landscape incentive program within their service areas and the Division of Water Resources operates the program throughout the rest of the state.

Infrastructure plays a role in the resilience of Utah to past and future drought. Water storage, such as in reservoirs, allows the collection of water other in times of excess for use in times of shortage. A large network dams already exist in Utah for this purpose and this approach has largely allowed agriculture to develop as it has. Storage capacity and distribution infrastructure largely dictate the potential for using dams for mitigating drought. Expansion of the current network of dams remains possible, but also faces regulatory obstacles and introduces an additional burden of maintaining and monitoring more infrastructure. Constructing or expanding dams also creates new hazards associated with dam failure, described in Section 4.7.

Ultimately, the question remains where water will run out first. The answer is not clear, and agencies and municipalities have water management tools at their disposal to avoid such a situation and, in fact, are proactively managing water to avoid widespread water shortage. An analysis of development trends in LHMPs (see Section 3.7 Development Trends) noted some specific concerns with drought including Salt Lake County where increased population density and development will put further stress on limited water resources.

4.8 FLOOD

4.8.1 Description

Flooding is generally a temporary inundation of water onto normally dry land areas by overflow of water, an unusual rapid accumulation, mudflows, or runoff of surface waters from any source. Flooding is the most commonly occurring hazard in Utah despite the state being one of the driest parts of America. It occurs in Utah in many ways. It can be sudden or slow. It can affect mountain streams or slot canyons many miles from any rainstorm. It can even occur far from any river or other water body. Understanding the many forms of flooding in Utah is helpful to guide mitigation measures. Notably, floods in Utah are not only the most common but also the most expensive hazard. Of all the natural disasters occurring in Utah, floods consistently carry the highest price tag year after year. This underscores the critical importance of comprehensive flood preparedness and mitigation strategies to safeguard both the state's residents and its economic interests.

Additionally, Utah's unique geographical features contribute to its vulnerability to flooding. The state's varied topography, including steep canyons and arid plateaus, can lead to rapid runoff during intense rainfall. Urban areas, with their impervious surfaces, can exacerbate flooding, creating challenges for drainage systems. Moreover, the proximity of many communities to rivers and streams further amplifies flood risks. As climate patterns evolve, understanding and addressing these localized vulnerabilities will become even more crucial for effective flood risk management in Utah.

Types of Flood and Inundation Hazards

Flash Floods: A flash flood is a type of pluvial flooding that can result when precipitation is either too much or too fast for the ground to absorb all the water. By definition, flash floods occur within six hours of a significant rainfall or event such as a dam breach, but inundation of low-lying areas can occur within seconds with little or no warning. Slot canyons are notorious for experiencing flash floods.

Source: NPS

Long-Term Rainfall Events: Large storm events can stall out over an area for days. These heavy rains can lead to severe flooding by oversaturating the ground, overfilling storm drains, or causing rivers to spill over their banks or levees.

Groundwater Flooding Events: Occur when the water table, which is the level at which the ground is saturated with water, rises above the ground's surface. This phenomenon is often a result of prolonged periods of heavy rainfall, changes in land use, or urban development that reduces the natural permeability of the ground.

Alluvial Fan Flooding: Flooding can occur on the surface of an alluvial fan, the area at the base of a valley where the land becomes less steep. This allows floodwater to spread out, taking paths that are difficult to predict. Alluvial fan flooding is characterized by active sediment transport and potentially high-velocity flow.

Channel Migration Hazards: Stream channels often change over time, migrating laterally across their floodplain. Channel migration can happen slowly, as a stream erodes one bank and deposits sediment on the other. Abrupt shifts of the river channel are also possible, particularly during flood events. Either way, channel migration can endanger assets outside of mapped flood zones.

Dam Failure or Outlet Flooding: Dam failure can occur with little warning. Intense storms may produce a flood in a few hours or even minutes for upstream locations. Flash floods occur within six hours of the beginning of heavy rainfall and dam failure may occur within hours of the first signs of breaching. Other failures and breaches can take much longer to occur, from days to weeks, as a result of debris jams or the accumulation of melting snow. This hazard is discussed in the Dam Incident Section.

Levee and Canal Breaches: In the situations where floodwaters either (1) run over the top of the levee and reaches nearby structures, known as ‘overtopping’, or where (2) floodwaters cause the levee to erode, creating an opening for floodwater to flow through, known as a ‘breach’. Canals can have similar issues and overtop or breach and lead to localized flood problems.

Source: Tom Smart, Desert News.

Overtopping: Consist of water level behind a dam rising above the top of a dam and spilling over to the other side. Wave overtopping also exists where wave run-up flows over the top of a crest or slope, usually a beach, dune, or structure.

Spring Snowmelt River Flooding: Warmer temperatures and resulting snow melt can produce large amounts of runoff in a short period of time, as each cubic foot of compacted snow contains gallons of water. During the early spring, frozen land prevents melting snow or rainfall from seeping into the ground. The water then runs off the surface and flows into lakes, streams, and rivers, causing excess water to spill over their banks.

Rain-on-Snow Flooding: Rain-on-snow events are most significant for exacerbating the already-tenuous situation of spring snowmelt. During spring snowmelt, any additional runoff from rainfall can be sufficient to cause streams to flow over their banks. Further compounding the situation, rainfall is relatively efficient at convectively transferring heat from the atmosphere to the snowpack and has the potential to melt large amounts of snow rapidly. Cumulative runoff from these three sources can greatly exceed predictions of runoff from any one source. The rain-on-snow runoff process has caused flooding and even dam failures in Utah, such as the 2017 failure of the 21 Mile Dam.

Ice Jam: Pieces of floating ice carried with a stream's current can accumulate at any obstruction and block stream flow. Ice jams can develop near river bends, mouths of tributaries, points where the river slope decreases, downstream of dams and upstream of bridges or obstructions. The water that is held back may cause flooding upstream of the ice jam or, if the ice jam suddenly breaks free, flash flooding downstream. If the obstruction suddenly breaks, then flash flooding may occur downstream.

Sheet/Pluvial Flooding: A type of flooding that occurs when precipitation is either too much or too fast for soils to absorb all the water. Sometimes this occurs when soils become fully saturated and are unable to accept additional precipitation. Other times the rate of rainfall simply overwhelms the rate that water can physically infiltrate the surface. Either way, excess water flows broadly overland or accumulates as standing water.

Ponding: In hydrologic terms, 'ponding' is where runoff collects in depressions or low-lying areas that cannot easily drain out. These areas of shallow flooding often resemble ponds and are typically characterized by an average depth ranging from one to three feet.

Shoreline Flooding: Shoreline flooding refers to the inundation of large lakes caused by variations in water levels in lakes lacking an outlet or with restricted outflow. This type of flooding can result from a variety of factors, including high snowmelt runoff, wind, storm events, and even seismic events that alter water levels. The wind and wave action with these floods can erode shorelines that are normally above the high-water mark, resulting in extensive soil erosion, transport and lake deposition.

Debris/Mudflow: Describes a condition where there is a river, creek, tributary, flow, or inundation of liquid mud down a hillside usually as a result of a dual condition of loss of brush cover, and the subsequent accumulation of water on the ground preceded by a period of unusually heavy or sustained rain. A mudflow may occur as a distinct phenomenon while a landslide is in progress and will be recognized as such by the Administrator only if the mudflow, and not the landslide, is the proximate cause of damage that occurs. -CFR 44 definition.

Conditions That Affect Floods

Some aspects of Utah's geography can affect the location, severity, and frequency of flooding. For example, heavy mountain precipitation and runoff is capable of causing flooding in distant, and much drier, parts of the state. Southern Utah has a higher risk of flash flooding due to its slot canyons and infrequent but heavy storm systems. Wildfires can leave burn scars that dramatically reduce the permeability of soils, vastly accelerate runoff following rainfall, and increase the risk of flooding and flash flooding. Debris flows associated with burn scar runoff are especially prone to destructive debris flows. Table 4-26 provides a list of conditions that can exacerbate the flood hazard in Utah.

Table 4-26 Conditions Which May Exacerbate Flooding

IMPERMEABLE SURFACES	CONSTRICTIONS
Steeply sloped watersheds	Obstructions
Debris	Droughts
Contamination	Soil saturation
Velocity	Wildfire
Soil erosion	Erosion hazard zones
New construction/urban development	Invasive vegetation
Climate variability	Severe weather events
High water tables	Snowpack runoff and rain on snow

Source: FEMA with modifications

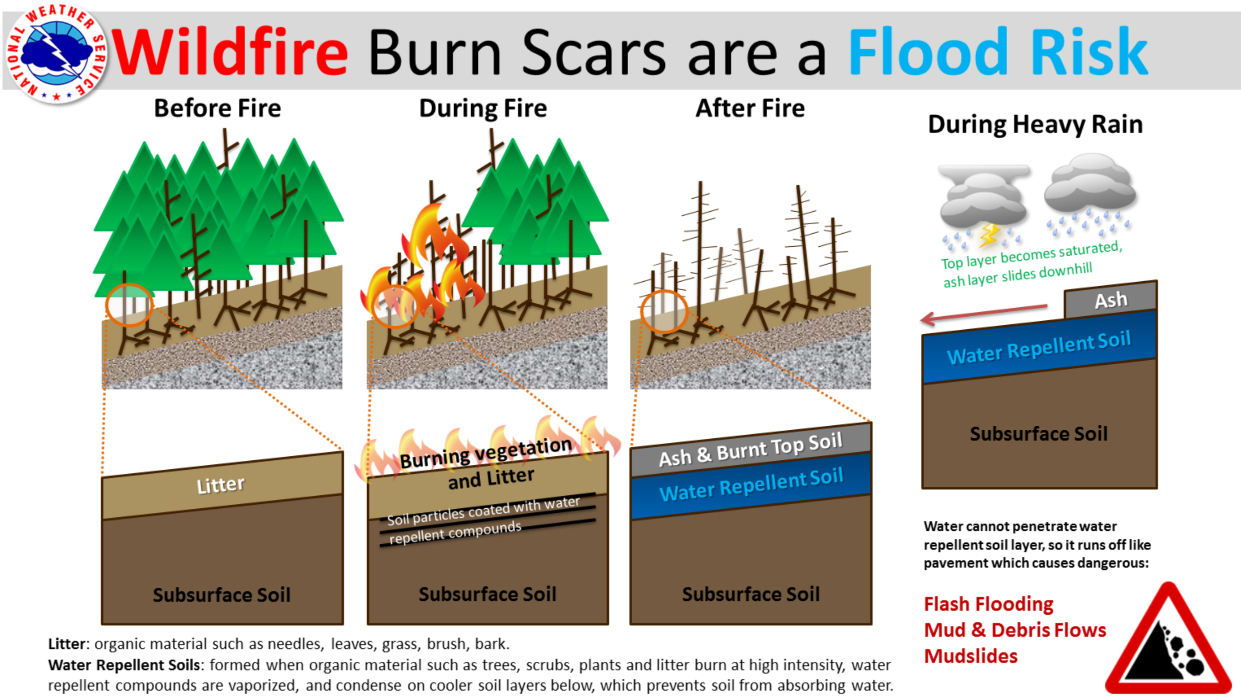
Closed basin flooding: A portion of the Great Basin resides in Utah and contains various closed basin lakes. The Great Salt Lake, for example, is an endorheic lake that has no outflow and achieves equilibrium through evaporation. Other closed basin lakes either do not have a natural outlet or only a relatively small one to discharge surplus water. This can lead to flooding as snowmelt or other precipitation cause the lake level to rise faster than it can drain. Closed basin flooding lasts longer as it cannot peak and recede as easily as rivers or streams.

Severe cloudburst storms: Cloudburst storms are defined by a rainfall rate equal to or greater than 3.9 inches per hour. They consist of both micro and macro downbursts. A downburst that is less than 2.5 miles in diameter is considered a microburst. A downburst that is greater than 2.5 miles in diameter is considered a macroburst. Both can result in high wind speeds and heavy precipitation. Cloudbursts have been recorded in Utah for over a century and continue to be a difficult to predict threat.

Snowpack melt rates: Utah has a total of 41 key irrigation reservoirs for water storage. How well they fill is dependent on the amount of snowfall received and the temperature through the winter. A gradual warming in the spring can lead to manageable snowmelt. When warmer and/or wet spring conditions occur, there is a possibility for flooding from excess snowpack runoff.

Burn Scars: Following a wildfire, the ground can be covered in a burn scar that has the potential to develop into a debris flow, following precipitation events. The presence of burn scars can also dramatically increase the risk of flooding (Figure 4-51).

Figure 4-51 Flood Risk and Burn Scars



Drought - Increased intensity of rain events may increase drought vulnerability and are not always effective drought relief. Soil erosion from intense rain events can damage healthy soil. Droughts can still happen even in a wetter climate while going quickly from drought to flood or flood to drought within months.

Water Quality Hazards

A substantial concern regarding flood hazards is their impact on water quality and aquatic habitats. Flooding can cause foreign contaminants to pollute waterways and move downstream. Too much sediment or nutrients entering a waterway has negative impacts on downstream water quality. If a water level rises too high, it can remove vegetation or degrade slopes and increase erosion. This can cause loss of habitat, dispersal of unwanted weed species, lower fish production, loss of proper wetland functions, release of contaminants, and loss of recreational areas. Floods can also overwhelm wastewater treatment plants and cause overflow discharges. Standing waters caused by floods can cause considerable risks. They may conceal hazards beneath the water surface, such as downed power lines, open plumbing or irrigation ditches, or other hazards. In addition, diseases such as E. coli, Hepatitis, HIV/AIDS, TB, and others can potentially exist in standing flood waters, coming from sewage overflow or flood victims.

There are many possible sources of chemical contamination during floods, including:

- Dumping grounds
- Graveyards
- Chemical factories and warehouses
- Oil storage and gas stations
- Municipal and private sewer systems and septic tanks
- Chemical heavy businesses, i.e., drycleaners
- Household chemicals

Common contaminants include but are not limited to:

- Agricultural chemicals, pesticides, fertilizers
- Lubricants, hydraulic oils, crude oil
- Flammable liquids, gasoline, propane, kerosene
- Corrosive liquids, batteries
- Heavy metals, arsenic, mercury, lead, copper, chromium
- Paint, solvents, polyester resin
- Cleaners and household chemicals, aerosols, detergents

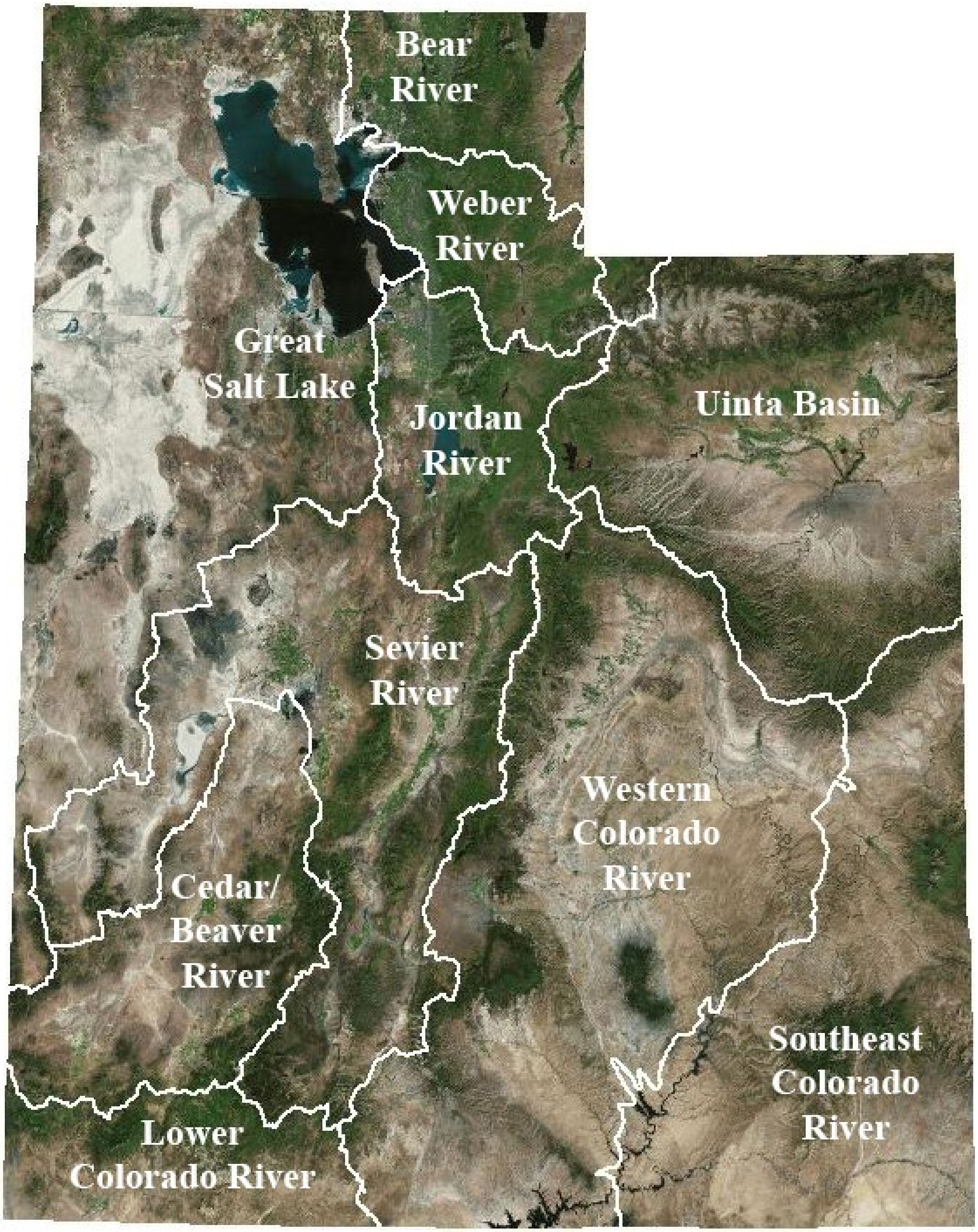
4.8.2 Geographic Area

Watersheds

A watershed is an area of land that drains to a given point, such as to the mouth of a river. Watersheds are 'nested.' Most major rivers have very large watersheds and are assigned a relatively short Hydrologic Unit Code (HUC) and tributary streams are assigned increasingly longer codes. For example, the Upper Colorado River watershed is assigned a 2-digit HUC (HUC 2) of 14, while the Duchesne Watershed is assigned a HUC 8 of 14060003 that indicates it is located within the Upper Colorado River basin. There are 65 HUC 8 watersheds within Utah.

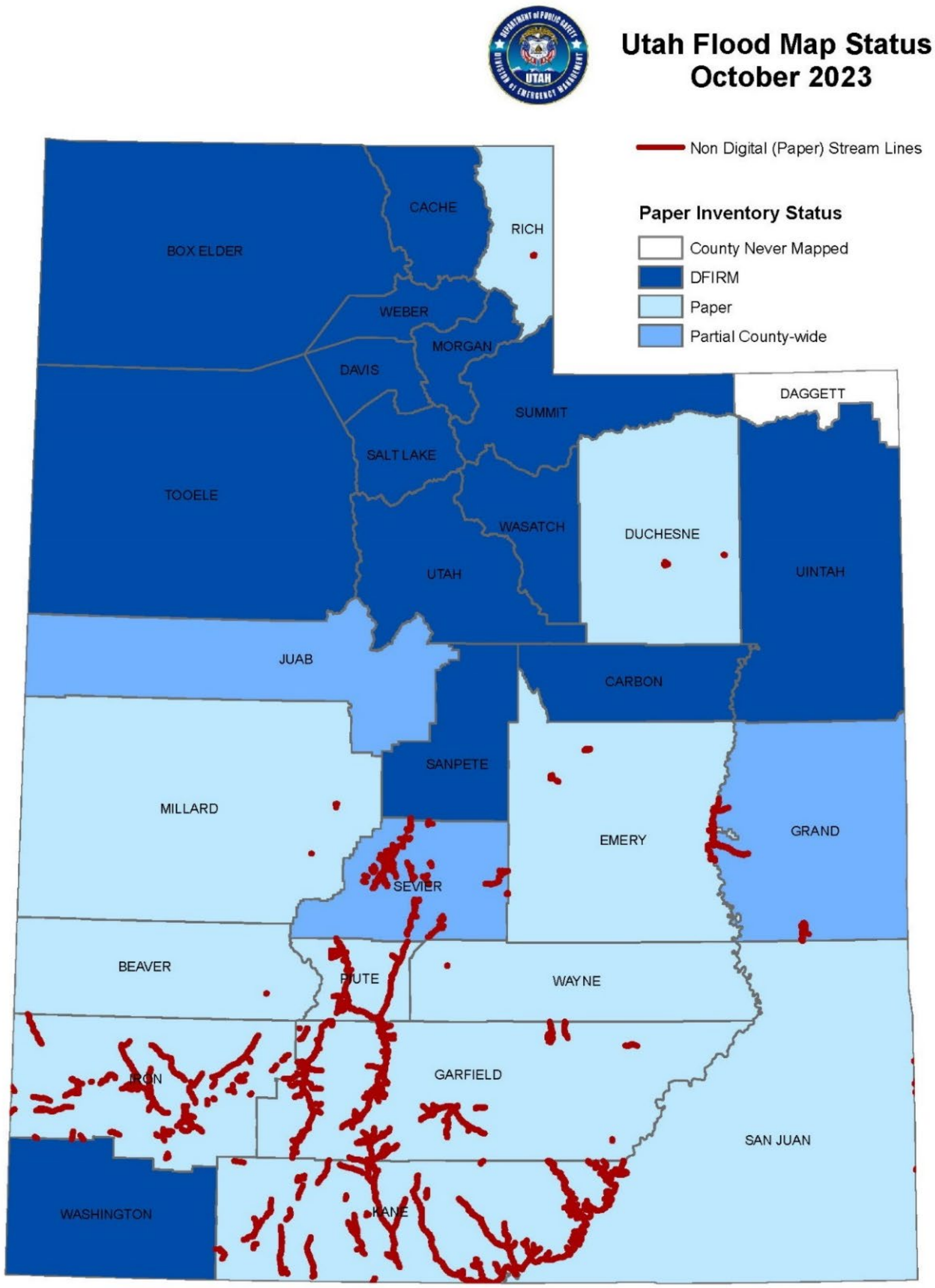
The major rivers within Utah include the Colorado, Green, San Juan, Bear, Blacks Fork, and Sevier Rivers. Notable tributary rivers include the Dirty Devil, Dolores, Escalante, Paria, Price, San Rafael, White and Virgin Rivers. Watersheds draining to these, and other rivers are shown in Figure 4-52.

Figure 4-52 Major Utah Watersheds



The figure below (Figure 4-53) shows FEMA flood hazard mapping status as of October 2023. Dark blue areas are the digitally mapped FEMA 1% Annual Chance Floodplains. Light blue represents counties that have FEMA paper maps only, and light purple are where counties have partial county-wide maps. The non-shaded county indicates that FEMA has not mapped floodplains for Daggett County as of 2023.

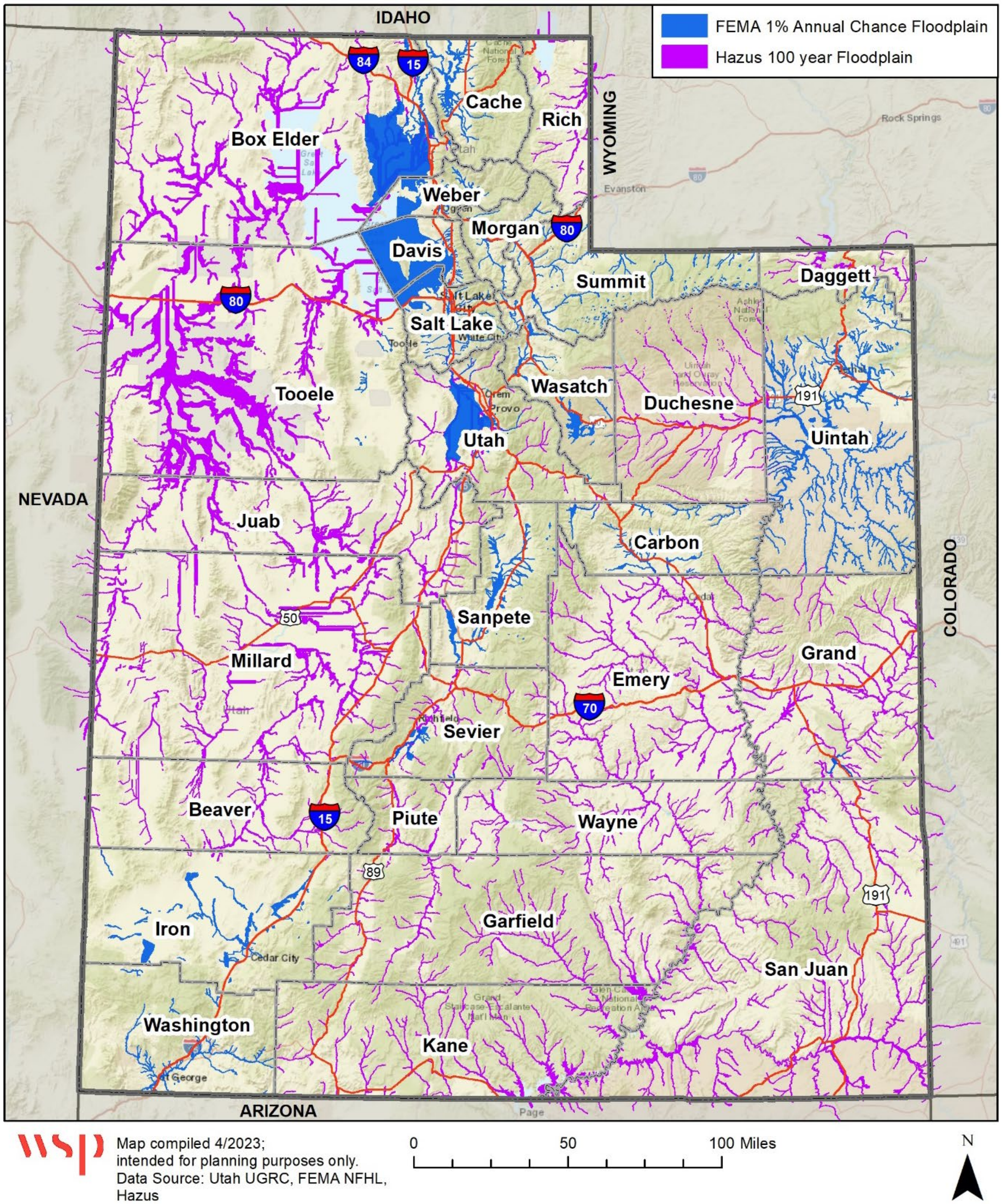
Figure 4-53 FEMA Paper Flood Insurance Rate Map (FIRM) Status



Source: FEMA, Utah DEM

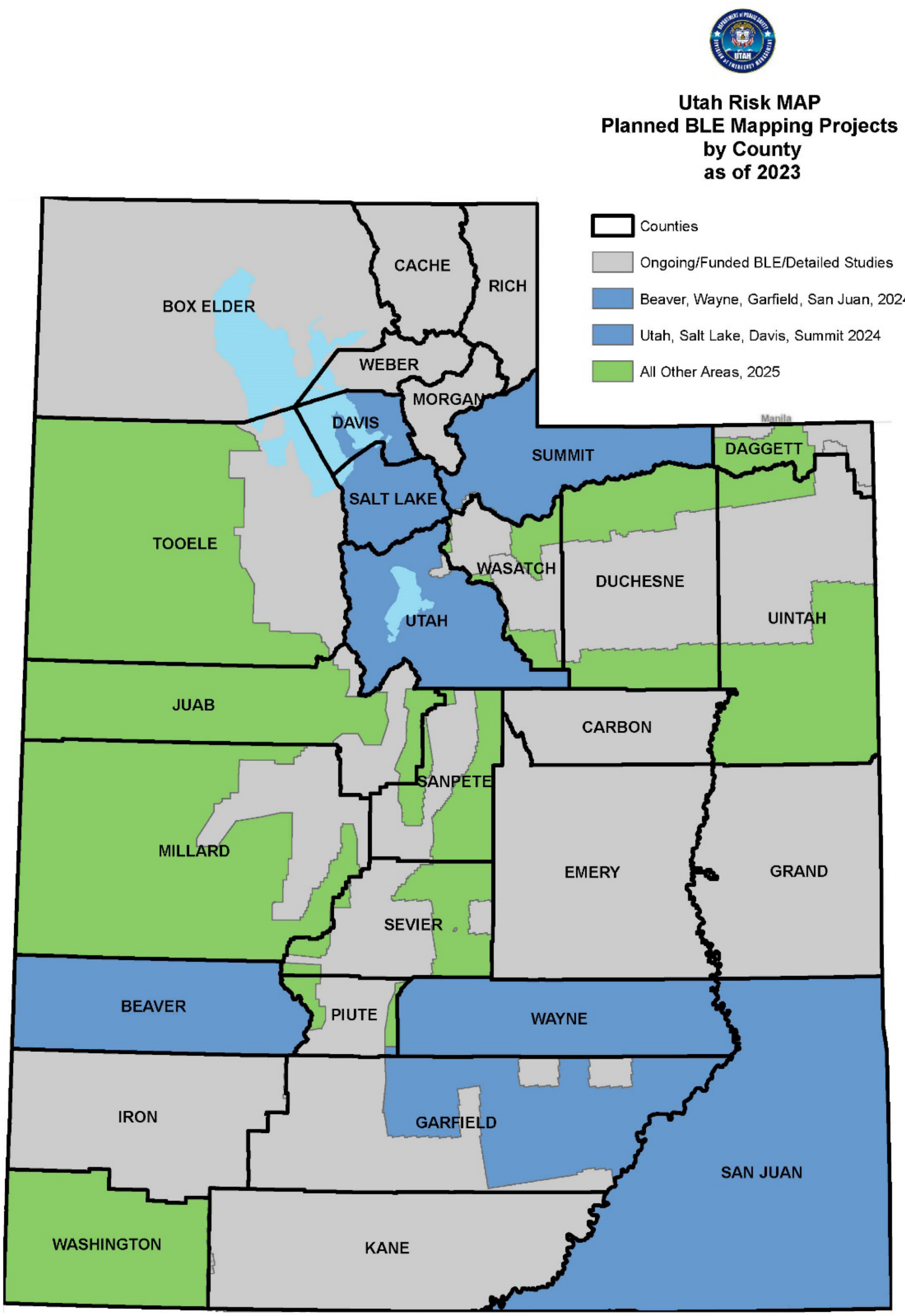
Utah's 1% annual chance of flooding hazards statewide are shown in Figure 4-54, below. Multiple flood layers from different sources were used in the analysis to create a full coverage of flood hazards for the state through the utilization of FEMA's NFHL (as of 01/01/2023) and Preliminary DFIRM layers for Cache, Iron, and Weber Counties that weren't present in the NFHL. FEMA Region VIII also provided 1% annual chance flood risk areas based on Hazus flood models to help supplement areas where FEMA flood data was not available.

Figure 4-54 Utah FEMA and Hazus Floodplain Hazards



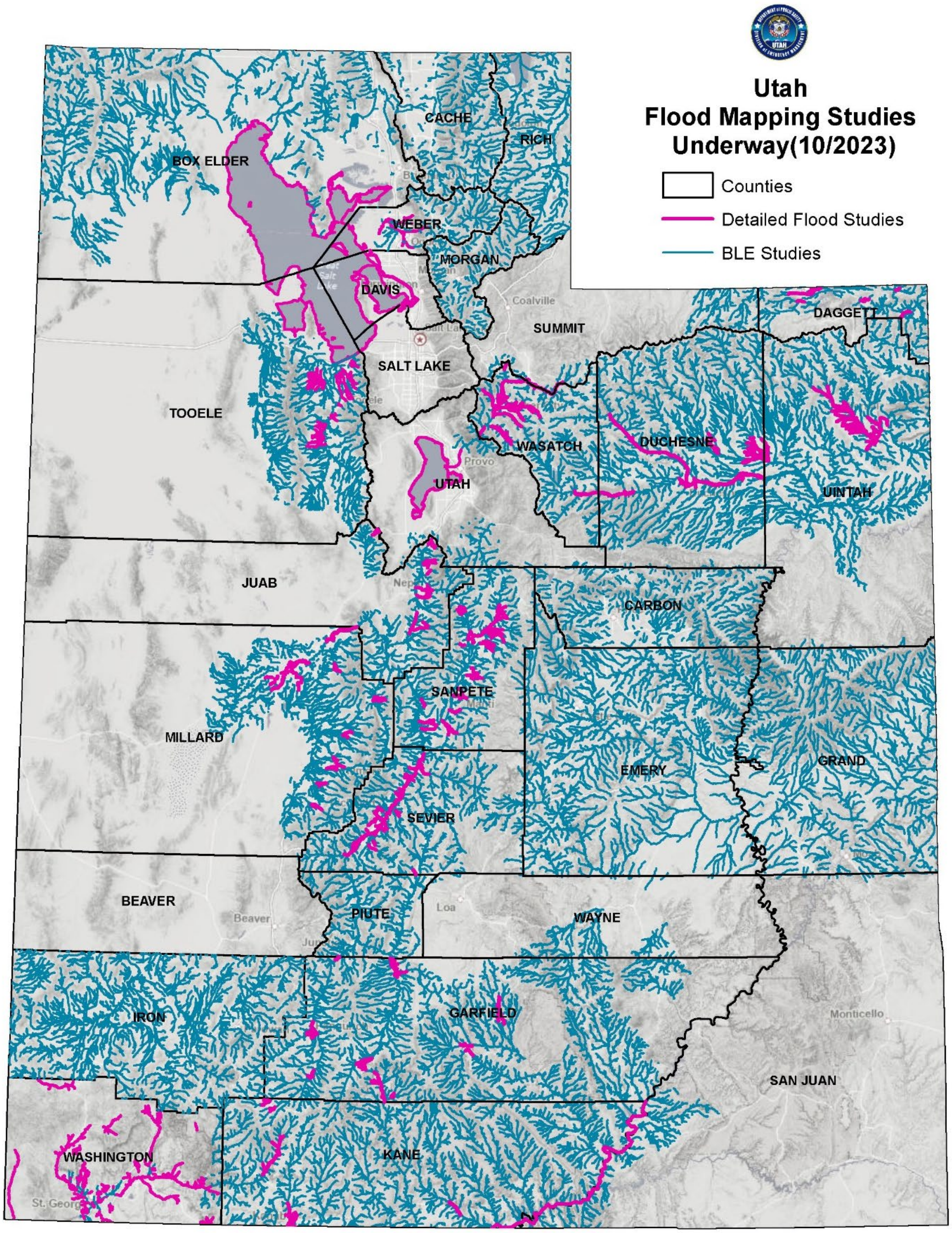
Utah DEM has begun additional flood modeling referred to as Base Level Engineering (BLE) that will be helping to fill in gaps in digital flood hazard mapping across the state. Base Level Engineering is an automated riverine hydrologic and hydraulic modeling approach that builds on lessons learned to produce a base line understanding of a community's flood risk. This mapping initiative is currently underway and contains 7,994 stream miles within the State and 28,448 that will be completed in 2023. Figure 4-55 shows the status of the BLE projects and estimated completion. Figure 4-56 depicts all of the BLE mapped streams currently mapped and projects underway, along with detailed studies.

Figure 4-55 Planned Base Level Engineering Mapping Projects



Source: FEMA, Utah DEM

Figure 4-56 Base Level Engineering and Detailed Flood Mapping Studies Underway



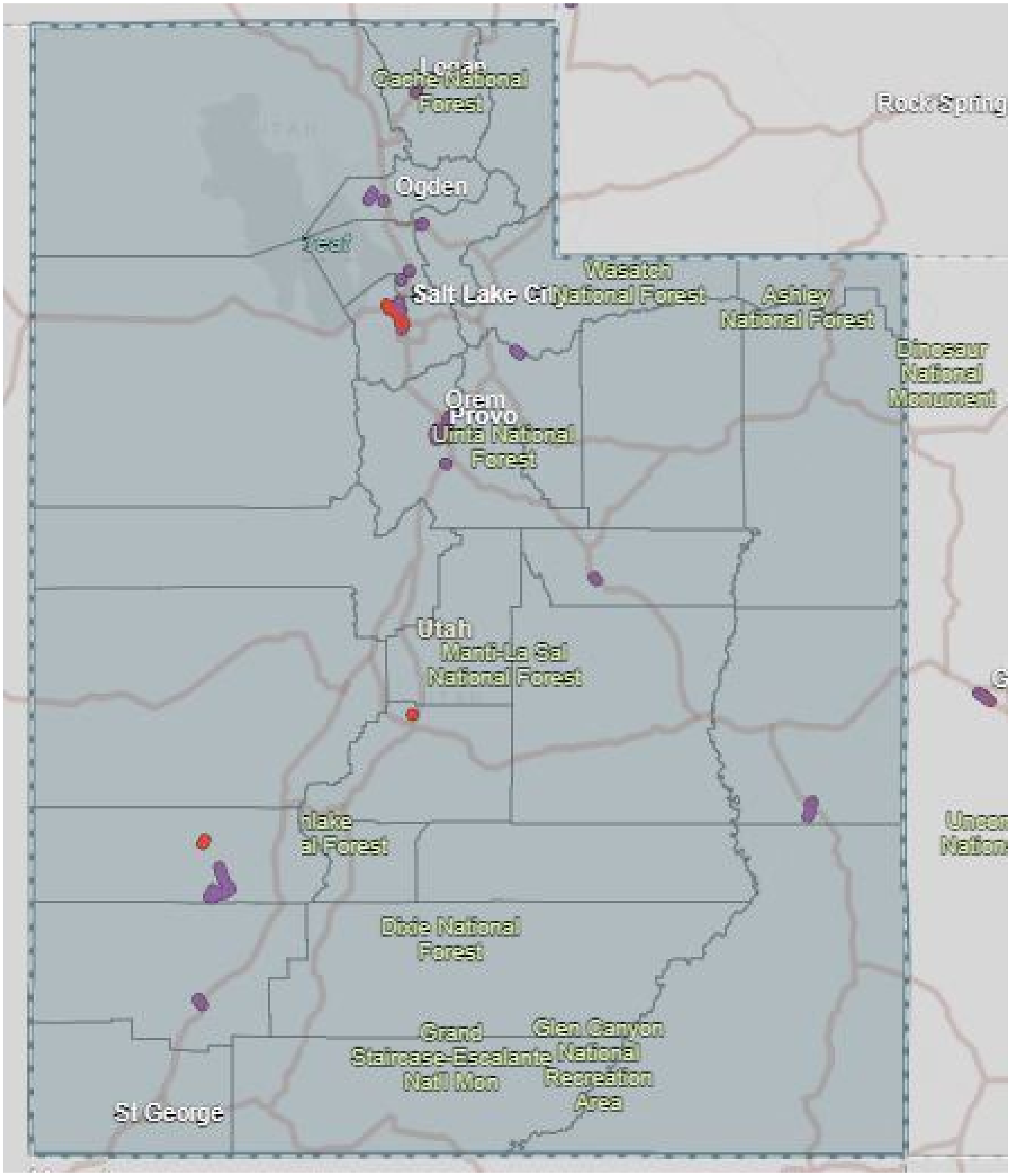
BLE: "Base Level Engineering" (Initial flood risk assessment)

Prepared by: Jamie Huff, Utah DEM 10-2023

Levees

According to the 2023 USACE National Levee Database, Utah has 45 levee systems (Figure 4-57), four were constructed by USACE (red) and 41 were constructed by other entities (purple).

Figure 4-57 USACE Levee Systems in Utah



Source: USACE National Levee Database 2023

4.8.3 Extent/Magnitude

Magnitude and severity can be described or evaluated in terms of a combination of the different levels of impact that a community sustains from a hazard event. Specific examples of the range of negative impacts from flooding in the State of Utah are summarized as follows:

- Floods cause damage to private property that often creates financial hardship for individuals and families;
- Floods cause damage to public infrastructure resulting in increased public expenditures and demand for tax dollars;
- Floods cause loss of personal income for agricultural producers that experience flood damages;
- Floods cause loss of income to businesses relying on recreational uses of regional waterways;
- Floods cause emotional distress on individuals and families; and
- Floods can cause injury and death.

Floods present a risk to life and property, including buildings, their contents, and their use. Floods can affect crops and livestock. Floods can also affect lifeline utilities (e.g., water, wastewater, and power), transportation, jobs, tourism, the environment, and the local and regional economies. The impact of a flood event can vary based on geographic location to waterways, soil content and ground cover, and construction. The extent of the damage of flooding ranges from very narrow to widespread based on the type of flooding and other circumstances such as previous rainfall, rate of precipitation accumulation, and the time of year.

Another common way to express the extent of flooding is in flood zone designations and recurrence intervals. The commonly mapped large flood events include the 1% Annual Chance and 0.2% Annual Chance floods which are described below. Other extents of flooding are noted in the table below.

Table 4-27 FEMA Flood Zones and Risk Descriptions

FEMA Flood Zone Designations				
Undetermined Risk	**Low Risk**	**Moderate Risk**	**High Risk**	**Coastal High Risk**
Increasing Risk →				
Zone D	Zones C and X (unshaded)	Zones B and X (shaded)	Zones A, AE, A1-30, AH, AO, A99	Zones V, VE, V1-30
	Non-Special Flood Hazard Area (NSFHA)		Special Flood Hazard Area (SFHA)	

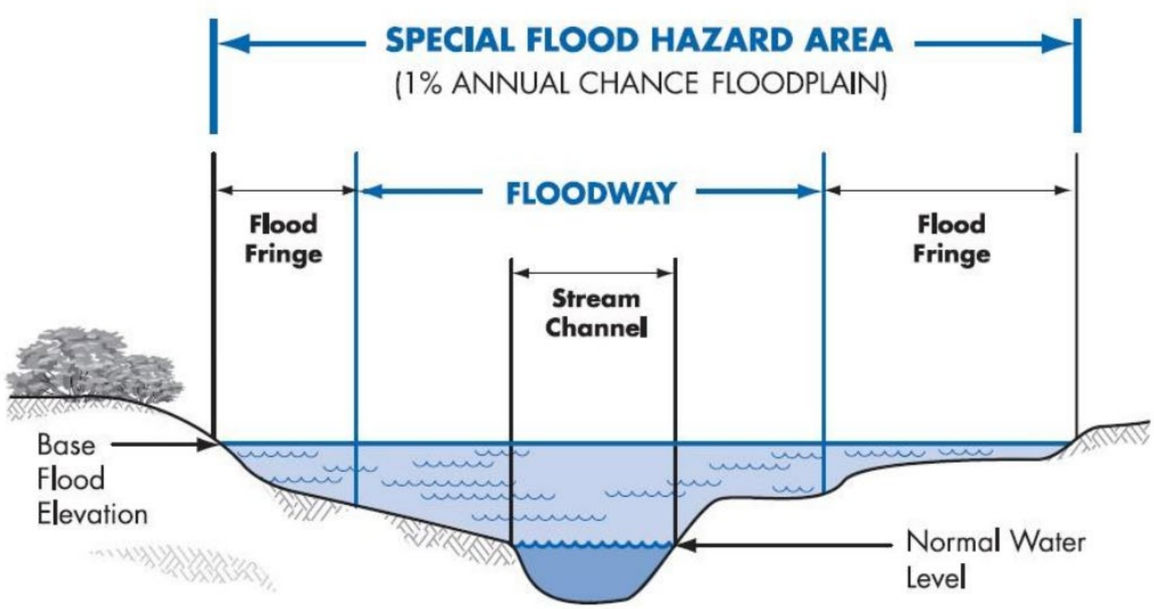
Source: Climate Check

Table 4-28. Flood Recurrence Intervals

FLOOD RECURRENCE INTERVAL	CHANCE OF OCCURRENCE DURING ANY GIVEN YEAR
5 year	20%
10 year	10%
50 year	2%
100 year	1%
500 year	0.2%

1% Special Flood Hazard Area (100-year flood): Applies to an area that has a 1 percent chance, on average, of flooding in any given year. It is unlikely, but possible, for a 100-year flood to occur more frequently, or even twice in a single year. The 1% chance flood is also referred to as a 100-year-flood and as the *base flood*. Some agencies use the term *1% Annual Exceedance Probability* to more clearly communicate the meaning of the so-called 100-year flood.

Figure 4-58. FEMA 1% Annual Chance Floodplain Profile



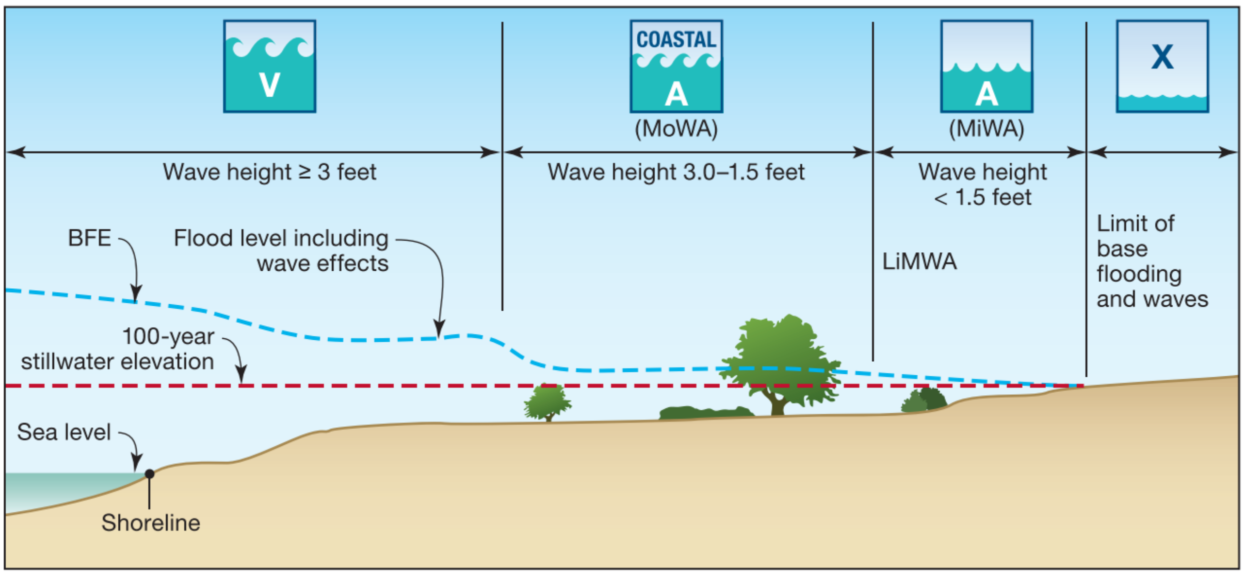
0.2% Special Flood Hazard Area (500-year flood): A 0.2 percent (500-year) floodplain is an area at risk for flooding from a bayou, creek or other waterway overflowing during a 0.2 percent (500-year) flood. Structures located in a 0.2 percent (500-year) floodplain have a minimum of a 0.2 percent chance of flooding in any given year.

Shoreline Flooding: Refers to the inundation of large lakes caused by variations in water levels in lakes lacking an outlet or with restricted outflow. The risk of shoreline flooding can be influenced by factors such as heavy precipitation, rapid snowmelt, and the natural topography of the area.

Figure 4-59 shows an example of a transect perpendicular to the shoreline. To address the challenge of shoreline flooding, FEMA has established Base Flood Elevations (BFEs) as a means of distinguishing varying wave heights in different geographical zones, namely Zones V, Zone A, and Zone X. Wave height, in simple terms, represents the vertical distance between the highest point (crest) and the lowest point (trough) of a wave as it travels across the water surface.

- Zone V: Portion of the Special Flood Hazard Area (SFHA) that extends from offshore to the inland limit of a primary frontal dune along an open shoreline, and any other area subject to high-velocity wave action from storms.
- Costal A Zone (MoWA): Portion of the coastal SFHA where base flood wave heights are between 1.5 and 3 feet, and where wave characteristics are deemed sufficient to damage many NIFP-compliant structures on shallow or solid wall foundations.
- Zone A (MiWA): Portion of the Coastal SFHA where base flood wave heights are less than 1.5 feet.
- Zone X: The flood hazard is less severe here than in the SFHA.

Figure 4-59 FEMA Shoreline Elevations and Associated Flood Zones



Source: FEMA P-55 Coastal Construction Manual

Some lakes in Utah that are particularly susceptible to shoreline flooding include:

- Great Salt Lake: Located in northern Utah, is a closed basin with no outflowing rivers and three rivers flowing into the lake (Jordan, Weber, and Bear rivers). In the past, this has resulted in high water levels impacting low elevated development. The last time the Great Salt Lake flooded was in 1983. In response to this event, the state declared a state of emergency and rushed to build a pump station to divert excess water to the desert landscape near the Salt Flats. There is VE (velocity with elevation) zone in Davis County, located on the south end of the Great Salt Lake.
- Bear Lake: Located in northeastern Utah near the Idaho border, has seen fluctuations in water levels due to variations in snowmelt and precipitation. High water levels in Bear Lake can lead to shoreline flooding and impact nearby communities.

4.8.4 Past Occurrences

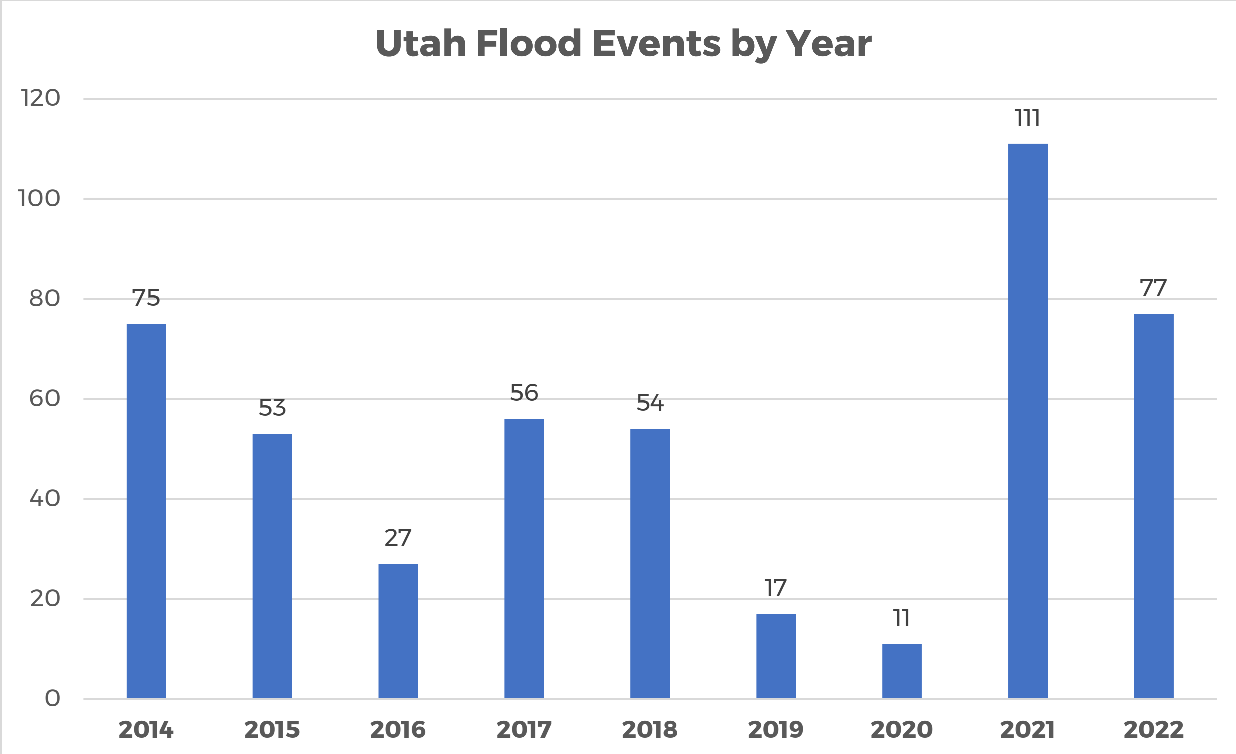
There have been ten federally declared flooding events in Utah from 1953 to present as reflected in Table 4-29. These disasters involved severe storms, landslides, mudflow, dam failures, and snowmelt. While these are the only declared events, there are many localized flood events that occur each year in Utah, seen in Figure 4-60.

Table 4-29 Utah FEMA Flooding Declared Disasters, 1953-2023

DECLARATION NUMBER	YEAR DECLARED	INCIDENT TYPE	DECLARATION TITLE	COUNTY
DR-4311-UT	2017	Flood	SEVERE WINTER STORMS AND FLOODING	Box Elder, Cache
DR-4088-UT	2012	Flood	SEVERE STORM AND FLOODING	Washington
DR-4011-UT	2011	Flood	FLOODING	Beaver, Box Elder, Cache, Daggett, Duchesne, Emery, Millard, Morgan, Piute, Salt Lake, Sanpete, Sevier, Summit, Uintah, Uintah and Ouray Indian Reservation, Utah, Tooele, Wasatch, Weber
DR-1955-UT	2011	Flood	SEVERE WINTER STORM AND FLOODING	Garfield, Kane, Washington
DR-1598-UT	2005	Flood	FLOODING AND LANDSLIDES	Beaver, Box Elder, Kane, Iron, Tooele, Uintah, Sevier, Uintah and Ouray Indian Reservation, Wasatch
DR-1576-UT	2005	Severe Storm	SEVERE STORMS AND FLOODING	Kane, Washington
DR-820-UT	1989	Flood	DIKE FAILURE & FLASH FLOODING	Washington
DR-760-UT	1986	Flood	HEAVY RAINS, SNOWMELT & FLOODING	Cache, Morgan, Wasatch, Weber
DR-720-UT	1984	Flood	SEVERE STORMS, MUDFLOW, LANDSLIDES & FLOODING	Box Elder, Davis, Juab, Millard, Sanpete, Salt Lake, Sevier, Summit, Tooele, Utah, Wasatch, Weber
DR-680-UT	1983	Flood	SEVERE STORMS, LANDSLIDES & FLOODING	Beaver, Box Elder, Carbon, Daggett, Duchesne, Emery, Davis, Garfield, Juab, Millard, Morgan, Piute, Rich, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, Weber

Source: FEMA.gov

Figure 4-60 Number of Flood Events in Utah 2014 - 2023



Source: WSP analysis of NCEI data

There has been no recorded crop damage and a total of $96,994,000 of property damage from flooding events in Utah since 2014 (Table 4-30). The year with the highest amount of recorded property damage since 2014 is 2022 with $36,256,800. According to the National Centers for Environmental Information, there have been 12 injuries and 25 deaths in Utah from floods since 2014. Of these years, 2021 had 111 flooding incidents, the most of any year (Figure 4-60, Table 4-30). Record snowpack during the 2022-2023 also contributed to flooding from snowmelt runoff during the spring and early summer months of 2023 while this plan was being updated.

Table 4-30. Utah NCEI Flooding Events Data 2014-2022

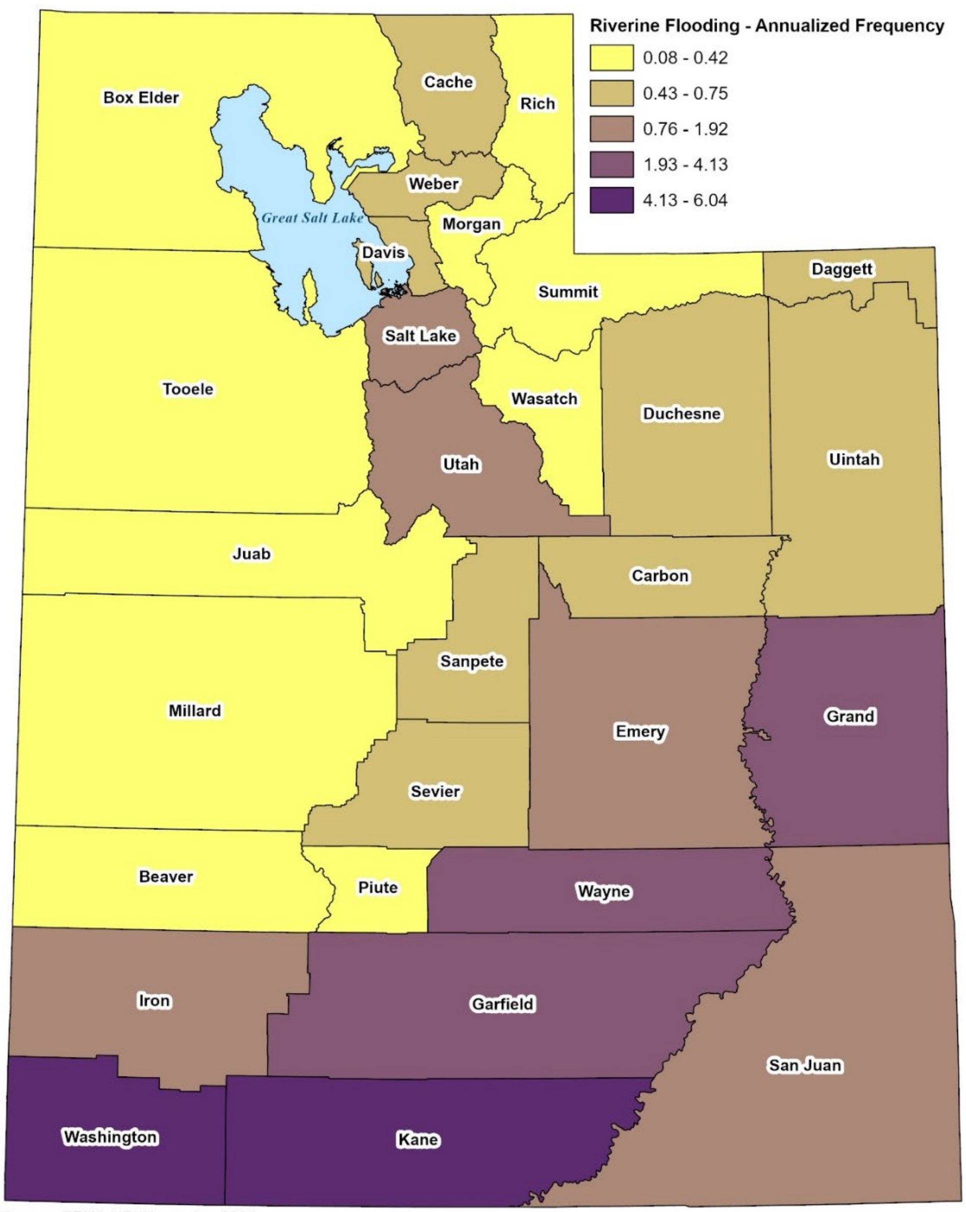
YEAR	FLOOD EVENTS PER YEAR	DEATHS	INJURIES	PROPERTY DAMAGE COST
2014	75	2	2	$5,375,000
2015	53	20	3	$1,595,000
2016	27	0	0	$5,152,000
2017	56	0	3	$19,590,000
2018	54	0	0	$1,620,000
2019	17	0	0	$139,000
2020	11	2	0	$5,390,000
2021	111	1	4	$21,881,200
2022	77	0	0	$36,256,800
Total	**481**	**25**	**12**	**$96,994,000**

4.8.5 Probability

The FEMA National Risk Index (NRI) was used for the basis of probability of a flood occurrence in any one year by county. Numbers greater than 1.0 indicate a probability of more than 1 flood occurring in any one year (Figure 4-61). Despite its desert climate, the southwestern portion of Utah has the highest probability of experiencing a flood event, notably Washington and Kane Counties. This area is influenced by the southwestern monsoon as well as atmospheric rivers from the west.

The effect of climate change on the probability of flood is discussed in Section 4.8.6, *Climate Change Considerations*. Discussion of the populations likely to be most severely impacted by flood is provided in Section 4.8.8, *Vulnerability of Jurisdictions*, specifically in the subsection titled *Population Impacts*.

Figure 4-61 Utah NRI Riverine Flooding Annualized Frequency by County



Source: FEMA NRI November 2021

4.8.6 Climate Change Considerations

Section 4.7.6 evaluated climate change impacts on precipitation from the perspective of drought; here we extend that analysis to the opposite extreme, flood. As documented in Figure 4-46, total statewide annual precipitation in Utah varies considerably, but has changed very little since the late 1800s (Khatri & Strong, 2020). As is the case with the drought hazard, the story of how climate change affects flooding requires a more nuanced analysis.

Rainfall intensity is a crucial characteristic of precipitation that profoundly affects flooding. More rapid rainfall infiltrates less, increases runoff, and accumulates faster in low-lying areas. Even in a world of less precipitation, flooding would plausibly increase if the precipitation that does fall, falls faster.

For decades, climate change experts, government reports, and academic literature have predicted an increase precipitation intensity. The theoretical basis of these predictions was strong, though studies of actual trends in precipitation records did not detect significant changes in precipitation in the state of Utah (e.g., dos Santos et al., 2011). More recent analyses, however, suggest this may be changing. Specific to the State of Utah, Gu et al. (2022) documents significant increases in potential maximum precipitation over 24-hour and 3-hour periods (Gu et al., 2022). These authors attribute the change to increased intensity of convective storms. What this apparent trend means for flooding in Utah remains the subject of study, but the implications are concerning,

One clear trend in precipitation with implications for flooding is the change in snowpack (Figure 4-47). Since 1955, the snowpack has peaked earlier and has had a reduced season length. These trends are also expected to continue into the foreseeable future. Due primarily to increasing air temperature, the proportion of precipitation that falls as snow will continue to decline. Warmer conditions are simply less likely to produce snow. Also, warmer conditions cause the snow line, the lowest elevation at which snow falls, to recede. As the snowline moves upward, the area receiving snowfall is reduced.

While a reduced snowpack is undoubtedly an important factor for flooding in Utah, the flood issue remains complex and is not well understood. It seems intuitive that a reduced snowpack should reduce spring runoff flooding and reduce the opportunity for rain-on-snow events. However, climate change may play out in ways that simply redistribute flood risk or even amplify the risk for some. For example, intense winter storms may drop rain rather than snow and increase the risk of wintertime flooding (Khatri and Strong, 2020) while decreasing the risk of runoff-driven flooding.

In some cases, seemingly unconnected aspects of climate-change could affect flooding in Utah more profoundly than changes in precipitation. For example, fire scars left by climate-change driven wildfire often become dramatically less able to absorb precipitation. This type of change often overwhelms other factors and leads directly to more flooding in wildfire-affected areas.

Likewise, Utah remains the fastest growing state in the Union and development pressures inevitably increase impervious areas as roads, parking lots, houses, and other infrastructure are constructed to accommodate population growth. This process sets off a race between development, which increases flood risk, and stormwater infrastructure construction and maintenance, which mitigates that risk. The balance of these two forces largely determines the frequency of flooding in urban areas to a much greater degree than precipitation changes.

From a planning perspective, all of the changes described here that increase the rate of runoff can be thought of as increasing the strain on our stormwater infrastructure and flood-control measures such as dams, levees, and canal systems. The current challenge to the academic community and flood mitigation practitioners is to advance our understanding of how changes in the climate and our built environment will alter risk throughout the state and design infrastructure that is capable of mitigating these evolving risks.

4.8.7 Vulnerability of State Assets

The vulnerability of state assets to flood is dependent on the type, location, construction, height, and age of the asset, as well as the quality and maintenance of nearby stormwater infrastructure. If these qualities remain constant through time, vulnerability will also be stable.[18] The assessment of state asset vulnerability assumes that the nature of state assets is consistent with what has existed over the past decade and provides a measure of the vulnerability of state assets to severe weather in the near future. In addition, millions of people rely on state facilities and the services they provide. Discussion of the consequences of losing jurisdiction assets is distinct and is addressed in Section 4.8.8 *Vulnerability of Jurisdictions*, especially in the subsection titled *Community Lifelines and Infrastructure.*

For the current ESHMP update, state assets data was provided by the Utah Division of Risk Management. The vulnerability analysis conducted for this plan utilized a GIS overlay of the state assets using Hazus and FEMA NFHL for flood hazards as a planning level exposure analysis. The "select by location" option was then utilized in order to determine how many potentially flood vulnerable state facility structures exist per county. Iron County has the highest total value of state facilities at risk with $12,860,570 of state assets within the floodplain. This is followed by Weber County with $11,078,753 in total value. Third is Salt Lake County which has $9,555,348 worth of state facility properties at risk. Assets in Iron, Salt Lake, and Utah counties should be considered higher vulnerability, due to the elevated risk in the counties based on the NRI. The total value of state facilities within the 1% annual chance of flooding is $66,091,101 (Table 4-31).

The results of the GIS overlay analysis are considered a planning level analyses suitable for identifying the potential assets exposed. In rare circumstances does exposure equate to potential loss. As an estimate of potential future dollar losses to state assets, a percentage of 25% was applied to the assets within the hazard area, yielding a potential of $16.5M in losses. This assumption is based on the typical losses associated with a two-foot-deep flood, based on flood depth damage correlations, that typically results in a loss equivalent of 25% of the structure value. A more detailed site-specific assessment would be required to further refine vulnerability and loss potential. The State Asset Database developed for this ESHMP update contains additional information on each asset such as the address and building identifier and can be referenced with Utah DEM.

Table 4-31 State Assets at Risk to FEMA and Hazus 1% Annual Chance Flood Hazard by County & FEMA Lifeline

COUNTY	COMMUNICATIONS	ENERGY	FOOD, WATER, SHELTER	HAZARDOUS MATERIAL	HEALTH AND MEDICAL	SAFETY AND SECURITY	TRANSPORTATION	TOTAL COUNT	TOTAL VALUE
Beaver	-	-	-	-	-	-	-	**0**	**$0**

18 It is acknowledged that vulnerability may remain stable while risk changes as exposure to hazards changes.

COUNTY	COMMUNICATIONS	ENERGY	FOOD, WATER, SHELTER	HAZARDOUS MATERIAL	HEALTH AND MEDICAL	SAFETY AND SECURITY	TRANSPORTATION	TOTAL COUNT	TOTAL VALUE
Box Elder	-	-	-	-	-	4	-	**4**	**$1,268,533**
Cache	-	-	-	-	-	1	-	**1**	**$72,000**
Carbon	-	-	-	-	-	-	-	**0**	**$0**
Daggett	-	-	-	-	-	-	-	**0**	**$0**
Davis	-	-	-	-	-	16	-	**16**	**$5,447,806**
Duchesne	-	-	-	-	-	3	-	**3**	**$307,000**
Emery	-	-	-	-	-	19	-	**19**	**$2,301,440**
Garfield	-	-	-	-	-	4	-	**4**	**$2,370,000**
Grand	-	-	-	-	-	7	-	**7**	**$4,311,000**
Iron*	-	-	-	-	-	17	-	**17**	**$12,860,570**
Juab	-	-	-	-	-	-	-	**0**	**$0**
Kane	-	-	-	-	-	-	-	**0**	**$0**
Millard	-	-	-	-	-	1	-	**1**	**$4,000**
Morgan	-	-	-	-	-	5	-	**5**	**$749,288**
Piute	-	-	-	-	-	-	-	**0**	**$0**
Rich	-	-	-	-	-	-	-	**0**	**$0**
Salt Lake*	-	-	-	-	-	11	-	**11**	**$9,555,348**
San Juan	-	-	-	-	-	-	-	**0**	**$0**
Sanpete	-	-	-	-	-	1	-	**1**	**$1,748,700**
Sevier	-	-	-	-	-	2	-	**2**	**$1,265,616**
Summit	-	-	-	-	-	11	-	**11**	**$1,690,676**
Tooele	-	-	-	-	-	-	-	**0**	**$0**
Uintah	-	-	-	-	-	11	-	**11**	**$4,405,818**
Utah*	-	-	-	-	-	18	-	**18**	**$3,865,909**
Wasatch	-	-	-	-	-	16	-	**16**	**$2,570,844**
Washington	-	-	-	-	-	2	-	**2**	**$32,800**
Wayne	-	-	-	-	-	1	-	**1**	**$185,000**
Weber	-	-	-	-	-	4	-	**4**	**$11,078,753**
Total	**0**	**0**	**0**	**0**	**0**	**154**	**0**	**154**	**$66,091,101**

Source: Source: Utah, Risk Management, FEMA NFHL, Hazus, WSP Analysis; *considered higher risk counties based on NRI.

The state agencies with the highest count of structures in potential flood hazard areas include Natural Resources - Parks & Recreation, Natural Resources - Wildlife Resources and Transportation (UDOT). The highest dollar exposure, as an estimate of potential loss, are associated with Natural Resources - Parks & Recreation and Transportation (UDOT). Additional details are provided in Table 4-32 below.

Table 4-32 Summary of State Asset Exposure by Agency

AGENCY	COMMUNICATIONS	ENERGY	FOOD, WATER, SHELTER	HAZARDOUS MATERIAL	HEALTH AND MEDICAL	SAFETY AND SECURITY	TRANSPORTATION	TOTAL COUNT	TOTAL VALUE
Administrative Services - Facilities (DFCM)	-	-	-	-	-	3	-	3	$7,890,500
Davis Technical College	-	-	-	-	-	1	-	1	$553,000
Environmental Quality Department	-	-	-	-	-	1	-	1	$56,000
Natural Resources - Parks & Recreation	-	-	-	-	-	99	-	99	$17,607,590
Natural Resources - Wildlife Resources	-	-	-	-	-	18	-	18	$11,428,300
Transportation (UDOT)*	-	-	-	-	-	22	-	22	$13,573,958
University Of Utah	-	-	-	-	-	4	-	4	$337,000
Utah State University	-	-	-	-	-	3	-	3	$3,974,000
Weber State University	-	-	-	-	-	3	-	3	$10,670,753
Total	0	0	0	0	0	154	0	154	$66,091,101

Source: Utah, Risk Management, FEMA NFHL, Hazus, WSP Analysis; *does not account for bridge infrastructure

According to the current FEMA NFHL and preliminary DFIRMs, three counties within Utah have areas protected by levee flood zones or Areas with Reduced Flood Risk Due to Levee zones (Salt Lake, Morgan and Utah counties; Iron County is a fourth county that according to the SHMT has a levee protected area but is not represented due to paper map limitations). A total of seven Safety and Security lifeline facilities are located within these levee protected areas in Utah: two facilities in Salt Lake County and five in Utah County. There is a total of $12.9 million of State Assets within the Protected by Levee Flood Hazards, $1.9 million in Salt Lake County and $10.9 million in Utah County. The agencies that have ownership of these assets include Utah Valley University with $10.6 million, Natural Resources - Utah Geological Survey with $1.8 million, and Natural Resources - Parks & Recreation with $495k (see Table 4-34).

Table 4-33 State Assets within FEMA NFHL Areas Protected by Levee Flood Hazard by County and FEMA Lifeline

COUNTY	COMMUNICATIONS	ENERGY	FOOD, WATER, SHELTER	HAZARDOUS MATERIAL	HEALTH AND MEDICAL	SAFETY AND SECURITY	TRANSPORTATION	TOTAL COUNT	TOTAL VALUE
Salt Lake	-	-	-	-	-	2	-	2	$1,948,672
Utah	-	-	-	-	-	5	-	5	$10,990,000
Total	0	0	0	0	0	7	0	7	$12,938,672

Source: Utah, Risk Management, FEMA NFHL, WSP Analysis

Table 4-34 State Assets within FEMA NFHL Areas Protected by Levee Flood Hazard by Agency and FEMA Lifeline

AGENCY	COMMUNICATIONS	ENERGY	FOOD, WATER, SHELTER	HAZARDOUS MATERIAL	HEALTH AND MEDICAL	SAFETY AND SECURITY	TRANSPORTATION	TOTAL COUNT	TOTAL VALUE
Natural Resources - Parks & Recreation	-	-	-	-	-	2	-	2	$495,000
Natural Resources - Utah Geological Survey	-	-	-	-	-	1	-	1	$1,848,672
Utah Valley University	-	-	-	-	-	4	-	4	$10,595,000
Total	0	0	0	0	0	7	0	7	$12,938,672

Source: Utah, Risk Management, FEMA NFHL, WSP Analysis

State Insured Loss Analysis

Based on the analysis of loss claims from Utah Risk Management Agency there has been $10.7 million in loss claims related to flooding during the time period of 2012-2022. Within this 10-year timeframe there were 45 total flood claims, with the University of Utah having 30 of the claims. One event on 10/3/2021 had a claim for $10 million due to a clogged drain from a torrential rain event. The average annualized loss estimates for state assets based on this data is approximately $1M. This is considered approximation of the expected loss to state assets moving forward, unless tempered by mitigation efforts.

As stated above, the analysis provided in this ESHMP update forecasts impacts in the near term based on recent loss data. This approach assumes the type, location, construction, height, and age of state assets remains constant over time, as well as the quality and maintenance of nearby stormwater infrastructure.

The consequence of state assets lost to flood hazards is substantial. First, flood damage is expensive, and recovery creates a burden for jurisdictions and their tax base. Second, the exposure of higher education facilities to flood appears to be very high. Damage to these facilities is disruptive to lives and livelihoods, though cascading failure is not a primary concern. Parks and Recreation has a somewhat less extensive exposure, with consequences likely related to inconvenience and lost recreation opportunity. Roads and bridges also have significant exposure to flooding. This exposure is concerning for affecting the transportation community lifeline and potentially being very disruptive, especially in rural areas.

Climate change will likely amplify challenges to state assets from flooding. The most dramatic and rapid increase in flood danger is caused by wildfire scars, which are increasingly a result of climate change. In affected areas, flood danger can go from normal to unprecedented seemingly overnight, often outstripping what can reasonably be expected from stormwater infrastructure. Anticipating which specific state assets will be more vulnerable due to wildfires in watersheds that have not yet occurred has not been attempted. However, flood damage and sedimentation of bridges and roadways and infrastructure located along roadways and bridges is a particular concern.

Changes in the type of precipitation from snow to rain will likely change, or perhaps redistribute, flood risk (see Section 4.8.6 *Climate Change Considerations*). This will change the hydrologic conditions that state-owned infrastructure was designed for, perhaps beyond the safety margins included in design specifications. In such cases, vulnerability of state assets will increase accordingly. Similarly, climate change predictions have long anticipated a change to more intense rainfall. This appears to be a developing trend (see Section 4.8.6 *Climate Change Considerations*). If the trend continues, rainfall will increase the strain on stormwater infrastructure and could increase flooding. Flooding is a complex process and has many factors beyond climate change. Predicting which state assets will be placed more at-risk specifically due to climate change-altered flooding is uncomfortably speculative as of this ESHMP update.

Table 4-35 Insured Flood Losses by State Agency 2012-2022

STATE AGENCY	TOTAL LOSS CLAIMS
Facilities Construction & Management (DFCM) – Maintenance	$37,759
Human Services Department	$36,001
Snow College	$50,000
Southern Utah University	$0
Transportation (UDOT)	$25,000
University of Utah	$10,309,877
Utah Tech University	$199,756
Weber State University	$45,000
Total	$10,703,393

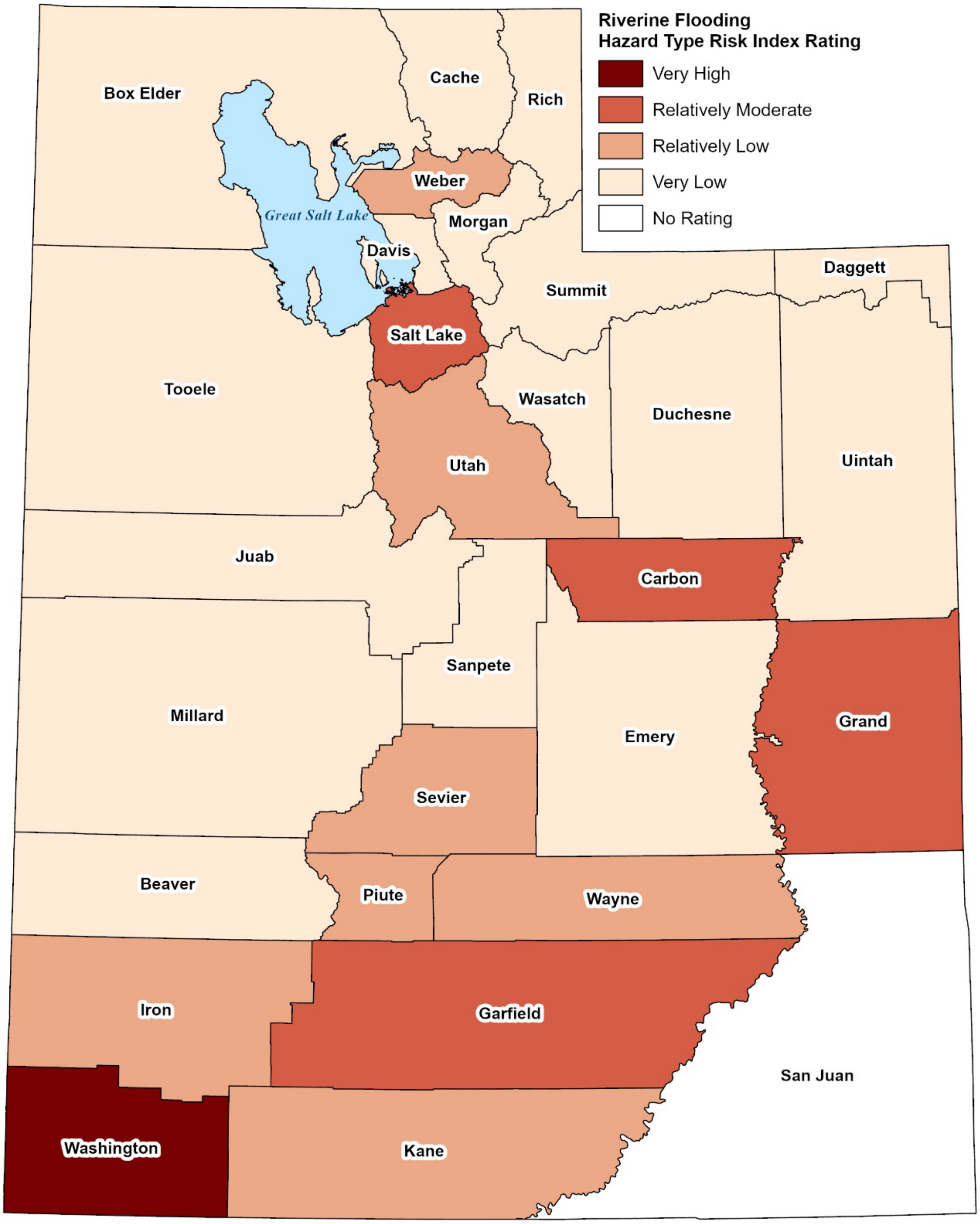
Source: Utah Division of Risk Management

4.8.8 Vulnerability of Jurisdictions

National Risk Index Assessment

The NRI was used to analyze the State's vulnerability to flood. The NRI defines risk as the potential for negative impacts as a result of a natural hazard and determines a community's risk relative to other communities by examining the expected annual loss and social vulnerability in a given community in relation to that community's resilience. County-level NRI flood risk rating is shown in Figure 4-62.

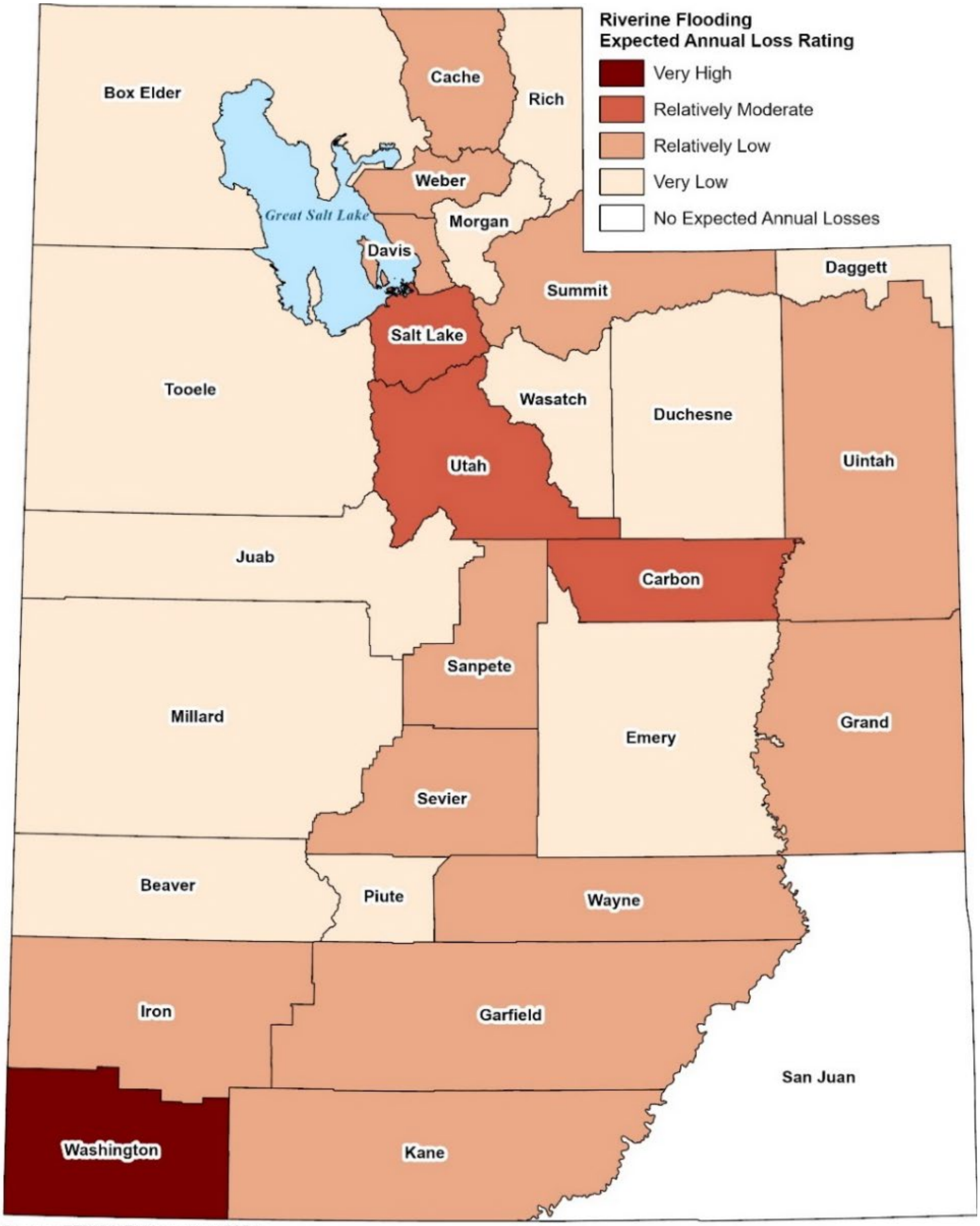
Figure 4-62 Utah NRI Riverine Flood Risk Index Rating by County



Source: FEMA NRI November 2021

The NRI also utilizes Estimated Annual Loss (EAL) as an indicator of risk. EAL represents the average economic loss in dollars resulting from natural hazards each year. It is calculated for each hazard type and quantifies loss for relevant consequence types: buildings, people, and agriculture. EAL is calculated using a multiplicative equation that includes exposure, annualized frequency, and historic loss ratio risk factors for such as riverine flooding. Based on this analysis Washington County has the highest EAL, followed by Salt Lake, Utah and Carbon counties.

Figure 4-63 NRI Expected Annual Loss Rating by County for Flooding

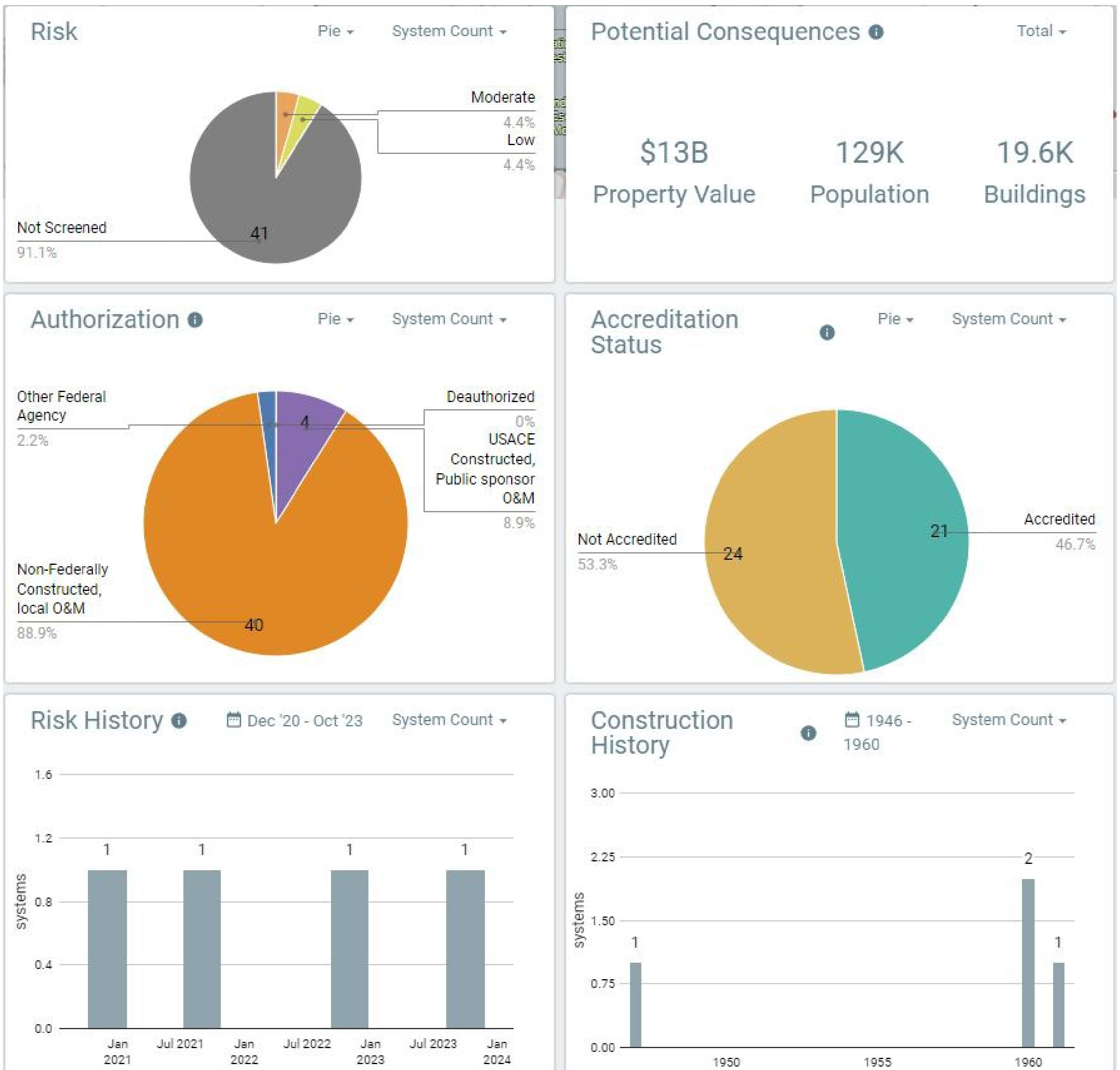


Source: FEMA NRI November 2021

Levee Risk

Risk from levee failure was also evaluated in this ESHMP update. The USACE National Levee Database provides insights into Utah's levee risk landscape. A snapshot of the USACE National Levee Database is depicted in Figure 4-64 with a summary of statistics for Utah. Utah's levees serve as essential safeguards, protecting an impressive $13 billion in property value, along with 129,000 residents and nearly 19,600 buildings. This emphasizes the critical economic and societal value of these levees in safeguarding property, infrastructure, and communities from potential losses and damages due to flooding. It underscores the substantial benefits that arise from the presence and effectiveness of these levees in mitigating flood risks.

Figure 4-64 Utah Levee Synopsis



Source: USACE National Levee Database Dashboard

While these figures showcase the considerable protective infrastructure in place, there is an opportunity for refinement. It's worth noting that a substantial 91.1% of these levees have not undergone formal risk screening. This indicates a potential area for improvement in terms of preparedness and understanding of potential flood events. Alongside this, around 4.4%, are categorized as having moderate risk, with another 4.4% considered low risk, showcasing varying levels of vulnerability.

In terms of authorization sources, Utah's approach to flood protection is characterized by collaboration and local involvement. Only a minor 2.2% of levees receive authorization from federal agencies other than the US Army Corps of Engineers. Interestingly, none of the levees are directly constructed by the USACE, highlighting the community-driven nature of flood risk management. The majority, or 88.9%, are locally constructed and maintained, emphasizing the essential role played by local communities and authorities.

A key finding is the accreditation status, where 53.3% of levees currently lack accreditation. While this represents an opportunity for improvement, it's important to recognize that 46.7% of levees meet the established flood protection standards, providing a level of protection up through the 1% annual chance flood.

In light of these insights, there is a valuable opportunity to focus efforts on accrediting the currently non-accredited levees. This strategic initiative will further fortify the state's overall resilience and preparedness against potential flood events, ensuring the continued safety of both property and residents.

Flood Insurance Statistics

Another way of evaluating vulnerability to flood is to consider recent insured losses. As with similar analyses elsewhere in this ESHMP update, this approach assumes the type, location, construction, height, and age of state assets, as well as the quality and maintenance of nearby stormwater infrastructure remains stable.

All of Utah's 27 counties participate in the National Flood Insurance Program (NFIP) as of January 2023 (see Table 4-36 below). As of January 2023, there were a total of 3,694 policies in force with Salt Lake County having the highest number of policies with 1,157. Utah County had 695 policies and Washington County had 362 polices. This coincides with these three counties having some of the highest risk state-wide to flooding. Overall, the number of polices has decreased since 2018 when the total was 3,839, representing a decrease of 145 policies (Note: according to DEM the number of policies increased substantially during the spring of 2023 flood awareness campaign).

There has been $7,538,297 in total net payments due to flood insurance claims as of January 2023 (an increase of approximately $1.3M since 2018), with Salt Lake County having $1.6M of these total payouts, followed by Washington County ($1.1M) and then Davis County ($1M). This correlates directly with the number of loss claims. Salt Lake and Davis County have the highest number of claims filed with 403 and 171 claims respectively. While Washington County has had the 3rd largest payout of NFIP claims filed in Utah, this has been due to 56 cumulative claims in total. The average annualized payout for the period 1976-2022 equates to roughly $164k.

Table 4-36 details the NFIP statistics for Utah by county as of January 2023.

Table 4-36 Flood Insurance Statistics for Utah Counties

County	Number of Losses	Total Net Payment	Active Policies	Total Premium + Policy Fee
Beaver	1	$3,447	0	$0
Box Elder	16	$292,350	25	$14,173
Cache	41	$125,856	96	$60,944
Carbon	8	$322,288	34	$43,108
Daggett	0	$0	1	$248
Davis	171	$1,010,917	320	$149,451
Duchesne	6	$9,196	5	$2,867
Emery	4	$12,159	8	$4,485
Garfield	1	$7,179	10	$7,918
Grand	7	$146,466	111	$53,706
Iron	21	$106,071	117	$67,634
Juab	6	$0	4	$1,855
Kane	6	$72,035	29	$17,826
Millard	48	$772,031	12	$9,855
Morgan	9	$10,887	35	$25,192
Piute	1	$3,672	5	$3,215
Rich	1	$2,842	3	$1,377
Salt Lake	403	$1,691,403	1,157	$629,443
Summit	35	$93,134	237	$150,824
Tooele	6	$53,746	28	$12,057
Uintah	14	$80,456	43	$25,724
Unknown	69	$855,787	99	$60,553
Utah	100	$483,085	695	$346,252
Wasatch	11	$26,389	65	$33,840
Washington	56	$1,129,772	362	$321,996
Wayne	2	$0	0	$0
Weber	74	$227,130	193	$118,930
Total	**1,117**	**$7,538,297**	**3,694**	**$2,163,473**

Source: Fema.gov and FEMA NFIP Pivot Data as of 01-11-23

Repetitive Loss Properties

As of 2023, Utah has a total of 33 repetitive loss properties that collectively have resulted in $1.3M in losses, or 17% of the total NFIP claims paid out. The number of properties increased from 25 to 33 since 2019. The largest number of repetitive loss properties and claims is in Salt Lake County. In Utah the local jurisdictions are expected to monitor their respective repetitive loss properties and if any of them are to become severe repetitive loss properties the responsibility falls on the community to make sure that the property is brought into compliance with NFIP regulations. As of 2023 there were not any severe repetitive loss properties in the state.

Table 4-37 Utah Repetitive Loss Properties as of January 2023

COUNTY	COMMUNITY NAME	NUMBER OF PROPERTIES	NUMBER OF CLAIMS	TOTAL PAID
BOX ELDER COUNTY	BOX ELDER COUNTY	1	2	$100,200
CACHE COUNTY	CACHE COUNTY	3	8	$45,973
CACHE COUNTY	LOGAN, CITY OF	1	2	$35,721
DAVIS COUNTY	DAVIS COUNTY	2	4	$61,828
DAVIS COUNTY	WOODS CROSS, CITY OF	1	2	$26,500
GRAND COUNTY	MOAB, CITY OF	1	3	$70,845
IRON COUNTY	IRON COUNTY	1	2	$8,114
MILLARD COUNTY	MILLARD COUNTY	1	2	$50,172
MORGAN COUNTY	MORGAN COUNTY	1	2	$6,941
SALT LAKE COUNTY	MURRAY, CITY OF	2	6	$87,576
SALT LAKE COUNTY	RIVERTON, CITY OF	1	2	$22,046
SALT LAKE COUNTY	SALT LAKE CITY, CITY OF	5	14	$123,219
SALT LAKE COUNTY	SALT LAKE COUNTY	6	15	$549,511
SALT LAKE COUNTY	WEST JORDAN, CITY OF	1	2	$13,435
UNKNOWN	BOX ELDER COUNTY	1	2	$48,076
UNKNOWN	UNKNOWN	1	2	$9,809
UTAH COUNTY	PROVO, CITY OF	1	2	$8,235
WASHINGTON COUNTY	WASHINGTON COUNTY	1	2	$10,121
WEBER COUNTY	OGDEN, CITY OF	1	2	$8,953
WEBER COUNTY	WEBER COUNTY	1	2	$15,613
Total		**33**	**78**	**$1,302,888**

Source: Fema.gov and FEMA NFIP Pivot Data as of 01-18-23

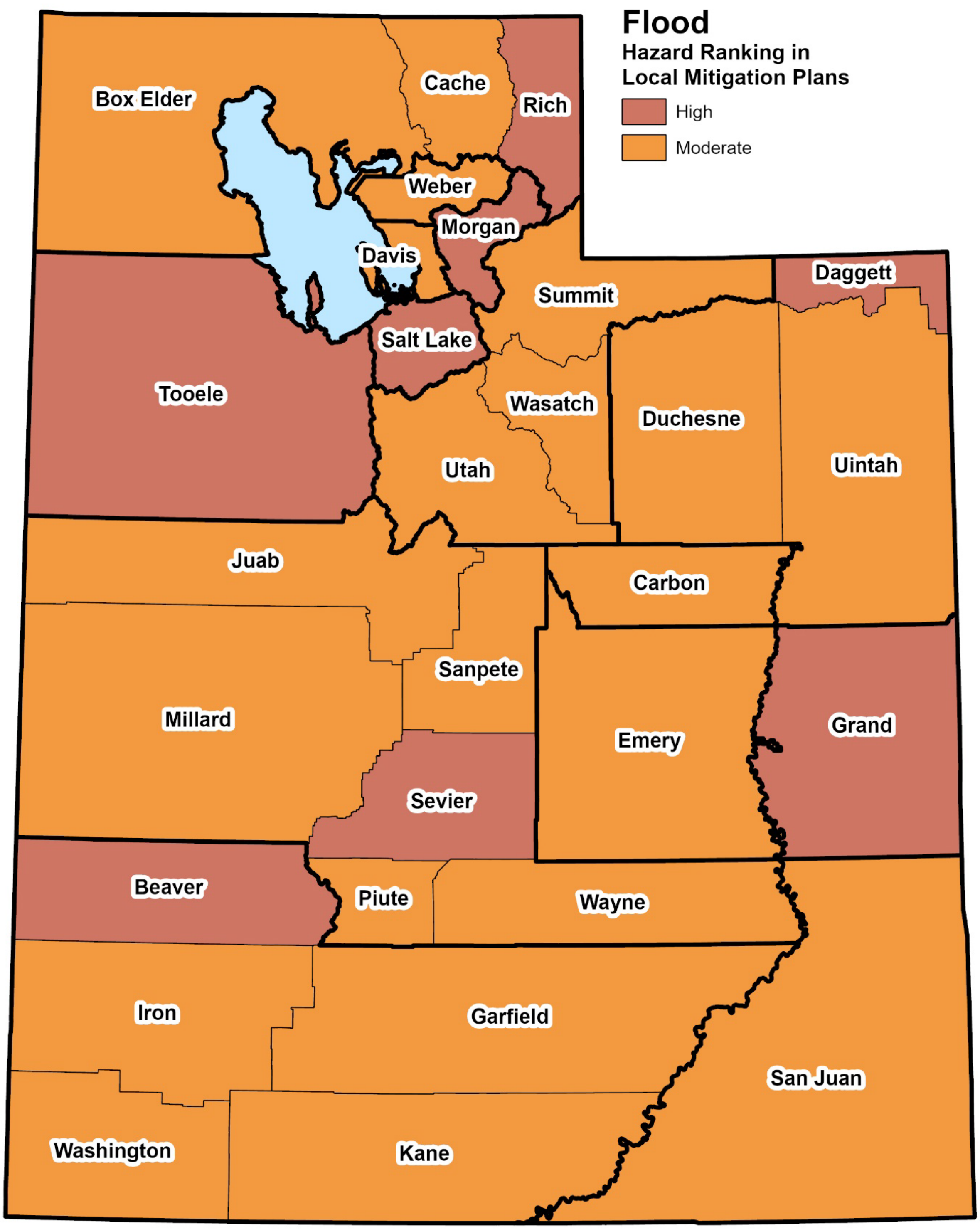
Local Hazard Mitigation Plan Assessment

Local Hazard Mitigation Plans (LHMPs) were reviewed to gather data on flood vulnerabilities and loss estimates related to people, residential units, commercial units, and critical facilities. Not all LHMPs reported on such data. Salt Lake, Tooele, Cache, Davis, and Weber reported the most people at risk of flooding. Washington County reported the highest number of residential units at risk to flood with 8,687 units with a total value of $1,756,890,240. There are six counties that reported over $100,000,000 in residential unit values at risk from flooding (Box Elder, Cache, Iron, Salt Lake, Tooele, and Washington counties).

Iron County reported the highest number of commercial units vulnerable to flooding with 345 commercial units with total value of $142,570,470. However, Salt Lake County had the highest value for commercial units at risk from flooding of $331,750,000. There were four counties that reported over $100,000,000 in commercial unit value being at risk from flooding.

The figure below shows the overall hazard ranking for flood for each county as reported in the LHMPs. The hazard ranking is calculated from a combination of severity (categorized from 0-4) and frequency (categorized from 0-4). This allows for a ranking from 0-8 when combined.

Figure 4-65 Flood Hazard Rankings from LHMPs



Source: Bear River AOG 2021, Carbon 2018, Davis 2022, Emery 2018, Five County AOG 2022, Grand 2018, Mountainland AOG 2022, Morgan 2022, San Juan 2018, Six County AOG 2021, Salt Lake 2020, Tooele 2022, Uintah Basin 2019, and Weber 2016.

Population Impacts

Impacts of flood on people in Utah ranges from death and physical harm to displacement, property damage, and inconvenience. Based on the NCEI data provided in the Past Occurrences section there have been 25 deaths and 12 injuries associated with flooding between 2014 and 2022. More commonly, flood can be disruptive to the lives of people due to damage to dwellings and property, or from the loss of services people depend on, such as transportation.

Vulnerability to these impacts is not distributed evenly across the population. Deaths and injuries typically happen when motorists become ensnared in floodwaters. This can, but does not always, occur when motorists ignore advice of emergency managers and drive through flooded areas. Children are another group that is notoriously vulnerable to being swept away by floodwaters. Outdoors adventurers exploring slot canyons are also more vulnerable to death and injury from flash floods.

People living in floodplain areas are most vulnerable to displacement. Perhaps the most extreme example of this is homeless persons taking refuge in floodplain areas. These people are both physically exposed to hazards and are defined to be socially vulnerable (see Section 3.5.1).

Another vulnerable situation can also easily occur in typically rural areas. Rural populations tend to be most reliant on transportation and are particularly vulnerable to flood damage to roads and bridges. Where flood damage is especially severe, it can also disrupt livelihoods. Floodplain mapping is poor or non-existent in many rural areas of Utah.

Social vulnerability Index information available through the National Risk Index webpage provides a useful tool to identify places in Utah that are more likely to have residents that are especially vulnerable to the impacts of all hazards, including flood. This information is presented in Section 3.5.1, Figure 3-6 and Figure 3-7. Similarly, community resilience is discussed in Section 3.5.2 and presented in Figure 3-10 and Figure 3-11. Residents who reside in counties with high social vulnerability and low community resilience are most likely to be severely impacted by the effects of flood. This includes San Juan, Piute, Washington, Kane, Garfield, Grand, and Carbon Counties, most of which are in the southern part of the state, and some have high flood risk such as Washington County in particular.

Additional study at a local level will very likely enable better hazard mitigation for vulnerable populations. The state-level analysis in this section can be used in LHMPs to identify counties that are likely at increased risk from flood. However, local analysis can provide far more actionable information, such as *why* these counties are at risk and *how* to mitigate those vulnerabilities. In addition, local analyses are able to evaluate much finer scales, such as which populations within the county are most vulnerable, and how to mitigate risk for those populations. In the case of flood, reducing the vulnerability of specific vulnerable populations, such as unhoused persons living in floodplains, and warnings/signage to motorists in problem areas, can be addressed more effectively in the local plans of counties throughout the state. In future ESHMP updates, the role of the state-level vulnerability analysis will expand to verifying that local level analyses appropriately evaluate vulnerabilities and possibly to facilitating such analysis.

Community Lifelines and Infrastructure

Specific identification of lifelines and infrastructure on a statewide scale remains a work in progress. In some local hazard mitigation plans this information can be referenced, but not in a consistent manner. Box Elder County reported the highest number of critical facilities at risk from flooding with 64 facilities. Vulnerable infrastructure commonly includes roads, culverts, and bridges. To address deficiencies in data needed to conduct a proper analysis of infrastructure and lifeline vulnerability, Utah DEM has created a critical infrastructure inventory tool in 2023 that will help to inform this section in future updates.

4.8.9 Changes in Development

Development changes in Utah, such as urbanization, infrastructure development, and alterations to natural landscapes can contribute to an increased risk of flooding in the state. Throughout the state, Kane and Washington county have the highest annualized flooding frequency, followed by Garfield, Wayne, and Grand county. The expansion of urban areas can lead to increased impervious surfaces like roads and buildings, reducing natural water absorption. This can result in higher runoff during storms, increasing the risk of flash floods. The construction of dams, levees, and other infrastructure can influence local hydrology. While these structures are often designed to manage water flow, improper planning or maintenance can lead to increased flood risks.

The implementation of sustainable practices and the establishment of resilient infrastructure are essential measures to reduce the impact of floods and safeguard Utah communities form potential consequences arising from extreme weather events. Local authorities and environmental agencies frequently assume pivotal roles in enforcing regulations aimed at mitigating flood risks associated with development.

The counties experiencing the most development pressures in the state all participate in the NFIP, requiring adherence to floodplain management regulations. Despite the pressures from population growth and increased development being felt in many counties, the overall flood risk should not be increasing, assuming local floodplain regulations and standards are being effectively implemented and local mitigation measures to curb stormwater runoff are taking place. An analysis of development trends in LHMPs (see Section 3.7 Development Trends and Table 3-3 specifically) did yield some concerns with flooding, notably in Emery, Toole, Weber counties. The southwestern counties of Beaver, Garfield, Iron, Kane, and Washington also noted expanding development potentially raising risk with flooding. Grand County noted a top priority was to create more open space in 100-year and geologic hazard areas. Urbanization contributing to more runoff was also noted in some of the rapidly growing counties along the Wasatch Front.

However, significant flood losses often occur outside of mapped flood hazard areas, accounting for approximately 40% of NFIP flood insurance claims. Rural areas often have outdated flood hazard mapping or none at all, making floodplain management and risk determination more challenging. More extensive and improved flood hazard mapping should improve flood risk determinations to existing and future development over time, though the areas experiencing the most growth are mapped. Given long-term climate trends including the potential for more extreme precipitation events that could exceed mapped flood hazard areas, coupled with increased development and increased runoff associated with urbanization, flood risk may still increase despite efforts to reduce this risk.