

2.3 TORNADO

Tornadoes are rapidly rotating funnels of wind extending from storm clouds to the ground. They form during severe thunderstorms when cold air overrides a layer of warm air, causing the warm air to rise rapidly. The midsection of the United States experiences a higher rate of tornadoes than other parts of the country because of the recurrent collision of moist, warm air moving north from the Gulf of Mexico with colder fronts moving east from the Rocky Mountains (FEMA, MHIRA 40).

Tornadoes are the most hazardous when they occur in populated areas. Tornadoes can topple mobile homes, lift cars, snap trees, and turn objects into destructive missiles. Among the most unpredictable of weather phenomena, tornadoes can occur at any time of day, in any state in the union, and in any season. While the majority of tornadoes cause little or no damage, some are capable of tremendous destruction, reaching wind speeds of 200 mph or more.

Tornadoes are not spatial hazards. As a result, it is often difficult to profile tornadoes and determine the exact risk. However, estimations can be developed by analyzing historic occurrences and past declarations. While Ohio does not rank among the top states for the number of tornado events, it does rank within the top 20 states in the nation for fatalities, injuries, and dollar losses, indicating that it has a relatively high likelihood for damages resulting from tornado.

Tornadoes are measured by damage scale for their winds—greater damage would equate to greater wind speed. The original F-scale was developed without considering a structure's integrity or condition as it relates to the wind speed necessary to damage it. Different winds may be needed to cause the same damage depending on how well-built a structure is. Also, the process of rating the damage was a judgment call with the original F-scale—arbitrary judgments were the norm. The Enhanced F-scale took effect February 1, 2007.

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

Table 2.3.a.

Fujita Scale		Examples of Possible Damage	Enhanced Fujita Scale	
F Number	3-Second Gust (mph)		EF Number	3-Second Gust (mph)
0	45-78	<u>Light damage.</u> Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.	0	65-85
1	79-117	<u>Moderate damage.</u> Surface peeled off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads.	1	86-110
2	118-161	<u>Considerable damage.</u> Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.	2	111-135
3	162-209	<u>Severe damage.</u> Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.	3	136-165
4	210-261	<u>Devastating damage.</u> Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.	4	166-200
5	262-317	<u>Incredible damage.</u> Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized missiles fly through the air in excess of 100-yards; trees debarked; incredible phenomena will occur.	5	Over 200

Source: <http://www.spc.noaa.gov/faq/tornado/ef-scale.html>

RISK ASSESSMENT

Location

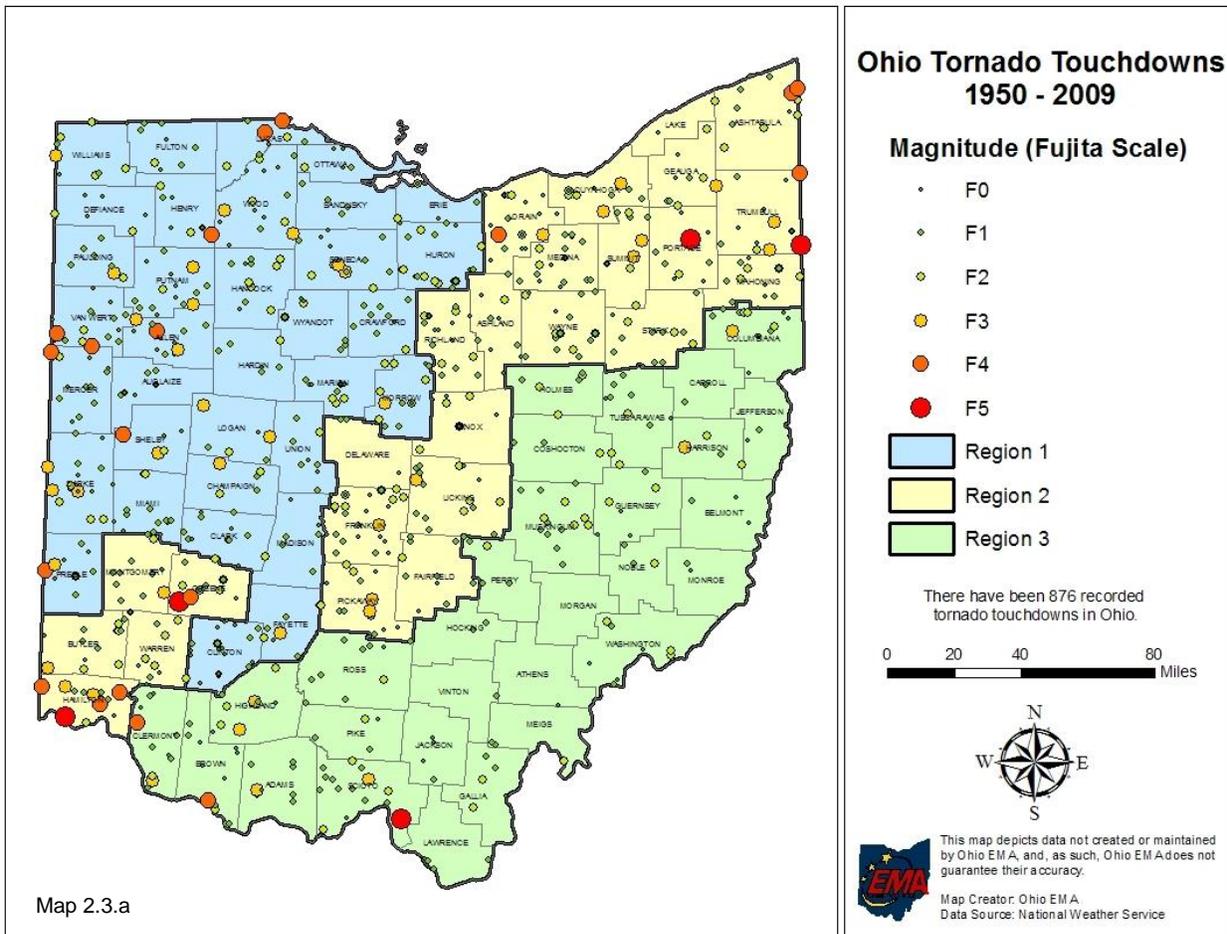
Ohio has a significant history of past tornado events. Map 2.3.a depicts the touchdowns of 876 tornadoes that have struck the State of Ohio between 1950 and 2009, and Map 2.3.b shows all F3 – F5 tornado paths in the Regions. In Ohio, tornadoes have higher frequency in the spring and summer months of April, May, June, and July (see Chart 2.3.a). These storms have caused nearly 300 deaths and over 5,400 injuries in the State. Between 1964 and 2004 ten tornadoes created damage that resulted in federal disaster declarations (see Table 2.3.b). All three Regions in the state have had tornado declarations.

LHMP Data

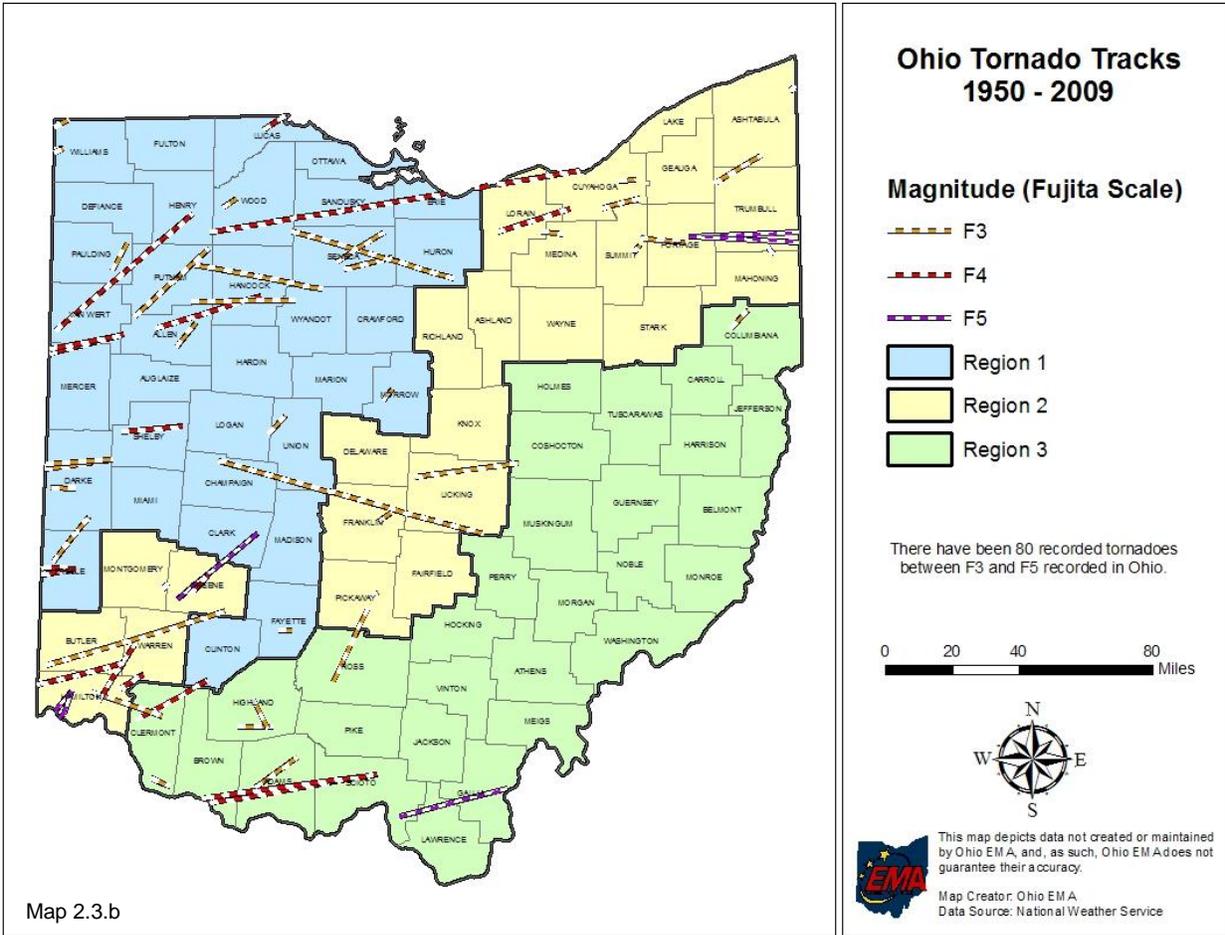
Greene County. Although tornadoes can occur throughout the state, the City of Xenia appears to be especially tornado-prone. According to the Greene County LHMP, “Nineteen tornadoes were reported in Greene County, Ohio since 1884. These tornadoes caused 43 deaths, 1,377 injuries and over \$1 billion dollars of damage. Xenia was the location of seven tornadoes, responsible for the majority of the fatalities and caused the highest amount of damage.” Greene County

considers tornadoes major hazards with the potential of high damage, personal injury, and loss of life. They have conducted a number of studies involving tornadoes and have incorporated those studies into their LHMP.

Wayne County. The Wayne County All Hazards Mitigation Plan of October 2006 provides a “Current State of Mitigation” Section of their plan which credits storm watcher programs, public awareness campaigns and weather sirens to preventing any loss of life throughout 21 tornadoes since May 1957. Regardless of these successes, the plan also focuses on actions such as the need for updating siren systems for outdoor notification, NOAA weather radios for indoor notification, alert systems for critical facilities and improving building codes for residential and commercial construction. Also, the greatest loss estimation was based on an EF-5 scenario hitting the City of Wooster with an estimated affected general building stock of over \$544 million. In addition to property loss, Wayne County estimated loss of commercial inventory, productivity, shipping capability and potential contracts that may lead to job elimination to compensate for total losses



Map 2.3.a



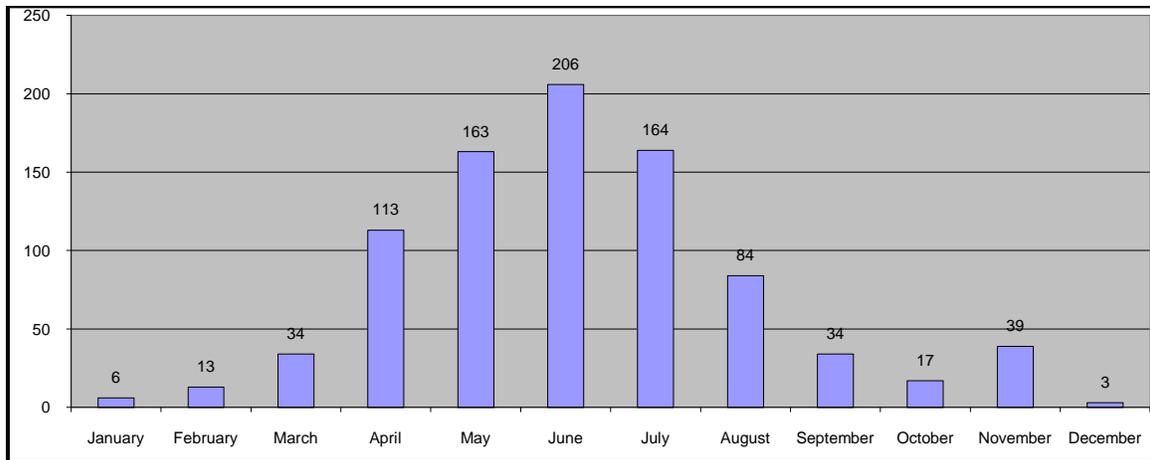
Map 2.3.b

Van Wert County. The aftermath of the 2002 Veteran’s Day Weekend Tornado Outbreak left Van Wert County in the emergency management spotlight for saving lives through aggressive public education campaigns for several years prior to the event. Although the event incurred two fatalities and 17 injured, the outcome could have been worse. The tornado slammed into a movie theater; however, people knew to take shelter in reinforced mason latrines when the tornado warnings were issued. These actions saved over 60 lives, which is contrary to the 1924 Lorain-Sandusky tornado where 72 people died, including 15 inside a collapsed cinema. The October 2005 Countywide All Natural Hazards Mitigation Plan determined that the occurrence of tornadoes was low, however, the damage was evaluated as an excessive impact to infrastructure. Also, the multi-hazard map shows that tornadoes travel in a northeasterly direction. The 2002 tornado almost traversed the entire county diagonally from the southwest to the northeast. Loss estimates were approximately \$2.6 million per event, with the exception of 2002 where damage resulted in \$30 million. There were many businesses that were disrupted by the clean-up process. The plan also states that since Van Wert has a relatively small population, many communities rely on the support of others throughout the county for recovery.

Lorain County. The June 2009 County all Natural Hazards Plan mapped the F-4 tornadoes of 1953 and 1965. These tornadoes resulted in extensive property damage with \$36.2 million in 1953 and \$25 million in 1965. An F-2 tornado left behind \$2.5 million in damage in 1986. Another tornado caused \$7.5 million in property damage in 1992. It was determined that even though the frequency of tornadoes in the county was low, they still caused moderate property damage, as the general building stock is estimated at over \$8 billion. Since 1953, there have been 18 recorded deaths and approximately 160 injuries attributed to tornadoes in Lorain County. The plan also states that as the population is forecasted to increase, the potential for injury or death will increase as well.

Chart 2.3.a

Frequency of Ohio Tornadoes by Month, 1950 - 2009



Source: SeverePlot Software, NOAA, <http://spc.noaa.gov/software/svrplot2/>

Table 2.3.b

Tornado Disaster Declarations by Region																																		
Region 1											Region 2											Region 3												
County	DR-191	DR-238	DR-421	DR-642	DR-738	DR-870	DR-1227	DR-1343	DR-1444	DR-1484	County	DR-191	DR-238	DR-421	DR-642	DR-738	DR-870	DR-1227	DR-1343	DR-1444	DR-1484	County	DR-191	DR-238	DR-421	DR-642	DR-738	DR-870	DR-1227	DR-1343	DR-1444	DR-1484		
Allen	X										Ashland											X	Adams			X							X	
Auglaize									X		Ashtabula				X									Athens					X	X				
Champaign											Butler			X		X								Belmont					X	X				
Clark			X								Cuyahoga	X									X	X		Brown		X								
Clinton											Delaware	X		X										Carroll										X
Crawford											Fairfield					X								Clermont		X			X					
Defiance											Franklin			X		X	X			X	X			Columbiana				X	X					X
Darke											Geauga					X								Coshocton				X		X		X		
Erie											Greene			X					X					Gallia		X								
Fayette			X								Hamilton			X										Guernsey						X				
Fulton											Knox						X							Harrison	X				X	X				
Hancock	X			X					X		Lake													Highland	X									
Hardin											Licking					X								Hocking					X					
Henry									X		Lorain	X					X				X			Holmes										
Huron									X		Mahoning						X				X		X	Jackson					X	X				
Logan											Medina	X				X				X	X			Jefferson					X	X				X
Lucas	X										Montgomery													Lawrence					X					
Madison			X								Pickaway	X		X				X						Meigs						X				
Marion											Portage				X	X						X		Monroe					X	X				
Morrow	X			X		X					Richland						X				X	X		Morgan						X				
Mercer	X										Stark										X	X		Muskingum					X	X				
Miami											Summit			X		X				X	X			Noble						X				
Ottawa						X		X			Trumbull				X	X					X	X		Perry					X	X				
Paulding			X					X			Warren			X										Pike					X					
Preble											Wayne													Ross					X					
Putnam			X	X				X																Scioto		X								
Sandusky						X		X																Tuscarawas						X				
Seneca	X							X																Vinton					X					X
Shelby	X																							Washington						X				
Union																																		
Van Wert	X																																	
Williams																																		
Wood																																		
Wyandot				X																														

Past Occurrences

One of the most significant storms is the April 1974 storm known as the Super-outbreak. One-hundred forty-eight tornadoes charged across Alabama, Georgia, Illinois, Indiana, Kentucky, Michigan, Mississippi, North Carolina, Ohio, South Carolina, Tennessee, Virginia, and West Virginia, killing 330 people and injuring 5,484 others. Within Ohio, the storm particularly affected Xenia, a municipality in Greene County (Region 1), where 37 tornadoes left 30 people dead, 1,100 injured, and more than 1,000 homes destroyed (NOAA, <http://www.publicaffairs.noaa.gov/storms/>). In September 2000, Xenia was again struck by an F4 tornado, damaging or destroying 300 homes and businesses, killing one person, and injuring 115 (Xenia 3-3).

Another notable storm occurred in April 1999 in the counties of Clinton, Hamilton, and Warren. The tornadoes killed four people, injured 42, and damaged or destroyed 400 structures, causing about \$82 million in losses (Ohio EMA 16).

In more recent years there have been two disaster declarations DR-1444, which was for tornado-related damage, and DR-1484, which covered tornado and flood related damage. DR-1444 was in November 2002 and affected several counties in Region 1 and Region 2 and caused damage in Coshocton County, which is located in Region 3. The damage from this disaster was relative to a tornado that registers an F-4 on the Fujita Scale. Many of the residents of the impacted counties were left homeless, many were trapped in debris, damage to commercial structures created localized unemployment, hundreds of injuries were reported, and multiple lives were lost.

DR-1484 occurred in August 2003 and was the most recent declaration that included tornadic damage. The primary damage from this disaster was flood related, and a more thorough discussion of those issues can be found in the flood section of the Risk Assessment. However, Mahoning County was damaged by a tornado that spawned from the storm. The tornado was confirmed as an F-1 and affected part of the City of Youngstown and parts of the unincorporated areas of the County. The tornado was 50-100 yards wide and eight miles long. Sixty homes received major damage and 20 received minor damage. The estimated loss from this tornado was \$900,000 and approximately 33% of the structures were insured.

In 2010 there were three significant events where tornadoes severely impacted Ohio communities.

The first event occurred in June 5 - 6, when a major tornado outbreak affected the Midwestern United States and Great Lakes Region. At least 46 tornadoes were confirmed from Iowa to southern Ontario and Ohio as well as northern New England. Tornadoes moved through northern Ohio affecting Fulton, Lucas, Wood, Ottawa, Richland, Holmes and Tuscarawas Counties. While all counties sustained heavy structural damage, the event resulted in seven people dead in Wood County. The Governor of Ohio issued an Emergency Proclamation for the event and requested a Presidential Declaration for the area, however, none was

granted. Regardless, tornadoes ranged from EF-0 northeast of Lucas, Ohio in Richland County, to an EF-4 tornado that resulted in 78 homes with major damage and 97 with minor damage. The total residential loss was approximately \$7,545,300. Thirty-two businesses had major damage and three had minor damage resulting in \$4,661,000 in losses. The Counties experienced a total of \$1,263,858 in infrastructure damage.

The second event occurred when severe weather and tornadoes swept across the state in the afternoon of September 16th. The National Weather Service confirmed 11 tornadoes in Wayne, Holmes, Fairfield, Athens, Perry, Meigs, Delaware and Tuscarawas Counties 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, while six were injured in Meigs County. State and county teams assessed the damaged structures to be 62 destroyed, 77 with major damage, 113 with minor damage and 373 structures as affected. Residential loss equated to 2,227 claims amounting in \$11,400,000, while business losses included 287 claims amounting in \$4,700,000. There were 421 auto claims resulting in a loss of \$1,200,000.

The third event occurred October 27th 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. This led to the development of a squall line producing 50-60 mph wind gusts in some areas. In addition, the strong wind shear associated with the weather system created a favorable environment for the development of tornadoes. The National Weather Service confirmed eight tornadoes in Auglaize, Fayette, Franklin, Licking, Paulding, Pickaway and Van Wert Counties. The tornadoes ranged from EF-0 to EF-2. The most severe impact occurred in the Cridersville area of Auglaize County. Preliminary damage assessments resulted in seven destroyed homes, five with major damage, four with minor damage and 29 affected. No businesses were reported to be affected.

Probability of Future Events

Between 1950 and 2009, Ohio has experienced 876 tornadoes, an average of 14.6 storms annually. Statewide, there is approximately a 4 percent chance of having a tornado of any size on any given day (this represents a probability based on the occurrence of past tornado events: 14.6 tornadoes divided by 365 days = 0.04 occurrences per day). The likelihood of a tornado is normally lower during the winter and higher during the summer. While tornado occurrences are generally considered to be unpredictable, 8.3 percent of past occurrences (1950 – 2009) involve EF3 - EF5 tornadoes with wind speeds of at least 136 mph. Based on historic occurrences the counties with the incidence include Franklin, Lorain, Van Wert, Clinton and Wood. Trumbull, Greene and Hamilton Counties have had the greatest number of EF5 tornadoes.

Table 2.3.c shows that the majority of tornadoes in Ohio (over 70 percent), fall in the gale to moderate categories (EF0 to EF1) causing light to moderate damage, such as breaking tree limbs or overturning mobile homes. Twenty-nine, or 3.3 percent, of past tornadoes have been EF4 or EF5 with wind speeds similar to those that affected Xenia in the 1974 Superoutbreak.

Table 2.3.c

Number and Percent of EF0 – EF5 Tornadoes in Ohio			
Category	Estimated Wind Speed (mph)	Number of Tornadoes*	Percent of Tornadoes*
EF0	65 – 85	257	29.3%
EF1	86 – 110	364	41.6%
EF2	111 – 135	182	20.8%
EF3	136 – 165	44	5.0%
EF4	166 – 200	23	2.6%
EF5	200+	6	0.7%
Total Tornadoes from 1950 - 2009		876	100%

*As of October 28, 2009. The numbers and percentages of tornadoes were based on the Fujita scale and the Enhanced-Fujita scale.

Source: NOAA National Climatic Data Center, Storm Event Database, October 2010.

For a more detailed understanding of the probability of future occurrence for the state, Tables 2.3.d, 2.3.e, and 2.3.f project the probability of future occurrence based on past occurrences in each county.

In Region 1, Clinton, Huron, Van Wert and Wood Counties have the highest incidence of tornadoes, as their combined occurrences account for 9% of the tornadoes that have touched down in Ohio from 1950 - 2009. Over 45% of the F0 and F3 tornadoes in the state have occurred in this Region, and over 40% of all 876 tornadoes have occurred here.

In Region 2, Franklin, Lorain, Medina, and Richland Counties have the highest incidence of tornadoes, as their combined occurrences account for 9.5% of the tornadoes that have touched down in Ohio from 1950 - 2009. Nearly 48% of the F4 tornadoes and over 83% of the F5 tornadoes in the state have occurred in this Region. Since this Region is distinguished as being the most developed and having the highest population among the three Regions, it makes sense a high number of damaging tornadoes (F4s and F5s) occur here—there is more to damage and more people at risk.

Table 2.3.d

Number and Incidence of Tornadoes in Region 1														
County	F0		F1		F2		F3		F4		F5		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Allen	5	1.9%	5	1.4%	0	0.0%	2	4.5%	1	4.3%	0	0.0%	13	1.5%
Auglaize	4	1.6%	5	1.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	9	1.0%
Champaign	0	0.0%	2	0.5%	2	1.1%	1	2.3%	0	0.0%	0	0.0%	5	0.6%
Clark	4	1.6%	7	1.9%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	12	1.4%
Clinton	14	5.4%	6	1.6%	2	1.1%	0	0.0%	0	0.0%	0	0.0%	22	2.5%
Crawford	1	0.4%	7	1.9%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	9	1.0%
Darke	5	1.9%	3	0.8%	5	2.7%	4	9.1%	0	0.0%	0	0.0%	17	1.9%
Defiance	4	1.6%	0	0.0%	2	1.1%	0	0.0%	0	0.0%	0	0.0%	6	0.7%
Erie	3	1.2%	2	0.5%	2	1.1%	0	0.0%	0	0.0%	0	0.0%	7	0.8%
Fayette	2	0.8%	3	0.8%	1	0.5%	1	2.3%	0	0.0%	0	0.0%	7	0.8%
Fulton	2	0.8%	5	1.4%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	8	0.9%
Hancock	2	0.8%	4	1.1%	5	2.7%	0	0.0%	0	0.0%	0	0.0%	11	1.3%
Hardin	1	0.4%	4	1.1%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	6	0.7%
Henry	3	1.2%	2	0.5%	2	1.1%	0	0.0%	1	4.3%	0	0.0%	8	0.9%
Huron	6	2.3%	7	1.9%	7	3.8%	0	0.0%	0	0.0%	0	0.0%	20	2.3%
Logan	1	0.4%	2	0.5%	1	0.5%	2	4.5%	0	0.0%	0	0.0%	6	0.7%
Lucas	2	0.8%	3	0.8%	2	1.1%	0	0.0%	3	13.0%	0	0.0%	10	1.1%
Madison	2	0.8%	4	1.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	6	0.7%
Marion	6	2.3%	3	0.8%	4	2.2%	0	0.0%	0	0.0%	0	0.0%	13	1.5%
Mercer	4	1.6%	6	1.6%	1	0.5%	0	0.0%	1	4.3%	0	0.0%	12	1.4%
Miami	5	1.9%	8	2.2%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	14	1.6%
Morrow	3	1.2%	4	1.1%	5	2.7%	1	2.3%	0	0.0%	0	0.0%	13	1.5%
Ottawa	3	1.2%	1	0.3%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	5	0.6%
Paulding	0	0.0%	5	1.4%	1	0.5%	1	2.3%	0	0.0%	0	0.0%	7	0.8%
Preble	3	1.2%	4	1.1%	1	0.5%	1	2.3%	1	4.3%	0	0.0%	10	1.1%
Putnam	5	1.9%	7	1.9%	1	0.5%	2	4.5%	0	0.0%	0	0.0%	15	1.7%
Sandusky	0	0.0%	4	1.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	4	0.5%
Seneca	4	1.6%	7	1.9%	3	1.6%	2	4.5%	0	0.0%	0	0.0%	16	1.8%
Shelby	2	0.8%	0	0.0%	1	0.5%	1	2.3%	1	4.3%	0	0.0%	5	0.6%
Union	2	0.8%	5	1.4%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	8	0.9%
Van Wert	8	3.1%	6	1.6%	2	1.1%	0	0.0%	2	8.7%	0	0.0%	18	2.1%
Williams	3	1.2%	2	0.5%	4	2.2%	1	2.3%	0	0.0%	0	0.0%	10	1.1%
Wood	9	3.5%	3	0.8%	4	2.2%	2	4.5%	0	0.0%	0	0.0%	18	2.1%
Wyandot	2	0.8%	4	1.1%	2	1.1%	0	0.0%	0	0.0%	0	0.0%	8	0.9%
TOTAL	120	46.7%	140	38.5%	67	36.8%	21	47.7%	10	43.5%	0	0.0%	358	40.9%

Table 2.3.e

Number and Incidence of Tornadoes in Region 2														
County	F0		F1		F2		F3		F4		F5		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Ashland	6	2.3%	4	1.1%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	11	1.3%
Ashtabula	1	0.4%	4	1.1%	7	3.8%	0	0.0%	3	13.0%	0	0.0%	15	1.7%
Butler	4	1.6%	4	1.1%	4	2.2%	1	2.3%	0	0.0%	0	0.0%	13	1.5%
Cuyahoga	3	1.2%	4	1.1%	3	1.6%	2	4.5%	0	0.0%	0	0.0%	12	1.4%
Delaware	1	0.4%	2	0.5%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	4	0.5%
Fairfield	3	1.2%	7	1.9%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	11	1.3%
Franklin	10	3.9%	7	1.9%	6	3.3%	1	2.3%	0	0.0%	0	0.0%	24	2.7%
Geauga	2	0.8%	4	1.1%	4	2.2%	0	0.0%	0	0.0%	0	0.0%	10	1.1%
Greene	3	1.2%	4	1.1%	5	2.7%	0	0.0%	1	4.3%	1	16.7%	14	1.6%
Hamilton	2	0.8%	5	1.4%	2	1.1%	2	4.5%	3	13.0%	1	16.7%	15	1.7%
Knox	4	1.6%	1	0.3%	5	2.7%	0	0.0%	0	0.0%	0	0.0%	10	1.1%
Lake	1	0.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	0.1%
Licking	3	1.2%	9	2.5%	4	2.2%	1	2.3%	0	0.0%	0	0.0%	17	1.9%
Lorain	12	4.7%	4	1.1%	2	1.1%	1	2.3%	1	4.3%	0	0.0%	20	2.3%
Mahoning	6	2.3%	6	1.6%	4	2.2%	0	0.0%	0	0.0%	0	0.0%	16	1.8%
Medina	6	2.3%	11	3.0%	2	1.1%	0	0.0%	0	0.0%	0	0.0%	19	2.2%
Montgomery	1	0.4%	8	2.2%	1	0.5%	1	2.3%	0	0.0%	0	0.0%	11	1.3%
Pickaway	5	1.9%	7	1.9%	4	2.2%	2	4.5%	0	0.0%	0	0.0%	18	2.1%
Portage	4	1.6%	3	0.8%	1	0.5%	0	0.0%	0	0.0%	2	33.3%	10	1.1%
Richland	7	2.7%	9	2.5%	4	2.2%	0	0.0%	0	0.0%	0	0.0%	20	2.3%
Stark	1	0.4%	8	2.2%	3	1.6%	0	0.0%	0	0.0%	0	0.0%	12	1.4%
Summit	1	0.4%	5	1.4%	3	1.6%	2	4.5%	0	0.0%	0	0.0%	11	1.3%
Trumbull	5	1.9%	3	0.8%	1	0.5%	3	6.8%	3	13.0%	1	16.7%	16	1.8%
Warren	5	1.9%	4	1.1%	4	2.2%	0	0.0%	0	0.0%	0	0.0%	13	1.5%
Wayne	2	0.8%	10	2.7%	5	2.7%	0	0.0%	0	0.0%	0	0.0%	17	1.9%
TOTAL	98	38.1%	133	36.5%	77	42.3%	16	36.4%	11	47.8%	5	83.3%	340	38.8%

Table 2.3.f

Number and Incidence of Tornadoes in Region 3														
County	F0		F1		F2		F3		F4		F5		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Adams	1	0.4%	7	1.9%	0	0.0%	1	2.3%	0	0.0%	0	0.0%	9	1.0%
Athens	1	0.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	0.1%
Belmont	2	0.8%	1	0.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	3	0.3%
Brown	5	1.9%	5	1.4%	1	0.5%	0	0.0%	1	4.3%	0	0.0%	12	1.4%
Carroll	0	0.0%	2	0.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	0.2%
Clermont	3	1.2%	5	1.4%	1	0.5%	1	2.3%	1	4.3%	0	0.0%	11	1.3%
Columbiana	7	2.7%	4	1.1%	3	1.6%	1	2.3%	0	0.0%	0	0.0%	15	1.7%
Coshocton	0	0.0%	2	0.5%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	3	0.3%
Gallia	1	0.4%	2	0.5%	2	1.1%	0	0.0%	0	0.0%	0	0.0%	5	0.6%
Guernsey	2	0.8%	1	0.3%	2	1.1%	0	0.0%	0	0.0%	0	0.0%	5	0.6%
Harrison	0	0.0%	1	0.3%	2	1.1%	1	2.3%	0	0.0%	0	0.0%	4	0.5%
Highland	2	0.8%	4	1.1%	3	1.6%	2	4.5%	0	0.0%	0	0.0%	11	1.3%
Hocking	0	0.0%	2	0.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	0.2%
Holmes	0	0.0%	4	1.1%	3	1.6%	0	0.0%	0	0.0%	0	0.0%	7	0.8%
Jackson	3	1.2%	1	0.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	4	0.5%
Jefferson	1	0.4%	1	0.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	0.2%
Lawrence	1	0.4%	5	1.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	6	0.7%
Meigs	0	0.0%	2	0.5%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	3	0.3%
Monroe	1	0.4%	1	0.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	0.2%
Morgan	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Muskingum	1	0.4%	9	2.5%	5	2.7%	0	0.0%	0	0.0%	0	0.0%	15	1.7%
Noble	0	0.0%	2	0.5%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	3	0.3%
Perry	0	0.0%	4	1.1%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	5	0.6%
Pike	1	0.4%	2	0.5%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	4	0.5%
Ross	1	0.4%	7	1.9%	1	0.5%	0	0.0%	0	0.0%	0	0.0%	9	1.0%
Scioto	1	0.4%	9	2.5%	3	1.6%	1	2.3%	0	0.0%	1	16.7%	15	1.7%
Tuscarawas	2	0.8%	5	1.4%	3	1.6%	0	0.0%	0	0.0%	0	0.0%	10	1.1%
Vinton	0	0.0%	1	0.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	0.1%
Washington	3	1.2%	2	0.5%	4	2.2%	0	0.0%	0	0.0%	0	0.0%	9	1.0%
TOTAL	39	15.2%	91	25.0%	38	20.9%	7	15.9%	2	8.7%	1	16.7%	178	20.3%

In Region 3, Brown, Columbiana, Muskingum, and Scioto Counties have the highest incidence of tornadoes, as their combined occurrences account for 6.5% of the tornadoes that have touched down in Ohio from 1950 - 2009. Combined, 20.3% of all tornado touchdowns recorded during that 60-year period occurred in this Region.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

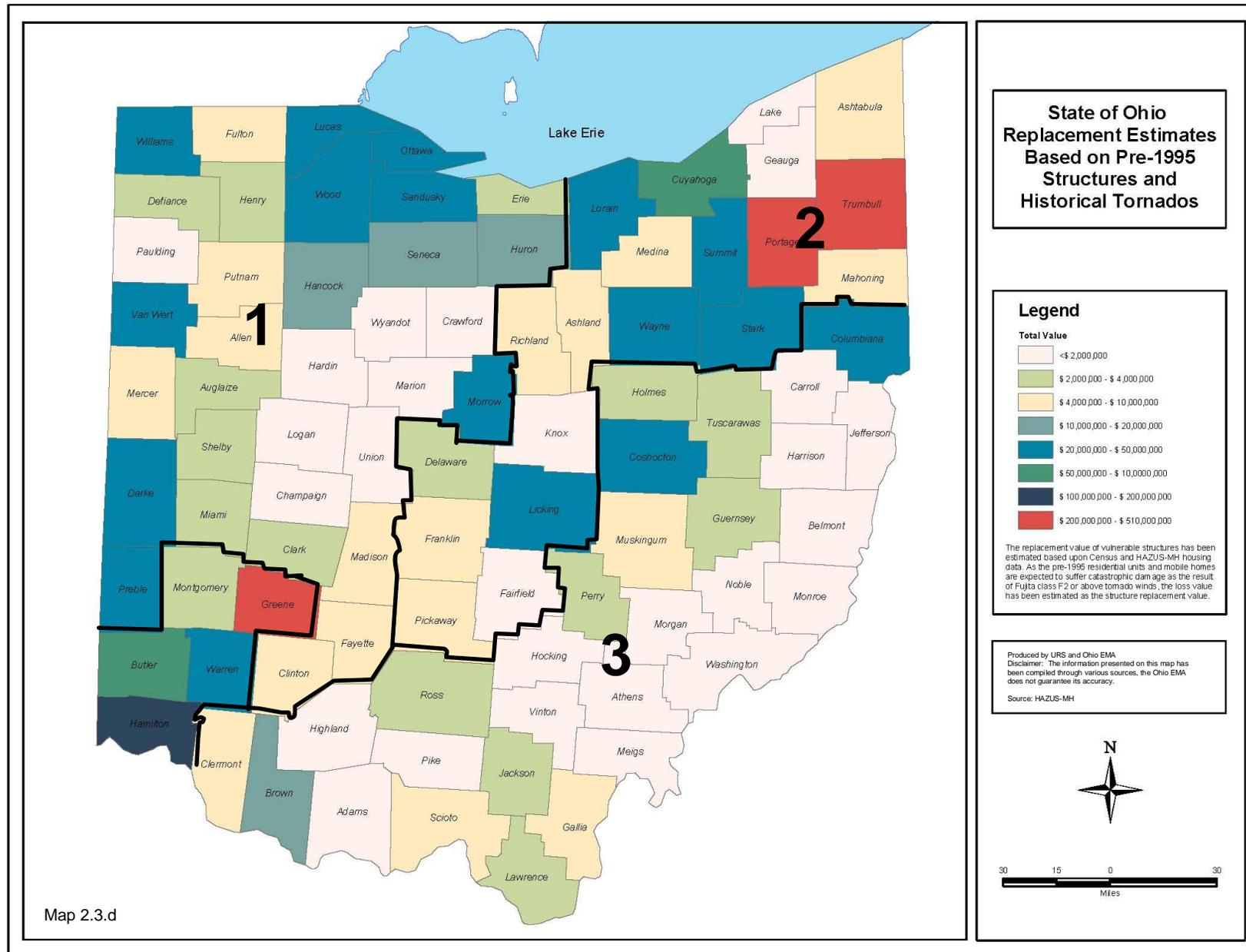
Methodology

The Tornado Relative Risk column indicates the relative likelihood of the occurrence of a strong tornado (EF2 or above). These relative ratings were determined by review of actual tornado occurrences over a 50-year period. Based on the frequency of occurrence, each county has been assigned into a high, medium, or low *relative* risk categories.

There is a high probability that mobile homes and residential units built without wind-resistant construction standards would suffer catastrophic destruction as the result of a strike by an EF2 or stronger tornado. On a statewide basis, Ohio does not have building codes that address wind resistance for most types of residential dwellings. However, since 1995 many local codes that address wind resistance have been adopted. Therefore, structures constructed prior to 1995 are potentially more susceptible to catastrophic destruction as the result of a tornado strike than those constructed after 1995.

By using U.S. Census Bureau housing data, the age of structures can be assessed on a countywide basis and the year 1995 was used as a benchmark to separate the most vulnerable pre-1995 housing stock from later construction. In addition, mobile homes are considered highly vulnerable to catastrophic damage from tornadoes and high wind regardless of construction date. Census housing data also include information on the number of mobile or manufactured homes for each county. The actual numbers of vulnerable residential housing units in each county was determined based on adding the resulting totals for residential structures built before 1995 and mobile homes. Vulnerable structures represent a percentage of the residential and total building units, indicating the relative exposure of the county to tornado damage.

The average residential home value of vulnerable structures has been estimated based upon census and HAZUS-MH housing data. As the pre-1995 residential units and mobile homes are expected to suffer catastrophic damage from class EF2 or greater tornado winds/damage, the loss value has been estimated as the structure replacement value. Map 2.3.c shows the number of pre-1995 structures by county. Map 2.3.d shows replacement estimates based on pre-1995 structures and historical tornadoes.



County commercial and governmental unit counts have been calculated from the number of structures per census block according to the general building stock data in HAZUS-MH. Average values for commercial and governmental units have been based on HAZUS-MH residential average value. Commercial unit average value equals three times HAZUS-MH residential census block average value. Governmental unit average value equals four times HAZUS-MH residential census block average value. Commercial and governmental pre-95 structures have been based on HAZUS-MH census block residential year built ranges. Historical damages are 50-year tornado damage totals for each county provided by NCDC / NOAA storm event database. At-risk totals have been calculated by multiplying pre-95 structures by their respective average values.

Results

Tables 2.3.f, 2.3.g, and 2.3.h provide information on the number of residential structures and the estimate of potential residential loss based on the number of structures, date of construction and average value by county for each Region.

Table 2.3.f

EF-2 Vulnerability and Estimate of Potential Residential Losses for Region 1									
County	Tornado Relative Risk	Res. Units (Incl. Mobile Homes)	Avg. Res. Home Value	Non Mobile Home Res. Units Pre-1995	Mobile Homes	Pre-1995 Res. + Mobile Homes	% Res. Pre-1995 & MH (At Risk Pop.)	\$ Value of Historic Tornado Damages (50 yrs. NOAA)	At Risk Total Value (Pre-1995 Res. + All Mobile Homes) x1,000
Allen	MEDIUM	35,116	\$68,837	28,643	2,264	30,907	88%	\$5,879,000	\$2,128,000
Auglaize	MEDIUM	15,483	\$92,359	9,557	856	10,413	67%	\$3,275,000	\$962,000
Champaign	HIGH	14,029	\$87,183	7,477	1,401	8,878	63%	\$578,000	\$774,000
Clark	HIGH	49,099	\$82,218	39,807	3,056	42,863	87%	\$3,118,000	\$3,524,000
Clinton	HIGH	14,211	\$89,214	8,344	1,561	9,905	70%	\$8,120,000	\$884,000
Crawford	MEDIUM	16,401	\$75,545	11,384	1,287	12,671	77%	\$1,780,000	\$957,000
Darke	MEDIUM	17,992	\$87,458	10,674	910	11,584	64%	\$30,713,000	\$1,013,000
Defiance	MEDIUM	14,471	\$79,561	9,253	1,415	10,668	74%	\$2,578,000	\$849,000
Erie	LOW	28,326	\$103,990	22,023	1,606	23,629	83%	\$3,495,000	\$2,457,000
Fayette	HIGH	9,633	\$82,187	6,633	673	7,306	76%	\$5,585,000	\$600,000
Fulton	MEDIUM	14,738	\$99,753	8,001	1,517	9,518	65%	\$5,353,000	\$949,000
Hancock	HIGH	24,756	\$98,415	16,115	2,084	18,199	74%	\$14,553,000	\$1,791,000
Hardin	HIGH	11,048	\$67,522	6,062	1,236	7,298	66%	\$553,000	\$493,000
Henry	HIGH	10,624	\$79,781	5,498	1,042	6,540	62%	\$2,578,000	\$522,000
Huron	MEDIUM	19,854	\$89,372	11,682	1,881	13,563	68%	\$5,879,000	\$1,212,000
Logan	HIGH	19,872	\$77,790	11,161	2,599	13,760	69%	\$60,808,000	\$1,070,000
Lucas	HIGH	140,239	\$85,349	128,931	5,331	134,262	96%	\$578,000	\$11,459,000
Madison	HIGH	12,605	\$102,672	8,184	1,255	9,439	75%	\$3,118,000	\$969,000
Marion	MEDIUM	21,697	\$70,649	15,167	1,471	16,638	77%	\$8,120,000	\$1,175,000
Mercer	MEDIUM	14,029	\$90,338	8,849	1,197	10,046	72%	\$1,780,000	\$908,000
Miami	MEDIUM	32,203	\$110,134	23,185	782	23,967	74%	\$67,753,000	\$2,640,000
Morrow	HIGH	12,198	\$83,621	5,695	1,972	7,667	63%	\$3,495,000	\$641,000
Ottawa	MEDIUM	24,635	\$105,435	15,163	4,002	19,165	78%	\$6,718,000	\$2,021,000
Paulding	MEDIUM	8,215	\$63,258	4,740	1,142	5,882	72%	\$5,353,000	\$372,000
Preble	MEDIUM	14,663	\$91,528	8,904	807	9,711	66%	\$138,450,000	\$889,000
Putnam	HIGH	11,430	\$86,129	6,447	982	7,429	65%	\$14,553,000	\$640,000
Sandusky	MEDIUM	21,184	\$86,086	12,670	1,620	14,290	67%	\$2,578,000	\$1,230,000
Seneca	MEDIUM	19,897	\$77,134	11,286	1,559	12,845	65%	\$28,000	\$991,000
Shelby	HIGH	15,723	\$95,786	10,050	971	11,021	70%	\$3,103,000	\$1,056,000
Union	LOW	13,271	\$112,133	6,806	1118	7,924	60%	\$275,000	\$889,000
Van Wert	MEDIUM	10,949	\$68,697	5,886	937	6,823	62%	\$2,750,000	\$469,000
Williams	LOW	14,386	\$79,873	8,156	1,473	9,629	67%	\$5,778,000	\$769,000
Wood	HIGH	40,100	\$105,421	28,775	4,970	33,745	84%	\$5,195,000	\$3,557,000
Wyandot	MEDIUM	8,041	\$76,954	4,100	731	4,831	60%	\$1,440,000	\$372,000
REGIONAL TOTALS		751,118	\$2,952,382	525,308	57,708	583,016		\$425,910,000	\$51,232,000

Table 2.3.g

EF-2 Vulnerability and Estimate of Potential Residential Losses for Region 2									
County	Tornado Relative Risk	Res. Units (Incl. Mobile Homes)	Avg. Res. Home Value	Non Mobile Home Res. Units Pre-1995	Mobile Homes	Pre-1995 Res. + Mobile Homes	% Res. Pre-1995 & MH (At Risk Pop.)	\$ Value of Historic Tornado Damages (50 yrs. NOAA)	At Risk Total Value (Pre-1995 Res. + All Mobile Homes) x1,000
Ashland	LOW	17,620	\$90,561	10,622	1,417	12,039	68%	\$7,203,000	\$1,090,000
Ashtabula	HIGH	37,671	\$75,642	24,788	3,912	28,700	76%	\$6,353,000	\$2,171,000
Butler	HIGH	102,651	\$107,639	85,029	4,956	89,985	88%	\$60,808,000	\$9,686,000
Cuyahoga	HIGH	399,032	\$108,816	303,202	3,214	306,416	77%	\$67,753,000	\$33,343,000
Delaware	MEDIUM	39,474	\$194,198	16,580	1,319	17,899	45%	\$3,800,000	\$3,476,000
Fairfield	MEDIUM	40,497	\$120,319	25,943	1,549	27,492	68%	\$1,538,000	\$3,308,000
Franklin	MEDIUM	302,592	\$111,630	226,183	4,953	231,136	76%	\$6,718,000	\$25,802,000
Geauga	HIGH	31,135	\$165,026	21,468	1,368	22,836	73%	\$1,853,000	\$3,769,000
Greene	HIGH	45,416	\$122,301	42,040	835	42,875	94%	\$268,860,000	\$5,244,000
Hamilton	HIGH	234,751	\$114,903	147,443	3,302	150,745	64%	\$138,450,000	\$17,321,000
Knox	MEDIUM	18,318	\$88,612	10,996	1,254	12,250	67%	\$250,000	\$1,085,000
Lake	HIGH	73,399	\$136,994	70,356	2,329	72,685	99%	\$3,275,000	\$9,957,000
Licking	HIGH	49,158	\$101,874	34,008	3,509	37,517	76%	\$10,078,000	\$3,822,000
Lorain	LOW	89,269	\$110,349	76,386	3,470	79,856	89%	\$300,000	\$8,812,000
Mahoning	MEDIUM	81,767	\$62,176	76,558	1,980	78,538	96%	\$5,660,000	\$4,883,000
Medina	MEDIUM	46,980	\$148,399	34,362	703	35,065	75%	\$28,860,000	\$5,204,000
Montgomery	MEDIUM	173,462	\$95,186	108,276	3,811	112,087	65%	\$2,578,000	\$10,669,000
Pickaway	MEDIUM	17,324	\$92,297	10,453	2,291	12,744	74%	\$1,853,000	\$1,176,000
Portage	HIGH	49,739	\$108,343	39,249	5,514	44,763	90%	\$3,353,000	\$4,850,000
Richland	MEDIUM	41,696	\$77,608	34,861	2,523	37,384	90%	\$553,000	\$2,901,000
Stark	HIGH	119,039	\$92,407	102,110	3,825	105,935	89%	\$10,208,000	\$9,789,000
Summit	HIGH	171,766	\$107,341	151,050	2,525	153,575	89%	\$2,800,000	\$16,485,000
Trumbull	HIGH	77,034	\$79,154	66,361	5,301	71,662	93%	\$285,000	\$5,672,000
Warren	HIGH	49,723	\$138,478	33,288	1,012	34,300	69%	\$380,000	\$4,750,000
Wayne	LOW	36,561	\$96,691	24,042	3,959	28,001	77%	\$30,175,000	\$2,707,000
REGIONAL TOTALS		2,346,074	\$2,746,944	1,775,654	70,831	1,846,485		\$663,944,000	\$197,972,000

Table 2.3.h

EF-2 Vulnerability and Estimate of Potential Residential Losses for Region 3									
County	Tornado Relative Risk	Res. Units (Incl. Mobile Homes)	Avg. Res. Home Value	Non Mobile Home Res. Units Pre-1995	Mobile Homes	Pre-1995 Res. + Mobile Homes	% Res. Pre-1995 & MH (At Risk Pop.)	\$ Value of Historic Tornado Damages (50 yrs. NOAA)	At Risk Total Value (Pre-1995 Res. + All Mobile Homes) x1,000
Adams	MEDIUM	12,853	\$49,195	6,636	3,162	9,798	76%	\$505,000	\$482,000
Athens	LOW	22,548	\$68,278	13,430	4,709	18,139	80%	\$250,000	\$1,238,000
Belmont	LOW	25,839	\$58,405	17,275	2,732	20,007	77%	\$50,000	\$1,169,000
Brown	MEDIUM	18,186	\$69,872	9,044	3,820	12,864	71%	\$10,078,000	\$899,000
Carroll	MEDIUM	13,079	\$74,100	7,032	2,250	9,282	71%	\$300,000	\$688,000
Clermont	HIGH	59,058	\$109,471	45,576	6,110	51,686	88%	\$5,660,000	\$5,658,000
Columbiana	MEDIUM	40,719	\$67,917	25,599	4,829	30,428	75%	\$28,860,000	\$2,067,000
Coshocton	HIGH	15,607	\$68,418	8,731	2,625	11,356	73%	\$27,530,000	\$777,000
Gallia	MEDIUM	14,508	\$58,048	8,111	3,489	11,600	80%	\$9,150,000	\$673,000
Guernsey	MEDIUM	17,318	\$56,318	9,960	2,969	12,929	75%	\$3,353,000	\$728,000
Harrison	LOW	7,433	\$48,630	3,823	1,289	5,112	69%	\$353,000	\$249,000
Highland	HIGH	17,438	\$67,372	8,934	3,244	12,178	70%	\$1,100,000	\$820,000
Hocking	LOW	12,097	\$68,437	6,602	2,136	8,738	72%	\$28,000	\$598,000
Holmes	LOW	11,757	\$91,042	6,075	1,610	7,685	65%	\$505,000	\$700,000
Jackson	MEDIUM	13,570	\$56,309	7,882	2,676	10,558	78%	\$7,203,000	\$595,000
Jefferson	LOW	27,889	\$54,788	21,717	2,802	24,519	88%	\$6,353,000	\$1,343,000
Lance	HIGH	25,923	\$54,973	17,960	4,576	22,536	87%	\$50,000	\$1,239,000
Meigs	MEDIUM	11,733	\$45,300	5,785	2,862	8,647	74%	\$27,530,000	\$392,000
Monroe	LOW	7,387	\$51,237	3,501	1,393	4,894	66%	\$30,713,000	\$251,000
Morgan	LOW	8,124	\$51,759	4,113	1,853	5,966	73%	\$3,800,000	\$309,000
Muskingum	HIGH	30,350	\$71,016	20,764	3,647	24,411	80%	\$1,538,000	\$1,734,000
Noble	LOW	5,763	\$51,408	2,458	1,141	3,599	62%	\$5,585,000	\$185,000
Perry	MEDIUM	13,659	\$62,872	6,507	2,433	8,940	65%	\$9,150,000	\$562,000
Pike	HIGH	12,809	\$58,139	7,412	3,295	10,707	84%	\$268,860,000	\$622,000
Ross	HIGH	28,884	\$72,480	16,684	5,284	21,968	76%	\$353,000	\$1,592,000
Scioto	MEDIUM	30,362	\$52,115	20,984	4,640	25,624	84%	\$1,100,000	\$1,335,000
Tuscarawas	MEDIUM	33,769	\$80,508	18,564	4,080	22,644	67%	\$1,250,000	\$1,823,000
Vinton	LOW	6,643	\$45,723	3,160	1,901	5,061	76%	\$30,473,000	\$231,000
Washington	LOW	25,972	\$67,097	16,894	4,117	21,011	81%	\$36,273,000	\$1,410,000
REGIONAL TOTALS		571,277	\$1,831,227	351,213	91,674	442,887		\$517,953,000	\$30,369,000

Tables 2.3.i, 2.3.j, and 2.3.k provide information on the number of commercial structures and the estimate of potential commercial structure loss based on the number of structures, date of construction and average value by county for each Region.

Table 2.3.i

EF-2 Vulnerability and Estimate of Potential Commercial Losses for Region 1							
County	Tornado Relative Risk	Commercial Units	Average Commercial Value (3x Res. Ave. Value)	Commercial Units Pre-1995	% Comm. Pre-1995	Dollar Value of Historic Tornado Damages (50 yrs. NOAA)	At Risk Total Value (Pre-1995 Commercial)
Allen	MEDIUM	466	\$216,735	386	83%	\$5,879,000	\$83,659,710
Auglaize	MEDIUM	112	\$297,135	97	87%	\$3,275,000	\$28,822,095
Champaign	HIGH	84	\$286,329	72	86%	\$578,000	\$20,615,688
Clark	HIGH	385	\$261,177	306	79%	\$3,118,000	\$79,920,162
Clinton	HIGH	108	\$293,388	89	82%	\$8,120,000	\$26,111,532
Crawford	MEDIUM	80	\$244,326	67	84%	\$1,780,000	\$16,369,842
Darke	MEDIUM	107	\$276,537	91	85%	\$30,713,000	\$25,164,867
Defiance	MEDIUM	108	\$259,167	90	83%	\$2,578,000	\$23,325,030
Erie	LOW	332	\$349,257	267	80%	\$3,495,000	\$93,251,619
Fayette	HIGH	71	\$257,247	60	85%	\$5,585,000	\$15,434,820
Fulton	MEDIUM	110	\$331,698	94	85%	\$5,353,000	\$31,179,612
Hancock	HIGH	279	\$317,820	226	81%	\$14,553,000	\$71,827,320
Hardin	HIGH	62	\$227,661	52	84%	\$553,000	\$11,838,372
Henry	HIGH	61	\$263,655	53	87%	\$2,578,000	\$13,973,715
Huron	MEDIUM	160	\$300,087	136	85%	\$5,879,000	\$40,811,832
Logan	HIGH	114	\$266,022	96	84%	\$60,808,000	\$25,538,112
Lucas	HIGH	2,027	\$262,665	1703	84%	\$578,000	\$447,318,495
Madison	HIGH	59	\$340,014	49	83%	\$3,118,000	\$16,660,686
Marion	MEDIUM	224	\$224,808	185	83%	\$8,120,000	\$41,589,480
Mercer	MEDIUM	86	\$289,254	72	84%	\$1,780,000	\$20,826,288
Miami	MEDIUM	305	\$336,726	247	81%	\$67,753,000	\$83,171,322
Morrow	HIGH	30	\$297,954	25	83%	\$3,495,000	\$7,448,850
Ottawa	MEDIUM	147	\$375,780	121	82%	\$6,718,000	\$45,469,380
Paulding	MEDIUM	24	\$222,180	19	79%	\$5,353,000	\$4,221,420
Preble	MEDIUM	72	\$292,035	62	86%	\$138,450,000	\$18,106,170
Putnam	HIGH	101	\$282,102	86	85%	\$14,553,000	\$24,260,772
Sandusky	MEDIUM	142	\$276,498	125	88%	\$2,578,000	\$34,562,250
Seneca	MEDIUM	147	\$250,818	129	88%	\$28,000	\$32,355,522
Shelby	HIGH	96	\$303,744	80	83%	\$3,103,000	\$24,299,520
Union	LOW	86	\$366,747	71	83%	\$275,000	\$26,039,037
Van Wert	MEDIUM	79	\$224,376	70	89%	\$2,750,000	\$15,706,320
Williams	LOW	93	\$266,754	78	84%	\$5,778,000	\$20,806,812
Wood	HIGH	501	\$361,752	416	83%	\$5,195,000	\$150,488,832
Wyandot	MEDIUM	62	\$257,331	55	89%	\$1,440,000	\$14,153,205
REGIONAL TOTALS		6,920	\$9,679,779	5,775		\$425,910,000	\$1,635,328,689

Table 2.3.j

EF-2 Vulnerability and Estimate of Potential Commercial Losses for Region 2							
County	Tornado Relative Risk	Commercial Units	Average Commercial Value (3x Res. Ave. Value)	Commercial Units Pre-1995	% Comm. Pre-1995	Dollar Value of Historic Tornado Damages (50 yrs. NOAA)	At Risk Total Value (Pre-1995 Commercial)
Ashland	LOW	96	\$297,678	82	85%	\$7,203,000	\$24,409,596
Ashtabula	HIGH	224	\$250,800	193	86%	\$6,353,000	\$48,404,400
Butler	HIGH	1,304	\$334,416	1052	81%	\$60,808,000	\$351,805,632
Cuyahoga	HIGH	7,165	\$326,907	5600	78%	\$67,753,000	\$1,830,679,200
Delaware	MEDIUM	383	\$597,747	284	74%	\$3,800,000	\$169,760,148
Fairfield	MEDIUM	319	\$369,438	263	82%	\$1,538,000	\$97,162,194
Franklin	MEDIUM	5,004	\$337,038	3855	77%	\$6,718,000	\$1,299,281,490
Geauga	HIGH	299	\$512,148	240	80%	\$1,853,000	\$122,915,520
Greene	HIGH	431	\$372,669	326	76%	\$268,860,000	\$121,490,094
Hamilton	HIGH	4,606	\$346,338	3716	81%	\$138,450,000	\$1,286,992,008
Knox	MEDIUM	95	\$282,414	80	84%	\$250,000	\$22,593,120
Lake	HIGH	1,005	\$422,865	792	79%	\$3,275,000	\$334,909,080
Licking	HIGH	481	\$325,863	382	79%	\$10,078,000	\$124,479,666
Lorain	LOW	1,144	\$343,434	900	79%	\$300,000	\$309,090,600
Mahoning	MEDIUM	1,097	\$188,598	900	82%	\$5,660,000	\$169,738,200
Medina	MEDIUM	698	\$446,247	563	81%	\$28,860,000	\$251,237,061
Montgomery	MEDIUM	2,393	\$287,112	1857	78%	\$2,578,000	\$533,166,984
Pickaway	MEDIUM	88	\$313,020	71	81%	\$1,853,000	\$22,224,420
Portage	HIGH	432	\$362,688	334	77%	\$3,353,000	\$121,137,792
Richland	MEDIUM	443	\$246,243	358	81%	\$553,000	\$88,154,994
Stark	HIGH	1,453	\$282,630	1196	82%	\$10,208,000	\$338,025,480
Summit	HIGH	2,412	\$321,444	1946	81%	\$2,800,000	\$625,530,024
Trumbull	HIGH	759	\$252,069	618	81%	\$285,000	\$155,778,642
Warren	HIGH	457	\$423,396	345	75%	\$380,000	\$146,071,620
Wayne	LOW	272	\$321,486	224	82%	\$30,175,000	\$72,012,864
REGIONAL TOTALS		33,060	\$8,564,688	26,177		\$663,944,000	\$8,667,050,829

Table 2.3.k

EF-2 Vulnerability and Estimate of Potential Commercial Losses for Region 3							
County	Tornado Relative Risk	Commercial Units	Average Commercial Value (3x Res. Ave. Value)	Commercial Units Pre-1995	% Comm. Pre-1995	Dollar Value of Historic Tornado Damages (50 vs. NOAA)	At Risk Total Value (Pre-1995 Commercial)
Adams	MEDIUM	38	\$197,322	32	84%	\$505,000	\$6,314,304
Athens	LOW	159	\$239,247	130	82%	\$250,000	\$31,102,110
Belmont	LOW	236	\$195,318	207	88%	\$50,000	\$40,430,826
Brown	MEDIUM	56	\$263,715	46	82%	\$10,078,000	\$12,130,890
Carroll	MEDIUM	43	\$265,317	36	84%	\$300,000	\$9,551,412
Clermont	HIGH	594	\$362,706	484	81%	\$5,660,000	\$175,549,704
Columbiana	MEDIUM	257	\$225,315	220	86%	\$28,860,000	\$49,569,300
Coshocton	HIGH	87	\$245,946	73	84%	\$27,530,000	\$17,954,058
Gallia	MEDIUM	102	\$229,071	83	81%	\$9,150,000	\$19,012,893
Guernsey	MEDIUM	113	\$195,489	96	85%	\$3,353,000	\$18,766,944
Harrison	LOW	23	\$177,066	20	87%	\$353,000	\$3,541,320
Highland	HIGH	84	\$248,493	69	82%	\$1,100,000	\$17,146,017
Hocking	LOW	48	\$246,438	40	83%	\$28,000	\$9,857,520
Holmes	LOW	182	\$313,155	154	85%	\$505,000	\$48,225,870
Jackson	MEDIUM	61	\$211,704	51	84%	\$7,203,000	\$10,796,904
Jefferson	LOW	216	\$179,535	178	82%	\$6,353,000	\$31,957,230
Lawrence	HIGH	78	\$197,988	62	79%	\$50,000	\$12,275,256
Meigs	MEDIUM	38	\$182,805	32	84%	\$27,530,000	\$5,849,760
Monroe	LOW	38	\$185,421	33	87%	\$30,713,000	\$6,118,893
Morgan	LOW	30	\$202,092	25	83%	\$3,800,000	\$5,052,300
Muskingum	HIGH	286	\$235,728	238	83%	\$1,538,000	\$56,103,264
Noble	LOW	25	\$192,033	22	88%	\$5,585,000	\$4,224,726
Perry	MEDIUM	37	\$225,798	32	86%	\$9,150,000	\$7,225,536
Pike	HIGH	60	\$236,715	49	82%	\$268,860,000	\$11,599,035
Ross	HIGH	185	\$259,434	152	82%	\$353,000	\$39,433,968
Scioto	MEDIUM	188	\$180,240	158	84%	\$1,100,000	\$28,477,920
Tuscarawas	MEDIUM	223	\$269,772	192	86%	\$1,250,000	\$51,796,224
Vinton	LOW	15	\$193,548	13	87%	\$30,473,000	\$2,516,124
Washington	LOW	183	\$235,107	153	84%	\$36,273,000	\$35,971,371
REGIONAL TOTAL		3,685	\$6,592,518	3,080		\$517,953,000	\$768,551,679

Tables 2.3.l, 2.3.m, and 2.3.n provide information on the number of local governmental structures and the estimate of potential local governmental structure loss based on the number of structures, date of construction and average value by county for each Region.

Table 2.3.l

EF-2 Vulnerability and Estimate of Potential Governmental Structure Losses for Region 1							
County	Tornado Relative Risk	Gov. Units	Average Governmental Value (4x Res. Ave. Value)	Governmental Units Pre-1995	% Gov. Pre-1995	Dollar Value of Historic Tornado Damages (50 yrs. NOAA)	At Risk Total Value (Pre-1995 Governmental)
Allen	MEDIUM	27	\$288,980	22	81%	\$5,879,000	\$6,357,560
Auglaize	MEDIUM	5	\$396,180	4	80%	\$3,275,000	\$1,584,720
Champaign	HIGH	4	\$381,772	3	75%	\$578,000	\$1,145,316
Clark	HIGH	6	\$348,236	5	83%	\$3,118,000	\$1,741,180
Clinton	HIGH	15	\$391,184	12	80%	\$8,120,000	\$4,694,208
Crawford	MEDIUM	6	\$325,768	5	83%	\$1,780,000	\$1,628,840
Darke	MEDIUM	4	\$368,716	3	75%	\$30,713,000	\$1,106,148
Defiance	MEDIUM	5	\$345,556	4	80%	\$2,578,000	\$1,382,224
Erie	LOW	16	\$465,676	13	81%	\$3,495,000	\$6,053,788
Fayette	HIGH	4	\$342,996	3	75%	\$5,585,000	\$1,028,988
Fulton	MEDIUM	6	\$442,264	5	83%	\$5,353,000	\$2,211,320
Hancock	HIGH	6	\$423,760	5	83%	\$14,553,000	\$2,118,800
Hardin	HIGH	3	\$303,548	3	100%	\$553,000	\$910,644
Henry	HIGH	4	\$351,540	3	75%	\$2,578,000	\$1,054,620
Huron	MEDIUM	8	\$400,116	7	88%	\$5,879,000	\$2,800,812
Logan	HIGH	3	\$354,696	3	100%	\$60,808,000	\$1,064,088
Lucas	HIGH	27	\$350,220	23	85%	\$578,000	\$8,055,060
Madison	HIGH	10	\$453,352	8	80%	\$3,118,000	\$3,626,816
Marion	MEDIUM	11	\$299,744	9	82%	\$8,120,000	\$2,697,696
Mercer	MEDIUM	3	\$385,672	3	100%	\$1,780,000	\$1,157,016
Miami	MEDIUM	10	\$448,968	8	80%	\$67,753,000	\$3,591,744
Morrow	HIGH	3	\$397,272	2	67%	\$3,495,000	\$794,544
Ottawa	MEDIUM	4	\$501,040	3	75%	\$6,718,000	\$1,503,120
Paulding	MEDIUM	3	\$296,240	2	67%	\$5,353,000	\$592,480
Preble	MEDIUM	9	\$389,380	8	89%	\$138,450,000	\$3,115,040
Putnam	HIGH	3	\$376,136	3	100%	\$14,553,000	\$1,128,408
Sandusky	MEDIUM	4	\$368,664	4	100%	\$2,578,000	\$1,474,656
Seneca	MEDIUM	5	\$334,424	4	80%	\$28,000	\$1,337,696
Shelby	HIGH	4	\$404,992	3	75%	\$3,103,000	\$1,214,976
Union	LOW	1	\$488,996	1	100%	\$275,000	\$488,996
Van Wert	MEDIUM	2	\$299,168	2	100%	\$2,750,000	\$598,336
Williams	LOW	3	\$355,672	3	100%	\$5,778,000	\$1,067,016
Wood	HIGH	13	\$482,336	11	85%	\$5,195,000	\$5,305,696
Wyandot	MEDIUM	6	\$343,108	5	83%	\$1,440,000	\$1,715,540
REGIONAL TOTALS		243	\$12,906,372	202		\$425,910,000	\$76,348,092

Table 2.3.m

EF-2 Vulnerability and Estimate of Potential Governmental Structure Losses for Region 2							
County	Tornado Relative Risk	Gov. Units	Average Governmental Value (4x Res. Ave. Value)	Governmental Units Pre-1995	% Gov. Pre-1995	Dollar Value of Historic Tornado Damages (50 yrs. NOAA)	At Risk Total Value (Pre-1995 Governmental)
Ashland	LOW	7	\$396,904	6	86%	\$7,203,000	\$2,381,424
Ashtabula	HIGH	18	\$334,400	16	89%	\$6,353,000	\$5,350,400
Butler	HIGH	45	\$445,888	36	80%	\$60,808,000	\$16,051,968
Cuyahoga	HIGH	267	\$435,876	209	78%	\$67,753,000	\$91,098,084
Delaware	MEDIUM	7	\$796,996	5	71%	\$3,800,000	\$3,984,980
Fairfield	MEDIUM	12	\$492,584	10	83%	\$1,538,000	\$4,925,840
Franklin	MEDIUM	562	\$449,384	433	77%	\$6,718,000	\$194,583,272
Geauga	HIGH	10	\$682,864	8	80%	\$1,853,000	\$5,462,912
Greene	HIGH	31	\$496,892	23	74%	\$268,860,000	\$11,428,516
Hamilton	HIGH	136	\$461,784	110	81%	\$138,450,000	\$50,796,240
Knox	MEDIUM	7	\$376,552	6	86%	\$250,000	\$2,259,312
Lake	HIGH	37	\$563,820	29	78%	\$3,275,000	\$16,350,780
Licking	HIGH	26	\$434,484	21	81%	\$10,078,000	\$9,124,164
Lorain	LOW	28	\$457,912	22	79%	\$300,000	\$10,074,064
Mahoning	MEDIUM	44	\$251,464	36	82%	\$5,660,000	\$9,052,704
Medina	MEDIUM	24	\$594,996	19	79%	\$28,860,000	\$11,304,924
Montgomery	MEDIUM	90	\$382,816	70	78%	\$2,578,000	\$26,797,120
Pickaway	MEDIUM	16	\$417,360	13	81%	\$1,853,000	\$5,425,680
Portage	HIGH	11	\$483,584	8	73%	\$3,353,000	\$3,868,672
Richland	MEDIUM	8	\$328,324	6	75%	\$553,000	\$1,969,944
Stark	HIGH	23	\$376,840	19	83%	\$10,208,000	\$7,159,960
Summit	HIGH	69	\$428,592	56	81%	\$2,800,000	\$24,001,152
Trumbull	HIGH	24	\$336,092	20	83%	\$285,000	\$6,721,840
Warren	HIGH	7	\$564,528	5	71%	\$380,000	\$2,822,640
Wayne	LOW	9	\$428,648	7	78%	\$30,175,000	\$3,000,536
REGIONAL TOTALS		1,518	\$11,419,584	1,193		\$663,944,000	\$525,997,128

Table 2.3.n

EF-2 Vulnerability and Estimate of Potential Governmental Structure Losses for Region 3							
County	Tornado Relative Risk	Gov. Units	Average Governmental Value (4x Res. Ave. Value)	Governmental Units Pre-1995	% Gov. Pre-1995	Dollar Value of Historic Tornado Damages (50 yrs. NOAA)	At Risk Total Value (Pre-1995 Governmental)
Adams	MEDIUM	4	\$263,096	3	75%	\$505,000	\$789,288
Athens	LOW	12	\$318,996	10	83%	\$250,000	\$3,189,960
Belmont	LOW	13	\$260,424	11	85%	\$50,000	\$2,864,664
Brown	MEDIUM	3	\$351,620	2	67%	\$10,078,000	\$703,240
Carroll	MEDIUM	6	\$353,756	5	83%	\$300,000	\$1,768,780
Clermont	HIGH	16	\$483,608	13	81%	\$5,660,000	\$6,286,904
Columbiana	MEDIUM	9	\$300,420	8	89%	\$28,860,000	\$2,403,360
Coshocton	HIGH	3	\$327,928	3	100%	\$27,530,000	\$983,784
Gallia	MEDIUM	2	\$305,428	2	100%	\$9,150,000	\$610,856
Guernsey	MEDIUM	3	\$260,652	3	100%	\$3,353,000	\$781,956
Harrison	LOW	3	\$236,088	3	100%	\$353,000	\$708,264
Highland	HIGH	6	\$331,324	5	83%	\$1,100,000	\$1,656,620
Hocking	LOW	8	\$328,584	7	88%	\$28,000	\$2,300,088
Holmes	LOW	5	\$417,540	4	80%	\$505,000	\$1,670,160
Jackson	MEDIUM	5	\$282,272	4	80%	\$7,203,000	\$1,129,088
Jefferson	LOW	7	\$239,380	6	86%	\$6,353,000	\$1,436,280
Lawrence	HIGH	6	\$263,984	5	83%	\$50,000	\$1,319,920
Meigs	MEDIUM	2	\$243,740	2	100%	\$27,530,000	\$487,480
Monroe	LOW	4	\$247,228	3	75%	\$30,713,000	\$741,684
Morgan	LOW	2	\$269,456	2	100%	\$3,800,000	\$538,912
Muskingum	HIGH	10	\$314,304	8	80%	\$1,538,000	\$2,514,432
Noble	LOW	2	\$256,044	2	100%	\$5,585,000	\$512,088
Perry	MEDIUM	5	\$301,064	4	80%	\$9,150,000	\$1,204,256
Pike	HIGH	4	\$315,620	3	75%	\$268,860,000	\$946,860
Ross	HIGH	6	\$345,912	5	83%	\$353,000	\$1,729,560
Scioto	MEDIUM	8	\$240,320	7	88%	\$1,100,000	\$1,682,240
Tuscarawas	MEDIUM	6	\$359,696	5	83%	\$1,250,000	\$1,798,480
Vinton	LOW	3	\$258,064	3	100%	\$30,473,000	\$774,192
Washington	LOW	5	\$313,476	4	80%	\$36,273,000	\$1,253,904
REGIONAL TOTALS		168	\$8,790,024	142		\$517,953,000	\$44,787,300

Region 1 has the second highest number (583,016) of vulnerable residential structures with an estimated potential loss of \$51,232,000,000. Within Region 1, Lucas County has the largest number of residential structures (134,262) that include pre-1995 and mobile homes. As a result, Lucas has the highest estimate of potential residential loss in the Region (\$11,459,000,000). Wyandot County has the lowest number of vulnerable residential structures within the Region (4,831). In addition, they have the lowest estimate of potential residential loss in the Region at \$372,000,000.

Additionally, Region 1 has the second highest number (5,775) of commercial structures vulnerable to tornadoes with a total at-risk value of \$1,635,328,689. Within Region 1, Lucas County has the largest number of commercial structures

vulnerable with a total estimated, potential loss of \$447,318,495. Paulding County has the least amount of commercial structures at risk (19) with a total estimated potential loss of \$4,221,420.

Region 1 also has the second highest number of local governmental structures vulnerable to tornadoes (202), worth an estimated \$76,348,092. Again, Lucas County has the highest vulnerability within the Region with a total of 23 local governmental structures at risk, and they have a total estimated value of \$8,055,060.

Region 2 has the highest number (1,846,485) of vulnerable residential structures with an estimated potential loss of \$197,972,000,000. Within the Region, Cuyahoga County has the largest number of residential structures that were built prior to 1995. As a result, Cuyahoga County has the highest estimate of potential residential loss in the Region (\$33,343,000,000). Ashland County has the lowest number of vulnerable residential structures within the Region (12,039). Knox County exhibits the lowest estimate of residential vulnerability in the Region with \$1,085,000,000.

Region 2 greatly supersedes Regions 1 and 3 in the number (26,177) of commercial structures vulnerable to tornadoes, with an estimated vulnerability of \$8,667,050,829. Within Region 2, Cuyahoga County has the largest number of commercial structures vulnerable with a total estimated vulnerability of \$1,830,679,200. Pickaway County has the least amount of commercial structures at risk (71) with a total estimated vulnerability of \$22,224,420.

As with residential and commercial vulnerability, Region 2 has the highest vulnerability to tornadoes for local governmental structures with a total of 1,193 structures worth \$525,997,128. Franklin County has the highest number of local governmental structures vulnerable (433) with a total estimated value of \$194,583,272.

Region 3 has the lowest number (442,887) of vulnerable residential structures worth an estimated \$30,369,000,000. Within Region 3, Clermont County has the largest number of residential structures built prior to 1995. As a result, Clermont County has the highest estimate of potential residential loss in the Region (\$5,658,000,000). Noble County has the lowest number of vulnerable residential structures within the Region (3,599), also exhibiting the lowest estimate of potential residential loss in the Region (\$185,000,000).

In addition to the lowest number of residential structures vulnerable to tornadoes, Region 3 also has the lowest number of commercial structures (3,080) vulnerable to tornadoes. The total estimated risk for these commercial structures is \$768,551,679. Within the Region Clermont County has the largest number (484) of commercial structures vulnerable with a total, estimated risk of \$175,549,704.

Again, Region 3 has the least governmental structure vulnerability. The Region has 142 local governmental structures vulnerable to tornadoes, with a total at-risk value of \$44,787,300. Within the Region Clermont County has the highest

vulnerability with 13 local, governmental structures worth an estimated \$6,286,904.

VULNERABILITY ANALYSIS & LOSS ESTIMATE OF STATE OWNED CRITICAL FACILITIES

The methodology to determine the vulnerability of state-owned structures and critical facilities to tornadoes were identified in section 2.1. Since tornadoes are non-spatial hazards and have the potential to affect all state-owned structures and critical facilities in the state, this section defaults to the overall discussion of state-owned structures and critical facilities identified in section 2.1, Table 2.1.a, and Appendix C.