

2018 UTAH EARTHQUAKE WORKING GROUP MEETINGS UTAH QUATERNARY FAULT PARAMETERS WORKING GROUP AGENDA Wednesday, February 14, 2018 Utah Department of Natural Resources Building, Auditorium (1st floor) 1594 West North Temple, Salt Lake City, Utah

8:00 Refreshments

- 8:00 Welcome, Overview of Meeting, and Review of Last Year's Activities: Steve Bowman, Utah Geological Survey
 - 8:15 U.S. Geological Survey, Earthquake Hazards Program Update: Ryan Gold, U.S. Geological Survey
 - 8:30 Utah Geological Survey Paleoseismology Team Update: Emily Kleber, Greg McDonald, and Adam Hiscock, Utah Geological Survey
- 8:45 Technical Presentations of Work Completed or In Progress
 - 8:45 Updated Seismic Imaging of the Salt Lake City Area from 2015 and 2017 Campaigns: Lee Liberty, Boise State University
 - 9:15 New Utah Earthquakes (1850 to 2016) and Quaternary Faults Map: Steve Bowman, Utah Geological Survey and Walter Arabasz, University of Utah Seismograph Stations
 - 9:30 Detailed Mapping of the Wasatch Fault Zone, Utah and Idaho, Using High-Resolution Lidar Elevation Data: Greg McDonald, Adam Hiscock, and Emily Kleber
 - 9:45 Technical Summary of the Traverse Ridge Paleoseismic Site in Draper, Utah: Joseph Phillips and Nate Toke, Utah Valley University
- 10:00 Break (15 minutes)
- 10:15 Technical Presentations of Work Completed or In Progress (continued)
 - 10:15 Preliminary Findings from Trenches on the Levan and Fayette Segments of the Southern Wasatch Fault Zone, Central Utah: Greg McDonald, Adam Hiscock, and Mike Hylland, Utah Geological Survey
 - 10:30 New West Valley Fault Zone Mapping with Insights from Consultant Investigations: Adam McKean, Utah Geological Survey
 - 10:45 Wasatch Landslides and Paleoseismic Record: Brendon Quirk, University of Utah
 - 11:00 Reconnaissance Investigation of the Thousand Lake Fault near Bicknell, Utah: Joseph Phillips and Nate Toke, Utah Valley University

- 11:15 Frontier Observatory for Research in Geothermal Energy (FORGE) Milford Site Quaternary Faulting: Emily Kleber and Tyler Knudsen, Utah Geological Survey
- 11:45 Update of Ongoing Studies to Evaluate the Seismic Potential of the Joes Valley Fault Zone, East-Central Utah: Julia Howe and Lucy Piety, U.S. Bureau of Reclamation
- 12:00 Lunch (1 hour, register at <u>http://2018uewg.eventbrite.com</u> for on-site hot lunch)
- 1:00 Technical Presentations of Work Completed or In Progress (continued)
 - 1:00 Topliff Hills Fault Investigation Update: Mike Bunds, Utah Valley University
 - 1:30 A Review of the California Approaches for Evaluating Fault Activity: Robert Tepel, retired
 - 2:00 Progress Towards an Updated Nevada Seismic Hazards Model: Rich Koehler, Nevada Bureau of Mines and Geology
 - 2:15 Update from the 2017 8th International Workshop on Paleoseismology, Active Tectonics and Archeoseismology Meeting: Emily Kleber, Utah Geological Survey
 - 2:45 Extra discussion time for technical presentations
- 3:00 Break (15 minutes)
- 3:15 Discussion Benefits of Incorporating Consultant Surface-Fault-Rupture Investigations into Urban Geologic Mapping, Adam McKean, Utah Geological Survey
- 3:45 Discussion Working Group 2019 Fault Investigation Priorities See figure 1 for a map of Utah and surrounding area Quaternary faults, table 1 for the UQFPWG list of faults requiring additional investigation, table 2 and figure 2 for the list of faults included in the U.S. Geological Survey National Seismic Hazard Maps and/or the UGS Hazus Utah fault database, table 3 for a status of current paleoseismic investigations for Utah priority faults and fault segments, and tables 4 and 5 for the UQFPWG 2018 fault priority list.
- 5:00 Adjourn

Working Group Members

Utah Geological Survey (UQFPWG Co-Chair)
Utah Valley University
University of Utah, Department of Geology & Geophysics
U.S. Geological Survey, Earthquake Hazards Program
U.S. Geological Survey, Earthquake Hazards Program, IW Coordinator
Utah Geological Survey (UQFPWG UGS Liaison)
Utah Geological Survey
Utah State University
Utah Geological Survey (UQFPWG Co-Chair)
Utah Geological Survey, Emeritus
Southern Utah University
Utah Geological Survey
University of Utah Seismograph Stations
U.S. Geological Survey, National Seismic Hazard Maps Liaison
U.S. Bureau of Reclamation
Utah Valley University
Lettis Consultants International
Weber State University

Publications

Paleoseismic investigations published by the Utah Geological Survey (UGS) are found in the *Paleoseismology of Utah Series* (https://geology.utah.gov/?page_id=5283). Most of the U.S. Geological Survey (USGS), Earthquake Hazards Program, National Earthquake Hazards Reduction Program 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/mp-13-3.pdf).

The UGS published a new 1:500,000-scale statewide earthquake epicenter and Quaternary fault map in 2017, based on the updated *Utah Quaternary Fault and Fold Database* and a completely revised earthquake catalog, as Map 277: *Utah Earthquakes (1850 to 2016) and Quaternary Faults* (https://ugspub.nr.utah.gov/publications/maps/m-277.pdf). The earthquake catalog was published as OFR 667 (https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-667/ofr-667.pdf), and the data is available at https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-667/ofr-667.zip). Professionally printed 44" x 62" copies are available from the Natural Resources Map & Bookstore (https://www.utahmapstore.com/m277.html).

Utah Quaternary Fault and Fold Database

The UGS updated the *Utah Quaternary Fault and Fold Database* on January 1, 2017, incorporating new data and a complete review of previously published data through the end of 2013. Ongoing updates are being reviewed by UGS for 2013–2017 published Quaternary faults. 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 (<u>https://gis.utah.gov/data/geoscience/quaternary-faults/</u>). 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 <u>https://geology.utah.gov/resources/data-databases/qfaults/</u>.



Figure 1. Utah and surrounding area Quaternary faults and folds (for Utah from the <u>Utah Quaternary Fault and</u> <u>Fold Database</u>; Utah Geological Survey, 2017). Nevada faults are from the <u>Quaternary Faults in Nevada</u> map database (dePolo, 2008), and faults in Arizona, Colorado, Idaho, and Wyoming are from the <u>Quaternary Fault and</u> <u>Fold Database of the United States</u> (USGS, 2006). Additional Quaternary faults may exist, but they have not been mapped, may not have surface exposures, or were mapped subsequent to the latest database revisions.

Utah Lidar Elevation Data Availability

A significant area of high-resolution (≤ 1 meter) lidar elevation data in the state of Utah is now available totaling over 6846 square miles (mi²) from AGRC (<u>https://gis.utah.gov/data/elevation-terraindata/</u>) and OpenTopography (<u>http://opentopography.org</u>). 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 3 shows the existing and planned lidar data available in Utah. An additional 14,452 mi² is planned for acquisition in 2018. For major Quaternary faults, data is now available for the East and West Cache, Hurricane, Wasatch, and West Valley fault zones. The UGS is using this data to map fault traces associated with these fault zones 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. 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*, in UGS Circular 122, pages 33 to 58, <u>https://ugspub.nr.utah.gov/publications/circular/c-122.pdf</u>).

Utah Consensus-Based Quaternary Fault Parameters

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 (Lund, 2005; <u>https://ugspub.nr.utah.gov/publications/bulletins/B-134.pdf</u>), 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. The available paleoseismic trenching data are most abundant on the six central, active segments of the Wasatch fault zone (WFZ), and are much less abundant for faults elsewhere in Utah.

Based on recent work by the Working Group on Utah Earthquake Probabilities (that included a comprehensive evaluation of all paleoseismic data in the Wasatch Front region as defined by the group <u>http://ugspub.nr.utah.gov/publications/misc_pubs/mp-16-3/mp-16-3.pdf</u>), and the UGS Hazus Utah fault database (<u>https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-631.pdf</u>), the UGS is incorporating these updated Quaternary fault parameters in the UGS *Utah Quaternary Fault and Fold Database* for release in 2018.

Working Group Fault Investigation Priorities

In 2005, the UQFPWG developed a list of Quaternary faults and fault segments (table 1) that the working group identified as requiring additional investigation to adequately characterize Utah's earthquake hazard to a minimally acceptable level. The list was expanded during subsequent UQFPWG meetings in 2007, 2009, and annually between 2010 and 2017. Table 2 lists the faults and fault segments (earthquake sources) incorporated in the UGS *Utah Quaternary Fault and Fold Database*, 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 in table 1 may need additional investigation. Table 3 lists the current status of paleoseismic investigations for priority faults and fault segments in table 1. Tables 4 and 5 list the 2018 UQFPWG priority faults and fault segments. Figure 4 shows recommended WFZ future paleoseismic investigations by DuRoss (from 2016 UQFPWG presentation), based on data gaps. The UQFPWG will review the 2018 fault-investigation priorities and make changes as necessary for the 2019 priority list.



Figure 2. Faults included in the UGS Hazus Utah fault database, except the Cedar City-Parowan monocline and faults were removed in 2016 (see table 1; database updated through 2013, <u>UGS Open-File Report 631</u>).

Utah Fault or Fault Segment		UQFPWG Priorities	
		Additions	
Nephi segment, Wasatch fault zone ^{2,3}	1		
West Valley fault zone ^{2,3}	2		
Weber segment, Wasatch fault zone ^{2,3} – most recent event	3		
Weber segment, Wasatch fault zone ^{2,3} – multiple events	4		
Utah Lake faults and folds ³	5		
Great Salt Lake fault zone ^{2,3}	6		
Collinston and Clarkston Mountain segments, Wasatch fault zone ³	7		
Sevier and Toroweap faults ^{2,3}	8		
Washington fault zone ³ (includes Dutchman Draw fault ²)	9		
Cedar City-Parowan monocline (removed 2016) ^{3,4} and Paragonah fault ^{2,3}	10		
Enoch graben ³	11		
East Cache fault zone ^{2,3}	12		
Clarkston fault ^{2,3}	13		
Wasatch Range back-valley faults (includes Morgan fault ² and Main Canvon fault ³)	14		
Hurricane fault zone ^{2,3}	15		
Levan segment Wasatch fault zone ^{2,3}	16		
Gunnison fault ³	17		
Scipio Valley faults ³	18		
Faults beneath Bear Lake	19		
Faster Bear Leke fault zone ^{2,3}	20		
Bear River fault zone ^{2,3}			
Brigham City segment Wasatch fault zone ^{2,3} – most recent event		-	
Carrington fault Great Salt Lake fault zone ³		2007	
Carring for hart, Oreal Safe Lake fault zone ^{2,3} – penultimate event		2007	
Rozelle section East Great Salt Lake fault ³		-	
Salt Lake City segment. Wasatch fault $zone^{2.3}$ – northern part		2009	
Warm Springs fault/East Bench fault ^{2,3} subsurface geometry and connection		200)	
Brigham City segment. Wasatch fault zone ^{2,3} runture extent (north and south ends)		2010	
Northarn Provo segment, Wasatch fault zone ^{2,3} long term earthquake record			
Torthern Tovo segment, wasach faut zoie ² - long-term carinquake fecord		2011	
Hansel Valley fault ^{2,3}			
Acquire new neleoseismic information to address data gaps for the five central segments of the			
Wegetch built zone		2012	
Focus on the youngest earthquakes (3.5 kg): large early Holocome latest Plaistocome searns: and	+	Modified	
Focus on the youngest compared strong and $(5-5 \text{ and })$, angle, carly protocone-match reductions of the source scarps, and sendow faulting (West Vallay fault cond. ^{2,3} and then to the fault one fault $(3-5)$		2017	
Improve the long-term earthquake record for Cache Valley (East ^{1,2,3} and West Cache ^{2,3} fault zones)		2017	
Is recently acquired lider data to more accurately man the traces of the Waster Walley and		2013	
Hurricene fault zones, and search for and man as appropriate previously undiscovered mid-valley.		2014	
Quaternary faults ⁵		2014	
	******	Modified	
East ^{1,2,3} and West Bear Lake, East and West Cache ^{1,2,3} , and Hurricane ^{1,2,3} fault zones		2017	
Acquire earthquake timing information for the Utab I ake faults ^{1,3} to investigate the relation of		2017	
earthquakes to large earthquakes on the adjacent Provo segment of the Wasatch fault zone ^{3,4}			
Acquire new polacese intrinsition to address data gans for the porthern Quirrh fault zone ³		2015	
Acquire hew pareoseismic information to address data gaps for the northern order of data zone .		2015	
(chiefly urban) Utah hazardous faults ⁵ Identify future paleoseismic terach sites			
	+	Modified	
East ^{1,2,3} and West Bear Lake, East and West Cache ^{1,2,3} , Oquirrh ^{2,3} , and Hansel Valley ^{2,3} fault zones		2017	
Acquire and analyze information on salt tectonics and its relation to the Main Canyon fault ^{1,3} , Sevier			
detachment/Drum Mountains fault zone ³ , Bear River fault zone ^{2,3} , Spanish Valley (Moab area),			
Joes Valley fault zone ^{4,3} , Levan ⁴ and Fayette segments ^{4,3} of the Wasatch fault zone, Scipio Valley		2016	
Iauns", and the Gunnison fault."	ł	4	
Keine the latest Quaternary earthquake chronology for the Loplitt Hills fault ³ .		1	

Table 1. List of Quaternary faults and fault segments identified by the UQFPWG since 2005 as requiring additional investigation to adequately characterize Utah's earthquake hazard to a minimally acceptable level.

¹ Original priorities from the 2005 UQFPWG meeting.
 ² Earthquake source on the USGS National Seismic Hazard Maps.

³ Earthquake source listed in the UGS Hazus Utah fault database (<u>UGS Open-File Report 631</u>).
⁴ Fault removed from the list at the 2016 UQFPWG meeting, based on new information about the structure.

⁵ See figure 3 for a map of lidar data availability in Utah and the surrounding area.

Table 2. Earthquake sources (faults and fault segments) in the USGS National Seismic Hazard Maps (NSHM) or the UGS Hazus Utah fault database (<u>UGS Open-File Report 631</u>) that are not listed in table 1. These faults may warrant additional investigation.

Litch Foult on Foult Segment	Included In	
Otali Fault of Fault Segment		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 3. Current status of paleoseismic investigations for Utah priority faults and fault segments identified by the UQFPWG as requiring additional investigation to adequately characterize Utah's earthquake hazard to a minimally acceptable level. Note that faults or fault segments listed as having received some level of paleoseismic investigation does not imply that all of the paleoseismic data necessary to fully characterize those faults or fault segments has been acquired; further investigation of those structures may be necessary. All of the faults/fault sections or segments listed remain priorities and should be considered for future investigation if a compelling case can be made for the need to acquire additional paleoseismic data.

Eault or Eault Serment UQF	UQFPWG	UQFPWG Investigations	
Fault or Fault Segment	Priority ¹	Status ^{2,3} (as of 1/2018)	Institution ⁴
Nephi segment, Wasatch fault zone ^{5,6}	1	UGS Special Study <u>124</u> and <u>151</u> <u>USGS SI Map 2966</u> <u>UGS FTR Report</u>	UGS/USGS
		Fault trace hazard mapping ongoing	UGS
Granger fault, West Valley fault zone ^{5,6}	2	UGS Special Study 149 Fault trace hazard mapping ongoing	UGS/USGS UGS
Weber segment, Wasatch fault zone ^{5,6} – most recent event	3	UGS Miscellaneous Publication 05-8 UGS Special Study 130	UGS/USGS
Weber segment, Wasatch fault zone ^{5,6} – multiple events	4	UGS Miscellaneous Publication 05-8 UGS Special Study 130	UGS/USGS
Utah Lake faults and folds ⁶	5	UUGG FTR Report	UUGG/ BYU
Great Salt Lake fault zone ^{5,6}	6	<u>UUGG FTR Report</u> Janecke and Evans (2017)	UUGG USU
Collinston and Clarkston Mountain segments, Wasatch fault zone ⁶	7	UGS Special Study 121 Map: UGS Open-File Report 638 Fault trace hazard mapping ongoing	UGS
Sevier and Toroweap faults ^{5,6}	8	UGS Special Study 122	UGS
Washington fault zone ⁶	9	UGS Miscellaneous Publication 15-6 UGS Open-File Report 583	UGS
<i>Cedar City-Parowan monocline (removed 2016)</i> ^{5,6,7} and Paragonah fault ^{5,6}	10	Map: <u>UGS Map 270</u> 2016 presentation file	UGS
Enoch graben ⁶	11	Map: UGS Open-File Report 628	UGS
Fact Cash a fault - an 256	12	USU FTR Report	USU
East Cache fault zone	12	Fault trace hazard mapping ongoing	UGS
Clarkston fault ^{5,6}	13	UGS Special Study 98 Fault trace hazard mapping ongoing	UGS
Wasatch Range back-valley faults Main Canyon fault ⁶	14	UGS Miscellaneous Publication 11-2 UGS Miscellaneous Publication 10-5	USBR USBR
Hurricane fault zone ^{5,6}	15	UGS Special Study 119	UGS
Levan segment, Wasatch fault zone ^{5,6}	16	UGS Map 229 Map: UGS Open-File Report 640 Fault trace hazard mapping ongoing Paleoseismic investigation ongoing	UGS
Gunnison fault ⁶	17	No activity	
Scipio Valley faults ⁶	18	No activity	
Faults beneath Bear Lake	19	No activity	
Eastern Bear Lake fault zone ^{5,6}	20	No activity	
Bear River fault zone ^{5,6}		AGU Abstracts: 2012 and 2013 USGS ongoing	USGS/UGS
Brigham City segment, Wasatch fault zone ^{5,6} – most recent event	2007	UGS Special Study 142	UGS/USGS
Carrington fault, Great Salt Lake fault zone ⁵		No activity	
Provo segment, Wasatch fault zone ^{5,6} – penultimate event]	No activity	
Rozelle section, East Great Salt Lake fault ⁶		Janecke and Evans (2017)	USU
Salt Lake City segment, Wasatch fault zone ^{5,6} – north part	2009	UGS Special Study 149 Fault trace hazard mapping ongoing	UGS/USGS UGS
Warm Springs fault/East Bench fault ^{5,6} subsurface geometry and connection	2010	BSU FTR Report Ongoing	BSU

Foult or Foult Segment	UQFPWG	Investigations	
Fault of Fault Segment	Priority ¹	Status ^{2,3} (as of 1/2018)	Institution ⁴
Brigham City segment, Wasatch fault zone ^{5,6} rupture extent (north and south ends)	_	Fault trace hazard mapping ongoing	UGS
Northern Provo segment, Wasatch fault zone ^{5,6} -long- term earthquake record		USGS work ongoing UGS FTR Report	USGS/UGS
	2011	Robinson (1986)	UUGG
Hansel Valley fault zone ^{5,6}		McCalpin (1985), McCalpin and others (1992), Janecke and Evans (2017)	USU
Acquire new paleoseismic information to address data gaps for the five central segments of the Wasatch fault zone ^{5,6}			
Nephi segment ^{5,6} – long-term earthquake record		UGS Special Study 159	UGS/USGS
Provo, Salt Lake City and Nephi segments, Wasatch fault zone ^{5,6} segmentation	2012	Ongoing	
Corner Canyon site		UGS FTR Report	UGS/USGS
The Menter of Alaine Stee		USGS work ongoing	
Flat, Maple, and Alpine sites		UGS FTR Report	0565/065
Fort Canyon fault ^{5,6} , Traverse Mountains salient		Ongoing	UVU
Focus 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).	Modified 2017	Ongoing	
Taylorsville fault, West Valley fault zone		UGS ongoing	UGS/USGS
Improve the long-term earthquake record for Cache Valley (East and West Cache fault zones ^{5,6}).	2013	No activity	
East Cache fault zone ^{5,6}	2013	Evans and McCalpin (2012)	USU/GEO- HAZ
U. lidente martine effete U. S. Weestel 56		Lidar data of the Wasatch and West Valley fault zones acquired.	UGS/State of Utah
and West Valley ^{5,6} fault zones.	2014	UGS Open-File Reports <u>638</u> and <u>640</u> Hurricane, Wasatch, and West Valley fault zones mapping ongoing	UGS
East ^{5,6} and West ⁶ Bear Lake, East and West Cache ^{5,6} , and Hurricane ^{5,6} fault zones	Modified 2017	East and West Cache fault zones lidar and mapping ongoing.	UGS
Acquire new paleoseismic information to address data gaps for the northern Oquirrh fault zone ^{5,6} .		No activity	
Acquire high resolution aerial imagery (Lidar, Structure from Motion [SfM], etc.) and map high-risk (chiefly urban) Utah hazardous faults. Identify future paleoseismic trench sites.	2015	Lidar: Portions of the Little Valley, Scipio, Strawberry, Paunsaugunt, Pavant Range, and other faults, and the Bear River, Sevier/ Toroweap, and Topliff Hills fault zones planned in 2018.	UGS/State of Utah
		Mapping: Hansel Valley fault zone Janecke and Evans (2017)	USU
East ^{5,6} and West ⁶ Bear Lake, East and West Cache ^{5,6} , Oquirrh ^{5,6} , and Hansel Valley ^{5,6} fault zones	Modified 2017	Lidar: Remaining portions of the East and West Bear Lake, East and West Cache, and Oquirrh fault zones planned in 2018.	UGS/State of Utah
		Lidar/Mapping: East and West Cache fault zones lidar and mapping ongoing.	UGS
Acquire and analyze information on salt tectonics and its relation to the Main Canyon fault ⁶ , Sevier	2016	Levan and Fayette segments, Wasatch fault zone paleoseismic	UGS/USGS
detachment/Drum Mountains faults ⁶ , Bear River fault zone ^{5,6} , Spanish Valley (Moab area), Joes Valley fault zone ^{5,6} , Levan ^{5,6} and Fayette ⁶ segments of the Wasatch fault zone, Scipio Valley faults ⁶ , and the Gunnison fault ⁶ .		Joes Valley fault zone trenching ongoing in 2017, and planned for 2018.	USBR
		Lidar: Most of Moab/Spanish Valley planned in 2018.	UGS/State of Utah

Foult on Foult Segment	UQFPWG	Investigations	
Fault of Fault Segment	Priority ¹	Status ^{2,3} (as of 1/2018)	Institution ⁴
Refine the latest Quaternary earthquake chronology for the Topliff Hills fault ⁶ .	2016	Lidar: planned in 2018.	UGS/State of Utah

¹ See table 1 for complete working group priority list.

² FTR (Final Technical Report) to the USGS, Earthquake Hazards Program (https://geohazards.usgs.gov/cfusion/external_grants/research.cfm).

³ Click on URL links to investigation report files available online.

⁴ BSU (Boise State University), BYU (Brigham Young University), GEO-HAZ (GEO-HAZ Consulting, Inc.), USBR (U.S. Bureau of Reclamation), USGS (U.S. Geological Survey, Earthquake Hazards Program), UGS (Utah Geological Survey), USU (Utah State University), UUGG (University of Utah Department of Geology & Geophysics), UVU (Utah Valley University).

⁵ Earthquake source on the USGS National Seismic Hazard Maps (<u>https://earthquake.usgs.gov/hazards/hazmaps/</u>).

⁶ Earthquake source listed in the UGS Hazus Utah fault database (UGS Open-File Report 631).

⁷ Fault removed from the list at the 2016 UQFPWG meeting, based on new information about the structure.

Table 4. Utah Quaternary Fault Parameters Working Group 2018 list of highest priority Quaternary faults or fault segments requiring additional investigation to adequately characterize Utah's earthquake hazard to a minimally acceptable level. The list will be reviewed at this meeting and revised as needed to develop the 2019 priority list.

Fault or Fault Segment (Not in Priority Order)	Investigations	
	Status (as of 1/2018) ^{1,2}	Institution
Acquire new paleoseismic information to address data gaps for (a) the	Nephi segment, Spring Lake and North Creek sites: <u>UGS Special</u> <u>Study 159</u>	UGS/USGS
five central segments of the Wasatch fault zone ^{3,4} (including focusing on the youngest earthquakes [3-5 ka]; large, early Holocene–latest	Provo segment, Flat Canyon site: USGS ongoing, <u>UGS FTR Report</u>	USGS/UGS
Pleistocene scarps; and secondary faulting [West Valley fault zone ^{3,4} and Utah Lake faults and folds ⁴]), (b) the northern segment of the	Salt Lake City segment, Corner Canyon site: <u>UGS FTR Report</u>	UGS/USGS
Oquirrh fault zone ^{3,4} , (c) refining the latest Quaternary earthquake chronology for the Topliff Hills fault ⁴ , and (d) the East and West Cache ^{3,4} fault zones. Examples of paleoseismic data to acquire	Provo segment, Dry Creek and Maple Canyon sites: USGS ongoing, <u>UGS</u> <u>FTR Report</u>	USGS/UGS
include extent of surface-faulting rupture, earthquake timing, displacement, and subsurface fault geometry.	Fort Canyon fault, Traverse Mountains salient: ongoing	UVU
	Southern segment, East Cache fault zone: FTR Report	USU/GEO- HAZ
Use recently acquired lidar ⁵ data to more accurately map the traces of the East ^{3,4} and West ⁴ Bear Lake, East and West Cache ^{3,4} , and Hurricane ^{3,4} fault zones, and search for and map as appropriate previously undiscovered mid-valley Quaternary faults.	Hurricane and East and West Cache fault zones lidar and mapping ongoing.	UGS
Acquire earthquake timing information for the Utah Lake faults ⁴ to investigate the relation of earthquakes on that fault system to large earthquakes on the adjacent Provo segment of the Wasatch fault zone (independent or coseismic ruptures, fault pairs?).	No activity	
Acquire high-resolution aerial imagery (lidar ⁵ , Structure from Motion,	Mapping: East and West Cache fault zones ongoing.	UGS
the East ^{3,4} and West ⁴ Bear Lake, East and West Cache ^{3,4} , Oquirrh ^{3,4} , and Hansel Valley ^{3,4} fault zones), and identify new paleoseismic trench sites.	Lidar: Remaining portions of the East and West Bear Lake, East and West Cache, and Oquirrh fault zones planned in 2018.	State of Utah/UGS
Acquire and analyze information on salt tectonics and its relation to the Main Canyon fault ⁴ , Sevier detachment/Drum Mountains faults ⁴ , Bear River fault zone ^{3,4} , Spanish Valley (Moab area), Joes Valley fault zone ^{3,4} , Levan ^{3,4} and Fayette ⁴ segments of the Wasatch fault zone, Scipio Valley faults ⁴ , and the Gunnison fault ⁴ .	Levan and Fayette segments paleoseismic investigation ongoing.	UGS
	Moab quadrangle salt-tectonics- related ground subsidence hazard mapping ongoing.	UGS
	Lidar: Most of Moab/Spanish Valley planned in 2018.	UGS/State of Utah

¹ FTR (Final Technical Report) to the USGS, Earthquake Hazards Program.

² Click on URL link to investigation report files available online.

- ³ Earthquake source on the USGS National Seismic Hazard Maps.
- ⁴ Earthquake source listed in the UGS Hazus Utah fault database (UGS Open-File Report 631).

⁵ See figure 3 for a map of lidar data availability in Utah and the surrounding area.

Table 5. Utah Quaternary Fault Parameters Working Group 2018 list of other priority faults or fault segments requiring further investigation to adequately characterize Utah's earthquake hazard to a minimally acceptable level. The list will be reviewed at this meeting and revised as needed to develop the 2019 priority list.

Fault or Fault Segment UQFPWG Priority ¹	UQFPWG	Investigations	
	Status (as of 1/2018) ²	Institution	
Paragonah fault ^{3,4}	105	No activity	
Enoch graben ⁴	11	Map: UGS Open-File Report 628	UGS
Clarkston fault, West Cache fault zone ^{3,4}	13	UGS Special Study 98 Mapping ongoing	UGS
Gunnison fault ⁴	17	No activity	
Scipio Valley faults ⁴	18	Lidar: planned in 2018.	State of Utah/UGS
Faults beneath Bear Lake	19	No activity	
Eastern Bear Lake fault zone ⁴	20	Lidar: planned in 2018.	State of Utah/UGS
Carrington fault, Great Salt Lake fault zone ⁴	2007	No activity	
Rozelle section, Great Salt Lake fault zone ^{4,6}	2007	Janecke and Evans (2017)	USU

¹ See table 1 for complete working group priority list.

² Click on URL link to investigation report files available online.

³ Earthquake source on the USGS National Seismic Hazard Maps.

⁴ Earthquake source listed in the UGS Hazus Utah fault database (<u>UGS Open-File Report 631</u>).

⁵ The Cedar City-Parowan monocline was removed from Priority 10 in the 2016 meeting, based on new information from geologic mapping in the area (<u>UGS Map 270</u> and <u>2016 presentation file</u>).

⁶ Previous highest priority fault or fault segment.



Figure 3. Map of lidar data availability in Utah and the surrounding area. Proposed data to be acquired in 2018 with USGS Quality Level (QL) 1 (0.5 m) in bright orange and QL2 (1 m) in purple, data acquired prior to 2018 with QL2 or better in yellow and \geq QL3 in green, other state \leq QL2 data in dark orange, and unknown quality in gray.



Figure 4. Recommended Wasatch fault zone future paleoseismic investigations by DuRoss (from 2016 UQFPWG presentation). Red shading denotes areas along faults where additional basic paleoseismic data is needed and blue shading denotes areas near and on segment boundaries where additional paleoseismic data is needed.