Annual Project Summary

LONG RECURRENCE RECORDS FROM THE WASATCH FAULT ZONE, UTAH

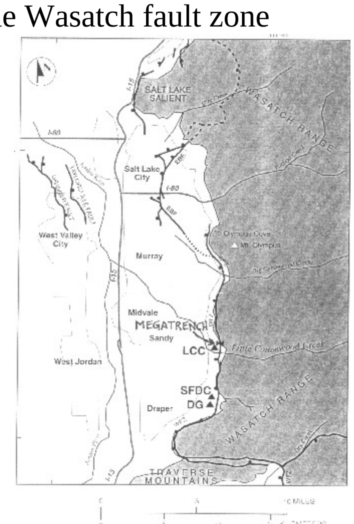
Contract 99HQGR0058

Principal Investigator:
James P. McCalpin
GEO-HAZ Consulting, Inc.
P.O. Box 1377, 1221 Graves Ave.
Estes Park, CO 80517
OFFICE: (970) 586-3217
FAX: (970) 577-0041
www.geohaz.com/geohaz

Co-PI
Craig V. Nelson
URS Corporation
Salt Lake City, UT 84102-1959
craig_nelson@urscorp.com

Program Element II.5: Identify active faults, define their geometry, and determine the characteristics and dates of past earthquakes

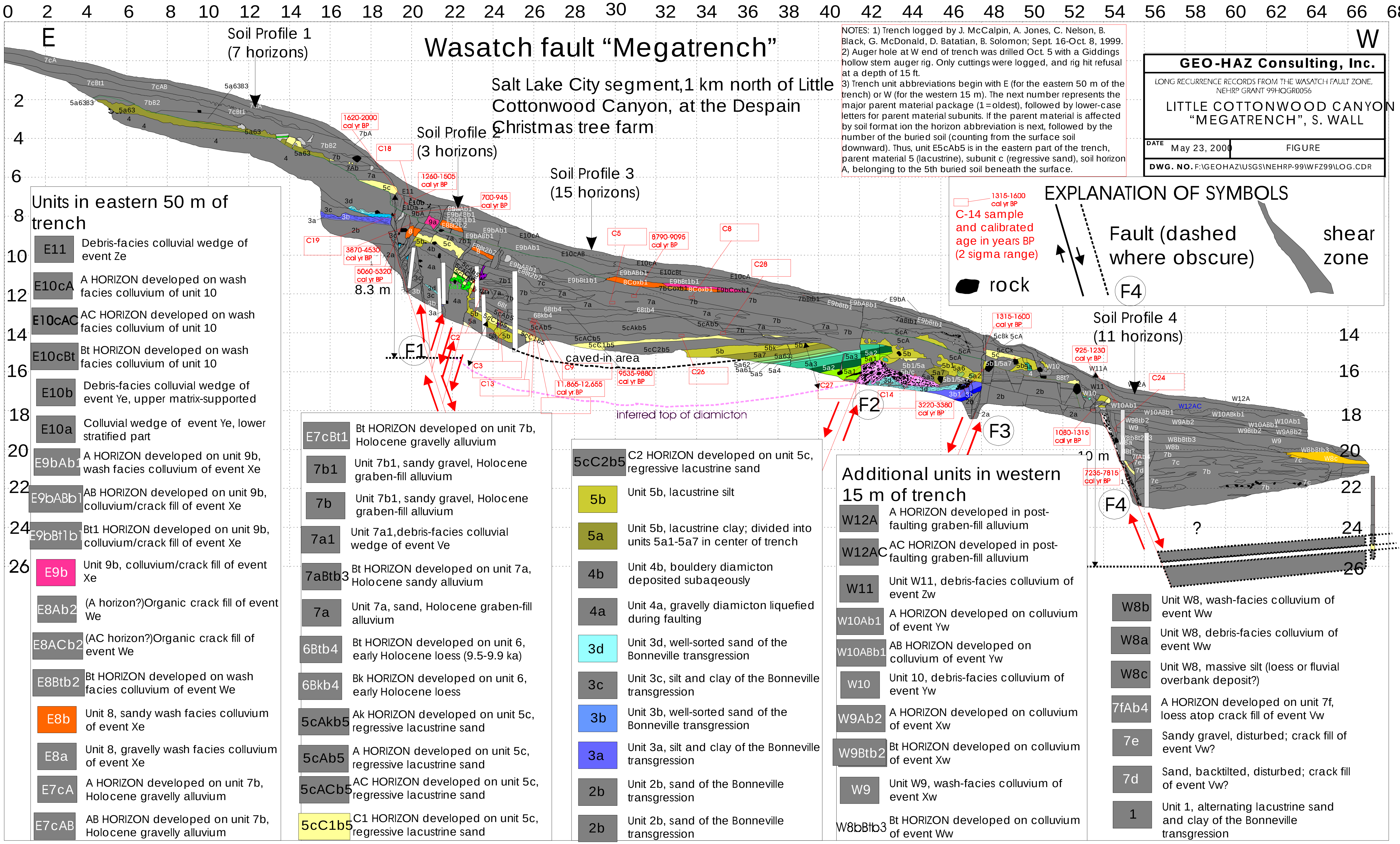
Investigations Undertaken The Wasatch fault "megatrench" was excavated in Sept. 1999 across an 18 m-high double-scarp of the Salt Lake City segment of the Wasatch fault zone (WFZ), 1 km north of the mouth of Little Cottonwood Creek (Fig. 1).



The trench and accompanying auger hole exposed 26 m of vertical section, roughly 4 times that of the typical trench on the WFZ (Fig. 2). Each of the two fault scarps transected were underlain by normal faults with 7-9.5 m of vertical displacement measured on the top of Bonneville-age

Fig.2 4. Photograph of the WFZ megatrench looking east from the toe of the trench. Note person for scale near head of trench on right-hand bench. The Quaternary deposits exposed in the trench define five distinct color bands (from dark brown at the head, to white, light brown, white, to brown at the toe). The uppermost dark brown deposit is distal Holocene alluvial fan and local slopewash. The next white band (downslope) is thin Lake Bonneville lacustrine sediments, which are in fault contact with Holocene alluvium (next light brown band). The next thick white band is the same Bonneville lacustrine sediments, downfaulted 8 m down-toward-the-viewer by the upper (eastern) fault strand. The final brown band is more Holocene alluvium and colluvium, which is in fault contact with the lake beds along the lower (western) fault strand. That fault has 9.5 m of throw measured on the top of the lake beds. The inner slot at lower center was not deep enough to expose lake beds on the downthrown side of the lower fault strand, but an auger hole encountered the top of lake beds 2.2 m below the trench floor.

lake beds (ca. 15,500 years old). Each fault was fronted by 3-4 colluvial wedges, indicating 3-4 post-Bonneville faulting events on each fault (Fig. 3). The one surprise in the trench was the existence of a thick buried soil developed atop the lake beds and underlain by scarp-derived colluvium. This soil argues for a long period of fault inactivity between ca. 9,000 years ago and 15,500 years ago. That time span is roughly 4 times as long as the typical intervals between major earthquakes on this segment of the WFZ. The quiescent interval could be either an irregularity typical of the long-term behavior of the WFZ, or a response to the drying up of Lake



0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68
E
W
Soil Profile 1 (7 horizons)
Wasatch fault "Megatrench"
Salt Lake City segment, 1 km north of Little Cottonwood Canyon, at the Despain Christmas tree farm
Soil Profile 2 (3 horizons)
Soil Profile 3 (15 horizons)
Soil Profile 4 (11 horizons)
NOTES: 1) Trench logged by J. McCalpin, A. Jones, C. Nelson, B. Black, G. McDonald, D. Batatian, B. Solomon; Sept. 16-Oct. 8, 1999. 2) Auger hole at W end of trench was drilled Oct. 5 with a Giddings hollow stem auger rig. Only cuttings were logged, and rig hit refusal at a depth of 15 ft. 3) Trench unit abbreviations begin with E (for the eastern 50 m of the trench) or W (for the western 15 m). The next number represents the major parent material package (1=oldest), followed by lower-case letters for parent material subunits. If the parent material is affected by soil format ion the horizon abbreviation is next, followed by the number of the buried soil (counting from the surface soil downward). Thus, unit E5cAb5 is in the eastern part of the trench, parent material 5 (lacustrine), subunit c (regessive sand), soil horizon A, belonging to the 5th buried soil beneath the surface.
GEO-HAZ Consulting, Inc.
LONG RECURRENCE RECORDS FROM THE WASATCH FAULT ZONE, NEHRP GRANT 99HQGR0056
LITTLE COTTONWOOD CANYON "MEGATRENCH", S. WALL
DATE May 23, 2000
FIGURE
DWG. NO. F:\GEOHAZ\USGS\NEHRP-99\WFZ99\LOG.CDR
EXPLANATION OF SYMBOLS
1315-1600 cal yr BP
C-14 sample and calibrated age in years BP (2 sigma range)
rock
Fault (dashed where obscure)
F4
shear zone
8.3 m
F1
F2
F3
F4
caved-in area
inferred top of diamicton
1620-2000 cal yr BP
1260-1605 cal yr BP
700-945 cal yr BP
3870-4530 cal yr BP
5060-5320 cal yr BP
8790-9095 cal yr BP
9535-9880 cal yr BP
11,865-12,655 cal yr BP
1315-1600 cal yr BP
925-1230 cal yr BP
3220-3380 cal yr BP
1080-1315 cal yr BP
7235-7815 cal yr BP
C18 C19 C5 C8 C28 C2 C3 C13 C9 C26 C27 C14 C24
10 m
?
Units in eastern 50 m of trench
E11 Debris-facies colluvial wedge of event Ze
E10cA A HORIZON developed on wash facies colluvium of unit 10
E10cAC AC HORIZON developed on wash facies colluvium of unit 10
E10cBt Bt HORIZON developed on wash facies colluvium of unit 10
E10b Debris-facies colluvial wedge of event Ye, upper matrix-supported
E10a Colluvial wedge of event Ye, lower stratified part
E9bAb1 A HORIZON developed on unit 9b, wash facies colluvium of event Xe
E9bABb1 AB HORIZON developed on unit 9b, colluvium/crack fill of event Xe
E9bBt1b1 Bt1 HORIZON developed on unit 9b, colluvium/crack fill of event Xe
E9b Unit 9b, colluvium/crack fill of event Xe
E8Ab2 (A horizon?)Organic crack fill of event We
E8ACb2 (AC horizon?)Organic crack fill of event We
E8Btb2 Bt HORIZON developed on wash facies colluvium of event We
E8b Unit 8, sandy wash facies colluvium of event Xe
E8a Unit 8, gravelly wash facies colluvium of event Xe
E7cA A HORIZON developed on unit 7b, Holocene gravelly alluvium
E7cAB AB HORIZON developed on unit 7b, Holocene gravelly alluvium
E7cBt1 Bt HORIZON developed on unit 7b, Holocene gravelly alluvium
7b1 Unit 7b1, sandy gravel, Holocene graben-fill alluvium
7b Unit 7b1, sandy gravel, Holocene graben-fill alluvium
7a1 Unit 7a1,debris-facies colluvial wedge of event Ve
7aBtb3 Bt HORIZON developed on unit 7a, Holocene sandy alluvium
7a Unit 7a, sand, Holocene graben-fill alluvium
6Btb4 Bt HORIZON developed on unit 6, early Holocene loess (9.5-9.9 ka)
6Bkb4 Bk HORIZON developed on unit 6, early Holocene loess
5cAkb5 Ak HORIZON developed on unit 5c, regressive lacustrine sand
5cAb5 A HORIZON developed on unit 5c, regressive lacustrine sand
5cACb5 AC HORIZON developed on unit 5c, regressive lacustrine sand
5cC1b5 C1 HORIZON developed on unit 5c, regressive lacustrine sand
5cC2b5 C2 HORIZON developed on unit 5c, regressive lacustrine sand
5b Unit 5b, lacustrine silt
5a Unit 5b, lacustrine clay; divided into units 5a1-5a7 in center of trench
4b Unit 4b, bouldery diamicton deposited subaqeously
4a Unit 4a, gravelly diamicton liquefied during faulting
3d Unit 3d, well-sorted sand of the Bonneville transgression
3c Unit 3c, silt and clay of the Bonneville transgression
3b Unit 3b, well-sorted sand of the Bonneville transgression
3a Unit 3a, silt and clay of the Bonneville transgression
2b Unit 2b, sand of the Bonneville transgression
2b Unit 2b, sand of the Bonneville transgression
Additional units in western 15 m of trench
W12A A HORIZON developed in post-faulting graben-fill alluvium
W12AC AC HORIZON developed in post-faulting graben-fill alluvium
W11 Unit W11, debris-facies colluvium of event Zw
W10Ab1 A HORIZON developed on colluvium of event Yw
W10ABb1 AB HORIZON developed on colluvium of event Yw
W10 Unit 10, debris-facies colluvium of event Yw
W9Ab2 A HORIZON developed on colluvium of event Xw
W9Btb2 Bt HORIZON developed on colluvium of event Xw
W9 Unit W9, wash-facies colluvium of event Xw
W8bBtb3 Bt HORIZON developed on colluvium of event Ww
W8b Unit W8, wash-facies colluvium of event Ww
W8a Unit W8, debris-facies colluvium of event Ww
W8c Unit W8, massive silt (loess or fluvial overbank deposit?)
7fAb4 A HORIZON developed on unit 7f, loess atop crack fill of event Vw
7e Sandy gravel, disturbed; crack fill of event Vw?
7d Sand, backtilted, disturbed; crack fill of event Vw?
1 Unit 1, alternating lacustrine sand and clay of the Bonneville transgression

Bonneville between 15,000 years ago and ca. 11,000 years ago, which relieved a huge weight on the downthrown fault block of the WFZ. If it was an unloading effect, it died out by the time of Event W, and that it has not affected the regular 1300-1400 year recurrence cycle since that time Fig. 4). Therefore, we do not propose to favor or disfavor any of McCalpin and Nishenko's recurrence models based on the long recurrence times observed while the lake was drying up.

However, we can apply the results of some more recent recurrence studies to the likelihood of the various recurrence models. For example, the highest 100-year conditional probability calculated by McCalpin and Nishenko (1996) was 57%, based on a Weibull model of recurrence with a mean of 1328 years and a COV of only 0.04. By comparison, conditional probabilities based on lognormal models with COVs of 0.21 and 0.5 indicated probabilities of 22% and 11%, respectively (Table 5). So, is the COV of long-term recurrence on the SLC segment closer to 0.04, 0.21, or 0.5?

McCalpin and Slemmons (1998) inventoried all published paleoseismic chronologies that contained 3 or more well-dated events. They found that, as a group, worldwide normal faults with a large span of slip rates and mean recurrences tended to have an average COV of recurrence of 0.35. The same data set for all fault types yielded an average COV of recurrence of 0.36. In addition, the more paleoearthquakes that had been dated at a local trench site, the closer the COV of that local recurrence series approached 0.36. McCalpin and Slemmons argued that a relatively short recurrence series at a site (say, containing only 3-4 events, or 2-3 recurrence intervals) could yield a wide possible range of recurrence COVs, ranging from ca. 0.04 to 0.8. However, the site chronologies with successively more events tended to have COVs that converged on the value 0.36. They further argued that, for the purposes of making conditional probability estimates, it would be preferable to use the value COV=0.36 rather than use an "apparent" COV value from a short (3-4 event) recurrence series.

Their conclusions suggest that we should probably not lend much weight to the probability estimate of 57% in Table 5, which is based on a COV=0.04 from only 4 events on the SLC segment. Instead, we should probably assume a long-term recurrence COV of 0.36 for the SLC segment. Note that 0.36 falls almost exactly halfway between the COVs of 0.21 and 0.5, which resulted in probability estimates of 22% and 11%, respectively, for the next 100 years. If we assume that conditional probability varies linearly with COV over this relatively small range, then an assumed recurrence COV=0.36 would imply a conditional probability of 16% for M>7 earthquakes in the next 100 years.

GEO-HAZ Consulting, Inc.

Fig. 4. Space-time diagram of paleoearthquakes dated in previous studies, and in the megatrench.