FAULT TRACE MAPPING AND SURFACE-FAULT-RUPTURE SPECIAL STUDY ZONE DELINEATION OF THE WASATCH FAULT ZONE, UTAH AND IDAHO

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REPORT OF INVESTIGATION 280
UTAH GEOLOGICAL SURVEY
UTAH DEPARTMENT OF NATURAL RESOURCES
2020

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Cover photo: *Along the Wasatch fault zone, the Wasatch mountains meet the flats of urban growth in Alpine, Utah.*

Suggested citation:

McDonald, G.N., Kleber, E.J., Hiscock, A.I., Bennett, S.E.K., and Bowman, S.D., 2020, Fault trace mapping and surface-fault-rupture special study zone delineation of the Wasatch fault zone, Utah and Idaho: Utah Geological Survey Report of Investigation 280, 23 p., https://doi.org/10.34191/RI-280.

REPORT OF INVESTIGATION 280
UTAH GEOLOGICAL SURVEY
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Publisher's note: This Report of Investigation (RI-280) makes reference to the *Utah Geologic Hazards Portal* as the repository of the fault mapping discussed herein. However, at the time of publication of RI-280, the *Utah Geologic Hazards Portal* was nearing completion but not yet publicly available. Due to the March 18, 2020, magnitude 5.7 Magna earthquake, and the increased interest in the Wasatch fault zone, the Utah Geological Survey expedited publication of RI-280 and released the associated fault mapping in the *Utah Quaternary Fault and Fold Database* (https://geology.utah.gov/apps/qfaults/index.html); until public launch of the *Utah Geologic Hazards Portal*, that is where the mapping can be found.

Publisher's note 06/26/25: Mapping associated with this report is available in the Utah Geologic Hazards Portal (https://hazards.geology.utah.gov/) and in a geodatabase included with this report.

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This material is based upon work supported by the U.S. Geological Survey under grant no. G17APD0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Geological Survey. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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LINK TO FAULT MAPPING

Mapping associated with this report is available in the Utah Geologic Hazards Portal (https://hazards.geology.utah.gov/) and in a geodatabase included with this report.

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ABSTRACT

The Wasatch fault zone (WFZ) is a 220-mile-long (350-km) fault zone divided into 10 structural segments extending from southeastern Idaho to central Utah. The central five segments of the WFZ underlie the densely populated Wasatch Front region, where the majority of Utah's population and economy are proximal to the fault zone. The West Valley fault zone (WVFZ) is an antithetic structure related to the WFZ and runs through the Salt Lake Valley. Communities on or adjacent to the WFZ are at risk of earthquake damage, due to their proximity to the fault zones. During 2016–2018, the Utah Geological Survey and a U.S. Geological Survey collaborator performed updated fault mapping of 39 7.5' quadrangles along the WFZ using recently acquired high-resolution topographic data derived from airborne light detection and ranging (lidar) elevation data. Previous geologic mapping, paleoseismic investigations, historical aerial photography, and field investigations were also used to identify and map surface fault traces and infer fault locations. Special study zones were delineated around fault traces to facilitate understanding of the surface-rupturing hazard and associated risk. Defining these special study zones encourages the creation and implementation of municipal and county geologic-hazard ordinances dealing with hazardous faults. We identified potential paleoseismic investigation sites where fault scarps appear relatively pristine, are located in geologically favorable settings, and where additional earthquake timing data would be beneficial to the continued earthquake research of the WFZ. The fault geometries, attributes, and special study zones were published in the online *Utah Geologic Hazards Portal* simultaneously with this Report of Investigation (RI). This report contains supplementary material describing the data and methods used to perform the mapping and in locating potential paleoseismic investigation sites in the study area. This work is critical to raise awareness of earthquake hazards in areas of Utah experiencing rapid growth.

INTRODUCTION AND PURPOSE

The Wasatch fault zone (WFZ) is located within the densely populated Wasatch Front region. Over 85 percent of Utah's population of ~3.1 million (U.S. Census Bureau, 2017) lives within 15 miles of the WFZ (figure 1). Estimates of future growth predict that the state's population will exceed 5 million by 2050 (Utah Foundation, 2014), with rapid growth spreading outward from existing communities and encroaching on the already partially urbanized and hazardous fault zones. Paleoseismic sites along the WFZ provide evidence of repeated surface-rupturing earthquakes during the latest Pleistocene to Holocene (Working Group on Utah Earthquake Probabilities [WGUEP], 2016). The immediate proximity of Utah's growing populous regions to the WFZ results in substantial risk to the state's population and the long-term stability of state and regional economies.

The Wasatch Front region faces the greatest earthquake risk in the Intermountain West. Three factors contribute to the earthquake risk in Utah: (1) high population density (U.S. Census Bureau, 2017), (2) a large number of unreinforced masonry buildings ([URMs], approximately 185,000 in the Wasatch Front region [unpublished tax-assessment data from the Utah Division of Emergency Management]), and (3) the proximity to the active WFZ (see Earthquake Engineering Research Institute [EERI], 2015; WGUEP, 2016).

The relatively recent technology of collecting airborne light detection and ranging (lidar) elevation data has greatly improved our mapping capabilities. The ability to create sub-meter resolution, bare-earth elevation models, can reveal subtle patterns created by geologic processes, including landslides and fault zones (Meigs, 2013). During 2013–2014, the Utah Geological Survey (UGS), the U.S. Geological Survey (USGS) Earthquake Hazards Program, the Salt Lake County Surveyor's Office, and local cities funded the collection of airborne lidar data by the State of Utah for the greater Wasatch Front area of Utah to support a diverse set of flood mapping, geologic, transportation, infrastructure, solar energy, and vegetation projects (Utah AGRC, 2013-14; OpenTopography, 2013-14). This is in addition to a 2008 dataset collected over parts of the Intermountain Seismic Belt (ISB) (Smith and Sbar, 1974) that includes an area along the WFZ near Nephi, Utah (OpenTopography, 2008). These WFZ lidar data are publicly available from the Utah Automated Geographic Reference Center (AGRC) (https://gis.utah.gov/data/elevation-and-terrain) and the National Science Foundation OpenTopography facility (https://opentopography.org).

Previous investigations have produced valuable mapping and knowledge of the extent of the WFZ that has been used to guide land-use planning, but no detailed compilation existed or spe-

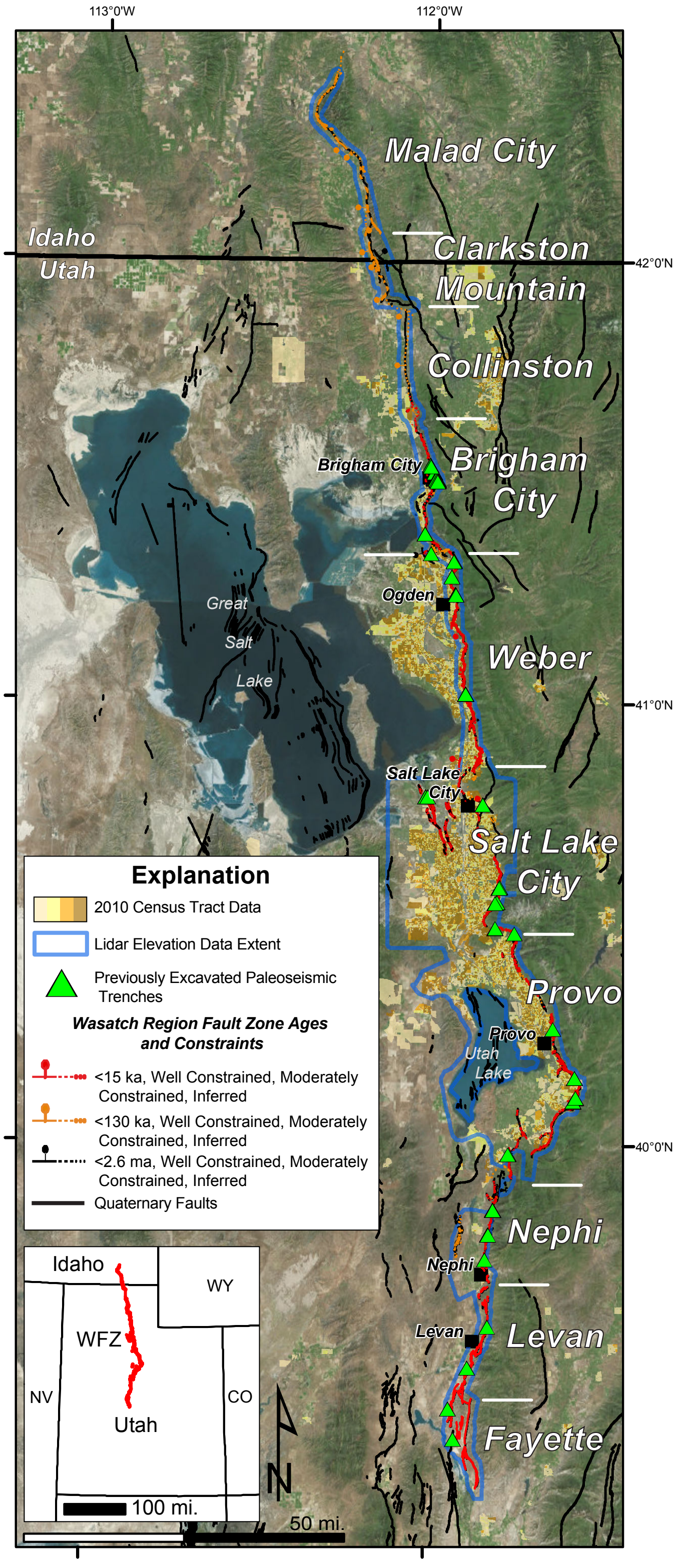

Figure 1. Segments of the Wasatch fault zone (WFZ) in northern Utah and southern Idaho. The WFZ is co-located with dense and growing population centers along the Wasatch Front. Green triangles indicate published paleoseismic research sites. Census data from 2010 are approximate population per census block. Imagery from Google World Imagery. Figure modified from DuRoss and others (2016).

cial-study zones defined for fault traces along all 10 segments of the WFZ. The majority of previous geologic mapping of the WFZ was completed prior to the availability of lidar elevation data. Most of this mapping was published at a scale of 1:50,000 (Personius, 1990; Machette, 1992; Personius and Scott, 1992; Nelson and Personius, 1993; Harty and others, 1997; Hylland and Machette, 2008) or on various 1:24,000-scale geologic quadrangles published by the UGS, the USGS, or academic institutions. The tools used to complete this previous mapping included available aerial stereo-pair photographs, field mapping, and topographic maps.

The purpose of this investigation was to map at a maximum scale of about 1:10,000 using lidar elevation data to detect previously unmapped fault traces, define special-study zones, and find potential sites for future paleoseismic investigations of the WFZ. In November 2016, the UGS received matching funding from the USGS Earthquake Hazards Program, External Grants Program for the project. As part of a Final Technical Report (FTR) (McDonald and others, 2018), 39 7.5' quadrangles were submitted to the USGS showing surface fault geometries mapped at 1:10,000 scale or greater (1:24,000 scale in highly disturbed urban areas), approximate age categories determined from previous geologic mapping, and special-study zones delineated for faults in Utah, using methods defined by Lund and others (2016). The southernmost two segments, the Levan and Fayette, were previously mapped using lidar and special study zones defined in Hiscock and Hylland (2015). In spring 2020, the UGS compiled these and other recent efforts and published complete fault geometries and attributes as well as special-study zones of the WFZ in the *Utah Geologic Hazards Portal* (Utah Geological Survey, 2020) and submitted fault geometries and attributes to the USGS *Quaternary Fault and Fold Database of the United States*. These two online databases represent the most up-to-date fault geometries of the WFZ and will continue to be updated beyond the publishing of this report. This report details the methods used to map the fault geometries and fault attributes and delineate surface-fault rupture hazard investigation areas (Lund and others, 2016). Additionally, this report identifies potential paleoseismic sites first published in the USGS FTR report (McDonald and others, 2018).

BACKGROUND

Geologic Setting

The WFZ is within a north-south trending region of intraplate seismicity extending from Arizona to northwestern Montana demarcated as the ISB (figure 2). Earthquakes within the ISB define the transition from the Basin and Range Province (BRP, easternmost Nevada to central Utah) to the Colorado Plateau (Four Corners region) and the WFZ defines the eastern boundary of the BRP. The ISB has generated historic, large magnitude (**M**) earthquakes, including the 1959 **M** 7.5 Hegben Lake and the 1983 **M** 7.3 Borah Peak earthquakes (figure 2; University of Utah Seismograph Stations [UUSS], 2019). The 220-mile-long (350 km) Wasatch fault zone is the most continuous and seismically active fault zone within the ISB and normal fault in North America. The WFZ accommodates about 50 percent of the east-west extension across the eastern BRP (Chang and others, 2006).

The WFZ and accompanying zone of deformation extends from north of Malad City, Idaho, south to Fayette, Utah, and is defined by a prominent topographic escarpment along the western bases of Elkhorn Mountain, the Malad Range, the Clarkston and Wellsville Mountains, the Wasatch Range, and the San Pitch Mountains. Regional extension and uplift of the Wasatch Range via normal faulting earthquakes is thought to have begun ~18 Ma (Parry and Bruhn, 1987) and continues today (Chang and others, 2006). Quaternary fault scarps on the western flank of the Wasatch Range cut alluvial fans, glacial moraines, shorelines, and deltas related to Pleistocene Lake Bonneville (Machette, 1992). The WFZ has been divided into as many as 10 segments based on fault geometry, fault displacement, and timing of the most recent events (figure 1)

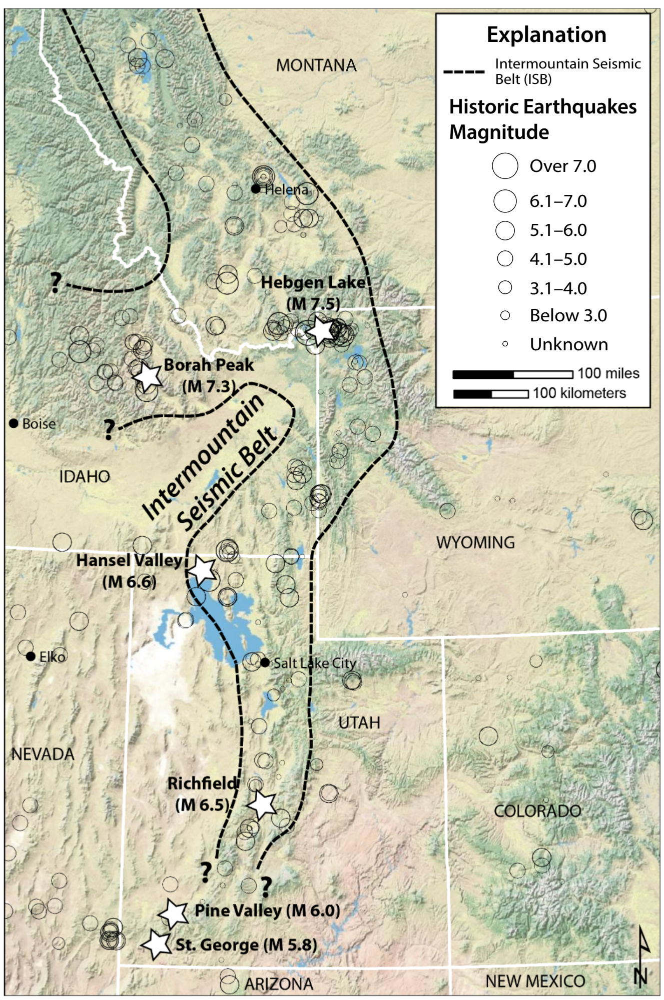

Figure 2. *The western United States showing the Intermountain Seismic Belt (ISB) and historic large earthquakes in the ISB and their magnitudes (UUSS, 2019).*

(Swan and others, 1980; Schwartz and Coppersmith, 1984; Machette and others, 1992; Wheeler and Krystinik, 1992). From north to south, the segments are the Malad City, Clarkston Mountain, Collinston, Brigham City, Weber, Salt Lake City, Provo, Nephi, Levan, and Fayette. The West Valley fault zone (WVFZ) extends through the north-central part of Salt Lake Valley. Although not technically part of the WFZ, Hylland and others (2014) determined the WVFZ is an antithetic structure seismogenically linked to the Salt Lake City segment of the WFZ, and we therefore treat it as part of the WFZ in our discussion of the Salt Lake City segment.

Paleoseismic data from over 40 years of investigations show the five central segments of the WFZ have had recurrent Holocene surface-rupturing earthquakes (summarized by Machette and others [1992], McCalpin and Nishenko [1996], Lund [2005], DuRoss [2008], and WGUEP [2016]). The WFZ releases strain in large-magnitude (about **M** 6.5–7.5) surface-rupturing earthquakes along one or more seismogenic fault segments. The WFZ has a mean recurrence estimate for surface-rupturing earthquakes of 1.1–1.3 kyr and a vertical slip rate of 1.3–2.0 mm/yr (Working Group on Utah Earthquake Probabilities [WGUEP], 2016). Using a long record of paleoseismic data, DuRoss and others (2016) analyzed how structural segment boundaries could be barriers to potential earthquake rupture and found that partial-segment and spillover ruptures are possible along the WFZ.

Previous Work

The WFZ is the most studied Quaternary normal fault in the world (WGUEP, 2016). The fault has been characterized in geologic mapping projects, site-specific paleoseismic trenching investigations, and synthesis studies to best characterize the distribution, history, and patterns of surface-rupturing earthquakes. Geologic evidence for recent earthquakes along the WFZ was first identified by G.K. Gilbert in his investigations of the Quaternary geology of the Salt Lake Valley (Gilbert, 1891). Gilbert initially theorized the ability of the WFZ to generate recurring, large, surface fault rupturing earthquakes, but it was not until the 1970s that the first large-scale investigation of the WFZ's earthquake potential occurred. Low-sun-angle stereo-paired aerial photographs were collected along the WFZ, WVFZ, and the East and West Cache fault zones, and subsequent 1:24,000-scale fault trace mapping was completed by Cluff and others (1970, 1973, 1974). From that work, several paleoseismic trenches were excavated (Swan and others, 1981a, 1981b, 1981c). The WFZ was initially subdivided into six segments (Swan and others, 1981a, 1981b, 1981c; Schwartz and Coppersmith, 1984) and then further divided into the current model of 10 segments (Machette and others, 1992). The initial paleoseismic trenching activities during the 1970s and 1980s were compiled into USGS Professional Paper 1500A (Machette and others, 1992), which provided the most complete set of paleoseismic data of the most active segments of the WFZ and discussed the role of fault segmentation on the WFZ to date.

As the fields of paleoseismology, tectonic geomorphology, and Quaternary geology and mapping improved over the decades, the WFZ was continuously re-visited by the UGS, the USGS, and academic institutions, adding to the increasing body of work characterizing the fault zone. In the early 1990s, maps of the surficial Quaternary geology and fault traces of the WFZ from the Brigham City segment to the Provo segment were published by the USGS (Personius, 1990; Machette, 1992; Personius and Scott, 1992; Nelson and Personius, 1993). These 1:50,000-scale "strip maps" synthesized much-needed detail and geologic context for the distribution of faulting and used the most up-to-date stratigraphic terminology and concepts. The UGS and USGS collaborators published surficial geologic maps of the Nephi segment (Harty and others, 1997) and the Levan-Fayette segments (Hylland and Machette, 2008). Additionally, more work had been published about the regional deposits associated with late Pleistocene Lake Bonneville that improved the relative age of surficial deposits (summarized in Oviatt and Shroder, 2016), and thus helped better characterize the relative age and slip rate of faults that cut, deform, and/or offset these deposits.

The UGS has continuously improved bedrock and Quaternary geologic mapping of the state of Utah by publishing 30' x 60' (1:100,000 or 1:62,500 scale) and 7.5' (1:24,000 scale) geologic maps. With the rapid growth of urban areas in Utah, the UGS has responded to the increasing need of detailed surficial geologic mapping in urban areas of Utah to identify and assess geologic hazards pertinent to growth. With the collection and distribution of lidar elevation data in Utah, the UGS has sought and received funding via the USGS Earthquake Hazards Program, External Research Grants Program to re-map the WFZ, WVFZ (Hiscock and Hylland, 2015; McDonald and others, 2018), the East and West Cache fault zones, and the Bear Lake, Oquirrh, and Topliff Hills faults (in progress) at 1:10,000 or 1:24,000 scale, depending upon urban surface disturbance.

Over 40 years of paleoseismic trenching along the WFZ has resulted in unprecedented paleoseismic constraints of earthquake timing of a normal, intraplate fault system. Over the last decade or more, scientists have used this paleoseismic record to understand whether segment boundaries along the WFZ have controlled the rupture propagation of fault slip and, in turn, earthquake magnitude during large prehistoric earthquakes (Bennett and others, 2015; DuRoss and others, 2016). These data, paired with seismological observations and geophysical modeling, allowed the WGUEP to publish a thorough report of the earthquake probabilities for the greater Wasatch Front region of Utah, Idaho, and Wyoming (WGUEP, 2016).

Information for characterizing Quaternary-active faults and folds in Utah is continually incorporated into the Hazardous (Quaternary age) Faults layer of the *Utah Geologic Hazards Portal* (Utah Geological Survey, 2020). This online map and database started with the first statewide compilations by Anderson and Miller (1979) and Hecker (1993) of Quaternary faults and folds in Utah. In 2003, Hecker's comprehensive database was updated and expanded by Black and others (2003) as Utah's contribution to the creation of the USGS *Quaternary Fault and Fold Database of the United States*. The *Utah Quaternary Fault and Fold Database* was first published online in 2016 and was a stand-alone web-map and the main source for Quaternary fault geometries until the publishing of the *Utah Geologic Hazards Portal* (Utah Geological Survey, 2020) in spring 2020, in conjunction with this RI. Within the *Geologic Hazards Portal*, the mapping for this RI is nested under the Earthquake Hazards tab and labeled as Hazardous (Quaternary age) Faults for fault mapping and Surface Fault Rupture Special Study Zones for special study zones. The *Utah Geologic Hazards Portal* maintains general compatibility with the current *Quaternary Fault and Fold Database of the United States* (USGS, 2018) by using guidelines set by Haller and others (1993).

DATA SOURCES

Lidar Elevation Data

We used the 0.5-m-pixel WFZ lidar elevation datasets to create digital elevation models (DEMs) to identify surface fault traces and other linear geomorphic features. DEMs include slope-shade images (figure 3), slope maps, aspect maps, and hillshade images with different illumination directions and altitudes. We used GlobalMapper (v.18) software to generate these derivative images, as well as to generate topographic profiles and elevation contours, to investigate fault-scarp morphologies and to help distinguish fault-derived scarps and lineaments from Lake Bonneville shorelines and other geomorphic features.

Aerial Photography

Historical aerial photography stereo pairs from the *UGS Aerial Imagery Collection* (https://geodata.geology.utah.gov/imagery/) were used throughout the investigation. These photographs were most useful for mapping in urban areas, where surface fault traces have been obscured by modern ground disturbance (table 1). This collection includes low-sun-angle photographs of the fault zone, taken in the early 1970s that predate much of the residential, business, and infrastructure development along these fault zones (Cluff and others, 1970, compiled in Bowman and others, 2015). Additionally, for the Salt Lake Valley and other areas along the WFZ, the UGS collection includes historical aerial photos of various ages dating back to 1936.

Previous Geologic Mapping

Previous surficial geologic mapping was also useful for this project (table 2). USGS and UGS surficial geologic strip maps of the five central segments of the WFZ (Personius, 1990; Machette, 1992; Personius and Scott, 1992; Nelson and Per-

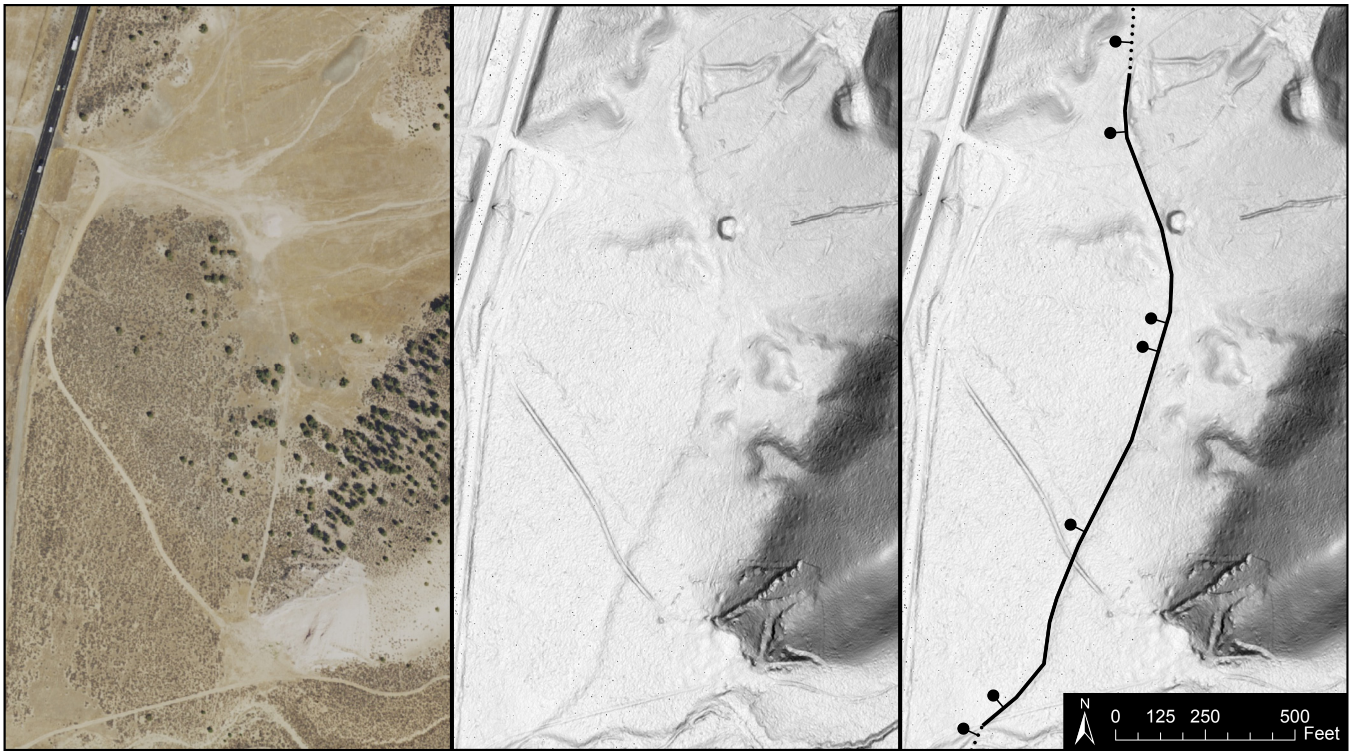

Figure 3. *Comparison between aerial photography (left) and lidar slope-shade images (center and right) from the Wasatch fault zone. The fault trace is faintly visible in the aerial photo, but far more visible on the slope-shade images. The right image shows the interpreted fault trace based on the slope-shade image (bar and ball on downthrown side of fault).*

sonius, 1993; Harty and others, 1997) were valuable references for our new lidar mapping. Additionally, 7.5-minute geologic quadrangle mapping from Utah and Idaho were used as a check of our fault-trace mapping. Some of the quadrangles are presently unpublished, specifically maps along the Salt Lake City segment (see individual plates in McDonald and others, 2018).

METHODS

Fault Mapping

Fault traces were mapped according to UGS best practices and the experience of the authors of each map. Each mapper used complementary techniques to best identify fault scarps indicative of previous surface fault rupture or deformation. The lidar DEMs and derivative products, such as slope-angle maps, slope-aspect maps, and topographic contours, proved to be the most useful tools when mapping most of the WFZ. Topographic contours generated from the lidar data were particularly useful when differentiating between fault scarps and paleo-shorelines, especially along the northern segments of the WFZ. In areas of extensive urban development, the oldest available (in some cases, pre-development) stereo-paired images were used to identify and map fault traces as a complement to the lidar data. These photos were particularly useful in identifying and accurately mapping fault traces that have been obscured by development, among other land uses. For the Salt Lake City segment in particular, due to extensive urban surface disturbance in some areas, 1:10,000-scale mapping was not possible, and mapping was performed at no greater than 1:24,000 scale.

Fault Attributes

Attributes are assigned within an Esri ArcGIS geodatabase and in the *Utah Quaternary Fault and Fold Database*. Fault attributes include fault zone name, fault section name, structure number, mapped scale, fault dip direction, slip sense, slip rate category, structure class, and structure age category. These attributes generally follow those established by Haller and others (1993) for the USGS *Quaternary Fault and Fold Database of the United States*.

Across Utah, basic attributes of faults are mainly determined from surficial mapping and lidar elevation data, and in some cases, refined by field reconnaissance, or natural or man-made exposure (e.g., dip direction, slip sense). The structure age category and slip rate category are more difficult to determine as paleoseismic data for most Utah Quaternary faults were not available. The exception to this is the WFZ, although several sections of each fault zone lack paleoseismic data. Updates of these attributes to the *Utah Geologic Hazards Portal* are completed using the most recent geologic information available.

Table 1. *Aerial photography sets used.*

Fault Zone	Segment	Imagery Year	Project Code	Agency	Link
WFZ	All	1970	1970 WF	Woodward-Lundgren & Associates	https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-632/ofr-632txt.pdf
WFZ	Nephi	1971	1971 EXP	USDA Forest Service	https://geodata.geology.utah.gov/imagery/
WFZ	Nephi, Provo	1953	1953 AMS	Army Mapping Service	https://geodata.geology.utah.gov/imagery/
WFZ	Nephi, Provo	1952	1952 CVX	USDA Agricultural Stabilization and Conservation Service	https://geodata.geology.utah.gov/imagery/
WFZ	Provo	1972	1972 CVX	USDA Agricultural Stabilization and Conservation Service	https://geodata.geology.utah.gov/imagery/
WFZ	Provo	2001	2001 614190	USDA Forest Service	https://geodata.geology.utah.gov/imagery/
WFZ	Provo	1938	1938 SLA	U.S. Bureau of Reclamation	https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-537/OFR-537.pdf
WFZ	Brigham City	1937	1937 AAH	USDA Agricultural Adjustment Administration	https://geodata.geology.utah.gov/imagery/
WFZ	Brigham City	1965	1965 AAH	USDA Agricultural Stabilization and Conservation Service	https://geodata.geology.utah.gov/imagery/
WFZ	Brigham City	1959	1959 AAH	USDA Commodity Stabilization Service	https://geodata.geology.utah.gov/imagery/
WFZ	Brigham City	1980	1980 614190	USDA Forest Service	https://geodata.geology.utah.gov/imagery/
WVFZ	NA	1937	1937 AAL	USDA Agricultural Adjustment Administration	https://geodata.geology.utah.gov/imagery/
WVFZ	NA	1971	1971 AAL	USDA Agricultural Stabilization and Conservation Service	https://geodata.geology.utah.gov/imagery/
WVFZ	NA	1958	1958 AAL	USDA Agricultural Stabilization and Conservation Service	https://geodata.geology.utah.gov/imagery/
WFZ	Salt Lake City	1937	1937 AAL	USDA Agricultural Adjustment Administration	https://geodata.geology.utah.gov/imagery/
WFZ	Salt Lake City	1958	1958 AAL	USDA Agricultural Stabilization and Conservation Service	https://geodata.geology.utah.gov/imagery/
WFZ	Salt Lake City	1971	1971 AAL	USDA Agricultural Stabilization and Conservation Service	https://geodata.geology.utah.gov/imagery/
WFZ	Salt Lake City	1946	1946 AAL	USDA Agricultural Adjustment Administration	https://geodata.geology.utah.gov/imagery/
WFZ	Salt Lake City	1963	1963 AAL	USDA Forest Service	https://geodata.geology.utah.gov/imagery/
WFZ	Salt Lake City	2001	2001 614190	USDA Forest Service	https://geodata.geology.utah.gov/imagery/

WFZ – Wasatch fault zone; WVFZ – West Valley fault zone; NA – not applicable

Table 2. *Geologic maps used.*

Fault Zone	Segment	Publication Year	Publisher	Authors	Title	Reference	Scale	Publication URL
WFZ	Malad City	1999	IGS	Link, P.K., and Stanford, L.R.	Geologic map compilation of the Pocatello 30' x 60' quadrangle	Idaho Geological Survey Technical Report 99-2	1:100,000	http://geology.isu.edu/maps/Pocatello_T-99-2-m.pdf
WFZ	Malad City	2001	IGS	Pope, A.D., Blair, J.J., and Link, P.K.	Geologic map compilation of the Wakley Peak quadrangle	Idaho Geological Survey Technical Report 01-4	1: 24,000	https://www.idahogeology.org/product/t-01-4
WFZ	Malad City	1991	USGS	Oriel, S.S., Platt, L.B., and Allmendinger, R.W.	Reconnaissance geologic map of the Elkhorn Peak quadrangle, Bannock and Oneida Counties, Idaho	USGS MF-2162	1: 24,000	https://pubs.er.usgs.gov/publication/mf2162
WFZ	Malad City	1949	University of Wisconsin	Hanson, A.M.	Geology of the southern Malad Range and vicinity in northern Utah	Ph.D. Dissertation, University of Wisconsin	1:38,400	
WFZ	Clarkston Mountain	2004	IGS	Long, S.P., Link, P.K., Janecke, S.U., and Rogers, D.W.	Geologic map of the Henderson Creek quadrangle, Oneida County, Idaho	IGS Technical Report T-04-3	1: 24,000	https://www.idahogeology.org/product/t-04-3
WFZ	Clarkston Mountain	2003	UGS	Biek, R.F., Oaks, R.Q., Janecke, S.U., Solomon, B.J., and Swenson Barry, L.M.	Geologic maps of the Clarkston and Portage 7.5' quadrangles, Box Elder and Cache Counties, Utah and Franklin and Oneida Counties, Idaho	UGS Map 194	1: 24,000	https://ugspub.nr.utah.gov/publications/geologicmaps/7-5quadrangles/M-194.pdf
WFZ	Collinston	1986	UGS	Oviatt, C.G.	Geologic map of the Cutler Dam quadrangle, Box Elder and Cache Counties, Utah	UGMS Map 91	1: 24,000	https://ugspub.nr.utah.gov/publications/geologicmaps/7-5quadrangles/M-91.pdf
WFZ	Collinston	1985	UGS	Davis, F.D.	Geologic map of the northern Wasatch Front, Utah	UGMS Map 53A	1: 24,000	https://ugspub.nr.utah.gov/publications/maps/m-53a.pdf
WFZ	Collinston	1990	USGS	Personius, S.F.	Surficial geologic map of the Brigham City segment and adjacent parts of the Weber and Collinson segments, Wasatch fault zone, Box Elder and Weber Counties, Utah	USGS Miscellaneous Investigations Series Map I-1979	1:50,000	https://pubs.usgs.gov/imap/2199/
WFZ	Collinston	1999	UGS	Jensen,, M.E., and King, J.K.	Geologic map of the Brigham City 7.5-minute quadrangle, Box Elder and Cache Counties, Utah	UGS Map 173	1: 24,000	https://ugspub.nr.utah.gov/publications/geologicmaps/7-5quadrangles/M-173.pdf
WFZ	Brigham City	1995	USGS	Dover, J.H.	Geologic map of the Logan 30' x 60' quadrangle, Cache and Rich Counties, Utah, and Lincoln and Uinta Counties, Wyoming	USGS Miscellaneous Investigations Series Map I-2210	1:100,000	https://pubs.er.usgs.gov/publication/i2210
WFZ	Brigham City	2018	UGS	McKean, A.P., Balgord, E.A., Yonkee, W.A., and Hiscock, A.I.	Geologic map of the Willard quadrangle, Box Elder County, Utah	UGS Map 278DM	1: 24,000	https://ugspub.nr.utah.gov/publications/misc_pubs/mp-06-8.pdf
WFZ	Brigham City	1985	USGS	Crittenden Jr., M.D., and Sorensen, M.L.	Geologic map of the North Ogden quadrangle and part of the Ogden and Plain City quadrangles, Box Elder and Weber Counties, Utah	USGS Miscellaneous Investigations Series Map I-1606	1: 24,000	https://pubs.er.usgs.gov/publication/i1606
WFZ	Brigham City	2012	UGS	Harty, K.M., Lowe, M., and Kirby, S.M.	Geologic map of the Plain City quadrangle, Weber and Box Elder Counties, Utah	UGS Map 235 DM	1: 24,000	https://ugspub.nr.utah.gov/publications/maps/m-253.pdf
WFZ	Brigham City	2016	UGS	Coogan, C.C., and King, J.K.	Interim geologic map of the Ogden 30' x 60' quadrangle, Box Elder, Cache, Davis, Morgan, Rich, and Summit Counties, Utah, and Uinta County, Wyoming	UGS Open-File Report 633DM	1:100,000	https://ugspub.nr.utah.gov/publications/geologicmaps/30x60quadrangles/ofr-653.pdf
WFZ	Weber	1990	USGS	Nelson, A.R., and Personius, S.F.	Surficial geologic map of the Weber segment, Wasatch fault zone, Weber and Davis Counties, Utah	USGS Miscellaneous Investigations Series Map I-2199	1:50,000	https://pubs.er.usgs.gov/publication/i2199?currow=195
WFZ	Weber	2004	UGS	Yonkee, W.A., and Lowe, M.	Geologic map of the Ogden quadrangle, Weber and Davis Counties, Utah	UGS Map 200	1: 24,000	https://ugspub.nr.utah.gov/publications/geologicmaps/7-5quadrangles/M-200.pdf
WFZ	Weber	2007	UGS	Solomon, B.J.	Surficial geologic map of part of the Kaysville quadrangle, Davis County, Utah	UGS Map 224	1: 24,000	https://ugspub.nr.utah.gov/publications/geologicmaps/7-5quadrangles/M-224.pdf
WFZ	Weber	in progress	UGS	Anderson, Z.W., McKean, A.P., and Yonkee, W.A.	Interim geologic map of the Bountiful Peak 7.5' quadrangle, Davis and Morgan Counties, Utah	UGS Open-File Report	1: 24,000	
WVFZ	Salt Lake City	2013	UGS	McKean, A.P., and Hylland, M.D.	Interim geologic map of the Baileys Lake quadrangle, Salt Lake and Davis Counties, Utah	UGS Open-File Report 624	1: 24,000	https://ugspub.nr.utah.gov/publications/open_file_reports/OFR-624.pdf
WVFZ	Salt Lake City	1992	USGS	Personius, S.F., and Scott, W.E.	Surficial geologic map of the Salt Lake City segment and parts of adjacent segments of the Wasatch fault zone, Davis, Salt Lake, and Utah Counties, Utah	USGS Miscellaneous Investigations Series Map I-2106	1:50,000	https://pubs.er.usgs.gov/publication/i2106
WVFZ	Salt Lake City	2011	UGS	Castleton, J.J., Elliot, A.H., and McDonald, G.N.	Geologic hazards of the Magna quadrangle, Salt Lake County, Utah	UGS Special Study 137	1: 24,000	https://ugspub.nr.utah.gov/publications/special_studies/SS-137/SS-137.pdf
WVFZ	Salt Lake City	2007	UGS	Solomon, B.J., Biek, R.F., and Smith, T.W.	Geologic map of the Magna quadrangle, Salt Lake County, Utah	UGS Map 216	1: 24,000	https://ugspub.nr.utah.gov/publications/geologicmaps/7-5quadrangles/m-216.pdf
WFZ, WVFZ	Salt Lake City	in prep	UGS	McKean, A.P.	Interim geologic map of the Salt Lake City North quadrangle, Salt Lake and Davis Counties, Utah	UGS Open-File Report	1: 24,000	

WFZ – Wasatch fault zone; WVFZ – West Valley fault zone

Table 2. *Continued.*

Fault Zone	Segment	Publication Year	Publisher	Authors	Title	Reference	Scale	Publication URL
WFZ, WVFZ	Salt Lake City	2017	UGS	McKean, A.P.	Interim geologic map of the Salt Lake City South quadrangle, Salt Lake County, Utah	UGS Open-File Report 676	1: 24,000	https://ugspub.nr.utah.gov/publications/open_file_reports/OFR-624.pdf
WFZ	Salt Lake City	in prep	UGS	Anderson, Z.W., McKean, A.P., and Yonkee, W.A.	Interim geologic map of the Fort Douglas quadrangle, Salt Lake and Davis Counties, Utah	UGS Open-File report	1: 24,000	
WFZ	Salt Lake City	1987	USGS	Van Horn, R., and Crittenden, M.J.	Map showing surficial units and bedrock geology of the Fort Douglas quadrangle and parts of the Mountain Dell and Salt Lake City North quadrangles, Davis, Salt Lake and Morgan Counties, Utah	USGS Miscellaneous Investigations Series Map I-1762	1: 24,000	https://pubs.er.usgs.gov/publication/i1762
WFZ	Salt Lake City	2018	UGS	McKean, A.P.	Interim geologic map of the Sugar House 7.5' quadrangle, Utah	UGS Open-File Report 687	1: 24,000	https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-687.pdf
WFZ	Salt Lake City	2018	UGS	McKean, A.P., and Solomon, B.J.	Interim geologic map of the Draper 7.5' quadrangle, Salt Lake and Utah Counties, Utah	UGS Open-File Report 683	1: 24,000	https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-683/ofr-683.pdf
WFZ	Provo	2005	UGS	Biek, R.F.	Geologic map of the Lehi quadrangle and part of the Timpanogos Cave quadrangle, Salt Lake and Utah Counties, Utah	UGS Map 210	1: 24,000	https://ugspub.nr.utah.gov/publications/geologicmaps/7-5quadrangles/M-210_Lehi.pdf
WFZ	Provo	2011	UGS	Constenius, K.N., Clark, D.L., King, J.K., and Ehler, J.B.	Interim geologic map of the Provo 30' x 60' quadrangle, Utah, Wasatch, and Salt Lake Counties, Utah	UGS Open-File Report 586DM	1: 62,000	https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-586.pdf
WFZ	Provo	1992	USGS	Machette, M.N.	Surficial geologic map of the Wasatch fault zone, eastern part of Utah Valley, Utah County and parts of Salt Lake and Juab Counties, Utah	USGS Miscellaneous Investigation Series Map I-2095	1:50,000	https://pubs.er.usgs.gov/publication/i2095
WFZ	Provo	2010	UGS	Solomon, B.J., Constenius, K.K., and Machette, M.N.	Interim geologic map of the Orem quadrangle, Utah County, Utah	UGS Open File Report 567	1: 24,000	https://ugspub.nr.utah.gov/publications/open_file_reports/OFR-567.pdf
WFZ	Provo	2009	UGS	Solomon, B.J., and Machette, M.N.	Geologic map of the Provo 7.5' quadrangle, Utah County, Utah	UGS Map 233	1: 24,000	https://ugspub.nr.utah.gov/publications/geologicmaps/7-5quadrangles/M-233.pdf
WFZ	Provo	2008	UGS	Solomon, B.J., and Machette, M.N.	Interim geologic map of the southwest (Utah Valley) part of the Springville quadrangle, Utah County, Utah	UGS Open File Report 524	1: 24,000	https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-524.pdf
WFZ	Provo	2007	UGS	Solomon, B.J.	Geologic map of the Spanish Fork quadrangle, Utah County, Utah	UGS Map 227	1: 24,000	https://ugspub.nr.utah.gov/publications/geologicmaps/7-5quadrangles/M-227.pdf
WFZ	Provo, Nephi	2009	UGS	Clark, D.L.	Geologic map of the West Mountain quadrangle, Utah County, Utah	UGS Map 234	1: 24,000	https://ugspub.nr.utah.gov/publications/geologicmaps/7-5quadrangles/M-234.pdf
WFZ	Provo, Nephi	2015	UGS	Dinter, D.A.	Paleoseismology of faults submerged beneath Utah Lake [poster] *in* Lund, W.R., editor, Proceedings Volume, Basin and Range Province Seismic Hazards Summit III	UGS Miscellaneous Publication 15-5		https://ugspub.nr.utah.gov/publications/misc_pubs/mp-15-5/mp-15-5_proceedings.pdf
WFZ	Nephi	1989	Utah County	Robinson, R.M.	Draft mapping of faults on the Slate Jack Canyon quadrangle, Utah			
WFZ	Nephi	2010	UGS	Solomon, B.J.	Interim geologic map of unconsolidated deposits in the Payson Lakes quadrangle, Utah County, Utah	UGS Open-File Report 571	1: 24,000	https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-571.pdf
WFZ	Nephi	1997	UGS	Harty, K.M., Mulvey, W.E., and Machette, M.N.	Surficial geologic map of the Nephi segment of the Wasatch fault zone, eastern Juab County, Utah	UGS Map 170	1:50,000	https://pubs.usgs.gov/imap/2095/report.pdf
WFZ	Nephi	2010	UGS	Solomon, B.J.	Interim geologic map of unconsolidated deposits in the Santaquin 7.5' quadrangle, Utah and Juab Counties, Utah	UGS Open-File Report 570	1: 24,000	https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-570.pdf
WFZ	Nephi	2004	UGS	Felger, T.J., Machette, M.N., and Sorensen, M.L.	Provisional geologic map of the Mona quadrangle, Juab and Utah Counties, Utah	UGS Open-File Report 428	1: 24,000	https://ugspub.nr.utah.gov/publications/open_file_reports/OFR-428.pdf

WFZ – Wasatch fault zone; WVFZ – West Valley fault zone

Structure age categories in the *Utah Geologic Hazards Portal* and the USGS *Quaternary Fault and Fold Database of the United States* reflect the best available timing information for the most recent surface-rupturing earthquake on that fault trace. The last suspected paleo-event (Haller and others, 1993; Crone and Wheeler, 2000) is inferred from fault surface expression, previous Quaternary geologic mapping, reconnaissance of fault scarps, and paleoseismic data (where available). The UGS uses the age categories framework originally established by Haller and others (1993) with the addition or revision of age categories based on trends within the community:

- Latest Pleistocene to Holocene – a fault whose movement in the past 15,000 years before present (ybp) (Western States Seismic Policy Council [WSSPC], 2018) has been large enough to break the ground surface.
- Late Quaternary – a fault whose movement in the past 130,000 ybp (WSSPC, 2018) has been large enough to break the ground surface.
- Middle Quaternary – a fault whose movement in the past 750,000 ybp (WSSPC, 2018) has been large enough to break the ground surface.
- Quaternary – a fault whose movement in the past 2,600,000 ybp (Walker and others, 2018) has been large enough to break the ground surface.

Special-Study Zone Delineation

We delineated surface-fault-rupture special-study zones along the WFZ and associated fault traces mapped in Utah in accordance with Utah State Code 79-3-202(f) that define areas where additional investigation is warranted to evaluate the risk from surface faulting prior to residential, business, and infrastructure development. Together with the fault traces, these special-study zones are critical to the creation and implementation of municipal and county geologic-hazard ordinances associated with hazardous faults and understanding surface-rupturing hazard and associated risk.

We categorized Quaternary faults along the WFZ as "well constrained," "moderately constrained," or "buried or inferred" traces. We considered a fault well constrained if its trace is clearly detectable as a physical feature on the ground surface. We mapped faults as moderately constrained, where a geologic feature or geomorphic expression of a fault scarp exists, but a precise location of the fault is not evident. We mapped inferred faults where based on geologic evidence a fault should exist but no surface expression is evident (Bryant and Hart, 2007). For well-constrained faults, the special-study-area zones extend 500 feet (152 m) on the downthrown side and 250 feet (76 m) on the upthrown side of each fault trace. For moderately constrained and buried or inferred faults, the special study zones extend 1000 feet (305 m) on each side of the suspected fault trace. The special-study area dimensions are based on the *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah* (Lund and others, 2016).

Several criteria were established for distinct circumstances pertaining to fault-related special-study zones. For traces of buried or inferred faults less than 1000 feet (305 m) long that lie between and on-trend with well-constrained faults, the well-constrained fault special-study-area zone was used (figure 4A). For buried or inferred faults greater than 1000 feet (305 m) long, the special study area includes 1000 feet (305 m) on both side of the fault. For inferred faults at the end of a mapped fault trace that are longer than 1000 feet (305 m), we used an inferred fault special-study-zone area (figure 4B). In areas where a buffer "window" exists (a space between the buffer zones of two sub-parallel fault traces), we include the window in the buffer zone if its width is less than the greater of the two surrounding buffers (figure 4c). In situations where the ground expression of the fault scarp is wider (in mapview) than the fault special-study area (750 feet [229 m]) and does not cover the entire fault scarp, the 1000-foot (305-m) buffer was used. This is only applicable in one location on the southern end of the Weber segment east of Bountiful and in two locations on the Salt Lake City segment along the East Bench fault where the fault is well constrained. Where two or more well-constrained faults are antithetic to, and within 250 feet of each other, the buffer zone created for the primary fault supersedes zones for any secondary faults. For example, a 500-foot (152 m) downthrown side special-study area on a main fault trace may extend beyond the 250-foot (76 m) upthrown side special-study area associated with an antithetic fault, and therefore, be used for the special study zone.

Identification of Potential Paleoseismic Investigation Sites

We analyzed each fault segment of the WFZ for potential paleoseismic investigation sites (table 3) as part of our fault-trace mapping (figures 5, 6, and 7). Sites were identified based on: (1) the presence of a normal, preferably single fault scarp, (2) scarp heights logistically reasonable for excavating a paleoseismic trench (roughly 2–30 feet [0.5–10 m]), (3) the displacement of young deposits (late Pleistocene to Holocene), and (4) surfaces and scarps mostly undisturbed from residential, business, and infrastructure development activities. Sites that could fill in data gaps between previous paleoseismic investigations and sites within areas of ongoing development were considered even if they did not meet all four criteria. Due to the rural and undeveloped nature of several WFZ segments, many sites are identified in this report but are not discussed in detail.

Because paleoseismic investigation opportunities are limited by funding availability and time constraints, the UGS works to maintain a relationship with local geologic and en-

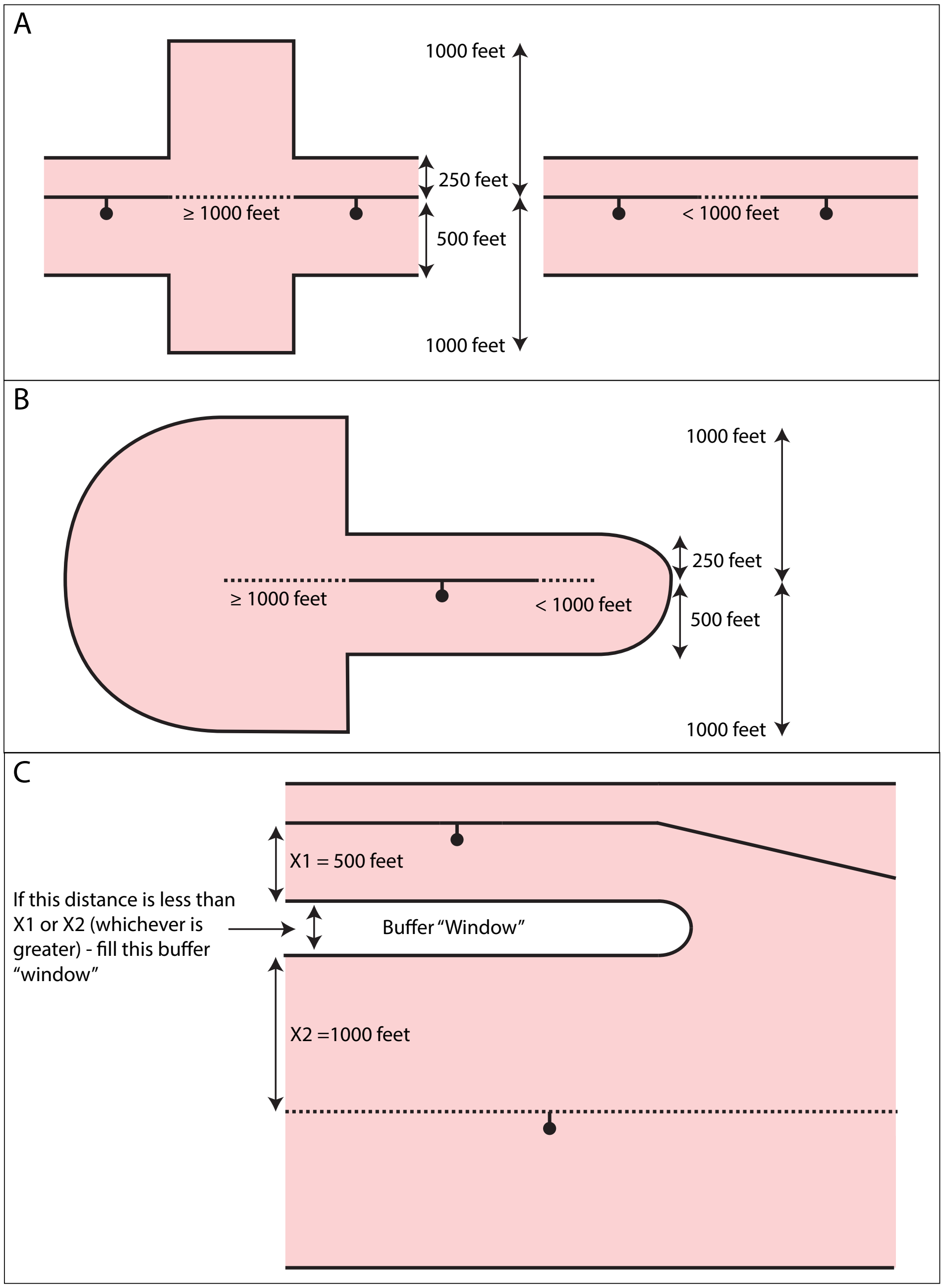

Figure 4. *Examples of special circumstances used when creating surface-fault-rupture special-study zones (after Lund and others, 2016).* ***A)*** *Where an inferred or approximately located fault trace is mapped continuously between two well-located faults and the length of the inferred or approximately located traces is less than 100 feet, the well-located buffer widths will be used.* ***B)*** *Where a well-located fault trace ends and is mapped with a short (less than 1000 feet) inferred or approximately located trace on the end, the well-located buffer width will be used.* ***C)*** *Where a buffer "window" between two fault trace special-study zones occurs, if the "window" width is less than the greater of the two buffer widths on either side of it, fill the buffer "window" making it part of the special-study zone.*

gineering consultants who conduct trenching investigations for clients along the fault, particularly in Salt Lake Valley. The UGS is often invited to visit consultant trenches for a few hours to observe and document faulting. While not as useful as a full paleoseismic research investigation, these site visits still provide useful information in areas where we will most likely never be able to conduct a full research-level investigation.

FAULT MAPPING AND POTENTIAL PALEOSEISMIC SITES BY SEGMENT

The main features mapped along the WFZ are topographic scarps interpreted to be formed by past surface-rupturing earthquakes. The following sections detail specific datasets and how they were utilized to best interpret the location, extent, and age category of faulting for each segment of the WFZ and describe a few of the most preferred paleoseismic trenching sites.

Table 3. *Potential paleoseismic study sites.*

Site Number	Fault Zone	Fault Segment	Comments	NAD83 UTM Zone 12N	
				Northing	Easting
MCS-01	WFZ	Malad City	Scarp on inset surface; may be one of 2 or 3 strands.	4696742	392081
MCS-02	WFZ		Good scarp with antithetic; footwall surface graded up drainage.	4690810	387904
MCS-03	WFZ		Fault cuts inset surface; complex site.	4690308	387635
MCS-04	WFZ		Approximately 3-meter high, west-facing scarp on alluvium.	4677308	395705
CMS-01	WFZ	Clarkston Mtn	Subtle scarp on alluvium. Footwall may be af2 or older.	4645874	403697
CMS-02	WFZ		Elgrove Canyon trailhead; best potential Clarkston Mountian site (figure 6).	4643537	404720
CMS-03	WFZ		Potential scarp on older fan deposits.	4642114	404395
CS-01	WFZ	Collinston	Scarp(s) on post-Bonneville fan deposits.	4614606	410885
CS-02	WFZ		Short scarp on older deposits.	4611755	411967
BCS-01	WFZ	Brigham City	Scarp on late Pleistocene(?) fan, possible graben; at Brigham City/Collinston segment boundary.	4610699	411825
BCS-02	WFZ		Subtle scarp on young alluvial fan; possible shoreline.	4608713	411792
BCS-03	WFZ		Offset shoreline crest; scarps on post-Bonneville fan to south.	4606461	413116
BCS-04	WFZ		Graben in older fan deposits.	4604829	413877
BCS-05	WFZ		Scarp cutting young fan alluvium; near Brigham City/Weber segment boundary.	4577860	418056
WS-01	WFZ	Weber	Scarp cutting young fan alluvium; at Brigham City/Weber segment boundary.	4577848	419802
WS-02	WFZ		Several well-defined scarps in area; cutting alluvial fans of various ages.	4577120	420573
WS-03	WFZ		Several scarps cutting young alluvium.	4575796	421590
WS-04	WFZ		Well-defined scarp sheltered in drainage; potentially shoreline escarpment.	4572700	421857
WS-05	WFZ		Scarp cutting young alluvium.	4571111	420964
WS-06	WFZ		Graben with well-defined antithetic scarp.	4569379	420743
WS-07	WFZ		Two well-defined scarps cutting alluvium.	4564935	422259
WS-08	WFZ		Graben in Lake Bonneville deposits.	4553147	424457
WS-09	WFZ		Well-defined scarp in younger alluvium.	4552616	424308
WS-10	WFZ		Several relatively undisturbed scarps.	4548870	424216
WS-11	WFZ		Scarp cutting younger alluvium.	4544771	424189
WS-12	WFZ		Well-defined scarp on undeveloped lot in residential area.	4526478	428071
WS-13	WFZ		Relatively undisturbed scarp in residential area.	4523256	426595
WS-14	WFZ		Well-defined scarp in colluvium; potential for older events.	4522560	427768
WS-15	WFZ		Possible site on northern extent of Warm Springs fault, very subtle scarp in lateral spread.	4525352	423041
WVFZ-01	WVFZ	West Valley	Scarp in waste dump lot, could be slightly modified, only northern west-dipping Taylorsville fault.	4511870	420352
WVFZ-02	WVFZ		Empty lot, undisturbed scarp, best sites on northern Granger fault.	4511332	416322
WVFZ-03	WVFZ		Empty lot, undisturbed scarp, best sites on northern Granger fault.	4511122	416353
WVFZ-04	WVFZ		Empty lot, undisturbed scarp, best sites on northern Granger fault.	4510950	416628
WVFZ-05	WVFZ		Empty lot, undisturbed scarp, southern Granger fault.	4506218	418214
WVFZ-06	WVFZ		Redwood Road, previously trenched, disturbed site, southern Taylorsville fault.	4504079	420315
SLCS-01	WFZ	Salt Lake City	Empty lot, southern Warm Springs fault.	4514586	424652
SLCS-02	WFZ		Golf course on East Bench fault, need ground penetrating radar (GPR) to assess site.	4507446	427105
SLCS-03	WFZ		Golf course on fault west of East Bench fault, need ground penetrating radar (GPR) to assess site.	4507165	426236
SLCS-04	WFZ		Photomapped scarp, city park land.	4487689	430986
SLCS-05	WFZ		Clean scarp, city park land, undisturbed.	4487678	431034
SLCS-06	WFZ		Clean scarp, city park land, undisturbed.	4487656	431077
SLCS-07	WFZ		Open lot, uncomplicated zone of faulting.	4486279	429631
PS-01	WFZ	Provo	Scarp in complex zone of faulting cutting older fan; vegetated area.	4477748	436151
PS-02	WFZ		Scarp at mouth of canyon in young alluvium. Disturbance from roads, but seems minimal.	4472085	437543
PS-03	WFZ		Scarp in complex zone of faulting cutting older fan; vegetated area.	4467831	440712
PS-04	WFZ		Scarp at mouth of canyon in alluvium. Vegetated area; close to parking lot.	4465897	442570
PS-05	WFZ		Scarp in young alluvium just north of wetlands (figure 6); state owned land.	4447889	448517
PS-06	WFZ		Scarp on west side of West Mountain, scarp cutting young alluvium, could also trench north of here.	4440624	428306
PS-07	WFZ		Slightly disturbed site on Benjamin fault, near canal in field, could trench north or south from here.	4435738	437257

WFZ - Wasatch fault zone; WVFZ - West Valley fault zone

Table 3. Continued.

Site Number	Fault Zone	Fault Segment	Comments	NAD83 UTM Zone 12N	
				Northing	Easting
PS-08	WFZ	Provo	Relatively undisturbed trench site on Benjamin fault, in zone of distributed faulting.	4431076	438452
PS-09	WFZ		Narrow graben near Woodland Hills, clean scarp, could trench across entire graben. Potential for shallow bedrock. Could also likely trench north or south.	4427955	444219
PS-10	WFZ		Scarp on young alluvium in Loafer Canyon, undisturbed, forested.	4427761	443450
PS-11	WFZ		Large scarp cutting young alluvium, slight disturbance near base of scarp.	4429731	445552
PS-12	WFZ		Scarp on alluvium in Santaquin Canyon, good site near Provo/Nephi segment boundary.	4421313	435776
NS-01	WFZ	Nephi	Undisturbed scarp on alluvium, potential for shallow bedrock.	4401274	429074
NS-02	WFZ		Large scarp on alluvim, undisturbed, eastern fault in small graben.	4402680	429439
NS-03	WFZ		Large undisturbed scarp (8-10 m high), small drainage basin, potential for shallow bedrock.	4404118	429557
NS-04	WFZ		Undisturbed scarp in mouth of Willow Creek, previously trenched.	4405699	429921
NS-05	WFZ		Scarp on alluvium, mouth of small drainage, potential for shallow bedrock.	4406460	429743
NS-06	WFZ		Scarp away from range front on Mendenhall fault, undisturbed.	4415621	429769

WFZ - Wasatch fault zone; WVFZ - West Valley fault zone

Malad City Segment

The Malad City segment (MCS) is the northernmost segment of the WFZ, extending from just north of the Utah-Idaho border along the west flank of the Malad Range to the northern end of Elkhorn Mountain north of Malad City, Idaho. Previous mappers (Cluff and others, 1974; Machette and others, 1992) terminated the fault at the northern end of the Malad Range. More recent mapping (Pope and others, 2001) indicates the fault extends farther north and west along the western flank of Elkhorn Mountain.

We mapped several well-constrained fault traces along the northern part of the MCS along the western flank of Elkhorn Mountain. These scarps are on alluvial-fan deposits that are likely mid- to late Pleistocene in age; however, the fan ages are not well constrained. Modern drainages are incised up to 50–65 feet (15–20 m) below the alluvial pediments that are typically cored by Tertiary volcaniclastic bedrock. Previous mapping showed the faults as either cutting Tertiary deposits or as Quaternary alluvium on the hanging wall against Tertiary bedrock on the footwall. Our lidar mapping of the faults, together with field reconnaissance, indicates several locations where faults displace likely coeval mid to late Pleistocene alluvial surfaces. Further, we identified two sites at the mouths of two unnamed drainages on the northwest flank of Elkhorn Mountain where fault scarps displace terraces a few meters above the modern drainages that are inset into, and thus younger than, the inferred mid to late Pleistocene surfaces.

We identified four potential paleoseismic investigation sites near the northern end of the MCS west of Elkhorn Mountain. We found no well-constrained fault scarps along the southern part of the MCS along the west flank of the Malad Range. To date, there have been no paleoseismic investigations performed for the MCS, making it a good candidate for future investigations.

Clarkston Mountain Segment

The Clarkston Mountain segment (CMS) is the shortest WFZ segment and is mostly defined by a steep, linear range front escarpment with predominantly moderately located or inferred faults. The few well-constrained fault traces occur mostly on pre-Lake Bonneville (late Pleistocene) deposits. Previous mapping consisted of primarily moderately constrained faults defined by faceted spurs and brecciated and cemented “flat irons” along the range front with local, discontinuous scarps in likely late Pleistocene deposits. Our lidar mapping revealed some additional younger escarpments, including a 3.2-foot high (1 m) fault scarp at the very northern end of the segment near Henderson Creek that displaces several Lake Bonneville transgressive shorelines, including a highstand platform. Farther south are several relatively short, well-constrained fault traces near the southern end of the segment.

We identified three potential paleoseismic investigation sites at the southern end of the segment. The best expressed site is at the mouth of Elgrove Canyon (table 3, CMS-02), where a 21-foot (6.4-m) high scarp offsets alluvium and has potentially correlative surfaces on both the footwall and hanging wall (figure 6). To date, paleoseismic data for the CMS are limited to field reconnaissance and scarp profiling (Hylland, 2007a), making it a good candidate for future investigations.

Collinston Segment

The Collinston segment (CS) extends from the southern end of Clarkston Mountain to the Coldwater Canyon reentrant east of Honeyville. The CS is poorly constrained and mostly expressed as an inferred or moderately located fault zone. Previous mappers found no fault scarps on post-Lake Bonneville deposits (Cluff and others, 1974; Machette and others, 1992). Our mapping using high-resolution lidar data did not reveal any previously unrecognized fault traces for most of the seg-

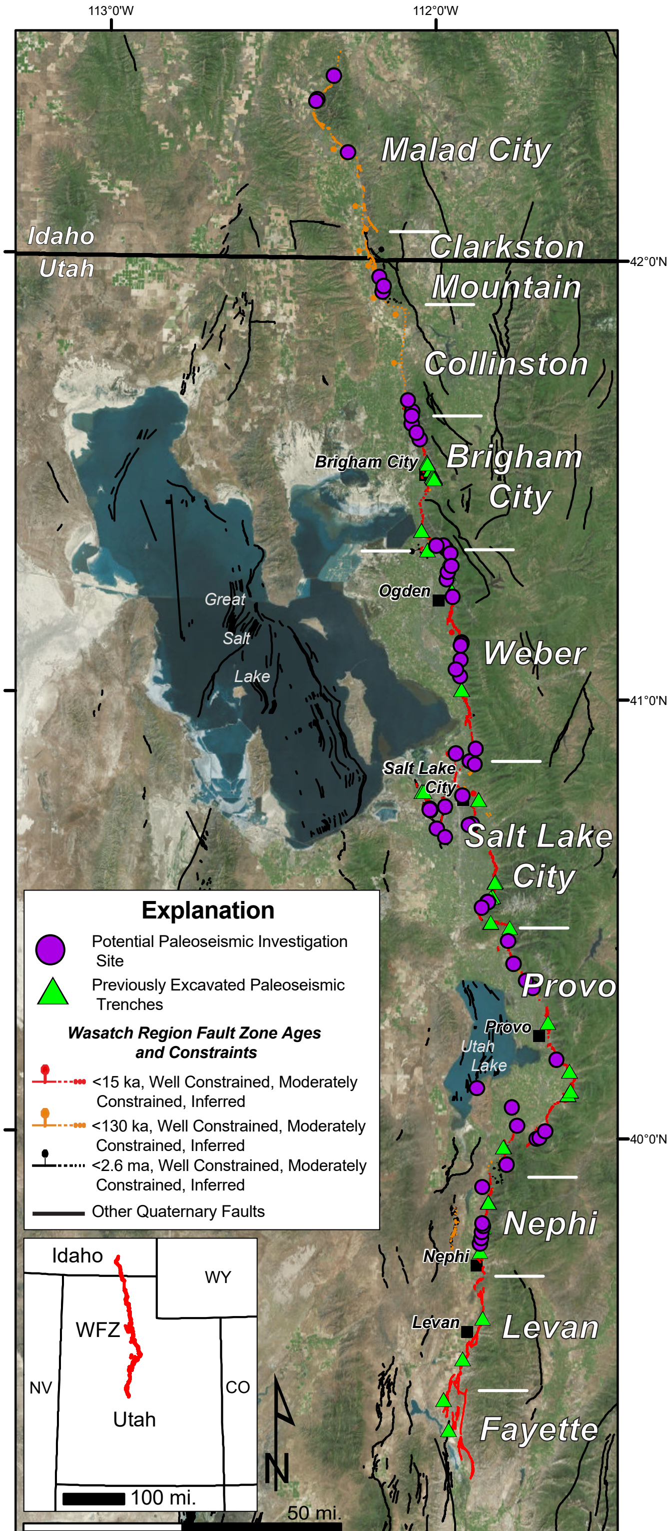

Figure 5. Potential paleoseismic trenching sites identified in this investigation along the Wasatch fault zone. Previous investigations in green. WFZ segment names in white.

ment. Machette and others (1992) inferred the lack of young fault scarps along this length of the WFZ may be due to a transfer of slip to the east onto the West Cache fault zone along the west side of Cache Valley, where Holocene surface faulting has been documented (Black and others, 2000).

At the southern end of the CS, where its boundary with the Brigham City segment (BCS) is defined within the Coldwater Canyon reentrant, there are several well- and moderately defined scarps in an area of complex faulting (Personius, 1990; Machette and others, 1992; Hylland, 2007a). Several fault scarps of varying ages are visible on lidar-derived imagery, including many that are several meters high, on presumed mid- to late Pleistocene surfaces. The eastern margin of the reentrant is delineated by a semi-contiguous fault that is well defined where it displaces pre-Bonneville deposits. Some fault scarps have been modified by Lake Bonneville, including up to 160-foot-high (50 meter) escarpments, the bases of which have been enhanced by the highstand shoreline. We infer the elevated surfaces were emplaced by faulting and Lake Bonneville obscured the youngest fault scarps. East of these escarpments, a well-preserved graben displacing the same surfaces is evident that similarly lacks fault scarps cutting the youngest local deposits.

We identified three potential paleoseismic trench sites in the Coldwater Canyon reentrant. The well-constrained scarps are on likely late Pleistocene or older alluvial-fan deposits, but appear relatively well preserved. As with the CMS, paleoseismic data for the CS are limited to field reconnaissance and scarp profiling (Hylland, 2007a), making it a good candidate for future investigations.

Brigham City Segment

The Brigham City segment (BCS) is the northernmost of the five central WFZ segments and has well-constrained scarps in Holocene and older deposits along its entire length. The character of the segment changes from south to north. To the north, scarps become less sharp/more weathered, consistent with decreased fault activity, and the fault traces become less continuous, shorter, and fewer.

The lidar data facilitated more detailed mapping of the BCS, especially from Box Elder Canyon south to Long Bench, where the BCS angles to the east-southeast and overlaps the north end of the Weber segment (WS) ~ 1 mile (1.6 km) to the east. Notably, we identified several geomorphically young scarps at the southern terminus of the BCS, in addition to several clusters of weathered scarps on mid- to late Pleistocene surfaces.

The BCS has been the subject of several previous paleoseismic investigations (Personius, 1991; McCalpin and Forman, 2002; DuRoss and others, 2012). However, both spatial and temporal gaps in the earthquake timing data still exist for the segment. The BCS has local residential, business, and infra-

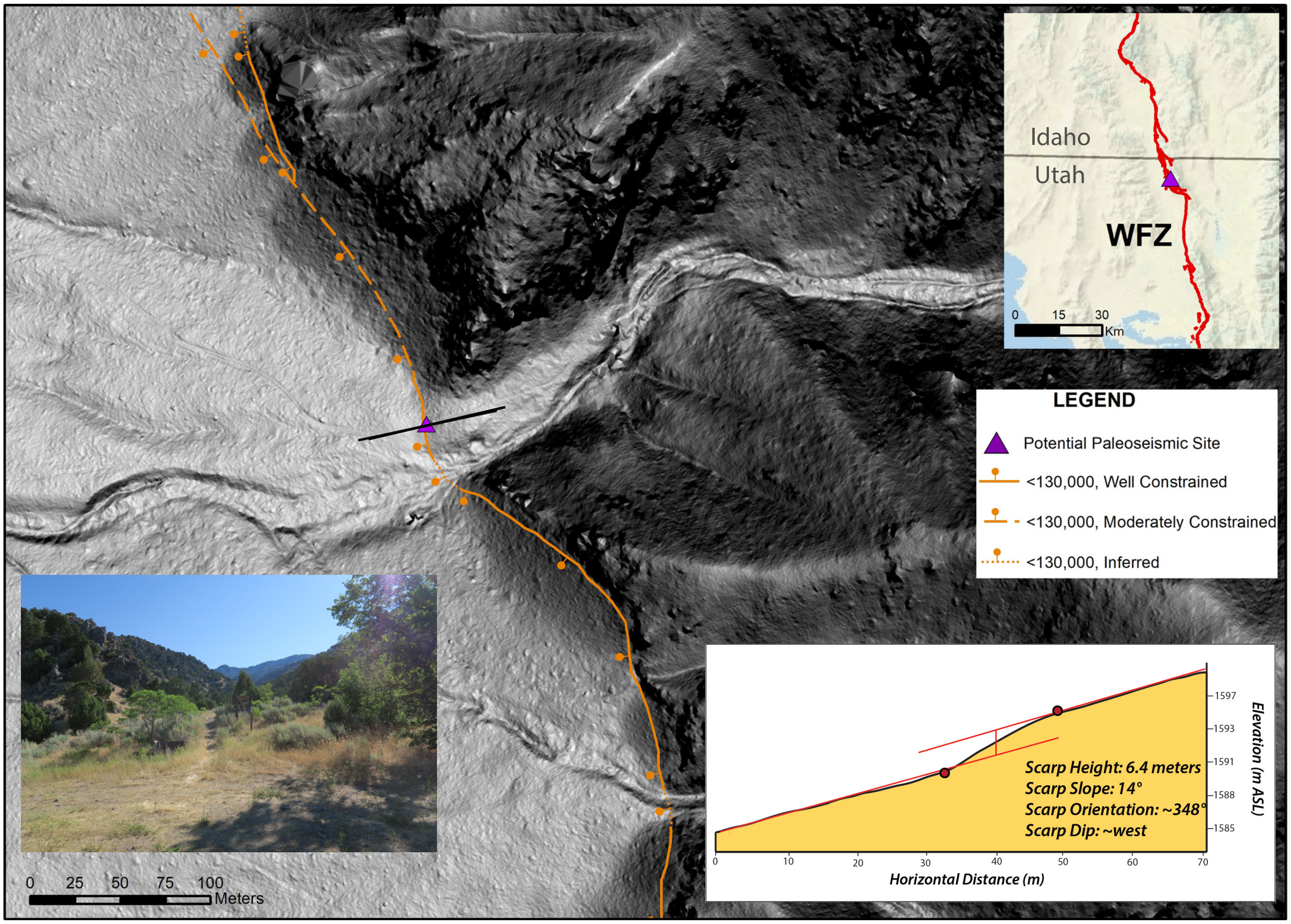

Figure 6. *Example of potential paleoseismic trench site at the mouth of Elgrove Canyon on the Clarkston Mountain segment, Wasatch fault zone. The scarp vertical height is 6.4 meters and dips to the west (scarp profile location shown by black line; bar and ball on downthrown side of fault). Very little apparent anthropogenic modification has occurred at this site, making it a good candidate for a paleoseismic investigation.*

structure development in several places, but many undisturbed scarps remain that upon further investigation could potentially be trenched for paleoseismic data. We identified five potential paleoseismic trench sites (table 3; BCS-01-05) focusing on the ends of the segment where data are lacking and may provide information about partial- and multi-segment ruptures.

Weber Segment

The WS has been active throughout the Holocene and has fault scarps that are young-looking and high, and a well-constrained main trace that is relatively continuous. For most of its length, the WS is a complex and often distributed zone of both synthetic and antithetic scarps cutting Lake Bonneville deposits and younger alluvium. Much of the WS is already disturbed by residential, business, and infrastructure development, somewhat limiting the usefulness of high-resolution lidar for improved fault mapping, although we did map previously unrecognized traces and refined and improved the level of detail of many scarps using both lidar-derived imagery and georeferenced aerial photos supplemented with limited field checking.

At the northern end of the WS north of North Ogden Canyon in an area of rapid residential growth where, until recently, little disturbance from development had occurred, we mapped several short but well-constrained fault traces. Many of these faults occur as well-delineated, clustered zones on young alluvial fans from Maguire Canyon to Rice Creek. Farther south from North Ogden Canyon to Weber Canyon, the lidar-derived imagery revealed a few previously unmapped scarps and allowed us to refine mapping of the fault traces that were previously mapped (Nelson and Personius, 1993; Yonkee and Lowe, 2004). The WS south of Weber Canyon forms a relatively straight, south to southeast-trending, complex zone of faults locally forming narrow and sometimes deep grabens with young and high scarps on Lake Bonneville and younger alluvial deposits. The fault zone continues south-southeast mostly along the range front. The southern part of the WS is a complex and distributed zone of both synthetic and antithetic faults on mostly Lake Bonneville deposits. Dense residential, business, and infrastructure development of the Bountiful City area limits the lidar's usefulness, but it, together with 1950s and older georeferenced aerial photos, were useful for mapping faults scarps and interpreting questionable lineaments and geomorphic features.

Potential paleoseismic trench sites for most of the WS are limited due to urban development along the fault. Previous investigations (Swan and others, 1981a, 1981b, 1981c; Nelson and others, 2006; DuRoss and others, 2009) have improved the paleoseismic record of the segment, but like the Brigham City segment, spatial and temporal data gaps still exist. Additional data are also needed near ends of the segment, particularly the southern end, to improve our understanding of segment boundaries, including possible partial- and multi-segment ruptures. The lidar data helped identify a few potential trench sites worth further investigation to determine their viability. Several sites within urbanized areas appear relatively undisturbed, but require additional field reconnaissance and scarp analysis to evaluate their geologic and paleoseismic context.

Salt Lake City Segment and the West Valley Fault Zone

The Salt Lake City segment (SLCS) and the 11-mile (18 km) long WVFZ comprise the east and west bounding faults of a large (2 to 8-mile-wide) intrabasin graben that crosses the heavily urbanized and densely populated Salt Lake Valley. The WVFZ has long been considered an antithetic structure to the SLCS and recent paleoseismic investigaitons indicate episodic coseismic rupture of the WVFZ with the SLCS (Hylland and others, 2014, 2017; DuRoss and Hylland, 2015).

The SLCS is subdivided into three subsections separated by left steps, from north to south: the Warm Springs, East Bench, and Cottonwood faults. The Warm Springs fault lies along the west end of the Salt Lake salient, which defines the SLCS-WS segment boundary. On the south end of the SLCS and Salt Lake Valley, the Cottonwood fault terminates at the Traverse Mountains, marking the SLCS-Provo segment boundary. Recent USGS NEHRP-funded research has been conducted by Boise State University to image subsurface fault locations between the Warm Springs and East Bench faults within and near downtown Salt Lake City using shallow seismic methods (Liberty, 2016). These data will help us identify new faults and more accurately map fault traces in this densely populated and highly developed area. Data from that project are pending final interpretation and thus not included in this report, but will be integrated into the *Utah Geologic Hazards Portal* upon publication.

The WVFZ is subdivided into two subparallel main traces known as the Granger (western trace) and Taylorsville (eastern trace) faults. Most scarps on the WVFZ are only 1.5–5 feet (0.5–1.5 m) high but rise to a maximum height of 20 feet (6 m) on the southern end of the Granger fault (Hylland and others, 2014).

Geologic mapping of 7.5' quadrangles along the SLCS and WVFZ is complete or is currently being completed by UGS geologic mappers (Baileys Lake [McKean and Hylland, 2019], Salt Lake City North [in progress], Fort Douglas [in progress], Salt Lake City South [McKean, 2017], Sugar House [McKean, 2018], and Draper [McKean and Solomon, 2018]). Fault trace data for the Salt Lake City North, Fort Douglas, Salt Lake City South, Sugar House, and Draper quadrangles comes from unpublished or open-file maps, and is therefore considered preliminary and may change when final maps are published and will be updated in the *Utah Geologic Hazards Portal* as this new mapping is finalized.

The SLCS has been the subject of numerous paleoseismic investigations (Swan and others, 1981a, 1981b, 1981c; Black and others, 1996; Schwartz and Lund, 1988; McCalpin, 2002; DuRoss and others, 2014, 2018; Hiscock and DuRoss, 2016). However, most of this work has focused on the Cottonwood fault, except for one investigation on the northern East Bench fault (DuRoss and others, 2014). Disturbance of the original fault traces by mining and urbanization on all three SLCS faults severely limits future conventional paleoseismic trench investigations. Several potential sites for paleoseismic investigation on the East Bench and Warm Springs faults would benefit from geophysical imaging to confirm suitability of future trench sites. On the Cottonwood fault, potential sites for paleoseismic investigation may require multiple trenches through a complex zone of faulting.

Several paleoseismic investigations have been performed for the WVFZ (Keaton and others, 1987; Keaton and Currey, 1989; Solomon, 1998; Hylland and others, 2014, 2017), but more data are needed to further understand faulting behavior of the WVFZ and its relation to faulting on the SLCS. Several potential paleoseismic investigation sites exist on the WVFZ. Most of these sites are not ideal for paleoseismic trenching because the scarps have been disturbed, but these may be the only option for further investigation of the WVFZ. One site on the Granger fault (table 1 – WVFZ-05) where it crosses a private, vacant lot and appears relatively undisturbed, has good potential for a paleoseismic investigation barring property access constraints.

Provo Segment

The Provo segment (PS) has been well studied (table 2; Lund and others, 1991; Lund and Black, 1998; Olig and others, 2011; Bennett and others, 2014, 2018; Hiscock and others, 2015) and like the Salt Lake City and Weber segments, has experienced extensive surface modification due to decades of urban development. Much of the PS was mapped in preparation for paleoseismic trenching at the Alpine site on the northern PS and the Flat Canyon site on the southern PS. High-resolution lidar elevation data generally improved the detail of mapping for distributed faulting in Quaternary deposits along the PS. Fault scarps, especially in grabens that were never identified or poorly characterized, were mapped in detail, and some fault traces that were not previously identified were mapped. In areas of recent residential, business, and infrastructure development, where lidar data are less use-

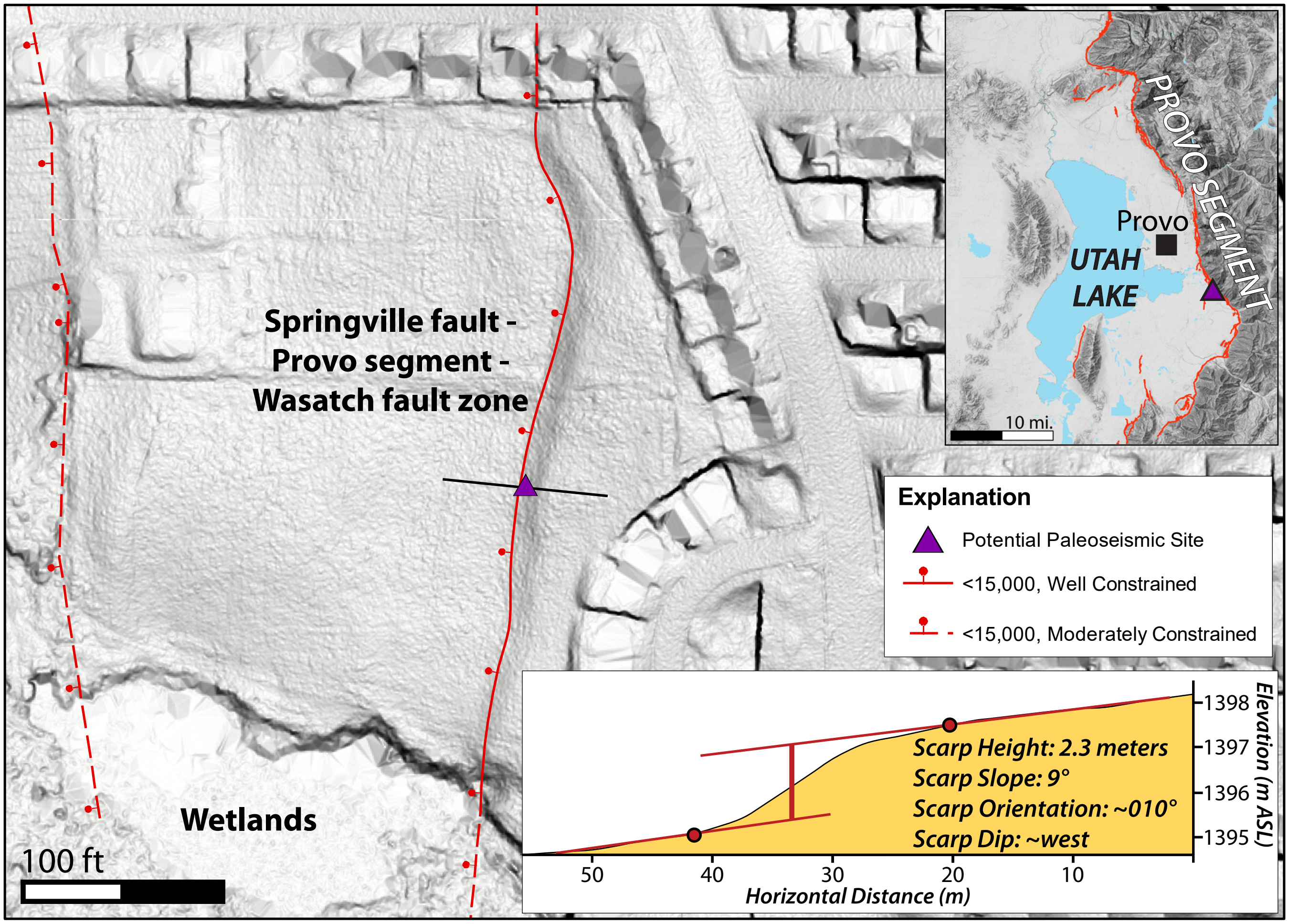

Figure 7. *Example of a potential paleoseismic site on the Springville fault, Provo segment, Wasatch fault zone shown with 0.5m lidar DEM slope shade model. The site is at the DNR Springville Fish Hatchery in Springville, Utah. The scarp vertical height is 2.3 meters and dips to the west (scarp profile location shown by black line; bar and ball on downthrown side of fault). Very little apparent anthropogenic modification has occurred at this site, making it a good candidate for a paleoseismic investigation.*

ful, stereo-paired historical aerial photos were helpful, as was the surficial geologic map of the WFZ in eastern Utah Valley (Machette, 1992).

A few notable improvements of the PS fault mapping are briefly discussed, starting in the north and working south. The PS begins at Corner Canyon (Draper, Utah), where the east-west-oriented Fort Canyon fault connects the Salt Lake City segment to the Provo segment. Toké and others (2017) mapped apparent and inferred scarps of the Fort Canyon fault using bare-earth DEMs in preparation for paleoseismic trenching (Toké and Horns, 2017). We did not include all of their mapping, but rather agreed with where they had mapped scarps that appeared to have ruptured in the Holocene. The PS continues east along the Fort Canyon fault for ~ 4 miles (6.4 km), where it turns abruptly south. About 0.6 miles (1 km) south of this fault bend, approximately 1.5 miles (2.5 km) east of Alpine at the northeast part of Utah Valley, we map inferred Quaternary faults at the range front and Holocene traces ~0.6 miles (1 km) to the east cutting bedrock within the Wasatch Range. Bennett and others (2018) interpreted these as landslides possibly associated with paleo-earthquakes on the PS. North of Provo Canyon is a large area of Quaternary landsliding associated with the Upper Mississippian Great Blue Limestone and Pennsylvanian–Upper Mississippian Manning Canyon Shale (Solomon and others, 2010). Several faults cut these deposits creating a wide zone of scarps (~ 1400 feet [420 m]) before stepping to the east into Provo Canyon.

East of Provo, the PS is expressed as a series of en echelon faults and grabens that are partially obfuscated by urban development. Between Provo and Springville, the PS is expressed as a more complex and distributed fault zone near the base of the range front. At Springville, the PS bends to the southeast. Fault traces follow the range front through that stretch, except for a few north-south trending traces and the Springville fault, which splays from the primary PS trace through the western extent of Springville. Using lidar-derived DEMs, the Springville fault was identified and mapped an additional ~1/2-mile (0.8 km) to the south using subtle slope variations and confirmed in the field. The WFZ continues southeast along the range front through Hobble Creek (Swan and others, 1981b) and south, where well-constrained grabens in Lake Bonneville sediments are mapped (Machette, 1992).

Farther south, additional grabens along the prominent west-facing scarp cut late Pleistocene to Holocene alluvial fans and transgressive Lake Bonneville deposits, notably in a complex zone of faulting north of the mouth of Spanish Fork Canyon, where the PS bends westward. Faults south of Spanish Fork Canyon also cut transgressive and deltaic Lake Bonneville and younger deposits.

Continuing south and nearing its southern terminus, the PS trends southwest towards the range front and near the community of Woodland Hills, the main trace follows the range front, forming a narrow graben. The Woodland Hills fault lies northwest of the main trace of the PS and is topographically above Lake Bonneville highstand deposits, but locally cuts alluvial-fan deposits graded to the Pleistocene lake. This fault has been studied previously by the U.S. Bureau of Reclamation (Machette, 1992). Between the main trace of the PS and the Woodland Hills fault, we identified previously unmapped fault traces that run through the neighborhoods of Woodland Hills. The geomorphic character of these scarps suggests they are not Holocene-active, but likely late Quaternary-active (movement within the past 130,000 years).

Lake Mountain is an isolated, roughly 8-mile-long (13 km) mountain range several miles west of the southern part of the PS that is on trend with interbasin faults interpreted beneath Utah Lake (Dinter, 2014). We mapped several previously unrecognized fault traces along the west side of West Mountain. Our mapping, along with previous work (Clark, 2009), found no evidence for Quaternary surface faulting on the east side of West Mountain. The faults on the west side cut Lake Bonneville deposits and younger alluvium indicating Holocene activity. Several of the faults mapped by Dinter (2014) beneath Utah Lake are on-trend with traces we mapped at the northwest flank of Lake Mountain, but no surface scarps definitely link these two zones of faulting.

The PS is largely obscured by residential, business, and infrastructure development and relatively few potential paleoseismic sites remain. Past paleoseismic trenches on the PS have provided timing information for multiple earthquakes in the late Pleistocene and Holocene. The northern portion of the PS and the Fort Canyon fault area have been recently trenched (Hiscock and others, 2015; Toké and others, 2017; Bennett and others, 2018) Other trenches on the central PS were excavated in the 1990s and earlier (Lund and others, 1991; Machette and others, 1992; Lund and Black, 1998; Olig and others, 2011 and compiled in Bowman and Lund, 2013). Paleoseismic sites identified for potential future investigation (table 3) focus on areas that have sparse paleoseismic data or that are undergoing rapid urban development. Many sites on the central PS have extensive disturbance and need to be further assessed before trenching is proposed. A promising site in terms of accessibility and feasibility is on land administered by the Utah Division of Wildlife Resources, near the old Springville Fish Hatchery (figure 7). This scarp was briefly excavated by a geotechnical company in December 2017, and revealed deformed late Pleistocene to Holocene alluvium. Several other potential paleoseismic sites exist along the southern PS. The Woodland Hills graben has several potential paleoseismic investigation sites; however, due to its proximity to the range front, the potential for encountering shallow bedrock needs to be considered. Another potentially good site is in Loafer Canyon, where a relatively undisturbed scarp offsets young alluvium (table 3).

Nephi Segment

The Nephi segment (NS) is the southernmost of the five central segments of the WFZ and to date has been the subject of much research (table 2; Jackson, 1991; Harty and others, 1997; Machette and others, 2007; DuRoss and others, 2017). Due to the relatively undisturbed nature of the Nephi segment (NS), the high-resolution lidar data are useful for identifying new traces and improving the detail of mapped faults. The NS consists of two subsections—a 10.6-mile long (17-km) lng northern strand and a 15.5-mile-long (25-km) southern strand, separated by a 3 mile (4.8-km) wide right step-over zone west of Santaquin Canyon.

The northern strand extends to the Benjamin fault in southern Utah Valley and overlaps several miles of the southern PS a few miles to the east, where the segment boundary is defined by an eastward stepping en echelon zone of faults. Faults at this NS northern terminus were mapped in greater detail and extended farther north by ~1.5 miles (2.4 km) than previously mapped. In addition, we mapped new traces at the southern part of the northern strand, within a zone of bedrock faults along the western front of Dry Mountain, south of Santaquin City.

The southern strand of the NS is expressed as a continuous, prominent, west-dipping main trace along the range front on the east side of Juab Valley. Locally, antithetic faults form small- to moderately sized discontinuous grabens. The Mendenhall fault, which extends into the valley approximately 5-miles (8-km) north of Mona, was mapped in greater detail and extended farther to the northwest. In several places along the southern strand, the main trace of the fault crosses late Pleistocene landslide complexes (Harty and others, 1997) along the Mt. Nebo range front, where faulting bifurcates and faults become difficult to discern from landslide-related escarpments. We mapped fault scarps through these landslide deposits, where they could be discerned from internal landslide-related features.

Based on data from multiple paleoseismic investigations, the most recent surface-fault-rupturing earthquake on the WFZ occurred on the NS approximately 200 ± 90 years ago (DuRoss and others, 2017). Both the northern and southern strands of the NS are largely undeveloped, so abundant potential paleoseismic investigation sites exist. While the NS has been the focus of multiple paleoseismic investigations (Jackson, 1991; Machette and others, 2007; DuRoss and others, 2008 [Santaquin site – SS-124]; DuRoss and others, 2017), both spatial and temporal gaps could be targeted, given the number and distribution of undisturbed scarps cutting variously aged alluvial-fan deposits.

Along the west side of Juab Valley is a complex zone of well-constrained fault scarps cutting pre-Lake Bonneville alluvial-fan deposits. The faults were originally identified in unpublished mapping by the former Utah County geologist (Robison, 1986) and is included in the *Utah Geologic Hazards Portal*. Our mapping extends previously mapped fault traces on older alluvial-fan surfaces above the Lake Bonneville high-stand shoreline. The scarps are weathered, bisected, and locally eroded by younger alluvial drainages. We therefore classify them as Late Quaternary-active (movement within the past 130,000 years) given a lack of better age-constraining data. The faulted alluvial-fan surfaces may be mid- to late Pleistocene in age, but no numerical age estimates are presently available for the deposits. This ~8-mile-(13 km-) long zone of complex faulting is mostly undeveloped with many potential paleoseismic investigation sites, making it a candidate for future paleoseismic research. Additional data would also provide insight into the relationship, if any, of these faults to the WFZ.

Levan Segment

The Levan segment (LS) is the second southernmost segment of the WFZ and has been the subject of recent mapping and paleoseismic work. Hylland and Machette (2008) performed detailed mapping of the LS before the availability of lidar data, and more recently, Hiscock and Hylland (2015) refined fault trace mapping of the segment using the recently-acquired lidar data. The LS forms the eastern margin of southern Juab Valley and extends from the town of Nephi, southward to the Juab–Sanpete County line. Geomorphic evidence suggests that most of the LS scarps are Holocene in age. An exception is near the mouth of Old Pinery Canyon just south of the town of Nephi, where scarps are distributed laterally across basin-fill deposits and have smooth, rounded crests and lower slope angles, suggesting movement in the late Quaternary (past 130,000 years).

Paleoseismic research on the LS includes mapping and scarp profiling (Hylland, 2007b; Hylland and Machette, 2008), examination of a natural exposure of the fault at Deep Creek (Schwartz and Coppersmith, 1984; Jackson, 1991), and trenching near Skinner Peaks (Jackson, 1991). In fall 2017, the UGS excavated two trenches on the Levan and Fayette segments, as funded by a collaborative agreement with the USGS Earthquake Hazards Program. The project included excavating a trench near Skinner Peaks. Due to the rural setting of the LS, many potential, relatively undisturbed trench sites remain.

Fayette Segment

The Fayette segment (FS) is the southernmost of the WFZ segments, extending from Chriss Canyon in southern Juab County to near the southern end of the San Pitch Mountains east of the town of Fayette in Sanpete County. Hylland and Machette (2008) mapped the FS at the same time they mapped the LS and similarly Hiscock and Hylland (2015) remapped the FS using recently acquired lidar. Hylland and Machette (2008) subdivided the FS into three strands: a 7.5-mile- (12-km) long northern strand, a 4-mile- (6.4-km) long southwestern strand, and a 6-mile- (9.7-km) long southeastern strand. Topographic scarp profiling and geomorphic expression of the scarps suggest the northern strand to be Quaternary in age (movement in the past 2,600,000 years), and the southwestern and southeastern strands Holocene (past 11,700 years) and late Quaternary (past 130,000 years), respectively.

Paleoseismic research on the FS has been limited to mapping and scarp profiling (Hylland, 2007b; Hylland and Machette, 2008). In fall 2017, the UGS excavated two trenches on the Levan and Fayette segments, as funded by a collaborative agreement with a USGS Earthquake Hazards Program grant. The trench was excavated on a Holocene scarp on the southwestern strand, near Hells Kitchen Canyon and Utah Highway 28. Several potential trench sites remain on the southwestern strand, while the northern strand is mapped as moderately constrained, inferred, or cutting bedrock, and thus lacks potentially trenchable scarps. The southeastern strand cuts mid-Pleistocene or older valley-fill deposits with typically high scarps. One scarp at the mouth of Mellor Canyon northeast of Fayette, displaces an alluvial deposit inset into an older surface and appears amenable to trenching, pending further investigation.

SUMMARY

This report describes the motivation and methods involved in our re-mapping of the WFZ using high resolution lidar elevation data that has been published in its final form in the *Utah Geologic Hazards Portal* (Utah Geological Survey, 2020). We summarize the detailed mapping of fault zones in Utah and Idaho, based upon the analysis of high-resolution airborne lidar-derived products, historical aerial photos, previous geologic mapping, and field reconnaissance. Paleoseismic trench sites were identified along the fault traces as suggestions for future investigation by the UGS, USGS, or any interested organizations. The motivation for this work was timely due to the availability of high-resolution lidar elevation data for the entire WFZ and the rapidly growing population and increasing development along the Wasatch Front.

Surface-fault rupture special-study zones were created based on the certainty of the fault trace mapping and fault geometry. The special-study area dimensions are based on the *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah* (Lund and others, 2016). These special-study zones are delineated to assist in land-use planning and regulation for local governments. Paleoseismic sites were identified in Utah and Idaho to foster future paleoseismic research in areas that are being rapidly developed or are in areas lacking good earthquake timing and recurrence information.

ACKNOWLEDGMENTS

This work was funded by the USGS Earthquake Hazards Program, External Grants Program (award number G17AP00001), the UGS, and a USGS Mendenhall Postdoctoral Fellowship awarded to S. Bennett. This work was made possible through the financial support of the USGS Earthquake Hazards Program, Salt Lake County and their local city partners, the Utah Division of Emergency Management, the UGS, the U.S. Environmental Protection Agency, and the Utah Automated Geographic Reference Center in the acquisition of the 2013–2014 State of Utah Wasatch Front lidar elevation data.

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