3. UNDERSTANDING IOWA'S HAZARDS

Iowa experiences significant variability in weather conditions due to its geographic location, even on a day-to-day basis. For example, on December 28, 2013, Sioux City experienced a 24-hour period where the temperature dropped from a high of 62 degrees to -3 degrees the next day. The regularity of these swings in the weather have prompted common phrases around the state such as "if you don't like the weather now just wait 10 minutes." Unfortunately, variability in Iowa's weather is often associated with hazardous conditions with far reaching impacts on the health, economy, and transportation within the state. In this chapter, the various hazards that impact Iowa's transportation system are profiled.

Natural Hazards Impacting Iowa's Transportation System

The guidance for the PROTECT Program published by FHWA on July 29, 2022, states, "If developed, Resilience Improvement Plans shall be consistent with State and local hazard mitigation plans, including as required by the Federal Emergency Management Agency (FEMA) (23 U.S.C 176(e)(2)B; 42 U.S.C. 5165)." Iowa's State Hazard Mitigation Plan identifies 19 natural and other hazards. Of those 19, nine were chosen to be evaluated and prioritized in this plan due to their potential impacts to mobility and transportation systems in Iowa. The nine hazards include dam/levee failure, drought, excessive heat/cold, freeze/thaw, flooding (flash and riverine), landslide, hail and thunderstorms, tornado/windstorm, and winter storms.

Other Hazards Impacting Iowa's Transportation System

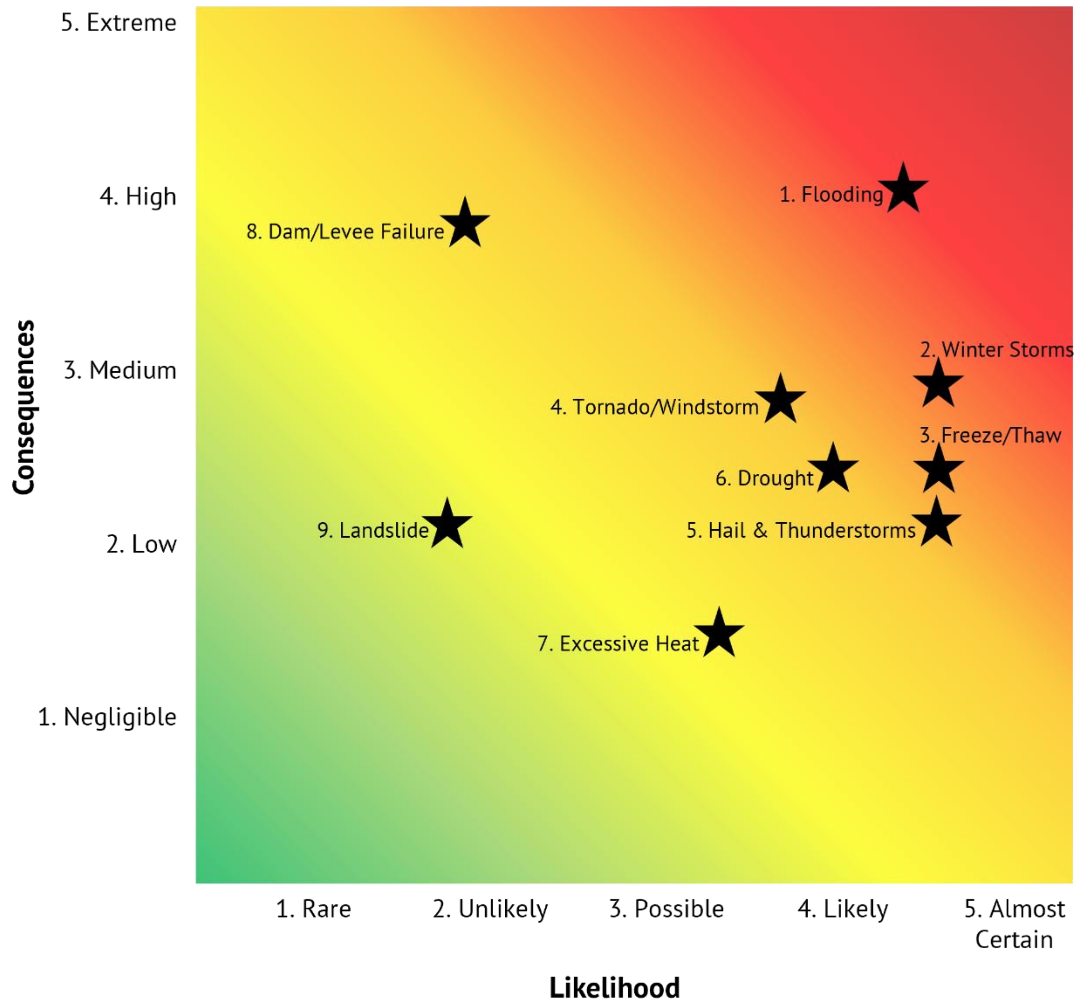
Although the primary focus of this plan is on natural hazards that impact the transportation system, it is important to recognize that departments of transportation are increasingly faced with hazards that do not originate from weather events or natural processes. These could include human induced events such as arson, cyber-attacks, and terrorism. There are also hazards related to the types of vehicles and commodities that travel on the transportation system. For example, hydrogen and electric vehicles have, on rare occasions, exploded and caught fire. Similarly, there are hazardous materials that travel on semi-trucks, trains, barges, and pipelines that could pose a significant threat to communities if an accident were to happen. In the unlikely event that one of these hazards does occur in Iowa, the impacts (e.g., loss of life, damage of infrastructure, delay in travel, etc.) could be very similar to that of a natural hazard.

3.1 Natural Hazard Assessment and Prioritization

Iowa is vulnerable to several natural hazards that can result in various impacts and consequences to the transportation system. The Iowa DOT Resiliency Working Group (RWG) was asked to evaluate and prioritize these natural hazards through a risk-based assessment considering the likelihood and consequence of each. For likelihood, lower response values indicated that the hazard rarely occurred and higher response values indicated a higher probability of occurrence. For consequence, lower values indicated a lower impact to the Iowa transportation system while higher values indicated significant damages. Risk or vulnerability is calculated by multiplying the likelihood and consequence.

Flooding was prioritized as the highest risk hazard to Iowa's transportation system while landslides were the lowest overall risk. Many of the hazards identified are likely to occur (e.g., thunderstorms, drought, and freeze/thaw) but the impact or consequences of these events do not present as significant of a threat to Iowa's transportation system. In other instances, the consequences of an event (e.g., dam/levee failure) would cause significant damage to the transportation system but the likelihood of those events are rare.

Figure 3.1: Risk prioritization matrix



For the purposes of this plan, the RWG has grouped the nine hazards into three different tiers based on risk scores and preferred mitigation methods for each. The tiers are outlined in Table 3.1. While each tier of hazards is being targeted with a particular mitigation approach, individual hazards may involve a variety of mitigation measures as appropriate.

Table 3.1: Risk prioritization scores

Tier	Hazard	Likelihood	Consequence	Risk	Preferred mitigation methods
Tier 1	Flooding	4.02	3.94	15.83	Take proactive steps to mitigate the risks of these hazards
	Winter Storms	4.27	2.88	12.28	
	Freeze/Thaw	4.23	2.38	10.04	
Tier 2	Tornado/ Windstorm	3.31	2.77	9.18	Have strategies in place to quickly react when these events occur
	Hail & Thunderstorms	4.23	2.02	8.55	
	Drought	3.6	2.33	8.41	
Tier 3	Excessive Heat	3.69	1.69	6.22	Monitor and conduct prevention activities as appropriate
	Dam/Levee Failure	1.58	3.71	5.87	
	Landslide	1.42	2.02	2.86	

3.2 Hazard Profiles

Flooding (Flash and Riverine)

Description

Flooding occurs when the flow of water is greater than the normal capacity of the stream channel. Flash and riverine flooding are two different types of events, although most people often refer to these as simply "flooding." A flash flood occurs when water levels rise quickly with little warning, often a result of intense rainfall over a brief period. These floods can be compounded by other factors such as snowmelt, ice jam release, and frozen or saturated soil. The real danger presented by flash flooding is how quickly waters reach full peak and the damage this causes over a short period of time. Riverine flooding, on the other hand, often occurs gradually over the course of days. These floods result in partial or complete inundations of normally dry lands near rivers.

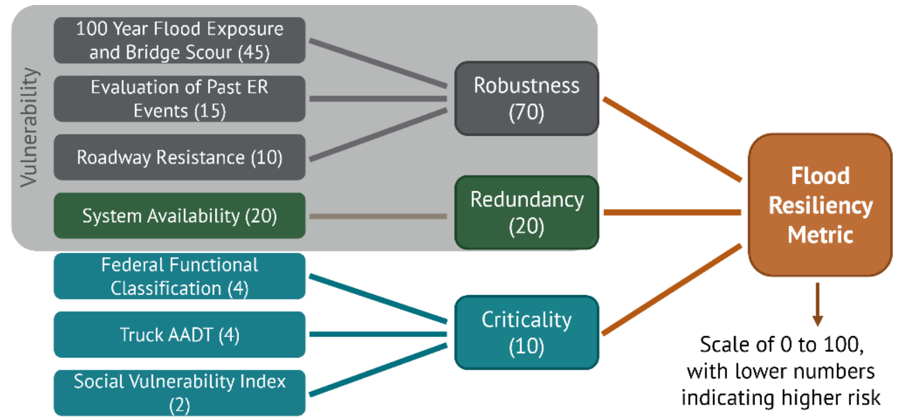
Analysis and Mapping

Floods are the most common and widespread of all natural disasters in Iowa. There is special emphasis on planning for and mitigating these events due to the frequency and associated cost. As part of the last update of the State Long Range Transportation Plan (SLRTP), a statewide flood resiliency analysis was developed to screen the Primary Highway System for locations vulnerable to 100-year flood events. The analysis was comprised of three broad components and seven individual factors that ultimately comprised a composite metric to assess Iowa's vulnerability to flooding.

Frequent flooding

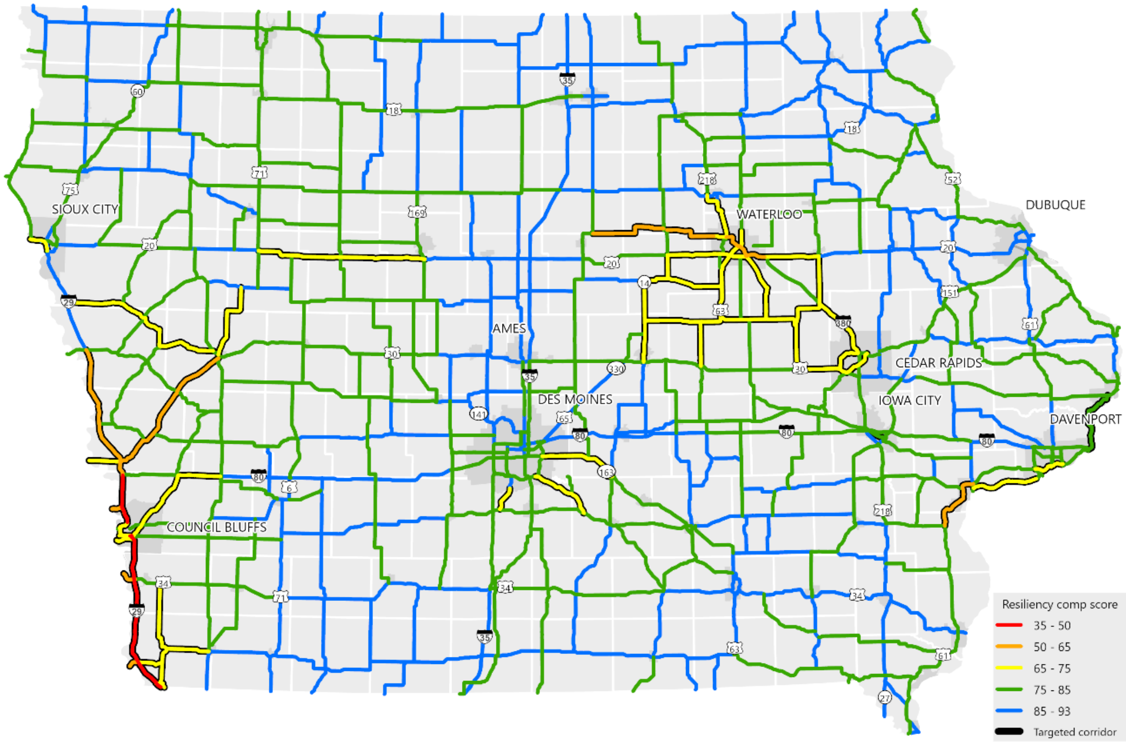
In the last 30 years, every county in the state has received at least five Presidential Disaster Declarations that included flooding.

Figure 3.2: Flood resiliency analysis factors and weighting



The data for each attribute were normalized on a 1 (worst) to 10 (best) scale, then combined based on the weighting factors which were determined by the RWG. The maximum composite score is 100; higher scores indicate greater resiliency to a 100-year flood event, whereas lower scores indicate greater vulnerability to those events. The analysis helps identify corridors where strategies related to preparedness for possible flooding events and infrastructure improvements to enhance the resiliency of the system may be most beneficial. Figure 3.3 shows the results of the flood resiliency analysis. The overall distribution of corridor-level composite ratings ranged from 36.6 to 93.4, with a corridor-level average of 82.4. To identify corridors of most concern from a long-range planning perspective, corridors with a composite score that was one or more standard deviation below the statewide average were identified. There are 72 such corridors with an average composite score of 75.1.

Figure 3.3: Flood resiliency analysis composite scores and corridors targeted for resiliency improvements



Impacts to Transportation

Flooding has significant short- and long-term impacts. In the short term, route closures affect all highway traffic, from commuters to freight transportation to emergency services. This inconvenience can be compounded by the out-of-distance travel required to detour around closed areas. These distances can be long when there are limited routes across rivers or when there is significant flooding throughout the river basin. Flooding can have significant impacts on other modes of transportation as well. Normal operations for transit operators, railroads, barge companies, and airlines can be delayed or canceled until flood waters recede. Iowans who rely on walking or cycling can be impacted when flood waters cut off normal routes.

The most significant long-term impact flooding has on transportation is the inundation and destruction of roadways and bridge structures, both of which are susceptible to erosive forces of water during a flood event. When a roadway is overtopped, the erosive nature of the flowing water can cause the shoulder and embankment of the roadway to be compromised and eventually result in washout or breach. Similarly, bridge scour is the removal of sediment from bridge abutments/piers caused by flowing water and can result in downstream scour holes that can eventually undermine the integrity of the structure.

Winter Storms

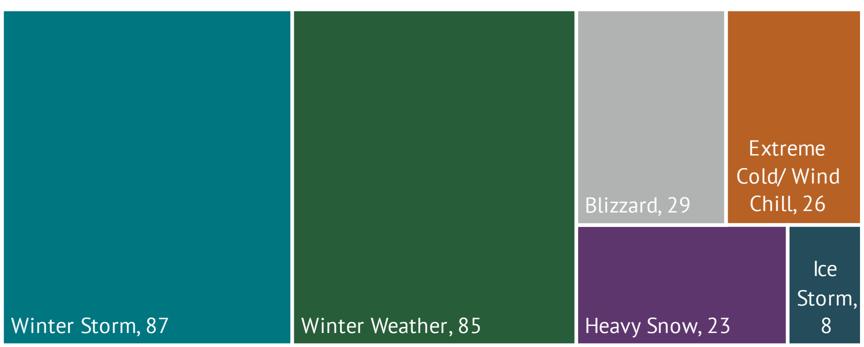
Description

"Winter storms" is a generalized term that includes blizzards, heavy and blowing snow, freezing rain, and extreme cold. Blizzards are storms that last three hours or longer with sustained winds of 35 mph or more, often resulting in reduced visibility of a quarter mile or less or whiteout conditions. Heavy snows are events of six inches of snow or more in a 12-hour period. Blowing snow events occur when loose snow begins to drift, which is more likely in rural areas where there are less objects to obstruct wind. Freezing rain can result in ice storms that cause power outages from downed trees, limbs, and utility poles. Extreme cold occurs when temperatures are near zero degrees Fahrenheit and can be magnified by wind.

Analysis and Mapping

Iowa, like many of the northern Midwest states, experiences time periods with poor weather and/or roadway conditions, especially during the winter season (October through April). These winter weather events are cataloged by the National Centers for Environmental Information (NCEI).

Figure 3.4: Winter weather events from 2018-2022

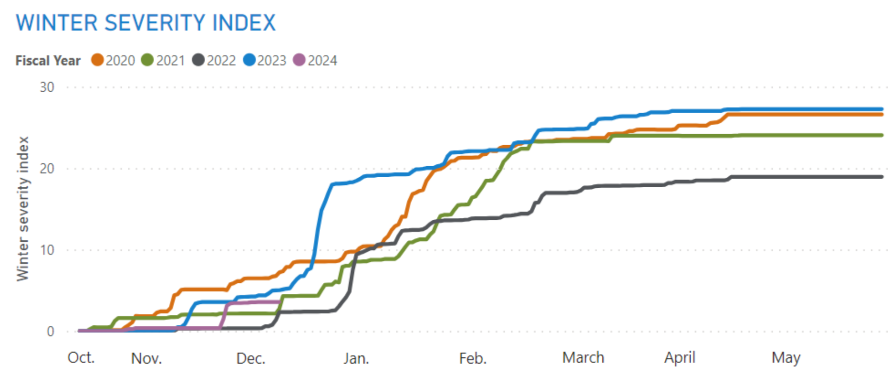


Source: NCEI

From 2018 to 2022, winter weather storms resulted in three deaths directly attributed to the event, 10 deaths and 16 injuries indirectly attributed, and $516,800 in property damage – $377,000 from ice storms alone.

The Iowa DOT has developed a winter severity index that provides a score for locations based on event duration, event frequency, snowfall amount, and temperature. The duration and frequency are normalized by the expected extreme for each event, then scaled by an "importance" factor. Generally, colder pavement temperatures during an event result in higher index scores, which correlate to more severe winters.

Figure 3.5: Iowa DOT winter severity index, 2019-2023



Impacts to Transportation

The mobility and safety of Iowa's transportation users can be compromised during winter weather events. Significant snowfall, extreme cold, high winds, and ice can all immobilize Iowa's transportation system resulting in travel delay, vehicle crashes, and the need for around-the-clock maintenance of the roadways.

Excessive Heat and Freeze/Thaw

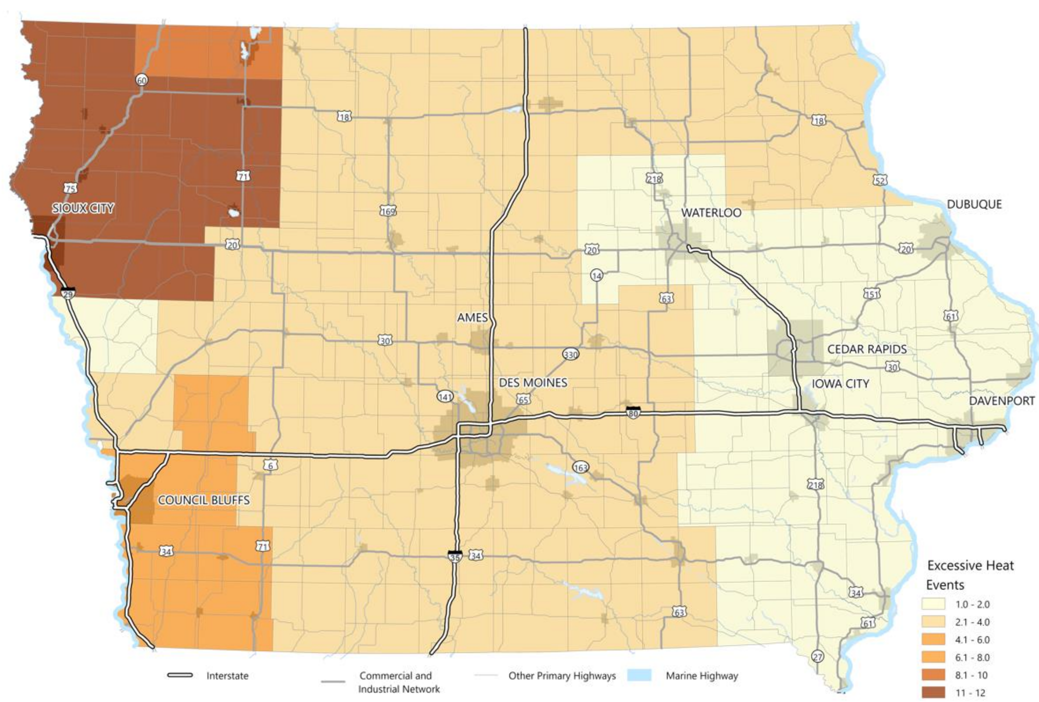
Description

Excessive heat can generally be defined as a period where the temperature is substantially hotter and/or more humid than average for a location at a given time of year. The National Weather Service in Des Moines defines excessive heat as a heat index greater than 110 degrees Fahrenheit for two or more consecutive days. This is not the only temperature related threat in Iowa as temperatures can also fluctuate rapidly. This can lead to dramatic freeze/thaw cycles that occur when air temperature drops low enough to freeze water, then increase enough for it to thaw again. These types of temperature changes occur most frequently from fall until spring in Iowa.

Analysis and Mapping

Since 2009, most Iowa counties have experienced at least one excessive heat event. The most frequent occurrence of these events has happened in northwest and southwest counties. Data collection of excessive heat events began in 2009, so while it is not appropriate to say that the western counties are more likely to see these types of events, one could surmise there may be a trend.

Figure 3.6: Excessive heat events in Iowa, 2009-2019



Source: NCEI

Impacts to Transportation

Excessive heat and drastic variability in freeze/thaw cycles can have significant impacts to transportation. Pavement buckling can occur when the air temperatures reach extreme highs. Pavement needs space to expand when temperatures rise and buckling occurs when there is not enough space available and/or expansion of the pavement happens rapidly. There are also modal considerations during excessive heat. Railroad tracks may buckle (referred to as a "sun kink") when temperatures are excessive; the bending, warping, or distortion of rail tracks can cause issues and potentially derail engines or rail cars. Excessive heat events can cause reduced transit ridership as transit users are particularly vulnerable if transit stops do not provide refuges, which can result in users experiencing heat related illnesses.

Thunderstorms & Hail and Tornado/Windstorm

Description

Thunderstorms come in different forms and produce threatening conditions such as tornados, windstorms, and hail. Although hailstorms can produce damage that impacts Iowa travel, the focus of this section will be on thunderstorms that produce tornados and windstorms. Portions of Iowa are in what has been colloquially defined as "Tornado Alley," an area of the country stretching from central Texas to northern South Dakota where tornadoes are most frequent. Tornados are violently rotating columns of air that contact the earth's surface with wind speeds ranging from 65 mph to over 300 mph and diameters up to two miles wide. The peak month for tornadoes in Iowa is June followed by May, July, and April; however, they can occur any month of the year. Like tornados, windstorms involve violent winds that can cause extreme damage. A type of windstorm known as a derecho includes high wind gusts (at least 58 mph) oriented in one direction along a wide, straight swath of land for an extended period. Most derechos will occur between May and August but can occur in the cooler months as well.

Analysis and Mapping

When and where a tornado or derecho will happen is unpredictable. When tornadoes do occur, they are rated based on estimated wind speeds and related damage under the Enhanced Fujita (EF) Scale. When tornado damage is surveyed, it is compared to a list of Damage Indicators (DIs) and Degrees of Damage (DoD), which provide better estimates of the range of wind speeds the tornado likely produced. From that, an EF rating (0-5) is assigned. From 1992-2022 there were 1,773 tornados in Iowa. Since 2007, when the Enhanced Fujita Scale was initiated, there have been five tornados with EF-4 ratings or above.

Table 3.2: Enhanced Fujita Scale

EF Rating	3 Second Gust (mph)	Description
0	65-85	Gale
1	86-110	Weak
2	111-135	Strong
3	136-165	Severe
4	166-200	Devastating
5	Over 200	Incredible

Source: NOAA NWS

Windstorms are rated on the Beaufort Wind Scale that relates windspeed and description of potential resulting damage. Windstorms have occurred in every county in Iowa. In the five-year period between December 2017 and November 2022, Iowa experienced more than 400 wind events according to the NCEI Storm Events Database. This includes thunderstorm wind, straight-line high or strong winds, and funnel clouds, which are tornado-like events that do not have contact with the ground. These events caused three fatalities (and at least one more indirectly). Property damage from those events was estimated to be $12,245,000 with crop damages over $700,000.

Table 3.3: Beaufort Wind Scale

Windspeed (mph)	Description - Visible Condition
0	Calm smoke rises vertically
1 to 4	Light air direction of wind shown by smoke but not by wind vanes
4 to 7	Light breeze wind felt on face; leaves rustle; ordinary wind vane moved by wind
8 to 12	Gentle breeze leaves and small twigs in constant motion; wind extends light flag
13 to 18	Moderate breeze raises dust and loose paper; small branches are moved
19 to 24	Fresh breeze small trees in leaf begin to sway; crested wavelets form on inland water
25 to 31	Strong breeze large branches in motion; telephone wires whistle; umbrellas used with difficulty
32 to 38	Moderate gale whole trees in motion; inconvenience in walking against wind
39 to 46	Fresh gale breaks twigs off trees; generally impedes progress
47 to 54	Strong gale slight structural damage occurs; chimney pots and slates removed
55 to 63	Whole gale trees uprooted; considerable structural damage occurs
64 to 72	Storm very rarely experienced; accompanied by widespread damage
73+	Hurricane-like devastation occurs

Source: NOAA NWS

Impacts to Transportation

Tornados and windstorms can devastate areas with strong winds that pick up debris and move it significant distances. This can include cars, trees, and even vertical structures like buildings and homes. All forms of transportation may be impacted during these events. Traditional transportation infrastructure such as roadways are typically left undamaged; however, in many cases debris removal and maintenance are required. These storms can also cause power outages and communication disruptions that can impact the ability of the Iowa DOT to coordinate response efforts across the state.

Drought

Description

A drought is defined as a period consisting of abnormally dry weather that persists long enough to impact agriculture and water supplies. During this period, the soil moisture does not meet the water needs of a particular region. In Iowa, drought can occur throughout the state and be particularly challenging as there has been a tendency to quickly transition from drought to flood and back to drought within short periods of time.

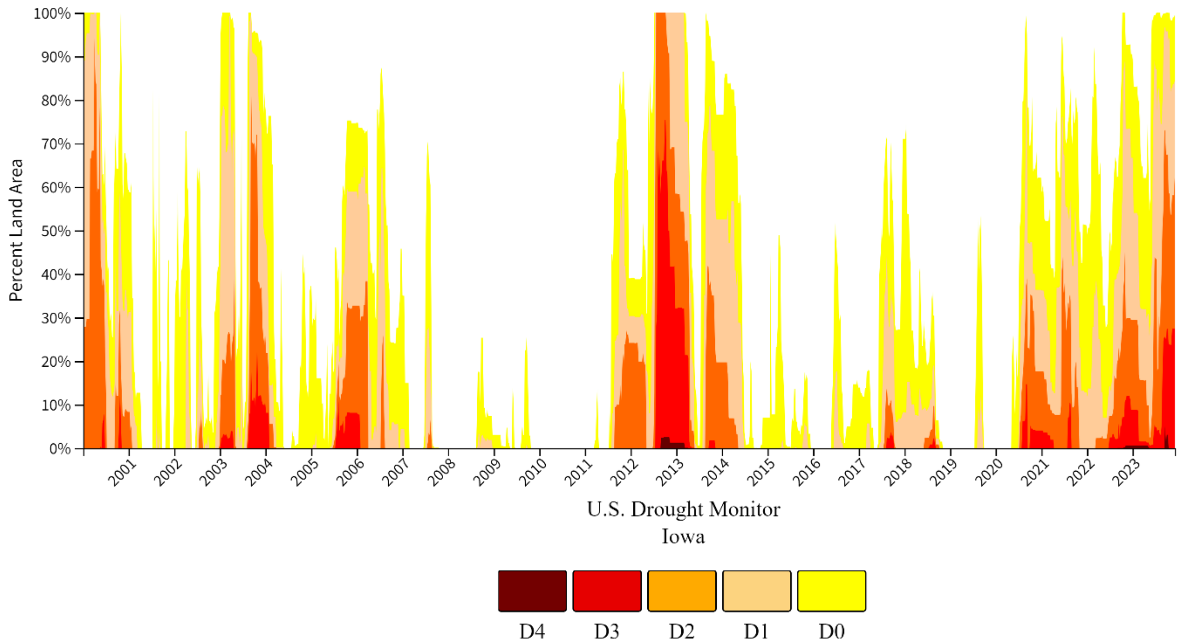
Analysis and Mapping

Drought is tracked and monitored nationally by the National Drought Mitigation Center in partnership with several federal agencies using the U.S. Drought Monitor (USDM). The USDM uses criteria that are evaluated and updated weekly to determine the severity of drought based on regional specific indicators.

The northwest and central portions of Iowa have typically experienced the most pronounced drought conditions while the northeast portion of the state has experienced the fewest non-consecutive weeks of drought.

Figure 3.7: U.S. Drought Monitor categories and Iowa drought conditions, 2000-2023

Category	Description	Example Percentile Range for Most Indicators	Values for Standard Precipitation Index and Standardized Precipitation-Evapotranspiration Index
None	Normal or wet conditions	31 or above	-0.49 or above
D0	Abnormally Dry	21 to 30	-0.5 to -0.79
D1	Moderate Drought	11 to 20.99	-0.8 to -1.29
D2	Severe Drought	6 to 10.99	-1.3 to -1.59
D3	Extreme Drought	3 to 5.99	-1.6 to -1.99
D4	Exceptional Drought	0 to 2.99	-2.0 or less



Source: National Integrated Drought Information System

Impacts to Transportation

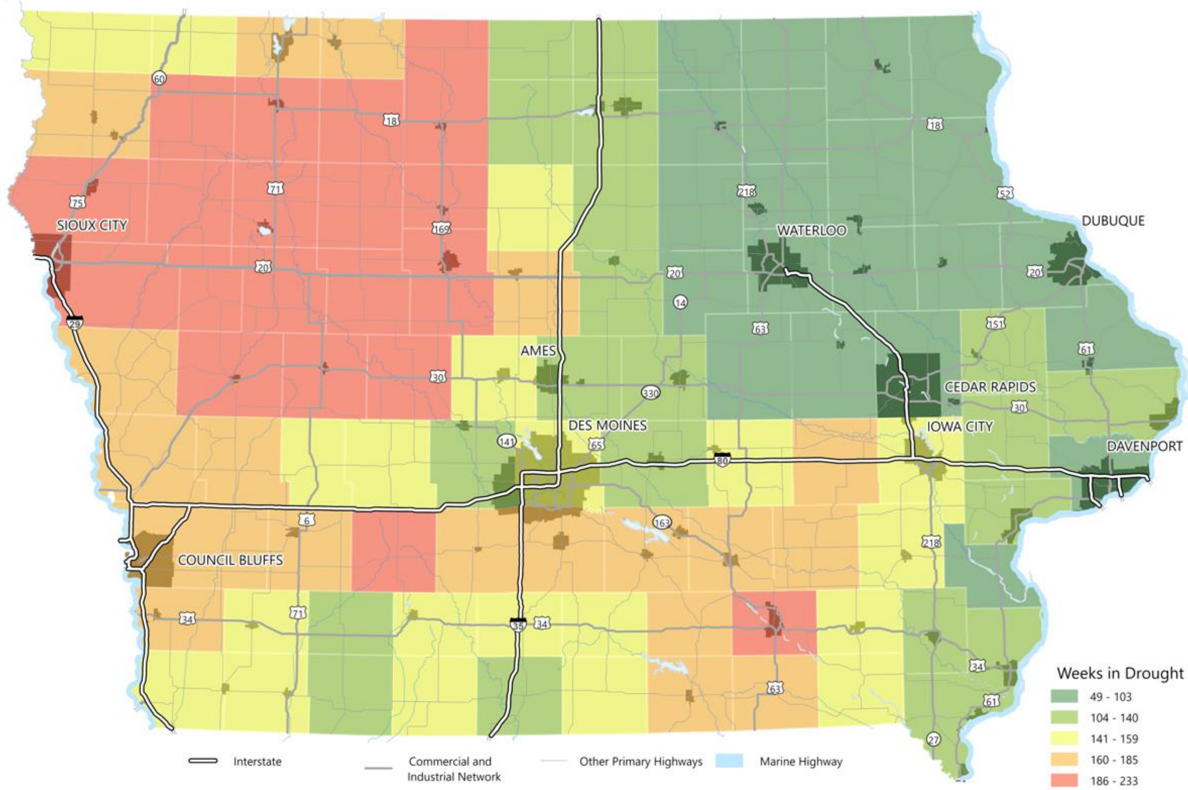
Iowa is known for its prime topsoil, plentiful rainfall, and widespread river systems which make it one of the top agriculture production areas in the world. Farmers and ranchers who depend on rainfall to water their crops and support grazing lands can be severely impacted by even short-term droughts, especially considering supplemental irrigation is rarely practiced in the state. Iowa producers rely on a robust highway system, a dense network of rail lines, and major consolidation points like elevators and barge terminals to export agricultural products outside of the state. Drought's largest impact to this supply chain is low water levels on the Mississippi and Missouri rivers. As recently as the fall of 2022, drought impacted barge capacity on the Mississippi River. Low water levels meant that limits needed to be placed on barge capacity resulting in about a one third loss in capacity and a 41% jump in barge shipping prices year over year. Ironically, only six months later in the spring of 2023, the Mississippi River was experiencing significant flooding.

Abnormally Dry

Iowa ended 2023 with over 80% of its land area in drought.

Over one third of Iowa was in extreme drought.

Figure 3.8: Non-consecutive weeks in Severe Drought (D2) or worse, 2000-2022



Source: U.S. Drought Monitor

Dam/Levee Failure

Description

Dams and levees provide essential functions in the protection of communities and the controlled flow of water. A dam is an artificial barrier constructed to hold back water, typically used for flood control, erosion control, water supply impoundment, hydroelectric power generation, and recreation (artificial lake). Levees are man-made structures, usually made of earthen embankment, and are designed to contain, control, or divert the flow of water to provide protection during flood events. The construction of a dam or levee can create opportunities for development in what would otherwise be considered flood-prone areas. Failures of dams or levees can have catastrophic impacts to communities and transportation within a region. Dam failures can occur for many reasons, including prolonged rainfall or flooding, overtopping, internal erosion caused by embankment or foundation leakage, improper maintenance, improper design, improper operation, or failure of upstream dams. Levee failures are often caused by foundation failure, levee boils/sand boils, surface erosion, and/or overtopping.

Analysis and Mapping

In Iowa, dams are grouped into three different classifications according to the downstream damage that would result from a failure. These three classifications are:

- **High Hazard –** Failure may create a serious threat of loss of human life.
- **Moderate Hazard –** Failure may damage isolated residential structures, industrial or commercial buildings, moderately-traveled roads, or interrupt major utility services, but does not present a substantial risk of loss of human life. This also includes dams and associated impoundments that are themselves of public importance (e.g., associated with public water supply systems, industrial water supply or public recreation, or integral features of a private development complex).
- **Low Hazard –** Damage from a failure would be limited to loss of the dam, livestock, farm outbuildings, and agricultural land.

The location and condition of levees within the state are primarily inventoried in the National Levee Database (NLD), which includes the FEMA accreditation status. The three levels of accreditation are:

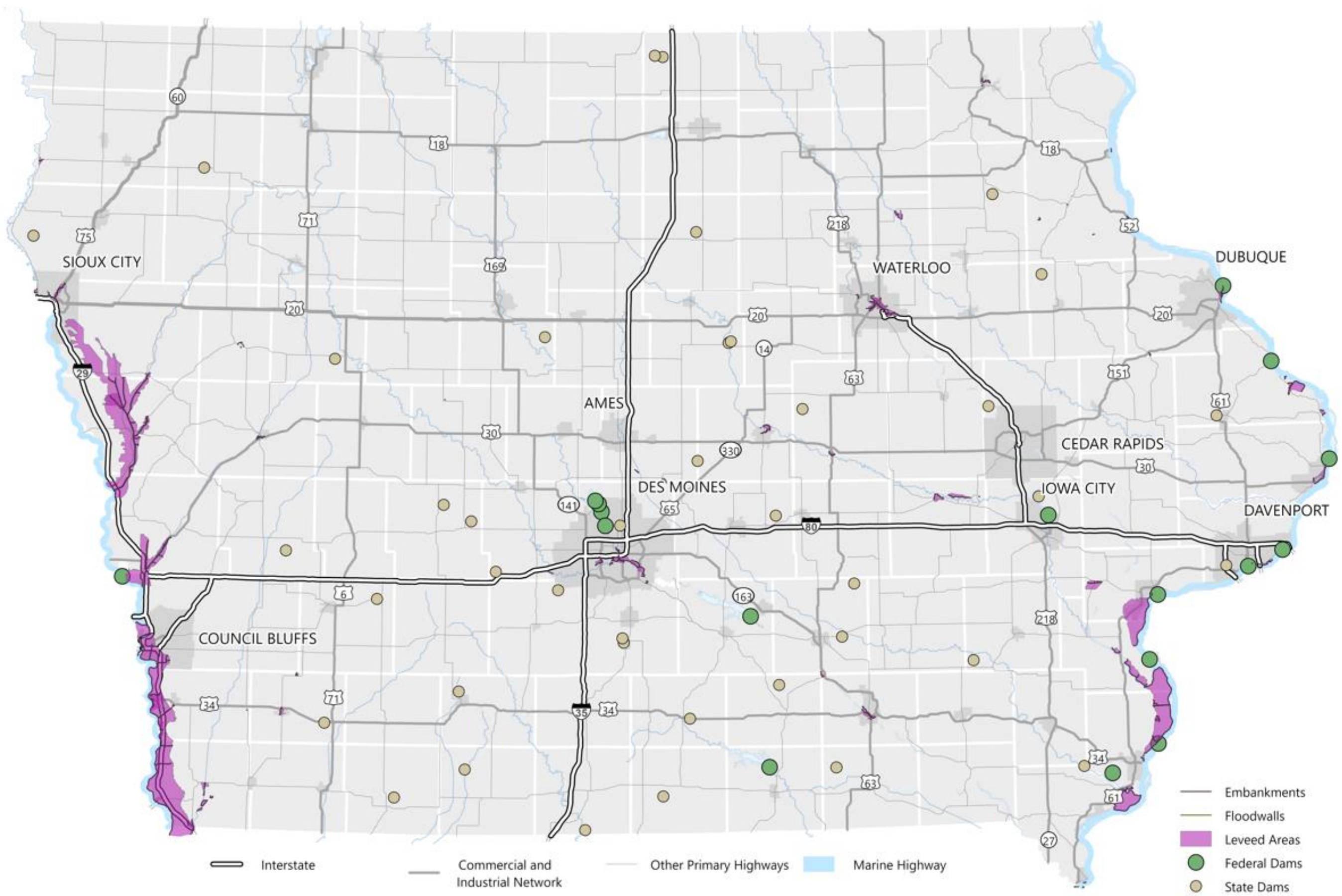
- **Accredited Levee System –** meets the design, data, and documentation requirements of 44 CFR 65.10.
- **Provisionally Credited Levee (PAL) System –** Previously accredited as providing base flood hazard reduction on an effective Flood Insurance Rate Map (FIRM), and for which FEMA is awaiting data and or documentation that will show compliance with 44 CFR 65.10.
- **Non-Accredited System or De-Accredited System –** Not providing base flood hazard reduction on an effective FIRM.

Non-levee embankments have been identified by the Iowa Department of Natural Resources (DNR) using LiDAR (light detection and radar) mapping. The non-levee embankments are not accredited in any way but may contain, control, or divert the flow of temporary flood waters in some cases.

Impacts to Transportation

Dam and levee failures are infrequent but do occur occasionally following periods of intense rainfall and/or flooding. The largest impact of failures is the quick release and flow of water in areas they were intended to protect (e.g., communities and transportation systems). This typically exacerbates tenuous natural disasters and hinders emergency and rescue operations. The most recent dam failure in Iowa occurred in July of 2010 at Lake Delhi. The most recent levee failures occurred in southwest Iowa in 2019 following significant flooding, which impacted several primary highways including I-29, I-680, and U.S. 34.

Figure 3.9: Dams, levees, and embankments in Iowa



Landslide

Description

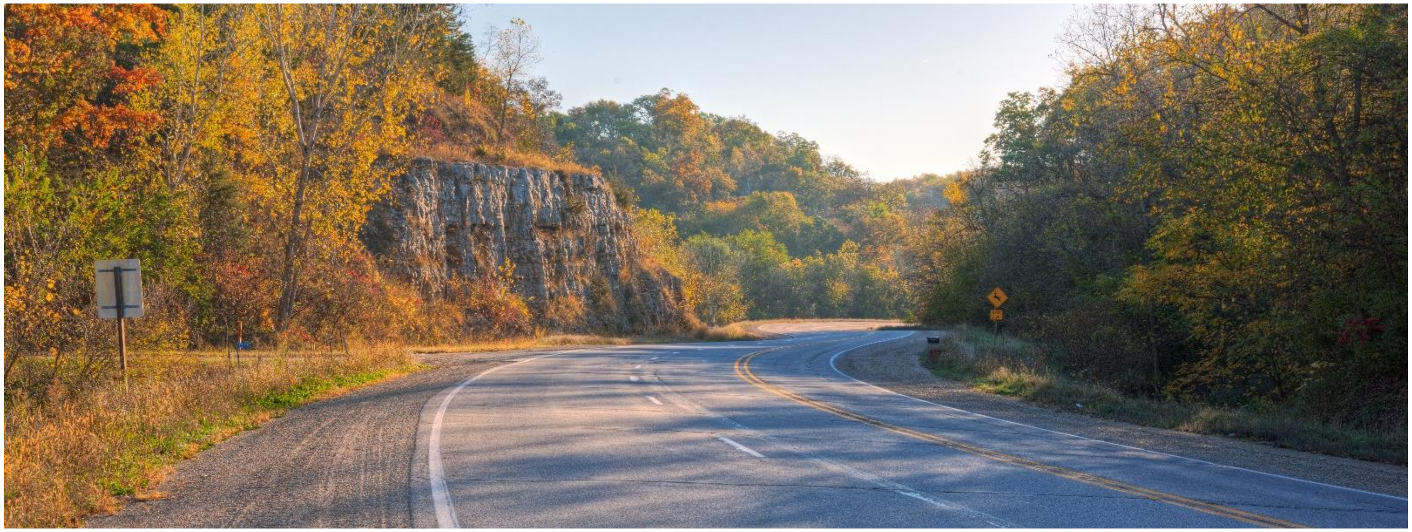
Landslides are natural phenomenon that occur when rainstorms, fires, or human activities modify the slope and drainage of the landscape in slide-prone areas. Rockfalls occur when susceptible rock, earth, and/or debris move down a slope under the force of gravity and water. These events can be small or large and move at varying speeds.

Analysis and Mapping

Although a significant landslide or rockfall has not occurred in Iowa, the risk still exists with the right combination of factors. Data collection of landslides and rockfalls in Iowa is sporadic with no state agency maintaining an inventory or database. The United States Geological Survey (USGS) does collect data at a national level as part of the Landslide Hazards Program. There were 13 events in Iowa from 2007-2019 with no fatalities or significant damage reported.

Impacts to Transportation

Landslides and rockfalls typically cause network blockages, delays, damage, and closures on the transportation system with the impact typically contained to the area the landslide/rockfall occurred. Economic and societal impacts can go beyond that area through delay costs associated with the closures and/or damage.



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