2024

Utah Seismic Safety Commission Report and Recommendations

USSC

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Cover image: Seismic retrofits underway at the Salt Lake Temple

Introduction

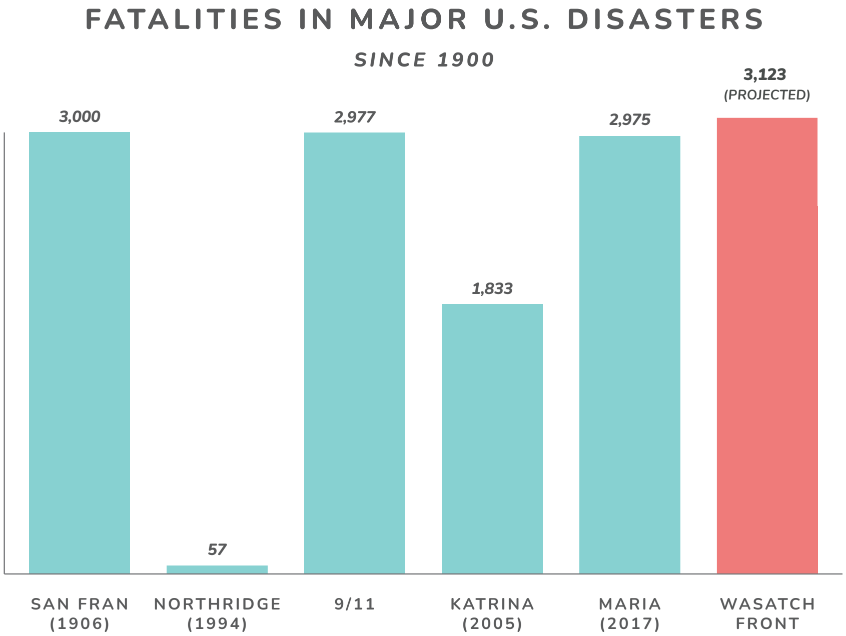
The Salt Lake Temple is currently undergoing a major seismic upgrade to prepare for the "Big One."

The Federal Emergency Management Agency (FEMA) has called the Wasatch fault "one of the most catastrophic natural threat scenarios in the U.S."[1] In 2016, it was estimated that the Wasatch Front region has a 43% chance of experiencing a magnitude 6.75 or greater earthquake in the next 50 years — a likelihood that has only increased in the intervening years.[2] In other words, the Wasatch Front's odds of experiencing "the Big One" are essentially equivalent to a coin toss.

Without proactive measures, an expected magnitude (M) 7.0 earthquake (89 times stronger than the 2022 Magna M5.7 earthquake) on the Salt Lake City segment of the Wasatch fault ("The Big One") would be among the deadliest disasters in U.S. history. It would leave hundreds of thousands of Utahns without shelter and critical lifeline services, with some services not being restored for six months or more.[3] The damage to infrastructure and income would result in short term economic losses estimated at $75 billion.[4] Long-term losses would undoubtedly be much larger, as people leave, many never to return, and businesses close, many never to reopen. In fact, **Utah's economy and way of life may never fully recover from the "Big One."** Other places that have experienced this level of disaster, including New Orleans and Christchurch, have taken years, even decades, to recover—if they recover at all.

Because of this threat to the state, the Utah Legislature, ever interested in preparing Utah for the future, created the Utah Seismic Safety Commission (USSC) in 1994 and tasked it with reviewing earthquake-related hazards and risks, preparing and prioritizing recommendations to mitigate those hazards and risks, and presenting those recommendations to state and local governments.

This report contains the Commission's recommendations for targeted, prioritized steps that will mitigate the impacts of a major earthquake. While these actions will not eliminate all or even most of the severe damage that will occur, they have the potential to significantly reduce the initial devastation and enable the state to recover more quickly. These recommendations have been discussed and vetted with a variety of experts and key stakeholders and were coordinated with Envision Utah's disaster resilience working groups.



Investing in Utah's disaster resilience now helps to decrease the risk of true catastrophe, and it also makes clear economic sense. Recent research by (FEMA) shows that, on average, **every dollar spent on disaster mitigation now avoids six dollars in future disaster costs.**[5] **Few other types of investments can boast that kind of economic payoff.**

1. Wasatch Front URM Risk Reduction Strategy Best Practices and Replicability, FEMA 2022
2. Earthquake Probabilities for the Wasatch Front Region in Utah, Idaho, and Wyoming, UGS 2016.
3. Scenario for a Magnitude 7.0 Earthquake on the Wasatch Fault--Salt Lake City Segment, EERI 2015
4. Lifeline Systems Analysis for Wasatch Fault Planning, Great Utah ShakeOut M7.0 Scenario, DEM 2021
5. Natural Hazard Mitigation Saves Interim Report Fact Sheet, FEMA 2018

What we can do to save lives and the economy

The USSC recommends the following prioritized actions:

1. KEEP WATER FLOWING

Invest an additional $125 million in seismic improvements for the four major water aqueducts that serve over two million residents. Should any one of these pipelines rupture in an earthquake, many hundreds of thousands of Utahns would be left without water for six months or even longer. The total cost of improving these four pipelines is over $550 million, the bulk of which has non-legislative funding sources. The Utah Legislature allocated $50 million in 2023, which will leverage district and FEMA money to fully fund two of the projects. The remaining two projects have a funding gap of $125 million.

2. KEEP OUR KIDS SAFE

Allocate $4 million to the applicable school districts to evaluate or design retrofits or replacements for each of the 130+ school campuses that likely contain seismically unsound unreinforced masonry (URM) construction. Over 70,000 Utah children who attend school in these buildings are at high risk in an earthquake. These buildings are also important gathering and sheltering places and essential for resuming normal life after a disaster.

3. KEEP OUR COMMUNITIES AND MARKETS INFORMED

Fund $300,000 per year for two years to increase public awareness of the high risk from Utah's 140,000 unreinforced masonry (URM) buildings. These buildings, built before 1976, are scattered across the state and include single family homes, multifamily structures, and offices. Improved public awareness will increase market function and efficiency and apply market pressure to upgrade more of these buildings.

4. KEEP OUR BUILDINGS STANDING

Ensure adequate building code enforcement for important or large buildings. Rigorous structural plan reviews by independent and qualified experts, particularly for larger, complex buildings, can improve seismic safety of structural systems and possibly prevent very expensive—and potentially deadly—issues in an earthquake. Specifically, the USSC recommends that every building classified as International Building Code Risk Category III or IV (e.g., a hospital, school, or police station) or larger than 200,000 square feet be required to undergo a plan review conducted by a Utah-licensed Professional Structural Engineer.

5. BUILD AN EARTHQUAKE EARLY WARNING SYSTEM

Pursue an earthquake early warning (EEW) system for the Wasatch Front. A legislatively funded study found that an EEW system is feasible in Utah and, for areas that are not immediately proximate to the epicenter, provide adequate warning time for people to get under a sturdy table or desk and for automated systems to shut off trains, surgeries, and utilities, and take other critical actions. The state should fund close to $5 million in capital costs and nearly $1 million in annual costs for operations and maintenance and pursue a partnership with USGS to adopt the West Coast ShakeAlert system.

Accomplishments

In 2023, Utah appropriated $50 million to bolster the seismic resilience of our aqueducts.

Due to the magnitude of the challenge, improving Utah's seismic resilience will require continual and incremental steps. In recent years, significant progress has occurred. Here are some examples:

- **Water**: To increase the likelihood that Utahns have running water in the months following an earthquake, the Utah Legislature allocated $50 million in 2023 to enhance the seismic resilience of our aqueducts, leaving a remaining gap of $125 million. This funding leverages additional money from water conservancy districts and FEMA.
- **Schools**: Efforts to retrofit, replace, and close unreinforced masonry (URM) school buildings and other public structures persist. In 2022, the Utah Division of Emergency Management (UDEM) and FEMA completed and released an inventory of unreinforced masonry buildings on school campuses. Recent legislative funding for school capital needs adds to local efforts.
- **Public Awareness:** Efforts to raise awareness about seismic risks among Utahns and legislators have gained momentum. The receipt of a FEMA grant for an outreach campaign represents a significant milestone. This initiative, now getting underway, promises to empower our communities with the knowledge needed to effectively prepare for seismic events.
- **Unreinforced Masonry:** UDEM completed a Statewide Residential Seismic Retrofit Grant Program Feasibility Study that provides guidance for decision makers as they consider creating a statewide grant program for retrofitting URM homes and other buildings.
- **Policymaker Awareness.** In September 2023, the Legislative Auditor General released a report identify the seismic risk to aqueducts and unreinforced masonry buildings as among the most important critical vulnerabilities in Utah.
- **Research**: In 2023, the Utah Legislature allocated $2.5 million to establish an Earthquake Engineering Research Center at Utah State University. This center will help bridge the gap between what we know about the devastating effects of earthquakes and how to better design our infrastructure to withstand them.
- **Early Warning System:** In 2022, the Utah Legislature funded a feasibility study for an earthquake early warning system to provide critical seconds of warning that could reduce destruction and loss of life by triggering automated responses from a variety of key actors. The Utah Geological Survey has since completed the feasibility study.

While there is still much work to be done, these accomplishments represent a collective commitment to Utah's safety and prosperity.

6. High-Risk List: Identifying and Mitigating Critical Vulnerabilities in Utah

Recommendations

Upgrade Water Infrastructure

Water infrastructure resilience is one of Utah's most critical needs in the face of an expected large earthquake.[6] **In the event of a major earthquake on the Wasatch fault, water and sewer service across the Wasatch Front is projected to be disrupted for more than a million people for many months**. Unlike freeway infrastructure, which is rebuilt far more often (at a much higher cost), much of Utah's major water instructure is over 50 years old. The Wasatch Front's most important aqueducts are located across and along major hazardous faults, landslide areas, high ground shaking areas, and liquefaction areas, putting them at high risk for significant damage.

A plausible modeling scenario estimated that around 330,000 homes, or roughly one million people, will still be without water three months after a major Wasatch fault earthquake event.[7] Not only is water essential for life and for disaster response on the Wasatch Front, but it is essential for Utah's economy. Businesses along the Wasatch Front that are at risk of losing water contribute to more than 75% of Utah's economy.[9] Moreover, water is a critical aspect of other infrastructure and services, including power, medical care, and fire response. Without water, interdependent systems and infrastructure will remain offline.

The impacts will extend to the rest of Utah, as well as the greater Intermountain West, which is reliant on food, fuel, and other supplies sourced from the Wasatch Front. If Utah's communities are without water for months, businesses will collapse and families will relocate. As a result, Utah's economy would take years, even decades, to recover.

Construction of the Salt Lake Aqueduct began in 1940 and was completed in 1951. Unlike our freeways, much of Utah's aqueduct infrastructure has not been updated for generations.

7. Community Resilience Planning Guide for Buildings and Infrastructure
8. Scenario for a Magnitude 7.0 Earthquake on the Wasatch Fault
9. Utah Chapter of the Earthquake Engineering Research

PROPOSED WATER PROJECTS

The USSC recommends four critical water projects for protecting the supply of water to the Wasatch Front following an earthquake and subsequent aftershocks. The four projects on the following pages relate to large pipelines, called aqueducts, that carry water across the Wasatch fault or through high ground shaking and liquefaction areas. They provide a majority of the water for our most populated areas.

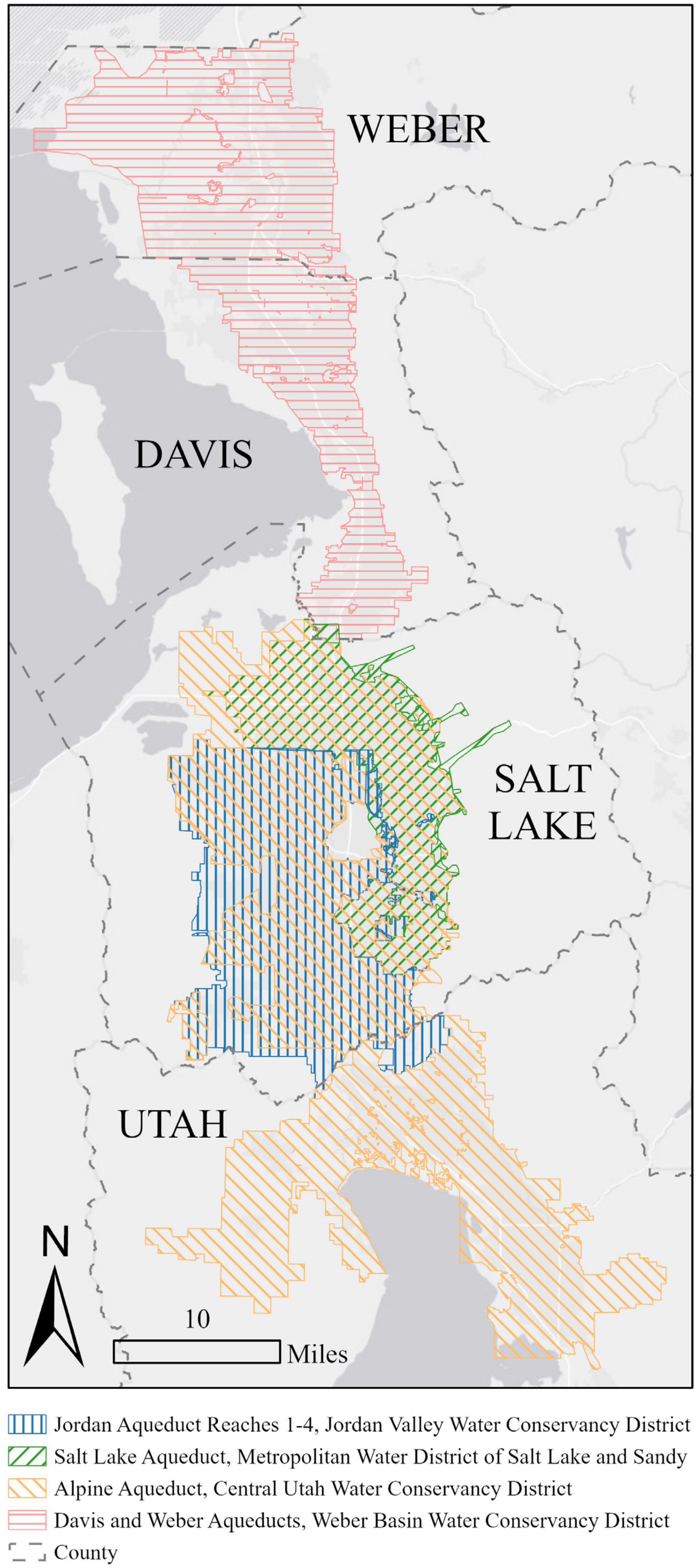
Without water from these four main aqueducts, other seismic upgrades to the water and sewer system will have negligible impact because there will be no water in the network. Additionally, if an aqueduct were to rupture, flooding would follow, although the specific impacts have yet to be modeled.

From a water supply standpoint, the Wasatch Front is a unique metropolitan area. We are far more at risk from a major seismic event. Not only does much of Wasatch Front water come from a great distance through the dams, tunnels, and aqueducts of the Central Utah Project, the Provo River Project, and the Weber Basin Project, the vast majority of this water crosses the Wasatch Fault in three major aqueducts as it enters our urban valleys. The fourth aqueduct in this list does not cross the fault; however, it is located in a predicted high ground shaking and liquefaction area.

These massive aqueducts were built three generations ago, before the seismic risks of the Wasatch fault were understood, and it is unlikely that they will withstand the “Big One.” These four projects have been identified by their respective water districts, who have estimated upgrade costs. The total cost of these projects is over $550 million. The water conservancy districts estimated that, after local and federal funds are applied, there is a shortfall of approximately $175 million that is needed to allow the projects to proceed in the near future rather than many years later. In 2023, the Utah Legislature allocated $50 million, which, when combined with district and FEMA money, will fully fund the Davis Aqueduct and Alpine Aqueduct projects. The legislative money has also provided funding for engineering studies for the other two aqueducts. The gap to fund the remaining two projects is estimated at $125 million.

Funding upgrades now will greatly reduce the repair time and costs in the future. A barrier to recovery time is that spare parts cannot be kept on hand or in storage for these aqueduct projects, and would have to be custom manufactured and brought in from outside the state after the earthquake. These aqueduct projects will reduce the chance that major repairs are needed, making them a key element of accelerating Utah’s recovery.

Areas Served by Aqueduct Projects

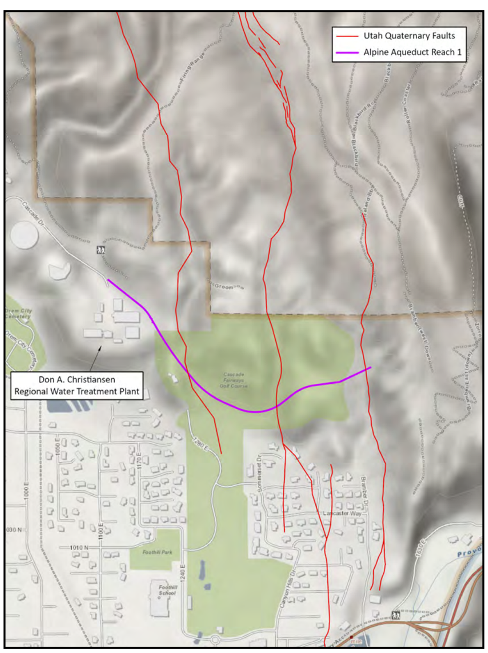


ALPINE AQUEDUCT RELOCATION | CENTRAL UTAH WATER CONSERVANCY DISTRICT

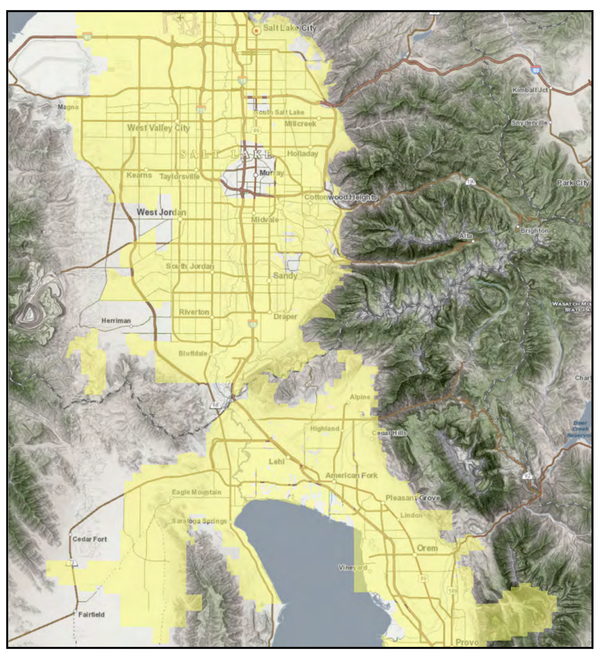
The Alpine Aqueduct brings water from the Central Utah Project to Utah and Salt Lake Counties, **serving more than one million people**. Reach 1 of the aqueduct is critical to delivering water to the Don A. Christensen Regional Water Treatment Plant for Salt Lake County and northern Utah County. The aqueduct runs close to and across the mapped traces of the Wasatch fault and through active landslide areas that have already damaged the pipeline. A large magnitude earthquake would likely rupture the ground beneath the aqueduct, and strong shaking from aftershocks could continually weaken infrastructure and slow repairs.

The district keeps some spare materials on hand for minor repairs over a short length of the aqueduct, but it is not feasible to store materials for repairing a long section. As a result, repairing damage from a minor earthquake could take days to weeks. If the aqueduct were to suffer major damage over a longer length, the materials would need to be custom manufactured and could take six months or more to secure materials and make the repairs.

A portion of this aqueduct needs to be relocated to a new alignment to ensure water deliveries through the Alpine Aqueduct Reach 1 continue without incident. The total projected cost to construct the new alignment is $75 million. The Central Utah Water Conservancy District is asking for $22.5 million from the Utah Legislature to support the project.

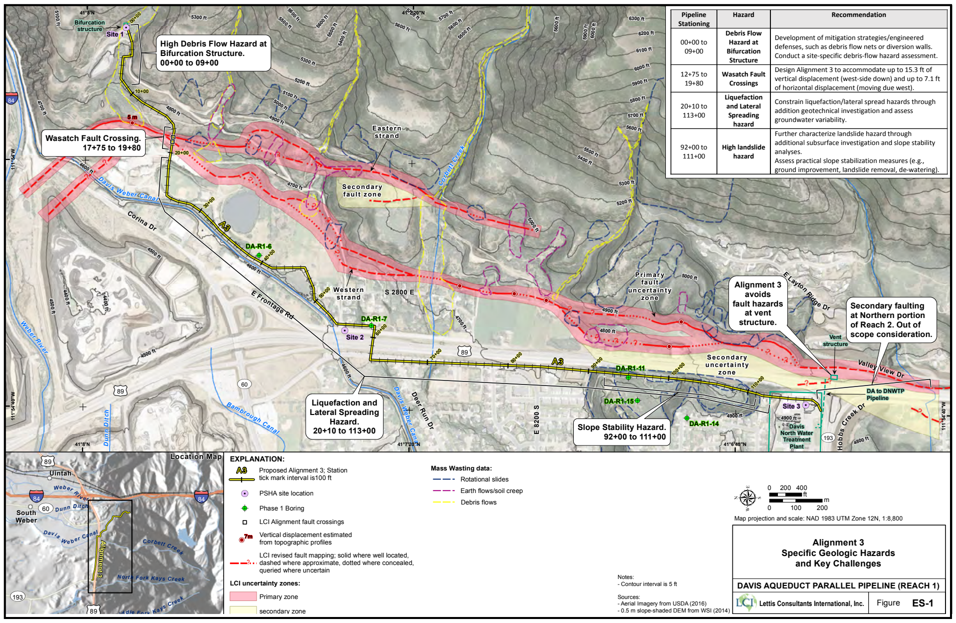


The Alpine Aqueduct (purple) crosses faults (red) in multiple locations as well as a known landslide area.



The Alpine Aqueduct serves over one million people in both Salt Lake and Utah counties.

DAVIS AQUEDUCT REDUNDANT PIPELINE | WEBER BASIN WATER CONSERVANCY DISTRICT



The Davis Aqueduct cross the fault in multiple locations as well as a known landslide area.

One of the primary water sources in northern Utah is the Weber River. A diversion off this river directs water through a tunnel known as the Gateway Tunnel. After the outlet of the tunnel, a bifurcation structure directs water north through the Weber Aqueduct and south through the Davis Aqueduct. The Davis and Weber Aqueducts provide raw water for agriculture and culinary water **used by approximately 621,000** people along the Wasatch Front.

The Davis Aqueduct is highly vulnerable to seismic and other geologic hazards. If the Davis Aqueduct were ruptured, the entire system, including the Weber Aqueduct, would have to be shut down at the bifurcation structure because splash-over within the bifurcation structure would allow water to flow into the damaged Davis Aqueduct. As a result, water supply to the entire population of 621,000 would be disrupted.

Due to the age, size, and complexity of installation associated with the aqueduct, as well as the anticipated damage from an earthquake, significant spare parts are not readily available. The ultimate downtime associated with aqueduct failure is difficult to determine as there are multiple factors impacting repair, such as the extent of damage to the aqueduct, labor availability, potential flooding or other degradation of access to the aqueduct, and material availability in Utah. It is reasonable to assume that the downtime could easily exceed six months.

The Weber Basin Water Conservancy District has studied the construction of a parallel aqueduct project in Davis County. This project consists of the construction of a parallel water aqueduct and associated appurtenances to increase seismic and geologic hazard resilience of the overall Davis Aqueduct system. The parallel aqueduct would include 12,000 feet of steel piping, beginning near the bifurcation structure and continuing west and south to the Davis North Water Treatment Plant. The total estimated cost of this project is $80 million, which includes construction and engineering costs. The project was awarded a FEMA grant to support construction and the Weber Basin Water Conservancy District is asking for $30 million in project support from the Utah Legislature.

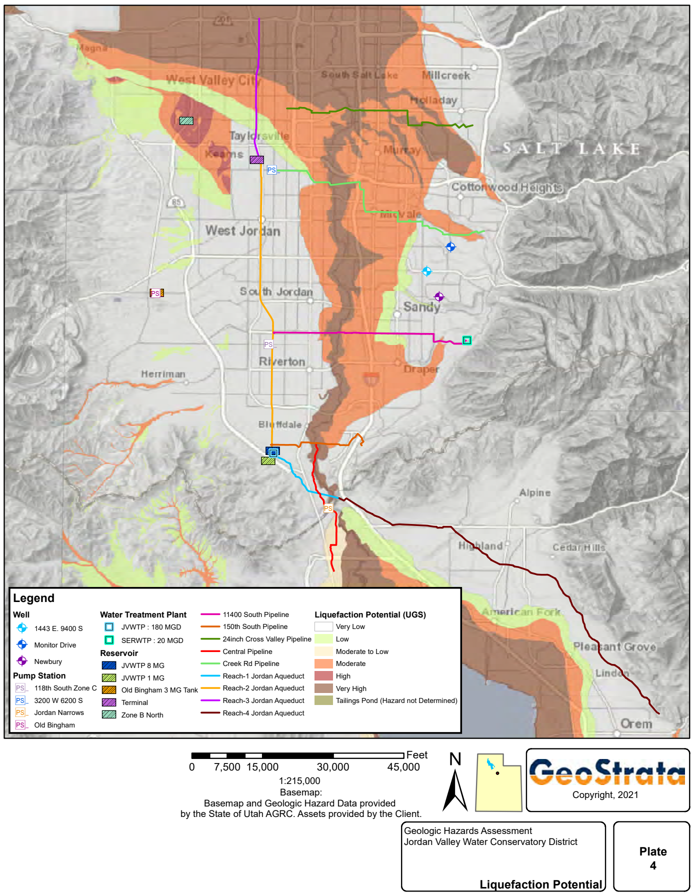
SALT LAKE AQUEDUCT HARDENING | METROPOLITAN WATER DISTRICT OF SALT LAKE AND SANDY

The Salt Lake Aqueduct is a 42-mile, mostly reinforced concrete pipe that begins at the base of Deer Creek Dam in Wasatch County, runs through Utah County, and terminates in Salt Lake County near the mouth of Parleys Canyon. The pipeline, which **serves around 450,000 people**, was built in the 1940s and has several segments that are subject to earthquake damage where they cross the Wasatch fault. A recent risk assessment identified a high risk of joint failure during an earthquake due to ground deformation and ground shaking. Failed joints on an active aqueduct pose a secondary risk of landslides caused by saturated soils and flooding with the aqueduct location along the bench areas in Utah and Salt Lake Counties.

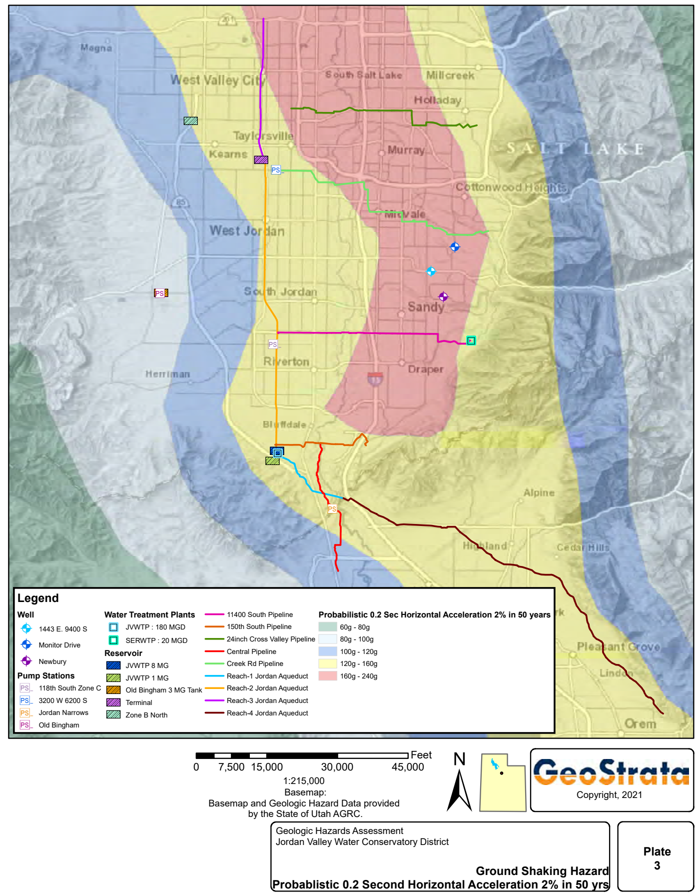
The risk assessment identified four segments in Pleasant Grove, Cedar Hills, Draper, and Cottonwood Heights as being the most critical. Mitigation for these four segments is expected to cost $160.4 million. The Metropolitan Water District of Salt Lake and Sandy is requesting $85.1 million from the Utah Legislature to support this project. The economic benefit is approximately $203M per segment at a cost-benefit ratio of 5.5 to 10. Currently, construction for one segment is set to begin in 2041, and the other three are scheduled to begin construction in 2045.

JORDAN AQUEDUCT REACHES 1-4 | JORDAN VALLEY WATER CONSERVANCY DISTRICT

While the Jordan Aqueduct Reaches 1-4 does not cross major fault lines like the three aqueducts above, it is located in a predicted high ground shaking and liquefaction potential area. **The aqueduct serves drinking water to over one million people.** Most of the Jordan Aqueduct Reaches 1-4 is steel pipe with unrestrained joints. These unrestrained joints have a high potential to separate when subjected to high ground acceleration and/or liquefaction. Repair of a large number of separated joints would likely take at least two to three months. Welding or otherwise restraining the joints in high vulnerability areas could prevent separation. Hardening pipe joints is estimated to cost $75 million. The Jordan Valley Water Conservancy District is asking for $37.5 million in legislative assistance to implement the project.



The Jordan Aqueduct has multiple segments that pass through liquefaction zones, which will likely displace the pipeline.



The Jordan Aqueduct has multiple segments that pass through ground acceleration zones. A large earthquake could damage and seperate the pipeline.

Improving the seismic resilience of these aqueducts will not guarantee that a Wasatch Front resident will have water service shortly after an earthquake. An earthquake could damage treatment or distribution infrastructure, the connection from a house to the distribution line in the street, and/or sewage transport and treatment facilities. However, these projects will substantially increase the likelihood that water is in the system and potentially available nearby for each resident. The projects will also significantly reduce the timeline for restoring full water service.

Reduce Risk of URM Schools

Many of Utah's schools are URMs. **The State of Utah published a statewide inventory of unreinforced masonry construction in public K-12 schools.[10] Findings from the inventory suggest that at least 130 school campuses include URMs where at least 72,000 Utah children spend all or part of their school hours.** Some school districts have been very proactive at renovating or replacing URMs over the years, but many remain. It's essential to continue to retrofit or rebuild the remaining buildings. If a large magnitude earthquake were to occur during school hours, tens of thousands of Utah school children would be at risk of death or serious injury in government-owned buildings. The moderate M 5.7 Magna earthquake caused significant damage to Westlake Junior High School, a partial URM building. Students and staff would have likely been injured or killed if students had been in school. An M 7 earthquake would release approximately 100 times as much energy as the Magna event and be far more devastating to the many schools with similar vulnerabilities.

West High School is a URM school that was retrofitted in 1996.

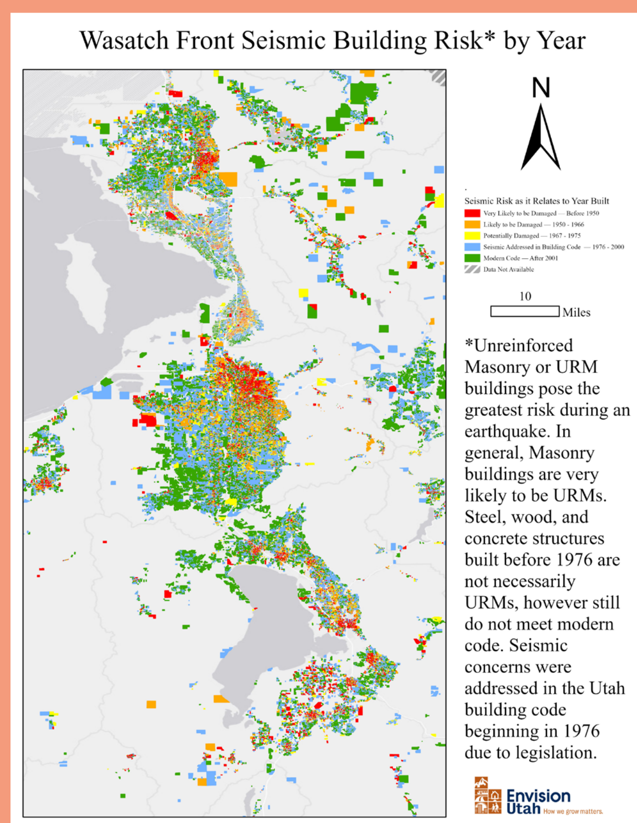
In addition to protecting Utah's students, teachers, and staff, addressing URM school buildings is important for recovery from our disaster. For these schools to function as emergency shelters or gathering places during and after a disaster, they need to withstand the disaster itself. Moreover, disruption of this key education infrastructure could have extensive economic consequences; The sooner schools can reopen, the sooner parents can go back to work, the sooner our economy can recover, and the sooner society can go back to normal.

URMs: UTAH'S MOST VULNERABLE BUILDINGS

In Utah, unreinforced masonry buildings (URMs) pose the greatest risk to life in the event of a major earthquake. These are buildings constructed of brick or block without reinforcing steel, which makes them extremely susceptible to damage from earthquake ground shaking.

While Utah's adopted building codes have not allowed this kind of construction since 1976, it has been estimated that more than 140,000 URMs are still standing today,[11] including single family homes, apartment buildings, schools, and offices—far more than in the entire state of California. URMs make up roughly 20% of our occupied buildings.

URMs will be the primary source of deaths and injuries from a major earthquake. Further, these buildings will likely be uninhabitable and unusable after the earthquake, and many will require complete reconstruction or demolition. After the 2011 Christchurch earthquake and aftershocks, tens of thousands of buildings were unsafe to reenter, and many of them were eventually demolished.



10. Utah K-12 Public Schools Unreinforced Masonry Inventory
11. Wasatch Front Unreinforced Masonry Risk Reduction Strategy

FEMA, the State of Utah, and many other stakeholders collaborated to create the Wasatch Front Unreinforced Masonry Risk Reduction Strategy, which identifies mitigation strategies that would greatly reduce the URM risk in Utah. The strategy highlights five key recommendations to reduce URM seismic risk — the first priority being a URM School Risk Reduction Program. A national goal supported by the Earthquake Engineering Research Institute is for schools to be URM free by 2033.

Since the release of the strategy document in March 2021, the Utah Division of Emergency Management (DEM) has undertaken the first step in the URM School Risk Reduction Program, an inventory of Utah public K-12 schools, continuing previous inventory work funded in 2015 by the Utah Legislature. Due to DEM and FEMA funding, the statewide inventory of URM school buildings is complete. To continue moving this effort forward, the USSC recommends that the Legislature provide financial assistance to local education agencies (LEAs) to conduct feasibility studies for retrofitting or replacing URM buildings. This could be done by allocating $4 million to LEAs for multidisciplinary feasibility studies, including a detailed seismic evaluation, for each of the 130 school campuses with URMs. The $4 million would be distributed as follows:

- $20,000 per elementary school campus, 88 in total
- $30,000 per middle school campus, 22 in total
- $50,000 per high school campus, 22 in total

Qualifying feasibility studies should include an analysis of the educational program; a seismic evaluation (ASCE 41 Tier 1 or ASCE 41 Tier 1 and 3); proposed retrofit schemes; and mechanical, electrical, and plumbing evaluations by licensed architects and engineers sufficient to generate a cost estimate. This feasibility study funding would enable LEAs to examine at-risk schools and develop cost estimates for replacing these structures or retrofitting them to modern seismic safety standards.

For those districts who have already conducted such an evaluation, the allocated money could be used for contracting with a grant writer to seek design and construction money, or alternatively could be applied to design costs.

Studying these schools should not increase any risk of liability, because Utah Code specifies that conducting a seismic safety evaluation of a school does not affect a school district's potential liability.[12]

West Lake Junior High suffered extensive damage during the Magna 5.7 earthquake of 2020. If remote learning due to the COVID-19 pandemic had not kept students home, it's likely that this damage would have caused injuries or even death.

12. Utah Code § 53G-4-608

Increase Public Awareness of Risks

Even though Utah's 140,000 URMs are scattered throughout our historic pioneer communities, public awareness of the risk is low. Many people live or work in these buildings but do not understand their vulnerability. As a result, few upgrades happen, and the market does not adequately take seismic soundness into account when setting prices or evaluating risk.

Salt Lake City's "Fix the Bricks" program is leveraging federal grant money to fund upgrades to single-family homes. There is currently a long waiting list for grants, and the program is seeking to affect 200 homes per year. Given the estimate that there are 140,000 URMs in Utah, at this rate it will take 700 years to complete them all. Currently this popular program does not extend to the majority of the URM homes that are located outside Salt Lake City. For this reason, DEM sought and received federal funding to conduct a feasibility study for a statewide program. This study points to key considerations that could inform creation of a statewide grant program, but there is no need to wait for the creation of such a program to begin increasing awareness.

Ensuring the market functions appropriately with respect to seismic risk requires increased public awareness. With increased awareness, more Utahns will voluntarily improve or rebuild their homes, ask realtors and sellers whether a home being sold is a URM, request upgrades during a transaction, and put pressure on landlords.

The USSC proposes a public awareness campaign in order to (1) help Utah residents better appreciate Utah's earthquake risk and understand the need for greater risk mitigation, (2) educate Utahns about URMs and their risk, and (3) motivate individuals to take measures to retrofit their URMs. This campaign would include the following:

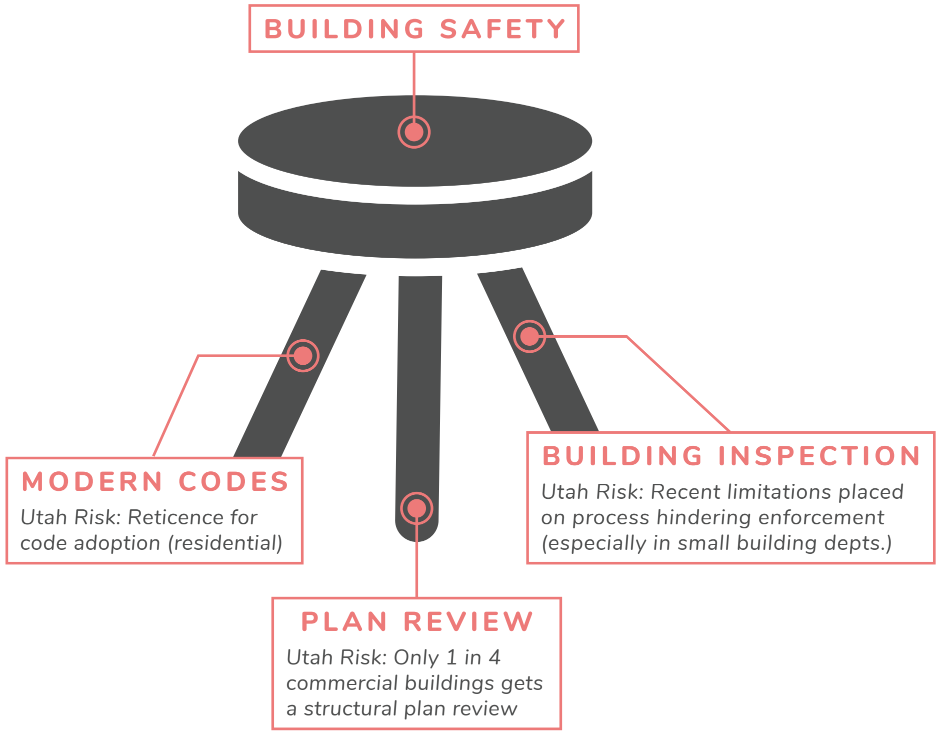
- Creating a website where Utahns can find information about URMs. The website will help people understand the risks from URMs, identify whether their home is a URM, and connect to resources for upgrading seismic resilience.
- Creating videos, pamphlets, and other assets that can be used to educate Utahns and invite them to visit the website.
- Running a public awareness campaign utilizing the assets that have been created. Much of the campaign would likely utilize digital advertising that targets residents in areas with older construction or who are searching for information about refinancing or remodeling. Flyers could be distributed to residents who are seeking remodeling permits. Postcards could be mailed to residents of homes built prior to 1976.

The total cost of this campaign over the next two years is estimated to be $600,000.

Ensure Seismic Structural Plan Reviews for Utah's Largest and Most Important Buildings

Due to Utah's rapid population and economic growth, almost half of the buildings that will exist in 2060 have not yet been built,[13] and many of our existing buildings will be rebuilt in that same timeframe. Ensuring these new buildings quickly return to functionality following a large magnitude earthquake is key to keeping Utahns in their homes, at their jobs, and continuing life as normal. Utah's building code is an important tool, requiring that seismic protection be incorporated into building design and construction.

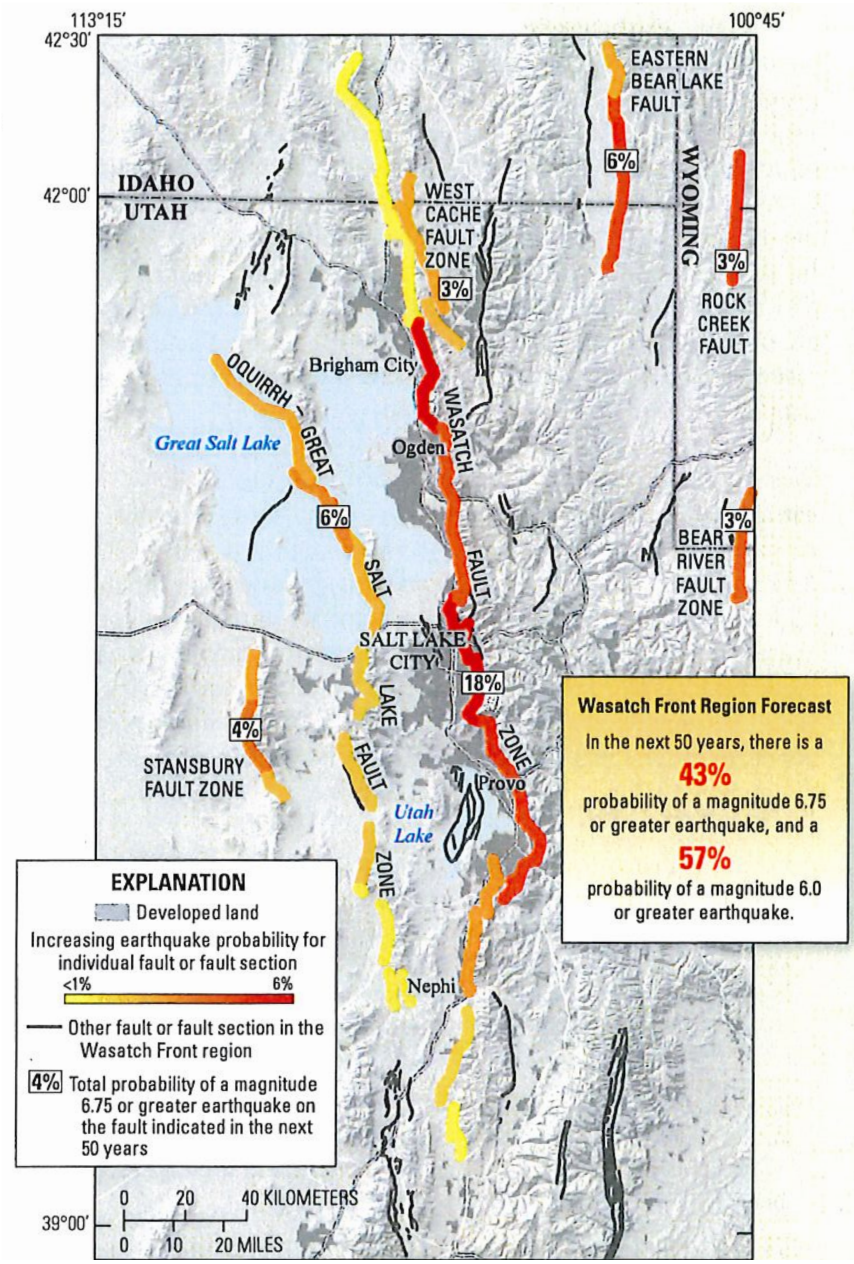
Ensuring building seismic safety is like a three-legged stool. One leg is adoption of comprehensive building codes, the second is quality structural plan reviews, and the third is building inspection. Without all three legs, seismic resilience is not guaranteed in our communities.



While it is essential for building codes to have appropriate standards, when plans are not adequately reviewed or buildings are not appropriately inspected, many buildings can still be unsafe, as was seen with the recent Surfside condominium tower collapse in Florida. Plan reviews and inspections are particularly important for larger, more complex structures, yet the Structural Engineers Association of Utah (SEAU) has estimated that only 1 in 4 of the commercial buildings in Utah receive a structural plan review from a qualified reviewer.[14]

New construction provides an opportunity to build resilient communities in Utah.

13. Your Utah, Your Future Disaster Resilience Vision
14. Survey by the Structural Engineers of Utah (SEAU) Seismic Committee in 2012.



Magnitude 6.75 or greater earthquake probabilities may vary along faults (yellow to red fault colors), but entire fault probabilities are labeled. For example, the total probability for the entire Wasatch fault is 18 percent. Only faults with a probability of 2 percent or greater are shown. Modified from Working Group on Utah Earthquake Probabilities, 2016.

FEMA takes Utah's adopted building codes and enforcement into account when evaluating Utah grant requests. In other words, Utah's ability to access millions of dollars in federal funding for disaster mitigation depends on ensuring codes are up to date and enforced. The State of Utah regularly reports on the status of code adoption and building inspection to determine our eligibility. As a result, adopting and enforcing the latest version of the International Building Code (IBC) is important to obtaining federal grants.

Currently, many buildings undergo plan reviews for fire, egress, and other life safety measures, but structural engineering reviews are often neglected or performed by individuals without sufficient technical knowledge of structural seismic codes. It is more likely that many buildings could underperform during and after a major earthquake—particularly larger, more complex buildings.

The IBC assigns risk categories to buildings based on the consequences and risks in the event of building failure. The intent is to assign higher risk categories, and hence higher design criteria, to buildings or structures that provide essential community services necessary to cope with an emergency situation or that have grave consequences to either the building occupants or the population around the building in the event of a structural failure.

The highest risk categories—Categories III and IV—include buildings occupied by large numbers of people, police stations, schools, hospitals, and utility infrastructure like power stations. Because of the importance of these buildings, as well as their structural complexity, the USSC recommends plan reviews be required to be conducted by a Utah-licensed Professional Structural Engineer for structures classified as Risk Categories III and IV and buildings occupied by people that are greater than 200,000 gross square feet.[15]

People in our communities expect to be safe in their homes, schools, and places of business. Only by ensuring that new construction meets the standards of modern building codes, through plan review and building inspection, can we meet this expectation and ensure that we make a full economic recovery after a seismic disaster.

15. These guidelines are a rough approximation of the boundary used by the Professional Engineers and Professional Land Surveyors Licensing Act. Ut Code 58-22-102 (14)

Provide Utah with an Earthquake Early Warning System

The Utah Legislature, in the 2022 General Session, appropriated funding to study the feasibility of implementing an earthquake early warning (EEW) system in Utah. Funding was provided to the three primary agencies in the Utah Earthquake Program—the Utah Division of Emergency Management (UDEM), the Utah Geological Survey (UGS), and the University of Utah Seismograph Stations (UUSS). The study consisted of four main activities: reviewing the history and development of EEW systems within the U.S. and around the world; assessing the potential performance of an EEW system in Utah; determining what enhancements to the existing Utah seismic network would be needed to implement an EEW system; and conducting an online survey of Utah stakeholders to assess their knowledge of and potential interest in an EEW system.

The premise of EEW is that the initial, fast-moving "primary waves" of a large earthquake can be detected, and used to characterize the earthquake and send an alert before the slower, more damaging "secondary waves" arrive at a given location. After a significant earthquake occurs, an EEW system can provide seconds to tens of seconds of warning before the onset of strong ground shaking. This time window, although brief, allows for actions that can reduce the shaking impact—trains can be slowed or stopped, safety controls at critical facilities can be activated, students can take cover under desks, elevators can stop at the nearest floor, generators can be activated at hospitals, and so on.[16] Thus, EEW systems have become increasingly popular in the U.S. and around the world, both in areas that routinely experience large earthquakes, such as California and Japan, and in areas where large earthquakes are less common, such as in Oregon and South Korea.

HOW EARLY EARTHQUAKE WARNING WORKS

1. When a fault ruptures and creates an earthquake, the fault sends out different types of seismic waves. The fast-moving, but less damaging, P-wave is the first to arrive. This wave is used to issue a warning before the slower but more damaging waves (S-wave and surface) arrive.
2. Sensors detect P-waves and immediately transmit data to an earthquake alert center.
3. The location, size, and estimated shaking of the earthquake are determined at the earthquake alert center.
4. A message is sent to partners, such as transportation agencies, emergency facilities, and hospitals, to alert people to Drop, Cover, and Hold On as well as trigger automated actions, such as shutting down a train or halting industrial processes.

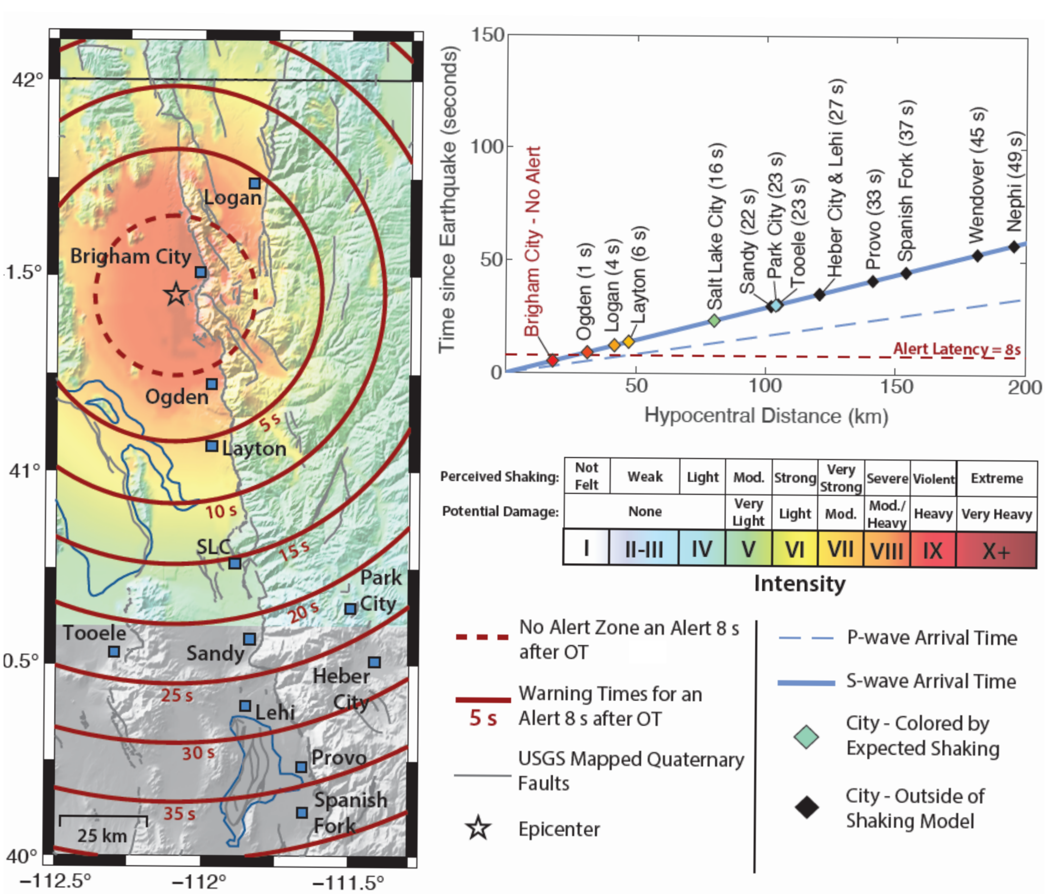
Possible scenario for implementing an earthquake early warning system in Utah. An earthquake on the Brigham City segment of the Wasatch fault may give populated areas to the south 10 or more seconds to prepare.

16. ShakeAlert® Earthquake Early Warning System and Warning Times

In partnership with the U.S. Geological Survey (USGS), the UUSS maintains a network of over 200 seismograph stations throughout the state. These instruments record ground motion as small as 1 nanometer up to one hundred times per second. Seismologists use these data to detect and locate about 1,500 earthquakes per year. The UUSS processing system currently generates alerts and notifications to stakeholders and the public. This system, however, was not designed as an EEW system and the notifications are generally distributed within a few minutes of the earthquake origin time, much slower than the few seconds needed for EEW. Significant enhancements to the existing Utah seismic network are required to operate an effective EEW system in Utah.

An EEW system can provide a brief time window of seconds to tens of seconds to take actions such as slowing trains, activating safety controls, and more to reduce the impact of strong ground shaking.

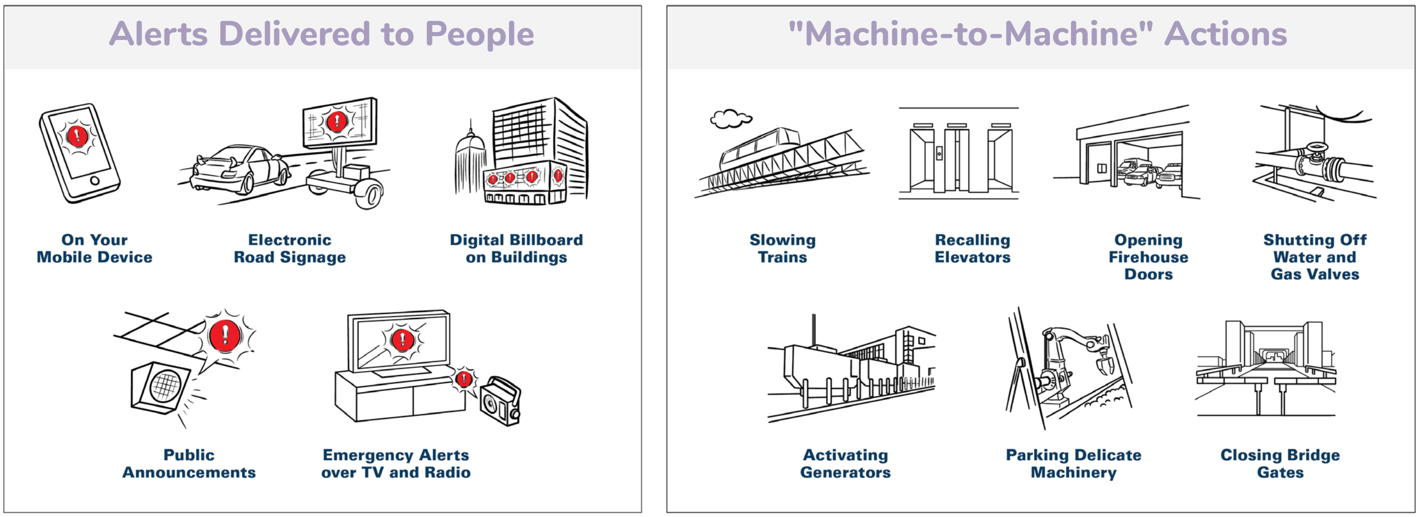
The primary recommendation of the study is that the State of Utah should pursue a partnership with the USGS to expand the ShakeAlert EEW system to the region around the Wasatch fault zone. ShakeAlert currently operates in California, Oregon, and Washington. Implementing ShakeAlert in Utah would leverage the tens of millions of dollars that have been invested in technical development and allow for formal cost-sharing with the federal government; however, this would require federal legislative support. Based on historical data, shaking alerts would likely be issued relatively infrequently, perhaps once every two years along the Wasatch Front, potentially providing up to 15–30 seconds of warning in advance of noticeable ground shaking and up to 5–15 seconds of warning in advance of strong ground shaking, depending on where the earthquake occurred. Owing to the proximity of Utah's population centers to the major fault systems, there will always be areas that are too close to the earthquake epicenter—where the maximum shaking and damage will occur—to receive an alert before the damaging waves pass. The primary utility of an EEW system in Utah would be in automated actions that could be performed with a few seconds of warning and alerting population centers outside of the maximum shaking area, but where strong shaking is still expected. For example, if the Brigham City segment of the Wasatch fault system were to rupture in an M 7.0 earthquake, Brigham City would experience the strongest shaking but is too close to receive an alert. Outside of this zone, Ogden, Logan, Layton, and Salt Lake City are expected to experience moderate to severe shaking and could receive 1, 4, 6, and 16 seconds of warning, respectively.



This map and a plot of the warning times with distance from the earthquake.

These cities and others outside of the no-alert zone could implement automated and personal protective actions ahead of the damaging waves.

The stakeholder survey suggested that while many respondents saw the value in automated EEW actions, few had a previous or good understanding of EEW and there were concerns regarding false alarms and the need for education. Therefore, EEW system buildout should be accompanied by working with private and state organizations to develop implementation plans. On the West Coast, ShakeAlert is used to automatically slow or stop Southern California Metrolink trains to prevent injury, derailment, and infrastructure damage, to alert staff and patients via public address system and radio in Cedars-Sinai Medical Center, and to automatically close water system valves in the City of Grants Pass to prevent water loss if a pipe is damaged, among many other examples.[17]



Examples of automated actions powered by ShakeAlert®

Importantly, the existing seismic network along the Wasatch Front is near the density required for the ShakeAlert system to function reliably. Relatively few new seismograph stations would need to be installed and many existing stations could be upgraded to develop a prototype ShakeAlert system. In this scenario, upgrade costs would primarily involve improving the speed and robustness of the telemetry systems used to transmit the data from the individual seismograph stations to the processing hub at the University of Utah. Establishing a partnership with the USGS ShakeAlert project would allow Utah to leverage the existing ShakeAlert knowledge base in terms of data flow, cybersecurity, and sociological studies on how best to engage the public so that effective action is taken once an alert is received.

In many cases, seismic risk in Utah is best reduced by either retrofitting or replacing old, vulnerable structures, such as unreinforced masonry buildings, and other infrastructure. Given how common these structures are in Utah, with over 140,000 unreinforced masonry buildings along the Wasatch Front alone, this process will be both expensive (tens of billions of dollars) and time-consuming (decades). Implementation of an EEW system in Utah represents an opportunity to work in parallel with these efforts and reduce the seismic risk in Utah in a shorter time frame, while the building stock and infrastructure are gradually retrofitted or replaced. An EEW system will not negate the need for infrastructure upgrades and URM retrofit/replacement, and vice versa; retrofit and replacement will not negate the usefulness of EEW. Most earthquake-related injuries and casualties result from people falling and objects falling on people. Warning for people to get under a sturdy table or desk before shaking starts can help protect from structural failures in URMs but also injury from unsecured objects and furniture in well-built structures.[18] Automated actions to shut off utilities in conjunction with more resilient infrastructure can help the state recover more quickly. With appropriate funding, the study anticipates that a fully functional EEW system could be operational along the Wasatch Front by 2030, with capitalization costs near $5 million and annual costs for operations and maintenance near $1 million. By adopting the ShakeAlert framework, both costs could be shared under a state-federal partnership with the USGS. The system can later be expanded statewide.

17. https://www.shakealert.org/education-and-outreach/case-studies/

18. https://www.shakeout.org/