balanced Growth Plans have been adopted throughout the State of Ohio and over half of those plans were adopted in the past three years. The plans must be adopted at the local level with support from local governments that represent at least 75% of the geographic land area of a watershed, and 75% of the local governments in the watershed and 75% of the population in the watershed. Once local support requirements are met, the state conducts a final review prior to endorsing the plan to ensure compliance with the criteria of the program.

The following Watershed Balanced Growth Plans have been adopted at the local level and endorsed by the State of Ohio:

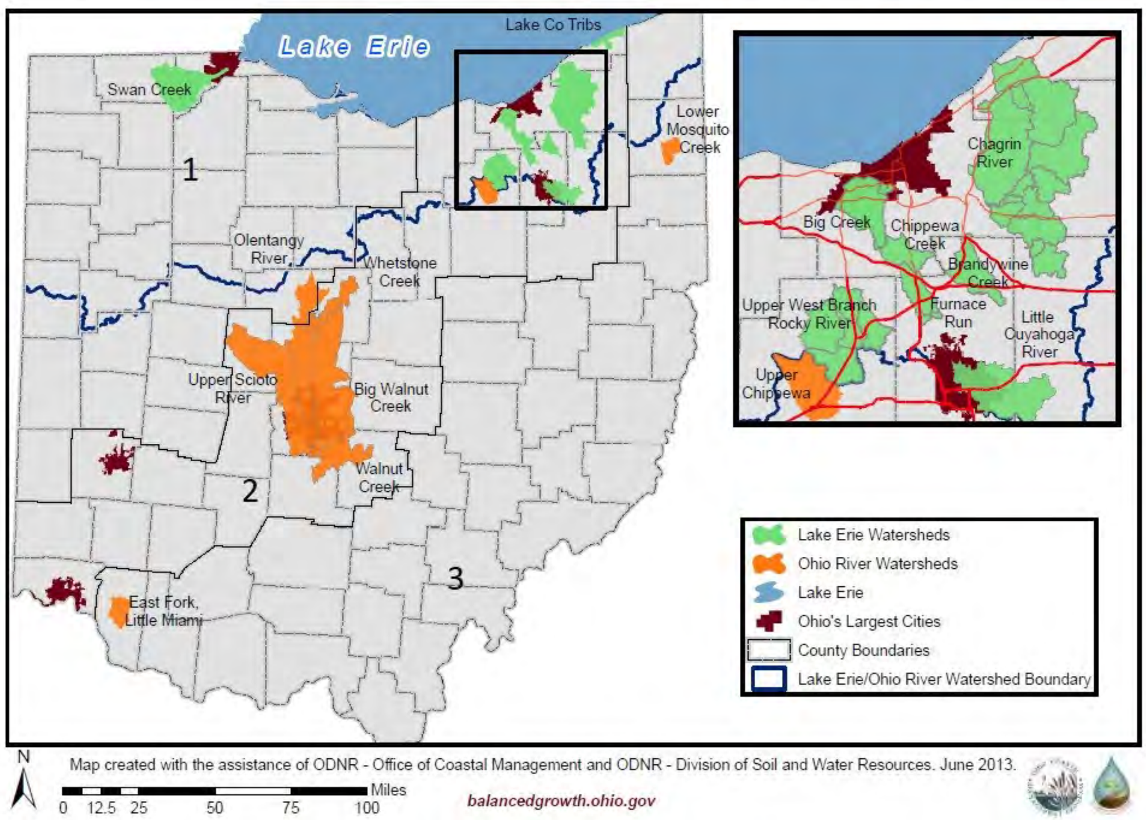
- Chippewa Creek Watershed (December 2008)
- Upper West Branch Rocky River Watershed (June 2009)
- Chagrin River Watershed (September 2009)
- Swan Creek Watershed (September 2009)
- Big Creek Watershed (June 2011)
- Furnace Run (December 2011)
- Eastern Lake County Coastal Tributaries (December 2011)
- Middle East Fork (February 2012)
- Lower Mosquito Creek (February 2012)
- Upper Chippewa Creek (April 2012)
- Olentangy River (April 2012)
- Walnut Creek (February 2013)
- Brandywine Creek (March 2014)

These 13 endorsed Watershed Balanced Growth Plans are spread across 18 different counties throughout the State. The following counties have at least one State Endorsed Watershed Balanced Growth Plan within their borders:

- Clermont
- Cuyahoga
- Delaware
- Fairfield
- Franklin
- Fulton
- Geauga
- Lake
- Licking
- Lucas
- Marion
- Medina
- Morrow
- Pickaway
- Portage
- Summit
- Trumbull
- Union

The majority of the endorsed plans in the State are primarily located within central and north eastern parts of the State. Of these 18 counties, two counties (Franklin, Medina), have specifically incorporated the State Endorsed Watershed Balanced Growth Plan into their Local Hazard Mitigation Plan and nine of counties have references to local watershed and storm water management plans throughout their Local Hazard Mitigation Plans. The continued adoption of the Watershed Balanced Growth Plans throughout the State will encourage sound planning and land use development Statewide. These activities will promote linkages between Balanced Growth Plans and local hazard mitigation plans which will minimize adverse effects of future growth and contribute to more resilient communities.

Balanced Growth Planning Partnership Watersheds



HARMFUL ALGAL BLOOMS

The Ohio Sea Grant Program states Harmful Algal Blooms (HAB) are caused by a combination of warm water temperatures (above 60 degrees Fahrenheit) and high concentrations of phosphorus in the water. Typically, a high concentration of phosphorus and nitrogen in cold weather will produce a bloom of diatoms, in cool weather we would expect a bloom of green algae, and in warm weather we often see blue-green algae.

One of the main focuses on reducing the number of HABs is to reduce the amount of phosphorus, which is one of the three major components in most fertilizers, followed by nitrogen and potassium. Phosphorus entering natural water ways is a major issue in the state. In Lake Erie, more than 65% of the phosphorus that causes HABs comes from agricultural fertilizer and manure runoff. Some phosphorus also comes from sewage treatment plants, combined sewer overflows, water treatment plants, cleaning products, faulty septic tanks and residential lawn fertilizers. The largest phosphorus load, about 80-90%, happens during heavy rain storms when fertilizer and other phosphorus sources are quickly washed into rivers and streams that flow into Lake Erie.

HABs can produce toxins that are capable of causing illness and sometimes even death. Microcystin is the most concerning toxin as it causes skin rashes, GI problems and varying degrees of nervous system, liver and kidney damage. While most healthy adults recover from contact with the toxin, it can be more problematic to children, the elderly and people with pre-existing conditions that weaken their systems. Exposure has also killed people in other parts of the world. The toxin can also be fatal to pets that drink or come in contact with contaminated water.

LAKE ERIE

Lake Erie is the southernmost, shallowest and warmest of the Great Lakes. Its watershed has the least forest, the most agricultural land and the second-most urban/suburban land. Therefore, Lake Erie gets more sediment and nutrients (fertilizer runoff, sewage, etc.) than the other lakes, while also having environmental conditions that favor algal blooms. HABs typically occur first in Maumee Bay at the mouth of the Maumee River and in Sandusky Bay at the mouth of the Sandusky River because blue-green algae prefer warm water and high concentrations of phosphorus. Both bays are very warm and shallow, and the watersheds of both rivers have very high percentages of farm land (the Maumee is the largest tributary to the Great Lakes and drains 4.2 million acres of agricultural land). As a result, both streams contain very high concentrations of phosphorus that eventually feeds into Lake Erie.

CLIMATE CHANGE

Climate change will bring more rain and snow, higher average temperatures and flooding to the Great Lakes region. More rain and snowfall increases runoff of the nutrients that fuel harmful algal blooms into the lake. The cyanobacteria that cause HABs also prefer the warmer water that comes with the higher air temperature caused by climate change. When combined, these changing conditions can increase the severity of harmful algal blooms.

OHIO'S DOMESTIC ACTION PLAN (DAP)

https://lakeerie.ohio.gov/planning-and-priorities/02-domestic-action-plan

Ohio's Domestic Action Plan (DAP) will advance efforts toward the proposed 40 percent nutrient reduction target put forth in the Great Lakes Water Quality Agreement of 2012 (GLWQA). Ohio's DAP will expand on the collaborative implementation initiatives and will also include the Central Basin as well as the Western Basin of Lake Erie. The DAP was developed with input through meetings and conversations with various stakeholder groups and state agencies.

While the focus of the DAP is to achieve nutrient reductions from the base year of 2008, we also need to consider the potential impact of new sources of phosphorus coming into in the watershed, the increased frequency and severity of rainfall events, and how these changes pose challenges to the over-all net reduction of nutrients as we work towards the established goals.

The governors of Ohio and Michigan and the premier of Ontario committed to a goal of reducing phosphorus loadings to Lake Erie by 40 percent through the signing of the western basin of Lake Erie Collaborative Agreement (Collaborative), first in 2015 and again in 2019. The Collaborative was intended to serve as the precursor to the Ohio Domestic Action Plan (DAP). Ohio's DAP will advance efforts toward the proposed nutrient reduction targets put forth in the GLWQA under Annex 4

(Nutrients). The DAP expands on the Collaborative implementation initiatives and includes the central basin as well as the western basin of Lake Erie.

The Goals of the Ohio Domestic Action Plan:

- Achieve a 40 percent total spring load reduction in the amount of total and dissolved reactive phosphorus (TP and DRP) entering Lake Erie's western basin from the Maumee River by the year 2025. A spring (March – July) Flow-Weighted Mean Concentration (FWMC) of 0.23 mg/l TP and 0.05 mg/l DRP and a target of 860 metric tons (1.9 million lb.) total phosphorus and 186 MT (410,000 lb.) dissolved reactive phosphorus in the Maumee River is predicted to be a 40 percent reduction from the base year of 2008.
- Achieve a 40 percent total spring load reduction in the amount of total and dissolved reactive phosphorus (TP and DRP) entering Lake Erie's western basin from the Portage and Toussaint Rivers by the year 2025.
- Achieve a 40 percent total spring load reduction in the amount of total and dissolved reactive phosphorus (TP and DRP) entering Sandusky Bay from the Sandusky River to protect water quality in Sandusky Bay.
- Achieve a 40 percent total annual load reduction in the amount of total phosphorus entering Lake Erie's central basin by the year 2025. This goal applies to priority tributary watersheds to the central basin of Lake Erie in Ohio, which include the Maumee, Toussaint, Portage, Sandusky, Huron, Vermilion, Cuyahoga and Grand River.

The Domestic Action Plan is based on the following guiding principles:

- Implementation of point and nonpoint nutrient reduction practices.
- Verification of targeted practice implementation and effectiveness.
- Documentation of water quality changes resulting through the implementation of nutrient reduction practices.
- Adaptability to allow for the modification of programs, practices and policy as new information is obtained and changes occur.
- Accountability to ensure compliance with rules and laws, establish clear areas of responsibilities, and that the commitment is made and kept toward achieving the goals.

H2Ohio

In March 2019, Governor DeWine introduced H2Ohio, a water quality initiative to invest in targeted, long-term solutions to ensure clean and safe water in Lake Erie and throughout Ohio. The H2Ohio Fund will provide the resources necessary to plan and implement targeted long-term water solutions. There are three strategies that are key to H2Ohio: land-based protection, water-based restoration, and science-based monitoring and research.

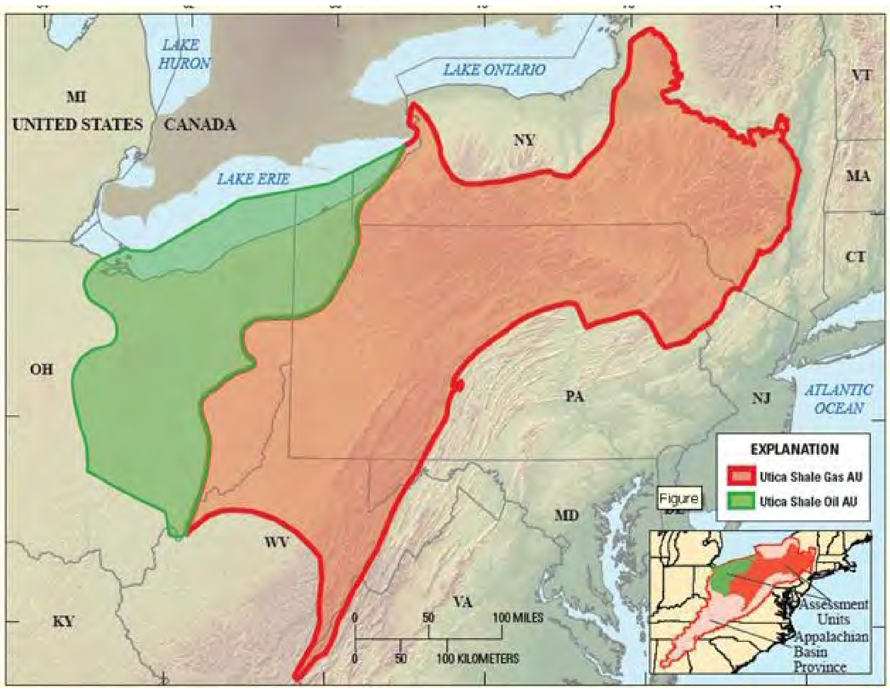
Through collaboration among the Ohio Department of Natural Resources (ODNR), Ohio Environmental Protection Agency (Ohio EPA), Ohio Department of Agriculture (ODA), and Ohio Lake Erie Commission (OLEC), H2Ohio will address critical water quality needs and support innovative solutions to some of the state's most pressing water challenges.

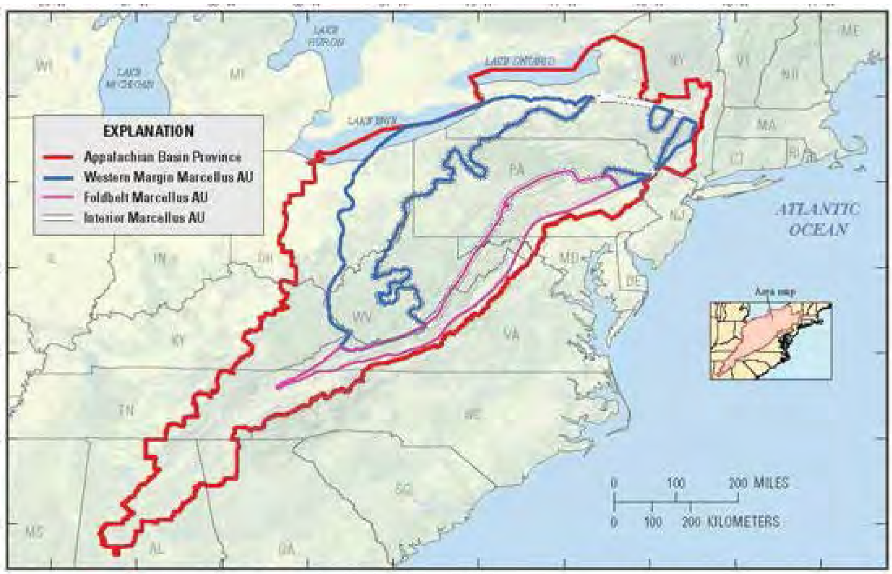
H2Ohio is a statewide initiative. However, it has been designed, in part, to address the specific needs of Lake Erie. Strategies adopted and funded as part of H2Ohio for nutrient reduction specific to Lake Erie will be detailed within Ohio's Domestic Action Plan. The primary focus of H2Ohio for the purposes of the DAP will be on implementation of agricultural best management practices

(BMPs), wetland restoration, and improvements to wastewater infrastructure. Actions supplementing H2Ohio goals have been incorporated throughout the DAP. Information on H2Ohio including projects that have been implemented to date and future efforts can be found at: https://h2.ohio.gov/.

HYDRAULIC FRACTURING

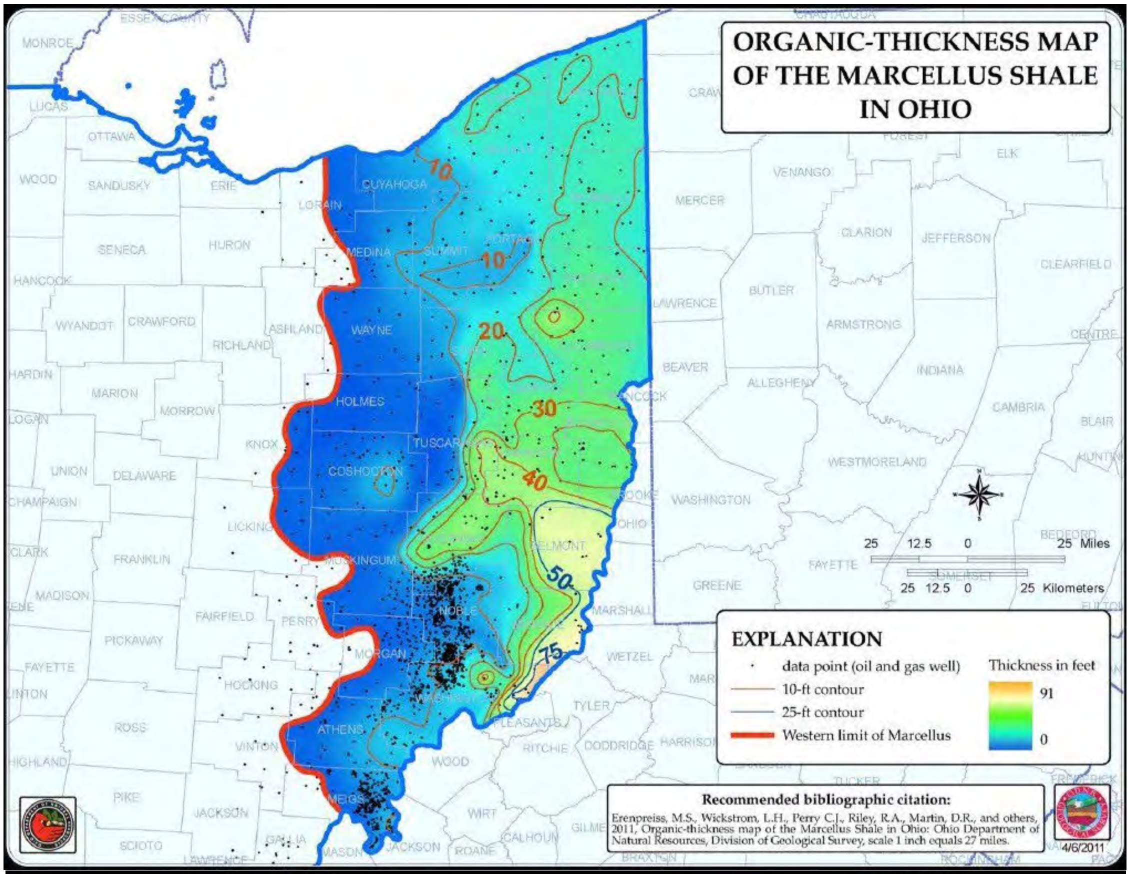
Together, the Marcellus and Utica Shale regions extend across New York, Pennsylvania, Maryland, West Virginia, Ohio and portions of Kentucky and these deposits sit between 7,000 and 12,000 feet below ground. Both the Marcellus and the Utica shale regions are important geologic formations because they hold large reserves of natural gas. Researchers estimate the Marcellus Shale alone could contain as much as 363 trillion cubic feet of natural gas. Ohio is experiencing far less Marcellus Shale drilling than several of the neighboring states because the Marcellus Shale is much thinner on its western edge.

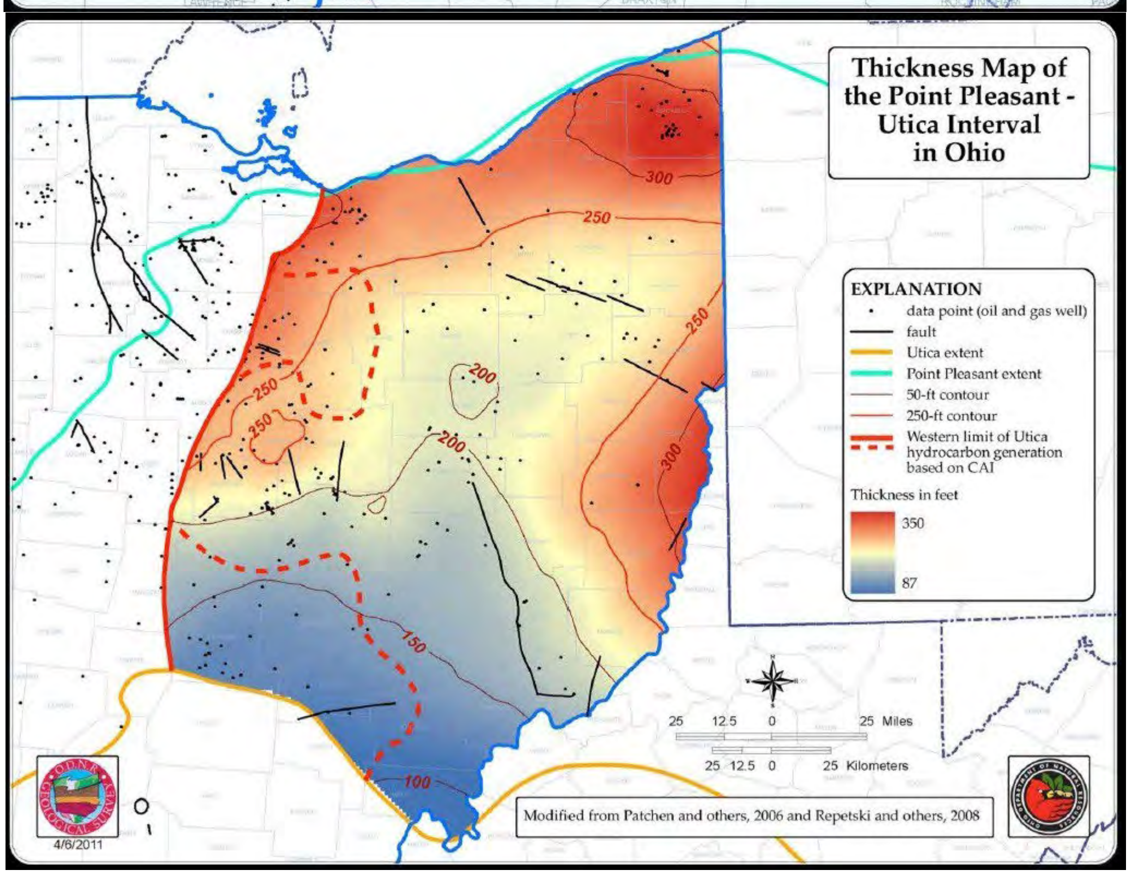




However, Ohio has and will continue to see a significant increase in drilling as much of the state sits over the Utica Shale Formation. The extraction of natural gas from the shale is a two-step process of horizontal drilling and hydraulic fracturing. The process starts with a production well, which is drilled thousands of feet downward and then gradually angled out horizontally through the shale deposit. After the well is drilled, a mixture of water, sand and chemical additives is injected at very high pressure to fracture the shale. This part of the process called hydraulic fracturing or fracing, is a technique used in the oil and gas industry since the 1950's.

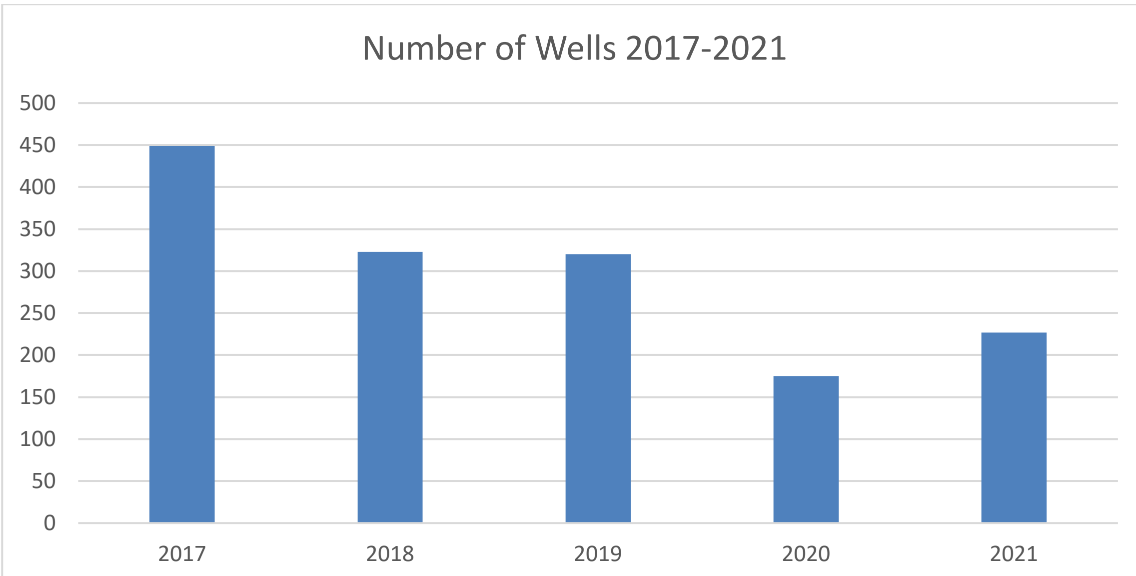
Per the ODNR Division of Geological Survey, resource estimates indicate the Devonian-age Marcellus Shale is the largest exploration play in the eastern United States. Recently, the application of horizontal drilling combined with multi-staged hydraulic fracturing to create permeable flow paths from wellbores into shale units has resulted in a drilling boom for the Marcellus in the Appalachian Basin states of Pennsylvania, West Virginia, southern New York, and eastern Ohio. Fracturing technology also may have application in other shale units, such as the Ordovician-age Utica Shale, which extends across much of the Appalachian Basin region. While limited production has occurred in the Utica up to this point, thickness and widespread geographical extent indicate it may also have great oil-and-gas potential.


ORGANIC-THICKNESS MAP OF THE MARCELLUS SHALE IN OHIO
EXPLANATION
data point (oil and gas well)
10-ft contour
25-ft contour
Western limit of Marcellus
Thickness in feet
91
0
25 12.5 0 25 Miles
25 12.5 0 25 Kilometers
Recommended bibliographic citation:
Erenpreiss, M.S., Wickstrom, L.H., Perry C.J., Riley, R.A., Martin, D.R., and others, 2011, Organic-thickness map of the Marcellus Shale in Ohio: Ohio Department of Natural Resources, Division of Geological Survey, scale 1 inch equals 27 miles.
4/6/2011


Thickness Map of the Point Pleasant - Utica Interval in Ohio
EXPLANATION
data point (oil and gas well)
fault
Utica extent
Point Pleasant extent
50-ft contour
250-ft contour
Western limit of Utica hydrocarbon generation based on CAI
Thickness in feet
350
87
25 12.5 0 25 Miles
25 12.5 0 25 Kilometers
Modified from Patchen and others, 2006 and Repetski and others, 2008
4/6/2011

CURRENT STATE OF NATURAL GAS AND OIL DRILLING IN OHIO

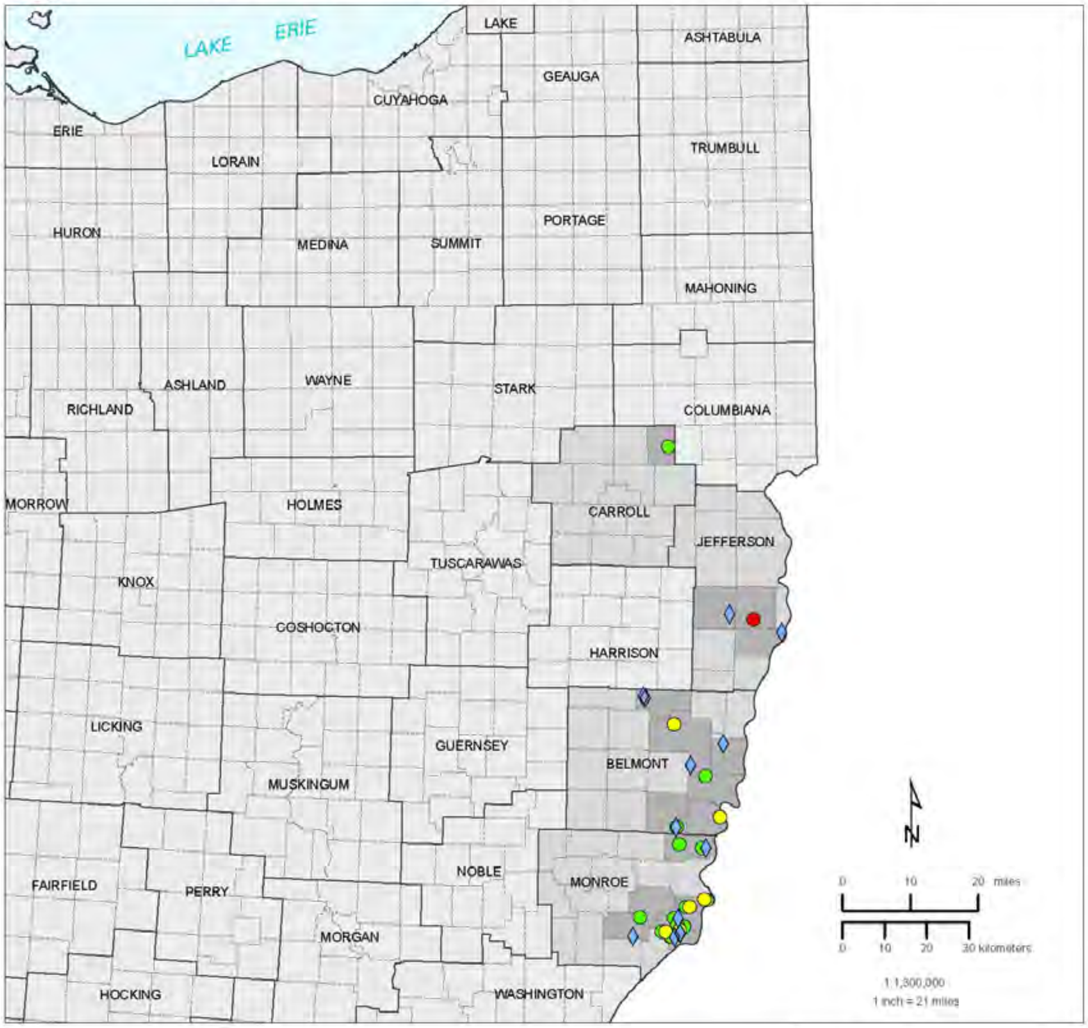
The Ohio Oil & Gas Summary issued each year reflects the most up to date information and trends effecting Ohio's oil and gas industries. The 48th edition of this Summary noted that 227 oil and gas wells were drilled in the state is 2021 and this is down from a peak of 1089 new wells drilled in 2008. The spike of wells drilled from 2005-2008 was related to the exploration of the Devonian Shale.



The ODNR Division of Oil and Gas Resources Management indicates the activity of horizontal well drilling in the Marcellus and Utica-Point Pleasant Shale in the State. As this map indicates the current and future activity will occur in the eastern and southeastern portions of the State.

OHIO DEPARTMENT OF NATURAL RESOURCES

HORIZONTAL MARCELLUS WELL ACTIVITY IN OHIO



EXPLANATION

Horizontal Well status as of 07/08/2023

- PERMITTED-(Permitted; Not Drilled; Canceled) (22)
- DRILLED-(Drilling; Well Drilled) (16)
- PRODUCING-(Producing; Plugged Back) (46)
- Lost Hole or Final Restoration (1)
- Township with activity (15)
- County with activity (4)

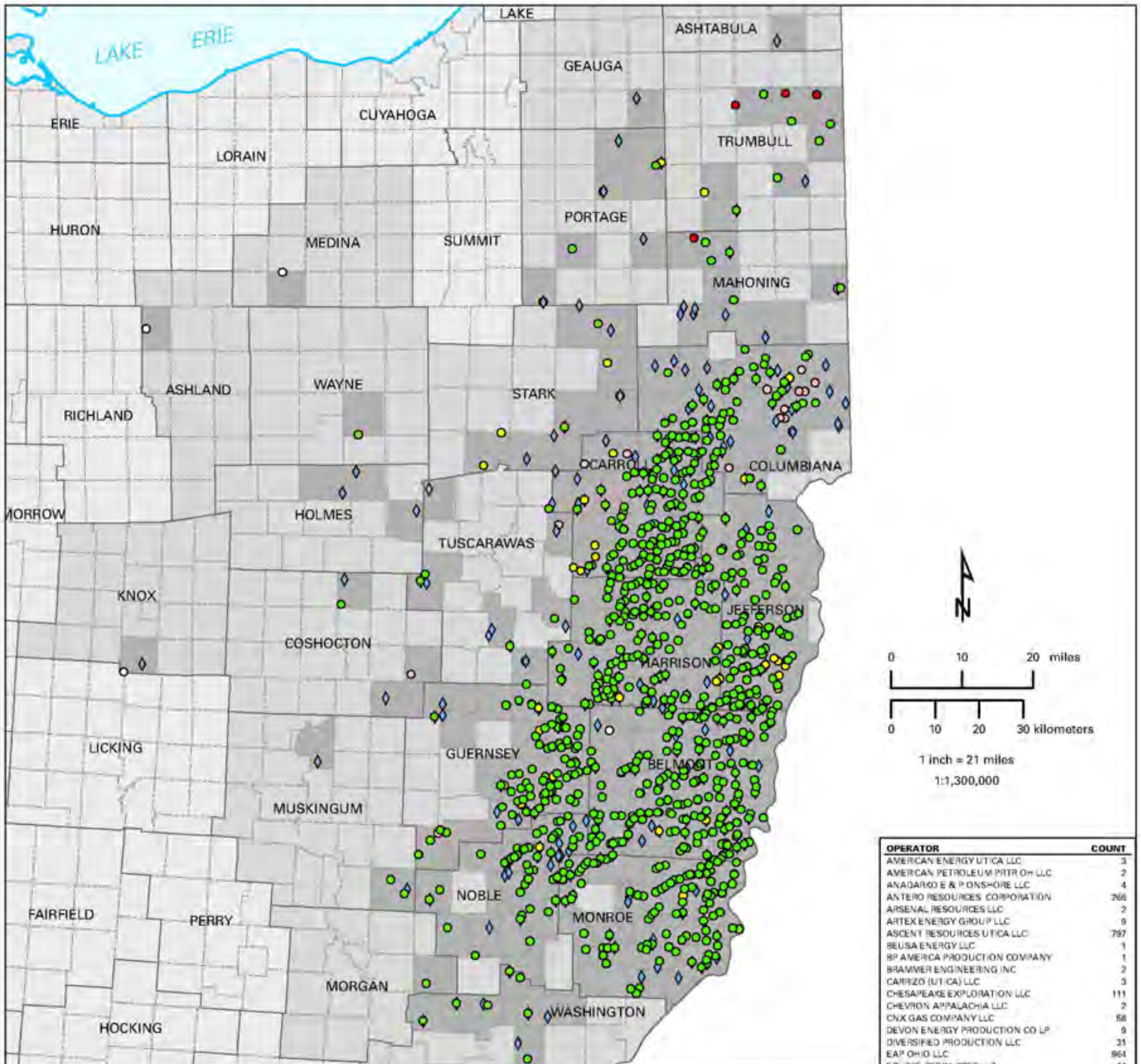
OPERATOR	COUNT
ASCENT RESOURCES UTICA LLC	7
CNX GAS COMPANY LLC	1
EAP OHIO LLC	1
ECLIPSE RESOURCES I LP	3
EM ENERGY OHIO LLC	1
Energex Power, Inc.	1
EQUINOR USA ONSHORE PROPERTIES INC.	15
GULFPORT APPALACHIA LLC	2
HESS OHIO RESOURCES LLC	3
PHILLIPS EXPLORATION INC	1
PROTEGE ENERGY II LLC	1
SWN Production (Ohio) LLC	38
TRIAD HUNTER LLC	8
XTO ENERGY INC.	3
TOTAL	85

Map includes well activity through the second quarter of the year ending in June 2023. Well permit information from the ODNR Division of Oil and Gas Resources Management

Recommended citation: Ohio Department of Natural Resources, 2023, Horizontal Marcellus Well Activity in Ohio - Quarter 2: Columbus, scale 1:1,300,000, revised 08/17/2023.

OHIO DEPARTMENT OF NATURAL RESOURCES

HORIZONTAL UTICA - PT PLEASANT WELL ACTIVITY IN OHIO



OPERATOR	COUNT
AMERICAN ENERGY UTICA LLC	3
AMERICAN PETROLEUM PRTR OH LLC	2
ANADARKO E & P ONSHORE LLC	4
ANTERO RESOURCES CORPORATION	266
ARSENAL RESOURCES LLC	2
ARTEX ENERGY GROUP LLC	9
ASCENT RESOURCES UTICA LLC	797
BEUSA ENERGY LLC	1
BP AMERICA PRODUCTION COMPANY	1
BRAMMER ENGINEERING INC	2
CARRIZO (UTICA) LLC	3
CHESAPEAKE EXPLORATION LLC	111
CHEVRON APPALACHIA LLC	2
CNX GAS COMPANY LLC	58
DEVON ENERGY PRODUCTION CO LP	9
DIVERSIFIED PRODUCTION LLC	31
EAP OHIO LLC	964
ECLIPSE RESOURCES I LP	44
EM ENERGY OHIO LLC	7
ENERVEST OPERATING LLC	20
EOG RESOURCES INC	6
EQT PRODUCTION COMPANY	2
EQUINOR USA ONSHORE PROPERTIES INC	45
GEOPETRO LLC	17
GULFPORT APPALACHIA LLC	451
GULFPORT ENERGY CORPORATION	49
HALCON OPERATING COMPANY INC	4
HESS OHIO DEVELOPMENTS LLC	24
HESS OHIO RESOURCES LLC	1
HG ENERGY LLC	2
HILCORP ENERGY COMPANY	109
INR OHIO LLC	47
NORTHWOOD ENERGY CORP	6
PDC ENERGY INC	8
PIN OAK ENERGY PARTNERS LLC	33
PROTEGE ENERGY III LLC	1
R E GAS DEVELOPMENT LLC	9
RICE DRILLING D LLC	149
SIERRA RESOURCES LLC	3
STATOIL USA ONSHORE PROPERTIES INC	5
SUMMIT PETROLEUM INC	6
SWEPI LP	1
SWN Production (Ohio) LLC	215
TRIAD HUNTER LLC	6
UTICA RESOURCE OPERATING LLC	45
XTO ENERGY INC	80
TOTAL	**3,660**

EXPLANATION

Horizontal well status as of 7/2/2022

- PERMITTED-(Permitted; Not Drilled; Canceled)
- DRILLED-(Drilling; Well Drilled)
- PRODUCING-(Producing; Plugged Back)
- INACTIVE-(Drilled Inactive; Shut in)
- Lost Hole or Final Restoration
- Dry and Abandoned
- Plugged and Abandoned

Well permit information from the ODNR Division of Oil and Gas Resources Management

Recommended citation:
Ohio Department of Natural Resources, 2022, Horizontal Utica-Point Pleasant Well Activity in Ohio: Columbus, scale 1:1,300,000, revised 7/8/2022.

ENVIRONMENTAL CONCERNS

Some citizens and local governments are aware and concerned about the environmental and societal impacts of drilling activity in their communities. The primary concerns noted in "Drilling for Natural Gas in the Marcellus and Utica Shales: Environmental Regulatory Basics" by ODNR & OEPA dated January 2014 are:

- The possible impacts of brine or flowback water on ground water resources
- The hydraulic fracturing fluid compositions and their possible health effects
- Increased road traffic and higher road maintenance costs
- Method of disposal for the brine, hydraulic fracturing fluid and other substances related to the drilling
- Possible increase in seismic activity from injection wells
- Possible increase in air pollution from the drilling related activities

REGULATION OF NATURAL GAS DRILLING IN THE MARCELLUS AND UTICA SHALE

The regulation of Natural Gas Drilling in the Marcellus and Utica Shale lies with primarily two bodies in the State of Ohio: the Ohio Department of Natural Resources (ODNR) and the Ohio Environmental Protection Agency (OEPA). The table below is a summary of ODNR and OEPA regulatory authorities over oil/gas drilling and production activities.

Summary of ODNR and Ohio EPA regulatory authority over oil/gas drilling and production activities

	Ohio Department of Natural Resources	Ohio Environmental Protection Agency
Drilling in the shale deposits	✓ Issues permits for drilling oil/gas wells in Ohio. ✓ Sets requirements for proper location, design and construction requirements for wells. ✓ Inspects and oversees drilling activity. ✓ Requires controls and procedures to prevent discharges and releases. ✓ Requires that wells no longer used for production are properly plugged. ✓ Requires registration for facility owners with the capacity to withdraw water at a quantity greater than 100,000 gallons per day.	✓ Requires drillers obtain authorization for construction activity where there is an impact to a wetland, stream, river or other water of the state. ✓ Requires drillers obtain an air permit to install and operate (PTIO) for units or activities that have emissions of air pollutants.
Wastewater and drill cutting management at drill sites	✓ Sets design requirements for on-site pits/lagoons used to store drill cuttings and brine/flowback water. ✓ Requires proper closure of on-site pits/lagoons after drilling is completed. ✓ Sets standards for managing drill cuttings and sediments left on-site.	✓ Requires proper management of solid wastes shipped off-site for disposal.
Brine/flowback water disposal	✓ Regulates the disposal of brine and oversees operation of Class II wells used to inject oil/gas-related waste fluids. ✓ Reviews specifications and issues permits for Class II wells. ✓ Sets design/construction requirements for Class II underground injection wells. ✓ Responds to questions/concerns from citizens regard safety of drinking water from private wells from oil/natural gas drilling.	
Brine/flowback water hauling	✓ Registers transporters hauling brine and oil/gas drilling-related wastewater in Ohio.	
Pumping water to the drill site from a public water supply system		✓ Requires proper containment devices at the point of connection to protect the public water system.

The ODNR Division of Oil and Gas summarizes below the impacts and effects of the three primary legislative acts that created the current framework for regulating the oil and gas industry in the State of Ohio.

SENATE BILL 165

On March 31, 2010 Governor Ted Strickland signed Substitute SB 165, the first major revision to Ohio oil and gas law in twenty-five years. Many significant changes were implemented as a result of passage of this new legislation which became effective on June 30, 2010. The bill provided for enhanced permitting authority in urban areas, strengthened funding for operations and orphan well plugging, added additional notification requirements by the industry and expanded enforcement provisions.

SENATE BILL 315

On June 11, 2012, Governor John Kasich signed landmark oil and gas regulatory legislation, which established one of the nation's toughest regulatory frameworks for overseeing the new technologies that allow for the exploration of natural gas in deep shale rock formations. Among other things, SB 315 creates the nation's first combined well construction and hydraulic fracturing chemical disclosure requirement, requires the sharing of all chemical information with doctors, allows appeals to the Ohio Oil & Gas Commission for certain permitting concerns prior to pursuing court action, and requires operators to take pre-drilling water samples and to disclose the proposed source of water used in wet drilling and hydraulic fracturing.

HOUSE BILL 507

Ohio Governor Mike DeWine signed House Bill 507 into law on January 6, 2023. The new law mandates new oil and gas leasing by requiring state agencies to lease oil and gas interests owned or controlled by those agencies. Specifically, the text of the law provides, "…a state agency shall lease, in good faith, a formation within a parcel of land that is owned or controlled by the state agency for the exploration for and development and production of oil or natural gas. Additionally, the new law defines natural gas as a "green energy." Ultimately, the result will be natural gas production from minerals underlying state parks.

Concerns have been voiced about the new law which now mandates drilling opportunities on prized state park lands meant for recreation and conservation. Environmental groups are concerned with this development, citing negative impacts to the water quality, air quality, and adjacent property. It is also difficult for many to conceive an interpretation of natural gas production as "green."

One lawsuit has already been filed against the State of Ohio and the Ohio Department of Natural Resources, which seeks an injunction and a declaratory judgment that finds HB 507 unconstitutional. In particular, the plaintiffs allege that HB 507 violates the "one-subject rule" and "three-consideration rule" of the Ohio Constitution. At this early stage, answers of both defendants have been filed with the court; and the Plaintiffs recently filed a Merit Brief to issue an injunction and to declare HB 507 unconstitutional.

While some see HB 507 as an ever-encroaching threat to environmental protection, the opposite can be said: the new law seeks to add regulation to the 2011 law that allowed the development of the oil and gas underlying state parks in the first place. The 2011 law, however, lacked the appropriate processes and rules. Moving forward, it's likely that House Bill 507 will result in a streamlined permitting process for oil and gas operations on state lands, but operators should be prepared to follow new and changing regulations promulgated by the ODNR.

LOCAL LAND USE, ZONING REGULATION, AND HOME RULE
https://www.lsc.ohio.gov/assets/organizations/legislative-service-commission/files/members-briefs-volume-134-municipal-home-rule.pdf

In the state, municipal corporations (cities and villages) have certain powers granted to them in Article XVIII of the state Constitution that exist outside their authority found in the Revised Code. Because these powers originate in the Constitution, laws passed by the General Assembly that interfere with them are invalid as applied to municipal corporations unless those laws otherwise are sanctioned by the Constitution. These constitutionally granted powers, known as “home rule” power include the power of local self-government, the exercise of certain police powers, and the ownership and operation of public utilities. “Police power” has been defined as the authority to make regulations for the public health, safety, and morals and the general welfare of society. Municipal laws for the exercise of municipal police powers cannot be in conflict with general laws. Included in these “Police power” regulations are local land use and zoning regulation.

Per the American Bar Association, on February 17, 2015, the Ohio Supreme Court ruled that a city ordinance aimed at limiting fracing operations cannot be used to circumvent the state's authority over oil and gas drilling. Specifically, the court held in State ex rel. Morrison v. Beck Energy Corp., No. 2015-Ohio-485, that because the state had granted a permit to a drilling company under a state regulatory scheme governing oil and gas operations, the municipality could not pass ordinances setting forth additional restrictions.

The case arises out of a dispute over a permit that Beck Energy Corp. obtained from the state of Ohio to drill an oil and gas well within the Munroe Falls city limits. Beck Energy obtained its permit pursuant to an Ohio statute that (1) provided uniform statewide regulation of oil and gas production; (2) gave a state agency the sole and exclusive authority to regulate the permitting, location, and spacing of oil and gas wells; and (3) required parties seeking to drill a new well to obtain a state permit.

Soon after Beck Energy began drilling, however, Munroe Falls filed a lawsuit seeking an injunction to prohibit the drilling. The city argued that Beck Energy violated city ordinances requiring the company to meet certain conditions before it began drilling. The trial court granted the city’s request for injunctive relief and prohibited Beck Energy from drilling until it complied with the city’s ordinances. The court of appeals reversed, holding that the state statute governing drilling operations prohibited the city from enforcing its ordinances. Munroe Falls sought relief from the Ohio Supreme Court.

The main issue before the Ohio Supreme Court was whether the state’s Home Rule Amendment allowed Munroe Falls to enforce its own permitting scheme on top of the state’s permitting system. The Ohio constitution’s Home Rule Amendment gives local municipalities the broadest possible powers of self-government in connection with all matters that are strictly local and do not infringe on matters that are of a statewide nature. But the amendment provides that a municipal ordinance must yield to a state law if (1) the municipality’s ordinance represents an exercise of police power, rather than of local self-government; (2) the statute is a general law; and (3) the ordinance conflicts with the state statute.

After analyzing these three factors, the Ohio Supreme Court concluded that Munroe Falls’ ordinances had to yield to the state statute. The city did not dispute—and the court agreed—that its ordinances amounted to an exercise of police power. Likewise, the court determined that the Ohio statute constituted a general law, as the law operated uniformly throughout the state.

THE NORTHSTAR 1 CLASS II INJECTION WELL AND SEISMIC EVENTS IN YOUNGSTOWN

A preliminary report was released by ODNR in March 2012 on the Northstar 1 Class II Injection Well and the Seismic Events in the Youngstown, Ohio Area. The reports show that since March 2011, the Youngstown area has experienced 12 low-magnitude seismic events along a previously unknown fault line. These events ranged from 2.1- to 4.0-magnitude and were recorded by the ODNR Ohio Seismic Network (OhioSeis). The OhioSeis network works closely with the U.S. Geological Survey to monitor and study all seismic activity within the state. Prior to the network's establishment in 1999, monitoring earthquakes in Ohio was sporadic at best. In fact, before the network was operational, the Ohio Geological Survey was unable to accurately determine any seismic events below an approximate magnitude of 3.1. A station at Youngstown State University joined the network in 2003.

Before 2011, OhioSeis had not recorded earthquake activity with epicenters located in the Youngstown area. Also, no fault line had been previously mapped within the boundaries of Youngstown or Mahoning County. However, the broad geographical area does have a history of seismic activity, and Mahoning Valley residents have felt earthquakes from nearby faults. In fact, the area has experienced at least three prior earthquakes in the past 25 years.

The 2011 earthquakes are distinct from previous seismic activity in the region because of their proximity to a Class II deep injection well, known as the Northstar 1 well. In fact, all of the events were clustered less than a mile around the well. Northstar 1 is one of 177 operational Class II deep injection wells primarily used for oil and gas fluid waste disposal (Ohio Disposal Wells). The well is drilled 200' into the rock formation known as the Precambrian layer at a depth of 9,184' and began injection in December 2010.

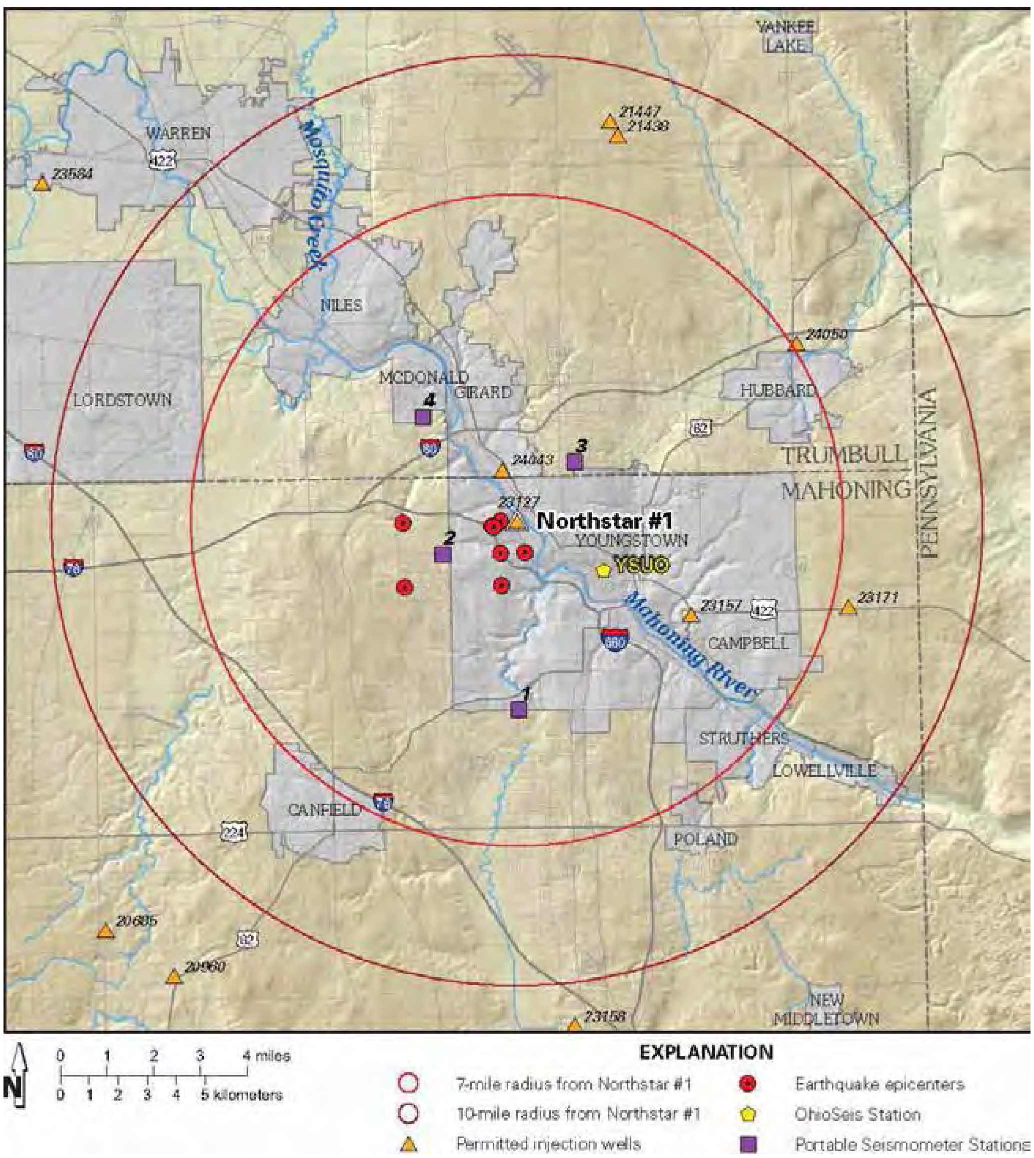
The below table, provide by the US EPA, describes the six categories or "classes" of injection wells, along with the estimated national inventory for each class. The six classes are based on similarity in the fluids injected, activities, construction, injection depth, design, and operating techniques.

This categorization ensures that wells with common design and operating techniques are required to meet appropriate performance criteria for protecting underground sources of drinking water.

Classes	Use	Inventory
Class I	Inject hazardous wastes, industrial non-hazardous liquids, or municipal wastewater beneath the lowermost Underground Sources of Drinking Water (USDW).	680 wells
Class II	Inject brines and other fluids associated with oil and gas production, and hydrocarbons for storage.	172, 068 wells
Class III	Inject fluids associated with solution mining of minerals beneath the lowermost USDW.	22,131 wells
Class IV	Inject hazardous or radioactive wastes into or above USDWs. These wells are banned unless authorized under a federal or state ground water remediation project.	33 sites
Class V	All injection wells not included in Classes I-IV. In general, Class V wells inject non-hazardous fluids into or above USDWs and are typically shallow, on-site disposal systems. However, there are some deep Class V wells that inject below USDWs.	400,000 to 650,000 wells Note: an inventory range is presented because a complete inventory is not available.
Class VI	Inject Carbon Dioxide (CO_2) for long term storage, also known as Geologic Sequestration of CO_2.	6-10 commercial wells expected to come online by 2016. (Interagency Task Force on Carbon Capture and Storage)

Ohio runs its Class II deep injection program on behalf of the U.S. EPA. As a result, the state meets and, in many instances, far exceeds U.S. EPA standards and regulations for the program. Since the program's inception in 1983, more than 202 million barrels of oilfield fluids have been disposed of, with no reports of subsurface ground water contamination incidents. In addition, no seismic event had been previously linked to operations at any of the state's Class II wells.

The earthquakes and their potential link to the Northstar 1 deep injection well were closely scrutinized by state geologists and regulators, who performed 35 separate inspections of the well from April 26 to Dec. 15, 2011. Each inspection indicated the well was operating within its permitted injection pressure and volume. In addition, ODNR regulators conducted additional testing of the well to determine if injection fluids were entering permitted injection zones. Tracer tests showed injections were reaching appropriate zones and were within permitted injection intervals. However, the tests proved inconclusive with regard to the volume of fluid entering the Precambrian layer. As a result, state regulators requested the well owner plug the Precambrian section of the Northstar 1 borehole, and the well operator voluntarily agreed to the procedure, albeit on a delayed timetable. With only one seismometer deployed in the Youngstown area, state geologists lacked the necessary data on the earthquakes' depth and exact location to draw a direct correlation between the seismic events and the deep injection well.



LAMONT-DOHERTY EARTH OBSERVATORY AT COLUMBIA UNIVERSITY

In November 2011, the ODNR Director ordered the Ohio Geological Survey to seek an outside research partner and deploy the needed portable seismometers around the Youngstown area. The Lamont-Doherty Earth Observatory at Columbia University had the available equipment and was willing to assist the state. The seismometers were deployed on Dec. 1, 2011. On Dec. 24, the newly deployed equipment recorded a 2.7-magnitude earthquake in the area. Data from the portable seismometers was downloaded and analyzed by experts at Lamont- Doherty. On Dec. 29, Lamont-Doherty presented ODNR with their preliminary findings, which indicated the seismic event depth was 2,454' below the injection well.

Based on the Lamont-Doherty data, ODNR regulators ordered the immediate halt of injections at Northstar 1, either voluntarily by the operator or by agency order. The next day, the Youngstown area experienced a 4.0-magnitude seismic event. Gov. John Kasich immediately placed an indefinite moratorium on three drilled deep injection wells and one well with a permit pending in the vicinity of the Northstar 1 well.

INDUCED SEISMICITY

Geologists believe it is very difficult for all conditions to be met to induce seismic events. In fact, all the evidence indicates that properly located Class II injection wells will not cause earthquakes. To induce an earthquake a number of circumstances must be met:

- A fault must already exist within the crystalline basement rock and that fault must already be in a near-failure state of stress.
- An injection well must be drilled deep enough and near enough to the fault and have a path of communication to the fault.
- The injection well must inject a sufficient quantity of fluids at a high enough pressure and for an adequate period of time to cause failure, or movement, along that fault (or system of faults).

A number of coincidental circumstances appear to make a compelling argument for the recent Youngstown-area seismic events to have been induced:

- The Northstar 1 well began injection operations in December 2010. Roughly three months later, the first seismic events were noted and were fairly close to the well.
- Subsequent seismic events were clustered around the vicinity of the wellbore.
- Evidence of permeability zones within the Precambrian basement rock is interpreted in some of the geophysical logs obtained from within the Northstar 1 well; and (Logs A, B, C, and D).
- Once sufficient monitoring equipment was in place, the focal depths of events were found to be about 4,000' laterally and 2,500' vertically from the wellbore terminus.

It appears there are observed permeability zones within the Precambrian basement rock in the drill coring logs recorded by the Battelle Memorial Institute during the drilling of Northstar 1. These logs were not available to inform regulators of possible issues in geological formations prior to well operation. Instead, Battelle produced and made the logs available to provide geologists with additional information on the region's geological formations. In the future, ODNR will require the Class II well owner to provide a suite of geophysical logs germane to the respective injection well.

To establish a better understanding of what may have happened, further analysis and detailed modeling of all factors must be completed on the Northstar 1 well and the surrounding geology. This work is already underway through ODNR and cooperating agencies and institutions.

FUTURE EVENTS

As the number of oil, gas, and injection wells in the state increases, so does the potential for environmental impacts. The state is mitigating this risk by enhancing regulatory and monitoring programs for well drilling and waste disposal operations. Additional information on these efforts can be found at the ODNR Division of Oil and Gas website: https://ohiodnr.gov/discover-and-learn/safety-conservation/about-ODNR/oil-gas. The state's direction will be to continue to take steps to ensure that oil and natural gas development benefits the citizens of the state and does not adversely impact human health and the environment.

CLIMATE CHANGE

The Intergovernmental Panel on Climate Change defines climate change as "A change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use." The National Oceanic Atmospheric Administration defines climate change as "a non-random change in climate that is measured over several decades or longer. The change may be due to natural or human-induced causes."

The Ohio State University's climate outreach notes that, "Climate change, two words that are already synonymous with changes in weather patterns across the world, from global warming to increased rainfall and severe storms. But climate change affects different areas in different ways – while some regions will see increased precipitation in the form of snow or rain, others will dry out because of reduced rainfall. And while overall temperatures across the globe are likely to increase, climate change can also be related to an increase in freezing temperatures and severe winter storms. Ohio is likely to be affected by a number of these phenomena, and adapting to different weather conditions will be important to maintain quality of life in the area."

Climate change acts as an amplifier of existing natural hazards. The fact that climate change is occurring is not disputed and over the past several decades there has been a marked increase in the frequency and severity of weather-related disasters, both nationally and in the state. This trend is being driven in part by changing global and regional climate conditions. The preponderance of available scientific evidence for anthropogenic forcing of climate change is overwhelming, or simply stated climate change is, in part, being caused by human actions, rather than natural factors alone. It is important that all levels of government and all sectors of society have at least a basic understanding of the potential impacts of climate change. The best available scientific data and modeling suggest that climate change has and will continue to impact natural hazards in the state. While the impacts of climate change may vary by regions and jurisdictions throughout the state, it is clear that the potential consequences of climate change will have significant impacts on all the citizens of the state.

OHIO EMERGENCY MANAGEMENT AGENCY SUMMARY ANALYSIS

The scientific studies and data referenced within this section come to one cohesive conclusion, climate change will have an impact on the natural hazards in the state through 2100. The greatest impact to the natural hazards in the state from climate change will be from the changes in precipitation rate and variability. To put it simply, these changes will lead to increased flooding in the spring and fall and increased periods of drought in the summer. Another impact on the state from the effects of climate change is a warming trend that will enhance the possibility of extended and increased extreme heat wave events. This climate change related warming trend will likely lead to an increased evaporation /transpiration feedback cycle, which will lead to reduced availability of water resources.

Since many of the anticipated effects of climate change exacerbate or accelerate existing natural hazards, many of the possible mitigation and adaptation strategies already exist. Based upon the best available scientific data and studies, Ohio EMA would make the following general mitigation and adaption strategy recommendations:

1. Develop greater built environment resilience
2. Improve stormwater infrastructure
3. Increase water quality and resource protection
4. Enhance essential utility resilience

These recommendations will be useful and positive actions regardless of the long-term impacts of the climate change on the state. Each of these recommendations will be addressed in greater detail later in this section.

LITERATURE AND STUDIES REVIEW

While there is a considerable amount of climate change data and related studies available, there are still challenges in synthesizing the data from the available scientific sources into both the state and local hazard mitigation plans, due to the spatial context of the data in the Midwest. The majority of these studies use a spatial resolution of the entire United States or a regional approach such as focusing on the Great Lakes or Midwest Regions. There is a limited amount of data available that specifically address the impacts and effects of climate change at the state, watershed or local level for Ohio.

The fact that climate change is occurring is not disputed. The current scientific data and modeling suggest that climate change has and will impact the state. The challenges in determining the probability and severity of future impacts can make it difficult to determine with an absolute degree of certainty the full degree of impact climate change may have on the state. This is also further complicated by the fact that information gathered is continually evolving. Therefore, this section will not attempt to estimate potential losses. This section will only provide information on the potential impacts climate change may have on some of our already existing hazards profiled within the SOHMP.

This section incorporates basic scientific findings and the most current projections for global climate change as they have the potential to impact the state and the Great Lakes Region. This section will not address any one specific jurisdiction or region in an attempt to determine risk as has been completed for natural hazards within this plan update. In some instances, examples of potential impacts to specific areas are incorporated. It is important to note that in such instances, the analysis has been conducted by scientists and subject matter experts as referenced, and not by Ohio EMA Staff. As climate science evolves and improves, future updates to this plan will incorporate any new or improved relevant climate change data.

Several new or updated climate resiliency or related studies have been completed since the 2014

SOHMP, but the underlying issues with the availability of downscaled climate change data continues to be a challenge. The new or updated studies include:

- Ohio River Basin - Formulating Climate Change Mitigation/Adaptation Strategies through Regional Collaboration with the ORB Alliance
- NOAA National Centers for Environmental Information State Summary for Ohio
- Climate Resilience in Ohio, A Public Health Approach to Preparedness and Planning – Ohio Public Health Association
- Fifth National Climate Assessment
- Smart Growth Fixes for Climate Adaptation and Resilience – EPA
- ODOT Infrastructure Resiliency Plan
- Climate Change, Extreme Precipitation and Flooding: The Latest Science - Union of Concerned Scientist
- Local Jurisdiction Climate, Sustainability or Resiliency Plans

OHIO RIVER BASIN– FORMULATING CLIMATE CHANGE MITIGATION/ADAPTATION STRATEGIES THROUGH REGIONAL COLLABORATION WITH THE OHIO RIVER BASIN ALLIANCE

https://usace.contentdm.oclc.org/digital/collection/p266001coll1/id/5108/

The Huntington District of the USACE, in collaboration with the Ohio River Basin Alliance, the Institute for Water Resources, the Great Lakes and Ohio River Division, and numerous other Federal agencies, non-governmental organizations, research & academic institutions, prepared the Ohio River Basin Climate Change Pilot Report.

The report provides downscaled climate modeling information for the entire basin with forecasts of future precipitation and temperature changes as well as forecasts of future streamflow at numerous gaging points throughout the basin. These forecasts are presented at the Hydrologic Unit Code-4 sub-basin level through three 30-year time periods between 2011 and 2099 developed as part of the response to climate change pilot study of the Ohio River basin.

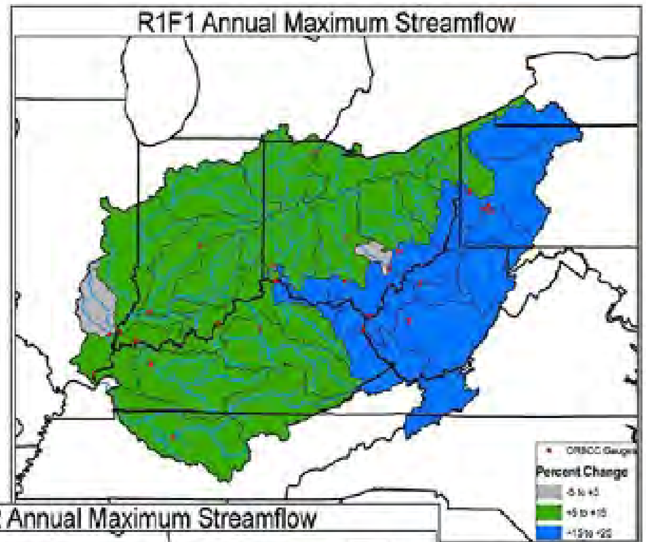
This pilot study was one of the first studies that has developed a downscaled model using current climate change data. This model was developed using archived CMIP3 and CMIP5 Climate and Hydrology Projections, which were in turn downscaled to the river basin level. The downscaled modeling results included both observed data for the 1951-2001(R1) and three 30-year forecast periods; 2011-2040(F1), 2041- 2070(F2) and 2071-2099(F3). The pilot study produced stream flow outputs for the following nine measures:

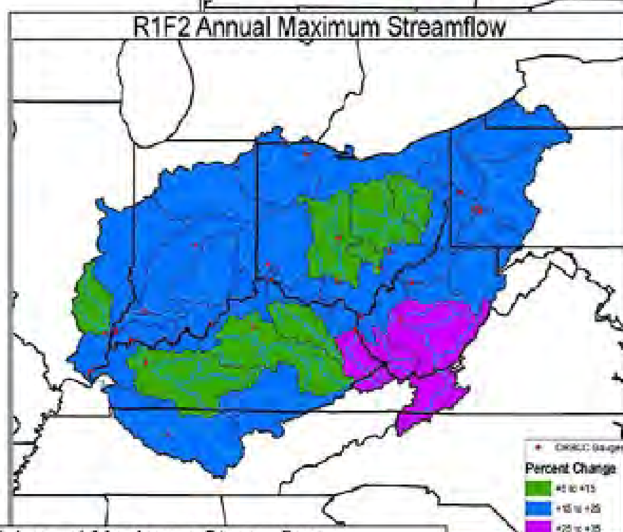
1. Annual % change mean flow
2. Annual % change maximum flow
3. Annual % change minimum flow
4. March % change mean flow
5. March % change maximum flow
6. March % change minimum flow
7. October % change mean flow
8. October % change maximum flow
9. October % change minimum flow

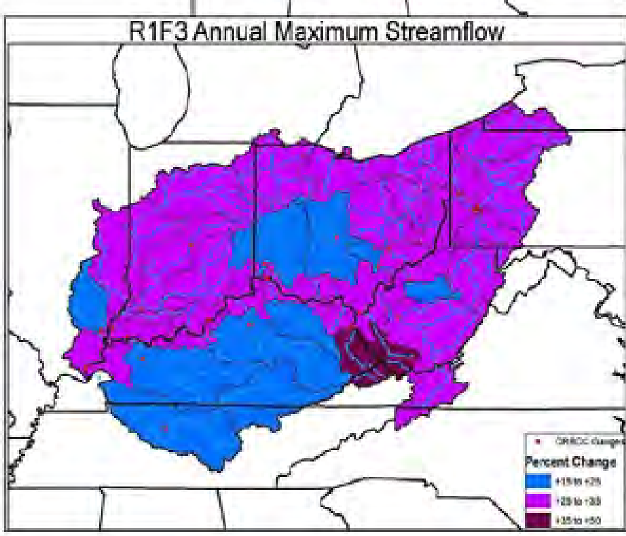
Thematic basin maps have been created to represent the above noted data, these maps highlight the percent changes for the three 30-year periods which are referenced in the maps below as F1 (2011-2040), F2 (2041-2070) and F3 (2071- 2099). The thematic basin maps for the percent change in annual maximum stream flow and percent change in October maximum stream flow have been included for reference. The remainder of the thematic basin maps are available in the draft study.

The downscaling of these ensemble climate models suggest the overall mean, maximum and minimum flows will generally be within range of recent history through the year 2040. After the year 2040, the increases occur in the mean and maximum flows in the 10% to 40% range. There are some watersheds in northern and eastern Ohio that appear to experience greater than 40% increases in mean and maximum flows. This appears to occur primarily from later summer until early winter. The autumn increases in maximum flows may enhance early cool season flood events in late autumn and early winter. These increases could lead to worsening spring flooding beyond 2040. The models suggest that droughts could lengthen or shift more between spring, summer and autumn beyond 2040. The models also suggest that the overall variability is also likely to increase with time as well.

Percent Change in Annual Maximum Stream Flow: In terms of the annual % change in the annual max flows; F1 shows an increase in the max flows across portions of PA and WV within the basin. In F2, this higher max discharge trend continues, but spreads into OH and IN and the Cumberland River watershed.

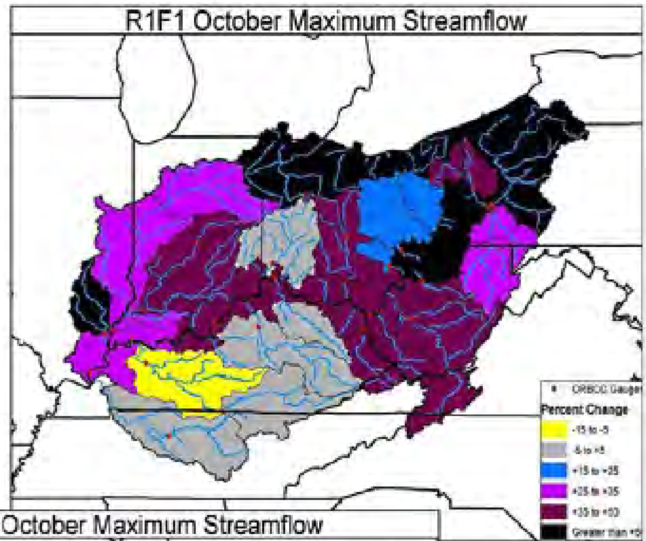


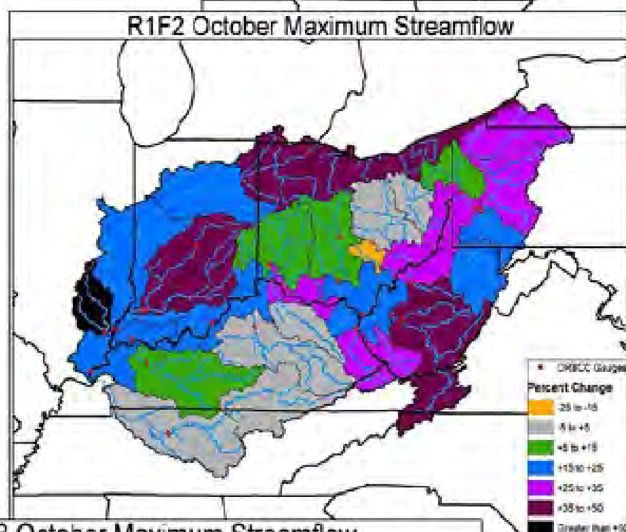


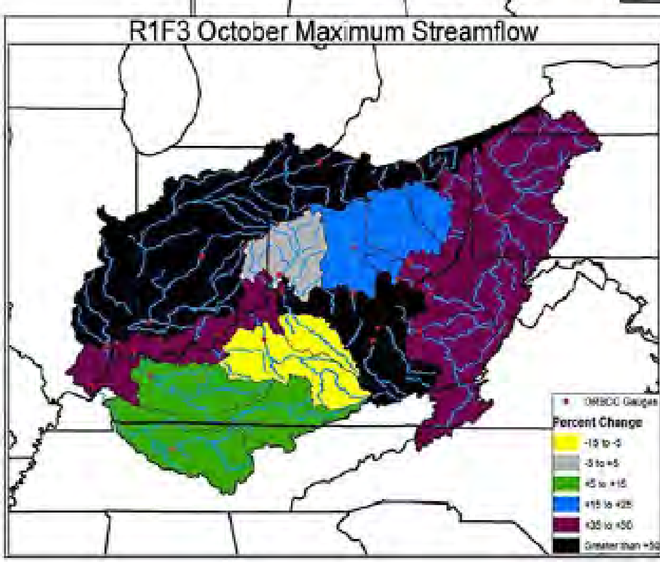


The % change in max flow increases markedly in the Kanawha and Big Sandy River sub-basins. In F3, the annual % change in max flows increases substantially across PA, WV, OH, IN and IL. The increase in annual % change in max flows appears significant in the Big Sandy River watershed during this third period. The progression of these flow changes is shown below in the three figures.

Percent Change in October Maximum Stream Flow: Period F1 shows increases in % change of max flow over much of the basin and substantially higher October flows in the Allegheny River and Little Wabash River watersheds and significant increases in the Kanawha, Scioto, Big Sandy and White River watersheds over the base condition.







Period F2 shows some relaxing of the wetter October conditions but the Kanawha, White River and Little Wabash remain higher than the base condition flows. Period F3 shows a return to higher October flows across the basin with the exception of central OH and KY. Substantial increases during this period are seen in the Big Sandy River, White River and Wabash River watersheds.

The report also included the results of preliminary investigations into the various impacts that forecasted climate change may have on ecosystems and infrastructure, and recommends mitigation and adaptation strategies. The mitigation and adaptation strategies in the pilot study can be deployed at all levels of government, private or corporate ownership to address the anticipated climate change impacts identified in the report and other effects cited in the research literature. Strategies for addressing unavoidable, residual impacts of climate change were also developed, along with objective assessments of the likelihood of success. These strategies include:

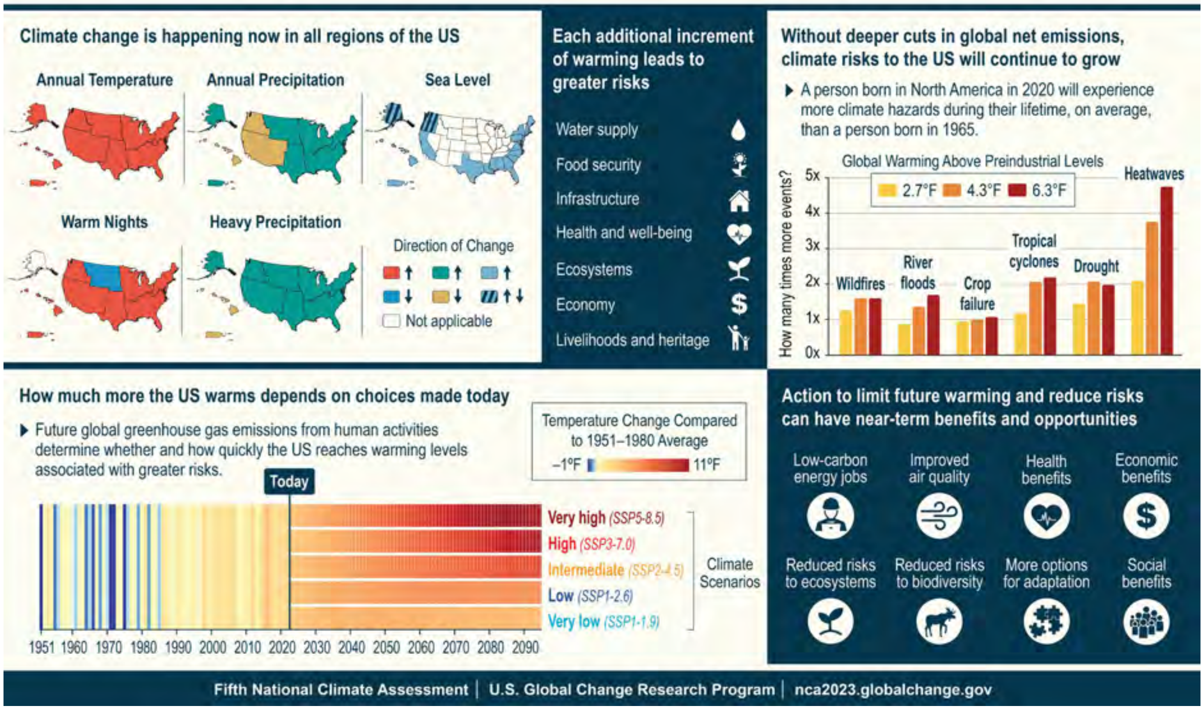
- Restoring Wetlands
- Reconnecting Floodplains
- Reducing Consumptive Uses of Water
- Harvesting Precipitation and Flood Flows
- Drought Contingency Planning
- Increasing Nutrient and Abandoned Mine Drainage Management
- Modifying Thermoelectric Power Plant Cooling Systems
- Reducing Flood Damages Through Nonstructural Measures
- Increasing Water Quality and Flow Discharge Monitoring
- Promoting Wise Land Use Management
- Modifying Reservoir Operations, Policies and Structures
- Managing Ecosystem Stress
- Temporal Staging

The report then recommends “next-steps”, which include filling in numerous data gaps identified during the study process. Many gaps in knowledge, understanding, and modeling need to be filled and much more investment will be required to assure ourselves that (1) the downscaled modeling results displayed in this pilot study are updated on a regular basis (at least decadal), (2) the mitigation and adaptation measures identified remain current based on new strategies and the documented successes or failures of applied strategies by others, and (3) the USACE accept an Army Strong role in leading basin water managers toward a comprehensive plan for basin water planning that can offset the potential effects of climate change on infrastructure and the ecosystems that are dependent upon operation of those facilities.

FIFTH NATIONAL CLIMATE ASSESSMENT
https://nca2023.globalchange.gov/

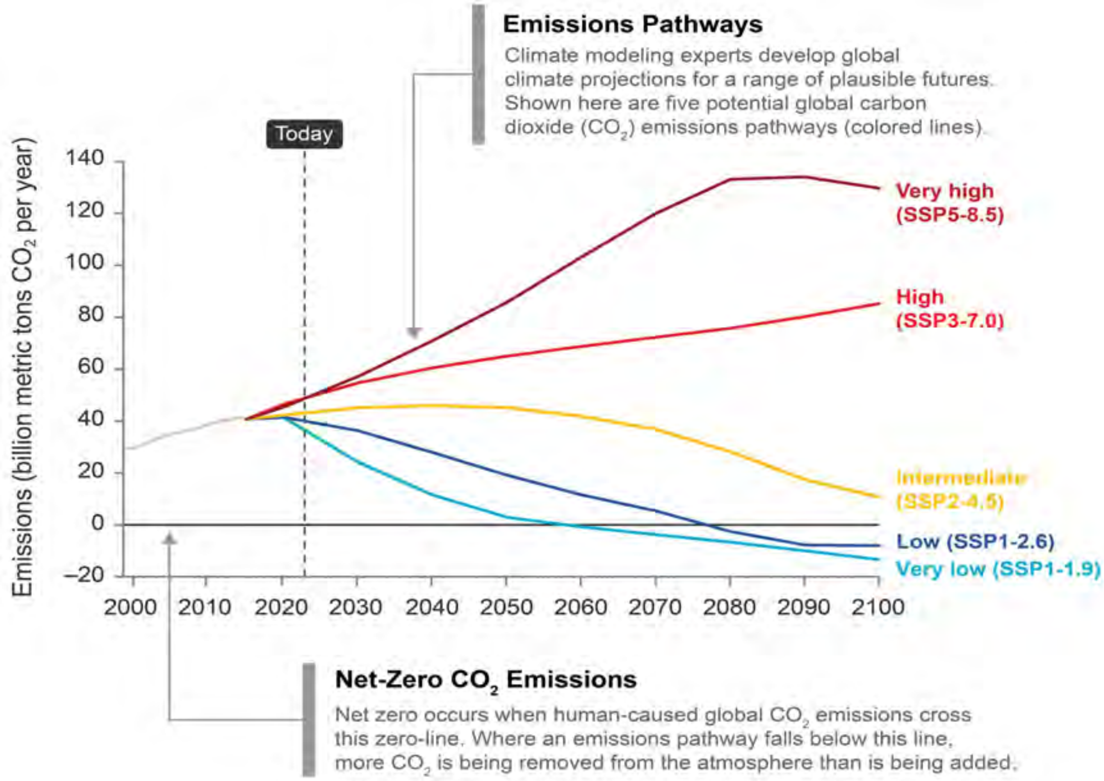
The National Climate Assessment is the authoritative assessment of the science of climate change, with a focus on the United States, and serves as the foundation for efforts to assess climate-related risks and inform decision-making. The climate of the United States is strongly connected to the changing global climate and this assessment highlights past, current, and projected climate changes for the United States and the globe.

The effects of human-caused climate change are already far-reaching and worsening across every region of the United States. Rapidly reducing greenhouse gas emissions can limit future warming and associated increases in many risks. Across the country, efforts to adapt to climate change and reduce emissions have expanded since 2018, and US emissions have fallen since peaking in 2007. However, without deeper cuts in global net greenhouse gas emissions and accelerated adaptation efforts, severe climate risks to the United State of United States will continue to grow.



The more the planet warms, the greater the impacts. Without rapid and deep reductions in global greenhouse gas emissions from human activities, the risks of accelerating sea level rise, intensifying extreme weather, and other harmful climate impacts will continue to grow. Each additional increment of warming is expected to lead to more damage and greater economic losses compared to previous increments of warming, while the risk of catastrophic or unforeseen consequences also increases.

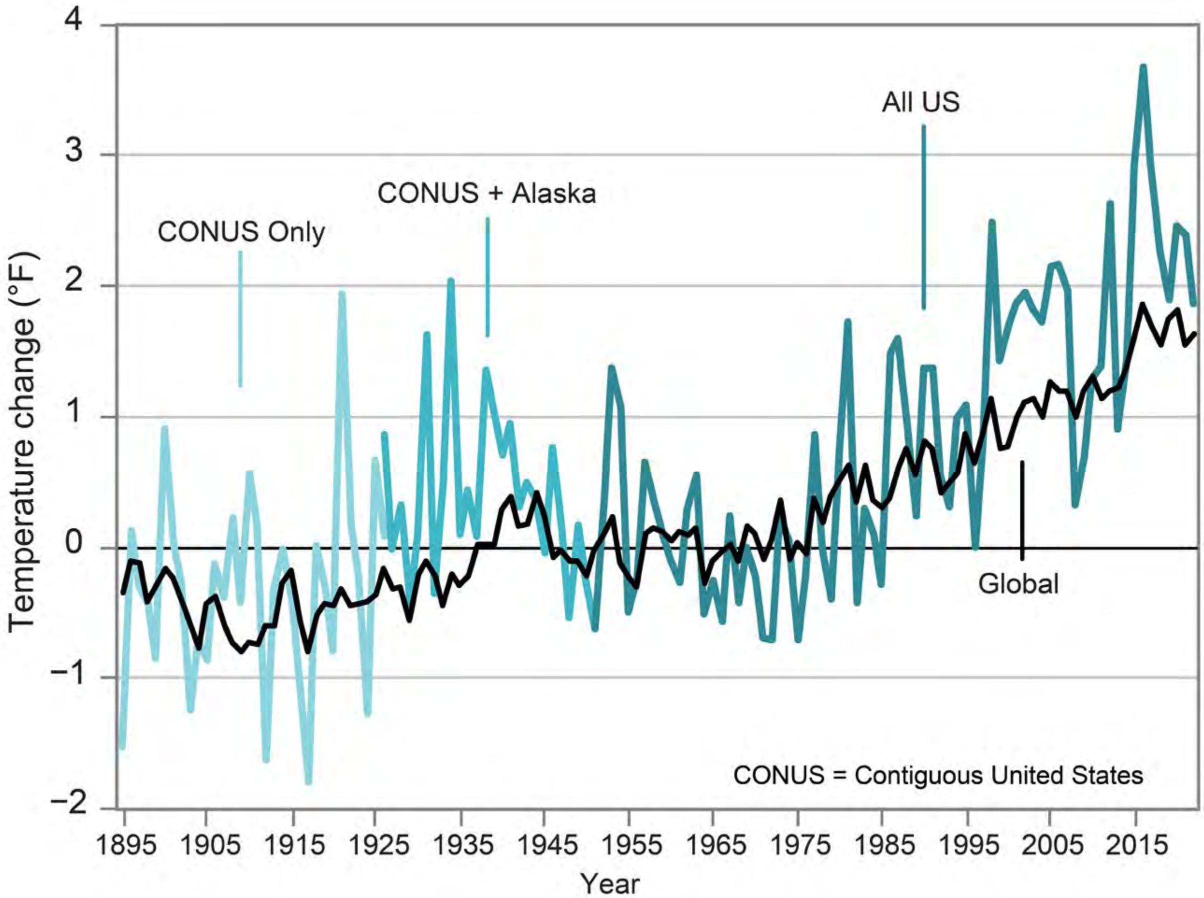
While US greenhouse gas emissions are falling, the current rate of decline is not sufficient to meet national and international climate commitments and goals. US net greenhouse gas emissions remain substantial and would have to decline by more than 6% per year on average, reaching net-zero emissions around midcentury, to meet current national mitigation targets and international temperature goals; by comparison, US greenhouse gas emissions decreased by less than 1% per year on average between 2005 and 2019.



The five scenarios shown (colored lines) demonstrate potential global carbon dioxide (CO2) emissions pathways modeled from 2015 through 2100, with the solid light gray line showing observed global CO2 emissions from 2000 to 2015. Many projected impacts described in this report are based on a potential climate future defined by one or more of these scenarios for future CO2 emissions from human activities, the largest long-term driver of climate change. The vertical dashed line, labeled “Today,” marks the year 2023; the solid horizontal black line marks net-zero CO2 emissions. Adapted with permission from Figure TS.4 in Arias et al. 2021.

The below graph shows the change in US annual average surface temperature during 1895–2022 compared to the 1951–1980 average. The temperature trend changes color as data become available for more regions of the US, with Alaska data added to the average temperature for the contiguous US (CONUS) beginning in 1926 (medium blue line) and Hawaiʻi, Puerto Rico, and US-Affiliated Pacific Islands data added beginning in 1951 (dark blue line). Global average surface temperature is shown by the black line. Figure credit: NOAA NCEI and CISESS NC.

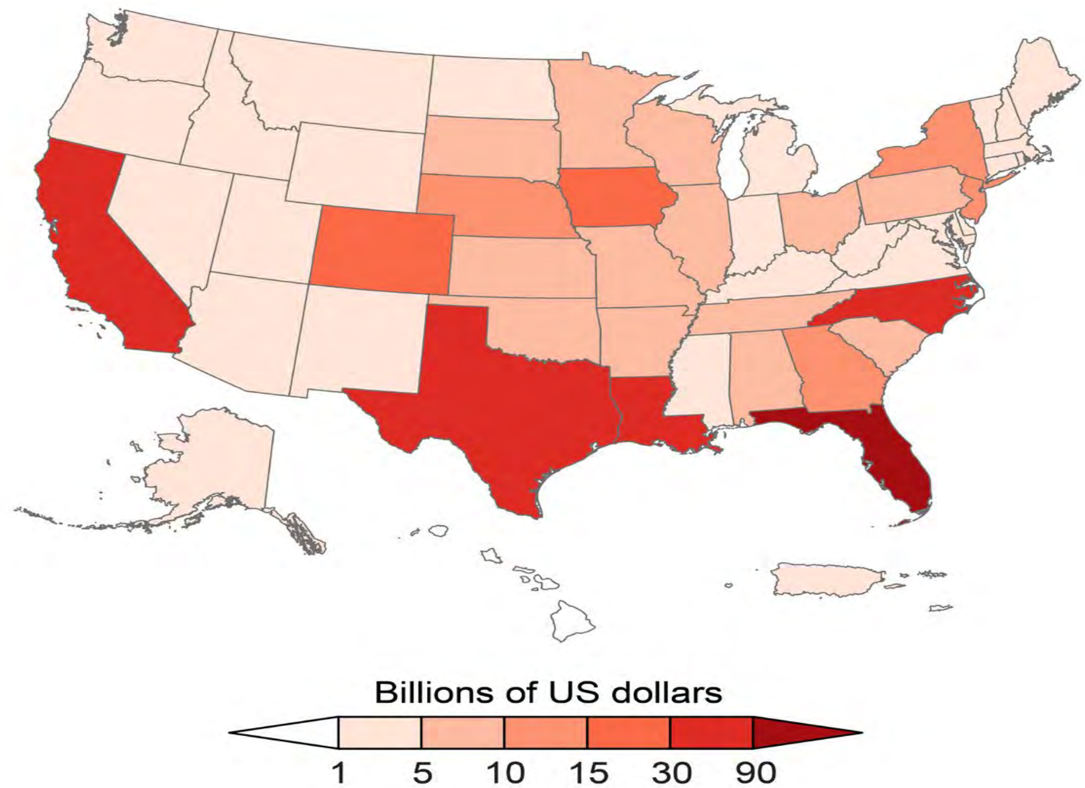
Across all regions of the US, people are experiencing warming temperatures and longer-lasting heatwaves. Over much of the country, nighttime temperatures and winter temperatures have warmed more rapidly than daytime and summer temperatures. Many other extremes, including heavy precipitation, drought, flooding, wildfire, and hurricanes, are becoming more frequent and/or severe, with a cascade of effects in every part of the country.



One of the most direct ways that people experience climate change is through changes in extreme events. Harmful impacts from more frequent and severe extremes are increasing across the country—including increases in heat-related illnesses and death, costlier storm damages, longer droughts that reduce agricultural productivity and strain water systems, and larger, more severe wildfires that threaten homes and degrade air quality.

Some communities are at higher risk of negative impacts from climate change due to social and economic inequities caused by ongoing systemic discrimination, exclusion, and under- or disinvestment. Many such communities are also already overburdened by the cumulative effects of adverse environmental, health, economic, or social conditions. Climate change worsens these long-standing inequities, contributing to persistent disparities in the resources needed to prepare for, respond to, and recover from climate impacts.

The below maps shows the damages by state from billon dollar disasters, between 2018 and 2022, 89 such events affected the US, including 4 droughts, 6 floods, 52 severe storms, 18 tropical cyclones, 5 wildfires, and 4 winter storm events.

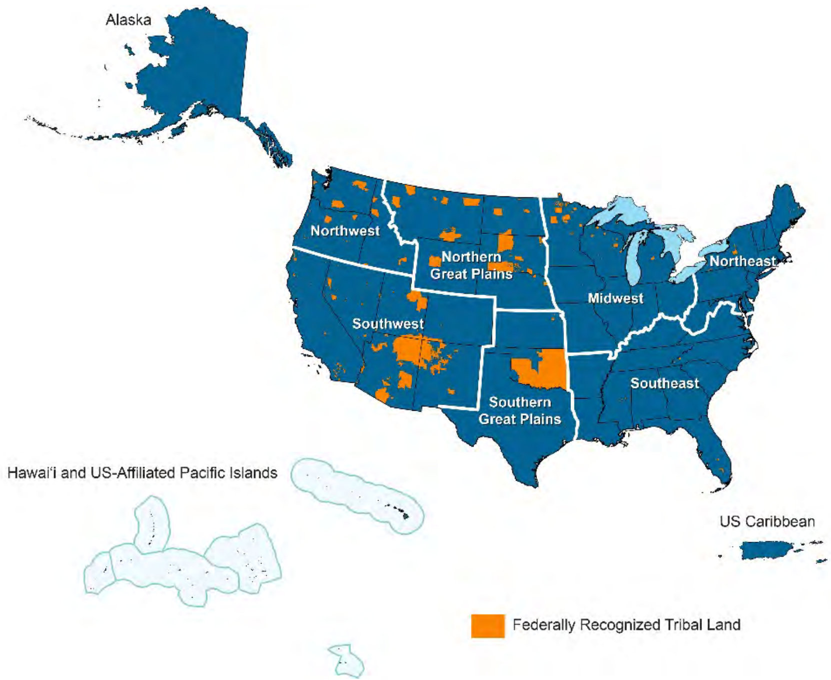


Th Fifth Climate Assessment lays out several current and future climate risks to the United States. These include:

- Safe, reliable water supplies are threatened by flooding, drought, and sea level rise.
- Disruptions to food systems are expected to increase
- Homes and property are at risk from sea level rise and more intense extreme events
- Infrastructure and services are increasingly damaged and disrupted by extreme weather and sea level rise
- Climate change exacerbates existing health challenges and creates new ones
- Ecosystems are undergoing transformational changes
- Many regional economies and livelihoods are threatened by damages to natural resources and intensifying extremes
- Job opportunities are shifting due to climate change and climate action
- Climate change is disrupting cultures, heritages, and traditions

These current and future risk broadly apply across the nation and generally echo other climate change studies in stating that climate change will like have broad impacts in many sectors of American life. For communities across the country, climate change creates new risks and exacerbates existing vulnerabilities, presenting growing challenges to human health and safety, quality of life, and the rate of economic growth.

The Fifth National Climate Assessment further delineates the impacts of climate change by breaking down the nations into 10 Regions. The State of Ohio is located within the Midwest region, so that is the region we will focus on.



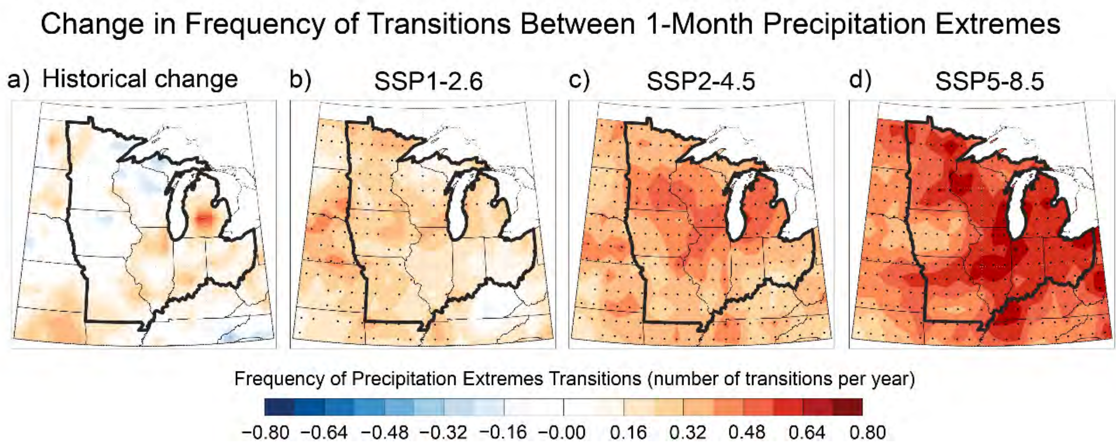
MIDWEST CHAPTER
https://nca2023.globalchange.gov/chapter/24/

NCA5 identifies 5 key messages in the Midwest Chapter:

1. Climate-Smart Practices May Offset Complex Climate Interactions in Agriculture
2. Adaptation May Ease Disruptions to Ecosystems and Their Services
3. Climate Adaptation and Mitigation Strategies Improve Individual and Community Health
4. Green Infrastructure and Investment Solutions Can Address Costly Climate Change Impacts
5. Managing Extremes Is Necessary to Minimize Impacts on Water Quality and Quantity

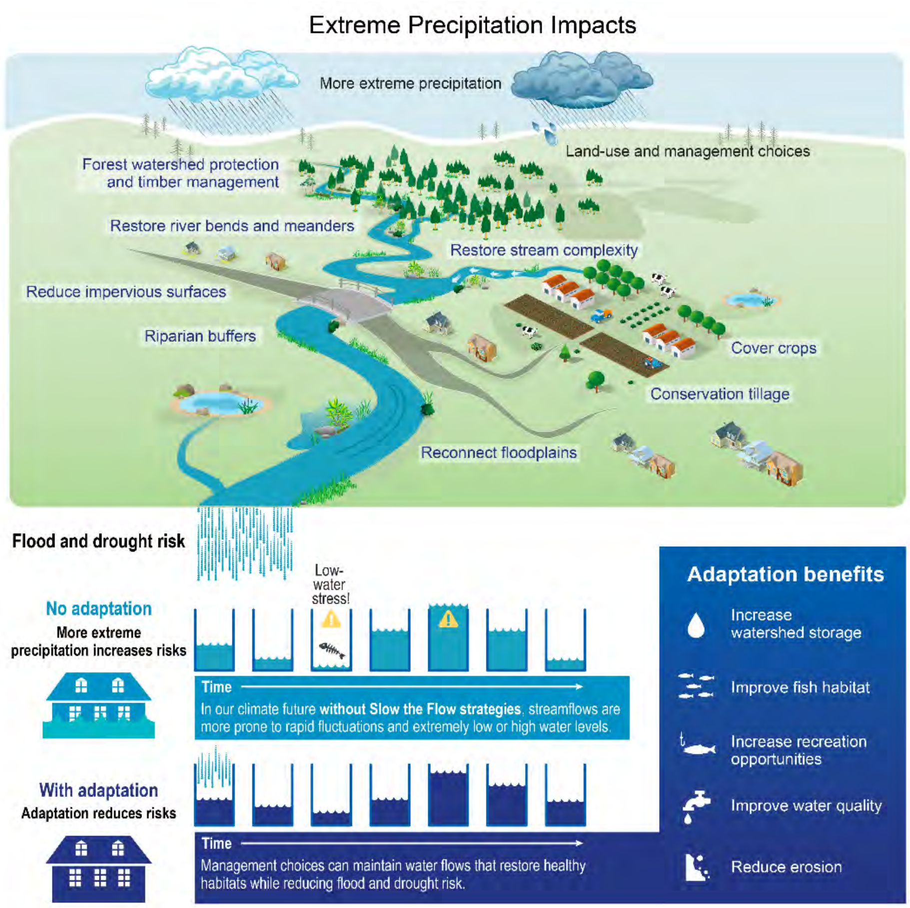
CLIMATE - SMART PRACTICES MAY OFFSET COMPLEX CLIMATE INTERACTIONS IN AGRICULTURE

Crop production is projected to change in complex ways due to increasing extreme precipitation events and transitions between wet and dry conditions as well as intensification of crop water loss. Changes in precipitation extremes, timing of snowmelt, and early-spring rainfall are expected to pose greater challenges for crop and animal agriculture, including increased pest and disease transmission, muddier pastures, and further degradation of water quality. Climate-smart agriculture and other adaptation techniques provide a potential path toward environmental and economic sustainability.



ADAPTATION MAY EASE DISRUPTIONS TO ECOSYSTEMS AND THEIR SERVICES

Ecosystems are already being affected by changes in extreme weather and other climate-related changes, with negative impacts on a wide range of species. Increasing incidence of flooding and drought is expected to further alter aquatic ecosystems, while terrestrial ecosystems are being reshaped by rising temperatures and decreasing snow and ice cover. Loss of ecosystem services is undermining human well-being, causing the loss of economic, cultural, and health benefits. In response, communities are adapting their cultural practices and the ways they manage the landscape, preserving and protecting ecosystems and the services they provide.



CLIMATE ADAPTATION AND MITIGATION STRATEGIES IMPROVE INDIVIDUAL AND COMMUNITY HEALTH

Climate change has wide-ranging effects on lives and livelihoods, healthcare systems, and community cohesion. These diverse impacts will require integrated, innovative response from collaborations between public health and other sectors, such as emergency management, agriculture, and urban planning. Because of historical and systemic biases, communities of color are especially vulnerable to these negative impacts. Mitigation and adaptation strategies, such as expanded use of green infrastructure, heat-health early warning systems, and improved stormwater management systems, when developed in collaboration with affected communities, have the potential to improve individual and community health.

While many of the worst wildfires occur in the western US, there are scattered areas of high wildfire risk throughout the Upper Midwest. Wildfire smoke from both local and distant sources poses a threat to human health by aggravating cardiovascular and respiratory conditions such as heart arrhythmias and asthma. Below is a satellite image from the June of 2023 showing the impacts to air quality in Ohio from ongoing Canadian wildfires.

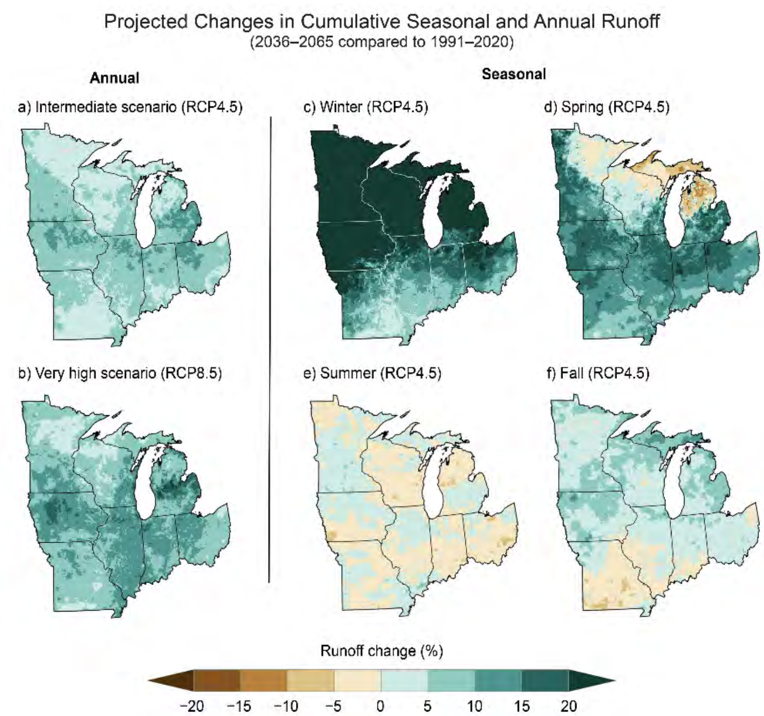
16 Jul 2023 17:06Z - NOAA/NESDIS/STAR - GOES-East - GEOCOLOR Composite - CGL

GREEN INFRASTRUCTURE AND INVESTMENT SOLUTIONS CAN ADDRESS COSTLY CLIMATE CHANGE IMPACTS

Increases in temperatures and extreme precipitation events are already challenging aging infrastructure and are expected to impair surface transportation, water navigation, and the electrical grid. Shifts in the timing and intensity of rainfall are expected to disrupt transportation along major rivers and increase chronic flooding. Green infrastructure and public and private investments may mitigate losses, provide relief from heat, and offer other ways to adapt the built environment to a changing climate.

MANAGING EXTREMES IS NECESSARY TO MINIMIZE IMPACTS ON WATER QUALITY AND QUANTITY

Storm water management systems, transportation networks, and other critical infrastructure are already experiencing impacts from changing precipitation patterns and elevated flood risks. Green infrastructure is reducing some of the negative impacts by using plants and open space to absorb storm water. The annual cost of adapting urban storm water systems to more frequent and severe storms is projected to exceed $500 million for the Midwest by the end of the century.



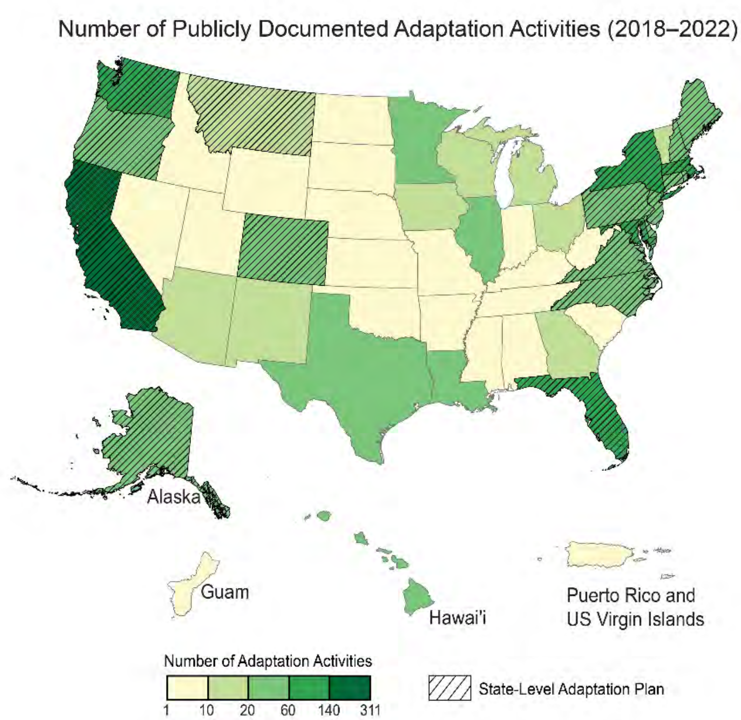
ADAPTION
https://nca2023.globalchange.gov/chapter/31/

Adaptation is essential for human and ecological survival in this rapidly changing, complex, and interconnected world. Adaptation activities are occurring across the US but have been small in scale, incremental in approach, and lacking in sufficient investment. Transformative approaches will be necessary to adequately address current and future risks. To improve capacity and promote an equitable future, adaptation activities must address the uneven distribution of climate harms and incorporate collaboration with local communities. NCA5 has 6 key messages about adaptation and its future impacts on climate changes nationwide:

1. Adaptation Is Occurring but Is Insufficient in Relation to the Pace of Climate Change
2. Effective Adaptation Requires Centering Equity
3. Transformative Adaptation Will Be Needed to Adequately Address Climate-Related Risks
4. Effective Adaptation Governance Empowers Multiple Voices to Navigate Competing Goals
5. Adaptation Requires More than Scientific Information and Understanding
6. Adaptation Investments and Financing Are Difficult to Track and May Be Inadequate

ADAPTATION IS OCCURRING BUT IS INSUFFICIENT IN RELATION TO THE PACE OF CLIMATE CHANGE

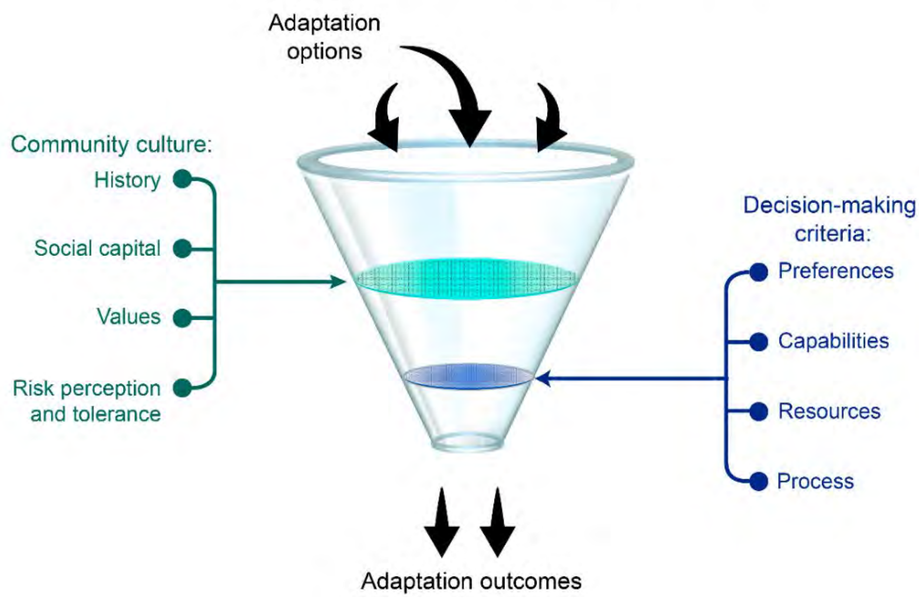
Diverse adaptation activities are occurring across the U.S. Adaptation activities are increasingly moving from awareness and assessment toward planning and implementation, with limited advancement toward monitoring and evaluation. Numerous social, economic, physical, and psychological barriers are preventing more widespread adoption and implementation of adaptation. Current adaptation efforts and investments are insufficient to reduce today's climate-related risks and are unlikely to keep pace with future changes in the climate.



EFFECTIVE ADAPTATION REQUIRES CENTERING EQUITY

People and communities are affected by climate change in different ways. How people and institutions adapt depends on social factors, including individual and community preferences, capacity, and access to resources. Adaptation processes, decisions (about whether, where, and how adaptation occurs), and actions that do not explicitly address the uneven distribution of climate harms, and the social processes and injustices underlying these disparities, can exacerbate social inequities and increase exposure to climate harms.

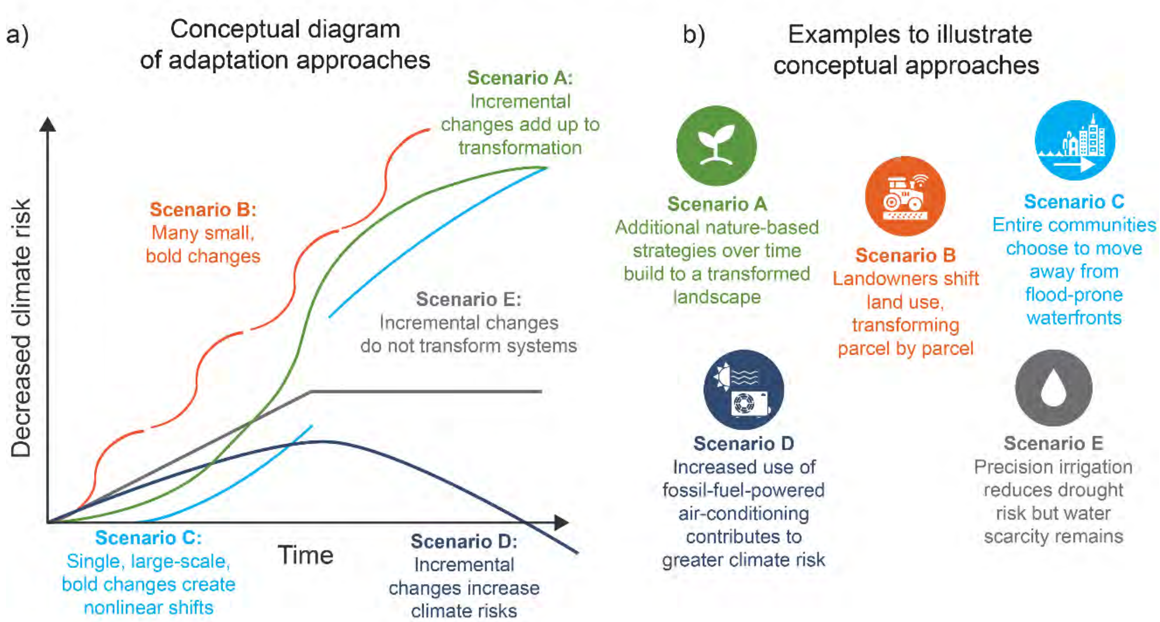
Adaptation Actions Defined by Multiple Factors



TRANSFORMATIVE ADAPTATION WILL BE NEEDED TO ADEQUATELY ADDRESS CLIMATE-RELATED RISKS

Climate adaptation actions undertaken in the United States to date have generally been small in scale and incremental in approach, involving minor changes to business as usual. Transformative adaptation, which involves more fundamental shifts in systems, values, and practices, will be necessary in many cases to adequately address the risks of current and future climate change. New monitoring and evaluation methods will also be needed to assess the effectiveness and sufficiency of adaptation and to address equity.

Incremental and Transformative Adaptation Approaches



EFFECTIVE ADAPTATION GOVERNANCE EMPOWERS MULTIPLE VOICES TO NAVIGATE COMPETING GOALS

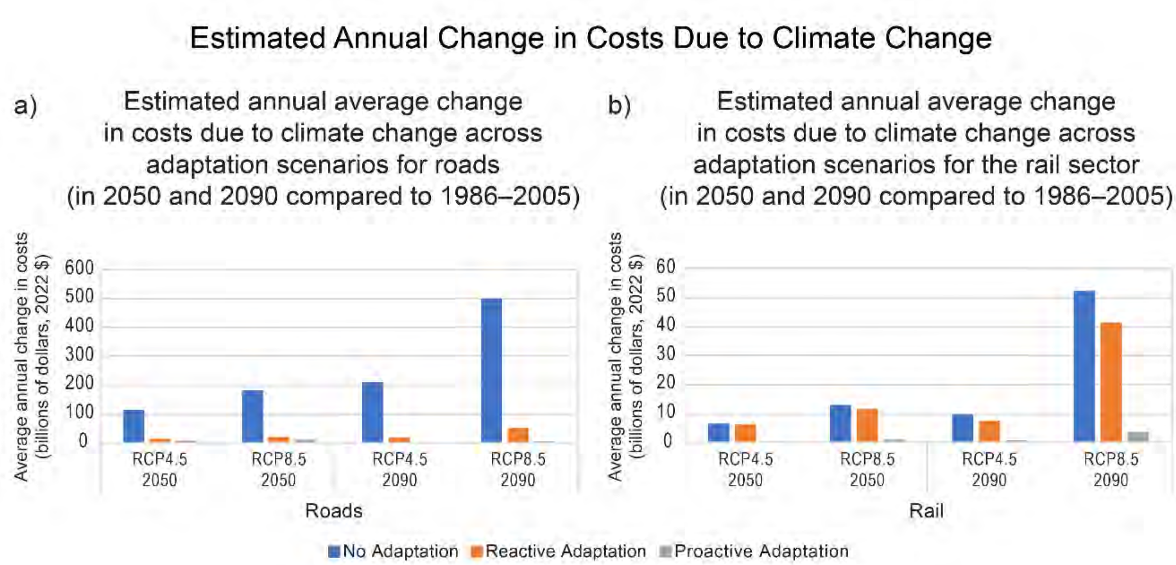
Adaptation involves actors from government, private-sector, nongovernmental (e.g., nonprofit and for-profit institutions), and civil society organizations, which often have different priorities and approaches. Adaptation decision-makers must balance competing goals while also addressing uncertainties regarding future climate change and the ways that political, social, and technological systems will be transformed (high confidence). To minimize the potential for adaptation actions to benefit some at the expense of others, adaptation processes must emphasize collaboration, center equity and justice, and incorporate a wide range of values and knowledge sources

ADAPTATION REQUIRES MORE THAN SCIENTIFIC INFORMATION AND UNDERSTANDING

Effective adaptation to a changing climate requires both decision-relevant climate information and evidence-based decision-making approaches. Adaptation requires that researchers intentionally collaborate with communities to identify goals, assess vulnerability, improve capacity, and address contextual factors, such as values, culture, risk perception, and historic injustices. Climate services can be improved by ensuring access for historically disinvested communities and by attention to procedural and recognitional equity when scientists work with communities and decision-makers.

ADAPTATION INVESTMENTS AND FINANCING ARE DIFFICULT TO TRACK AND MAY BE INADEQUATE

Investments in adaptation are being made at the federal, state, territorial, Tribal, and local levels, as well as within the private sector, but they are not always evenly distributed, coordinated, tracked, or reported and may be inadequate. Future adaptation investment needs are expected to be significant, although projected amounts vary due to uncertainty in future emissions trajectories, associated impacts, and the timing of implementation. Proactive adaptation can reduce some of the most severe costs of future climate change, particularly under very high emissions scenarios in the late 21st century, although adaptation is still needed in the present for communities and infrastructure that may not be well adapted to face current climate conditions. The graphic below illustrates the increased cost of roads and rails under different adaptation scenarios.



MITIGATION
https://nca2023.globalchange.gov/chapter/32/

The 5th NCA defines climate change mitigation as efforts to reduce emissions or to remove carbon from the atmosphere with the goal of avoiding or reducing the effects of climate change, which is different from adapting systems and activities to a changed climate. To meet international climate goals, global carbon dioxide (CO_2) emissions would need to reach net zero by around 2050. NCA5 has 5 key messages about mitigation and its future impacts on climate changes nationwide:

1. Successful Mitigation Means Reaching Net-Zero Emissions
2. We Know How to Drastically Reduce Emissions
3. To Reach Net-Zero Emissions, Additional Mitigation Options Need to Be Explored
4. Mitigation Can Be Sustainable, Healthy, and Fair
5. Governments, Organizations, and Individuals Can Act to Reduce Emissions

SUCCESSFUL MITIGATION MEANS REACHING NET-ZERO EMISSIONS

Greenhouse gas emissions in the United States decreased by 12% between 2005 and 2019, mostly due to replacing coal-fired electricity generation with natural gas–fired and renewable generation. However, US net greenhouse gas emissions remain substantial and would have to decline by more than 6% per year on average, reaching net zero around midcentury, to meet current national climate targets and international temperature goals.

WE KNOW HOW TO DRASTICALLY REDUCE EMISSIONS

A US energy system with net-zero emissions would rely on widespread improvements in energy efficiency, substantial electricity generation from solar and wind energy, and widespread electrification of transportation and heating. Low-carbon fuels would still be needed for some transport and industry applications that are difficult to electrify. Land-related emissions in the US could be reduced by increasing the efficiency of food systems and improving agricultural practices and by protecting and restoring natural lands. Across all sectors, many of these options are economically feasible now.

TO REACH NET-ZERO EMISSIONS, ADDITIONAL MITIGATION OPTIONS NEED TO BE EXPLORED

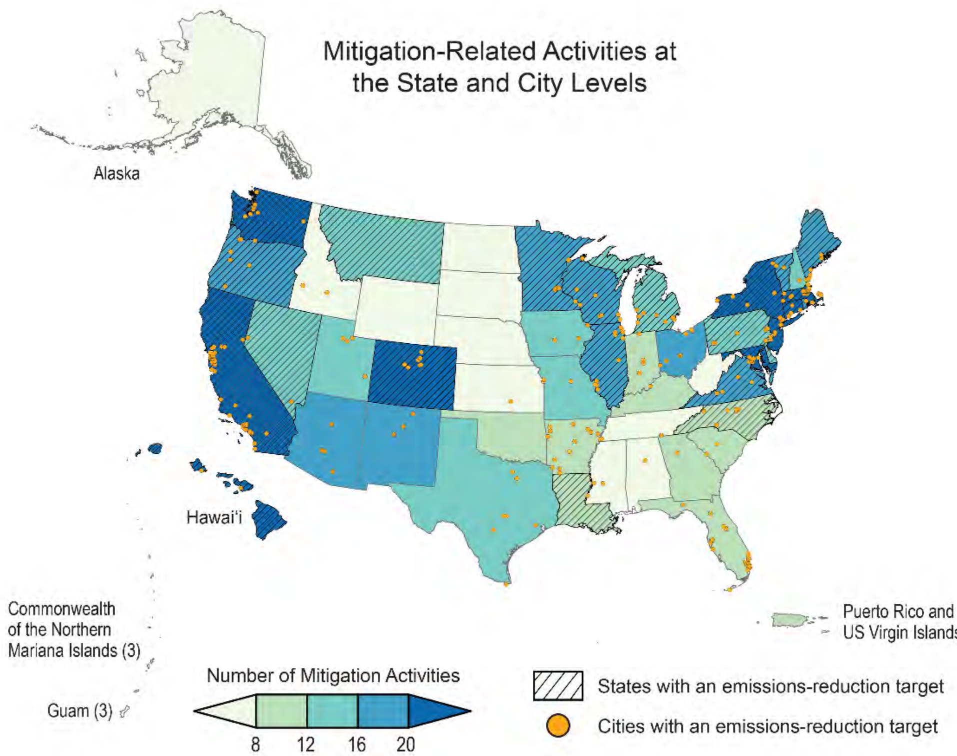
Although many mitigation options are currently available and cost-effective, the level and types of energy technologies and carbon management in net-zero-emissions energy systems depend on still-uncertain technological progress, public acceptance, consumer choice, and future developments in institutions, markets, and policies. Attractive targets for further research, development, and demonstration include carbon capture, utilization, and storage; long-duration energy storage; low-carbon fuels and feedstocks; demand management; next-generation electricity transmission; carbon dioxide removal; modern foods; and interventions to reduce industry and agricultural emissions.

MITIGATION CAN BE SUSTAINABLE, HEALTHY, AND FAIR

Large reductions in US greenhouse gas emissions could have substantial benefits for human health and well-being. Mitigation is expected to affect pollution, the use of land and water resources, the labor force, and the affordability, reliability, and security of energy and food. An equitable and sustainable transition to net-zero-emissions energy and food systems in the United States could help redress legacies of inequity, racism, and injustice while maximizing overall benefits to our economy and environment.

GOVERNMENTS, ORGANIZATIONS, AND INDIVIDUALS CAN ACT TO REDUCE EMISSIONS

Mitigation efforts can be supported by a range of actors and actions, from choices made by individuals to decisions made by businesses and local, Tribal, state, and national governments. Actions with significant near-term potential include sector-based policies accelerating deployment of low-carbon technologies, city-level efforts to promote public transportation and improve building efficiency, and individual behavioral changes to reduce energy demand and meat consumption.



U.S. CLIMATE RESILIENCE TOOLKIT
https://toolkit.climate.gov/

The U.S. Climate Resilience Toolkit is a website designed to help people find and use tools, information, and subject matter expertise to build climate resilience. The Toolkit offers information from all across the U.S. federal government in one easy-to-use location. Its goal is to improve people's ability to understand and manage their climate-related risks and opportunities, and to help them make their communities and businesses more resilient to extreme events.

The Resilience Toolkit highlight several of the most impactful and useful tools available to help manage climate-related risks and opportunities, and to help guide in building resilience to extreme event. Most of these tools reference the assumptions and recommendations of the 5th National Climate Assessment.

Several of the tools available through the U.S. Climate Resilience Toolkit have variable levels of impact on the State of Ohio based upon their focus or datasets used. Below are highlighted several of the more useful tools for the State of Ohio:

CLIMATE MAPPPING FOR RESILIENCE AND ADAPTION (CMRA)
https://resilience.climate.gov/

Climate Mapping for Resilience and Adaptation (CMRA) helps people assess their local exposure to climate-related hazards. Understanding exposure is the first step in determining which people, property, and infrastructure could be injured or damaged by climate-related hazards, and what options might be available to protect these assets.

CMRA is particularly recommended for people working with community organizations and in local, Tribal, state, and Federal government offices who wish to pursue grant funds available through the Bipartisan Infrastructure Law and/or other Federal grant funds to support equitable climate resilience building projects.

LOCATING AND SELECTION SCENARIOS ONLINE (LASSO)
https://lasso.epa.gov/

The LASSO tool guides you step-by-step through the process of identifying and downloading climate change scenarios—or projections—that are relevant to your interest or research question. At each step you will define criteria that will subset climate change information from a much larger archive, with LASSO providing helpful information and suggestions along the way. At the end of the process, you will have the option to download maps, figures and GIS-ready spatial data, or use an interactive scatterplot widget to customize or change your choices.

THE CLIMATE EXPLORER
https://crt-climate-explorer.nemac.org/
The Climate Explorer offers climate projections through 2100 for every county in the United States. For the contiguous U.S. and island territories, the tool shows climate projections for temperature, precipitation, and related climate variables for two possible futures—one in which humans make a significant attempt to reduce global emissions of heat-trapping gases (lower emissions), and one in which the rate of global emissions continues rising through 2100 (higher emissions).

CLIMATE AND ECONOMIC JUSTICE SCREENING TOOL
The Climate and Economic Justice Screening Tool or CEJST was created via Executive Order 14008 on Tackling the Climate Crisis at Home and Abroad. President Biden directed the White House Council on Environmental Quality (CEQ) to develop a geospatial mapping tool to identify disadvantaged communities that face burdens. The tool has an interactive map and uses datasets that are indicators of burdens.

CATEGORIES OF BURDENS
The tool uses datasets as indicators of burdens. The burdens are organized into categories. A community is highlighted as disadvantaged on the CEJST map if it is in a census tract that is (1) at or above the threshold for one or more environmental, climate, or other burdens, and (2) at or above the threshold for an associated socioeconomic burden.

In addition, a census tract that is completely surrounded by disadvantaged communities and is at or above the 50% percentile for low income is also considered disadvantaged. The CEJST has a category of burden that specifically addresses climate change and its impacts on disadvantaged communities. For climate change, communities are identified as disadvantaged if they are in census tracts that:

- ARE at or above the 90th percentile for expected agriculture loss rate OR expected building loss rate OR expected population loss rate OR projected flood risk OR projected wildfire risk
- AND are at or above the 65th percentile for low income

For the State of Ohio, there were 90 census tracts identified as disadvantaged by climate change, with the top five counties with the most census tracts being Scioto (9), Hamilton (8), Lawrence (7), Belmont (6) and Jefferson (5).

County	# of Climate Change Disadvantaged Census tracts	County	# of Climate Change Disadvantaged Census tracts
Adams	1	Licking	1
Athens	4	Logan	1
Belmont	6	Lucas	2
Brown	2	Meigs	4
Butler	2	Montgomery	4
Columbiana	2	Morgan	1
Coshocton	2	Muskingum	2
Cuyahoga	1	Richland	1
Defiance	2	Ross	1
Fairfield	2	Scioto	9
Franklin	4	Seneca	2
Gallia	3	Stark	1
Hamilton	8	Summit	1
Hancock	1	Trumbull	3
Jackson	1	Tuscarawas	1
Jefferson	5	Washington	3
Lawrence	7		

ODOT INFRASTRUCTURE RESILIENCY PLAN
https://environment.transportation.org/wp-content/uploads/2022/03/final_report_odot_infrastructure_vulnerability_assessment_5_6_16.pdf

The plan's executive summary states that the key objective of the study was to identify the vulnerability of the Ohio Department of Transportation's (ODOT's) infrastructure to climate change effects and extreme weather events. The analysis includes a discussion and analysis of the type of transportation assets vulnerable, the degree of exposure, sensitivity, adaptive capacity, and the potential approaches to adapt to these changes. The study includes:

- Understanding the vulnerability of ODOT's overall transportation system to climate change;
- Determining potential consequences from a broad range of potential climate impacts;
- Identifying facilities at risk to climate change impacts within Ohio by type;
- Identify range of adaptation and/or sustainability options (activities) that ODOT should consider in detail in future adaptation studies
- Providing the foundation for ODOT to integrate the results of this vulnerability assessment into future decision-making processes and future adaptation/resiliency studies.

Utilizing ODOT's existing GIS systems, the project team developed additional GIS mapping and analytics to evaluate the vulnerability of ODOT's infrastructure to climate change effects. This effort determined that the primary climate change effect of concern is the increased incidence of heavy precipitation events, which will impair the functioning of core assets -- highways, bridges, and culverts.

A summary of this study's recommendations is below:

- Identify a lead office within ODOT- Office of Planning.
- Completion of Annual Tasks by the Resiliency Lead
- Ongoing refinement of VAST model for the 3 asset types (highways, bridges, culverts):
- Interagency Coordination

CLIMATE CHANGE, EXTREME PRECIPITATION AND FLOODING: THE LATEST SCIENCE – UNION OF CONCERNED SCIENTISTS

https://www.ucsusa.org/sites/default/files/attach/2018/07/gw-fact-sheet-epif.pdf

This report is a synopsis by Union of Concerned Scientist of the latest scientific findings on how and why precipitation and flooding patterns have changed in the United States, a summary of the possible future scenarios, and recommendations. While coastal flooding and sea level rise are important parts of the complete picture of flood risk, this synopsis focuses on flooding of inland areas.

According to the 2017 Climate Science Special Report, flooding across the United States is changing, though not uniformly across the country. The data shows that flood frequency has increased in the Mississippi Valley and the Midwest over the last century, including an increase in moderate and major flood frequency in the Midwest. Across the country, increasingly frequent heavy rain is one of the most obvious weather changes. The regions experiencing increases in extreme precipitation generally align well with those experiencing increases in flood frequency. Increases in extreme precipitation frequency and intensity are projected to continue across much of the United States over the 21st century, particularly in the northern and Midwestern regions.

The reports cite several current Federal flood risk reductions programs that may help to mitigate future flood risk such as the Hazard Mitigation Assistance suite of grant programs, HUD CDBG Disaster Recovery grants, and several others. The report also recommends several possible reforms to the NFIP that would establish risk-based insurance rates, fund mapping that factor for future conditions and provide incentives for investment in flood risk reduction measures. Additionally, the report suggests several policies that could be implemented at all levels of government, not just at the federal level. The possible policies include:

- Plan, design, build, retrofit and maintain infrastructure to withstand the reality of climate change.
- Incentivize regional flood risk planning to help consolidate funding and resources and implement flood resilience measures on a larger scale.

- Design and implement policies that incentivize good behavior.
- Ensure targeted funding and resources for disadvantaged populations.

The report concludes by stating our current climate no longer replicates many past patterns. Our future climate will only stray farther from what we have come to expect and have developed our societies to withstand. To adapt, we must understand these unfolding precipitation and flooding trends, prepare for changes, and learn to be more resilient amidst them. But, vitally, we are only adaptable to a point, beyond which the damages, costs, and strain will create deep harm. We must recognize the climate risks to the U.S. landscape that we simply cannot cope with, and we must strive to reduce changes to our climate and thus slow, and where we can, outright avoid these dangerous risks.

CLIMATE CHANGE IN THE MIDWEST: IMPACTS, RISKS, VULNERABILITY, AND ADAPTATION

S.C. Pryor, Provost's Professor of Atmospheric Science at Indiana University Bloomington and editor of the Journal of Geophysical Research Atmospheres edited and released Climate Change in the Midwest: Impacts, Risks, Vulnerability, and Adaptation in 2013. This book presents research that focuses on identifying and quantifying the major vulnerabilities to climate change in the Midwest. The book addresses the key sectors that may have vulnerabilities amplified by the effects of climate change, including agriculture, human health, water, energy and infrastructure.

The climate vulnerability assessment performed in the book came to the following conclusions for the Midwest:

1. The average temperature may increase 1 to 3 degrees Celsius over the next several decades. Projected change in the climate models indicate a clear tendency towards increased frequency of heat waves. Further cold- air outbreaks and other extreme cold spells will still occur but with reduced likelihood.
2. That rainfall will increase variably across the Midwest over the next several decades. The rainfall potential will increase 20-30% in the spring and winter months and there will be a significant increase in variability of precipitation events in the summer and fall months. There is evidence to suggest a split in future rainfall events, leading to a greater likelihood of droughts in the summer months and floods in the fall months.
3. Some other affects include the likelihood of warmer nights and possibly warmer days leading to an increased susceptibly to pests. The warming will likely cause a reduction in crop yields and the evaporation / transpiration feedback will lead to less available water resources.
4. The projected soil loss through erosion is expected to be significant and greater than anything that has occurred in the previous century.
5. The most direct impact of climate on human health is heat-related morbidity and mortality. The climate models indicate an increase in heat stress across all models over the course of the 21st century.
6. Using the concepts of stream flow elasticity, projected increases in precipitation over much of the Midwest are estimated to increase by 16- 20%

DROUGHT, EXTREME SUMMER WEATHER AND INVASIVE SPECIES

The studies and reports referenced above indicate that a warming trend will increase over the next several decades up to the extent of the studies/reports which is 2100. This warming trend will increase the possibility of extended and increased extreme heat wave events. The average temperature may increase 1 to 3 degrees Celsius over the next several decades throughout the Midwest. The projected change in the climate models indicate a clear tendency towards increased frequency of heat waves. Further cold-air outbreaks and other extreme cold spells will still occur, but with reduced likelihood. The studies suggest that a warming trend combined with increased variability of rainfall events in the summer months will lead to increasing periods of drought in the state and the Great Lakes region. The models suggest that droughts could lengthen or shift more between spring, summer and autumn beyond 2040. The warming trend will likely cause a reduction in crop yields and the evaporation / transpiration feedback will lead to less available water resources for human consumption, recreation and agricultural purposes. The changes in precipitation, drought and heat patterns will also create more heat related stress on crops and livestock. The changing weather patterns may also lead to a greater amount of crop pests and pathogens ranging farther northward.

FLOODING, SEVERE THUNDERSTORMS, SEVERE WINTER/ICE STORMS

The studies and reports referenced above indicate that one of the primary impacts on the state from climate change will be the changes in precipitation rates and variability. The studies also indicated that rainfall will increase variably across the Midwest over the next several decades. The increased variability of precipitation events will mostly occur in the summer and fall months. There is evidence to suggest a split in future rainfall events, leading to a greater likelihood of droughts in the summer months and floods in the fall months.

The studies also indicated that after the year 2040, the increases occurring in the mean and maximum stream flows will be in the 10% to 40% range with the north and northeast parts of that state experiencing greater than 40% increases. These increases appear to occur primarily from later summer until early winter, with the autumn increases in maximum stream flows enhancing early cool season flood events in late autumn/early winter. These increases also indicated the possibility of worsening spring flooding beyond 2040.

MITIGATION AND ADAPTION STRATEGIES

As the climate change data specific to the state becomes more readily available, mitigation and adaptation will be one of the focuses of dealing with the impacts of climate change. Ohio EMA has recommended four mitigation and adaption strategies that will help alleviate the future impacts of climate change on the natural hazards within the state. These strategies are recommended because they will have positive impacts regardless of climate change and its predicted long-term impacts.

DEVELOP GREATER BUILT ENVIRONMENT RESILIENCE

The built environment refers to the any buildings or structures which are manmade as opposed to the natural environment. Developing resilience in the built environment is an important mitigation action, especially when you factor for the probability of increasing precipitation rates and variability. Examples of actions that increase resilience of the built environment include:

- Reduce the number of pre-FIRM flood prone, repetitive loss and severe repetitive loss structures through FEMA mitigation grant programs.
- Adopting building, zoning and floodplain regulations that include higher standards than the minimum regulatory requirements.
- Encourage resilient local land use regulation through the Ohio Balanced Growth Initiative.

IMPROVE STORMWATER INFRASTRUCTURE

Stormwater infrastructure is normally designed to convey or capture flows associated with a designed storm event; the scale of which is based on a probability distribution of observed rainfall events. One of the underlying assumptions of the atypical design approach is that the rainfall probability distribution is static. The best available climate change models indicate that future larger precipitation events will occur with an increasing frequency. The existing stormwater infrastructure, which was designed with current storm approach, cannot be expected to provide the intended level of protection throughout its lifetime service. Examples of actions that improve stormwater infrastructure are:

- Encourage increased green infrastructure and the use of low impact development strategies to reduce stormwater.
- Seek to minimize impervious surfaces such as parking lots, roads, and rooftops in sensitive areas.
- Encourage riparian buffers along streams, rivers, and waterways to maintain natural floodplains.
- Protect and reestablish wetlands to hold runoff and recharge groundwater.
- Implement the separation of combined storm and sanitary sewer overflows to reduce pollution from sewage, bacteria, and E. Coli entering waters during storm event

INCREASE WATER QUALITY AND RESOURCE PROTECTION

The current climate change models indicate that its effects will have a variety of impacts on ground water resources and water quality. The higher water and air temperatures and changes in the timing, intensity, and duration of precipitation will impact water quality and ground water resources. Examples of actions that can be pursued to increase water quality and provide ground and surface water resources protection include:

- Encourage effective water-conservation strategies during summer months, and consider year-round water-conservation strategies for water-intensive users.
- Implement the separation of combined storm and sanitary sewer overflows to reduce pollution from sewage, bacteria, and E. Coli entering waters during storm events.
- Recommend sewer and septic systems be upgraded to reduce non-point source pollution from urban areas, farmland, and other sources.
- Ensure that water extractions and diversions are appropriately planned and factor the future impacts of climate change.

ENHANCE UTILITY AND ENERGY RESILIENCE

Water, electricity, and wastewater treatment are three utility services that are essential for modern daily life. These three utilities support business, industry, recreation, housing, hospitals and schools in communities across the state. These essential utility services have been traditionally planned, designed and operated with an assumption that the future environment is mostly static and predictable. The scientific climate change models show that increasingly variable and extreme precipitation patterns and temperature increases crises will intensify the risks faced by these essential utility services. With these risks in mind, essential utilities need to be working to strengthen their resilience to extreme climate events, also seeking ways to mitigate the impacts of climate change. Examples of actions that can be pursued to assist utilities services in increasing their resiliency include:

- Engage and educate stakeholders, having their active engagement will help to build shared an understanding and support for utility initiatives
- Strengthen existing utility transmission generation networks so they are able to cope with the future demand resulting from climate change.
- Encourage the development and construction of green infrastructure to help lessen the impact of the increasing extreme climate events.
- Support the upgrade of neglected infrastructure networks to provide an efficient supply of utilities.

ADDRESS INEQUITABLE EFFECTS OF CLIMATE CHANGE

Climate change doesn't affect all people equally, according to the report. Low-income communities and communities of color tend to be at higher risk of the impacts of climate change due to things like systemic discrimination and underinvestment in those communities. The effects of those warmer, fluctuating wet and dry conditions predicted in Ohio, tend to be amplified in low-income communities and communities of color that tend to lack things like effective infrastructure and greenspace to prevent things like flooding and warmer temperatures.

Urban areas such as Dayton, Cincinnati, Cleveland and Columbus have the potential to become heat islands, a term used to describe communities that experience hotter temperatures than surrounding neighborhoods. Per the 5th NCA, communities like these could become as much as 12 degrees hotter during a heatwave than nearby, wealthier communities because of those inequities. Examples of ways to address the inequitable effects of climate change include:

- Careful placement and design of green infrastructure provides benefits beyond flood reduction, such as reducing the urban heat island effect and providing relief to city residents during heatwaves
- Increased tree cover, weatherization programs, improved stormwater management, heat-health early warning systems, and culturally relevant climate education and climate services can yield multiple benefits for individual and community health while helping to advance more equitable climate adaptation.
- Improving data, technical services, and tools on climate-related health risks, racial and socioeconomic disparities, and socioenvironmental determinants of health would help increase the effective management of emerging and anticipated climate and health-related risks

LOCAL CLIMATE CHANGE ADAPTATION AND MITIGATON PLANS

Ohio's largest 6 cities (Columbus, Cleveland, Cincinnati, Toledo, Akron and Dayton) and the City of Athens have all, in varying levels, identified potential climate change impacts for the city and either acknowledge the need for future adaptation planning (Toledo, Dayton) or have already created adaptation/action plans (Athens, Columbus, Cleveland, Cincinnati, Akron).

Commonly identified impacts by the cities include:

- Health implications from deteriorated air quality and increased temperatures, and;
- Increased heavy precipitation and storm events.

Among cities with adaptation plans:

- Energy efficiency, transportation, water and food access are commonly reoccurring themes.

- The cities of Akron, Cincinnati and Cleveland have all identified quantitative, city-wide greenhouse gas reduction goals.
- The cities of Columbus, Cincinnati and Cleveland cite lack of federal and/or state level action on climate change as a driver for its city level adaptation and mitigation planning.

Actions/Recommendations:

- Athens has 10 key recommendations (pertaining to sustainability more generally).
- Columbus has 43 recommendations grouped into 8 thematic areas.
- Cincinnati has 80 recommendations (several recommendations per each objective).
- Cleveland has several actions per each of the 28 objectives.
- Akron has “strategies” for consideration but no finalized recommendations or actions.

The subsequent pages summarize the following documents:

- The Greenprint for Akron (2012)
- The Athens Sustainability Action Plan (2018)
- Columbus Climate Action Plan (2021)
- The Green Cincinnati Plan (2023)
- The Cleveland Climate Action Plan (2018)
- Strategy for a Sustainable Dayton (2020)
- Going Beyond Green: Toledo-Lucas County Sustainability Plan (2014)

AKRON

The City of Akron has recognized likely impacts of climate change on the city and has laid out 7 guiding principles as part of its sustainability plan for the city. The city has completed a study to identify baseline levels and sources of emissions in order to achieve tangible Green House Gas (GHG) reductions. The City of Akron’s Climate Action Plan was completed using the International Council for Local Environmental Initiatives (ICLEI)’s Climate and Air Pollution Planning Assistance software and is intended to identify where policymakers will need to target emissions reduction activities if they are to make significant progress toward adopted targets.

ATHENS

This plan was produced by the City of Athens Environment and Sustainability Commission, and it covers a range of topics including energy, economy, solid waste, food, housing and development, transportation, water, air, and greenhouse gas emissions. The City of Athens developed 10 recommendations for a path moving forward in regard to sustainability and to reduce greenhouse gas emissions.

COLUMBUS

This plan was formulated based on the collaboration between the City of Columbus leadership, Columbus Climate Commitments Working Group, and community stakeholders. The purpose of this document is to combat the effects of climate change while imparting equity and environmental justice to disproportionately affected community members. As of 2020, the City of Columbus seeks to reach carbon neutrality by 2050 based upon the recommendations from the Intergovernmental Panel on Climate Change (IPCC) and is using guidance based off of the Paris Climate Agreement. The Action Plan includes 13 strategies and 32 quantifiable actions. In developing the plan, an acknowledgement towards mitigation and adaptation were made to address both the cause and effect of climate change. Just to name a few, some of the existing and anticipated impacts that were identified: increased precipitation, increased flooding and flood risk, impact on vulnerable infrastructure, extreme heat, and deteriorated air quality. This plan builds upon existing plans and programs within the city such as Sustainable 2050, Smart Columbus, Clean Energy Columbus, SWACO Solid Waste Management Plan, Blueprint Columbus, and Sustaining Scioto.

CINCINNATI

The Green Cincinnati Plan has been the City's sustainability plan since 2008. Updated every five years (2013, 2018, and now 2023), the GCP has helped Cincinnati earn a reputation as an international leader in climate action. Since 2008, the actions outlined in the GCP have helped deliver a 36.6% reduction in the City's carbon emissions. The 2023 GCP is organized into eight Focus Areas that articulate the City's Visions, Goals, Strategies, and Actions in response to the climate crisis. These areas include Buildings and Energy, City Operations, Community Activation, Food, Mobility, Natural Environment, Resilience & Climate Adaptation, and Zero Waste.

CLEVELAND

The 2013 Cleveland Climate Action Plan (updated in 2018) established an overarching GHG reduction goal of 80% below 2010 emissions by 2050, with interim goals of 16% reduction by 2020 and 40% reduction by 2030. The plan identified 28 objectives across five focus areas (energy efficiency and green building, clean energy, sustainable transportation, clean water and vibrant green space, more local food, less waste) and cross-cutting priorities as well as goals through numeric targets and time frames for achieving targets. Additionally, it identifies actions, which are specific strategies that will be implemented to meet the goals and objectives.

DAYTON

This sustainability plan was crafted by the Dayton City Department Heads, the Environmental Advisory Board, and the Internal City Green Team. One of the main objectives is to guide the city in a green and resilient direction. Dayton's strategies are oriented towards becoming as sustainable (efficient) as possible, and to plan for more frequent, severe storms and extreme weather events to come, and ensure that the community and vulnerable populations are as resilient as possible in recovering from these events.

A framework was developed that created goals for a focus area and 5 key principles that can be seen in the recommendations within every focus area. The five principles were based off of what stakeholders thought would create a sustainable direction for the city by incorporating climate mitigation, infrastructure, resilience, economic development, and equity into each focus area. The climate mitigation principle details the importance of protecting natural resources, especially water and air, and limiting greenhouse gas emissions. The focus areas that Dayton has selected for this plan; ground and surface water projects; air pollution projects; renewable energy projects; climate change adaptation projects; solid waste management projects; land use and community garden projects; transportation projects; financial projects; and environmental awareness projects. Each of these focus areas include an overview of the existing context within Dayton, and provides intended action items related to promoting sustainability within the scope of the aforementioned 5 key principles.

TOLEDO

Two plans were referenced including the Going beyond Green: Toledo-Lucas County Sustainability Plan (2014) and the Toledo Recovery Plan (2021). The intention of the Going Beyond Green Plan is taking a broader look into the partnership between Toledo-Lucas County region to protect and restore natural systems, enhance social systems, and grow healthy economic systems in our communities. Also known as the triple-bottom line, these three systems were translated into 7 focus areas. Within the natural systems, the focus area includes concern for water quality and supply as well as land and natural resource use. The social system focus area will examine healthy, active, and safe communities together with education, engagement, and empowerment. The economic systems will manage assess community vitality; infrastructure investments; and economy and workforce development. Within these focus areas, there were 21 priority actions as well as 4 catalyst project that aim to jump-start the Going Beyond Green plan. The 2021 Recovery Plan was linked to funding associated with COVID 19 federal relief. This plan focusses on community building goals with a prioritization of sustainability including more efficient housing, uptown sewer/water innovation project, and an extension of urban forest canopy funding.

UNIVERSITY CLIMATE ACTION PLANS

Many universities participated in agenda-setting for climate change, mitigating climate change impacts, and achieving climate neutrality. Many of the listed schools framed their plans and are signatories of the American College and University President's Climate Commitment (ACUPC) produced by Second Nature. This university-level leadership aspires to take action with regard to carbon neutrality and resilience in order to transform society towards a sustainable, healthy, and prosperous future. Other universities created these plans as a result of the International Panel on Climate Change (IPCC) report about the importance of achieving "net zero" emissions by 2050.

THE UNIVERSITY OF TOLEDO CLIMATE ACTION PLAN, 2011

This plan was formulated on the commitments toward climate neutrality that were set by the American College and University Presidents Climate Commitment. This plan is motivated by two actions that the University of Toledo will commit to for completing the ACUPC goals: establish a policy that all campus structures will be built to U.S. Green Building Council's LEED Silver standard or equivalent and encourage and provide access to public transportation for all faculty, staff, students. The mitigation plan was framed with reducing Carbon emissions and developing strategies around mitigating these emissions. Some of the university's commitments outlined in the document includes establishing an institutional structure, measuring greenhouse gas emissions, tangible actions, climate action plan, and reporting requirements.

BOWLING GREEN STATE UNIVERSITY CLIMATE ACTION PLAN, 2015

This plan was formulated toward achieving climate neutrality by 2040 based off of the American College and University President's Climate Commitment. This plan provides "Tangible Actions" as a result of delving in to the university's contributions of carbon emissions. These actions include strategies for waste management, increasing access and usage to public transportation, establishing a new construction policy that adheres to U.S. Green Building Council's LEED Silver Standard or equivalent, and adopting energy efficient appliance purchases that are Energy Star certified. The plan has four areas of focus which include energy, transportation, solid waste, and education and research. In these different areas of focus, the university displays the current status, the goals, and the proposed actions to take upon to mitigate carbon emissions.

DENISON UNIVERSITY CAMPUS SUSTAINABILITY PLAN, 2015

This plan has an emphasis on sustainability efforts. Several efforts Denison has been a part of toward sustainability includes signing the Talloires Declaration, forming the Campus Sustainability Committee, creating an Office of Sustainability, and signing the President's Climate Commitment. Denison's goal outlined in their previous 2012 Sustainability Plan includes achieving carbon neutrality by 2030. Five focus areas have been defined in which to achieve the various goals they had set teaching, education, and research; community; energy and emissions; dining; other campus operations.

OBERLIN COLLEGE CARBON NEUTRALITY RESOURCE MASTER PLAN, IMPLEMENTATION, STRATEGY, AND ECONOMIC APPROACH, 2016

This plan discusses Oberlin College's role of carbon neutrality, specifically, in reference to the American President's Climate Commitment for achieving neutrality in 2025. As a result, this plan identified actionable, implementable, and financeable steps so that Oberlin College can achieve to overarching goal of carbon neutrality. In order to better understand how to set goals toward carbon neutrality, this plan provides an existing context and analysis of Oberlin's campus. The original phase of the plan tackled energy and electricity strategies, and to expand it further, two other strategies were developed to continue a path forward incorporating the implementation of energy and water conservation measures as well as adopting a hot water energy system.

UNIVERSITY OF CINCINNATI SUSTAINABILITY + CLIMATE ACTION PLAN, 2019

The University of Cincinnati developed a plan that emphasizes the campus's role with sustainability and climate action using the Second Nature, American College & University Presidents' Climate Commitment, and Advancement of Sustainability in Higher Education frameworks to motivate the formation of this plan. There was an effort to coordinate the City of Cincinnati's Office of Environment and Sustainability and University of Cincinnati's Office of Sustainability to determine linkages and connections between the city and the university's Climate Action plans. Several topical connections were identified to be addressed such as the built environment, education and outreach, energy, food, natural systems, resilience, transportation, and waste. Within each of these topical areas, subtopics were developed that may be directly or indirectly correlated to mitigation efforts including the development of a Sustainability District, supporting urban agriculture, supporting stormwater management practices, conducting an urban heat island assessment, preparing for emergencies as a result of climate change, just to name a few.

THE PATH TO CARBON NEUTRALITY: OHIO STATE CLIMATE ACTION PLAN, 2020

The Ohio State University developed a plan to achieve carbon neutrality by 2050. This builds upon the American College & University President's Climate Commitment, university-wide sustainability goals developed in 2015, as well as prior Climate Action Plans. There are two stated goals for achieving carbon neutrality by addressing both university building energy use and transportation related emissions. In doing so, research related to the existing conditions has been conducted as a foundation for strategies moving forward. Some of the key recommendations for carbon management that have been divulged include use the following framework: avoid new emissions, reduce existing emissions, replace sources of emissions, and offset remaining emissions. To avoid emissions, the strategy is to minimize consumption of carbon-intensive activities. To reduce emissions, the strategy is to make the university's current operations more efficient. To replace emissions, this involves change the sources of energy that are more carbon-intensive to transition to renewable energy sources. In offsetting emissions, the university aspires to obtain certified credits through projects like direct sequestration and emission displacement.

OHIO UNIVERSITY SUSTAINABILITY AND CLIMATE ACTION PLAN, 2021

The essence of this plan is to provide a road map in achieving carbon neutrality based upon the Presidents' Carbon Commitment and the OHIO strategic priority of "enhancing the University's national position as a cutting-edge laboratory for sustainability." In addition to these two commitments, the university also aligns with the Advancement of Sustainability in Higher Education; Sustainability Tracking, Assessment, and Rating System; and the United Nations Sustainable Development Goals. Within the plan, there are 4 broad categories and 16 topical sections that are divided into understanding current conditions, goals related to the topic, metrics to achieve the goals, strategies moving forward, and cost and benefit of implementation. The topics included within the plan are administrative support, Accessing accurate climate information, education, and interpretation is critical for policy makers and all sectors of Ohio's economy and will enhance the quality of life, health, food and water security, and economic prosperity of Ohioans.

CLIMATE CHANGE ADAPTATION LITERATURE AND STUDIES REVIEW

There are several current studies that suggest various climate change adaption strategies for the Great Lakes or Midwestern region. Many of these studies do not provide enough downscaled data or go into sufficient detail to warrant full inclusion within this current iteration of the plan update. As climate science evolves and improves, future updates to this plan will incorporate any new or improved relevant climate change adaption strategies.

THE STATE CLIMATE OFFICE OF OHIO

http://changingclimate.osu.edu/

The State Climate Office of Ohio (SCOO) is a new team based at The Ohio State University (OSU) that connects Ohioans with transformative climate information. SCOO embodies four core mission activities focused on connecting people and climate: Communication, Information Services, Education & Outreach, and Research. They have already forged many partnerships that should yield positive impacts with regard to climate-related engagement and communication, including connections with OSU Extension in the College of Food, Agriculture, and Environmental Science (CFAES) and its associated instrumental observation network, the Ohio Agricultural Research and Development Center (OARDC) Weather Network; the Ohio Emergency Management Agency (OEMA); and the Midwest Regional Climate Center (MRCC).

NOAA – NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION STATE SUMMARY OF OHIO

https://statesummaries.ncics.org/oh

The State Climate Summaries were produced to meet a demand for state-level information in the wake of the Third U.S. National Climate Assessment, released in 2014. The summaries cover assessment topics directly related to NOAA's mission, specifically historical climate variations and trends, future climate model projections of climate conditions during the 21st century, and past and future conditions of sea level and coastal flooding.

The three key takeaways from the Ohio Summary are:

- Historically unprecedented warming is projected by the end of the 21st century and increases in extreme heat are of particular concern for Cincinnati, Columbus and other urban areas where urban heat island effect raises summer temperatures.
- Winter and spring precipitation are projected in increase. Extreme precipitation is projected to increase, potentially causing more frequent and intense floods.
- The intensity of future droughts is projected in increase. Future summer droughts are likely to be more intense.

SMART GROWTH FIXES FOR CLIMATE ADAPTATION AND RESILIENCE- EPA

https://www.epa.gov/smartgrowth/smart-growth-fixes-climate-adaptation-and-resilience

The Environmental Protection Agency's (EPA) Smart Growth Fixes for Climate Adaptation and

Resilience: Changing Land Use and Building Codes and Policies to Prepare for Climate Change (2017) is intended to help local jurisdictions develop strategies to prepare for climate change impacts through land use, zoning and building code policies. The policy options described in this publication bring multiple short- and long-term environmental, economic, health, and societal benefits that can not only prepare a community and its residents and businesses for the impacts of climate change, but also improve everyday life.

The strategies can be worked into a local community's regular processes, for example, through scheduled updates to zoning and building codes. This approach allows incremental change, which might be easier for some communities because it costs little or nothing extra compared to "business as usual", and gives communities the opportunity to adjust codes based on the most up-to-date climate observations and projections. To help communities determine which policy and code changes might be best for them, the options in each chapter are categorized as modest adjustments, major modifications, and wholesale changes.

The options can address one, some or all of the following hazards: flooding and precipitation, sea level rise, extreme heat, drought, and wildfire. Examples of the options include, but are not limited to:

- Use regional climate change, population demographics, transportation demand, and related projections to understand where community assets could be vulnerable.
- Evaluate development incentives to see if they encourage development in particularly vulnerable areas.
- Design open space in flood plains for multiple amenities.
- Adopt a site plan requirement that requires all new development to retain all stormwater on-site.
- Establish a task force to review building codes, development patterns, and other relevant issues.

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

While the availability of downscaled climate change data has become more readily available at nationally compared to the previous iterations of this plan, there is still a lack of easily accessible and digestible downscaled data for the State of Ohio and the Midwest in general. As quality data becomes more readily available the state will assess it vulnerability in terms of population, structures and critical facilities at risk. The state will also encourage the inclusion of such data in local hazard mitigation plans once the data is granular enough to support the analysis.