



2019 UTAH EARTHQUAKE WORKING GROUP MEETINGS UTAH QUATERNARY FAULT PARAMETERS WORKING GROUP SUMMARY

Tuesday, February 5, 2019

Utah Department of Natural Resources Building, Auditorium (1st Floor)
1594 West North Temple, Salt Lake City, Utah

WELCOME AND INTRODUCTION

Emily Kleber (Utah Geological Survey [UGS]) called the 2019 Utah Quaternary Fault Parameters Working Group (UQFPWG) meeting to order at 8:30 a.m. After welcoming Working Group members and guests, she summarized the UQFPWG's past activities and outlined the Working Group's purpose and goals for the future.

UQFPWG Purpose and Goals

- Serves as one of three standing committees created to help set and coordinate Utah's earthquake-hazard research agenda.
- Reviews ongoing paleoseismic research in Utah and updates the Utah consensus slip-rate and recurrence-interval database as necessary.
- Provides advice/insight regarding technical issues related to fault behavior in Utah and the Basin and Range Province.
- Identifies and prioritizes future Utah Quaternary fault paleoseismic investigations.

U.S. Geological Survey Update

Ryan Gold, Intermountain West Coordinator for the USGS Earthquake Hazards Program, gave a summary and status of the External Research Support function, and information on the upcoming 2020 funding announcement for proposals.

TECHNICAL PRESENTATIONS

The following presentations were made on current paleoseismic research and related activities in Utah (most presentations are available at

https://geology.utah.gov/docs/pdf/2019_UQFPWG_presentations.pdf):

- West Cache and Great Salt Lake Fault Zones: Suzanne Janecke, Utah State University
- Paleoseismic Investigation of the Levan and Fayette Segments of the Wasatch Fault Zone, Utah: Adam Hiscock, Greg McDonald, and Mike Hylland, Utah Geological Survey

- Detailed Mapping of the Wasatch Fault Zone, Utah and Idaho, Using High-Resolution Lidar Elevation Data: Greg McDonald, Adam Hiscock, and Emily Kleber, Utah Geological Survey
- Enigmatic Intrabasin Faults in Parowan Valley, Southwestern Utah: Tyler Knudsen, Utah Geological Survey
- Update of Ongoing Studies to Evaluate the Seismic Potential of the Joes Valley Fault Zone, East-Central Utah: Lucy Piety, U.S. Bureau of Reclamation
- Seismic Land Streamer Results Highlight Earthquake Risks for the Salt Lake City Urban Center: Lee Liberty, Boise State University
- Normal Faults in Northeastern Salt Lake Valley — New Faults and New Names: Adam McKean, Utah Geological Survey
- New Insights on Faults of the Salt Lake Salient: Zachary Anderson, Utah Geological Survey
- Update on U.S. Geological Survey Wasatch Fault Research: Chris DuRoss, U.S. Geological Survey
- Lidar Mapping of the Wasatch Fault Zone and Integration into the Utah Quaternary Fault Database: Emily Kleber, Greg McDonald, and Adam Hiscock, Utah Geological Survey

Technical Presentations of Work Completed or In Progress — Posters

- Zachary Anderson, Utah Geological Survey
 - New Insights on the Structural and Basin Evolution of the Salt Lake Salient and Wasatch Fault Zone Near Salt Lake City, Utah
- Mike Bunds, Utah Valley University
 - Three Dimensional Aseismic Creep Deformation from Differencing of Structure from Motion and LiDAR High Resolution Topography on the San Andreas Fault, California
- Chris DuRoss, U.S. Geological Survey
 - Using Relative Structural Complexity of Fault Segment Barriers to Model Prehistoric Earthquake Rupture Histories
- Adam Hiscock, Utah Geological Survey
 - Paleoseismic Investigation of the Levan and Fayette Segments of the Wasatch Fault Zone, Utah
- Emily Kleber, Utah Geological Survey
 - Preliminary Assessment of Quaternary Faulting Based on High Resolution Topographic Data Near the FORGE Geothermal Site, Mineral Mountains, Utah
- Joel Pederson, Utah State University
 - New Mapping and Terrace Chronology in Moab, Utah Establishes Fault Slip and Subsidence Rates Due to Late Quaternary Salt Deformation

TECHNICAL DISCUSSION ITEMS

Emily Kleber led a discussion addressing issues or topics of interest that were brought up throughout the morning and afternoon sessions. The topics, discussed below in more detail, include salt tectonics and Joes Valley, lidar and surface fault rupture, and the Rudys Flat fault.

At the 2019 meeting, preliminary results were presented by the U.S. Bureau of Reclamation (USBR) from several paleoseismic investigations on the Joes Valley fault zone. The USBR has spent substantial time and effort investigating the seismic history of faults in the Joes Valley area in order to assess the risk to USBR infrastructure in the area. The group discussed the implications of having salt at depth (Arapien Shale) and what that may mean for determining if the Joes Valley area faults have abrupt rupture driven by salt, or tectonic rupture driven by crustal forces. After discussing what salt deformation “looks like,” citing the Moab-Spanish Valley as “textbook” salt tectonics (i.e., salt anticline collapse, and diapirism), the group agreed that Joes Valley is likely not a solely salt-driven system and that the role of salt is not easily determined. The USBR emphasized that the goal of their study is to understand the risk, not the mechanism.

Ivan Wong asked how geophysically located faults beneath Salt Lake City will be addressed for future surface fault rupture investigations. Lee Liberty’s recent work locating the extent of basin faults using seismic imaging indicates that there is a previously unidentified risk of surface fault rupture from faults that have no geologic evidence of surface rupture. The group expressed interest in better understanding the geologic context for fault-offset deposits recognized in Liberty’s work. Steve Bartlett of the University of Utah previously collected CPT (cone penetration test, 2004–2007) data on profiles in a similar area as Liberty’s work. This data may help identify the age of sediments offset by faults identified in Liberty’s work. The group agreed that there should be more data collected to better understand the geologic context of offset deposits from Liberty’s studies. Ivan implored the UGS to set criteria for better understanding of these faults, similar to criteria in UGS Circular 122.

The group also discussed a presentation from Zach Anderson (UGS) who is currently mapping the Fort Douglas quadrangle. This quadrangle includes the Rudys Flat fault (Utah Quaternary Fault and Fold Database, 2019). In Anderson’s mapping and presentation (see 2019 presentations), he cites a lack of geologic evidence for Quaternary movement of the Rudys Flat fault and suggested that it be removed from the database. The group agreed with Anderson’s evidence, and agreed to remove it from the *Utah Quaternary Fault and Fold Database*, effective in 2019.

UQFPWG 2020 FAULT INVESTIGATION PRIORITIES

The Working Group’s list of highest priority fault investigations for 2020 includes (not in priority order) (table 1):

- Acquire new paleoseismic information to address data gaps for the northern segments of the Wasatch fault zone (Clarkston Mountain, Collinston, and Malad City).
- Use recently acquired lidar data to more accurately map the traces of the
 - East and West Bear Lake fault zones (funded March 2019),
 - Morgan fault,
 - Oquirrh fault zone (funded March 2019),
 - Hurricane fault zone, and
 - additional fault zones discussed: Hansel Valley, Bear River, Stansbury, Gunnison, Sevier/Toroweap, Mineral Mountains West, Beaver Basin, Crater Bench/Drum Mountain, Scipio, and Little Valley.

This does not include other priorities that have carried over from previous years. Those are identified in Table 2.

WORKING GROUP PRODUCTS AND RELATED DATA

The final agenda, speaker presentations, and this summary document are available on the UQFPWG web page at <https://geology.utah.gov/hazards/earthquakes-faults/utah-earthquake-working-groups/quaternaly-fault-parameters/>. Paleoseismic investigations that developed out of the UQFPWG meetings and published by the UGS are available in the *Paleoseismology of Utah* series at <https://geology.utah.gov/hazards/technical-information/paleoseismology-of-utah-series/>. Most of the USGS NEHRP funded investigations for Utah that were not published by the UGS are compiled in UGS Miscellaneous Publication 13-03 (https://ugspub.nr.utah.gov/publications/misc_pubs/mp-13-3/mp13-03.pdf).

Utah Quaternary Fault and Fold Database

The UGS updated the *Utah Quaternary Fault and Fold Database* in January 2019, incorporating new mapping and fault attributes. Ongoing updates are being reviewed by the UGS for Quaternary faults mapped in peer-reviewed publications from 2013 to 2018. Users of any Quaternary fault trace and related data acquired from the UGS or the Utah Automated Geographic Reference Center (AGRC) State Geographic Information Database (SGID) in the past are advised to use the updated database available from the AGRC SGID (<https://gis.utah.gov/data/geoscience/quaternaly-faults/>). This single, comprehensive feature class will be periodically updated as new and/or updated data become available and replaces the six previously available feature classes of variable completeness. A web mapping application for the database is available at <https://geology.utah.gov/resources/data-databases/qfaults/>.

Utah Lidar Elevation Data Availability

A significant coverage of high-resolution (≤ 1 meter) lidar elevation data in the state of Utah is now available totaling over 6846 square miles (mi^2) from AGRC (<https://gis.utah.gov/data/elevation-terrain-data/>) and OpenTopography (<http://opentopography.org>). UGS and AGRC led partnerships of multiple, diverse local, state, and federal agencies, and non-governmental organizations have been instrumental in acquiring new, high-quality public domain lidar data. Figure 1 shows the existing and planned lidar data available in Utah. An additional 14,452 mi^2 was acquired in 2018, with a final release in mid-2019. For major Quaternary faults, data are now available for the East and West Cache, Hurricane, Wasatch, and West Valley fault zones. The UGS is currently using these data to map fault traces of the East and West Cache fault zones (USGS G17AP00071, report due September 2019) at scales of 1:10,000, where possible, or 1:24,000, where the ground surface has been significantly disturbed by urbanization and other activities. Data will soon be available for the East and West Bear Lake, Oquirrh, and Sevier fault zones. The mapping is used to define Special Study Zones around fault traces, where paleoseismic investigations are highly recommended by the UGS for new development (see Lund and others, 2016, *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah*, UGS Circular 122, pages 33 to 58, <https://ugspub.nr.utah.gov/publications/circular/c-122.pdf>).

MEETING ATTENDANCE
Working Group Members (* Speaker)

Steve Bowman	Utah Geological Survey
Michael Bunds	Utah Valley University
David Dinter	University of Utah, Department of Geology & Geophysics
Chris DuRoss*	U.S. Geological Survey, Earthquake Hazards Program
Ryan Gold*	U.S. Geological Survey, Earthquake Hazards Program, IW Coordinator
Adam Hiscock*	Utah Geological Survey (UQFPWG UGS Liaison)
Michael Hylland	Utah Geological Survey
Susanne Janecke*	Utah State University
Emily Kleber*	Utah Geological Survey (UQFPWG Chair)
William Lund	Utah Geological Survey, Emeritus
Greg McDonald	Utah Geological Survey
Jim Pechmann	University of Utah Seismograph Stations
Ivan Wong	Lettis Consultants International

Guests (* Speaker)

Sofia Agopian	GeoStrata, Inc.
Zack Anderson*	Utah Geological Survey
Kaitlin Askelson	IGES, Inc.
Jack Bloom	Retired
Seth Dee	Nevada Bureau of Mines and Geology
Gordon Douglass	Utah Geological Survey
Pete Doumit	IGES, Inc.
Ben Erickson	Utah Geological Survey
Rich Giraud	Utah Geological Survey
David Glass	IGES
Michael Hansen	RB&G Engineering
Douglas Hawkes	AGEC
Julia Howe	U.S. Bureau of Reclamation
Bill Keach	Utah Geological Survey
Tyler Knudsen	Utah Geological Survey
Rich Koehler	Nevada Bureau of Mines and Geology
Lee Liberty*	Boise State University
Elliott Lips	Great Basin Earth Science
Adam McKean*	Utah Geological Survey
Bob Oakes	Utah State University
Kristine Pankow	University of Utah Seismic Stations
Joel Pederson*	Utah State University
Lucille Piety*	U.S. Bureau of Reclamation
Greg Schlenker	GLS Geoscience
David Simon	Simon Associates
Grant Willis	Utah Geological Survey

History of the Utah Quaternary Fault Parameters Working Group Since 2005

The main goal of the UQFPWG is to characterize hazardous earthquake fault sources in Utah. The working group began in 2003 by developing consensus slip-rate (SR) and recurrence-interval (RI) data for all Utah trenched faults, based on a comprehensive evaluation of paleoseismic-trenching data available at that time for Utah's Quaternary faults, and where the data permitted, assigned consensus preferred RI and vertical SR estimates for the faults and/or fault sections reviewed. Trenching data were available for 33 of Utah's known 211 Quaternary faults/fault sections and related structures.

In 2005, the UQFPWG developed a list of Quaternary faults and fault segments (Lund, 2005, table 2; figure 2) that the working group identified as requiring additional investigation to adequately characterize Utah's earthquake hazard to a minimally acceptable level. Since then, the Working Group has added an additional 12 faults/fault segments to the list: five in 2007; one in 2009; one in 2010; four in 2011; three general recommendations regarding the five central segments of the Wasatch fault zone, fault zone mapping, and acquisition of high-resolution imagery in 2012, 2014, 2015, respectively; one in 2016, plus the relationship of salt tectonics to eight faults or fault zones; and slightly modified the existing list of highest priorities in 2017 and 2018. Table 1 lists the faults and fault segments (earthquake sources) incorporated in the USGS National Seismic Hazard Maps, and/or the UGS Hazus Utah fault database (updated through 2013, UGS Open-File Report 631). Faults not listed may need additional investigation.

Working Group Fault Investigation Priorities Recap from 2018 Meeting

The UQFPWG conducts an annual review of progress made toward investigating the faults and fault segments on the priority list. Based on that review, the Working Group establishes a short list of the highest priority faults and fault segments for future investigation. The list of highest priority faults and fault segments is published on the UGS website (<https://geology.utah.gov/hazards/earthquakes-faults/utah-earthquake-working-groups/>), which is then referenced by the USGS Earthquake Hazards Program in their annual External Research Support (National Earthquake Hazards Reduction Program [NEHRP]) request for proposals.

The Working Group's list of highest priority fault investigations for 2019 included (not in priority order):

- Acquire new paleoseismic information to address data gaps for (a) the five central segments of the Wasatch fault zone (including focusing on the youngest earthquakes [3-5 ka]; large, early Holocene–latest Pleistocene scarps; and secondary faulting [West Valley fault zone and Utah Lake faults and folds]), (b) the northern segment of the Oquirrh fault zone, (c) the Topliff Hills fault, and (d) the East and West Cache fault zones. Examples of paleoseismic data to be acquired include surface rupture extent, earthquake timing, displacement, and fault geometry.
- Use recently acquired lidar data to more accurately map the traces of the East and West Bear Lake, East and West Cache, and Hurricane fault zones, and search for and map previously undiscovered mid-valley Quaternary faults.
- Acquire earthquake timing information for the Utah Lake fault zone to investigate the relation of earthquakes on that fault system to large earthquakes on the adjacent Provo segment of the Wasatch fault zone (coseismic or independent rupture, fault pairs?).

- Acquire high-resolution aerial imagery (lidar, Structure from Motion, etc.), map high-risk (chiefly urban) Utah hazardous faults (including the East and West Bear Lake, East and West Cache, Oquirrh, and Hansel Valley fault zones), and identify new paleoseismic trench sites.
- Acquire and analyze information on salt tectonics and its relation to the Main Canyon fault, Sevier detachment/Drum Mountains fault zone, Bear River fault zone, Spanish Valley (Moab area) faults, Joes Valley fault zone, Levan and Fayette segments of the Wasatch fault zone (in progress), Scipio Valley faults, and the Gunnison fault.

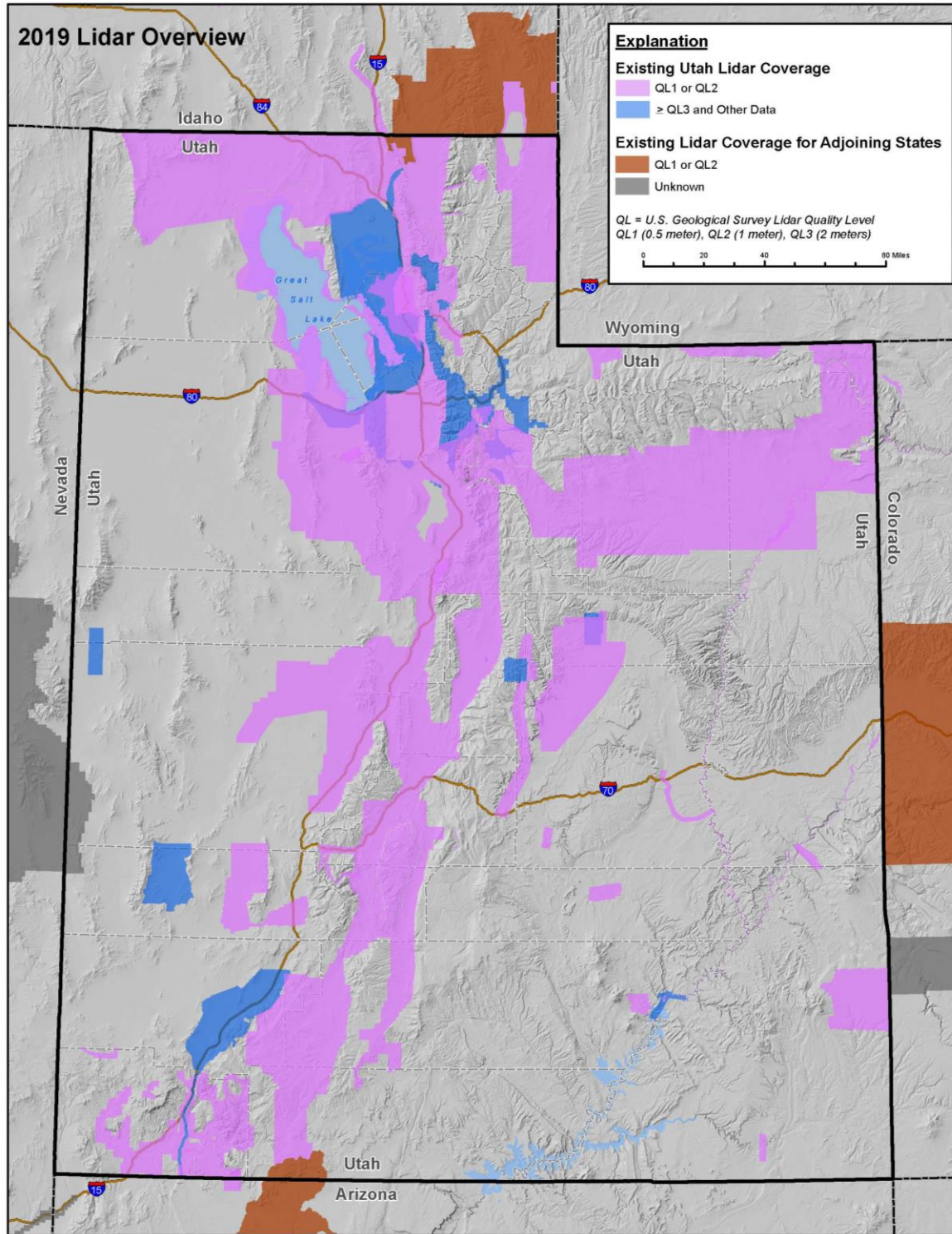


Figure 1. Map of lidar data availability in Utah and the surrounding area.

Table 1. Earthquake sources (faults and fault segments) in the USGS National Seismic Hazard Maps (NSHM) or the UGS Hazus Utah fault database ([UGS Open-File Report 631](#)). These faults may warrant additional investigation.

<i>Utah Fault or Fault Segments</i>	Included In	
	NSHM	Utah Hazus
Beaver Basin intrabasin/eastern margin faults	--	Yes
Crater Bench/Drum Mountains fault zone	--	Yes
Crawford Mountains (west side)	--	Yes
Cricket Mountains fault (west side)	--	Yes
Fish Springs fault	--	Yes
House Range (west side) fault	--	Yes
Joes Valley fault zone	Yes	Yes
Little Valley faults	--	Yes
Malad segment, Wasatch fault zone	--	Yes
Mineral Mountains (west side) faults	--	Yes
North Promontory fault	Yes	Yes
Oquirrh fault zone	--	Yes
Oquirrh-Southern Oquirrh Mountains fault zone	Yes	Yes
Parowan Valley faults	--	Yes
Pavant/Tabernacle/Beaver Ridge/Meadow-Hatton/White Sage Flat faults	--	Yes
Porcupine Mountain faults	--	Yes
Scipio/Pavant Range/Maple Canyon/Red Canyon faults	--	Yes
Skull Valley faults (southern part)	--	Yes
Snake Valley faults	--	Yes
Snow Lake graben	--	Yes
Stansbury fault zone	Yes	Yes
Strawberry fault	Yes	Yes
Wah Wah Mountains (south end)	--	Yes
West Cache fault, Wellsville section	Yes	Yes
Western Bear Lake fault	--	Yes

Table 2. Status of proposed and published paleoseismic-related investigations based on priorities developed by the UQFPWG since 2005. If there are any missing publications, please send the reference to ekleber@utah.gov.

Study Type	Utah Fault or Fault Segment	UQFPWG Priorities		Investigation Status (as of 2/2019)
		2005	Additions	
Earthquake Timing	Nephi segment, Wasatch fault zone	1	2012 2017	UGS FTR Report, 05HQGR0098 (2005) USGS SI Map 2966 (2007) UGS Special Study 124 (2008) UGS FTR Report, G12AP20076 (2014) UGS Special Study 151 (2014) UGS Special Study 159 (2017) UGS FTR, G17AP00001 (2018)
	West Valley fault zone	2	2017	UGS Special Study 149 (2014)
	Granger fault		2011 2017	UGS FTR, G15AP00117 (2017)
	Taylorsville fault			
	Weber segment, Wasatch fault zone – most recent event and multiple events	3 4	2012 2017	UGS Miscellaneous Publication 05-8 (2006) UGS FTR, 07HQGR0093 (2007) UGS Special Study 130 (2009)
	Utah Lake faults and folds	5	2015 2017	UUGG FTR Report, G08AP0016 (2014)
	Acquire earthquake timing information to investigate the relation of earthquakes to large earthquakes on the Provo segment.			
	Great Salt Lake fault zone	6	2007	UUGG FTR Report, G08AP0016 (2014) Janecke and Evans (2017)
	Rozelle section, East Great Salt Lake fault Carrington fault, Great Salt Lake fault zone			
	Collinston and Clarkston Mountain segments, Wasatch fault zone	7	--	UGS Special Study 121 (2007) UGS Open-File Report 638 (2015)
	Sevier and Toroweap faults	8	2016	UGS Special Study 122 (2008)
	Washington fault zone (includes Dutchman Draw fault)	9	--	UGS Open-File Report 583 (2011) UGS Miscellaneous Publication 15-6 (2015)
	Cedar City-Parowan monocline (removed 2016) and Paragonah fault	10	--	UGS Map 270 (2015) 2016 presentation file Paragonah fault, no activity
	Enoch graben	11	--	UGS Open-File Report 628 (2014)
	East Cache fault zone	12	2013	USU FTR Report, 07HQGR0079 (2012)
Clarkston fault	13	--	UGS Special Study 98 (2000) UGS Special Study 121 (2007) UGS Open-File Report 638 (2015) UGS FTR, G17AP00001 (2018)	
Wasatch Range back-valley faults (includes Morgan fault and Main Canyon fault)	14	--	UGS Miscellaneous Publication 11-2 (2011) UGS Miscellaneous Publication 10-5 (2010)	

Study Type	Utah Fault or Fault Segment	UQFPWG Priorities		Investigation Status (as of 2/2019)
		2005	Additions	
Earthquake Timing	Hurricane fault zone	15	--	UGS Special Study 119 (2007)
	Levan segment, Wasatch fault zone	16	--	UGS Map 229 (2008) UGS Open-File Report 640 (2015) G17AP00060 (2017), UGS FTR due Fall 2019
	Gunnison fault	17	--	No activity
	Scipio Valley faults	18	2017	No activity
	Faults beneath Bear Lake	19		No activity
	Eastern Bear Lake fault zone	20	--	No activity
	Provo segment, Wasatch fault zone			
	Penultimate event and long-term earthquake record	--	2007 2011 2012 2017	UGS Map 02-7 (2002) URS FTR Report, 02HQGR0109 (2011) UGS FTR Report, G13AC00165 (2015) Bennett and others, 2018 (BSSA)
	Fort Canyon fault, Traverse Mountains salient	--	2012	UVU FTR, G16AP00104 (2017)
	Brigham City segment, Wasatch fault zone			
	Most recent event and rupture extent	--	2007 2011	UGS Special Study 142, (2012)
	Salt Lake City segment, Wasatch fault zone	--	2009	
	Penrose Drive	--	2012	UGS FTR Report, G10AP00068 (2010) UGS Special Study 149 (2014)
	Corner Canyon site	--	2012	UGS FTR Report, G14AP00057 (2014)
	Bear River fault zone	--	2007	AGU Abstracts: 2012 and 2013
	Acquire new paleoseismic information to address data gaps for the five central segments of the Wasatch fault zone	--	2012	DuRoss and Hylland, 2015 (BSSA) DuRoss and others, 2018 (GRL)
	Topliff Hills fault	--	2016	No activity
Northern Oquirrh fault zone	--	2015 2017	Bunds and others, Poster 1 and Poster 2	
High Resolution Mapping and Paleoseismic Trench	Wasatch and West Valley fault zones	--	2014 2017	UGS Open-File Report 638 (2015) UGS Open-File Report 640 (2015) UGS FTR G17AP00001 (2018)
	Hansel Valley fault zone	--	2011	No activity
	Eastern Bear Lake fault zone	--	2015 2017	UGS (in progress)
	East and West Cache fault zones	--	2015 2017	G17AP00071 awarded 2017, FTR due Fall 2019
	Hurricane fault zone	--	2014 2017	No activity

Study Type	Utah Fault or Fault Segment	UQFPWG Priorities		Investigation Status (as of 2/2019)
		2005	Additions	
	Oquirrh fault zone	--	2015 2017 2018	Bunds and others, Poster 1 , Poster 2 , and Poster 3 , and presentation
Salt Tectonics	Levan and Fayette segments of the Wasatch fault zone	--	2016	G17AP00060 awarded 2017, FTR due May 2019
	Main Canyon fault Sevier detachment/Drum Mountains fault zone Bear River fault zone Spanish Valley (Moab area) Joes Valley fault zone Scipio Valley faults Gunnison fault	--	2016	Lidar data collected in 2018 in vicinity of Bear River fault zone, Scipio Valley fault, and Gunnison fault.
Other	Warm Springs fault/East Bench fault subsurface geometry and connection	--	2010	BSU FTR G15AP00054 (2015) BSU FTR G17AP00052 (2017)