DIGITAL MAPPING TECHNIQUES 2015

The following was presented at DMT'15
(May 17-20, 2015 - Utah Geological Survey,
Salt Lake City, UT)

The contents of this document are provisional

See Presentations and Proceedings
from the DMT Meetings (1997-2015)

http://ngmdb.usgs.gov/info/dmt/

Using Multiple GIS Resources and Information Databases to Overcome Challenges of Geologic Mapping in Urban Areas: Geologic Remapping of the Warm Springs Fault, Utah

Adam McKean

Mapping Geologist with the Geologic Hazards Program

Warm Springs Fault of the Salt Lake City Segment of the Wasatch Fault Zone

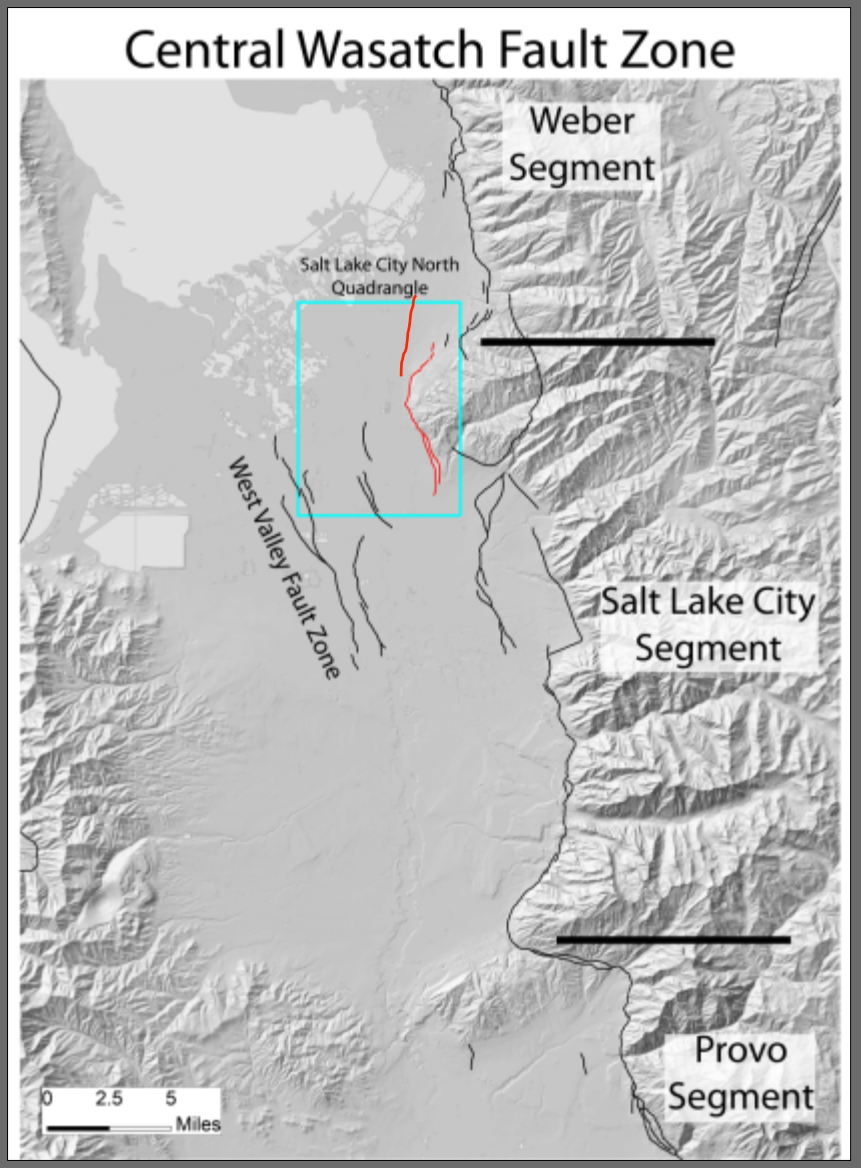
Warm Springs Fault

Current length - 6 mi. (10 km)

New length - 9 to 9.5 mi. (14.5-15.5 km)

Paleoseismic History

- 9 m displacement (3 events), Gilbert, 1890; in Hunt, 1982
- 14-16 m displacement (6-8 events in latest Quat.), Personius and Scott, 1992
- Est. max 12 m displacement at Washington School (Robinson and Burr, 1991)
- Currey, 1992, inferred 3 faults on Capitol Hill with max cumulative 21 m offset since ~20 ka
- Up to 2m offset at Salt Palace, 2-3 events since ~8.1 ka (fault and/or lateral spread interpretations) Korbay and McCormick, 1999; Simon and Shlemon, 1999



Remapping the Warm Springs Fault

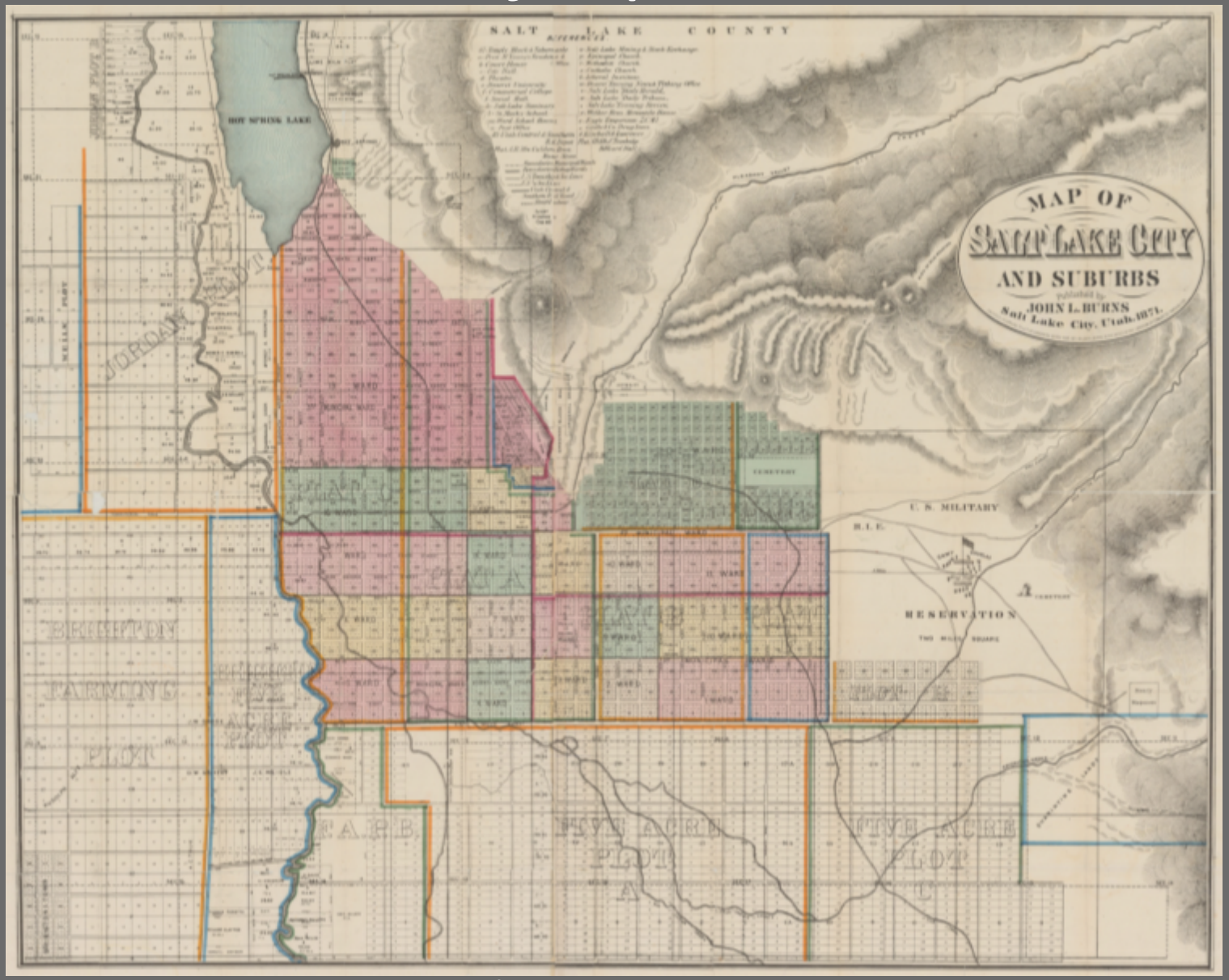
Why is it needed?

- Determine southward extent of faulting, if possible
- Understand Warm Springs fault rupture history
  - Surface fault rupture length
  - Recurrence interval
  - Age of faulting
  - Magnitude of earthquake events
- Interest in a possible Warm Springs and East Bench fault connection (Lee Liberty, BSU, NEHRP funded seismic project)
- Update maps and data for city and county special study zone

UGS Projects

- Remapping of the geology of the Salt Lake City North 7.5-minute quadrangle
  - STATEMAP 2013-2014
- Remapping of the Wasatch fault zone using LiDAR
  - 0.5 meter LiDAR acquired of the entire Wasatch fault zone (UGS and partners 2013-2014)
- Geologic Hazard Mapping Initiative
  - Currently mapping in Salt Lake and Utah Counties

One major problem…



John L. Burns, 1871

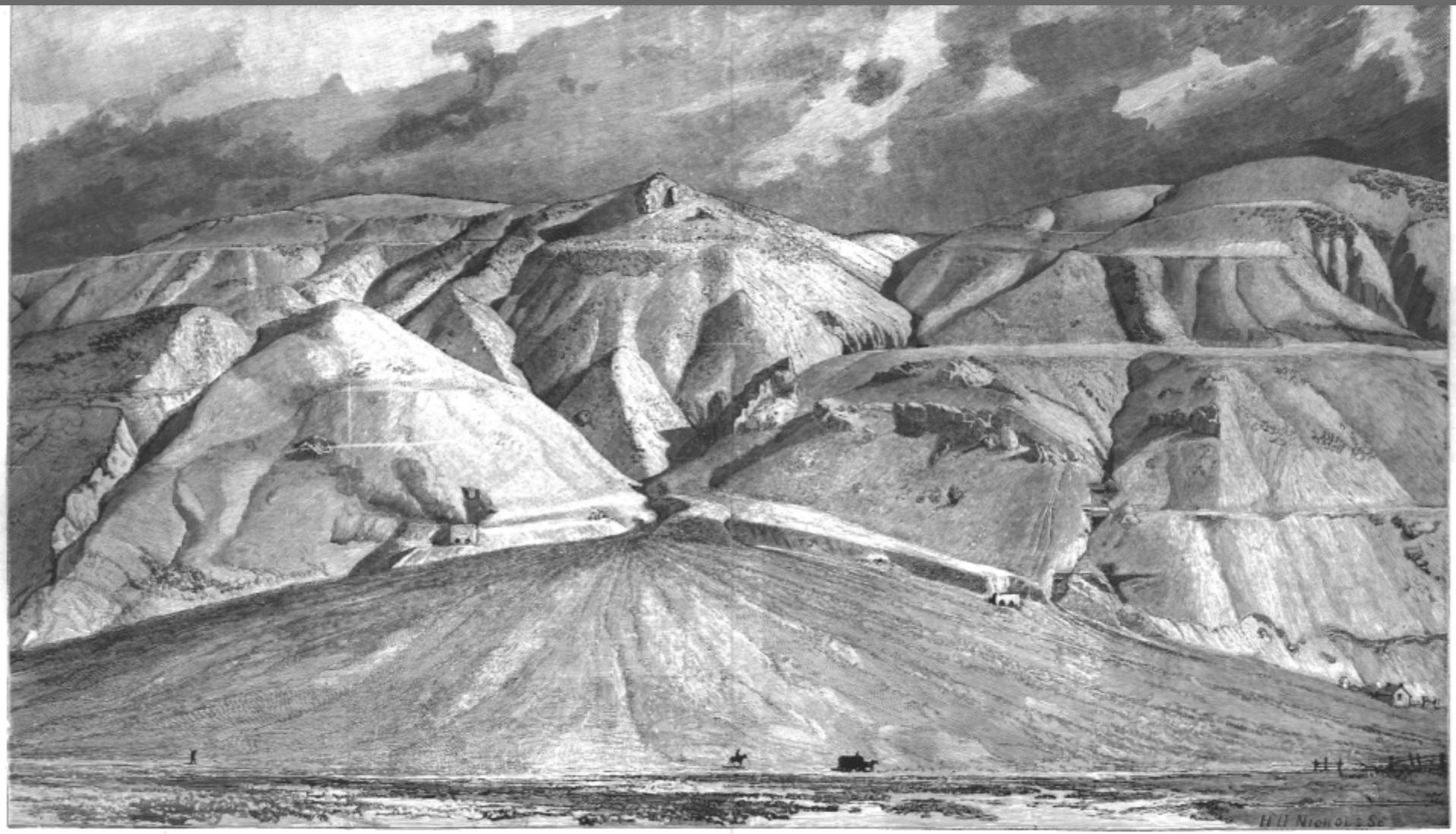
Map courtesy of the Church History Library, The Church of Jesus Christ of Latter-day Saints

And its not getting better

Mapping Resources

- Historical photographs
- Aerial photographs
- LiDAR
- Gravity
- Previous geologic mapping
- Geotechnical investigations
- Surface fault rupture investigations
- Cone penetrometer test (CPT) investigations
- NRCS soil maps

Jones Canyon, Holocene alluvial fan



FAULT SCARP CROSSING ALLUVIAL CONE, NEAR SALT LAKE CITY.

Drawn by W. H. Holmes.

Gilbert, 1890

Evolution of the Wasatch Fault Zone

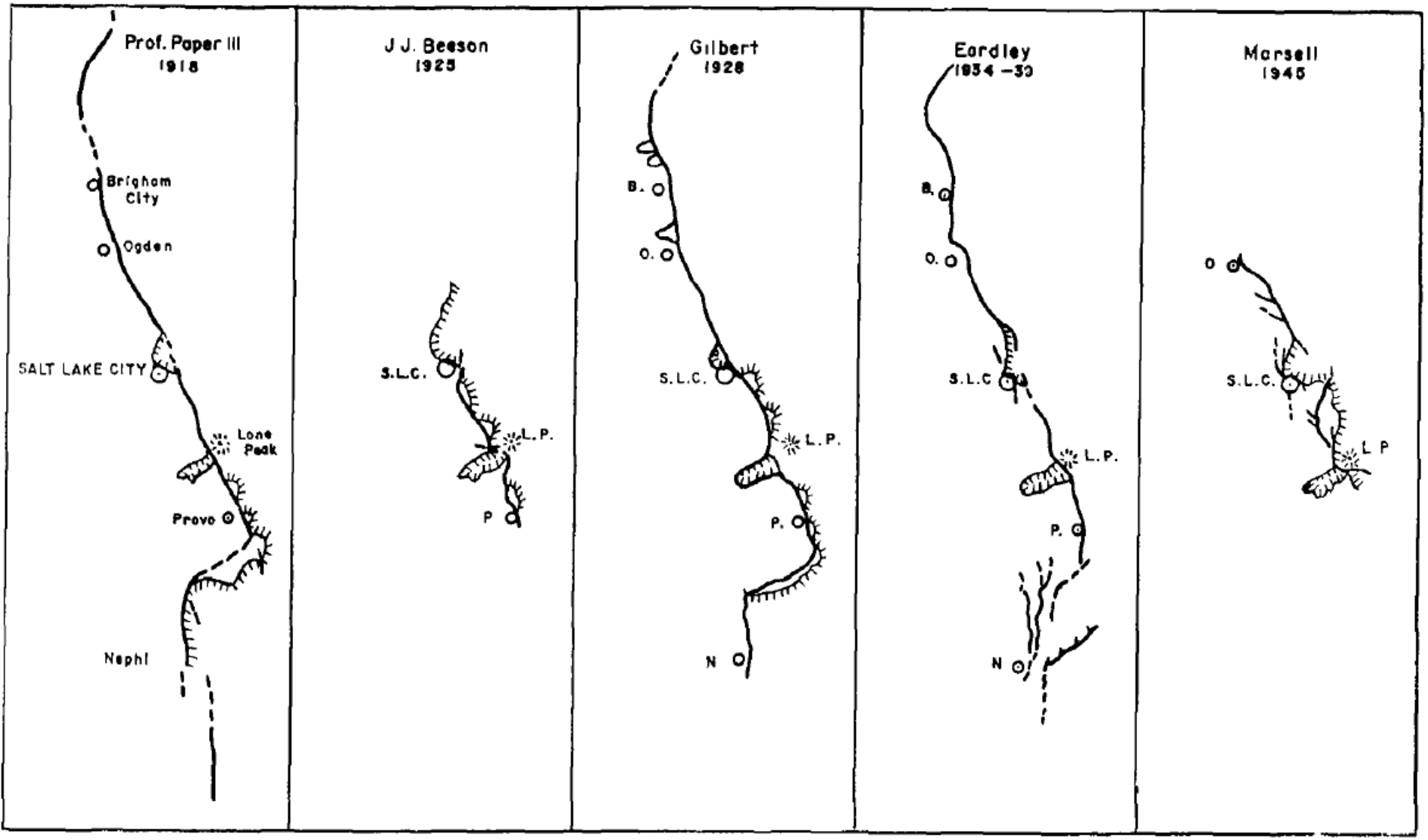
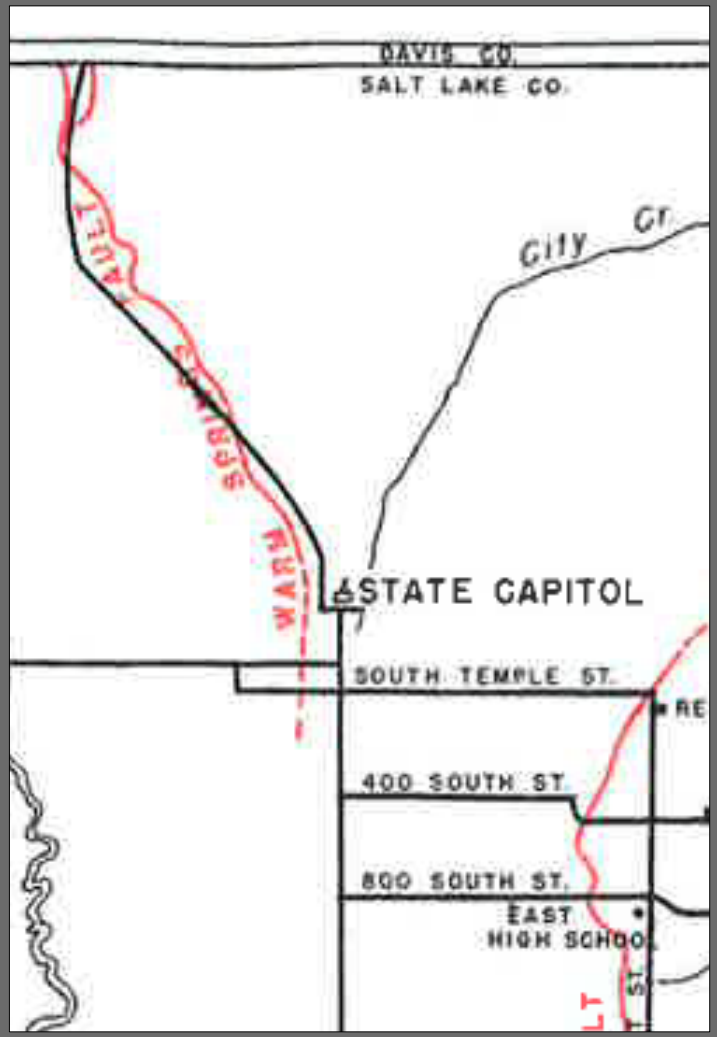


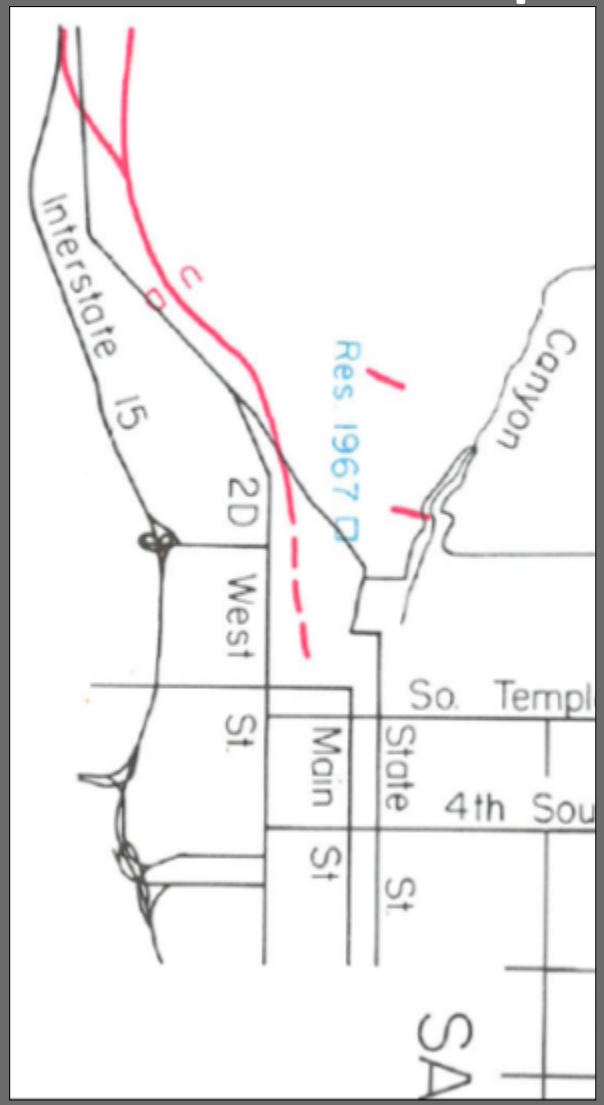
Figure 1. Sketch maps showing successive revisions by various authors in the fault pattern of the Wasatch fault zone.

Marsell, 1969

Evolution of the Warm Springs Fault



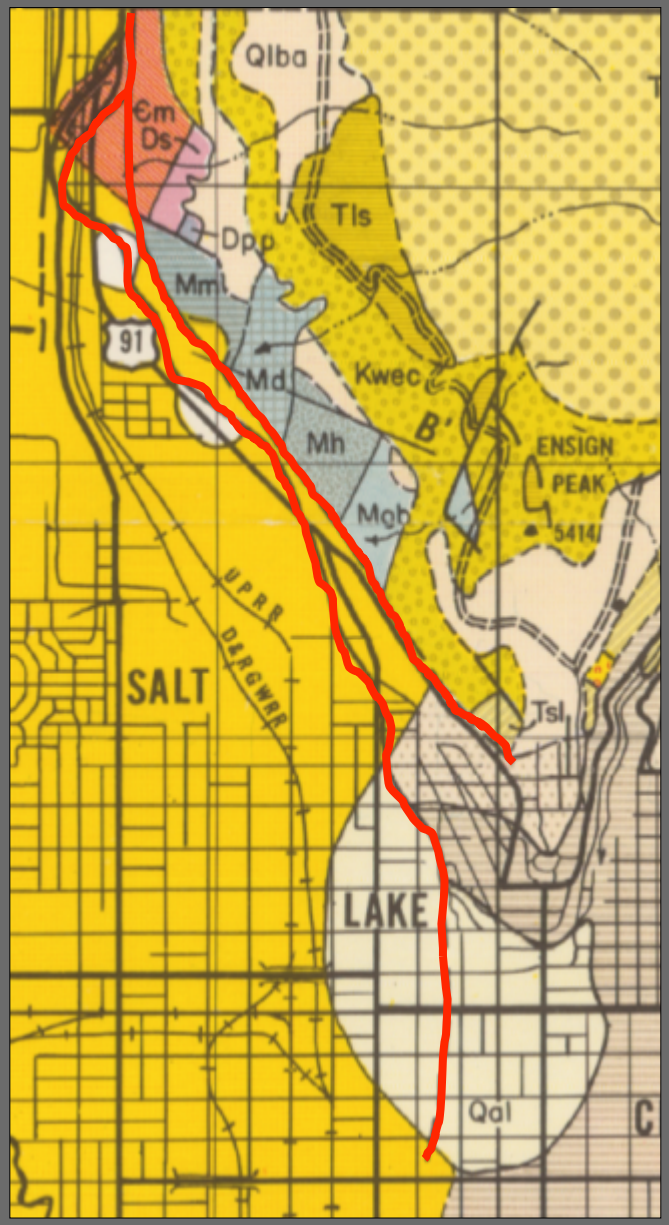
College of Mines and Mineral Industries, University of Utah, 1968



UGMS Map 27, 1969

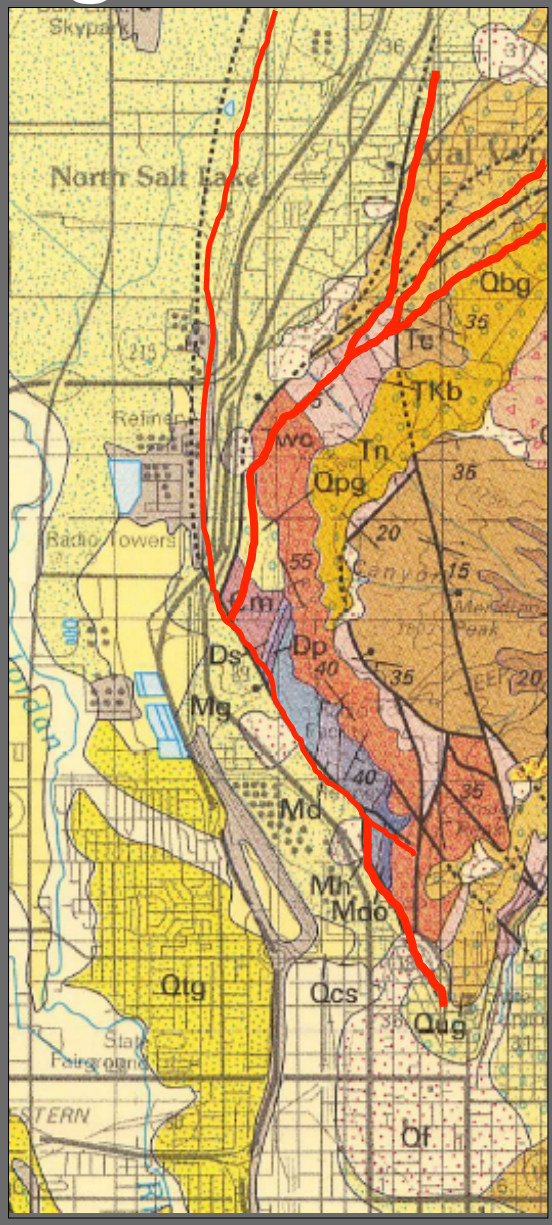
UGMS Map 42, Kaliser, 1976

Evolution of the Warm Springs Fault



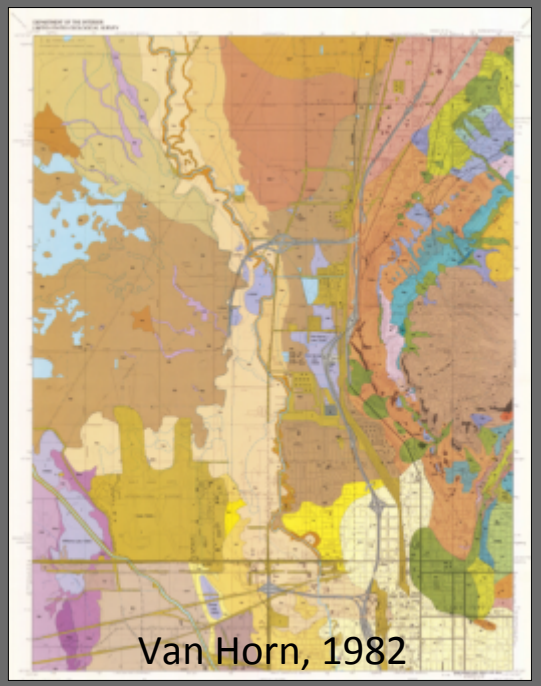
Marsell and Threet, 1960

Miller, 1980



Bryant, 1990

Van Horn, 1981



Van Horn, 1982

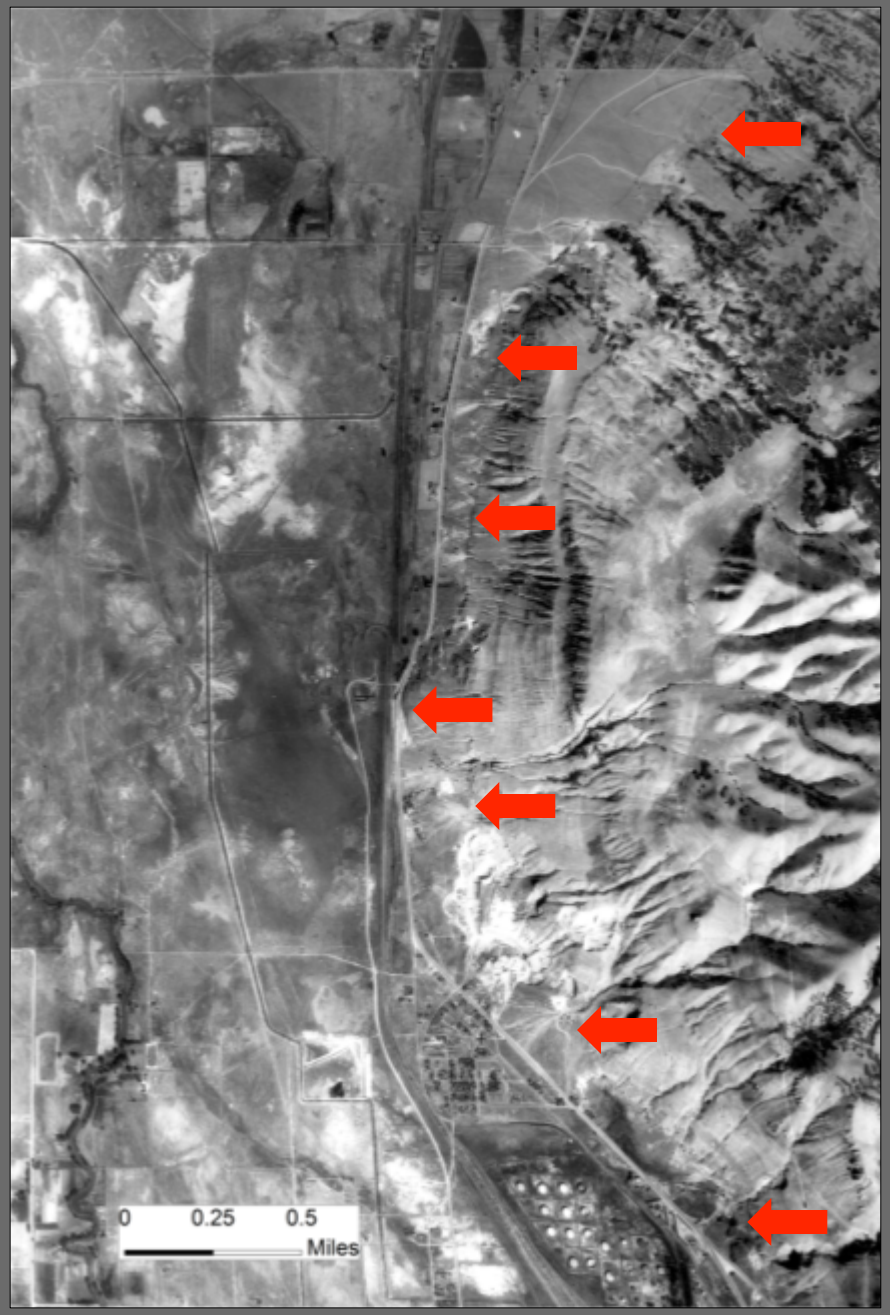
Scott and Shroba, 1985

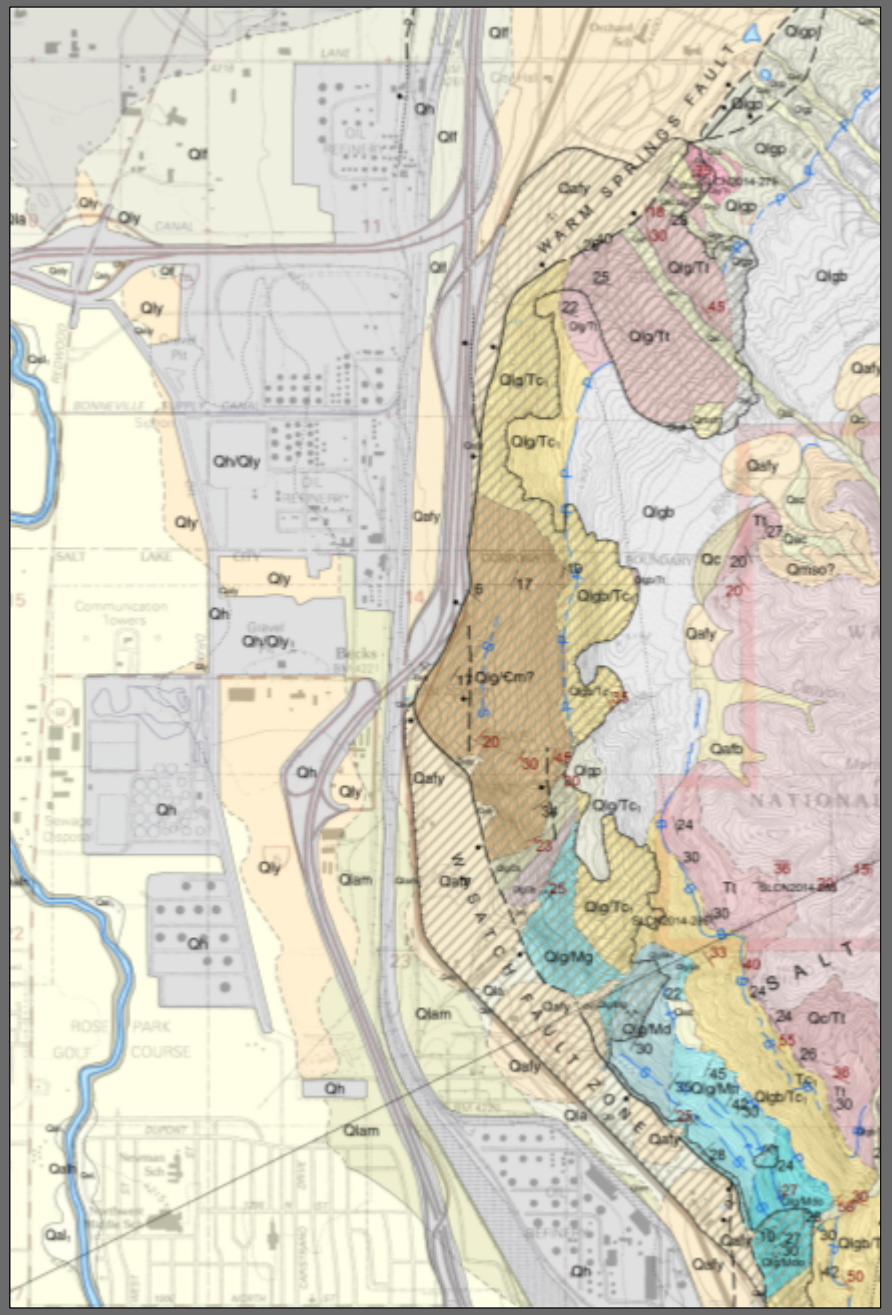
Personius and Scott, 1992

Northern Warm Springs Fault

Central Warm Springs Fault

Southern Warm Springs Fault





1937, USDA aerial photographs


Marsell and Threet, 1960


0
0.25
0.5
Miles


Kaliser, 1976


0
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Van Horn, 1982


0 0.25 0.5
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Scott and Shroba, 1985


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Personius and Scott, 1992


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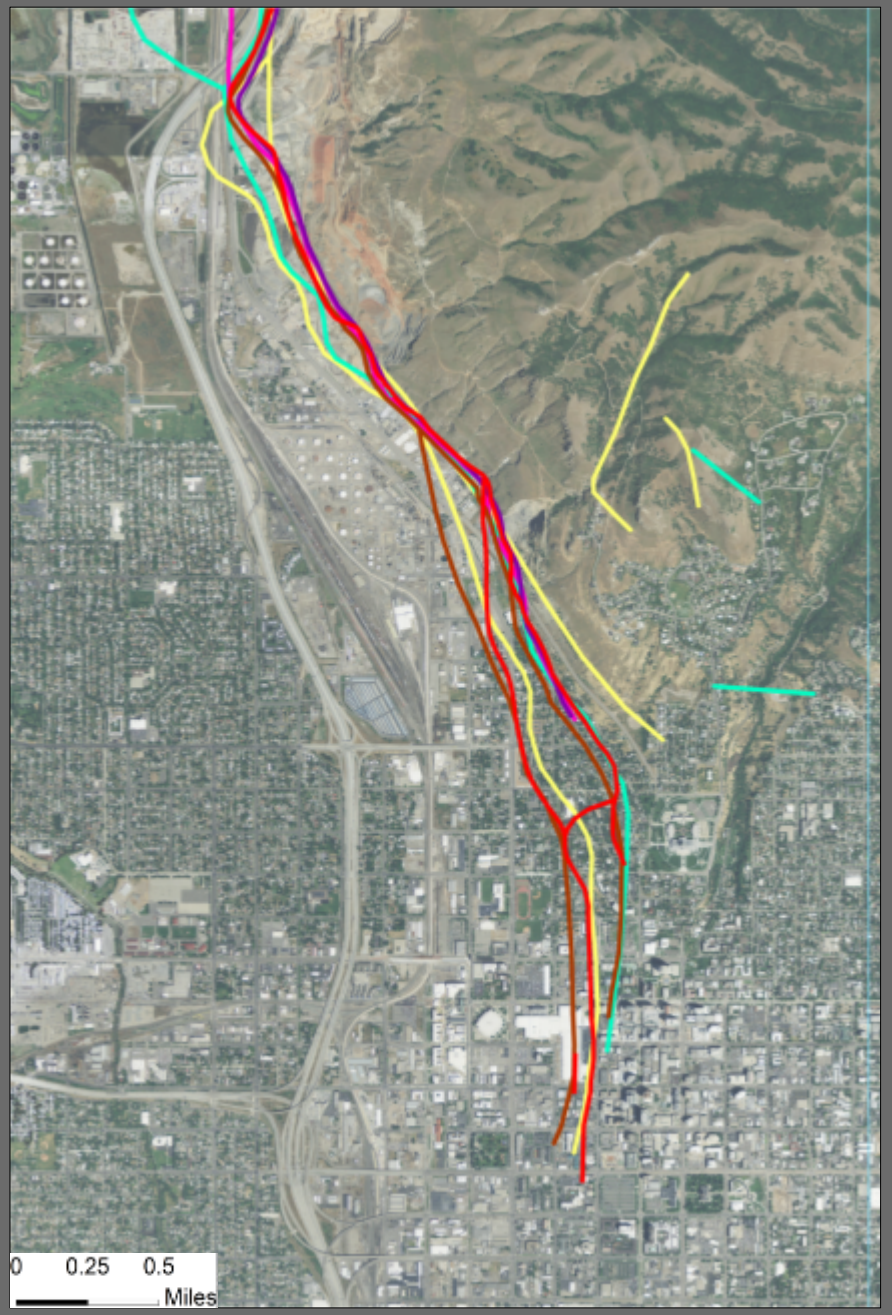
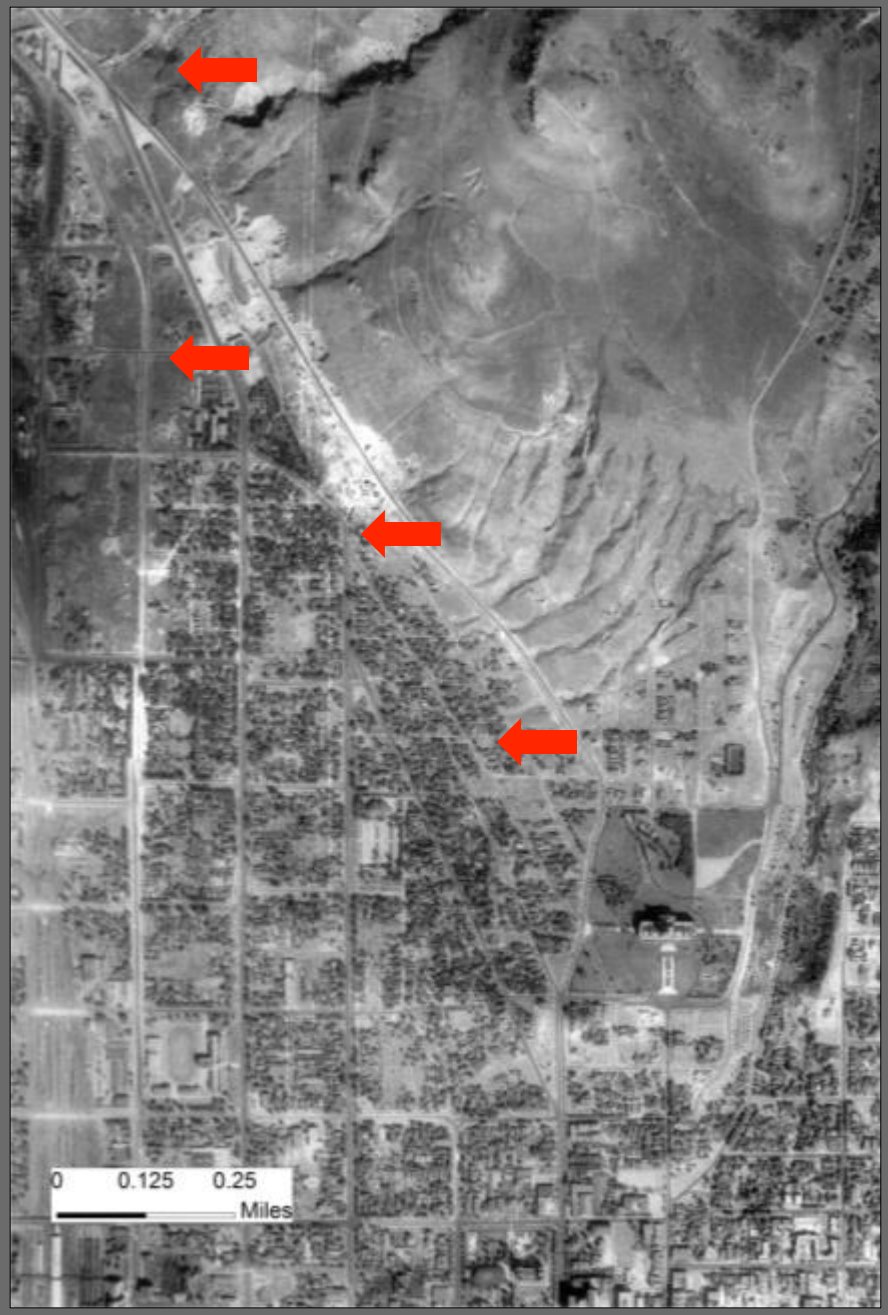
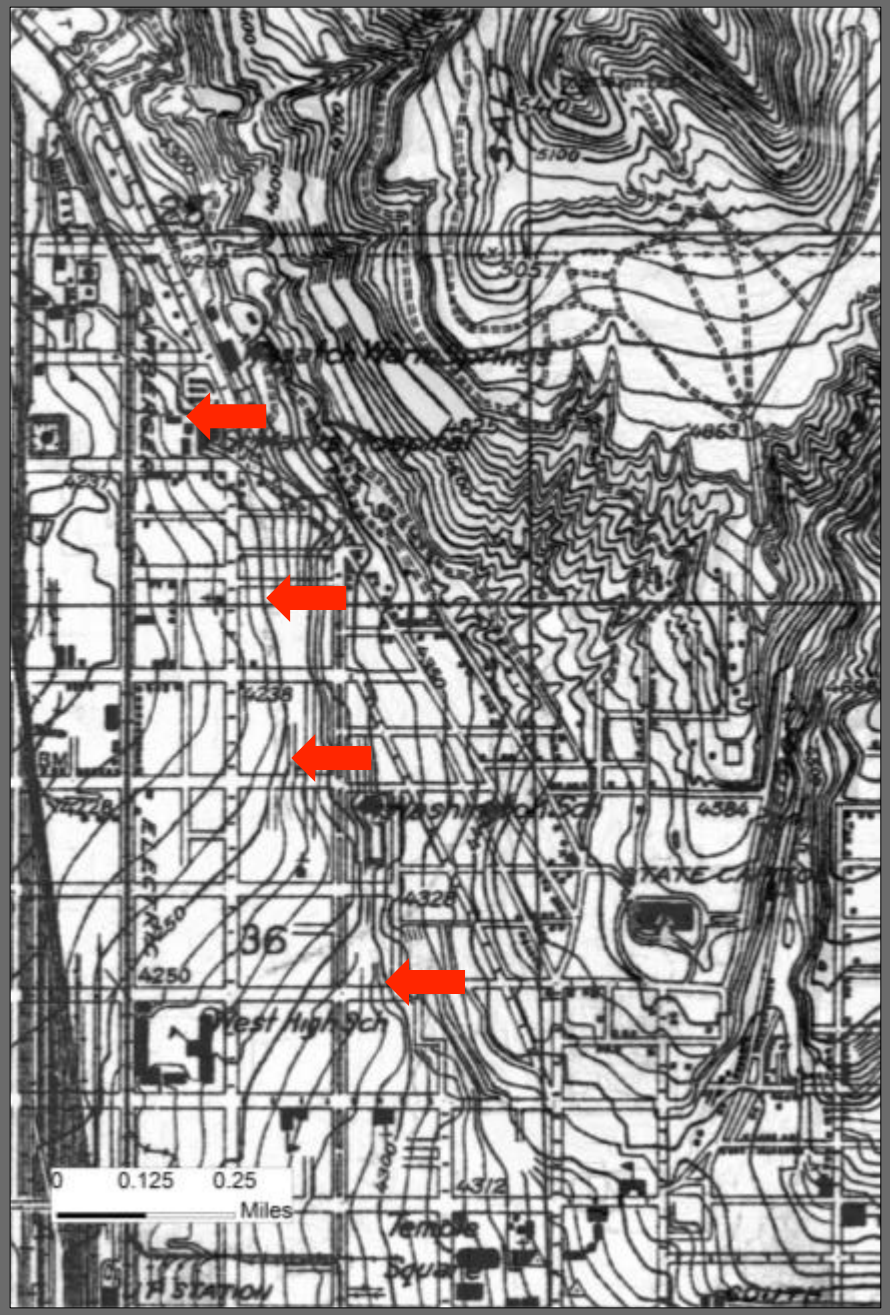
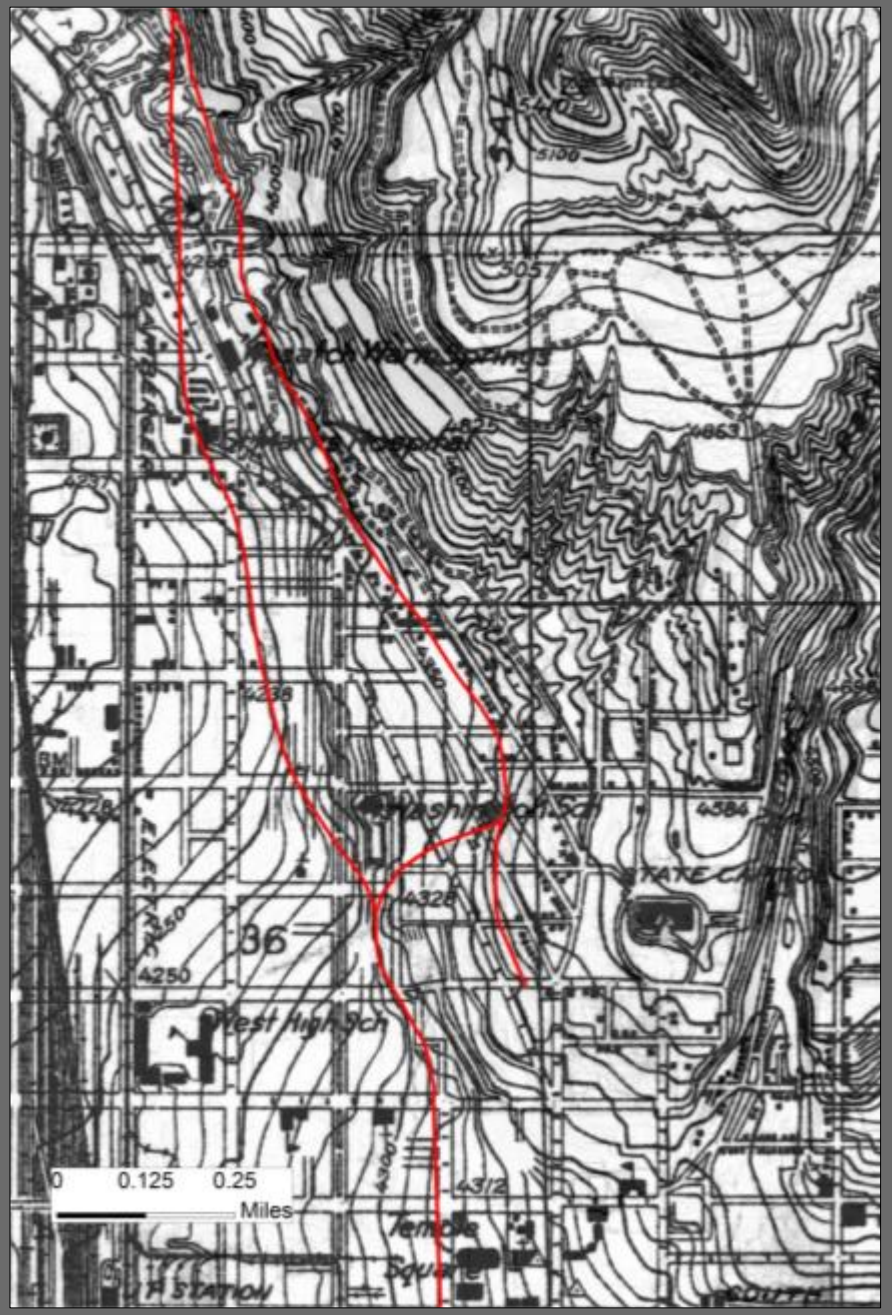

0 0.25 0.5
Miles

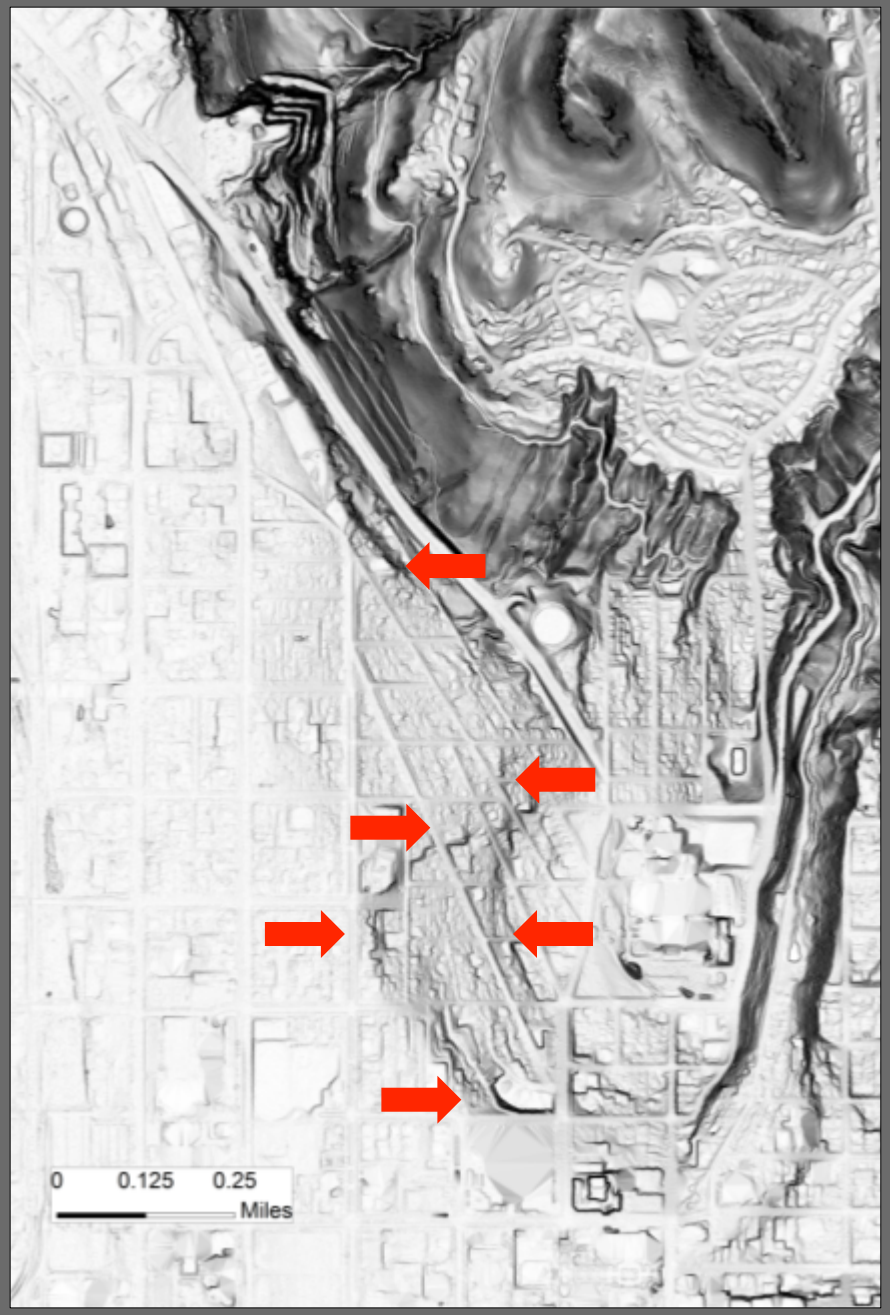


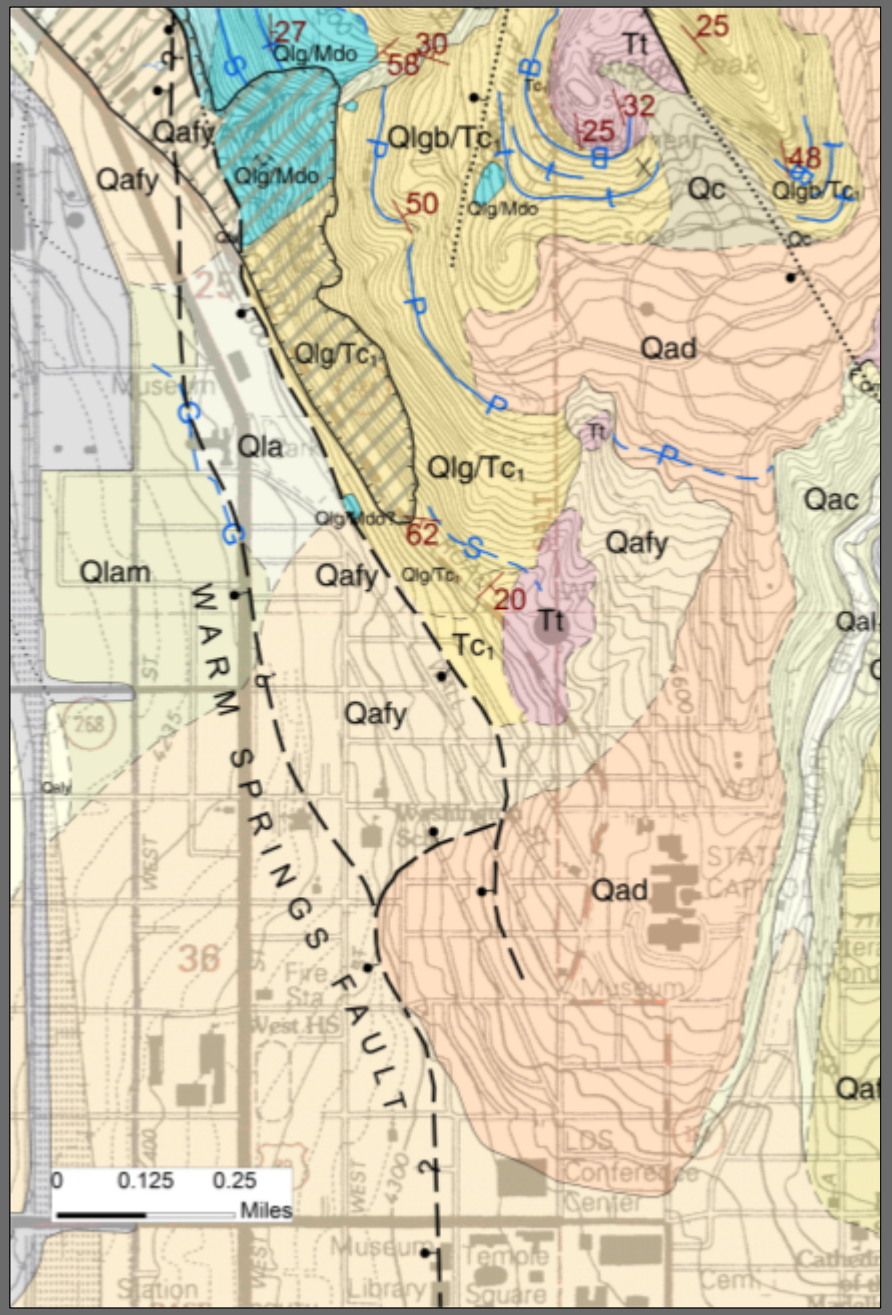
1937, USDA aerial photographs



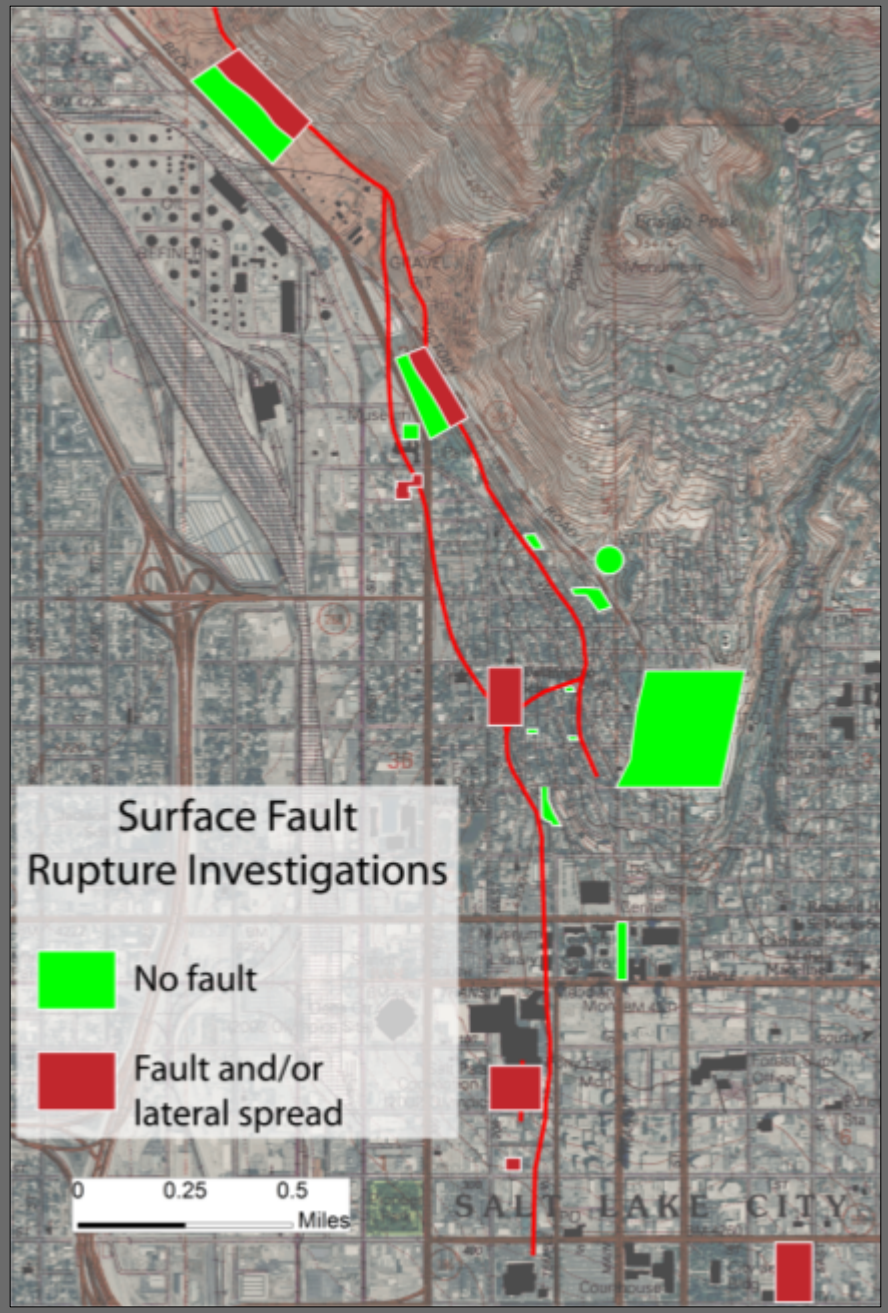


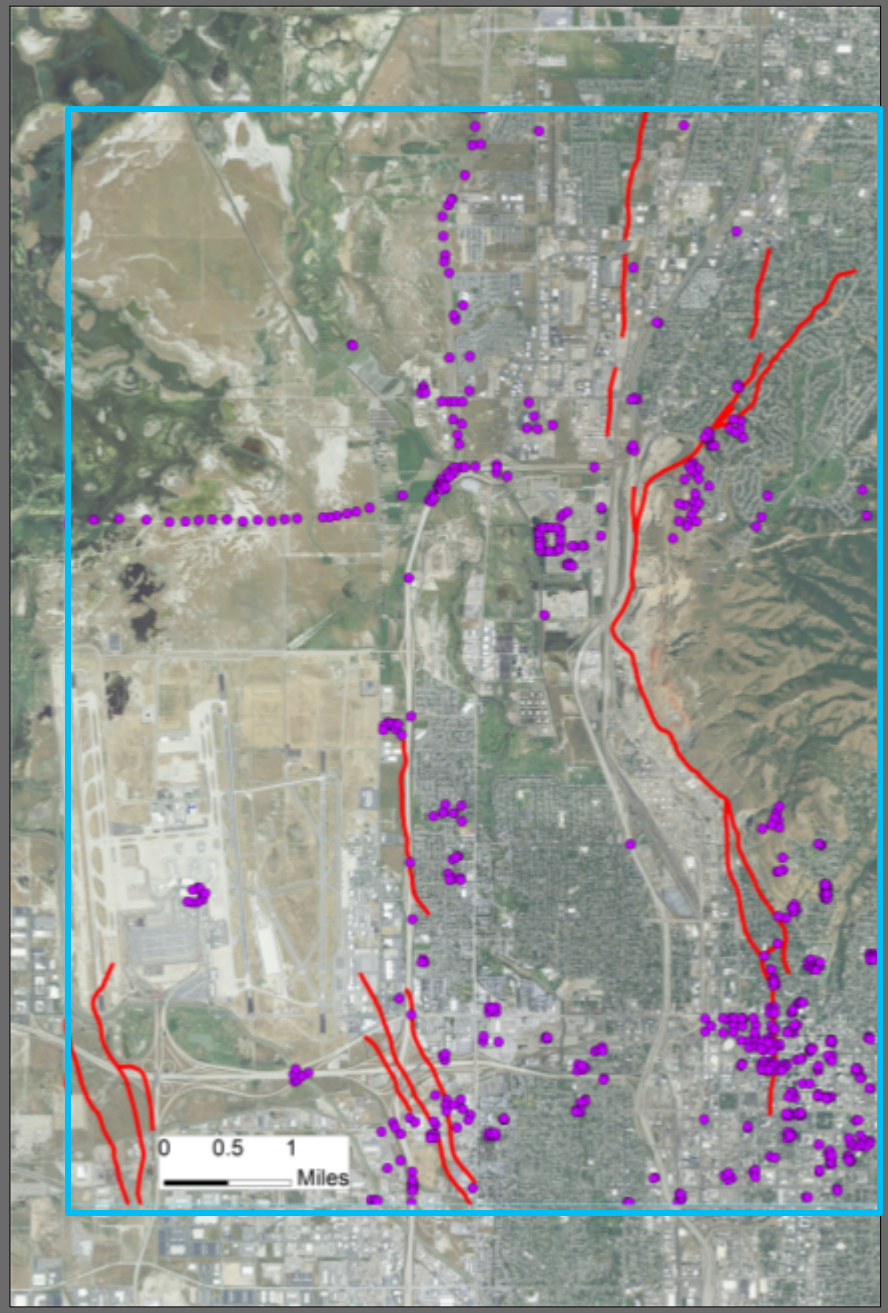
1934 topographic map of Salt Lake City and Vicinity





0.5 m LiDAR, 2014

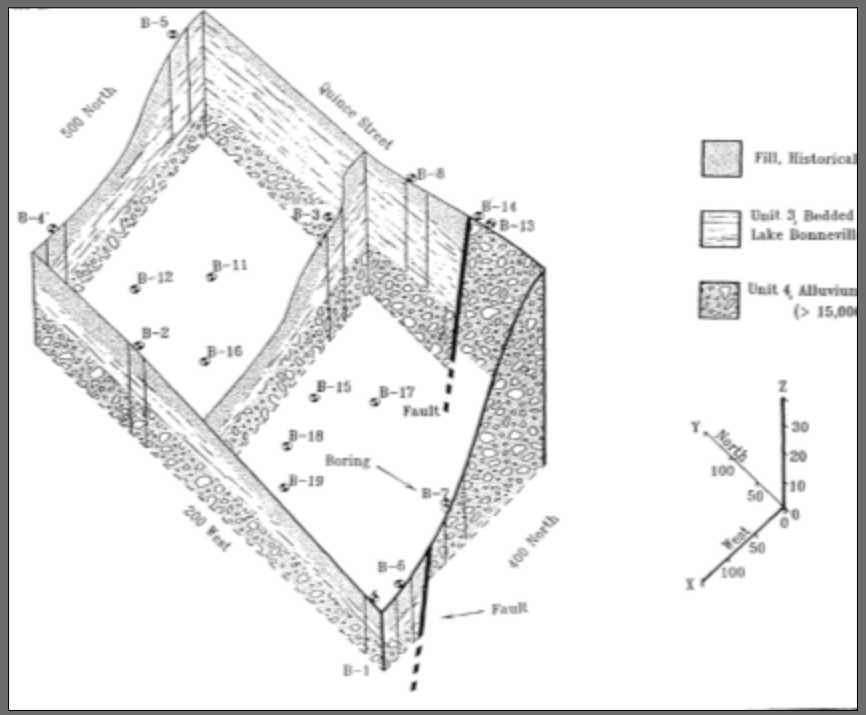

Surface Fault
Rupture Investigations
No fault
Fault and/or
lateral spread
0
0.25
0.5
Miles
SALT LAKE CITY

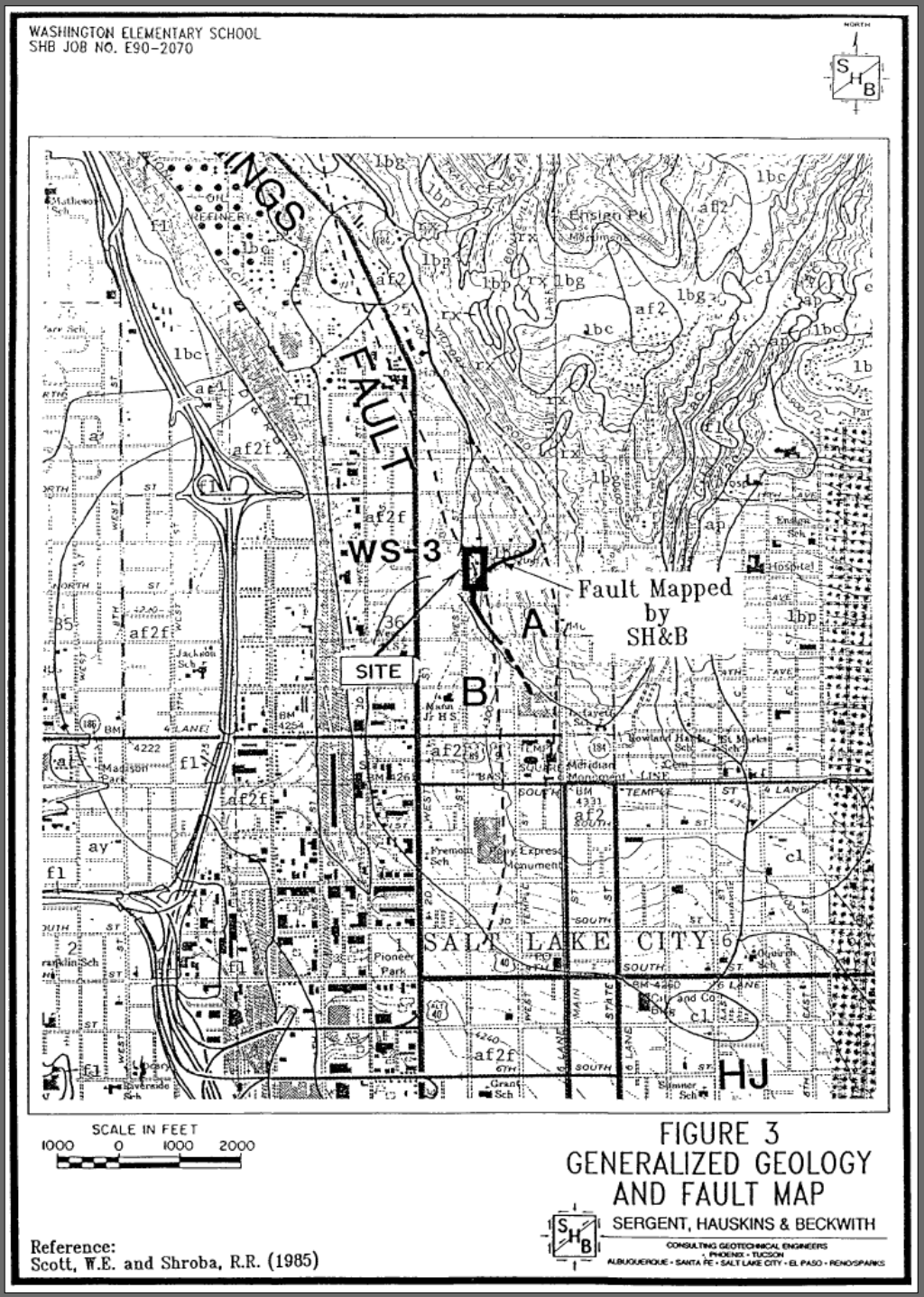

0
0.5
1
Miles

Washington Elementary School

(Sergent, Hauskins & Beckwith, 1991)

- Confirm Warm Springs fault as far south as 400 N. and 200 W.
- Connection between “A” and “B” faults proposed





Salt Palace Convention Center Expansion

Salt Palace Convention Center Expansion

THURSDAY, JAN. 7, 1999

Deseret News

METRO

Fault causes suspension of Salt Palace expansion

Experts don't know if it extends under existing building

ing study, those options could range from abandoning the current Salt Palace expansion construction site to simply building around the fault.

The Salt Palace expansion was expected to be completed in July of 2000.

What is not certain is if the fault extends

The Salt Lake Tribune UTAH Wednesday, February 3, 1999

Consultants Say Salt Palace Faults Are Small, Safe

They recommend resumption of construction project, but county commissioners will wait a week

METRO

Section B

Salt Lake / Davis

FRIDAY, APRIL 16, 1999

BOUNTIFUL • SALT LAKE CITY • MILLCREEK • HOLLADAY-COTTONWOOD • SANDY • MURRAY • WEST VALLEY CITY • TAYLORSVILLE • WEST JORDAN

Fault under site, geologist says

Report on Salt Palace project under dispute

concluded that a tectonic fault runs beneath the site.

In his final report given to the county late last month, David Simon of the geotechnical consulting firm Simon/ By-

tion, a much less serious condition than a fault and one whose consequences can be minimized or eliminated by structural modifications.

At worst, Kleinfelder and

County officials now find themselves in the position of choosing between conflicting opinions. They have chosen the one that will permit construction to go forward.

Simon's response was that rather than "changing his mind," as others have put it, the county asked for his preliminary conclusions and he gave them. He has repeatedly

The Salt Lake Tribune

UTAH

SECTION D

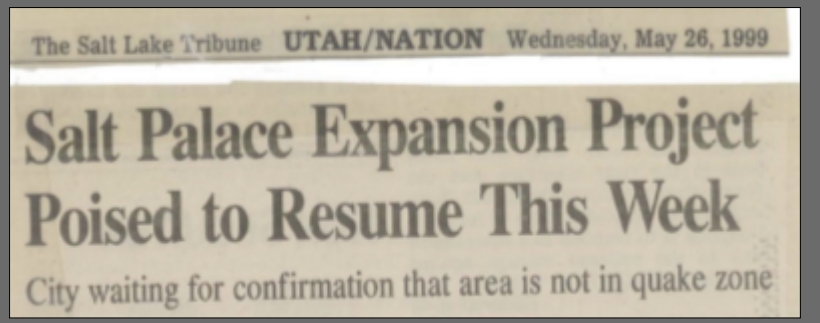
SATURDAY

STATE OF THE STATE, D-4

APRIL 17, 1999

County Blasted on Palace Quake Safety

Expansion will proceed despite consultants' conflicting reports on whether a fault lurks under site



The Salt Lake Tribune UTAH/NATION Wednesday, May 26, 1999

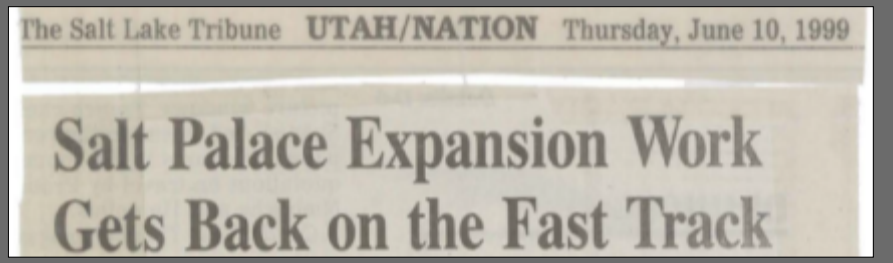
Salt Palace Expansion Project Poised to Resume This Week

City waiting for confirmation that area is not in quake zone

Wednesday, April 21, 1999

Geologists Muzzled On Salt Palace Fault

BY LEE SIEGEL

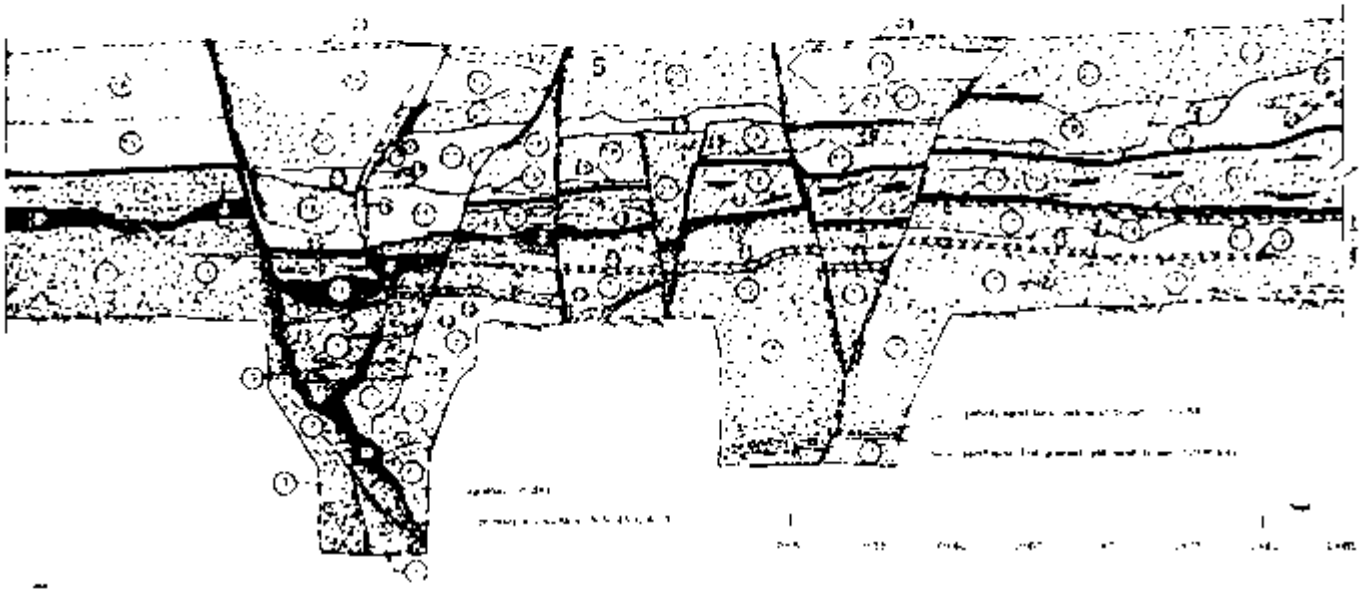


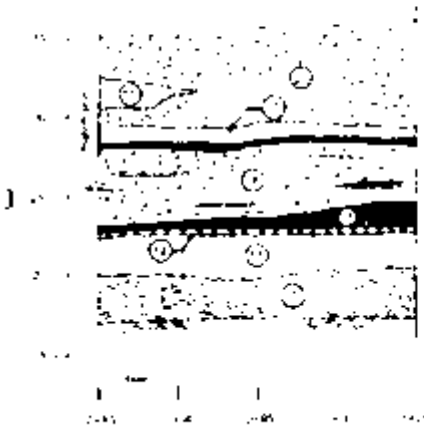
The Salt Lake Tribune UTAH/NATION Thursday, June 10, 1999

Salt Palace Expansion Work Gets Back on the Fast Track

west

east

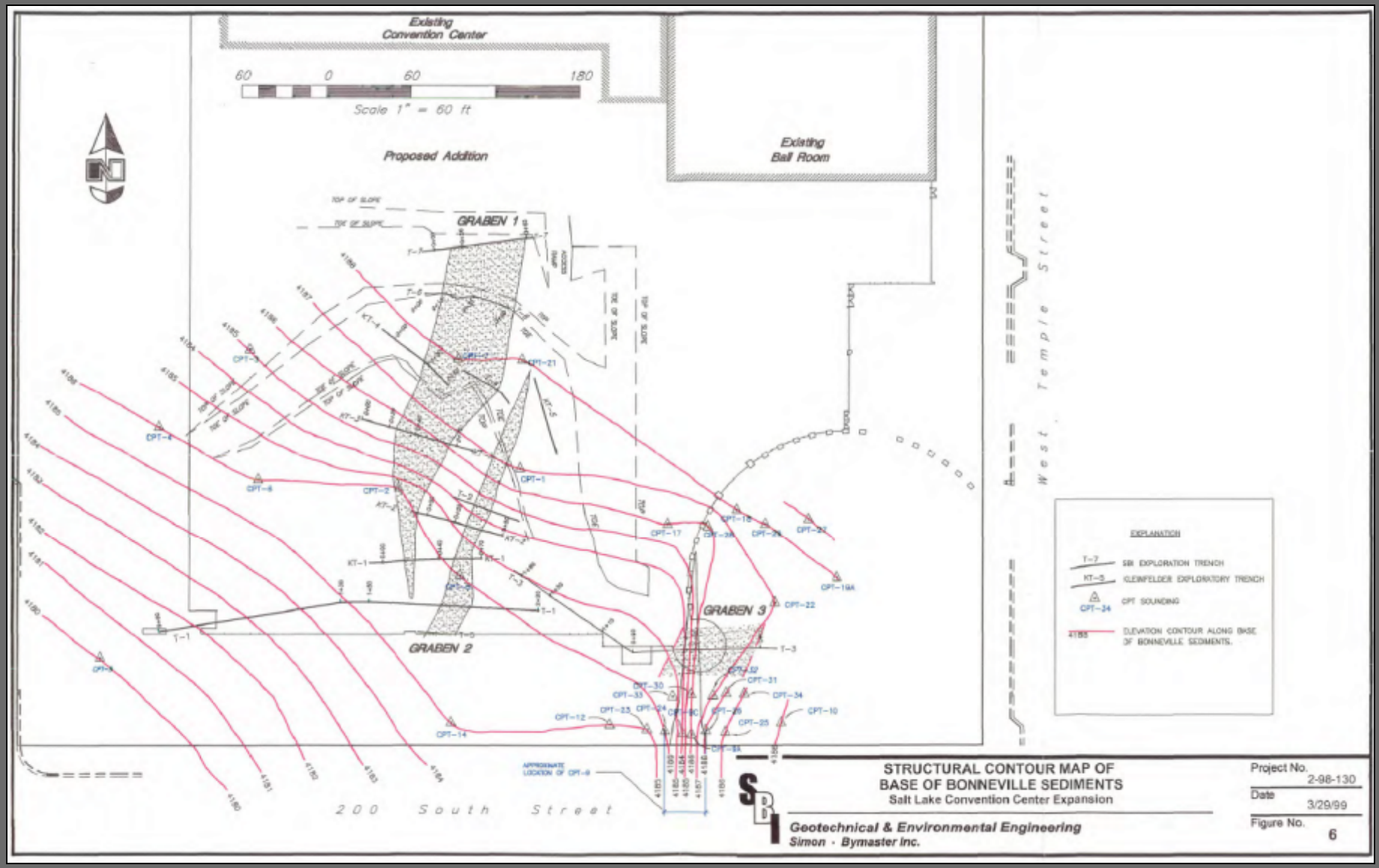




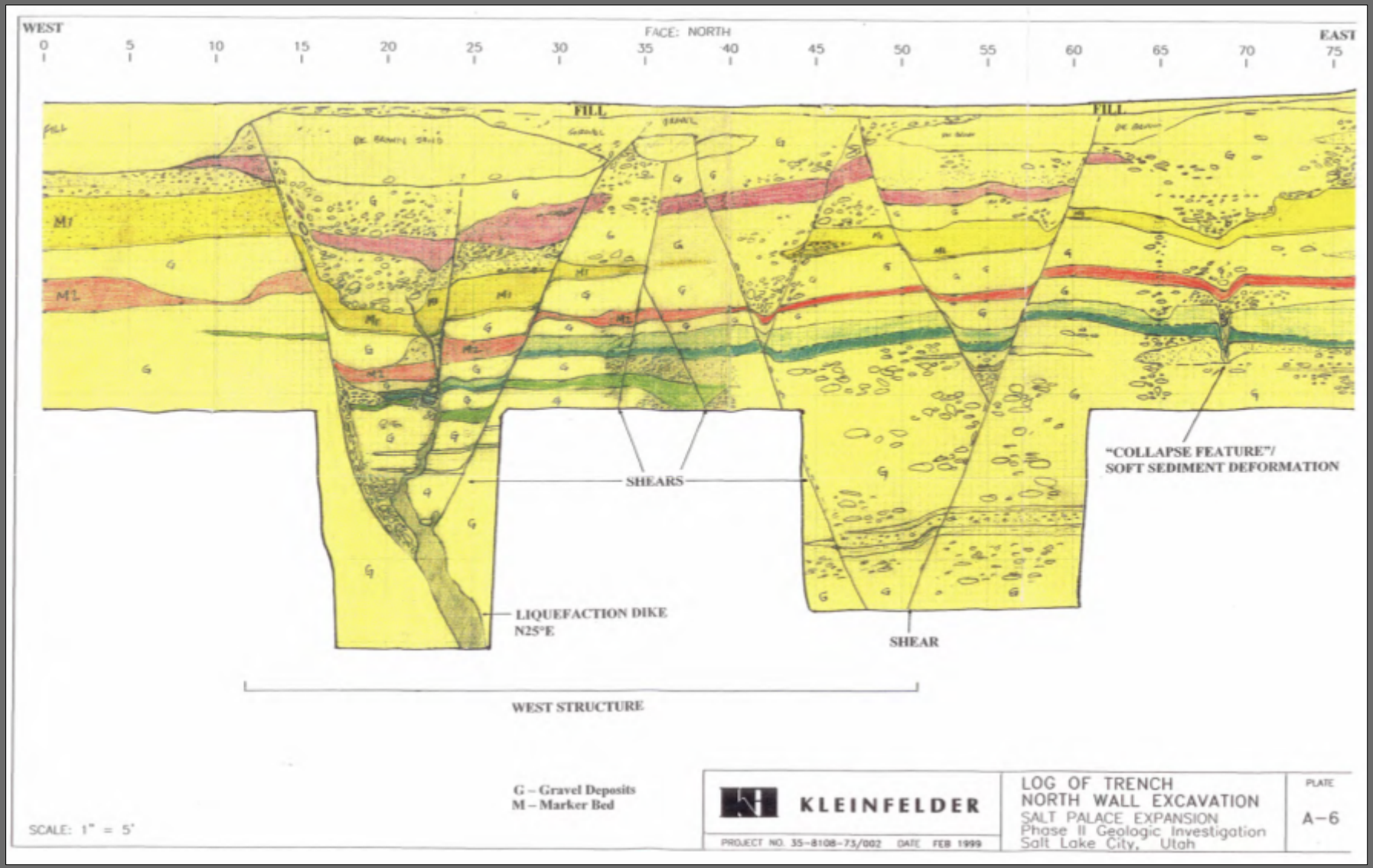
EXPLANATION

TRENCH PROFILE T-6

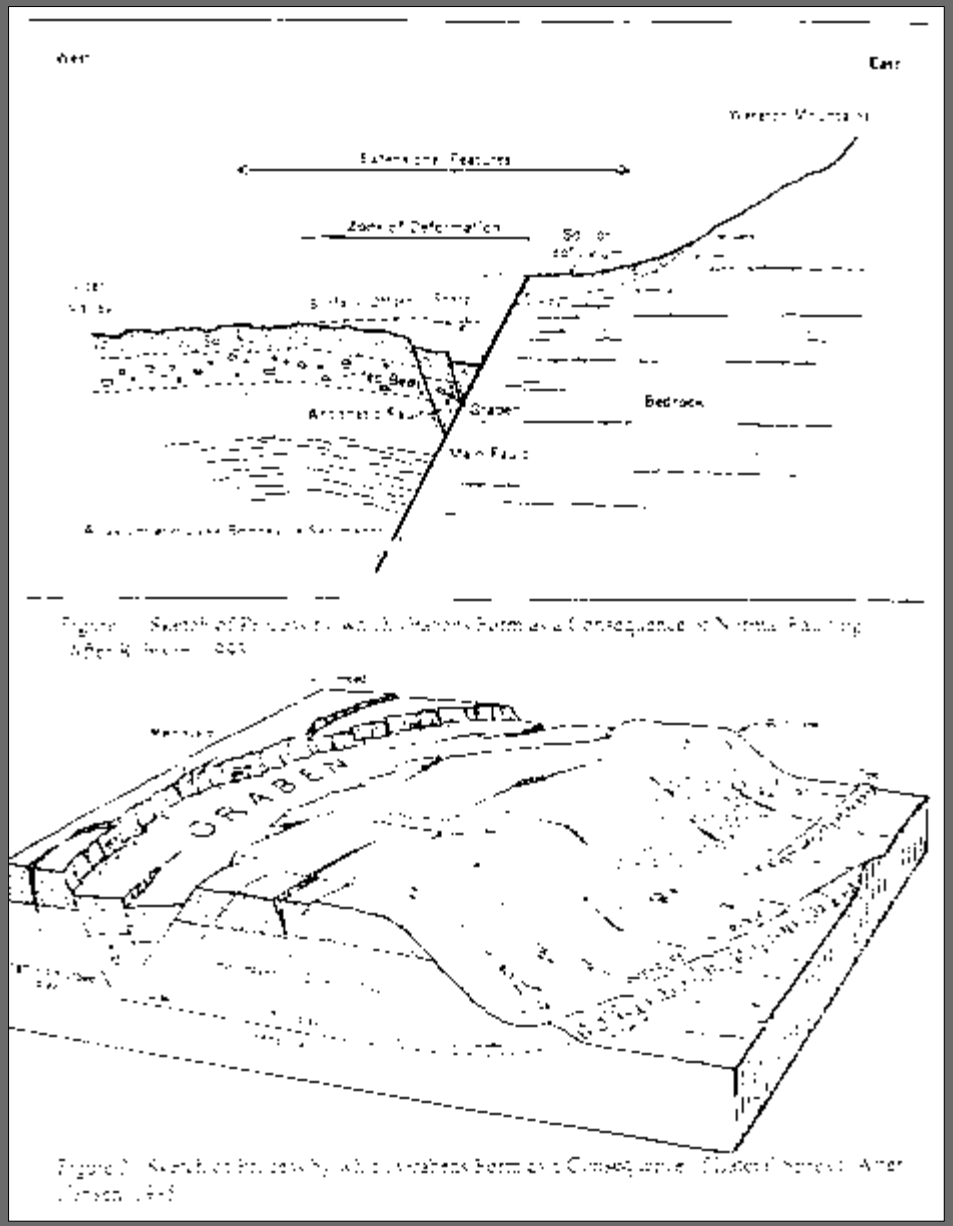
Simon Bymaster, Inc., March 29, 1999

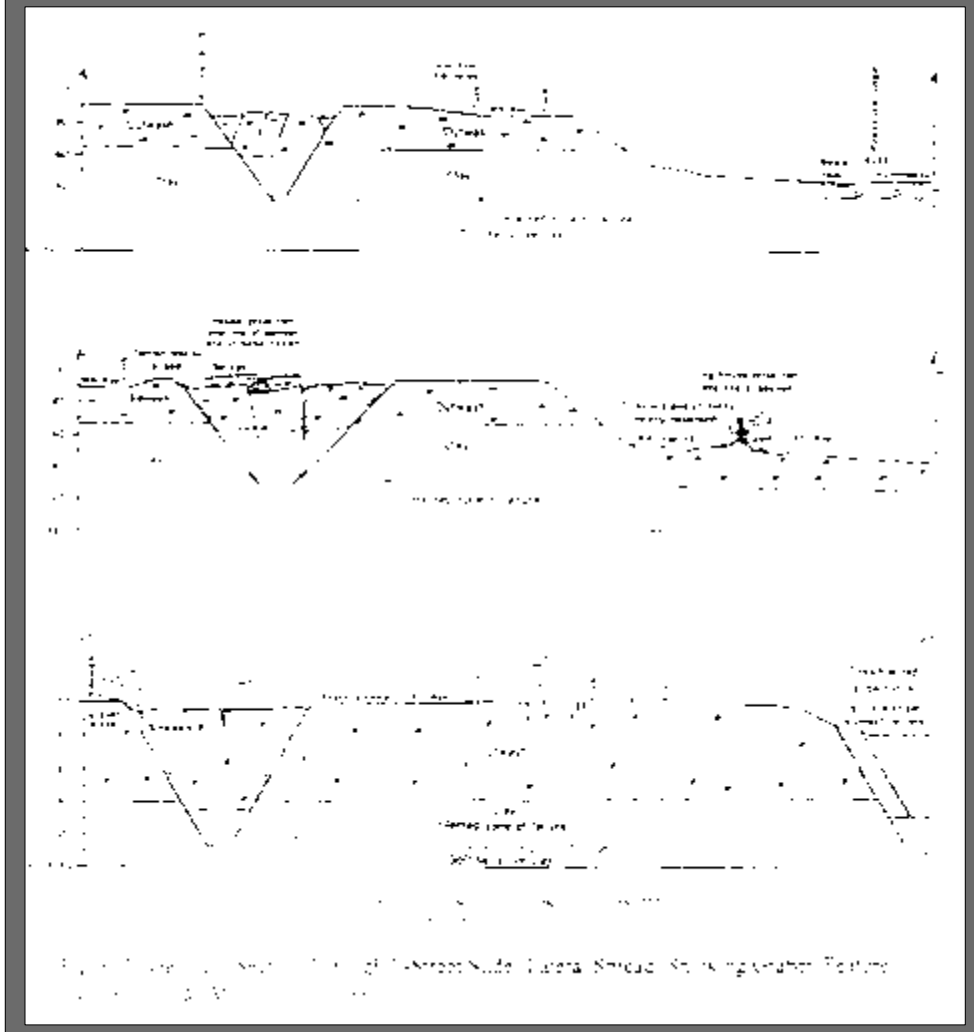


Simon Bymaster, Inc., March 29, 1999



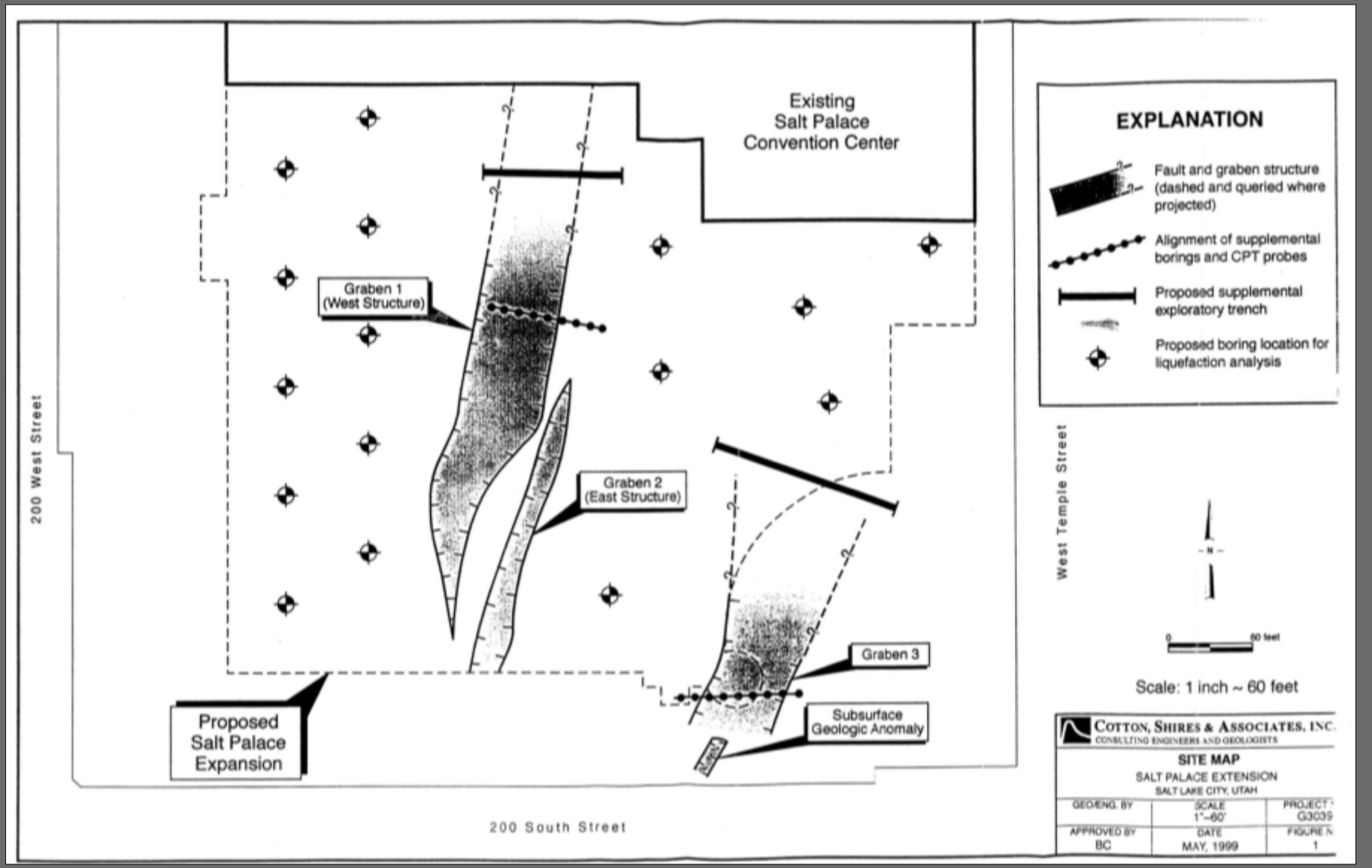
Kleinfelder, Inc. February 26, 1999



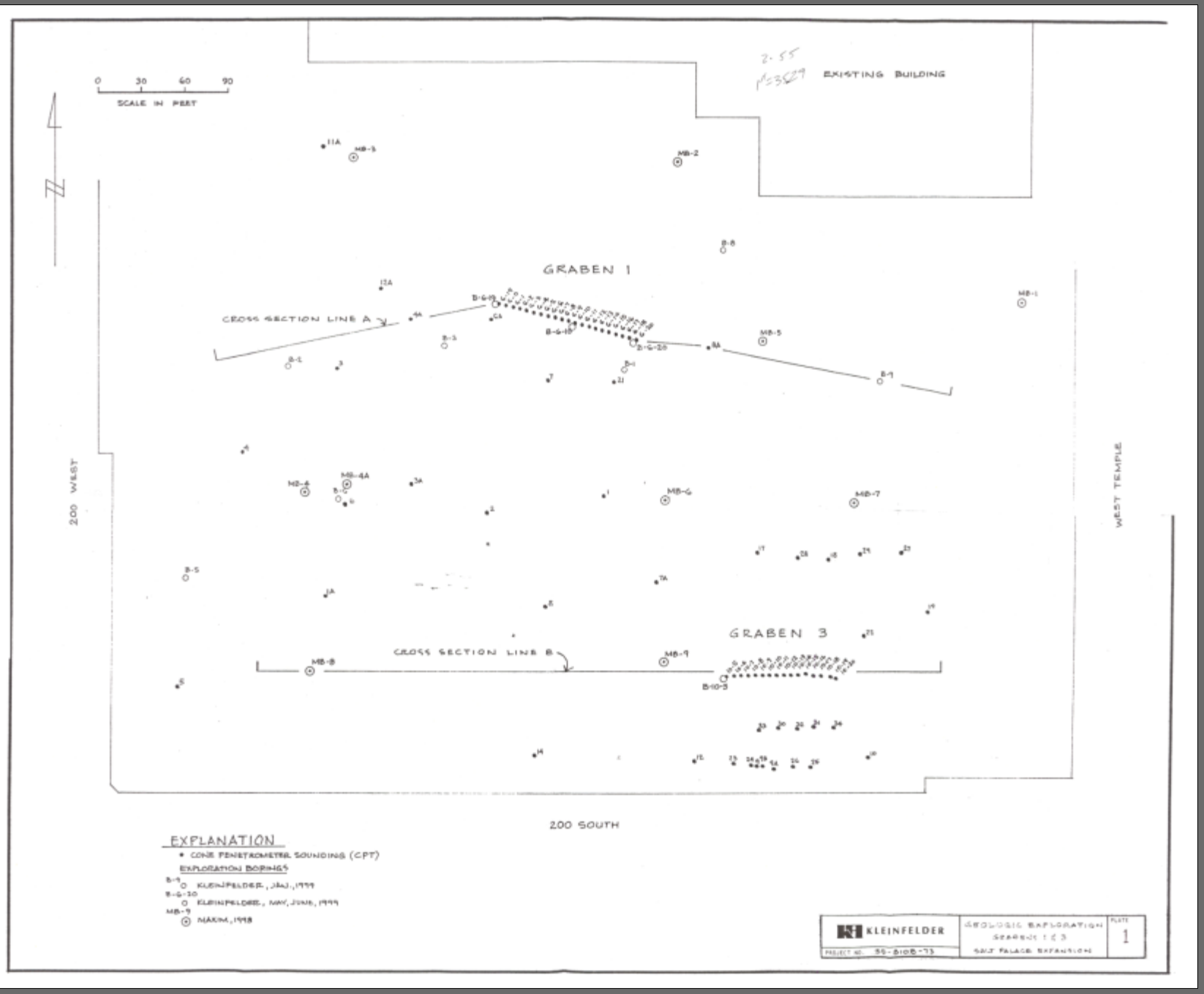


Kleinfelder, Inc. February 26, 1999

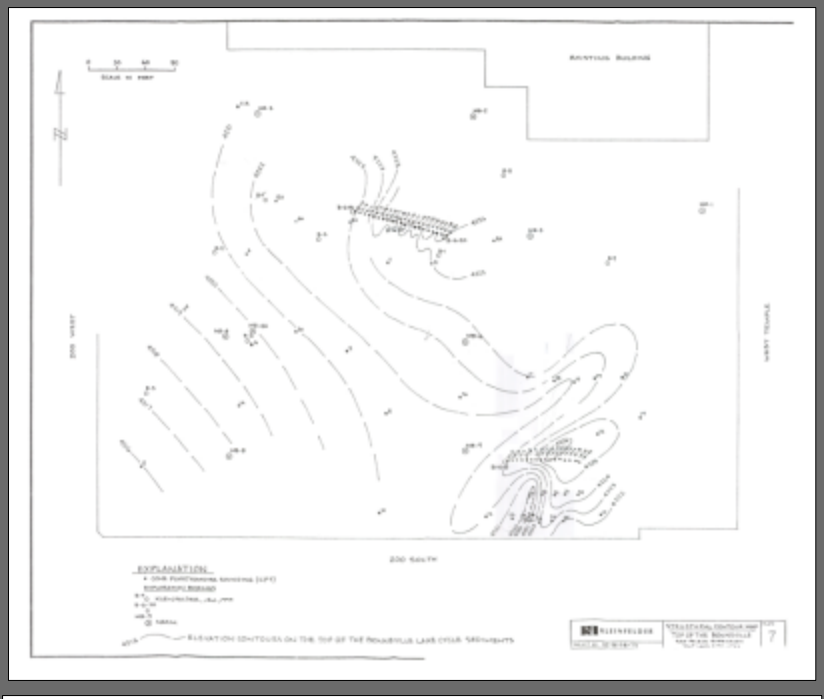
Great Alaska Earthquake, 1964

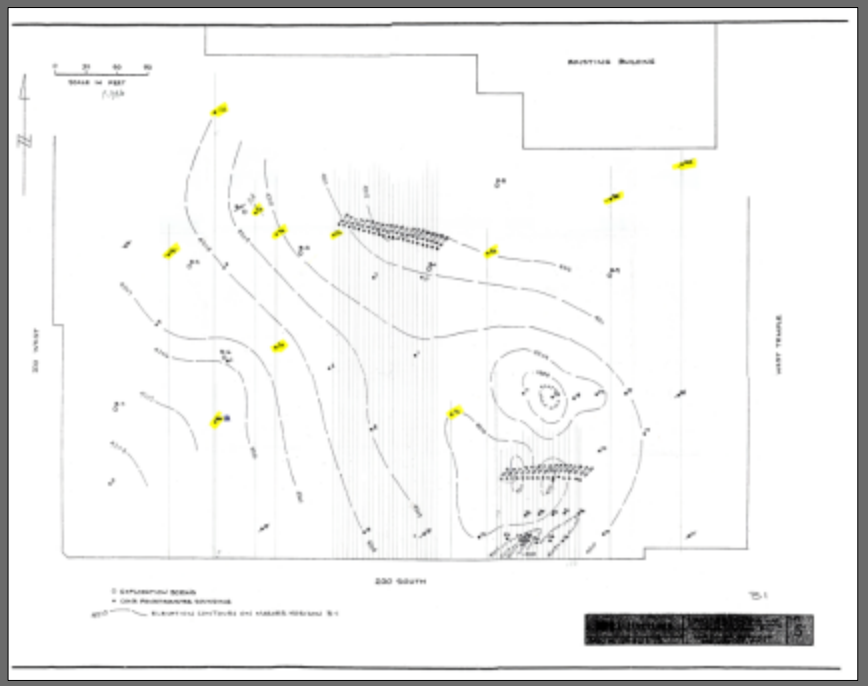


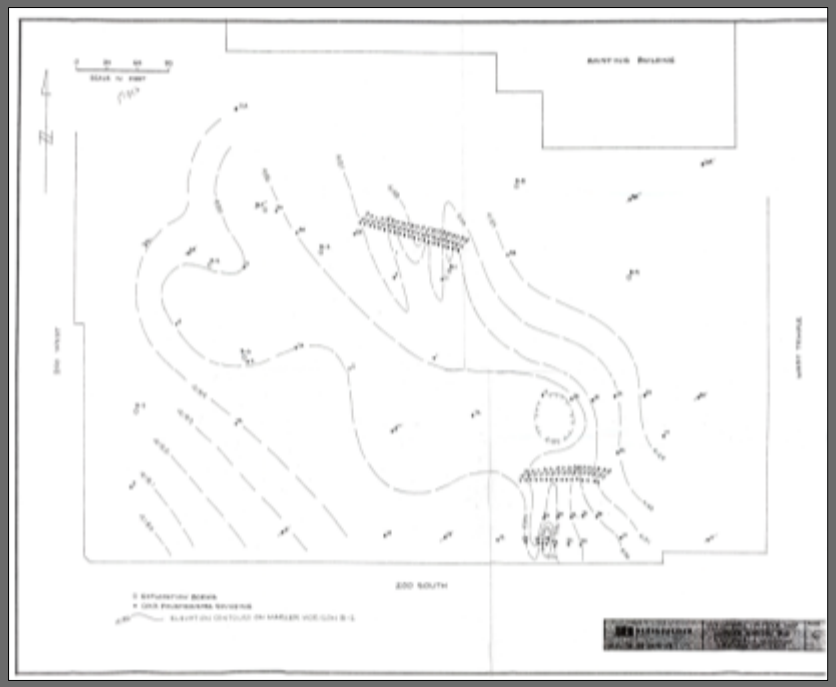
Cotton, Shires & Associates, Inc., July 30, 1999

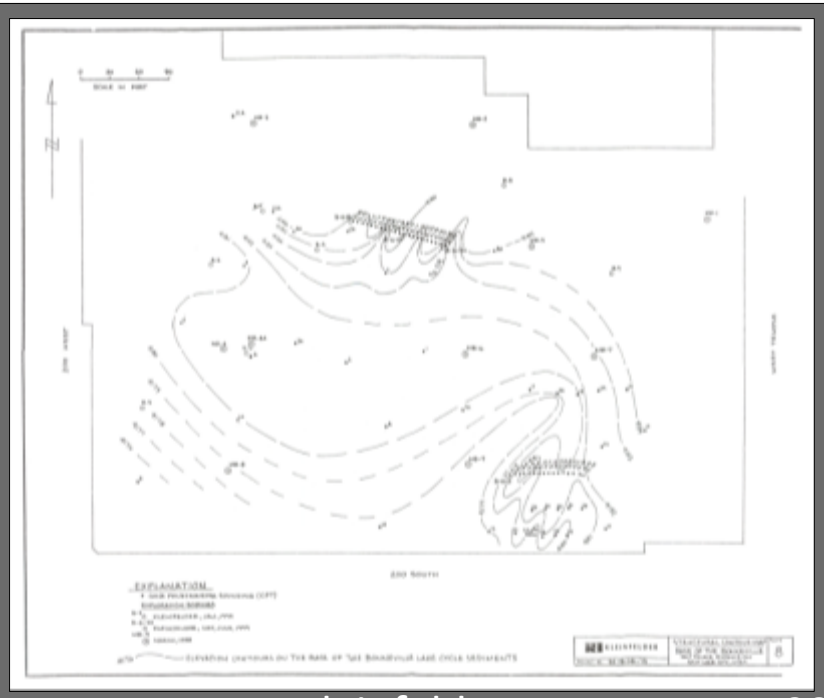


Kleinfelder, Inc. February 26, 1999

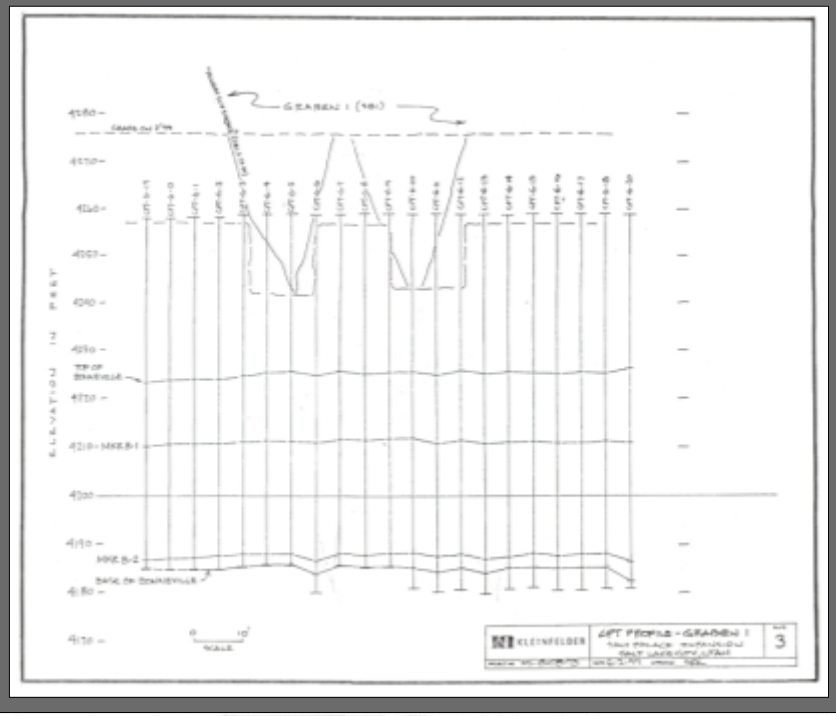


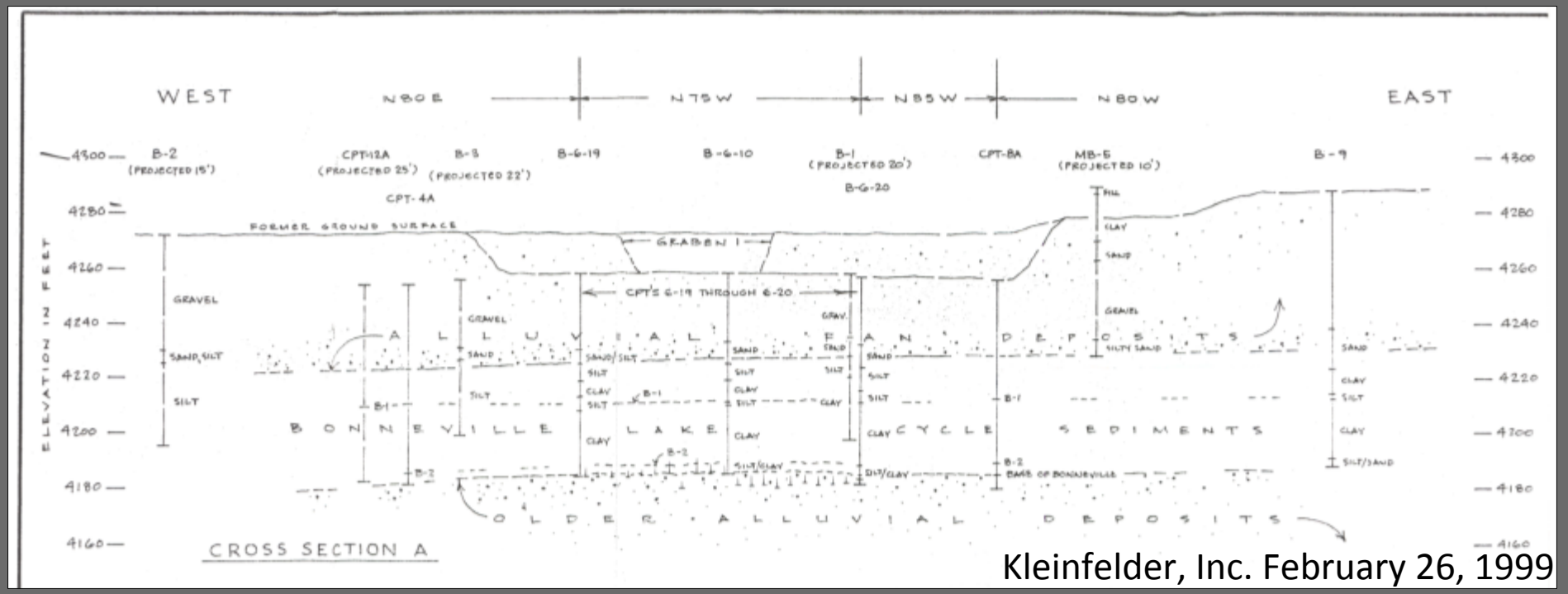






Kleinfelder, Inc. June 5, 1999





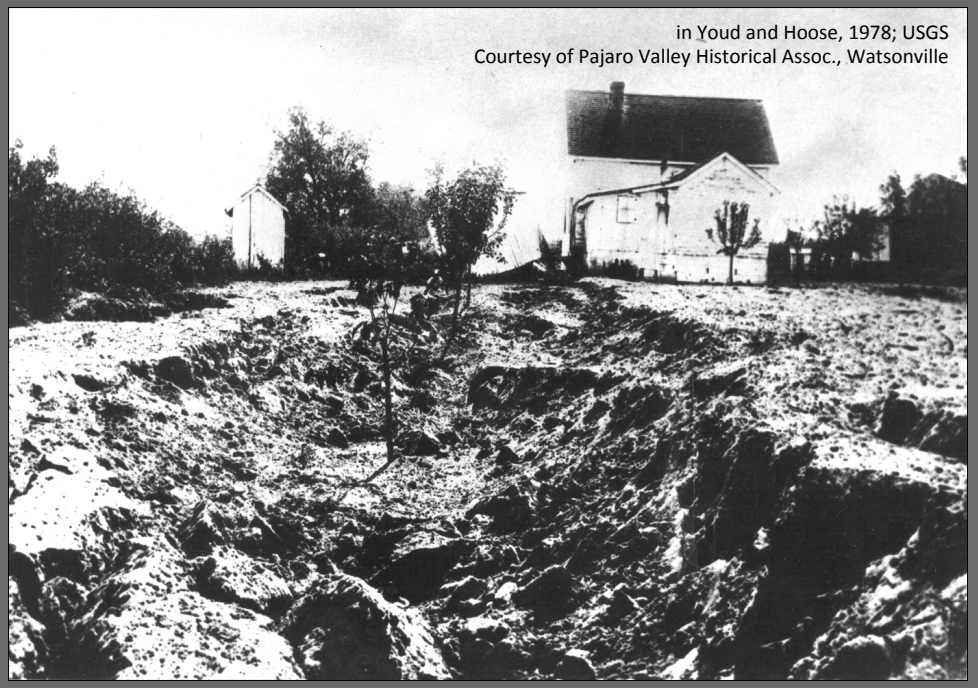
Kleinfelder, Inc. February 26, 1999

The faults at the Salt Palace site are sufficiently well developed in that they were been traced across the site with reliable consistency. They generally trend to the northwest as a series of near parallel faults that form three graben structures. The nearly horizontal sedimentary layers of alluvium that underlie the site were displaced by these faults. In some exposures the offsets approximate five to six feet, while most faulting is generally measured in inches. In our opinion, the characteristics of the fault record did not allow a definitive judgement regarding their origin. It was simply not scientifically possible to determine exclusively from the surface exposures if the faults were the result of active tectonic ground faulting associated with a large magnitude earthquake that passed through the site, or lateral spreading due to strong ground shaking and liquefaction. Both phenomena are capable of producing the same paleoseismic record exhibited in the Salt Palace exposures.

Cotton, Shires & Associates, Inc., July 30, 1999

Borah Peak Earthquake, 1983

Great Alaska Earthquake, 1964



Borah Peak Earthquake, 1983

San Francisco Earthquake, 1906

Summary of Investigation

- Simon Bymaster Inc.
  - Tectonic fault grabens
  - Liquefaction dikes
  - No large west-dipping fault
  - 3 colluvial wedges, on 3 separate faults
  - Vertically aligned (rotated) clasts along faults
  - Base of Bonneville displaced 3 to 9 feet
- Kleinfelder, Inc.
  - Liquefaction-induced lateral spread failures due to two seismic events
  - No large west-dipping fault
  - Lake Bonneville deposits not vertically offset
  - Mitigation for minor liquefaction recommended

Summary of Investigation

CONCLUSION AND RECOMMENDATION

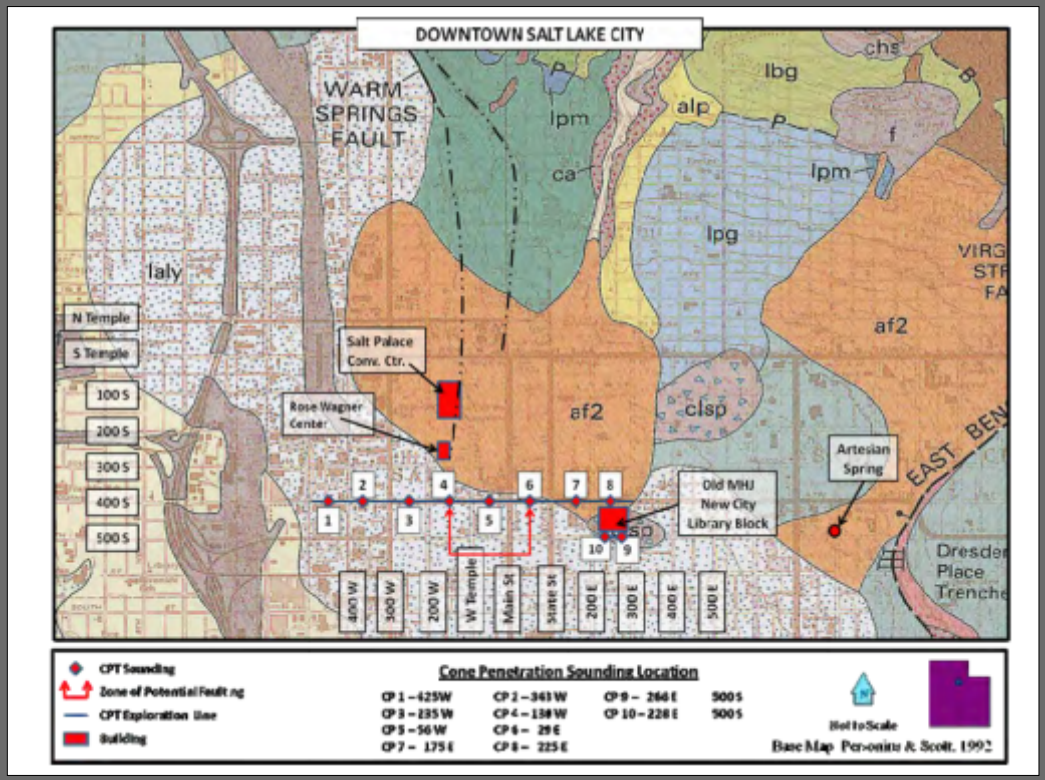
We are convinced that small vertical variations of the marker horizon (B-2) within the Bonneville Formation do exist, but inasmuch as they are significantly less than fault displacements seen in near surface exposures, it is unlikely that the near-surface faults are primarily of tectonic origin. We recognize that not every aspect of the faulted structures seen in the construction excavations can be easily attributed to a single mode of origin. We do find it compelling, however, that the faulting does not extend to the deep subsurface marker bed (B-2) of the Bonneville Formation. Significant faulting of the near-surface alluvial beds, without pronounced vertical offsets in older underlying geology, makes the non-tectonic origin more reasonable. Furthermore, we believe that analysis of the potentially liquefiable sediments by Dr. Youd is of sufficient scope to justify the conclusion that if defensive measures are taken to accommodate minor lateral spread and ground settlement at the Salt Palace site, adequate safety can be achieved.

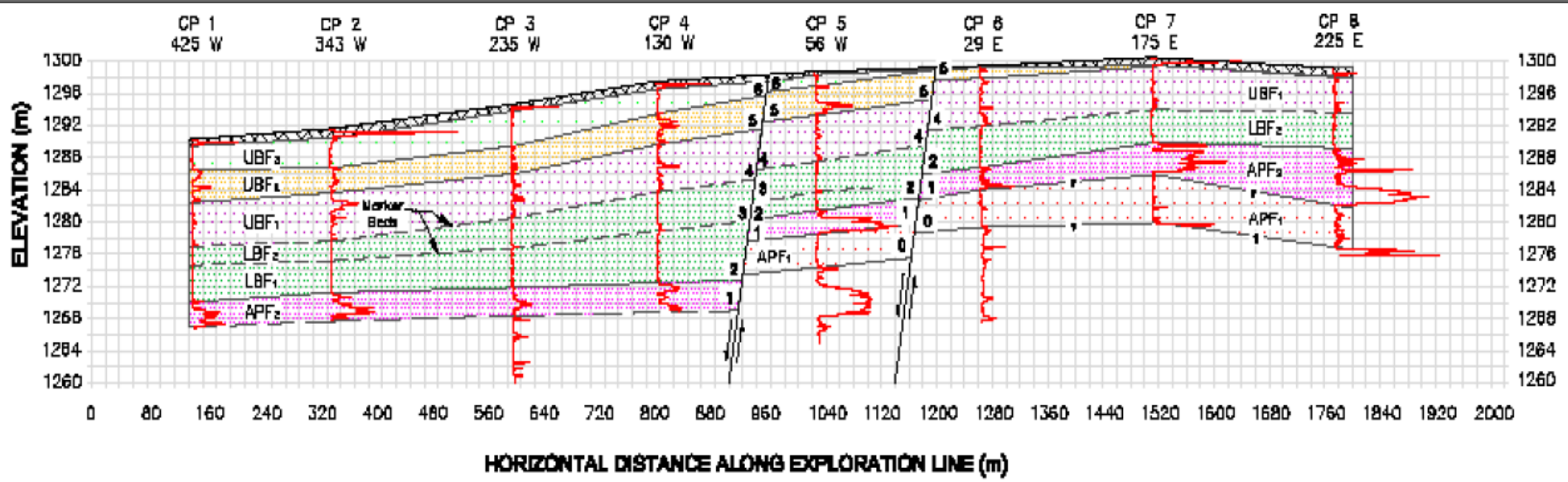
In light of our current understanding of the potential level of risk at this site to lateral spread and ground movement, we are concerned about the structural integrity of the existing Salt Palace Convention Center. In our opinion, the risk is high that ground settlement and spreading of "a few inches" could adversely impact the existing structure. We recommend that the project geotechnical and structural engineering consultants review this concern and provide the City with a report outlining their findings and recommendations.

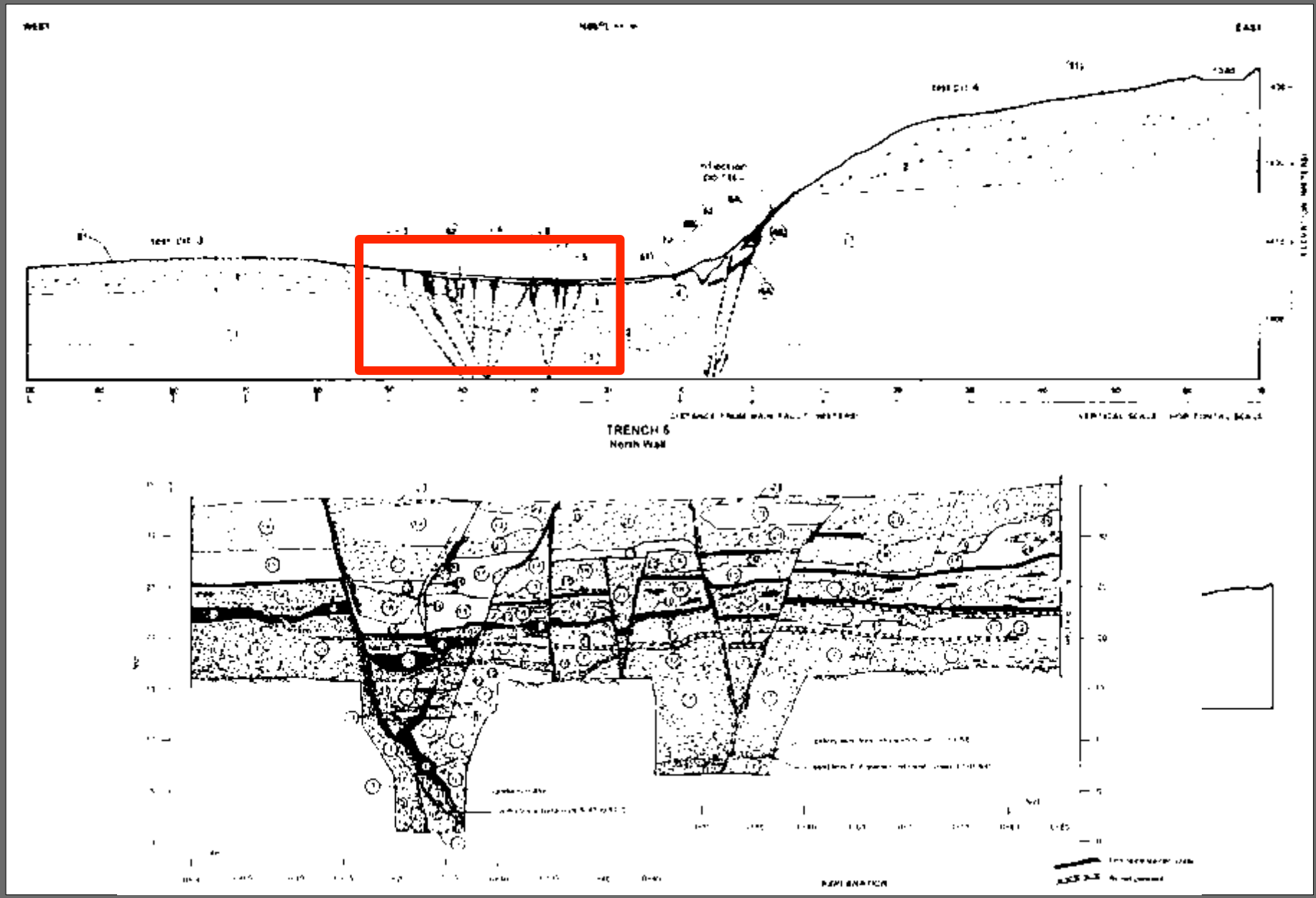
Cotton, Shires & Associates, Inc., July 30, 1999

Leeflang, 2008

- Found evidence for tectonic faulting
- CPT between 130 and 56 West shows approximately 8.7 meters (28.5 ft) of vertical offset of late Pleistocene lacustrine and alluvial deposits
- Even with about 240 meter (~780 ft) spacing, their interpreted vertical offset is significant

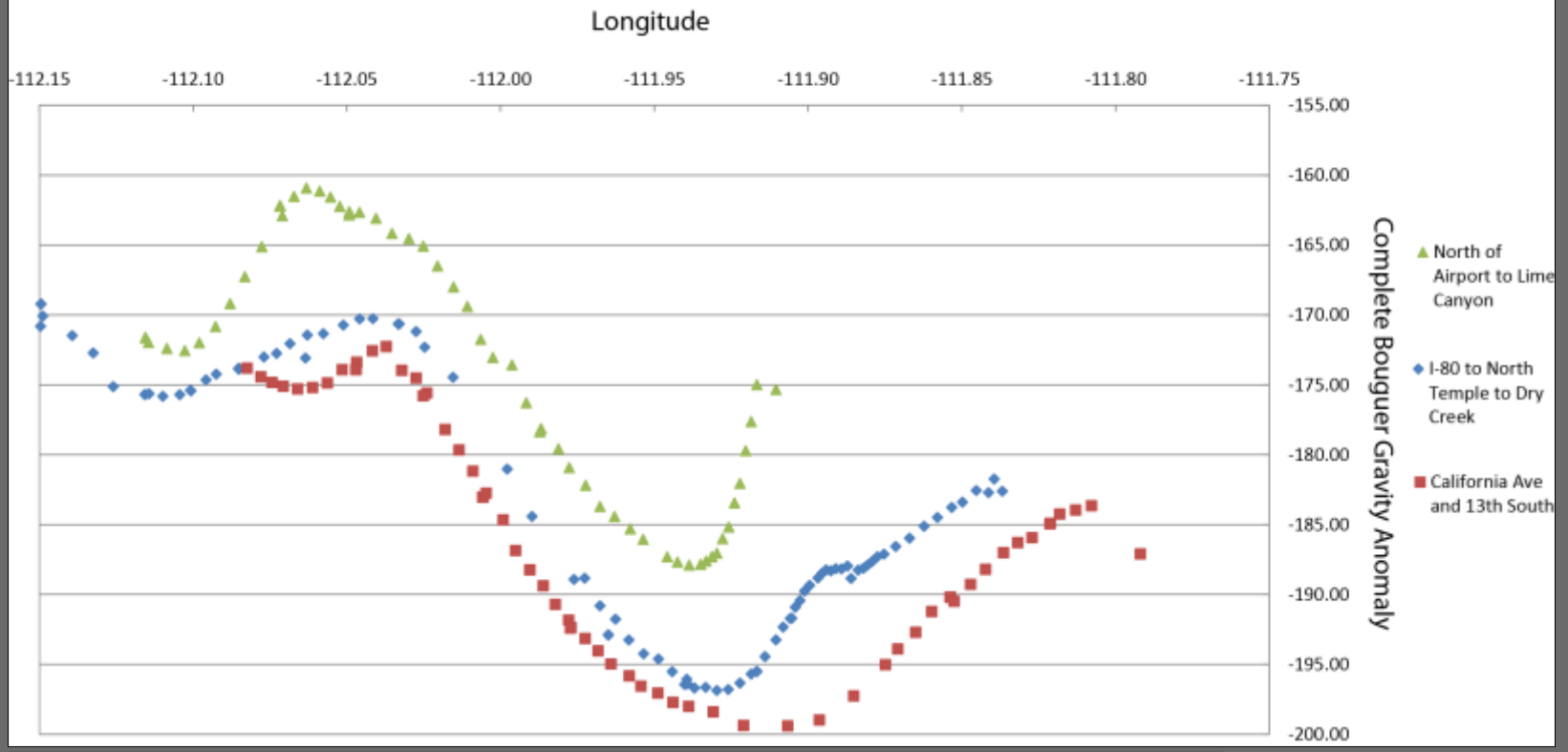


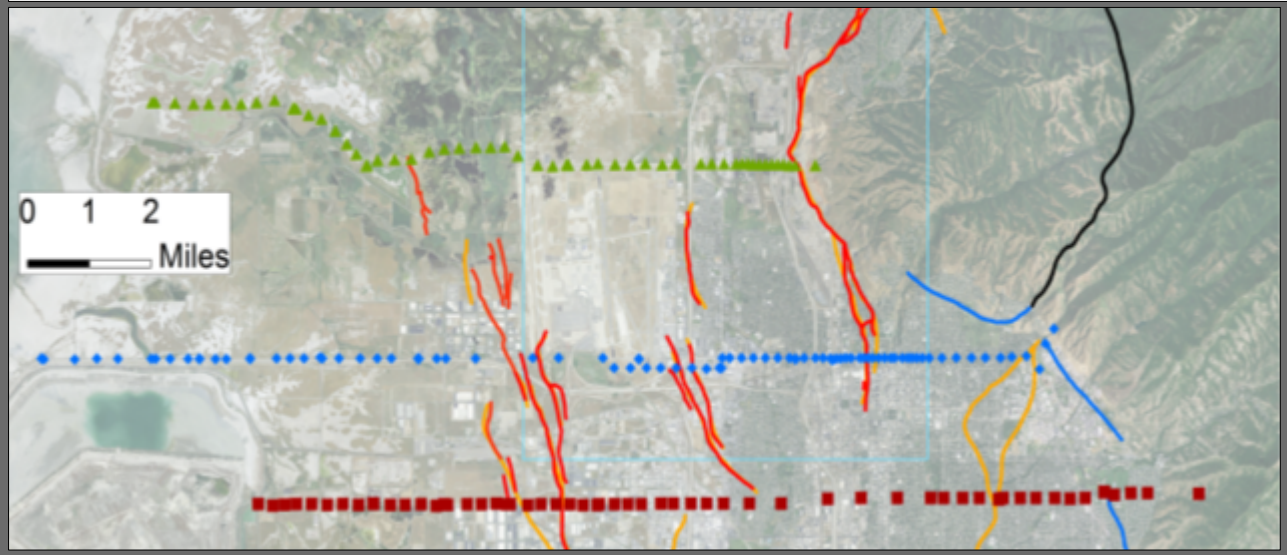




Swan and others, 1979

Gravity Profiles of the Salt Lake Valley Graben





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SUNDAY/DECEMBI

Vanishing Fault

Salt Lake County's 1989 geologic-hazards map showed possible paths of the Wasatch fault in downtown Salt Lake City. But downtown sections of the fault vanished from the 1997 version of the map, even though geologists say the fault probably extends at least to North Temple. Even before the fault disappeared, special studies to look for the fault were not done as required on some new buildings.

1989 Map

NORTH

Special Study Area
Known Fault
Suspected Fault

(Some buildings below did not exist in 1989.)

1997 Map

NORTH

Special Study Area
Known Fault

Black Hawk

Victory Rd

State Capitol

700 N.

Washington School

300 N.
200 N.

Assembly Bldg. site

Temple Square

Salt Palace

Performing Arts Center

Gateway West

N. Temple
S. Temple
100 S.
200 S.
300 S.
400 S.
500 S.
600 S.

Jordan River

400 W.
300 W.
200 W.
W. Temple
Main St.
State St.

Source: Salt Lake County

Steve Baker / The Salt Lake Tribune

WHERE'S THE FAULT?

New Map Omits Potential Hazard

BY LEE SIEGEL

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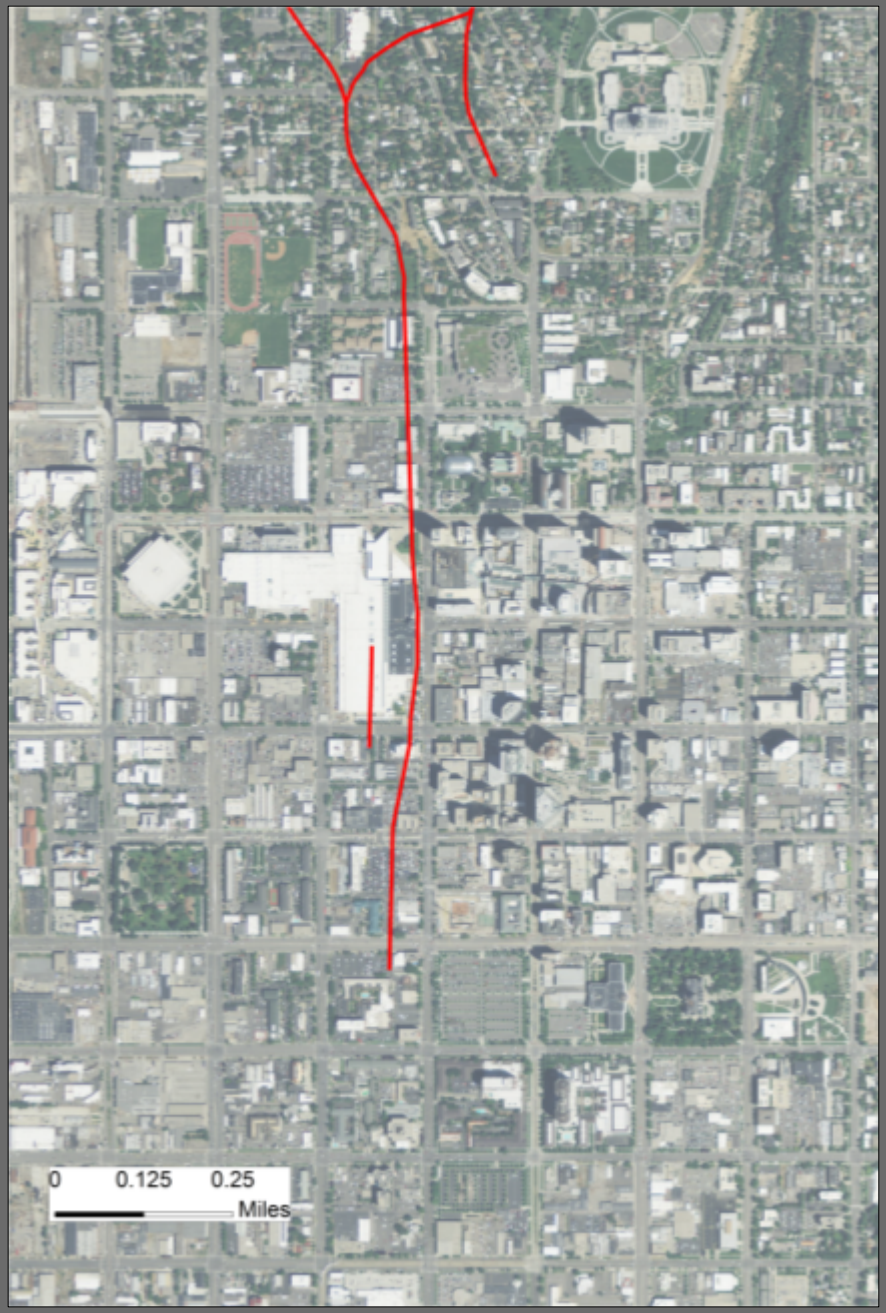
When a building sits directly on a fault line, a major earthquake not only will shake it, but also literally can rip the structure apart. Salt Lake City

struction began on those three projects.

"That's irresponsible," said engineering geologist Bruce Kaliser, a former Utah Geological Survey official. "These geotechnical professionals must know a horse comes before the cart. Professionals can get

"To be, or not to be- that is the question"

- Two types of conservative fault mapping
  - To include the fault
  - Or to not including the fault
- The answer lies in the data
  - The available data suggest continuing the western fault trace to at least 400 South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Seismic imaging of faults beneath Salt Lake City

Lee Liberty, BSU

- Funding provided by US Geological Survey National Earthquake Hazards Reduction Program (NEHRP)
- Characterize the Wasatch fault system through downtown Salt Lake City
- Field work planned for June 2015
- Seismic land streamer setup
- Collaborators include: Jim Pechmann (UofU), UGS, Bob Carey (DHS)

Images from Lee Liberty, BSU

Figure 2. Proposed seismic profiles in north Salt Lake City will cross known and inferred locations of the Warm Springs fault. We propose to operate from west to east along West Girard, 500 North and 300 North and complete all profiles in one day.

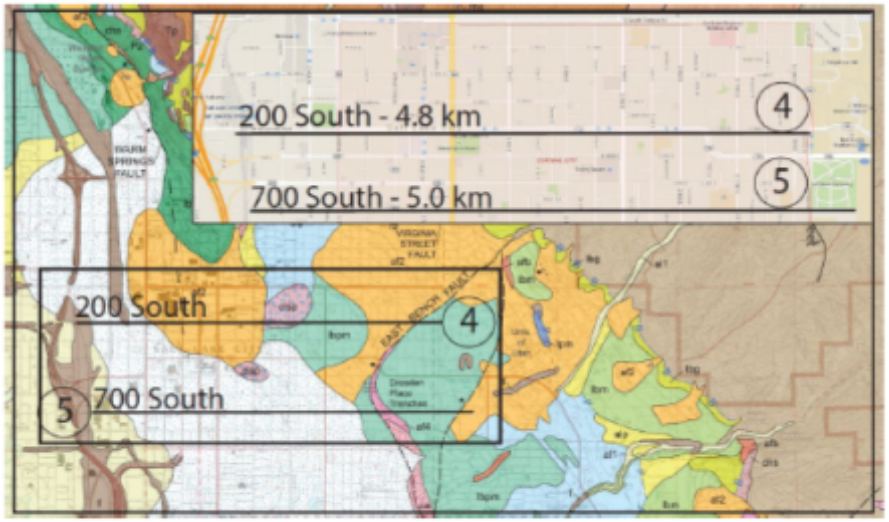

Figure 3. Proposed seismic profiles in downtown Salt Lake City. We propose to operate from west to east along 200 South and 700 South and complete all profiles in two or three days.


Thank you

UTAH GEOLOGICAL SURVEY

SURVEY NOTES

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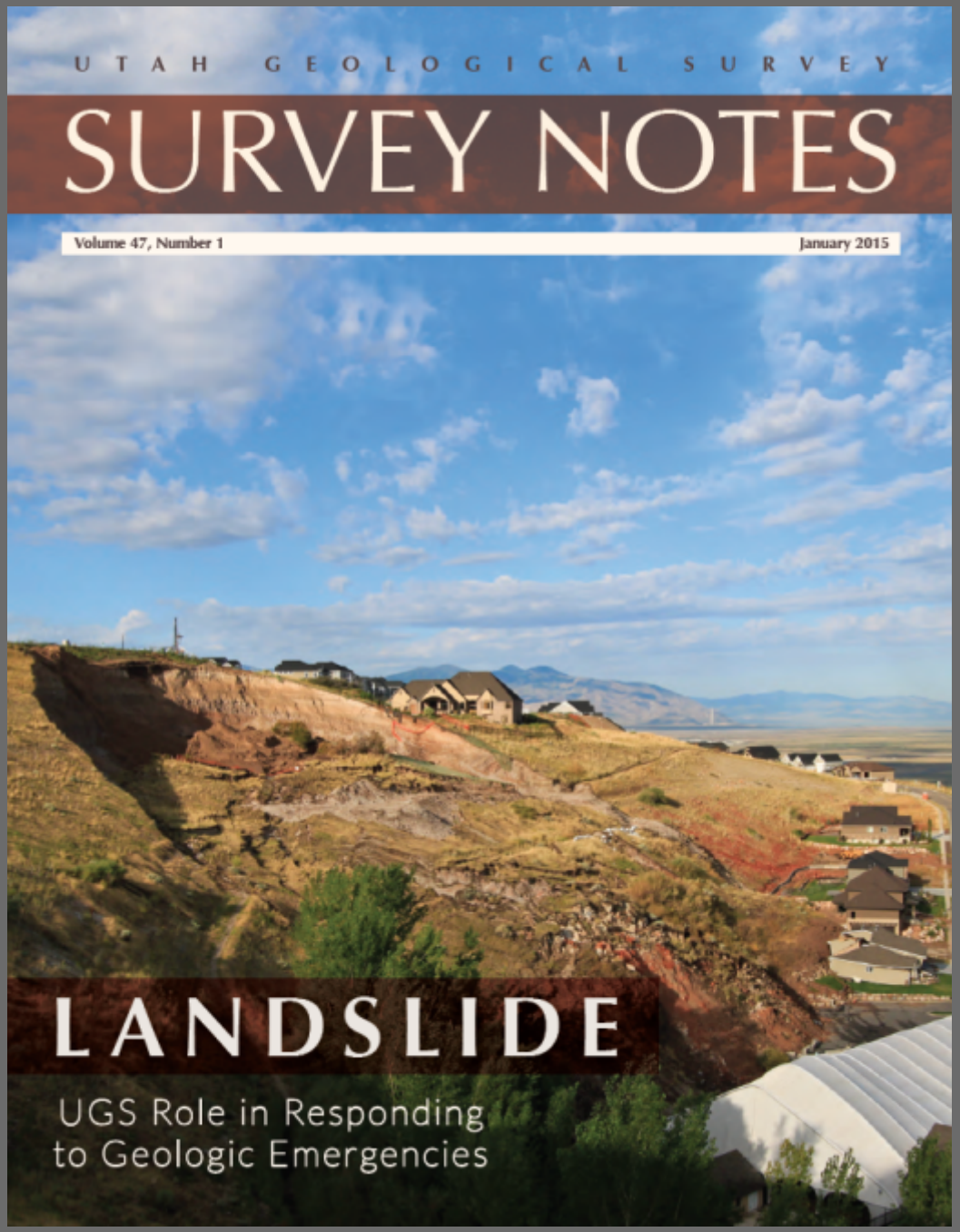

LANDSLIDE

UGS Role in Responding to Geologic Emergencies