State of Ohio
Hazard Identification and Risk Assessment
(HIRA)

Ohio Emergency Management Agency
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Foreword

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This 2018 edition of the State of Ohio Hazard Identification and Risk Assessment (HIRA) provides current research and updates on those natural, technological and human-caused hazards to which the state of Ohio is most vulnerable. Knowledge of these hazards, their frequency, and the state's overall vulnerability to them allows state and local government officials to better assess their risks and to plan and prepare for the consequences.

This revision is an update to the Spring/ Summer 2013 HIRA. This HIRA has been reviewed in its entirety, with all information evaluated and updated as necessary. This document was prepared by Planning, Training and Exercise Branch at the Ohio Emergency Management Agency (Ohio EMA) with the assistance of all branches within the agency and other state/federal partners. The information contained in this HIRA is a compilation of research from federal, state, and local government sources, as well as from public sources.

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Introduction

The intent of this document is to be a useful tool for state and local emergency management partners to rate the risk, determine vulnerability, and predict the adverse impact of disasters and emergencies. The HIRA does not provide policy or action-based recommendations to manage hazards. This document is one element of a comprehensive emergency management program that incorporates mitigation, preparedness, response and recovery. Mitigation plans, the State of Ohio Emergency Operations Plan, as well as standard operating procedures, round-out a comprehensive program to manage hazards.

Emergency management in Ohio is governed by Ohio Revised Code (ORC) 5502. Section 5502.21 mandates that the EMA, a division of the Department of Public Safety, is the primary coordinating agency for statewide emergency readiness activities to meet the threats posed by various hazards.[1] In cooperation with other state offices and agencies, the agency has developed this analysis of the primary hazards that may threaten both lives and property.

For the purpose of this HIRA, we will use the ORC definition of hazard. 'Hazards' in Chapter 5502.21 of the ORC are defined as: "… any actual or imminent threat to the survival or overall health, safety, or welfare of the civilian population that is caused by any natural, human-made, or technological event."[2]

A catastrophic incident, as defined in the FEMA National Response Framework, is "any natural or manmade incident, including terrorism that results in extraordinary levels of mass casualties, damage, or disruption severely affecting the population, infrastructure, environment, economy, national morale, and/or government functions."

As defined by the ORC, "Hazard identification means an identification, historical analysis, inventory, or spatial distribution of risks that could affect a specific geographical area and that would cause a threat to the survival, health, safety, or welfare of the civilian population, the property of that population, or the environment."[3] The National Fire Protection Association (NFPA) Standard 1600 requires entities to "identify hazards, monitor those hazards, the likelihood of their occurrence, and the vulnerability of people, property and the environment, and the entity itself to those hazards"[4] as part of the risk assessment process.

Upon reviewing the literature in hazard analysis, over seventy hazards were identified. These hazards include those listed in NFPA 1600, the Homeland Security Council and DHS-developed National Planning Scenarios, Ohio EMA's State of Ohio Enhanced Hazard Mitigation Plan, and Ohio Homeland Security documents.

To help categorize the hazards, this HIRA analysis utilizes three major groups based primarily on the categories recommended in the Federal Emergency Management Agency's Comprehensive Preparedness Guide 101. The categories are Natural, Human Caused and Technological as shown in Figure 1. Each of the hazards identified are not mutually exclusive. Some hazards are not germane to Ohio and/or not likely enough a scenario to warrant consideration in this hazard identification and risk analysis.

A General Overview of Hazards in Ohio

The most damaging hazards/events in Ohio are floods and tornadoes. Other severe weather events, such as winter storms, have also led to floods or costly recovery actions. Drought has also led to agricultural losses and forced water users to seek assistance during these sustained periods of insufficient precipitation. Ice storms can take a greater toll, especially in regards to travel, infrastructure, and power and communication lines. When an ice storm strikes, roads can turn deadly, leaving schools and businesses closed.

For over 200 years, earthquakes, often centered in the Anna (Shelby County) Seismic Zone, have also occurred in Ohio, with most classified as “minor” in nature. Northeastern Ohio, east of Cleveland, has been particularly active in recent years. A large-scale (regional) event involving the New Madrid, Missouri fault, could significantly affect portions of southwestern Ohio.

Activities associated with humankind also have their effects such as woodland and field fires which represent high economic impact to costly resources. Mine closings have led to issues related to subsidence and landslides. From the 1940s until the present, closings were made without actions to prevent shaft collapses. Urban expansion, or new highway construction, has led to damages related to these collapses. Class I and other earthen dams also pose a potential threat to adjacent or downstream communities. Many of these dams serve as up-ground reservoirs or recreational sites. If not properly built or maintained, they may fail, leading to downstream flooding and strained response capabilities.

In addition to fossil fuels, electric power generation uses nuclear technology. Three nuclear generating facilities are sited in, or within five miles of, Ohio. The 50-mile ingestion pathway from the Enrico Fermi plant in Michigan also extends into Ohio. Three separate U.S. Department of Energy (DOE) facilities also pose a potential risk. The issue of on-site waste treatment and the removal from these sites poses a unique hazard for adjacent communities. In the event of a problem, local subdivisions (and the state) would be engaged in extensive recovery actions. Two of the three DOE facilities are in the process of being decommissioned.

Passenger and cargo airlines continue to cover the state’s airspace daily and railway accidents remain a matter of concern in areas of high traffic density. Like other hazards, transportation events may not occur regularly, but authorities in areas with a high density of air or rail traffic should weigh the potential of a transportation emergency.

Since 1964, nearly 60 major emergency events in Ohio have received a Presidential Declaration of Disaster. As a result, Ohioans have received hundreds of millions in federal assistance monies. The Ohio EMA has aided both the public and private sectors in obtaining this assistance. Although hazards may either decrease, or increase, from a strictly numerical standpoint, inflationary labor and material trends have caused overall recovery costs to rise. Each new event is more costly to the state and nation than its predecessors.

As national mutual aid between states grows, our state may have to respond to hazards not necessarily associated with Ohio. Most recently, Ohio sent personnel and equipment to Texas, Florida, Massachusetts, the Carolinas, the Virgin Islands, Puerto Rico, Hawaii, and North Dakota in response to EMAC requests.

An Ohio Profile

All geographical and political subdivisions of the state are vulnerable to some form of natural, technological, or other hazard. The effects of these hazards (regardless of type or size) will vary due to geography, climate or land use. Examination of the State's characteristics provides a better understanding of these hazards and their associated risks.

Geography and Climate

With a total land area of 40,952.6 square miles, and a 2017 population in excess of 11,658,609 (a gain of approximately 100,000 persons since the last risk assessment), nationally, Ohio ranks 34th in total area, and 7th in population.

Topographically, the state presents a varied combination of landforms, which are diagonally divided across the state between the flat, glaciated, areas of the north-northwest, to the unglaciated highlands in the south and southeast. The steeply incised landforms in the south and east often contribute to flooding, mudslides, and other effects via rapid runoff from heavy rains and melt water. In the north and west, the level topography is subject to flooding when heavy snowstorms are followed by rapid melt water discharges.

The state possesses a continental climate ranging through the year from cold, damp winters, to warm, humid summers with prevailing westerly wind patterns throughout the year. The average temperature in Ohio is 52.5°F with an average monthly high of 86°F (July) and average monthly low of 19°F (January). The average annual rainfall is 40.16 inches.

Ohio's Economy

Ohio has a diversified economy, with goods-producing activities including agriculture, natural resources and mining, construction, and manufacturing, which contribute $53.1 billion to the state's economy; an 18% increase from 2011. The majority of this increase is due to recent increases in the extraction of the shale oil resources of the southeastern highlands.

Ohio's $10 billion agricultural industry is dependent on the State having some of the most fertile and ideal farming conditions in the country. The west and northwest sections of the state are characterized by glaciated plains, with large deposits (up to 400 feet-deep) of fertile soil and wide expanses of lands that were flattened by glacial retreat, which make these rich lands ideal for agricultural production with modern, heavy farm machinery.

Major service industries/trade, such as utilities, healthcare, finance/insurance, and business services contribute another $163 billion to the state's growing economy.

An extensive transportation network of roads, rail lines, waterways, and air travel supports the state's economy. State, federal and interstate highways form connecting links to, or around, major metropolitan areas. The state's large and medium-sized cities host commercial air traffic carriers. Ohio's railway infrastructure ranks fourth nationally in rail route mileage, and eighth overall in carloads carried. Waterborne commerce (via barge or ship) contributes to local economies along the Ohio River and along the Lake Erie shore.

Historical Review of Disasters

For almost 200 years, the State of Ohio has recorded casualties (injuries and fatalities) associated with disasters varying in origins and effects. The more noteworthy of these, which resulted in loss of life or economic damages, are listed in Figure 1. Historical Events and Impacts below.

Figure 1. Historical Events and Impacts

Name of Disaster	Year	Hazard/Event Type	Location	Casualties
Cholera Epidemic	1849/50	Bio/Epidemiological	Statewide	5,000 +
Rail Bridge Collapse	1876	Transportation	Ashtabula	92
Collinwood School Fire	1908	Fire	Cleveland	17
Easter Flood	1913	Flood	S/SW Ohio	467
Influenza Epidemic	1918	Bio/Epidemiological	Statewide	Multiple Thousands
Sandusky/Lorain Tornado	1924	Tornadoes	Lorain and Sandusky	85
Cleveland Clinic Fire	1929	Fire	Cuyahoga	123
Millwood Mine Disaster	1930	Mine Fire – Collapse	Athens Co.	82
Penitentiary Fire - Columbus	1930	Prison Fire	Franklin Co.	322
Extreme Heat	1934	Heat Wave	Statewide	160
Winter Flood	1937	Flood	Statewide	250
Gas Explosion & Fire	1944	Technological + Fire	Cleveland	130
Blizzard	1950	Winter Storm	Statewide	Unknown
Penitentiary Fire - Columbus	1952	Prison Fire	Franklin Co.	0
Winter/Spring Floods	1959	Flood	Statewide	Unknown
Nursing Home Fire	1963	Fire	Marietta	95
Tornado	1965	Tornadoes	Toledo, Lima, Strongsville. Delaware, Mercer, Seneca, and Shelby counties	55
Lake Central/TWA Crashes	1967	Transportation	N&W Ohio	70 + (Combined)
Prison Riot - Columbus	1968	Other (Prison Riot)	Franklin Co.	5
Xenia Tornadoes	1974	Tornadoes	Greene Co.	30; 1150 injured
Blizzard	1978	Winter Storm	Statewide	51
Explosion/Fire - Miamisburg	1986	Technological + Fire	Butler Co.	0
Train wreck-HAZMAT Spill	1986	Transportation	Miamisburg	0
Flash Flood – Shadyside	1990	Flash Flood	Belmont Co.	26
Prison Riot – Lucasville	1993	Other (Prison Riot)	Scioto Co.	11
Floods (from snow runoff)	1996	Flood	Statewide	0

Name of Disaster	Year	Hazard/Event Type	Location	Casualties
Severe Storms/Floods	1997	Flood	Southern Ohio	5
Severe Storms/Floods	1998	Flash Flood	Central/east central & SE	12
Xenia Tornadoes	2000	Tornadoes	Greene Co.	1; 100 injured
Van Wert Tornado	2002	Tornadoes	Van Wert (1 of 83 tornadoes in 17 states)	5
Winter Storms	2004-05	Severe Winter Weather	Statewide	0
Severe Winter Weather	2005	Ice Storm	Statewide	0
Severe Storms	2007	Flooding	Statewide	0
Wind Storm	2008	High Wind Storm	Statewide	7
H1N1	2009/10	Pandemic	Statewide	119 (total influenza deaths, including H1N1)
Severe Weather & Tornadoes	2010	Tornado	Wood, Fulton, Ottawa & Lucas counties	6
Severe Weather; Flooding	2011	Flooding	Ohio River	0
Winter Storm	2012	Blizzard	NW Ohio	0
Severe Weather (Derecho)	2012	High Wind	From NW Ohio to SE Ohio	1 (subsequent heatwave may have caused other deaths)
Hurricane Sandy	2012	Hurricane; High Wind	Northern Ohio	0
Train Derailment/Explosion	2012	Technological - HazMat	Franklin	
Severe Weather and Tornadoes	2012	Tornado; Severe Thunderstorms	Clermont, Hamilton, Highland, Pike, Adams, Lawrence, Athens	4
Cridersville Tornado	2013	High Wind, Flooding	Auglaize, Perry, Morrow	0
Traffic Accidents (90 car pileup)	2013	Winter Storm	SW Ohio	1; 28 injured
Flooding	2014	Flooding	Summit, Clark, Highland	0
Toledo Water	2014	Harmful Algal Bloom	Lucas	0
Severe Weather	2014	Power Outage, Propane Shortage	Summit	0
Ebola Response	2014	Public Health Emergency	Summit	0

Name of Disaster	Year	Hazard/Event Type	Location	Casualties
Severe Weather	2014	Tornado, High Wind	Mahoning, Highland	0
Winter Storm	2014	Winter Storm, Power Outage	Gallia, Darke, Warren, Highland	0
Akron Plane Crash	2015	Aircraft	Summit	9
Argo Shipwreck	2015	HazMat	Lake Erie	0
Kettering Tornado	2015	Tornado	Montgomery	0
Stark County Radium Response	2016	Radiological	Stark	0
Tornadoes	2016	Tornado	Statewide (24)	0
Tornadoes	2017	Tornado	Statewide (39)	0
Cincinnati Fifth Third Bank Shooting	2018	Active Aggressor	Hamilton	4 (incl. shooter)/2 injured
Flooding	2018	Flood	SE Ohio and Ohio River	1
Ross Correctional Facility Unknown Substance	2018	Public Health Emergency	Ross	0

Source: *Ohio Almanac/Contributing agencies/Ohio EMA*

The previous figure shows some of the historically serious events (with hazards) occurring since 1849 by events and mortality statistics, but not property damages or other costs.

Since 1964, many events have received a Declaration of Disaster by the President of the United States as shown in Figure 2. Presidential Major and Emergency Disaster Declarations in Ohio with Costs, by County (1964-18) which provides a breakout of the types of federal assistance, funds provided, incident type, as well as date declared with federal disaster number.

These incidents have affected both people and property. Gubernatorial Declarations have often been used for a number of other events, not qualifying for federal assistance via Presidential Declarations, as “Emergencies” or “Disasters.” This process serves to initiate coordinated state response efforts for areas requiring assistance beyond local capabilities.

Figure 2. Presidential Major and Emergency Disaster Declarations in Ohio with Costs, by County[5] (1964-18)

Disaster Declaration Number	Date Declared	Federal Disaster Programs	Incident Type	Counties Declared	Funds Provided
DR- 167	March 24, 1964	PA	Heavy rains and flooding	Adams, Athens, Auglaize Belmont, Brown, Butler, Carroll, Clermont, Clinton, Columbiana, Coshocton, Cuyahoga, Delaware, Fairfield, Franklin, Gallia, Geauga, Guernsey, Greene, Hamilton, Harrison, Hocking, Jackson, Jefferson, Lake, Lawrence, Licking, Medina, Meigs, Miami, Monroe, Morgan, Muskingum, Noble, Perry , Pickaway, Pike, Preble, Richland, Ross, Scioto, Summit, Trumbull, Tuscarawas, Vinton, Warren, Washington,	$571,482 (P)
DR- 191	April 14, 1965	PA	Tornadoes and high winds	Allen, Cuyahoga, Delaware, Hancock, Harrison, Highland, Lorain, Lucas, Medina, Mercer, Morrow, Pickaway, Seneca, Shelby, Van Wert	$275,248 (P)
DR- 238	May 4, 1968	PA	Tornadoes	Brown, Clermont, Gallia, Licking, Scioto	$270,000 (P)
DR- 243	June 5, 1968	PA	Heavy rains and flooding	Adams, Athens, Brown, Butler, Clermont, Clinton, Fairfield, Franklin, Fayette, Gallia, Greene, Guernsey, Hamilton, Hocking, Jackson, Lawrence, Licking, Meigs, Monroe, Montgomery, Morgan, Noble, Perry, Pickaway, Pike, Ross, Scioto, Vinton, Warren, Washington	$600,000 (P)
DR- 266	July 15, 1969	PA	Heavy storms and floods	Ashland, Ashtabula, Coshocton, Cuyahoga, Erie, Harrison, Holmes, Huron, Lake, Lorain, Lucas, Medina, Morgan, Muskingum, Ottawa, Richland, Sandusky, Seneca, Stark, Trumbull, Tuscarawas, Wayne, Wood	$1,000,000 (P)
DR- 345	July 19, 1972	PA	Storms and flooding	Ashtabula, Belmont, Cuyahoga, Jefferson, Lake, Lorain, Monroe	$1,328,098 (P)
DR- 362	November 24, 1972	PA	Storms and flooding	Erie, Lake, Lorain, Lucas, Ottawa	$615,863 (P)
DR- 377	April 27, 1973	PA	Storms and flooding	Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa, Sandusky	$1,417,975 (P)
DR- 390	June 4, 1973	PA	Mudslides	Hamilton, Washington	$1,434,684 (P)

Disaster Declaration Number	Date Declared	Federal Disaster Programs	Incident Type	Counties Declared	Funds Provided
DR- 421	April 4, 1974	PA/IFG	Tornadoes and high winds	Adams, Butler, Clark, Delaware, Fayette, Franklin, Greene, Hamilton, Madison, Paulding, Pickaway, Putnam, Summit, Warren,	$10,250,454 (P) $1,945,833 (I)
DR- 436	May 31, 1974	PA	Heavy rains and flooding	Lucas, Ottawa, Sandusky	$858,824 (P)
DR- 445	July 11, 1974	PA	Heavy rains and flooding	Warren	$507,364 (P)
DR- 480	September 11, 1975	PA	Floods	Belmont, Cuyahoga, Jefferson, Lake,	$3,320,493 (P)
DR- 3055-EM	January 26, 1978	PA	Severe blizzard conditions	All 88 counties	$3,546,669 (P)
DR- 630	August 23, 1980	PA/IFG	Heavy rains and flooding	Belmont, Columbiana, Guernsey, Jefferson, Monroe, Muskingum, Noble	$1,653,327 (P) $669,820 (I)
DR- 642	June 16, 1981	PA/IFG	Tornado, high winds and flooding	Hancock, Morrow, Putnam, Wyandot (IA) Morrow (PA)	$346,950 (P) $47,382 (SCB)** $515,593 (I)
DR- 653	March 26, 1982	PA/IFG	Flood	Defiance, Fulton, Henry, City of Toledo (Lucas), Paulding, Wood County (IA)	$157,390 (P)
				Defiance, Paulding, Village of Grand Rapids (Wood only) (PA)	$268,187 (I)
DR- 738	June 3, 1985	PA/IFG	Tornadoes	Ashtabula, Columbiana, Coshocton, Licking, Portage, Trumbull (IA)	$1,556,950 (P)
				Trumbull (PA)	$419,751 (SCB)** $424,893 (I)
DR-796	June 9, 1905	IFG	Floods	Crawford, Marion, Morrow, Richland	$1,066,258 (I) $266,564 (SCB)**

Disaster Declaration Number	Date Declared	Federal Disaster Programs	Incident Type	Counties Declared	Funds Provided
DR- 831	June 10, 1989	IFG	Severe storms and flooding	Butler, Coshocton, Cuyahoga, Franklin, Geauga, Greene, Lake, Licking, Lorain, Mercer, Montgomery, Preble, Warren	$2,363,868 (I) $590,967 (SCB)**
DR- 870	June 6, 1990	PA/IFG/HMGP *	Severe storm, tornadoes, and flooding	Athens, Belmont, Butler, Columbiana, Fairfield, Hamilton, Harrison, Hocking, Jackson, Jefferson, Lawrence, Licking, Monroe, Muskingum, Perry, Pike, Richland, Vinton (PA/IA) Clermont, Franklin, Mahoning, Morrow, Madison, Ross, Trumbull (IA only)	$10,847,075 (P) $4,331,497 (I) $3,849,783 (SCB)** $630,000 (M) $630,000 (S)
DR- 951	August 4, 1992 (IA)	PA/IFG/HMGP *	Severe storms, tornadoes, flooding	Cuyahoga, Franklin, Logan, Mahoning, Medina, Mercer, Ross, Shelby, Summit, Trumbull, Van Wert (PA/IA)	$8,308,334 (P)
	August 14, 1992 (PA/HMGP)			Auglaize, Belmont, Columbiana, Erie, Fairfield, Fulton, Geauga, Jefferson, Lorain, Lucas, Ottawa, Portage, Wood (PA only)	$2,081,117 (I) $2,474,083 (SCB)** $250,000 (M) $350,000 (CDBG)+
DR-1065	August 25, 1995	IFG/HMGP	Severe storms and flooding	Champaign, Erie, Logan, Lorain, Licking, Marion, Mercer, Miami, Scioto, Shelby, Washington	$3,493,319 (I) $81,731 (SCB)** $721,500 (M)
DR-1097	January 27, 1996	PA/IFG/ HMGP	Ohio River flooding	Adams, Belmont, Columbiana, Gallia, Jefferson, Lawrence, Meigs, Monroe, Scioto, Washington (PA/IA) Brown, Clermont, Hamilton (IA)	$4,335,000 (P) $1,822,056 (I) $1,617,991 (SCB)** $1,721,655 (M)
DR-1122	June 24, 1996	PA/HMGP	Severe storms and flooding	Adams, Belmont, Brown, Butler, Clermont, Gallia, Hamilton, Hocking, Jefferson, Lawrence, Meigs, Monroe, Paulding, Scioto, Vinton, Williams	$10,811,838 (P) $2,702,960 (S) $1,137,951 (M)

Disaster Declaration Number	Date Declared	Federal Disaster Programs	Incident Type	Counties Declared	Funds Provided
DR-1164	March 4, 1997	IA/PA/HMGP	Flash flooding on inland rivers/streams and Ohio River flooding	Adams, Athens, Brown, Clermont, Gallia, Hamilton, Highland, Hocking, Jackson, Lawrence, Meigs, Monroe, Pike, Ross, Scioto, Vinton, Washington (IA/PA/HMGP) and Morgan (PA/HMGP)	$29,666,825 (P) $22,196,350 (I) $9,821,524 (M) $9,821,524 (S) $9,740,294 (NRCS)*+
DR-1227	June 30, 1998	IA/PA/MIT	Flash flooding, flooding, high winds and tornadoes.	Athens, Belmont, Coshocton, Guernsey, Harrison, Jackson, Jefferson, Knox, Meigs, Monroe, Morgan, Morrow, Muskingum, Noble, Ottawa, Perry, Pickaway, Richland, Tuscarawas, Washington; (IA only) Franklin, Sandusky (PA only) Holmes	$21,803,771 (P) $14,312,348 (I) $9,000,000 (M) $9,000,000 (S) $10,410,817 (NRCS)*+
DR-1321	March 7, 2000	IA/MIT	Flash flooding, flooding	Adams, Gallia, Jackson, Lawrence, Meigs, Pike and Scioto	$1,914,189 (I) $297,310 (M) $297,310 (S)
DR-1339	August 25, 2000	IA/MIT	Flooding	Lucas	$7,898,840 (I) $1,132,279 (M) $1,132,279 (S)
DR-1343	September 26, 2000	IA/PA/MIT	High winds and tornadoes	Greene	$189,051 (I) $3,430,810 (P) $558,025 (M) $558,025 (S)
DR-1390	August 8, 2001	PA/MIT	Flooding	Brown, Butler, Clermont and Hamilton	$ 7,712,456 (P) $ 876,439 (M) $ 876,439 (S)
DR-1444	November 18, 2002	IA/MIT	Tornados, Severe Storms	Ashland, Auglaize, Coshocton, Cuyahoga, Franklin, Hancock, Henry, Huron, Lorain, Medina, Ottawa, Paulding, Putnam, Sandusky, Seneca, Summit, Union, Van Wert, Wayne and Wood	$ 11,668,849 (I) $ 139,068 (M) – $ 48,409 (S) $ 2,297,222 (SDRP)
DR-1453*	March 24, 2003	IA/PA/MIT	Ice/Snow Storm	Adams, Gallia, Jackson, Lawrence, Meigs, Pike and Scioto (IA/PA); Athens, Belmont, Darke, Delaware, Fayette, Franklin, Greene, Guernsey, Harrison, Hocking, Licking, Madison, Miami, Monroe, Morgan, Montgomery, Muskingum, Noble, Perry, Preble, Ross , Union, Vinton and Washington (PA)	$ 16,689,841 (I) $ 39,621,605 (P) * $ 2,415,899 (M) $ 2,415,899 (S) -

Disaster Declaration Number	Date Declared	Federal Disaster Programs	Incident Type	Counties Declared	Funds Provided
DR-1478*	July 15, 2003	IA/MIT	Severe Storms, flooding	Auglaize, Columbiana, Crawford, Darke, Logan, Mahoning, Mercer, Pike, Shelby and Van Wert (IA/MIT); Adams, Auglaize, Darke, Logan, Mercer, Pike, Shelby and Van Wert (SDRP)	$ 6,451,793 (I) $ 145,762 (M)* $ 13,721 (S) $ 2,976,949 (SDRP)
DR-1484*	August 1, 2003	IA/PA/MIT	Severe storms, tornadoes and flooding	Carroll, Columbiana, Cuyahoga, Franklin, Jefferson, Mahoning, Medina, Portage, Richland, Stark, Summit and Trumbull (IA/MIT); Adams, Columbiana, Carroll, Jefferson, Mahoning, Medina, Monroe, Portage, Stark, Summit, Trumbull and Vinton (PA)	$ 135,723,395 (I) $ 13,160,834 (P)* $ 6,016,488 (M) $ 162,790 (S) -
EM-3187*	August 23, 2003	PA Only	Power Outage	Ashland, Ashtabula, Cuyahoga, Erie, Geauga, Huron, Knox, Lake, Lorain, Lucas, Portage, Summit and Trumbull	$ 2,067,222 (P)*
DR-1507*	January 26, 2004	IA/PA/MIT	Landslide, severe storms and landslides	Belmont, Jefferson, Morgan, Ross, Tuscarawas and Washington (IA/PA/MIT); Franklin, Licking (IA/MIT); Athens, Guernsey, Harrison, Monroe, Noble and Perry (PA/MIT)	$ 3,408,934 (I) $ 14,811,923(P*) $ 875,265 (M)* $ 164,804 (S) -
DR-1519*	June 3, 2004	IA/PA/MIT	Severe storms and flooding	Athens, Carroll, Columbiana, Cuyahoga, Delaware, Guernsey, Harrison, Hocking, Holmes, Medina, Noble, Perry, Portage, Summit and Tuscarawas (IA/PA/MIT); Crawford, Geauga, Licking, Logan, Lorain, Mahoning, Richland and Stark (IA/MIT) and Knox and Jefferson (PA/MIT)	$ 30,238,921 (I)* $ 14,060,750 (P) * $ 2,305,560 (M) $ 748,426 (S) -
DR-1556*	September 19, 2004	IA/PA/Mit	Severe storms and flooding	Athens, Belmont, Carroll, Columbiana, Gallia, Guernsey, Harrison, Jefferson, Meigs, Monroe, Morgan, Muskingum, Noble, Perry, Tuscarawas, Vinton and Washington (IA/PA/MIT); Lawrence, Mahoning, Stark and Trumbull (IA/MIT)	$ 47,455,690 (I) $ 35,597,480 (P)* $ 3,948,349 (M)* $ 2,300,000 (S)
EM-3198*	January 11, 2005	PA Only	Snow Removal and Response	Butler, Champaign, Clark, Crawford, Darke, Delaware, Erie, Franklin, Greene, Hamilton, Hardin, Huron, Logan, Madison, Marion, Miami, Montgomery, Morrow, Preble, Richland, Sandusky, Seneca, Shelby, Union, Warren and Wyandot	$ 11,116,398 (P)*

Disaster Declaration Number	Date Declared	Federal Disaster Programs	Incident Type	Counties Declared	Funds Provided
DR-1580*	February 15, 2005	IA/PA/MIT	Severe winter storms, ice and mudslides	Clark, Sandusky, Warren and Miami (IA/MIT); Ashland, Auglaize, Athens, Belmont, Coshocton, Crawford, Delaware, Fairfield, Franklin, Guernsey, Henry, Hocking, Holmes, Huron, Jefferson, Licking, Logan, Morgan, Muskingum, Pickaway, Pike, Richland, Ross, Scioto, Stark, Tuscarawas, Washington and Wyandot (IA/PA/MIT); Adams, Allen, Brown, Carroll, Champaign, Clermont, Columbiana, Darke, Fayette, Hancock, Hardin, Harrison, Highland, Knox, Lorain, Marion, Medina, Meigs, Mercer, Monroe, Montgomery, Morrow, Noble, Paulding, Perry, Putnam, Seneca, Shelby, Union, Van Wert and Wayne (PA/MIT)	$ 13,823,757 (I)* $123,935,836 (P)* $7,534,746 (M)* $1,500,000 (S) -
EM-3250	September 13, 2005	PA	Hurricane Katrina Emergency Shelter Operations	All 88 Counties were included in the federal declaration	$2,499,103 (P)*
DR-1651*	July 2, 2006	IA/MIT	Severe storms and flooding	Cuyahoga, Erie, Huron, Lucas, Sandusky and Stark	$25,001,761 (I)* $1,798,019 (M) $593,090 (S)
DR-1656*	August 1, 2006	IA/PA/MIT	Severe storms and flooding	Ashtabula, Geauga and Lake	$25,895,531 (I)* $9,282,843 (P)* $3,411,736 (M) $1,137,245 (S)
DR-1720	August 28, 2007	IA/PA/MIT	Severe storms and flooding	Allen, Crawford, Hancock, Hardin, Putnam, Richland, Wyandot (IA/PA/MIT); Seneca (IA/MIT)	$45,452,363 (I) $12,688,139 (P) $6,630,799 (M) $1,984,493 (S)
EM-3286	April 24, 2008	PA	Snow	Ashtabula, Brown, Clermont, Clinton, Crawford, Delaware, Fairfield, Franklin, Geauga, Greene, Hardin, Huron, Lake, Morrow, Richland, Union and Wyandot	$9,481,809 (P) est.

Disaster Declaration Number	Date Declared	Federal Disaster Programs	Incident Type	Counties Declared	Funds Provided
DR-1805	October 24, 2008	PA/MIT	Wind Event	Ashland, Brown, Butler, Carroll, Champaign, Clark, Clermont, Clinton, Coshocton, Delaware, Fairfield, Franklin, Greene, Guernsey, Hamilton, Harrison, Highland, Hocking, Holmes, Knox, Licking, Madison, Miami, Montgomery, Morrow, Perry, Pickaway, Preble, Shelby, Summit, Tuscarawas, Union, and Warren	$47,968,724 (P) $6,507,249 (M)
DR-4002	July 13, 2011	PA/MIT	Severe storms, landslides	Adams, Athens, Belmont, Brown, Clermont, Gallia, Guernsey, Hamilton, Hocking, Jackson, Jefferson, Lawrence, Meigs, Monroe, Morgan, Noble, Pike, Ross, Scioto, Vinton, Washington	$45.8 Million (PA) $5,046,137 (M)
EM-3346	June 30, 2012	PA (for Direct Assistance only)	Severe storms,	All 88 counties	PA was for Direct Assistance only, no financial assistance
DR-4077	August 20, 2012	PA/MIT	straight-line winds (derecho)	Adams, Allen, Athens, Auglaize, Belmont, Champaign, Clark, Coshocton, Fairfield, Franklin, Gallia, Guernsey, Hancock, Hardin, Harrison, Highland, Hocking, Jackson, Knox, Lawrence, Licking, Logan, Meigs, Miami, Monroe, Morgan, Morrow, Muskingum, Noble, Paulding, Perry, Pickaway, Pike, Putnam, Shelby, Van Wert, Vinton, Washington, Wyandot	Initial Estimates of: $22.0 Million (PA) est. $3.4 Million (M) est.
DR-4098	January 3, 2013	PA/MIT	Severe storms, flooding	Ashtabula, Cuyahoga	Initial Estimates of: $17.8 Million (PA) est. $2.7 Million (M) est.
DR-4360	April 17, 2018	PA/MIT	Severe storms, flooding, landslides	Adams, Athens, Belmont, Brown, Columbiana, Coshocton, Gallia, Hamilton, Harrison, Jackson, Jefferson, Lawrence, Meigs, Monroe, Morgan, Muskingum, Noble, Perry, Pike, Scioto, Vinton, Washington	Initial Estimates of: $65 Million (PA) est. $9.75 Million (M) est.

(M) – Hazard Mitigation Grant
(S) – State Match to Federal Hazard Mitigation funds
(P) – Public Assistance
(I) Individual Assistance includes FEMA Disaster Housing, SBA loans for homes, personal property and businesses and FEMA/State Other Needs Assistance grants for families and individuals
(NRCS)*+ - Natural Resources Conservation Service
* Indicates the disaster is not officially closed.

HMGP first available with disaster declared after 1987.
(SCB)** - State Controlling Board funds
(SDRP)**State Disaster Relief Program
(CDBG)+ - Community Block Grant funds provided by the Ohio Department of Development
EM 3187 is an Emergency Declaration for Public Assistance

Detailed Hazard Overview

Natural Hazards - Meteorological

Flood, Flash Flood, Seiche

Ohio can experience four types of floods. *Riverine* (The overflow of rivers and streams from rains or melt water); *Flash* (A fast rising of streams or “dry-gulch” waters after heavy rain/snowmelt); *Urban and Small Stream* (An overflow of storm sewers and streams after a heavy rainfall); and *Coastal (Seiche)* (Floods along the Lake Erie shoreline, often associated with severe storms and/or seiche waves).

Flood/Riverine (Total Risk = 633) constitutes a significant threat to life and property in the state of Ohio. Riverine floods result from prolonged heavy rain over a large area. Riverine floods are more common in winter and spring when the soil is saturated or frozen. Large-scale weather systems producing heavy rain are most common during these seasons. The National Weather Service issues flood warnings several hours or days before riverine floods develop. Also, there may be two or more days of preparation before the flood crests on the major rivers in Ohio. Heavy rains in Ohio may cause floods on the rivers flowing into the Ohio River, such as the Muskingum, Scioto, and Miami Rivers, without causing a large flood on the Ohio River. On the other hand, heavy rains in Pennsylvania and West Virginia may cause a flood on the Ohio River even if heavy rain has not fallen over Ohio.[6]

Flash Floods and Seiche (Total Risk = 564) are the result of intense local rainfall and usually last a few hours. Normally, little warning precedes flash flooding. One of the deadliest flash floods occurred in Shadyside, a community on the Ohio River in Belmont County, late on June 14, 1990. Twenty-six people lost their lives in a brief flash flood on Wegee Creek and Pipe Creek near Shadyside. Flash flooding began at 9:30 p.m. and was over in 30 minutes.

Lake Erie is particularly prone to short-term, wind-caused fluctuations because of its shallowness and elongation. These can lead to extreme seiche waves of up to 16 feet between the ends of the lake. The seiche effect can cause oscillation back and forth across the lake for some time until it settles down again. In May 1942, two seiche-related waves unexpectedly battered the Ohio shore between Bay Village and Conneaut. Madison-on-the-Lake received the brunt of the waves. The first wave ranged between 4 and 20 feet, and the second, following 15 minutes later, was 6 to 8 feet high. The seiche wave killed seven people.

Although often confined to specific drainage systems or geographic regions, floods can pose a threat to over 700 communities and potentially hundreds of thousands of residents in all 88 counties. Protective actions (evacuation/sheltering) may deplete both material and fiscal resources. Floodwaters have also damaged key infrastructure elements (roads, bridges and sanitary facilities). Infrastructure damages may also lead to an increase in infectious diseases in some affected areas. Other collateral problems include power outages and transportation delays. Mudslides, a component of the 1990 Shadyside event, are often a flood-related concern in the south-southeast areas of the state. The costs in labor, time and monies for flood-related mitigation and preparation actions may also be exceedingly high.

In the late 1990s, two major floods affected the state within a space of 16 months. The first, in February 1997, caused flash and riverine flooding in 18 southern counties. In June 1998, a varied weather pattern with tornadoes, severe storms, and flash flooding struck 23 counties on a northwest to southeast track. Variable weather patterns in late winter frequently cause flooding throughout Ohio and especially in southern counties where rivers converge. In February 2018 severe storms were followed by disastrous flooding resulting in federal declarations for 22 counties. These events affected thousands of residents and caused millions of dollars in business and residential losses The following chart provides a comparison of the 1998 and 2018 events.

Figure 3. Flood Damage Comparison Chart for Ohio[7]

Critical Element	1998	2018
Overall Financial Impact	$184.3 million	$74.75 million (est.)
Federally Declared Counties	23	22
Casualties (Deaths)	12	1

Flooding increases environmental vulnerability in several ways. Pipelines can be exposed if cover is washed away, leaving them vulnerable to breakage and spills which can contaminate the environment. Similarly floods can carry contaminants to unspoiled places, causing exposure to chemicals and other toxins. Flooding also poses problems for sewage and water treatment infrastructure, increasing risk of contaminating surface and groundwater sources and downstream ecosystems.

Windstorm, Tornadoes

Windstorms and Tornadoes (Total Risk = 690) are the primary natural hazard to the state. These violent, rotary windstorms can attain wind-speeds up to 300+ mph and often accompany or follow severe thunderstorms. They may occur anywhere, at any time of the year with unpredictable, severe effects. In Ohio, tornadoes are more frequent in the spring and summer months of April, May, June, and July. Other severe storm associated winds, not classified as tornadoes, may be almost as violent and damaging. Tornadoes and windstorms have a high potential to cause loss of life, damage or destroy property, and overwhelm local response capabilities.

Tornado effects vary according to wind-speed, duration on the ground, and topography. From 1950 to 2010, the National Weather Service reported 1053 tornado touchdowns in Ohio. Ohio averages 16 tornados per year resulting in an average of 3 fatalities per year with Northwest counties at highest risk. Estimated losses over a 30-year period are in excess of $110+ million. The Lorain and Xenia storms cost more than 100 lives and caused millions of dollars in property damages. As in the case of floods, the costs and duration of recovery may extend over years.

On April 9, 1999, a tornado in Clinton, Hamilton, and Warren counties killed four and injured 42 while destroying or damaging over 400 dwellings. Estimated financial losses were in the millions for the storm, which the National Weather Service termed as the most devastating in terms of casualties since the 1985 event, which killed 18 Ohioans.

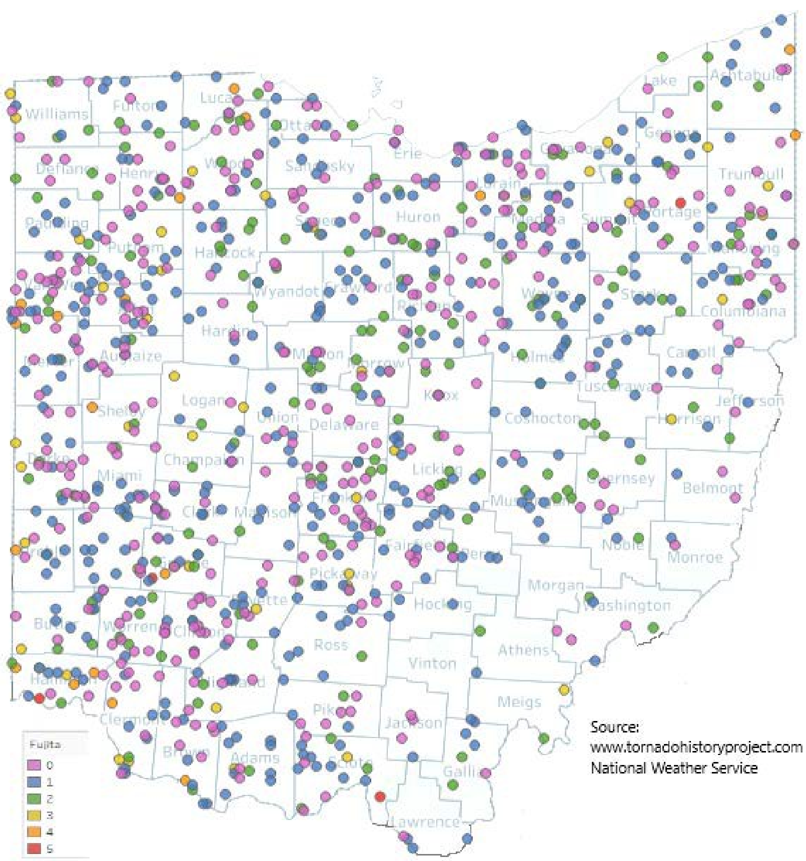
One of the most destructive windstorms in the state's history hit Ohioans on September 14, 2008. Remnants from Hurricane Ike moved through Ohio with tropical storm force winds, leaving nearly two million homes and businesses without electricity during the height of the emergency. Eighty-four of Ohio's 88 counties reported some type of windstorm damage, fallen debris or power outages. Seven Ohioans died from injuries sustained from the windstorm. This event also resulted in a Presidential Declaration for 33 counties.

In 2010, three significant events severely impacted Ohio's communities. The first event occurred June 5-6, 2010, when a major tornado outbreak affected the Midwestern United States and Great Lakes Region. The event resulted in seven people dead in Wood County. The second event occurred when severe weather and tornadoes swept across the state in the afternoon of September 16, 2010. The National Weather Service confirmed 11 tornadoes in Athens, Delaware, Fairfield, Holmes, Meigs, Perry, Tuscarawas, and Wayne counties and in the Tarlton, Ohio area. No deaths were associated with the event.

The third event occurred October 27, 2010, when a very intense area of low pressure pushed east through the Great Lakes Region, with a strong cold front moving through the Ohio Valley. Wind gusts of 50-60 mph were recorded in some areas of the state. The National Weather Service confirmed eight tornadoes in Auglaize, Fayette, Franklin, Licking, Paulding, Pickaway and Van Wert counties. No deaths occurred with this event. Late season tornado outbreaks are rare but not unlikely. On November 5, 2017, Ohio experienced a statewide outbreak of 17 tornadoes in a single day.

Windstorms and tornadoes are not typically associated with causing environmental problems, though they have the ability to create massive amounts of woody debris and construction debris, which requires coordination with environmental regulators, haulers and landfills. This was noted and experienced during the response and recovery operations in the Village of Moscow (Clermont County) in March 2012.

Figure 4. Ohio's Tornado History (1950-2016)



<u>*Snow, Ice, Hail and Sleet*</u>

Blizzard or Ice Storm (Total Risk = 665) are the fourth leading weather-related threat to the state. These include heavy snowfall with extreme cold and ice, or a combination of the three.

Over 500 Winter Storms from 1950 to present are reported by the National Weather Service. The storms of 1913, 1940, 1950, 1977, 1978, 1994, 1996, and 2004/2005 were especially damaging. Some winter storms have occurred in specific sectors of the state; south/southeast (1984); east/northeast (1993); and south/central (1994). However, the storms of 1950 and 1978 were statewide in nature and of a severity that required massive state/federal response and recovery efforts.

In addition to structural and power line damages, these storms have a potential for collateral effects; isolation and economic disruption (from roadway and business closings) along with ice dams and floods caused by the melting process.

Winter weather is not associated with increased environmental vulnerability.

Natural Hazards - Biological

<u>*Public Health Emergency*</u>

Public Health Emergency (Total Risk = 808) which includes emerging diseases, such as plague, smallpox, anthrax, West Nile Virus, foot and mouth disease, Severe Acute Respiratory Syndrome (SARS), Pandemic Influenza, Bovine Spongiform Encephalopathy (BSE), commonly known as mad cow disease, are becoming increasingly prevalent on the world stage. This type of event would likely affect multiple states and would likely have global impact. The impacts of Pandemic Influenza, Ebola and other viruses have become a planning priority for the state of Ohio as well as at the federal level. Likewise, certain health conditions such as the Methicillin-resistant Staphylococcus aureus (MRSA) staph infection are coming to prevalence in the media.

A pandemic outbreak has the potential to infect large numbers of Ohio citizens, which could easily overwhelm the health care system in the state, and impact the personnel needed to respond and recover from such an event. A pandemic outbreak could also jeopardize essential functions by causing high levels of absenteeism in critical services areas. Large numbers of people would likely become ill or expire. Examples such as the 1918/19 Influenza Pandemic demonstrate the potential for loss of human life and significant impacts on society.

A continuous significant concern has been the emergence of a Pandemic Influenza or other human infectious disease, such as the recent Novel Influenza A (H1N1). The outbreak initially emerged in April 2009 for two months and then increased activity again in October 2009 for another four months. The H1N1 was not considered to have a high severity; however, it was considered extremely virulent in younger populations and pregnant women. From August 30 through January 30, 2010, the cumulative total for Ohio influenza confirmed hospitalizations is 3,194 individuals per Ohio Disease Reporting System (ODRS). At least 51 people hospitalized with H1N1 infection died in Ohio during that period. Fortunately there was not a significant impact to infrastructure or on personnel needed to respond and recover.

Diseases which cause widespread human deaths would have an impact on the environment in terms of the disposal of human remains and the handling of bio-hazardous waste.

Environmental and regulatory factors would have to be evaluated in the disposal of both human remains and bio-hazardous waste.

Diseases which cause widespread deaths of animals, both captive and wild, would have an effect on public health and the environment in terms of disposal of the carcasses. Whether the infected animals are buried, burned or left in place, a large quantity and concentration of carcasses may impact air, soil and groundwater.

Natural Hazards - Geological

Earthquakes

Earthquakes (Total Risk = 574) are defined as a rapid motion of the ground accompanied by shaking, faulting (surface and subsurface) and ground failure. Earthquakes from two points affect Ohio: events having epicenters within the state, and those occurring along the New Madrid, Missouri Fault Zone. Figure 6 shows a map of earthquake epicenters for Ohio and adjacent areas.

More than 200 earthquakes with magnitude of 2.0 or greater with epicenters in Ohio have occurred since 1776, and 15 of these events are known to have caused minor to moderate damage. Fortunately, these events have not resulted in fatalities, only minor injuries.

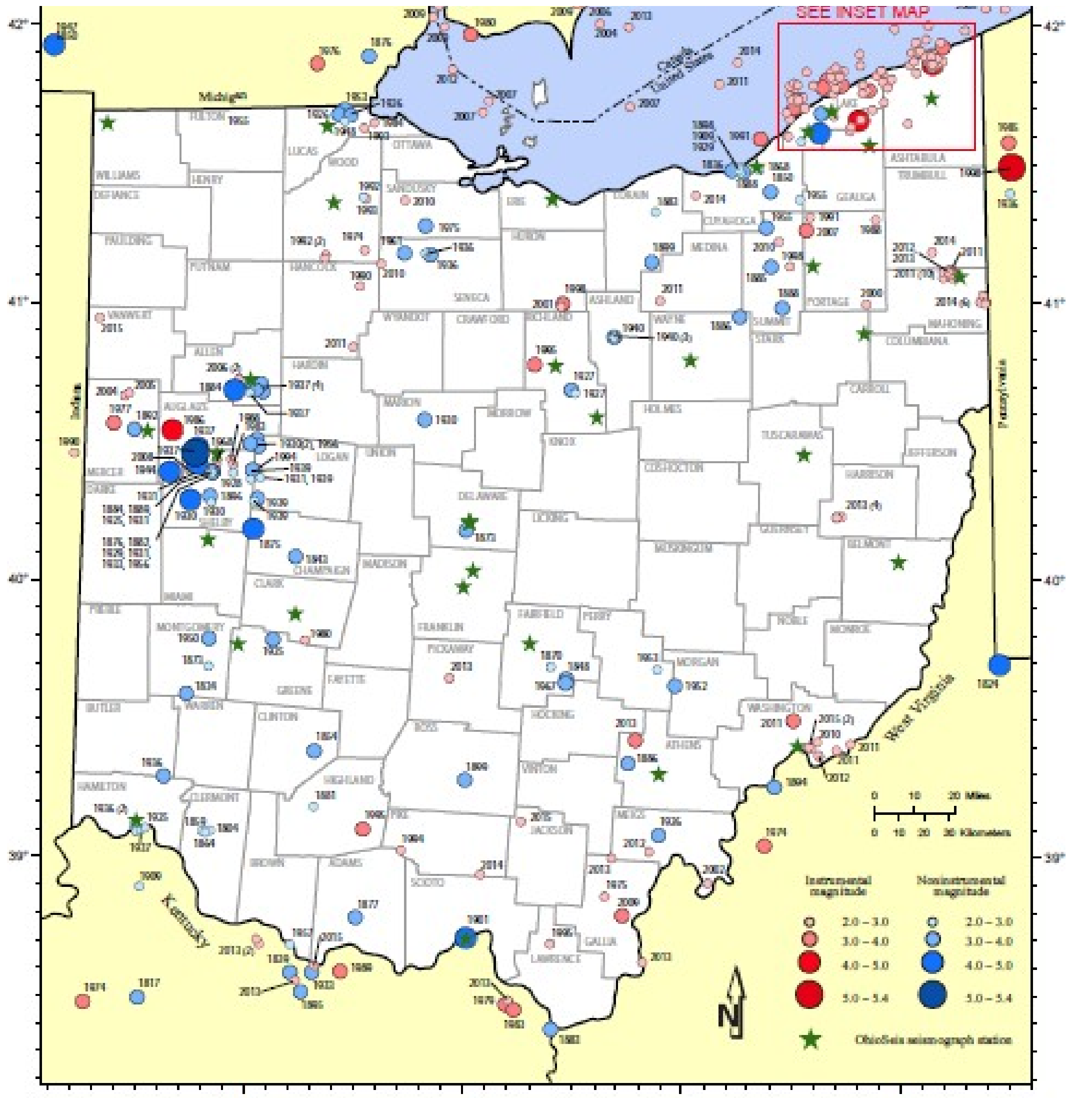
Most earthquakes that occurred in Ohio before the 1960s have been located and assigned intensities and approximate magnitudes based on newspaper accounts. Epicentral locations for many of these events probably have a considerable margin of error. Non-instrumental data should be used cautiously. (Hansen, 2015, p.4)[8]

Seismic activity is concentrated in, but not confined to, three areas of the state. Historically, the most active area, with at least 40 earthquake events since 1875, is the Anna Seismogenic Zone centered in Shelby County, (western Ohio). Many other events have occurred in the Lake County area, or in the southeast, and have caused minor to moderate damage.

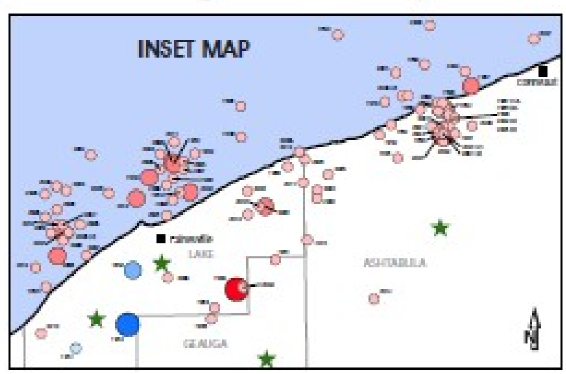
Other counties with documented earthquake epicenters include Adams, Allen, Ashland, Ashtabula, Athens, Auglaize, Brown, Butler, Champaign, Clermont, Cuyahoga, Gallia, Geauga, Greene, Hamilton, Hancock, Hardin, Highland, Hocking, Jackson, Lake, Lucas, Marion, Meigs, Mercer, Montgomery, Muskingum, Perry, Pike, Portage, Preble, Putnam, Richland, Ross, Sandusky, Scioto, Seneca, Shelby, Summit, Washington, Williams, Wood, and Wyandot.

The state would also be affected by events generated by the New Madrid Fault Zone, extending from Arkansas to Indiana along the Mississippi and Ohio River Valleys. This fault generated the most powerful earthquakes ever documented in the Continental U.S. in a four-month period during 1811 and 1812. If earthquakes of this intensity occur again, devastating damages in our southwestern counties could be expected. Figure 5 lists the counties potentially impacted, and effects from a major New Madrid earthquake in Ohio.

Figure 5. Earthquake Epicenters in Ohio and Adjacent Areas



Locations of felt earthquakes or those with magnitudes of 2.0 or greater in Ohio and its border areas. Locations and magnitudes of historic earthquakes are represented by symbols corresponding to felt area or maximum epicentral MMI. Noninstrumental locations may be in error by a considerable distance, especially for early events.



Source: *Ohio Department of Natural Resources, Ohio Division of Geological Survey, 2012, Earthquake epicenters in Ohio and adjacent areas*

Figure 6. Effects of a Major New Madrid Earthquake in Ohio

Mercalli Intensity	Effects	Counties Potentially Affected
VI	Felt by all, indoors & outdoors. Many people frightened and excited. Liquids set in strong motion. With slight damage in poorly built structures. Fallen & cracked plaster with a considerable quantity of broken dishes & glassware.	Allen, Ashland, Auglaize, Crawford, Cuyahoga, Defiance, Erie, Geauga, Hancock, Hardin, Henry, Huron, Lake, Logan, Lorain, Mahoning, Marion, Medina, Mercer, Morrow, Ottawa, Paulding, Portage, Putnam, Richland, Sandusky, Seneca, Shelby, Stark, Summit, Trumbull, Van Wert, Wayne, Wood, & Wyandot. (Approx. 4 million people in 36 counties)
VII	Many people find it difficult to stand. Slight damage in ordinary buildings., Considerable amounts of fallen plaster & numerous broken windows & fallen cornices	Athens, Belmont, Carroll, Champaign, Clark, Columbiana, Coshocton, Darke, Delaware, Franklin, Fulton, Gallia, Guernsey, Harrison, Holmes, Jackson, Jefferson, Knox, Lawrence, Licking, Lucas, Madison, Meigs, Miami, Monroe, Morgan, Noble, Tuscarawas, Union, Washington, and Williams (Approx. 3 million people in 31 counties)
VIII	Alarm approaches panic. Branches of trees broken. Changes in the flow of well & spring water. Considerable damage in ordinary substantial buildings. Fallen walls, factory stacks, towers, & monuments. Heavy furniture overturned.	Adams, Brown, Butler, Clermont, Clinton, Fairfield, Fayette, Greene, Hamilton, Highland, Hocking, Montgomery, Muskingum, Pickaway, Perry, Pike, Preble, Ross, Scioto, Vinton, & Warren (Approx. 3 million people in 21 counties)

Source: *U. S. Geological Survey, Maximum Seismic Interactions Map for New Madrid Seismic Zone; Algermission & Hopper*

Collateral effects from an earthquake could be extensive and may include hazardous material spills, landslides, subsidence, dam failures, fires, groundwater contamination, pipeline breaks, infrastructure disruptions, epidemics, floods, along with theft/looting.

Earthquakes can cause a tremendous increase in environmental vulnerability. Beyond the tremendous amounts of debris that will need to be managed, the possibility of broken pipelines increases the likelihood of cascading impacts that include contamination. The possibility of water and sewage treatment facilities being damaged and taken offline similarly increases the risk to ground and surface waters and the ecosystems they feed. Sustained fires, also a possibility following earthquake associated structural collapses, would also lead to a possibility of toxic fumes and a certainty of degraded air quality.

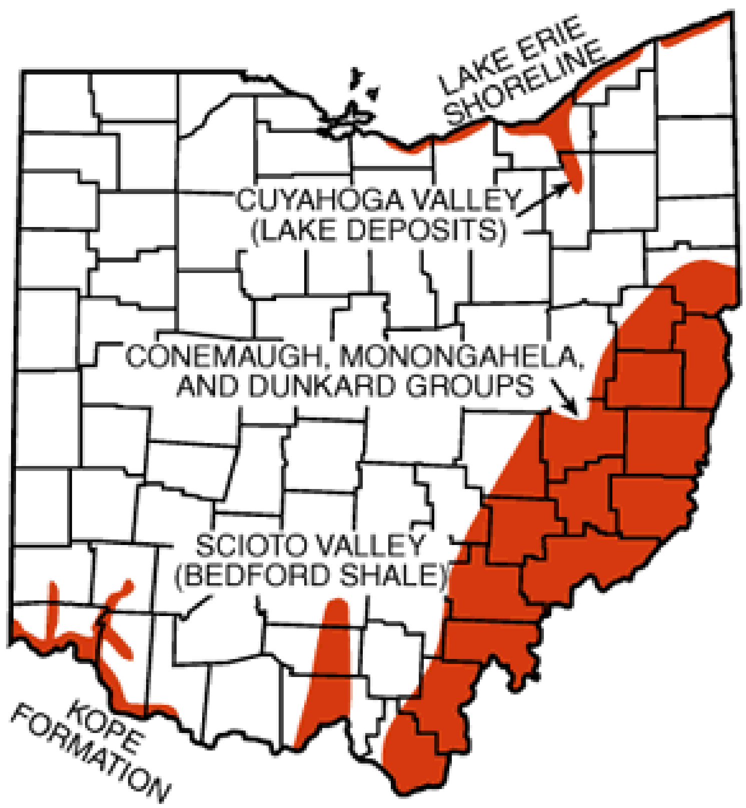
Landslide, Mudslide, Subsidence (and Mines)

Landslide, Mudslide and Subsidence (Total Risk = 375) are the second major geological threat. *Subsidence* is defined as a drop in the earth's surface due to a collapse in bedrock or other underlying material (coal pillars, rock, etc.) into underground mines or other open space.

Land or Mudslides are defined as downward and outward movements of slopes due to rains or melting snow with accompanying damage and debris deposition. They may also include sudden collapses of mines, tunnel walls, or supports with resulting damage to surface structures or features (buildings and highways).

Landslides include three types. A *Rotational Slump* occurs when weak rock or sediment moves as a mass in a slow or imperceptible movement. A more common event, *Earthflow*, involves rock, sediment, or weathered surface materials moving down slope in a mass. *Rock fall* is seen asthe most common and dangerous form of movement. Rock from a cliff or cut will fall onto roadways or structures. This action is common during periods of late winter or early spring thawing. Traffic vibration, undercut slopes, increased weight on slopes, or the removal of vegetation and ensuing erosion may also contribute to these events. Events have been traced back to 1923 at various sites. They occur mainly through the Ohio or Scioto River Valleys, or elsewhere in the eastern portion of the state with some occurring along the eastern Lake Erie Shoreline shown in red on Figure 3 below.

Figure 7. Ohio Subsidence and Landslides



During and after WWII, when the demand for mineral resources was high, the state had over 700 active coal mines. As the supply of coal in many mines was exhausted, the mines were abandoned with little or no preparation. Supporting pillars of coal in shaft mines were mined away prior to closings. In the mid-1990s, over 6,000 closed or abandoned underground mines were estimated to exist in 37 counties with over 61,000 acres of land affected by closings or site abandonment.

Abandoned mines have also occasionally collapsed with damage to surface structures or costly infrastructure damage. On March 5, 1995, a twelve foot section of Interstate 70 in Guernsey County collapsed due to an abandoned underground mine subsidence. In addition, landslides and mudslides affecting roadways have led to costly repair actions by state and local governments. It is estimated that repair or replacement costs could reach $9 million or more if a major highway is involved. The ODNR Division of Geological Survey has detailed maps for approximately 4,200 abandoned mines in Ohio and estimate there are approximately an additional 2,000 abandoned mines not detailed on maps.

Subsidence and landslides, particularly during floods, have also led to the temporary relocation of farmsteads, housing units, or businesses. Landslide, Mudslide, Subsidence and Mine Collapses have the potential, albeit on a lesser scale, to cause similar environmental impacts as earthquakes (see above).

Human-caused - Accidental

Radiological Incidents (Nuclear Power Generating Sites)

Radiological Incidents (Nuclear Power Generating Sites) (Total Risk =1186) are the greatest human-caused, accidental hazard and ranked as the 2nd hazard in the state overall. The release (or potential for release) of radioactive materials could initiate protective actions (evacuation or sheltering) for populations residing within a 10-mile Emergency Planning Zone (EPZ), and affect the ingestion pathway within a 50-mile EPZ of a site. Ohio residents could potentially be affected by three nuclear power generating facilities operating in or near the state:

- Davis-Besse Nuclear Power Station located in Port Clinton (Ottawa County)
- Perry Nuclear Power Plant located in North Perry (Lake County)
- Beaver Valley Power Station located in Shippingport, Pa. (Beaver County)

In an emergency involving a single power plant, over 95,000 residents could be affected by accidental emissions. Response and recovery actions could cost millions of public and private sector dollars.

Environmental impacts of a nuclear disaster can cause the permanent contamination of some areas downwind from plants that receive fallout. These areas would not be suitable for agriculture for generations nor could they be occupied.

Water Control Structure (Dam/Levee Failure)

Water Control Structure (Dam/Levee Failure) (Total Risk = 570) is the second greatest human-caused hazard and ranked thirteenth in the state, a change from 6th overall in the 2013 HIRA. The change is perhaps a reflection of the state's successful response to the failing Buckeye Lake Dam and its timely remediation which nears completion in 2018. Dam/Levee Failure is defined as a gradual or immediate collapse or failure of water impounding systems or structures, resulting in downstream damages.

Dams in Ohio have been divided into four classes; I, II, III, IV, based upon a downstream threat potential. Figure 9 shows the number of Class I dams by county. There are 365 Class I dams in the state. The failure of a Class I dam would result in the probable loss of life or pose a serious hazard to health, property and high-value industrial or commercial properties or public utilities in the below-dam inundation plain. A Class I dam is one with a volume capacity of over 5,000 acre-feet or a height greater than 60 feet. Although damages to Class I dams pose the greatest threat to human life, Class II and III units could also pose a similar threat if affected.

Figure 8. Class I Dams in Ohio

Source: ODNR - Division of Water Resources, 2018

The Ohio Department of Natural Resources has identified most dams in the state and categorized each by their impact to citizens in the event of failure. A review of similar events in other states illustrates the possible consequences: Buffalo Creek, W.Va. suffered 125 casualties and $400 million in property damages; Lawn Lake, Colorado incurred three casualties and $21 million in property damages; and the town of Toccoa, Georgia, suffered 39 casualties and $30 million in property damages.

Water control structure failures have the potential to cause similar environmental impacts as flooding, landslides and subsidence and earthquakes.

Transportation Failure (including Bridge/Structure Collapse)

Transportation Failure (Total Risk = 402) is primarily related to bridge/structure collapse. Bridges are the most common type of collapse in the state. There are over 42,000 bridges in the state of

Ohio. The Ohio Department of Transportation (ODOT) is responsible for nearly 15,000 bridges on the state highway system. Our state has the second largest number of bridges in the country. Ohio law requires all bridges to be inspected on an annual basis. This applies to all bridges maintained by ODOT as well as county and city bridges.

The 2007 Interstate 35W bridge collapse in Minneapolis, Minnesota, brought to light challenges states face with structurally deficient bridges. Like Minnesota, Ohio has over a dozen highway deck truss bridges that share the same design structure as the I-35W Bridge. In 2009, Lake County replaced a similarly-designed bridge with twin bridges on Interstate 90 over the Grand River. The bridge partially collapsed in 1996 due to deteriorating corroded steel plates. No injuries were reported, but the bridge was closed for months for repairs. In another comparable case, the city of Cleveland's Inner belt Bridge is undergoing more than $150 million in repairs.

In 1983 a bridge collapsed in Antwerp (Paulding County) killing five people. The 30-foot stone and asphalt structure caved-in and four cars plunged into a dry creek bed. Another notable bridge collapse occurred in Ohio on December 15, 1967. The Silver Bridge over the Ohio River collapsed killing 46 people. The bridge connected the towns of Point Pleasant, West Virginia, and Managua, Ohio.

More recently, Ohio resources have been used to respond to building structural collapse rescues. On July 7, 2010, the Ohio Regional Urban Search and Rescue and the northwest area's Regional Structural Collapse Response Unit responded to a significant structural collapse in Fremont. Support columns inside a food processing plant partially collapsed the roof structure. Area-wide assistance was requested for two workers trapped under the debris. One person was killed and the other was trapped for hours beneath the rubble.

Structural/building collapse will remain a primary human-caused hazard in Ohio, primarily due to the threats faced in this state. Significant threat concerns include the impact from tornadoes, earthquakes, snow loads, landslides, gas explosions, acts of terrorism, and environment.

The collapse of a building or other structure may lead to environmental damages through hazardous materials releases, the atmospheric release of asbestos or other harmful substances, and the contamination of the water table through sewage release or other chemicals. Contaminated debris may pose special challenges for waste disposition or recycling.

Impact on plants, animals and humans and associated eco-systems is a concern when in immediate proximity to the collapse. Multiple deaths are expected as well as long-term consequences to the eco-system in the immediate area. Depending on the purpose of the structure and its date of construction lead and asbestos may be present and their contamination could readily be spread through water and wind movement.

Urban Fire

Urban Fire (Total Risk = 540) ranks fairly high as a human-caused hazard, primarily due to its impact on people. Cleveland is noted by fire historians for the Collinwood School Fire in 1908 that killed 172, as well as the Cleveland Clinic Fire in 1929 that killed 123.

Structural fires pose many of the same environmental challenges of building collapse with an added immediate impact to the atmosphere. Depending on what materials are in the structure, it is possible that air quality could deteriorate for an unknown length of time and pose an immediate threat to life and long term threat to well-being.

Hazardous Materials

Hazardous Materials (Total Risk = 674) incidents remain the most common form of accidental threat to Ohio, occurring almost daily. A hazardous materials spill can be the result of human negligence, an intentional act, or a natural hazard. Human negligence occurs predominantly during the manufacture, transport, or storage of the hazardous material. An intentional act would be considered either a terrorist act, criminal act, or act of vandalism. A hazardous materials spill can be a secondary effect of a natural hazard (e.g., flooding, earthquake, or severe weather).

Environmental impacts - Although major chemical accidents and spills seem most threatening, it is the smaller, more routine accidents and spills that have a greater impact on humans, wildlife, economy, and environment. Some of the most common spills involve tanker trucks and railroad tankers containing gasoline, chlorine, or other industrial chemicals. The National Environmental Law Center reported that 34,500 accidents involving toxic chemicals were reported to the EPA's Emergency Response and Notification System between 1988 and 1992, meaning that on average, a toxic chemical accident was reported nineteen times a day in the United States, or nearly once every hour. [9]

Human Caused Hazards - Intentional

Terrorism (CBRNE)

Terrorism incidents, involving CBRNE - Chemical (Total Risk = 1055), Biological (Total Risk = 947), Radiological (Total Risk = 1193), Nuclear & Explosives (Total Risk = 330), are ranked as the highest human-caused intentional hazard. The Federal Bureau of Investigation (FBI) defines terrorism incidents as the "…unlawful use of force or violence against persons or property to intimidate, or coerce a government, civilian population, or any segment thereof in the furtherance of political and social objectives." The victims of terrorism may not always, however, be the intended, or most concerned, elements of society.

Although events such as the World Trade Center Bombing/Destruction (1993 & 2001) and Oklahoma City bombing (1995) did not occur in Ohio, the threat, real or implied, to employ terrorism in this state, remains. Threats often involved the employment of Weapons of Mass Destruction (WMD), to include bombs and pathogens, and can be directed at targets in both rural and urban-industrial settings.

In 1995, an Ohio resident with ties to unorganized militias was able to order, via mail, samples of Plague bacilli. Although that attempt was thwarted, the events of 2001 show that the bio-terrorist threat remains viable.

One of the most dangerous emerging threats to our country is the criminal and terrorist use of Improvised Explosive Devices (IEDs). IEDs have the potential to make a lethal impact, with relatively low-tech skills needed to produce them. IEDs have been the weapon of choice for foreign terrorists since the first World Trade Center attack in 1993 and for domestic terrorists since the Oklahoma City bombing in 1995. This threat has expanded to include both Vehicle-born Improvised Explosive Devices (VBIEDs) and small arms attacks.

IEDs have an enormous potential for influencing public perception and for creating an atmosphere of fear and uncertainty. A car bomb exploding in the middle of a busy urban setting can quickly undermine emergency response efforts to protect the public.

An act of terrorism's impact on the environment can be very large and can be felt by the environment in several different ways.

Chemical incidents are unlikely to have a significant effect on electric utilities, natural gas utilities, pipelines nor water courses. Such incidents would create some debris, though not an unmanageable amount. Chemical terrorism would however have a large impact on both the short-term quality of the air, and long-term quality of waste water systems, aquatic ecosystems and soils that sustain wildlife.

A biological incident probably would not compromise utilities, displace waterways, create large amounts of debris, nor have a large-scale effect on air quality, but could certainly effect sewage systems, septic systems, waterway ecosystems, soil usability - and subsequently the plant life and wild life that depend on them.

A radiological incident has the potential to make a large impact on air quality due to fallout from the device; contamination of water utilities, storm sewers, sewage and septic systems; contamination of water eco-systems; and soil contamination from both the device itself and from radioactive water leeching into the soil. Such an incident has less likelihood of effecting electric, natural gas, pipelines, utilities; watercourses; or of creating an immediate debris problem.

A nuclear incident would have a huge impact on the environment. All utilities and wastewater systems would be compromised. Air quality would be hampered by smoke, lead, and asbestos from damaged older structures. Water courses could be displaced thereby altering their ecosystems. Soil would be contaminated not only from fallout/debris, but also by released hazardous material and raw sewage. The harm to wildlife habitat would be catastrophic and long-lasting.

Explosive incidents have the potential to impact electric, water, natural gas, pipelines, and utilities. These types of incidents would pollute the air with smoke, lead fumes and asbestos. Explosive incidents would alter water ecosystems by rerouting, damming or displacing waterways. Explosive incidents would potentially contaminate soil with not only hazardous materials, but also debris. All of which in turn effect wildlife habitat and the environment. Such an incident has less likelihood of affecting storm sewers, sewage and septic systems, or of creating overwhelming amounts of debris.

Primary sources of data for determining the likelihood or probability of occurrence for human-caused, intentional acts of terrorism are risk assessments by the Ohio Department of Natural Resources and Ohio Homeland Security's Ohio Strategic Analysis Information Center (SAIC). Other sources of data include weekly Ohio SAIC intelligence summaries, U.S. Coast Guard risk assessments on intentional pollution in both ports and in rivers, U.S. Forest Service intelligence summaries, and classified federal intelligence reports containing vulnerability information.

From that, risk to the environment can be assessed not in terms of percentage, but in terms of magnitude and of impact on plant, animal, and human life as well as the eco-systems in which they interact. In accordance with the Magnitude factor used throughout the Hazard Identification and Risk Analysis Update 2011, magnitude of risk to the environment due to terrorism of all types is overall rated as "Localized." This term does not mean that resulting damage would be unimportant, but rather when all the possible types are considered collectively, the average is projected to be small in geographical scope with less than 10 of 88 counties expected to be impacted.

Vulnerability of the environment can be assessed similarly using the Impact on Humans factor used in the 2018 HIRA. Impact on plants, animals and associated eco-systems is rated at “High” because they will be either the focus of such an attack, or will be in immediate proximity to an attack without means of evacuation. The movement of wind and water could easily spread the damage. Multiple deaths are expected as well as long-term consequences.

Hazard Grouping

Figure 9. Threats and Hazards Identified

Natural Hazards	
Biological	Public Health Emergency
Geological	Earthquake
	Landslide / Erosion
Meteorological	Blizzard or Ice Storm
	Drought
	Flood, Riverine, Areal, Coastal (Forecasted)
	Flood, Seiche / Standing Wave (Unpredicted)
	Hurricane
	Space Weather
	Temperature Extremes
	Tornado/High Wind/Thunderstorm
	Urban/Flash flood
	Wild Fire
Human-Caused	
Intentional	Active Aggressor (stalking, abduction, workplace violence, threat)
	Aircraft Incident
	Animal/Crop Eco-terrorism
	Civil Disturbance
	Cyber Attack/IT System Security Breach
	Electromagnetic Pulse (EMP)
	Electrical Grid Failure
	Hostage Situation
	IT Infrastructure Disruption
	Labor Action
	Mass Communications Interruption
	Planned Public Event
	Terrorism, CBRNE (bomb, suspicious powder, etc.)
Accidental/ Technological	Accidental Hazmat Release
	Dam Failure
	Emergency Generator Failure
	Fuel Shortage Nuclear Accident
	Pipeline Failure
	Sewer Failure
	Shortage of Critical Materials
	Space Debris
	Transportation Incident
	Urban Fire
	Water Supply Incident

Example Hazard Scenarios

Each type of hazard that could affect the State will have varying consequences based on the severity of the event. For instance, the consequences of an earthquake to the impact factors in this analysis would differ greatly based on the magnitude of the earthquake scenario being considered. For hazards that have historically occurred in the State, the scenarios considered as part of this consequence analysis were developed based on the magnitude of events that have actually occurred. Following is a brief description of the hazard scenarios used by the authors to evaluate the consequences of each hazard.

Flood (Riverine)
Storms that produced heavy rains in March result in severe flooding in southern, Ohio. Widespread damages to private and public property occur throughout the area. Eighteen counties are declared Federal and State Disaster areas. Nearly 20,000 people are evacuated. Over 6,500 residences and 833 businesses are affected. Five deaths are attributed to the flood and preliminary damages are estimated at over $200 million (Ohio River flooding March 1-2, 1997, USGS Water-Resources Investigation Report 97-4149).

Windstorm, Tornado
Severe weather and tornadoes swept across the state. The National Weather Service confirmed 11 tornadoes in Wayne, Holmes, Fairfield, Athens, Perry, Pickaway, Meigs, Delaware and Tuscarawas counties and in the Tarlton, Ohio area that borders 3 counties. The tornadoes ranged from EF-0 to EF-3. Athens, Meigs, Pickaway, Perry and Wayne Counties declared a local state of emergency. Thirteen people were injured in Athens County, and six were injured in Meigs County. The following structure damage estimates were compiled by the State and county teams: 62 destroyed, 77 with major damage, 113 with minor damage and 373 structures as affected. Residential loss equated to 2,227 insurance claims totaling $11,400,000, while business losses included 287 claims totaling $4,700,000. There were 421 auto insurance claims resulting in a loss of $1,200,000 (State Hazard Mitigation Plan, Section 2.3).

Flash Flood, Seiche
Three to four inches of rain fall in a little over one hour causing a flash flood in southeastern Ohio. The total rainfall over a three hour period is estimated at 5.5 inches. Soils saturated from previous rains and narrow, steep-sided valleys cause the water to rise quickly. A wall of water rushing down the valley claims 26 lives, destroys 80 homes and damages 250 residences. There are also significant impact to roads and bridges in the valley (Shadyside, Ohio event June 1990).

Snow, Ice, Hail, Sleet
A February storm produces heavy snowfall across the majority of the State and freezing rain and ice along the Ohio River. The storm causes widespread power outages, road closures, business and school closures. Households are isolated and sensitive populations are at risk as many are without heat and communication systems have been damaged. Storm debris on roads delays early attempts to restore critical facilities and services. Fifteen counties are declared Federal and State disaster areas. Insured losses exceed $25 million and government expenses and uninsured losses exceed $10 million (FEMA DR-1453 Hazard Mitigation Post-Event Strategy).

Radiological Incidents (Nuclear Power Generating Site)
During the July 4th weekend, a massive heat wave created a breaking point to the electric grid resulting in a loss of power at the Beaver Valley Power Station. The primary containment vessel

is compromised, creating a major release of radiation across portions of Ohio and Pennsylvania. Residents living within a 10-mile radius of the plant are evacuated. Thousands of other residents living outside the radius self-evacuate due to fear creating transportation issues.

Water Control Structure (dam/levee failure)
Near record spring precipitation, compounded by a series of spring storms led to a Class I dam failure upstream of a highly populated area in central Ohio. The inundation area downstream of the dam contains business, residential, commercial and other uses. There were 550 casualties and thousands of injuries. Property and infrastructure damage totals over $600 million. Bridges, culverts and other stream crossings were destroyed 20 miles downstream of the dam. The event caused significant environmental contamination downstream of the dam and habitat degradation in the reservoir and surrounding park.

Disease – Animal
Emerging diseases and others, such as anthrax, foot and mouth disease, Avian and Swine Influenza, Bovine Spongiform Encephalopathy (BSE), commonly known as mad cow disease, are becoming increasingly prevalent on the world stage. Outbreaks are often regional, if not global, in nature. Disease outbreaks are a planning priority for the State of Ohio and also at the federal level. Diseases which cause widespread deaths of animals, both captive and wild, would have an effect on the environment in terms of disposal of the carcasses. Whether the infected animals are buried, burned or left in place, a large quantity and concentration of carcasses may impact air, soil and groundwater.

Building/Structure Collapse
Bridges are the most common type of collapse in the state. There are over 42,000 bridges in Ohio, the second largest number of bridges in the country. The Ohio Department of Transportation (ODOT) is responsible for nearly 15,000 bridges on the state highway system. Ohio law requires all bridges to be inspected on an annual basis. This applies to all bridges maintained by ODOT as well as county and city bridges.

The 2007 Interstate 35W bridge collapse in Minneapolis, Minnesota, brought to light challenges states face with structurally deficient bridges. Like Minnesota, Ohio has over a dozen highway deck truss bridges that share the same design structure as the I-35W Bridge. In 2009, Lake County replaced a similarly-designed bridge with twin bridges on Interstate 90 over the Grand River. The bridge partially collapsed in 1996 due to deteriorating corroded steel plates. No injuries were reported, but the bridge was closed for months for repairs. In another comparable case, the city of Cleveland's Inner belt Bridge is undergoing more than $150 million in repairs. The I-71 bridge in Morrow County (Jeremiah Morrow Bridge), similar in structure to the I-35 bridge, was replaced. In 1983 a bridge collapsed in Antwerp (Paulding County) killing five people. The 30-foot stone and asphalt structure caved-in and four cars plunged into a dry creek bed.

More recently, Ohio resources have been used to respond to building structural collapse rescues. On July 7, 2010, the Ohio Regional Urban Search and Rescue and the northwest area's Regional Structural Collapse Response Unit responded to a significant structural collapse in Fremont. Support columns inside a food processing plant partially collapsed the roof structure. Area-wide assistance was requested for two workers trapped under the debris. One person was killed and the other was trapped for hours beneath the rubble.

Terrorism (CBRNE)
Approximately 40,000 are gathered at a 32-acre park that is surrounded by a residential neighborhood and downtown Columbus for a popular annual community event. It is a clear Saturday in late June, with a temperature of 88 degrees and a mild wind blowing in a northeasterly direction. A radiological dispersion device (RDD) detonates at the northern end of the park. Debris recovers the streets and a cloud of dust quickly envelops the park and nearby homes. On-scene security and first responders are reporting countless injuries from the blast. As additional responders arrive, including initial Columbus bomb squad, a monitor detects radiation. As fire & EMS deal with the wounded, the bomb squad conducts an assessment and discovers radiation within the park's perimeter. There is mass chaos along with fears of radiation exposure from the crowd as well as near-by residents.

Electromagnetic Pulse (EMP)
A nuclear device is detonated at approximately 40 kilometers above the Earth's surface over a large metropolitan area. The resulting high-altitude EMP impacts critical systems over a 200 mile radius. A city water supply and a large gas and electric company experienced severe electromagnetic interference to their SCADA wireless networks. Both companies found themselves unable to actuate critical valve openings and closings under remote control of the SCADA electronic systems. This inability necessitated sending technicians to remote locations to manually open and close water and gas valves, averting a potential "catastrophic failure" of the distribution system for water and gas supplies to over 1 million residents. The potential consequences of a failure of this 825 mgd flow rate system ranged from severe flooding from spilling vents at thousands of gallons per minute, pipeline ruptures with ensuing water contamination issues, and extensive damage to private and public property. The source of the SCADA failure was interference to sensor systems and electronic controls from an electromagnetic pulse. (Evidenced by San Diego in November 1999 through offshore radar interference in November 1999.)

Explosion/Fire
A vehicle borne improvised explosive device is detonated in the parking garage of a government facility resulting in 150 confirmed fatalities with 500 injured. The building suffered vast damage and the effective blast radius affected approximately sixteen city blocks. (This was evidenced by the Oklahoma City blast of 1995.)

Fuel/Resource Shortage
A gulf-coast hurricane disrupts production, refinement and transportation of fuels. Refineries and pipelines are damaged and will be offline for months. Heading into the winter months and the requirements for heating fuels, this could have a tremendous impact on the availability and price of fuels. Hurricane Katrina caused these kinds of damages and caused some supply disruptions, especially for southwestern Ohio.

Earthquake (5.4 magnitude)
A 5.4 magnitude earthquake occurs at 5:00 PM on a weekday near the border of Lake and Geauga Counties in northern Ohio. Most people in these two counties run outdoors and the shaking is felt all along the Akron Magnetic Boundary. The communities of Mentor, Painesville and Chardon are the most heavily impacted. Damage to buildings varies depending on the quality of building construction. Some older buildings near the epicenter are destroyed and many other older buildings sustained damage. There are hundreds of collapsed chimneys and

many automobile accidents 20 miles from the epicenter (Based on the March 9, 1937 earthquake in Anna, Ohio).

Landslide, Mudslide, Subsidence

Above normal rainfall amounts were recorded at the three climate stations in Ohio during the months of March, April, and May, with April being the wettest month overall. Rainfall was above normal across the entire State, but the Cincinnati area experienced rainfall in April that surpassed the previous record by 4 inches. As a result of this significant rainfall, groundwater levels, soil moisture, lake and reservoir levels, and stream flow were well above normal for an extended period of time. During this time many roads are washed out due to flash flooding. Bridges and culverts suffered flood damage and over 500 slope failures occurred. The prolonged event results in over $45 million dollars in damages to roads, bridges and other infrastructure (Hazard Mitigation Strategy for FEMA-DR-4002).

Extreme Temperatures (heat, cold)

Severe summer storms damage trees causing downed power lines and outages statewide. Due to the widespread nature of the storms, many areas are without power for 4 - 6 days. Immediately after the storms, an extended heat wave affects the State. Since many areas are without power, cooling stations and shelters are opened in most counties. Hospitals emergency rooms are filled with sensitive populations overwhelmed by heat exhaustion and related symptoms. Despite efforts to remind citizens to check on their neighbors, 10 elderly people die from heat related complications.

Hazardous Material

In Miamisburg, Ohio on July 8, 1986 fifteen cars derailed rupturing a tank car carrying 12,000 gallons of white phosphorous. The white phosphorous ignited in the atmosphere and created a plume of phosphoric acid. In the hours and days following the derailment, the situation degraded, forcing the evacuation of an estimated 30,000 people; 569 persons were treated for various complaints during the incident. This evacuation represents the largest ever U.S. evacuation due to a train derailment involving hazardous materials, and the largest emergency evacuation in Ohio history.

Product Defect/Contamination

In 2010, an Ohio food producer issued a recall of romaine lettuce products that were linked to an outbreak of a foodborne illness from *E. coli* 0145 bacteria. Although no deaths were reported, 19 people were sickened, with 12 hospitalized, including three who developed a potentially life-threatening complication called hemolytic uremic syndrome, or HUS. The lettuce was shipped to 23 states, and the most cases of illness were reported in New York, Michigan and Ohio.

Civil Disturbance, Public Unrest, Riot

In 2001, the Cincinnati race riots is considered one of the largest urban disturbances in the United States since the Los Angeles riots of 1992. The four days of rioting were a reaction to the fatal shooting of a 19-year-old black male, by a white police officer. Full-scale rioting lasted nearly a week, with millions of dollars in property damage reported.

Drought

In July 1995, higher than normal temperatures and dry vegetation for two straight weeks create extreme drought conditions in 13 southern Ohio counties. Crops are adversely affected, as well as lawns, gardens, and other urban landscapes. Many municipalities mandated water-use restrictions by the end of June as water supplies approached critically low levels.

Mine Collapse
Thousands of abandoned coal mines in 35 Ohio counties pose a risk to residents, buildings and roads as they collapse, creating open holes or sinking patches of earth. In 2009, a house in village of Sugarcreek bowed and cracked its building façade and walls due to mine subsidence. Records from the Ohio Department of Natural Resources Division of the Geological Survey showed that an old abandoned coal mine ran under large portions of Sugarcreek. According to date from the geological survey office, Ohio is now home to about 5,000 documented abandoned underground mines (AUMs). As many as 2,000 additional AUMs might exist for which there are no records. Known AUMs are in Ohio's coal-rich Appalachian counties. More than 550 lane miles of Ohio's roads run over AUMs.

Fire (forest, range, urban, wildland)
A lighted cigarette tossed from a car window sparks a 200 acre wildfire in Lawrence County. Fire crews from neighboring townships, counties, cities and villages are dispatched to the scene. Despite conditions being relatively dry, and a moderate wind, fire crews are able to control the fire in two days. The area is sparsely populated and all residents were able to be evacuated ahead of the fire. Three fire fighters were injured, and two residential structures were destroyed in blaze (Based on historical wildfire data in Section 2.7 of the State of Ohio Hazard Mitigation Plan).

Geomagnetic Storm
A Geomagnetic Storm associated with a gigantic solar Coronal Mass Ejection (CME) produced widespread commercial power grid failures in Ohio and across the Midwest. As a result, the entire State and many surrounding states were without power for 36 hours. Damage to communication satellites affected banking, fuel distribution systems, cellular telephone networks and Global Positioning System signals. Several cities in the State experienced minor rioting and looting.

Energy/Power/Utility Failure
Twelve counties in northeast Ohio experience complete "blackout" for 5 days during a blizzard in mid-February after an unknown source corruptions electrical grid control systems.

Cyber Attack
An unknown cyber threat group breaches a variety of financial systems throughout Ohio and the United States siphoning funds from thousands of accounts from various banks and financial institutions.

Animal or Insect Infestation or damage
Since the discovery of Ohio's first Emerald Ash Borer (EAB) infestation in 2003, this exotic, invasive species has caused millions of dollars in damage to the State's wooded ecosystems, residential properties, urban forests, as well as to landscape and nursery businesses. The U.S. Department of Agriculture Forest Service estimated that there were 3.8 billion white ash trees in Ohio in 2003. The current estimate of all ash trees in the State is 254 million.
Northwestern Ohio, with its high percentage of ash trees and proximity to the Michigan EAB introduction site, was especially hard hit. Assistance requests from EAB-impacted landowners and communities are high. An ODNR Division of Forestry survey of communities returned a request of $11 million from more than 60 communities to provide for ash tree removal and replacement assistance. In the City of Toledo alone, more than 7,500 ash trees needed to be removed, dramatically impacting the urban right-of-way landscape (ODNR Division of Forestry website).

Air/Water Pollution/Contamination

In the late 1960s, about 2,500 pounds of sulfur dioxide escaped into the air from a burst pipe at a chemical plant located in the northern industrial part of Cincinnati. The release of sulfuric dioxide started at midnight and lasted for about 8 hours. People who are staying at about 200 meters to the east of the plant were affected. People were awakened by a rotten-egg smell and difficulty in breathing. Fortunately nobody was killed.

Communication Systems Interruptions
In June 2012, portions of Ohio's communications systems were severely disrupted due to a destructive windstorm "Derecho" that resulted in millions without electrical power during a record summer heat wave across the nation. The 2012 derecho severely disrupted 9-1-1-related communications called Public Safety Answering Points (PSAPs). In Ohio, 74 MARCS towers were on generator power during the height of the derecho.

Transportation Accident
In 1994, a commercial airline, Atlantic Coast Airlines, crashed on approach after a flight from Washington Dulles International Airport to Port Columbus International Airport. Five passengers and crew were killed and three people survived the accident. The aircraft slowed to a stall resulting in the aircraft impacting the ground less than 2 miles from the runway. After the impact, a fire started in or near the left engine, which spread to the rest of the aircraft.

Criminal Activity
A subject in a major urban area purchased an unusually high quantity of a chemical which could be used in the creation of an explosive device. A concerned citizen reported this information to the local fusion center which, in turn, processed and developed additional information, and shared information with the Federal Bureau of Investigation – Joint Terrorism Task Force and the Department of Homeland Security, and subsequently preventing an attack through successful interdiction. From this information/investigation, it is learned the subject has ties to a designated terrorist organization. In addition, it is learned the subject is in the process of building a significant explosive device to launch against American citizens.

Lightning Strikes
A three day outdoor music festival was held in western Ohio in July. The event drew 50,000 people to an open field area in a rural part of the State. A quickly developing severe summer storm directly hits the festival area causing two casualties from lightning strikes.

Space Debris
About 40,000 to 60,000 tons of space material falls onto the Earth each year, but most of it is mere dust. Larger materials fall during regular cycles called meteor showers, but again most of it is small enough to harmlessly burn up as it hits the Earth's atmosphere at high speeds. Material that does manage to strike the Earth's surface lands in random locations, and since 70% of the Earth's surface is water, these meteorites mostly go unnoticed by ordinary people. There is a 1-in-3,200 chance of satellite debris hitting a person on the ground. Throughout the entire 54 years of the Space Age there has been no report of anyone being injured or impacted by any re-entering debris.

Risk Assessment: The Analysis Process

Methodology

A hazard identification and risk assessment consists of three elements –establishing threat and hazard profiles, assessment of vulnerability related to each threat or hazard, and consequences expected should an incident occur. Research for this assessment involved the collection of both historical and statistical data, including review of available literature and interviews with professionals in various disciplines at the local-level and at the state-level. Information was then systematically analyzed for potential risk value. Composite risk values are calculated based on scores for several factors under each of the three elements. Because the analysis incorporates data applicable to the entire state, the data for any specific (county) jurisdiction may differ.

Figure 9. Threats and Hazards Identified lists the threats and hazards identified and as they were consolidated by subject matter experts for planning purposes.

Figure 11. Total Risk Values (Probability x Consequence) provides the numerical score, the hazard profile, vulnerability, and overall risk total for each hazard. The hazards are categorized primarily by FEMA's Comprehensive Preparedness Guide 101.

Threat and Hazard Profiles were determined based on: ***Frequency, Duration, Speed of Onset, and Magnitude.*** Vulnerability is determined based on impacts to: ***Business, Humans, Property, and the Environment.*** The consequence analysis further estimates the impacts to people, property and the environment by evaluating impacts to: ***the Public, First Responders, Business Continuity, Public Confidence, Economy, Facilities/Infrastructure, and the Environment (estimated remediation required).***

Generally, these factors were considered for an average occurrence of the hazard, not an incidence of catastrophic occurrence. The resulting risk total values allow hazards to be compared against each other to obtain a prioritization of hazards. Although this assessment considers the hazard analysis documented by the Ohio EMA's Mitigation Branch in the Ohio Enhanced Hazard Mitigation Plan, the threats and hazards identified and risk values determined in this report are used for planning purposes only. The outcome of this risk assessment is referenced in the State of Ohio Emergency Operations Plan and as Step 1 of the annual statewide Threat and Hazard Identification and Risk Assessment (THIRA) process.

Factors for Threat and Hazard Profiles

Frequency. *A key factor in the risk of a particular hazard is the frequency with which it occurs. Some hazards have been relatively frequent in this state while others were only sporadic. For this hazard analysis, the frequency with which an event occurs is based on historical reports and query of subject matter experts from various state and local authorities as well as the number of Gubernatorial Declarations associated with the hazard agent. Using these criteria provides a wider variety of hazards than utilizing presidential declarations alone. State declaration records from Ohio's Secretary of State date back to 1991.*

4	Highly Likely	Near 100% probability in next year. Many state declarations have occurred.
3	Likely	Between 10 and 100% probability in next year, or at least one chance in 10 years. Some state declarations have occurred.

2	Possible	Between 1 to 10% probability in the next year, or at least 1 in the next 100 years. Very few state declarations have occurred.
1	Unlikely	<1% probability in next 100 years. No state declarations are likely.

***Duration** may be defined as "time on the ground" or the time-period of response to a hazard or event. Transportation accidents may last a few hours whereas a tire fire may last a week and a flood several weeks. Duration, therefore, may not always be indicative of the degree of damage, but it remains an important planning factor.*

5	Excessive	More than 30 days
4	Long	7 to 30 days
3	Medium	1 to 7 days
2	Short	12 to 24 hours
1	Minimal	Less than half a day

***Speed of Onset** may affect all other factors due to lack of warning or time to prepare for impact. The lead-time required protecting lives and property varies greatly with each event. For instance, a slow-rising Ohio River flood may allow time to evacuate residents and begin flood fight measures, but flash floods can occur with little warning.*

4	Short-None	Minimal to no warning
3	Short	6 to 12 hours
2	Medium	12 to 24 hours
1	Extended	More than 24 hours

***Magnitude** is the geographic dispersion of the hazard. For instance, comparing the number of counties impacted by a flood on the Ohio River versus a transportation accident involving hazardous materials.*

4	Catastrophic	More than 50 counties impacted
3	Critical	25 to 50 counties impacted
2	Limited	10-25 counties impacted
1	Localized	Less than 10 counties impacted

Factors for Vulnerability

***Impact on Business** refers to enduring economic impact of the hazard on the community by an event.*

4	Complete shutdown of critical facilities for 30 days or more
3	Complete shutdown of critical facilities for at least two weeks
2	Complete shutdown of critical facilities for one week
1	Shutdown of critical facilities for less than 24 hours

***Impact on Humans.** This factor relates to the number of lives potentially lost to a particular hazard.*

4	High	Multiple deaths
3	Medium	Multiple severe injuries

2	Low	Some injuries
1	Minimum	Minor injuries

Impact on Property*. This factor relates to the amount of property potentially lost to a particular hazard agent. This factor can vary between jurisdictions based on economics, geographic amount owned, and demographics of the particular populations.*

4	High	More than 50% of property severely damaged
3	Medium	More than 25% of property severely damaged
2	Low	More than 10% of property severely damaged
1	Minimum	Less than 10% of property severely damaged

Impact on Environment. *This factor considers the impacts from the hazard event to the air, water, land, and biota.*

4	High	Catastrophic Impacts to the environment as a result of the event and/or cascading effects. Environmental impacts would have immediate and long term health effects to people. Significant resources required for remediation.
3	Medium	Localized and temporary Impacts to the environment as a result of the event and/or cascading effects. No immediate health threat to people and environmental remediation would restore the environment to acceptable limits.
2	Low	Impact to the environment would be minimal and only require a local response.
1	Minimum	Impact to the environment would not require remediation.

The impact categories considered for each hazard reflect broad impact categories in a nationally recognized consequence analysis standard. Each hazard was evaluated by subject matter experts using the high, medium, and low criteria (a rating of 4 represents “catastrophic impact” for each category, reserved for the most severe incidents) and the results are summarized in the Consequence Analysis Summary. Following is a brief description of some of the factors considered when determining how to rate the impact for each of the hazards.

Factors for Consequence Analysis

Public. *This category considers the overall impact to the citizens of the State caused by the hazard. The short and long term impacts caused by the hazard were considered in addition to efforts at the State and local level to mitigate, prepare for, respond to and recover from the event. The ranking is a general reflection of the State's resilience to the hazard being evaluated.*

3	High	Impacts to the public would likely exceed State resources and necessitate Federal assistance. Impacts would include multiple casualties.
2	Medium	Impacts to the public would likely not exceed State resources. Some casualties and injuries would occur.
1	Low	Impacts to the public would be managed at the local level.

First Responders. *This category considers the impact of the hazard event to police, fire, EMT, emergency management and other State and local officials that respond to the event. The threats to the health and safety of first responders posed by the hazard were considered in addition to staffing, training, and overall preparedness of first responders.*

3	High	Extreme threat posed to first responders, which would likely exceed local and State resources.
2	Medium	Significant threat posed to first responders, but would likely not exceed State and local resources.
1	Low	Threat posed by hazard would be managed at the local level.

Continuity of Operations. *This category considers the impact of the hazard event to State government's ability to continue or reestablish essential services.*

3	High	Impacts to essential functions as a result of the hazard event and/or cascading effects would be catastrophic. This failure would have an immediate cascading effect to public health and safety.
2	Medium	Impacts to essential functions as the result of the hazard event and/or cascading effects would be significant, but localized and temporary. This impact would create delayed response to public health and safety, but no immediate concerns.
1	Low	Impact to essential functions would be minimal and only require a local response.

Facilities/Infrastructure (i.e. Property). *This category considers the impacts of the hazard event to the built environment.*

3	High	The hazard event would result in catastrophic damages to the built environment. Damage to the built environment would have cascading and long term effects. Impacts would strain Federal resources and require extensive long term recovery efforts.
2	Medium	The hazard event would result in significant damages to the built environment and likely require the need for Federal resources to effectively recover.
1	Low	Effects to the built environment would be limited and likely not exceed the response and recovery efforts at the State and local level.

Economy. *This category considers the impact to the State economy from the hazard event.*

3	High	Cost to respond and recover from the event would quickly exceed the amount budgeted in the State Disaster Relief Fund requiring federal resources.
2	Medium	Cost to respond and recover from the event would likely not exceed the amount budgeted in the State Disaster Relief Fund.
1	Low	Cost to respond and recover from the event would likely not exceed local resources.

Environment (est. remediation). *This category considers the overall impact to the citizens of the State caused by the hazard. The short and long term impacts caused by the hazard were considered in addition to efforts at the State and local level to mitigate, prepare for, respond to and recover from the event. The ranking is a general reflection of the State's resilience to the hazard being evaluated.*

3	High	Impacts to the environment as the result of the hazard event and/or cascading effects would be catastrophic. Environmental impacts would have immediate and long term health effects to people. Significant resources would be required for environmental remediation.
2	Medium	Impacts to the environment as the result of the hazard event and/or cascading effects would be localized and temporary. There would be no immediate health threat to people and environmental remediation would restore the environment to acceptable limits.
1	Low	Impact to the environment would be minimal and only require a local response.

Public Confidence. *This category considers the impact a hazard event of each type could have on the public's confidence in the government and emergency management community.*

3	High	Significant negative impact. Downturn in public trust for the government's ability to respond to or recover from disaster.
2	Medium	Some negative impact. Public trust is eroded but recoverable as the recovery ensues.
1	Low	Little or no impact on the public trust.

Calculating Total Risk

Threat/Hazard Value (T) = (Duration + Speed of Onset + Frequency + Magnitude)/1.7
where 1.7 is a normalizing factor to adjust the scores to the model used in the FEMA Critical Asset Risk Management MGT-315, October 2016

Vulnerability Rating (V) – Compare the calculated vulnerability (below) to the table provided by FEMA to determine the vulnerability rating, which is used for final calculation and plotting on the risk graph.

Vulnerability Score = (Business + Human + Property + Environment)/2.2
where 2.2 is a normalizing factor to adjust scores to the 35 point scale for vulnerability ratings in FEMA Critical Asset Risk Management MGT-315, October 2016.

Figure 10. Vulnerability Ratings Table

Vulnerability Score	*Rating*
0-2	*1*
3-5	*2*
6-8	*3*
9-11	*4*
12-14	*5*
15-17	*6*
18-20	*7*
21-23	*8*
24-26	*9*
27-29	*10*
30-32	*11*
33-35	*12*

Consequence Value (C) = sum of scores for each of the seven factors described in the Consequence Analysis section above divided by 2 to adjust scoring of six Ohio factors vs three factors used in *FEMA Critical Asset Risk Management MGT-315, October 2016*.

Hazard and vulnerability are used to calculate an overall Probability (P), which is then multiplied by Consequence to assign a Total Risk Value.

Probability (P) = T x V

Total Risk = P x C

The table below provides the calculated results for each of the risk measures above. Throughout the series of calculations, the spreadsheet functions round the values to integers for ease of display. This compounds the rounding error and presents data totals which appear to be “miscalculated.” For this reason, the table should be viewed as representative values rather than attempting to re-create the totals through the calculations.

Data Summary and Hazard Ranking

Figure 11. Total Risk Values (Probability x Consequence) Ranked within Hazard Grouping

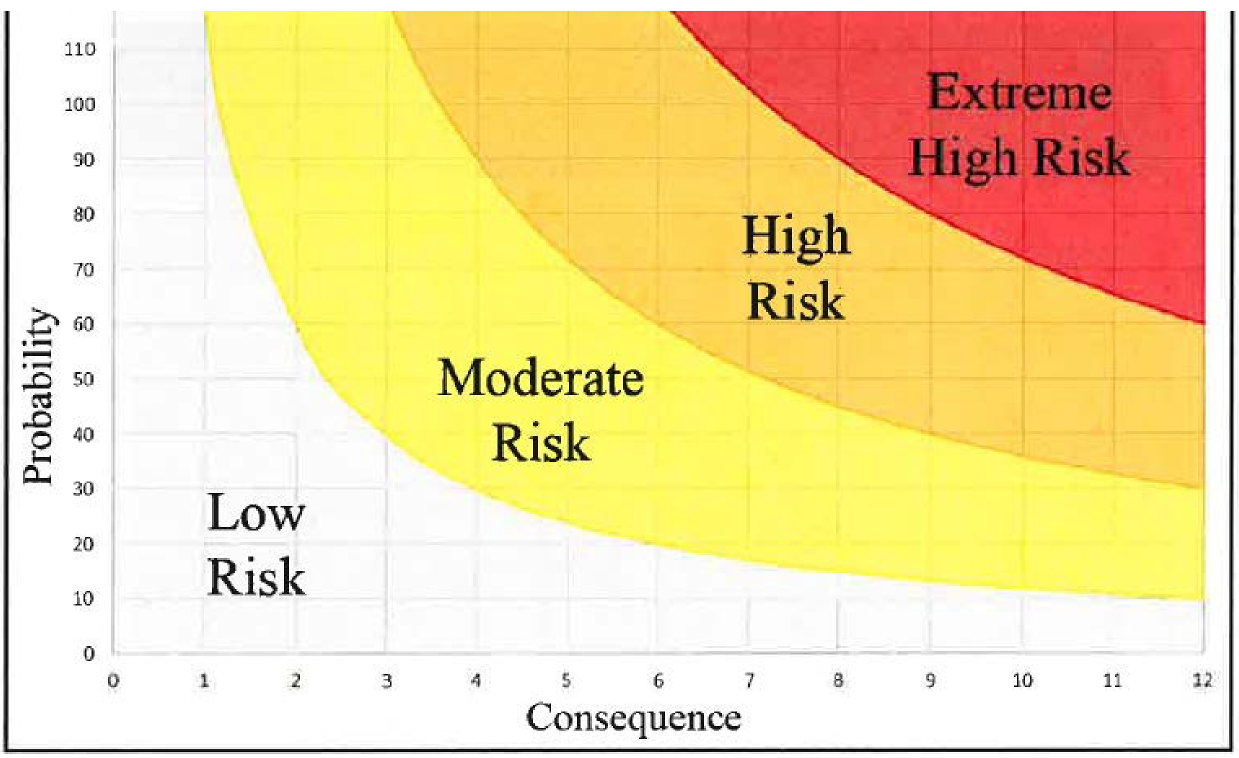
Hazard	Total Risk Value	Probability Value (P)	Consequence Value (C)	Threat/Hazard Value (T)	Vulnerability Rating (V)
Natural Hazards - Meteorological					
Tornado	690	64	11	7	9
Blizzard or Ice Storm	665	69	10	8	9
Flood, Riverine	633	64	10	7	9
High Winds	565	64	9	7	9
Urban/Flash flood	564	58	10	6	9
Wild Fire	536	53	10	6	9
Drought	470	52	9	6	8
Temperature Extremes	445	54	8	8	7
Hurricane	375	37	10	4	9
Severe Thunderstorm	356	42	8	7	6
Space Weather	287	35	8	6	6
Natural Hazards - Geological					
Earthquake	574	53	11	6	9
Landslide / Erosion	375	42	9	5	8
Natural Hazards - Biological					
Public Health Emergency	808	74	11	8	9
Mass Casualty Incident (Medical)	744	69	11	8	9
Human-Caused – Accidental/Intentional					
Electrical Grid Failure	597	58	10	8	7
Mass Communications failure	533	54	10	8	7
Water Supply Failure	517	52	10	6	8

Hazard	Total Risk Value	Probability Value (P)	Consequence Value (C)	Threat/Hazard Value (T)	Vulnerability Rating (V)
Aircraft Incident	500	53	9	6	9
IT Infrastructure Disruption	457	49	9	8	6
Transportation Failure	402	45	9	6	7
Sewer Failure	359	42	8	7	6
Human-Caused – Intentional					
Terrorism, Radioactive	1193	91	13	8	11
Terrorism, Chemical	1055	84	13	8	11
Terrorism, Biological	947	76	12	8	10
Animal/Crop Eco-terrorism	565	52	11	6	8
IT System Security Breach	515	58	9	8	7
Public Event Disturbance	399	45	9	6	7
Suspicious Powder	344	39	9	6	6
Bomb Threat	330	39	9	6	6
Hostage Situation	303	39	8	6	6
Civil Disturbance	300	35	8	6	6
Abduction	284	39	7	6	6
Mail/Package Bomb	283	32	9	5	6
Workplace Violence	275	35	8	6	6
Labor Action	274	35	8	6	6
Stalking	272	39	7	6	6
VIP Situation	247	32	8	5	6
Human-Caused - Accidental					
Nuclear Accident	1186	91	13	8	11
Mass Casualty Incident (Trauma)	675	64	11	7	9
Accidental Hazmat Release	674	64	11	7	9
Dam Failure	570	53	11	6	9

Hazard	Total Risk Value	Probability Value (P)	Consequence Value (C)	Threat/Hazard Value (T)	Vulnerability Rating (V)
Urban Fire	540	58	9	6	9
Shortage of Critical Materials	486	49	10	7	7
Natural Gas Failure	452	49	9	7	7
Fuel Shortage	420	45	9	6	7
Emergency Generator Failure	313	39	8	6	6
Flood, Internal	295	35	8	6	6
Space Debris	235	28	8	5	6

The relative severity of risk is graphically represented by plotting the Probability and Consequence Values as in Figure 5 below.

Figure 12. Total Risk Graph



Source: FEMA Critical Asset Risk Management MGT-315, October 2016

Hazards Ranked by Total Risk Value

1 Terrorism, Radioactive
2 Nuclear Accident
3 Terrorism, Chemical
4 Terrorism, Biological
5 Public Health Emergency
6 Mass Casualty Incident (Medical)
7 Tornado
8 Mass Casualty Incident (Trauma)
9 Accidental Hazmat Release
10 Blizzard or Ice Storm
11 Flood, Riverine
12 Electrical Grid Failure
13 Earthquake
14 Dam Failure
15 High Winds
16 Animal/Crop Eco-terrorism
17 Urban/Flash flood
18 Urban Fire
19 Wild Fire
20 Mass Communications failure
21 Water Supply Failure
22 IT System Security Breach
23 Aircraft Incident
24 Shortage of Critical Materials
25 Drought
26 IT Infrastructure Disruption
27 Natural Gas Failure
28 Temperature Extremes
29 Fuel Shortage
30 Transportation Failure
31 Public Event Disturbance
32 Landslide / Erosion
33 Hurricane
34 Sewer Failure
35 Severe Thunderstorm
36 Suspicious Powder
37 Bomb Threat
38 Emergency Generator Failure
39 Hostage Situation
40 Civil Disturbance
41 Flood, Internal
42 Space Weather
43 Abduction
44 Mail/Package Bomb
45 Workplace Violence
46 Labor Action
47 Stalking
48 VIP Situation
49 Space Debris

Impact on State Emergency Operations

Emergency managers have the task of coordinating mitigation, preparedness and planning, response and recovery efforts for the threats and hazards that Ohioans face. The State Emergency Operations Center and the emergency management staff coordinating its operations require all available information, tools, and expertise in their efforts to lessen the impact of disasters and to ensure as rapid a return to normal operations as possible.

Although Ohio EMA analyzed the consequences of all hazards (natural and human-caused) for their effect on the state's emergency operations, the most likely hazards determined to affect state emergency operations are those which impact the critical lifeline sectors of energy, water/sewer, and information technology.

In addition to critical lifelines, the State Emergency Operations Center's has vulnerabilities attributed to its proximity to an active airport (OSU Airport) to the south of the property and an active rail line to the east, which contributes substantial risk to egress to/from the facility as well as the potential for hazardous materials accidents which would require evacuation and relocation.

Although less likely, a public health emergency, such as the pandemic flu experienced during the H1N1 outbreak in 2009/2010, is of higher consequence to the state's emergency operations due to the resulting reduction in workforce for a prolonged period.

Method and Schedule for Review, Maintenance and Revision

The HIRA is reviewed informally by the general public via its availability on the Ohio EMA's website and is distributed, upon request, to any interested party. Formally, the HIRA is reviewed by planning partners representing the whole community (the State THIRA Workgroup members) who are identified for their subject matter expertise and support of core capabilities for emergency management. Effective with this revision, the HIRA is now included as Step 1 (Identification of Threats and Hazards) of the THIRA process, which is conducted annually.

As part of routine maintenance, this document, any reviews, and changes must be verified to conform to the current, approved Emergency Management Accreditation Program (EMAP) standard, and primarily to sections 4.1.1 to 4.1.3.

The HIRA will be revised as needed to remain current or correct typographical errors. Formal publication and re-approval will be completed at least once every five years. Significant revisions will be recorded in the Record of Changes on the following page.

Record of Changes

Change Number	Description of Change	Date	Authorized by
001	Section added on Assessing Risk and Vulnerability to the Environment for Building Collapse and Terrorism...	July 2008	Ted Filer
002	Added Record of Changes	July 2008	Patrick Sheehan
003	HIRA Update Change from Human-Caused Hazard to Manmade / Adversarial	December 2011	Portia Pulsifer
004	HIRA Update • Formatting changes and updates • Update Data in Tables • Update Environmental Impacts Analysis Statements and Scoring • Update footnotes and references that have changed • Added consequence analysis	Spring / Summer 2013	Pulsifer Sheehan Dragani Ferryman Little Merick
005	Reviewed and added analysis of risk and vulnerability State of Ohio Emergency Management Operations	Summer 2013	Sheehan
006	HIRA Update • Formatting changes and updates • Update data tables, analysis statements and scoring for consistency with FEMA Critical Asset Risk Management formulae • Update footnotes and references that have changed • Incorporated consequence analysis as part of total risk valuation • Updated analysis of risk and vulnerability to State of Ohio Emergency Management Operations	December 2018	Susan Wyatt
007	Added Disease, Human supporting data collected according to the methodology to Figure 11 and ranked hazards table; updated document release to reflect December 2018, version 1	February 2019	Susan Wyatt
008	Added specificity to the EMP scenario to indicate high-altitude nature of the attack and the size of the impact zone.	June 2019	Susan Wyatt
009	Removed “disease - human”; incorporated into public health emergency	October 2020	Dan Baker

Endnotes

[1] See Ohio Revised Code 5502.22 accessed at http://codes.ohio.gov/orc/5502.22
[2] See Ohio Revised Code 5502.21 (I) accessed at http://codes.ohio.gov/orc/5502.21
[3] See Ohio Revised Code 5502.21 (J) accessed at http://codes.ohio.gov/orc/5502.21
[4] See National Fire Protection Association. NFPA 1600: Standard on Disaster/Emergency Management and Business Continuity Programs, 2010 Edition, Pp. 1600-18
[5] As reported by the Ohio EMA Disaster Recovery Branch, information accurate as of October 2018
[6] *Thunder in the Heartland, A Chronicle of Outstanding Weather Events in Ohio*, 1996
[7] Ohio EMA Disaster Recovery Branch materials
[8] Hansen, Michael C. *Earthquakes in Ohio*, Ohio Department of Natural Resources, 2015.
[9] Pollution Issues, http://www.pollutionissues.com/