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INTRODUCTION AND PLANNING PROCESS

Purpose

Marion County and the participating cities, fire departments, colleges, and school districts prepared this Multi-Jurisdictional Hazard Mitigation Plan (HMP) to guide hazard mitigation planning to better protect the people and property of the County from the effects of natural hazard events. For the County, this plan serves as the plan update to their Local Hazard Mitigation Plan that was developed and approved by the Federal Emergency Management Agency (FEMA) in 2012. This plan will identify specific vulnerabilities and mitigation projects for the planning area, which has not changed since the 2012 HMP. This plan demonstrates the communities' commitments to reducing risks from hazards and serves as a tool to help decision makers direct mitigation activities and resources. This plan was also developed to make Marion County and the participating jurisdictions eligible for certain federal grant programs; specifically, the FEMA Hazard Mitigation Assistance (HMA) grants such as the Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program.

Background and Scope

Each year in the United States, natural disasters take the lives of hundreds of people and injure thousands more. Nationwide, taxpayers pay billions of dollars annually to help communities, organizations, businesses, and individuals recover from disasters. These monies only partially reflect the true cost of disasters, because additional expenses to insurance companies and nongovernmental organizations are not reimbursed by tax dollars. Many natural disasters are predictable, and much of the damage caused by these events can be alleviated or even eliminated.

Hazard mitigation is defined by FEMA as "any sustained action taken to reduce or eliminate long-term risk to human life and property from a hazard event." The results of a three-year, congressionally mandated independent study to assess future savings from mitigation activities provides evidence that mitigation activities are highly cost-effective. On average, each dollar spent on mitigation saves society an average of $4 in avoided future losses in addition to saving lives and preventing injuries (National Institute of Building Science Multi-Hazard Mitigation Council 2005).

Hazard mitigation planning is the process through which hazards that threaten communities are identified, likely impacts of those hazards are determined, mitigation goals are set, and appropriate strategies to lessen impacts are determined, prioritized, and implemented. This plan documents the hazard mitigation planning process undertaken by the Planning Team. It identifies relevant hazards and vulnerabilities in the planning area and sets forth a mitigation strategy to decrease vulnerability and increase resiliency and sustainability in Marion County.

In 2012, Marion County commissioned their Council of Governments (COG) to write the 2012 HMP. Much of the information within this plan has been updated since the 2012 plan, but the old plan will be used for reference purposes.

The Marion County Multi-Jurisdictional Hazard Mitigation Plan is a multi-jurisdictional plan that geographically covers the participating jurisdictions within Marion County's boundaries (hereinafter referred to as the planning area).
The following jurisdictions officially participated in the planning process:

1. Marion County (unincorporated population/demo data)
2. Bussey
3. Hamilton
4. Harvey
5. Knoxville
6. Marysville
7. Melcher-Dallas
8. Pella
9. Pleasantville
10. Swan

The following school district, colleges, hospitals or fire departments participated in the planning process:

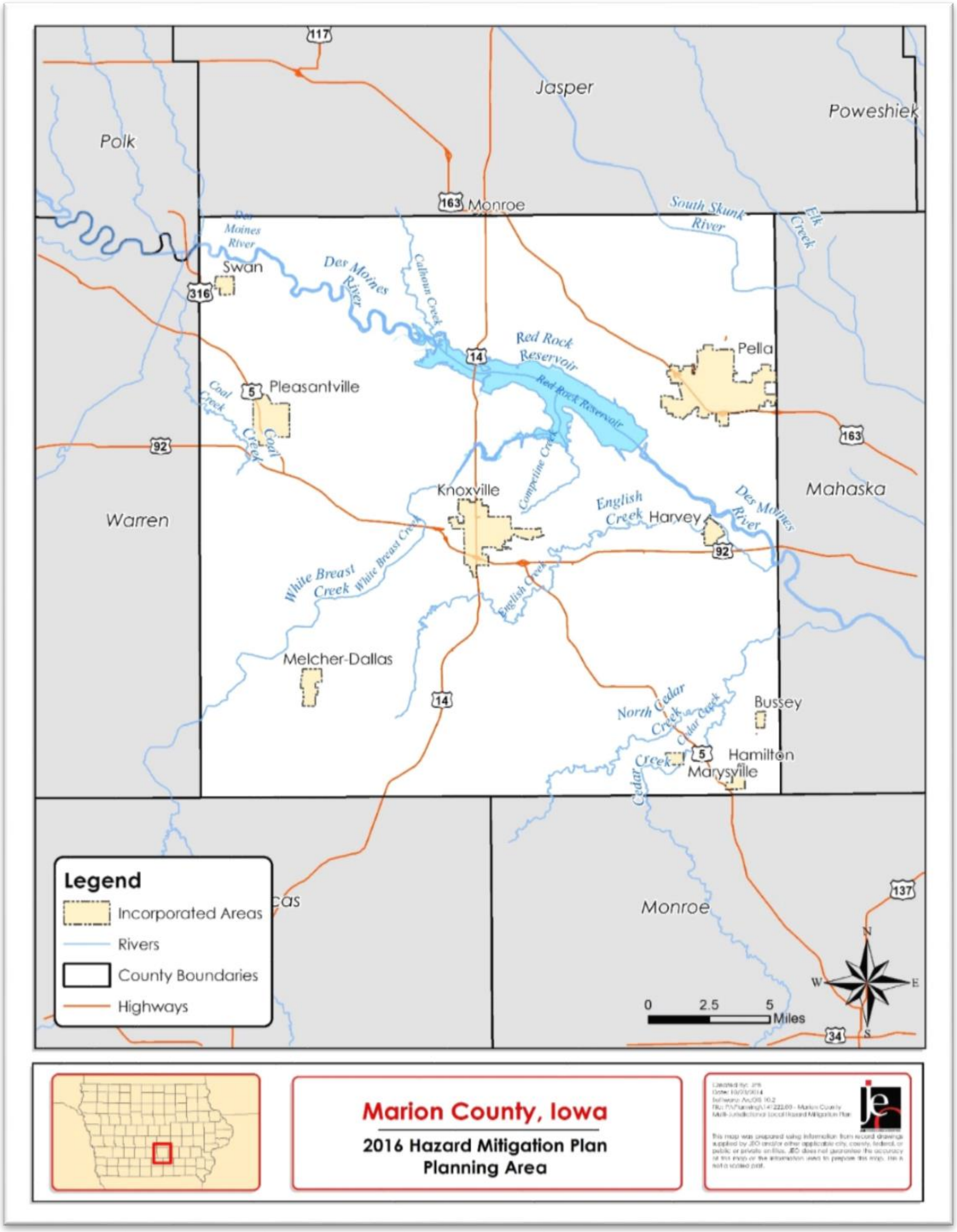
11. Knoxville Community School District
12. Melcher-Dallas Community School District
13. Pella Community School District
14. Pella Christian Schools
15. Pleasantville Community School District
16. Twin Cedars Community School District
17. Central College
18. Knoxville Hospital
19. Pella Regional Health Center

The following figure displays the location of Marion County in relation to the state of Iowa.

Figure 1: Location of Marion County

The following figure displays the location of the incorporated communities in relation to Marion County.

Figure 2: Location of Incorporated Communities



This plan was prepared pursuant to the requirements of the Disaster Mitigation Act of 2000 (Public Law 106-390) and the implementing regulations set forth by the Interim Final Rule published in the Federal Register on February 26, 2002, (44 CFR §201.6) and finalized on October 31, 2007. (Hereafter, these requirements and regulations will be referred to collectively as the Disaster Mitigation Act.) While the act emphasized the need for mitigation plans and more coordinated mitigation planning and implementation efforts, the regulations established the requirements that local hazard mitigation plans must meet in order for a local jurisdiction to be eligible for certain federal disaster assistance and hazard mitigation funding under the Robert T. Stafford Disaster Relief and Emergency Act (Public Law 93-288).

Information in this plan will be used to help guide and coordinate mitigation activities and decisions for local land use policy in the future. Proactive mitigation planning will help reduce the cost of disaster response and recovery to communities and their residents by protecting critical community facilities, reducing liability exposure, and minimizing overall community impacts and disruptions. The Marion County planning area has been affected by hazards in the past and the participating jurisdictions are therefore committed to reducing future impacts from hazard events and becoming eligible for mitigation-related federal funding.

Plan Organization

Section One – Introduction and Planning Process: This section includes the following: purpose; background and scope; an overview of the planning organization and planning process; and, information regarding multi-jurisdictional participation, public involvement, and coordination with other departments and agencies.

Section Two – Risk Assessment: This section includes an overview of hazard identification, assets at risk, as well as land use and development trends.

Section Three – Hazard Profiles and Vulnerability: This section provides individual hazard profiles for each hazard.

Section Four – Jurisdictional Profiles and Mitigation Capabilities: This section includes profiles for each participating jurisdiction along with discussion of capabilities.

Section Five – Mitigation Strategy: This section presents the mitigation strategy developed by the Planning Team based on the risk assessment.

Section Six – Plan Maintenance Process: This section contains the process which will be followed for plan implementation and maintenance, including monitoring and future updates.

Planning Process

44 CFR Requirement 201.6(c)(1): [The plan shall document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved .

The hazard mitigation planning process utilized for this hazard mitigation plan included: organizing resources; assessing risks; developing a mitigation strategy; and, implementing the plan and monitoring the progress. The four basic phases are described below:

- Organize Resources
  - Focus on the resources needed for a successful mitigation planning process. Essential steps include:
    - Organizing interested community members
    - Identifying technical expertise needed
- Assess Risks
  - Identify the characteristics and potential consequences of the hazard. Identify how much of the jurisdiction can be affected by specific hazards and the impacts they could have on local assets.
- Develop a Mitigation Plan
  - Determine what the priorities should be and look at possible solutions to avoid or minimize the undesired effects. The result is a hazard mitigation plan and strategy for implementation.
- Implement the Plan and Monitor Progress
  - Bring the plan to life by implementing specific mitigation projects and changing day-to-day operations. It is critical that the plan remains relevant to succeed. Thus, it is important to conduct periodic evaluations and make revisions as needed.

The Marion County Emergency Management Agency (MCEMA), located in Knoxville, Iowa, coordinated the planning process for the entire planning area. MCEMA is governed by Chapter 29C State Code of Iowa and enforced by the Marion County Emergency Management Commission consisting of Chair and Vice Chair positions selected from the commission members which consist of the Mayors of the corporate cities within Marion County, a Board of Supervisor member and the Marion County Sheriff.

Marion County EMA is responsible for county emergency planning requirements developed by the Iowa Homeland Security and Emergency Management Division under Chapter 29C and works in cooperation with the emergency response agencies within Marion County to develop emergency response planning, response and recovery guidance and serves as the initial contact and liaison for Iowa Homeland Security issues at the state and federal levels.

JEO Consulting Group, Inc. (JEO) was contracted by Marion County in January, 2015 to help complete the planning process and assemble the multi-jurisdictional hazard mitigation plan for Marion County, Iowa.

Hazard Mitigation Planning Committee

At the beginning of the planning process the plan sponsor established that JEO would guide the process and oversee the development of the hazard mitigation plan. The Planning Team consisted of representatives from various departments in Marion County. Additional technical support was provided to the Planning Team through staff from JEO, Iowa Homeland Security and Emergency Management (IHSEMD), and the Iowa Department of Natural Resources (IDNR).

Table 2: Hazard Mitigation Planning Committee

Name	Title	Jurisdiction
Jeff Anderson	Director – Emergency Management Agency	Marion County
Cory Frank	Environmental Health Coordinator	Marion County
Melissa Poffenbarger	Zoning Administrator	Marion County
Jeff Henson*	Planner/ Project Manager	JEO Consulting Group, Inc.
John Brennan*	Planner/ Project Coordinator	JEO Consulting Group, Inc.

**External Contributors*

The Planning Team meetings were held on:

- March 25, 2015; Knoxville, IA

Goals and Objectives

The goals and objectives for this planning process are as follows:

Goal 1: Protect the Health and Safety of Residents

> ***Objective 1.1:*** *Reduce or prevent damage to property or prevent loss of life or serious injury (overall intent of the plan)*

Goal 2: Reduce Future Losses from Hazard Events

> ***Objective 2.1:*** *Provide protection for existing structures, future development, critical facilities, services, utilities, and trees.*

> ***Objective 2.****2: Develop hazard specific plans, conduct studies or assessments, and retrofit buildings and facilities to mitigate for hazards and minimize their impact.*

> ***Objective 2.3:*** *Minimize the impact of hazard events through enacting or updating ordinances, permits, laws or regulations.*

> ***Objective 2.4:*** *Reduce or eliminate economic impacts from hazards.*

Goal 3: Increase Public Awareness and Education Regarding Vulnerabilities to Hazards

Objective 3.1: *Develop and provide information to the public and property owners about their risk and vulnerability to hazards.*

Goal 4: Improve Emergency Management Capabilities

Objective 4.1: *Develop or update City and/or County Emergency Response Plan(s) and procedures, and increase the capability to respond.*

Objective 4.2: *Develop or improve Evacuation Plans and procedures.*

Objective 4.3: *Improve warning systems and ability to communicate to the public during and following a disaster or emergency.*

Goal 5: Pursue Multi-Objective Opportunities (whenever possible)

Objective 5.1: *When possible, use existing resources, agencies, and programs to implement the projects.*

Objective 5.2: *When possible implement projects that achieve several goals.*

Goal 6: Enhance Overall Resilience and Promote Sustainability

Objective 6.1: *Incorporate hazard mitigation and adaptation into updating other local planning endeavors (e.g. comprehensive plans, zoning ordinance, subdivision regulation, etc)*

Multi-Jurisdictional Participation

44 CFR Requirement §201.6(a)(3): Multi-jurisdictional plans may be accepted, as appropriate, as long as each jurisdiction has participated in the process and has officially adopted the plan.

Marion County Emergency Management invited the incorporated cities, the school districts, various county and city departments, fire department personnel, library representatives, and state and federal agencies to participate in the Marion County Multi-Jurisdictional Hazard Mitigation Planning process. The jurisdictions that elected to participate in this plan were listed previously. The Disaster Mitigation Act requires that each jurisdiction participate in the planning process and officially adopt the multi-jurisdictional hazard mitigation plan (HMP). Each jurisdiction that chose to participate in the planning process and development of the plan, as a direct participant, was required to meet plan participation requirements defined at the beginning of the process, which included the following:

1. In order to participate in the plan, at least one representative from each jurisdiction had to be present at one of the 'hazard identification' public meetings. Sign-in sheets from all public meetings can be found in *Appendix C.*
2. For those jurisdictions unable to attend the scheduled public meetings two options were made available:
   a. Have a follow-up phone conversation with a JEO employee, to identify hazards with the employee
   b. Presenting the information at a one-on-one public meeting with a member of the Planning Committee and completing the meeting materials described above.

For both options they had to return the completed meeting materials along with a copy of their sign-in sheet. This effort enabled jurisdictions which could not attend a scheduled public meeting to participate in the plan.

3. Designated representatives from each participating jurisdictions were responsible for providing information specific to their jurisdiction such as studies, reports, and plans.
4. Participants were responsible for completing project prioritization worksheets as well as responding to data requests, which provided vital information necessary to successfully complete the plan (refer to *Appendix D*).
5. Designated representatives were also responsible for reviewing draft plan materials and final review of the plan prior to submittal to FEMA for approval.

The designated representatives and planning participants for all direct participants are shown in the following table.

Table 3: Designated Representatives, Direct Participants

Name	Title	Jurisdiction	Participated in 2012 Plan?
Jeff Anderson* Martha Dykstra Melissa Poffenbarger Kim Pettyjohn	Emergency Manager Communications Director Zoning Administrator Assistant Coordinator-Emergency Management	Marion County	Yes
Brian DesPlanque*	Superintendent	Bussey	Yes
Patrick Silvers*	Mayor	Hamilton	No
Dennis Seibert* Leonard Geery	Mayor City Superintendent	Harvey	Yes
Patrick Murphy Jim Mitchell Lauren Dietz Dennis Webb Dan Losada Aaron Adams*	WRF Superintendent Fire Chief Management Intern Street Supervisor Police Chief City Manager	Knoxville	Yes
Corey Bakalar*	Mayor	Marysville	No
Terry Fisher*	Councilmember	Melcher-Dallas	Yes

Marcia Slycord* Stephen Bennett Robert Bokinsky Mike Nardini George Wesselhoft Jeanette Vaughn	Arministrative Service Manager Police/Fire Specialist Chief of Police City Administrator Planning and Zoning Director Community Services Director	Pella	Yes
Bill Moore Joe Mrstik* Shane Broazeale John Franey	Mayor City Administrator Public Works Director City Council	Pleasantville	Yes
Stacy Harding*	City Council	Swan	Yes
Cassi Murra*	Superintendent	Knoxville Community School District	Yes
Randy Alger*	Superintendent	Melcher-Dallas Community School District	Yes
Greg Ebling*	Superintendent	Pella Community School District	Yes
Clyde Rinsema* Craig Juffer	Interim Principal Head of Teaching & Learning	Pella Christian Schools	No
Tony Aylsworth*	Superintendent	Pleasantville Community School District	No
Mark Bacus*	Building/Grounds Superintendent	Twin Cedars Community School District	Yes
Charlie Strey*	Dean of Students	Central College	Yes

Shawna Forst* Nathalie McCollam	Coordinator Facilities Specialist	Pella Health	Yes
Kellie Jones*	ED Coordinator	Knoxville Hospital	Yes

**Designated Representative*

The participating jurisdictions participated in the following Hazard Identification meetings:

- June 11, 2015; Knoxville, IA; Introductory Workshop, table top exercise, identifying responsibilities for planning process
- September 3, 2015; Knoxville, IA; (critical facilities, identifying hazards, updating mitigation projects)
- September 4, 2015; Pella, IA; (critical facilities, identifying hazards, updating mitigation projects)

These meetings were intended to provide the participants and the public with an overview of the work to be completed over the next few months and discuss what types of information would need to be provided to complete the plan. Meeting worksheets were distributed to provide an opportunity for public input on the identification of hazards, records of historical occurrences, establishment of goals and objectives, and potential mitigation alternatives (refer to *Appendix D*).

The participating jurisdictions participated in the following Project Identification Meetings:

- December 10, 2015; Knoxville, IA; (critical facilities, identifying hazards, updating mitigation projects)

Should a participating jurisdiction not be available to attend a meeting, follow-up one on one meetings were scheduled with individual participants. These one-on-one meetings utilized the most practical process possible, be it over the phone or in person.

Additionally, the planning committee organized a "Funding Workshop" after the participants had identified their mitigation actions. This way, jurisdictions were able to learn more about potential funding opportunities, for grants, and different loan programs at the federal, state, and local level. Presentations were delivered by representatives from Iowa Homeland Security and Emergency Management, USDA Rural Development, Iowa Financial Authority, and a local consultant. The presenters and offices are listed below:

- Jessica Turba — *State Hazard Mitigation & Disaster Recovery Planner*
Iowa Homeland Security
- Carol Tomb — *Project Officer*
Iowa Homeland Security
- Desirae Willms — *Community Programs Specialist*
USDA
- Lori Beary — Community Development Director

Iowa Finance Authority

- Clint Sloss — Planner, JEO Consulting Group, Inc

More information is provided in Appendix D for supplementary materials.

Coordination with Other Departments and Agencies

44 CFR Requirement 201.6(b): An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include: (2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process. (3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

Neighboring communities were informed of the planning process and given the opportunity to participate. The table below lists the neighboring jurisdictions that were notified throughout the planning process. Refer to *Appendix B* for a copy of the correspondence sent to the neighboring jurisdictions.

Table 4: Neighboring Jurisdictions

Neighboring Jurisdictions
Appanoose County
Davis County
Lucas County
Monroe County
Warren County

MCEMA and the Planning Committee made every effort to obtain all available local plans, studies, and reports. Various plans, documents, and sources of technical information were used throughout the development of the plan, and are listed below.

Table 5: General Plans, Documents, and Information

Document/ Plan	Source
Federal Emergency Management Agency (FEMA)	http://www.fema.gov
Disaster Mitigation Act of 2000 (DMA)	FEMA
Interim Final Rule (IFR)	FEMA
Local Mitigation Plan Review Guide	FEMA
Local Mitigation Planning Handbook	FEMA
Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards	FEMA
Understanding Your Risks: Identifying Hazards and Estimating Losses	FEMA
Hazard Mitigation Assistance Unified Guidance	FEMA
What is a Benefit: Guidance on Benefit-Cost Analysis on Hazard Mitigation Projects	FEMA
United States Department of Commerce	http://www.commerce.gov/
National Oceanic Atmospheric Administration (NOAA)	http://www.noaa.gov/
National Environmental Satellite, Data, and Information Service (NESDIS)	http://www.nesdis.noaa.gov/
National Climatic Data Center (NCDC)	http://www.ncdc.noaa.gov
Storm Prediction Center Statistics	http://www.spc.noaa.gov
United States Geological Survey (USGS)	http://www.usgs.gov/
United States Department of Agriculture (USDA)	http://www.usda.gov
United States Department of Agriculture – Risk Assessment Agency (RMA)	http://www.rma.usda.gov
National Agricultural Statistics Service (NASS)	http://www.nass.usda.gov/
The Census of Agriculture	http://www.agcensus.usda.gov/
National Drought Mitigation Center	http://drought.unl.edu
National Drought Mitigation Center – Drought Monitor	http://drought.unl.edu/dm/monitor.html
Multi-Resolution Land Characteristics Consortium- National Land Cover Database	http://www.mrlc.gov
National Drought Mitigation Center – Drought Impact Reporter	http://www.droughtreporter.unl.edu
High Plains Regional Climate Center	http://www.hprcc.unl.edu
United States Census Bureau	http://www.census.gov
National Flood Insurance Program (NFIP)	http://www.fema.gov
National Flood Insurance Program Community Status Book	FEMA, IDNR
National Flood Insurance Program Bureau and Statistical Agent BureauNet	FEMA
Flood Insurance Study	FEMA
FEMA Map Service Center	http://www.msc.fema.gov
National Historic Registry	http://www.nps.gov/nr
United States Small Business Administration	http://www.sba.gov
Iowa Homeland Security and Emergency Management	http://www.iowahomelandsecurity.org
Iowa State Hazard Mitigation Plan	IHSEMD
Iowa Department of Natural Resources	www.iowadnr.gov
Natural Resources Conservation Service (NRCS)	www.ia.nrcs.usda.gov
Iowa Forest Service	http://www.iowadnr.gov/Environment/Forestry.aspx
Iowa Department of Revenue	http://www.iowa.gov/tax/index.html

Public Involvement

44 CFR Requirement 201.6(b): An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include: (1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval.

Public involvement was a vital component to the development of this multi-jurisdictional plan. The public was invited to all meetings with participating jurisdictions, all of which are described in the previous section.

Below is a summary provided by the County of how information was locally distributed to the public, by Marion County, throughout the planning process:

- Information concerning the Marion County Hazard Mitigation Plan was distributed to the public throughout the planning process through the Marion County Emergency Management office, to all local newspapers, city and county offices, and libraries. Notices concerning the planning process were posted in public buildings throughout the county. Letters were sent to neighboring jurisdictions concerning the planning process.

The draft of the local multi-jurisdictional hazard mitigation plan was made available for public comment at the offices of the county emergency manager, on the Marion County website, and on the JEO Consulting Group project website. The above method was discussed with and approved by Iowa Homeland Security and Emergency Management.

Risk Assessment

44 CFR Requirement §201.6(c)(2): [The plan shall include] A risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure within Marion County, Iowa to these hazards. The goal of the risk assessment is to estimate the potential loss in the planning area, including loss of life, personal injury, property damage, and economic loss, from a hazard event. The risk assessment process allows communities in the planning area to better understand their potential risk to natural hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

The risk assessment for Marion County and participating jurisdictions follows the methodology described in FEMA's Local Mitigation Plan Review Guide, which includes a four-step process:

1. Identify Hazards
2. Profile Hazard Events
3. Inventory Assets
4. Estimate Losses

These steps are met in the following sections:

Hazard Identification – identifies the hazards that threaten the planning area

Assets at Risk – provides the planning area's total exposure to natural hazards, considering critical facilities and other community assets at risk

Existing and Future Land Use and Development- discusses areas of existing and planned future development

Hazard Profiles and Vulnerability – for each hazard, this section is divided into two parts (a) Hazard Profile discusses the threat to the planning area, the geographic location/extent at risk, previous occurrences of hazard events, and probability of future occurrence; and (b) Vulnerability Assessment further defines and quantifies populations, buildings, critical facilities and other community assets at risk to natural hazards.

Hazard Analysis Summary provides a summary of the hazard ranking

Hazard Identification

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the type…of all natural hazards that can affect the jurisdiction.

Marion County, Iowa previously developed a Hazard Mitigation Plan dated 2012. Although the County's previous plan will be superseded by this multi-jurisdictional plan, the 2012 plan has been consulted in development of the risk assessment and information included and updated where appropriate. The hazards profiled in the 2016 Marion County Hazard Mitigation Plan are listed below:

Hazards profiled in the 2016 Marion County Hazard Mitigation Plan

- Animal/Crop Disaease
- Dam Failure
- Drought
- Earthquake
- Expansive Soils
- Extreme Heat
- Flash Flood
- Grass and Wildland Fire
- Hailstorm
- Hazardous Materials
- Human Disease
- Infrastructure Failure
- Landslide
- Levee Failure
- River Flood
- Severe Winter Storm
- Sinkhole
- Thunderstorm/Lightning
- Tornado
- Transportation Incidents
- Windstorm

To facilitate consistency within planning efforts in the State, and to enable comprehensive statewide analysis, of local plans the Planning Team chose to reduce the number of hazards profiled during this plan update to concentrate on the hazards included in the 2013 State of Iowa HMP. Some of these hazards are profiled together, due to having similar attributes (severe winter storm/extreme cold, thunderstorm/lightning/hail, grass/wildfire). Participants prioritized the hazards of greatest concern for their jurisdiction from the State of Iowa's HMP hazard list. These hazards will be examined at a local level, and at a planning area-wide basis. The Planning Team reviewed data and discussed the impacts of each of these hazards. The table below provides the list of hazards in the State Hazard Mitigation Plan.

Hazards Included in 2013 Iowa State Hazard Mitigation Plan

1. Animal/Crop/Plant Disease
2. Dam Failure/Levee Failure
3. Drought
4. Earthquake
5. Expansive Soils
6. Extreme Heat
7. Flash Flood
8. Grass or Wildland Fire
9. Hazardous Materials
10. Human Disease
11. Infrastructure Failure
12. Landslide
13. Radiological
14. River Flooding
15. Severe Winter Storm
16. Sinkholes
17. Terrorism
18. Thunderstorm & Lightning/Hail
19. Tornado/Windstorm
20. Transportation Incident

Review of Disaster Declaration History

Additional information used by the Planning Team to identify relevant hazards for Marion County included events that triggered federal disaster declarations. Federal and/or state declarations may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. If the disaster is so severe that both the local and state government capacities are exceeded; a federal emergency or disaster declaration may be issued allowing for the provision of federal assistance.

FEMA also issues emergency declarations, which are more limited in scope and do not include the long-term federal recovery programs of major disaster declarations. Determinations for declaration type are based on scale and type of damages and institutions or industrial sectors affected.

The table below lists federal disaster and emergency declarations that included Marion County from 1965 to 2015.

Table 6: FEMA Disaster Declarations that included Marion County, Iowa 1/1965-10/2015

Disaster Declaration Number	Declaration Date	Disaster Type
DR-4134	7/31/2015	Severe Storms, Tornadoes, Straight-Line Winds, And Flooding
DR-4119	5/31/2013	Severe storms, straight-line winds, and flooding
DR-1930	7/29/2010	Severe storms, flooding, and tornadoes
DR-1763	5/27/2008	Severe storms, tornadoes, and flooding
DR-1737	1/4/2008	Severe winter storm
DR-1688	3/14/2007	Severe winter storms
DR-3239	9/10/2005	Hurricane Katrina evacuation
DR-1230	7/2/1998	Severe storms, tornadoes and flooding
DR-1191	11/26/1997	Severe snowstorms
DR-996	7/9/1993	Severe storms & flooding
DR-868	5/26/1990	Severe storms & flooding
DR-443	6/24/1974	Severe storms & flooding
DR-386	5/23/1973	Severe storms & flooding
DR-269	8/14/1969	Heavy rains & flooding
DR-259	4/25/1969	Flooding
DR-193	4/22/1965	Flooding

Source: Federal Emergency Management Agency, www.fema.gov

Additional Farm Service Agency Small Business Administration Declared Disasters are listed below:

Table 7: Small Business Administration Declared Disasters

Declared	Disaster Number	Description and Documents
06/20/2015 through 06/25/2015	IA-00064	Severe Storms, Tornadoes, Straight-Line Winds, and Flooding
04/17/2013 through 04/30/2013	IA-00052	Severe Storms, Straight-line Winds, and Flooding
06/01/2010	IA -00024	Severe Storms, Flooding, and Tornadoes
05/25/2008	IA-00015	Severe Storms, Tornadoes, and Flooding

12/10/2007 through 12/11/2007	IA-00013	Severe Winter Storm
02/23/2007 through 03/02/2007	IA-00006	Severe Winter Storms

Table 8: Hazards Identified for Each Participating Jurisdiction

Jurisdiction	Animal/Plant/Crop	Dam Failure/Levee Failure	Drought	Earthquake	Expansive Soils	Extreme Heat	Flash Flood	Grass or Wildland Fire	Hazardous Materials	Human Disease	Infrastructure Failure	Landslide	Radiological	River Flooding	Severe Winter Storm	Sinkholes	Terrorism	Thunderstorm/Lightning /Hail	Tornado/Windstorm	Transportation Incident
Marion County	○	○	○	○	○	○	●	○	●	●	●	○	○	●	●	○	○	○	●	○
Cities																				
Bussey	○	○	○	○	○	○	●	●	●	○	○	○	○	●	●	○	○	●	●	●
Hamilton	○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	○	○	●	●	●
Harvey	○	○	○	○	○	○	●	○	○	○	●	○	○	●	●	○	○	●	○	○
Knoxville	○	●	○	○	○	○	●	○	●	○	○	○	○	●	○	○	○	○	○	○
Marysville	○	○	○	○	○	○	○	●	○	○	○	○	○	●	●	○	○	○	●	○
Melcher-Dallas	○	○	○	○	○	○	●	○	●	○	●	○	○	○	●	○	○	○	●	○
Pella	○	○	○	○	○	○	○	○	●	○	○	○	○	○	●	○	○	●	●	●
Pleasantville	○	○	○	○	○	○	●	○	○	○	●	○	○	○	○	○	○	●	●	●
Swan	○	○	○	○	○	○	●	○	○	○	○	○	○	●	●	○	○	●	●	○
School Districts / Colleges																				
Central College	○	○	○	○	○	○	○	○	○	●	●	○	○	○	●	○	○	●	●	○
Knoxville CSD	○	○	○	○	○	●	○	○	○	●	○	○	○	○	●	○	●	○	●	●
Melcher-Dallas CSD	○	○	○	○	○	○	○	●	○	○	●	○	○	○	○	○	○	●	●	○
Pella Christian Schools	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	●	●	○
Pella CSD	○	●	○	○	○	○	●	○	○	○	●	○	○	●	○	○	○	●	●	○
Pleasantville CSD	○	○	○	○	○	○	○	○	●	○	○	○	○	○	●	○	○	●	●	○
Twin Cedars CSD	○	○	○	○	○	○	●	●	○	○	○	○	○	○	●	○	○	●	●	○
Health Centers																				
Knoxville Hospital & Clinics	○	●	○	○	○	○	●	○	●	○	○	○	○	●	●	○	○	○	●	○
Pella Regional Health Center	○	●	○	○	○	○	●	○	●	○	○	○	○	●	●	○	○	●	○	○

Note: The "open" dot indicates that the hazard is not ranked as a significant concern by the local planning team. The "closed" dot indicates that the hazard has been identified by the local planning team as a top concern for the respective jurisdiction.

For this multi-jurisdictional plan, the risks are assessed for each jurisdiction where they deviate from the risks facing the entire planning area. The planning area is fairly uniform in terms of climate and topography as well as building construction characteristics. Accordingly, the geographic areas of occurrence for weather-related hazards do not vary greatly across the planning area for most hazards. The more urbanized areas within the planning area have more assets that are vulnerable to the weather-related hazards and varied development trends impact the future vulnerability. More rural areas have more assets (crops/livestock) that are vulnerable to animal/plant/ crop disease. These differences are discussed in greater detail in the vulnerability sections of each hazard.

The hazards that have the potential to vary across the planning area in terms of geographic areas at risk include dam and levee failure, grass or wildland fire, and river flood.

Data on the impacts of hazards in the planning area was collected from the following sources:

- Iowa Hazard Mitigation Plan (September 2013)
- Marion County Hazard Mitigation Plan (2012)
- Information on past extreme weather and climate events from the National Oceanic and Atmospheric Administration‘s (NOAA) National Climatic Data Center (NCDC)
- Iowa Department of Natural Resources
- Disaster declaration history from the Federal Emergency Management Agency (FEMA)
- Disaster declaration history from the Farm Service Agency Small Business Administration
- The National Drought Mitigation Center Drought Reporter
- US Department of Agriculture‘s (USDA) Risk Management Agency Crop Insurance Statistics
- Information provided by local jurisdictions
- Various articles and publications available on the internet (sources are indicated where data is cited)

It should be noted that information sources have some limitations. NOAA receives their information from a variety of sources, which include but are not limited to: county, state and federal emergency management officials, local law enforcement officials, "skywarn" spotters, NWS damage surveys, newspaper clipping services, the insurance industry, and the general public. The data documents only those storms and other significant weather phenomena that are serious enough to cause loss of life, injuries, significant property damage, and/or disruption to commerce. Some information appearing in NWS Storm Data may be provided by or gathered from sources outside the NWS, such as the media, law enforcement and/or other government agencies, private companies, individuals, etc. The reliability of the data is highly dependent on the data sources. In addition, it represents only the information that was reported, as opposed to what actually happened. The decision whether or not to report is made subjectively, based on the opinion of the reporter rather than parameters defined by the NWS.

Additionally, it is important to note that the NCDC's period of record for different disasters may change, based on the disaster. Tornado has the longest period of record, beginning January of 1950, in January 1955, Thunderstorm Wind, and Hail were added to the period of record. In January 1996, the remaining 48 hazards were added to the NCDC's protocol. As technology improves, NCDC data becomes more complete. Early records, especially those before 1996, may be missing pertinent information, as it was not included in the database.

Other NCDC data limitations include the fact that at this time, the only lightning data contained in the NCDC Website are lightning events that resulted in fatality, injury, or property or crop damage. Tornado data is skewed by the fact that a tornado may contain multiple segments. A tornado that crosses a county line or state line is considered a separate segment for NCDC reporting purposes. Also, a tornado that lifts off the ground for less than five minutes or 2.5 miles is considered a separate segment. If the tornado lifts off the ground for greater than five minutes or 2.5 miles, it is considered a separate tornado. The tornadoes reported in NCDC Storm Events Database are in segments, and are not necessarily separate tornadoes.

The NCDC tries to use the best available information, but because of time and resource constraints, information from these sources may be unverifiable. For this reason, the accuracy or validity of the information is not guaranteed by the NCDC. The damage amount information is received from a variety of sources, including those listed above. The NCDC Website cautions that property and crop damage information "should be considered as a broad estimate." In many cases it is evident that losses are poorly captured if they are captured at all. For this reason, a variety of sources have been used in an attempt to give a fuller picture of the consequences of natural hazards in the planning area.

Assets at Risk

This section assesses the population, structures, critical facilities and infrastructure, and other important assets in the planning area that may be at risk to natural hazards. The following tables show the total population, building count, estimated value of buildings, estimated value of contents and estimated total exposure to parcels by jurisdiction.

Population data is based on the 2010 data from the U.S. Census Bureau. Building counts and Building Exposure values are based on parcel data provided by the Marion County Assessor's Office. Land values are not included because land remains following disasters, and subsequent market devaluations are frequently short term and difficult to quantify. Additionally, state and federal disaster assistance programs generally do not address loss of land or its associated value (other than crop insurance).

Table 9: Maximum Population and Parcel Value by Jurisdiction

Jurisdiction	Population (2013)	Building Count	Parcel Value
Marion County (Unincorporated)	11,681	11,502	$1,174,020,166
Bussey	431	209	$7,009,860
Hamilton	186	88	$2,890,439
Harvey	356	180	$5,379,331
Knoxville	7,300	4,722	$405,737,731
Marysville	29	47	$1,196,900
Melcher-Dallas	1,254	1,234	$39,297,324
Pella	10,346	4,911	$1,016,623,616
Pleasantville	1,677	1,153	$77,903,831
Swan	58	91	$1,665,470
Total	**33,318**	**24,137**	**$2,731,724,668**

Sources: Marion County, Iowa Assessor

Table 10: Building Counts by Usage Type and Value

Jurisdiction	Commercial/ Industrial	Ag/Out Building	Dwelling	Public	Total
Bussey	12	7	177	9	**205**
Hamilton	1	12	71	1	**88**
Harvey	8	36	123	4	**180**
Knoxville	382	1,434	2,664	90	**4,722**
Marysville	0	8	37	1	**46**
Melcher-Dallas	45	218	919	21	**1,234**
Pella	542	263	3,757	47	**4,911**
Pleasantville	112	68	861	21	**1,153**
Swan	0	6	83	0	**91**
Marion County	1,348	6,854	14,900	305	**24,137**

Source: Marion County Assessor
**Information on public buildings was gathered by JEO using the following methodology:*
The Marion County Assessors website provided information on public information of building counts. Assessment was not available for public use.

Critical Facilities and Infrastructure
A critical facility may be defined as one that is essential in providing utility or direction either during the response to an emergency or during the recovery operation. The following is a summary of the inventory of critical and essential facilities and infrastructure in the planning area.

National Historic Registry
The historic sites located within the planning area, according to the National Register of Historic Places, are listed below. These sites were not evaluated as to their proximity to flooding hazard areas.

Table 11: National Historic Sites

Community	Name of Structure	Address
Bussey	Ellis, Evan F., Farmhouse	Off Hwy. 156
Hamilton	Hammond Bridge	170th Pl. over North Cedar Cr.
Harvey	Harvey Railroad Bridge	Harvey Island Rd.
Knoxville	Hays, E. R., House	301 N. 2nd St.
Knoxville	Marion County Courthouse	Main St.
Knoxville	Coal Ridge Baptist Church and Cemetery	1034 IA S71
Knoxville	Knoxville WPA Athletic Field Historic District	Bounded by Lincoln St., Robinson St., Stadium St. and Marion St.
Knoxville	Knoxville Veterans Administration Hospital Historic District	1515 W. Pleasant St.
Lacona	St. Joseph's Roman Catholic Church and Cemetery Historic District	1 mile E of jct. of Co. Rd. G76 and SE. 97th St.
Pella	Van Loon, Dirk, House	1401 University Ave.
Pella	Scholte, Dominie Henry P., House	739 Washington St.
Pella	Van Asch, William, House--Huibert Debooy Commercial Room	1105, 1107, & 1109 W. Washington St.
Pella	Van Spanckeren, B. H. and J. H. H., Row Houses	505--507 Franklin St.
Pella	Chicago, Rock Island and Pacific Passenger Depot--Pella	Jct. of Main and Oskaloosa Sts.
Pella	Pella Opera House	611 Franklin St.
Pella	Wabash Railroad Bridge	216th Pl. over Des Moines R.
Pella	East Amsterdam School	1010 198th Place
Pella	Vander Wilt, Dirk and Cornelia J., Cottage	925 Broadway St.
Pella	Van Den Berg, Hendrik J. and Wilhelmina H., Cottage	1305 W. Washington St.
Pella	Porter--Rhynsburger House	514 Broadway St.
Pella	Koelman, Philipus J. and Cornelia, House	1005 Broadway
Pella	First Christian Church	824 Franklin St.
Pella	Van Maren, Henry and Johanna, House--Diamond Filling Station	615 Main St.
Pella	Ten Hagen Cottage-Stegman Store	1110 W. Washington St.
Pella	Peoples Nationals Bank	717 Main St.
Pella	Tuttle, Thomas F. and Nancy, House	608 Lincoln St.

Federal and/or State Properties

There are a number of Federal properties within Marion County, specifically at the Knoxville Veteran's Affairs Center. Additionally, the Red Rock Dam is a US Army Corps of Engineers certified dam. As such, there are a series of federal buildings in the immediate area of the dam, such as a Project Office, Visitors Center, and other administrative buildings.

The Iowa State Hazard Mitigation Plan lists Marion County as no state owned buildings. However, the Marion County Assessor lists the county as having 16 facilities, 12 of which are DNR facilities. Mitigation projects such as safe rooms/storm shelters and emergency sirens, are highly recommended and should be considered for any future state properties.

Transportation Infrastructure

Streets and Highways

A well-developed highway system serves the county. The main east-west route serving Marion County is Iowa Highway 5, and the main north-south route is Iowa Highway 14. Iowa Highway 163 also operates in the northeastern portion of the county and County Highways T14, T15, T17, G71, G 76, G40, G42, G28, and S45 are other important corridors. Interstate 35 is located approximately 15 miles west of the county, and Interstate 80 is located approximately 10 miles north of the county.

Marion County falls within the Central Iowa Regional Transportation Planning Alliance (CIPTRA). CIPTRA maintains a Long Range Transportation Plan through 2035 which includes the following notable information regarding Marion County.

- According to the Pipeline and Hazardous Materials Safety Administration there are 93 miles of pipeline facilities in Marion County.

- The Heart of Iowa Regional Transit Agency (HIRTA) is the public transit provider for Marion County. Between 2006 and 2012, HIRTA provided 487,286 rides.

- There are approximately 134 daily messengers that commute from Marion County to the Des Moines Metropolitan area.

- The plan outlines the following eight CIRTPA projects to be completed in Marion County.

Table 12: CIRTPA Projects to be completed in Marion County

Street	Project Description	Type of Work	Program Year	Cost
50th	Adkins to Jasper Co Line	Bridge Replacement	2016	$250,000
108th	Perry to Pierce	Bridge Replacement	2017	$250,000
Coolidge Street	Over BNSF RR, from IA 316 to Swan	Bridge Rehabilitation	2015	$250,000
T17	From IA 91 to Pella Co. Line	Pavement Rehab	2016	$1,500,000
S45	MD to Hwy 5	Pavement Rehab	2017	$1,500,000
Story Drive	G-76 to 94th	Bridge Replacement	2016	$450,000
Hayes Drive	Pvile to 20th	Bridge Replacement	2015	$150,000

Air Transport
The following four airports are located in Marion County:

1. Knoxville Area Community Hospital Heliport - 0IA0
   Knoxville, Iowa
   Facility Usage: Private

2. Knoxville Muni Airport - OXV
   Knoxville, Iowa
   Facility Usage: Public

3. Pella Community Hospital Heliport - 7IA9
   Pella, Iowa
   Facility Usage: Private

4. Pella Muni Airport - PEA
   Pella, Iowa
   Facility Usage: Public

Rail Transport

Marion County has two rail lines operating within the county. Railroads operating include Marion County are:

Burlington Northern Santa Fe (BNSF)
Union Pacific (UP)

The BNSF line enters the county in the northwest from Des Moines, passes through Pleasantville, Knoxville, Flagler, Harvey, Bussey, and Hamilton before existing the county just south of Hamilton.

The UP line operates exclusively in the western section of the county. The UP line enters the county southwest of Pleasantville, proceeds southwest to Melcher-Dallas, and exits the county due south of Melcher-Dallas.

Figure 2 shows rail lines in Marion County.

Figure 1: Marion County Roads and Highways

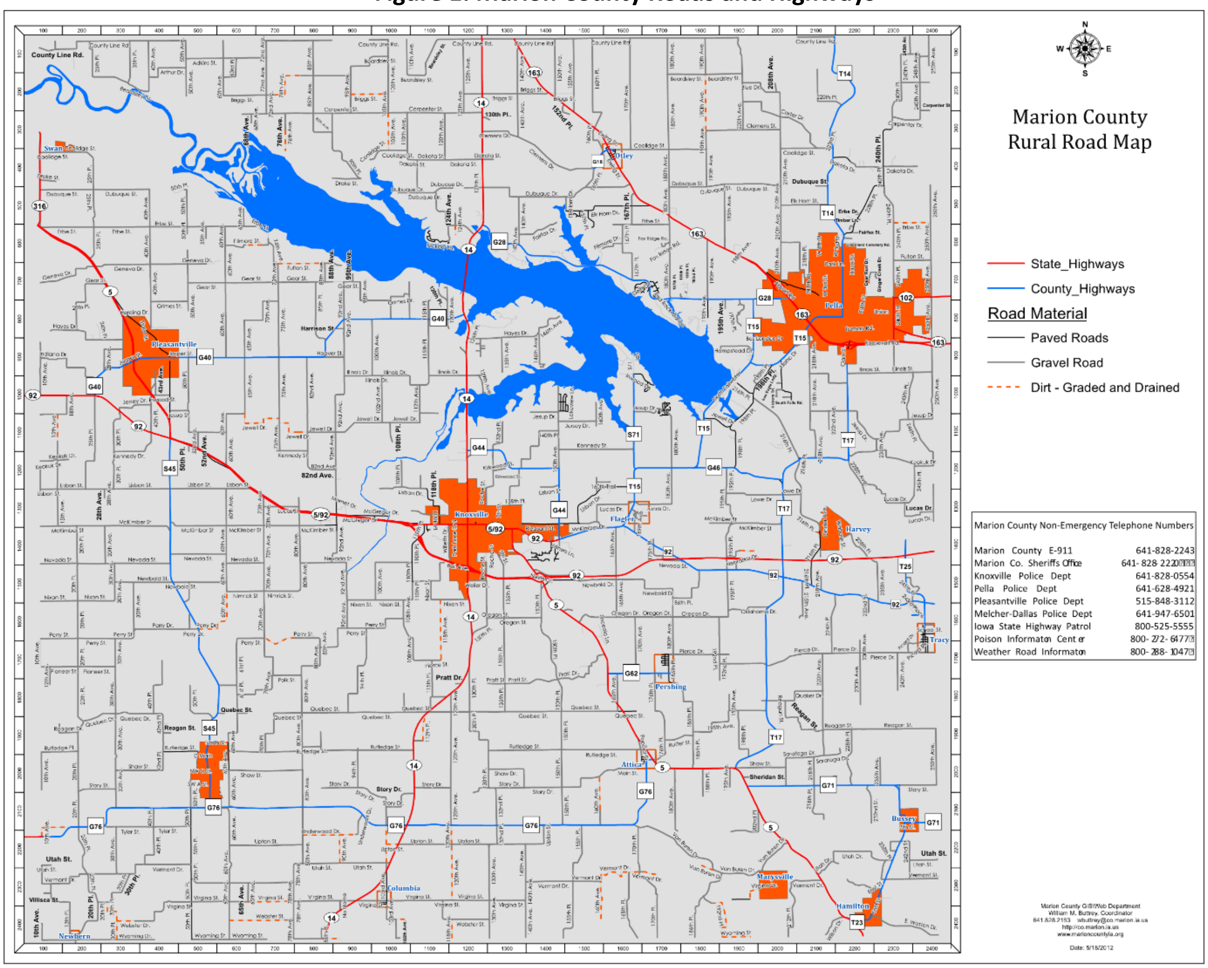
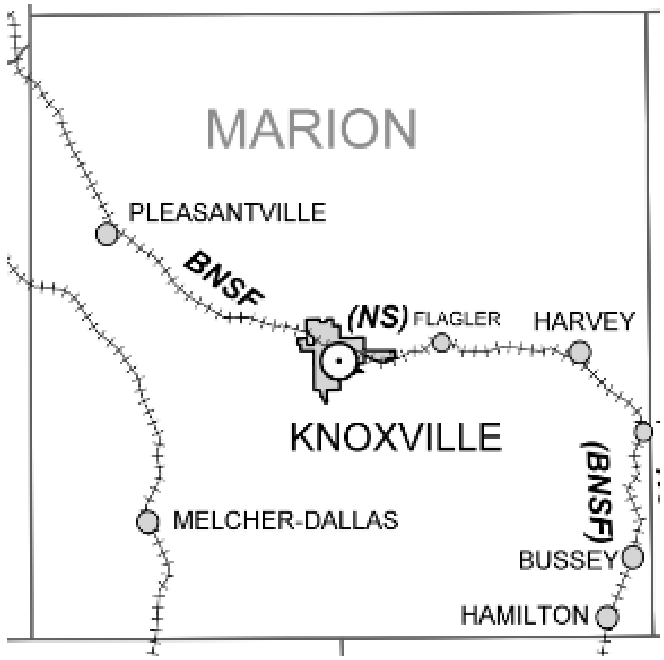
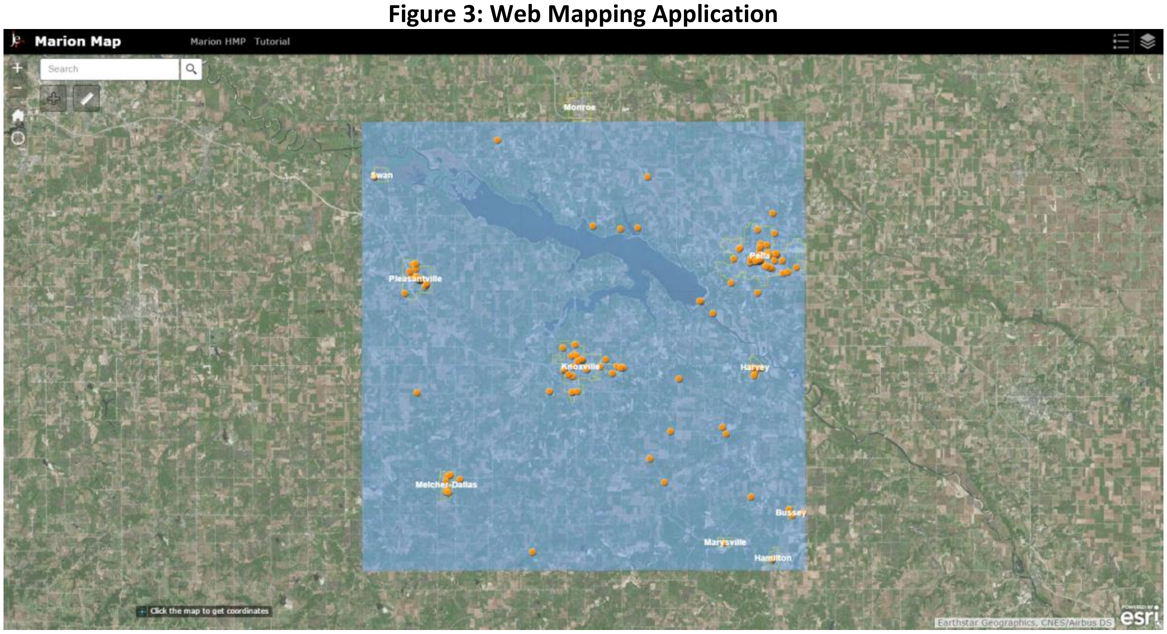


Figure 2: Marion County Railways



Each participating jurisdiction identified critical facilities vital for disaster response, providing shelter to the public, and essential for returning the jurisdiction's functions to normal during and after a disaster. Critical facilities were identified through the use of an online web mapping application developed specifically for this project (Figure 3). Critical facilities are listed and mapped for each participating jurisdiction. For more details on a given community's critical facilities, please refer to the Participant Sections.

Figure 3: Web Mapping Application



Participating jurisdictions also identified facilities which house vulnerable populations and might be more at risk or susceptible to the effects of hazards. These may include, but are not limited to, mobile home parks, nursing homes, campgrounds, fairgrounds, and parks. These also include educational facilities with concentrated populations, hospitals and care facilities with special needs populations, major employers, and gathering locations.

Table 13: County Educational Facilities/ School Districts

School or Building Site	Location	Estimated Enrollment	Address (District Offices)
Central College	Pella, IA	1,400	812 University, Pella, IA 50219
Knoxville CSD	Knoxville, IA	1,726	309 W Main St, Knoxville, IA 50138
Melcher-Dallas CSD	Melcher-Dallas, IA	306	214 S Main St, Melcher-Dallas, IA 50163
Pella Christian Schools	Pella, IA	768	300 Eagle Lane, Pella IA 50219
Pella CSD	Pella, IA	2,550	2013 East University St, Pella IA 50219
Pleasantville CSD	Pleasantville, IA	743	415 Jones St, Pleasantville, IA 50225
Twin Cedars CSD	Bussey, IA	374	2204 Highway G71, Bussey IA 50044

**CSD= Community School District*

Table 14: Highly Vulnerable Areas and Populations Summary - Hospitals and Care Facilities

Facility	Location	Estimated Census	Address
Knoxville Hospital	Knoxville, IA	45,000 patients annually	1002 S. Lincoln St, Knoxville, IA
Pleasantville Clinic	Pleasantville, IA		104 N. Washington St, Pleasantville, IA
E.J. McKeever Medical Clinic	Melcher-Dallas, IA		113 N. Main St, Melcher-Dallas, IA
Pella Regional Health Center	Pella, IA	70,000 patients annually	404 Jefferson St, Pella, IA
Pella Elder Care	Pella, IA	Not Available	413 Jefferson St, Pella, IA
Pleasantville Senior Center	Pleasantville, IA	Not Available	116 E. Monroe St, Pleasantville
Veteran's Affairs	Knoxville, IA	Not Available	1515 W Pleasantville St, Knoxville, IA

Table 15: Highly Vulnerable Areas and Populations Summary - Major Employers

Company	Location	Address
Pella Windows & Doors	Pella, IA	102 Main St, Pella, IA 50219
Vermeer Corporation	Pella, IA	1210 E. Vermeer Rd, Pella, IA 50219

**Does not duplicate facilities already listed, such as hospitals and schools.*

Existing and Future Land Use and Development

Existing Land Use

According to the USGS' National Land Cover Database, agriculture encompasses 70 percent of the total land use area and is the primary land use in the county. Forested land accounts for 12 percent, developed land at 9 percent, and other classifications below 5 percent.

The county is divided into the following classifications:

- Agricultural 70 percent
- Forest 12 percent
- Developed 9 percent
- Grassland/Herbaceous 5 percent
- Open Water 1.5 percent
- Woody Wetlands 1.4 percent
- Emergent Wetlands < 1 percent
- Barren Land < 1 percent

Future Land Use

Marion County seeks to provide a wide variety of development opportunities that contribute to effective use of public resources and protection/maintenance of natural resources. Future land use will be a key management issue in order to achieve a prosperous county. Marion County will need to coordinate future growth policies with agriculture and each of its communities. The land use goals of Marion County are to utilize a combination of development policies and regulations to manage future growth and development and to guide said growth in the direction of the effective use of the land.

Future land use will be guided through a coordinated process which examines growth opportunities as they relate to existing corporate limits and the areas surrounding those entities. Additionally, the comprehensive plan for Marion County recognizes the necessity of consulting with specialized agencies regarding future growth. This should include organizations with knowledge regarding hazardous or potentially hazard prone areas where growth should be avoided. The Future Land Use Objectives outlined in the comprehensive plan recognizes the need to consider hazard related factors when identifying areas for future development. Soil conditions, floodplain, and bridge maintenance and development or identified as specific concerns related to residential expansion.

Diagrams from Marion County's Comprehensive Plan are specific to communities, and can be found within each community's respective *Participant Section*. The following maps illustrate current land use for Marion County and participating jurisdictions. As the maps indicate, land use changes are expected for the urban areas which are experiencing growth.

Figure 4: Marion County Current Land Use

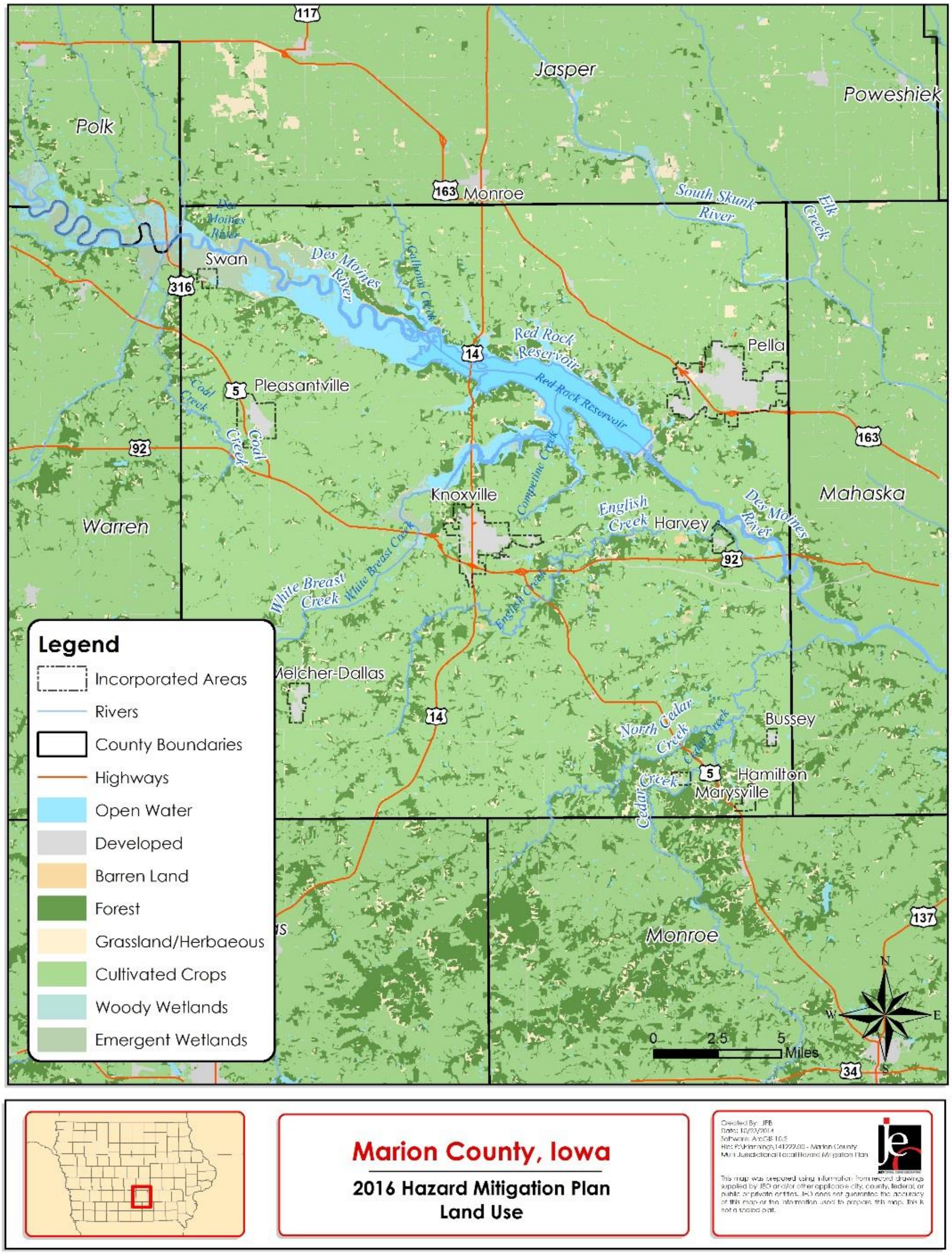


Figure 5: Bussey Current Land Use

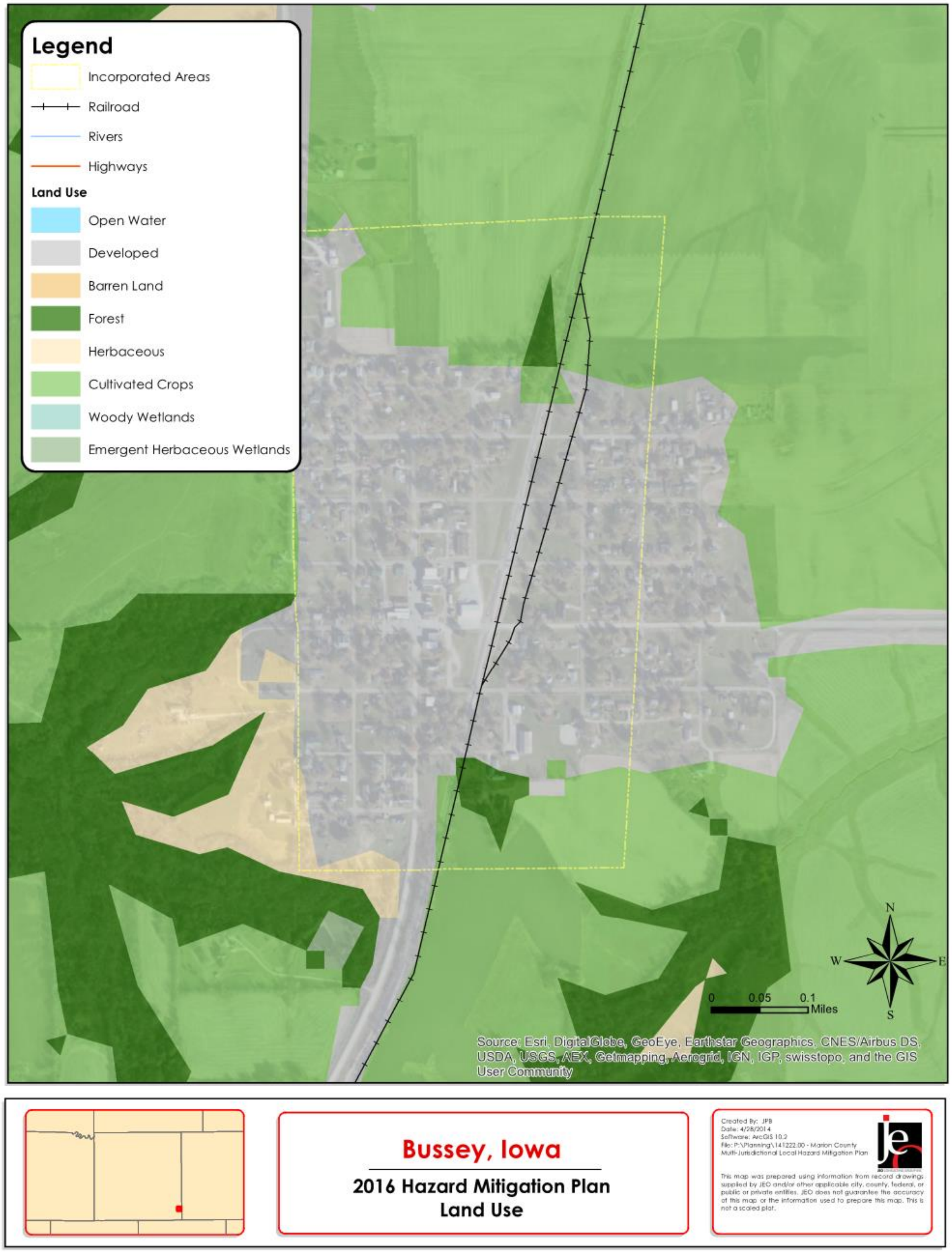


Figure 6: Hamilton Current Land Use

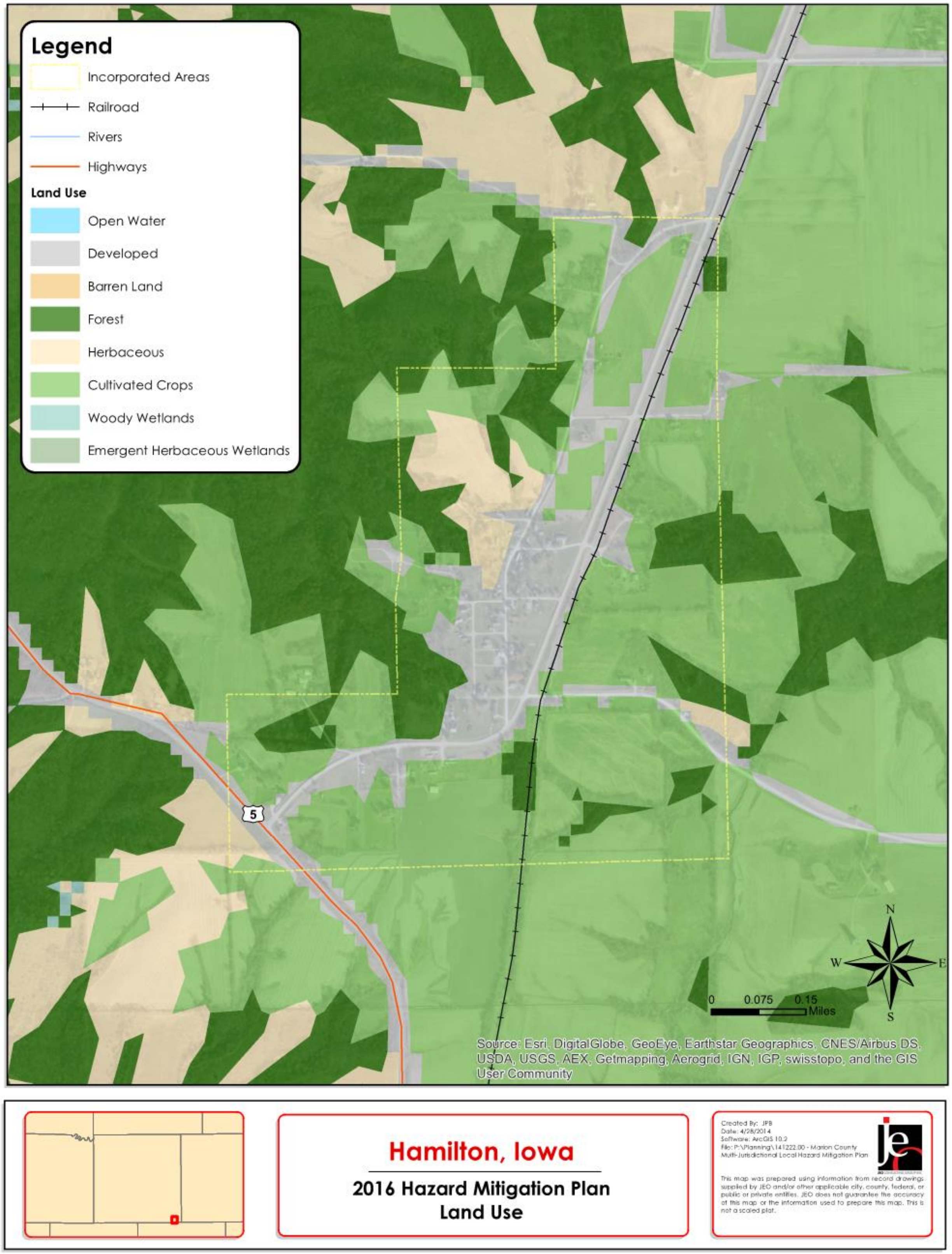


Figure 7: Harvey Current Land Use

Figure 8: Knoxville Current Land Use

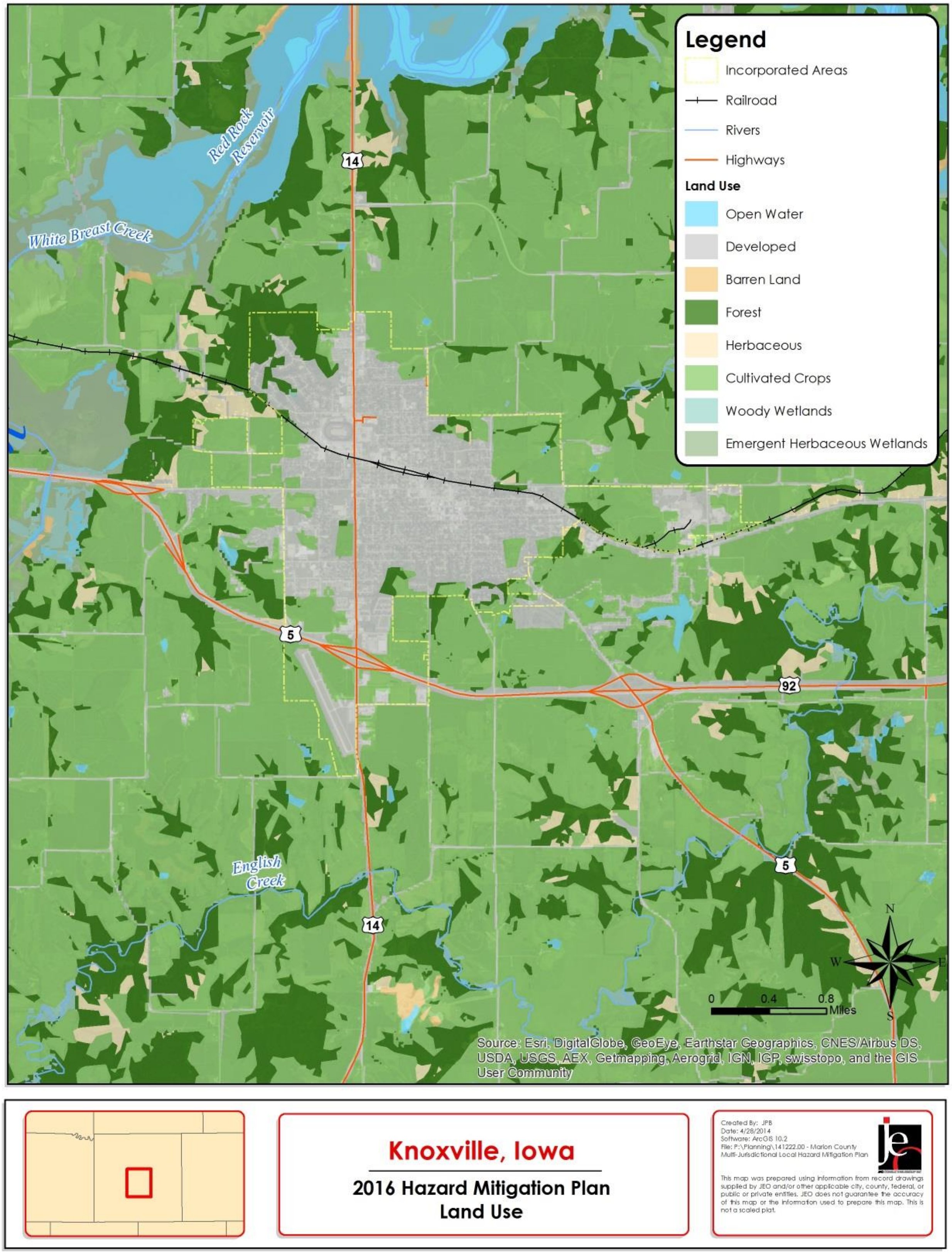


Figure 9: Marysville Current Land Use

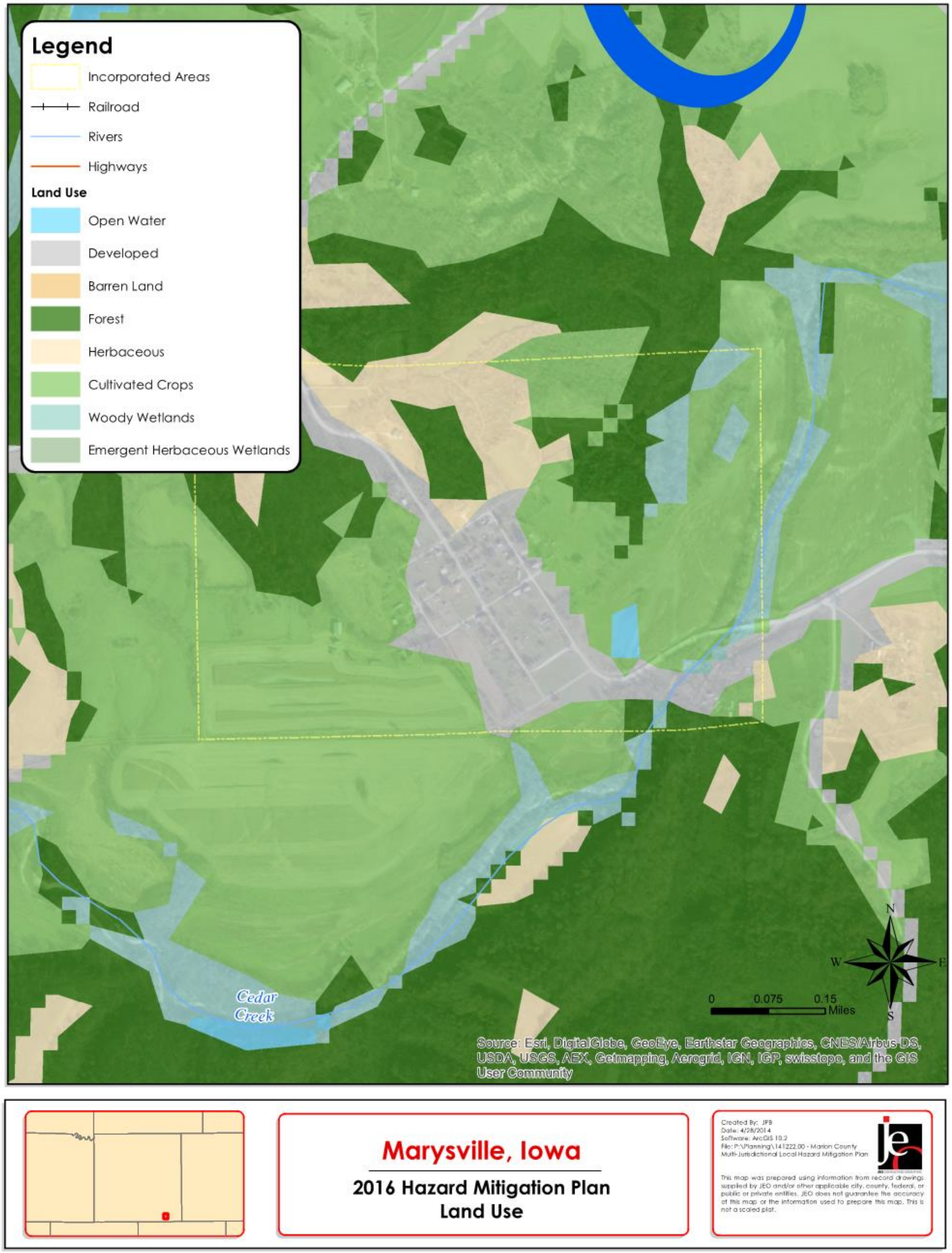


Figure 10: Melcher-Dallas Current Land Use

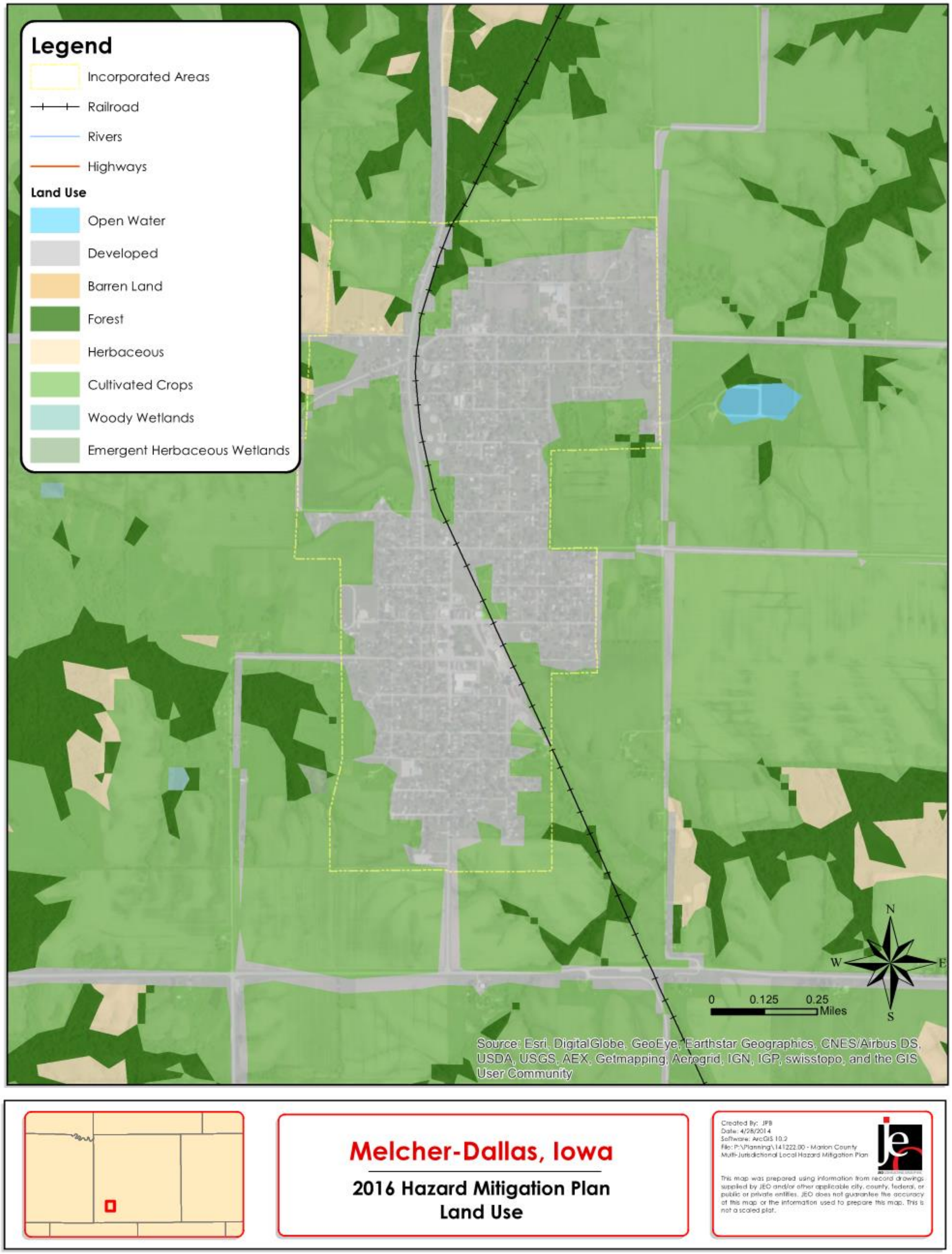


Figure 11: Pella Current Land Use Map

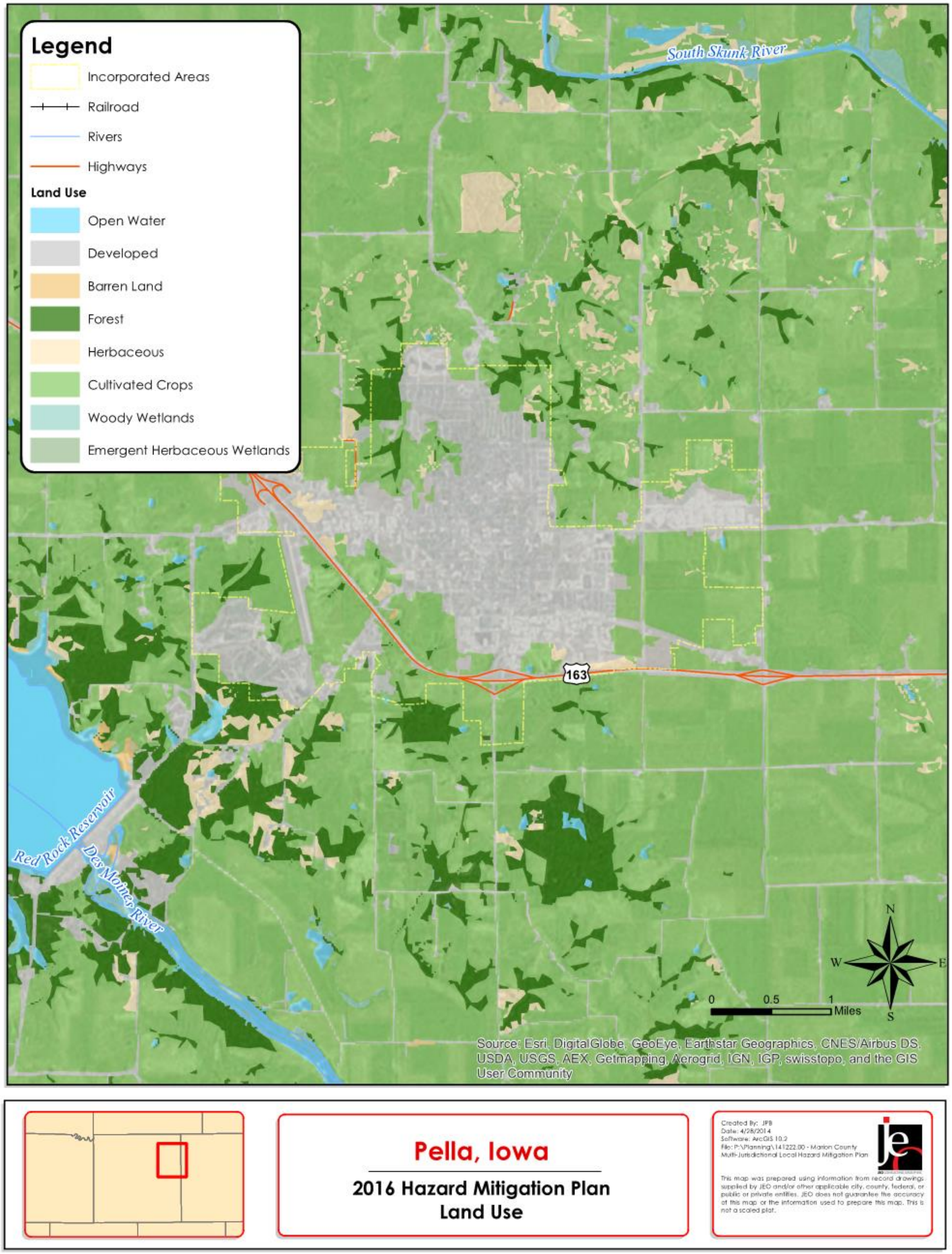


Figure 12: Pleasantville Current Land Use Map

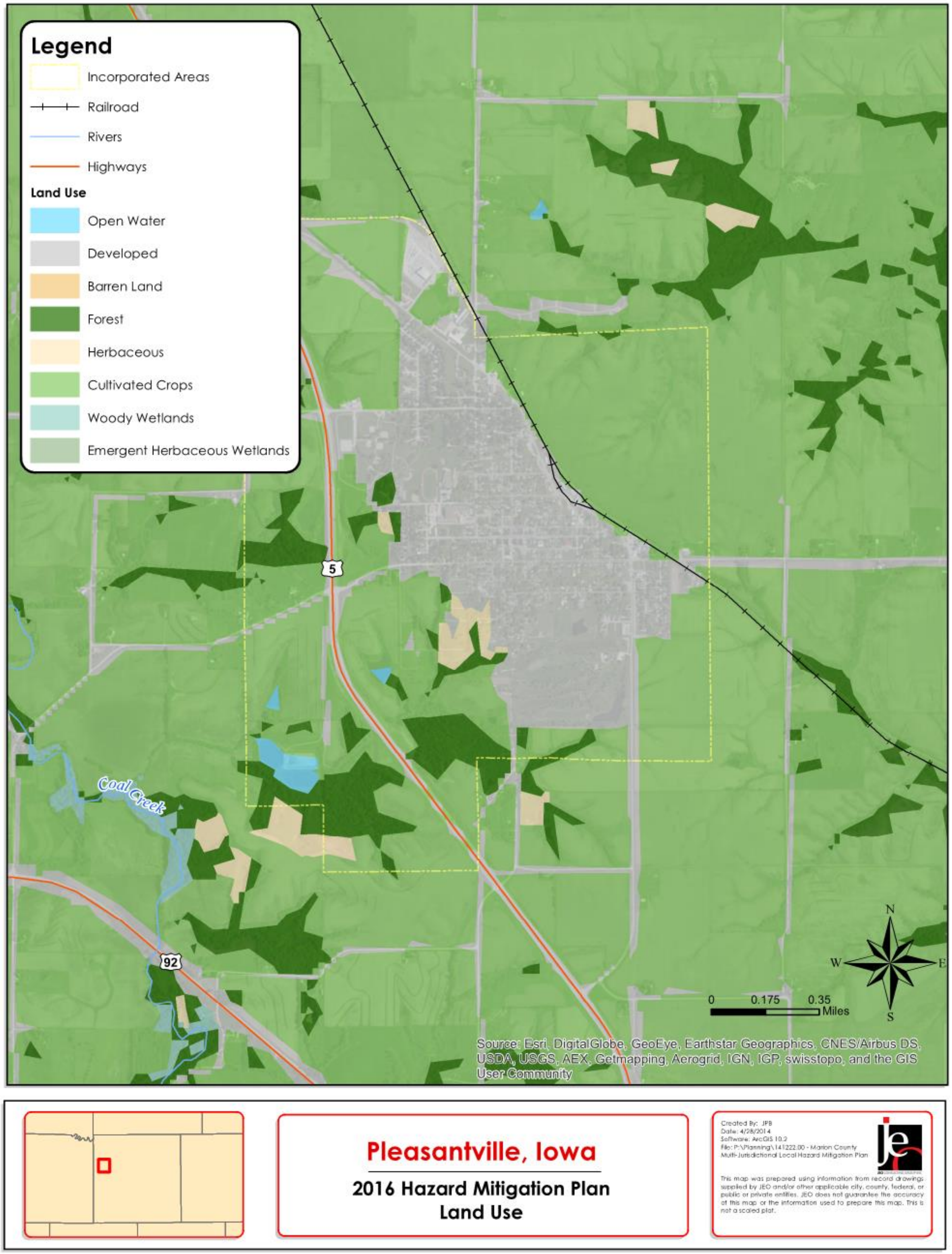
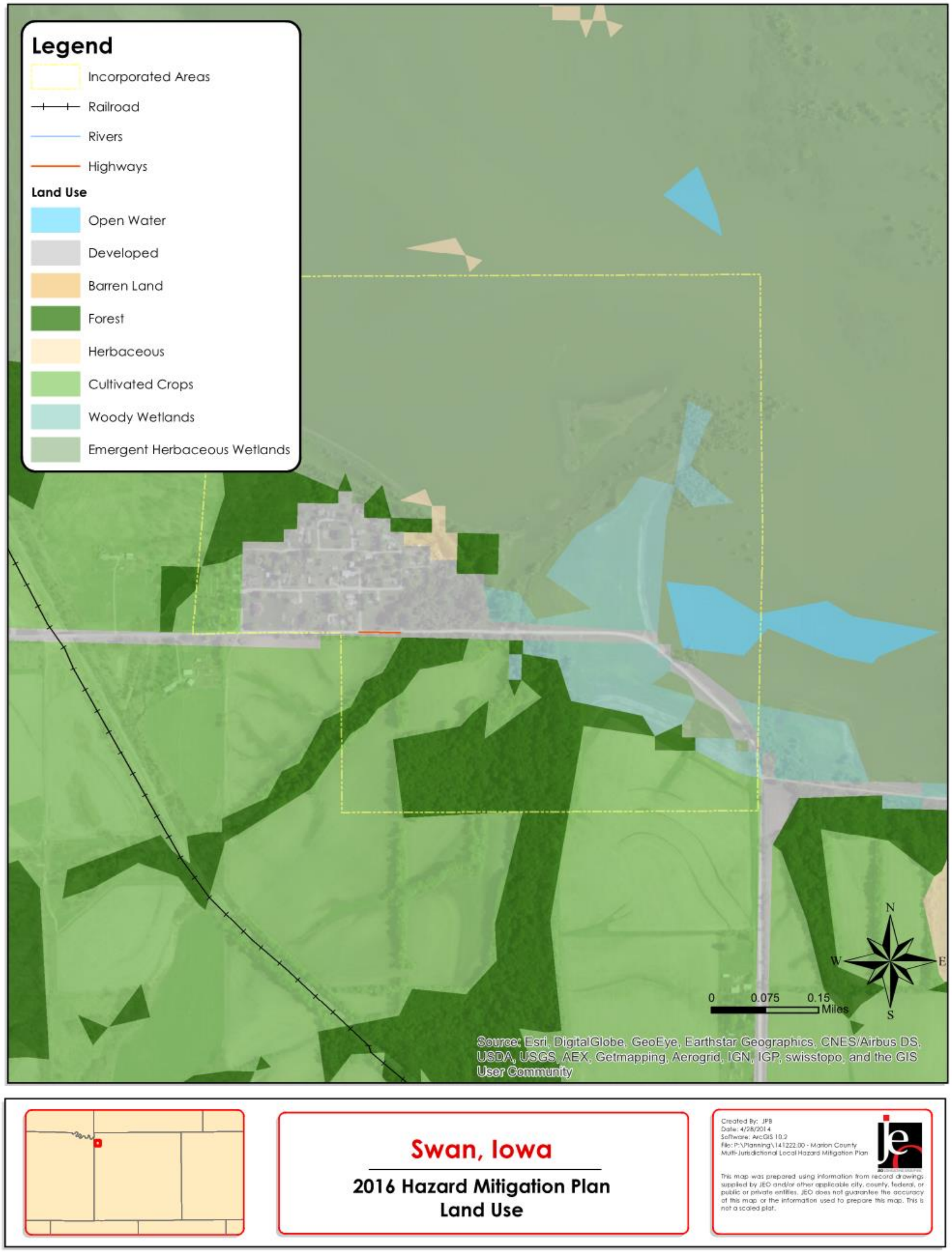


Figure 13: Swan Current Land Use Map



HAZARD PROFILES AND VULNERABILITY

Animal/Crop/Plant Disease

Animal/Crop/Plant Disease	
No. of Events	Undefined
Time Period	16 years
Probability	100%
Magnitude	Undefined
Deaths	0
Injuries	0
Property Damages	$0
Crop Damages	$702,908
Average Annual Damages Agricultural Damages (2000-2015)	$43,931

Agricultural infestation is the naturally occurring infection of vegetation, crops or livestock with insects, vermin, or diseases that render the crops or livestock unfit for consumption or use. Because of Iowa's substantial agricultural industry and related facilities and locations, the potential for infestation of crops or livestock poses a significant risk to the economy of the State. Iowa cropland is vulnerable to disease and other agricultural pests. Iowa farmers harvested an estimated 75.5 billion acres of corn, and 6.2 billion acres of soybeans according to the USDA figures in 2009. Iowa's total agricultural output reached $97.4 million, and livestock sales contributing 16 billion to that total (USDA National Agricultural Statistics Service, 2009 Census of Agriculture).

Some level of agricultural infestation is normal in Iowa. The concern is when the level of an infestation escalates suddenly, or a new infestation appears, overwhelming normal control efforts. The levels and types of agricultural infestation appear to vary by many factors, including cycles of heavy rains and drought.

Animal Disease

Agricultural incidents are naturally occurring infection of livestock with insects, vermin, or diseases that render the livestock unfit for consumption or use. In 2007, the state of Iowa ranked number one in the U.S. for livestock inventory of poultry egg layers with 53,793,712 and for hogs and pigs inventory of 19,295,092, and an inventory of 11,404,869 for pullets for laying flock replacement. Iowa is also ranked #9 in the U.S. for 4,002,111 turkeys and ranked #7 for 3,982,344 cattle and calves. With this substantial agricultural industry and related facilities throughout the State, the potential for infestation of livestock poses a significant risk to the Iowa economy.

The Iowa Department of Agriculture and Land Stewardship (IDALS) monitors and reports on the following animal reportable diseases in Iowa:

- Avian Influenza
  Avian influenza continues to be of concern in Iowa as the State is number one in poultry egg layers (over 53 million), 10th nationally in turkey production (over 9 million) and 5th in turkey processing in 2011 which is even higher inventories than in 2007. Source: IDALS 2012 Newsletter.
- Bovine Spongiform Encephalopathy (BSE) Disease
  Bovine Spongiform Encephalopathy (BSE) —mad cow disease, is a chronic, degenerative disease affecting the central nervous system of cattle. Cases have been found world-wide since 1986, but in Canada and the U.S. only a single cow was reported with BSE in 2003.
- Chronic Wasting Disease
  Chronic Wasting Disease (CWD) is a fatal, neurological disease of farmed and wild deer and elk. The disease has been identified in wild and captive mule deer, white-tailed deer and North American elk, and in captive black-tailed deer. CWD belongs to the family of diseases known as

transmissible spongiform encephalopathies (TSEs). Recently from 1996 to June 2002, it was diagnosed in farmed elk herds in Colorado, Kansas, Montana, Iowa, Oklahoma, South Dakota, and the Canadian Provinces of Alberta and Saskatchewan. Then from 2000 to June 2002, CWD has also been found in wild deer in northwestern Iowa, southern New Mexico, southwestern South Dakota, south central Wisconsin, northwestern Colorado, and the Canadian Province of Saskatchewan. Source: http://www.iowaagriculture.gov/animalIndustry/cwdFacts.asp.

- Exotic Newcastle Disease
  Exotic Newcastle disease (END) is a contagious and fatal viral disease affecting all species of birds. There was an epidemic of END in California in 2003 that is resulting in the death of millions of chickens and other birds, and costing millions of dollars. END is probably one of the most infectious poultry diseases in the world. END is so virulent that many birds die without showing any clinical signs.
- Foot and Mouth Disease
  Foot-and-mouth disease or hoof-and-mouth disease (Aphthae epizooticae) is an infectious and sometimes fatal viral disease that affects cloven-hoofed animals, including domestic and wild bovids. The virus causes a high fever for two or three days, followed by blisters inside the mouth and on the feet that may rupture and cause lameness. North America has been free of FMD for many years.
- Johne's Disease
  Johne's (yo-knees) disease is a contagious, chronic and eventually fatal infection that affects the small intestine of ruminants, including cattle, sheep and goats. Johne's, also called Para tuberculosis, is a slow progressive wasting disease with an incubation period of usually 2 or more years. Johne's is a reportable disease, but not a quarantineable disease.
- Pseudo rabies
  Pseudo rabies is a viral disease most prevalent in swine, often causing newborn piglets to die. Older pigs can survive infection, becoming carriers of the pseudo rabies virus for life. Other animals infected from swine die from pseudo rabies, which is also known as Aujeszky's disease and "mad itch." Infected cattle and sheep can first show signs of pseudo rabies by scratching and biting themselves. In dogs and cats, pseudo rabies can cause sudden death. The virus does not cause illness in humans. Due to an extensive eradication program, Iowa & the rest of United States are free of pseudo rabies.
- Scrapie
  Scrapie is a fatal, degenerative disease affecting the central nervous system of sheep and goats that is very similar to BSE (mad cow disease), although it does not cause disease in humans, and has been present in the U.S. for over 50 years. Infected flocks that contain a high percentage of susceptible animals can experience significant production losses. In these flocks over a period of several years, the number of infected animals increases and the age at onset of clinical signs decreases making these flocks economically unviable. Animals sold from infected flocks spread scrapie to other flocks. The presence of scrapie in the U.S. also prevents the export of breeding stock, semen, and embryos to many other countries. Currently there is a national program underway to eradicate scrapie in the U.S.

Producers are required by state law to report any of the reportable animal diseases to the IDALS's Bureau of Animal Industry. The IDALS's Bureau of The Center for Agriculture Security is the lead coordinating bureau for any emergency response for an agriculture incident.

Crop Pests/Plant Diseases

A plant disease outbreak or a pest infestation could negatively impact crop production and agriculturally dependent businesses. An extreme outbreak or infestation could potentially result in billions of dollars in production losses. The cascading net negative economic effects could result in wide-spread business failures, reduction of tax revenues, harm to other state economies, and diminished capability for this country to compete in the global market.

Many factors influence disease development in plants, including hybrid/variety genetics, plant growth stage at the time of infection, weather (e.g., temperature, rain, wind, hail, etc.), single versus mixed infections, and genetics of the pathogen populations. The two elements of coordination and communication are essential when plant diseases or pest infestations occur. The United States Department of Agriculture/ Animal Plant Health Inspection Service, local producers, local government, assessment teams, and state government entities must work together to effectively diagnose the various plant hazards to determine if immediate crop quarantine and destruction is required.

Iowa State University, College of Agriculture and Life Sciences, has The Plant and Insect Diagnostic Clinic http://www.ipm.iastate.edu/ipm/info/insects that provides diagnosis of plant problems (plant diseases, insect damage, and assessment of herbicide damage) and the identification of insects and weeds from the field, garden, and home. According to the Plant and Insect Diagnostic Clinic, the following are common known crop pests/diseases in Iowa:

- Pests – rootworm, tomato fruitworm, two spotted spider mite
- Corn Diseases – Corn Smut, gray Leaf Spot, Stewart's Wilt, Diplodia Ear Rot, and Stalk Rot
- Soybean Diseases – Soybean Rust and Soybean Cyst Nematode.

Geographic Location/Extent

All of Marion County is subject to animal/livestock incidents and agricultural infestations. According to 2012 data published by USDA Census of Agriculture, there are 1,024 farms in the County which cover 264,902 acres of land, and account for 70 percent of the surface land in the County. Presently, the extent of animal and plant diseases have been local impacts.

Animal Disease Location/Extent

The table below provides the inventory number of hogs and pigs and cattle in Marion County compared to the State. According to the USDA's Census of Agriculture, in 2012, Marion County produced 107,067 hogs and pigs and 42,766 head of cattle and had a total livestock value of $6,777,809,000. Livestock value as a percent of total economic output for the county was 0.3 percent.

Table 16: Livestock Summary for Marion County and the State of Iowa, 2012

Livestock			
		Marion Co.	**Iowa**
Hogs and pigs	Inventory	26,763	20,445,666
	Sold	80,301	49,355,848
Cattle	Inventory	28,001	3,893,683
	Sold	14,765	4,504,373
Total livestock value ($1,000)		$10,385	$6,767,424

Source: USDA Census of Agriculture, 2012

Crop Disease Location/Extent

The table below provides the crops harvested in Marion County compared to the State according to the USDA Census of Agriculture information. In 2012, Marion County farmers harvested 9 million bushels of corn and 3 million bushels of soybeans. Production of all crops in Marion County contributed $137 million.

Table 17: Crop Summary for Marion County and the State of Iowa, 2012

Crops and Cropland				
	Marion Co.		Iowa	
	Corn	Soybeans	Corn	Soybeans
Acres harvested	81,040	76,940	13,709,408	9,301,594
Bushels harvested (million)	9,070,849	3,431,112	1,835,358,239	406,951,953
Output of all crops	110,989,000		17,366,814,000	
Market value of all crops	$137,892,000		$30,821,532,000	

Source: USDA Census of Agriculture, 2012

Previous Occurrences

There have been a total of 77 sheep flocks in Iowa that have been found to be infected with Scrapie since the accelerated national Scrapie Eradication Program started in November 2001. In fiscal year 2005, Iowa had a high of 15 newly infected flocks. The number of new infected flocks has been decreasing since that time. Iowa's last infected flock was found in June 2010.

According to the Iowa Department of Public Health, Center for Acute Disease Epidemiology, there were 0 reported case of Rabies in Marion County in 2013. While no neighboring counties had reports of rabies, 12 rabies infections were found in Iowa in 2013.

According to the U.S. Department of Agriculture's Risk Management Agency, during the 15-year period from 2000-2015, combined annual losses due to crop infestation totaled $702,908

The table below provides a summary of insured crop losses as a result of crop infestations.

Table 18: Annual Losses for Insured Crops Due to Infestation for Marion County

	Corn	Soybeans	Other	Total
2000	$3,847	$0	$0	$3,847
2001	$1,347	$0	$0	$1,347
2002	$471	$9,263	$0	$9,734
2003	$87	$0	$0	$0
2004	$578	$0	$0	$578
2005	$3,592	$0	$0	$3,592
2006	$0	$0	$0	$0
2007	$0	$0	$0	$0
2008	$0	$0	$0	$0
2009	$0	$0	$0	$0
2010	$614,592	$0	$0	$614,592
2011	$0	$0	$0	$0

2012	$58,412	$0	$0	$58,412
2013	$0	$0	$0	$0
2014	$0	$7,830	$0	$7,830
2015	$2,976	$0	$0	$2,976
Total	$685,902	$17,093	$0	$702,908
Average Annual Loss	$42,868	$1,068	$0	$43,931

Source: http://www.rma.usda.

The insurable loss is adjusted to estimate losses to all insurable crops by considering that 93.5 percent of corn and soybean crops in the State were insured (2011 Iowa Crop Insurance Profile from USDA's Risk Management Agency).

Probability of Future Occurrence

The planning area experiences agricultural losses nearly every year as a result of naturally-occurring diseases that impact animals/livestock. There are three reportable diseases: Avian influenza, Exotic Newcastle Disease, and Scrapie that could become a problem in Iowa at any time. The IDALS is constantly monitoring livestock and extensive eradication programs in the U.S. have already wiped out several of these reportable diseases.

Vulnerability

A widespread infestation of animals/livestock and crops could impact the economic base of the County. According to the Iowa State University, University Extension, 2009, all ag-related productions, processing and input supplying activities in Marion County represent 8.20 percent of the county's total industrial output.

Buildings, infrastructure, and critical facilities are not vulnerable to this hazard. Its impacts are primarily economic and environmental, rather than structural affects.

According to data from ISU Extension Services, based on a worst case scenario where 75 percent of livestock is lost in a given year due to agricultural infestations, the total direct costs in Marion County could approach $508,356,750.

Rough estimates of potential direct losses from a maximum threat event fall in a range of 1-50 percent of annual crop receipts. According to data from ISU Extension Services, based on a worst case scenario where 50 percent of crop production is lost in a given year due to agricultural infestations, the total direct costs could approach $68.5 million within the county.

Future Development

Future development is not expected to significantly impact the planning area's vulnerability to this hazard. However, if crop production and numbers of animals/livestock increases, the amount vulnerable to infestation also increases.

Dam Failure

Dam Failure

A dam is defined as a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water. Dams are typically constructed of earth, rock, concrete, or mine tailings. Dam failure is the uncontrolled release of impounded water resulting in downstream flooding, affecting both life and property. Dam failure can be caused by any of the following: flooding; earthquakes; flow blockages; landslides; lack of maintenance; improper operation; poor construction; vandalism; or terrorism.

Dam Failure	
No. of Events	0
Time Period	Not available
Probability	Not available
Magnitude	Not available
Deaths	Not available
Injuries	Not available
Property Damages	Not available
Crop Damages	Not available
Average Annual Damages	Not available

The thresholds for what institutes a dam falls under State regulation are outlined in Iowa Administrative Code 567-71.3 and are listed below. The thresholds are primarily based on both dam height and water storage volumes. State regulated dams are those dams that meet the following:

In rural areas:

a) Any dam designed to provide a sum of permanent and temporary storage exceeding 50 acre-feet at the top of dam elevation, or 25 acre-feet if the dam does not have an emergency spillway, and which has a height of 5 feet or more.

b) Any dam designed to provide permanent storage in excess of 18 acre-feet and which has a height of 5 feet or more.

c) Any dam across a stream draining more than 10 square miles.

d) Any dam located within 1 mile of an incorporated municipality, if the dam has a height of 10 feet or more, stores 10 acre-feet or more at the top of dam elevation, and is situated such that the discharge from the dam will flow through the incorporated area.

In urban areas:

Any dam which exceeds the thresholds in 71.3 (1) “a”, “b”, or “d”.

Low head dams:

Any low head dam on a stream draining 2 or more square miles in an urban area, or 10 or more square miles in a rural area.

Dams are classified by the State of Iowa into three categories based on the potential risk to people and property in the event of failure. The classification can change over time due to changes in development downstream from the dam. In addition, older dams may not have been built to the standards of their updated classification when this occurs. The Iowa Department of Natural Resources performs annual inspections on all high hazard dams in the state.

Table 19: Dam Hazard Classification Definitions

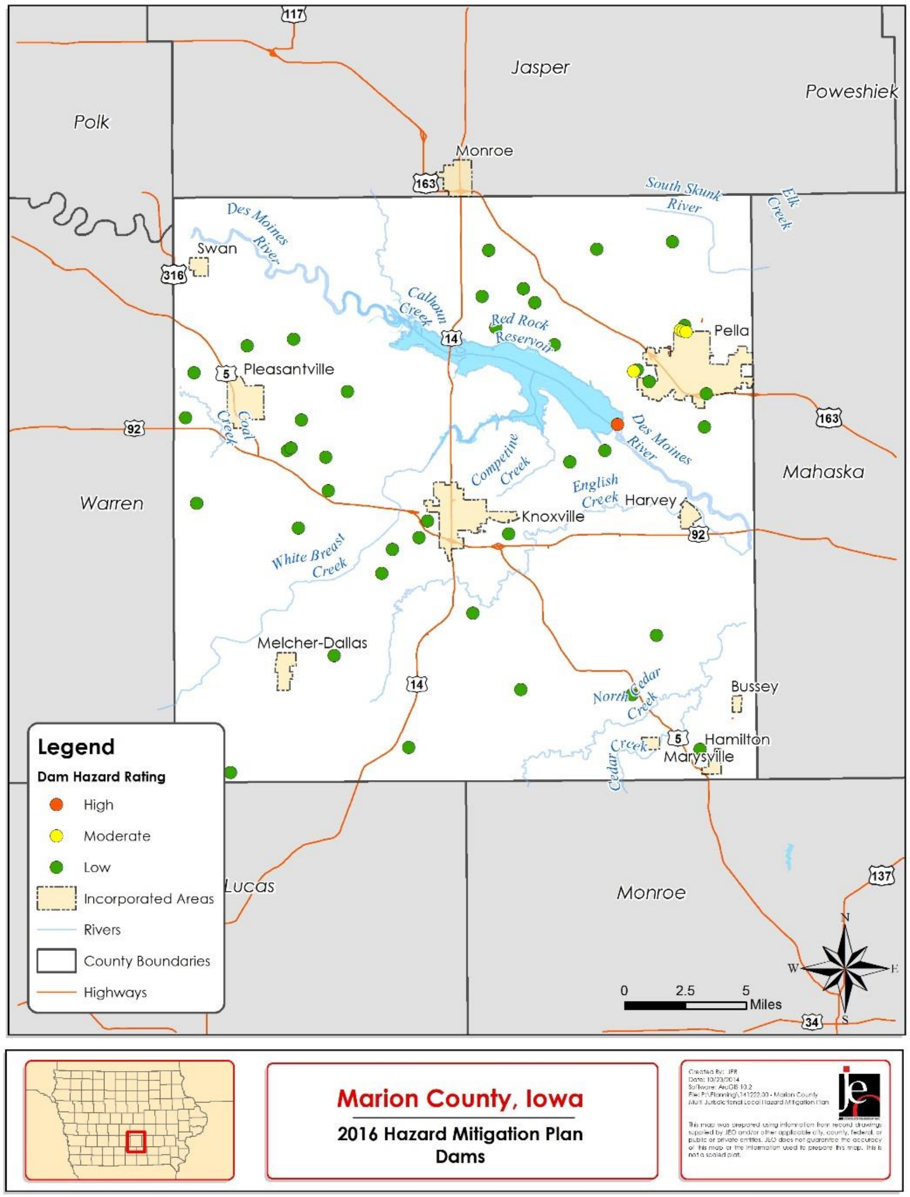
Hazard Class	Definition
High	A structure shall be classified as high hazard if located in an area where failure may create a serious threat of loss of human life or result in serious damage to residential, industrial, or commercial areas, important public utilities, public buildings, or major transportation facilities.
Moderate (Significant)	A structure shall be classified as moderate hazard if located in an area where failure may damage isolated homes or cabins, industrial or commercial buildings, moderately traveled roads or railroads, interrupt major utility services, but without substantial risk of loss of human life. In addition, structures where the dam and its impoundment are of themselves of public importance, such as dams associated with public water supply systems, industrial water supply or public recreation, or which are an integral feature of a private development complex, shall be considered moderate hazard for design and regulatory purposes unless a higher hazard class is warranted by downstream conditions.
Low	A structure shall be classified as low hazard if located in an area where damages from a failure would be limited to loss of the dam, loss of livestock, damages to farm outbuildings, agricultural lands, and lesser used roads, and where loss of human live is considered unlikely.

Source: Iowa Department of Natural Resources

Geographic Location/Extent

The National Inventory of Dams database lists 46 dams in Marion County; 41 of the 46 dams are low hazard dams, 4 are significant hazard dams, and 1 high hazard dam. The high hazard dam is the Red Rock Dam, built in 1969, which holds the largest lake in the State of Iowa, Lake Red Rock.

Figure 14: Dams in the Planning Area



Previous Occurrences

No additional historical occurrences or records of damages from dam failure were discovered after discussion with Marion County, the Planning Team, or public meeting participants.

Upstream Dams Outside the Planning Area

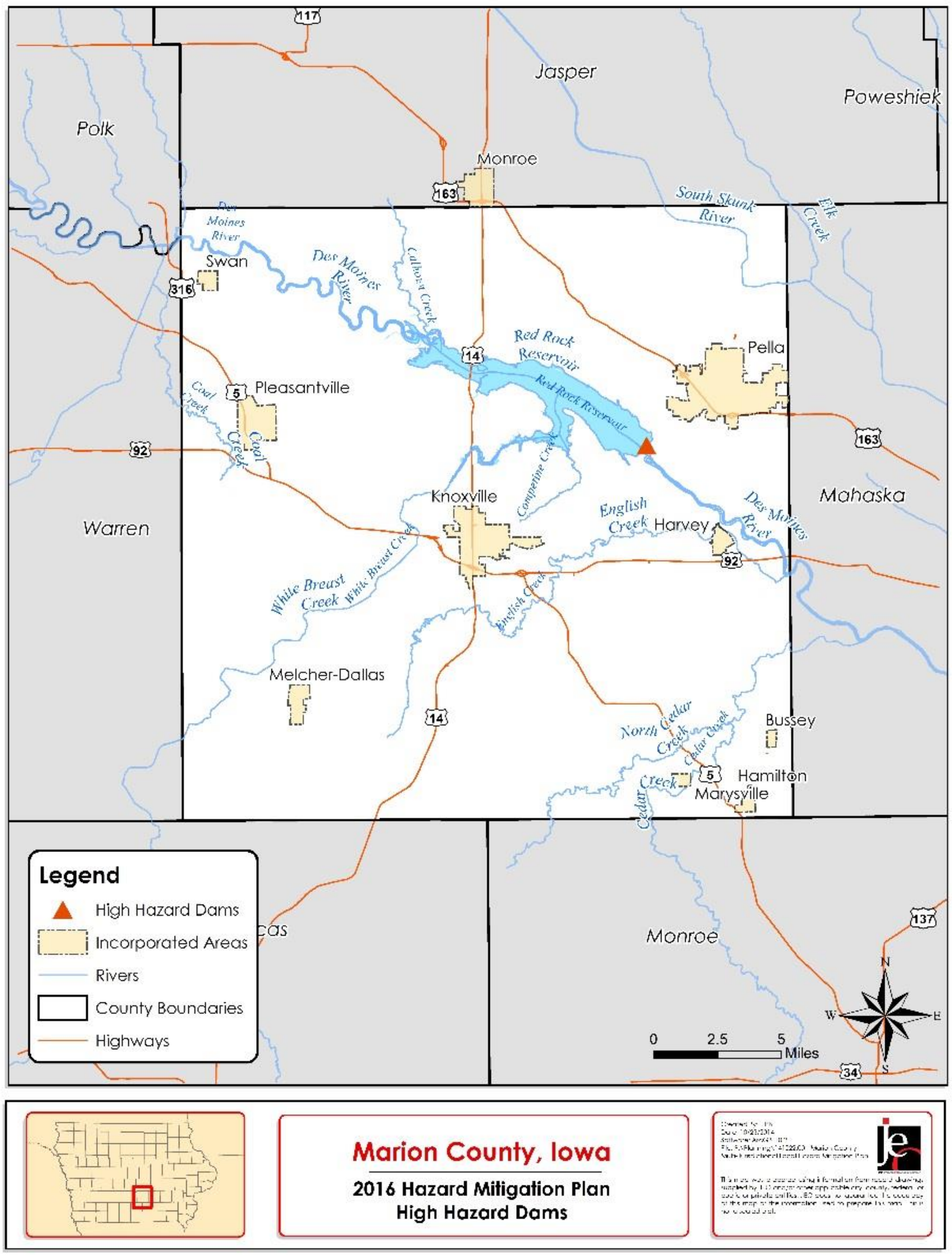
There are approximately 33 high hazard dams upstream of Marion County, which may affect the county adversely. Most of these dams are unlikely to significantly impact the planning area, excluding the

Salorville Dam, which holds such a significant volume of water, a dam failure would likely result in flooding within Marion County.

Probability of Future Occurrence

There is no data available that would provide a basis for estimating dam failure in Marion County, and standard inspection and maintenance practices support a low probability of dam failures in Marion County.

Figure 15: High Hazard Dams in Planning Area



Vulnerability

Dam failure is typically an additional or secondary impact of another disaster such as flooding or earthquake.

While the probability of a future dam failure is low, the residents and farm land below the Red Rock Dam is vulnerable to a dam breach. The Red Rock Reservoir contains 114,400 cubic feet of water, which would inundate downstream areas, should the dam fail. This will impact primarily the city of Harvey, which sits on the Des Moines River, less than 5 miles down-river. Additionally, a flood event would inundate acres of farm land, causing damages to a crops which would likely be lost.

Future Development

Future development located downstream from dams in floodplains or inundation zones would increase vulnerability to this hazard. It is recommended that citizens in inundation areas be made aware of the unique protection they enjoy below a dam.

Drought

Drought is generally defined as a condition of moisture levels significantly below normal for an extended period of time over a large area that adversely affects plants, animal life, and humans. Drought conditions can also be defined in terms of meteorological, hydrological, agricultural, and socioeconomic.

Drought	
No. of Events	1,380 weeks of drought
Time Period	1917-2013 (96 years)
Probability	27% annual chance
Magnitude	Mild Drought
Deaths	0
Injuries	0
Property Damages (1996-2015)	$12,650,000*
Crop Damages (2000-2015)	$56,273,546
Average Annual Damages: Property Damages (1996-2015) Agricultural Damages (2000-2015)	 $632,500* $3,517,096

*While the NCDC does record these losses, they are not included in the event narrative, nor can they be substantiated. These are likely agricultural losses which were miscategorized.

Meteorological drought is defined on the basis of the degree of dryness (in comparison to some —normal or average amount) and the duration of the dry period. A meteorological drought must be considered as region-specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region.

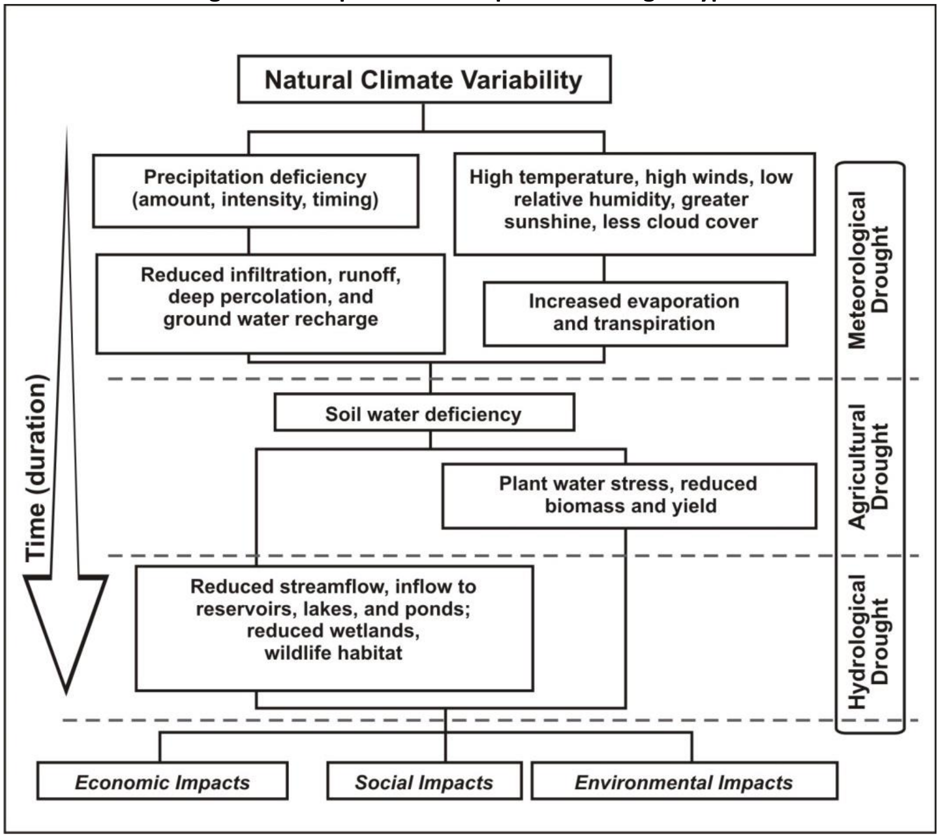
Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., streamflow, reservoir and lake levels, ground water). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, streamflow, and ground water and reservoir levels. As a result, these impacts are out of phase with impacts in other economic sectors.

Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evaporation, soil water deficits, reduced ground water or reservoir levels, and so forth. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per hectare and a reduction of final yield. However, if topsoil moisture is sufficient for early growth requirements, deficiencies in subsoil moisture at this early stage may not affect final yield if subsoil moisture is replenished as the growing season progresses or if rainfall meets plant water needs.

Socioeconomic drought refers to when physical water shortage begins to affect people.

The following figure indicates different types of droughts, their temporal sequence, and the various types of effects that they can have on a community.

Figure 16: Sequence and Impacts of Drought Types



Source: National Drought Mitigation Center, University of Nebraska-Lincoln

The four different types of drought all have significance in Iowa. A meteorological drought is the easiest to determine based on rainfall data and is an easier drought to monitor from rain gauges and reports. A hydrological drought means that stream and river levels are low, which also has an impact for surface water and ground water irrigators. In addition, in-stream discharges that fall below a pre-required level also place the state in regulatory difficulty with U.S. Fish and Wildlife and with neighboring states over cross-border flowage rights. An agricultural drought represents difficulty for Iowa‘s agricultural-based economy and is also relatively easy to monitor based on crop viabilities for different regions.

The National Drought Mitigation Center (NDMC) located at the University of Nebraska in Lincoln provides drought monitoring and technical assistance to all areas of the world. NDMC‘s website is found at http://www.drought.unl.edu/. Specific drought impacts by county are recorded at http://droughtreporter.unl.edu/.

The impacts of drought can be categorized as economic, environmental, or social. Many economic impacts occur in agriculture and related sectors, including forestry and fisheries, because of the reliance of these sectors on surface and subsurface water supplies. In addition to obvious losses in yields in both crop and livestock production, drought is associated with increases in insect infestations, plant disease, and wind erosion. Droughts also bring increased problems with insects and disease to forests and reduce growth. The incidence of forest and range fires increases substantially during extended droughts, which in turn places both human and wildlife populations at higher levels of risk. Income loss is another indicator used in assessing the impacts of drought because so many sectors are affected.

Although environmental losses are difficult to quantify, increasing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects. Environmental losses are the result of damages to plant and animal species, wildlife habitat, and air and water quality, forest and range fires, degradation of landscape quality, loss of biodiversity, and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example may be degraded through the loss of wetlands, lakes, and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality, with increased soil erosion, may lead to a more permanent loss of biological productivity of the landscape.

Social impacts mainly involve the public safety, health, conflicts between water users, reduced quality of life, and inequities in the distribution of impacts and disaster relief. Many of the impacts specified as economic and environmental has social components as well.

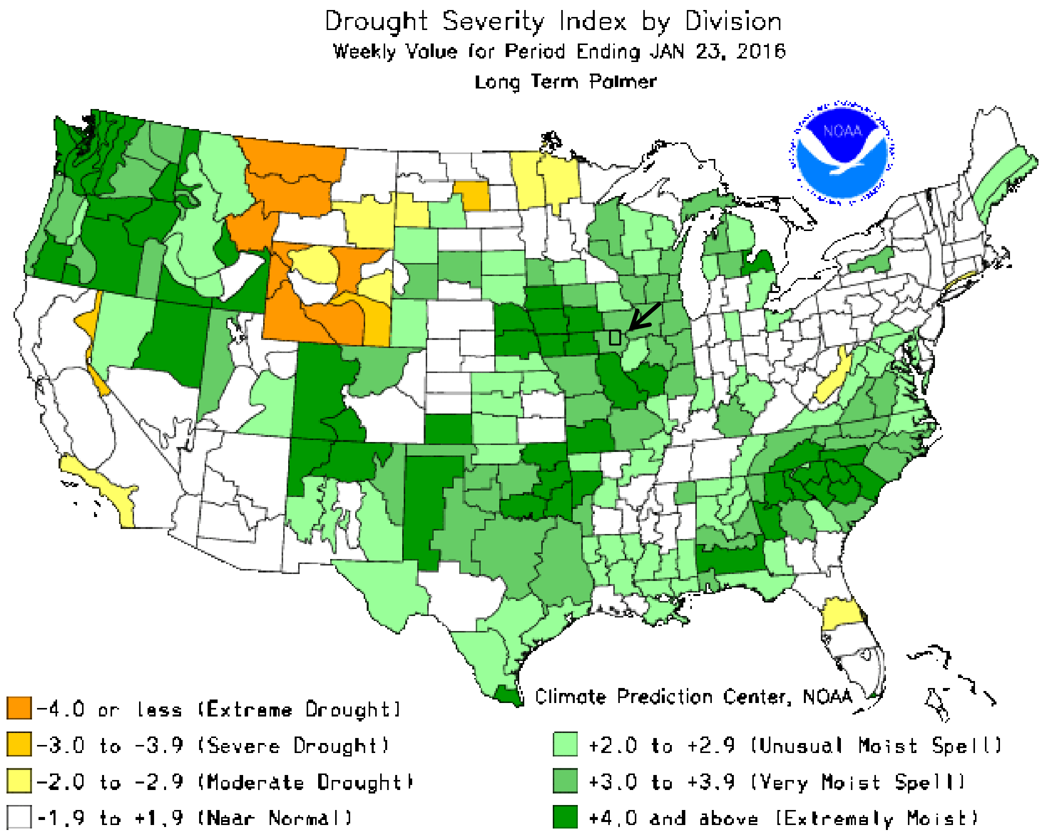
Although drought is not predictable, long-range outlooks may indicate an increased chance of drought, which can serve as a warning. A drought period can last for months, years, or even decades. It is rarely a direct cause of death, though the associated heat, dust, and stress can all contribute to increased mortality.

Periods of drought are normal occurrences in all parts of Iowa. Drought in Iowa is caused by severely inadequate amounts of precipitation that adversely affect farming and ranching, surface and ground water supplies, and uses of surface waters for navigation and recreation. Because of these impacts, drought can have significant economic and environmental impacts. Drought can also lead to increased probability and severity of wildfires and wind erosion.

The Palmer Drought Severity Index, devised in 1965, was the first drought indicator to assess moisture status comprehensively. It uses temperature and precipitation data to calculate water supply and demand, incorporates soil moisture, and is considered most effective for unirrigated cropland. It primarily reflects long-term drought and has been used extensively to initiate drought relief.

The Palmer Drought Severity Index for the period ending on January 23, 2016 is provided below. The index indicates moderate to severe drought levels in the planning area (shown approximately by the red box).

Figure 17: Palmer Drought Severity Index for JAN 23, 2016



Geographic Location/Extent

All of Marion County is at risk of drought. The area has a mean of 31.02 inches of rainfall per year. Successive years or extended periods of time with below average amounts of rain or snow result in drought. According to the Palmer Drought Severity Index (PDSI), in the period of record (1/1917-12/2013) Marion County has experienced 1,380 weeks of mild drought, 420 weeks of moderate droughts, and 54 severe droughts, and 5 weeks of extreme drought. The PDSI is a differnet data set with a longer period of record which accounts for the difference in event frequency as reported by the NCDC.

Figure 18: Marion County PDSI Drought Magnitude (1/1917-12/2013)

	Number of Droughts	Weeks of Drought
Mild (-1)	230	1,380
Moderate (-2)	67	420
Severe (-3)	8	54
Extreme (-4)	1	5

Source: National Drought Mitigation Center

Previous Occurrences

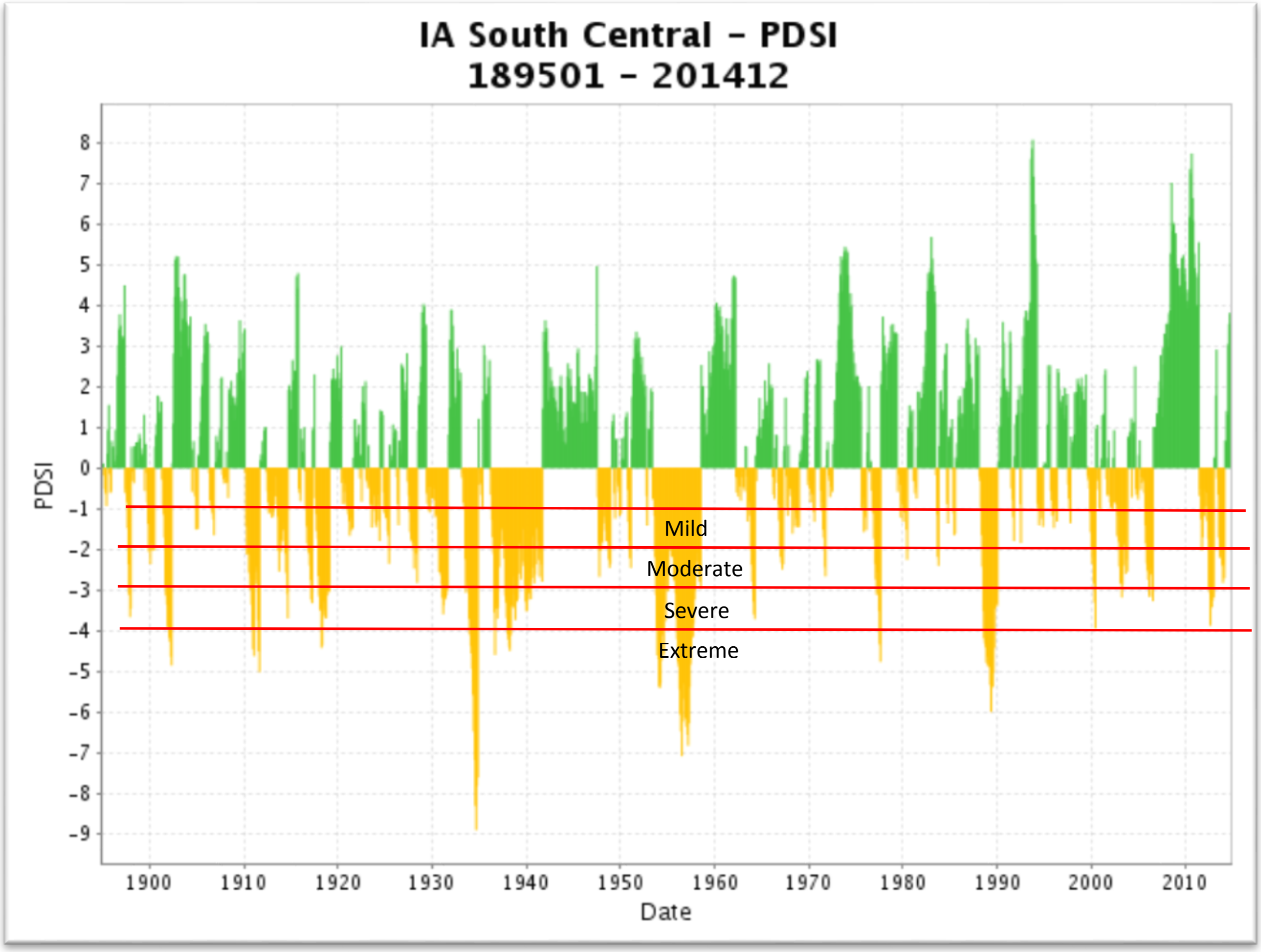
The PDSI is utilized by climatologists to standardize global long-term drought analysis. The PDSI was developed in 1965 to measure dryness based on recent precipitation and temperatures. The PDSI has data for more than one hundred years, which allows for the review and analysis of past drought trends. The data for the planning area was collected from Iowa South Central which includes the planning area, between the years of 1917 and 2016. Figure 19 shows the data from this time period. The negative Y axis represents a drought, for which '-2' indicates a moderate drought, '-3' a severe drought, and '-4' an extreme drought. Table 20 shows the details of the PDSI classifications.

Table 20: Palmer Drought Severity Index

Numerical Value	Description	Numerical Value	Description
4.0 or more	Extremely wet	-0.5 to -0.99	Incipient dry spell
3.0 to 3.99	Very wet	-1.0 to -1.99	Mild drought
2.0 to 2.99	Moderately wet	-2.0 to -2.99	Moderate drought
1.0 to 1.99	Slightly wet	-3.0 to -3.99	Severe drought
0.5 to 0.99	Incipient wet spell	-4.0 or less	Extreme drought
0.49 to -0.49	Near normal	--	--

Source: Climate Prediction Center

Figure 19: Palmer Drought Severity Index



Using the PDSI, the planning area had extreme droughts 1 times since 1917. Moderate droughts occurred in all decades in the period of record. The most recent drought of note occurred in 2012, which resulted in over $11 million in insurance losses. While the planning area is highly prone to damages as a result of drought, no participating jurisdiction ranked drought as a top concern for a jurisdiction, this may be a result of the largely non-structural impacts of drought, many individuals may not see this as a typical 'disaster'.

The table below provides a summary of insured crop losses as a result of drought.

Table 21: Annual Losses for Insured Crops Due to Drought for Marion County

	Corn	Soybeans	Total
2000	$54,433	$67,466	$121,899
2001	$518,643	$204,709	$723,352
2002	$46,609	$52,298	$98,907
2003	$246,554	$1,418,011	$1,664,565
2004	$298,401	$68,112	$366,513

2005	$94,019	$20,890	$114,909
2006	$218,278	$43,515	$261,793
2007	$325,375	$44,861	$370,236
2008	$8,230,920	$4,758,496	$13,989,416
2009	$703,285	$184,002	$887,287
2010	$9,304,935	$1,381,530	$10,686,465
2011	$1,790,685	$700,183	$2,490,868
2012	$10,693,386	$1,128,942	$11,822,328
2013	$6,688,295	$2,806,559	$9,494,854
2014	$1,908,138	$1,525,487	$3,433,625
2015	$466,785	$279,744	$746,529
Total	$41,588,741	$14,684,805	$56,273,546
Average Annual Loss	$2,599,296	$917,800	$3,517,096

Source: USDA RMA

The USDA reports from 2000-2015, Marion County received indemnities for $56,273,546 worth of crop loss. This accounts for more than $3,500,000 annually.

Probability of Future Occurrence

For the purpose of establishing probability, past occurrences will act as a predictor for future events. It is important to note that past records will not be a fool-proof predictor of future occurrences, and this formula does not take into account changing inputs, such as climate change. The planning area has experienced 1,380 weeks of drought in the 96-year period of record from the U.S. Drought Monitor. This reflects a 27.6% chance of annual occurrence.

Vulnerability

Negative impacts of drought are primarily economic and environmental. With Marion County's 1,024 farms covering 264,902 acres of land which equates to 70 percent of the land used for agriculture, the planning area has a high exposure to this hazard. Aside from agricultural impacts, other losses related to drought include costs of fire suppression and damage to roads and structural foundations due to the shrink of dynamic expansive soils during excessively dry conditions.

Areas associated with agricultural use are vulnerable to drought conditions which could result in a decrease in crop production or a decrease in available grazing area for livestock. According to the fifteen year period for which data is available from USDA's Risk Management Agency, (see table above) the average amount of annual claims paid for crop damage as a result of drought in Marion County was $3,517,096.

Future Development

From 2007 to 2012, harvested cropland increased by over 20,000 acres. Increases in acreage planted with crops would increase the exposure to drought-related agricultural losses. Increases in population would add additional strain on water supply systems to meet growing demand for potable water.

Earthquake

Earthquake	
No. of Events	0
Time Period	1995-2016 (21 years)
Probability	0.0%
Magnitude	>5.0
Deaths	0
Injuries	0
Property Damages	0
Crop Damages	0
Average Annual Damages	0

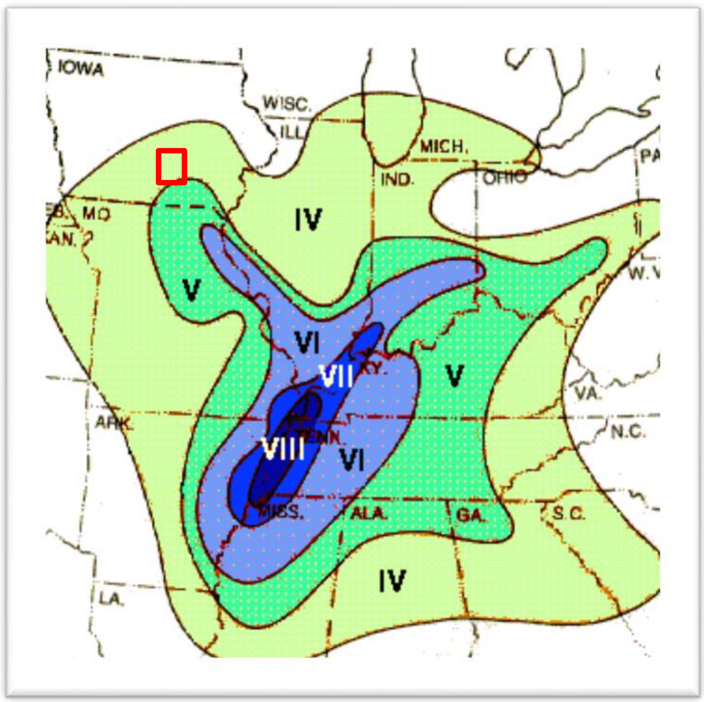
According to the USGS, an earthquake is a term used to describe both sudden slip on a fault, and the resulting ground shaking and radiated seismic energy caused by the slip, or by volcanic or magmatic activity, or other sudden stress changes in the earth. Earthquakes occur primarily along fault zones, tears in the Earth's crust, along which stresses build until one side of the fault slips, generating compressive and shear energy that produces the damage. Heaviest damage generally occurs nearest the epicenter which is that point on the Earth's surface directly above the point of fault movement. The composition of geologic materials between these points is a major factor in transmitting the energy to buildings and other structures on the Earth's surface.

Geographic Location/Extent

There are two regions of active seismicity in the Midwest: the Nemaha Ridge and the New Madrid Fault Zone. The Nemaha Ridge in Kansas and Nebraska, associated with the Humboldt Fault, is characterized by numerous small earthquakes that release stresses before they build to dangerous levels. The area is not considered a threat to Iowa. The New Madrid Fault Zone, however, has greater destructive potential, and is located along the valley of the Mississippi River, from its confluence with the Ohio River southward, and includes portions of Illinois, Kentucky, Tennessee, Missouri, Arkansas, and Mississippi.

Iowa counties are located in low risk zones as a whole. The southeastern part of the state of Iowa is more at risk to earthquake effects from the New Madrid Fault Zone. The figure to the right shows the estimated effects of a 6.5 Richter magnitude earthquake along the New Madrid Fault Zone. It suggests that Iowans in southwest counties could experience trembling buildings, some broken dishes and cracked windows, movement and falling of small unstable objects, abrupt openings or closing doors, and liquids spilling from open containers. About 29 other counties, from Page to Polk to Muscatine, could experience vibrations similar to the passing of a heavy truck, rattling of dishes and windows, creaking of walls, and swinging of suspended objects. These effects will vary considerably with differences in local geology and construction techniques. It is possible that Marion County can experience minor tremors due to earthquakes.

Figure 20: New Madrid Fault Zone Estimated Effects



Source: http://www.igsb.uiowa.edu/Browse/quakes/quakes.htm

The extent or severity of earthquakes is generally measured in two ways: 1) Magnitude Measurement utilizes the Richter Magnitude Scale and 2) Severity Measurement utilizes the Modified Mercalli Intensity Scale.

Richter Magnitude Scale

The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. Adjustments are included for the variation in the distance between the various seismographs and the epicenter of the earthquakes. On the Richter Scale, magnitude is expressed in whole numbers and decimal fractions. For example, a magnitude 5.3 might be computed for a moderate earthquake, and a strong earthquake might be rated as magnitude 6.3. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a tenfold increase in measured amplitude; as an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Modified Mercalli Intensity Scale

The effect of an earthquake on the Earth's surface is called the intensity. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and finally - total destruction. Although numerous intensity scales have been developed over the last several hundred years to evaluate the effects of earthquakes, the one currently used in the United States is the Modified Mercalli (MM) Intensity Scale. It was developed in 1931 by the American seismologists Harry Wood and Frank Neumann. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It does not have a mathematical basis; instead it is an arbitrary ranking based on observed effects.

The Modified Mercalli Intensity value assigned to a specific site after an earthquake has a more meaningful measure of severity to the nonscientist than the magnitude because intensity refers to the effects actually experienced.

The lower numbers of the intensity scale generally deal with the manner in which the earthquake is felt by people. The higher numbers of the scale are based on observed structural damage. Structural engineers usually contribute information for assigning intensity values of VIII or above.

Marion County has never experienced an earthquake, according to the USGS. The extent of a potential earthquake may not be determined.

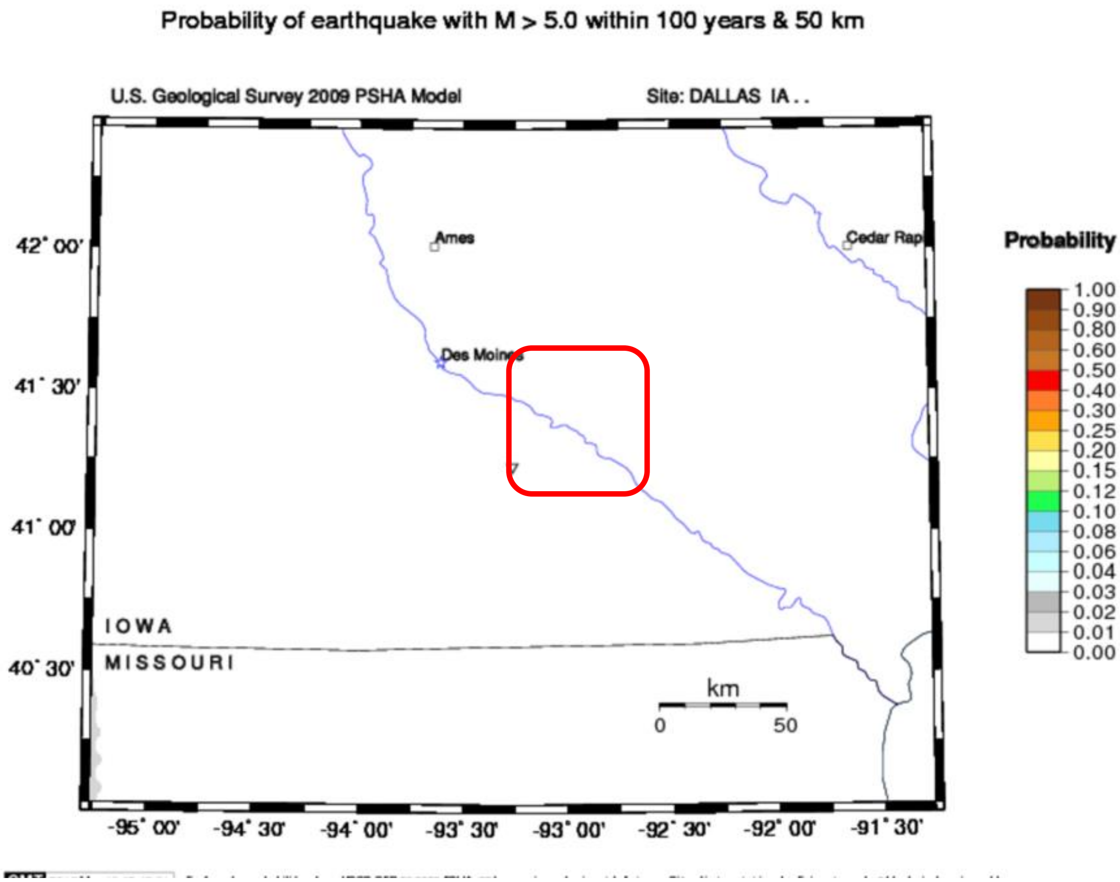
Previous Occurrences

Iowa has experienced minimal effects from only a few earthquakes in the past 175 years. The epicenters of 13 earthquakes have been located in the State with the majority along the Mississippi River. The strongest earthquake in Iowa occurred in Davenport in 1934 and resulted in only slight damage. There have been no epicenters in Marion County and no earthquake damages recorded in the County (Source: State of Iowa Hazard Mitigation Plan, 2013).

Probability of Future Occurrence

The following figure shows the probability of an earthquake with a magnitude greater than 5.0 occurring in Marion County in a 100-year time period. The circled area represents the approximate location of the County. The figure indicates that the probability of a 5.0 Magnitude or greater earthquake in the next 100 years is 0.00 percent.

Figure 21: Probability of a Magnitude 5.0 or Greater with 100 Years--Marion County



Source: United States Geological Survey, https://geohazards.usgs.gov/eqprob/2009/output/5841.pdf
Note: Circled area represents approximate location of Marion County, IA

Vulnerability

As discussed under the probability section, the probability of a 5.0 Magnitude or greater earthquake in the next 100 years is 0.00 percent. Although a damaging event is unlikely, and most structures in the County are not built to earthquake standards, any damage to existing and future development would likely be minor in nature.

Future Development

Future development is not expected to increase risk beyond contributing to the overall exposure of what could be damaged as a result of an unlikely event.

Expansive Soils

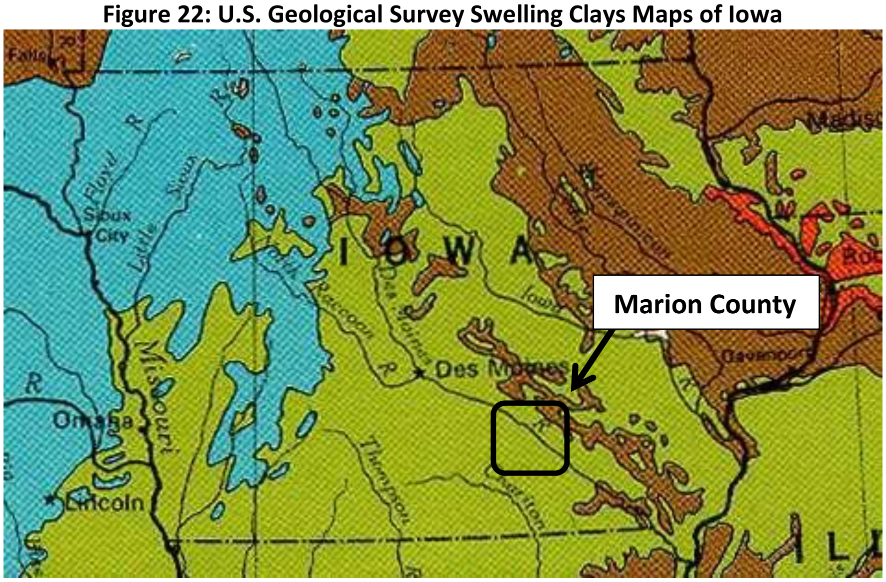
A relatively widespread geologic hazard for Iowa is the presence of soils that expand and shrink in relation to their water content. Expansive soils can cause physical damage to building foundations, roadways, and other components of the infrastructure when clay soils swell and shrink due to changes in moisture content. For Iowa, the vulnerability to this hazard most frequently is associated with soils shrinking during periods of drought.

Expansive Soils	
No. of Events	Unknown
Time Period	1996-2015 (19 years)
Probability	100%
Magnitude	Unknown
Deaths	0
Injuries	0
Property Damages	None reported/documented
Crop Damages	None reported/documented
Average Annual Damages	NA

Geographic Location/Extent

The figure below shows a map of the swelling potential of soils in Iowa. All of Marion County is located in an area where part of the soil unit (generally less than 50 percent) consists of clay having high swelling potential. This hazard affects all participating jurisdictions.

Figure 22: U.S. Geological Survey Swelling Clays Maps of Iowa



MAP LEGEND

- Unit contains abundant clay having high swelling potential
- Part of unit (generally less than 50%) consists of clay having high swelling potential
- Unit contains abundant clay having slight to moderate swelling potential
- Part of unit (generally less than 50%) consists of clay having slight to moderate swelling potential
- Unit contains little or no swelling clay
- Data insufficient to indicate clay content of unit and/or swelling potential of clay (Shown in westernmost states only)

Previous Occurrences

There is no data pertaining to damages from expansive soils; however, the frequency of damage from expansive soils can be associated with the cycles of drought and heavy rainfall which reflect changes in moisture content. Streets and parking lots throughout the County are damaged every year by expansive soils. Similarly, building foundations, patios and underground utilities are damaged as the soil expands and contracts to varying degrees and depths depending on hydrological conditions.

Probability of Future Occurrence

There will continue to be some damage to paved areas and foundations in Marion County due to swelling soils. Certain building and construction practices can alleviate these impacts.

Vulnerability

The entire planning area is vulnerable to structural damage as a result of shrinking and expanding soils, however, there is no data available to determine damage estimates for this hazard. In most cases, individual property owners, local governments and businesses pay for repairs for damages caused by this hazard.

Future Development

Existing and future development will continue to be vulnerable to expansive soils. As communities continue to develop and pave more land, it is expected that damages will increase due to expansive soils.

Extreme Heat

Extreme Heat	
No. of Events	2
Time Period	1995-2015
Probability	28 days above 90°F, annually
Magnitude	≥90 °F
Deaths	0
Injuries	0
Property Damages (1996-2015)	$135,000
Crop Damages (2000-2015)	$198,941
Average Annual Damages Property Damage (1996-2015) Agricultural Damage (2000-2015)	 $6,750 $11,871

Extreme heat is often associated with periods of drought, and is characterized by long periods of high temperatures in combination with high humidity. During these conditions, the human body has difficulties cooling through the normal method of the evaporation of perspiration. Health risks arise when a person is overexposed to heat. Extreme heat can also cause people to overuse air conditioners, which can lead to power failures. Power outages for prolonged periods increase the risk of heat stroke and subsequent fatalities due to loss of cooling and proper ventilation.

Along with humans, animals also can be affected by high temperatures and humidity. For instance, cattle and other farm animals respond to heat by reducing feed intake, increasing their respiration rate, and increasing their body temperature. These responses assist the animal in cooling itself, but this is usually not sufficient. The hotter the animal is, the more it will begin to shut down body processes not vital to its survival, such as milk production, reproduction, or muscle building.

Other related hazards include water shortages brought on by drought-like conditions and high demand. Local advisories, which list priorities for water use and rationing, are common during heat waves. Government authorities report that civil disturbances and riots are also more likely to occur during heat waves. In cities, pollution becomes a problem because the heat traps pollutants in densely populated urban areas. Adding pollution to the stresses associated with the heat magnifies the health threat to the urban population.

Table 22: Average Temperatures for Knoxville, IA

	Ave. High. (◦ F)	Ave. Min. (◦ F)
January	31.0	12.6
February	36.2	17.1
March	48.4	27.3
April	61.8	39.4
May	71.8	50.9
June	81.0	60.7
July	85.2	65.5
August	83.7	63.3
September	76.3	54.0
October	63.6	42.1
November	48.5	29.8
December	34.5	17.0

Source: Knoxville Iowa Climate (ID 134502)
http://climod.unl.edu/

For the planning area, the months with the highest temperatures are June, July, August and September. The National Weather Service has a system in place to initiate alert procedures (advisories or warnings) when the Heat Index is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for issuing excessive heat alerts is when the maximum daytime Heat Index is expected to equal or exceed 105 degrees Fahrenheit (°F) and the night time minimum Heat Index is 80°F or above for two or more consecutive days. A heat advisory is issued when temperatures reach 105 °F and a warning is issued at 115 °F.

Typical symptoms and health impacts of exposure to extreme heat are as follows:

Heat Index (HI)	Disorder
80-90° F (HI)	Fatigue possible with prolonged exposure and/or physical activity
90-105° F (HI)	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and/or physical activity
105-130° F (HI)	Heatstroke/sunstroke highly likely with continued exposure

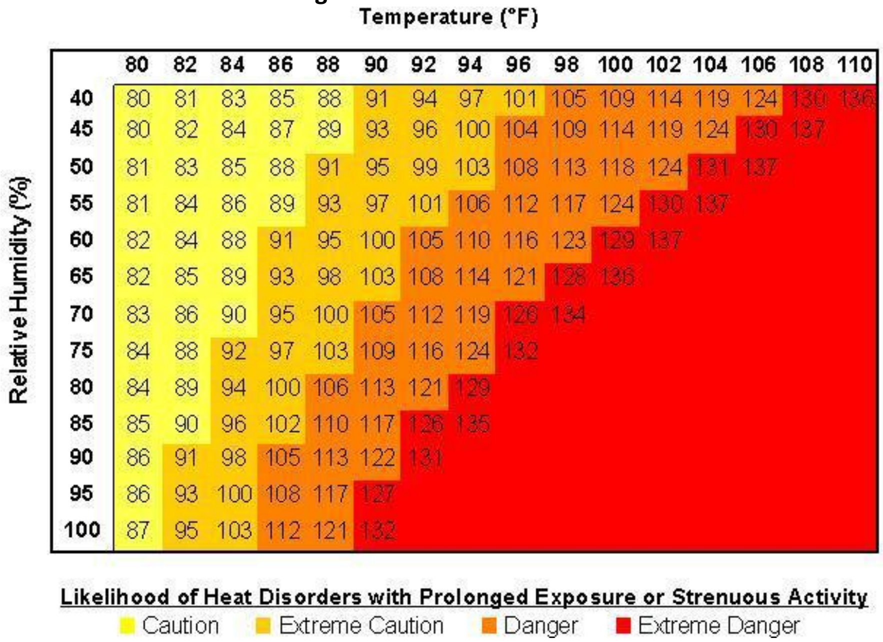
Those at greatest risk for heat-related illness include infants and children up to four years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications. However, even young and healthy individuals are susceptible if they participate in strenuous physical activities during hot weather. In agricultural areas, the exposure of farm workers, as well as livestock, to extreme temperatures is a major concern.

Geographic Location/Extent

The entire planning area is subject to extreme heat and all participating jurisdictions are affected.

A key factor to consider in regard to extreme heat situations is the humidity level relative to the temperature. As indicated in the following figure, as Relative Humidity increases, the temperature needed to cause a dangerous situation decreases. For example, for 100 percent Relative Humidity, dangerous levels of heat begin at 86°F where as a Relative Humidity of 50 percent, require 94°F. The combination of Relative Humidity and Temperature result in a Heat Index: 100 percent Relative Humidity + 86°F = 112°F Heat Index

Figure 23: Heat Index Chart



	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Source: National Weather Service (NWS)

Note: Exposure to direct sun can increase Heat Index values by as much as 15°F. The shaded zone above 105°F corresponds to "Danger" that may cause increasingly severe heat disorders with continued exposure and/or physical activity.

Previous Occurrences

According to information obtained from the National Climatic Data Center (NCDC) there have been two recorded extreme heat events from 1950-2015. Below the table are narratives provided by the NCDC regarding each event.

Table 23: NCDC Extreme Heat Events (1950-2015)

Date	Type	Property Damages
August 5, 2001	Heat	$0
July 15-28, 2011	Excessive Heat	$135,000
Total		**$135,000**

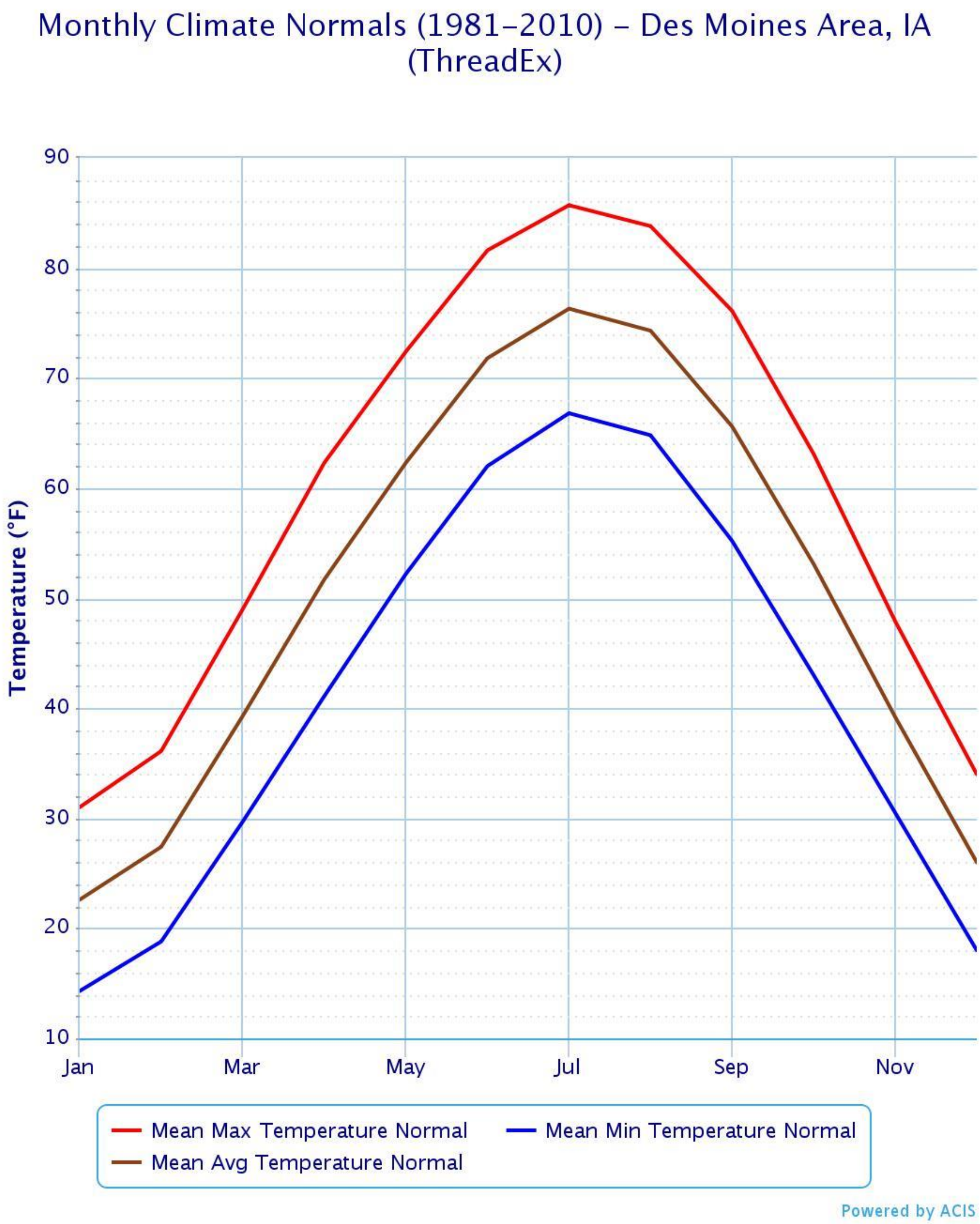
Source: NCDC

- **August 5, 2001:** Very warm and humid conditions that began in the last part of July continued into August. Temperatures during the day warmed into the 90s, with overnight lows remaining in the 70s. Dew point temperatures held in the mid-70s to low 80s through most of the time. An elderly woman passed away in Des Moines on the 5th. She was found in her home with the windows closed and temperatures in the house in excess of 100 degrees F. She had succumbed to the heat.

- **July 15, 2011:** A large area of high pressure developed in the upper atmosphere by the middle of July. Heat built up over Iowa, aided by the severe drought to the south across Kansas, Oklahoma, and Texas. Temperatures rose into the 90s each day through the period. Though most days did not see 100-degree heat, the dewpoint and overnight lows were very significant. Low temperatures during most of the nights were in the 70s, with many of the nights in the mid to upper 70s. Dew point temperatures failed to fall below 70 through most of the period, with frequent excursions in the upper 70s to low 80s. These conditions caused considerable stress on livestock. Reports indicated that at least 4,000 head of cattle and thousands of turkeys were killed by the suffocating heat. Livestock losses were estimated in the $5 to $10-million-dollar range.

The figure below provides the daily temperature averages and extremes for the Knoxville Grove, Iowa weather station for the period of record from 1948 to 2013.

Figure 24: Daily Temperature Averages and Extremes, Knoxville, Iowa (1981-2013)



Source: NOAA, NWS

During the sixteen-year period from 2000-2015, crop insurance claims paid as a result of losses related to extreme heat totaled to $189,941. According to USDA Risk Management Agency's 2011 Iowa Crop Insurance Profile, 94-95 percent of corn and soybeans are insured across the state of Iowa. The following table summarizes the claims paid by year and type of event.

Table 24: Annual Losses for Insured Crops Due to Extreme Heat for Marion County

	Corn	Soybeans	Other	Total
2000	$0	$0	$0	$0
2001	$0	$0	$0	$0
2002	$0	$0	$0	$0
2003	$1,265	$25,174	$0	$26,439
2004	$0	$0	$0	$0
2005	$0	$0	$0	$0
2006	$0	$0	$0	$0
2007	$0	$0	$0	$0
2008	$0	$0	$0	$0
2009	$0	$0	$0	$0
2010	$0	$0	$0	$0
2011	$44,371	$19,627	$11,329	$75,327
2012	$9,338	$0	$0	$9,338
2013	$72,526	$6,311	$0	$78,837
2014	$0	$0	$0	$0
2015	$0	$0	$0	$0
Total	$127,500	$51,112	$11,329	$189,941
Average Annual Loss	$7,969	$3,195	$708	$11,871

Source: http://www.rma.usda.

Probability of Future Occurrence

Extreme heat is a regular part of the climate for the planning area; there is a 100 percent probability that temperatures greater than 90°F will occur annually.

Vulnerability

Those at greatest risk for heat-related illness include infants and children up to four years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications. To determine jurisdictions within the planning area with populations that may be more vulnerable to extreme heat, demographic data was obtained from the 2010 Census on numbers of people in each jurisdiction under age 5 and over age 65.

Heat-related illness or death is generally the greatest concern resulting from extreme heat events. Although historically no heat-related deaths are known, the potential exists. The table below provides the demographic data obtained for populations under age 5 and 65 and over in the planning area.

Table 25: Marion County Population Under Age 5 Over 65, 2010 Census Data

Jurisdiction	Total Population	Population Under Age 5 (Percent)	Population Age 65 and Older (Percent)
Bussey	422	7.7%	16.5%
Hamilton	130	5.9%	2.7%
Harvey	235	4.8%	16.0%
Knoxville	7,313	7.7%	18.3%
Marysville	66	10.3%	24.1%
Melcher-Dallas	1,288	8.9%	16.7%
Pella	10,352	6.6%	15.9%
Pleasantville	1,694	5.7%	15.9%
Swan	72	0%	25.9%

Source: 2010 U.S. Bureau of the Census, Table DP-1

Area elder care facilities, senior housing facilities, and childcare facilities are vulnerable to extreme temperatures. Most notably, power failure during an extreme heat event could shut down these facilities' HVAC systems if back-up power capabilities were not available.

Another type of infrastructure damage that can occur as a result of extreme heat is road damage. When asphalt is exposed to prolonged extreme heat, it can cause buckling of asphalt-paved roads, driveways, and parking lots.

Estimated Loss of Electricity

According to the FEMA publication "What is a Benefit: Guidance on Benefit-Cost Analysis of Hazard Mitigation Project (June 2009)", if an extreme heat event occurred within the planning area, the following table assumes the event could potentially cause a loss of electricity for 10 percent of the population at a cost of $126 per person per day. In rural areas, the percent of the population affected and duration may increase during extreme events. The assumed damages do not take into account physical damages to utility equipment and infrastructure.

Jurisdiction	2010 Population	Population Affected (Assumed)	Electric Loss of Use Assumed Damage Per Day
Marion County	33,309	3,330	$419,580

Source: 2010 U.S. Census Bureau of the Census, Table DP-1

Future Development

The construction of infrastructure to support any future development should take extreme heat into account. Facilities such as nursing homes and day cares should be designed with access to back-up power generation. Public cooling centers should be established, especially during special summer events like sprint car races at the Knoxville Raceway.

Flash Flood

(Flooding caused by dam and levee failure and riverine flooding are discussed separately.)

Flash Flood	
No. of Events	27
Time Period	1996-2015
Probability	1.35 events/year
Magnitude	N/A
Deaths	0
Injuries	0
Property Damages (1996-2015)	$1,397,000
Crop Damages (2000-2015)	$255,000
Average Annual Damages Property Damage(1996-2015) Agricultural Damage (2000-2015)	 $69,850 $15,937

A flash flood is an event that occurs with little or no warning where water levels rise at an extremely fast rate. Flash flooding results from intense rainfall over a brief period, sometimes combined with rapid snowmelt, ice jam release, frozen ground, saturated soil or impermeable surfaces.

Ice jam flooding is a form of flash flooding that occurs when ice breaks up in moving waterways, and then stacks on itself where channels narrow. This creates a natural dam, often causing flooding within minutes of the dam formation.

Most flash flooding is caused by slow-moving thunderstorms or thunderstorms repeatedly moving over the same area. Flash flooding is an extremely dangerous form of flooding which can reach full peak in only a few minutes and allows little or no time for protective measures to be taken by those in its path. Flash flood waters move at very fast speeds and can move boulders, tear out trees, scour channels, destroy buildings, and obliterate bridges. Flash flooding often results in higher loss of life, both human and animal, than slower developing river and stream flooding.

In some cases, flooding may not be directly attributable to a river, stream, or lake overflowing its banks. Rather, it may simply be the combination of excessive rainfall or snowmelt, saturated ground, and inadequate drainage. With no place to go, the water will find the lowest elevations–areas that are often not in a floodplain. This type of flooding, often referred to as sheet flooding, is becoming increasingly prevalent as development outstrips the ability of the drainage infrastructure to properly carry and disburse the water flow

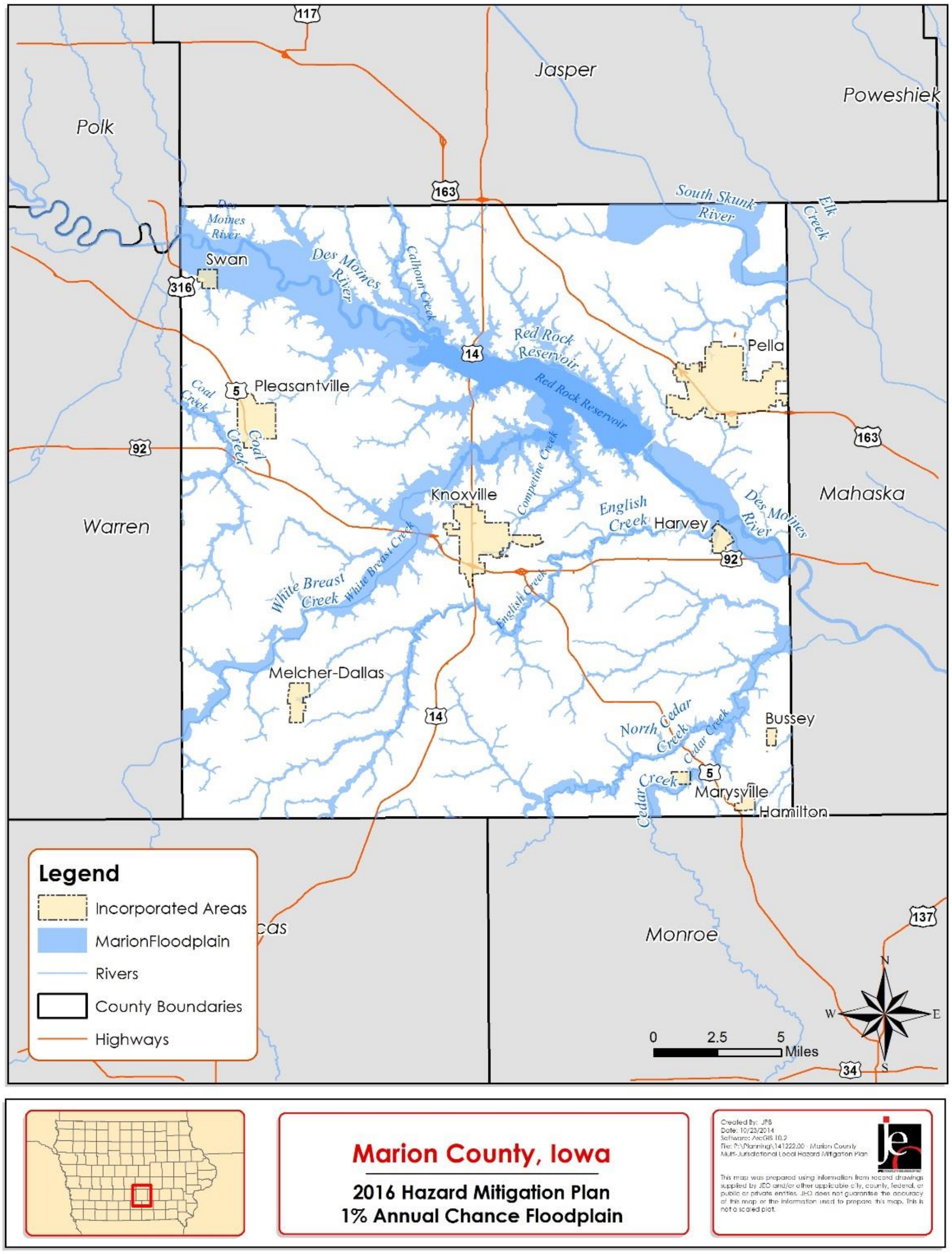
In certain areas, aging storm sewer systems are not designed to carry the capacity currently needed to handle the increased storm runoff. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns. This combined with rainfall trends and rainfall extremes all demonstrate the high probability, yet generally unpredictable nature of flash flooding in the planning area.

Although flash floods are somewhat unpredictable, there are factors that can point to the likelihood of flash floods occurring. Weather surveillance radar is being used to improve monitoring capabilities of intense rainfall. This, along with knowledge of the watershed characteristics, modeling techniques, monitoring, and advanced warning systems increases the warning time for flash floods.

Geographic Location/Extent

Flash flooding occurs in those locations of the in the planning area that are low-lying and/or do not have adequate drainage to carry away the amount of water that falls during intense rainfall events. According to NCDC, all participating jurisdictions within the county have a history of flash flooding events.

Figure 25: Marion County 1% Annual Chance Floodplain



Previous Occurrences

As discussed above, flash flooding is caused by intense rainfall over a brief period. The table below provides the top rainfall events at the Knoxville Weather Station since 1996:

Table 26: Top Rainfall Events, Knoxville Station 1996-2013

Date	Amount (Inches)		Date	Amount (Inches)
May 10, 1996	3.14		September 13, 2008	2.94
May 8, 1997	2.87		August 27, 2009	3.42
October 13, 1997	2.74		July 18, 2010	2.65
September 19, 2002	3.7		June 10, 2011	5.46
June 26, 2003	3.78		April 18, 2013	4.18
September 12, 2003	3.6		April 14, 2014	3.94
May 7, 2007	3.93		September 10, 2014	3.76
August 9, 2007	2.77		October 14, 2014	3.20
June 27, 2008	2.63		July 29, 2015	4.40
July 8, 2008	2.91		September 7, 2015	2.95

Source: Iowa State University Department of Agronomy http://mesonet.agron.iastate.edu/request/coop/fe.phtml

According to information obtained from the National Climatic Data Center (NCDC) there have been 27 recorded flash flood events from 1996-2015.

Table 27: NCDC Flash Floods in Marion County, 1996-2015

County	Jurisdiction	Date & Time	Damage to Property
Marion	Knoxville	6/18/1998 12:00	100K
Marion	Knoxville	6/23/2000 18:30	200K
Marion	East Portion	5/29/2002 16:00	100K
Marion	Countywide	6/25/2003 17:15	5K
Marion	Countywide	5/24/2004 19:15	100K
Marion	Countywide	5/24/2004 17:30	100K
Marion	Knoxville	5/7/2007 3:00	150.00K
Marion	Knoxville	6/3/2008 7:50	50.00K
Marion	Hamilton	6/3/2008 5:00	50.00K
Marion	Pella	6/8/2008 16:38	10.00K
Marion	Marysville	7/8/2008 4:30	50.00K
Marion	Newbern	7/8/2008 1:00	25.00K
Marion	Melcher	7/8/2008 1:00	25.00K
Marion	Attica	7/8/2008 0:40	25.00K

Marion	Pleasantville	6/12/2010 3:00	10.00K
Marion	Dunreath	6/12/2010 8:17	2.00K
Marion	Pleasantville	6/12/2010 11:45	50.00K
Marion	Fifield	8/10/2010 2:44	10.00K
Marion	Harvey	8/11/2010 0:35	50.00K
Marion	Tracy	8/11/2010 0:35	10.00K
Marion	Marysville	6/18/2010 17:51	10.00K
Marion	Knoxville	7/18/2010 4:50	25.00K
Marion	Columbia	7/18/2010 4:50	15.00K
Marion	Knoxville	6/9/2011 23:54	100.00K
Marion	Pella	6/10/2011 3:32	50.00K
Marion	Fifield	9/10/2014 4:25	25.00K
Marion	Knoxville	7/12/2014 16:45	50.00K
Total		**27 Events**	**$1,397,000**
Average		**1.42 Events/Year**	**$73,526**

Selected Event Histories
The following flooding event narratives were reported by the NCDC, narratives from significant events are provided chosen below:

- **June 23, 2000**- Another round of convection developed over Iowa during the afternoon hours as warm and unstable air was drawn north over the top of the outflow boundary left behind from convection during the mid-day hours. Very heavy rainfall over Wapello, Monroe, Mahaska, Davis, and Marion Counties caused considerable flash flooding. Reports indicate four to eight inches of rain in Marion County ... Needless to say, many houses were flooded by the heavy rainfall. Crop damage was also quite widespread due to crops drowning in flooded fields. The situation would not have been as serious if not for the fact that 3 to 6 inches of rain fell across most of these areas about a week earlier.

- **May 25, 2004**- The frontal system that had moved through the state on the night of the 22nd was returning north as a warm front. This time Iowa did not get completely into the warm sector…Hail was common with the stronger storm, with much of it in the one to one and three-quarter inch in diameter. Given the antecedent soil conditions in Iowa, flash flooding became a major issue. Numerous counties reported flash flooding as rainfall of one to 4 inches in spots resulted in flooded highways.

Probability of Future Occurrence
Using the frequency of past events to establish the likelihood of future occurrences, 27 events in 19 years suggests that flash flooding will occur in the planning area approximately 1.42 times in any given year.

Vulnerability
Previous occurrences of flash flooding in the county did not report any injuries or fatalities. Building damage is generally limited to water in basements where rain is too intense for drainage systems and natural drainage to carry water away from the structure. In addition, when combined storm/sanitary

sewer systems are overloaded, this can result in sewer back-up as described above. Generally, flash-flooding is short in duration and government services and business operations are not impacted.

A 2008 study examining social vulnerability as it relates to flood events found that low-income and minority populations are disproportionately vulnerable to flood events. These groups may lack resources that are needed to mitigate potential flood events as well as resources that are necessary for evacuation and response. In addition, low income residents are more likely to live in areas vulnerable to the threat of flooding but lack the resources necessary to purchase flood insurance. The study did find that flash floods are more often responsible for injuries and fatalities than prolonged flood events. Other groups that may be more vulnerable to floods, and specifically flash floods, include the elderly, those outdoors during rain events, and those in low-lying areas. Elderly residents may suffer from a decreased or complete lack of mobility and as a result be caught in flood-prone areas. Residents in campgrounds or public parks may be more vulnerable to flooding events as many of these areas exist in natural floodplains and can experience rapid rise in water levels resulting in injury or death.

Potential Losses to Existing Development

When roads and bridges are inundated by water, damage often occurs as the water scours materials around bridge abutments and gravel roads. The water 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/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.

Future Development

In planning future development, jurisdictions in the planning area should avoid development in low-lying areas near rivers and streams or where interior drainage systems are not adequate to provide drainage during heavy rainfall events. Future development should also take into consideration the impact of additional impervious surfaces to water run-off and drainage capabilities during heavy rainfall events.

Further, it is recommended that the county closely monitor any bridges exhibiting scouring near the piers. Scoring can dramatically impact the stability of the surrounding sediment, which may contribute to failure of the bridge.

Grass or Wildland Fire

Grass or Wildland Fire	
No. of Events	58
Time Period	2005-2015
Probability	5.3 events/year
Magnitude	6 acres (average)
Deaths	0
Injuries	1
Property Damages	Not Available
Crop Damages	Not Available
Average Annual Damages	Not Available

Iowa's urban/rural interface (areas where development occurs within or immediately adjacent to wildland, near fire-prone trees, brush, and/or other vegetation), is growing as metro areas expand into natural forest, prairies and agricultural areas that are in permanent vegetative cover through the Conservation Reserve Program (CRP). The state has the largest number of CRP contracts in the nation, totaling over 1.5 million acres. Most of this land is planted in cool and warm season grass plantings, tree plantings and riparian buffer strips. There is an additional 230,000 acres in federal ownership and conservation easements. The threat of wildland fire in the urban interface is greater now than it has been in more than a century and the problem is compounded by homeowners formerly from urban area that do not understand that all of the services generally taken for granted in the cities are not equally available.

Wildfires are frequently associated with lightning and drought conditions; as dry conditions make vegetation more flammable. As new development encroaches into the wildland/urban interface more and more structures and people are at risk. On occasion, ranchers and farmers intentionally set fire to vegetation to restore soil nutrients or alter the existing vegetation growth. Also, individuals in rural areas frequently burn trash, leaves and other vegetation debris. These fires have the potential to get out of control and turn into wildfires.

The risk of wildfires is a real threat to landowners across the state. The National Weather Service monitors the conditions supportive of wildfires in the state on a daily basis so that wildfires can be predicted, if not prevented.

The risk factors considered are:

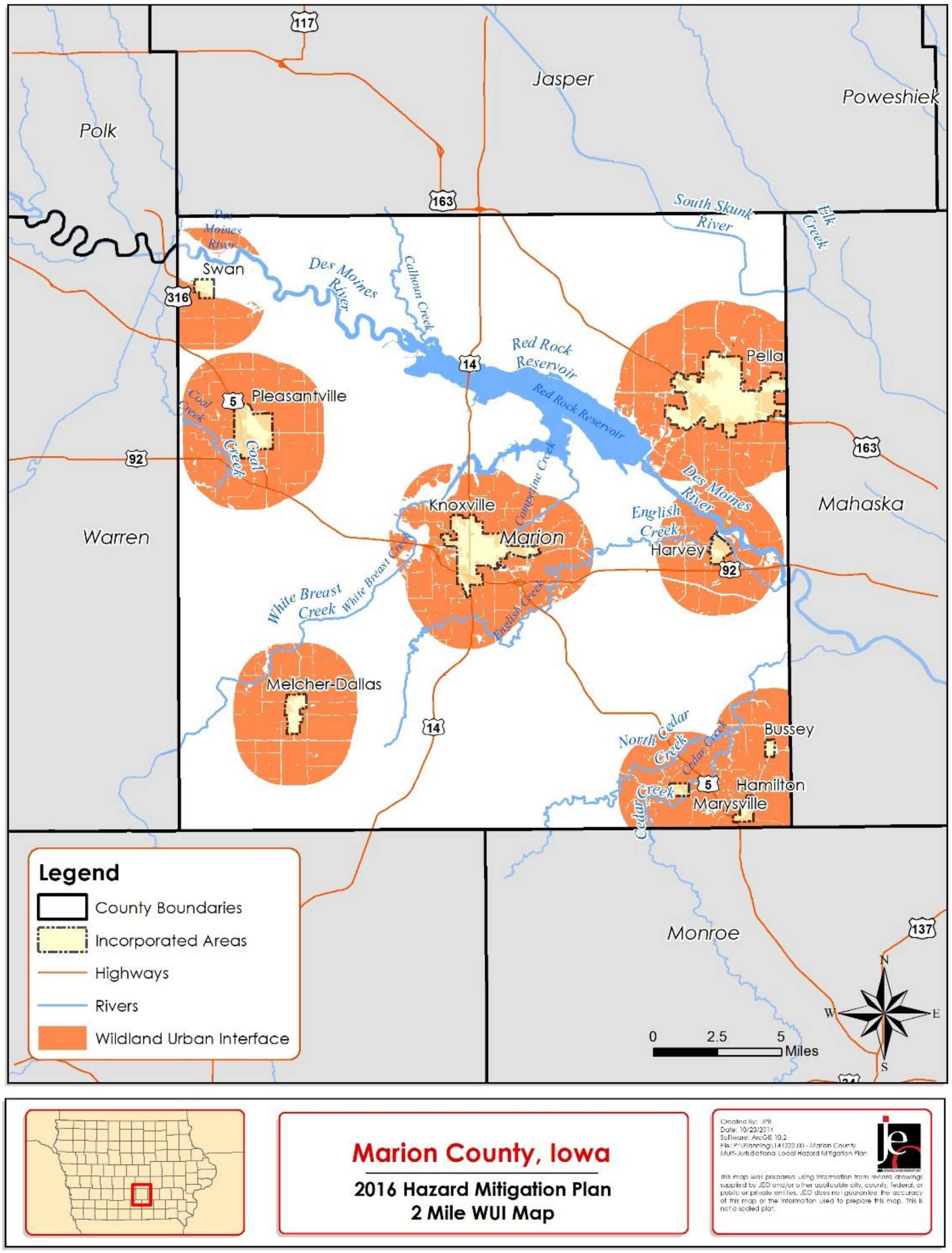
- High temperature
- High wind speed
- Fuel moisture (greenness of vegetation)
- Low humidity
- Small cloud cover

Geographic Location/Extent

To illustrate the location/extent of a likely wildfire event, a Wildland-Urban Interface (WUI) was developed, using the USGS' National Land Cover Database (NLCD). The WUI layer highlights especially dense fuel areas notated by the NLCD (forest, shrubland, herbaceous, and planted/cultivated) areas which are within 2 miles of a community. Because nearly two thirds of the land in Marion County is dedicated to agricultural purposes, these lands may be especially prone to grass/wildfires.

Figure 4 is not a regulatory map, and is shown only for planning purposes.

Figure 26: Marion County Wildland-Urban Interface



Previous Occurrences

According to information obtained from the Iowa Department of Natural Resources Forestry Bureau, there were 58 reported wildland or grass fires in Marion County from 2005-2013. In total, these 58 fires burned 772.96 acres. 10 of these fires were controlled burns, burning 108.91 acres. 3 were started accidently. Debris fires would fall into a class of purposely set fires that become uncontrolled; 44 debris fires burned 232.5 acres during the reporting period. The following table provides the number of acres burned each year from 2005-2015 by cause. There was one injuries reported for fire incidents. No fatalities were reported for any of the fires.

Table 28: Marion County Grass and Wildland Fires from 2005-2015

Cause	Number of Events	Total Acres
Lightning	0	0
Campfire	0	0
Smoking	2	9
Debris	44	232.5
Arson	1	0.8
Equipment	0	0
Railroad	0	0
Miscellaneous	1	1
Controlled Burn	10	108.91
Total	**58**	**352.21**

Source: Iowa Department of Natural Resources

Probability of Future Occurrence

When analyzing accidental, miscellaneous and uncontrolled debris fires, there has been an average of 3.1 fires burning 16.2 acres per year. However, most of these fires did not result in major damages.

Vulnerability

Areas that are most vulnerable to wildfire are agricultural areas where land is burned, rural areas where trash and debris are burned, and the wildland-urban interface areas.

Potential Losses to Existing Development

Wildfires can be responsible for extensive damage to crops, the environment and occasionally residential or business facilities. Homes built in rural areas are more vulnerable since they are in closer proximity to land that is burned and homeowners are more likely to burn trash and debris in rural locations. The vulnerability of structures in rural areas is exacerbated due to the lack of hydrants in these areas for firefighting and the distance required for firefighting vehicles and personnel to travel to respond. Potential losses to crops and rangeland are additional concerns.

Wildland/Grass fires can occur in city limits. However, the magnitude is generally lower due to proximity to firefighting services, and availability of dense fuels. There is less potential for wildland/grass fires impacting schools due to general locations away from Wildland Urban Interface Areas. Again, if a wildland/grass fire were to occur near school buildings, the magnitude would be lower due to close proximity to firefighting services.

Utilizing the data available from the Iowa Department of Natural Resources Forestry Bureau, during the 10-year period from 2005-2015, there were 47 fires that burned 243.3 acres. If grass and wildland fires continue at a similar rate, the average annual number of fires will be 3.1 fires burning an average 16.2 acres per year. Economic losses were not available from historical data. As a result, it is not possible to estimate future economic losses at this time.

Future Development

Future development in the wildland-urban interface would increase vulnerability to this hazard. Additionally, it is advisable to enact a defensible space ordinance which limits availability of fuel in close proximity to residences.

Hazardous Materials

Hazardous Materials	
No. of Events	10
Time Period	36
Probability	28% annually
Magnitude	11 gal- 13,057 gal
Deaths	0
Injuries	1
Property Damages	$147,042
Crop Damages	N/A
Average Annual Damages Property Damage (1980-2015)	$4,081

Marion County is home to a variety of hazardous materials, based on the industries which occur within it. Agriculture, and manufacturing each require chemicals for production of goods. Periodically, an unexpected release of these chemicals may occur, due to any number of factors. Hazardous materials may present an immediate threat to the health and safety of residents surrounding a potential spill. Additionally, hazardous materials may result in lasting impacts to agricultural fields, if soils should be impacted. The Iowa Hazard Mitigation Plan defines a fixed hazardous materials incident is the accidental release of chemical substances or mixtures which presents a danger to the public health or safety during production or handling at a fixed facility.

Chemicals are frequently transported throughout Marion County for both agricultural and industrial uses. These chemicals are transported over highways, pipelines, and rail lines. The Pipeline and Hazardous Materials Safety Administration (PHMSA) provides data on chemical spills. The PHMSA is a branch of the U.S. Department of Transportation, and they have jurisdiction over the transportation of hazardous materials, including delineating which chemicals will be defined as hazardous. The PHMSA uses nine classifications to describe the attributes of various chemicals. For first responders, having an understanding of how these chemicals behave is critical for an adequate response. As a result, the PHMSA works to utilize chemical placards to make responders aware of the contents of a storage container.

Geographic Location/Extent

To illustrate the location/extent of the planning area's vulnerability to Hazardous Materials, both hazardous chemical fixed sites and transportation routes are profiled below.

Figures 27, 28, and 29 below show locations where these chemicals are housed or transported.

Figure 27: Marion County Hazardous Chemical Fixed Sites

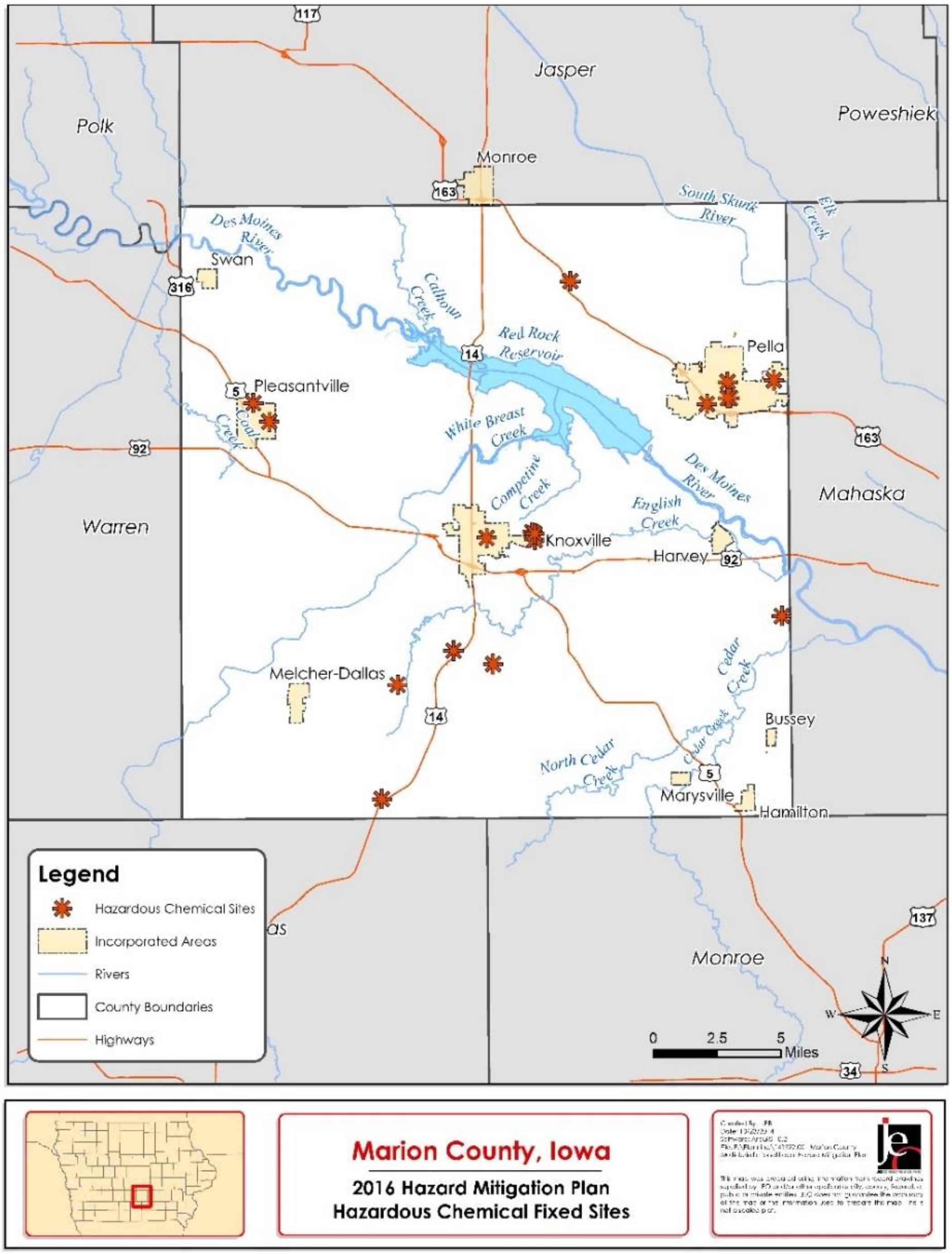


Figure 28: Marion County Pipelines

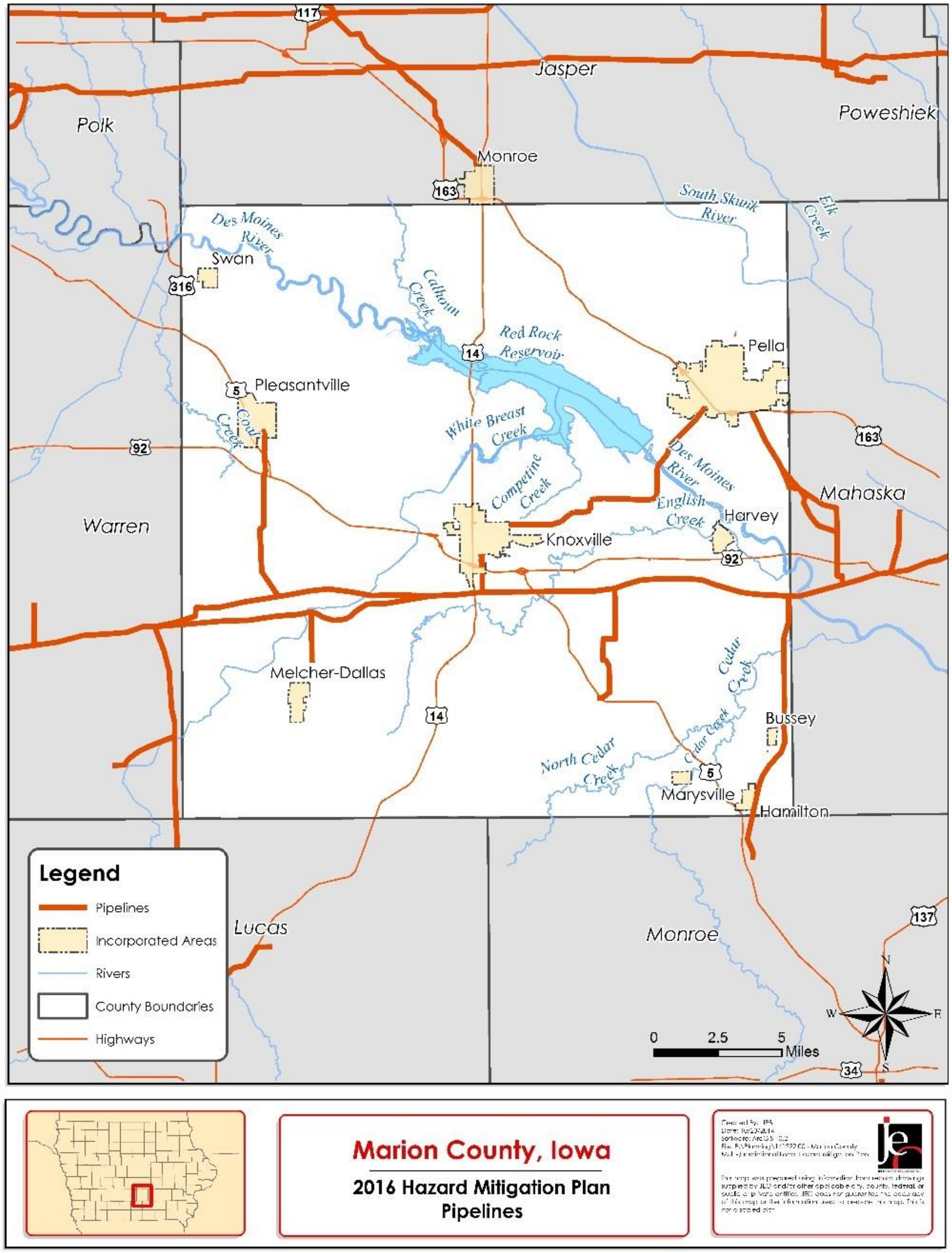
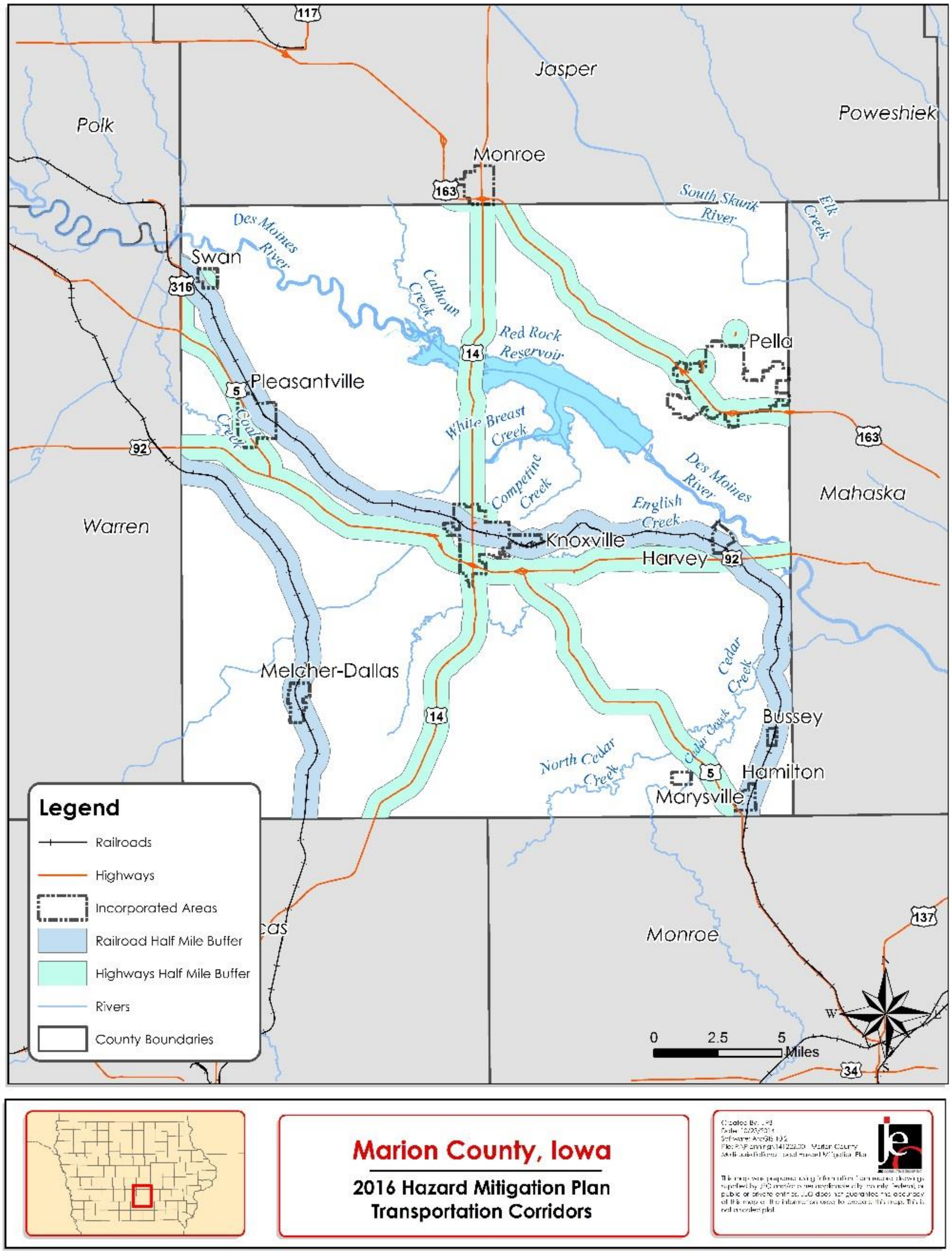


Figure 29: Transportation Corridors



Previous Occurrences

PHMSA reports that eleven chemical spills occurred during transportation events between January 1, 1980, and July 8, 2016. During these events, there has been one injury, no fatalities, and $2,845,951 in total damages from transportation spills.

The following table provides a list of the largest spills, incidents with injuries, or whether an evacuation was ordered due to transportation incidents involving hazardous materials.

Date of Event	Location of Release	Failure Description	Material Involved	Method of Transportation	Total Damage	Injuries	Evacuation (Yes/No)
4/18/2001	BUSSEY	Punctured	13,067 Liquid Gallons Fuel Oil	Rail	$26,345	0	No
1/17/1992	BUSSEY	Punctured	7,000 Liquid Gallons Gasoline	Highway	$9,200	0	No
4/18/2001	BUSSEY	None	6,000 Liquid Gallons Fuel Oil	Rail	$26,363	0	No
4/18/2001	BUSSEY	None	3,066 Liquid Gallons Fuel Oil	Rail	$25,283	0	No
4/18/2001	BUSSEY	None	4,000 Liquid Gallons Fuel Oil	Rail	$26,576	0	No
4/24/2001	KNOXVILLE	None	40 Gallons Fuel Oil	Rail	$26,051	0	No
11/12/1991	KNOXVILLE	None	11 Liquid Gallons Acrylic Acid	Highway	$7,119	1	No
6/17/1999	KNOXVILLE	None	30 Liquid Gallons Fuel Oil	Highway	$0	0	No
5/13/1981	PELLA	Punctured	2,145 Gallons Paint Material	Highway	$55	0	No
3/27/2008	PELLA	Ripped or Incompatible	Environmental Hazardous Substance	Highway	$50	0	No
TOTAL					**$147,042**	**1**	**No**

Probability of Future Occurrence

The historical record indicates that chemical releases during transport have a 28% chance of occurring annually in the planning area with 10 events over a 36-year period.

Vulnerability

Areas which are most vulnerable to hazardous materials events are those located within a half-mile of a primary transportation corridor (highway, railroad, or pipelines). Additionally, those located near hazardous chemical fixed sites or manufacturing centers may experience added vulnerability as a result of being located closer to these facilities.

Potential Losses to Existing Development

Hazardous material spills tend to be localized, if kept away from waterways, and their impacts are largely non-structural, unless they involve corrosive materials. Increased demand for hazardous materials may exacerbate vulnerability presented by hazardous materials. Utilizing the information provided by the PHMSA, during the 36-year period of 1980-2016, there were 10 accidental hazardous material spills. If hazardous material spills continue to occur at this rate, there will be one spill every 3.6 years, and $4,085 in damages annually.

Future Development

To limit further vulnerability to hazardous material events, it is recommended that development continue away from primary transportation corridors, where these chemicals are transported. Additionally, ordinances may be written to require that all chemical storage tanks must be properly mounted, outside of any known hazard areas, such as a special flood hazard area.

Human Disease

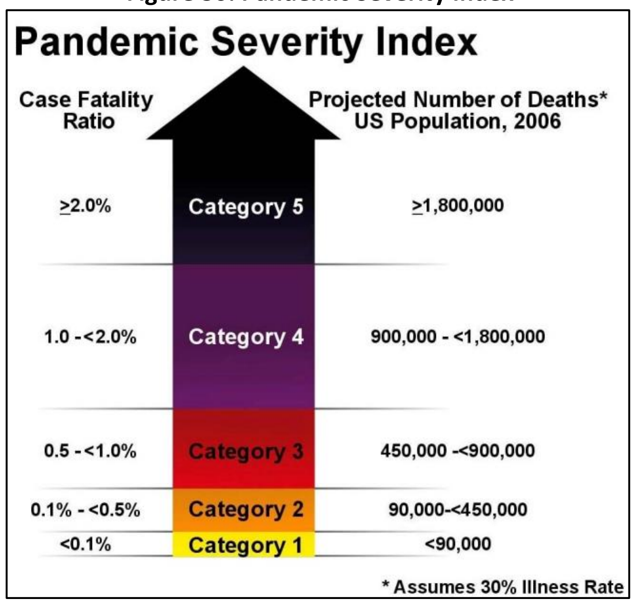
Hazardous Materials	
No. of Events	184 (annual average)
Time Period	10 years
Probability	100%
Magnitude	N/A
Deaths	1,838 (of top 5)
Injuries	2,362 (of top 10)
Property Damages	N/A
Crop Damages	N/A
Average Annual Damages	N/A

The Iowa Hazard Mitigation Plan defines a human disease incident as "a medical, health or sanitation threat to the general public including contamination, epidemics, plagues, or infestations."

The Iowa Department of Public Health tracks statistics on infectious diseases, environmental health and chronic illness, and works to minimize their impact throughout the state of Iowa. An important concern for the State of Iowa includes the vulnerability to a pandemic. According to the Iowa Hazard Mitigation Plan, a pandemic may have wide spread economic and societal implications for the state as a whole.

The Centers for Disease Control and Prevention (CDC) has published a "Pandemic Severity Index" (PSI) which may assist all response organizations in planning for and responding to a pandemic event. For each category delineated on the PSI, there are specific steps recommended for response. Since the creation of the tool, the CDC has created two additional tools, which are specific to the concern of influenza. The Influenza Risk Assessment Tool (IRAT) and the Pandemic Severity Assessment Framework (PSAF) have been created by the CDC to evaluate current risk to gauge potential pandemic impacts.

Figure 30: Pandemic Severity Index



For Marion County, in 2014, the top five causes of death were heart disease, "All Other Diseases" (residual), lung cancer, Alzheimer's disease, and cerebrovascular diseases (stroke). The top ten causes for hospitalization were, in descending order: pregnancy/delivery, pregnancy complications, heart disease, ill-defined conditions, mental health conditions, respiratory infections, digestive system diseases, osteoarthritis, urinary system diseases, and fractures.

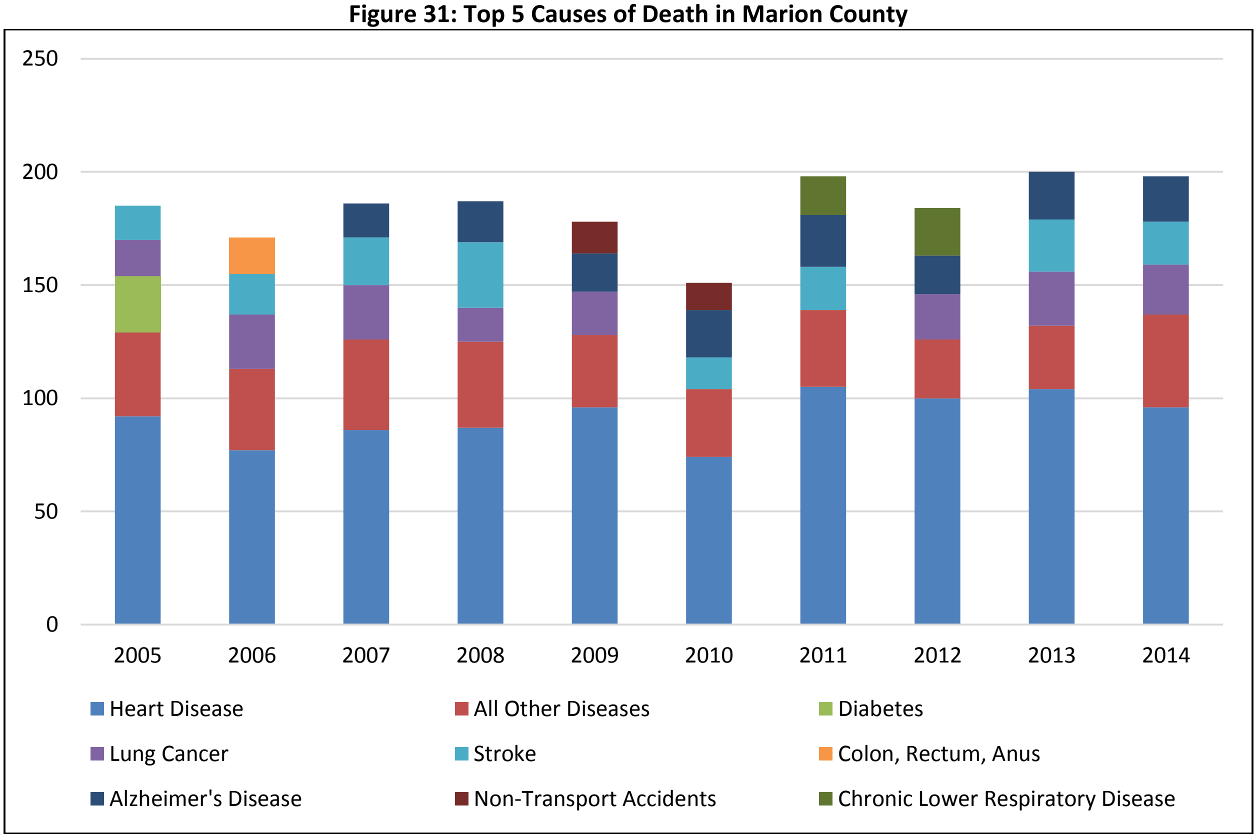
Geographic Location/Extent

The location of a human disease will reflect the population living in a given area. The more individuals in a given area will impact how transmissible a disease is.

Previous Occurrences

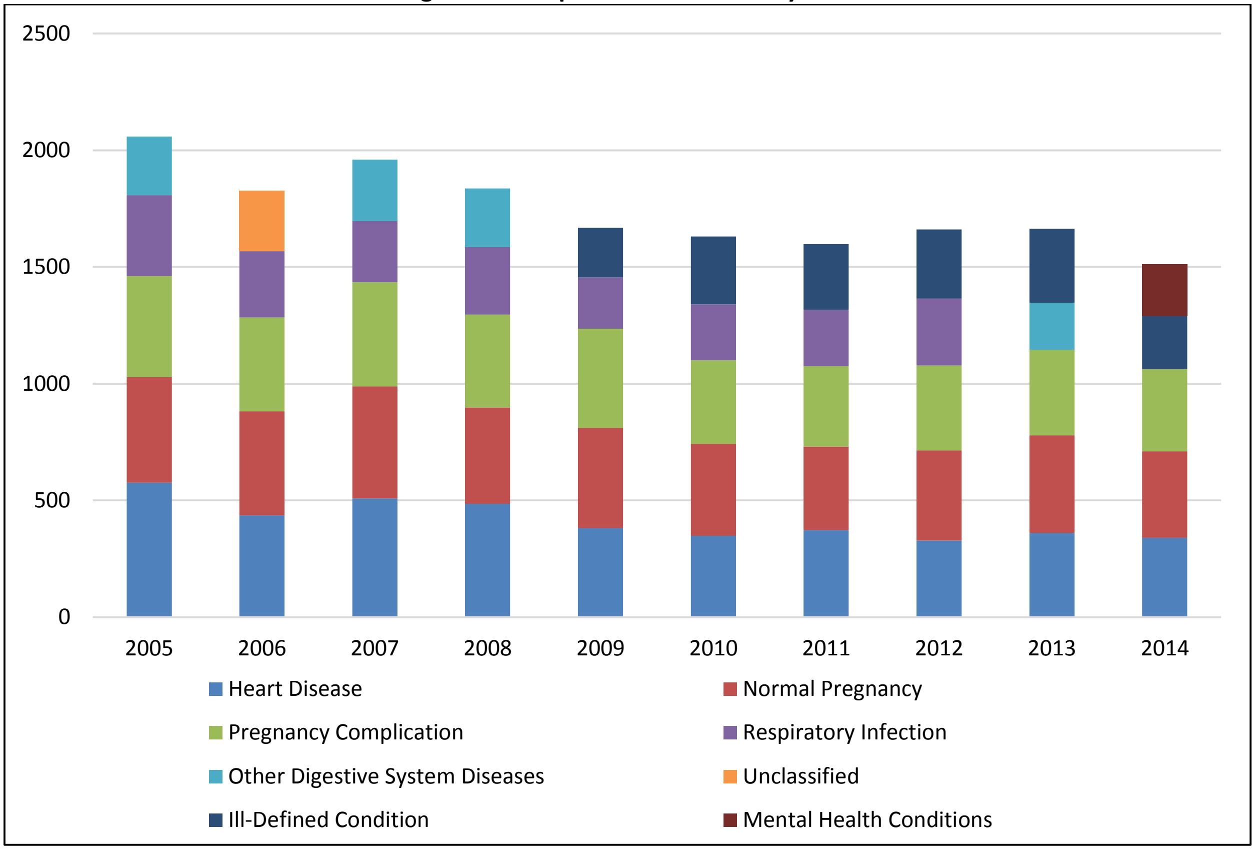
Marion County experiences 150-200 deaths per year, due to a variety of causes. The most common cause of death in Marion County is heart disease, which is often equal to that of the other top causes of death combined. This is similar to the statistics available at the state level, with minor variance. Data is only available for top 5 causes of death and top 10 causes of hospitalization at the county level. Further analysis will only include these two metrics.

Figure 31: Top 5 Causes of Death in Marion County



Source: Iowa Department of Public Health

Figure 32: Hospitalization Causes by Year



Source: Iowa Department of Public Health

Probability of Future Occurrence

Over the last ten years, the rate of hospitalization for heart disease has decreased, while the incidence of death related to heart disease has not changed.

Vulnerability

According to the Iowa Department of Public Health, those individuals 65 and older are most vulnerable to disease, especially individuals prone to heart disease. Additionally, those living in close proximity to one another are more vulnerable to contagious pandemics than those living in unincorporated areas of the county.

An added risk may be presented by Central College, as a result of study abroad trips and students traveling to underdeveloped countries, where infectious diseases may threaten student health.

Potential Losses to Existing Development

Human Disease is a non-structural hazard, and does not pose any threat to existing development.

Future Development

To limit further vulnerability from future human disease events, it is recommended that those involved in public health initiatives continue to emphasize educational materials, especially related to heart disease. The county intends to pursue further training opportunities for first responders.

Infrastructure Failure

The Iowa Hazard Mitigation Plan notes that there a variety of different occurrences which may be classified as infrastructure failure; including communication failure, energy failure, structural failure, and structural failure. The plan goes on to note that one potential cause of infrastructure failure is space weather/solar flares. Any sort of disruption in cell, electric, radio or other service may be considered a form of infrastructure failure.

Hazardous Materials	
No. of Events	Not Available
Time Period	Not Available
Probability	Not Available
Magnitude	Not Available
Deaths	Not Available
Injuries	Not Available
Property Damages	Not Available
Crop Damages	Not Available
Average Annual Damages	Not Available

Vulnerability can largely be measured as a result of aging infrastructure. According to FEMA's *Strategic Foresight Initiative* published in June 2011, "…infrastructure in the United States is becoming more prone to failure as the average age of structures increases". The publication goes on to note that many necessary updates to infrastructure failure may be considered cost prohibitive due to rising construction costs.

Some jurisdictions have noted concerns of infrastructure failure, such as Marion County, Melcher-Dallas, Harvey, Pleasantville, Central College, Melcher-Dallas Schools, and Pella Community School District. These concerns range from crumbling roadways and bridges, to inadequate sewer systems.

Geographic Location/Extent

Infrastructure failure is not correlated to a specific geographic area.

Previous Occurrences

There is no known database for recording infrastructure failure, and thus, previous occurrences may not be calculated.

Probability of Future Occurrence

With no recorded past events, future occurrences may not be calculated.

Vulnerability

Vulnerability is largely correlated to the age of structures. Older structures tend to be more vulnerable to failure.

Potential Losses to Existing Development

Losses are difficult to quantify due to a lack of recorded events. Potential losses will likely be related to aging structures.

Future Development

To limit further vulnerability from future infrastructure failure events, it is recommended that aging infrastructure be replaced or updated.

Landslide

Landslide	
No. of Events	0
Time Period	1996-2013 (18 years)
Probability	0%
Magnitude	Minor
Deaths	0
Injuries	0
Property Damages	0
Crop Damages	0
Average Annual Damages	0

A landslide is the downhill movement of masses of soil and rock by gravity. The basic ingredients for landslides are gravity, susceptible soil or rock, sloping ground, and water. Landslides occur when susceptible rock, earth, or debris moves down a slope under the force of gravity and water. Landslides may be very small or very large, and can move at slow to very high speeds. A natural phenomenon, small scale landslides have been occurring in slide-prone areas of Iowa long before human occupation. New landslides can occur because of rainstorms, fires, earthquakes, and various human activities that modify slope and drainage.

Geographic Location/Extent

The figure on the following page indicates landslide susceptibility and incidents rates across the State of Iowa. Marion County has a moderate susceptibility incidents rating for landslides. Marion County is of relatively flat terrain with no history of landslides. Southern Iowa is not mentioned as at risk in the Landslide Overview Map of the Conterminous United States issued by the United States Department of the Interior.

Previous Occurrences

There are no previous recorded occurrences of landslides in Marion County.

Probability of Future Occurrence

Based on the frequency of reported landslide events, a landslide would be expected each year in the southwestern and south central portions of the county.

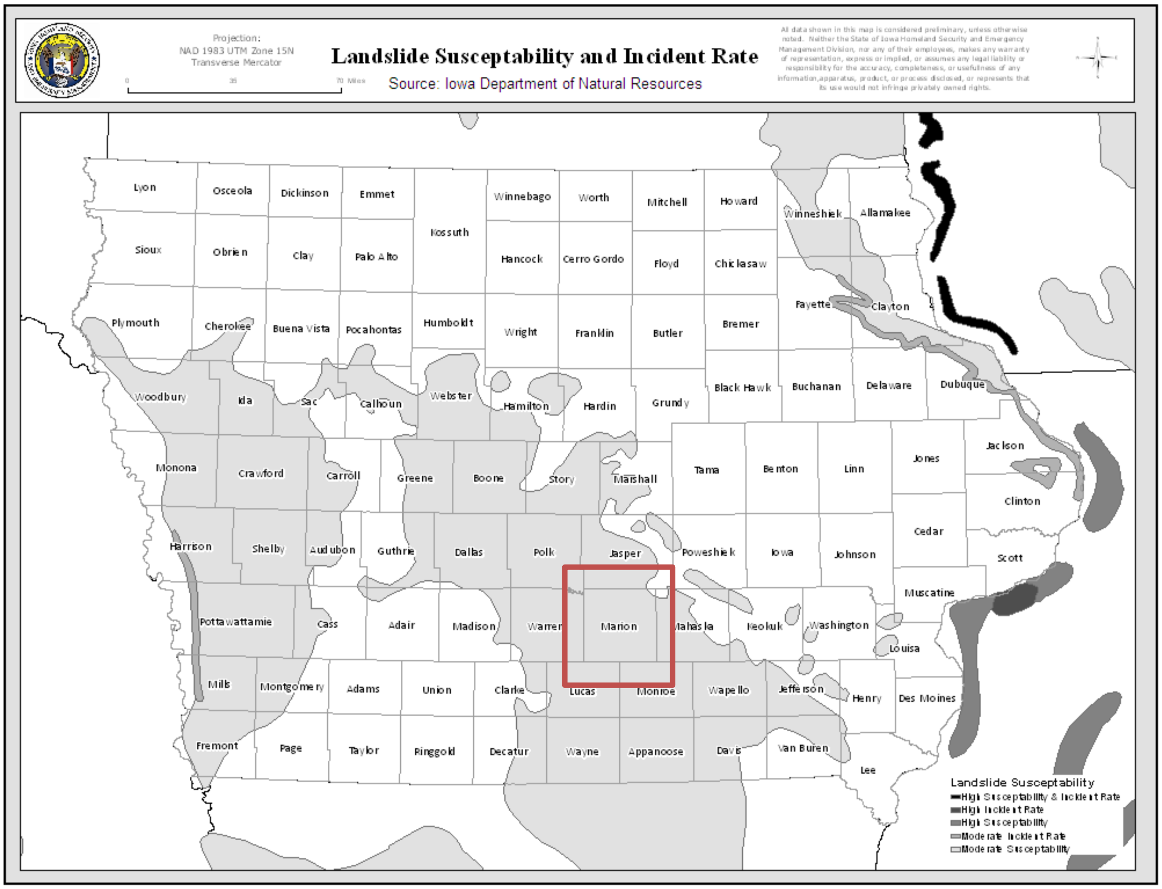
Vulnerability

There will continue to be minor landslides in the planning area. Damages are minimal and geographically limited. Existing development, more specifically, county roads in the southwestern and south central portions of the county are vulnerable to landslide.

Future Development

Future development downslope from areas prone to landslide will increase vulnerability to this hazard.

Figure 33: Landslide Susceptibility in Iowa



Source: *Iowa Department of Natural Resources*

Levee Failure

According to FEMA: "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 loss of life and injuries as well as damages to property, the environment, and the economy."

Levee Failure	
No. of Events	5
Time Period	1993-2010
Probability	Unknown
Magnitude	Minimal
Deaths	0
Injuries	0
Property Damages	Not Available
Crop Damages	Not Available
Average Annual Damages	Not Available

Levees range from small agricultural levees that protect farmland from high-frequency flooding to large urban levees that protect people and property from larger-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 of a levee as defined in FEMA's Publication —So You Live Behind a Levee" (http://content.asce.org/ASCELeveeGuide.html).

Overtopping: When a Flood Is Too Big
Overtopping occurs when floodwaters 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/Extent

Research indicates that there are no levees listed for Marion County in the National Levee Database (https://nld.usace.army.mil). After discussion with Marion County, the Planning Team, and the Iowa Department of Natural Resources, it was determined that there are no certified flood control structures located within the planning area. Flood control structures not certified by the U.S. Army Corps of Engineers are not federally recognized.

According to the 2012 HMP, there are levees which protect some developed areas within the Des Moines river valley, and the Skunk River valley has a levee near Pella. Additionally, the plan goes on to note that some earthen levee segments protect the communities of Clay Township, Swan and Harvey, as well as unincorporated areas. A levee is said to protect a private, industrial sand and gravel facility in Clay Township. The 2012 HMP notes that any existing levees likely exist to prevent damage to agricultural areas.

Through the process of updating this plan the local representatives for these communities and for the county were unable to substantiate the claims made in the 2012 HMP. In addition, the 2012 HMP contained no methodology that could be utilized to validate the information included in that document. Thus, for the 2016 HMP the county reports that there are potentially levees along the Des Moines River that provide some level of protection against floods, but the location of these structures and the level of protection are undocumented. This is consistent with the information available via the USACE Levee Database as well as the 2013 Iowa State Hazard Mitigation Plan. In the future the county would benefit from a study that would at minimum identify the location of small levees and if possible a quantification of the protection that these structures provide.

Previous Occurrences

According to the 2012 HMP, levees have failed in the Des Moines River Valley in 1993, 2009, and 2010. The 2012 HMP also cites “Federal Corps of Engineers levees”, which held against floods in 1993 and 2008.

The Sioux City Journal newpaper reported a levee breach in July of 2010 that resulted in the evacuation of approximately 10 families living east of Knoxville.

Probability of Future Occurrence

Absent records of previous levee failures in the planning area, the probability of a levee failure cannot be determined. It would be important to note, however, that levee failure is typically a secondary impact of another disaster such as flooding or earthquake, and while earthquakes are not common to the area, flooding does occur on a regular basis.

Vulnerability

Populations and assets which sit behind an uncertified levee may experience a higher level of vulnerability to a levee failure. This false sense of security may lead to increased development in inundation areas, especially due to the lack of a USACE-certified structure. Very old or very young populations, and those without access to transportation may experience a higher level of vulnerability to a levee failure; due to difficulties evacuating.

Future Development

It is recommended that future development continue away from any flood-prone areas, including low-lying areas behind uncertified levees. The county area may benefit from a study to determine the location and level of protection offered by any agricultural levees.

River Flooding

Note: Flooding caused by dam and levee failure and flash flooding are discussed separately.

River Flooding	
No. of Events	94
Time Period	1996-2015
Probability	5 events/year
Magnitude	20% of land within flood risk area
Deaths	0
Injuries	0
Property Damages (1996-2015)	$3,737,070
Crop Damages (2000-2015)	$4,610,589
Average Annual Damages Property Damage (1996-2015) Agricultral Damages (2000-2015)	 $186,853 $288,161

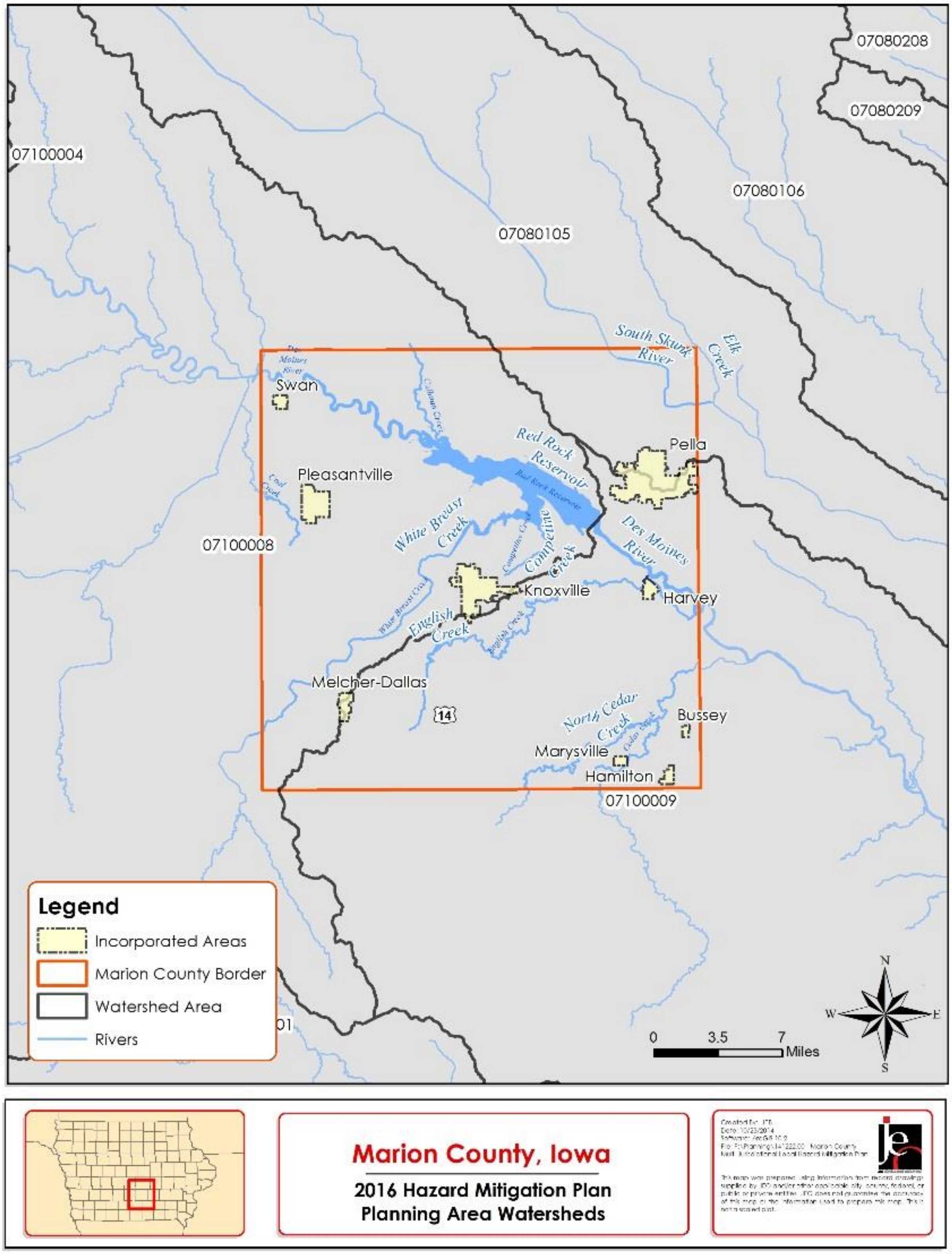
A flood is partial or complete inundation of normally dry land areas. Heavy precipitation can cause flooding either in the region of precipitation or in areas downstream. Heavy accumulations of ice or snow can also cause flooding during the melting stage. These events are complicated by the freeze/thaw cycles characterized by moisture thawing during the day and freezing at night. There are two main types of flooding in the planning area: river (or riverine) flooding and flash flooding which includes ice jam flooding.

Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt or ice melt. The areas adjacent to rivers and stream banks that carry excess floodwater during rapid runoff are called floodplains. A floodplain is defined as the lowland and relatively flat area adjoining a river or stream. The terms —base flood and —100-year flood refer to the area in the floodplain that is subject to a one percent or greater chance of flooding in any given year. Floodplains are a larger entity called a basin, which is defined as all the land drained by a river and its branches. Marion County crosses 3 watersheds as shown in the image to the right and as follows:

- South Skunk (07080105)
- Lake Red Rock (07100008)
- Lower Des Moines (07100009)

According to the 2012 HMP, Iowa has experienced 35 or more Presidential Disaster Declarations due to flooding since 1953. Many of these events have included Marion County. Marion County experiences added vulnerability due to the number of rivers within the county, including the Des Moines River, Skunk River, and White Breast River. To protect the county from dramatic flooding impacts, both the Red Rock Reservoir and the Saylorville reservoir were constructed for flood control. These dams allow local engineers to impound water temporarily and control the release of water.

Figure 19: Planning Area Watersheds



Source: https://cfpub.epa.gov/surf/

Geographic Location/Extent

Flooding has been a major problem for several of the communities in Marion County. For purposes of this hazard profile and vulnerability analysis, the geographic location/extent for river flooding will be considered as those areas at risk to the 1-percent annual chance flood (also known as the 100-year flood). The 1-percent annual chance flood has been adopted by FEMA as the base flood for floodplain management purposes.

Table 29: NFIP Status

NFIP Participation		
Jurisdiction	**Current Effective Map Date**	**NFIP Participant**
Bussey	11/16/2007	Yes
Hamilton	11/16/2007	Yes
Harvey	11/16/2007	Yes
Knoxville	11/16/2007	Yes
Marysville	11/16/2007	Yes
Melcher-Dallas	11/16/2007	Yes
Pella	11/16/2007	Yes
Pleasantville	11/16/2007	Yes
Swan	11/16/2007	No

The main flooding source in Marion County is the Des Moines River which runs from the north western area of the county to the south east border of the county. Numerous creeks and streams bisect the county as shown in the maps provided at the end of this hazard discussion. Historical cresting data for either of these rivers within the planning area was not available.

Effective FIRMS are available for Bussey, Hamilton, Harvey, Knoxville, Marysville, Melcher-Dallas, Pella, Pleasantville and Swan.

Approximately 116 square miles of Marion County is within the 1% Annual Flood Risk Area. This amounts to be 20% within the 1% Annual Flood Risk Area. Of the 24,137 buildings in Marion County, 379 are within the 1% Annual Flood Risk Area.

Below is information from the 2012 Marion County Hazard Mitigation Plan, which provides information regarding flooding areas within each jurisdiction.

Table 30: Flooding Impacts included in 2012 HMP

Jurisdiction	Flooding Details	500-Year Flood Event
Bussey	1 parcel on far southeast corner of city and sewer lagoons a half mile east	2% Inundated
Harvey	Des Moines River and small streams on north, west, and east sides of city including the sewer lagoons and extensive agricultural land along with approximately 25 parcels, including nearly 10 residential parcels fully or partly in the floodplain	20% Inundated
Knoxville	Compentine Creek along the south and east part of the city includes approximately	5% Inundated

	45 parcels, of which most are agricultural, city-owned, or residential. Of some 15 homes, several parcels are entirely within the floodplain area. The east portion includes a major road, the railroad, a church property, and open space. A small creek in the far northwest corner of town includes 4 non-residential parcels.	
Melcher-Dallas	An estimated 60-parcels in the center and eastern part of the town, with approximately 20 homes, 2 businesses, 5 agricultural parcels, and open space. Several residential lots are entirely in the floodplain. The planning team notes that travel in town is greatly hindered by the location of flooding.	15% Inundated
Pella	A small stream crosses the northwest portion of town whether new development has occurred, including approximately 25 parcels, 4 of which are agricultural, 1 is city-owned, and 18 are high-end residential parcels, but none of the residential parcels are fully in the floodplain. Along the east edge of town are two parcels partly in the floodplain, one of which is city-owned and the other is a $1.2 million apartment building	3% Inundated
Pleasantville	Southwest part of town bordering the sewer lagoons and including approximately 15 parcels of agricultural land and IDOT and City ROW.	3% Inundated
Swan	Northeast edge of city including approximately 8 parcels, 5 of which are residential, and none are entirely within the floodplain.	Not Included
Rural Incorporated Area	15% of the county area, including 10% of the land of the county, most of which is agriculture but also including roads, bridges, railroads, forested areas, public recreation lands, and some partial lots of acreages and farm structures.	15% of County

Source: 2012 Marion County HMP

According to the 2012 HMP, 1% of properties/buildings, 7% of values and 6% of Marion County's population occupies a Special Flood Hazard Area. Upstream dams have likely protected Marion County from past flooding events, but structures may be impacted by flooding.

Previous Occurrences

Marion County has had an extensive history of flooding as evidenced by the indicators and accounts offered as follows. The NCDC has recorded 90 flooding events in Marion County, the table below shows only storms which resulted in damages to either property or crops. Because a single precipitation cell may effect a number of different communities, the analysis of flooding will use the NCDC's 'event' metric, as opposed to an 'episode'.

Table 31: NCDC Flash Flood Events 1996-2015

Event ID	Date/Time	Jurisdiction	Property Damage
5540510	2/9/1996 6:00	BUSSEY	0.00K
5544666	5/9/1996 6:00	COUNTY-WIDE	0.00K
5544258	5/9/1996 23:30	COUNTY-WIDE	50K
5544266	5/10/1996 4:00	COUNTY-WIDE	0.00K
5544690	5/23/1996 15:00	COUNTY-WIDE	0.00K
5544714	5/26/1996 12:00	COUNTY-WIDE	0.00K
5553851	6/17/1996 3:00	COUNTY-WIDE	0.00K
5586122	2/18/1997 18:00	KNOXVILLE	0.00K
5613759	5/7/1997 18:00	KNOXVILLE	0.00K
5640165	4/7/1998 12:00	COUNTY-WIDE	15K
5640179	4/21/1998 6:00	KNOXVILLE	.5K
5646500	5/6/1998 21:15	COUNTY-WIDE	50K
5647095	5/7/1998 1:00	COUNTY-WIDE	25K
5647209	5/24/1998 6:00	COUNTY-WIDE	25K
5653131	6/8/1998 18:00	COUNTY-WIDE	50K
5653147	6/14/1998 9:00	BUSSEY	.1M
5654092	6/14/1998 16:00	BUSSEY	50K
5653160	6/18/1998 2:00	BUSSEY	.1M
5654302	6/18/1998 10:00	BUSSEY	40K
5653254	6/21/1998 6:00	KNOXVILLE	.1M
5653715	7/6/1998 3:00	BUSSEY	50K
5652951	7/6/1998 3:30	BUSSEY	25K
5668271	10/5/1998 6:00	KNOXVILLE ARPT	25K
5669397	10/17/1998 6:00	MELCHER	70K
5693678	5/16/1999 21:00	BUSSEY	.2M
5693708	5/21/1999 15:00	BUSSEY	50K
5699281	6/9/1999 6:00	KNOXVILLE	50K
5148595	6/24/2000 3:00	COUNTY-WIDE	50K
5233717	3/15/2001 15:00	MELCHER	5K
5233880	3/23/2001 18:00	COUNTY-WIDE	7.5K
5237733	4/7/2001 21:00	COUNTY-WIDE	.15M
5242551	5/11/2001 6:00	KNOXVILLE	25K
5246860	6/12/2001 15:00	COUNTY-WIDE	25K
5292696	5/11/2002 6:00	COUNTY-WIDE	10K
5294551	6/13/2002 16:00	COUNTY-WIDE	10K
5351969	5/4/2003 12:00	PLEASANTVILLE	5K
5352438	5/9/2003 6:00	BUSSEY	5K
5393687	5/22/2004 18:00	BUSSEY	.1M
5446552	5/13/2005 2:00	BUSSEY	30K
5454728	6/26/2005 0:00	RUNNELLS	74.07K
21810	4/25/2007 12:15	DALLAS	25.00K
20643	4/26/2007 6:00	BUSSEY	250.00K
25654	5/6/2007 23:30	BUSSEY	25.00K
20718	5/7/2007 6:11	BUSSEY	300.00K

49800	8/24/2007 6:45	BUSSEY	25.00K
73642	3/3/2008 9:00	BUSSEY	100.00K
92799	4/11/2008 1:30	BUSSEY	10.00K
92806	4/18/2008 6:00	HAMILTON	15.00K
105496	6/8/2008 15:30	PERSHING	500.00K
105716	6/26/2008 16:19	FIFIELD	10.00K
111900	7/8/2008 5:17	COUNTY-WIDE	10.00K
111899	7/8/2008 5:22	BUSSEY	10.00K
111998	7/28/2008 0:40	COUNTY-WIDE	50.00K
112000	7/28/2008 20:20	COUNTY-WIDE	25.00K
130734	9/13/2008 6:36	SWAN	0.00K
140010	12/27/2008 12:55	BUSSEY	5.00K
153804	3/8/2009 11:33	BUSSEY	25.00K
149635	3/8/2009 12:23	BUSSEY	25.00K
156339	4/27/2009 2:00	OLIVET	5.00K
156338	4/27/2009 2:00	BUSSEY	5.00K
156340	4/27/2009 2:00	BUSSEY	10.00K
158434	4/27/2009 6:28	OTLEY	10.00K
164385	5/14/2009 20:48	BUSSEY	10.00K
170041	6/18/2009 9:40	BUSSEY	5.00K
188988	8/27/2009 18:28	BUSSEY	0.00K
195893	10/23/2009 0:09	BUSSEY	0.00K
195898	10/29/2009 22:53	BUSSEY	0.00K
200729	12/25/2009 6:54	BUSSEY	0.00K
204514	1/24/2010 0:43	BUSSEY	0.00K
214739	3/10/2010 0:05	BUSSEY	25.00K
214776	3/19/2010 12:27	BUSSEY	25.00K
219713	4/25/2010 2:57	BUSSEY	50.00K
217183	4/25/2010 7:00	BUSSEY	50.00K
223545	5/11/2010 10:20	BUSSEY	5.00K
223548	5/13/2010 4:20	SWAN	50.00K
252543	6/12/2010 12:00	COUNTY-WIDE	0.00K
230786	6/14/2010 6:54	COUNTY-WIDE	75.00K
231122	6/22/2010 18:51	COUNTY-WIDE	25.00K
238667	7/5/2010 6:42	COUNTY-WIDE	10.00K
238702	7/18/2010 8:02	COUNTY-WIDE	100.00K
248965	8/9/2010 6:04	COUNTY-WIDE	50.00K
254794	9/24/2010 9:28	COUNTY-WIDE	0.00K
277862	2/17/2011 22:18	COUNTY-WIDE	10.00K
300896	5/25/2011 6:13	COUNTY-WIDE	25.00K
311333	6/10/2011 3:15	COUNTY-WIDE	100.00K
311384	6/27/2011 6:10	COUNTY-WIDE	25.00K
434982	4/18/2013 2:10	COUNTY-WIDE	25.00K
434983	4/18/2013 2:10	COUNTY-WIDE	25.00K
434990	4/18/2013 3:46	COUNTY-WIDE	10.00K
Total			**$3,712,070**

NCDC data from 1996 to 2015 shows that flooding caused $3,712,070 in structural damages. The RMA reports $4,610,589 in crop damages from 2000 to 2015.

Marion County has had an extensive history of flooding as evidenced by the indicators and accounts offered as follows. Eight federal disaster and emergency declarations the have included Marion County and were associated with flooding are highlighted below.

Table 25: Disaster Declarations that included Flooding for Marion County, Iowa

Disaster Number	Description	Declaration Date
DR-193	Flooding	4/22/1965
DR-269	Heavy Rains and Flooding	8/14/1969
DR-259	Flooding	4/25/1969
DR-386	Severe Storms and Flooding	5/23/1973
DR-443	Severe Storms and Flooding	6/24/1974
DR-868	Severe Storms and Flooding	5/26/1990
DR-996	Severe Storms and Flooding	7/9/1993
DR-1230	Severe Storms, Tornadoes and Flooding	7/2/1998
DR-4119	Severe Storms, Straight-Line Winds, and Flooding	5/31/2013

While the NCDC recorded 90 flooding events from 1996-2015, a few of the corresponding event narratives were used from the Midwestern Regional Climate Center.

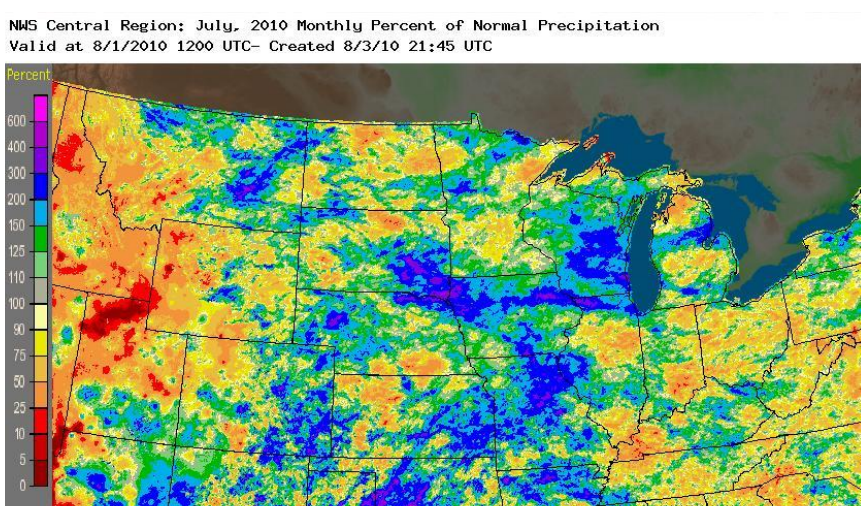
June, 2008 Flood

The Midwestern Regional Climate Center's (MRCC) Midwest Climate Watch identified significant rainfall resulting in flooding in north-central and south-central areas of the state. These events led to the governor declaring 29 counties under a state disaster proclamation.

July, 2010 Flooding

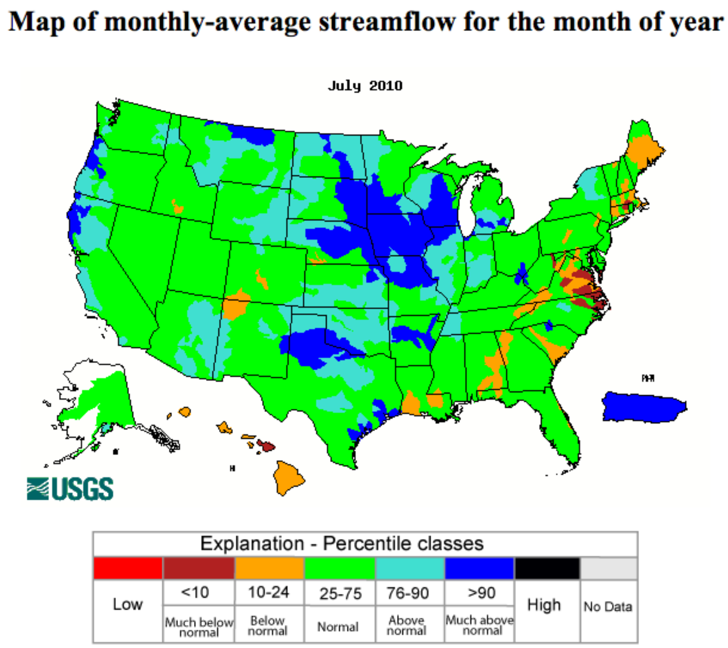
The MRCC's Midwest Climate watch identified significant rainfall resulting in flooding for much of the Midwest. Precipitation ranged from 25% to 300% above normal. Figure 34 shows Marion County between Nearly all of Iowa had precipitation above the 90th percentile average streamflow for July (Figure 35).

Figure 34: Monthly Percent of Normal Precipitation



Source: NWS

Figure 35: Monthly Streamflow for July 2010



Source: NWS, USGS

Repetitive Loss/Severe Repetitive Loss Properties

The Iowa Department of Natural Resources (IDNR) was contacted to determine if any existing buildings, infrastructure, or critical facilities are classified as NFIP Repetitive Loss Structures. According to the IDNR, the planning area has two NFIP Repetitive Loss Structures (as of April, 2016), both of which are in the unincorporated area of the county.

Crop Losses Due to Flooding

Insured crop losses associated with flooding are provided in the table below.

Table 26: Claims Paid in Marion County for Crop Loss as a Result of Flooding Events (2000-2015)

	Corn	Soybeans	Other	Total
2000	$0	$1,117	$0	$1,117
2001	$0	$1,205	$0	$1,205
2002	$5,564	$594	$0	$6,158
2003	$0	$0	$0	$0
2004	$151,769	$28,088	$0	$179,857
2005	$761	$1,327	$0	$2,088
2006	$0	$0	$0	$0
2007	$25,285	$4,884	$0	$30,169
2008	$1,905,579	$902,489	$0	$2,808,068
2009	$11,929	$12,700	$0	$24,629
2010	$384,374	$185,990	$0	$570,365
2011	$187,477	$22,159	$0	$209,636
2012	$0	$0	$0	$0
2013	$149,201	$10,086	$0	$159,287

2014	$342,260	$211,009	$0	$553,270
2015	$45,071	$19669	$0	$64,740
Total	$3,209,270	$1,401,317	$0	$4,610,589
Average Annual Loss	$200,579	$87,582	$0	$288,161

Source: http://www.rma.usda.

Over the sixteen-year data period associated with insured crop losses, $4,610,589 in claims were awarded. This represents an annual insured loss of $288,161.

Probability of Future Occurrence

With ninety NCDC reported flooding events over the 18-year period between 1996 and 2015, the planning area can expect a 100% chance of a flooding event occurring any given year.

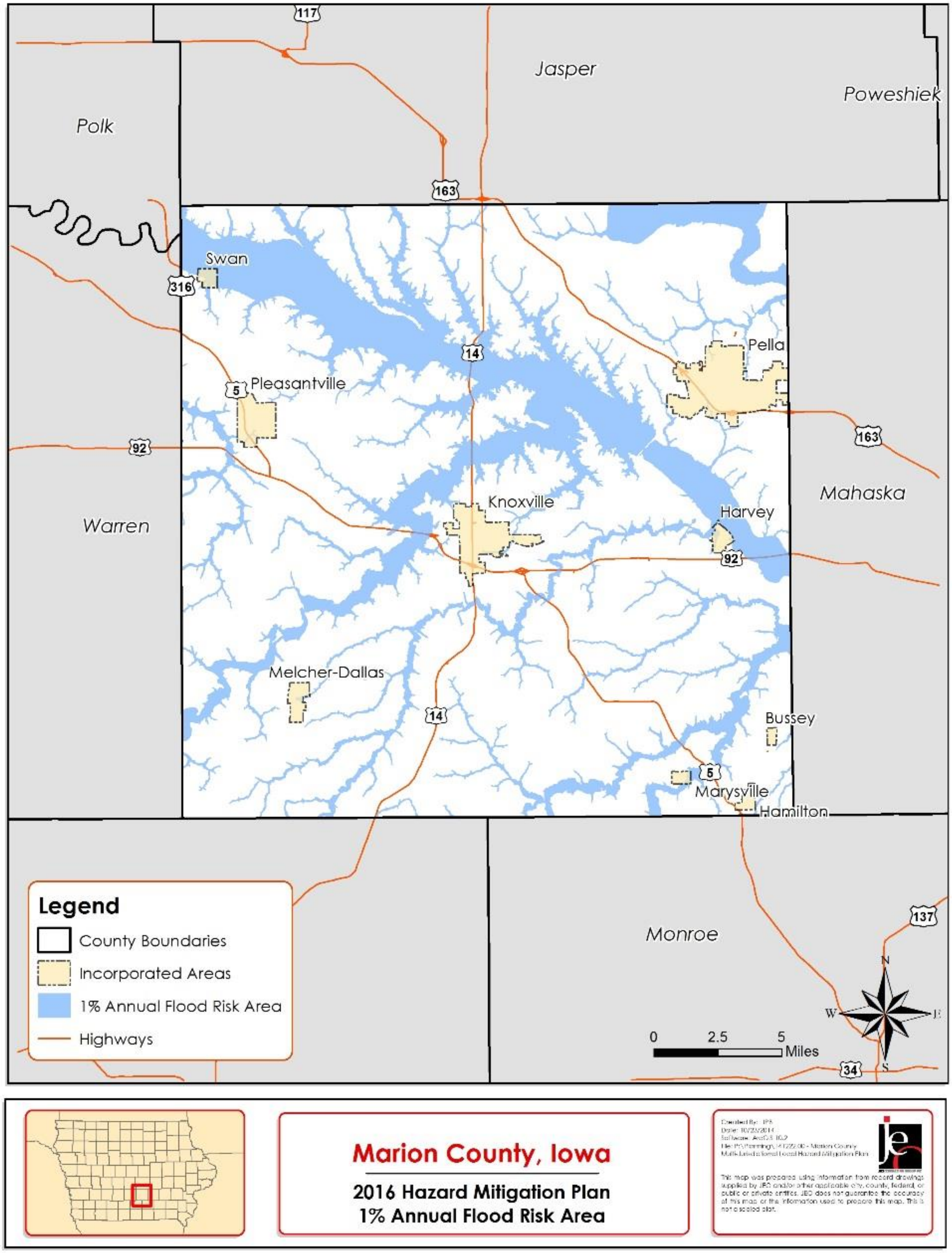
Vulnerability

The jurisdictions with a delineated 1% Annual Flood Risk Area, generally due to the presence and close proximity of significant floodway, are more vulnerable to riverine and flash flooding. The potential for localized low-land flooding, especially flash floods with heavy rains, for properties in or near low-lying areas as well as areas where drainage is inadequate is still present throughout rural areas of the County without a delineated 1% Annual Flood Risk Area.

A more detailed description of the areas impacted by flooding, specifically location and extent of flash flooding, for rural areas of the County without a delineated 1% Annual Flood Risk Area, may be considered for the five-year plan update. Figure 8 displays the 1% Annual Flood Risk Area.

According to the FEMA Map Service Center website (www.msc.fema.gov), all nine incorporated jurisdictions in Marion County, have FEMA-approved Flood Insurance Rate Map (FIRM) panels. The County itself does not have a FEMA-approved FIRM panel.

Figure 36: 1% Annual Flood Risk Area



Future Development

Any future development in floodplains would increase risk in those areas. For those communities that participate in the National Flood Insurance Program, enforcement of the floodplain management regulations will ensure mitigation of future construction in those areas. However, even if structures are mitigated, evacuation may still be necessary due to rising waters. In addition, floods that exceed mitigated levels may still cause damages.

It is recommended that development not occur in Lake Red Rock's flood pool area. During times of heavy precipitation, the flood pool temporarily impounds water to allow for a controlled release of water downstream.

Future development maps and 1% Annual Flood Risk Areas, when available, can be found in each of the participant's *Participant Sections.*

Figure 37: Bussey 1% Annual Flood Risk Area

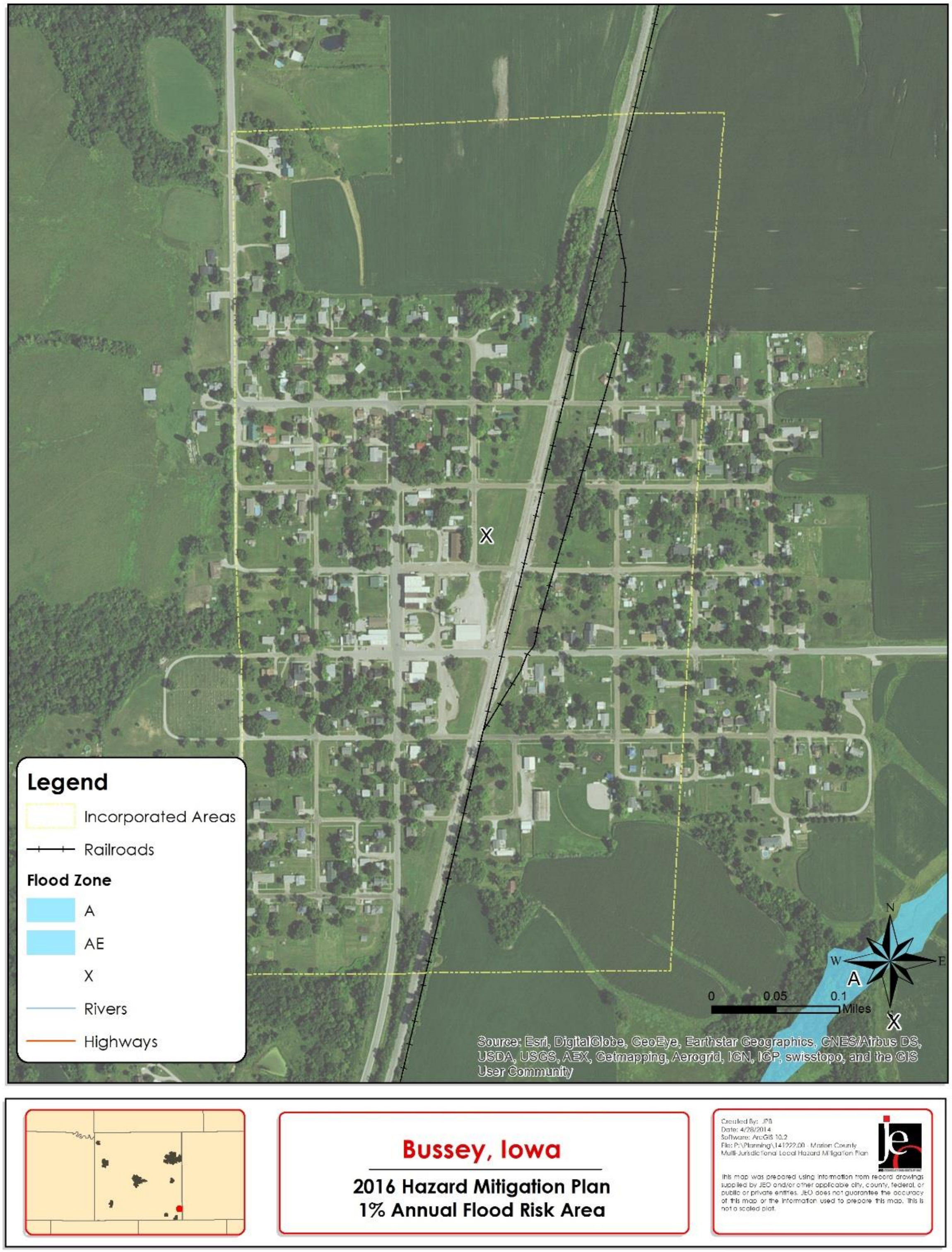


Figure 38: Hamilton 1% Annual Flood Risk Area

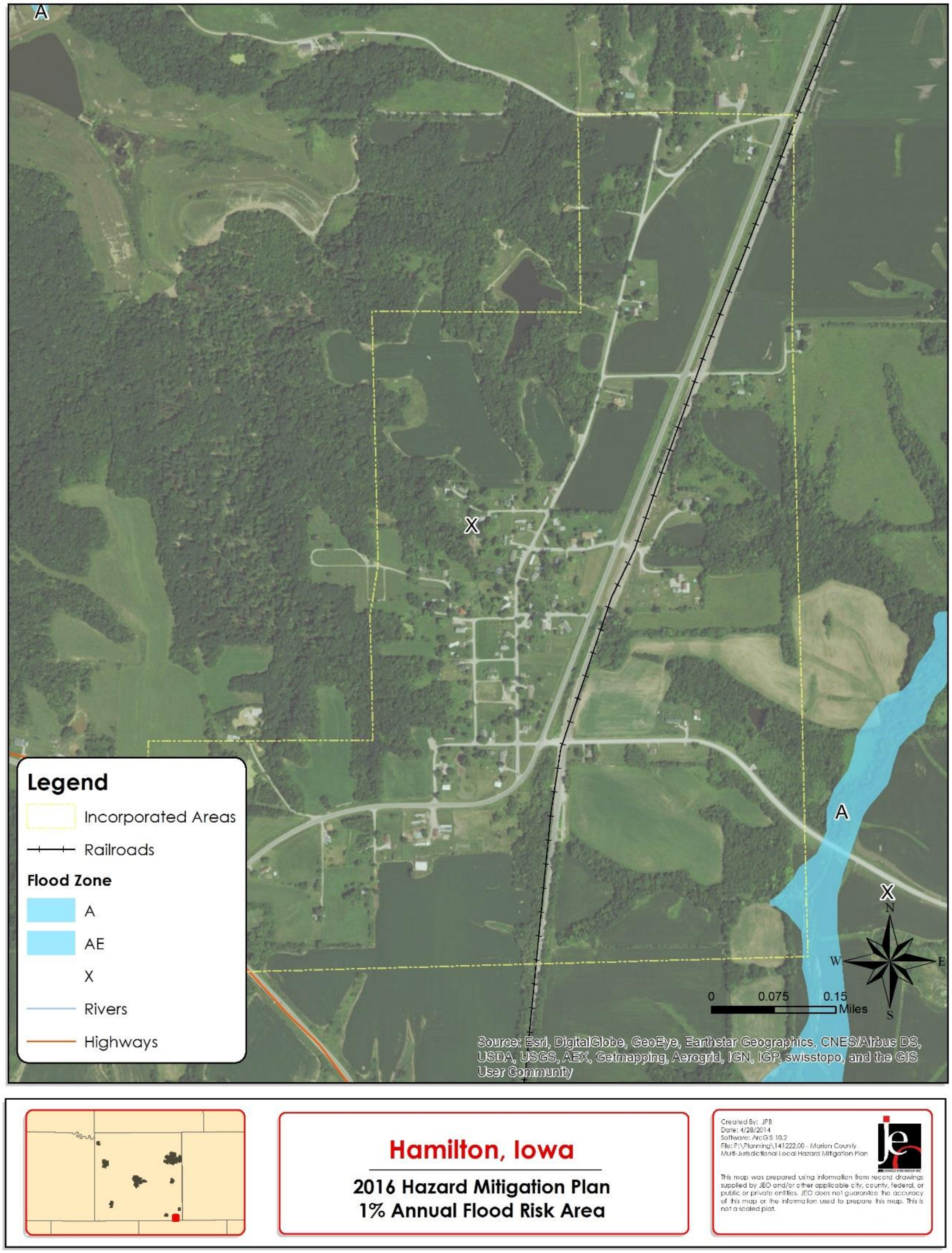


Figure 39: Harvey 1% Annual Flood Risk Area

Figure 40: Knoxville 1% Annual Flood Risk Area

Figure 41: Marysville 1% Annual Flood Risk Area

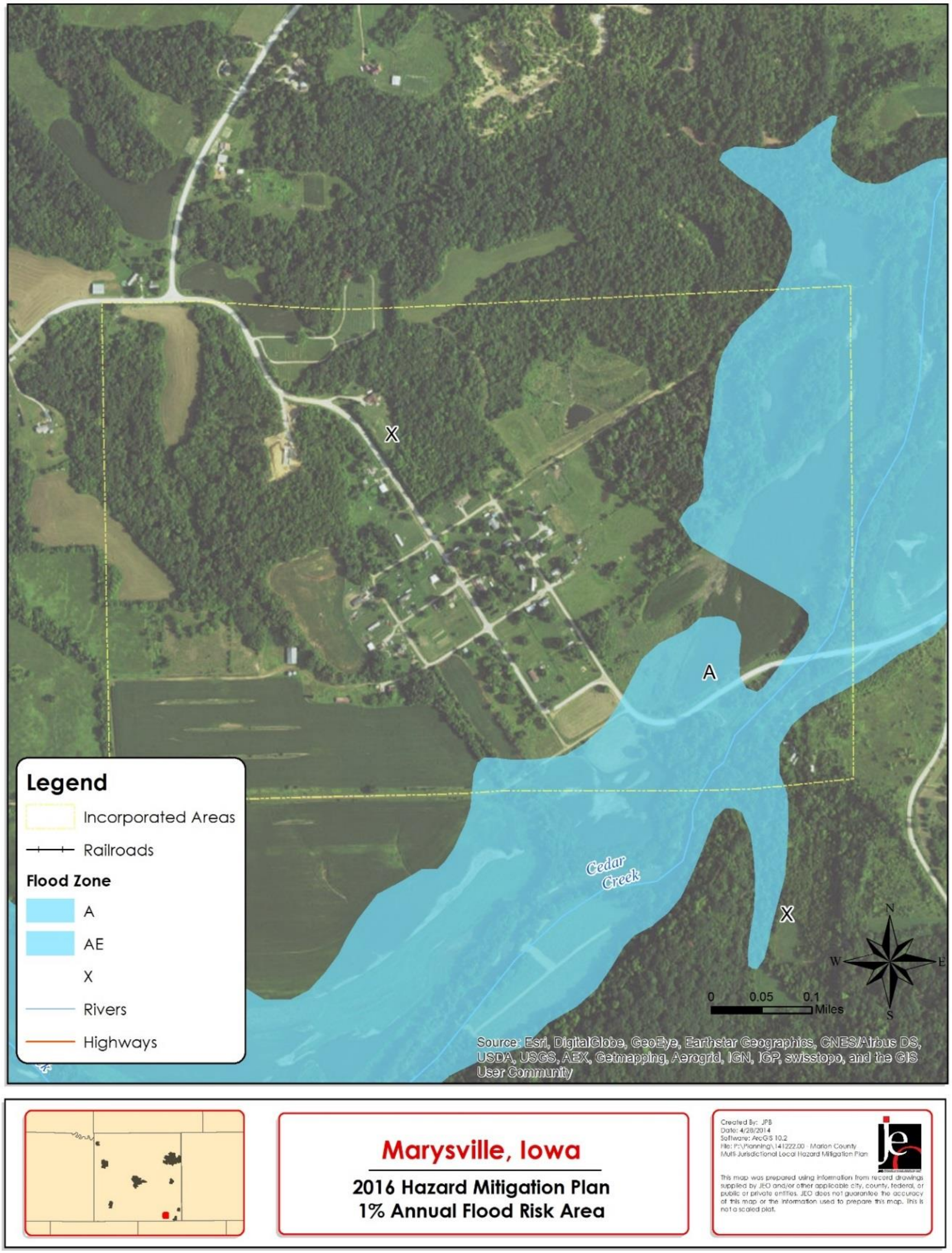


Figure 42: Melcher-Dallas 1% Annual Flood Risk Area

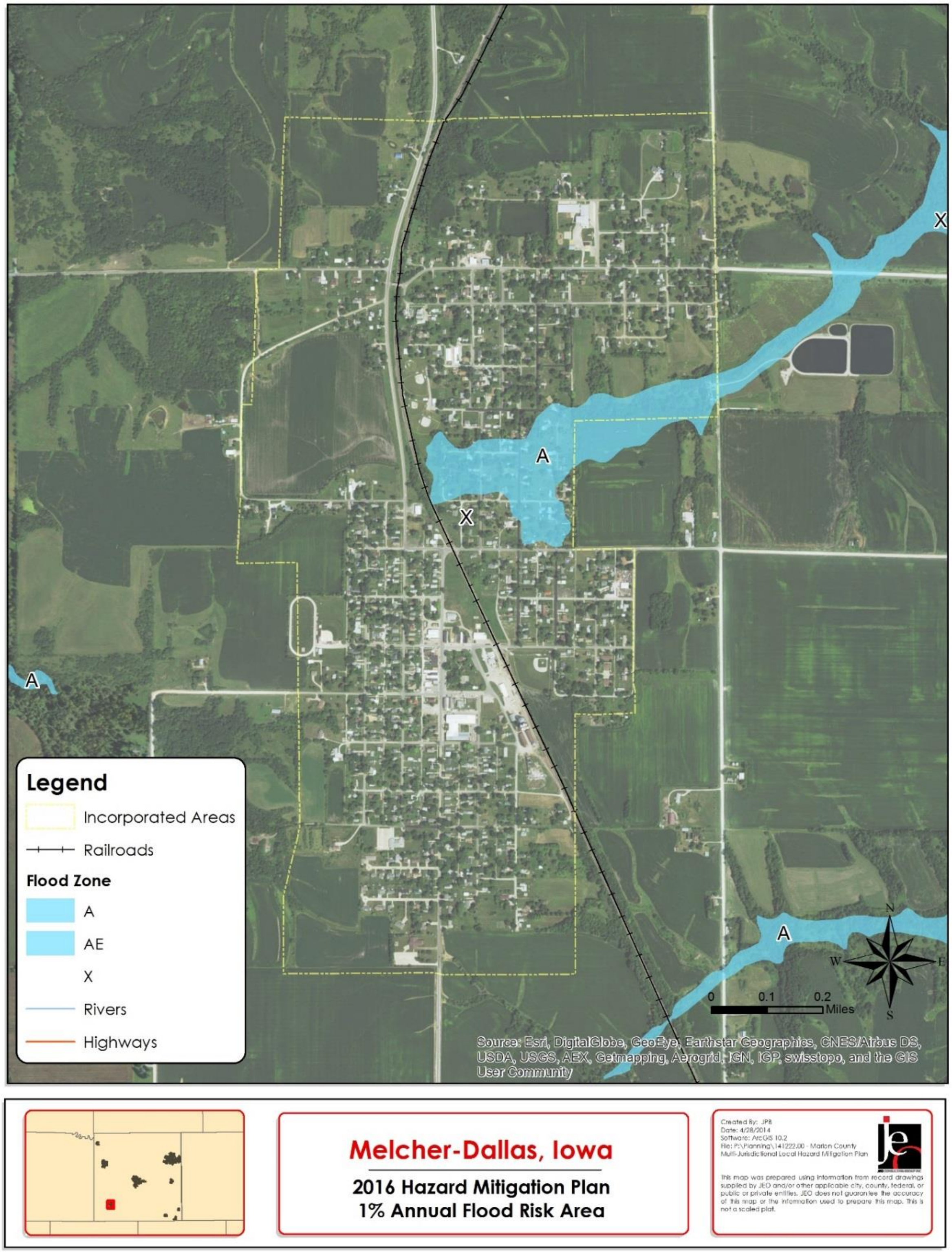


Figure 43: Pella 1% Annual Flood Risk Area

Figure 44: Pleasantville 1% Annual Flood Risk Area

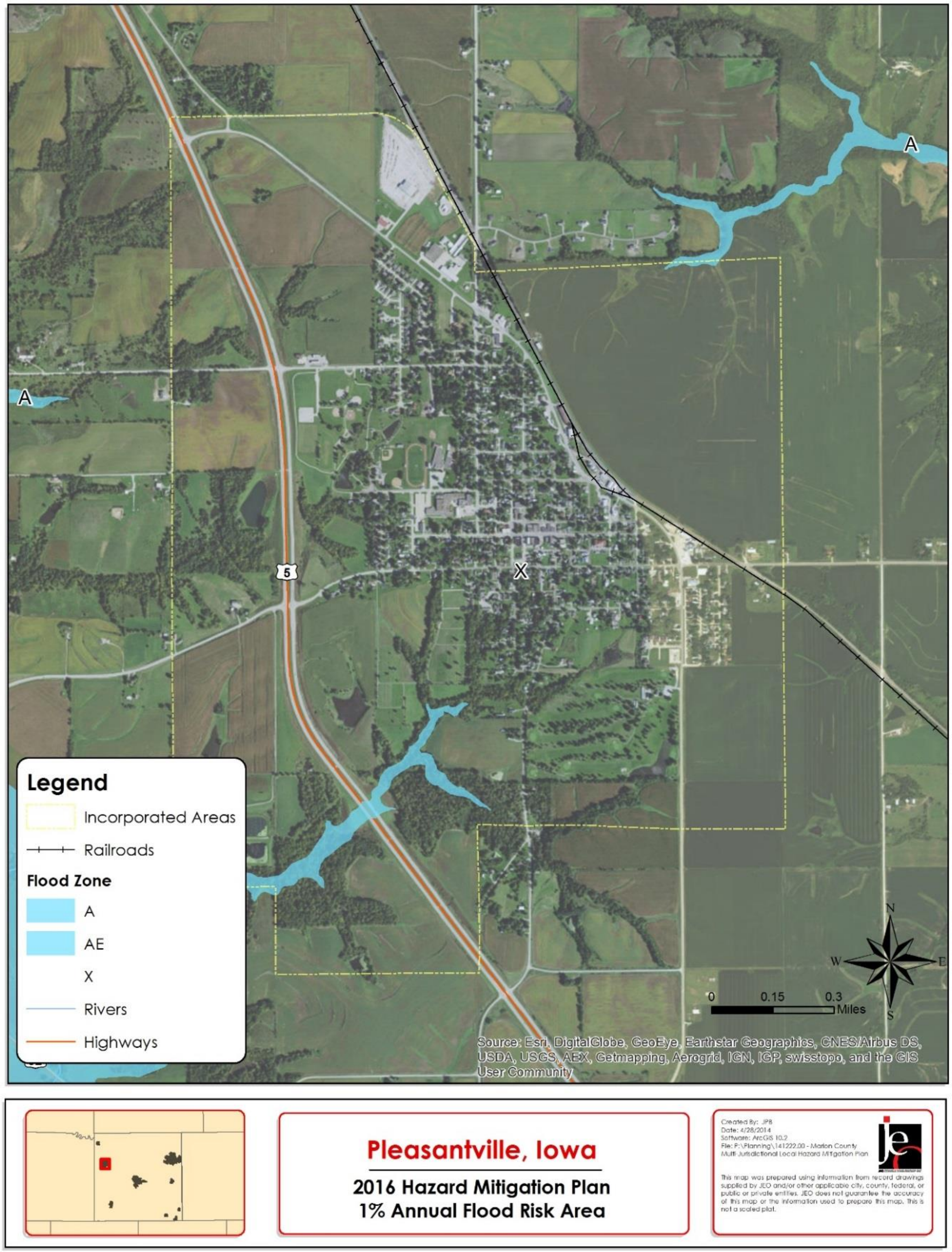
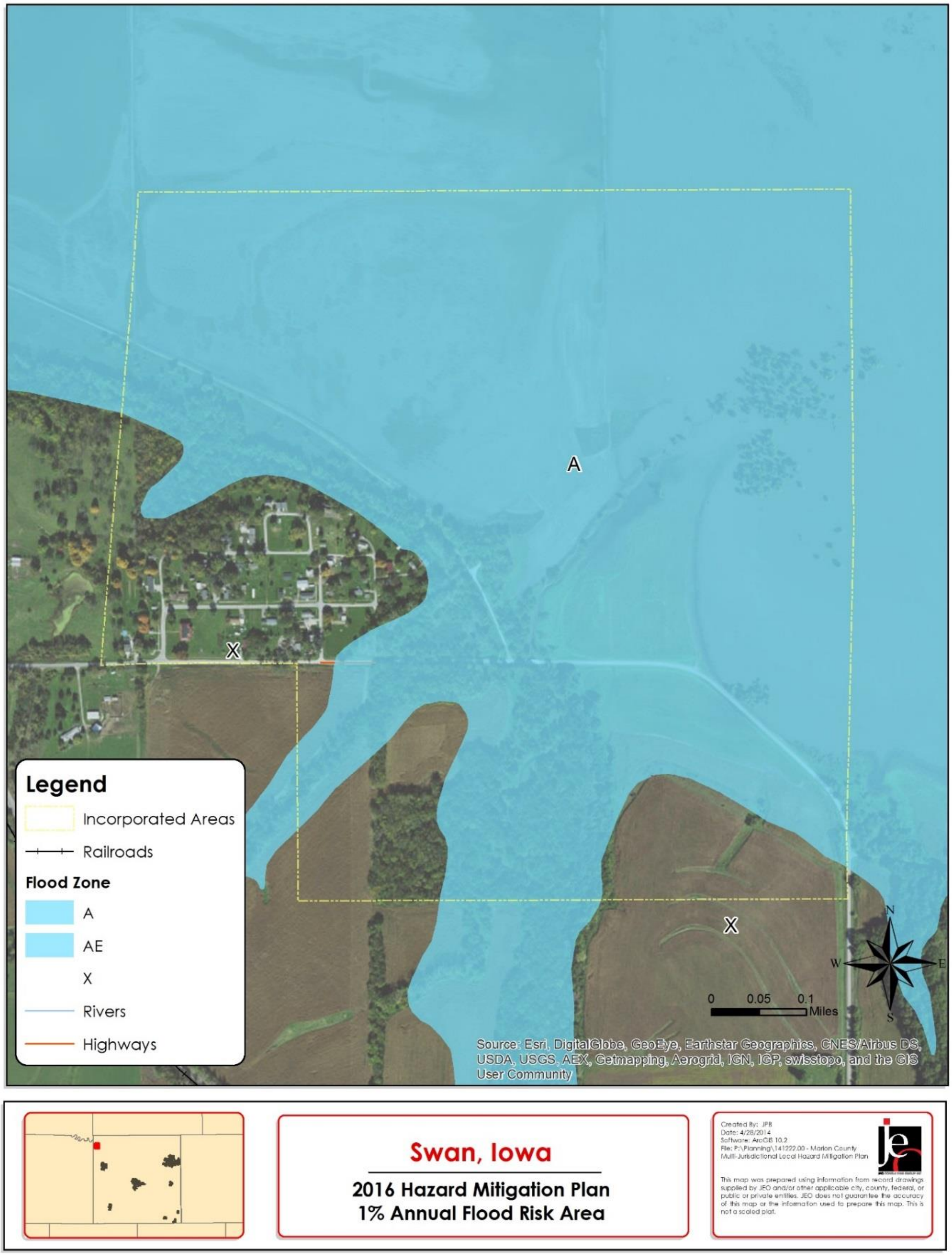


Figure 45: Swan 1% Annual Flood Risk Area



Severe Winter Storm & Extreme Cold

Severe Winter Storm	
No. of Events	8
Time Period	1996-2015
Probability	100%
Magnitude	~2.0-2.9 inches
Deaths	0
Injuries	0
Property Damages (1996-2015)	$122,656,000
Crop Damages* (2000-2015)	$1,595,856
Average Annual Damages* Property Damages (1996-2015) Agricultral Damages* (2000-2015)	$6,132,800 $99,741

*Because these data come from the RMA, which does not distinguish between severe winter storms and extreme cold, it is impossible to isolate these damages.

A major winter storm can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. The National Weather Service describes different types of winter storm events as follows:

- Blizzard—Winds of 35 mph or more with snow and blowing snow reducing visibility to less than 1/4 mile for at least three hours.
- Blowing Snow—Wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground picked up by the wind.
- Snow Squalls—Brief, intense snow showers accompanied by strong, gusty winds. Accumulation may be significant.
- Snow Showers—Snow falling at varying intensities for brief periods of time. Some accumulation is possible.
- Freezing Rain—Measurable rain that falls onto a surface with a temperature below freezing. This causes it to freeze to surfaces, such as trees, cars, and roads, forming a coating or glaze of ice. Most freezing-rain events are short lived and occur near sunrise between the months of December and March.
- Sleet—Rain drops that freeze into ice pellets before reaching the ground. Sleet usually bounces when hitting a surface and does not stick to objects.

Heavy accumulations of ice, often the result of freezing rain, can bring down trees, utility poles, and communications towers and disrupt communications and power for days. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians.

Severe winter storms include extreme cold, heavy snowfall, ice, and strong winds which can push the wind chill well below zero degrees in the planning area. Heavy snow can bring a community to a standstill by inhibiting transportation (in whiteout conditions), weighing down utility lines, and by causing structural collapse in buildings not designed to withstand the weight of the snow. Repair and snow removal costs can be significant. Ice buildup can collapse utility lines and communication towers, as well as make transportation difficult and hazardous. Ice can also become a problem on roadways if the air temperature is high enough so that precipitation falls as freezing rain rather than snow.

Extreme Cold

Extreme cold often accompanies severe winter storms and can lead to hypothermia and frostbite in people who are exposed to the weather without adequate clothing protection. Cold can cause fuel to congeal in storage tanks and supply lines, stopping electric generators. Cold temperatures can also overpower a building's heating system and cause water and sewer pipes to freeze and rupture. Extreme cold also increases the likelihood for ice jams on flat rivers or streams. When combined with high winds from winter storms, extreme cold becomes extreme wind chill, which is extremely hazardous to health and safety.

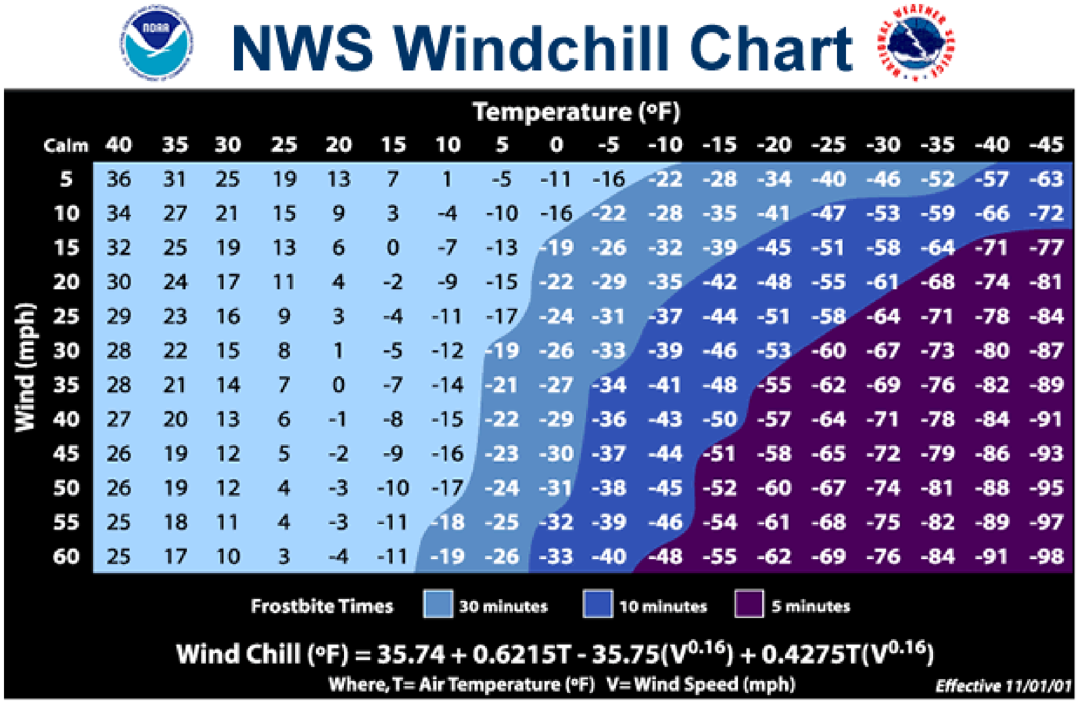
Extreme Cold	
No. of Events	7
Time Period	1996-2015
Probability	100%
Magnitude	
Deaths	0
Injuries	0
Property Damages (1996-2015)	$0
Crop Damages* (2000-2015)	NA
Average Annual Damages* (2000-2015)	0

*Because these data come from the RMA, which does not distinguish between severe winter storms and extreme cold, it is impossible to isolate these damages. For losses refer to the Severe Winter storm table.

For the region, the coldest months of the year are December, January, and February. The mean minimum for these months are all below freezing (average low for the three months 19.2°F). The mean max temperatures for the months of December, January, and February are near 33.9°F. Whenever temperatures drop decidedly below normal and as wind speeds increase people are at greater risk of hypothermia and frostbite, and when exposure lasts long enough, it can cause death.

Wind can greatly amplify the impact of cold ambient air temperatures. The figure below, provided by the National Weather Service, shows the relationship of wind speed to apparent temperature and typical time periods for the onset of frostbite.

Figure 24: Wind Chill Chart


NWS Windchill Chart

Temperature (°F)

Wind (mph)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

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

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

Effective 11/01/01

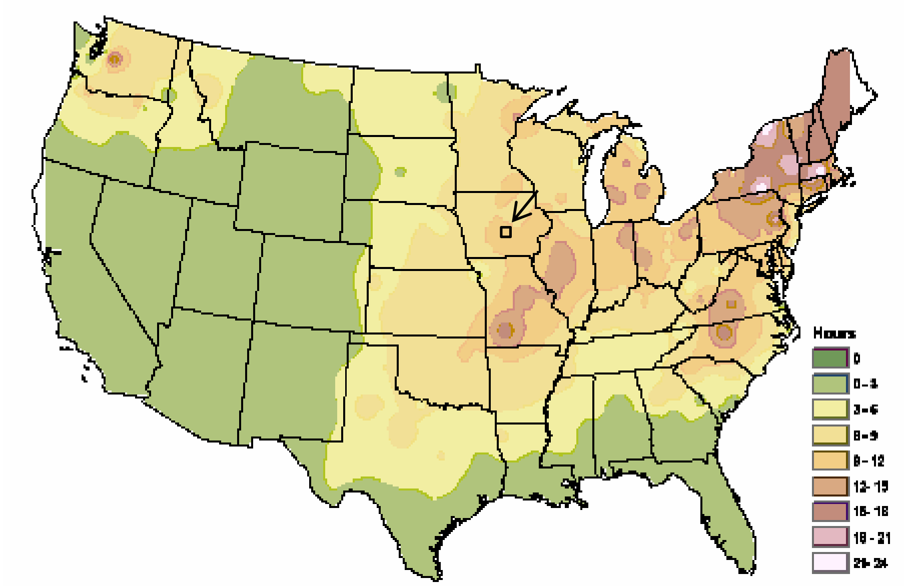
Source: NOAA

Geographic Location/Extent

Marion County, like the entire state of Iowa is vulnerable to heavy snow, extreme temperatures and freezing rain. The snow season normally extends from late October through mid-April, significant snows have fallen as early as October 10, (2009), and as late as May 28 (1947). Seasonally, the average is 35.3" inches of snow per year.

The figure below shows that the entire planning area (approximated with the outlined box) is in an area that receives between 9 and 12 hours of freezing rain per year.

Figure 25: Average Number of Hours per Year with Freezing Rain



Source: American Meteorological Society. —Freezing Rain Events in the United States.
http://ams.confex.com/ams/pdfpapers/71872.pdf

The most common snowfall events above two inches are between 2 and 2.9 inches. From 1951-2013, the Knoxville weather station experienced 153 events between 2 and 2.9 inches.

Table 29: Number of Daily Snowfall Events 2 Inches or Greater Recorded at the Knoxville Weather Station (1951-2013)

Inches of Snowfall	Number of Events
2 to 2.9	153
3 to 3.9	93
4 to 4.9	57
5 to 5.9	28
6	24
7 to 7.5	7
8 to 8.5	6
9 to 10	5
11	1
12	3
13	1
14	1
16	1

Source: Iowa Environmental Mesonet, Iowa State University Department of Agronomy,
http://mesonet.agron.iastate.edu/request/coop/fe.phtml

Previous Occurrences

The NCDC reports a variety of events which may be classified as severe winter storms. For the purposes of analysis; blizzard, cold/wind chill, extreme cold/wind chill, frost/freeze, heavy snow, ice storm, winter storm and winter weather will all be included in the Severe Winter Storm analysis. Additionally, as severe winter storms are large, regional events, which affect a variety of communities at the same time. Impacts are considered “zonal events” where the impacted area is county-wide.

67 severe winter storm events for the planning area from January 1996 through December 2015. Of the reported events, 40 events recorded damages. Below is a table of all NCDC events which recorded damages from 1996 to 2015. No recorded severe winter storm episodes resulted in deaths or injuries.

Table 32: NCDC [Extreme] Cold/Wind Chill Events from 1996-2015

County	Episode ID	Event Type	Date/Time	Property Damages
Marion	1403179	Cold/Wind Chill	1/18/1996 2:00	0.00K
Marion	1403187	Cold/Wind Chill	2/1/1996 16:00	0.00K
Marion	1032429	Cold/Wind Chill	5/1/1996 0:00	0.00K
Marion	1057532	Cold/Wind Chill	1/9/1997 21:00	0.00K
Marion	1057534	Cold/Wind Chill	1/15/1997 21:00	0.00K
Marion	1412612	Cold/Wind Chill	9/21/1999 1:00	0.00K
Marion	80506	Extreme Cold/Wind Chill	1/5/2014 21:00	0.00K

Source: NCDC

Table 33: NCDC Blizzard, Frost/Freeze, Heavy Snow, Ice Storm, Winter Storm & Winter Weather Events from 1996-2015

County	Episode ID	Event Type	Date/Time	Property Damages
Marion	1403179	5539499	1/18/1996 2:00	0.00K
Marion	1403180	5539750	1/18/1996 9:00	0.00K
Marion	1403184	5540261	1/26/1996 12:00	0.00K
Marion	1403300	5542214	1/28/1996 20:00	0.00K
Marion	1403187	5540486	2/1/1996 16:00	0.00K
Marion	1032429	5544917	5/1/1996 0:00	0.00K
Marion	1044572	5566601	9/14/1996 2:00	0.00K
Marion	1049520	5573988	11/14/1996 16:00	0.00K
Marion	1057532	5585412	1/9/1997 21:00	0.00K
Marion	1057534	5585625	1/15/1997 21:00	0.00K
Marion	47342	5613728	5/13/1997 0:00	0.00K
Marion	1070651	5622488	12/21/1997 14:00	2.05K
Marion	1072047	5629067	1/4/1998 6:30	20.4K
Marion	1073178	5634589	3/17/1998 2:00	5.88K
Marion	501363	5679174	1/1/1999 15:00	10K
Marion	502857	5682952	2/11/1999 9:00	5K
Marion	76884	5682230	3/8/1999 0:00	10K
Marion	1412612	5719145	9/21/1999 1:00	0.00K
Marion	104803	5165704	12/10/2000 21:00	24.9K
Marion	110583	5230802	2/8/2001 16:00	75K
Marion	110584	5230916	2/8/2001 23:00	50K
Marion	145634	5339540	1/28/2003 5:00	0.00K
Marion	146587	5338303	2/14/2003 11:00	5K
Marion	1638	7943	2/12/2007 22:30	0.00K
Marion	1860	9203	2/24/2007 3:00	250.00K
Marion	11200	61573	12/1/2007 6:00	10.00K
Marion	11327	62273	12/11/2007 0:00	100.00K
Marion	11586	63729	12/22/2007 12:00	0.00K
Marion	12487	68471	2/5/2008 11:00	10.00K
Marion	12757	70182	2/17/2008 2:00	50.00K
Marion	23652	138028	12/18/2008 19:00	20.00K
Marion	23834	139092	12/27/2008 8:00	5.00K
Marion	33134	193046	10/10/2009 2:00	0.00K
Marion	34353	198677	12/9/2009 1:00	50.00K
Marion	34887	201233	1/6/2010 16:00	25.00K
Marion	35081	202533	1/20/2010 3:00	100.00K
Marion	35157	203256	1/25/2010 14:00	75.00K
Marion	35506	210579	2/8/2010 7:00	10.00K
Marion	45538	269051	12/11/2010 19:00	75.00K
Marion	61074	365019	4/11/2012 0:00	0.00K
Marion	69515	417116	12/19/2012 19:00	25.00K
Marion	69518	417188	12/20/2012 2:00	100.00K
Marion	70259	421911	1/29/2013 22:00	25.00K

Marion	82285	495188	1/16/2014 16:00	10.00K
Marion	81205	486806	2/4/2014 16:00	0.00K
Marion	1416874	550810	2/1/2015 0:00	50.00K
Marion	1403179	5539499	1/18/1996 2:00	0.00K
Marion	1403180	5539750	1/18/1996 9:00	0.00K
Marion	1403184	5540261	1/26/1996 12:00	0.00K
Marion	1403300	5542214	1/28/1996 20:00	0.00K
Marion	1403187	5540486	2/1/1996 16:00	0.00K
Marion	1032429	5544917	5/1/1996 0:00	0.00K
Marion	1044572	5566601	9/14/1996 2:00	0.00K
Marion	1049520	5573988	11/14/1996 16:00	0.00K
Marion	1057532	5585412	1/9/1997 21:00	0.00K
Marion	1057534	5585625	1/15/1997 21:00	0.00K
Marion	47342	5613728	5/13/1997 0:00	0.00K
Marion	1070651	5622488	12/21/1997 14:00	2.05K
Marion	1072047	5629067	1/4/1998 6:30	20.4K
Marion	1073178	5634589	3/17/1998 2:00	5.88K
Total				$122,656,000
Average Annual Losses				$5,929,263

While event narratives do exist for the above episodes, Marion County is not mentioned explicitly, thus, are not included.

From 1965 to 2013, there have been two disaster declarations for Severe Winter Storms; one for snow, and one for a severe ice storm.

Table 28: Disaster Declarations that included Marion County and Winter Storms

Disaster Number	Description	Declaration Date
1191	Snow	11/20/1997
1737	Severe Ice Storm	1/4/2008

Table 29: Number of Daily Snowfall Events 2 Inches or Greater Recorded at the Knoxville Weather Station (1951-2013)

Inches of Snowfall	Number of Events
2 to 2.9	153
3 to 3.9	93
4 to 4.9	57
5 to 5.9	28
6	24
7 to 7.5	7

8 to 8.5	6
9 to 10	5
11	1
12	3
13	1
14	1
16	1

Source: Iowa Environmental Mesonet, Iowa State University Department of Agronomy, http://mesonet.agron.iastate.edu/request/coop/fe.phtml

Crop Losses Due to Severe Winter Storms (Weather)

Insured crop losses associated with severe winter weather are provided in the table below. Because the RMA does not identify losses as “severe winter storms”, the RMA uses “cold wet weather”, “frost”, “cold winter” and “freeze” to identify a severe winter storm. For the table below, “cold wet weather”, “frost”, “cold winter” and “freeze” were used to identify crop losses as a result of severe winter storms.

Table 30: Claims Paid in Marion County for Crop Loss as a Result of Severe Winter Storm Events (2000-2015)

	Corn	Soybeans	Other	Total
2000	$0	$0	$0	$0
2001	$0	$0	$0	$0
2002	$2,877	$645	$0	$3,522
2003	$0	$0	$0	$0
2004	$25,925	$585	$0	$25,925
2005	$371	$6,141	$0	$6,785
2006	$0	$804	$0	$804
2007	$25,285	$4,884	$0	$30,169
2008	$324,059	$1,924	$0	$325,983
2009	$179,484	$27,735	$2,319	$209,538
2010	$386,405	$185,991	$0	$572,396
2011	$209,343	$25,172	$0	$234,515
2012	$627	$0	$0	$627
2013	$22,530	$105,147	$0	$127,677
2014	$3,761	$13,587	$13,031	$30,379
2015	$27,536	$0	$0	$27,536
Total	$1,208,203	$372,615	$15,350	$1,595,856
Average Annual Loss	$75,513	$23,288	$959	$99,741

Source: http://www.rma.usda.

Over the sixteen-year data period associated with insured crop losses, $1,595,856 in claims were paid for winter storm weather events. This represents an annual insured loss of $99,741.

Probability of Future Occurrence

Based on research of historical occurrences, public input, and information received, severe winter storms have previously occurred in the planning area and the probability of severe winter storms occurring again is 100 percent.

According to NCDC, during the 20-year period from 1996 to 2015, the planning area experienced 67 winter storm events. This translates to an annual probability of approximately 3.5 winter storm events per year.

As population changes, this may result in changes in the area's vulnerability to natural disaster. If the population of the County rises, added stress on infrastructure may be a byproduct. If the population of the County declines, fewer tax dollars will be available to the county to maintain existing infrastructure and other resources.

Vulnerability

The entire planning area is vulnerable to the effects of winter storm. Winter storms tend to make driving more treacherous and can impact the response of emergency vehicles. The probability of utility and infrastructure failure increases during winter storms due to freezing rain accumulation on utility poles and power lines. Secondary effects from loss of power could include burst water pipes in homes without electricity during winter storms. Public safety hazards include risk of electrocution from downed power lines.

Buildings with overhanging tree limbs are more vulnerable to damage during winter storms. Businesses experience loss of income as a result of closure during power outages. In general, heavy winter storms increase wear and tear on roadways though the cost of such damages is difficult to determine. Businesses can experience loss of income as a result of closure during winter storms.

Also at risk are those without shelter or who are stranded, or who live in a home that is poorly insulated or without heat. Other impacts of extreme cold include asphyxiation (unconsciousness or death from a lack of oxygen) from toxic fumes from emergency heaters; household fires, which can be caused by fireplaces and emergency heaters; and frozen/burst pipes.

The National Institute on Aging estimates that more than 2.5 million Americans are especially vulnerable to hypothermia, with the isolated elderly being most at risk. About 10 percent of people over the age of 65 have some kind of temperature-regulating defect, and 3-4 percent of all hospital patients over 65 are hypothermic.

Elderly populations are considered particularly vulnerable to the impacts of winter storm and extreme cold events. The following table indicates the number of residents over 65 in each of the participating jurisdictions.

Table 31: Marion County Population over Age 65, 2010 Census Data

Jurisdiction	Total Population	Population Age 65 and Older (Percent)
Bussey	422	16.5%
Hamilton	130	2.7%
Harvey	235	16.0%
Knoxville	7,313	18.3%

Marysville	66	24.1%
Melcher-Dallas	1,288	16.7%
Pella	10,352	15.9%
Pleasantville	1,694	15.9%
Swan	72	25.9%

Future Development

Future development could potentially increase vulnerability to this hazard by increasing demand on the utilities and increasing the exposure of infrastructure networks.

Sinkholes

Sinkholes	
No. of Events	0
Time Period	Not available
Probability	1%
Magnitude	Ø
Deaths	Ø
Injuries	Ø
Property Damages (1996-2015)	Ø
Crop Damages (2000-2015)	Ø
Average Annual Damages (2000-2015)	Ø

As a result of Iowa's former mining operations, and Iowa's unique geology, sinkholes are found throughout much of the state. Many of these sinkholes are located in the northeast quadrant of the state. Marion County does not have any documented sinkhole areas, however, the vulnerability still exists due to many former mining operations, shown in Figure 26.

Geographic Location/Extent

The following maps show historic coal mining areas and sinkholes reported by the Iowa Department of Natural Resources. Marion County has no reported sinkholes, but the area does have many documented coal mines, and coal mine areas, which may become prone to a sinkhole event. These mines are found with increased frequency within the south-east quadrant of the county, and are included in Figure 26.

The 2012 HMP notes that there have been previous sinkhole disturbances as a result of underground utilities in Knoxville, Pella, Swan (2010), and at the Knoxville hospital. The City of Swan reported in 2012 that the main cause has been crumbling culverts, these were repaired quickly.

Previous Occurrences

The only occurrence of previous sinkhole events may be found in the previous Marion County Hazard Mitigation Plan, where a rural road collapsed over an abandoned mine in 2006.

Probability of Future Occurrence

The 2012 HMP includes the fact that Clay Township representatives noted sinkholes are "very rare, but old mines sink occasionally". Future occurrences of sink holes is possible, but are likely to be minor in scope. Marion County and the jurisdictions locate dwithin the county should work to document any furuer occurrence of sinkholes occurring within the county.

Vulnerability

Sinkholes have not occurred historically in the planning area, and there has been no coal mining activity in the area further limiting any potential for occurrence or vulnerability to the hazard.

Figure 26: Historic Coal Mining Areas

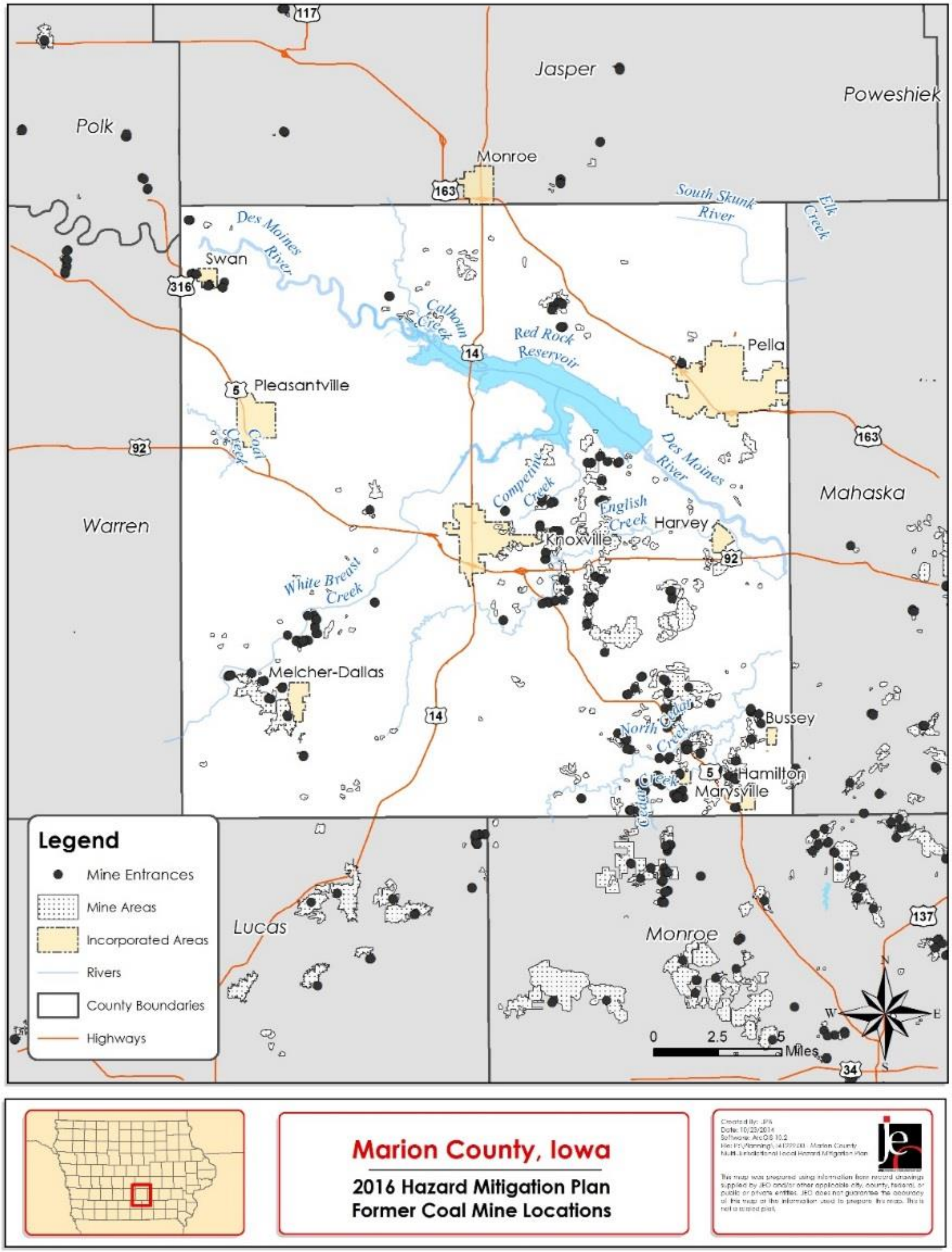
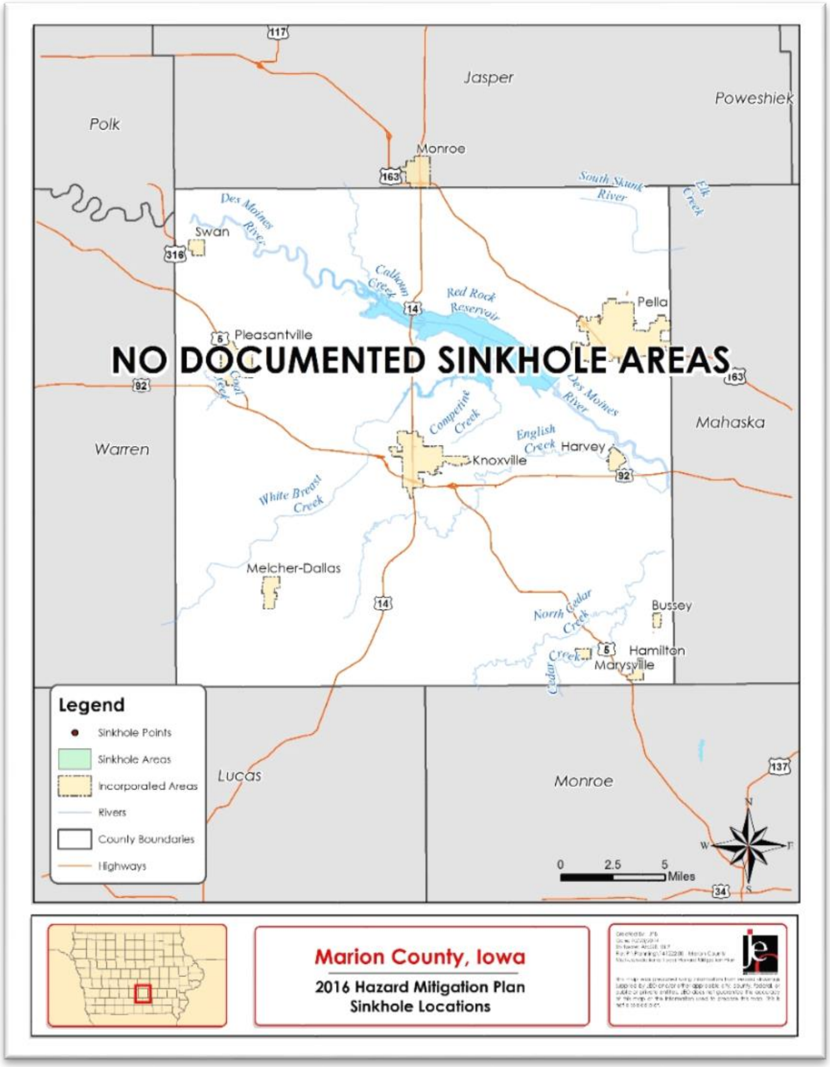


Figure 27: Sinkholes



Future Development

Future development would not be expected to be at risk from sinkholes. Development near historic coal mining sites should be monitored and entities wishing to build in these areas should consider studies of subterranean conditions.

Thunderstorms & Lightning/Hail

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. When the upper air which is cold sinks and the warm moist air rises, storm clouds or "thunderheads" develop resulting in thunderstorms. This can occur singularly, in clusters or in lines. The National Weather Service defines a thunderstorm as severe if it contains hail that is one inch or the wind gusts are at 58 mph or higher. At any given moment across the world, there are about 1,800 thunderstorms occurring. Severe thunderstorms most often occur in Iowa in the spring and summer, during the afternoon and evenings, but can occur at any time. The entire State of Iowa is at risk to the damaging effects of Severe Thunderstorms and Lightning. Other hazards associated with thunderstorms and lightning include: heavy rains causing flash flooding, tornadoes, and windstorm. These associated events are all discussed separate hazard sections (7 and 16 respectively). Hail, which is also frequently associated with thunderstorms, is discussed below.

Thunderstorms	
No. of Events	157
Time Period	1955-2015
Probability	2.6 times/year
Magnitude	N/A
Deaths	0
Injuries	6
Property Damages (1996-2015)	$2,509,000
Crop Damages (2000-2015)	$262,500
Average Annual Damages Property Damages (1996-2015) Agricultral Damages (2000-2015)	 $125,450 $16,406

Lightning	
No. of Events	3
Time Period	1996-2015
Probability	15% chance annually
Magnitude	N/A
Deaths	0
Injuries	0
Property Damages (1996-2015)	$62,000
Crop Damages (2000-2015)	$0
Average Annual Damages Property Damage (1996-2015)	 $3,263

Hail	
No. of Events	125
Time Period	1955-2015
Probability	2 events/year
Magnitude	1.2 inches (average)
Deaths	0
Injuries	0
Property Damages (1996-2015)	$660,000
Crop Damages (2000-2015)	$219,400
Average Annual Damages Property Damages (1996-2015) Agricultural Damages (2000-2015	 $33,000 $13,712

Lightning

Lightning is a natural electrical discharge of very short duration and high voltage between a cloud and the ground or within a cloud. Lightning is typically accompanied by a bright flash and thunder. All thunderstorms produce lightning which often strikes outside of the area where it is raining and is known to fall more than 10 miles away from the rainfall area. From 2006-2015, nationwide, deaths from lightning strikes ranged between 23 (2013) and 48 (2006). During this time period, men were nearly four times more likely to suffer a lightning strike fatality than women. Lightning strikes can start structural fires, wildland fires, and damage electrical systems and equipment.

Hail

According to the National Oceanic and Atmospheric Administration (NOAA), hail is precipitation that is formed when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere causing them to freeze. The raindrops form into small frozen droplets and then continue to grow as they come into contact with super-cooled water which will freeze on contact with the frozen rain droplet. This frozen rain 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.

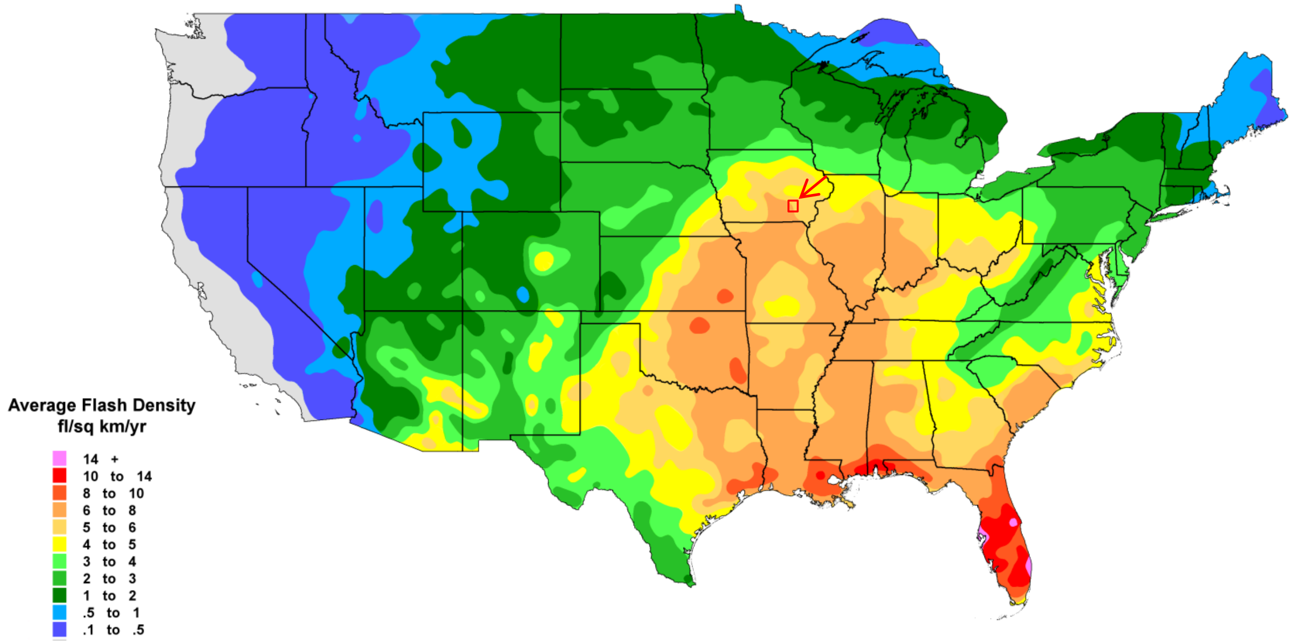
At the time when the updraft can no longer support the hailstone, it will fall down to the earth. For example, a ¼ diameter or pea sized hail requires updrafts of 24 mph, while a 2 ¾ diameter or baseball sized hail requires an updraft of 81 mph. The largest hailstone recorded in the United States was found in Vivian, South Dakota on July 23, 2010, measuring 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/Extent

Severe thunderstorms and associated lightning impact the entire county with relatively similar frequency. Although, these events occur similarly throughout the planning area, they are more frequently reported in more densely settled areas. In addition, damages are more likely to occur in these more densely populated areas. The figures on the following page show the distribution and frequency of thunderstorms in the U.S, and the number of lightning flash densities per square kilometer per year. The majority of Iowa has an average of 50-60 days with thunderstorms per year, while Marion County experiences 5 to 8 lightning flash densities per square kilometer per year. The approximate location of Marion County is indicated by a red box on each of the maps.

Often, “thunderstorm winds” are associated with thunderstorms, due to the dramatic gradient between two air parcels. From 1996-2015, the average wind magnitude was 52 knots. These high winds may contribute to strong updrafts creating, which can be indicators of large hailstones. Within Marion County, the average hail event from 1996-2015 was 1.2 inches in diameter.

Figure 29: Cloud to Ground Lightning Incidence in the Continental United States (1997-2012)



http://www.lightningsafety.noaa.gov/stats/NLDN_CG_Flash_Density_Km_1997-2012.png

Previous Occurrences

157 severe thunderstorm events have been reported by the NCDC between 1955 and 2015. The NCDC breaks down events as either a thunderstorm wind, or lightning, both of which are listed as severe thunderstorm events. Because thunderstorms may occur singularly, or in clusters, several thunderstorms may affect the area in the course of a few hours, the NCDC defines large, zonal occurrences as "episodes". Although the NCDC accounted for 160 local events, these events were spurred from 62 unique episodes. It is important to note that the NCDC's period of record does differ based on event type. The period of record for thunderstorm winds extend from 1955 to 2015 (current). While lightning events, only have records beginning in 1996. Table 34 shows NCDC reported events between 1955 and 2015, with over $10,000 in combined damages (property and crop damages).

Table 34: NCDC Reported Events between 1955 and 2015, with over $10,000 in damages

Event ID	Date/Time	Jurisdiction	Event Type	Property Damages	Crop Damages
10323729	8/14/1993 16:55	Pella	Thunderstorm Wind	50K	.5K
5598862	6/21/1997 2:19	KNOXVILLE	Thunderstorm Wind	1M	25K
5599712	6/21/1997 2:20	PLEASANTVILLE	Thunderstorm Wind	.15M	10K
5652883	6/29/1998 13:20	KNOXVILLE	Thunderstorm Wind	15K	3K
5653007	6/29/1998 13:20	PLEASANTVILLE	Thunderstorm Wind	50K	10K
5652885	6/29/1998 13:26	PELLA	Thunderstorm Wind	25K	2K
5652981	6/29/1998 15:18	KNOXVILLE	Thunderstorm Wind	150K	10K
5698941	6/10/1999 11:05	RED ROCK	Thunderstorm Wind	25K	2K
5156978	9/14/2000 1:52	KNOXVILLE ARPT	Thunderstorm Wind	5K	10K
5156979	9/14/2000 1:55	KNOXVILLE	Thunderstorm Wind	75K	50K
5156980	9/14/2000 2:00	PELLA	Thunderstorm Wind	10K	20K

5156981	9/14/2000 2:02	PELLA	Thunderstorm Wind	10K	20K
5287910	5/8/2002 19:40	HARVEY	Thunderstorm Wind	15K	0.00K
5378597	8/20/2003 14:39	KNOXVILLE	Thunderstorm Wind	10K	2K
5394729	5/22/2004 23:50	PELLA	Thunderstorm Wind	25K	0.00K
91632	5/30/2008 4:13	BUSSEY	Thunderstorm Wind	50.00K	0.00K
111005	8/5/2008 0:35	PELLA MUNI ARPT	Thunderstorm Wind	25.00K	0.00K
214631	4/6/2010 16:30	OTLEY	Thunderstorm Wind	150.00K	0.00K
225506	6/18/2010 9:37	PLEASANTVILLE	Thunderstorm Wind	15.00K	0.00K
227566	6/27/2010 3:35	MELCHER	Thunderstorm Wind	50.00K	0.00K
294452	5/29/2011 6:55	KNOXVILLE	Thunderstorm Wind	15.00K	0.00K
304604	6/26/2011 21:35	KNOXVILLE	Thunderstorm Wind	15.00K	0.00K
304574	6/26/2011 21:38	PELLA	Thunderstorm Wind	25.00K	0.00K
304575	6/26/2011 21:40	PELLA	Thunderstorm Wind	30.00K	0.00K
304577	6/26/2011 21:44	BUSSEY	Thunderstorm Wind	20.00K	0.00K
309147	7/11/2011 3:00	PELLA	Thunderstorm Wind	50.00K	50.00K
314322	7/22/2011 19:03	KNOXVILLE	Thunderstorm Wind	15.00K	0.00K
314317	7/22/2011 19:50	KNOXVILLE	Lightning	50.00K	0.00K
365315	4/14/2012 19:29	KNOXVILLE	Thunderstorm Wind	75.00K	0.00K
365318	4/14/2012 19:30	PERSHING	Thunderstorm Wind	100.00K	0.00K
365317	4/14/2012 19:35	KNOXVILLE ARPT	Thunderstorm Wind	100.00K	0.00K

Source: NCDC, 1955-2015

In Iowa, there have been 22 Presidential Declarations of Major Disaster since 1953 related to severe storms (11 since 1990) through 2015. In Marion County, there have been 3 Presidential Declarations of Major Disaster related to severe storms for the time period between 1953 and 2006, all of which have occurred since 2008. These disaster declarations are outlined below.

Table 35: Disaster Declarations that included Severe Storms in Marion County, Iowa

Disaster Number	Description	Declaration Date
1763	Severe Storms, Tornados, and Flooding	5/27/2008
1930	Severe Storms, Flooding, and Tornados	7/29/2010
4234	Severe Storms, Tornados, Straight-Line, Winds, and Flooding	7/31/2015

Lightning

Lightning events were not reported to NCDC prior to 1996. From 1996 to 2015, Marion County experienced 3 reported lightning events. During this 19-year time period reported lightning events caused no deaths nor injuries. Property damage totaled $62,000. The NCDC narratives of the event is outlined below:

Table 36: NCDC Lightning Events

Event ID	Date/Time	Jurisdiction	Event Type	Property Damages	Crop Damages
5540510	2/9/1996 6:00				
5415495	8/3/2004 20:30	PELLA	Lightning	10K	0.00K
340447	10/12/2011 12:47	BEWBERN	Lightning	2.00K	0.00K
314317	7/22/2011 19:50	KNOXVILLE	Lightning	50K	0.00K

Pella, IA	8/3/2004	$10,000 in Property Damages

A very unstable air mass was over Iowa during the afternoon of the 3rd. A cold front sank into northern Iowa during the afternoon. Numerous outflow boundaries were located over the state from previous convection as well. Temperatures rose into the mid 80s to low 90s, while dew point readings soared into the upper 70s to low 80s. By late afternoon, lifted indices were around -15 C., with CAPE values in the 6000 to 8000 J/kg range…Thunderstorms erupted very quickly during the late afternoon and evening hours. The main mode of severe weather from the storms was in the form of high winds. Winds gusted to between 60 and 80 MPH in several locations…There were spotty reports of hail with the system. Freezing levels being around 15000 feet AGL helped to limit hail size. The largest reports were of golf ball size hail, though most of the hail was in inch or less in diameter…Lightning struck a house in Pella during the evening. It caused damage throughout the house as all of the wiring in the house was destroyed by the surge of electricity. Several appliances were also destroyed by the strike…

Bewbern, IA	10/12/2011	$2,000 in Property Damages

…Lightning struck a house in Marion County, causing only minor damage…

Knoxville, IA	7/22/2011	$50,000 in Property Damages

An outflow boundary remained in place just south of Iowa from the previous night's convection. The air mass over Iowa became very unstable with high temperatures reaching the low 90s on the 22nd, with dew point readings in the mid-70s to low 80s. Precipitable water values increased to between 2 and 2.2 inches in a band extending from southwest into northeast Iowa as monsoonal moisture was drawn north…Thunderstorms developed over central into east central and northeast Iowa…Lightning struck an abandon church in Knoxville, setting it on fire. The fire was brought under control quickly…

Crop Losses Due to Excessive Moisture/Precipitation
Severe thunderstorms can take a toll on crop production in the planning area. According to the USDA's Risk Management Agency, there have not been any payments for insured crop losses specifically for thunderstorms but payments have been made for the associated heavy precipitation, hail and wind.

Insured crop losses associated with excessive moisture or precipitation are provided in the table below. Losses due to hail and wind are included with those hazard profiles on the following pages.

Table 37: Claims Paid in Marion County for Crop Loss as a Result of Excessive Moisture/Precipitation (2000-2015)

	Corn	Soybeans	Other	Total
2000	$21,637	$21,821	$0	$43,458
2001	$456,642	$177,526	$720	$634,888
2002	$30,762	$8,334	$0	$39,096
2003	$5,103	$9,817	$0	$14,920
2004	$83,464	$27,508	$0	$110,972
2005	$6,333	$10,583	$0	$16,916
2006	$622	$649	$0	$1,271
2007	$116,104	$35,787	$0	$151,891
2008	$3,145,440	$1,926,807	$1,606	$5,073,853
2009	$494,886	$143,567	$19,241	$657,694
2010	$8,344,563	$976,564	$4,228	$93,235,356
2011	$1,260,323	$460,838	$20,532	$1,741,694
2012	$30,829	$2,741	$0	$33,570
2013	$562,359	$306,096	$40,633	$909,089
2014	$551,912	$622,635	$0	$1,174,548
2015	$389,442	$257362	$0	$646,803
Total	$15,500,421	$4,988,635	$86,960	$104,486,019
Average Annual Loss	$968,776	$311,790	$5,435	$6,530,376

Source: http://www.rma.usda.

Over the sixteen year data period associated with insured crop losses, a total of $104,486,019 in claims were paid for excessive moisture or precipitation. This represents an annual insured loss of $6,530,376.

Probability of Future Occurrence

Reported thunderstorm events occurred 157 times between 1955 and 2015, and dmages reported as a result of lightning occurred 3 times between 1996 and 2015. It should be noted that lightning accompanies severe thunderstorms, and thus has occurred more than the three times reported by the NCDC, rather this is simply the number of lighting events that can be directly related to losses.

For future probability, Marion County can expect severe thunderstorms to occur multiple times in a given year (157 occurrences in a 61 year record), and damages directly attributable to occur in 18% of years (three occurrences in a 16 year record).

Vulnerability

In general, assets in the County are vulnerable to thunderstorm and lightning including people, crops, vehicles, and built structures. Most damages occur to electronic equipment located inside buildings, but structural damage can also occur when a lightning strike causes a building fire. Communications equipment and warning transmitters and receivers can also be knocked out by lightning strikes. There have not been any fatalities in Marion County from lightning strikes.

Future Development

Increased reliance on technology could increase vulnerabilities associated with the use of electronic equipment.

Hail

Hailstorms in Iowa cause damage to property, crops, and the environment and kill and injure livestock. In the United States, hail causes more than $1 billion in damage to property and crops each year. Much of the damage inflicted by hail is to crops. Even relatively small hail can shred plants to ribbons in a matter of minutes. Vehicles, roofs of buildings and homes, and landscaping are the other things most commonly damaged by hail. Hail has been known to cause injury to humans, occasionally fatal injury.

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

Geographic Location/Extent

The entire planning area, including all participating jurisdictions, is at risk to hailstorms. Table 38 shows typical damage impacts from a variety of hail sizes.

Table 38: Tornado and Storm Research Organization Hailstone 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	Widespread glass damage, vehicle bodywork damage
Destructive	41-50	1.6-2.0	Golf ball > Pullet's egg	Wholesale 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 > Soft ball	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: Tornado and Storm Research Organization (TORRO), Department of Geography, Oxford Brookes University; Notes: In addition to hail diameter, factors including number and density of hailstones, hail fall speed and surface wind speeds affect severity.

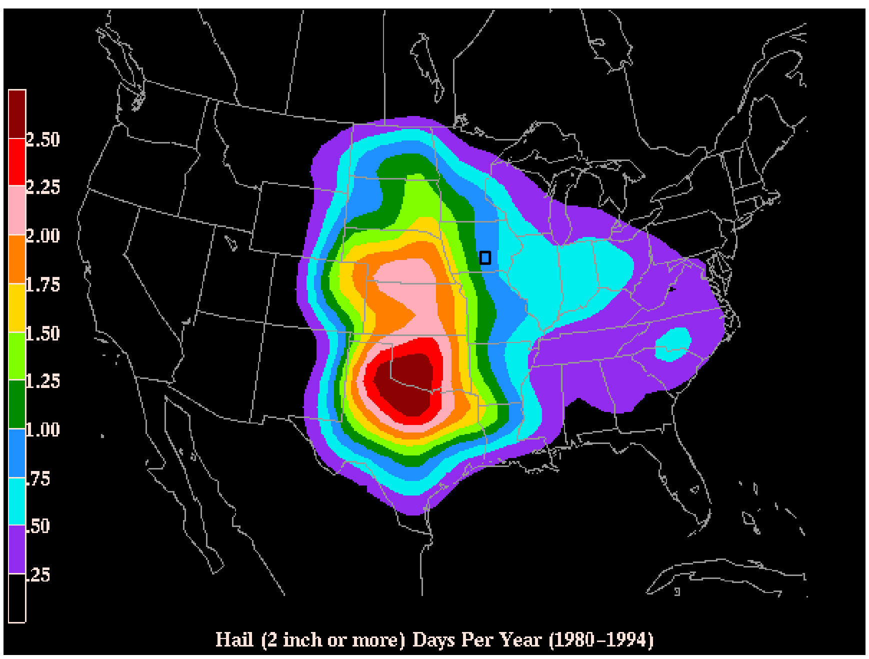
The figure below is based on hailstorm data from 1980-1994. It shows the probability of hailstorm occurrence (2 diameter or larger) based on number of days per year within a 12.5 mile radius of a given point on the map. Marion County is located in a region prone to .75 and 1 inch hail annually. This is consistent with the reported events which yield an average hailstone size of 1.16".

Table 39: Hail Events Summarized by Hail Size 1955-2015

Hail Size (inches)	Number of Events
0.75	12
0.88	32
1	35
1.25	2
1.5	4
1.75	12
2.5	3
3	2
4	1

Source: National Climatic Data Center

Figure 46: Annual Hailstorm Probability (2 Inch Diameter or Larger), United States 1980-1994



Source: NSSL, http://www.nssl.noaa.gov/users/brooks/public_html/bighail.gif

Note: Black square indicates approximate location of Marion County

Beginning January 5, 2010, the National Weather Service (NWS) issues a Severe Thunderstorm Warning whenever a thunderstorm is forecasted to produce wind gusts to 58 miles per hour (50 knots) or greater and/or hail size one inch (quarter-size) diameter which can produce significant damage (source: http://www.nws.noaa.gov/oneinchhail/).

Previous Occurrences

The NCDC reported 125 hail events in Marion County for the period between 1955 and 2015. NCDC data is more reliable for events date 1996 or more recent, thus losses associated with hail events between the years of 1996 and 2015. During these years Marion County sustained an estimated $660,000 in property damages from hail events. The table below shows all reported hail events larger than one inch in diameter, it should be noted that events with hail stones less than one inch in diameter have resulted in property damages accounting for the discrepancy in reported hail damages to property ($660,000) and the total included in the NCDC data table following.

Table 40: NCDC Reported Hail Events, Larger than 1 inch

Date	Jurisdiction	Magnitude (inch)	Property Damages
5/21/1957 13:00	*	1.5	0.00K
5/21/1957 13:25	*	1.5	0.00K
5/21/1957 13:25	*	1.5	0.00K
4/16/1960 11:30	*	2.75	0.00K
6/23/1973 16:00	*	1.75	0.00K
6/6/1980 14:00	*	1.75	0.00K
6/14/1980 18:50	*	2.75	0.00K
8/26/1983 21:31	*	1.75	0.00K
11/9/1984 7:30	*	2.5	0.00K
4/24/1986 23:56	*	1.75	0.00K
4/10/1992 17:15	*	1.75	0.00K
4/10/1992 17:15	*	1.75	0.00K
4/10/1992 17:15	*	1.75	0.00K
4/10/1992 17:55	*	1.75	0.00K
4/10/1992 18:17	*	1.75	0.00K
4/10/1992 18:17	*	1.75	0.00K
7/28/1992 16:30	*	1.5	0.00K
8/8/1995 8:18	PLEASANTVILLE	1.75	15K
5/24/1996 7:30	KNOXVILLE	1.75	10K
5/24/1996 8:55	TRACY	1.75	15K
5/24/1996 8:56	HARVEY	1.75	10K
5/20/1998 9:53	KNOXVILLE	2.5	10K
7/27/1999 19:30	KNOXVILLE	1.75	10K
7/3/2001 15:58	PLEASANTVILLE	1.75	10K
7/3/2001 16:14	OTLEY	3	15K
7/28/2002 19:25	SWAN	1.25	5K
4/30/2003 16:54	BUSSEY	1.75	10K
5/10/2003 16:25	PELLA	1.5	10K
8/3/2004 4:10	PLEASANTVILLE	1.75	15K
7/27/2008 22:33	KNOXVILLE	2.5	100.00K

4/5/2010 14:37	NEWBERN	1.75	5.00K
4/5/2010 14:40	MELCHER	1.5	50.00K
4/5/2010 14:51	FLAGLER	1.5	50.00K
4/5/2010 14:52	KNOXVILLE	1.75	10.00K
4/5/2010 14:54	KNOXVILLE	1.75	10.00K
4/5/2010 14:55	KNOXVILLE	1.25	3.00K
4/5/2010 14:55	KNOXVILLE	1.5	5.00K
4/5/2010 15:10	PELLA	1.75	5.00K
4/5/2010 15:12	PELLA	1.75	5.00K
9/19/2013 15:41	PLEASANTVILLE	1.75	25.00K
9/19/2013 15:50	PLEASANTVILLE	1.75	25.00K

*Not Available

According to the NCDC, the most common size of hail reported from 1955-2015 was 1.2 inches.

Crop Losses Due to Hail

Insured crop losses associated with hail are provided in the table below.

Table 41: Claims Paid in Marion County for Crop Loss as a Result of Hail (2000-2015)

	Corn	Soybeans	Other	Total
2000	$434	$3,202	$0	$3,636
2001	$894	$0	$0	$894
2002	$0	$165	$0	$165
2003	$0	$0	$0	$0
2004	$925	$1,541	$0	$2,466
2005	$1,480	$0	$0	$1,480
2006	$20,748	$12,701	$0	$33,449
2007	$0	$0	$0	$0
2008	$0	$0	$0	$0
2009	$796	$0	$0	$796
2010	$0	$0	$0	$0
2011	$0	$0	$0	$0
2012	$0	$0	$0	$0
2013	$63,744	$54,236	$0	$117,980
2014	$58,534	$0	$0	$58,534
2015	$0	$0	$0	$0
Total	$147,555	$71,845	$0	$219,400
Average Annual Loss	$9,222	$4,490	$0	$13,712

Source: http://www.rma.usda.

Over the sixteen year data period associated with insured crop losses, a total of $219,400 in claims were paid due to hail damages. This represents an adjusted annual insured loss of $13,712.

Probability of Future Occurrence

Based on this data, there have been 127 events in a 20-year period, producing an average of 6.35 hail events each year in Marion County. When limiting the probability analysis to hail events producing hail larger than one inch, there have been 17 events in an 18-year period. Based on this history, the probability of a destructive hail event in any given year is 94% percent.

Vulnerability

In general, hail can cause damages to people, the local economy, the built environment, infrastructure, and critical facilities. People may experience damages due to standing near windows, not seeking adequate shelter, or shattering windsheids. Economic losses may be a result of damages to the place of business itself. Hail may damage roofs, siding, windows, gutters, HVAC systems, which all may compromise the built environment. Finally, hail stones may damage power and utility lines, which can be of critical importance, especially in a disaster scenario.

Future Development

Future development will increase the risk of damages to buildings and infrastructure from hail. It is recommended that hail resistant materials and hail guards for HVAC systems be considered during construction and renovations. Building codes can be enhanced so that they require or recommend the use of hail resistant material as well. Existing structures can also incorporate hail resistant products such as concrete roof tiles and siding. Communities can also establish a Tree Board and tree ordinances to ensure urban canopies are safe and healthy, reducing the potential impacts of severe thunderstorms.

Tornado

The NWS defines a tornado as a violently rotating column of air extending from a thunderstorm to the ground. 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. In an average year, more than 900 tornadoes are reported in the United States, resulting in approximately 80 deaths and more than 1,500 injuries. High winds not associated with tornadoes profiled below.

Tornado	
No. of Events	27
Time Period	61 years
Probability	44%
Magnitude	EF0-EF2
Deaths	0
Injuries	10
Property Damages (1955-2015)	$2,170,000
Crop Damages (2000-2015)	$134,000
Average Annual Damages	
Property Damages (1996-2015)	$35,573
Agricultural Damages(2000-2015)	$8,375

Iowa is located in a part of the United States where tornadoes commonly occur as a result of converging Canadian, Gulf of Mexico and Pacific air masses. Iowa has experienced 1,466 tornadoes from 1980 through 2010 with 86 percent of them being rated F0 and F1, 14 percent rated F2 through F5. Only two F5 rated tornadoes have occurred in Iowa (Parkersburg in 2008 and Jordan in 1976). Since 1980, there have been on average 48 tornadoes per year in Iowa. Most tornadoes occurred in May and June, but tornadoes do occur in every month of the year in Iowa. Midafternoon through sunset is the peak time of day for tornado activity. There have been 747 injuries and 26 deaths attributable to tornadoes (source: National Weather Service, Iowa Tornado Climatology Report 1980-2010).

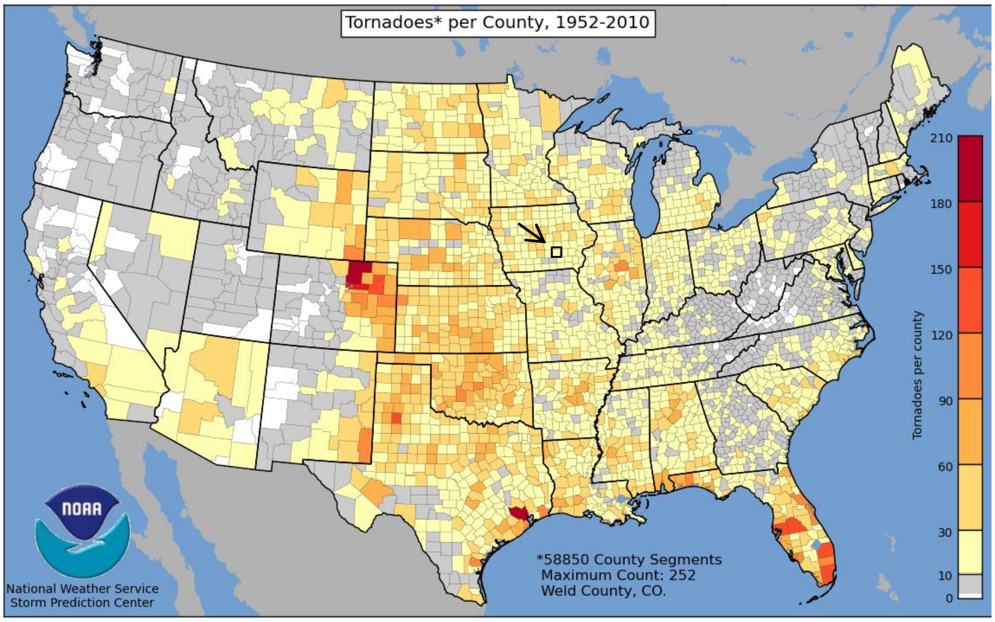
Tornadoes are classified according to the EF- Scale (the original F – Scale was developed by Dr. Theodore Fujita, a renowned severe storm researcher). The Enhanced F- Scale (see Table 24) attempts to rank tornadoes according to wind speed based on the damage caused. This update to the original F scale was implemented in the U.S. on February 1, 2007.

Geographic Location/Extent

Tornadoes can occur in the entire planning area. The figure to the right illustrates the number of tornados per county. Marion County is in an area that is shown as experiencing 10-30 tornadoes of this magnitude during this 58-year period. According to statistics reported by the NCDC, Marion County has experienced 27 tornados from 1996 to 2013. Of these, 1 was an EF0, 3 were EF1, 8 were F0, 10 were F1, and three were F2.

The wind speeds for the EF scale and damage descriptions are based on information on the NOAA Storm Prediction Center as listed in the table below. The damage descriptions are summaries. 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 located online at www.spc.noaa.gov/efscale/ef-scale.html.

Table 42: Tornado Activity in the United



Source: NOAA National Weather Service

Table 43: Enhanced Fujita Scale for Tornado Damage

FUJITA SCALE			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Number	Fastest 1/4-mile (mph)	3 Second Gust	EF Number	3 Second Gust	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	Over 200

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

Table 44: Enhanced Fujita Scale with Potential Damage

Scale	Wind Speed	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 EF0.
EF1	86-110	31.6%	Moderate. Roofs severely stripped; mobile homes overturned 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 completely 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 leveled; cars thrown and small missiles generated.
EF5	>200	<0.1%	Explosive. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 300 feet; steel reinforced concrete structures badly damaged; high rise buildings have significant structural deformation; incredible phenomena will occur.

Source: NOAA Storm Prediction Center

Previous Occurrences

Four of Marion County's disaster declarations were a result of a tornado event.

Table 45: Marion County Disaster Declarations Related to Tornado

Disaster Number	Description	Declaration Date
1230	Severe Storms, Tornados, Flooding	7/2/1998
1763	Severe Storms, Tornados, and Flooding	5/27/2008
1930	Severe Storms, Flooding and Tornados	7/29/2010
4234	Severe Storms, Tornados, Straight-Line Winds, and Flooding	7/31/2015

According to the NCDC, Marion County has experienced 27 tornado events from 1955 to 2015. These tornadoes caused no deaths but one tornado event inflicted 10 injuries. The 27 tornados observed by the NCDC resulted in $2,170,000 in property damages, and $134,000 in crop damages. It should be noted that the USDA's RMA does not report losses to crops resulting from tornadoic evnets between 2000 and 2015, thus crop loss data from the NCDC is utilized for this hazard.

Table 46: Recorded Tornadoes in Marion County, 1955-2015

Event ID	Date/Time	Jurisdiction	Magnitude	Property Damage	Crop Damages
10013250	5/28/1962 21:00	*	F2	250K	0.00K
10012217	6/22/1964 19:30	*	F2	25K	0.00K
10012340	6/4/1969 14:45	*	*	25K	0.00K
10011358	5/18/1971 14:15	*	F1	25K	0.00K
10014438	6/5/1972 17:56	*	F2	25K	0.00K
10014900	4/23/1976 19:20	*	F1	0.00K	0.00K
10014854	4/10/1981 17:55	*	F0	25K	0.00K
10012942	5/15/1982 14:10	*	F1	25K	0.00K
10012495	10/14/1984 16:21	*	F1	250K	0.00K

10018250	5/11/1985 15:40	*	F1	25K	0.00K
10015534	8/14/1986 17:37	*	F1	250K	0.00K
10013992	6/10/1986 20:43	*	F0	2.5K	0.00K
10015462	7/8/1987 14:50	*	F0	2.5K	0.00K
10024948	5/8/1988 11:03	*	F1	250K	0.00K
5645884	5/19/1998 15:45	PLEASANTVILLE	F0	0.00K	1K
5686950	4/8/1999 16:45	SWAN	F1	50K	0.00K
5142508	5/18/2000 11:04	SWAN	F1	5K	1K
5287899	5/8/2002 19:15	PLEASANTVILLE	F0	0.00K	0.00K
5351358	5/10/2003 16:26	COLUMBIA	F1	30K	0.00K
5454577	6/13/2005 19:30	MELCHER	F0	0.00K	1K
5454578	6/13/2005 19:47	MELCHER	F0	0.00K	1K
5453233	6/13/2005 19:53	KNOXVILLE	F0	0.00K	0.00K
25313	6/7/2007 11:48	COLUMBIA	EF0	0.00K	0.00K
53074	9/30/2007 17:26	PELLA	EF1	75.00K	100.00K
91657	5/30/2008 3:54	NEWBERN	EF1	50.00K	5.00K
91658	5/30/2008 4:07	COLUMBIA	EF2	750.00K	25.00K
96924	6/5/2008 23:25	SWAN	EF1	30.00K	0.00K
			TOTAL	**$2,170,000**	**$134,000**

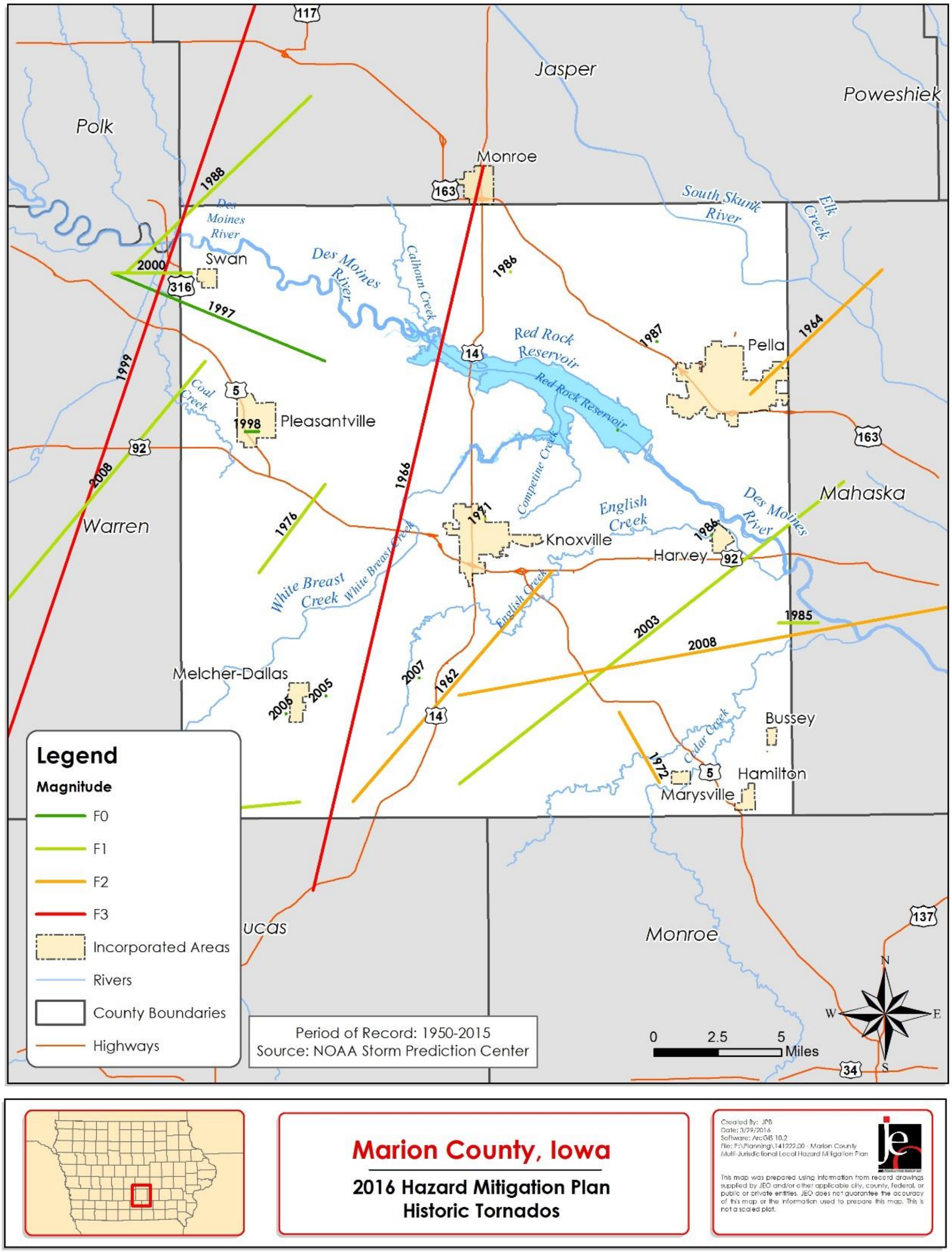
*Source: NCDC 1955-2016; *=Data Not Available*

The event narrative for the most damaging tornado follows, and its path as documented by the National Weather Service is discussed below:

> **May 30, 2008**- A very unstable air mass moved into Iowa during the day on the 29th as a warm front lifted north into the state during the afternoon. Low pressure approached from the west, along with a cold front so that the triple point was near the western Iowa, eastern Nebraska area by late afternoon. Thunderstorms erupted quickly during the late afternoon and evening hours in the unstable airmass. By evening, the low level jet was in the 40 to 60 kt range, feeding moisture into the state and pushing perceptible water values to around 200% of normal, in the 1.5 to 1.8-inch range…As the storms moved east, another tornado was on the ground for over 10 miles in Warren and Marion Counties. The most significant tornado occurred in Marion and Mahaska Counties where an EF2 tornado was on the ground for about 18 miles. Several homes were damaged along its path, two mobile homes were destroyed, and considerable damage was done to trees in the area. Up to 10 people were injured with this tornado, mainly in Attica. The official damage count from this tornado included 5 homes destroyed, 15 with major damage, and another 25 with minor damage.

The following figure displays the tornado that have tracked in Marion County from 1962 to 2015.

Figure 47: Historic Tornado Paths in Marion County



Probability of Future Occurrence

The National Climatic Data Center reported 27 tornadoes over the last sixty one years. This results in a 44 percent chance of a tornado occurring in the planning area in any given year.

Vulnerability

Marion County is located in a region of the United States with a high frequency of dangerous and destructive tornadoes. According to the Iowa Hazard Mitigation Plan, the estimated statewide losses have the tornado hazard listed as the 3rd highest hazard with losses of $36 million. The State Plan additionally estimates annual tornado losses for Marion County at $37,000. Estimates based on NCDC data suggest annual losses of $8,333.

Based on information from the NOAA Storm Prediction Center, a F2/EF2 tornado of this magnitude would tear roofs off well-constructed houses, foundations of frame homes would shift, mobile homes would be completely destroyed, large trees would snap or be uprooted, light objects would become missiles, and cars would be lifted off the ground. Several factors impact the severity of damage, including wind speed, time on the ground, length/width of the cell, population density, building density, age and construction of buildings, and time of day.

There are certain socio-economic factors which may increase the vulnerability of different populations. Citizens living in mobile homes, citizens who are elderly with decreased mobility/poor hearing or at higher risk for lasting impacts from a tornado event.

Future Development

In planning future development, jurisdictions in the planning area should work to ensure that all facilities housing large numbers of people and/or vulnerable populations have access to safe rooms. Additionally, safe rooms can be especially useful in areas with transient populations, such as parks and camp grounds. Many communities have included building/retrofitting safe rooms to FEMA standards within *Section 7: Participant Sections.*

Transportation Incidents

Transportation Incidents	
No. of Events	Rail: 6 Highway: 1,179
Time Period	Rail: 2016-2006 Highway: 2007-2010
Probability	Rail: 60% Highway: 100%
Magnitude	Not defined
Deaths	Rail: Not Available Highway: 14
Injuries	Rail: Not Available Highway: 740
Property Damages (1950-2015)	Not available
Crop Damages (2000-2015)	Not available
Average Annual Damages (2000-2015)	Not available

The Iowa HMP defines a transportation incident as encompassing air transportation, railway transportation, and waterway incidents. The plan states that "a transportation incident is described as an accident involving any mode of transportation that directly threatens life, property damage, injury, or adversely impacts a community's capabilities to provide emergency services."

There are municipal airports in both Knoxville and Pella. In addition to the airports, there are heliports serving the hospitals in both Knoxville and Pella. Areas surrounding the airports and helicopter landing pads likely experience a slightly higher vulnerability to transportation incidents, simply due to the proximity to the airport.

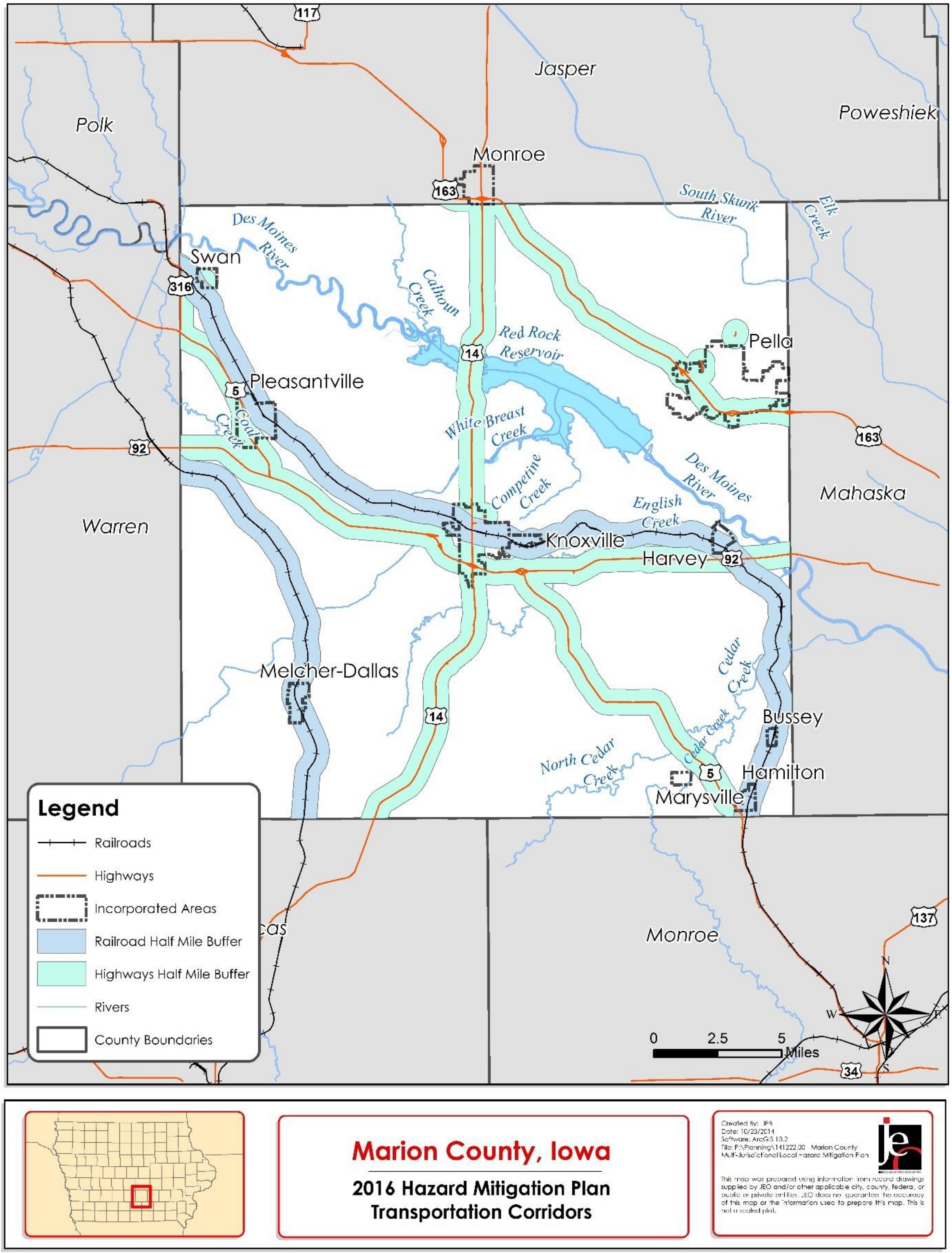
Marion County's roadways are primarily composed of two lane county roads, which transect the county. County Road 14 allows for transportation from the north to south, while county road 92 runs east/west through the center of the county, county road 5 runs from northwest to southeast through the county.

Further analysis will only include highway and rail transportation events, due to a lack of data for air transportation.

Geographic Location/Extent

Transportation incidents are most likely to occur on railways and frequently traveled roadways. Figure 48 shows transportation corridors in the planning area, as well as a half mile buffer area, which may be vulnerable to chemical release or spill from a road/railway. While any area of the planning area is vulnerable to an air transportation incident, those living near the Knoxville Municipal Airport (KOXV) and Pella Muni Airport (PEA) experience a higher level of vulnerability to an air incident.

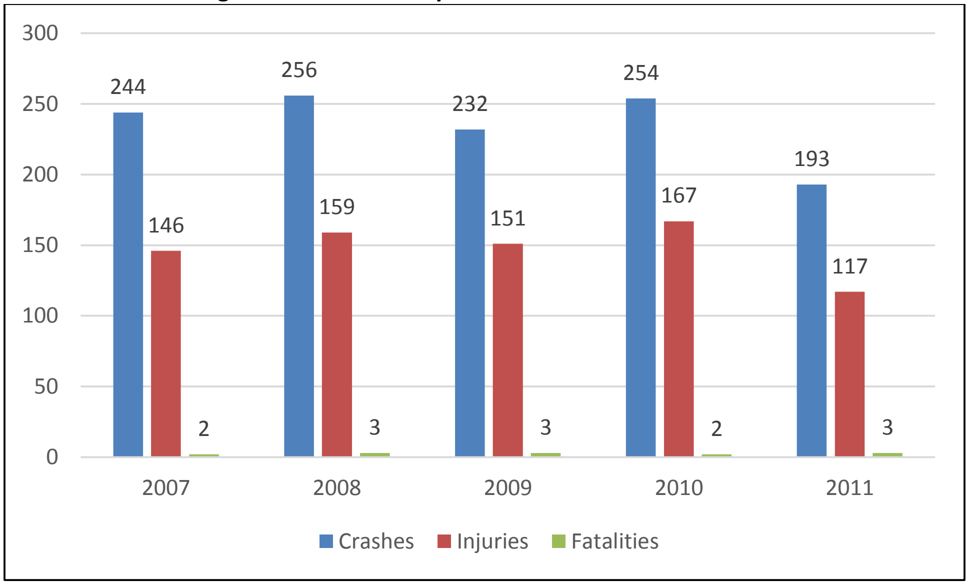
Figure 48: Transportation Corridors in Marion County



Previous Occurrences

The Iowa Department of Transportation (IDOT) maintains a database of car accidents, however, this database has not been updated since 2011. These data indicate that Marion County has experienced 1,179 crashes, 740 of which involved injuries, and 13 of which involved fatalities.

Figure 49: IDOT Transportation Incidents 2007-2011



Source: Iowa Department of Transportation

The Federal Railroad Administration maintains a database on rail equipment accidents, which has a period of record from 1975-2016, only records from 2006-2016 were analyzed. Of the state-wide events, six events occurred in Marion County. It is important to note that two sets of events occurred on the same day, and involved collisions with other trains, which resulted in two reports being filed. The collisions occurred on 12/19/2006 and 3/22/12.

Table 47: Railroad Incidents 2006-2016

Date	City	Railroad	Cars Derailed
12/19/06	Knoxville	Burlington Northern	29
12/19/06	Knoxville	Burlington Northern	0
5/14/07	Donnelly	Burlington Northern	0
3/22/12	Bussey	Burlington Northern	0
3/22/12	Bussey	Burlington Northern	0
12/9/14	Melcher-Dallas	Union Pacific	0

Source: Federal Railroad Administration

Probability of Future Occurrence

Future occurrence will largely be dependent on transportation conditions, and how well roadways are being maintained. It is likely that the county will continue to experience six rail incidents every ten years, and approximately 200-250 highway events per year.

Vulnerability

Those who spend more time on roadways will experience a higher level of vulnerability. Additionally, those who live within a half mile of a major transportation corridor may experience a higher level of vulnerability to transportation incidents, as well as any potential chemicals they may be carrying.

Future Development

It is recommended that major roadways undergo necessary updates and repairs, such as re-paving, re-grading or drainage improvements. It is also recommended that development continue away from major road and railways to limit citizens' vulnerability to transportation incidents, as well as potential chemical release/spill.

Windstorm

Windstorm	
No. of Events	29
Time Period	1996-2015
Probability	Approx. 1.5 events/yr
Magnitude	45 mph (avg)
Deaths	0
Injuries	0
Property Damages (1996-2015)	$879,110
Crop Damages (2000-2015)	$215,168
Average Annual Damages Property Damages (2000-2015) Agricultural Damages (2000-2015)	 $43,955 $13,448

High winds, often accompanying severe thunderstorms, can cause significant property and crop damage, threaten public safety, and have adverse economic impacts from business closures and power loss.

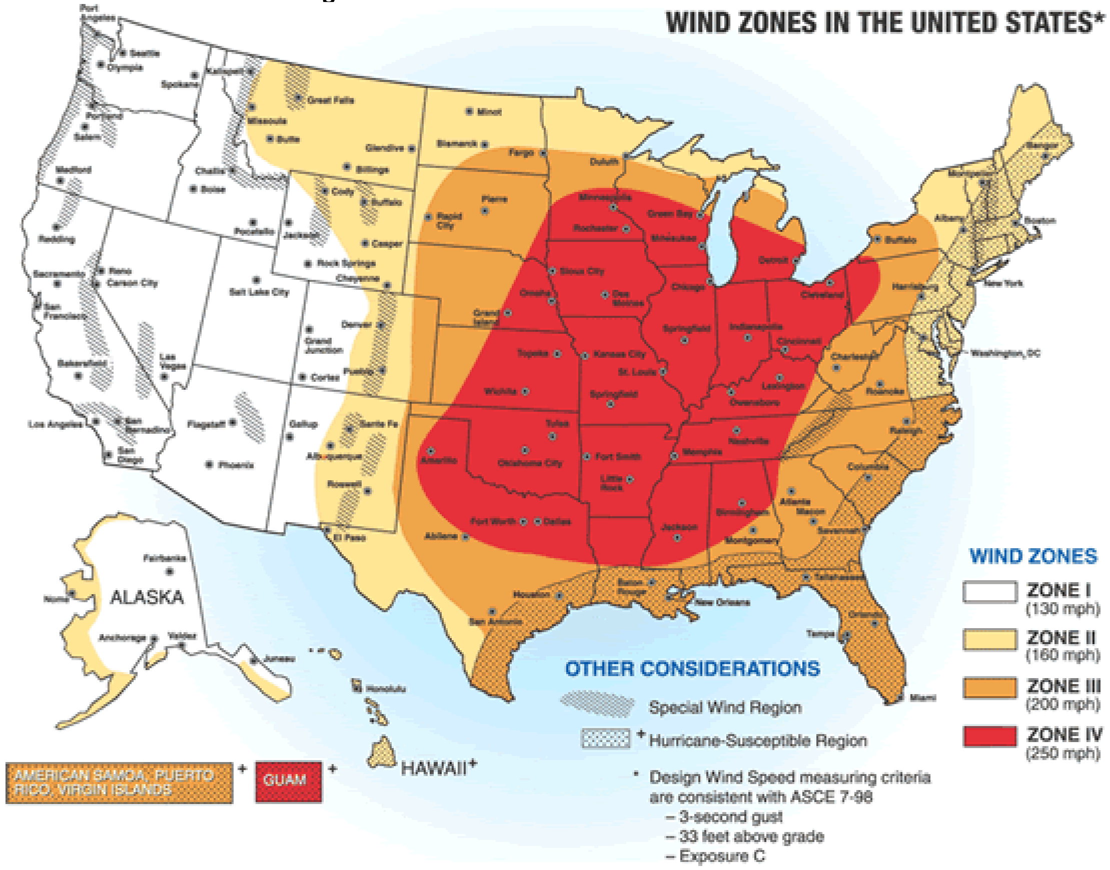
The damaging winds of thunderstorms include downbursts, microbursts, and straight-line winds. Downbursts are localized currents of air blasting down from a thunderstorm, which induce an outward burst of damaging wind on or near the ground. Microbursts are minimized downbursts covering an area of less 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. Straight-line winds are generally any thunderstorm wind that is not associated with rotation (i.e., is not a tornado). It is these winds, which can exceed 100 mph, which represent the most common type of severe weather and 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. One type of straight-line wind is the downburst, which can cause damage equivalent to a strong tornado and can be extremely dangerous to aviation.

Windstorms over Iowa typically occur between late April and early September, but, given the right conditions, they can develop as early as March. They are usually produced by supercell thunderstorms or a line of thunderstorms that typically develop on hot and humid days.

Geographic Location/Extent

All of Marion County is susceptible to high wind events. The County is located in Wind Zone IV, which is susceptible to winds up to 250 mph. All of the participating jurisdictions are vulnerable to this hazard. The following page shows the wind zones of the United States based on maximum wind speeds; the entire state of Iowa is located within wind zone IV, the highest inland categories. According to the NCDC, there have been 29 high wind events in Marion County from 1996-2015, which had an average magnitude of 45 miles-per-hour.

Figure 50: Wind Zones in the United States



Source:http://www.fema.gov/plan/prevent/saferoom/tsfs02_wind_zones.shtm

Previous Occurrences

Marion County was has received two disaster declarations for, in part, high wind events. A short description of the disaster is included in the table below.

Table 48: Windstorm Related Disaster Declarations

Disaster Number	Description	Declaration Date
4119	Severe Storms, Straight-Line Winds, and Flooding	5/31/2013
4234	Severe Storms, Tornados, Straight Line Winds, and Flooding	7/31/2015

According to the NCDC database, there were 29 high wind events between 1996 and 2015. During this time there were no deaths or injuries attributed to high winds; total property damages (as reported by the NCDC) for these events were estimated at $909,210.

Table 49: NCDC High Wind Events 1996-2015

Date/Time	Magnitude	Property Damage
1/17/1996 21:00	55	0.00K
2/10/1996 12:00	56	0.00K
10/29/1996 11:00	57	0.00K
4/25/1996 9:30	52	0.00K
3/24/1996 17:00	54	0.00K
4/30/1997 12:00	52	0.00K
4/6/1997 9:00	55	0.00K
4/12/1998 8:00	*	50K
11/10/1998 2:00	61	.3M
3/8/2000 11:00	50 E	10K
4/7/2001 4:00	50 M	50K
3/9/2002 6:00	*	50K
5/30/2003 14:00	35 ES	25K
11/12/2003 9:00	50 EG	50K
4/18/2004 15:10	35 MS	80K
4/27/2004 12:30	35 MS	75.11K
6/11/2004 22:07	52 MG	2K
1/22/2005 0:15	52 MG	10K
6/8/2005 9:00	50 EG	20K
11/12/2005 18:00	35 MS	50K
1/24/2006 9:30	52 MG	10K
10/26/2008 10:30	50 MG	25.00K
2/9/2009 22:30	51 MG	5.00K
10/27/2010 9:00	35 ES	25.00K
4/10/2011 14:30	52 MG	1.00K
5/3/2012 6:45	52 EG	1.00K
1/1/2012 3:00	37 MS	10.00K
7/22/2013 21:55	63 MG	5.00K
1/26/2014 15:00	35 MS	25.00K
TOTAL	**-**	**$879,110**

*Data not available
**MS=MG

Below are NCDC narratives from the three most damaging high wind events from the period of record (1996-2015).

High Wind	11/10/1998 2:00	$305,000 in damages

Strong winds behind a cold front Iowa experienced the worst November storm system since the great storm of 9 and 10 November 1975. During the 9th, low pressure developed over southeast Colorado. The low moved across Kansas during the afternoon and evening of the 9th and deepened to about 990 mb.

Warm and moist air was drawn north ahead of the low resulting in widespread across the state. Thunderstorms erupted during the late evening of the 9th, though no severe weather occurred. During the predawn hours of the 10th, a jet streak rotated around the base of the upper level low pressure area. The jet stream, combined with a tropospheric fold, resulted in explosive deepening of the low. As the low moved through Central Iowa pressures fell below 980 mb, with the low deepening to near 966 mb as it moved over northwest Iowa…Most of the state experienced a period of 12 to 18 hours of sustained winds of 35 to 50 MPH, with frequent gusts of 65 to 75 MPH…Almost every station in the state reported wind gusts above 60 MPH. Damage was widespread across the state with countless trees and power lines down…

High Wind	04/25/1996	$80,000 in damages

A warm front lifted north across the state during the previous night. At the same time, intense low pressure formed to the west of Iowa and tracked northeast through South Dakota into Minnesota. The low intensified as a negatively tilted upper level trough of low pressure in the upper atmosphere lifted northeast out of the southwest U.S. A strong jet and pronounced dry slot was evident in the warm sector of the system. The jet and dry slot tracked across Iowa during the afternoon and evening of the 18th. This set the stage for the high wind event. A very strong south to southwest flow developed over the state. Profiler data showed wind of 50 kts at 500 meters during much of the morning into the early part of the afternoon. The winds increased to 75 kts at the 500 meter level by the late afternoon and evening hours…During the day, winds were in the 30 to 35 MPH range across the state, with frequent gusts to around 55 MPH. During the late afternoon and early evening hours, winds increased with sustained winds of 40 MPH or more across most of the state, with many areas reporting gusts of 60 to 65 MPH. Widespread light damage was reported over the area, with scattered reports of significant wind damage. Several reports of tree, power line, and out building damage were received from around the state…In addition to the wind damage problems, dry conditions around the state lead to areas of blowing dust...

Most of the events in the NCDC database included reports of downed power poles, trees and tree limbs. Over the 20 year period-of-record, the NCDC reported over $30,000 in crop losses for the planning area. While there are differences in data collection, this is reflected by the USDA's RMA data as well.

Crop Losses Due to Windstorms

Insured crop losses associated with excessive winds are provided in the table below.

Table 50: Claims Paid in Marion County for Crop Loss as a Result of Excess Wind (2000-2015)

	Corn	Soybeans	Other	Total
2000	$61	$0	$0	$61
2001	$61	$0	$0	$61
2002	$0	$0	$0	$0
2003	$0	$0	$0	$0
2004	$8,231	$0	$0	$8,231
2005	$0	$0	$0	$0
2006	$0	$0	$0	$0
2007	$6,214	$0	$0	$6,214
2008	$0	$0	$0	$0
2009	$0	$0	$0	$0
2010	$0	$0	$0	$0

2011	$0	$0	$0	$0
2012	$0	$0	$0	$0
2013	$0	$0	$0	$0
2014	$133,740	$62,994	$0	$196,734
2015	$3,867	$0	$0	$3,867
Total	$152,174	$62,994	$0	$215,168
Average Annual Loss	$9,511	$3,937	$0	$13,448

Source: http://www.rma.usda.

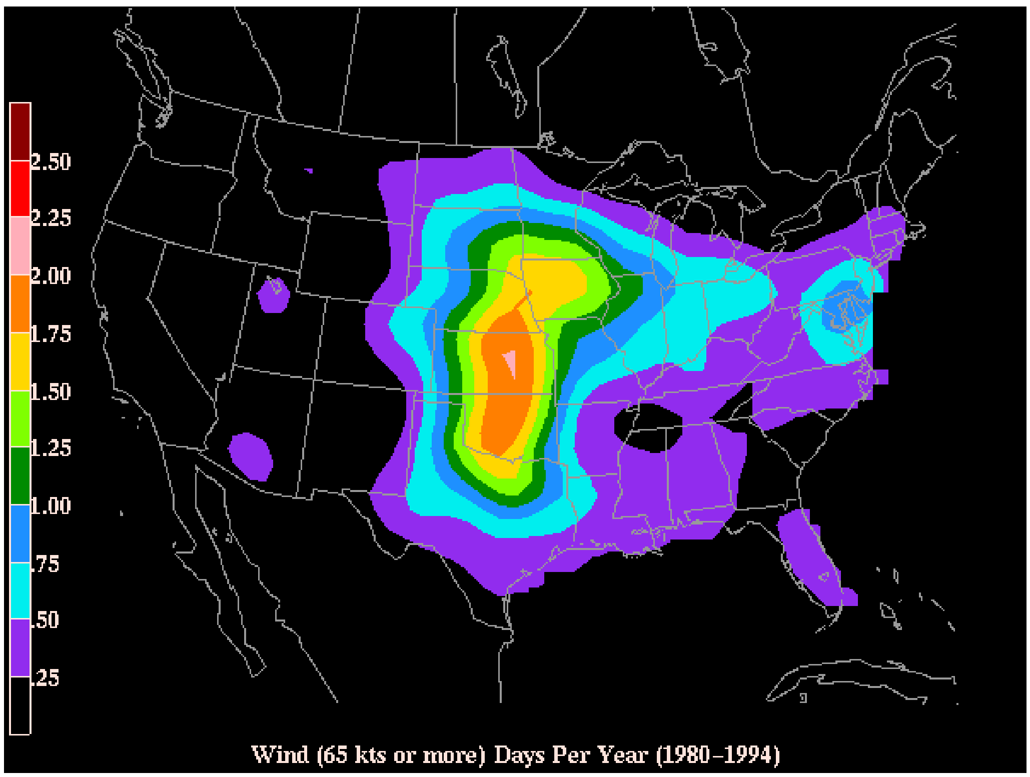
Over the sixteen-year data period associated with insured crop losses, a total of $215,168 in claims were paid for damages due to wind. This represents an annual adjusted loss of $13,448.

Probability of Future Occurrence

According to NCDC, there were 29 wind events in Marion County between 1996 and 2015; in any given year will likely be approximately 1-2 high wind events. This rate of occurrence is expected to continue in the future.

The figure to the right shows the annual probability of windstorm days in the United States based on data compiled from 1980 to 1994. This data set indicates annual probability of 1.5 to 1.75 days with winds of 65 knots or higher for Marion County.

Figure 51: Annual Windstorm Probability (65+ knots), United States 1980-1994



Source: *ttp://www.nssl.noaa.gov/users/brooks/public_html/bigwind.gif*

Vulnerability

Windstorm is primarily a public safety and economic concern, and the planning area is located in a region with high frequency of occurrence. Windstorm can cause damage to structures and power lines which in turn create hazardous conditions for people. Debris flying from high wind events can shatter windows in structures and vehicles and can harm people that are not adequately sheltered.

Campers, construction trailers, mobile homes, barns, and sheds and their occupants are particularly vulnerable as windstorm events in Marion County can be sufficient in magnitude to overturn these lighter structures.

The following table below provides the estimated numbers of mobile homes in each jurisdiction in the planning area as well as the unincorporated areas of the County. The jurisdiction with the most mobile homes is Knoxville.

Additionally, older homes which have not been maintained may be more susceptible to damage during windstorms. The following table also lists the percentage of homes built before 1970 in each jurisdiction.

Table 51: Housing Units that may be vulnerable to Windstorm Damage by Age and Type

Jurisdiction	Total Number of Housing Units	Number of Mobile Homes	Number of Homes Built before 1970 (Percent of Total)
Bussey	200	28	61%
Hamilton	76	15	28%
Harvey	141	29	13%
Knoxville	3,393	177	53%
Marysville	27	7	74%
Melcher-Dallas	668	49	59%
Pella	4,104	41	47%
Pleasantville	758	56	61%
Swan	28	12	39%

Source: U.S. Census Bureau, 2009-2013 American Community Surveys 5-year Estimates, Table DP04

Future Development

New development built to modern building codes, and well-maintained older buildings are unlikely to contribute to greater windstorm vulnerability. Of course, any structure, regardless of its age or construction, could be damaged by flying debris, fallen trees or tree limbs.

Hazard Analysis Summary

The following table provides a summary of all of the data collected and reviewed in association with the natural hazards addressed in this plan.

Table 52: Hazard Analysis Summary

Hazard	Number of Events	Probability	Annual Property Losses (1996-2015)	Adjusted Annual Crop Losses (2000-2015)	FEMA Disaster Declarations
Animal/Plant/Crop Disease	*	100%	*	$2,28	0
Dam Failure/Levee Failure	0	*	*	*	0
Drought	10	20% annually	$12,650,000	$56,273,546	0
Earthquake	0	0	0	0	0
Expansive Soils	0	100%	*	*	0
Extreme Heat	2	10% annually	$135,000	$0	0
Flash Flood	27	1.42x/year	$1,397,000	$255,000	9
Grass or Wildland Fire	58	5-6x/year	*	*	*
Landslide	*	*	*	*	0
River Flooding	94	5x/year	$196,688	$307,372	9
Severe Winter Storm	68	3.5x/year	$108,410	$83,992	2
Sinkholes	0	0	$0	$0	0
Thunderstorm Lightning Hail††	157 3 125	2.6x/year 15% annually 2x/year	$41,817 $3,263 $10,083	$4,375 $0 $3,657	3
Tornado† Windstorm	27 29	45% annually 1.5x/year	$33,384 $46,269	$8,933 $2,007	4 2

* Data Not Available
† Period of Record= 1950-2015
††Period of Record= 1955-2015

Since many hazards occur on an annual basis, losses associated with property or crops, and disaster declarations all provide a stronger basis for understanding the impact of hazards on jurisdictions in the planning area. FEMA Disaster declarations indicate that Marion County is heavily impacted by:

1. River and Flash flooding with 9 declarations
2. Tornados with 4 declarations
3. Thunderstorms/Lightning/Hail with a combined 3 declarations
4. Severe Winter Storms with 2 declarations/Windstorm (Straight-Line Winds) with 2 declarations

Annual Loss Estimation by Hazard for Marion County	
River Flood	$12,165,000
Drought	$7,822,000
Flash Flood	$111,000
Hail	$51,000
Winter Storm	$38,000
Source: Iowa Hazard Mitigation Plan, 2013 Update	

From an alternate perspective, property losses as recorded by the NCDC indicate that Marion County is impacted by

1. River Flooding with $12,165,000 in losses
2. Drought with $16,127 in losses
3. Flash Flood with $111,000 in losses
4. Hail with $51,000
5. Winter Storm with $38,000

Finally, USDA/RMA crop losses indicate the following hazard impacts:

1. Drought with $56,273,546 in losses
2. River Flooding with $4,610,589 in losses
3. Severe Winter Storm with $1,595,856 in losses
4. Thunderstorm/Lightning with $262,500 in losses
5. Flash Flood with $255,000 in losses
6. Hail with $219,400 in losses
7. Tornado with $134,000 in losses
8. Windstorm with $30,100 in losses
9. Animal/Plant/Crop Disease with $17,158 in losses

The primary hazard concerns and priority strategic actions which address those concerns, for each jurisdiction are provided in the jurisdictional profiles that follow.