

Dam Failure

Profiling Hazard Event

Dam failures result from the failure of manmade water impoundment structures. Dam failures are caused by one or a combination of the following: “breach from flooding or overtopping, ground shaking from earthquakes, settlement from liquefaction, slope failure, internal erosion from piping, failure of foundations and abutments, outlet leaks or failures, vegetation and rodents, poor construction, lack of maintenance and repair, misuse, improper operation, terrorism, or a combination of any of these” (Eldredge 46). The Utah State Engineer has been charged with regulating non-federal dams in the State since 1919. “In the late 1970's Utah started its own Dam Safety Section within the State of Utah Engineers Office to administer all non-federal dams in response to the Federal Dam Safety Act (PL-92-367)” (Eldredge 46). In 1990, the legislature directed the State Engineer to regulate all dams in the state, including federally owned dams, except those owned by the Bureau of Reclamation.

The State Dam Safety Section has developed a hazard rating system for all regulated dams in Utah. Downstream life and property, the size, height, volume, and incremental risk/damage assessments of dams are all variables used to assign dam hazard ratings in Dam Safety's classification system. Using the hazard ratings system, dams are placed into one of three classifications: high, moderate, and low (source from dam safety.org, “Dam Safety, Performance Report for the State of Utah”).

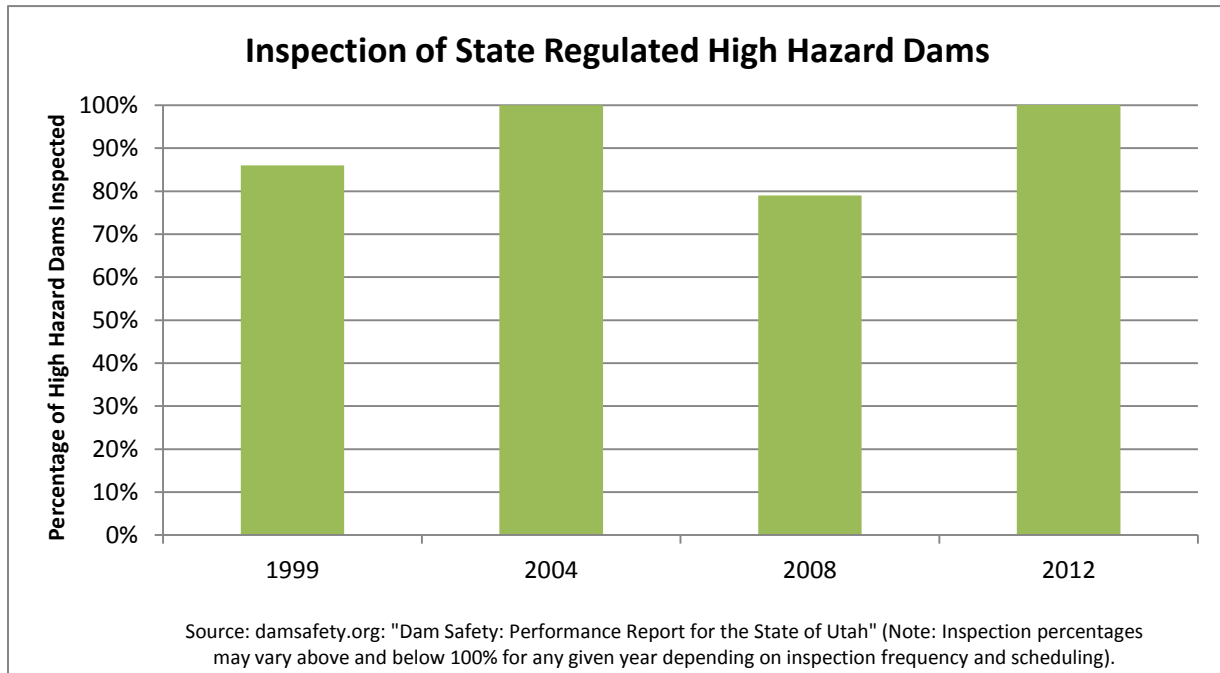
High Hazard: is typically defined as a dam whose failure or faulty operation will cause loss of human life and significant property destruction.

Moderate/Significant Hazard: is typically defined as a dam whose failure or faulty operation will cause significant property destruction.

Low Hazard: is typically defined as a dam whose failure or faulty operation will cause minimal property destruction.

The frequency of dam inspection is designated based on hazard rating: The Utah Division of Water Rights inspects high-hazard dams annually, moderate hazard dams biannually, and low-hazard dams every five years.

Figure 2B-1 Percentage of Inspection of State Regulated High Hazard Dams



The National Inventory of Dams (NID) contains a list of around 87,000 dams in the U.S. In addition to housing an inventory of the dams in Utah, they have also collected condition data on state regulated dams since 2009. The NID ranks dam conditions as the following:

Satisfactory – No existing or potential dam safety deficiencies are recognized.

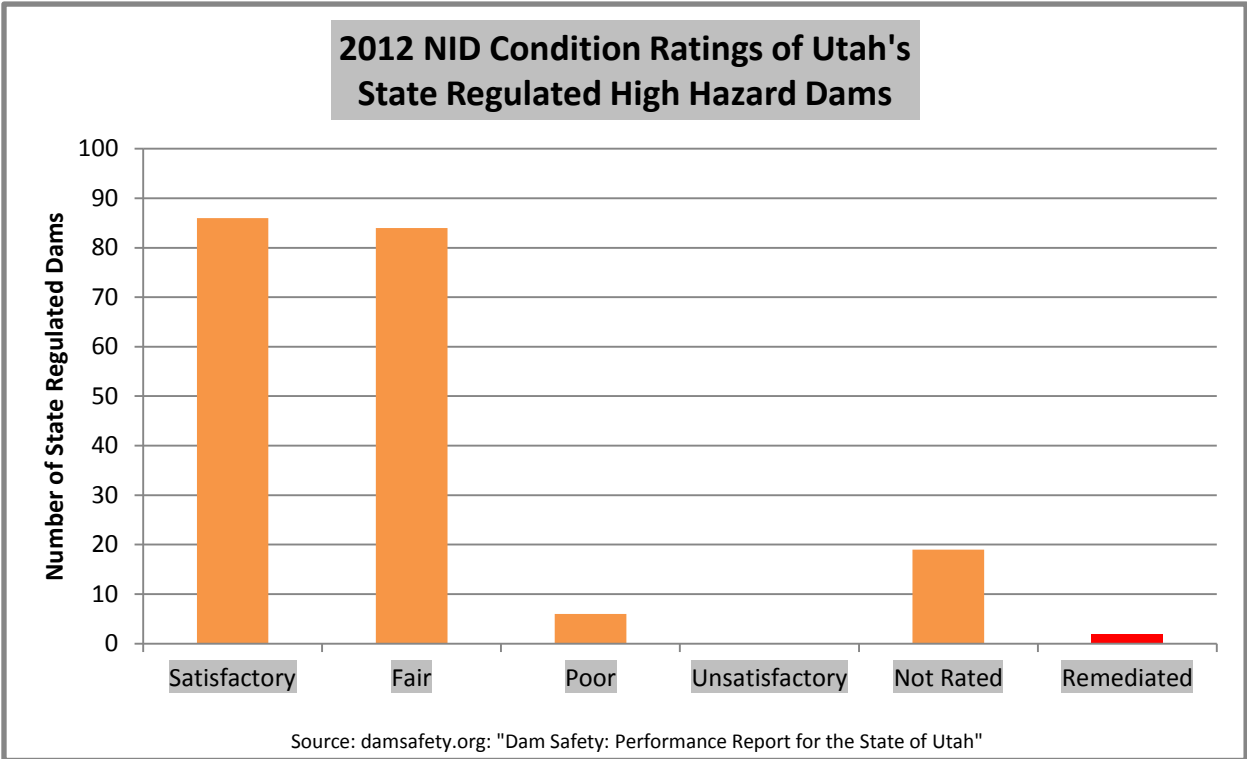
Fair – No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency.

Poor – A dam safety deficiency is recognized for loading conditions which may realistically occur. Remedial action is necessary.

Unsatisfactory – A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.

Not Rated – The dam has not been inspected or has been inspected but, for whatever reason, has not been rated.

Figure 2B-2 Condition Ratings of Utah’s State Regulated High Hazard Dams



According to the 2012 Dam Safety: Performance Report for the State of Utah by the Association of State and Dam Safety Officials, Utah contains the following list of NID and state regulated dams:

Total NID Dams	835
Total NID High Hazard Dams	233
Total State Regulated Dams	671
Total State Regulated High Hazard Dams	198

The Utah Division of Water Rights houses a large database of dams in Utah. They have categorized the dams by several inspection categories. These include uninspected dams, inspected dams (general), inspected dams (flood control), inspected dams (industrial), inactive dams, dams inspected by other agencies, federally inspected dams, dams planned or being designed, dams under construction, and other. The database contains a list of 6195 dams, with 247 of those dams being ranked as high hazard. Table 2B-1 lists the 247 high hazard dams (this includes planned dams).

Dam Failure

Table 2B-1 High Hazard Dams in Utah by County

Dam Name	County		
		SANDY CITY - EAST SANDY ELEMENTARY	Salt Lake
KENT'S LAKE NO 1 (UPPER)	Beaver	SANDY CITY - FLAT IRON MESA	Salt Lake
KENT'S LAKE NO 2 (MIDDLE)	Beaver	SANDY CITY - STORM MOUNTAIN DB	Salt Lake
MANDERFIELD (A.K.A. BEAVER)	Beaver	SOUTH JORDAN RDA DB	Salt Lake
ROCKY FORD (BEAVER)	Beaver	TWIN LAKES (SALT LAKE)	Salt Lake
THREE CREEKS (BEAVER)	Beaver	WHITE PINE	Salt Lake
BLUE CREEK	Box Elder	BARNEY'S CREEK(AIRPORT#2)DETENTION BASIN	Salt Lake
BOR ARTHUR V WATKINS	Box Elder	BLANDING CITY NO. 4	San Juan
MANTUA	Box Elder	KENS LAKE	San Juan
THREE MILE CREEK (PERRY CITY FCD) DB	Box Elder	LOYD'S LAKE(MONTICELLO)	San Juan
UTAH POWER & LIGHT - CUTLER	Box Elder	RECAPTURE CREEK	San Juan
WASHAKIE DAM	Box Elder	STARVATION CANYON	San Juan
BLACKSMITH UPPER DAM	Cache	DAIRY DAM	Sanpete
BOR HYRUM	Cache	FAIRVIEW LAKE	Sanpete
BOR NEWTON	Cache	GUNNISON	Sanpete
LOGAN CITY - DRY CANYON	Cache	HUNTINGTON	Sanpete
LOGAN FIRST DAM	Cache	NINEMILE	Sanpete
PORCUPINE	Cache	PALISADES LAKE	Sanpete
TONY GROVE LAKE DAM	Cache	ROLFSON	Sanpete
BOR SCOFIELD	Carbon	NARROWS PROJECT (GOOSEBERRY)	Sanpete
GRASSY TRAIL	Carbon	NARROWWS RESERVOIR DAM	Sanpete
BOR FLAMING GORGE	Daggett	COTTONWOOD WASH DETENTION BASIN	Sevier
LONG PARK (DAGGETT)	Daggett	DAIRY CANYON DETENTION BASIN	Sevier
ADAMS	Davis	FORSYTH	Sevier
BOR FARMINGTON EQUALIZING RESERVOIR	Davis	GLENWOOD DEBRIS	Sevier
BOUNTIFUL-NORTH CANYON(SDID#2)	Davis	JOHNSON	Sevier
BOUNTIFUL-OAKRIDGE (SDID #1)	Davis	KOOSHAREM	Sevier
CENTERVILLE - BARNARD CREEK (UPPER) DB	Davis	SAND H DEBRIS	Sevier
CENTERVILLE CANYON DEBRIS BASIN	Davis	THREE CREEKS (SEVIER)	Sevier
DAVIS COUNTY - FARMINGTON POND	Davis	BOR ECHO	Summit
DAVIS COUNTY -BARTON CREEK DB	Davis	BOR LOST LAKE	Summit
DAVIS COUNTY -HOLMES CREEK DB	Davis	BOR STATELINE SUMMIT CO.	Summit
DAVIS COUNTY -HOOPER DRAW DB	Davis	BOR TRIAL LAKE	Summit
DAVIS COUNTY -MUTTON HOLLOW DB	Davis	BOR WANSHIP	Summit
DAVIS COUNTY -PARRISH CREEK DB	Davis	BOR WASHINGTON LAKE	Summit
DAVIS COUNTY -RICKS CREEK DB	Davis	BOYER LAKE	Summit
DAVIS COUNTY -SHEPARD CREEK DB	Davis	DEER VALLEY SNOW MAKING RESERVOIR	Summit
DAVIS COUNTY -STONE CREEK DB	Davis	SMITH AND MOREHOUSE	Summit
DAVIS/WEBER COUNTY CANAL CO. KAYSVILLE	Davis	WHITNEY	Summit
DAVIS/WEBER COUNTY CANAL CO. LAYTON POND	Davis	PARK CITY MTN RESORT SNOWMAKING POND	Summit
DAVIS/WEBER COUNTY CANAL CO. SUNSET POND	Davis	BONNEVILLE DIKE- GREAT SALT LAKE	Tooele
DEUEL CREEK	Davis	GRANTSVILLE	Tooele
FARMINGTON IRRIGATION - RESERVOIR B	Davis	SETTLEMENT CANYON	Tooele
FARMINGTON IRRIGATION - RESERVOIR C	Davis	BOR RED FLEET	Uintah
HAIGHT CREEK (LOWER)	Davis	BOR STEINAKER	Uintah
HAIGHT CREEK (UPPER)	Davis	BOTTLE HOLLOW	Uintah
HOBBS	Davis	BROUGH	Uintah
HOLMES	Davis	BULLOCK DRAW	Uintah
KAYSVILLE	Davis	COTTONWOOD	Uintah
VALLEYVIEW #1(SDID#4 LOWER)	Davis	EAST PARK	Uintah
BIG SAND WASH DAM	Duchesne	LAPPOINT	Uintah
BIG SAND WASH EAST	Duchesne	M & S DAM	Uintah
BIG SAND WASH WEST	Duchesne	MONTES CREEK	Uintah
BOR MOON LAKE	Duchesne	PARADISE PARK	Uintah
BOR STARVATION	Duchesne	RED WASH	Uintah
BOR STEELWATER (UPPER)	Duchesne	WHITEROCKS LAKE	Uintah

Dam Failure

BROWNS DRAW	Duchesne	BIG EAST	Utah
CHEPETA LAKE	Duchesne	BOX LAKE (PAYSON CITY)	Utah
CLIFF LAKE (DUCHESNE)	Duchesne	HIGHLAND CITY - NORTHWEST PRESSURE IRR.	Utah
MIDVIEW (LAKE BOREHAM)	Duchesne	HIGHLAND CITY PRESSURE POND	Utah
RED CREEK (DUCHESNE)	Duchesne	LEHI CITY SANDPIT RESERVOIR	Utah
TWIN POTS	Duchesne	LINDON CITY DRY CANYON DEBRIS BASIN	Utah
ADOBE WASH REGULATING RESERVOIR	Emery	LINDON CITY IRRIGATION PROJECT ZONE II	Utah
BOR HUNTINGTON NORTH	Emery	LINDON CITY IRRIGATION PROJECT ZONE III	Utah
BOR JOES VALLEY	Emery	MAPLE LAKE	Utah
CLEVELAND	Emery	NORTH UTAH COUNTY - BATTLE CREEK	Utah
MILLER FLAT	Emery	NORTH UTAH COUNTY - DRY CREEK	Utah
MILLSITE	Emery	NORTH UTAH COUNTY - SILVER LAKE FLAT	Utah
UTAH POWER & LIGHT - ELECTRIC LAKE	Emery	NORTH UTAH COUNTY - TIBBLE FORK	Utah
OAK CREEK (A.K.A. UPPER BOWNS)	Garfield	NORTH UTAH COUNTY-GROVE CREEK DB	Utah
PANGUITCH LAKE	Garfield	PAYSON RESERVOIR	Utah
TROPIC	Garfield	PROVO CITY - ROCK CANYON DB	Utah
WIDE HOLLOW	Garfield	PROVO CITY - SLATE CANYON DB NO. 2	Utah
NEW WIDE HOLLOW	Garfield	PROVO CITY - SLATE CANYON DB NO. 3	Utah
MOAB CITY - TUSHER CANYON DETENTION	Grand	SANTAQUIN PRESSURE IRRIGATION RESERVOIR	Utah
MOAB CITY - WALKER CANYON DB	Grand	SARATOGA SPRINGS - ISRAEL CANYON	Utah
MOAB CITY - WHITE CANYON RETENTION	Grand	SPANISH FORK PRESSURE IRRIGATION POND	Utah
CEDAR CITY - FIDDLER CANYON DB #2	Iron	UTAH COUNTY - HOBBLE CREEK DEBRIS BASIN	Utah
CEDAR CITY DRY CANYON DB	Iron	UTAH COUNTY - SANTAQUIN DEBRIS	Utah
CEDAR CITY STEPHENS CANYON DB NORTH	Iron	WINWARD (PETE)	Utah
CEDAR CITY STEPHENS CANYON DB SOUTH	Iron	BOR CURRANT CREEK	Wasatch
LEIGH HILL RESERVOIR	Iron	BOR DEER CREEK	Wasatch
NEWCASTLE	Iron	BOR JORDANELLE	Wasatch
RED CREEK (IRON)	Iron	BOR SOLDIER CREEK	Wasatch
YANKEE MEADOW	Iron	CENTER CREEK NO. 1	Wasatch
MONA	Juab	CENTER CREEK NO. 2	Wasatch
SEVIER BRIDGE	Juab	CENTER CREEK NO. 3	Wasatch
JACKSON FLAT RESERVOIR	Kane	DEER VALLEY	Wasatch
CORN CREEK	Millard	DUTCH CANYON DAM - MIDWAY IRRIGATION	Wasatch
DMAD	Millard	JONES	Wasatch
GUNNISON BEND	Millard	LINDSAY (BENNETT) LOWER	Wasatch
BOR EAST CANYON	Morgan	MILL HOLLOW	Wasatch
BOR LOST CREEK (MORGAN)	Morgan	WASATCH COUNTY LAKE CREEK DEBRIS BASIN	Wasatch
NORTHWEST	Morgan	WITT LAKE	Wasatch
WILKINSON (HARRY)	Morgan	ANDERSON JUNCTION	Washington
BOX CREEK - LOWER (BEAVER CREEK)	Piute	ASH CREEK	Washington
BOX CREEK - UPPER (BEAVER CREEK)	Piute	BAKER	Washington
OTTER CREEK	Piute	ENTERPRISE (LOWER)	Washington
PIUTE	Piute	ENTERPRISE (UPPER)	Washington
BIRCH CREEK NO. 2	Rich	GUNLOCK	Washington
WOODRUFF CREEK	Rich	GYPSUM WASH	Washington
DRAPER PRESSURE IRRIGATION PROJECT	Salt Lake	IVINS BENCH	Washington
ENSIGN DOWNS DB (AKA VICTORY ROAD DB)	Salt Lake	KOLOB CREEK	Washington
JORDAN VALLEY WATER PURIFICATION UPPER	Salt Lake	QUAIL CREEK	Washington
KENNECOTT MINE BINGHAM CREEK	Salt Lake	QUAIL CREEK SOUTH DAM	Washington
LAKE MARY-PHOEBE	Salt Lake	SAND HOLLOW NORTH DAM	Washington
LITTLE DELL	Salt Lake	SAND HOLLOW WEST DAM	Washington
LITTLE VALLEY	Salt Lake	SOUTH CREEK - WASHINGTON COUNTY	Washington
MOUNTAIN DELL	Salt Lake	ST. GEORGE CITY - NAVAJO D.B.	Washington
OQUIRRH LAKE DAM/KENNECOTT DAYBREAK	Salt Lake	ST. GEORGE CITY-CITY CREEK D.B.	Washington
POINT OF THE MOUNTAIN RAW WATER RES	Salt Lake	STUCKI DEBRIS	Washington
RED BUTTE DAM	Salt Lake	TUACAHN WASH LOWER DETENTION BASIN	Washington
RED PINE	Salt Lake	WARNER DRAW	Washington
RIVERTON CITY - 3200 WEST POND	Salt Lake	WARNER VALLEY	Washington

Dam Failure

RIVERTON CITY - 4200 WEST POND	Salt Lake	MILL MEADOW	Wayne
RIVERTON CITY - BLACK RIDGE RESERVOIR	Salt Lake	BOR CAUSEY	Weber
SALT LAKE CO-CREEKSIDE PARK (BIG CTTNWD)	Salt Lake	BOR COMBE EQUALIZING RESERVOIR	Weber
SALT LAKE CO.-BIG COTTONWOOD (SPENCER`S)	Salt Lake	BOR OGDEN RIVER EQUALIZING RESERVOIR P	Weber
SALT LAKE COUNTY - SCOTT AVENUE	Salt Lake	BOR PINEVIEW	Weber
SALT LAKE COUNTY - SUGARHOUSE	Salt Lake	NORTH OGDEN CITY ORTON PARK/2100 NORTH	Weber
SALT LAKE COUNTY CHANDLER DRIVE (#13)	Salt Lake	OGDEN CITY - SULLIVAN HOLLOW	Weber
SALT LAKE COUNTY FEDERAL HEIGHTS (#1A)	Salt Lake	SOUTH OGDEN CITY BURCH CREEK (GLASMANN)	Weber
SALT LAKE COUNTY SHRINERS (#12)	Salt Lake	SOUTH OGDEN CITY BURCH CREEK DEBRIS	Weber
SALT LAKE COUNTY-ROTARY GLEN PARK	Salt Lake	TEN ACRE LAKE	Weber

Significant Dam Failure Events:

Laub Detention Dam Failure

Laub Detention Dam failed on September 11, 2012. A severe storm with heavy rainfall occurred prior to the failure. Numerous homes, businesses and roads were damaged. No lives were lost. A Presidential Disaster Declaration was declared for Washington County on November 3, 2012. The Dam was rebuilt in 2013 and was renamed “Tuacahn Wash Lower Detention Basin.”

Quail Creek

Quail Creek dam failed on New Year’s Eve, 1988, due to extensive foundation seepage. Failure caused approximately \$12 million in damage and cost approximately \$8 million to rebuild. No lives were lost.

Trial Lake Dam Failure

Trial Lake Dam failed in 1986 from piping of organics in the foundation contact. The BOR rebuilt the dam and the Corps repaired the damaged river channel.

DMAD Dam Failure

DMAD Dam failed in 1983 and a transient was killed trying to cross the flooding river on a suspended wire. The Gunnison Bend Dam was consequently breached proactively to keep it from overtopping.

Little Deer Creek

Little Deer Creek dam failed on its first filling on June 16, 1963, due to extensive foundation seepage. The catastrophic failure resulted in Utah’s first dam failure fatality killing Bradley Galen Brown, a four-year-old boy.

Assessing Vulnerability by Jurisdiction

Dam safety and dam construction, although improving, is still an imperfect and subjective discipline. Many dams can fail each year, however, the need to store water justifies the associated risks. To assess vulnerability by jurisdiction, the total number of dams classified as having a high hazard rating in each county were ranked (see Table 2B-2 and 2B-3). Thus, a county's level of risk is purely a function of the number of high hazard dams in the county. However, one should keep in mind many factors can cause a dam to fail.

Table 2B-2 Number of Dams with High Hazard Rating Per County

County	Number of High Hazard Dams
Salt Lake	30
Davis	27
Utah	24
Washington	20
Wasatch	14
Uintah	13
Duchesne	12
Summit	11
Sanpete	9
Weber	9
Iron	8
Sevier	8
Cache	7
Emery	7
Box Elder	6
Beaver	5
Garfield	5
San Juan	5
Morgan	4
Piute	4
Grand	3
Millard	3
Tooele	3
Carbon	2
Daggett	2
Juab	2
Rich	2
Kane	1
Wayne	1
Total	247

Table 2B-2 displays the number of high hazard dams by county from most to least. Salt Lake, Davis, Utah, and Washington counties have the highest number of high hazard dams and are also some of the highest populated counties. The county population per high hazard dam table (Table 2B-3) keeps Salt Lake, Davis, Utah and Washington counties within the top ten, with Salt Lake County again on the top. Carbon County only has 2 high hazard dams and has a high ranking of 7th as shown in Table 2B-3. Piute County has the least population per high hazard dam with 381 people.

Table 2B-3 Rankings by County of Population per High Hazard Dam

Ranking	County	Population per High Hazard Dam
1	Salt Lake	35,461
2	Weber	26,293
3	Utah	22,521
4	Tooele	19,957
5	Cache	16,503
6	Davis	11,697
7	Carbon	10,623
8	Box Elder	8,362
9	Washington	7,240
10	Kane	7,221
11	Iron	5,844
12	Juab	5,171
13	Millard	4,190
14	Summit	3,455
15	Grand	3,109
16	Sanpete	3,101
17	San Juan	2,993
18	Wayne	2,737
19	Uintah	2,656
20	Sevier	2,598
21	Morgan	2,455
22	Wasatch	1,805
23	Duchesne	1,604
24	Emery	1,562
25	Beaver	1,300
26	Rich	1,134
27	Garfield	1,019
28	Daggett	545
29	Piute	381

Source: Census 2012 estimate data and Utah Division of Water Rights.

Estimating Potential Losses by Jurisdiction

Analyses of the total area per county that is susceptible to dam failure inundation were conducted. High hazard dams and dam inundation area shape files were provided by the AGRC and the Bureau of Reclamation (BOR). The BOR and state dam failure inundation areas were clipped from each county in order to calculate the total area of potential loss per county. The BOR data provides various dam failure scenarios, such as sudden failure and sunny day failure. The highest potential inundation area was used for each listed BOR dam as to prevent overlapping and multiple summations of BOR dam inundation areas. Areas of potential loss due to dam failure inundation for each county were calculated using the “calculate geometry” function in ArcGIS.

In addition, the percent total potential inundation areas per county were also calculated to demonstrate how much risk due to dam failure inundations exists in each county. This was calculated by dividing the total area of the county by the total potential dam failure inundation area of the county. Maps were then created that visualize this distribution of potential dam failure inundation risk areas per county. All of the LHMPs did not report the number of their structures in dam failure inundation areas, as well as any damage or loss estimates.

The total potential inundation area by county is ranked for every county in Table 2B-4. Millard, Uintah, Weber, Iron and Duchesne counties dominate on the top of the list. Weber County is by far the most populated of those top five counties. Utah County, which has over 500,000 people, comes in at 6th place. Table 2B-5 shows the percent potential inundation area by county. Weber, Uintah, Millard and Utah Counties remain on the top with some of the most percent potential inundation area by county. Weber County has the most percent potential inundation area by county with 48.4%. This is over four times the area than the next county. Kane, San Juan, and Wayne counties have the least inundations areas in the state.

Table 2B-4 Total Potential Dam Failure Inundation by County

Rank	County	Total Potential Inundation Area by County (square miles)
1	Millard	560.1
2	Uintah	488.6
3	Weber	319.3
4	Iron	184.2
5	Duchesne	172.8
6	Utah	134
7	Emery	92.7
8	Sevier	80.9
9	Box Elder	79.6
10	Tooele	67.6
11	Washington	67.2
12	Morgan	62.5
13	Sanpete	58.5
14	Cache	52.5
15	Salt Lake	49.5
16	Beaver	48.6
17	Summit	44.5
18	Wasatch	34.6
19	Davis	30.6
20	Daggett	24.7
21	Garfield	23.9
22	Piute	18.6
23	Juab	17.9
24	Grand	17.6
25	Rich	12.4
26	Carbon	11.5
27	Wayne	7
28	San Juan	5.1
29	Kane	0
Total		2767

Table 2B-5 Percent Potential Inundation Area by County

Rank	County	Percent Potential Inundation Area by County (square miles)	Percentage of Utah's Population by County (2012 census data)
1	Weber	48.4%	8.3%
2	Uintah	10.8%	1.2%
3	Morgan	10.3%	0.3%
4	Millard	8.2%	0.4%
5	Utah	6.3%	18.9%
6	Salt Lake	6.1%	37.3%
7	Iron	5.6%	1.6%
8	Davis	4.8%	11.1%
9	Cache	4.5%	4.0%
10	Sevier	4.2%	0.7%
11	Sanpete	3.7%	1.0%
12	Daggett	3.5%	0.04%
13	Wasatch	2.9%	0.9%
14	Washington	2.8%	5.1%
15	Piute	2.4%	0.1%
16	Summit	2.4%	1.3%
17	Emery	2.1%	0.4%
18	Beaver	1.9%	0.2%
19	Duchesne	1.6%	0.7%
20	Box Elder	1.2%	1.8%
21	Rich	1.1%	0.1%
22	Tooele	0.9%	2.1%
23	Carbon	0.8%	0.7%
24	Garfield	0.5%	0.2%
25	Grand	0.5%	0.3%
26	Juab	0.5%	0.4%
27	Wayne	0.3%	0.1%
28	San Juan	0.1%	0.5%
29	Kane	0.0%	0.3%

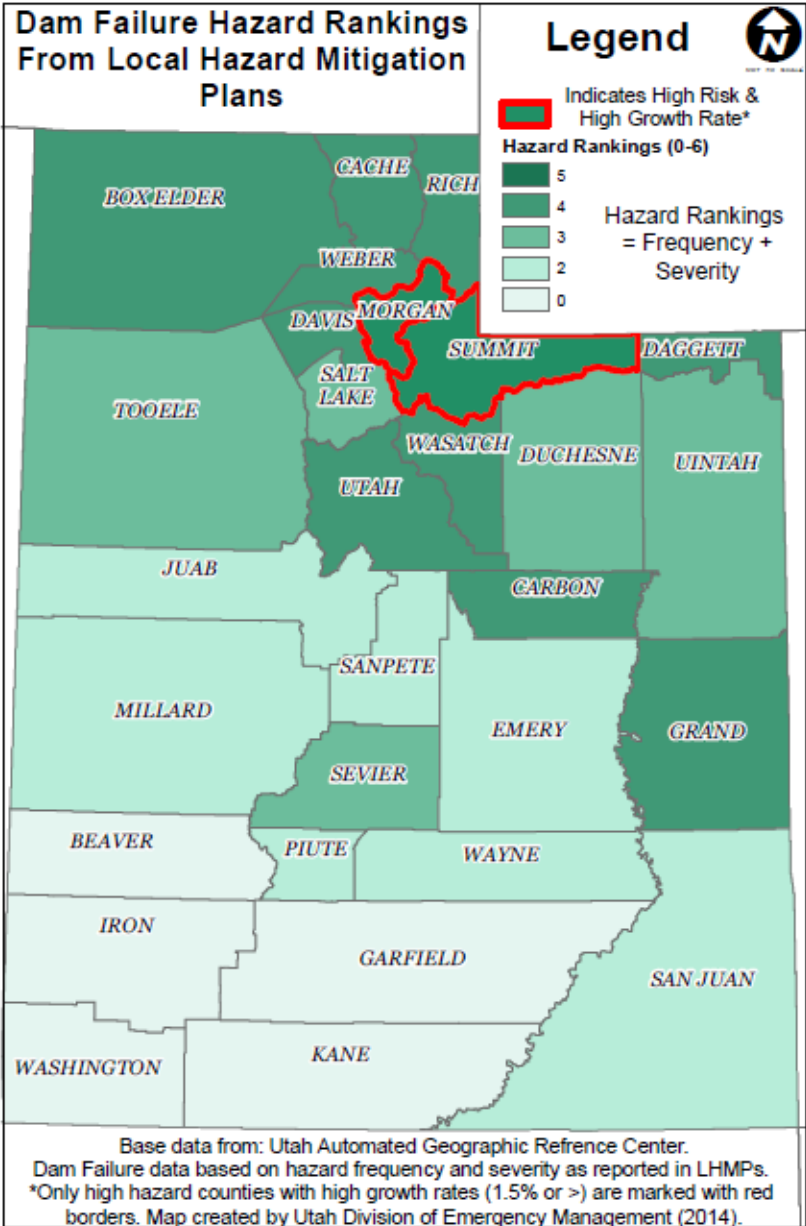
A map was also created that shows the hazard ranking of Dam Failure for each county as reported in the LHMPs (Figure 2B-3). The hazard ranking is calculated from a combination of severity (categorized from 0-3) and frequency (categorized from 0-3). This allows for a ranking from 0-6 to be scored. The Identifying Hazards section under Local Risk Assessments explains this process in greater detail.

The map also highlights the highest at risk counties (with a ranking of 5 or 6) whose population growth rates are 1.5% (the state average) or greater. This is designed to mark

areas of rapid growth and development by county that are the highest risk to dam failure as reported in LHMPs.

Based on the reporting in LHMPs, Morgan and Summit counties are perceived as having high vulnerability to dam failure. Morgan County was shown to have a high hazard ranking and a high growth rate, as well as being ranked third in Table 2B-5. Summit County was also ranked high in their LHMP to being vulnerable to dam failure and have also had a high growth rate from 2010 to 2012. Northern Utah is shown to be the most vulnerable to dam failure based on the LHMPs.

Figure 2B-3 Dam Failure Hazard Rankings from LHMPs



Vulnerable Structures and Dam Failure

Vulnerable structures and loss estimates to dam failure were not reported in LHMPs. Therefore, the general building stock data in HAZUS was used to estimate potential building exposure to dam inundation. Two dam inundation data sets for this analysis were used: one is from the Utah Division of Water Rights (data hosted by the Utah Automated Geographic Reference Center) and the other is from the Bureau of Reclamation (for official use only data). The HAZUS data used was updated by FEMA Region VIII for the 2012 ShakeOut full-scale exercise and the 2013 ShakeOut functional exercise. These updates occurred on the Census Tract level. Within the HAZUS database, the “hzBldgCountOccupT” and the “hzExposureOccupT” tables in addition to the Census Tract vector data were used. This analysis assumes that all of the buildings in a Census Tract are evenly distributed through the Tract.

The results of the analysis are found in Table 2B-6. The analysis was performed as follows. First, all of the buildings from the all HAZUS occupancy class were added together to derive the total number of buildings per Tract. Next, all of the exposure values were added to derive the total building value per Tract. These two values were used to determine the average value per structure in each Tract. The number of buildings exposed to the dam inundation hazard was estimated by dividing the area of each Tract in the hazard area by the total Tract area and then multiplying this percentage by the total number of buildings in the Tract. To determine the estimated building value exposure, the number of buildings was multiplied in each Tract in the hazard area by the estimated building value for that Tract. These results were aggregated to the county level using the Dissolve tool in ArcMap. Lastly, 2010 Census Population values (the most current in the HAZUS database) were used to determine a per capita exposure to dam inundation based on the estimated building value exposure in each county.

Based on the above analysis, Tooele, Utah, Weber, Duchesne, and Sevier counties have the highest per capita loss to dam inundation with \$19,466.99, \$18,474.72, 15,057.23, \$11,079.78, and \$10,796.48 respectively. Salt Lake County, the most populated in the state and the county with the second highest number of buildings in dam inundation areas, had the 7th highest per capita loss with \$9,090.77. Utah County had the highest number of buildings in dam inundation areas. The majority of the populated counties were also the counties with the highest loss estimates.

Table 2B-6 Utah HAZUS Building Stock Exposure to Dam Inundation

ID	County Fips	County	HAZUS Number of Buildings	HAZUS Total Building Value	Estimated Buildings in Inundation Areas	Estimated Building Value Exposure	Percent Building Value Hazard Exposure	2010 Census Population	Per Capita Hazard Exposure
1	49001	Beaver	3,095	\$634,540,000	53	\$10,863,090	1.71%	6,629	\$1,638.72
2	49003	Box Elder	18,419	\$3,266,465,000	845	\$148,926,654	4.56%	49,975	\$2,980.02
3	49005	Cache	39,176	\$7,652,669,000	3,743	\$632,764,077	8.27%	112,656	\$5,616.78
4	49007	Carbon	10,178	\$1,583,079,000	862	\$132,920,167	8.40%	21,403	\$6,210.35
5	49009	Daggett	1,214	\$132,735,000	41	\$4,543,393	3.42%	1,059	\$4,290.27
6	49011	Davis	102,061	\$20,932,159,000	11,323	\$2,258,170,036	10.79%	306,479	\$7,368.11
7	49013	Duchesne	9,333	\$1,293,305,000	1,326	\$206,155,809	15.94%	18,607	\$11,079.48
8	49015	Emery	4,753	\$659,792,000	109	\$15,354,558	2.33%	10,976	\$1,398.92
9	49017	Garfield	3,836	\$667,460,000	13	\$2,263,069	0.34%	5,172	\$437.56
10	49019	Grand	5,253	\$809,741,000	156	\$25,768,024	3.18%	9,225	\$2,793.28
11	49021	Iron	20,314	\$3,369,557,000	703	\$164,038,650	4.87%	46,163	\$3,553.47
12	49023	Juab	3,823	\$767,331,000	9	\$1,752,892	0.23%	10,246	\$171.08
13	49025	Kane	5,803	\$880,543,000	0	\$0	0.00%	7,125	\$0.00
14	49027	Millard	5,495	\$992,905,000	187	\$33,122,397	3.34%	12,503	\$2,649.16
15	49029	Morgan	3,201	\$636,754,000	128	\$25,479,264	4.00%	9,469	\$2,690.81
16	49031	Piute	934	\$146,040,000	21	\$3,337,562	2.29%	1,556	\$2,144.96
17	49033	Rich	3,105	\$402,553,000	20	\$2,532,195	0.63%	2,264	\$1,118.46
18	49035	Salt Lake	284,995	\$58,770,653,709	41,008	\$9,360,352,564	15.93%	1,029,655	\$9,090.77
19	49037	San Juan	6,093	\$893,281,000	10	\$1,513,459	0.17%	14,746	\$102.64
20	49039	Sanpete	10,837	\$1,837,826,000	137	\$23,911,707	1.30%	27,822	\$859.45
21	49041	Sevier	9,036	\$1,502,106,000	1,016	\$224,580,338	14.95%	20,802	\$10,796.09
22	49043	Summit	26,585	\$4,917,852,000	250	\$43,670,273	0.89%	36,324	\$1,202.24
23	49045	Tooele	19,995	\$3,611,438,000	7,706	\$1,132,164,838	31.35%	58,218	\$19,446.99
24	49047	Uintah	12,151	\$1,983,883,000	314	\$51,147,455	2.58%	32,588	\$1,569.52
25	49049	Utah	154,882	\$31,227,057,000	53,097	\$9,543,372,916	30.56%	516,564	\$18,474.72
26	49051	Wasatch	10,824	\$2,074,620,000	1,038	\$233,682,728	11.26%	23,530	\$9,931.27
27	49053	Washington	59,469	\$9,943,091,000	6,373	\$1,023,119,239	10.29%	138,115	\$7,407.73
28	49055	Wayne	1,529	\$217,481,000	4	\$618,957	0.28%	2,778	\$222.81
29	49057	Weber	90,334	\$16,285,461,000	19,090	\$3,481,772,973	21.38%	231,236	\$15,057.23

Development Trend Impacts

There are six high hazard dams in Utah being planned or designed as of 2014. The names of the dams are Warner Valley, Anderson Junction, Payson Reservoir, Lehi City Sandpit Reservoir, Park City Mountain Resort and Snowmaking Pond, and the Narrows Reservoir Dam. Two of these dams are in Utah County, two in Washington, one in Summit and one in Sanpete. One high hazard dam is under construction, the M & S dam in Uintah County. Of the 247 high hazard dams, Salt Lake, Davis, Utah, Washington, Wasatch, Uintah, Duchesne, Summit, Sanpete, and Weber Counties have the most high hazard dams. Of these 10 counties with a high number of high hazard dams, 9 of them have high growth rates from 2010-2012. Sanpete County experienced only 0.1% growth from 2010-2012 and even dropped to -0.3% from 2011-2012 (see Figures 2A-5 and 2A-6).

Based on the dam failure vulnerability analysis (see Figure 2B-5) 37 of the top 50 fastest growing cities are in the top 2 most vulnerable categories to dam failure. The other 13 cities are in the middle vulnerability category. As cities continue to grow in Utah, the potential impact of dam failure will increase. In 2012, the Laub Detention Dam in Washington County failed and flooded several homes and businesses. Washington County is one of the fastest growing areas in the state. Many dams in Utah were built many decades ago and are constructed of earthen materials. As communities continue to grow and encroach in dam failure inundation zones the threat will increase. The regular inspection of dams in Utah will hopefully allow mitigation strategies to be implemented before a catastrophic dam failure in the future.

Assessing Vulnerability by State Facilities

Updated state facilities data was provided by Utah Division of Risk Management. The 2012 state facility database was used for the 2014 plan update and is a different database than the last plan update. The updated state facilities shape file was overlaid on top of the Utah state dam failure inundation areas map as well as the federal dam failure inundation locations. Using ArcGIS, each dam inundation area was clipped from a county shape file for each county in Utah. The “select by location” option was then utilized in order to determine how many vulnerable structures exist per county. A total of 1859 state facilities were found to be in dam failure inundation areas, with Salt Lake, Utah, and Weber counties having the bulk of them. Seven counties were found to have no state facilities in dam failure inundation areas: Daggett, Juab, Kane, Piute, Rich, San Juan, and Wayne.

Table 2B-7 Number of State Owned Facilities in Dam Failure Inundation Areas

County Name	Facilities in Dam Inundation Areas
Salt Lake	638
Utah	320
Weber	239
Davis	91
Sevier	80
Morgan	60
Summit	55
Tooele	49
Washington	42
Iron	41
Emery	40
Grand	34
Carbon	33
Wasatch	27
Duchesne	26
Cache	25
Uintah	21
Sanpete	15
Millard	12
Garfield	8
Beaver	2
Box Elder	1
Daggett	0
Juab	0
Kane	0
Piute	0
Rich	0
San Juan	0
Wayne	0
Overall Total	1859

Estimating Potential Losses by State Facilities

Values estimating the potential losses by state-owned facilities were calculated by summing the current value of each state-owned facility per county that falls within the county's dam inundation areas. Current values of state facilities per county were provided by Risk Management. It is important to note that the current values represent the total value of the facilities located within a dam inundation area. These values assume that in the event of a dam breach, the state facilities within the dam inundation area would be completely destroyed rather than sustaining a particular amount of damage. Therefore, the current values overestimate the damage to state facilities in the event of most dam failures. The state facilities per capita loss to dam failure was also calculated.

Based on tables 2B-7 and 2B-8 and Dam Inundation State Facilities maps in Appendix R, State facilities have the greatest to lose in Salt Lake, Utah and Weber Counties. More analysis is needed to understand what is at risk in dam inundation areas. Figure 2B-4 is a map of the state facility per capita loss for dam failure for every county based on the insured value of the state owned facilities residing in their boundaries. Sevier, Morgan, and Duchesne counties have the highest state facility per capita loss for dam failure. All three of these counties have relatively low populations. The findings are ranked in Table 2B-8.

Table 2B-8 Total Value of State Owned Facilities in Dam Failure Inundation Area

County	Facilities in Dam Inundation Areas	Insured Value of State Facilities
Salt Lake	638	\$1,838,777,960
Utah	320	\$1,271,416,203
Weber	239	\$757,535,147
Davis	91	\$478,905,416
Tooele	49	\$175,324,485
Iron	41	\$162,560,177
Sevier	80	\$141,897,314
Washington	42	\$106,436,619
Duchesne	26	\$95,006,723
Cache	25	\$84,681,925
Wasatch	27	\$81,701,257
Summit	55	\$58,406,885
Morgan	60	\$57,467,639
Carbon	33	\$50,487,198
Grand	34	\$36,036,564
Sanpete	15	\$27,518,755
Emery	40	\$16,880,408
Beaver	2	\$8,148,000
Uintah	21	\$5,716,804
Garfield	8	\$5,534,213
Millard	12	\$4,146,260
Box Elder	1	\$192,500
Daggett	0	\$0
Juab	0	\$0
Kane	0	\$0
Piute	0	\$0
Rich	0	\$0
San Juan	0	\$0
Wayne	0	\$0
Overall Total	1859	\$5,464,778,452

Figure 2B-4 State Facilities per Capita Loss for Dam Failure

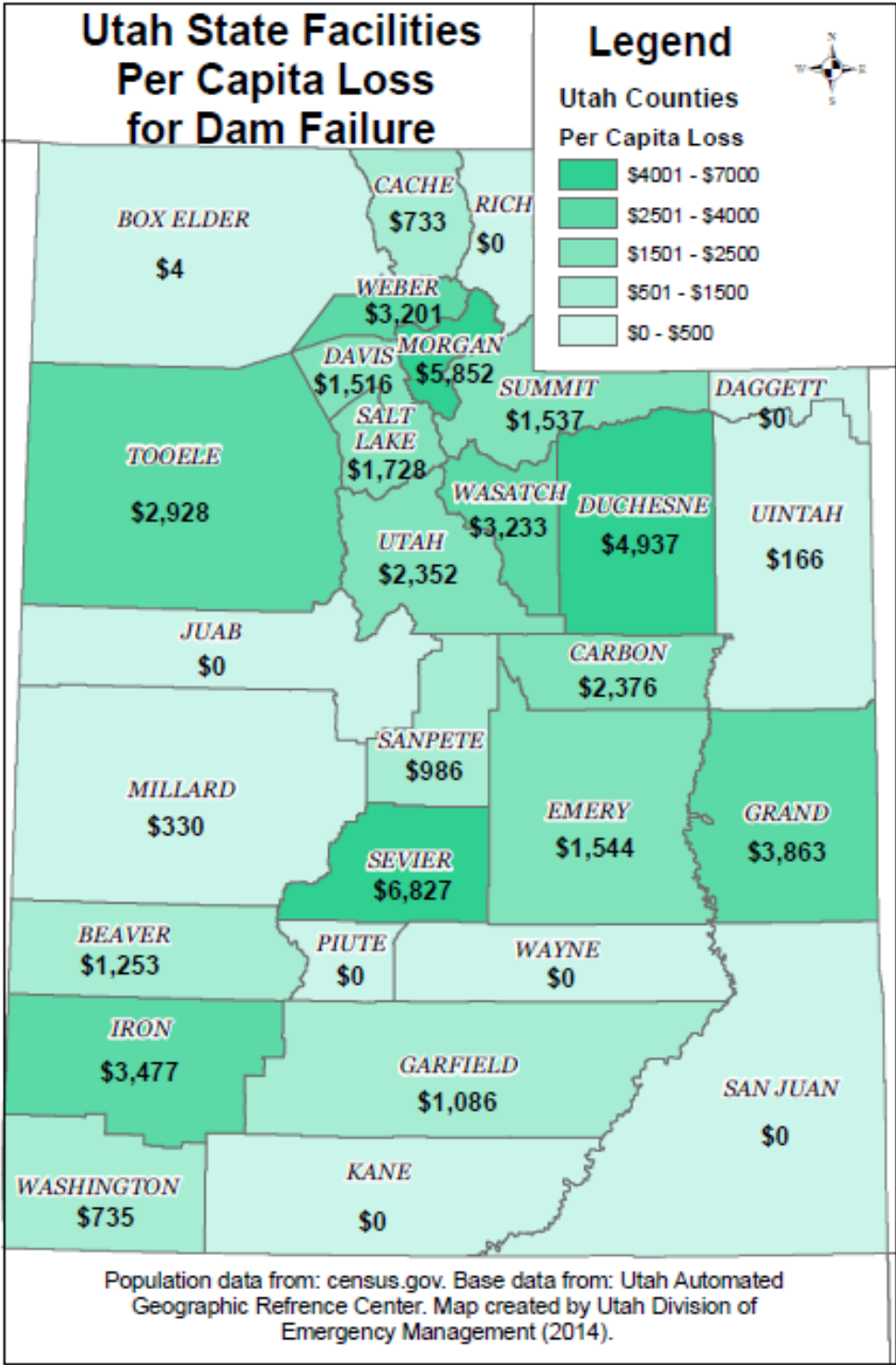


Table 2B-9 Rankings of Per Capita Loss to State Facilities for Dam Failure

Rank	County	Per Capita Loss to State Facilities	2011-2012 Population Growth Rates
1	Sevier	\$6,827.24	-0.6%
2	Morgan	\$5,851.51	1.9%
3	Duchesne	\$4,936.95	2.0%
4	Grand	\$3,863.27	0.6%
5	Iron	\$3,477.22	0.2%
6	Wasatch	\$3,232.75	3.8%
7	Weber	\$3,201.21	1.1%
8	Tooele	\$2,928.42	1.0%
9	Carbon	\$2,376.32	-0.5%
10	Utah	\$2,352.28	2.0%
11	Salt Lake	\$1,728.43	1.5%
12	Emery	\$1,543.99	-0.3%
13	Summit	\$1,536.90	1.5%
14	Davis	\$1,516.44	1.3%
15	Beaver	\$1,253.35	-0.4%
16	Garfield	\$1,086.20	-1.5%
17	Sanpete	\$986.12	-0.3%
18	Washington	\$735.01	2.3%
19	Cache	\$733.05	0.8%
20	Millard	\$329.88	-0.3%
21	Uintah	\$165.59	4.1%
22	Box Elder	\$3.84	-0.02%
23	Daggett	\$0	-6.0%
23	Juab	\$0	0.1%
23	Kane	\$0	-0.3%
23	Piute	\$0	0.5%
23	Rich	\$0	-2.2%
23	San Juan	\$0	1.1%
23	Wayne	\$0	-0.9%

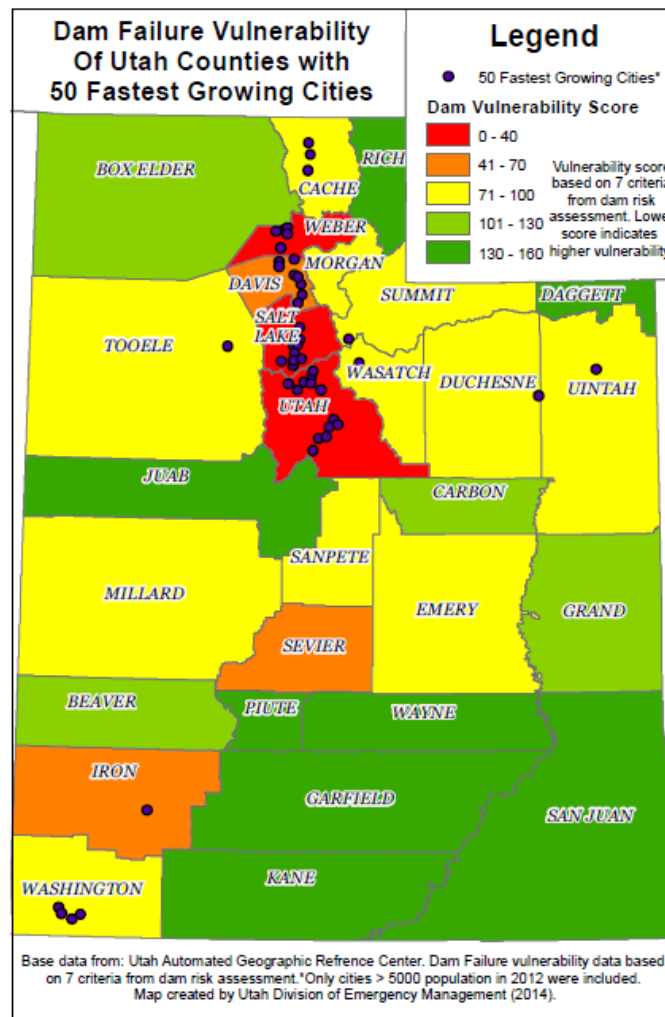
A vulnerability analysis was performed on based on data gathered from the dam failure risk assessment. Table 2B-10 and Figure 2B-5 show the results of this analysis (see page 72 for an explanation). Weber, Utah, Salt Lake, Iron and Davis counties have the highest vulnerability to dam failure based on the analysis. Most of these counties lie along the Wasatch Front. Most of the southeastern corner of Utah is at the lowest vulnerability to dam failure and is also not heavily populated.

Table 2B-10 Dam Failure Vulnerability Score of Utah Counties*

Rank	County	Vulnerability Score
1	Weber	28
2	Utah	31
3	Salt Lake	36
4	Iron	53
5	Davis	57
6	Sevier	61
7	Morgan	71
8	Tooele	72
9	Washington	73
10	Duchesne	81
11	Cache	84
12	Uintah	86
13	Summit	87
14	Wasatch	89
15	Millard	93
16	Emery	99
17	Sanpete	100
18	Carbon	108
19	Grand	110
20	Box Elder	115
21	Beaver	126
22	Garfield	141
23	Daggett	145
24	Juab	146
25	Piute	149
26	Kane	154
27	San Juan	155
28	Rich	157
29	Wayne	158

*Based on 7 criteria from dam failure risk assessment.

Figure 2B-5 Dam Failure Vulnerability with 50 Fastest Growing Cities



Vulnerability Analysis

A vulnerability analysis was conducted based on 7 criteria from the dam failure risk assessment. These 7 criteria come from Tables 2B-2 through 2B-8. Each of the criteria was ranked from 1 to 29 for each county (see Table 2B-8 as an example). The ranking numbers were combined for each county and then the totals were ranked from 1 to 29 to determine a vulnerability ranking. The counties with the lowest total ranking number would indicate the highest overall vulnerability to dam failure. For example, if a county ranked 1 for each of the criteria it would receive a vulnerability ranking of 7. Table 2B-9 and figure 2B-5 list the results of the analysis. This analysis does not represent the likelihood of dam failure impacting a county, but the vulnerability of a county to dam failure based on the seven criteria. The most vulnerable areas to dam failure based on the analysis are along the Wasatch Front, along with Sevier and Iron Counties. The Development Trends Impact section discusses the growing cities and dam failure.