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Wasatch fault zone, Brigham City section (Class A) No. 2351d

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Compiled in cooperation with the Utah Geological Survey

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Synopsis	**General:** The Wasatch fault zone is one of the longest and most tectonically active normal faults in North America. The fault zone shows abundant evidence of recurrent Holocene surface faulting and has been the subject of detailed studies for over three decades. Half of the estimated 50 to 120 post-Bonneville surface-faulting earthquakes in the Wasatch Front region have been on the Wasatch fault zone. Earthquake-timing, recurrence-interval, and displacement-rate estimates for the Brigham City, Weber, Salt Lake City, Provo, Nephi, and Levan sections of the Wasatch fault

	zone reflect the consensus values of the Utah Quaternary Fault Parameters Working Group (Lund, 2005 #6733). Lund (2005 #6733) did not evaluate the Clarkston Mountain, Collinston, and Fayette sections due to a lack of fault-trench data. The preferred values reported in Lund (2005 #6733) approximate mean values based on available paleoseismic-trenching data, and the minimum and maximum values approximate two-sigma (5th and 95th percentile) confidence limits. The confidence limits incorporate both epistemic (data limitation) and aleatory (process variability) uncertainty (Lund, 2005 #6733). **Sections:** This fault has 10 sections. The nearly 350-km-long Wasatch fault zone has traditionally been divided into seismogenic segments that are thought to rupture at least somewhat independently. The established model is used to define the sections described in this report. The southern eight sections are entirely in Utah. To the north, the Clarkston Mountain section straddles the state line between Idaho and Utah and the northernmost (Malad City) section is entirely in Idaho. The chronology of surface-faulting earthquakes on the Wasatch fault is one of the best dated chronologies in the world and includes 16 earthquakes since 5.6 ka, with an average repeat time of 350 yr. Four of the central five sections [2351e-h] ruptured in the last hundreds to about a thousand years ago, whereas the next section to the north, Brigham City [2351d], has not ruptured in the past 2,125 yr. Vertical displacement rates of 1–2 mm/yr are typical for the central sections during Holocene time. In contrast, middle and late Quaternary (<150–250 ka) rates on these sections are about an order of magnitude lower. This substantial change in the displacement rate may indicate a causal relation between increased Holocene rates of deformation and isostatic rebound/crustal relaxation following deep lake cycles such as Bonneville.
Name comments	**General:** **Section:** All section names follow those proposed by Machette and others (1991 #189; 1992 #607). Refers to fault number 6-6 of Hecker (1993 #642).
County(s) and State(s)	BOX ELDER COUNTY, UTAH WEBER COUNTY, UTAH
Physiographic province(s)	BASIN AND RANGE

Reliability of location	Good Compiled at 1:50,000 scale. *Comments:* Fault trace from 1:50,000 scale mapping of Personius (1990 #1232).
Geologic setting	Generally north-trending, range-bounding normal fault along the western side of the Malad Range (Clarkston Mountain), Wellsville Mountains, Wasatch Range, and San Pitch Mountains. The Wasatch fault zone marks the eastern boundary of the Basin and Range in northern Utah. Alluvial-fan deposits and lacustrine deposits of Pleistocene Lake Bonneville dominate the surficial geology along the fault zone.
Length (km)	This section is 37 km of a total fault length of 357 km.
Average strike	N9°W (for section) versus N10°W (for whole fault)
Sense of movement	Normal
Dip	65–80° W. *Comments:* Reported as 65-80° W. at Bowden Canyon trench (site 2351-7) in fluvial and debris-flow deposits; 70–80° W. at Pleasant View trench (site 2351-20) in lacustrine deposits (Personius, 1991 #2986).
Paleoseismology studies	A trench excavated in 1986 across a fault scarp on the Bowden Canyon alluvial fan at the Brigham City site (site 2351-7), east of Brigham City, exposed evidence for three surface-faulting earthquakes (Personius, 1991 #2986). The oldest of these events could not be directly dated. Radiocarbon age estimates on bulk-soil samples from paleosols and the base of the modern soil provide limiting ages for the penultimate and most recent events on the fault. Timing of the penultimate event may correlate with the timing of the most recent surface-faulting earthquake documented in the Pole Patch trench (site 2351-9) across a fault scarp on the Pleasant View salient, about 20 km south of the Brigham City trench (Personius, 1991 #2986). This scarp is associated with a short, off-trend fault in the area of the boundary between the Brigham City and Weber sections of the Wasatch fault. The trench exposed evidence for three surface-faulting earthquakes. Although a bulk-soil sample yielded a radiocarbon age estimate that closely approximates the age of the most recent

	event, other radiocarbon ages only poorly constrain the timing of the older events. In 1992 and 1993, 14 additional trenches were excavated across scarps of the Brigham City section to lengthen the paleoseismic record for this fault (McCalpin and Forman, 1994 #4626, 2002 #5177). These trenches were on the Provo-level delta at the mouth of Box Elder Canyon (site 2351-27). In total, the trenches exposed evidence for seven, or possibly eight, surface-faulting events. Earthquake timing is constrained by limiting ages obtained from radiocarbon and thermoluminescence dating of bulk soil samples. The most recent event here (event Z) is younger than the most recent event at the Brigham City trench; the timing of that earthquake correlates well with event Y here. Evidence was not observed for an earthquake correlative with the penultimate event at the Brigham City trench. A relatively wide range in limiting ages for event V suggests either a poorly constrained single event, or two separate events. McCalpin and Nishenko (1996 #4627) and McCalpin and Foreman (2002 #5177) prefer the two-event interpretation, resulting in a total of seven paleoearthquakes on the Brigham City section since 14–17 ka.
Geomorphic expression	West-facing scarps along the western base of the Wellsville Mountains and Wasatch Range. Scarps on the valley floor between Willard and Brigham City may be associated with incipient lateral spreads, but have orientations and relief consistent with a faulting origin. In the southern part of the section,15- to 20-m-high scarps on a Provo-level delta suggest as many as 6–10 surface-faulting events occurred since about 16 ka (assuming an average displacement per event of >2 m). However, only a few short, discontinuous scarps are on upper Holocene deposits near the southern section boundary, which is in contrast to the abundance of Holocene scarps on the Weber section to the south. Displacement per event is from 1.0 to 2.5 m. To the north, the boundary between the Brigham City and Collinston sections is defined by a change in fault trend and differences in the amount and timing of displacement of post-Lake Bonneville deposits.
Age of faulted surficial deposits	Holocene alluvial fan, debris-flow and stream deposits; late Pleistocene glacial, lacustrine, and alluvial fan deposits, and middle (?) Pleistocene alluvial fan deposits.
Historic	

earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* The Brigham City section is the northernmost section of the Wasatch fault zone that exhibits clear evidence of recurrent Holocene faulting along its entire length (Personius, 1988 #2996; Machette and others, 1992 #607). Lund (2005 #6733) determined the following paleoearthquake chronology, based on the interpretation of seven paleoearthquakes in the past 17 ky (McCalpin and Nishenko, 1996 #4627; McCalpin and Foreman, 2002 #5177), and incorporating both laboratory and geologic uncertainty: Z 2100±800 cal yr B.P. Y 3450±300 cal yr B.P. X 4650±500 cal yr B.P. W 5950±250 cal yr B.P. V 7500±1000 cal yr B.P. U 8500±1500 cal yr B.P. T >14,800±1200, <17,000 cal yr B.P.
Recurrence interval	1300 yr (preferred); minimum 500, maximum 2800 yr (<8.5 ka) *Comments:* Consensus recurrence-interval range reported in Lund (2005 #6733), based on the five interevent times between the six most recent paleoearthquakes (U–Z). The overall temporal pattern since 14.8 ka is one earthquake every 1–2 k.y. since 8.5 ka, with a long seismic gap between 8.5 and 14.8 ka. McCalpin and Forman (1994 #4626, 2002 #5177) indicate the approximately 6.3 k.y. long seismic gap may have been influenced by changes in the crustal stress regime associated with Lake Bonneville dessication, possibly causing crustal rebound to suppress extensional movements. The elapsed time since the last earthquake (2,100±800 yr) exceeds the preferred recurrence interval (1,300 yr), suggesting that the section is due for a surface faulting earthquake, unless strain accumulation rates have declined during the late Holocene. McCalpin and Nishenko (1996 #4627) suggest that the Brigham City section has a time-dependent earthquake probability that approaches or exceeds regional and fault-specific probabilities.
Slip-rate category	Between 1.0 and 5.0 mm/yr *Comments:* Lund (2005 #6733) indicates a Holocene paleoseismic slip rate of 1.4 mm/yr (preferred), and a consensus minimum-maximum range of 0.6–4.5 mm/yr, based on per-event vertical displacements from trenching ranging from 1–2.5 m (Personius, 1991 #2986) and the three recurrence intervals between events V, W, X, and Y. Long-term geologic slip rates

	based on vertically offset Provo-age deposits increase southward from 0.2 mm/yr near the northern section boundary to 1.4 mm/yr near Willard, Utah. Vertical displacement of deltaic deposits of the Bonneville phase of the Bonneville lake cycle at Willard Canyon indicate a long-term geologic slip rate of 1.5–1.6 mm/yr (Personius, 1990 #1232).
Date and Compiler(s)	2004 Bill D. Black, Utah Geological Survey Christopher B. DuRoss, Utah Geological Survey Michael D. Hylland, Utah Geological Survey Greg N. McDonald, Utah Geological Survey Suzanne Hecker, U.S. Geological Survey
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