Figure 3.14. Truesdale Flood Boundary

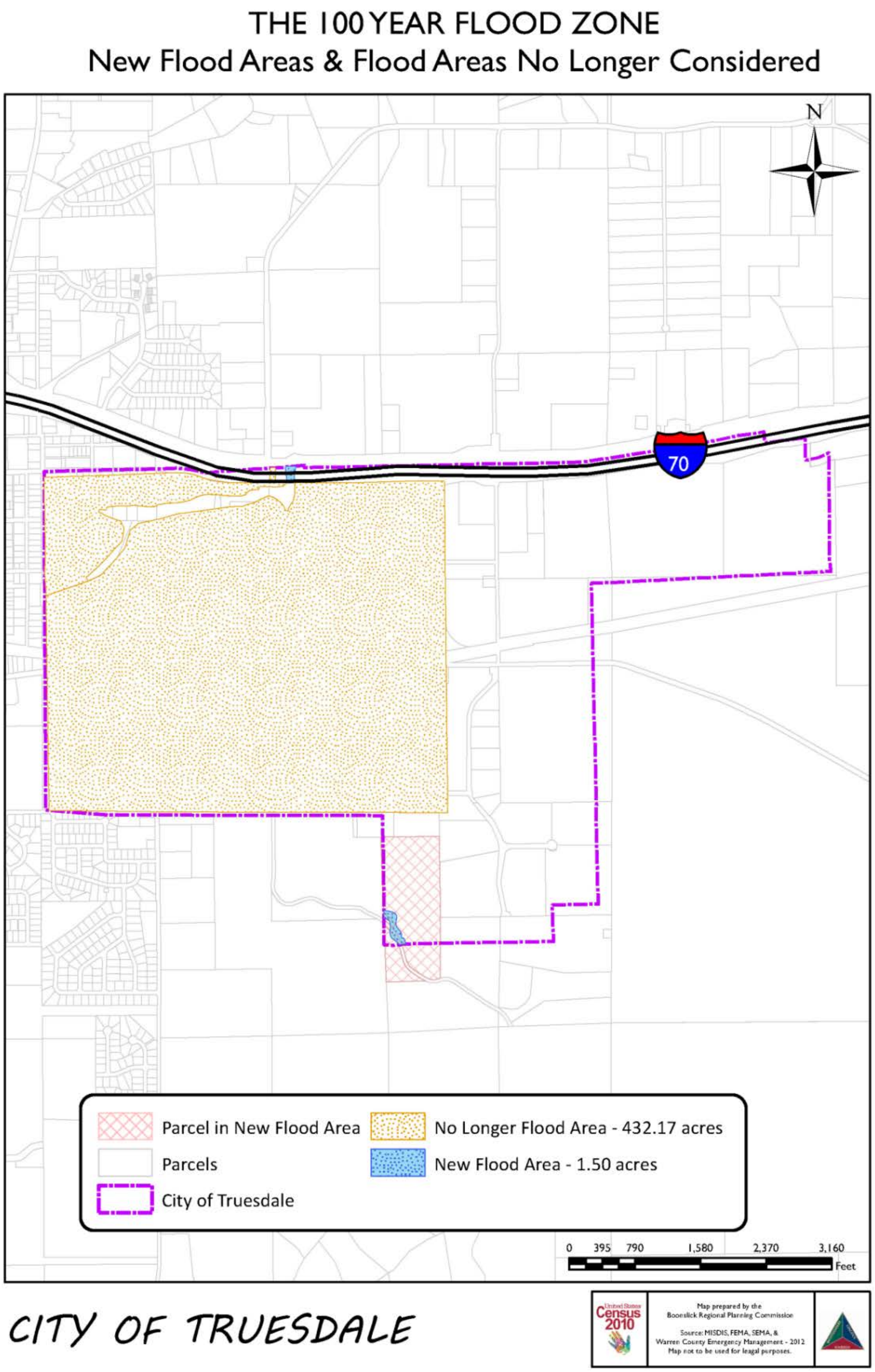


Figure 3.15. Wright City Flood Boundary

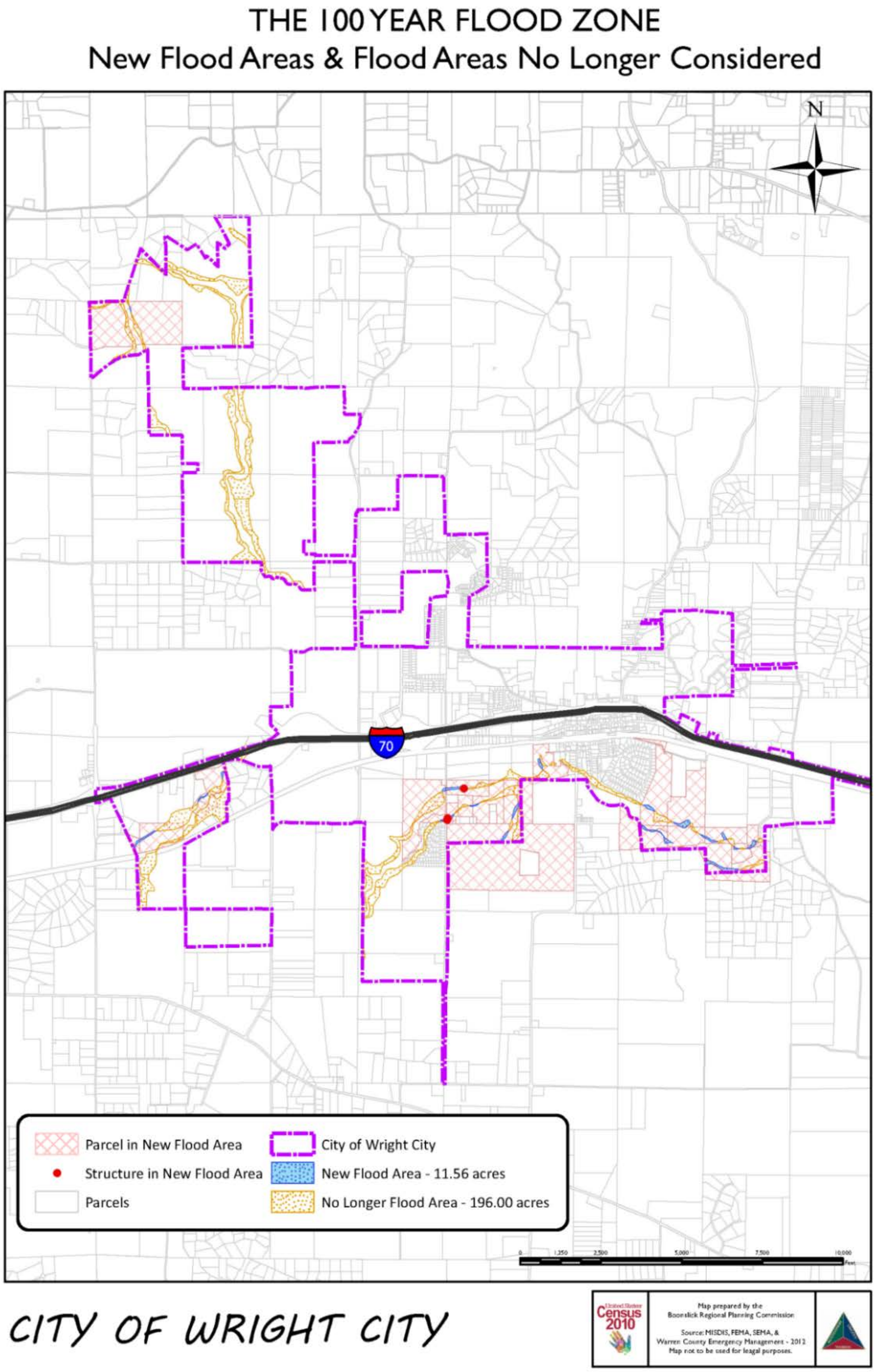
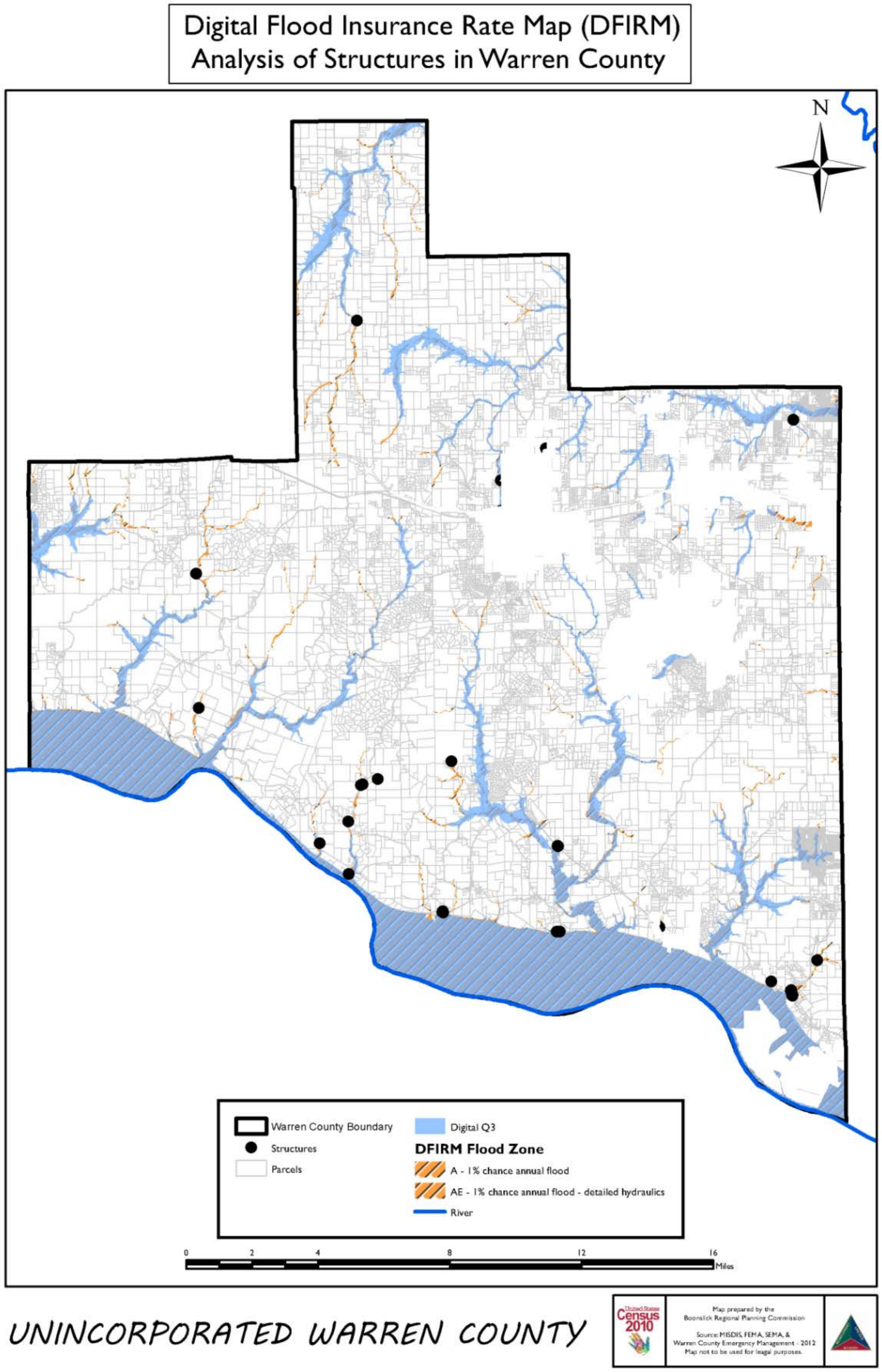


Figure 3.16. Warren County 100-Year Flood Showing Critical Infrastructures



According to NCDC there were 8 flood events in Warren County between January 1, 1994 and May 31, 2016. The following table shows these events.

Table 3.26. Warren County NCDC Flood Event Location, 1995 - 2015

Date	Type	Location	Deaths	Injury	Property Damage	Crop Damage
5/1/1996	Flood	Unincorporated Warren County	0	0	$ -	$ -
3/20/1998	Urban / Small Stream	Unincorporated Warren County	0	0	$ -	$ -
10/6/1998	Flood	Unincorporated Warren County	0	0	$ -	$ -
7/6/1999	Urban / Small Stream	Marthasville	0	0	$ -	$ -
6/20/2000	Urban / Small Stream	Unincorporated Warren County	0	0	$ -	$ -
5/7/2002	Flood	Treloar	0	0	$ -	$ 5,000
6/5/2010	Flood	Case				

Source: National Climatic Data Center

According to NCDC there were 19 flash flood events in Warren County between January 1, 1995 and May 31, 2016. The following table shows these events.

Table 3.27. Warren County NCDC Flash Flood Event Location,1995 - 2015

Date	Type	Location	Deaths	Injury	Property Damage	Crop Damage
5/16/1995	Flash Flood	Unincorporated Warren County	0	0	$ -	$ -
5/16/1995	Flash Flood	Unincorporated Warren County	0	0	$ 1,000	$ -
5/27/1995	Flash Flood	Unincorporated Warren County	0	0	$ -	$ -
4/28/1996	Flash Flood	Unincorporated Warren County	0	0	$ -	$ -

Date	Type	Location	Deaths	Injury	Property Damage	Crop Damage
6/22/1997	Flash Flood	Unincorporated Warren County	0	0	$ -	$ -
6/24/2000	Flash Flood	Unincorporated Warren County	0	0	$ -	$ -
5/7/2002	Flash Flood	Unincorporated Warren County	0	0	$ -	$ -
5/12/2002	Flash Flood	Unincorporated Warren County	0	0	$ -	$ -
5/12/2002	Flash Flood	Unincorporated Warren County	0	0	$ -	$ -
6/25/2003	Flash Flood	Unincorporated Warren County	0	0	$ -	$ -
12/7/2004	Flash Flood	Unincorporated Warren County	0	0	$ -	$ -
2/5/2008	Flash Flood	Marthasville	0	0	$ -	$ -
3/31/2008	Flash Flood	Dutzow	0	0	$ -	$ -
6/15/2009	Flash Flood	New Truxton	0	0	$ -	$ -
10/8/2009	Flash Flood	Truesdale	0	0	$ -	$ -
9/18/2010	Flash Flood	Warrenton	0	0	$ -	$ -
6/1/2013	Flash Flood	Warrenton	0	0	$ -	$ -
4/7/2015	Flash Flood	Dutzow	0	0	$ -	$ -
12/26/2015	Flash Flood	Case	0	0	$ -	$ -

Source: National Climatic Data Center

Severity/Magnitude/Extent

Missouri has a long and active history of flooding over the past century, according to the 2013 State Hazard Mitigation Plan. Flooding along Missouri's major rivers generally results in slow-moving disasters. River crest levels are forecast several days in advance, allowing community's downstream sufficient time to take protective measures, such as sandbagging and evacuations. Nevertheless, floods exact a heavy toll in terms of human suffering and losses to public and private property. By contrast, flash flood events in recent years have caused a higher number of deaths and major property damage in many areas of Missouri.

Flooding presents a danger to life and property, often resulting in injuries, and in some cases, fatalities. Floodwaters themselves can interact with hazardous materials. Hazardous materials stored in large containers could break loose or puncture as a result of flood activity. Examples are bulk propane tanks. When this happens, evacuation of citizens is necessary.

Public health concerns may result from flooding, requiring disease and injury surveillance. Community sanitation to evaluate flood-affected food supplies may also be necessary. Private water and sewage sanitation could be impacted, and vector control (for mosquitoes and other entomology concerns) may be necessary.

When roads and bridges are inundated by water, damage can occur as the water scours materials around bridge abutments and gravel roads. Floodwaters can also cause erosion undermining road beds. In some instances, steep slopes that are saturated with water may cause mud or rock slides onto roadways. These damages can cause costly repairs for state, county, and city road and bridge maintenance departments. When sewer back-up occurs, this can result in costly clean-up for home and business owners as well as present a health hazard.

National Flood Insurance Program (NFIP) Participation

Warren County and 6 of its communities participate in the National Flood Insurance Program as shown in the table below. Pendleton does not participate in NFIP because the village does not abut a floodplain. The second table below shows the NFIP Policy and Claim Statistics for Warren County and its communities.

Table 3.28. NFIP Participation in Warren County

Community ID Number	Community Name	NFIP Participant (Y / N)	Current Effective Map Date	Regular-Emergency Program Entry Date
290902	City of Foristell	Y	1/20/2016	2/24/1993
290284	Village of Innsbrook	Y	11/04/2009	07/14/2010
290444	City of Marthasville	Y	11/042009	09/14/1983
290511	City of Truesdale	Y	11/04/2009	12/29/2000
290443	County of Warren	Y	11/04/2009	04/03/1985
290648	City of Warrenton	Y	11/04/2009	05/16/1983
290654	City of Wright City	Y	11/04/2009	03/26/2008

Source: NFIP Community Status Book, 9/26/2013;http://www.fema.gov/national-flood-insurance-program/national-flood-insurance-program-community-status-book;

Table 3.29. NFIP Policy and Claim Statistics as of March 31, 2016

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
Village of Innsbrook	2	$420,000	0	0
City of Marthasville	16	$2,205,900	28	$524,360
County of Warren	49	$8,506,900	51	$727,915
City of Warrenton	4	$2,974,900	2	$165,367
City of Wright City	1	$42,000	0	0

Source: NFIP Community Status Book, 3/31/2016; http://bsa.nfipstat.fema.gov/reports/reports.html; *Closed Losses are those flood insurance claims that resulted in payment. Loss statistics are for the period from 1/1/1978 to 3/31/2016.

Repetitive Loss/Severe Repetitive Loss Properties

Repetitive Loss Properties are those properties with at least two flood insurance payments of $5,000 or more in a 10-year period. According to the Flood Insurance Administration, jurisdictions included in the planning area have a combined total of 28 repetitive loss properties. As of February 29, 2016, 28 properties have been mitigated, leaving no un-mitigated repetitive loss properties. The table below is a summary of Warren County Repetitive Loss Properties. There are no Severe Repetitive Loss Properties in the planning area.

Table 3.30. Warren County Repetitive Loss Properties

Jurisdiction	# of Properties	Type of Property	# Mitigated	Building Payments	Content Payments	Total Payments	Average Payment	# of Losses
City of Warrenton	1	Commercial	2	$143,810.37	$21,556.97	$165,367.34	$82,683.67	2
City of Marthasville	1	Residential	4	$57,663.25	$1,433.21	$59,096.46	$14,774.12	4
City of Marthasville	1	Non-Residential	3	$77,104.11	$14,880.90	$91,985.01	$30,661.67	3
City of Marthasville	1	Non-Residential	2	$24,040.30	$5,000.00	$29,040.30	$14,520.15	2
City of Marthasville	1	Non-Residential	2	$44,416.93	$10,502.77	$54,919.70	$27,459.85	2
Unincorporated Warren County	1	Residential	3	$37,443.77	$0.00	$37,443.77	$12,481.26	3
Unincorporated Warren County	1	Residential	2	$46,110.00	$3,256.60	$49,366.60	$24,683.30	2
Unincorporated Warren County	1	Residential	2	$72,416.89	$8,563.00	$80,979.89	$40,489.95	2
Unincorporated Warren County	1	Residential	2	$53,900.00	$0.00	$53,900.00	$26,950.00	2
Unincorporated Warren County	1	Residential	2	$42,739.93	$2,312.95	$45,052.88	$22,526.44	2
Unincorporated Warren County	1	Non-Residential	2	$23,870.70	$0.00	$23,870.70	$11,935.35	2
Unincorporated Warren County	1	Non-Residential	2	$37,253.21	$0.00	$37,253.21	$18,626.61	2
Unincorporated Warren County	1	Non-Residential	2	$26,156.92	$0.00	$26,155.92	$13,077.96	2

Source: Flood Insurance Administration as of February 29, 2016

Previous Occurrences

The largest disaster to impact Warren County in recent years was the Great Flood of 1993. Flash flooding was responsible for a woman's death as her home was swept downstream. Loss of agricultural lands, homes, businesses, and infrastructure, as well as the temporary closing of some local businesses, contributed to economic losses. Areas hardest hit by the flooding were along the Missouri River in southern Warren County. Typical, flooding of the Missouri River affects only the agricultural area of Warren County adjacent the Missouri River floodplain.

The table below summarizes FEMA Declared Flood Events from the past 20 years.

Table 3.31. Warren County FEMA Declared Flood Events Summary,1996 to 2016

Declaration No.	Event	Date
DR-1328	Severe Storms, Tornados, Straight Line Winds, and Flooding	May 5, 2000 – May 7, 2000
DR-1676	Severe Winter Storms and Flooding	January 1, 2007 – January 22, 2007
EM-3325	Flooding	June 1, 2011 – August 1, 2011
DR-4200	Severe Storms, Tornados, Straight Line Winds, and Flooding	September 9, 2014 – October 31, 2014
DR-4238	Severe Storms, Tornados, Straight Line Winds, and Flooding	May 15, 2015 – July 27, 2015
EM-3374	Severe Storms, Tornados, Straight Line Winds, and Flooding	December 22, 2015 – January 2, 2016

Source: NCDC, data accessed June 2, 2016

Probability of Future Occurrence

There were 7 declared floods in the 20 years between 1995 and 2015 making the probability of a declared flood event every 2.8 years. For declared flash flood events, the probability is one every 1.5 years. It should be noted that NOAA alerts the Warren County planning area dozens of times per year and each alert brings the possibility of loss of life or property damage depending on the circumstances.

Vulnerability

Vulnerability Overview

No HAZUS data is available for Warren County. However, HAZUS data is used for the 2013 State Hazard Mitigation Plan Total Direct Building Loss and Income Loss table which illustrates that Warren County could suffer a combined Total Direct Loss and a Total Income Loss of $40,105,240 in the event of a 100-year flood.

Potential Losses to Existing Development

The Missouri River Floodplain remains agricultural in nature with family farms sparely distributed within them. Portions of the Village of Innsbrook, the City of Marthasville, and areas of the Gasconade R-I School District lie within the Missouri's Floodplain and are frequently at risk of flooding.

Critical facilities at risk include the Washington Regional Airport just inside Warren County north of the City of Washington on MO 47. Missouri highways 47 and 94 in Warren County are also vulnerable to washout and closure due to Missouri River flooding. Warren County sections of MO 47 have been closed three times between May 2008 and January 2016 due to flooding. Likewise, MO 94 has been closed 11 times during the same period.

Impact of Future Development

Development upstream, in the form of additional levees, creates the greatest impact to Missouri River flooding in Warren County due to channeling additional water into waterways. The county regulates development within incorporated areas located in the floodplain of the Missouri River. Flash floods will continue to impact residents choosing to live in rural areas where low water crossings are required to access their homes. There is anticipated to be little or no increase in run off created by potential development.

Problem Statement

Warren County faces two major risk factors for flooding. The land that forms Warren County is included in the Missouri River basin that drains most of the northern and central part of the state. The Missouri River flows east along the county's southern boundary and joins the Mississippi River some 50 miles east of the county. The southern rim of the county lies directly in the Missouri River floodplain where most the 1993 flood damage occurred. According to the federal government's Flood Insurance Rating Maps (FIRM), for Warren County 15% of the land lies within the 100-year floodplain. The majority of that 15% lies directly adjacent to Missouri River levees. While flooding in southern Warren County will continue, loss of life and property, outside of that of crops, will remain unlikely. Flooding, particularly flash flooding, in the planning area's rivers and creeks will continue to be an issue due to the geography.

3.3.6 Levee Failure

Hazard Profile

Hazard Description

Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding. Floodwalls are concrete structures, often components of levee systems, designed for urban areas where there is insufficient room for earthen levees. When levees and floodwalls and their appurtenant structures are stressed beyond their capabilities to withstand floods, levee failure can result in injuries and loss of life, as well as damages to property, the environment, and the economy.

Levees can be small agricultural levees that protect farmland from high-frequency flooding. Levees can also be larger, designed to protect people and property in larger urban areas from less frequent flooding events such as the 100-year and 500-year flood levels.For purposes of this discussion, levee failure will refer to both overtopping and breach as defined in FEMA's Publication "So You Live Behind a Levee" (http://content.asce.org/ASCELeveeGuide.html). Following are the FEMA publication descriptions of different kinds of levee failure.

Overtopping: When a Flood Is Too Big

Overtopping occurs when flood waters exceed the height of a levee and flow over its crown. As the water passes over the top, it may erode the levee, worsening the flooding and potentially causing an opening, or breach, in the levee.

Breaching: When a Levee Gives Way

> A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass. A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little or no warning.

Earthen levees can be damaged in several ways. For instance, strong river currents and waves can erode the surface. Debris and ice carried by floodwaters—and even large objects such as boats or barges—can collide with and gouge the levee. Trees growing on a levee can blow over, leaving a hole where the root wad and soil used to be. Burrowing animals can create holes that enable water to pass through a levee. If severe enough, any of these situations can lead to a zone of weakness that could cause a levee breach. In seismically active areas, earthquakes and ground shaking can cause a loss of soil strength, weakening a levee and possibly resulting in failure. Seismic activity can also cause levees to slide or slump, both of which can lead to failure.

Geographic Location

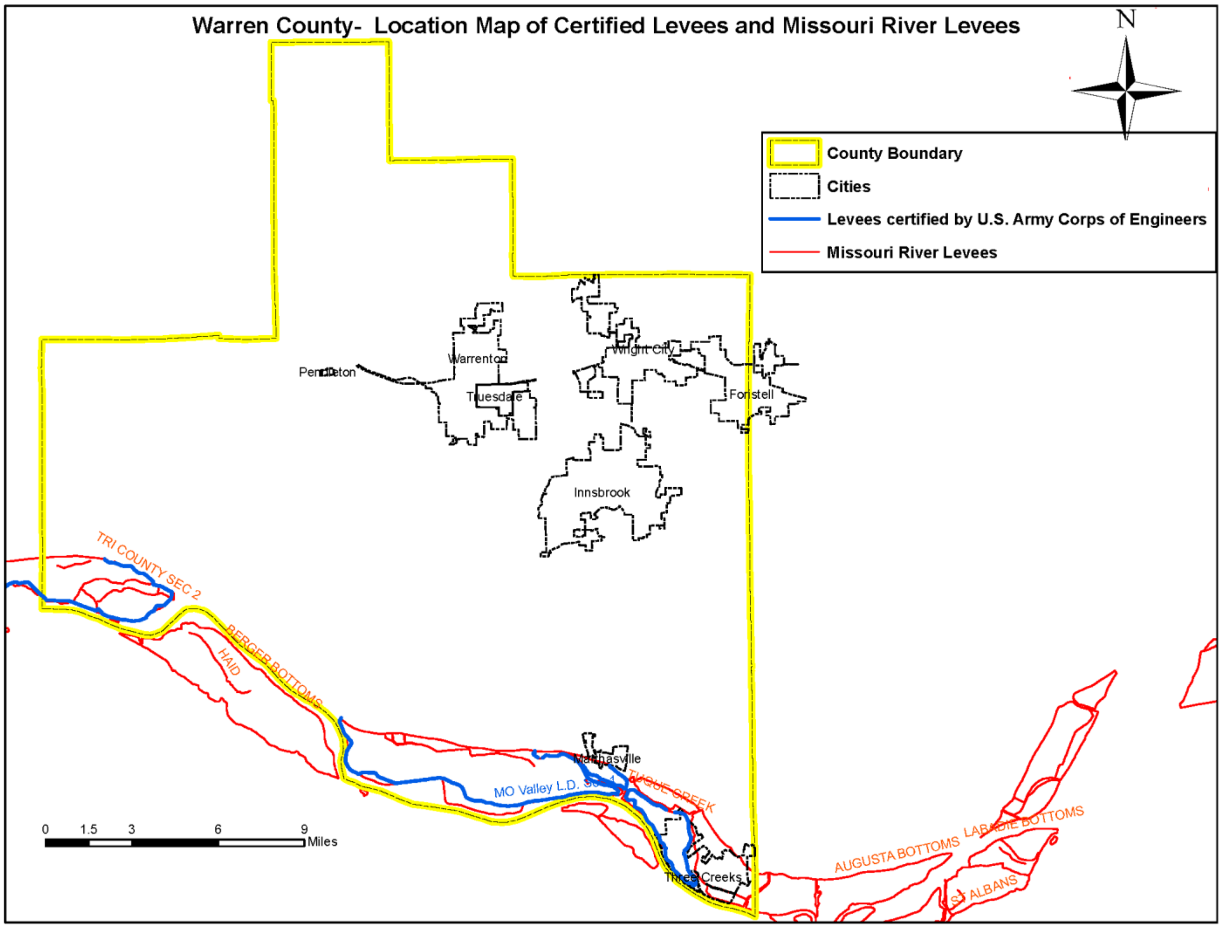
Missouri is a state with many levees. Currently, there is no single comprehensive inventory of levee systems in the state. Levees have been constructed across the state by public entities and private entities with varying levels of protection, inspection oversight, and maintenance. The lack of a comprehensive levee inventory is not unique to Missouri.

There are two concurrent nation-wide levee inventory development efforts, one led by the United State Army Corps of Engineers (USACE) and one led by Federal Emergency Management Agency (FEMA). The National Levee Database (NLD), developed by USACE, captures all USACE related levee projects, regardless of design levels of protection. The Midterm Levee Inventory (MLI), developed by FEMA, captures all levee data (USACE and non-USACE) but primarily focuses on levees that provide 1% annual-chance flood protection on FEMA Flood Insurance Rate Maps (FIRMs).

It is likely that agricultural levees and other non-regulated levees within the planning area exist that are not inventoried or inspected. These levees that are not designed to provide protection from the 1-percent annual chance flood would overtop or fail in the 1-percent annual chance flood scenario. Therefore, any associated losses would be taken into account in the loss estimates provided in the Flood Hazard Section.

Warren County has 6 levee districts which are shown in the following figure; Mo Valley, Tuque Creek, Three Creeks, Haid, Berger Bottoms, and Tri-County.

Figure 3.17. Certified Levees and Missouri River Levees in Warren County



Source: Boonslick Regional Planning Commission

None of these levees are shown on the DFIRMS for Warren County. The following DFIRMs are included for reference purposes only.

Figure 3.18. City of Marthasville – DFIRM 1% Chance of Flood Per Year

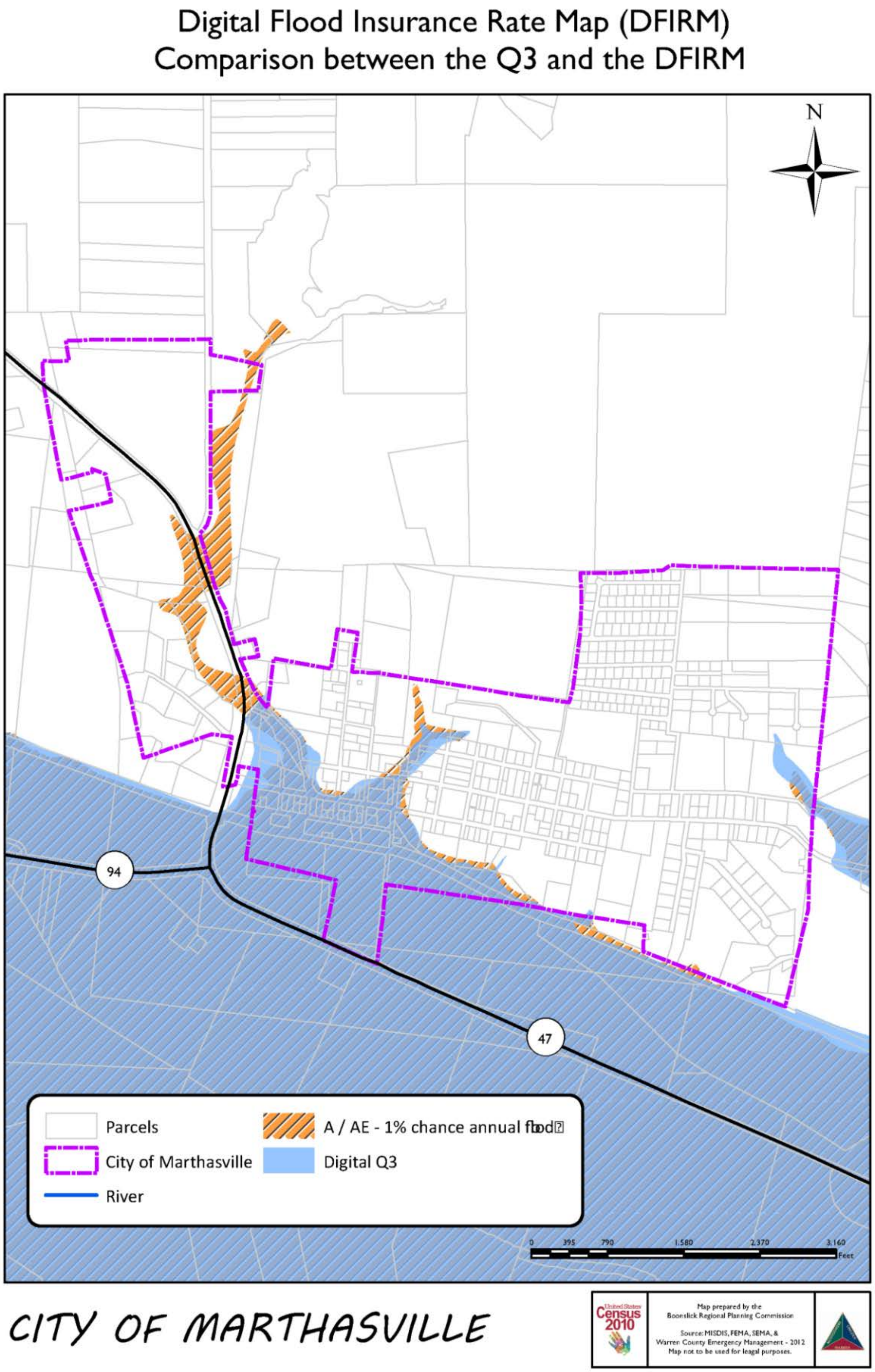


Figure 3.19. Village of Innsbrook – DFIRM 1% Chance of Flood Per Year

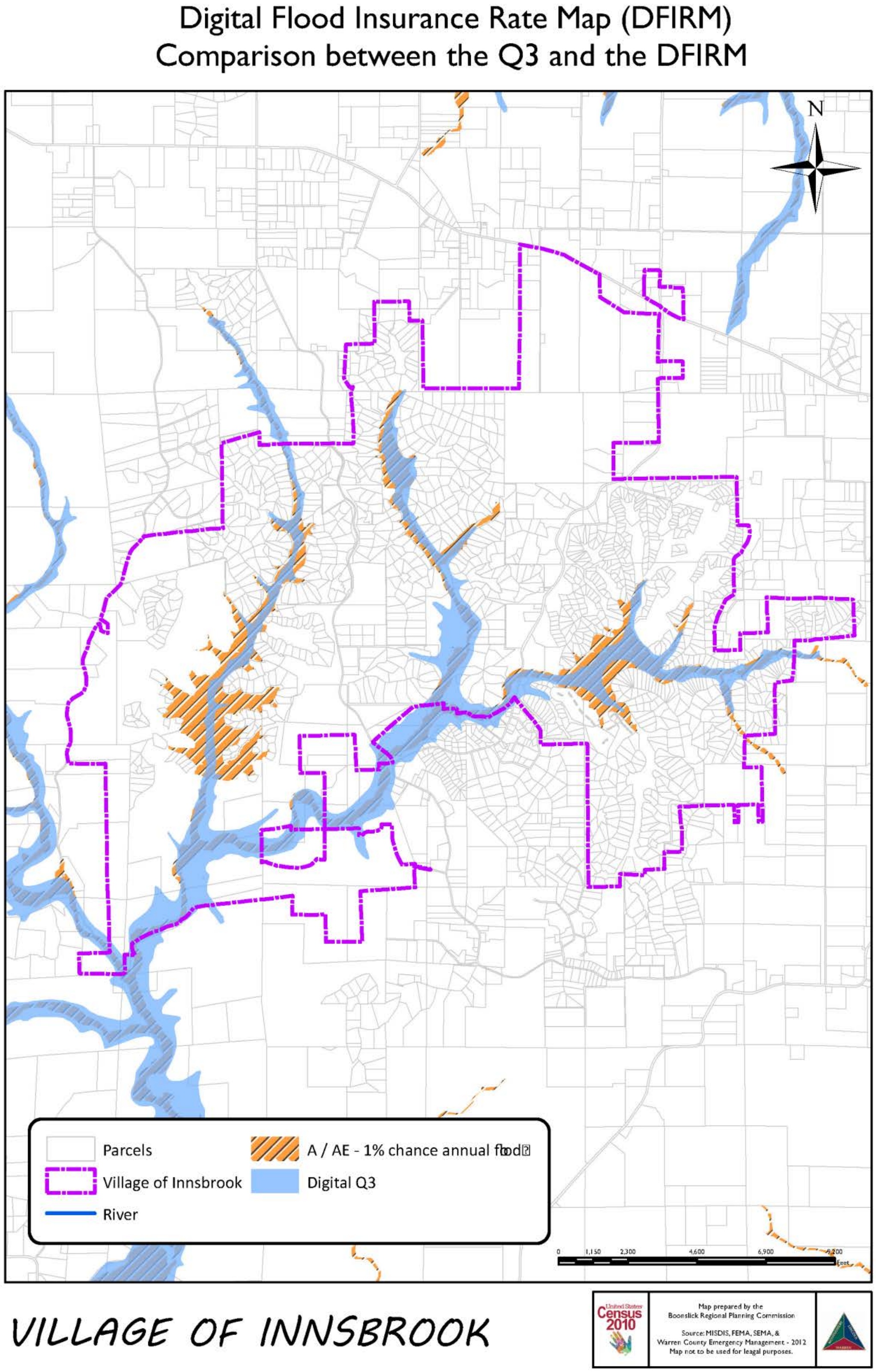


Figure 3.20. City of Truesdale – DFIRM 1% Chance of Flood Per Year

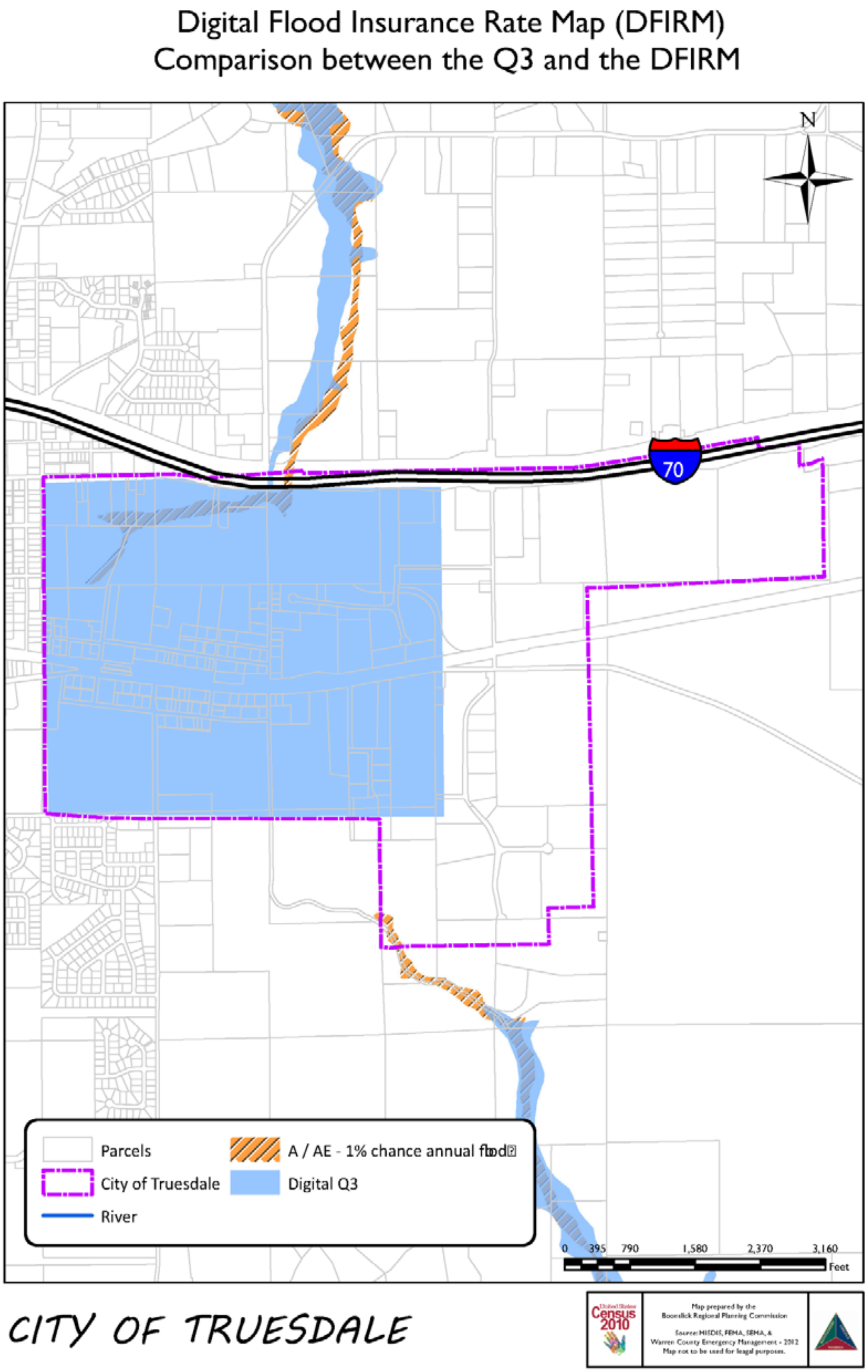


Figure 3.21. City of Warrenton – DFIRM 1% Chance of Flood Per Year

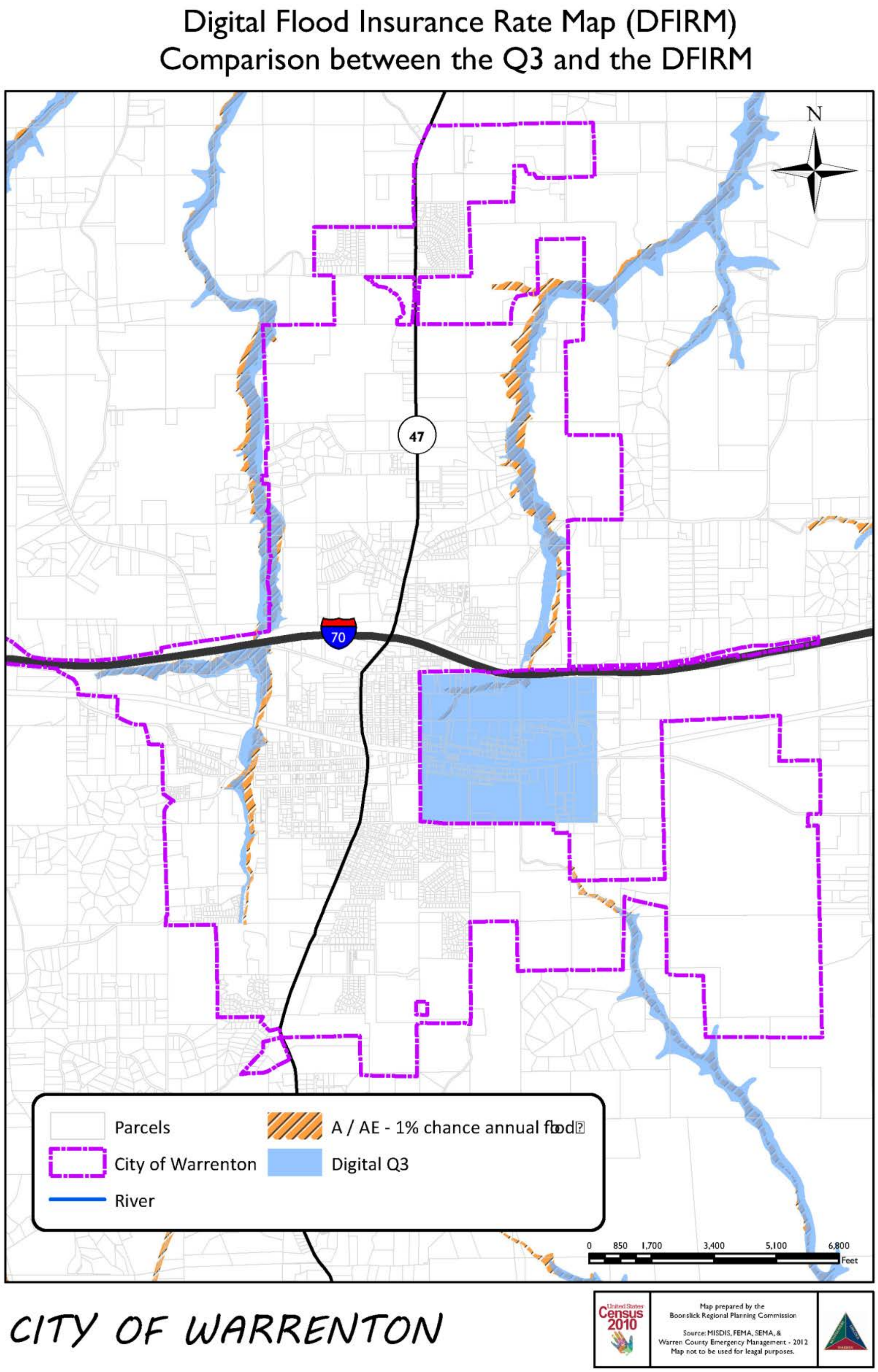


Figure 3.22. City of Wright City – DFIRM 1% Chance of Flood Per Year

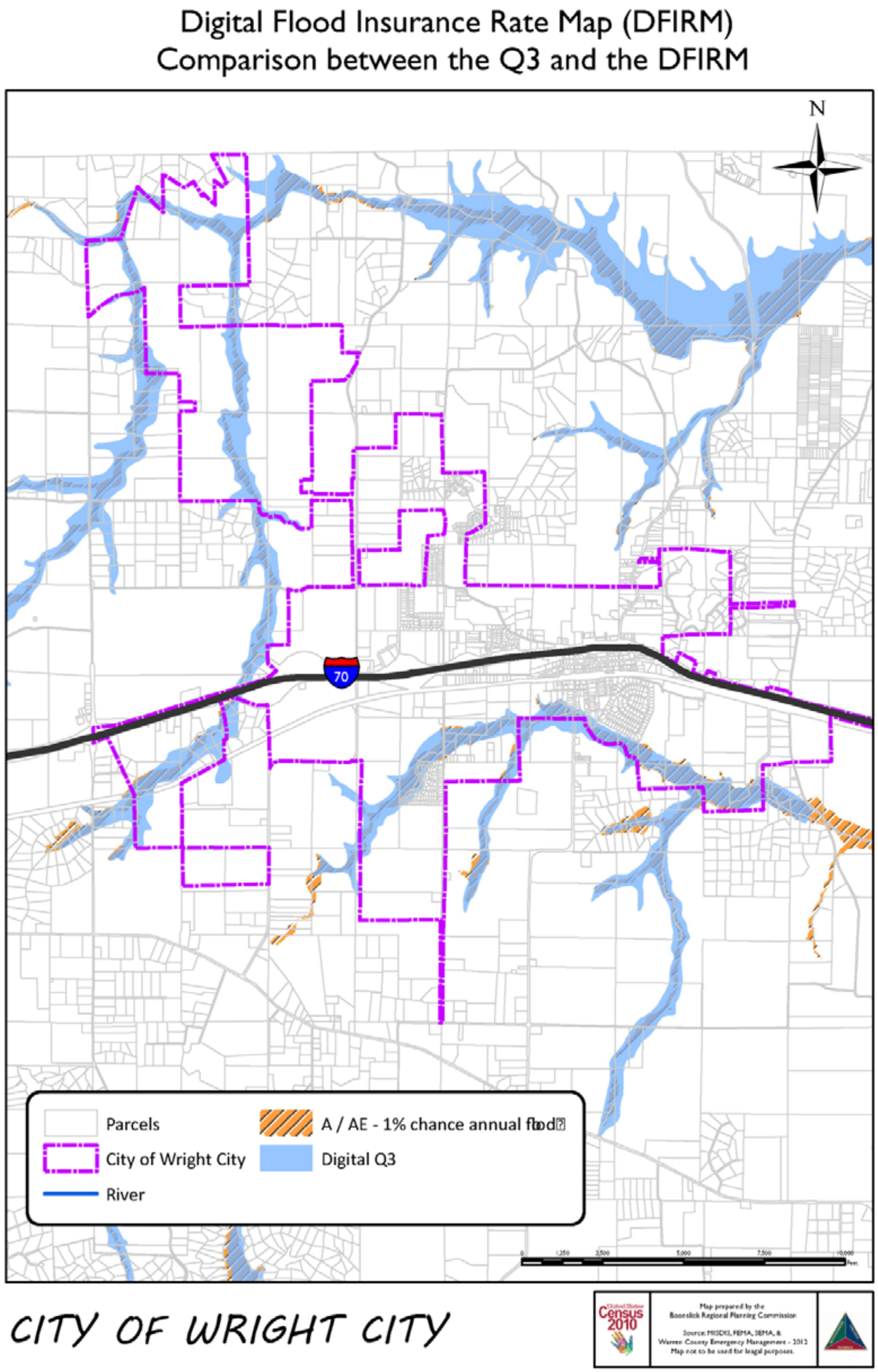
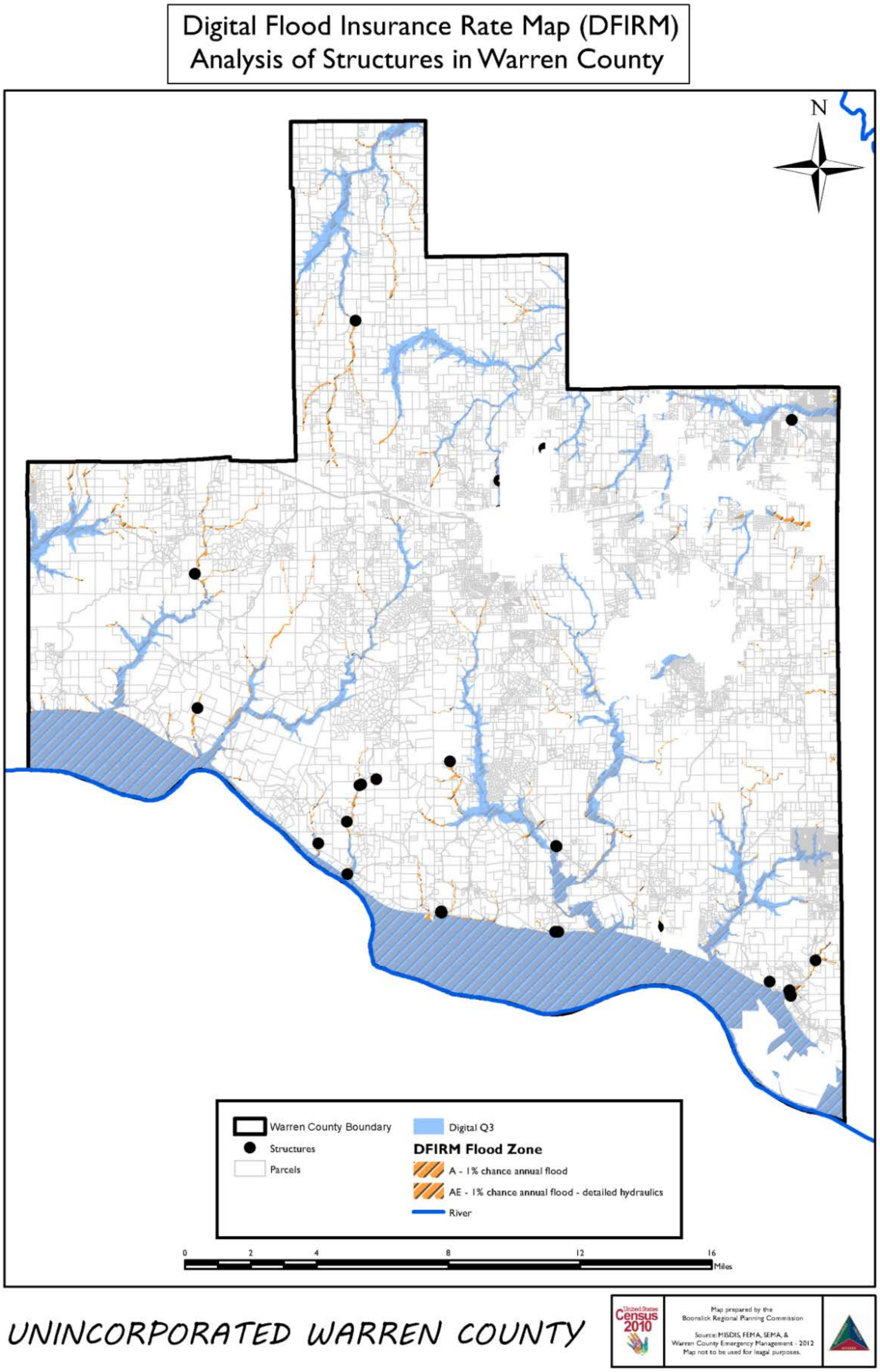


Figure 3.23. Incorporated Warren County – DFIRM 1% Chance of Flood Per Year



The levee failure is confined to the south of the county where the Missouri River flows east and joins Mississippi Rivers 50 miles east of the county. Although levees protect Routes 47 and 94 from Missouri River flooding, Charrette Creek, Toque Creek near Marthasville, and Lake Creek near Dutzow occasionally cause flooding and road closures.

It has been noted that in case of any major flood events, there could be a major economic loss to Warren County majorly to the City of Warrenton and Wright City. The reasons are that Routes 47 and 94 serve as a connections between Warren County, Franklin County, and Gasconade County. Many people who work in Warren County live in either Gasconade or Franklin Counties and vice-versa. Therefore, any levee failure in case of flood event would cause an effect on Warren County's economy.

Severity/Magnitude/Extent

Levee failure is typically an additional or secondary impact of another disaster such as flooding or earthquake. The main difference between levee failure and losses associated with riverine flooding is magnitude. Levee failure often occurs during a flood event, causing destruction in addition to what would have been caused by flooding alone. In addition, there would be an increased potential for loss of life due to the speed of onset and greater depth, extent, and velocity of flooding due to levee breach.

The USACE regularly inspects levees within its Levee Safety Program to monitor their overall condition, identify deficiencies, verify that maintenance is taking place, determine eligibility for federal rehabilitation assistance (in accordance with P.L. 84-99), and provide information about the levees on which the public relies. Inspection information also contributes to effective risk assessments and supports levee accreditation decisions for the National Flood Insurance Program administered by the Federal Emergency Management Agency (FEMA).

The USACE now conducts two types of levee inspections. Routine Inspection is a visual inspection to verify and rate levee system operation and maintenance. It is typically conducted each year for all levees in the USACE Levee Safety Program. Periodic Inspection is a comprehensive inspection led by a professional engineer and conducted by a USACE multidisciplinary team that includes the levee sponsor. The USACE typically conducts this inspection every five years on the federally authorized levees in the USACE Levee Safety Program.

Both Routine and Periodic Inspections result in a rating for operation and maintenance. Each levee segment receives an overall segment inspection rating of Acceptable, Minimally Acceptable, or Unacceptable. The table below defines the three ratings. The only USACE inspected levee in the planning area is the Tuque Creek levee which was inspected in October of 2012 and found to be minimally acceptable by the Corps.

Table 3.32. Definitions of the Three Levee System Ratings

Levee System Inspection Ratings	
Acceptable	All inspection items are rated as Acceptable.
Minimally Acceptable	One or more levee segment inspection items are rated as Minimally Acceptable or one or more items are rated as Unacceptable and an engineering determination concludes that the Unacceptable inspection items would not prevent the segment/system from performing as intended during the next flood event.
Unacceptable	One or more levee segment inspection items are rated as Unacceptable and would prevent the segment/system from performing as intended, or a serious deficiency noted in past inspections (previous Unacceptable items in a Minimally Acceptable overall rating) has not been corrected within the established timeframe, not to exceed two years.

Source: U.S. Corps of Engineers

Previous Occurrences

A one-day closure of Missouri Route 47 in 1990 resulted from flash flooding of Tuque Creek. The road has been closed three times since 1990 (twice in 1993 and once in 1995) when the Missouri River levees failed. Both Tuque Creek and Lake Creek are tributaries to Charrette Creek, which lies between Route 47 and the Missouri River. Tuque Creek and Lake Creek join with Charrette Creek so near the Missouri River they are susceptible to combined backwater effects during Missouri River and other significant flooding events. The jurisdiction close to the Missouri river is the City of Marthasville.

Probability of Future Occurrence

Three levee failures during the last 26 years produces a probability of occurrence as once every 8.6 years.

Vulnerability

Potential Losses to Existing Development

The Missouri River Floodplain remains agricultural in nature with family farms sparely distributed within them. Portions of the City of Marthasville lie within the Missouri's Floodplain and are frequently at risk of flooding due mainly to levee failure or overtopping. Critical facilities at risk include the Washington Regional Airport just inside Warren County north of the City of Washington on MO 47. That highway is also vulnerable to washout and closure from Missouri River flooding. Losses associated with overtopping or failure are included as flood losses in the Flood Section of this plan.

Impact of Future Development

Development upstream, in the form of additional levees, creates the greatest impact to Missouri River flooding in Warren County due to channeling additional water into waterways. The county regulates development within unincorporated areas located in the floodplain of the Missouri River. Flash floods and levee failures will continue to impact residents choosing to live in rural areas where low water crossings are required to access their homes. There is anticipated to be little or no increase in run off created by potential development.

Hazard Summary by Jurisdiction

As stated above, the agricultural areas of lower Warren County, along with the City of Marthasville, depend on levees to hold back flood waters. The Washington School District operates a small kindergarten through grade 6 attendance center in Marthasville. In addition, the Washington Regional Airport and MO 47 / MO 94 highways are vulnerable to closure and erosion during levee failure.

Problem Statement

Warren County faces two major risk factors associated with flooding and levee failure. The land that forms Warren County is included in the Missouri River basin that drains most of the northern and central part of the state. The Missouri River flows east along the county's southern boundary and joins the Mississippi River some 50 miles east of the county. The southern rim of the county lies directly in the Missouri River floodplain where most the 1993 flood damage occurred. According to the federal government's Flood Insurance Rating Maps (FIRM), for Warren County 15% of the land lies within the 100-year floodplain. The majority of that 15% lies directly adjacent to Missouri River levees. While flooding and associated levee failure in southern Warren County will continue, loss of life and property, outside of that of crops, will remain unlikely. Flooding, particularly flash flooding, and levee failure associated with the flooding in the planning area's rivers and creeks will continue to be an issue due the geography.

3.3.7 Thunderstorm/High Winds/Lightning/Hail

Hazard Profile

Hazard Description

Thunderstorms

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. When cold upper air sinks and warm moist air rises, storm clouds or 'thunderheads' develop resulting in thunderstorms. This can occur singularly, as well as in clusters or lines. The National Weather Service defines a thunderstorm as "severe" if it includes hail that is one inch or more, or wind gusts that are at 58 miles per hour or higher. At any given moment across the world, there are about 1,800 thunderstorms occurring. Severe thunderstorms most often occur in Missouri in the spring and summer, during the afternoon and evenings, but can occur at any time. Other hazards associated with thunderstorms are heavy rains resulting in floods and flash floods, high winds, hail, and tornadoes. Each of these hazards is discussed separately elsewhere in this section.

High Winds

A severe thunderstorm can produce winds causing as much damage as a weak tornado. The damaging winds of thunderstorms include downbursts, microbursts, and straight-line winds. Downbursts are localized currents of air blasting down from a thunderstorm, which induce an outward burst of damaging wind on or near the ground. Microbursts are minimized downbursts covering an area of less than 2.5 miles across. They include a strong wind shear (a rapid change in the direction of wind over a short distance) near the surface. Microbursts may or may not include precipitation and can produce winds at speeds of more than 150 miles per hour. Damaging straight-line winds are high winds across a wide area that can reach speeds of 140 miles per hour.

Lightning

All thunderstorms produce lightning which can strike outside of the area where it is raining and is has been known to fall more than 10 miles away from the rainfall area. Thunder is simply the sound that lightning makes. Lightning is a huge discharge of electricity that shoots through the air causing vibrations and creating the sound of thunder.

Hail

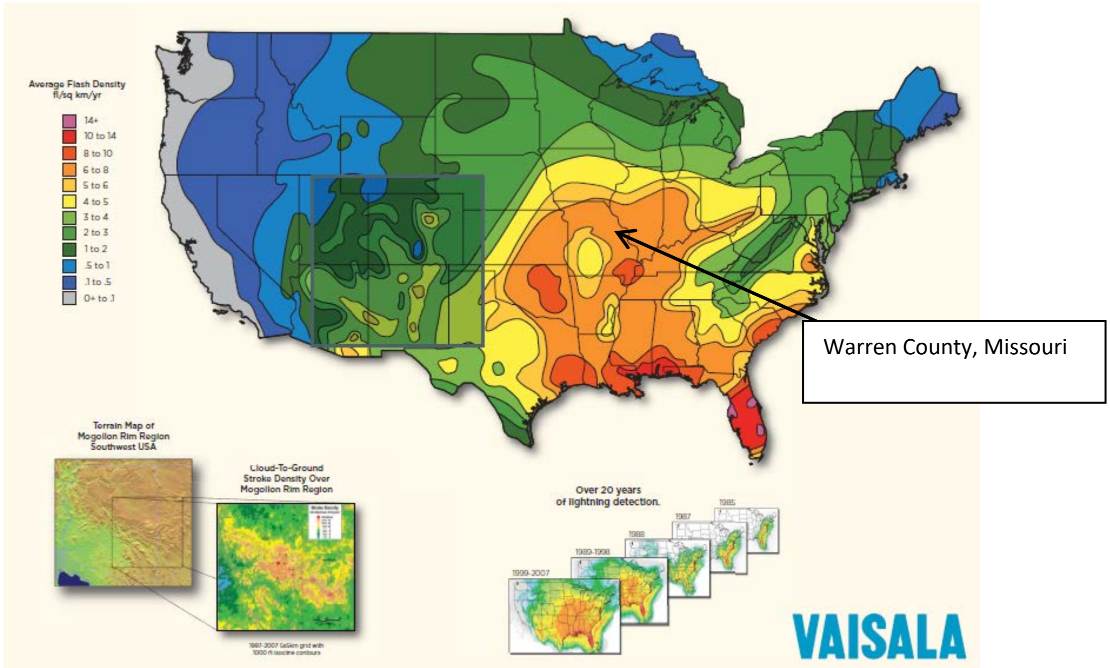
According to the National Oceanic and Atmospheric Administration (NOAA), hail is precipitation that is formed when thunderstorm updrafts carry raindrops upward into extremely cold atmosphere causing them to freeze. The raindrops form into small frozen droplets. They continue to grow as they come into contact with super-cooled water which will freeze on contact with the frozen rain droplet. This frozen droplet can continue to grow and form hail. As long as the updraft forces can support or suspend the weight of the hailstone, hail can continue to grow before it hits the earth.

At the time when the updraft can no longer support the hailstone, it will fall down to the earth. For example, a ¼” diameter or pea sized hail requires updrafts of 24 miles per hour, while a 2 ¾” diameter or baseball sized hail requires an updraft of 81 miles per hour. According to the NOAA, the largest hailstone in diameter recorded in the United States was found in Vivian, South Dakota on July 23, 2010. It was eight inches in diameter, almost the size of a soccer ball. Soccer-ball-sized hail is the exception, but even small pea-sized hail can do damage.

Geographic Location

Thunderstorms, high winds, hail, and lightning are county-wide hazards and can occur anywhere throughout the state of Missouri. Although these events occur similarly throughout the planning area, they are more frequently reported in more urbanized areas. In addition, damages are more likely to occur in more densely populated urban areas.

Figure 3.24. Location and Frequency of Lightning in the U.S.A.



Source: National Weather Service,
http://www.lightningsafety.noaa.gov/stats/08_Vaisala_NLDN_Poster.pdf

Figure 3.25. Wind Zones in the United States

Source: FEMA 320, Taking Shelter from the Storm, 3rd edition, http://www.weather.gov/media/bis/FEMA_SafeRoom.pdf

Severity/Magnitude/Extent

Severe thunderstorm losses are usually attributed to the associated hazards of hail, downburst winds, lightning and heavy rains. Losses due to hail and high wind are typically insured losses that are localized and do not result in presidential disaster declarations. However, in some cases, impacts are severe and widespread and assistance outside state capabilities is necessary. Hail and wind also can have devastating impacts on crops. Severe thunderstorms/heavy rains that lead to flooding are discussed in the flooding hazard profile. Hailstorms cause damage to property, crops, and the environment, and can injure and even kill livestock. In the United States, hail causes more than $1 billion in damage to property and crops each year. Even relatively small hail can shred plants to ribbons in a matter of minutes. Vehicles, roofs of buildings and homes, and landscaping are also commonly damaged by hail. Hail has been known to cause injury to humans, occasionally fatal injury.

In general, assets in the County vulnerable to thunderstorms with lightning, high winds, and hail include people, crops, vehicles, and built structures. Although this hazard results in high annual losses, private property insurance and crop insurance usually cover the majority of losses. Considering insurance coverage as a recovery capability, the overall impact on jurisdictions is reduced.

Most lightning damages occur to electronic equipment located inside buildings. But structural damage can also occur when a lightning strike causes a building fire. In addition, lightning strikes can cause damages to crops if fields or forested lands are set on fire. Communications equipment and warning transmitters and receivers can also be knocked out by lightning strikes. http://www.lightningsafety.noaa.gov/stats/08_Vaisala_NLDN_Poster.pdfandhttp://www.lightningsafety.noaa.gov/

Based on information provided by the Tornado and Storm Research Organization (TORRO), the table below describes typical damage impacts of the various sizes of hail.

Table 3.33. Tornado and Storm Research Organization Hail Storm Intensity Scale

Intensity Category	Diameter (mm)	Diameter (inches)	Size Description	Typical Damage Impacts
Hard Hail	5-9	0.2-0.4	Pea	No damage
Potentially Damaging	10-15	0.4-0.6	Mothball	Slight general damage to plants, crops
Significant	16-20	0.6-0.8	Marble, grape	Significant damage to fruit, crops, vegetation
Severe	21-30	0.8-1.2	Walnut	Severe damage to fruit and crops, damage to glass and Plastic structures, paint and wood scored
Severe	31-40	1.2-1.6	Pigeon's egg> squash ball	Wide spread glass damage, vehicle bodywork damage
Destructive	41-50	1.6-2.0	Golf ball> Pullet's egg	Whole sale destruction of glass, damage to tiled roofs, Significant risk of injuries
Destructive	51-60	2.0-2.4	Hen's egg	Bodywork of grounded aircraft dented, brick walls pitted
Destructive	61-75	2.4-3.0	Tennis ball> cricket ball	Severe roof damage, risk of serious injuries
Destructive	76-90	3.0-3.5	Large orange >Softball	Severe damage to aircraft bodywork
Super Hailstorms	91-100	3.6-3.9	Grapefruit	Extensive structural damage. Risk of severe or even Fatal injuries to persons caught in the open
Super Hailstorms	>100	4.0+	Melon	Extensive structural damage. Risk of severe or even Fatal injuries to persons caught in the open

Source:TornadoandStormResearchOrganization(TORRO),DepartmentofGeography,OxfordBrookesUniversity

Notes: In addition to hail diameter, factors including number and density of hail stones, hail fall speed and surface wind speeds affect severity. http://www.torro.org.uk/site/hscale.php

Straight-line winds are defined as any thunderstorm wind that is not associated with rotation (i.e., is not a tornado). It is these winds, which can exceed 100 miles per hour, which represent the most common type of severe weather. They are responsible for most wind damage related to thunderstorms. Since thunderstorms do not have narrow tracks like tornadoes, the associated wind damage can be extensive and affect entire (and multiple) counties. Objects like trees, barns, outbuildings, high-profile vehicles, and power lines/poles can be toppled or destroyed, and roofs, windows, and homes can be damaged as wind speeds increase.

The onset of thunderstorms with lightning, high wind, and hail is generally rapid. Duration is less than six hours and warning time is generally six to twelve hours. Nationwide, lightning kills 75 to 100 people each year. Lightning strikes can also start structural and wildland fires, as well as damage electrical systems and equipment.

Table 3.34. Crop Insurance Claims Paid in Warren County From Thunderstorms, 2005-2015

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2015	Soybeans	Cyclone	$1,632
Total			$1,632

Source: USDA Risk Management Agency, Insurance Claims, http://www.rma.usda.gov/data/cause.htm

Table 3.35. Crop Insurance Claims Paid in Warren County From High Winds, 2005-2015

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2011	Soybeans	Excessive Winds	$1,613
2011	All Other Crops	Excessive Winds	$4,926
2011	Corn	Excessive Winds	$38,139
2013	Sorgum	Excessive Winds	$15,151
Total			$59,829

Source: USDA Risk Management Agency, Insurance Claims, http://www.rma.usda.gov/data/cause.htm

Table 3.36. Crop Insurance Claims Paid in Warren County From Lightning, 2005-2015

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2005	Soybeans	Other – Lightning	$712
2010	Corn	Other – Lightning	$424
2012	Corn	Other – Lightning	$237,709
Total			$238,835

Source: USDA Risk Management Agency, Insurance Claims, http://www.rma.usda.gov/data/cause.htm

Figure 3.26. Crop Insurance Claims Paid in Warren County From Hail, 2005-2015

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2014	Soybeans	Hail	$2554
Total			$

USDA Risk Management Agency, Insurance Claims, http://www.rma.usda.gov/data/cause.htm

Previous Occurrences

The following figures show reported thunderstorm, high wind, lightning, and hail events from January 2005 through December 2015 along with the magnitude of the event (when available), and any associated deaths, injuries, or damage. Lightning and Strong Wind events are likely under-reported, judging from the figures obtained from NCDC.

Table 3.37. Thunderstorm Events, 2005-2015

Date	Event	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
6/10/2005	Thunderstorm Wind	50	0	0	$ -	$ -
6/13/2005	Thunderstorm Wind	52	0	0	$ -	$ -
6/13/2005	Thunderstorm Wind	55	0	0	$ -	$ -
9/19/2005	Thunderstorm Wind	57	0	0	$ -	$ -
9/19/2005	Thunderstorm Wind	57	0	0	$ -	$ -
4/2/2006	Thunderstorm Wind	55	0	0	$ -	$ -
6/10/2006	Thunderstorm Wind	52	0	0	$ -	$ -
7/19/2006	Thunderstorm Wind	55	0	0	$ -	$ -
7/21/2006	Thunderstorm Wind	60	0	0	$ -	$ -
8/18/2006	Thunderstorm Wind	52	0	0	$ -	$ -
6/18/2007	Thunderstorm Wind	52	0	0	$ -	$ -
8/12/2007	Thunderstorm Wind	52	0	0	$ -	$ -
10/18/2007	Thunderstorm Wind	52	0	0	$ -	$ -
3/8/2009	Thunderstorm Wind	62	0	0	$ -	$ -
7/20/2010	Thunderstorm Wind	52	0	0	$ -	$ -
8/20/2010	Thunderstorm Wind	52	0	0	$ -	$ -
10/26/2010	Thunderstorm Wind	56	0	0	$ -	$ -
2/27/2011	Thunderstorm Wind	56	0	0	$ -	$ -
5/23/2011	Thunderstorm Wind	52	0	0	$ -	$ -
5/23/2011	Thunderstorm Wind	59	0	0	$ -	$ -
6/10/2011	Thunderstorm Wind	56	0	0	$ -	$ -
6/27/2011	Thunderstorm Wind	56	0	0	$ -	$ -
7/3/2011	Thunderstorm Wind	61	0	0	$ -	$ -
7/3/2011	Thunderstorm Wind	61	0	0	$ -	$ -

Date	Event	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
8/4/2012	Thunderstorm Wind	56	0	0	$ -	$ -
10/17/2012	Thunderstorm Wind	56	0	0	$ -	$ -
4/15/2013	Thunderstorm Wind	52	0	0	$ -	$ -
5/31/2013	Thunderstorm Wind	56	0	0	$ -	$ -
4/28/2014	Thunderstorm Wind	52	0	0	$ -	$ -
7/7/2014	Thunderstorm Wind	61	0	0	$ -	$ -
7/7/2014	Thunderstorm Wind	51	0	0	$ -	$ -
7/25/2014	Thunderstorm Wind	52	0	0	$ -	$ -
6/25/2015	Thunderstorm Wind	56	0	0	$ -	$ -
TOTAL	**33**		**0**	**0**	**$ -**	**$ -**

Table 3.38. High Wind Events, 2005 - 2015

Date	Event	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
12/9/2009	Strong Wind	48KTS	0	0	$ 1,000	$ -
TOTALS	**1**		**0**	**0**	**$ 1,000**	**$ -**

Source: NCDC

Table 3.39. Lightning Events, 2005 - 2015

Date	Event	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
9/19/2005	Lightning	NA	0	0	0	0
TOTALS	**1**		**0**	**0**	**0**	**0**

Source: NCDC

Table 3.40. Hail Events, 2005 - 2015

Date	Event	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
1/12/2005	Hail	0.75	0	0	0	0

Date	Event	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
5/11/2005	Hail	0.75	0	0	0	0
5/11/2005	Hail	1.75	0	0	0	0
6/10/2005	Hail	1	0	0	0	0
6/13/2005	Hail	0.75	0	0	0	0
11/5/2005	Hail	0.75	0	0	0	0
2/16/2006	Hail	0.88	0	0	0	0
4/2/2006	Hail	0.75	0	0	0	0
5/24/2006	Hail	1	0	0	0	0
6/10/2006	Hail	1	0	0	0	0
6/10/2006	Hail	1	0	0	0	0
1/7/2008	Hail	0.75	0	0	0	0
3/27/2008	Hail	0.75	0	0	0	0
3/27/2008	Hail	1.25	0	0	0	0
3/27/2008	Hail	0.75	0	0	0	0
5/25/2008	Hail	0.88	0	0	0	0
5/25/2008	Hail	1.75	0	0	0	0
3/4/2011	Hail	0.88	0	0	0	0
4/19/2011	Hail	1.75	0	0	0	0
4/19/2011	Hail	1	0	0	0	0
4/22/2011	Hail	1	0	0	0	0
4/22/2011	Hail	4.5	0	0	0	0
4/22/2011	Hail	1.75	0	0	0	0
5/22/2011	Hail	1	0	0	0	0
5/22/2011	Hail	0.75	0	0	0	0
5/22/2011	Hail	1.75	0	0	0	0
5/22/2011	Hail	1	0	0	0	0

Date	Event	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
5/22/2011	Hail	1	0	0	0	0
5/22/2011	Hail	1.75	0	0	0	0
5/22/2011	Hail	2.5	0	0	0	0
5/22/2011	Hail	1.75	0	0	0	0
5/22/2011	Hail	1	0	0	0	0
5/25/2011	Hail	0.75	0	0	0	0
5/25/2011	Hail	1	0	0	0	0
7/3/2011	Hail	1	0	0	0	0
1/17/2012	Hail	1.75	0	0	0	0
1/17/2012	Hail	0.88	0	0	0	0
3/2/2012	Hail	1.75	0	0	0	0
3/2/2012	Hail	0.88	0	0	0	0
3/2/2012	Hail	1.5	0	0	0	0
3/15/2012	Hail	1	0	0	0	0
3/15/2012	Hail	0.88	0	0	0	0
4/28/2012	Hail	1.25	0	0	0	0
4/28/2012	Hail	1.75	0	0	0	0
9/7/2012	Hail	2.5	0	0	0	0
9/25/2012	Hail	0.75	0	0	0	0
5/10/2014	Hail	0.75	0	0	0	0
5/10/2014	Hail	0.88	0	0	0	0
5/10/2014	Hail	1.25	0	0	0	0
4/7/2015	Hail	1.75	0	0	0	0
4/7/2015	Hail	1.75	0	0	0	0
4/7/2015	Hail	2	0	0	0	0
4/8/2015	Hail	0.88	0	0	0	0

Date	Event	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
TOTALS	**53**		**0**	**0**	**0**	**0**

Source: NCDC

Probability of Future Occurrence

Each of these 4 events are likely to happen anywhere in Warren County at nearly any time of the year. Lightning and high wind events appear to be under-reported; however it is uncertain why. The current reported trends for those events indicates a probability of lightning or high winds occurring once every 10 years. Common sense tells us this is likely incorrect. There is simply not enough reliable data to perform an accurate trend analysis. The probability of severe thunderstorms is 3.3 events per year and for hail, 5.3 events per year.

Vulnerability

Warren County's total exposure to buildings due to thunderstorms and high winds is $3.1B and its exposure to crop damage from the same hazards is $18M.

Potential Losses to Existing Development

There is significant potential of loss to existing development, particularly crops, which will take damage from events of less severity than is required to cause damage to structures. Prior figures showing crop insurance claims paid support this statement.

Future Development

Additional development results in the exposure of more households and businesses vulnerable to damages from severe thunderstorms, high winds, lightning, and hail.

Hazard Summary by Jurisdiction

These hazards are area-wide. NCDC data does not indicate any particular community or area to have significantly higher losses as compared to another. The City of Warrenton is the county seat and the most populous of incorporated areas and would therefore be most at risk.

Problem Statement

The county, like the entire state of Missouri, is vulnerable to high winds, lightning, hail and thunderstorms.

3.3.8 Tornado

Hazard Profile

Hazard Description

The NWS defines a tornado as “a violently rotating column of air extending from a thunderstorm to the ground.” It is usually spawned by a thunderstorm and produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly. Often, vortices remain suspended in the atmosphere as funnel clouds. When the lower tip of a vortex touches the ground, it becomes a tornado.

Essentially, tornadoes are a vortex storm with two components of winds. The first is the rotational winds that can measure up to 500 miles per hour, and the second is an uplifting current of great strength. The dynamic strength of both these currents can cause vacuums that can overpressure structures from the inside.

Although tornadoes have been documented in all 50 states, most of them occur in the central United States due to its unique geography and presence of the jet stream. The jet stream is a high-velocity stream of air that separates the cold air of the north from the warm air of the south. During the winter, the jet stream flows west to east from Texas to the Carolina coast. As the sun moves north, so does the jet stream, which at summer solstice flows from Canada across Lake Superior to Maine. During its move northward in the spring and its recession south during the fall, the jet stream crosses Missouri, causing the large thunderstorms that breed tornadoes.

A typical tornado can be described as a funnel-shaped cloud in contact with the earth‘s surface that is “anchored” to a cloud, usually a cumulonimbus. This contact on average lasts 30 minutes and covers an average distance of 15 miles. The width of the tornado (and its path of destruction) is usually about 300 yards. However, tornadoes can stay on the ground for upward of 300 miles and can be up to a mile wide. The National Weather Service, in reviewing tornadoes occurring in Missouri between 1950 and 1996, calculated the mean path length at 2.27 miles and the mean path area at 0.14 square mile.

The average forward speed of a tornado is 30 miles per hour but may vary from nearly stationary to 70 miles per hour. The average tornado moves from southwest to northeast, but tornadoes have been known to move in any direction. Tornadoes are most likely to occur in the afternoon and evening, but have been known to occur at all hours of the day and night.

Geographic Location

Tornados can occur anywhere in Warren County.

Severity/Magnitude/Extent

Tornadoes are the most violent of all atmospheric storms and are capable of tremendous destruction. Wind speeds can exceed 250 miles per hour and damage paths can be more than one mile wide and 50 miles long. Tornadoes have been known to lift and move objects weighing more than 300 tons a distance of 30 feet, toss homes more than 300 feet from their foundations, and siphon millions of tons of water from water bodies. Tornadoes also can generate a tremendous amount of flying debris or “missiles,” which often become airborne shrapnel that causes additional damage. If wind speeds are high enough, missiles can be thrown at a building with enough force to penetrate windows, roofs, and walls. However, the less spectacular damage is much more common.

Tornado magnitude is classified according to the EF-Scale; or the Enhanced Fujita Scale, based on the original Fujita Scale developed by Dr. Theodore Fujita, a renown severe storm researcher. The EF-Scale; shown below, attempts to rank tornadoes according to wind speed based on the damage caused. This update to the original EF-Scale was implemented in the U.S. on February 1, 2007.

Table 3.41. Enhanced Fujita Scale for Tornado Damage

FUJITASCALE			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Number	Fastest¼-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	EF Number	3 Second Gust (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over200

Source: The National Weather Service, www.spc.noaa.gov/faq/tornado/ef-scale.html

The table below is based on information from the NOAA Storm Prediction Center. The table shows the wind speeds for the EF scale and summary descriptions of potential damage. For the actual EF scale it is necessary to look up the damage indicator(type of structure damaged) and refer to the degrees of damage associated with that indicator. Information on the Enhanced Fujita Scale’s damage indicators and degrees or damage is online at www.spc.noaa.gov/efscale/ef-scale.html.

Table 3.42. Enhanced Fujita Scale with Potential Damage

Enhanced Fujita Scale			
Scale	Wind Speed(mph)	Relative Frequency	Potential Damage
EF0	65-85	53.5%	Light. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e. those that remain in open fields) are always rated EF 0).
EF1	86-110	31.6%	Moderate. Roofs severely stripped; mobile homes over turned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	10.7%	Considerable. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes complete destroyed; large trees snapped or uprooted; light object missiles generated; cars lifted off ground.
EF3	136-165	3.4%	Severe. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown some distance.
EF4	166-200	0.7%	Devastating. Well-constructed houses and whole frame houses completely levelled; cars thrown and small missiles generated.
EF5	>200	<0.1%	Explosive. Strong frame houses levelled off foundations and swept away; automobile-sized missiles fly through the air in excess of 300ft.; steel reinforced concrete structure badly damaged; high rise buildings have significant structural deformation; incredible phenomena will occur.

Source: NOAA Storm Prediction Center, http://www.spc.noaa.gov/efscale/ef-scale.html

Enhanced weather forecasting has provided the ability to predict severe weather likely to produce tornadoes days in advance. Tornado watches can be delivered to those in the path of these storms several hours in advance. Lead time for actual tornado warnings is about 30 minutes. Tornadoes have been known to change paths very rapidly, thus limiting the time in which to take shelter. Tornadoes may not be visible on the ground if they occur after sundown or due to blowing dust or driving rain and hail.

Previous Occurrences

The 6 NCDC reported tornado events and damages for Warren County since 1993 are shown in the table below. Prior to that date, only really destructive tornadoes were recorded. There are limitations to the use of NCDC tornado data that must be noted. For example, one tornado may contain multiple segments as it moves geographically. A tornado that crosses a county line or state line is considered a separate segment for the purposes of reporting to the NCDC. Also, a tornado that lifts off the ground for less than 5 minutes or 2.5 miles is considered a separate segment. If the tornado lifts off the ground for greater than 5 minutes or 2.5 miles, it is considered a separate tornado. Tornadoes reported in Storm Data and the Storm Events Database are in segments.

Table 3.43. Recorded Tornadoes in Warren County, January 1993–May 2016

Date	Beginning Location	Ending Location	Length (miles)	Width (yards)	F/EF Rating	Deaths	Injuries	Property Damage	Crop Damages
4/13/1998	WARRENTON	WRIGHT CITY	8.5	50	F0	0	0	$ 500	$ -
4/10/2001	WRIGHT CITY	WRIGHT CITY	0.1	50	F0	0	0	$ 20,000	$ -
3/13/2006	WARRENTON	WARRENTON	2.0	50	F0	0	0	$ -	$ -
4/23/2010	PENDLETON	PENDLETON	0.1	10	EF0	0	0	$ -	$ -
4/23/2010	NEW TRUXTON	NEW TRUXTON	.12	10	EF0	0	0	$ -	$ -
1/29/2013	CONCORD HILL	CONCORD HILL	1.2	40	EF1	0	0	$ -	$ -
	Total							$ 20,500	$ -

Source: National Climatic Data Center, http://www.ncdc.noaa.gov/stormevents/

The next 6 figures show the paths of the above tornados along with details of the events. Each of the 6 figures were taken from the National Climatic Data Center, http://www.ncdc.noaa.gov/stormevents/

Data obtained from http://www.tornadohistoryproject.com/tornado/missouri shows a total of 11 tornados dating from July, 1971. Of those, there were 10 personal injuries and 1 death attributed to tornado events. We choose to rely on the NCDC Storm Events database because NCDC is a vetted source and data is accessible without advertising.

Figure 3.27. Details and Path of April 14, 1998 Tornado, Warren County

National Centers for Environmental Information

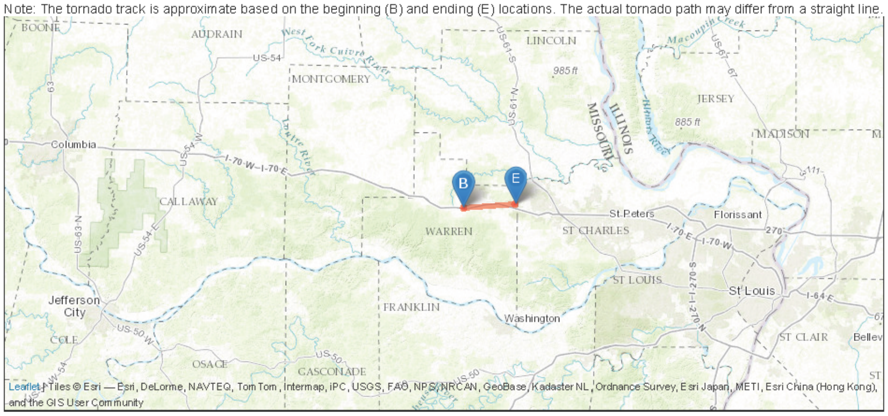
Storm Events Database

Event Details:

Event	**Tornado**
-- Scale	**F0**
-- Length	**8.5 Miles**
-- Width	**50 Yards**
State	**MISSOURI**
County/Area	**WARREN**
WFO	**LSX**
NCEI Data Source	**PDC**
Begin Date	**1998-04-13 15:09:00.0 CST**
Begin Location	**1E WARRENTON**
Begin Lat/Lon	**38.82/-91.12**
End Date	**1998-04-13 15:22:00.0 CST**
End Location	**3E WRIGHT CITY**
End Lat/Lon	**38.83/-90.97**
Deaths Direct/Indirect	**0/0** (fatality details below, when available...)
Injuries Direct/Indirect	**0/0**
Property Damage	**.5K**
Crop Damage	
Episode Narrative	**A weak tornado tracked from just east of Warrenton in Warren County to Lake St. Louis in St. Charles County. The tornado was spotted several times along the path by severe storm spotters, intermittently touching down but causing very little damage. The only reported damage of note was to the garage doors at the truck weigh station along Interstate 70 in Foristell.**

Event Map:

Note: The tornado track is approximate based on the beginning (B) and ending (E) locations. The actual tornado path may differ from a straight line.



All events for this episode:

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	0	0.50K	0.00K
WARRENTON	WARREN CO.	MO	04/13/1998	15:09	CST	Tornado	F0	0	0	0.50K	0.00K
FORISTELL	ST. CHARLES CO.	MO	04/13/1998	15:22	CST	Tornado	F0	0	0	0.00K	0.00K
Totals:								0	0	0.50K	0.00K

Figure 3.28. Details and Path of April 10, 2001 Tornado at Wright City

National Centers for Environmental Information

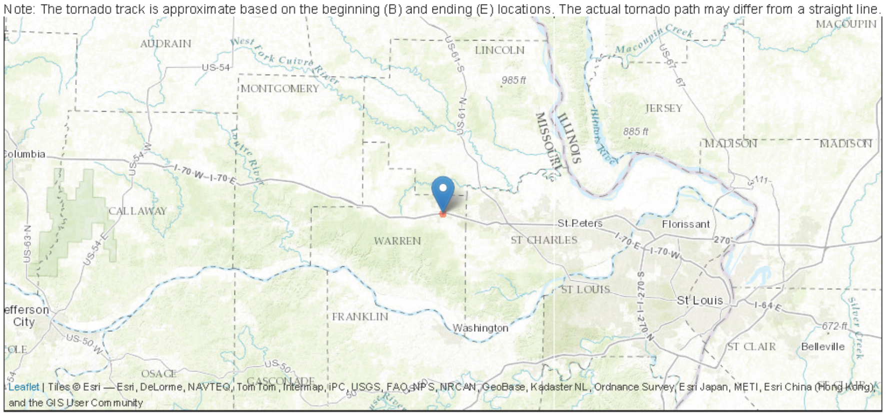
Storm Events Database

Event Details:

Event	**Tornado**
-- Scale	**F0**
-- Length	**.1 Miles**
-- Width	**50 Yards**
State	**MISSOURI**
County/Area	**WARREN**
WFO	**LSX**
Report Source	**NWS STORM SURVEY**
NCEI Data Source	**PDS**
Begin Date	**2001-04-10 19:20:00.0 CST**
Begin Location	**1W WRIGHT CITY**
Begin Lat/Lon	**38.83/-91.03**
End Date	**2001-04-10 19:20:00.0 CST**
End Location	**1W WRIGHT CITY**
End Lat/Lon	**38.83/-91.03**
Deaths Direct/Indirect	**0/0** (fatality details below, when available...)
Injuries Direct/Indirect	**0/0**
Property Damage	**20K**
Crop Damage	
Event Narrative	**A small tornado formed briefly just west of Wright City. One mobile home on a sales lot was overturned.**

Event Map:

Note: The tornado track is approximate based on the beginning (B) and ending (E) locations. The actual tornado path may differ from a straight line.



All events for this episode:

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	0	20.00K	0.00K
WRIGHT CITY	WARREN CO.	MO	04/10/2001	19:20	CST	Tornado	F0	0	0	20.00K	0.00K
Totals:								0	0	20.00K	0.00K

Figure 3.29.   Details and Path of March 13, 2006 Tornado, Warren County

National Centers for Environmental Information

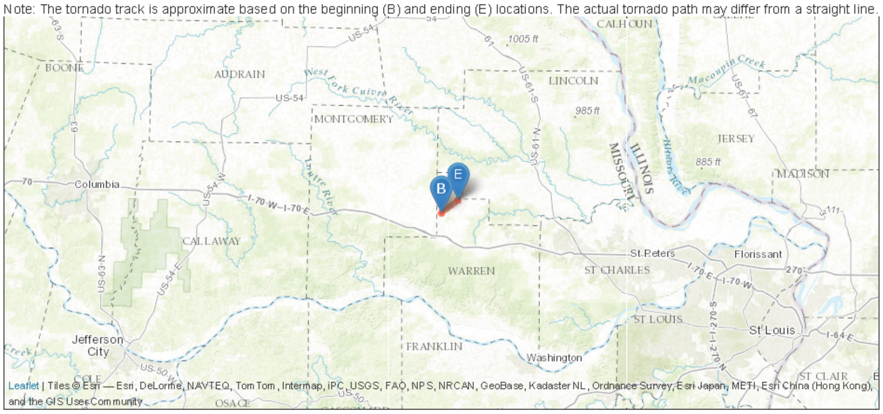
Storm Events Database

Event Details:

Event	**Tornado**
-- Scale	**F0**
-- Length	**2 Miles**
-- Width	**50 Yards**
State	**MISSOURI**
County/Area	**WARREN**
WFO	**LSX**
Report Source	**NWS STORM SURVEY**
NCEI Data Source	**PDS**
Begin Date	**2006-03-13 00:10:00.0 CST**
Begin Location	**10NW WARRENTON**
Begin Lat/Lon	**38.90/-91.25**
End Date	**2006-03-13 00:13:00.0 CST**
End Location	**9NNW WARRENTON**
End Lat/Lon	**38.93/-91.20**
Deaths Direct/Indirect	**0/0** (fatality details below, when available...)
Injuries Direct/Indirect	**0/0**
Property Damage	
Crop Damage	
Event Narrative	**The tornado that formed in Montgomery County in Jonesburg around Midnight CST March 13, continued into Warren County. The tornado moved through mostly forest area west of Highway A along Camp Creek causing tree damage before dissipating.**

Event Map:

Note: The tornado track is approximate based on the beginning (B) and ending (E) locations. The actual tornado path may differ from a straight line.



All events for this episode:

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	1	800.00K	0.00K
JONESBURG	MONTGOMERY CO.	MO	03/13/2006	00:00	CST	Tornado	F3	0	1	800.00K	0.00K
WARRENTON	WARREN CO.	MO	03/13/2006	00:10	CST	Tornado	F0	0	0	0.00K	0.00K
Totals:								0	1	800.00K	0.00K

Figure 3.30. Details and Path of April 23, 2010 Tornado, Pendleton

National Centers for Environmental Information

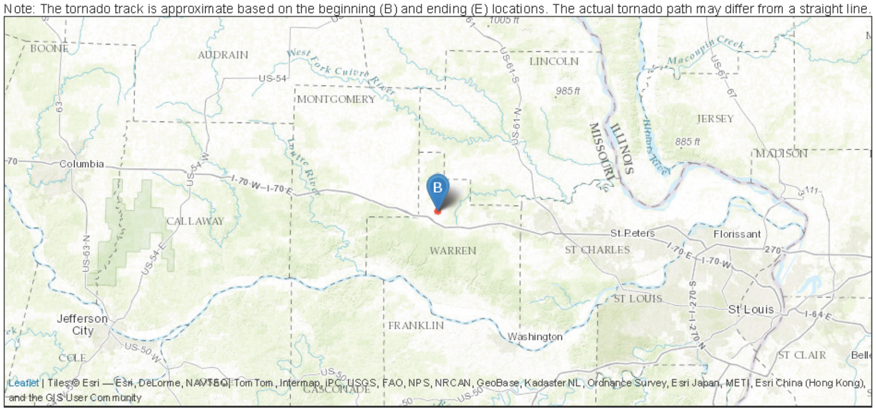
Storm Events Database

Event Details:

Event	**Tornado**
-- Scale	**EF0**
-- Length	**0.1 Miles**
-- Width	**10 Yards**
State	**MISSOURI**
County/Area	**WARREN**
WFO	**LSX**
Report Source	**Trained Spotter**
NCEI Data Source	**CSV**
Begin Date	**2010-04-23 17:40:00.0 CST-6**
Begin Location	**3NNE PENDLETON**
Begin Lat/Lon	**38.857/-91.2067**
End Date	**2010-04-23 17:41:00.0 CST-6**
End Location	**3NNE PENDLETON**
End Lat/Lon	**38.8581/-91.2055**
Deaths Direct/Indirect	**0/0** (fatality details below, when available...)
Injuries Direct/Indirect	**0/0**
Property Damage	**0.00K**
Crop Damage	**0.00K**
Episode Narrative	**Storms formed south of a warm front and moved north, interacting with the frontal boundary. Some of the storms produced brief tornado touch downs, while others produced very heavy rainfall.**
Event Narrative	**A tornado briefly touched down in a field. No damage was reported.**

Event Map:

Note: The tornado track is approximate based on the beginning (B) and ending (E) locations. The actual tornado path may differ from a straight line.



All events for this episode:

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	0	0.00K	0.00K
PENDLETON	WARREN CO.	MO	04/23/2010	17:40	CST-6	Tornado	EF0	0	0	0.00K	0.00K
NEW TRUXTON	WARREN CO.	MO	04/23/2010	18:11	CST-6	Tornado	EF0	0	0	0.00K	0.00K
HAWK PT	LINCOLN CO.	MO	04/23/2010	18:29	CST-6	Tornado	EF0	0	0	0.00K	0.00K
SILEX	LINCOLN CO.	MO	04/23/2010	18:48	CST-6	Tornado	EF0	0	0	0.00K	0.00K
CALIFORNIA	MONITEAU CO.	MO	04/23/2010	19:10	CST-6	Flash Flood		0	0	0.00K	0.00K

Figure 3.31. Details and Path of April 23, 2010 Tornado, New Truxton

National Centers for Environmental Information

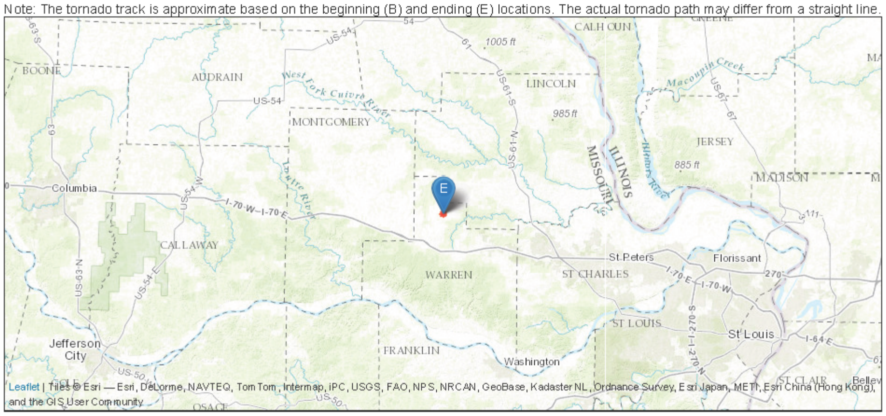
Storm Events Database

Event Details:

Event	**Tornado**
-- Scale	**EF0**
-- Length	**0.12 Miles**
-- Width	**10 Yards**
State	**MISSOURI**
County/Area	**WARREN**
WFO	**LSX**
Report Source	**Law Enforcement**
NCEI Data Source	**CSV**
Begin Date	**2010-04-23 18:11:00.0 CST-6**
Begin Location	**6SSE NEW TRUXTON**
Begin Lat/Lon	**38.9051/-91.1803**
End Date	**2010-04-23 18:12:00.0 CST-6**
End Location	**6SSE NEW TRUXTON**
End Lat/Lon	**38.9065/-91.1791**
Deaths Direct/Indirect	**0/0** (fatality details below, when available...)
Injuries Direct/Indirect	**0/0**
Property Damage	**0.00K**
Crop Damage	**0.00K**
Episode Narrative	**Storms formed south of a warm front and moved north, interacting with the frontal boundary. Some of the storms produced brief tornado touch downs, while others produced very heavy rainfall.**
Event Narrative	**A tornado briefly touched down in a field. No damage was reported.**

Event Map:

Note: The tornado track is approximate based on the beginning (B) and ending (E) locations. The actual tornado path may differ from a straight line.



All events for this episode:

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	0	0.00K	0.00K
PENDLETON	WARREN CO.	MO	04/23/2010	17:40	CST-6	Tornado	EF0	0	0	0.00K	0.00K
NEW TRUXTON	WARREN CO.	MO	04/23/2010	18:11	CST-6	Tornado	EF0	0	0	0.00K	0.00K
HAWK PT	LINCOLN CO.	MO	04/23/2010	18:29	CST-6	Tornado	EF0	0	0	0.00K	0.00K
SILEX	LINCOLN CO.	MO	04/23/2010	18:48	CST-6	Tornado	EF0	0	0	0.00K	0.00K
CALIFORNIA	MONITEAU CO.	MO	04/23/2010	19:10	CST-6	Flash Flood		0	0	0.00K	0.00K

Figure 3.32. Details and Path of January 29, 2013 Tornado, Concord Hill

National Centers for Environmental Information

Storm Events Database

Event Details:

Event	**Tornado**
-- Scale	**EF1**
-- Length	**1.17 Miles**
-- Width	**40 Yards**
State	**MISSOURI**
County/Area	**WARREN**
WFO	**LSX**
Report Source	**NWS Storm Survey**
NCEI Data Source	**CSV**
Begin Date	**2013-01-29 15:14:00.0 CST-6**
Begin Location	**1N CONCORD HILL**
Begin Lat/Lon	**38.6622/-91.1273**
End Date	**2013-01-29 15:15:00.0 CST-6**
End Location	**2NE CONCORD HILL**
End Lat/Lon	**38.6645/-91.1059**
Deaths Direct/Indirect	**0/0** (fatality details below, when available...)
Injuries Direct/Indirect	**0/0**
Property Damage	
Crop Damage	**0.00K**
Episode Narrative	**A strong cold front moved through the region, triggering showers and thunderstorms. Some of the thunderstorms produced large hail, damaging winds and a couple of tornadoes.**
Event Narrative	**A tornado touched down south of Concord Hill Road and west of State Highway 47. A concentrated area of tree damage was found approximately 165 yards south of Concord Hill Road across from an open field. This tree damage was consistent with wind speeds near the low end of the EF-1 range. Some loose siding was observed just west of State Highway 47 between Concord Hill Road and New Boston Lane. Additional structural and tree damage was then found between New Boston Lane and Charette Creek Road northeast of State Highway 47. This damage was consistent with wind speeds near the high end of the EF-0 range. The roof of a small barn, both the west and east sides, were uplifted and carried between 80 and 90 yards northeast. Material from the barn roof was lifted into the nearby trees. A couple of supporting poles from the barn were also uplifted approximately 8 inches. Several wooden 2x4s were found driven into the ground northeast of the barn. These 2x4s were driven approximately 8 to 10 inches into the ground with varying angles of entry. The tornado continued eastward where a two story residence was damaged. A few sections of the fascia on this home were uplifted and the brick veneer had become partially detached from the front wall. A large healthy cedar tree in the front of the residence was snapped near the ground and the tree was tossed to the northeast. Additional EF-0 damage was found on the property. The tornado lifted just east of this residence based on the lack of tree damage found to the east.**