UTAH GEOLOGICAL SURVEY

UTAH QUATERNARY FAULT PARAMETERS WORKING GROUP

Cache Valley earthquake, 1962

Tuesday, February 9, 2010

UQFPWG

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

2009 MEETING REVIEW

Presentations on paleoseismic work completed or in progress

- **Nephi segment, Spring Lake trenching update – UVU**
- **Weber segment, Rice Creek trenching results – UGS**
- **Brigham City segment, trenching update – USGS**
- **Geologic evidence for high-stress-drop earthquakes in the Rocky Mountains – USGS**
- **Results of tomographic imaging of the proposed Power Line trench site, Washington fault zone – UUGG**
- **Evaluating the seismic potential of the Joes Valley fault zone – USBR**
- **New Lidar data for the southern Wasatch Front – UUGG**
- **Update on contemporary deformation and stress field of the Wasatch Front – UUGG**

2009 MEETING REVIEW

(Continued)

Technical discussion items

- **Issues regarding the generalization of the surface trace of the Salt Lake City segment of the Wasatch fault zone on the National Seismic Hazard Maps**

- **West Valley fault zone, Part 1 – The "WVFZ Problem" and why it is an issue for the National Seismic Hazard Maps**

- **West Valley fault zone, Part 2 – Other active, graben-producing fault pairs in Utah/Basin and Range Province and issues they raise regarding the National Seismic Hazard Maps**

2010 FAULT PRIORITY LIST

2010 Highest Priority Faults/Fault Segments For Study			
Fault/Fault Section	**Priority**	**Investigation Status**	**Investigating Institution**
Northern Salt Lake City segment WFZ	1	No activity	
West Valley fault zone	2	No activity	
Penultimate event Provo segment WFZ	3	Trench site reconnaissance	UGS
Washington fault zone	4	Reconnaissance study	UGS
Rozelle section, Great Salt Lake fault	5	No activity	
Other Priority Faults/Fault Segments Requiring Further Study			
Fault/Fault Section	**Original UQFPWG Priority**	**Investigation Status**	**Investigating Institution**
Cedar City-Parowan monocline/ Paragonah fault	10	No activity	
Enoch graben	11	No activity	
Clarkston fault	13	No activity	
Gunnison fault	17	No activity	
Scipio Valley faults	18	No activity	
Faults beneath Bear Lake	19	No activity	
Eastern Bear Lake fault	20	No activity	
Carrington fault (Great Salt lake)	2007	No activity	
Bear River fault zone	2007	Scarp reconnaissance	USGS
Faults/Fault Segment Studies Complete or Ongoing			
Fault/Fault Section	**Original UQFPWG Priority**	**Investigation Status**	**Investigating Institution**
Nephi segment WFZ	1	UGS Special Study 124/USGS Map 2966/UVU study ongoing	UGS/USGS/UVU
Weber segment WFZ – most recent event	3	On going	UGS/USGS
Weber segment WFZ – multiple events	4	On going	UGS/USGS
Utah Lake faults and folds	5	Ongoing	UUGG
Great Salt Lake fault zone	6	Ongoing	UUGG
Collinston and Clarkston Mountain segments WFZ	7	UGS Special Study 121	UGS
Sevier/Toroweap fault	8	UGS Special Study 122	UGS
East Cache fault zone	12	Ongoing	USU
Wasatch Range back-valley faults	14	Ongoing	USBR
Hurricane fault zone	15	UGS Special Study 119	UGS
Levan segment WFZ	16	UGS Map 229	UGS
Brigham City segment WFZ – most recent event	2007	Ongoing	UGS/USGS

AGENDA

QUATERNARY FAULT PARAMETERS WORKING GROUP
Tuesday, February 9, 2010
Utah Department of Natural Resources Building, Room 2000 (2nd floor)
1594 West North Temple, Salt Lake City

7:00 Continental breakfast

7:30 Introduction, overview of meeting, review of last year's activities; Bill Lund, UGS

8:00 Technical presentations of work completed or in progress
8:00 – Brigham City segment, trenching update; Tony Crone/Steve Personius, USGS
8:20 – Washington fault northern segment, trenching update; Bill Lund/Tyler Knudsen, UGS
8:40 – Washington fault Southern Beltway trenching investigation; Dave Simon, Simon • Bymaster, Inc.
9:00 – U.S. Bureau of Reclamation Utah fault studies update; Larry Anderson, USBR
9:20 – Bear River fault zone, trenching update; Suzanne Hecker, USGS
9:40 – East Cache fault zone, trenching update; Jim Evans, USU

10:00 Break

10:20 Technical presentations of work completed or in progress
10:20 – Salt Lake City segment/West Valley fault zone investigation, progress report; Mike Hylland, UGS
10:40 – Working Group on Utah Earthquake Probabilities; Ivan Wong, URS/Bill Lund, UGS

11:00 Technical discussion item
Revised Weber segment slip-rate and recurrence-interval estimates; Chris DuRoss, UGS/Steve Personius, USGS

12:00 Lunch

AGENDA
(Continued)

1:00 Technical discussion item
Revised Weber segment slip-rate and recurrence-interval estimates – discussion

1:30 UQFPWG 2011 Quaternary fault study priorities

2:30 Adjourn

Update of Brigham City Segment Trenching

Investigations at Pearsons, Kotter, and Hansons Canyons

2010 Utah Quaternary Fault Parameters Working Group

Chris DuRoss
Greg McDonald
Stephen Personius
Anthony Crone
Richard Briggs

Kotter Canyon trench

Introduction

- **Purpose:**
  - **Determine elapsed time since most recent earthquake (MRE).**
  - **Improve constraints on times, displacements, and lengths of MRE surface rupture.**
  - **Refine correlation of MRE at paleoseismic study sites along the Brigham City Segment (BCS).**
  - **Evaluate segmentation of northern Wasatch fault zone, specifically between the Weber segment (WS) and the BCS. segments**

USGS

Brigham City Segment

- About 37 km long
  - From near Honeyville (Jim May Canyon) on north to Pleasant View salient on south

- Previous paleoseismic studies
  - Bowden Canyon (center)
  - Box Elder Canyon (center)
  - Pole Patch (on subsidiary fault at south end in segment boundary)

USGS

Why study the Brigham City segment?

1. Elapsed time since the MRE:

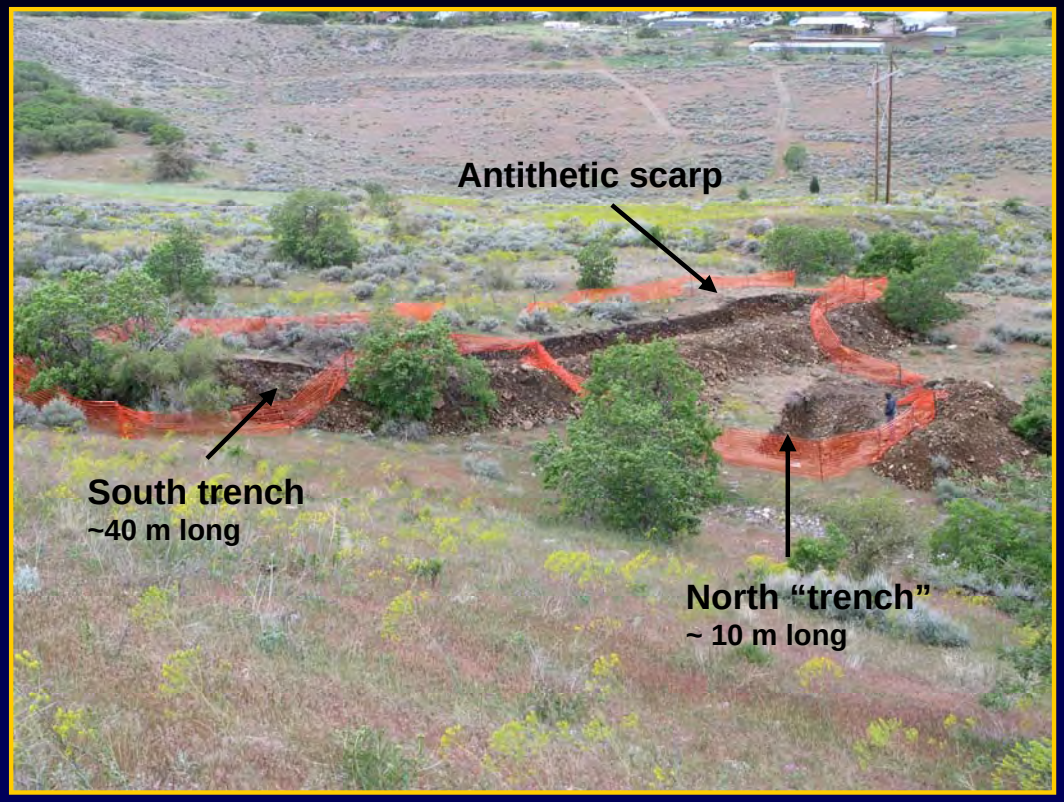
- UQFPWG Parameters for BCS
- MRE: 2100±800 cal yr B.P.
- Slip Rate: 0.6–1.4–4.5 mm/yr (max. range)
- Recurrence Interval: 1300±400 yr (based on last five events)
  500–1300–2800 (max. range)
- Does BCS have highest likelihood of next surface-rupturing earthquake?

2. Segmentation:

- Surficial mapping (Personius, 1991; DuRoss et al., 2010) indicates very young scarp at Pearsons Canyon near southern end of segment
- New results from northern Weber segment indicate surface ruptures at about 500-600 cal yr BP and about 1100-1300 cal yr BP
- Did younger Weber surface ruptures extend into southern BCS?

USGS

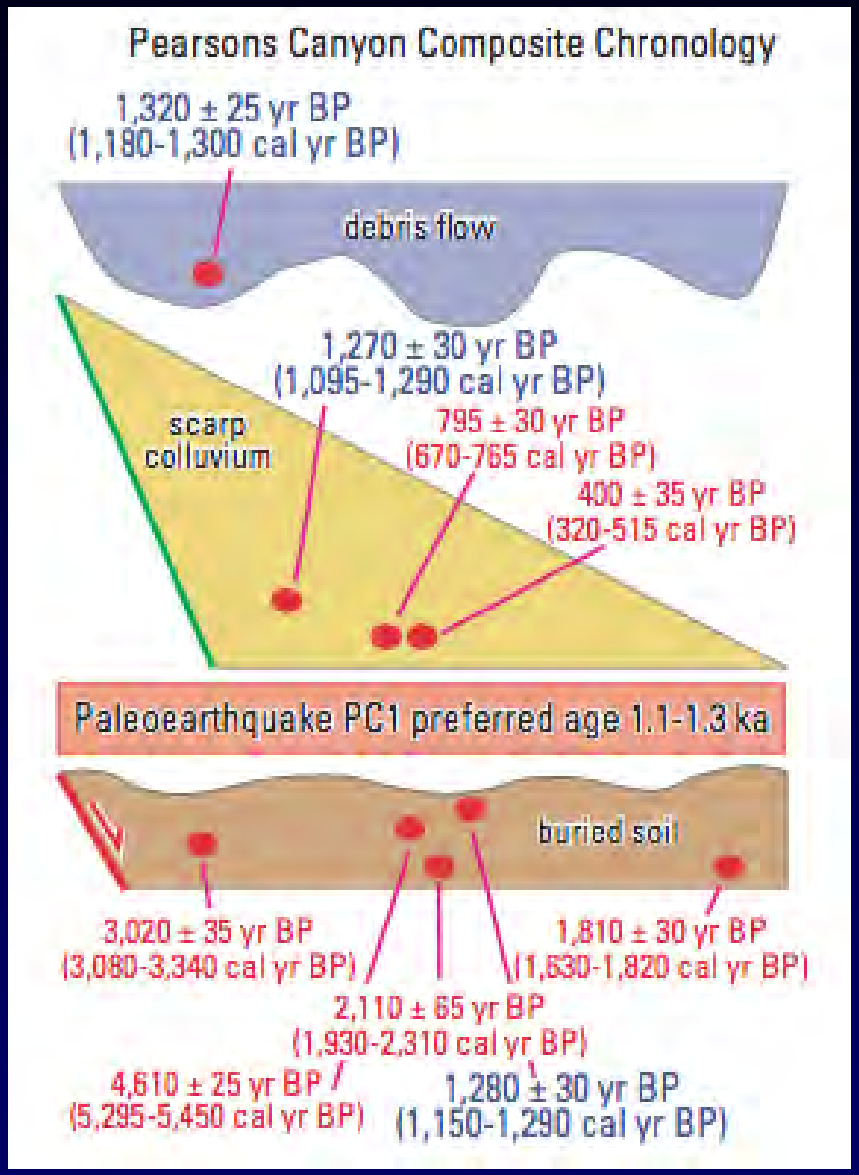
Pearsons North Trench Site



- Approximately 1- to 3-m-high scarp
- Small antithetic scarp <1 m high
- Formed on Holocene alluvial fan below Bonneville shoreline

USGS

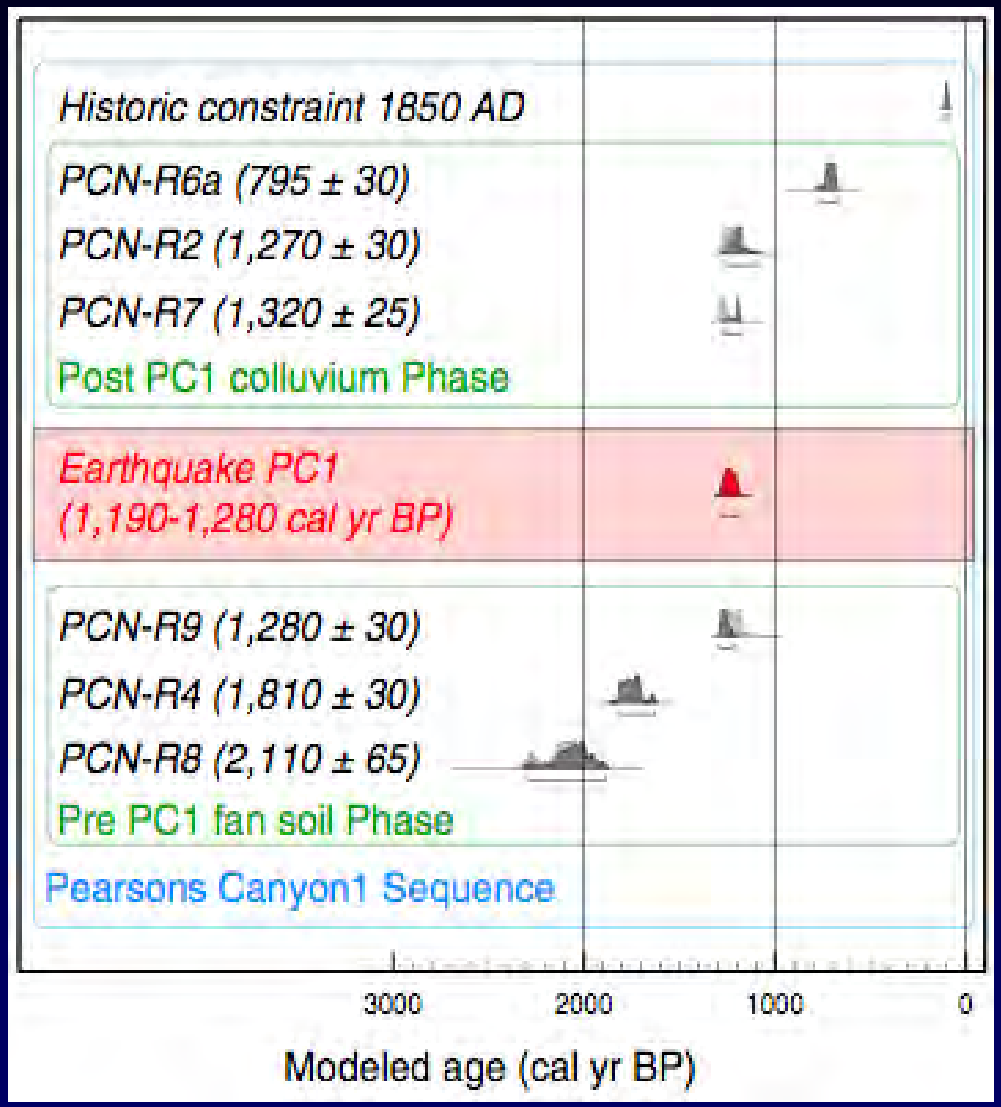
Pearsons North Trench Site



- **Diverse ranges of radiocarbon ages indicate abundant reworking of charcoal in deposits**
- **Bounding ages from scarp colluvium and debris-flow deposits above and buried soil on top of fan suggest MRE occurred about 1.1-1.3 ka**

USGS

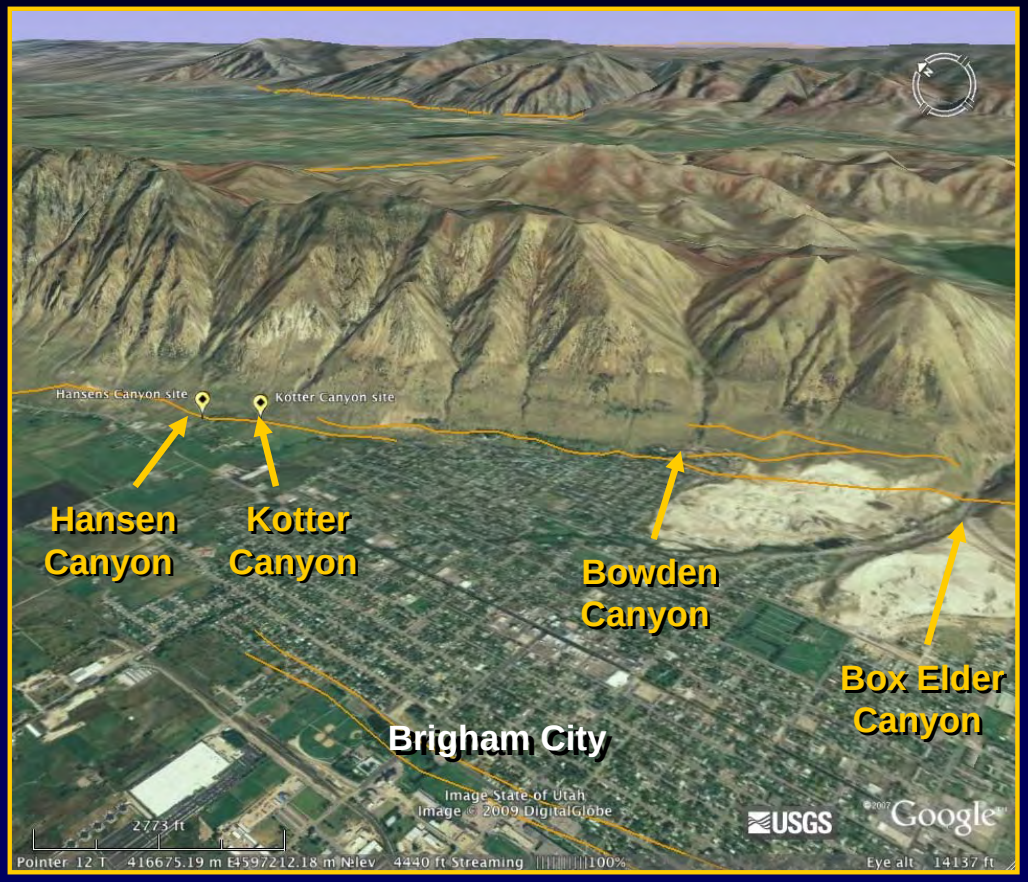
Pearsons North Trench Site



- **Composite OxCal (v. 4.1) model of selected radiocarbon ages from Pearsons Canyon North trench site.**
- **After excluding obvious outliers, two minimum ages and one maximum age tightly constrain earthquake PC1 to 1.2-1.3 ka.**

USGS

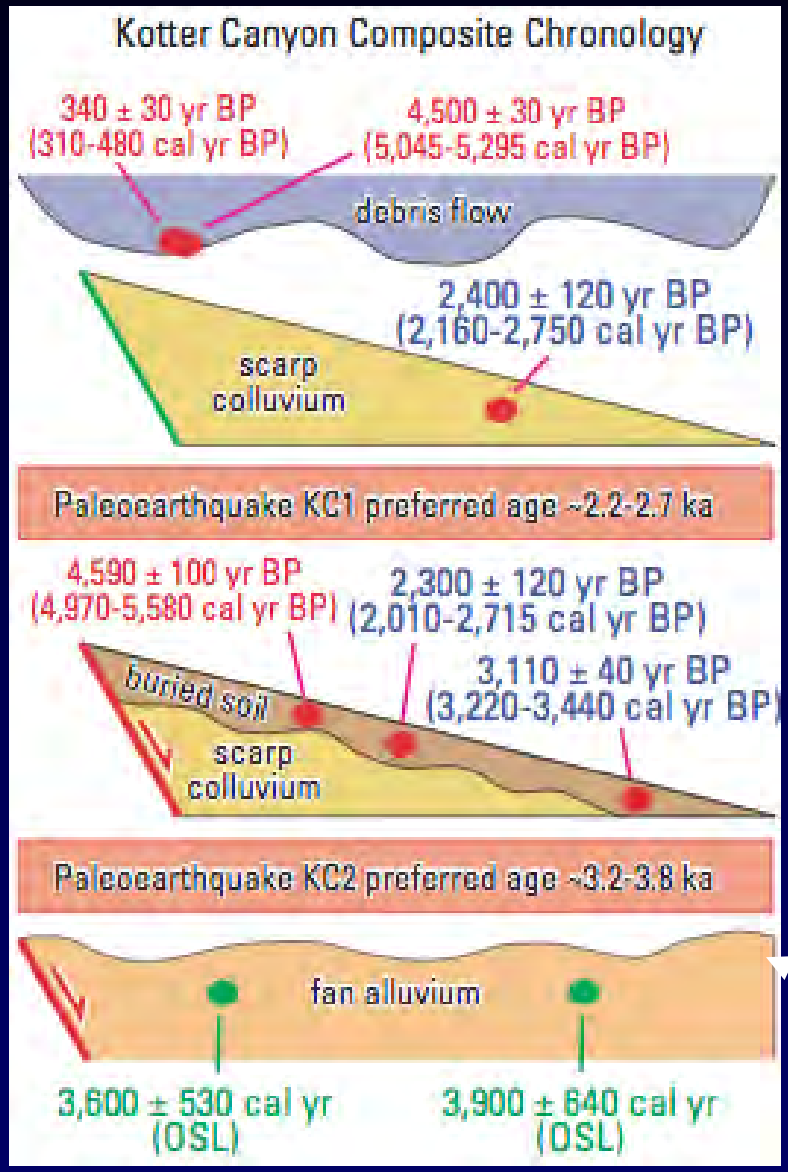
Hansen and Kotter Canyons Trench Sites



Sites are on northern part of BCS

USGS

Kotter Canyon Trench Site

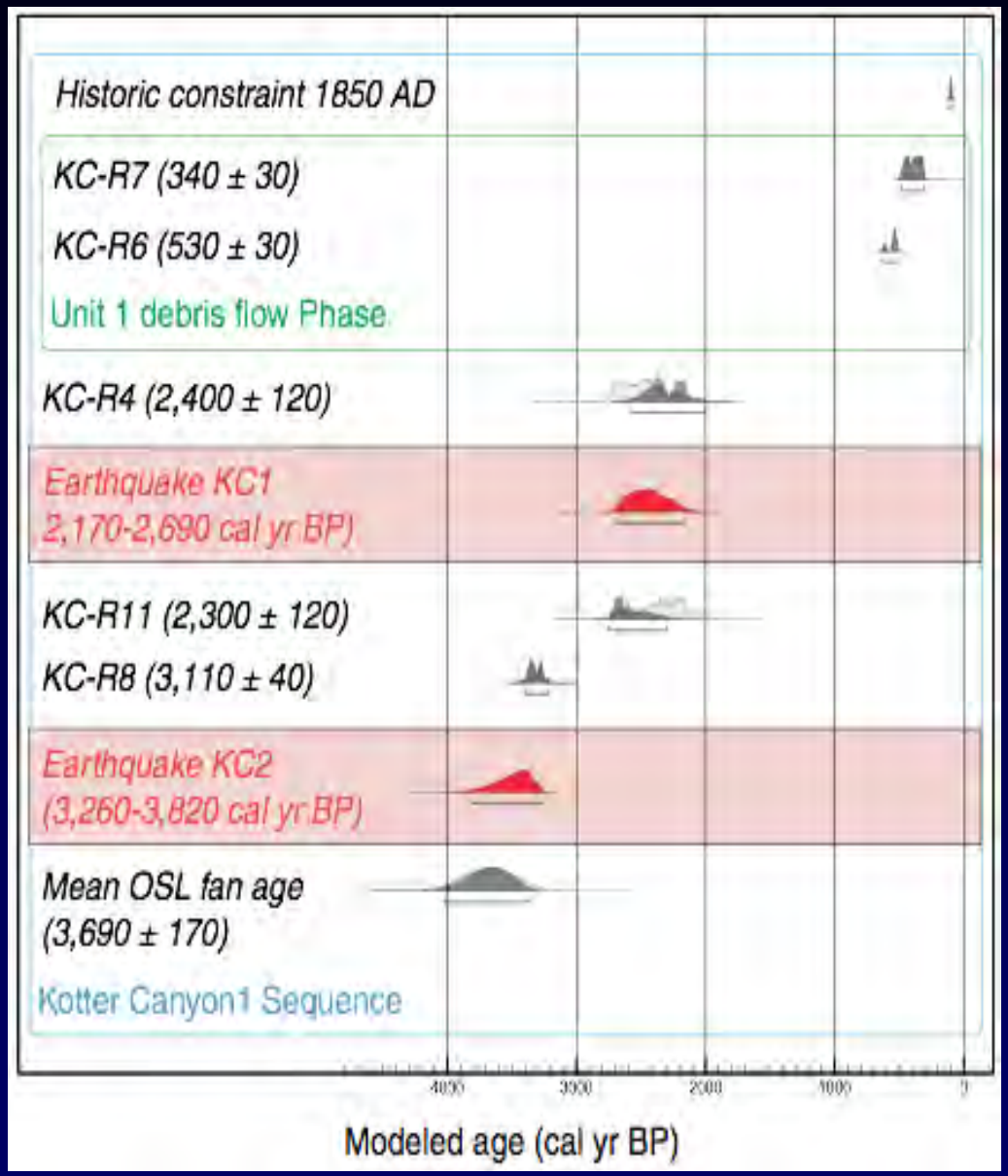


- **Diverse ranges of radiocarbon ages indicate abundant reworking of charcoal in deposits**
- **Stratigraphic evidence indicates two faulting events with preferred ages of 2.2-2.7 ka (KC1) and 3.2-3.8 ka (KC2).**
- **The two Kotter Canyon events correlate well with events Z (2.1 ± 0.8 ka) and Y (3.45 ± 0.3 ka) at Box Elder delta (ages from UQFPWG, 2005)**

No soil on fan alluvium

USGS

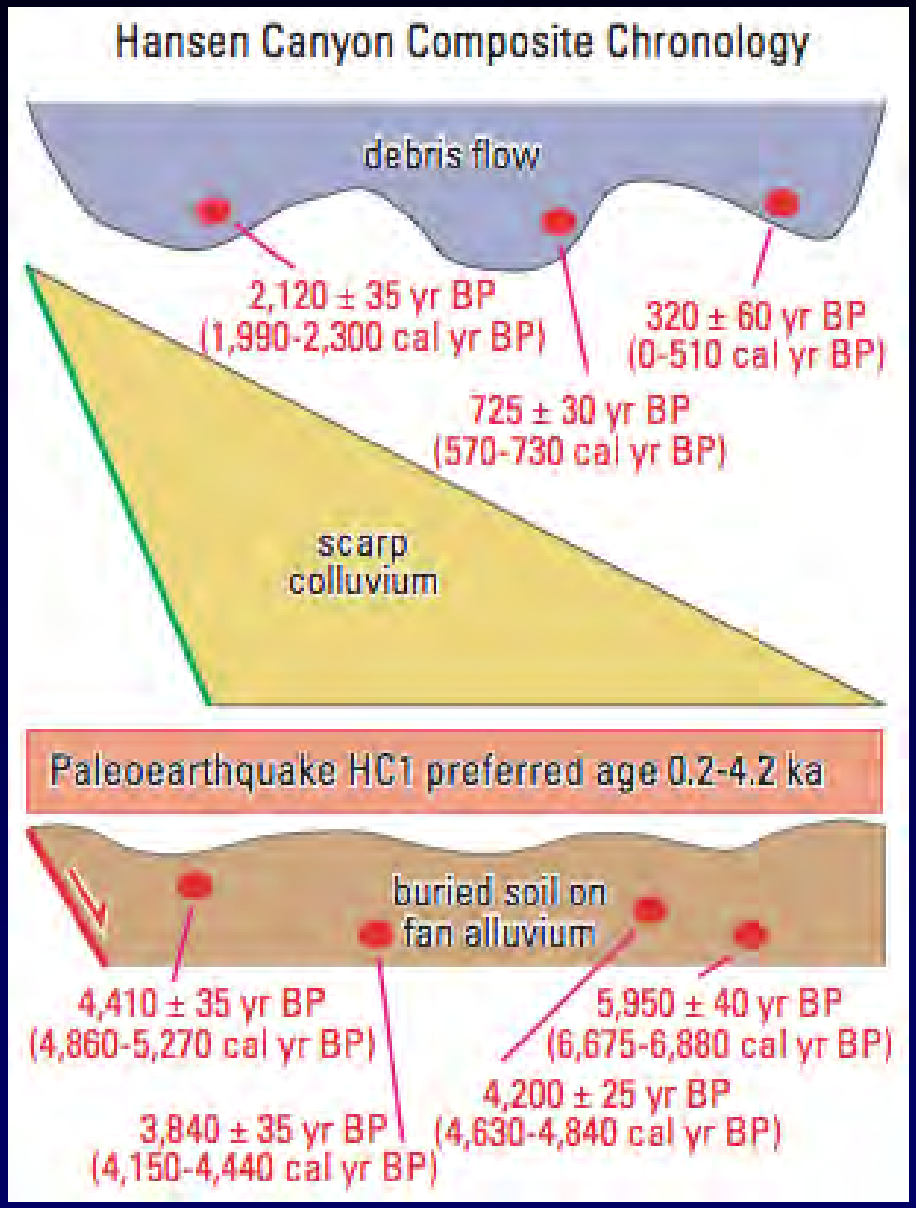
Kotter Canyon Trench Site



- OxCal (v. 4.1) model of selected radiocarbon ages from Kotter Canyon trench site.
- After excluding obvious outliers, minimum and maximum ages constrain earthquake KC1 to 2.2-2.7 ka and earthquake KC2 to 3.2-3.8 ka

USGS

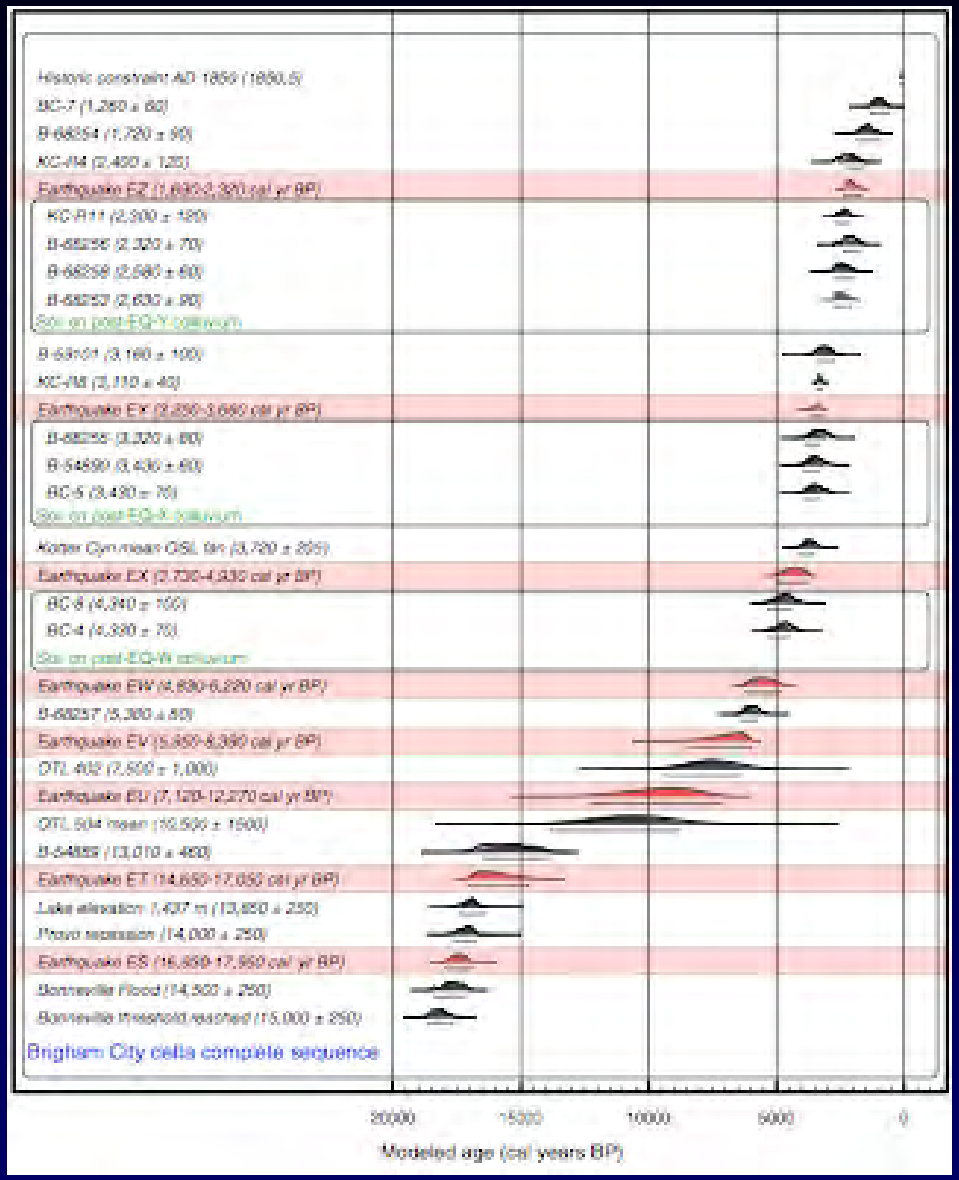
Hansen Canyon Trench Site



- Diverse ranges of radiocarbon ages indicate abundant reworking of charcoal in deposits
- One colluvial wedge on fan deposits
- Lack of minimum age constraints in scarp colluvium result in broad event-age estimate
- The Hansen Canyon MRE may correlate with events Z (2.1 ± 0.8 ka) or Y (3.45 ± 0.3 ka) at Box Elder delta (ages from UQFPWG, 2005)

USGS

Comparison with other BC segment sites

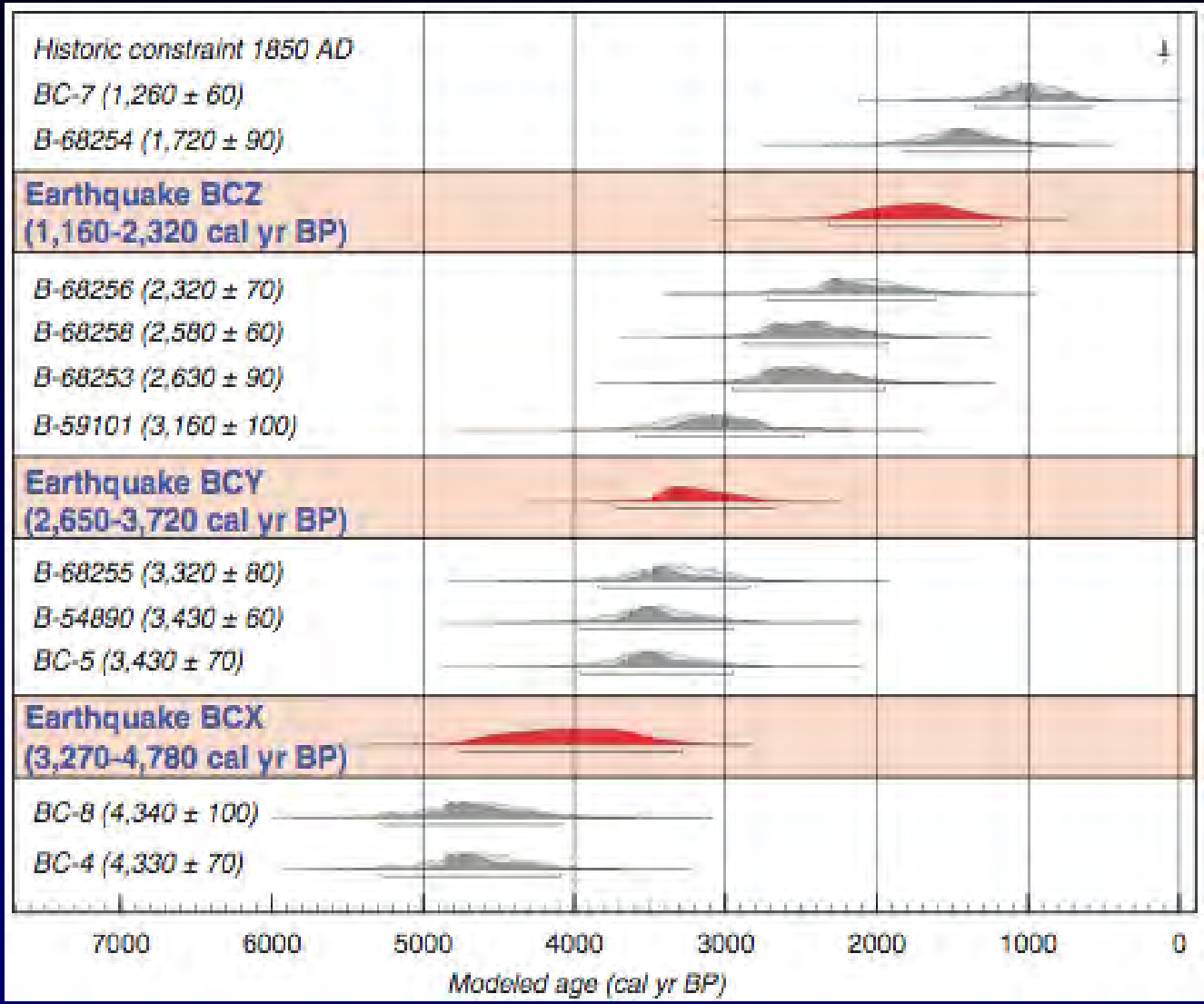


New OxCal Model for Box Elder Delta

- Preliminary OxCal (v. 4.1) model, using data from Bowden Canyon (Personius, 1991) and Box Elder Delta site (McCalpin et al., 2002); program treats all constraints in systematic manner.
- "Legacy" soil age calibrations use "delta-R" of 200 ± 200 yr to account for mean residence time (MRT) of soil organic matter
- Timing estimates of most earthquakes are broad, primarily from lack of closely-limiting minimum ages and reliance on TL and MRT ^{14}C dating.

USGS

Comparison with other BC segment sites

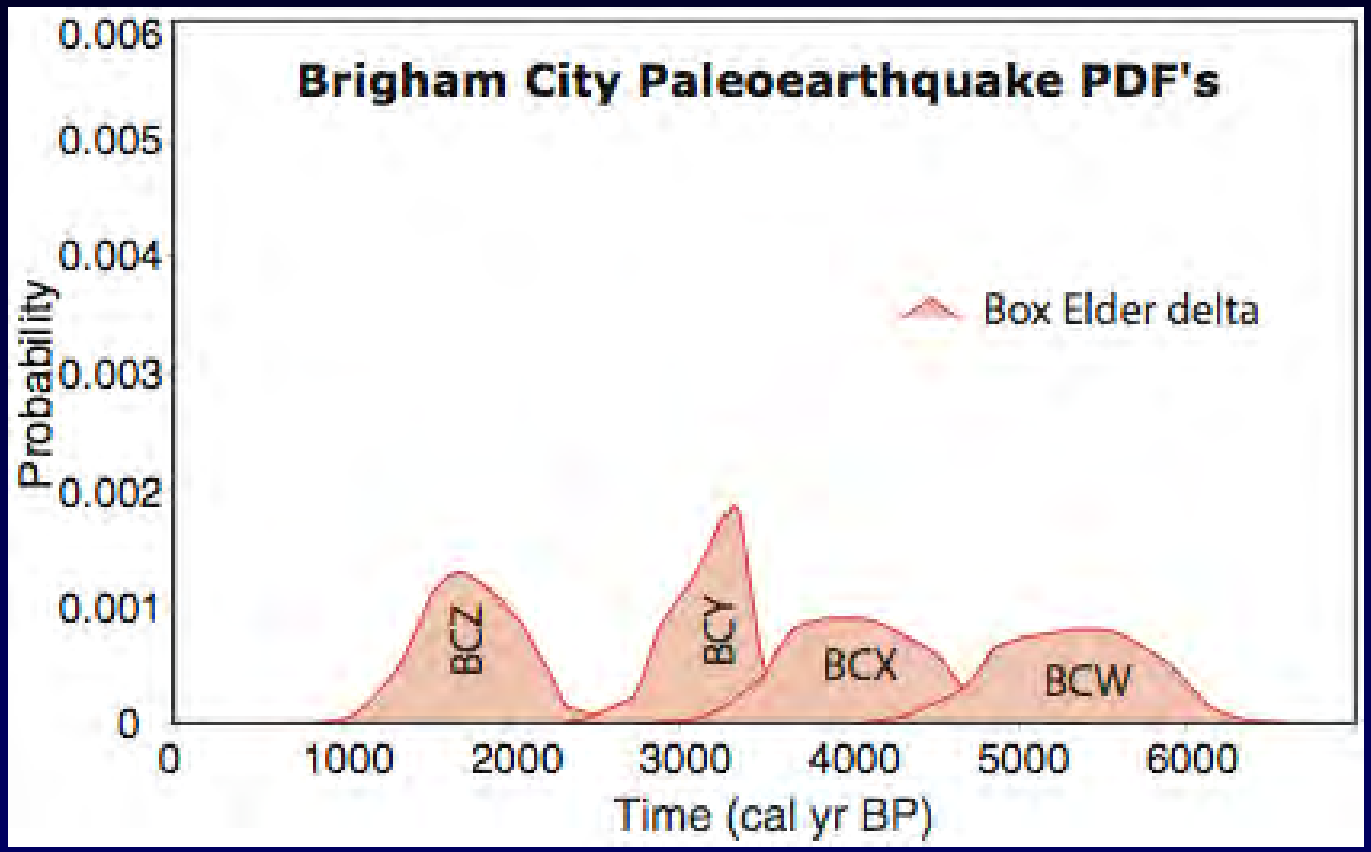


Box Elder Delta OxCal model

- Model of last three BC segment earthquakes using age constraints from Personius (1991) and McCalpin et al., 2002).
- Modeled event ages have broad uncertainties, primarily because of lack of closely-limiting minimum ages

USGS

Comparison with other BC segment sites

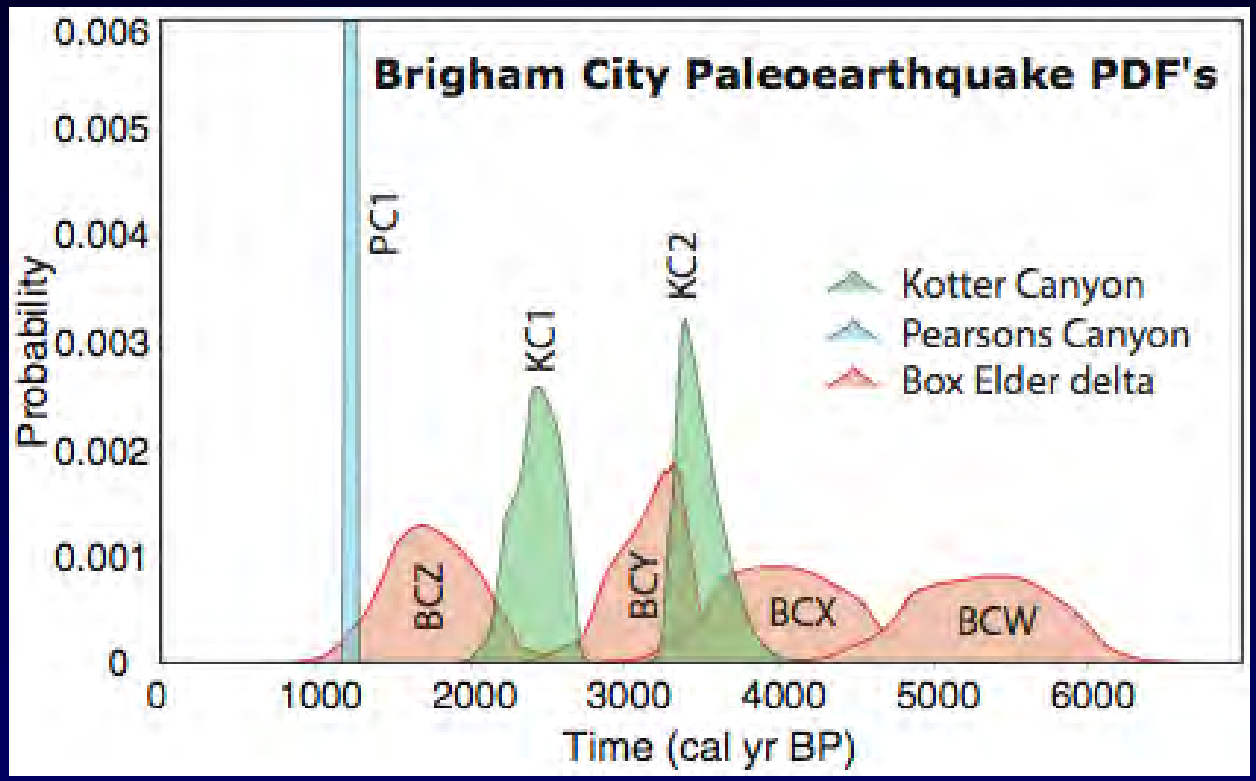


Box Elder Delta PDF plot

- Plot of OxCal-modeled ages (PDF's) of last 4 surface-rupturing earthquakes on the BC segment in vicinity of Brigham City, using data from Bowden Canyon (Personius, 1991) and Box Elder delta (McCalpin et al., 2002), and MRT correction of 200 ± 200 years

USGS

Comparison with other BC segment sites

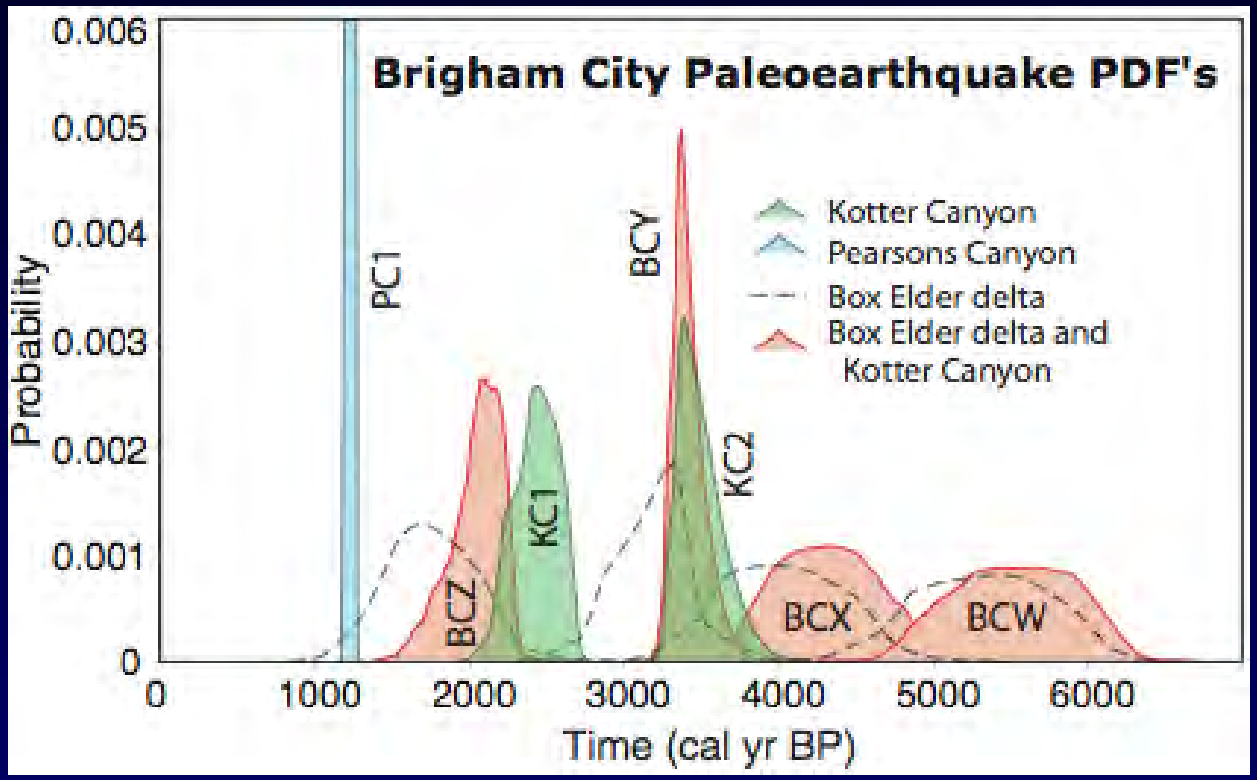


Results from 2008 trenching

- PDFs from Kotter Canyon (KC1, KC2) overlap with but are more narrowly defined and older than their assumed correlative events (BCZ, BCY) at Box Elder Delta
- Age of Pearsons Canyon MRE (PC1) is narrowly defined and younger than MRE elsewhere on segment

USGS

Comparison with other BC segment sites



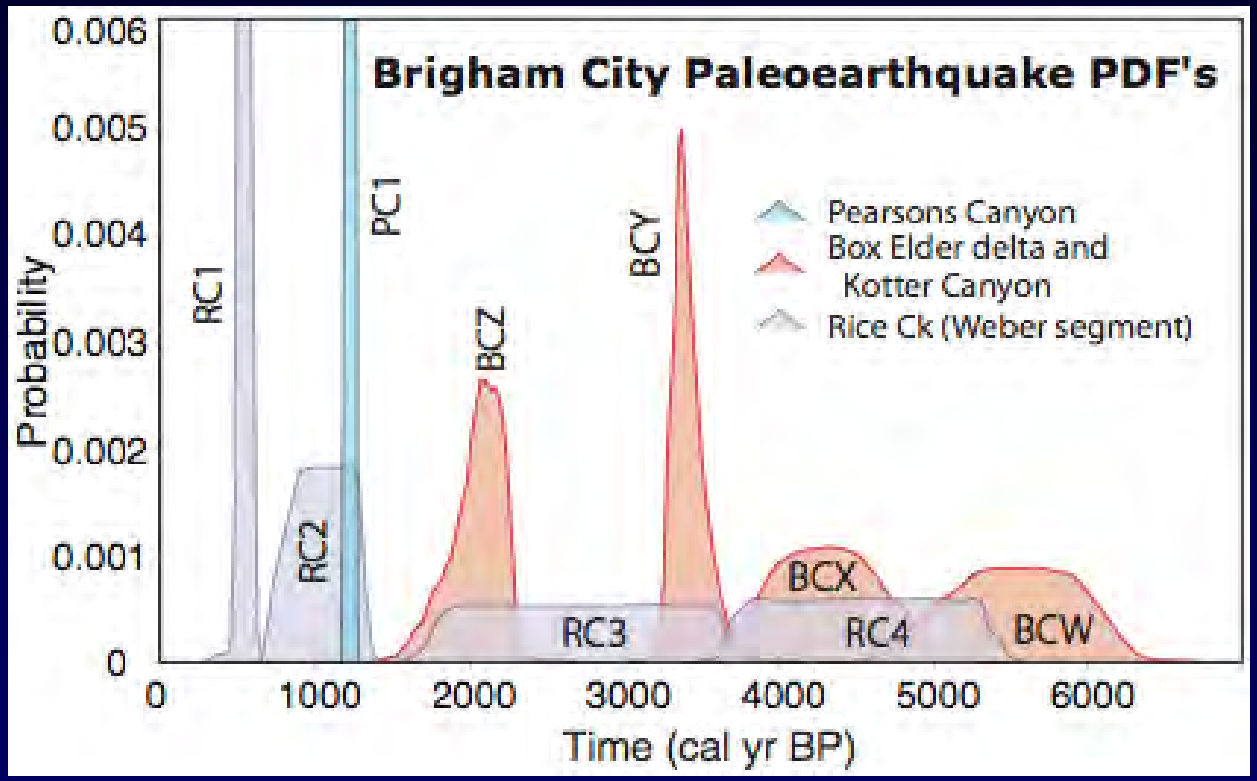
Combined OxCal results

- If the assumption of event correlation is correct (KC1=BCZ; KC2=BCY), then a combined OxCal model should yield improved age estimates
- Combined BCS model (light red PDFs) yields older event-age estimates for last 4 events and narrower age ranges
- Pearsons Canyon MRE (PC1) is younger than elsewhere on the BCS

USGS

Comparison with other BC segment sites

Correlation of Pearsons event

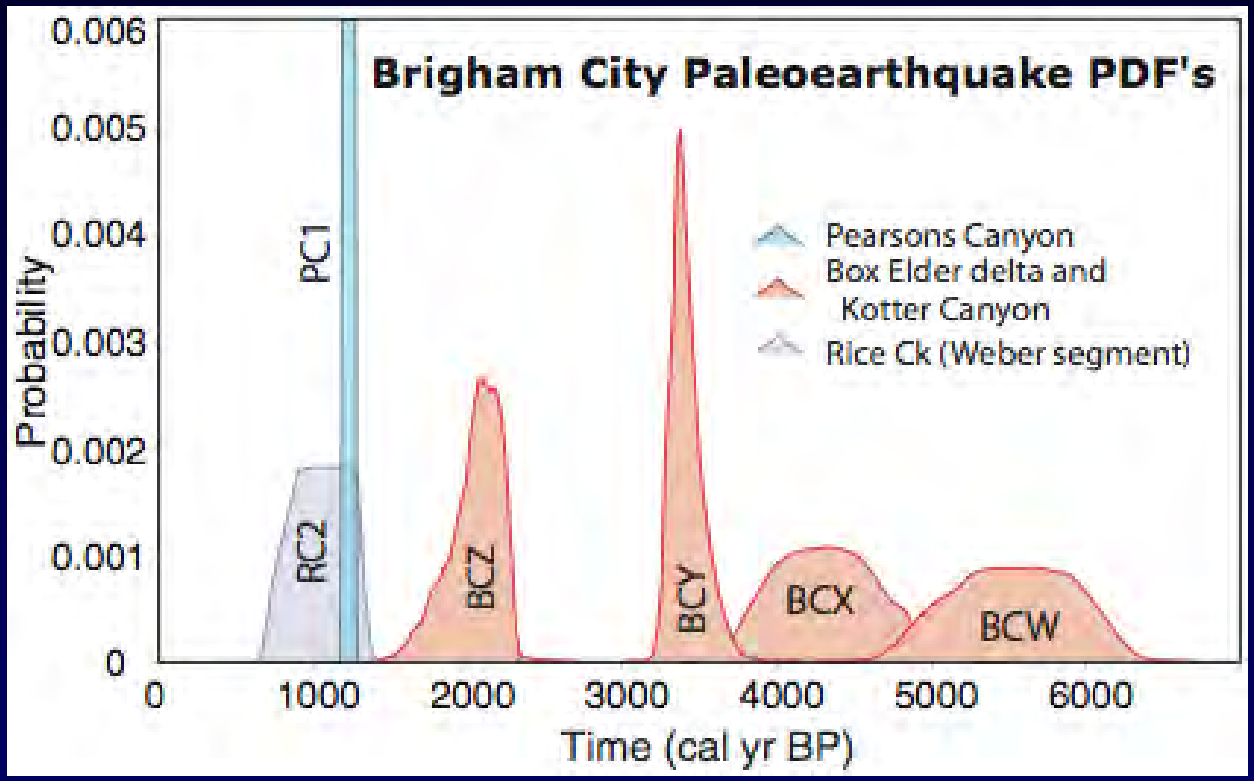


- Event PC1 PDF does not overlap with MRE PDF (BCZ) from Brigham City area
- Event PC1 PDF does overlap with event RC2 PDF from Rice Ck site on northern Weber segment
- We conclude earthquake RC2 ruptured into southern Brigham City segment at least as far north as our Pearsons Canyon North trench site

USGS

Summary of BC segment Paleoseismology

Earthquake Timing

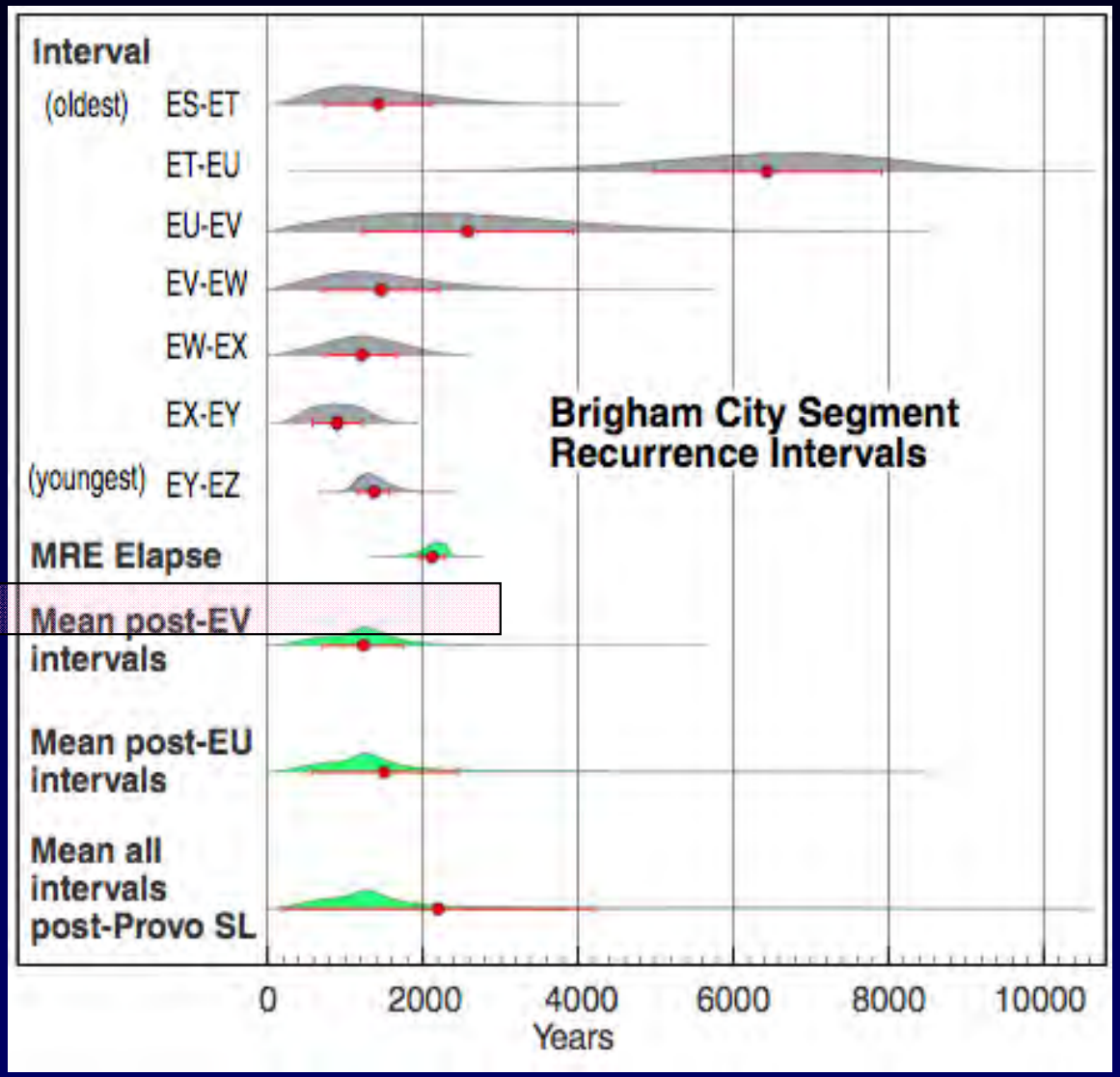


- Timing of last four events near Brigham City (2 sigma):
- BCZ: 1690-2320 cal yr
- BCY: 3250-3660 cal yr
- BCX: 3730-4930 cal yr
- BCW: 4830-6220 cal yr

- PC1: 1190-1280 cal yr (Weber segment RC2)

USGS

Summary of BC segment Paleoseismology



Earthquake Recurrence

- Recurrence time (mean and 1 sigma):
- EU-EV: 2580 ± 1360 yr
  EV-EW: 1460 ± 750 yr
  EY-EZ: 1370 ± 200 yr
  EW-EX: 1220 ± 460 yr
  EX-EY: 900 ± 320 yr
- MRE elapse time:
  2060 ± 170 yr
  (UQFPWG: 2100 ± 800)
- Mean (last 4 intervals):
  1230 ± 520 yr; COV=0.42
- Mean (last 5 intervals):
  1500 ± 940 yr; COV=0.63
  (UQFPWG: 1,300 ± 400)
- Mean (all 7 intervals):
  2200 ± 2000 yr; COV=0.91

USGS

Preliminary Results

			Brigham City Segment		Weber segment
Event	*UQFPWG*	*BC Comb. OxCal*	*Kotter Cyn.*	*Pearsons N Cyn.*	*Rice Creek*
1	2.1 ± 0.8 ka	1.7-2.3 ka	2.2-2.7 ka	1.2-1.3 ka	0.5-0.6 ka
2	3.5 ± 0.3 ka	3.3-3.7 ka	3.3-3.8 ka	–	0.7-1.4 ka
3	4.7 ± 0.5 ka	3.7-4.9 ka	–		1.8-3.7 ka
4	6.0 ± 0.3 ka	4.8-6.2 ka			3.7-5.4 ka
5	7.5 ±1.0 ka	6.0-8.4 ka			5.5-7.5 ka
6	8.5 ±1.5 ka	7.1-12.3 ka			>7.8-9.9 ka
7	>13.6, <17.0 ka	14.7-17.1 ka			
8	_	16.9-17.9 ka			

USGS

Brigham City Segment Conclusions

- 2008 trenching at Kotter Canyon confirms ~2 ka MRE 4 km north of Box Elder Delta
- Our OxCal analysis of all BCS paleoseismic data indicates:
- At least 8 paleoearthquakes on the BCS post-date the Bonneville Flood (17.2-18.4 ka)
- MRE near Brigham City: 1,690-2,320 cal yr BP (2 sigma)
- MRE elapse time: 2,060±170 yr (1 sigma) (from present)
- Mean of last 5 recurrence intervals: 1,500±940 yr (1 sigma)
- Mean of last 4 recurrence intervals: 1,230±520 yr (1 sigma)
- MRE at Pearsons Canyon: 1,190-1,280 cal yr BP; correlates with event RC2 at Rice Creek on Weber segment, indicating at least one Holocene earthquake ruptured through the southern segment boundary
- OxCal analysis of "legacy" and new chronological data are useful for site-to-site comparisons, refining event ages, and calculating robust recurrence-interval values and uncertainties

USGS

Remaining Issues on Brigham City Segment

- Location of northern termination of Weber RC2 (PC1) rupture between Pearsons Canyon and Box Elder delta
- Timing of Holocene ruptures near northern end of BC segment.
- Evidence for a submarine event “S” at Box Elder Delta
- Explanations for large apparent gap (6.4 ± 1.5 ky) between events “U” and “T” at Box Elder delta—missing events?
- MRT correction values for legacy soil ages

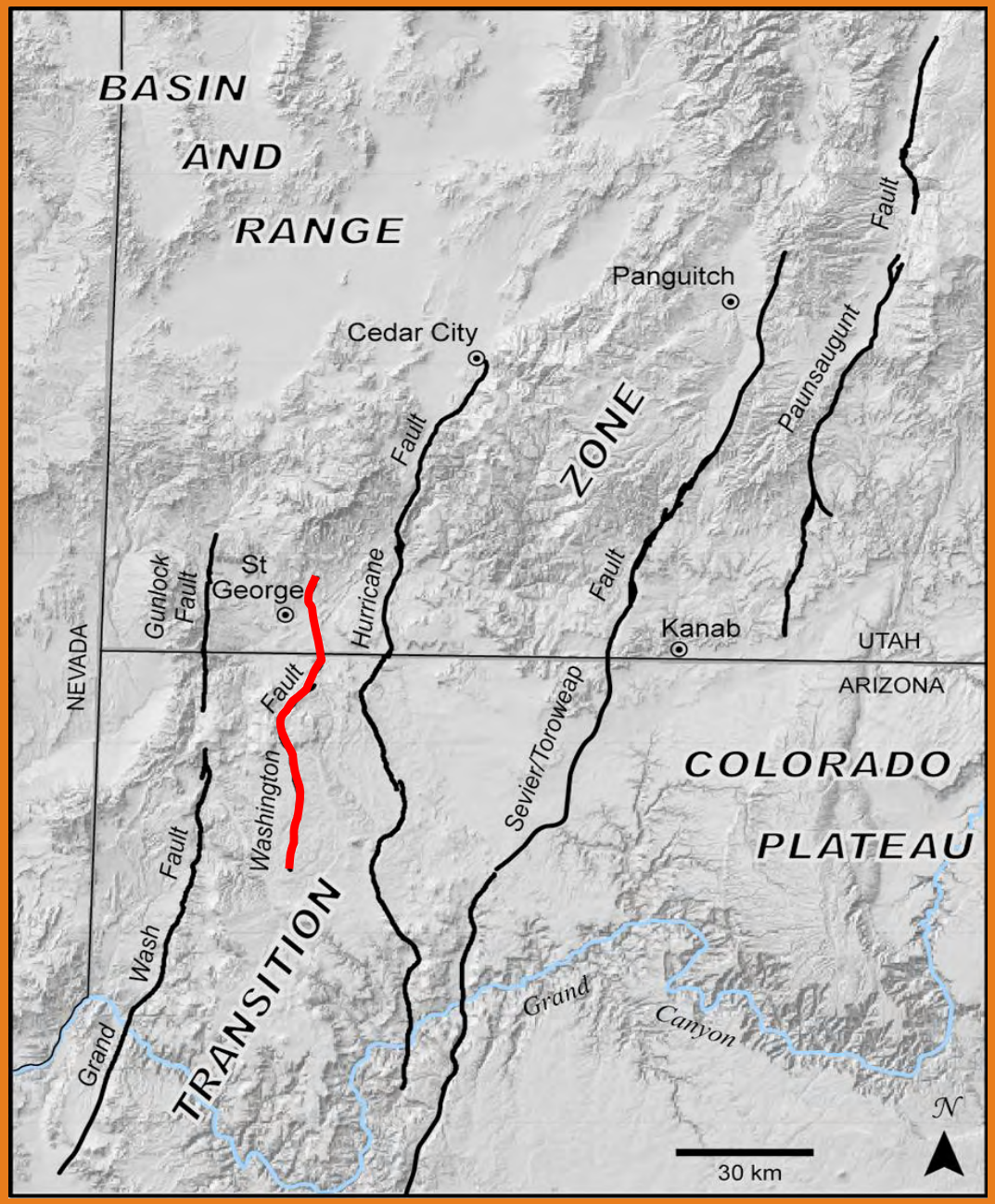
USGS

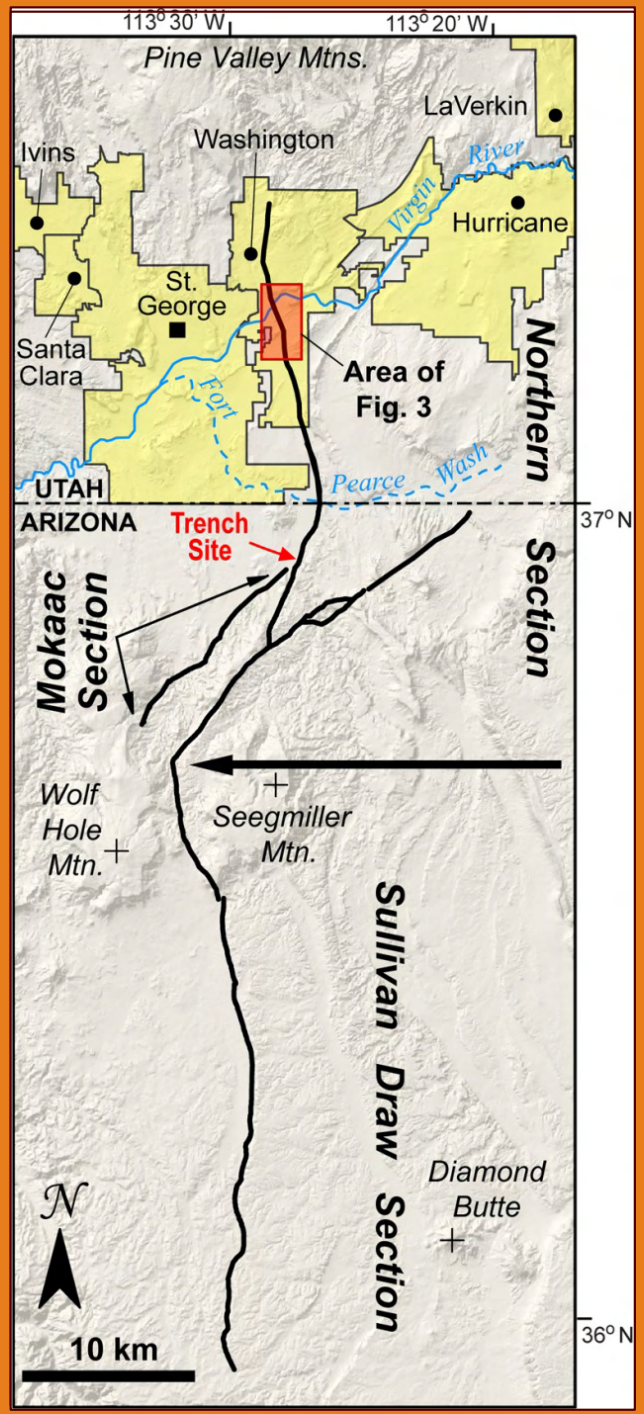
UTAH GEOLOGICAL SURVEY

WASHINGTON FAULT PALEOSEISMIC INVESTIGATION

William Lund and Tyler Knudsen
Utah Geological Survey

REGIONAL FAULT RELATIONS

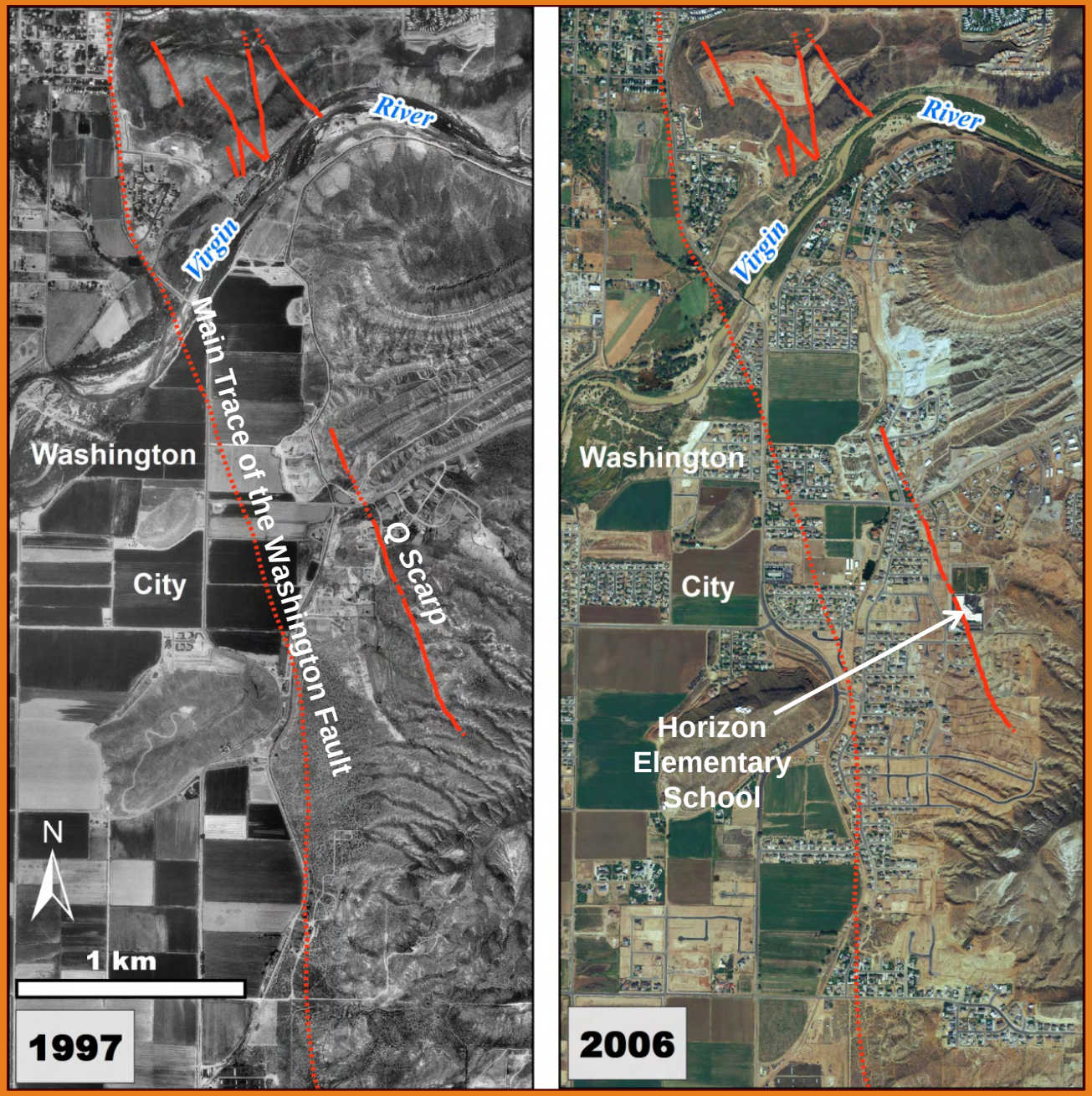




THREE FAULT SECTIONS

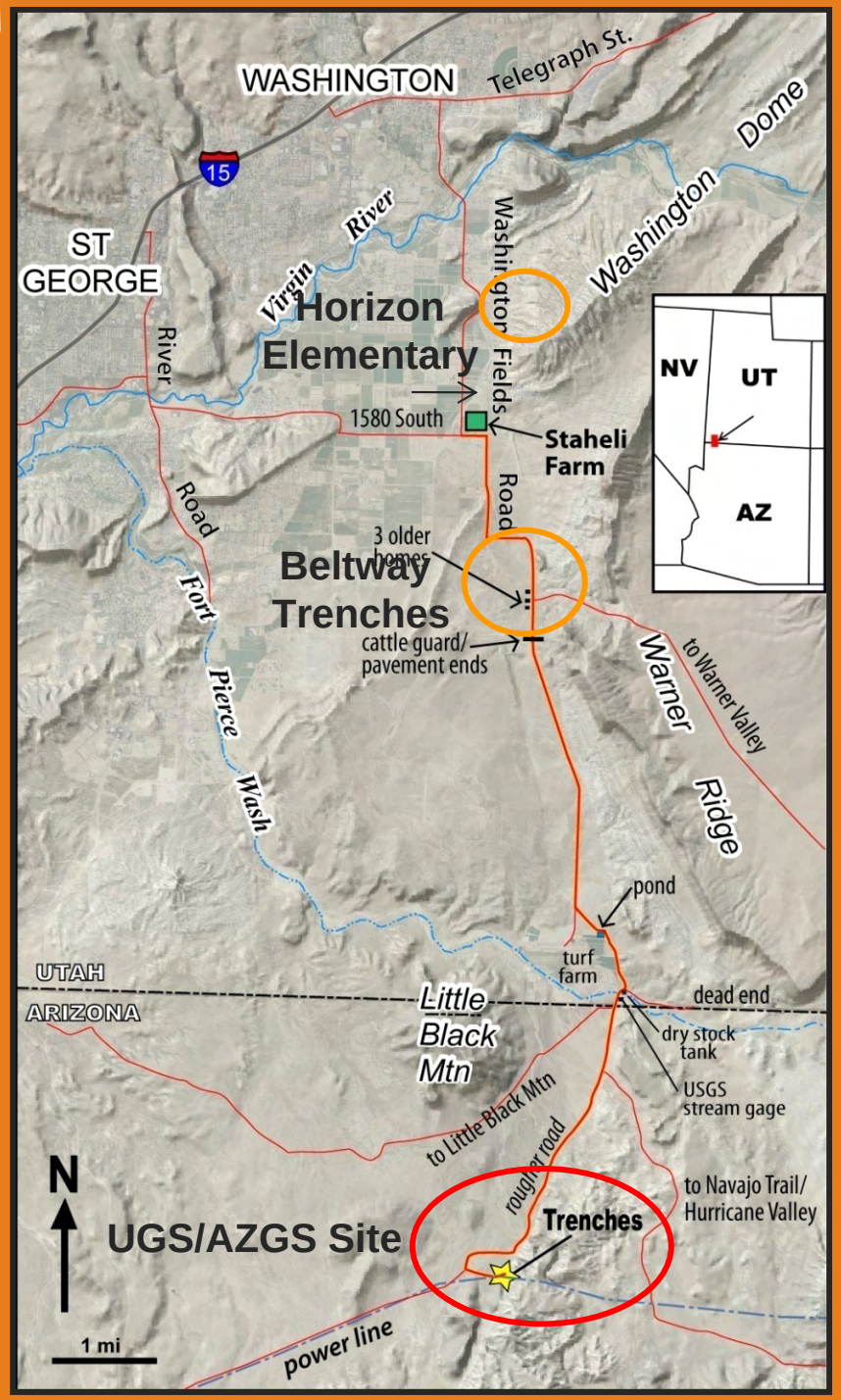
- *Sullivan Draw*
- *Mokaac*
- *Northern*

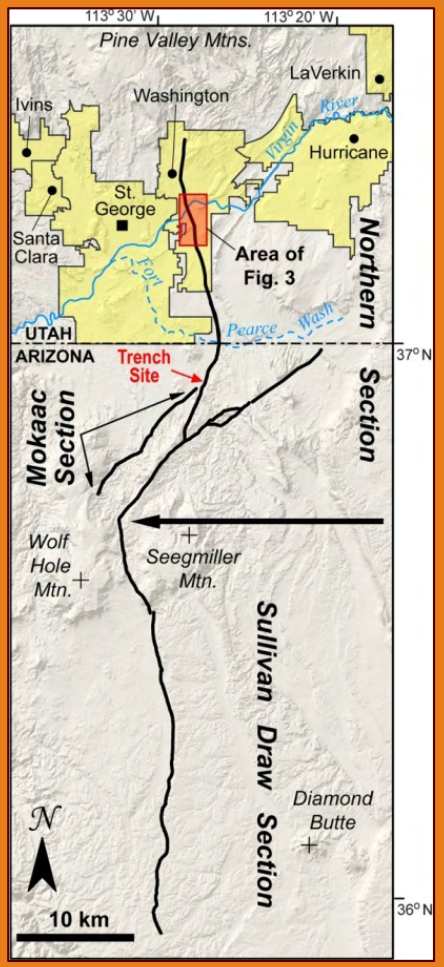
NORTHERN SECTION TRENDS INTO ST. GEORGE METROPOLITAN AREA



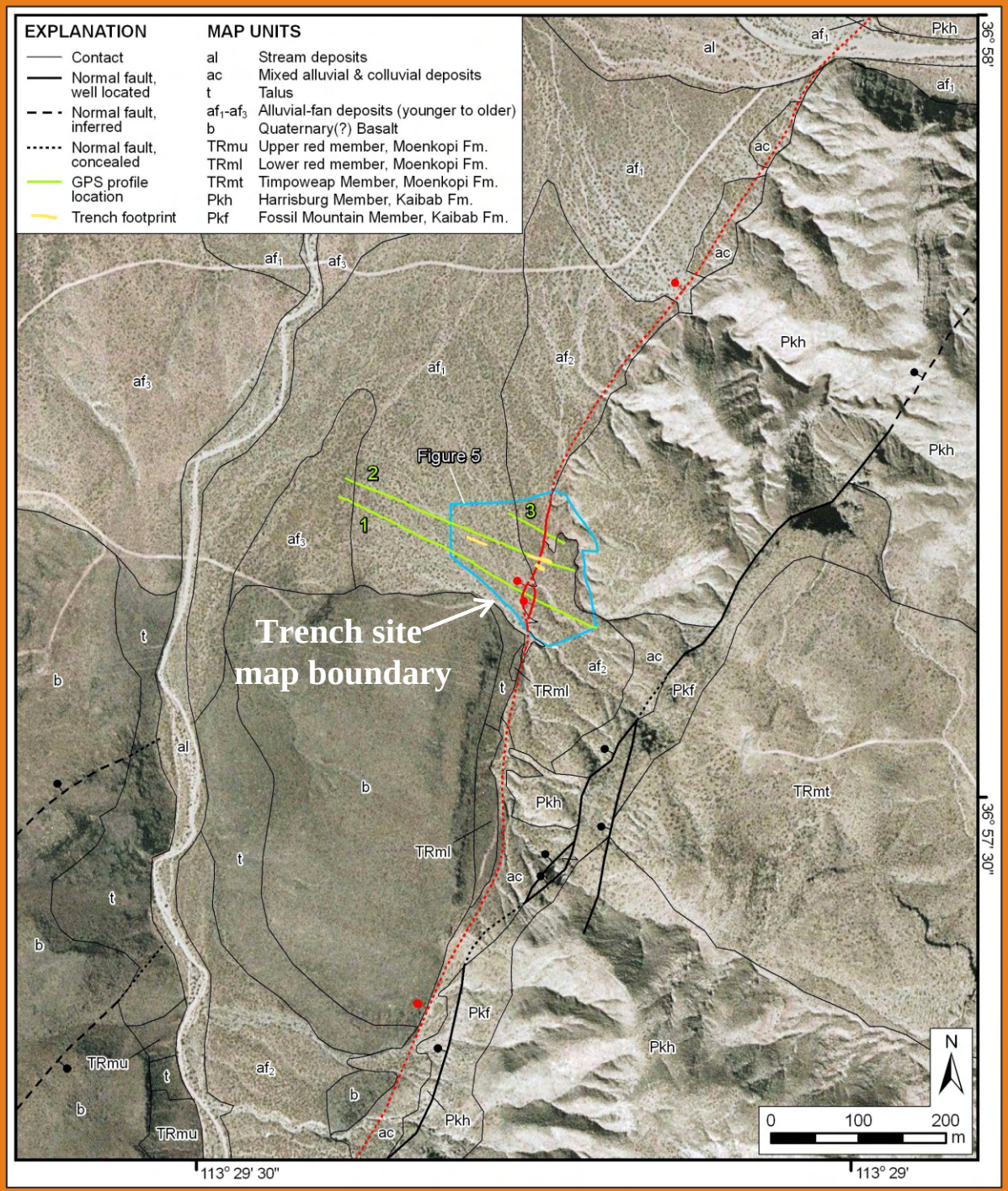
ST. GEORGE METRO URBANIZATION PLACES EVER MORE INFRASTRUCTURE AT RISK FROM A WASHINGTON FAULT EARTHQUAKE

UGS/AZGS TRENCH SITE IS ON THE ARIZONA STRIP THREE MILES SOUTH OF THE UTAH/ARIZONA BORDER



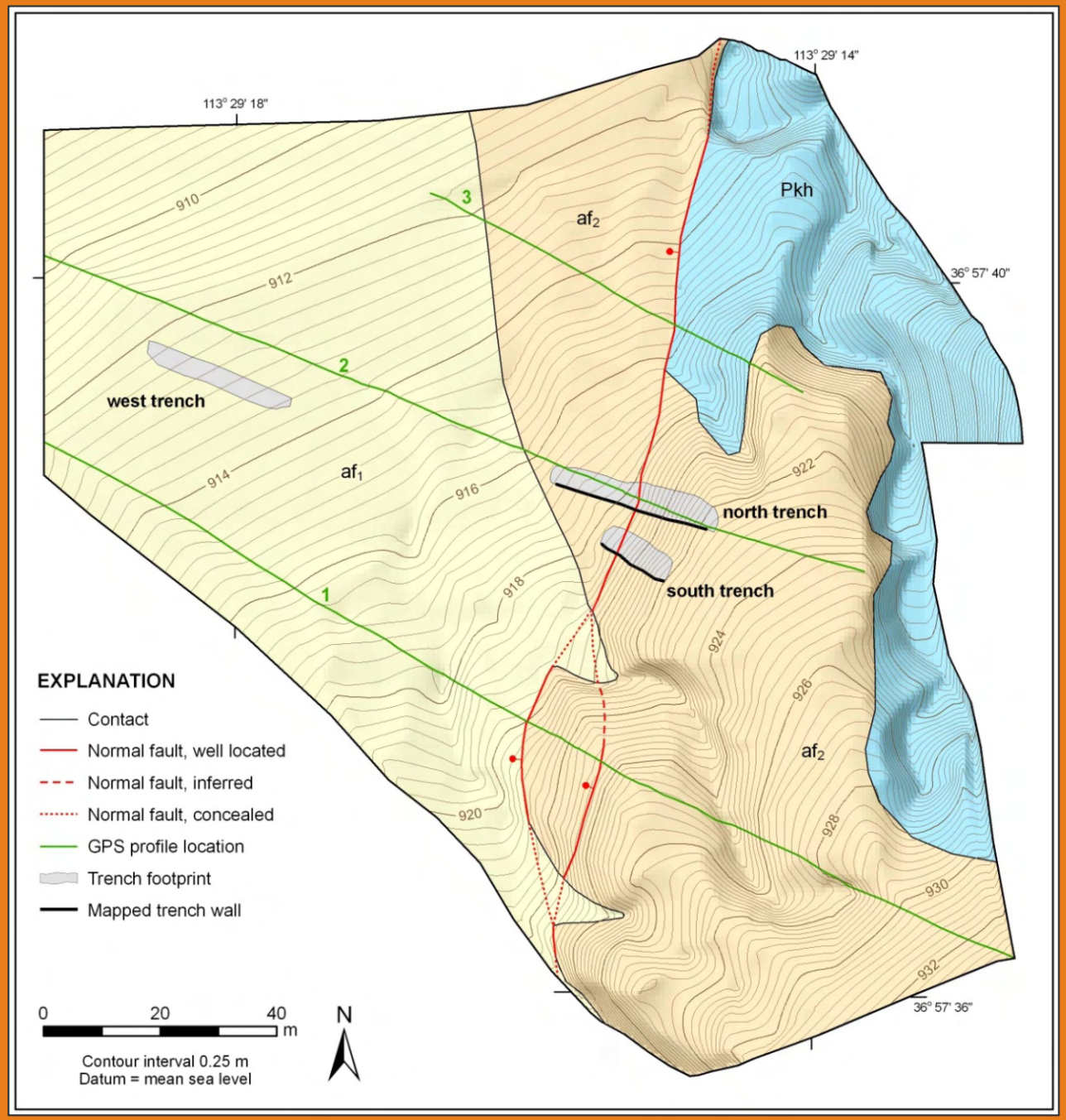


www.geology.utah.gov



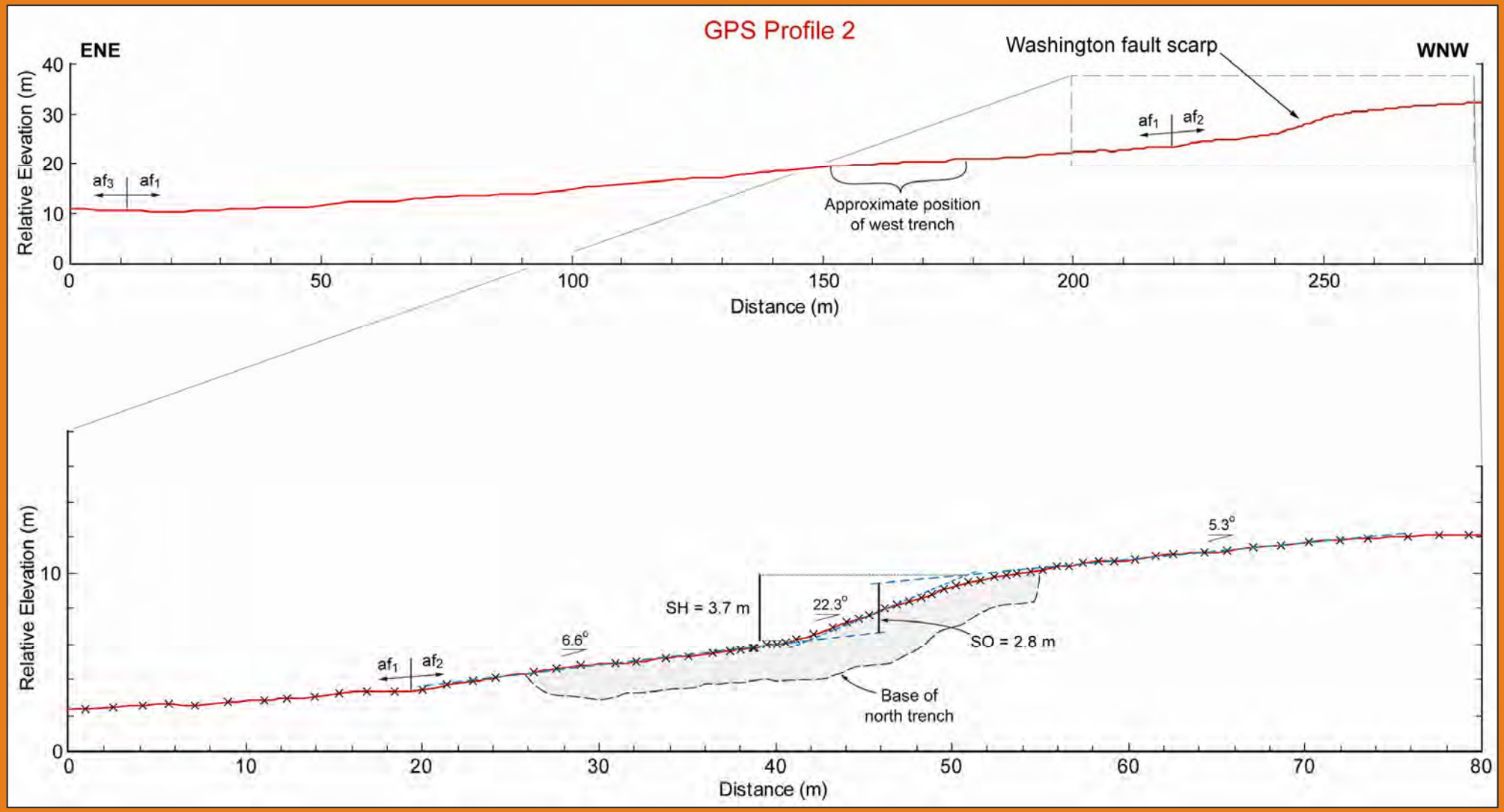
DUTCHMAN DRAW AREA GEOLOGIC MAP

DUTCHMAN DRAW FAULT SCARP

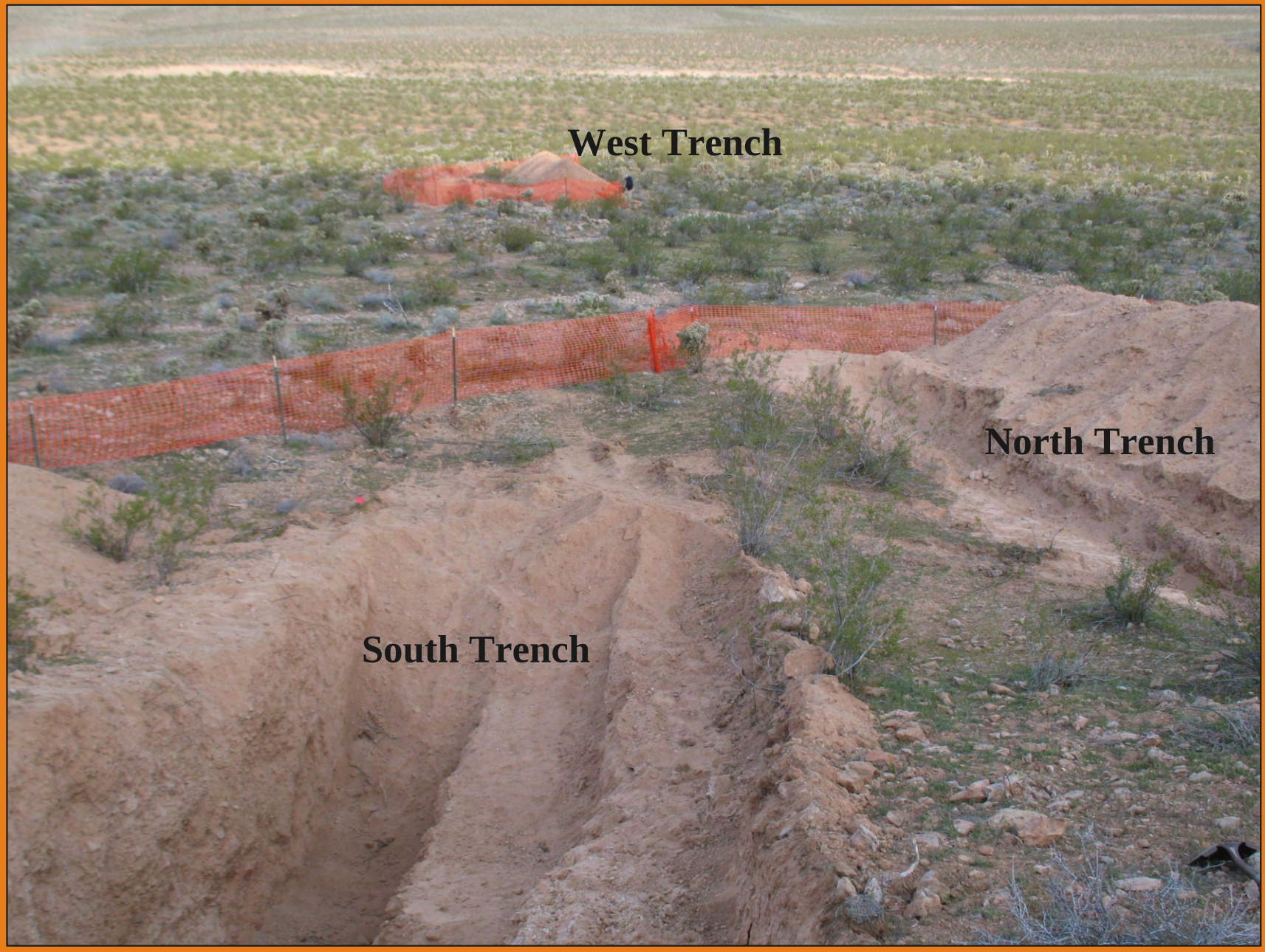


TRENCH SITE GEOLOGIC AND TOPOGRAPHIC MAP

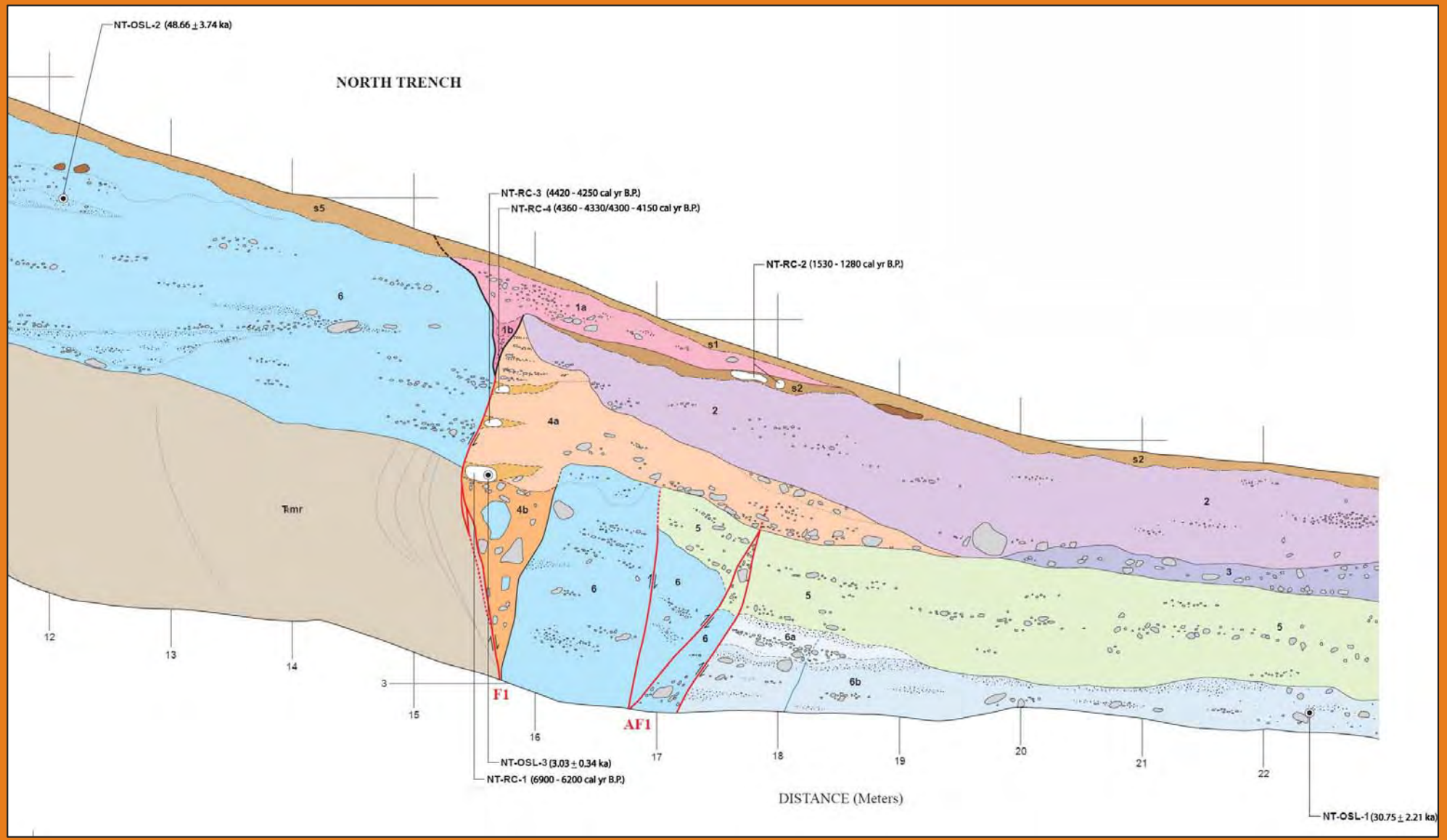
SCARP PROFILE



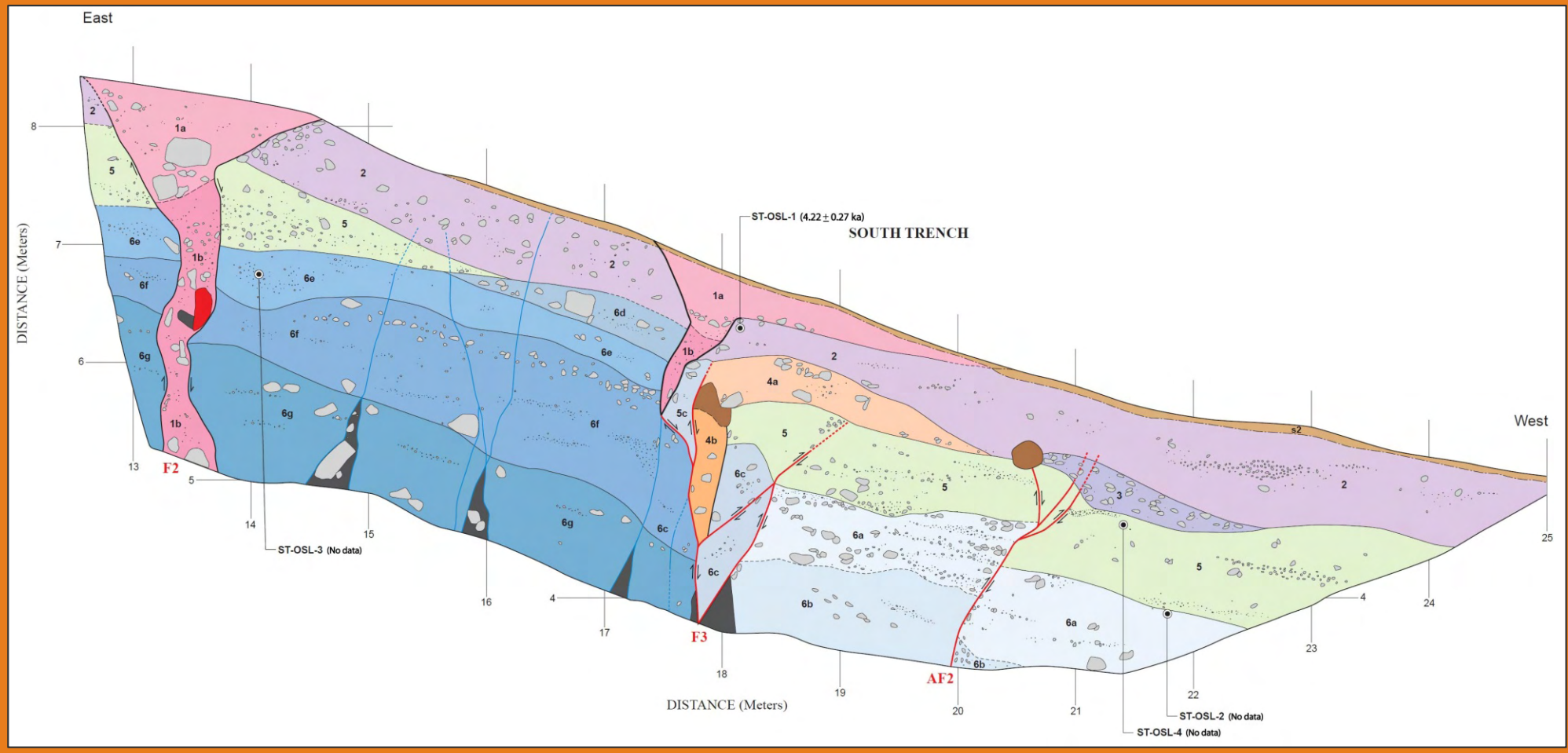
TRENCHING RESULTS



NORTH TRENCH FAULT ZONE (south wall)



SOUTH TRENCH (south wall)



SUMMARY OF TRENCHING RESULTS

- ***Two Holocene paleoearthquakes***
  PE1 < 1530-1280 cal yr B.P. ***(shortly after?)***
  PE2 > 6900-6200 cal yr B.P. ***(shortly before?)***

- ***No other events < 30.75 ± 2.21 ka*** ***(erosion?)***

Washington Fault Study

UDOT Project

Principal Investigators:

David Black (Rosenberg Associates)

Peter Rowley (Geologic Mapping Inc.)

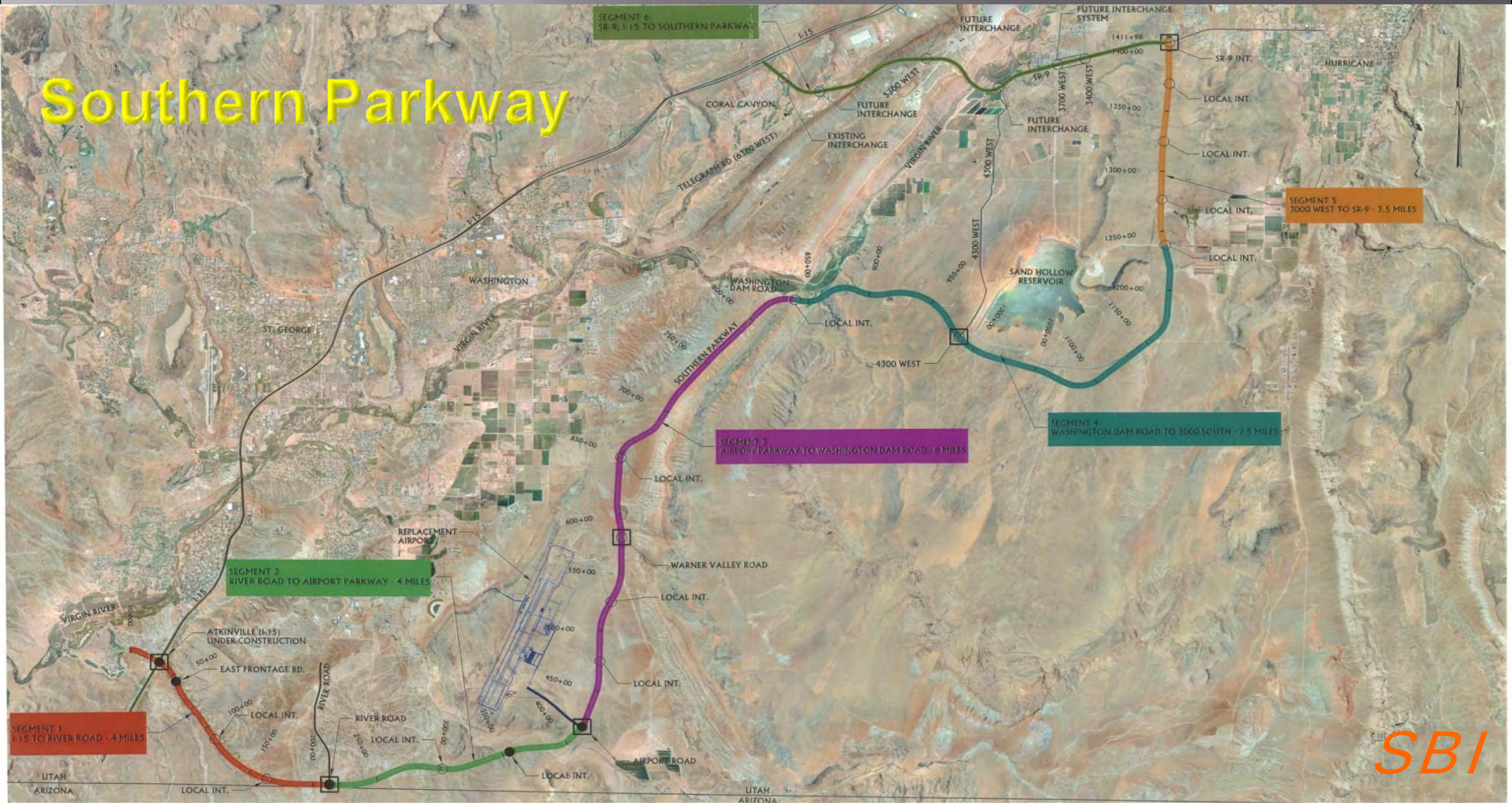
David Simon (Simon Bymaster Inc.)

Jon Hanson (Rosenberg Associates)

William Lund (Utah Geological Survey)

SBI

- **Four (4) lane divided highway with grade separated interchanges.**
- **27 miles long from Exit 2 on I-15 to SR-9 in Hurricane.**
- **Provides a critical transportation link for the St. George metropolitan area.**
- **Project consists of six (6) phases.**



GEOLOGIC HAZARDS AND ADVERSE CONSTRUCTION CONDITIONS

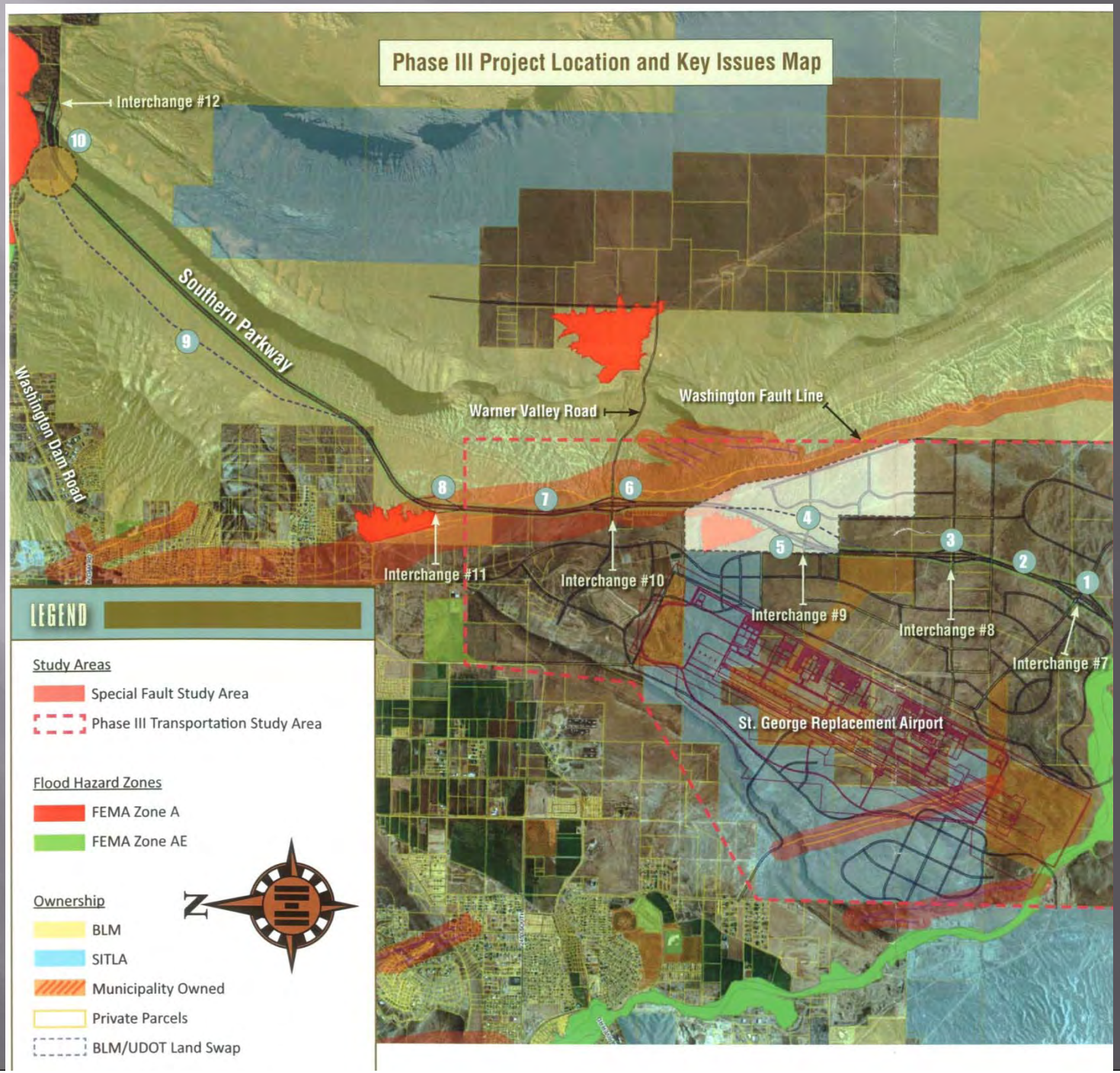
ST. GEORGE–HURRICANE METROPOLITAN AREA, WASHINGTON COUNTY, UTAH

by William R. Lund, Tyler R. Knudsen, Garrett S. Vice, and Lucas M. Shaw

SPECIAL STUDY 127
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
2008

SBI

Geologic Hazards



SBI

Purpose of Investigation

- Evaluate surface-fault-rupture-hazards for Phase III of the Washington Fault Zone
- Prevent the siting and construction of elevated structures astride a Holocene-age fault
- Assist with ongoing analyses

SBI

Tasks

- **Task I:** Research available literature, review aerial photographs, lineament analysis, detailed geologic mapping. Products include a detailed geologic map and a proposed Task II scope of work.
- **Task II:** Detailed subsurface fault investigation to evaluate the location, age of latest movement, displacement per event, and recurrence interval for the Washington fault.
- **Task III:** Present findings and recommendations in a written report.

SBI

Task I

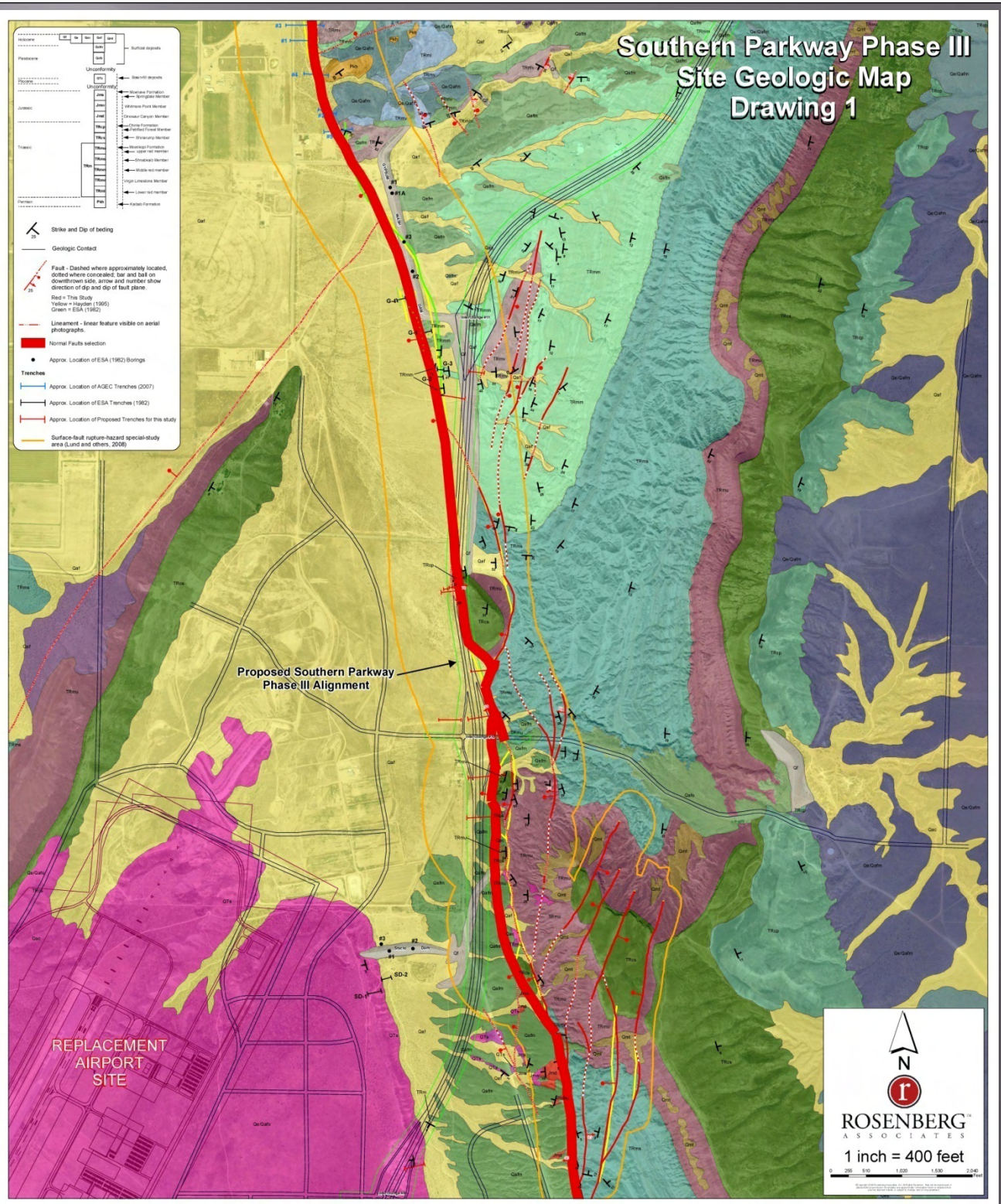
Geologic Mapping

Peter Rowley
Geologic Mapping Inc.

- **Mapped at a scale of 1= 500 ft; prior mapping performed at 1 = 2000 ft**
- **Geologic mapping consisted of modifying published UGS geologic maps (Hayden, 2005)**
- **Concentrated on the faults**

SBI

Geologic Map



SBI

Findings - Task I

- Several new faults, many splays identified
- Refined existing geology maps of area
- Along with GPS, provided greater confidence on fault locations

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TASK II

David Simon, P.G. (Simon Bymaster Inc.)
Jon Russell Hanson, P.E. (Rosenberg Associates)

SBI

GOALS OF FAULT INVESTIGATION

- **Fault Locations**
- **Displacement per surface-faulting event**
- **Recurrence of surface-faulting events**

SBI

Project Status

- Excavated 13 with a track-hoe, varying in length from about 50 to 500 feet.
- Trenches logged at a scale of 1-inch to 5 feet.
- Evidence of faulting was carefully recorded and located by GPS field survey.

SBI

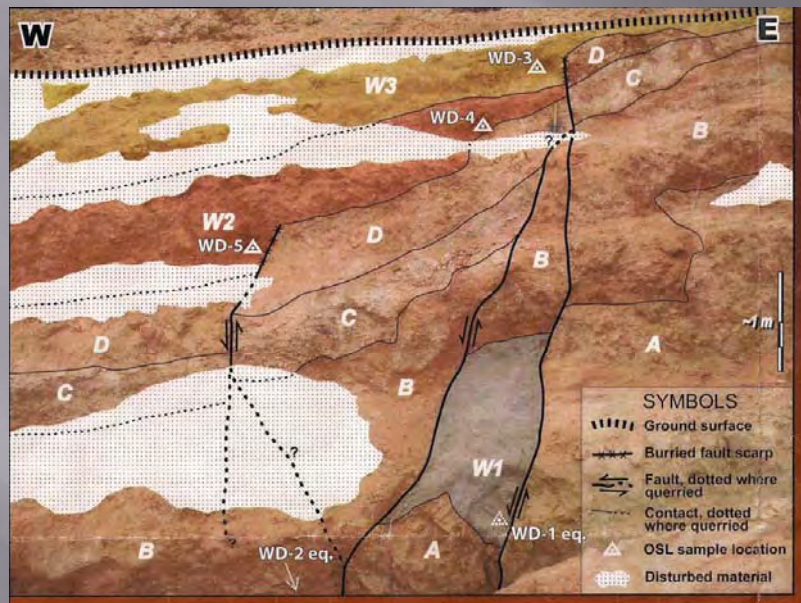
Project Status - continued

Trenching in 2007 by others (AGEC) in Washington Fields area exposed the main trace of the Washington fault. With limited time available before the trenches were closed, the UGS conducted a reconnaissance investigation of the exposed fault.

T-1 revealed a 13-foot-wide fault zone consisting of at least three splays that dip steeply to the west. Colluvial-wedge deposits provided evidence for three surface-faulting earthquakes that displaced mixed alluvial-colluvial-eolian deposits from about 1 foot to just less than 3.2 feet.

Project Status - continued

The UGS collected five samples of possible colluvial/eolian sand from within and below the colluvial wedges and submitted them to OSL for analysis to constrain the ages of the surface-faulting earthquakes.



OSL AGE ESTIMATES

Sample No.	Age (ka)	Remarks
WD-1	67.75 ± 4.56	PE-1 colluvial wedge
WD-2	75.57 ± 5.13	Pre-PE-1 basin-fill deposits
WD-3	18.59 ± 1.16	PE-3 colluvial wedge
WD-4	30.59 ± 2.10	PE-2 colluvial wedge
WD-5	30.81 ± 2.11	PE-2 colluvial wedge

- Three post-76-ka earthquakes
  - PE-1 shortly before ~68 ka (RI ~ 37 kyr)
  - PE-2 shortly before ~31 ka (RI ~ 12 kyr)
  - PE-3 shortly before ~19 ka
- Late Pleistocene MRE is more consistent with other studies

SBI

Project Status - continued

- However, the dates obtained were not considered reliable due to the absence of a detailed trench log. As part of investigation we cleaned and logged the trench so that the UGS dates can be utilized.
- Samples for age dating were obtained from 3 of the 13 trenches and have submitted to Paleo Research Institute (Golden, Colorado).
- In addition, charcoal samples obtained by the UGS from their Dutchman Draw (Arizona) fault study were also submitted for age dating.

SBI

Faulting

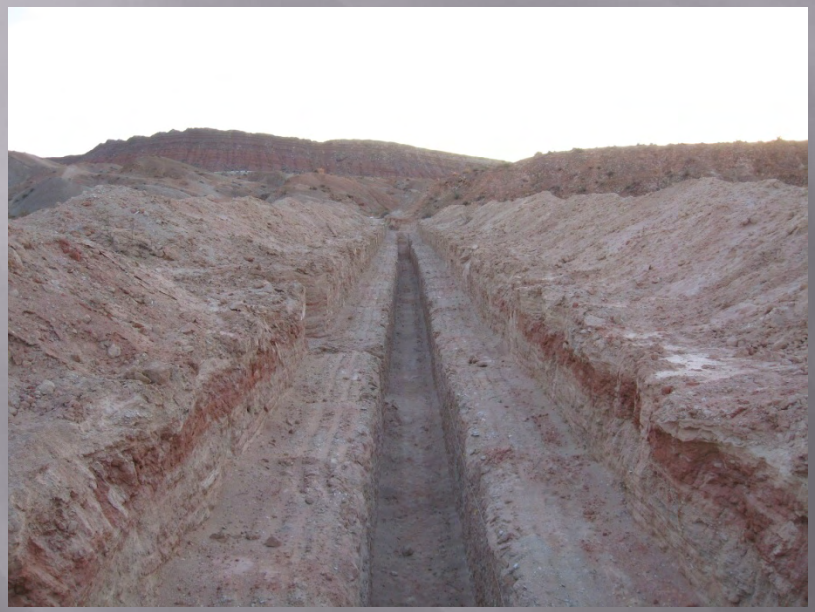
Exposures of fault were surprisingly variable over relatively short distances.

SBI

TRENCH 3

SBI

TRENCH 6



SBI

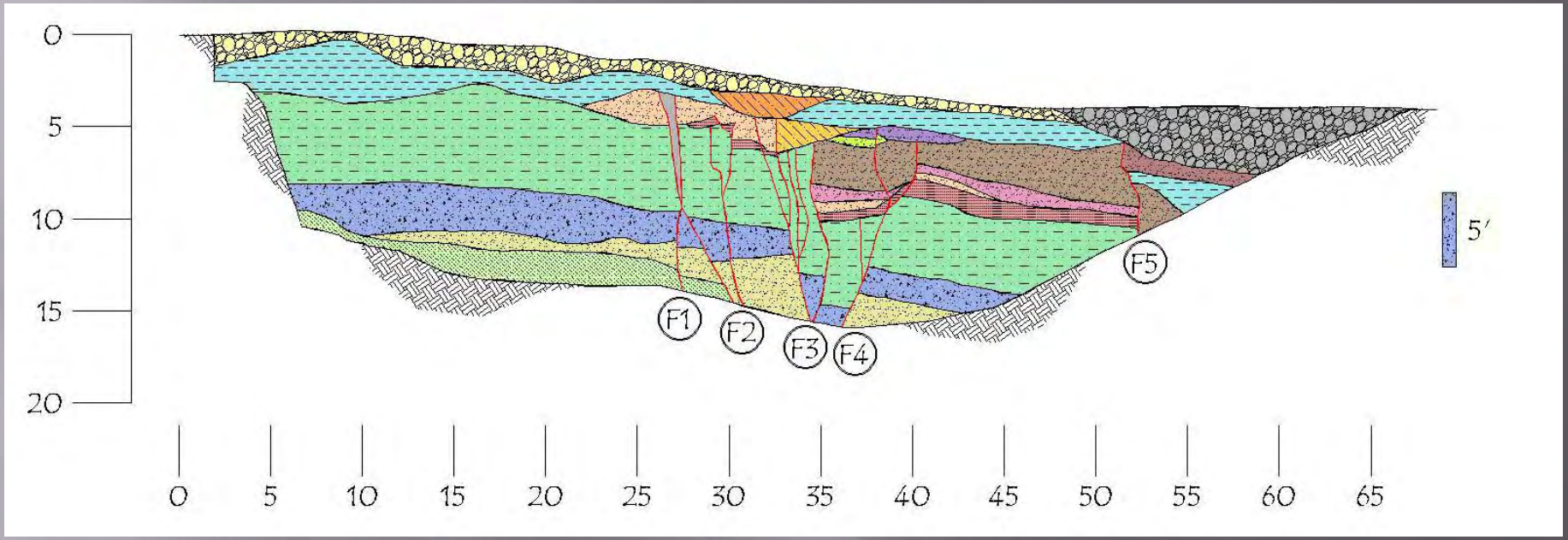
Trench 11

SBI

TRENCH 1

SBI

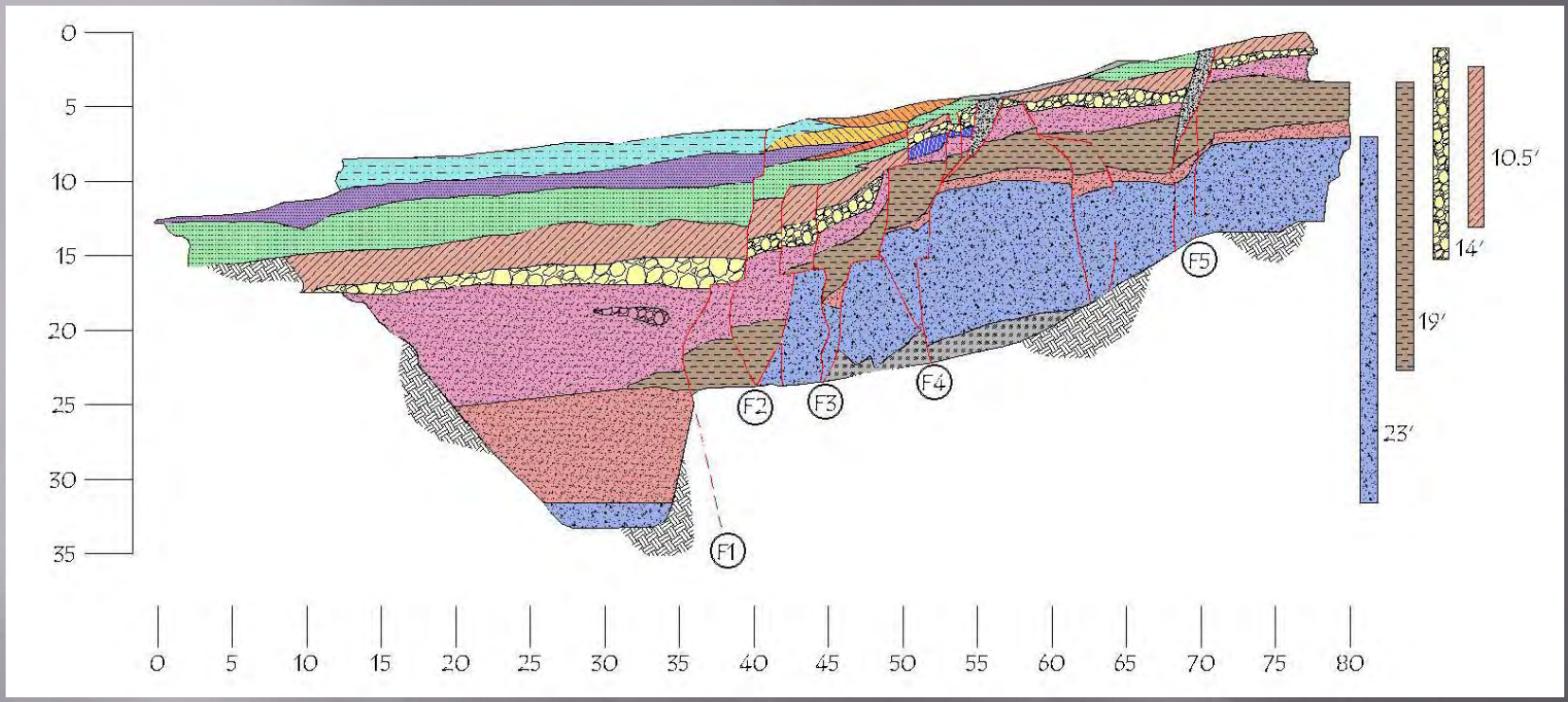
TRENCH T-4



Two surface faulting events documented, each with about 5 feet of net displacement.

SBI

WASHINGTON FIELDS TRENCH T-1



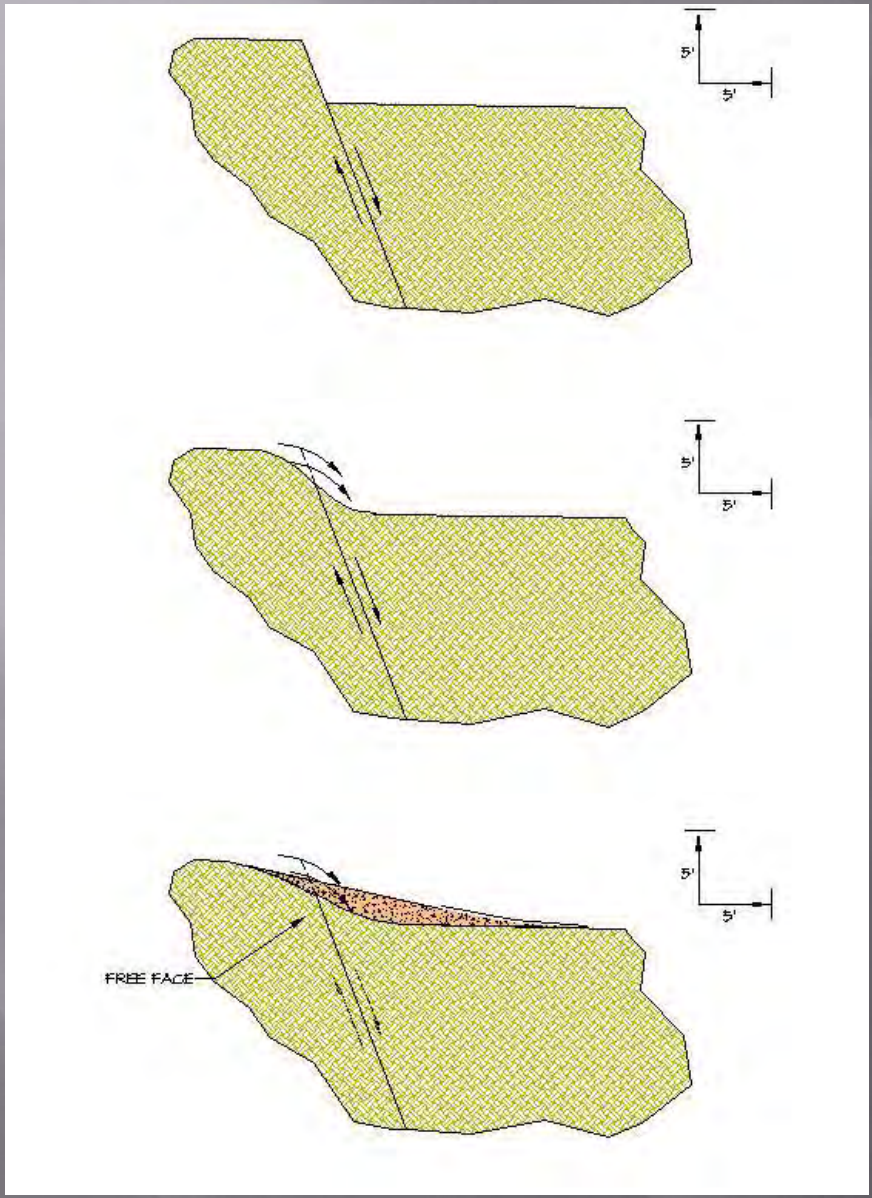
Three surface faulting events documented, each with about to 5 feet of net displacement.

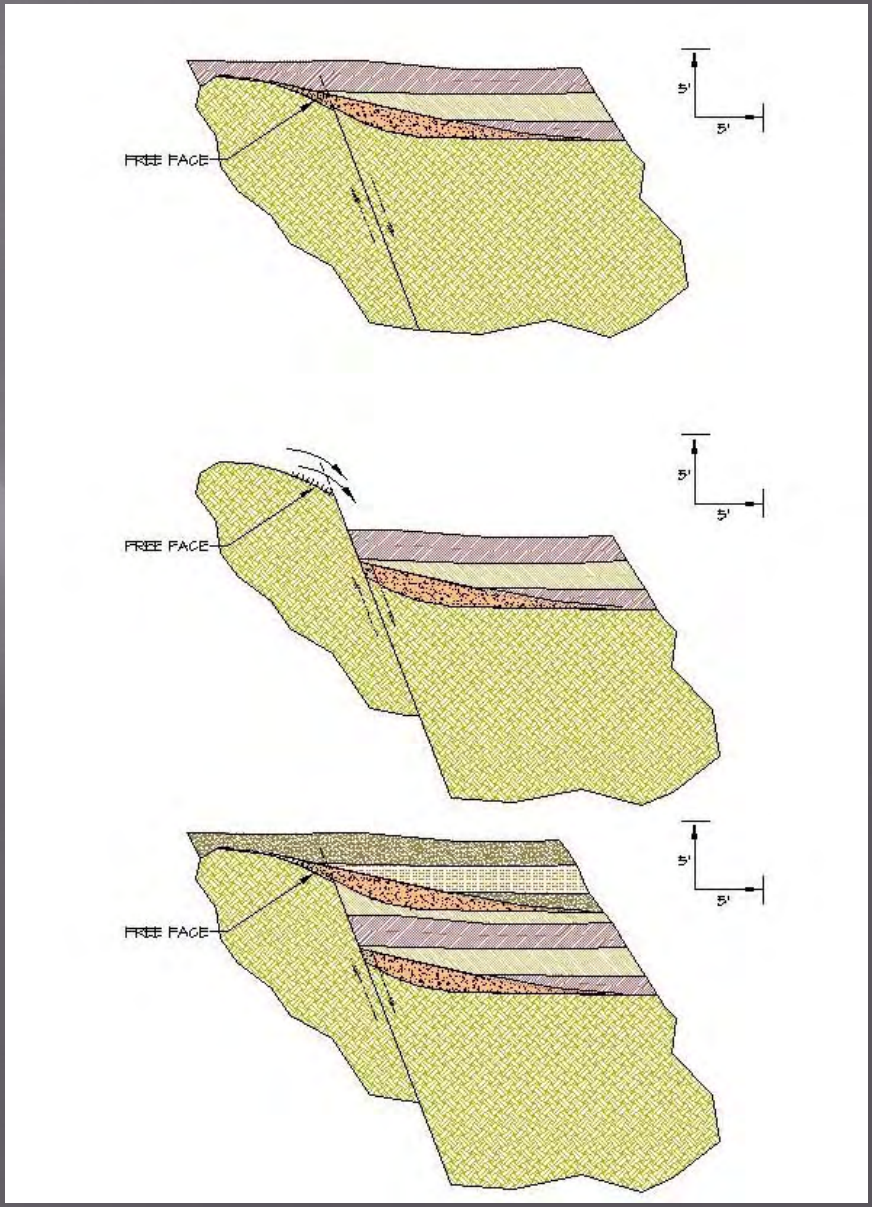
SBI

RECOMMENDATIONS

- Modification to proposed location of Interchange 10
- Possible modifications to roadway alignment so road crosses Washington fault closer to 90 degrees
- Recommended building setbacks

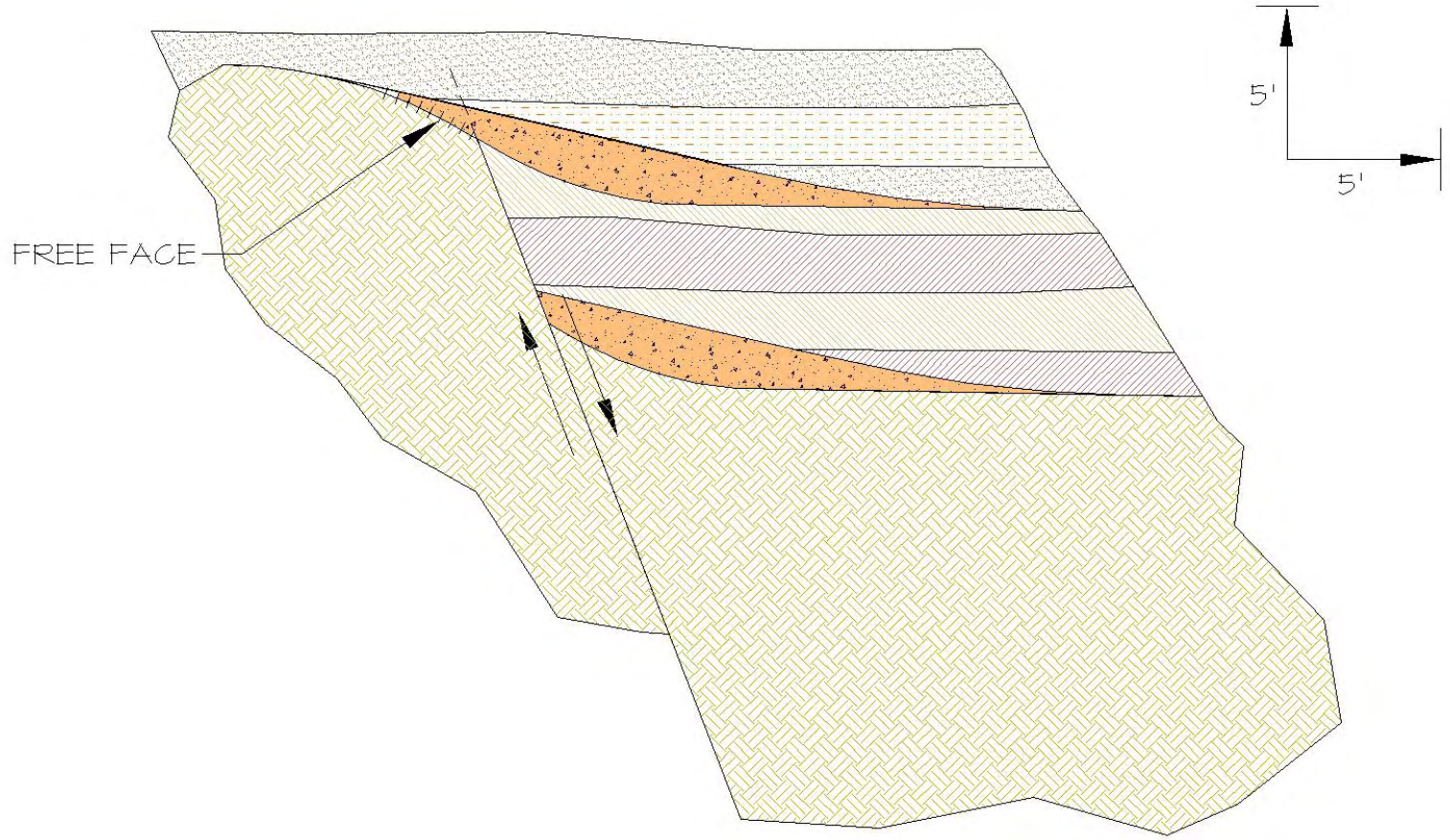
COLLUVIAL WEDGES





SBI

COLLUVIAL WEDGES



Thank You…

Questions…?

RECLAMATION

Managing Water in the West

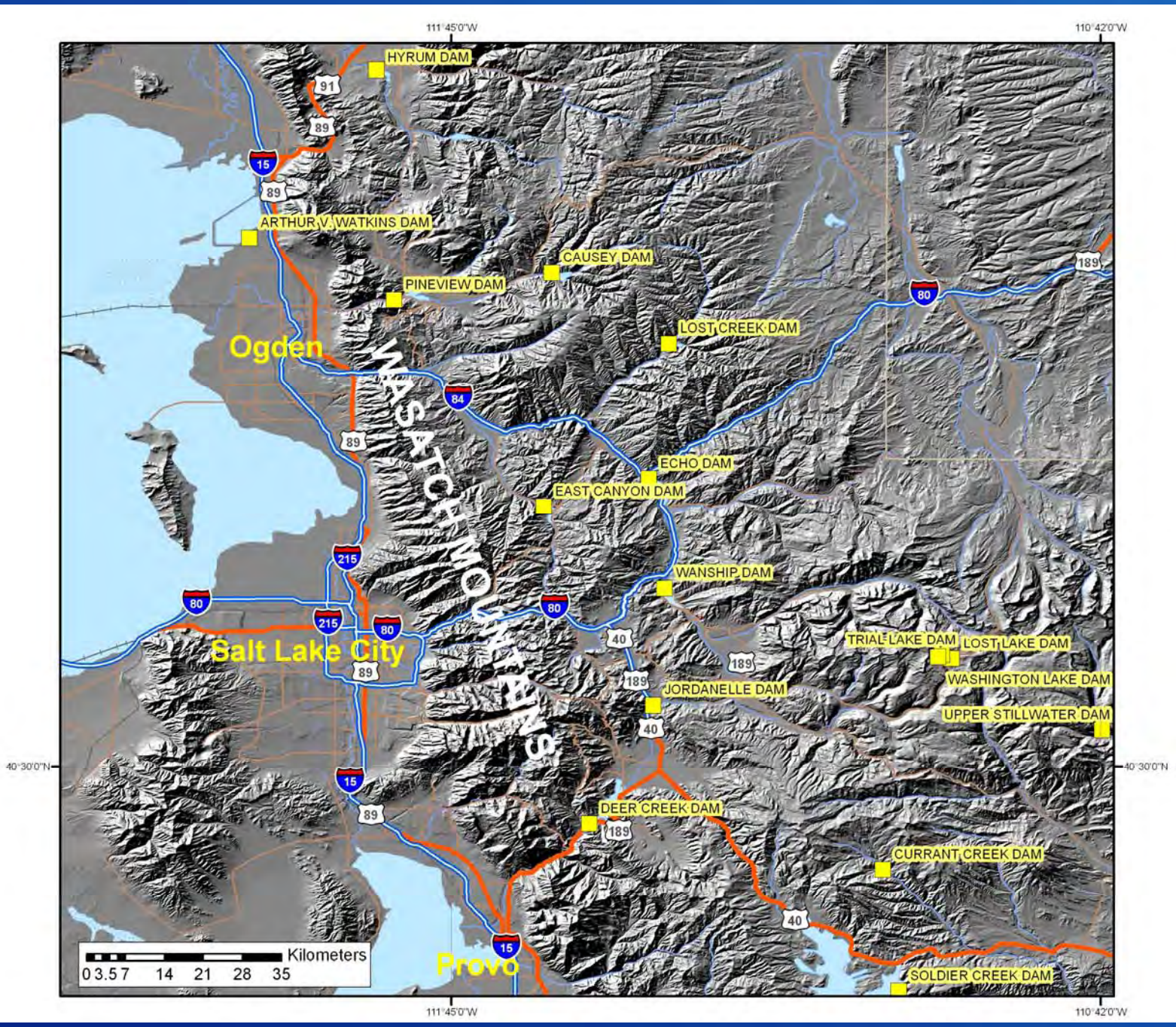
Reclamation Studies in Utah

Larry W. Anderson

Seismotectonics & Geophysics Group

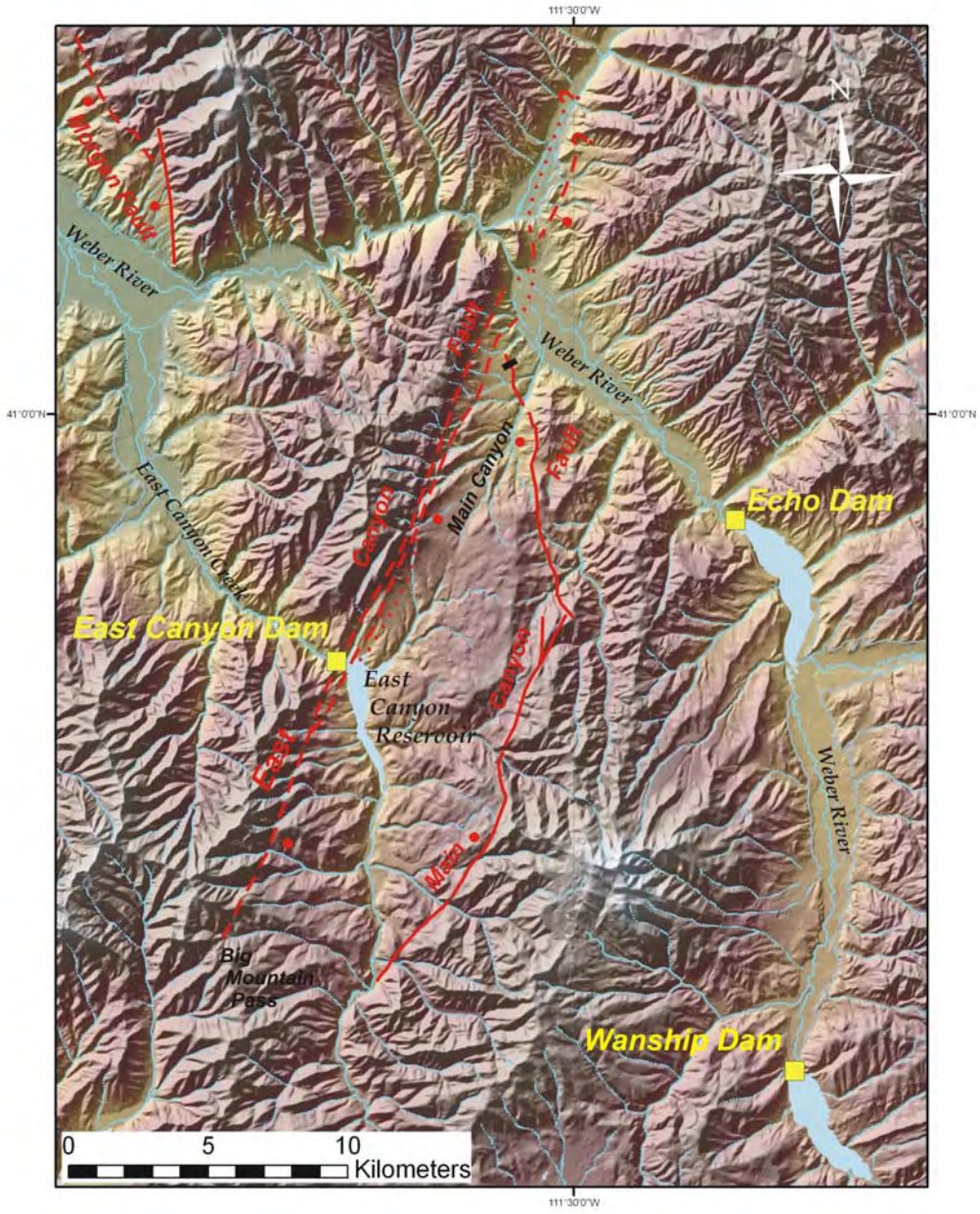
UQFPWG – February 9, 2010

U.S. Department of the Interior
Bureau of Reclamation



RECLAMATION

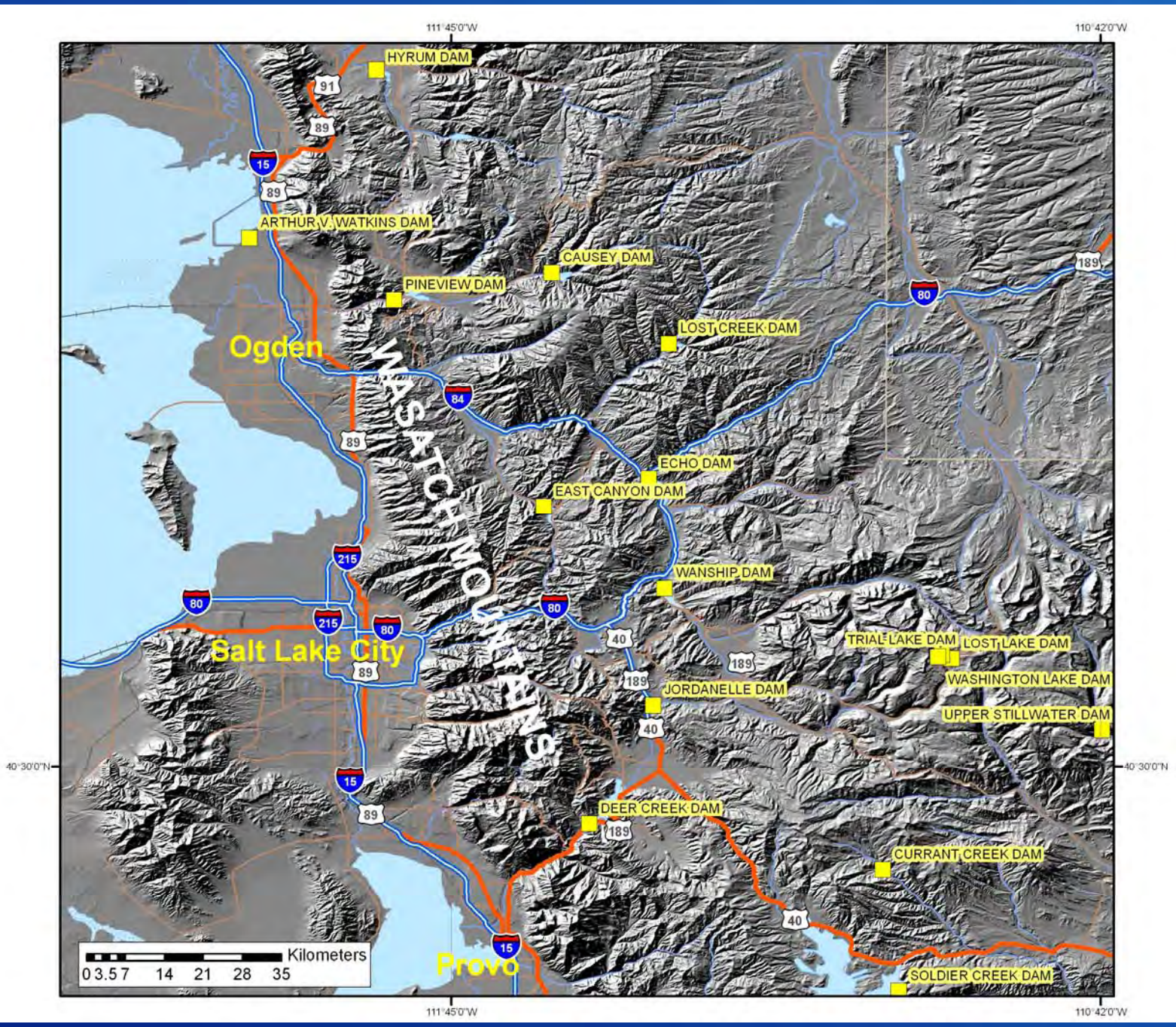
RECLAMATION



RECLAMATION

East Canyon & Echo Dams

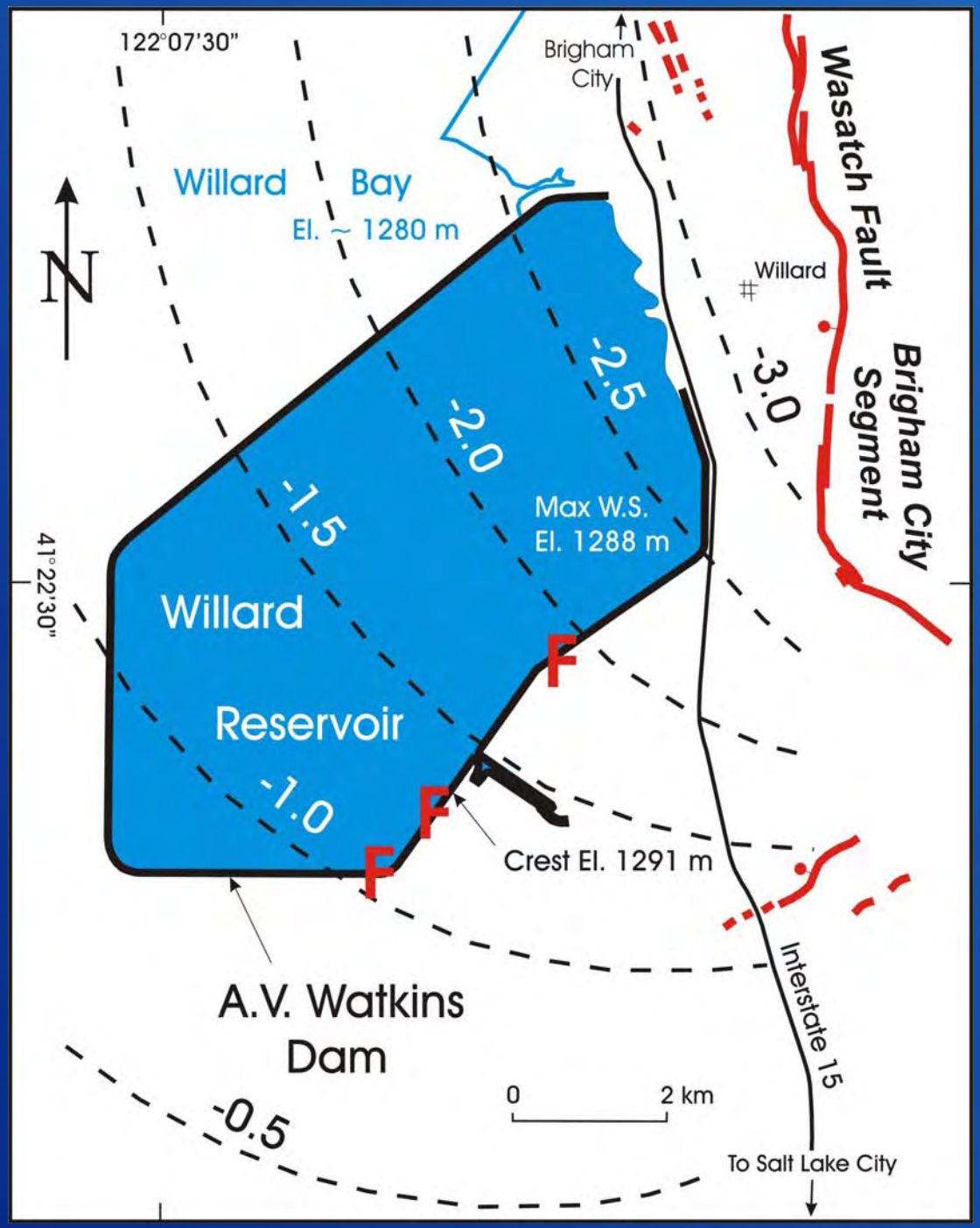
- Late Quaternary Faulting in East Canyon Valley - Piety et al. (2010) – Results from trenching the Main Canyon fault
- Updated and revised PSHA - Wong et al (in progress) – Complete in 2010



RECLAMATION

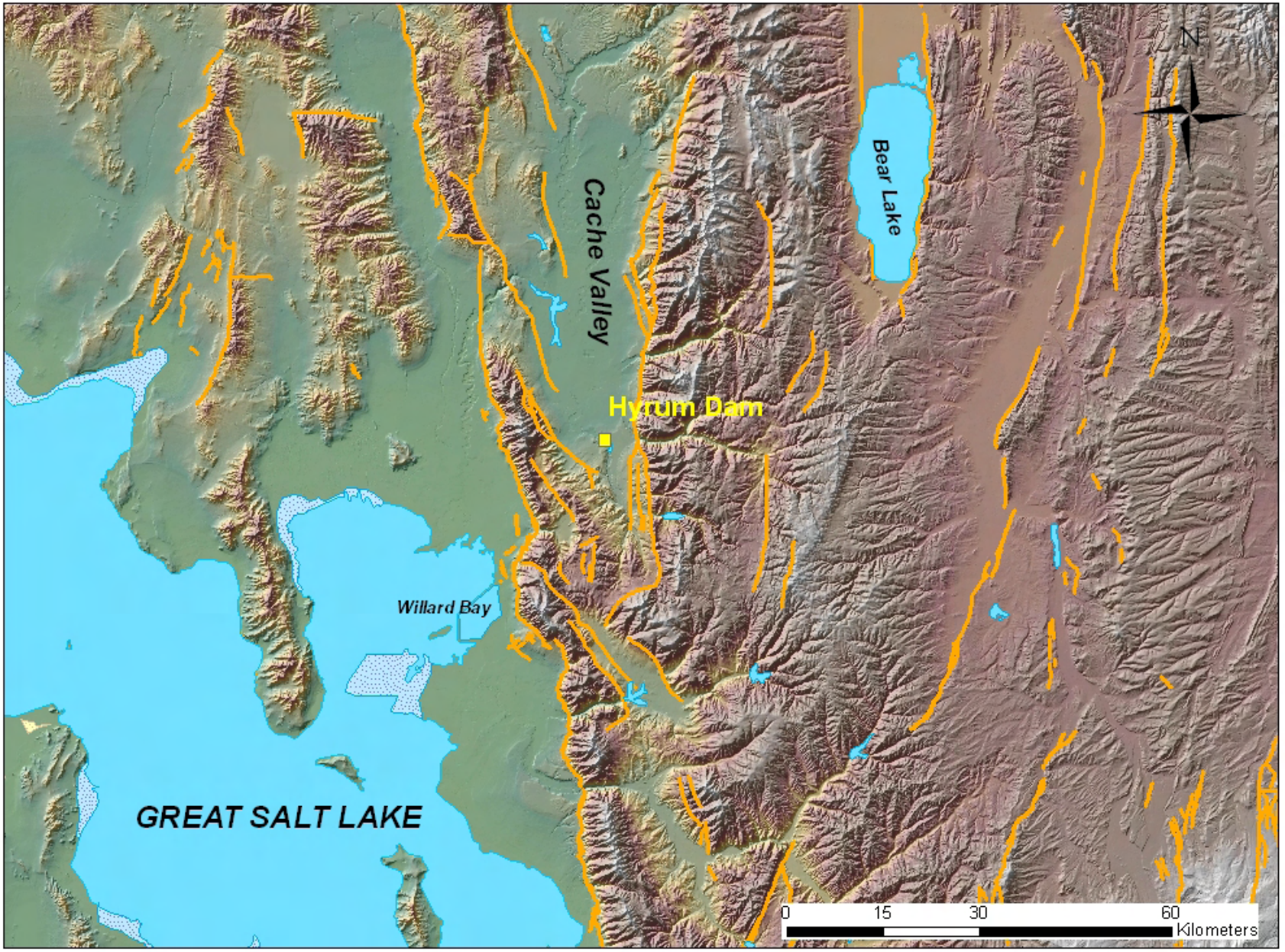
Arthur V. Watkins Dam

RECLAMATION



From Ostenaa & Wood (USBR, 1992)

RECLAMATION



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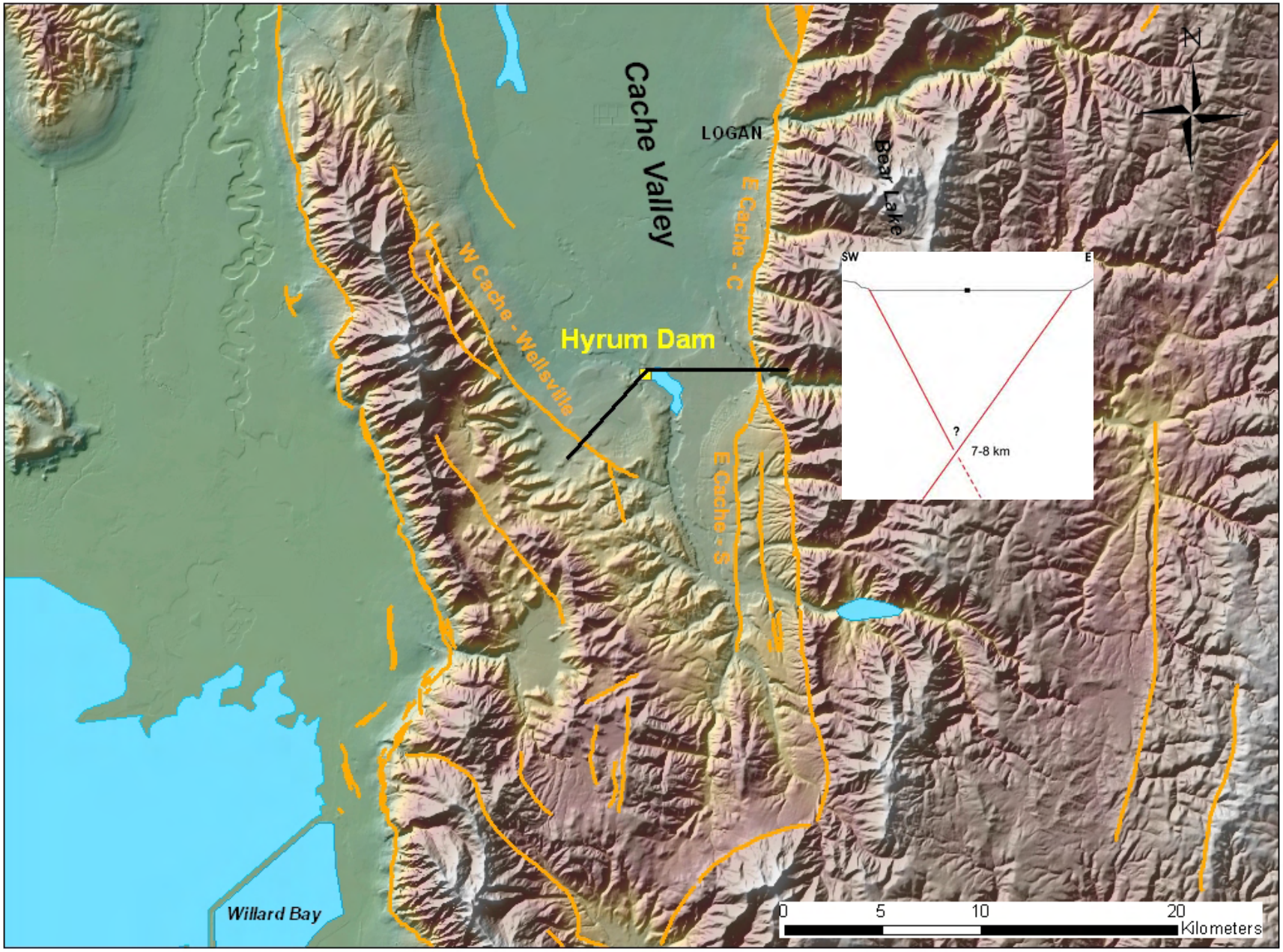
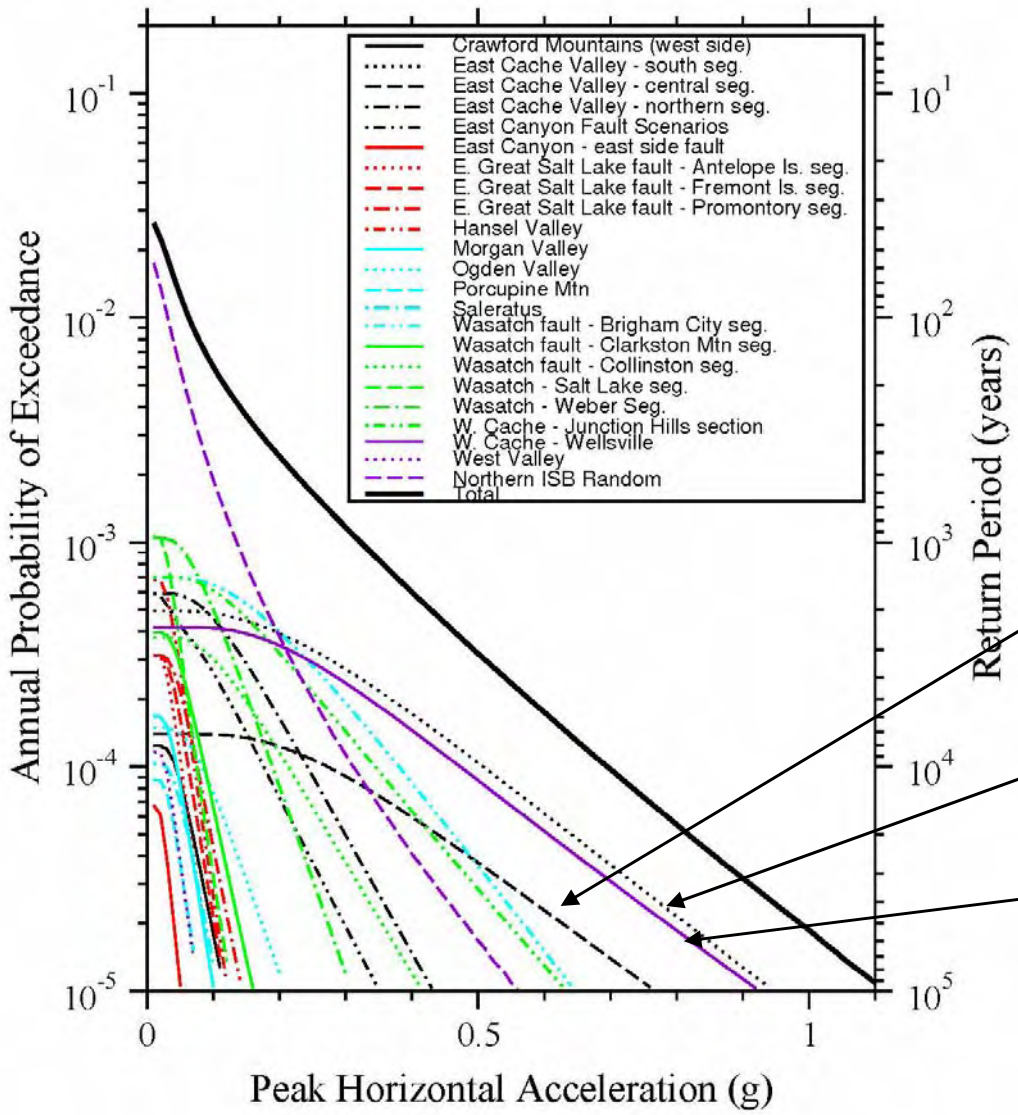


RECLAMATION

Hyrum - 2006

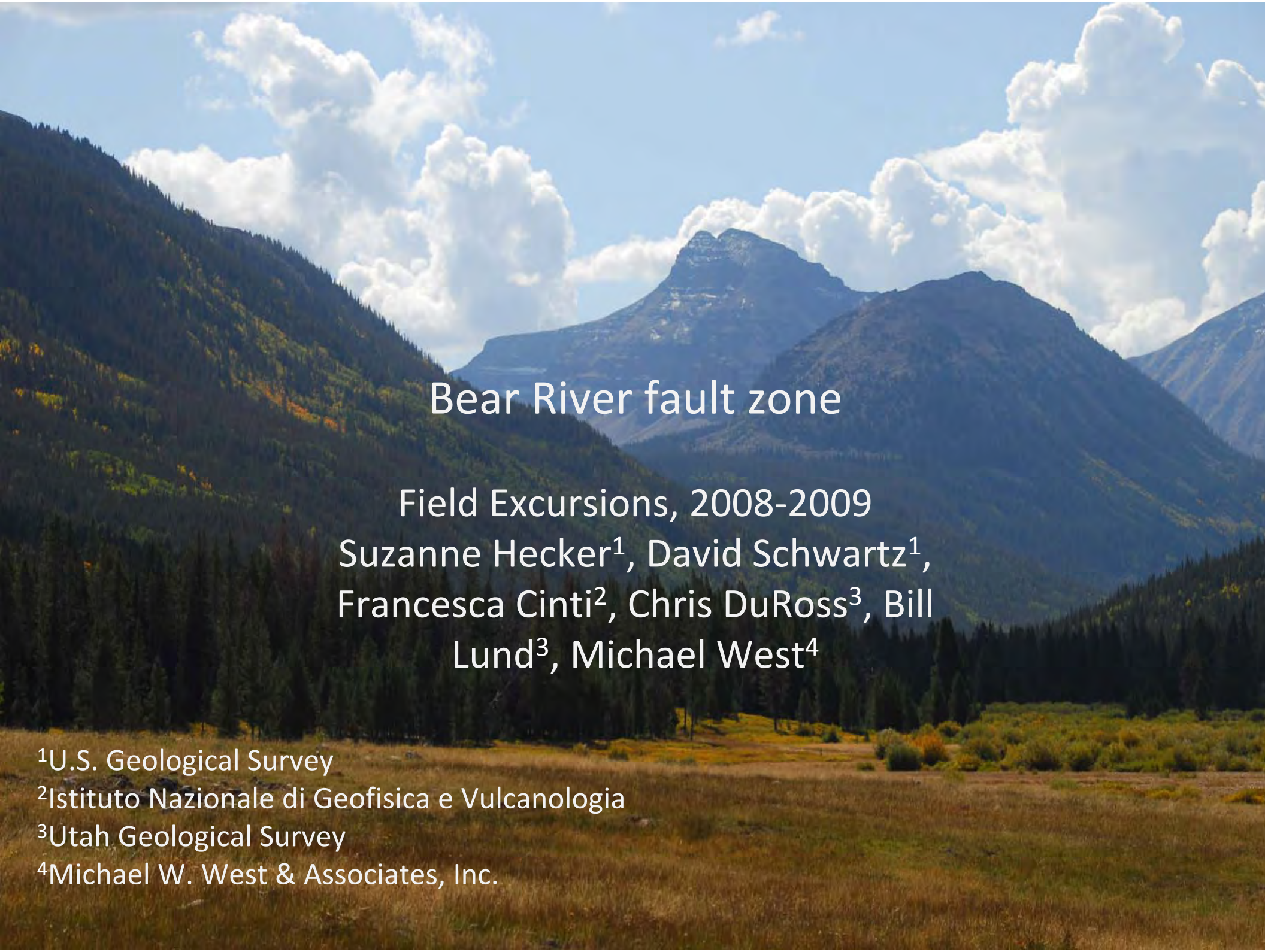


E. Cache-C: 4 K to 15 K (10K)

E. Cache-S: 0.01- 1.0 (0.08) mm/yr

W. Cache-Wells: 0.04-1.0 (0.2) mm/yr

RECLAMATION

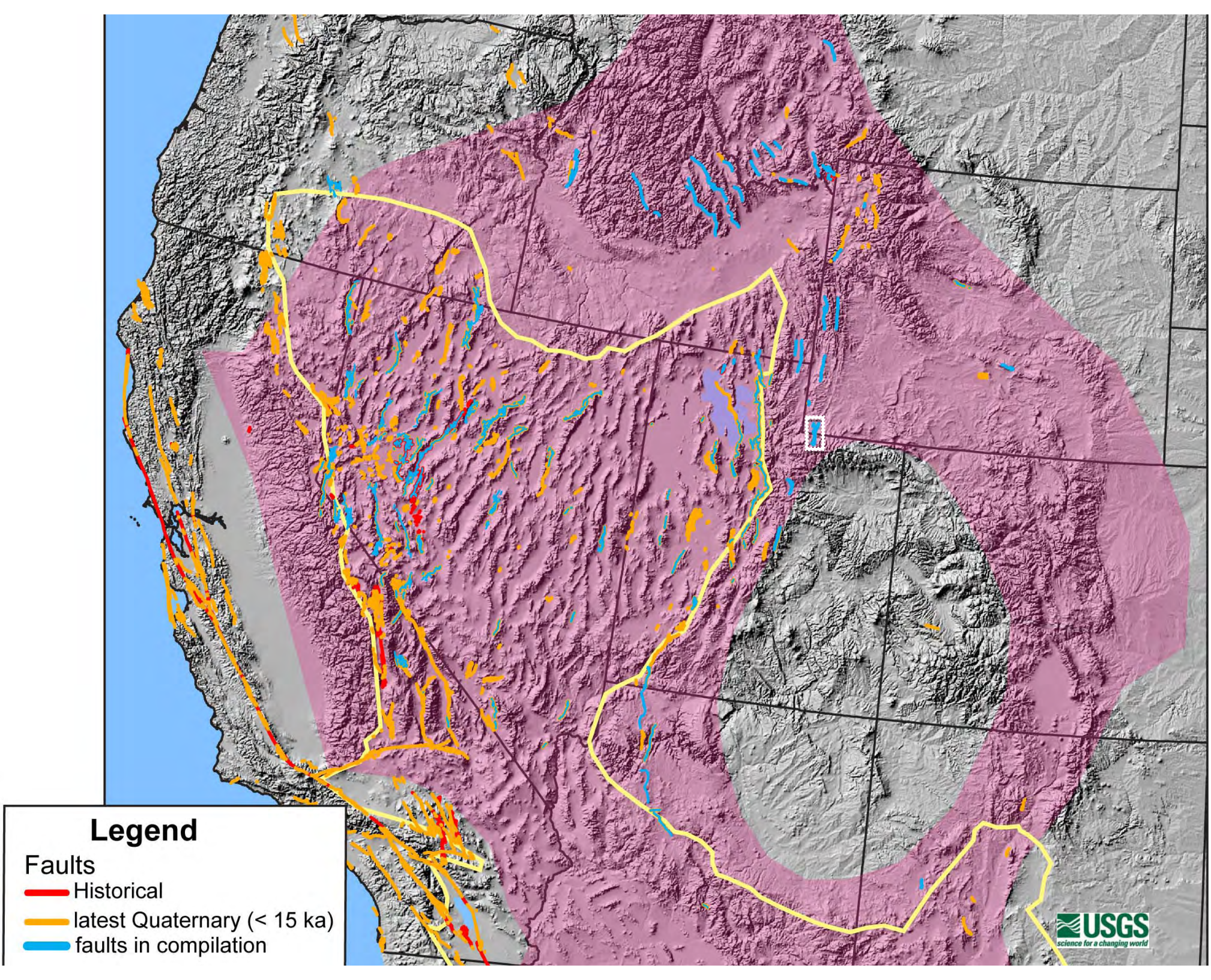


Bear River fault zone

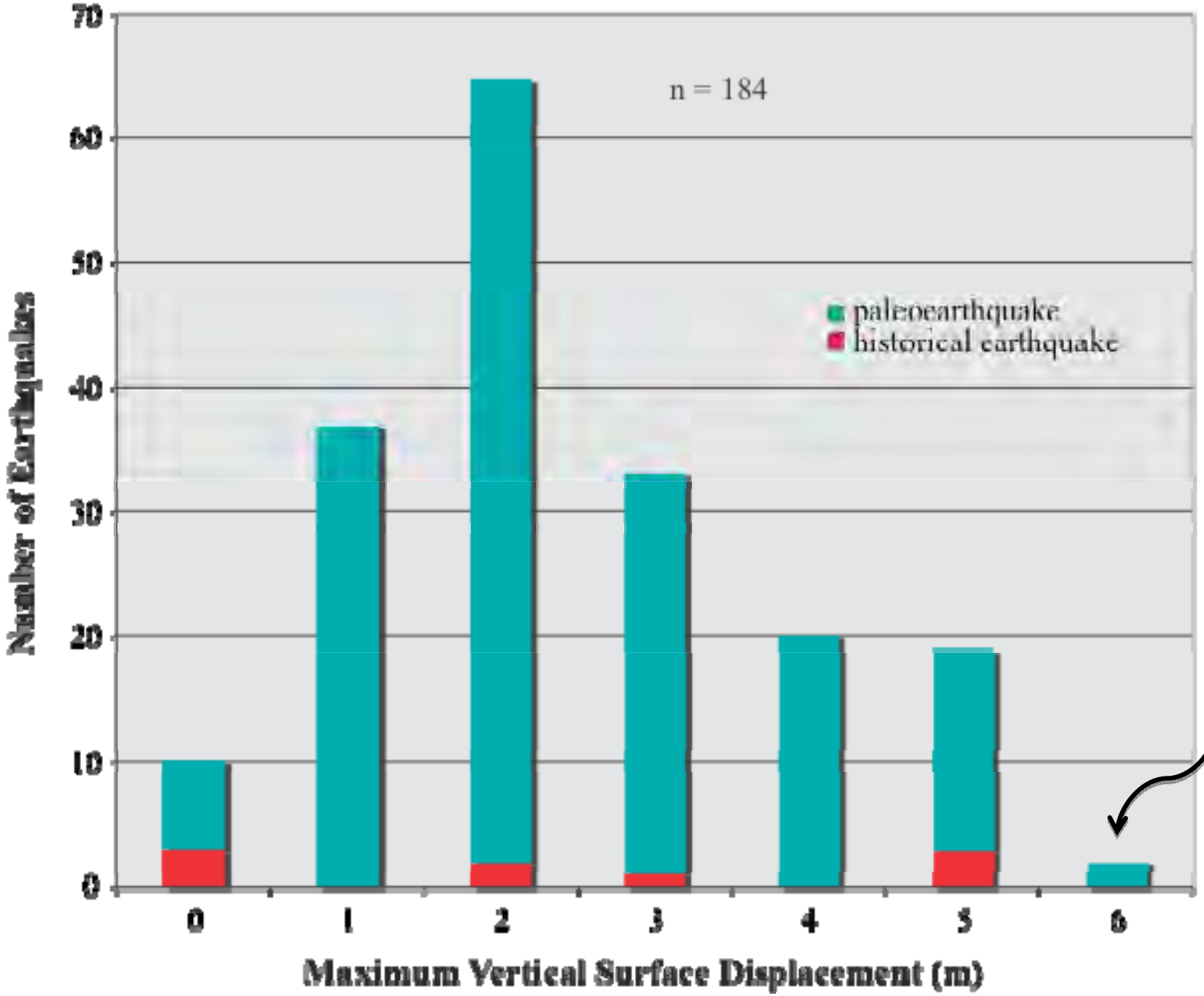
Field Excursions, 2008-2009

Suzanne Hecker[1], David Schwartz[1], Francesca Cinti[2], Chris DuRoss[3], Bill Lund[3], Michael West[4]

[1]U.S. Geological Survey
[2]Istituto Nazionale di Geofisica e Vulcanologia
[3]Utah Geological Survey
[4]Michael W. West & Associates, Inc.

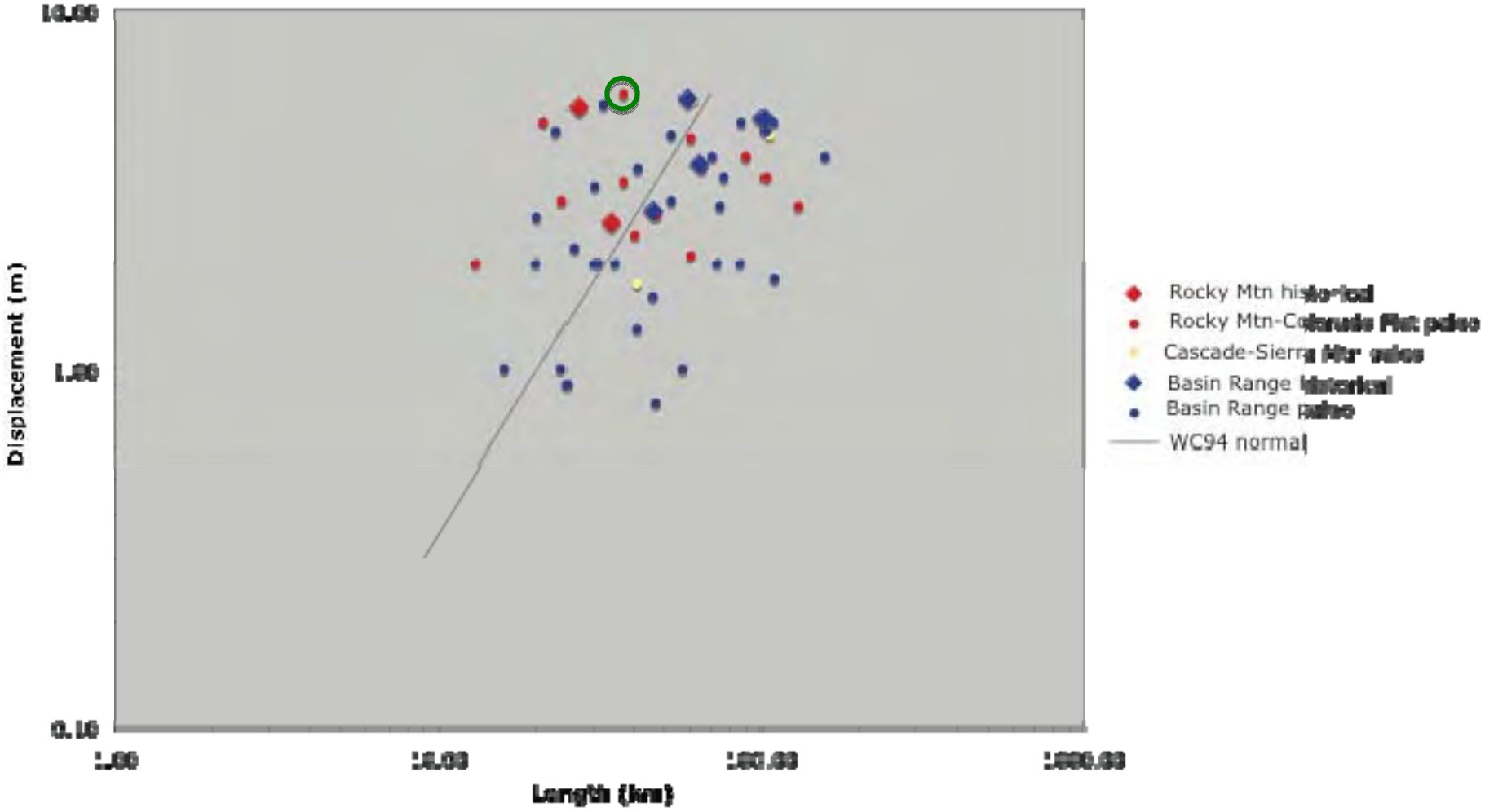

Legend
Faults
Historical
latest Quaternary (< 15 ka)
faults in compilation
USGS
science for a changing world

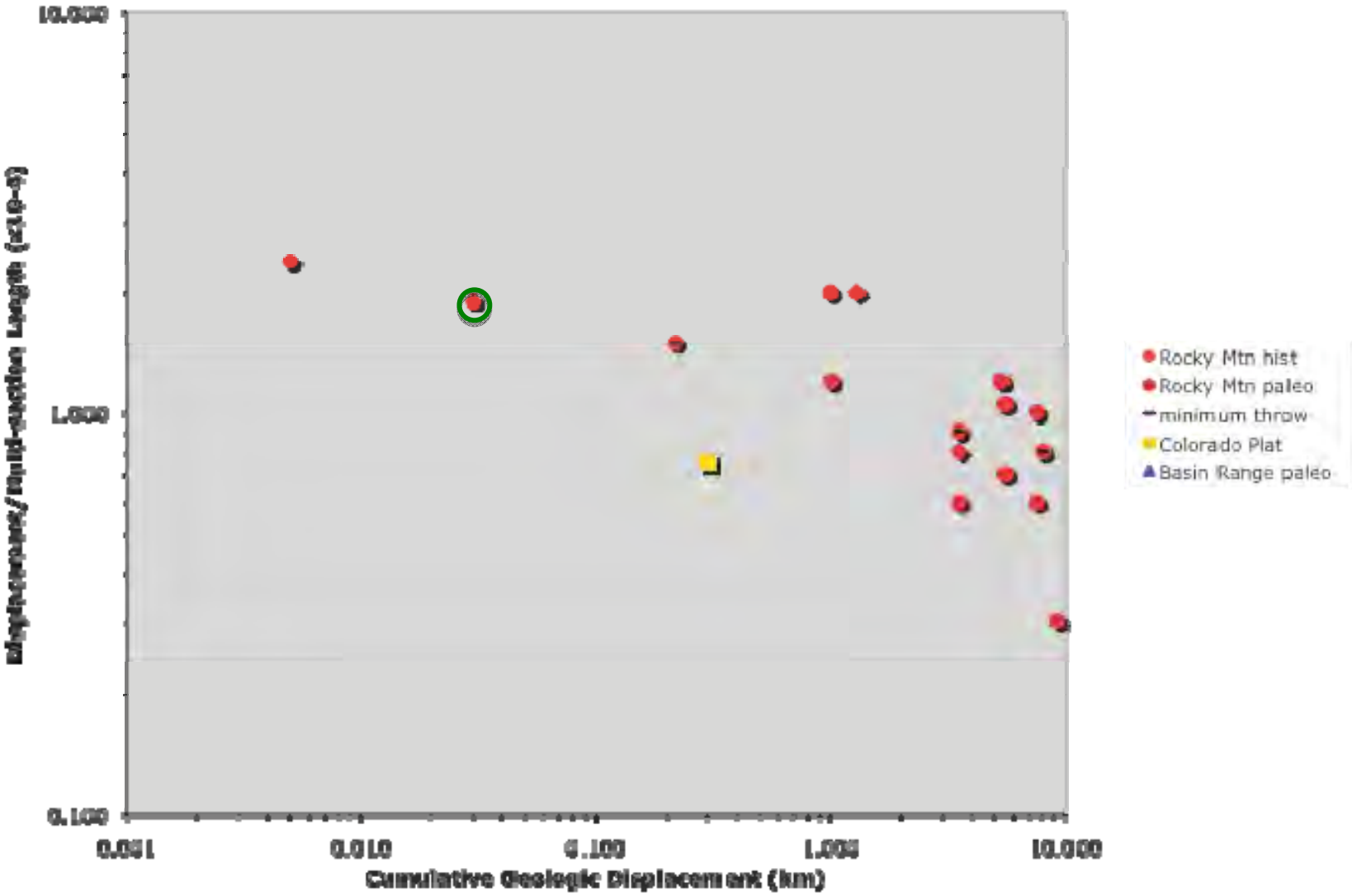
Western Cordillera



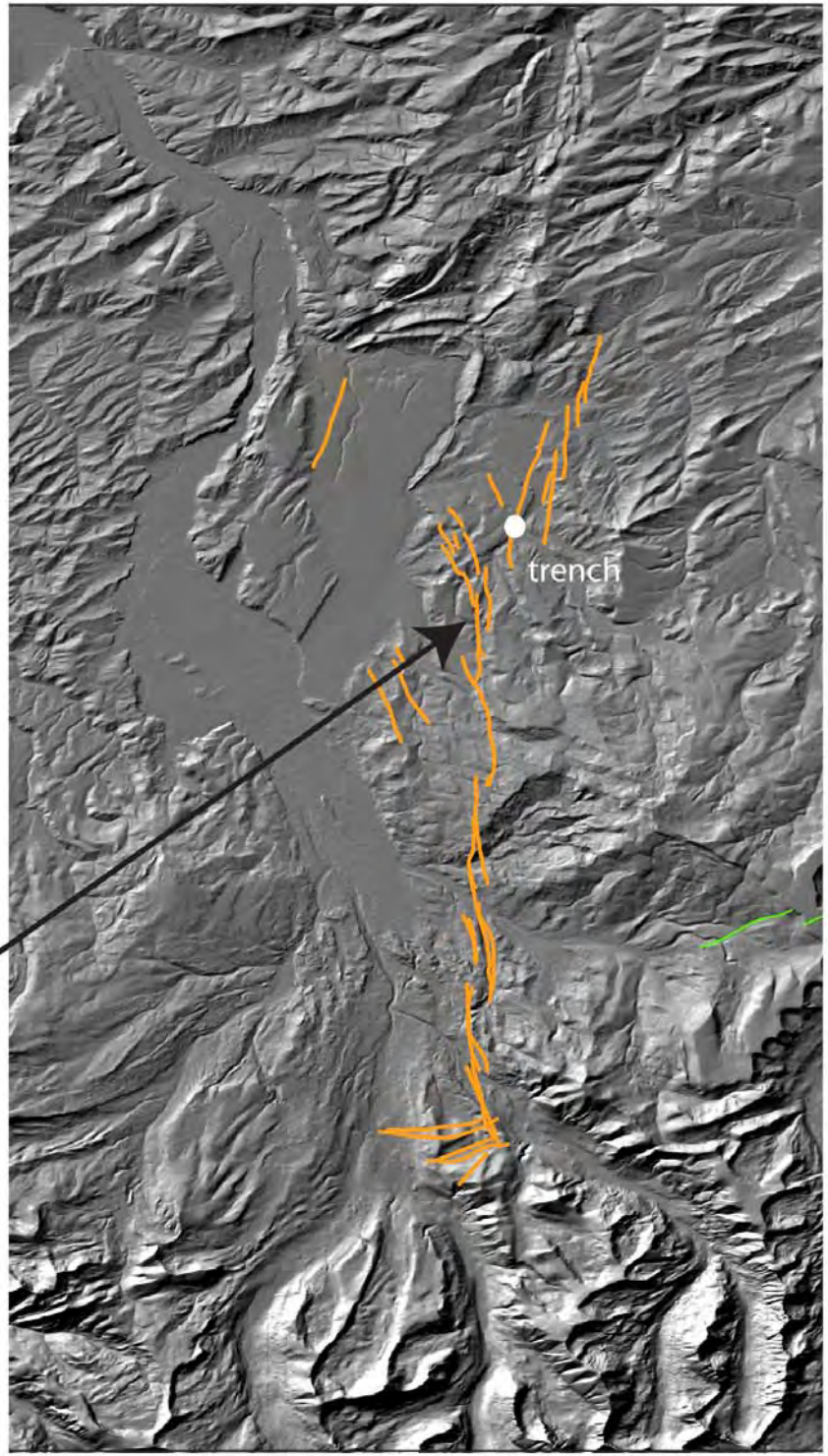
Bear River, (~6.3 m)

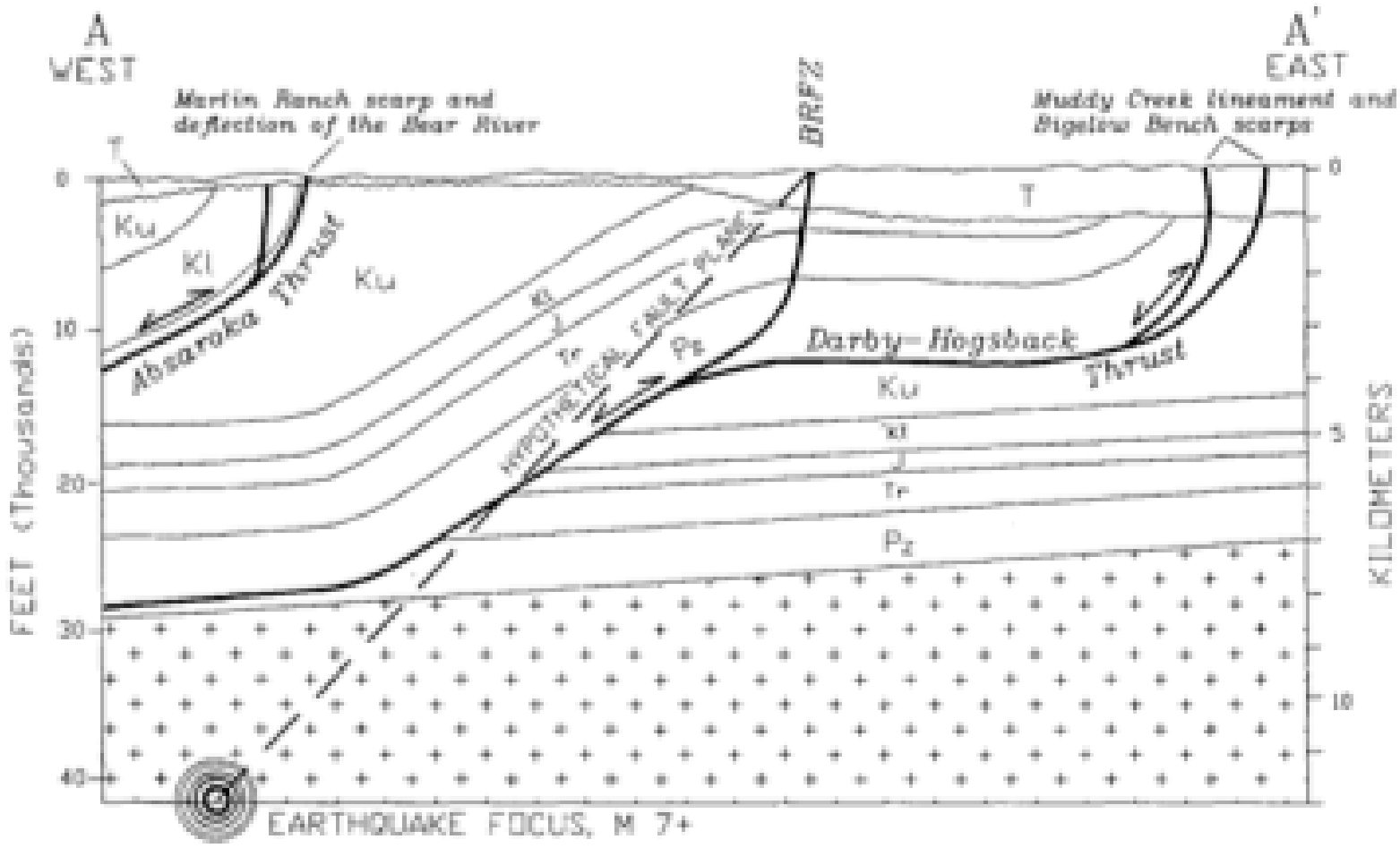
USGS science for a changing world


Displacement (m)
Length (km)
Rocky Mtn historical
Rocky Mtn-Colorado Plat. paleo
Cascade-Sierra Mtn paleo
Basin Range historical
Basin Range paleo
WC94 normal


Rocky Mtn hist
Rocky Mtn paleo
minimum throw
Colorado Plat
Basin Range paleo
Cumulative Geologic Displacement (km)

Bear River fault zone



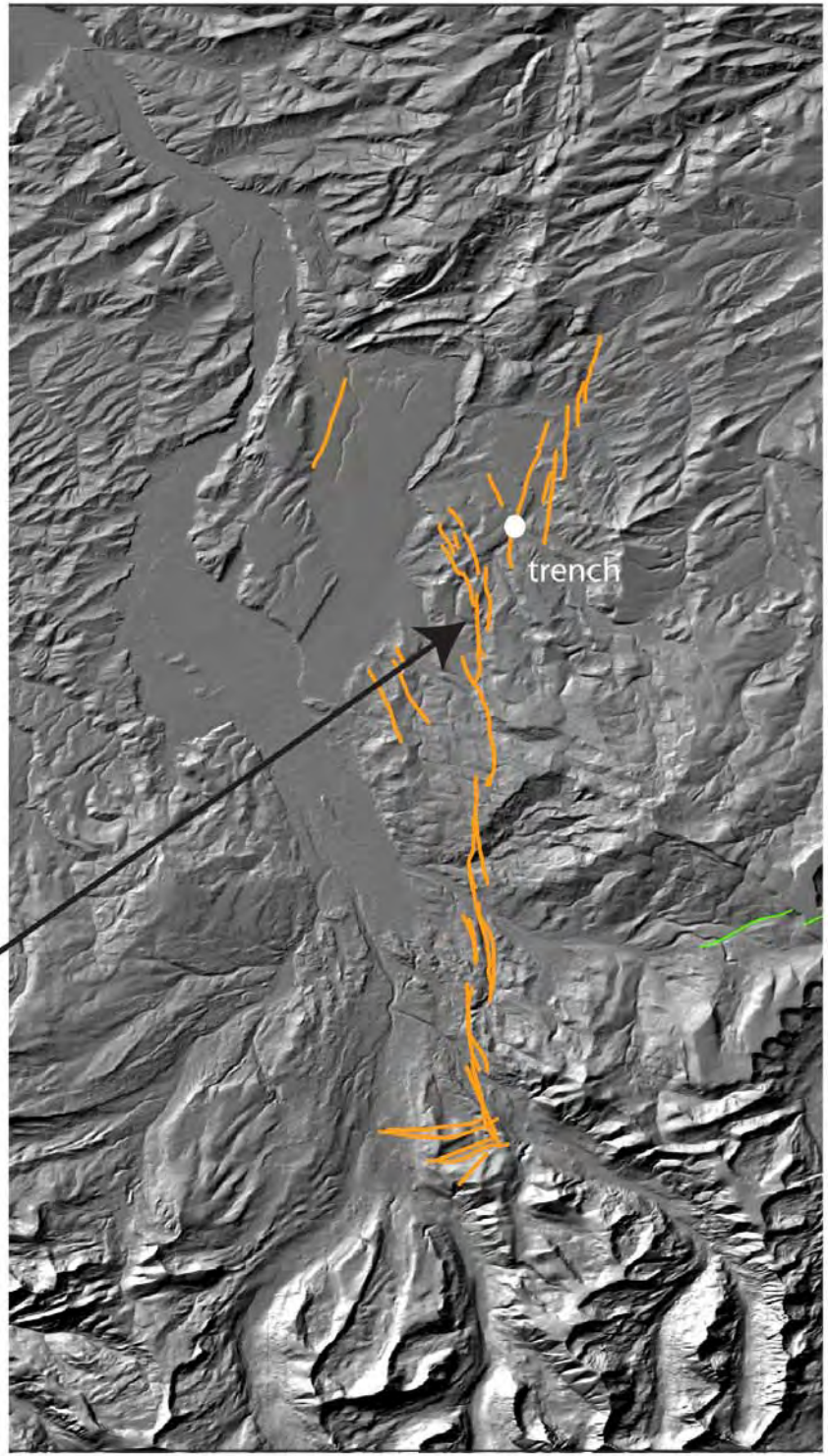


EXPLANATION

T	TERTIARY ROCKS	J	JURASSIC ROCKS	+ + + +	PRECAMBRIAN ROCKS
Ku	UPPER CRETACEOUS ROCKS	Tr	TRIASSIC ROCKS		Indicates initial reverse slip followed by normal slip.
Kl	LOWER CRETACEOUS ROCKS	Pz	PALEOZOIC ROCKS		

West, 1992

Bear River fault zone



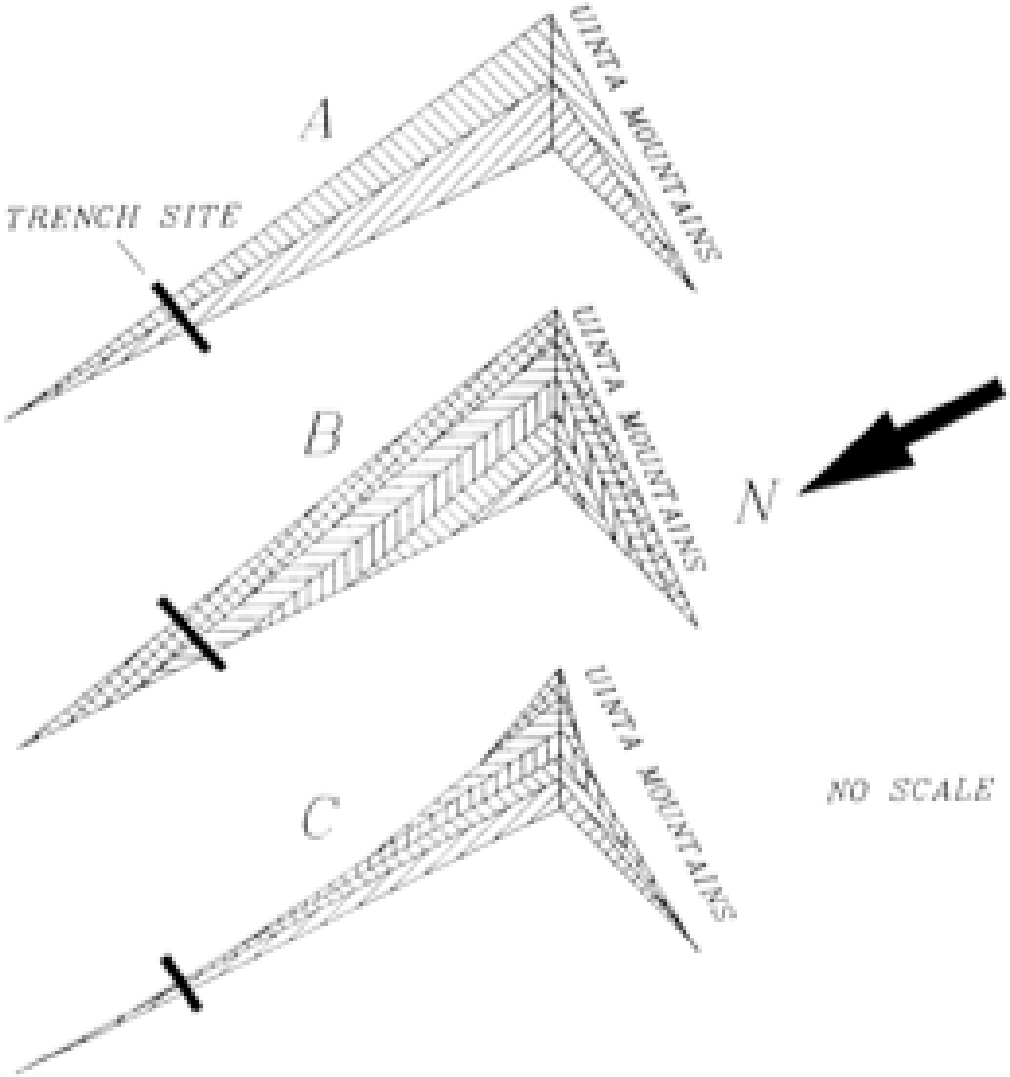
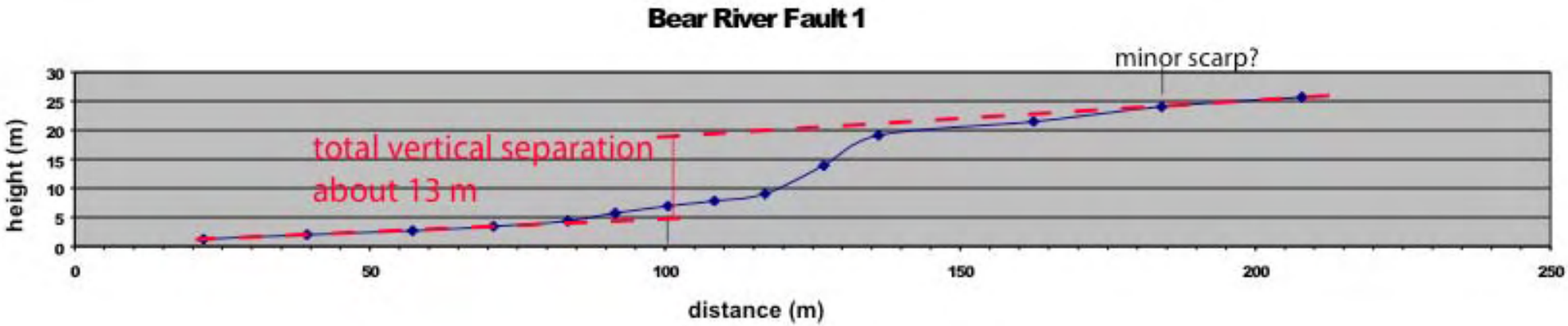


Figure 57. *Models for increasing scarp height from north to south along the Bear River fault zone: (A) two events of increasing north to south displacement and equal rapture length; (B) multiple events with increasing rupture length; (C) multiple events with decreasing rupture lengths. In all cases, a trench excavated in the northern part of the fault zone would consistently show two surface faulting events.*

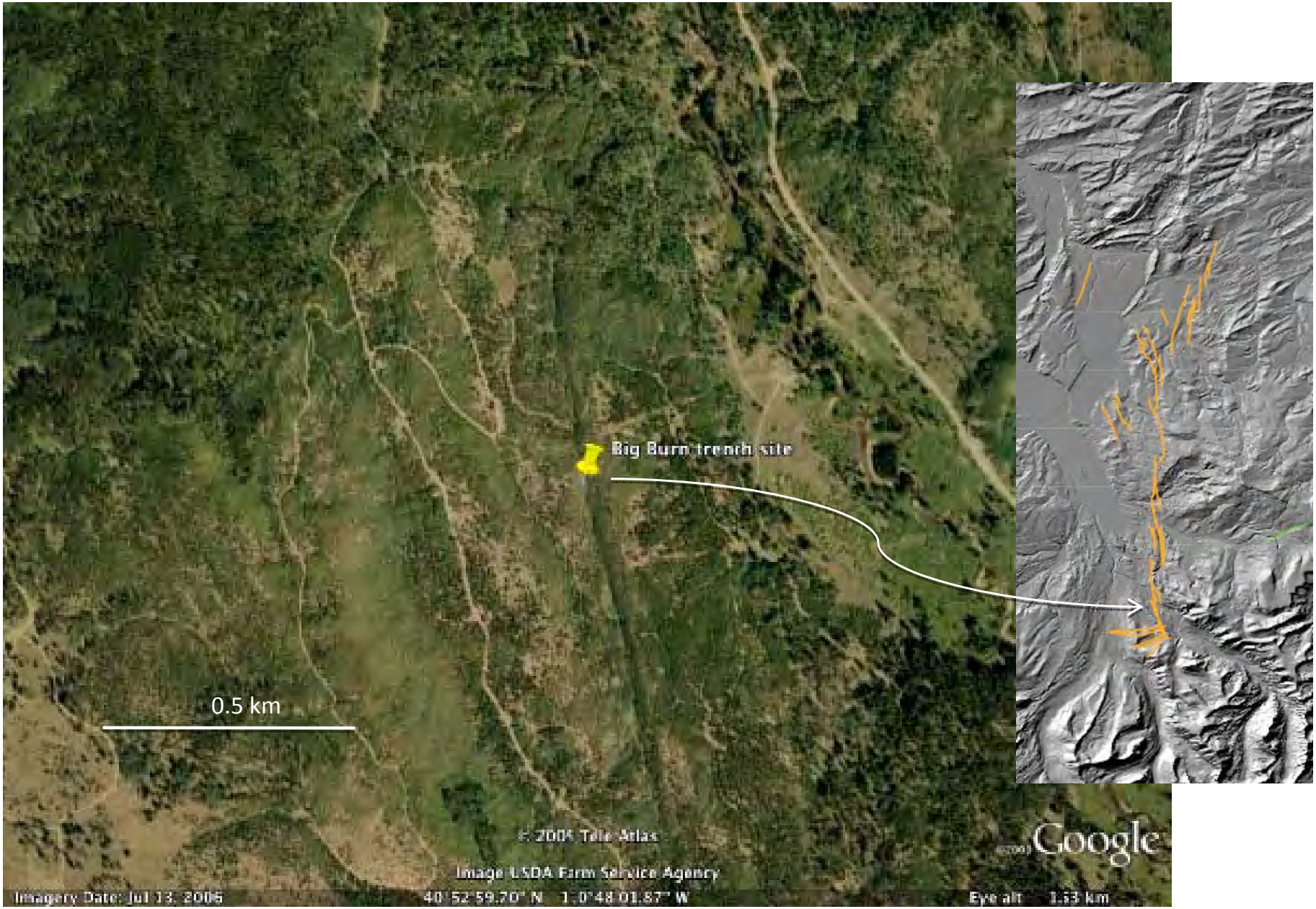
West, 1994


Lady Falcons
SCARP PROFILES
LESTER RANCH SCARP
LA CHAPELLE SCARP
WEBER MARTIN RANCH SCARP

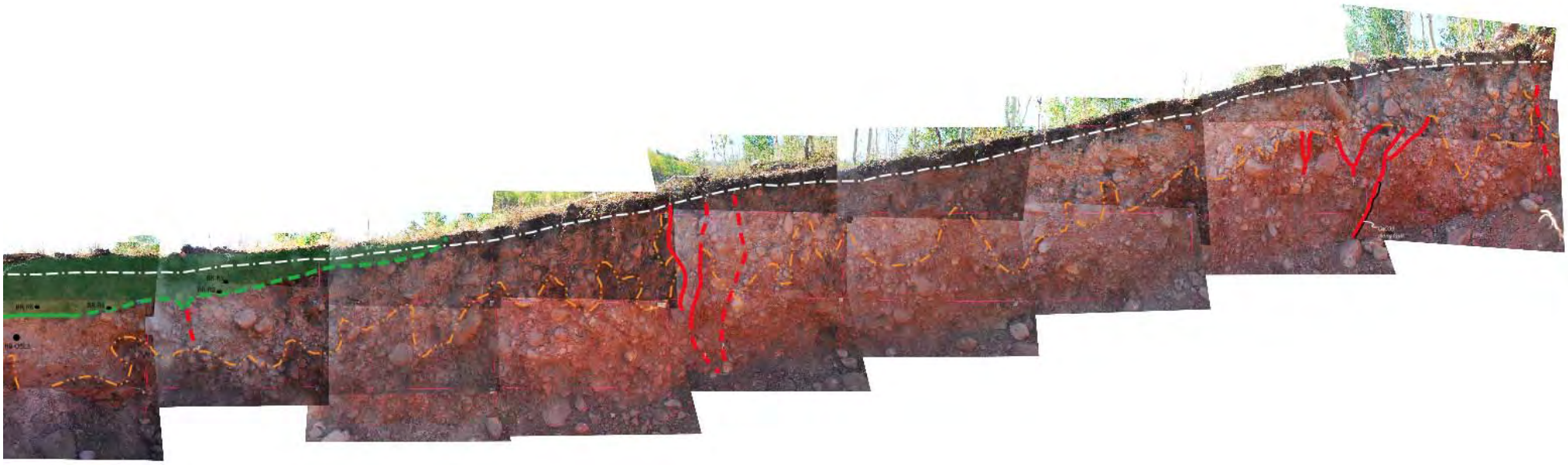

N
© 2008 Tele Atlas
©2007 Google
er 40°49'06.26" N 110°48'07.48" W
Streaming 100%
Eye alt 1.58 k



USGS
science for a changing world


Big Burn trench site
0.5 km
© 2004 Tele Atlas
Image USDA Farm Service Agency
Google
Imagery Date: Jul 13, 2005
40°52'59.70" N 1.0°48'01.87" W
Eye alt 1.53 km

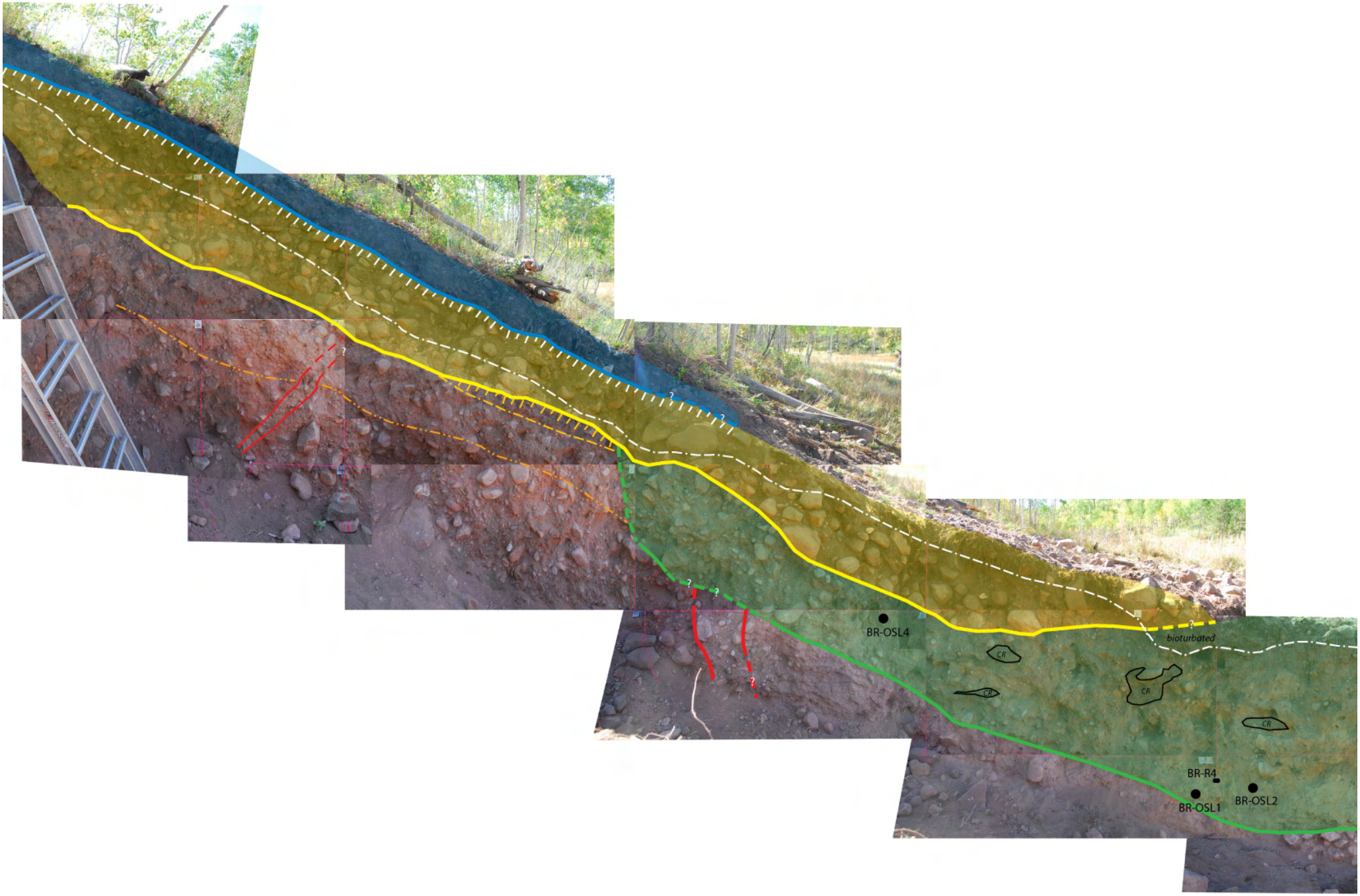

CAT



USGS
science for a changing world

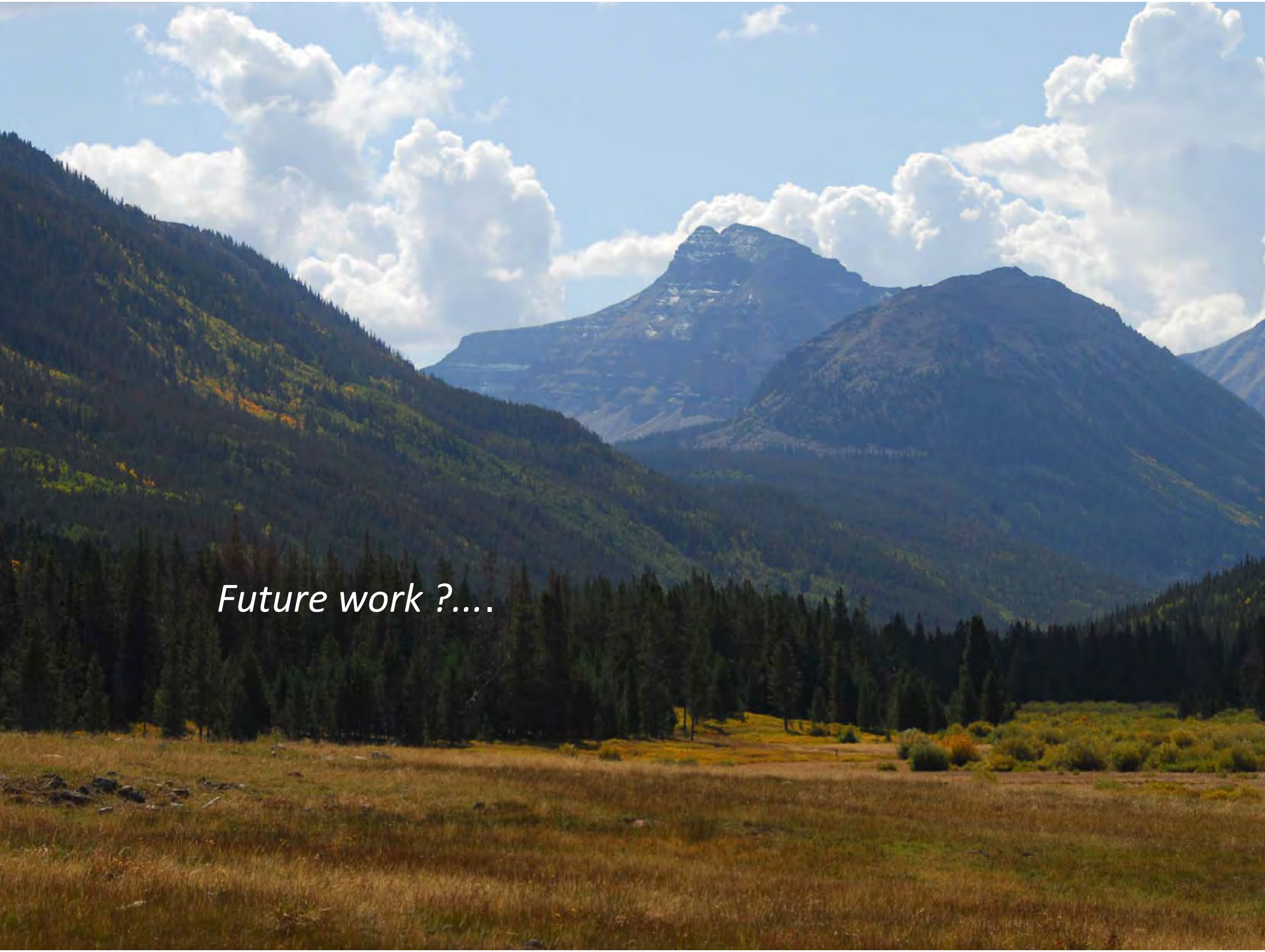
USGS
science for a changing world

USGS
science for a changing world



USGS
science for a changing world

USGS
science for a changing world


Future work ?....

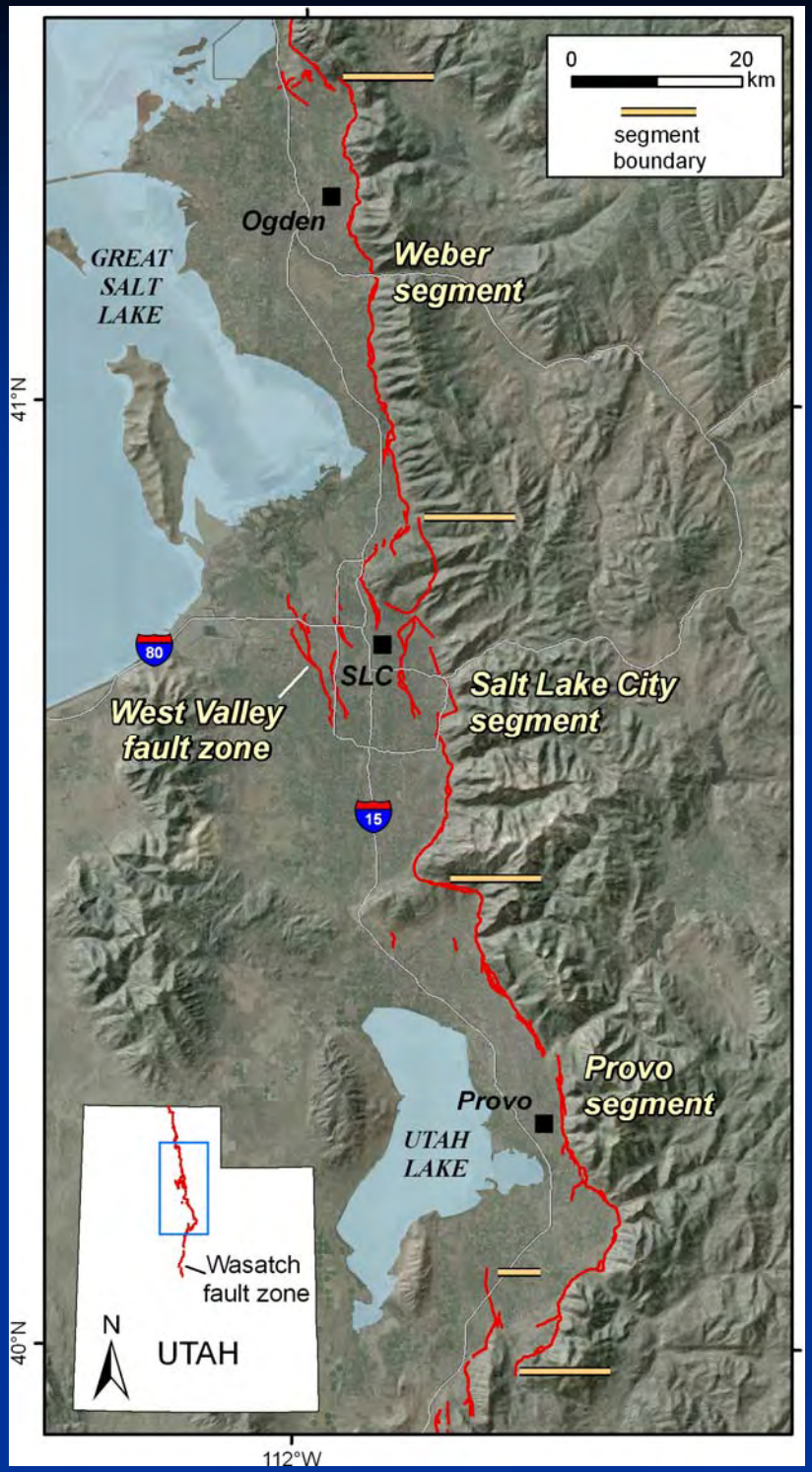

SCARP FORMS
DRAINAGE DIVIDE
DEADMAN CREEK SCARP
PROFILE #1
BIG BURN
East Fork Campground
Bear River Campground
Gaging Sta
CANAL
HILLIARD
Bear River
Carter Creek
Hill Air Force Base Recreation Camp
8
9
10
11
12
14
15
16
21
22
23


Moose Ln
Uinta Dr
Fir Ln
Mill Creek Rd
N Uintah Dr
W Uinta Dr
Forest Dr
E Fork Bear River Rd
© 2008 Tele Atlas
©2007 Google
Pointer 40°54'45.05" N 110°47'51.46" W
Streaming 100%
Eye alt 2.15 km

Paleoseismic Investigation to Compare Surface Faulting Chronologies of the West Valley Fault Zone and Salt Lake City Segment of the Wasatch Fault Zone, Salt Lake County, Utah

Christopher B. DuRoss and Michael D. Hylland
Principal Investigators

Research funded by the Utah Geological Survey and U.S. Geological Survey, National Earthquake Hazards Reduction Program



Goals

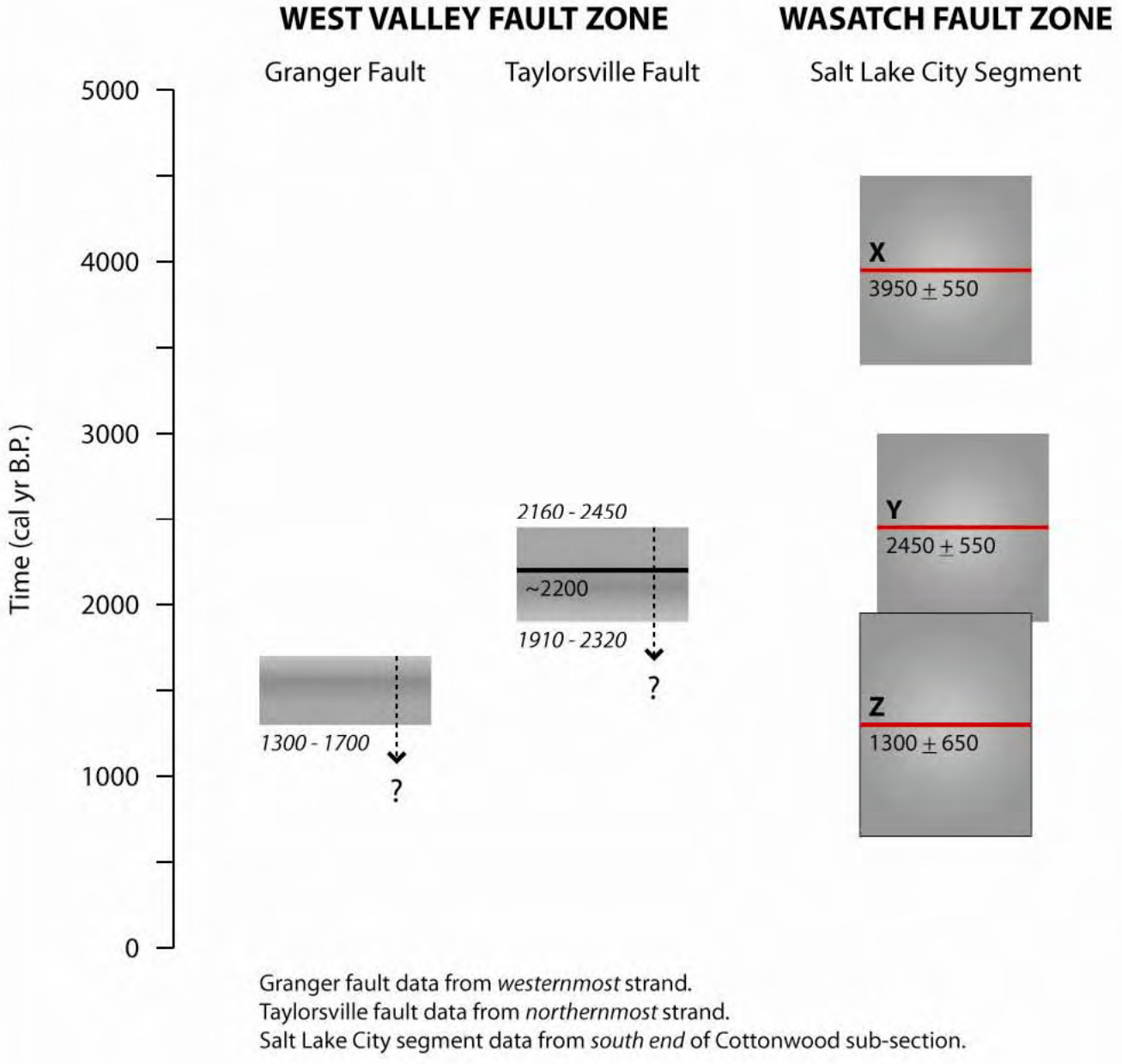
(1) Resolve timing and displacement of individual surface-faulting earthquakes on WVFZ and northern part of SLCS

(2) Clarify seismogenic relation (dependent or independent) between WVFZ and SLCS

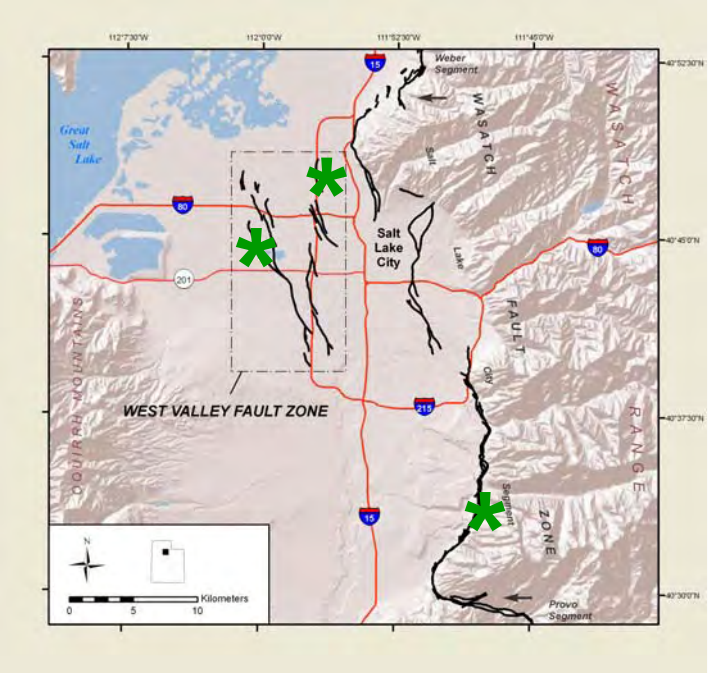
(3) Develop robust late Holocene recurrence-interval and slip-rate estimates for the WVFZ and SLCS

Secondarily, want to evaluate along-strike temporal variability in surface faulting of the SLCS, and possibility of spillover or multi-segment rupture between SLCS and Weber segment

Evidence for Coseismic Rupture of the West Valley Fault and Wasatch Fault



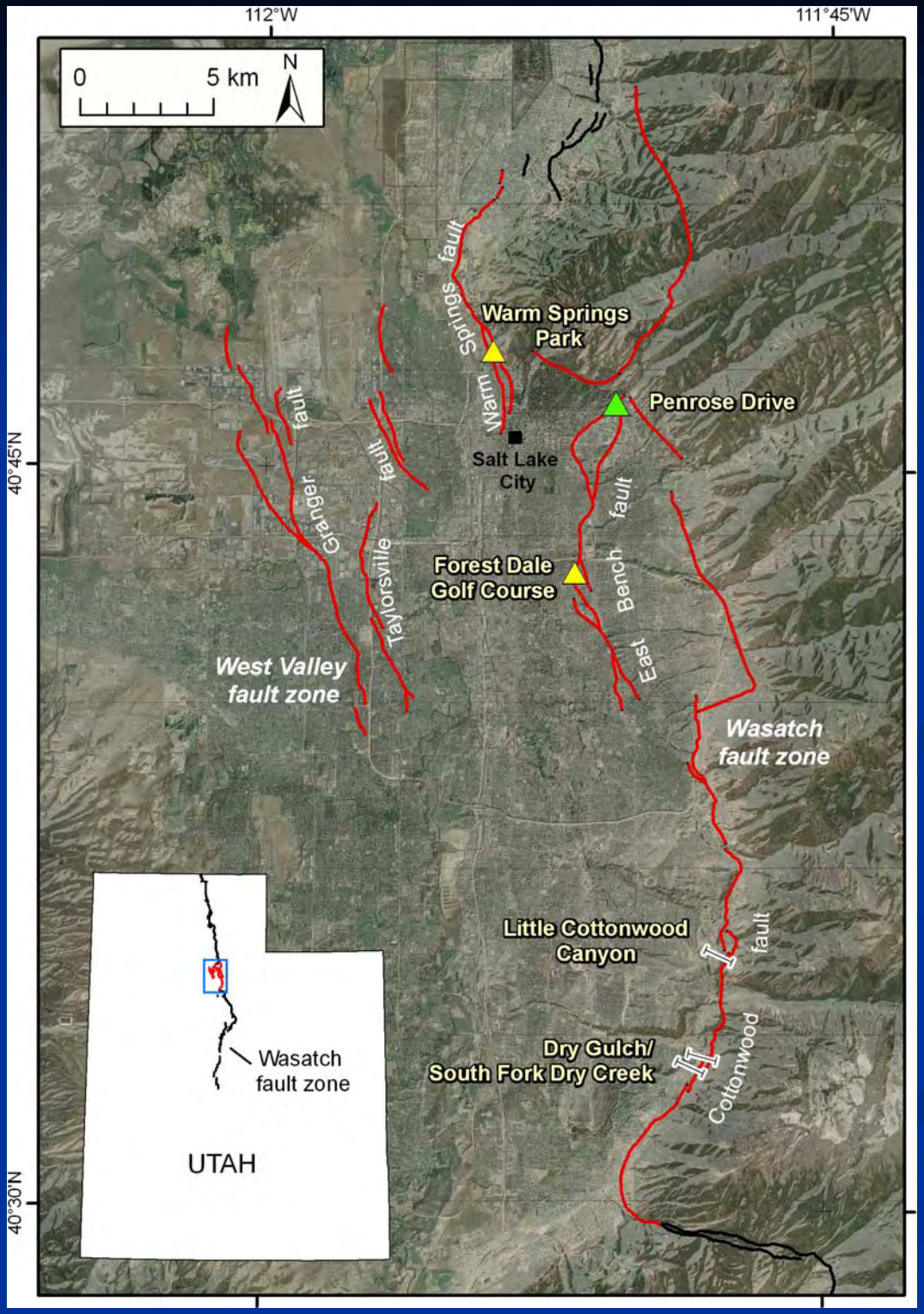
Granger fault data from *westernmost* strand.
Taylorsville fault data from *northernmost* strand.
Salt Lake City segment data from *south end* of Cottonwood sub-section.

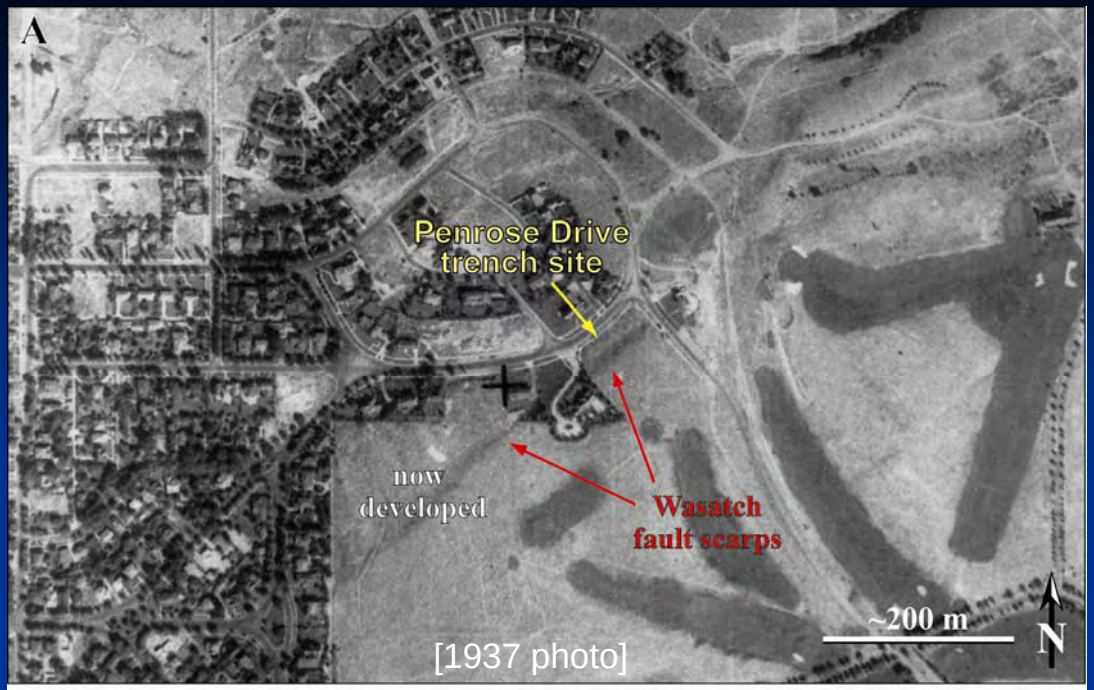


UQFPWG consensus preferred earthquake timing and uncertainty (Lund, 2005)

Average of maximum-limiting ages (Solomon, 1998)

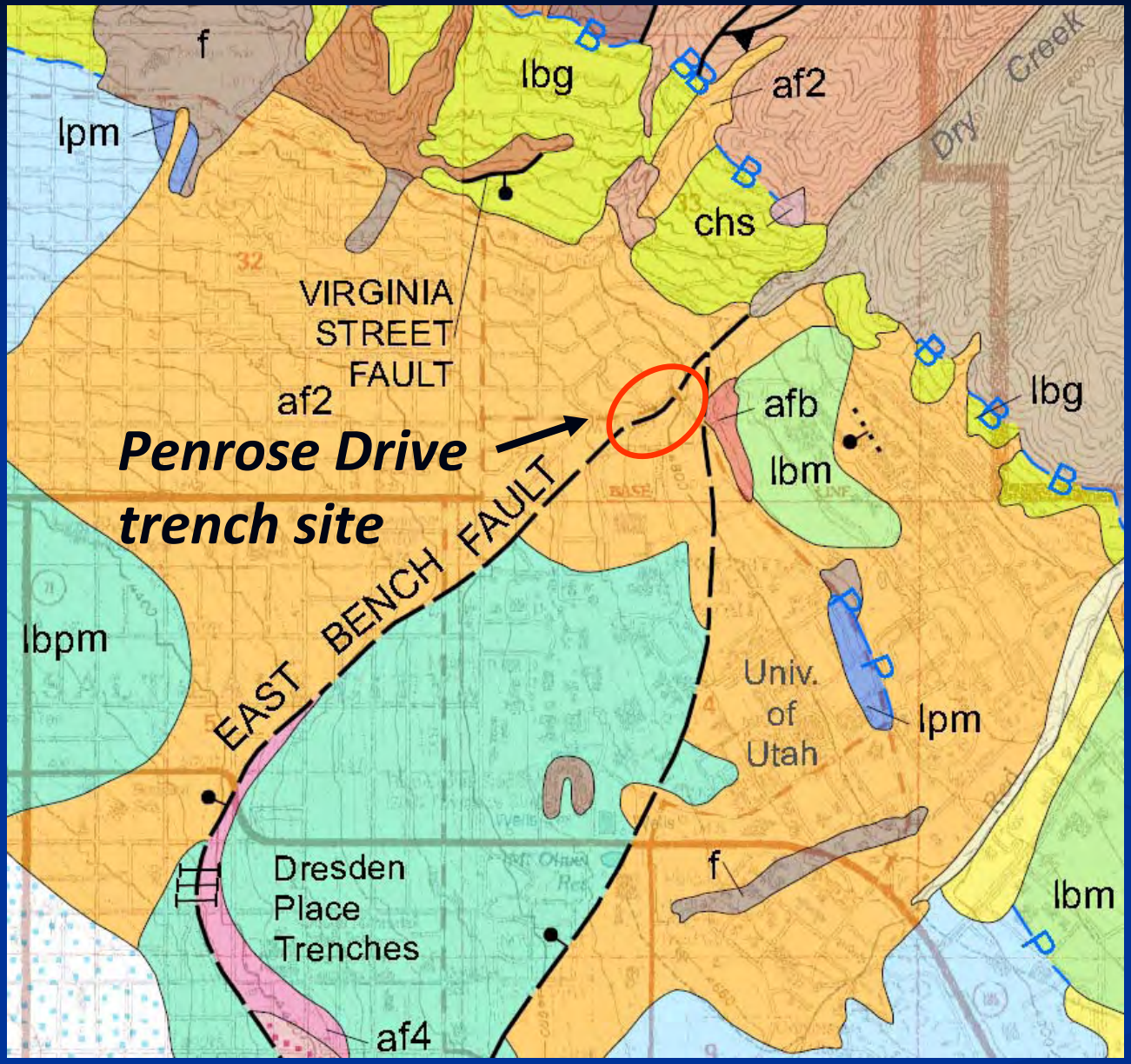
Minimum limit on timing unknown


112°W
111°45'W
40°45'N
40°30'N
0
5 km
N
Warm Springs fault
Warm Springs Park
Penrose Drive
Salt Lake City
Granger fault
Taylorsville fault
Forest Dale Golf Course
Bench fault
East
West Valley fault zone
Wasatch fault zone
Little Cottonwood Canyon
fault
Dry Gulch/ South Fork Dry Creek
Cottonwood
Wasatch fault zone
UTAH



Penrose Drive Site:

- Simple fault-trace geometry, no complicating mass-movement features
- Scarp appears unmodified
- Both up-thrown and down-thrown sides of scarp are well preserved
- Moderate scarp height (5-6 m)
- Anticipate geologic evidence for 2 or 3 events



Geologic Units:

af2 Fan alluvium (middle Holocene – uppermost Pleistocene)

afb Fan alluvium related to transgressive phase (upper Pleistocene)

lpm Lacustrine clay and silt (regressive) (uppermost Pleistocene)

lbg Lacustrine sand and gravel (transgressive) (upper Pleistocene)

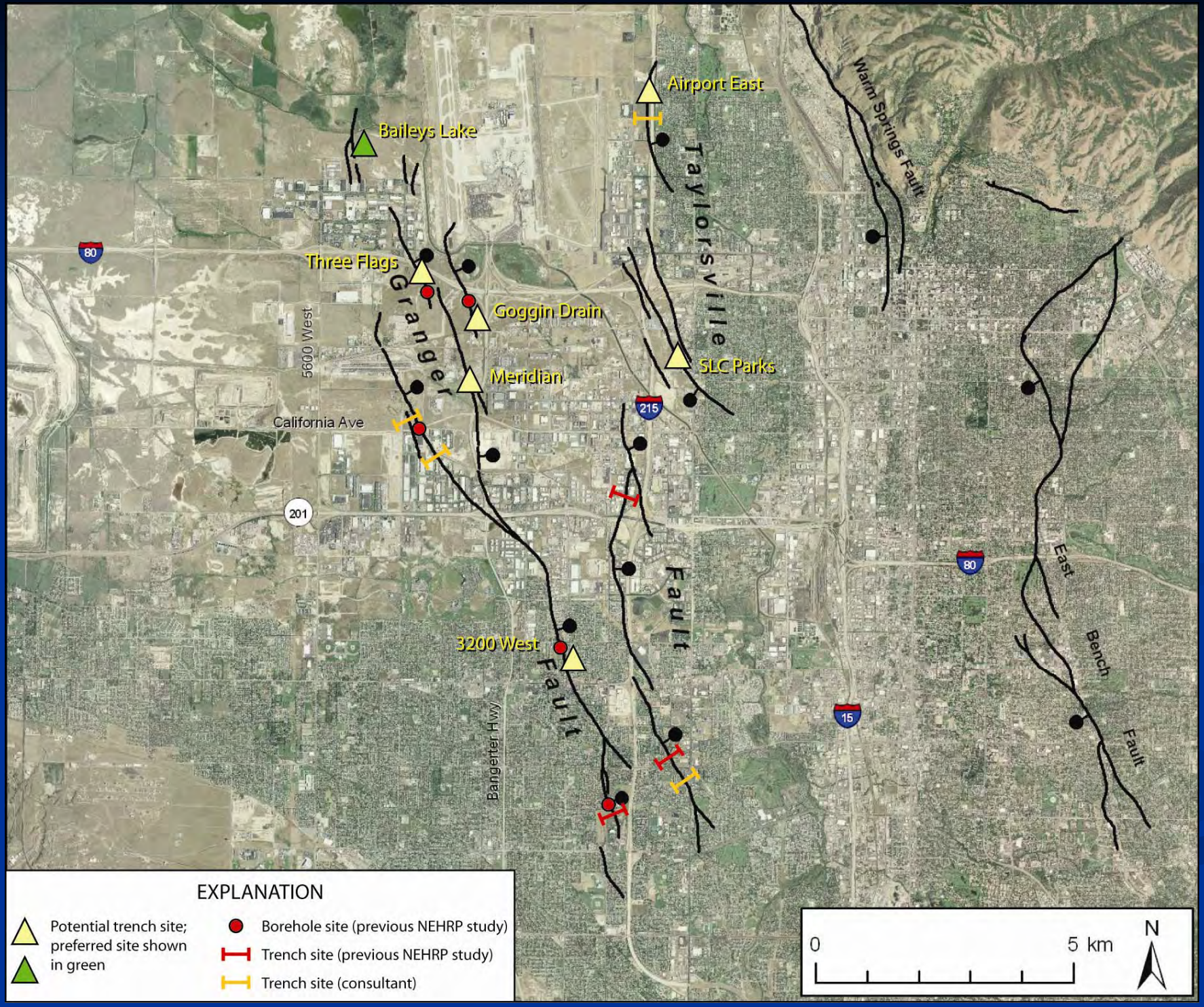
lbm Lacustrine clay and silt (transgressive) (upper Pleistocene)

lbpm Lacustrine clay and silt (undivided) (upper Pleistocene)

Dresden Place Trenches (1986):

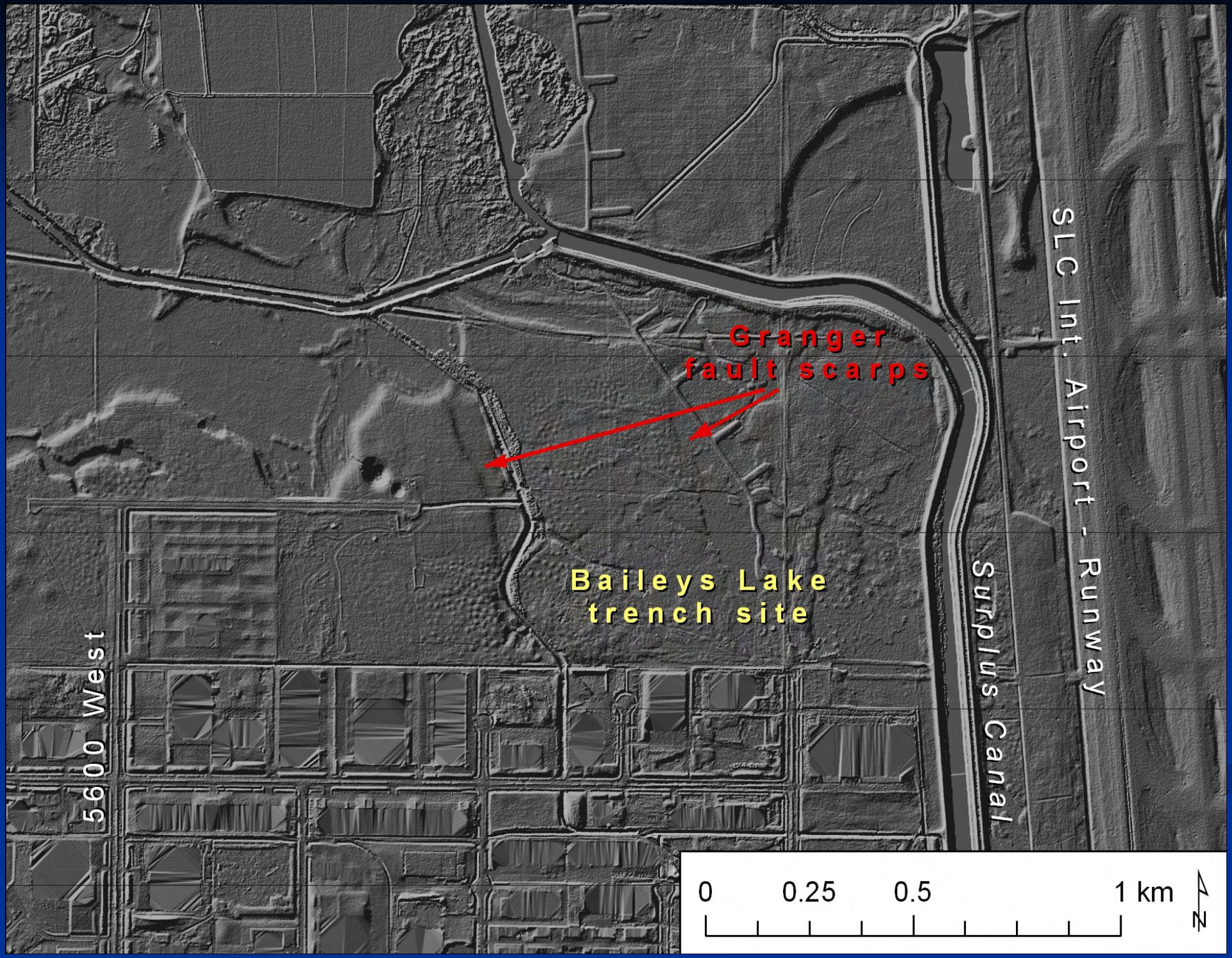
- ≥7 m deformation
- 3 m monoclinal warping—latest Pleistocene
- ≥4 m brittle deformation (fault offset)—Holocene

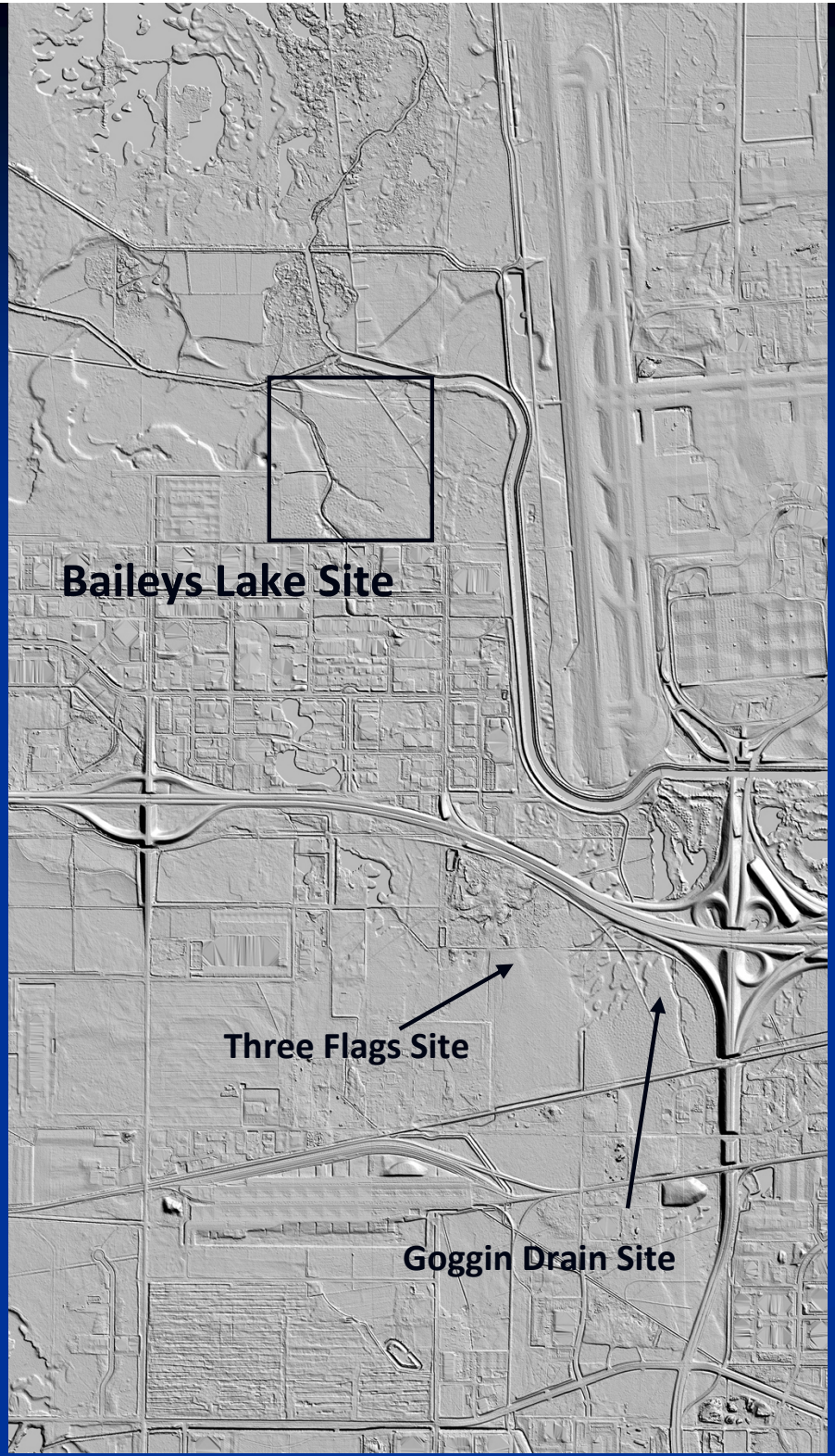
From Personius and Scott (1992)


Airport East
Baileys Lake
Warm Springs Fault
Taylorsville
Three Flags
Granger
Goggin Drain
5600 West
SLC Parks
Meridian
California Ave
215
80
201
East
Bench
Fault
3200 West
Fault
Bangerter Hwy
15
EXPLANATION
Potential trench site; preferred site shown in green
Borehole site (previous NEHRP study)
Trench site (previous NEHRP study)
Trench site (consultant)
0
5 km
N

Baileys Lake Site:

- Two scarps of different height (1 m and 0.5 m)
- Scarps appear relatively unmodified
- Anticipate geologic evidence for 2 or 3 events


Granger
fault scarps
Baileys Lake
trench site
5600 West
Surplus Canal
SLC Int. Airport - Runway
0
0.25
0.5
1 km
N



Three Flags Site (1989):

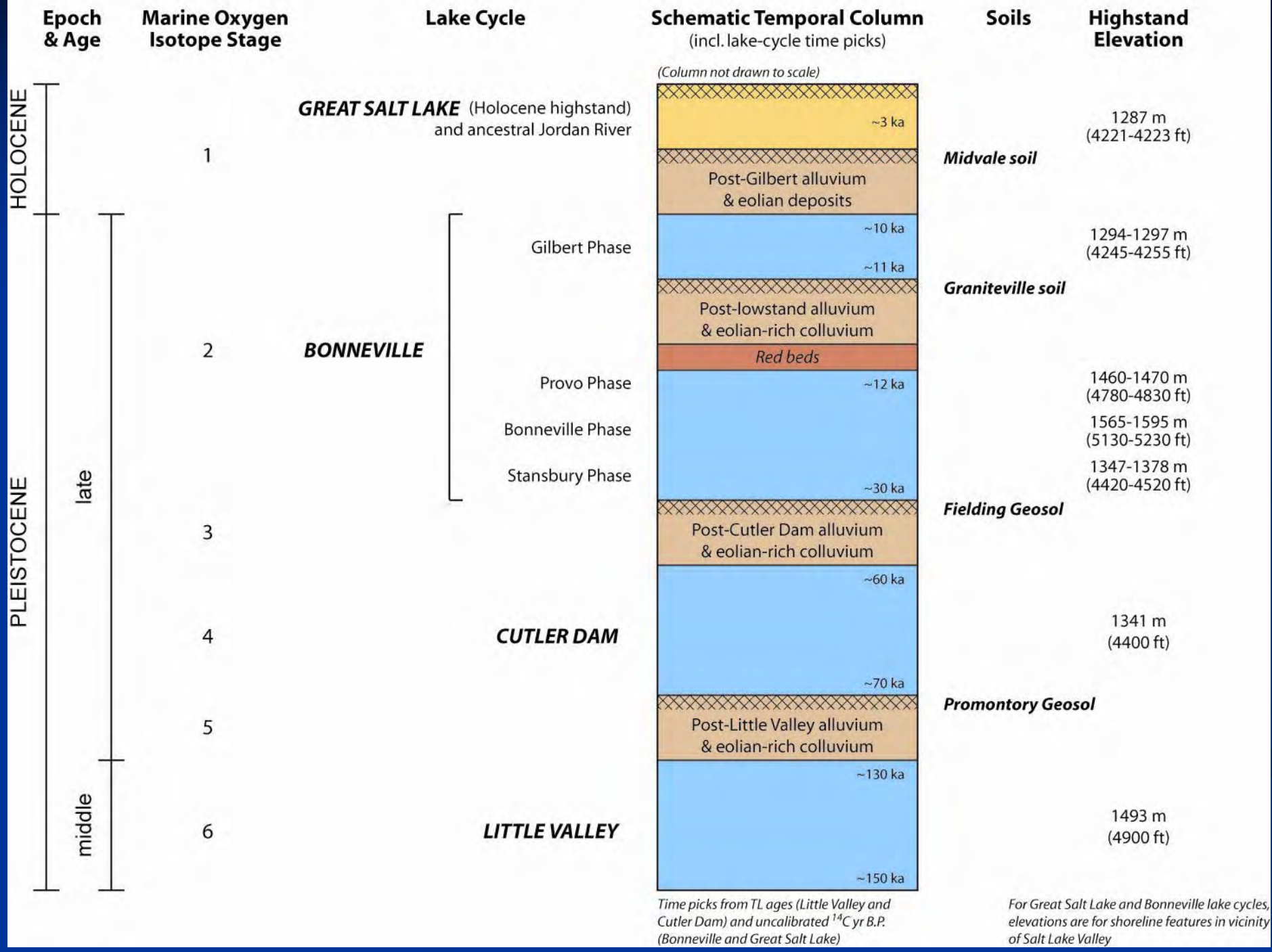
- Scarp 0.5-0.8 m high
- 0.7 m vertical separation (Holocene)

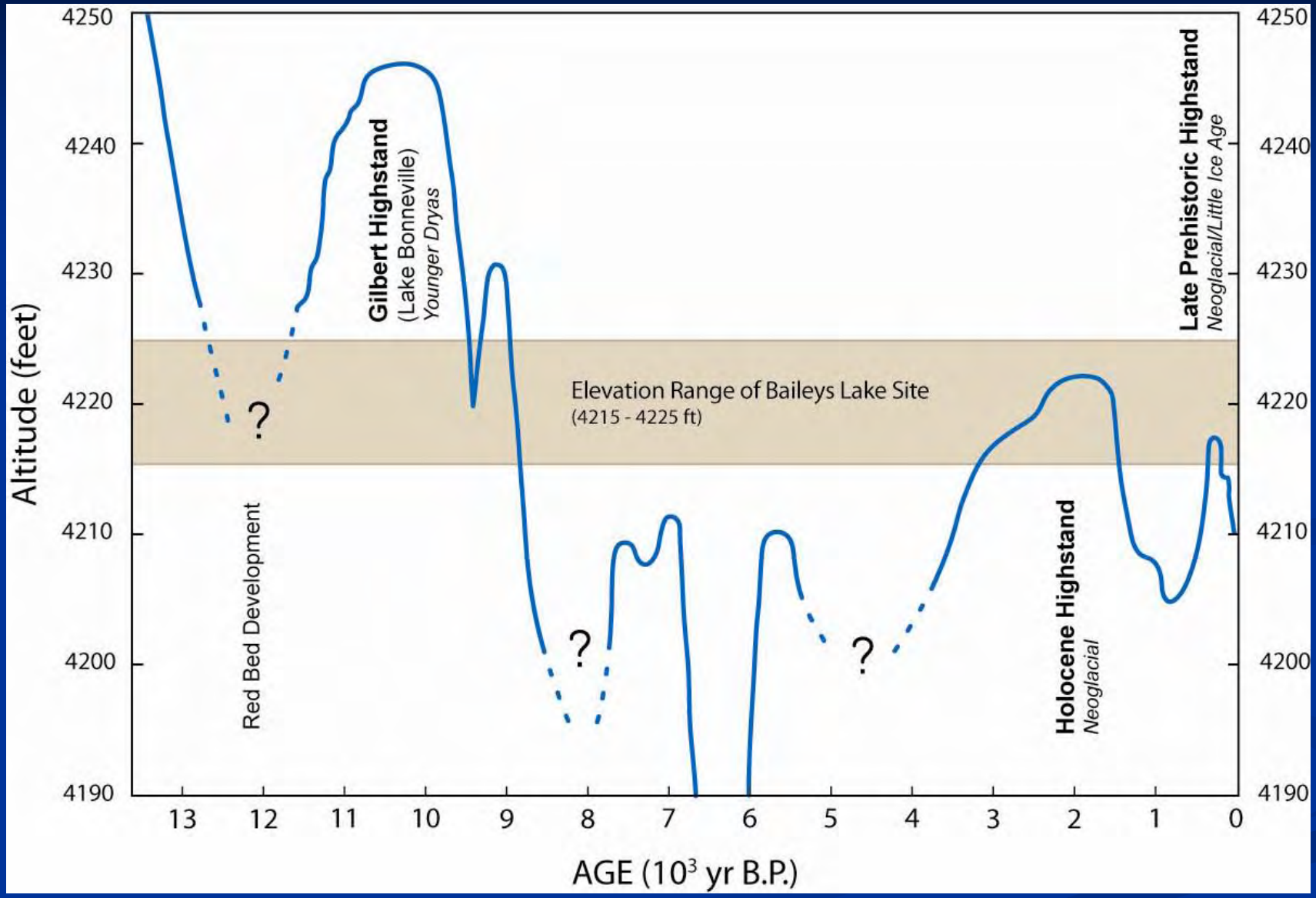
Goggin Drain Site (1989):

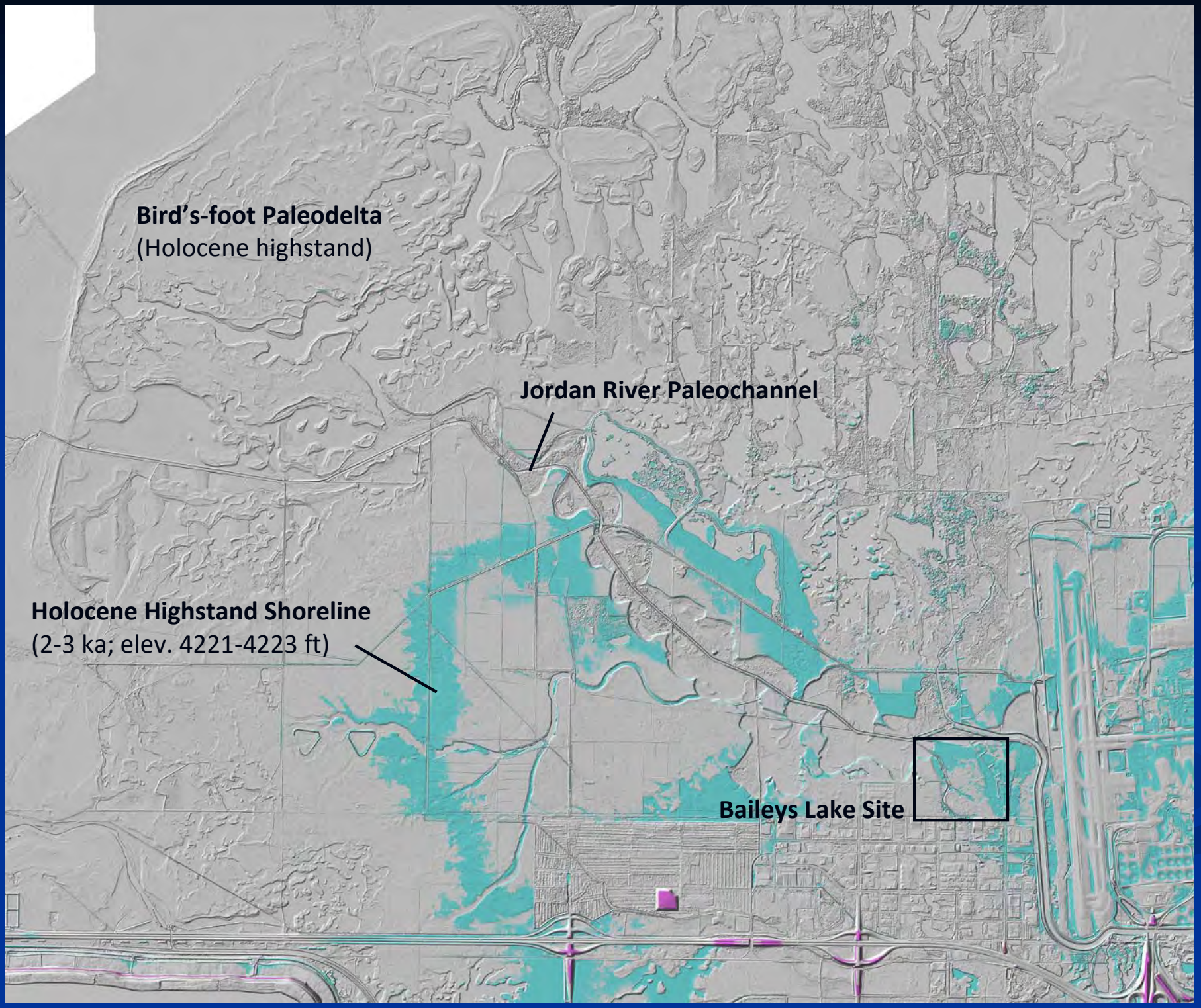
- Scarp 1.8-2.0 m high
- 1.4-1.5 m vertical separation (Holocene)
- 3-4 m vertical separation (post-30 ka)

Generalized Late Quaternary Stratigraphy of Northern Salt Lake Valley

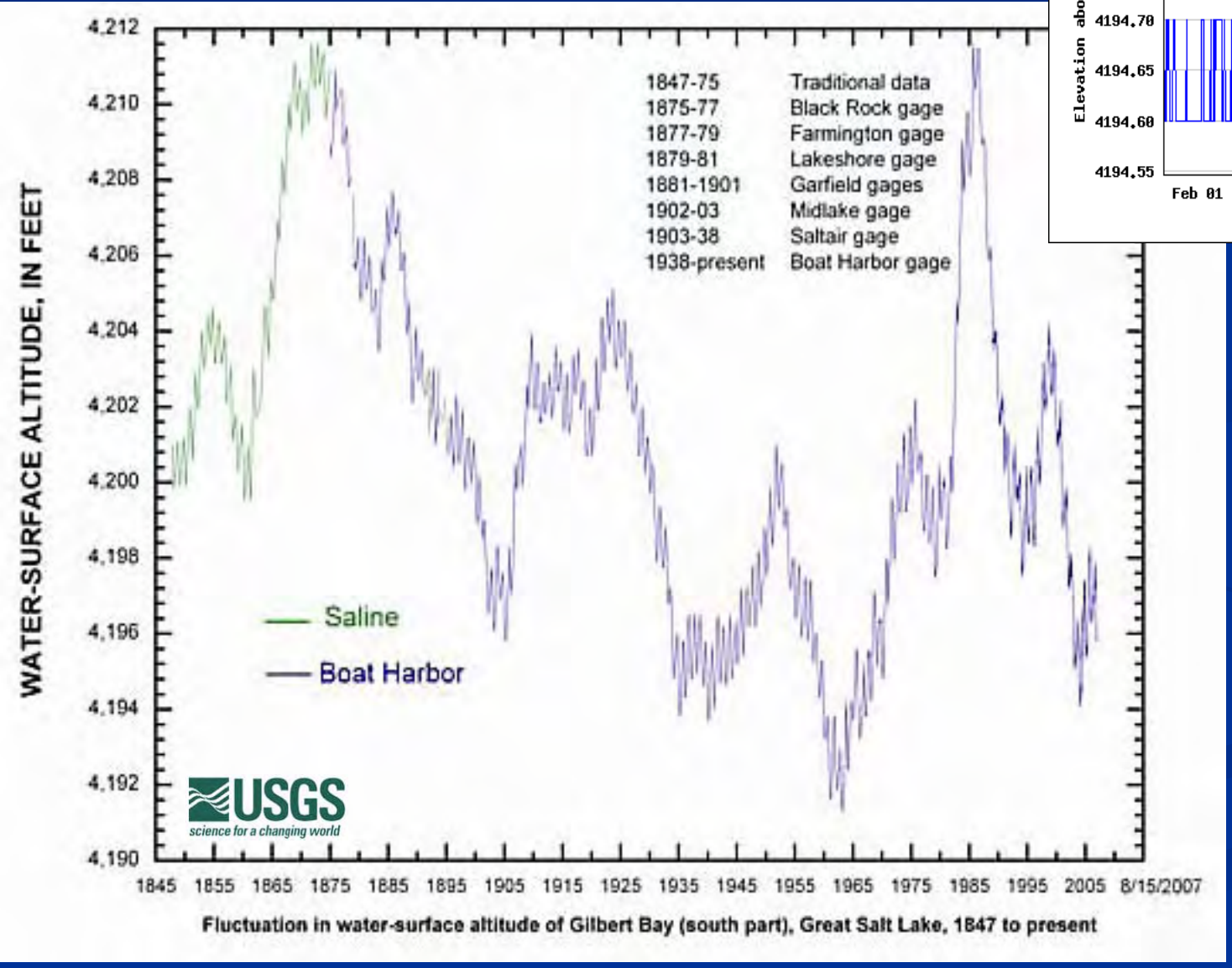
(modified from Keaton and Currey, 1989)



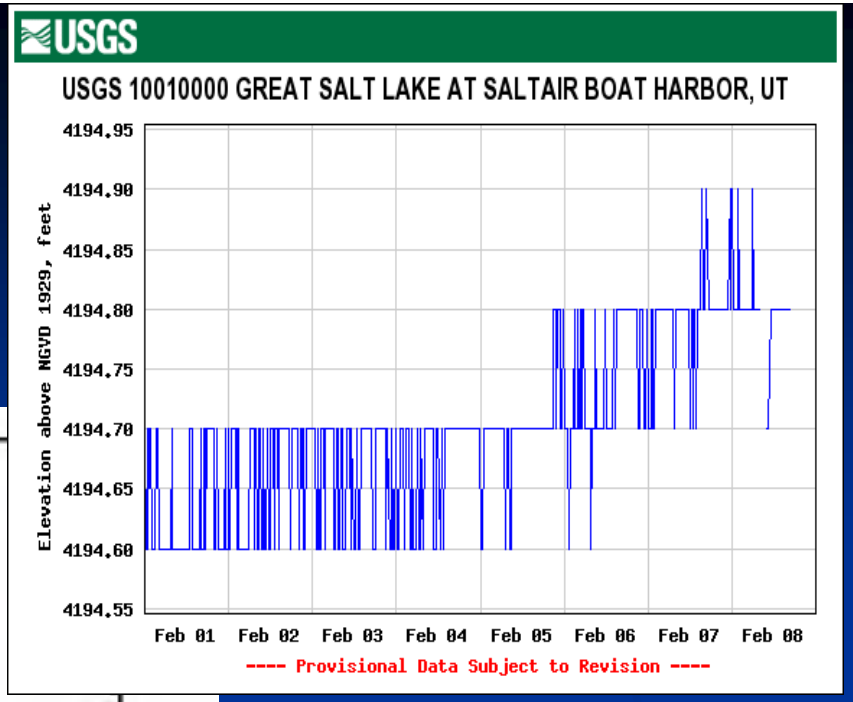

Altitude (feet)
4250
4240
4230
4220
4210
4200
4190
13
12
11
10
9
8
7
6
5
4
3
2
1
0
AGE (10^3 yr B.P.)
Gilbert Highstand
(Lake Bonneville)
Younger Dryas
Elevation Range of Baileys Lake Site
(4215 - 4225 ft)
Late Prehistoric Highstand
Neoglacial/Little Ice Age
Red Bed Development
Holocene Highstand
Neoglacial
?
?
?
?


Bird's-foot Paleodelta
(Holocene highstand)
Jordan River Paleochannel
Holocene Highstand Shoreline
(2-3 ka; elev. 4221-4223 ft)
Baileys Lake Site

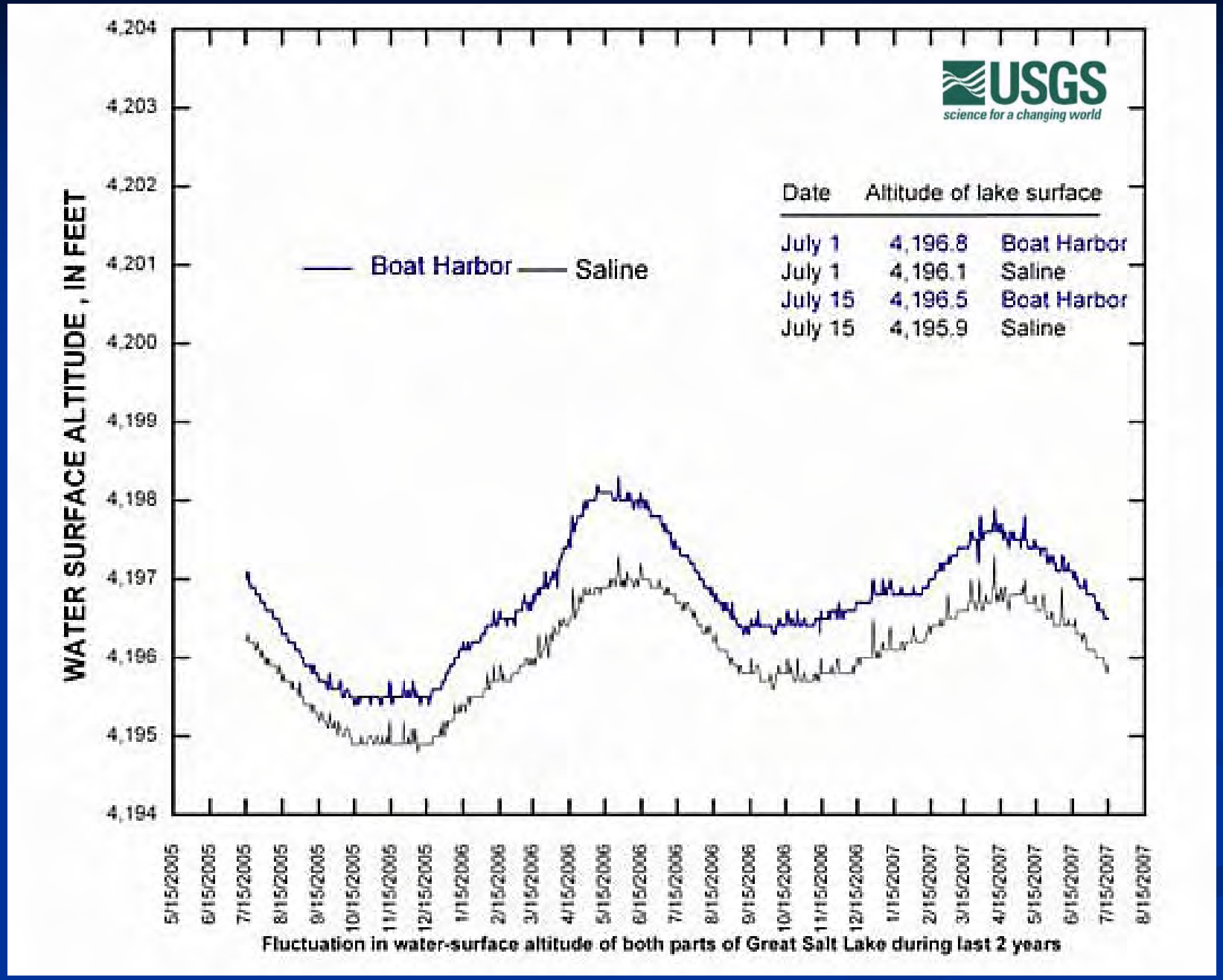
1980s NEHRP studies



Fluctuation in water-surface altitude of Gilbert Bay (south part), Great Salt Lake, 1847 to present

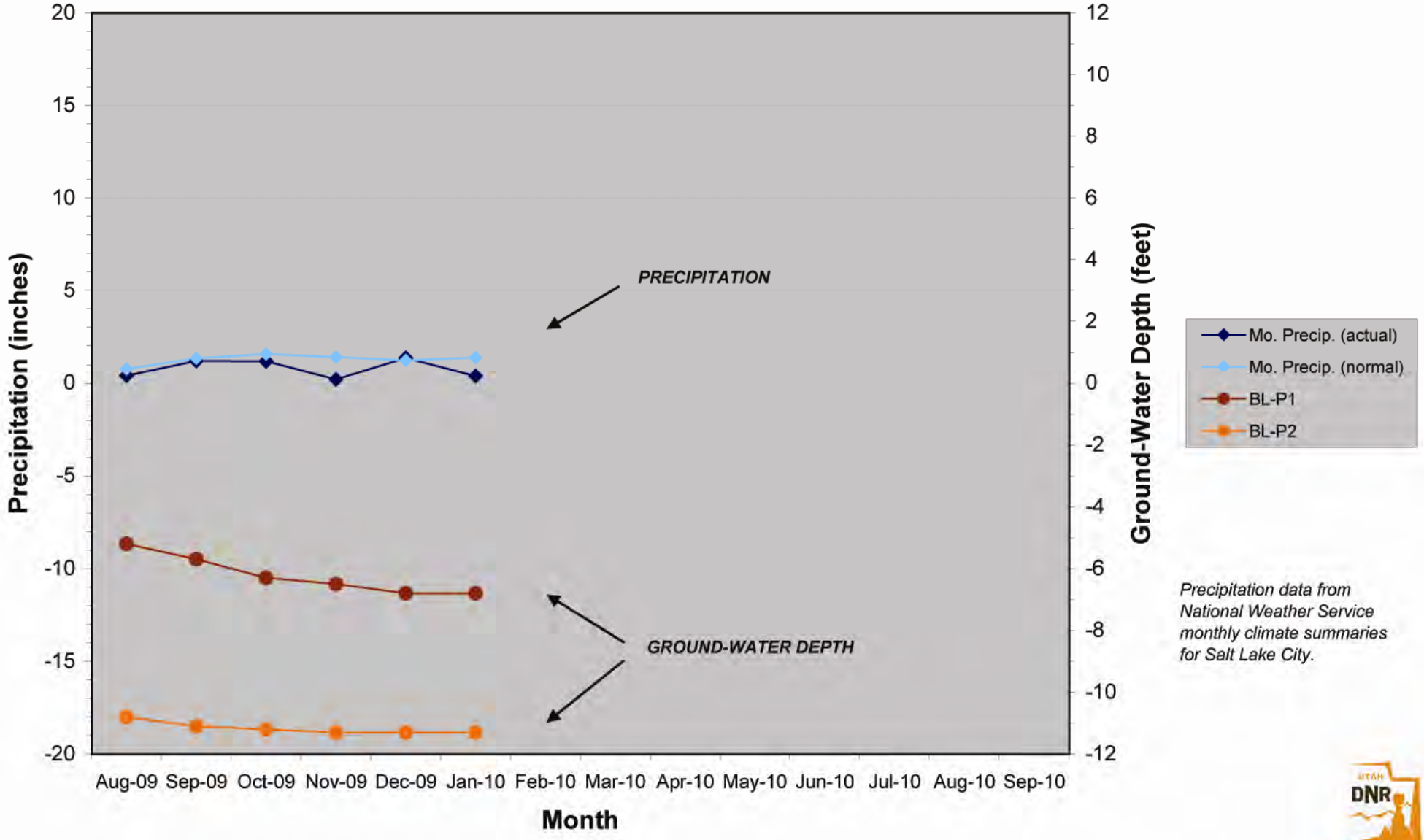


2010 NEHRP study!



Fluctuation in water-surface altitude of both parts of Great Salt Lake during last 2 years

Precipitation and Ground-Water Levels - Baileys Lake Site



Precipitation data from National Weather Service monthly climate summaries for Salt Lake City.

Calculating Time-Dependent Probabilities of Large Earthquakes for the Wasatch Front

Working Group on Utah Earthquake Probabilities

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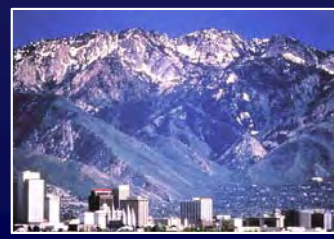
Salt Lake City, UT 9 February 2010

Introduction

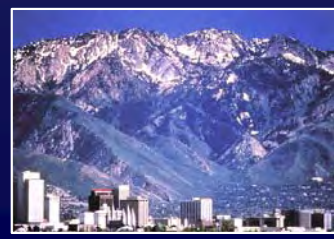
- In the past two decades, estimates of the probabilities of large earthquakes occurring in a specified time period have been developed in California for the SF Bay area, southern California, and most recently, statewide as part of the Unified California Earthquake Rupture Forecast (UCERF).

- The key to these forecasts is the availability of “requisite” information on the expected mean frequency of earthquakes and the elapsed time since the most recent large earthquake.



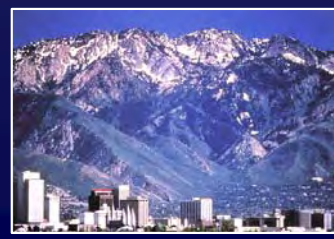
Introduction (cont.)

- Previous estimates of Wasatch Front earthquake probabilities have been made by individual authors using the limited data available at the time. The results of these investigations had little impact on public policy.
- Conversely, the California Working Group probability estimates have found a broad audience, and have been used to heighten public earthquake awareness, as a basis for retrofitting lifeline infrastructure, for adopting unreinforced masonry retrofit ordinances, and for setting earthquake insurance rates.



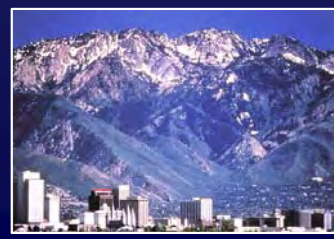
Wasatch Front

- The level of information on past earthquakes along the Wasatch fault, along with regional seismicity and geodetic data, is now sufficiently robust to provide the basis for making probabilistic estimates of future large earthquakes within the Wasatch Front.
- The methodologies necessary to estimate probabilities have been developed and refined by the various California Working Groups, and their experience can now be applied in Utah.



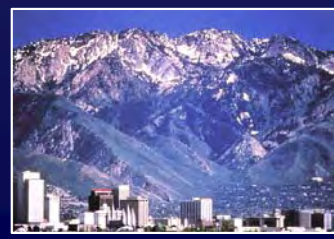
WGUEP

- A Working Group on Utah Earthquake Probabilities has been formed to develop an earthquake forecast for the Wasatch Front.
- The analyses will include both time-dependent and time-independent probabilities for the Wasatch fault and other faults in the Wasatch Front region.
- The WGUEP includes individuals who have extensive experience with the paleoseismology and seismology of faults in the Wasatch Front region, and who have participated in previous evaluations of seismic hazard using both time-dependent and time-independent approaches.



WGUEP Members

Walter Arabasz, UUSS
Tony Crone, USGS
Chris DuRoss, UGS
Nico Luco, USGS
Bill Lund, UGS (Coordinator)
Susan Olig, URS
Jim Pechmann, UUSS
Steve Personius, USGS
Mark Petersen, USGS
David Schwartz, USGS
Bob Smith, UUGG
Ivan Wong, URS (Chair)



Approach

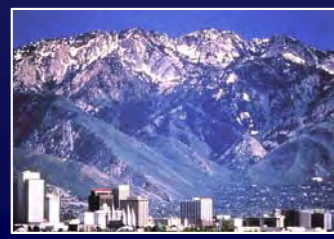
- An approach similar to that taken by the various California Working Groups will be followed by using SSHAC as guidelines.
- We will convene a series of workshops and meetings over a two-year period to review and develop model components. A SSHAC Level 2 process will be followed.
- Four models* will be implemented in the forecast process:
  1. Fault model
  2. Deformation model
  3. Earthquake rate model
  4. Probability model

* Epistemic uncertainties in all model input parameters will be explicitly address by the WGUEP.

Products

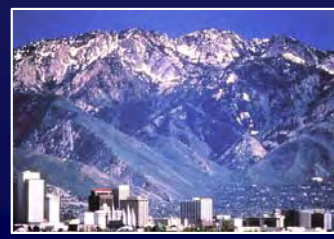
- The WGUEP will calculate the probability of a large earthquake ($M \geq 6.5$) in the Wasatch Front Region for a range of intervals varying from annually to 100 years.

- The earthquake probabilities that will be estimated are:
  1. Segment-specific for the Wasatch fault
  2. Total for the Wasatch fault
  3. Fault-specific for other major faults in the area
  4. Total for the Wasatch Front region.



Products (cont.)

- The final forecast will undergo a formal internal USGS review, and will be sent to the National Earthquake Prediction Council for review and comment as well.
- Media release of the WGUEP results will be handled by the UGS. Project results will be presented at meetings for the general public and at professional and scientific society meetings.



WEBER SEGMENT CONSENSUS DATA

Fault/Fault Section	Length (km) Straight Line	Length (km) Surface Trace	Earthquake Timing	Consensus Preferred Recurrence Interval	Consensus Preferred Vertical Slip Rate
Weber segment	56	61	Za 0.5+0.3 ka (partial segment rupture?) Zb 950+450 cal yr B.P. Y 3000+700 cal yr B.P. X 4500+700 cal yr B.P. W 6100+700 cal yr B.P.	Three most recent (W to Zb) interevent interval average recurrence: 1600±600 cal yr Four most recent (W to Za) interevent interval average recurrence: 1100±1400 cal yr WORKING GROUP PREFERRED RECURRENCE INTERVAL 500-1400-2400 yr	Y-Zb 0.6-0.9-1.4 mm/yr X-Y 1.0-1.9-4.3 mm/yr W-X 0.6-0.9-1.6 mm/yr Using an updated Lake Bonneville chronology and net-slip values from Nelson and Personius (1993) shows long-term slip rates as high as 2.0 mm/yr in Bonneville-phase deposits, and up to 1.3 mm/yr in Provo-phase deposits. WORKING GROUP PREFERRED VERTICAL SLIP RATE 0.6-1.2-4.3 mm/yr

2011 UTAH QUATERNARY FAULT RESEARCH PRIORITIES

Hansel Valley earthquake, 1934

2010 FAULT PRIORITY LIST

2010 Highest Priority Faults/Fault Segments For Study			
Fault/Fault Section	**Priority**	**Investigation Status**	**Investigating Institution**
Northern Salt Lake City segment WFZ	1	No activity	
West Valley fault zone	2	No activity	
Penultimate event Provo segment WFZ	3	Trench site reconnaissance	UGS
Washington fault zone	4	Reconnaissance study	UGS
Rozelle section, Great Salt Lake fault	5	No activity	
Other Priority Faults/Fault Segments Requiring Further Study			
Fault/Fault Section	**Original UQFPWG Priority**	**Investigation Status**	**Investigating Institution**
Cedar City-Parowan monocline/ Paragonah fault	10	No activity	
Enoch graben	11	No activity	
Clarkston fault	13	No activity	
Gunnison fault	17	No activity	
Scipio Valley faults	18	No activity	
Faults beneath Bear Lake	19	No activity	
Eastern Bear Lake fault	20	No activity	
Carrington fault (Great Salt lake)	2007	No activity	
Bear River fault zone	2007	Scarp reconnaissance	USGS
Faults/Fault Segment Studies Complete or Ongoing			
Fault/Fault Section	**Original UQFPWG Priority**	**Investigation Status**	**Investigating Institution**
Nephi segment WFZ	1	UGS Special Study 124/USGS Map 2966/UVU study ongoing	UGS/USGS/UVU
Weber segment WFZ – most recent event	3	On going	UGS/USGS
Weber segment WFZ – multiple events	4	On going	UGS/USGS
Utah Lake faults and folds	5	Ongoing	UUGG
Great Salt Lake fault zone	6	Ongoing	UUGG
Collinston and Clarkston Mountain segments WFZ	7	UGS Special Study 121	UGS
Sevier/Toroweap fault	8	UGS Special Study 122	UGS
East Cache fault zone	12	Ongoing	USU
Wasatch Range back-valley faults	14	Ongoing	USBR
Hurricane fault zone	15	UGS Special Study 119	UGS
Levan segment WFZ	16	UGS Map 229	UGS
Brigham City segment WFZ – most recent event	2007	Ongoing	UGS/USGS

2010 HIGHEST PRIORITY FAULTS/FAULT SEGMENTS FOR STUDY

Fault/Fault Section	Priority	Investigation Status	Investigating Institution
Northern Salt Lake City segment WFZ	1	Study funded (NEHRP)	UGS/USGS
West Valley fault zone	2	Study funded (NEHRP)	UGS/USGS
Penultimate event Provo segment WFZ	3	Trench site reconnaissance	UGS
Washington fault zone	4	Two trenching studies ongoing	UGS/Simon•Bymaster, Inc.
Rozelle section, Great Salt Lake fault	5	No activity	

OTHER PRIORITY FAULTS/FAULT SEGMENTS REQUIRING FURTHER STUDY

Fault/Fault Section	Original UQFPWG Priority	Investigation Status	Investigating Institution
Cedar City-Parowan monocline/ Paragonah fault	10	No activity	
Enoch graben	11	Cedar Valley earth fissure study	UGS
Clarkston fault	13	No activity	
Gunnison fault	17	No activity	
Scipio Valley faults	18	No activity	
Faults beneath Bear Lake	19	No activity	
Eastern Bear Lake fault	20	No activity	
Carrington fault (Great Salt Lake)	2007	No activity	
Bear River fault zone	2007	Trenching study	USGS

FAULTS/FAULT SEGMENT STUDIES COMPLETE OR ONGOING

Fault/Fault Section	Original UQFPWG Priority	Investigation Status	Investigating Institution
Nephi segment WFZ	1	UGS Special Study 124/USGS Map 2966/ ongoing UVU study	UGS/USGS/UVU
Weber segment WFZ – most recent event	3	UGS Special Study 130	UGS/USGS
Weber segment WFZ – multiple events	4	UGS Special Study 130	UGS/USGS
Utah Lake faults and folds	5	Ongoing	UUGG
Great Salt Lake fault zone	6	Ongoing	UUGG
Collinston and Clarkston Mountain segments WFZ	7	UGS Special Study 121	UGS
Sevier/Toroweap fault	8	UGS Special Study 122	UGS
East Cache fault zone	12	Ongoing	USU
Wasatch Range back-valley faults	14	Ongoing	USBR
Hurricane fault zone	15	UGS Special Study 119	UGS
Levan segment WFZ	16	UGS Map 229	UGS
Brigham City segment WFZ – most recent event	2007	Ongoing	UGS/USGS

UQFPWG QUATERNARY FAULT STUDY PRIORITY LIST

Fault/Fault Segment	Original UQFPWG Priority (2005)
Nephi segment WFZ	1
West Valley fault zone	2
Weber segment WFZ – most recent event	3
Weber segment WFZ – multiple events	4
Utah Lake faults and folds	5
Great Salt Lake fault zone	6
Collinston & Clarkston Mountain segments WFZ	7
Sevier/Toroweap fault	8
Washington fault	9
Cedar City-Parowan monocline/ Paragonah fault*	10
Enoch graben	11
East Cache fault zone	12
Clarkston fault*	13
Wasatch Range back-valley faults	14
Hurricane fault	15
Levan segment WFZ	16
Gunnison fault	17
Scipio Valley faults	18
Faults beneath Bear Lake	19
Eastern Bear Lake fault	20
Bear River fault zone	Added 2007
Brigham City segment WFZ – most recent event	Added 2007
Carrington fault (Great Salt Lake)	Added 2007
Northern Salt Lake City segment WFZ	Added 2009
Provo segment WFZ – penultimate event	Added 2007
Rozelle section – Great Salt Lake Fault	Added 2007

*Faults currently on Utah NSHM

SOME SUGGESTIONS FOR CONSIDERATION

UTAH FAULTS WITH LIMITED DATA THAT ARE INCLUDED ON THE NSHM

- **Clarkston fault, West Cache fault zone[1, 2,]**
- **Hansel Valley fault[2]**
- **Joes Valley fault zone[2]**
- **Morgan fault [2]**
- **North Promontory fault [2]**
  - **Paragonah fault – no trench data[1]**
- **Stansbury fault – no trench data [3]**
- **Strawberry fault [2]**
- **Wellsville fault, West Cache fault zone [2]**

FAULTS REQUIRING MORE DATA

- **Anderson Junction segment, Hurricane fault zone**
- **Nephi segment, Wasatch fault zone**

OTHER SUGGESTIONS RECEIVED

- **Carrington fault**

[1]Currently on UQFPWG priority list, [2]UQFPWG consensus slip-rate and recurrence-interval values using best available data, [3] Not previously considered by UQFPWG