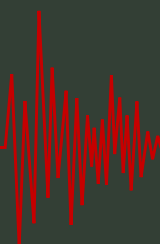


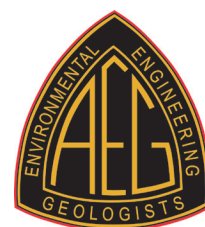
Proceedings Volume Basin and Range Province Seismic Hazards Summit III

Utah Geological Survey and
Western States Seismic Policy Council

edited by William R. Lund



January 12–17, 2015
Salt Lake City, Utah



MISCELLANEOUS PUBLICATION 15-5
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
2015

PROCEEDINGS VOLUME **BASIN AND RANGE PROVINCE** **SEISMIC HAZARDS SUMMIT III**

***UTAH GEOLOGICAL SURVEY AND
WESTERN STATES SEISMIC POLICY COUNCIL***

January 12–17, 2015

*Utah Department of Natural Resources Building, Auditorium
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Edited by

William R. Lund

Utah Geological Survey

Sponsored by

Intermountain Section of the Association of Environmental and Engineering Geologists

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PREFACE

This proceedings volume documents the results of the third Basin and Range Province Seismic Hazards Summit (BRPSHSIII) convened by the Utah Geological Survey and Western States Seismic Policy Council in Salt Lake City, Utah, on January 12–17, 2015. The purpose of BRPSHSIII was to bring together geologists, seismologists, geodesists, engineers, emergency planners, and policy makers to (1) present and discuss the latest seismic-hazard research in the Basin and Range Province, (2) to evaluate the implications of that research for earthquake-hazard reduction and public policy, and (3) to identify a path forward to further reduce risk from earthquakes in the Basin and Range Province.

BRPSHSIII consisted of seven technical sessions convened over a four-day period that featured 42 subject-matter-expert speakers (who gave 47 oral presentations) and 14 poster presentations. BRPSHSIII also included a one-day pre-summit short course titled *Characterizing Hazardous Faults—Techniques, Data Needs, and Analysis*, and a one-day post-summit field trip titled *Salt Lake City's Earthquake Threat and What is Being Done About It*, and a one-day U.S. Geological Survey (USGS) workshop titled *Evaluations of Hazardous Faults in the Intermountain Region—2015 Update*. This proceedings volume includes available technical session PowerPoint presentations, most with an accompanying abstract or short paper; available poster presentations; the short-course manual; the field-trip guidebook; summary of the USGS workshop; and an invited paper on luminescence dating techniques.

As proceedings volume editor, I thank the summit conveners, the technical-session moderators, subject-matter-expert speakers, poster presenters, paper authors, and the organizers of the short course and field trip who so willingly shared of their expertise, experience, and not least of all their time to make BRPSHSIII a success. The accumulated knowledge and wisdom contained in this volume regarding seismic-hazard characterization, analysis, emergency response, and public policy makes an important contribution to our understanding of earthquake hazards and seismic risk in the Basin and Range Province, and will serve as a technical and policy benchmark for years to come.

William R. Lund

Proceedings Volume Editor

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ACKNOWLEDGMENTS

DEDICATION

Gary Christenson and Craig dePolo

It is fitting that the Basin and Range Province Seismic Hazards Summit III (BRPSHSIII) proceedings volume be jointly dedicated to Gary Christenson and Craig dePolo, two long-time pillars of the Basin and Range Province earthquake community, for their outstanding contributions to understanding earthquake hazards and commitment to reducing seismic risk in the Basin and Range Province.

Gary Christenson



There are few scientists about whom it can be said that their outstanding dedication and performance truly made a significant impact on the safety and welfare of their fellow citizens. Gary Christenson is one such scientist, who through his long and distinguished career at the Utah Geological Survey (UGS) contributed greatly to the advancement of seismic safety in Utah and throughout the Basin and Range Province.

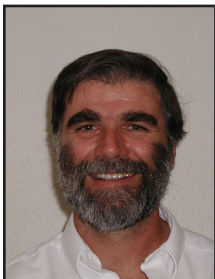
As a scientist, Gary authored 65 scientific publications, of which he was senior author on 42. Many of those publications made a significant contribution to improving seismic safety in Utah. Gary's contributions to the understanding of seismic hazards in Utah materially advanced the science, contributed substantially to risk reduction and hazard response, and helped institutionalize seismic-hazard mitigation across the state that will protect residents and their property for generations to come. Gary has an unparalleled capacity for assessing geologic hazards for effective hazard mitigation and policy development. He combines a scientist's rigorous, detailed identification and characterization of hazards, with a practical approach to getting nontechnical government and business leaders to deal with them effectively.

In addition to being a prolific scientist, during his 27-year career with the UGS, Gary served for 20 years as manager of the UGS's Geologic Hazards Program. During that time, Gary created what was widely recognized as one of the best and most effective state survey geologic-hazards programs in the nation. Gary's managerial, organizational, advisory, and editorial skills combined to make him a key contributor to Utah's state earthquake program. Those traits were particularly manifest in his wide-ranging contributions to the Utah Seismic Safety Commission, and his sound approach to managing seismic hazards in the public-policy arena. Gary worked quietly, but persistently and cogently, to build consensus and trust among often disparate stakeholder groups to deal with the state's seismic hazards. He provided critical leadership in implementing the County Geologist program. The concept of "embedding" a hazards geologist within county governments was unorthodox and novel, but laid the basis for some of the best local government planning, response, and mitigation efforts in the Intermountain West.

Gary represented Utah for many years on the Western States Seismic Policy Council (WSSPC), where he led or contributed to many important endeavors including the creation of the Basin and Range Province Committee, development of fault-activity-level definitions for hazardous Basin and Range Province faults, organizing the first WSSPC Basin and Range Province Seismic Hazards Summit, and hosting a Post-Earthquake Technical Clearinghouses workshop.

Gary was always too busy getting things done to seek the limelight. Because of that, it is entirely proper that in recognition of Gary's many efforts to advance the understanding of earthquake hazards and seismic risk in the Basin and Range Province, that the BRPSHSIII dedicates this proceedings volume to him.

Craig dePolo



Craig dePolo brings a unique combination of technical expertise, passion for seismic safety, and raw energy for getting things done to the investigation and mitigation of seismic hazards in the Basin and Range Province. Over a now nearly thirty-year distinguished career with the Nevada Bureau of Mines and Geology (NBMG), Craig has published more than 100 reports, maps, and abstracts dealing with earthquakes and hazardous faults in Nevada, several of which represent ground-breaking science for understanding active tectonics in the Basin and Range Province. Not least among them are the seminal NBMG publication *The 21 February 2008 Mw 6.0 Wells Nevada Earthquake*, to which Craig both contributed extensively and co-edited (NBMG Special Publication 36), and the *Quaternary Fault Map of Nevada* (NBMG Map 167) for which Craig received the Western States Seismic Policy Council's (WSSPC) 2010 Award in Excellence. Additionally, Craig and others' publication *Latest Quaternary Fault Movement Along*

the Las Vegas Valley Fault System, Clark County, Nevada, received the Association of Environmental and Engineering Geologists 2006 Best Publication Award.

In addition to his technical contributions, throughout his career, Craig has been a tireless advocate of earthquake-risk reduction and mitigation. He has worked closely with the Nevada geotechnical community to promote better recognition of geologic hazards of all types, and has been a leader in translating technical scientific reports into a format that can be easily understood by emergency preparedness personnel; state, county, and municipal officials; planners; and the general public. Noteworthy among these efforts are *Living with Earthquakes in Nevada* (NBMG Special Publication 27), *Earthquakes in Nevada and How to Survive Them* (NBMG pamphlet), helping develop HAZUS-based earthquake scenarios for Nevada communities (e.g., NBMG Special Publication 20), and producing with others, the *Nevada Earthquake Movie*. He spearheaded the 1996 publication of the *Planning Scenario for a Major Earthquake in Western Nevada* (NBMG Special Publication 20), which has been used many times in response and recovery exercises. In the days and months following the 2008 Wells earthquake, Craig was on the ground both investigating the event and then helping the community become better prepared for future earthquakes. Craig has served as Chair of the Nevada Hazard Mitigation and Planning Committee, is a long-time member of the Nevada Earthquake Safety Council, where he has served as Chair of the Mitigation Committee and co-Chair of the Research Committee, and he developed media workshops to prepare scripts to be read following a major damaging earthquake in Nevada. Additionally, Craig has often been the face of earthquake safety in Nevada, appearing numerous times both on TV and in print media to explain Nevada's earthquake hazards to the public and to advocate for earthquake preparedness.

While his technical and public outreach efforts in Nevada are many, we particularly wish to acknowledge Craig's commitment to reducing risk from seismic hazards throughout the entire Basin and Range Province. Prime examples include serving as Chair of WSSPC in 1992, and Chair of the WSSPC Basin and Range Province Committee from 1995–1999, a committee on which he remains an active member to the present. Craig was a key participant in the Basin and Range Province Earthquake Working Groups I and II, convened in 2006 and 2011, respectively, to provide recommendations to the U.S. Geological Survey for the 2007 and 2014 updates of the National Seismic Hazard Maps. Craig developed a generic state earthquake clearing-house plan, and organized a technology-transfer workshop in Salt Lake City to present the earthquake clearinghouses concept to other Basin and Range Province states. However, most notably, early in his career Craig recognized a need to periodically bring Basin and Range Province states and their partners together to address mutual earthquake-hazard issues and concerns. To this end, he conceived and organized the Basin and Range Province Seismic Hazards Summits I and II in 1997 and 2004, respectively, as an effective format to present and discuss the latest seismic-hazard research, to evaluate the implications of that research for earthquake-hazard reduction and public policy, and to identify a path forward to further reduce risk from earthquakes in the Basin and Range Province. Craig received the WSSPC 2004 Award in Excellence for BRPSHSII, and now in 2015, BRPSHSIII continues this tradition.

The Basin and Range Province has benefited greatly from Craig's expertise and unselfish willingness to contribute in any way possible to reduce seismic risk. It is with a deep sense of gratitude that the BRPSHSIII acknowledges Craig on behalf of the citizens of the Basin and Range Province, and is proud to dedicate this proceedings volume to him.

OVERVIEW

The Utah Geological Survey (UGS) and Western States Seismic Policy Council (WSSPC) convened the third Basin and Range Province Seismic Hazards Summit (BRPSHSIII) in Salt Lake City, Utah, on January 12–17, 2015. Basin and Range Province Seismic Hazards Summits are held at approximately decadal intervals to “take the pulse” of earthquake-hazard research and mitigation in the Basin and Range Province, and to explore issues and provide recommendations related to future earthquake-hazard research, mitigation, and public policy. BRPSHSIII builds directly upon the results of BRPSHSI held in May 1997 in Reno, Nevada (Lund, 1998), and BRPSHSII, also held in Reno in May 2004 (Lund, 2005).

As in the previous two summits, BRPSHSIII employed an interdisciplinary approach to reducing seismic risk by bringing together geologists, seismologists, geodesists, engineers, emergency managers, and policy makers to present and discuss the latest earthquake-hazards research, and to evaluate research implications for hazard reduction and public policy in the Basin and Range Province. BRPSHSIII consisted of seven technical sessions convened over four days; a poster session; a one-day, pre-summit workshop on *Characterizing Hazardous Faults—Techniques, Data Needs, and Analysis*; and a one-day, post-summit field trip titled *Salt Lake City's Earthquake Threat and What is Being Done About It*. Additionally, the U.S. Geological Survey (USGS) held a one-day workshop on *Evaluation of Hazardous Faults in the Intermountain West Region* (results to be published separately by the USGS), and the Intermountain Section of the Association of Environmental and Engineering

Geologists and the Utah Geological Association jointly sponsored the 2015 Richard H. Jahns Distinguished Lecture in Applied Geology in conjunction with BRPSHSIII.

BRPSHSIII's seven technical sessions included:

TS-1 Perspectives and User Needs

TS-2 M_{\max} Issues in the Basin and Range Province

TS-3 Ground Motions from Normal-Faulting Earthquakes

TS-4 Fault Segmentation and Rupture Patterns in the Basin and Range Province

TS-5 Earthquake Engineering and Risk Mitigation

TS-6 Emergency Management and Public Safety

TS-7 Using Geodesy to Characterize Seismic Hazard in the Basin and Range Province

Each session was chaired by a moderator experienced in the session topic and consisted of presentations by invited subject-matter experts. A discussion period was held after each technical session to explore questions, identify unmet needs, and solicit recommendations regarding seismic-hazard research and mitigation from the summit attendees. This proceedings volume includes most PowerPoint presentations made in the technical sessions, many with an accompanying abstract or short paper; poster presentations; the short course manual; and the field-trip guidebook. Questions, needs, and recommendations identified for future seismic-hazard research, mitigation, and public policy in the Basin and Range Province are provided below.

BRPSHSIII IDENTIFIED SEISMIC-HAZARD QUESTIONS, NEEDS, AND RECOMMENDATIONS

Discussion periods following each BRPSHSIII technical session and the wrap-up session at the end of the summit identified relevant questions, unmet needs, and recommendations regarding seismic-hazard investigation, mitigation, and public policy in the Basin and Range Province. The results of those discussions are summarized below, and it is hoped this interdisciplinary list will spur future examination of issues, guide seismic-hazard research and mitigation, and ultimately influence earthquake-risk-reduction public policy in the Basin and Range Province.

1. Is investing in Earthquake Early Warning (systems) more important/practical than continued earthquake hazard map refinement? The locations of critical facilities and population centers will always be better known than the locations of future earthquakes, and recent history has shown that damaging earthquakes often occur either outside the most hazardous regions (e.g., the M6.3 Christchurch earthquake of February 2011) or with unexpected properties (e.g., the multi-segment rupture of the great M9 Tohoku-Oki earthquake of March 2011).
2. The USGS National Seismic Hazard Maps do not incorporate the timing of the most recent earthquake on the fault sources used to prepare the maps (time-independent), and therefore may not accurately portray the current probabilistic hazard represented by those faults. Recommend that the USGS develop real-time (time-dependent) seismic-hazard maps for the United States that reflect the effects of earthquake timing and recurrence for those areas where the paleoseismic data permit it.
3. Geologic mapping and paleoseismic fault trenching studies remain key to reducing risk from seismic hazards in the Basin and Range Province by identifying and characterizing hazardous faults. It is not possible to effectively mitigate a hazard that has not been identified, accurately located, and characterized.
4. Recommend that the USGS and Basin and Range Province state geological surveys emphasize mapping and paleoseismic investigations of faults in and near urban areas, even where perceived probabilistic hazard is low because the faults have low slip rates. The time-independent hazard may be low, but the associated risk is high, and obtaining paleoearthquake chronologies along potentially hazardous faults is key to developing accurate hazard assessments for urban areas.

5. Recommend developing a Unified Geologic Hazard Code minimally at the state level, but preferably at the national or international level similar to the International Building Code and the International Residential Code that could serve as an objective, standardized ordinance for all jurisdictions with potential geologic hazards (including earthquake hazards).
6. There is a need to develop new, self-consistent magnitude regressions that address inconsistencies in estimating maximum magnitudes (M_{\max}) for active faults when derived from different source parameters. In the interim, recommend using the most statistically robust regressions available stemming from global, all-fault-type earthquake data when determining M_{\max} for Basin and Range Province faults.
7. Geologic observations of the variability of displacement at a point on a fault from a global dataset have a coefficient of variation (CV) of 0.5. Forward modeling of displacement-at-a-point variability using the Youngs and Coppersmith (1985) characteristic earthquake model yields results consistent with the global data set. Using the Gutenberg-Richter distribution with large M_{\max} yields CV values significantly larger than observed, and does not support the use of a large M_{\max} exponential model for probabilistic seismic-hazard analysis to describe the distribution of magnitudes on a fault either in the Basin and Range Province or globally.
8. The Enhancement of Next Generation Attenuation Relationships for Western US (NGA-West2) ground-motion-prediction models used to estimate ground-shaking hazard suffer from a lack of normal faulting strong-motion data not only from the Basin and Range Province, but globally. Hence, there may be considerable epistemic uncertainty on how applicable the models are for the Basin and Range Province. The models should be evaluated for regional differences in large distance attenuation and kappa prior to their use in the Basin and Range Province. A more concerted effort to collect normal-faulting data for earthquakes of M 5.0 and greater should be made and numerical ground-motion modeling should be performed to help better constrain the ground-motion models for the Basin and Range Province.
9. The hanging-wall effect contained in the NGA-West2 ground-motion models is a significant factor in estimating the seismic hazard in the Basin and Range Province because many urban centers are in the hanging wall of normal faults. Accurately capturing this effect in ground-motion models is critical particularly for bending faults which includes most normal faults.
10. Segmentation of faults in the Basin and Range Province is physically based (earthquake timing, fault structure, rupture kinematics) and provides the best approach for modeling earthquake rupture on Basin and Range Province faults. More study is required to characterize the potential for partial and multisegment ruptures, and of the effects of fault stepovers and gaps on arresting fault rupture.
11. Surface-faulting hazard in the Basin and Range Province is typically regulated over the Holocene Epoch (past ~ 11 kyr), which is as much as an order-of-magnitude longer recurrence interval than is used to mitigate other dangerous and destructive natural hazards such as floods, debris flows, landslides, liquefaction, and strong earthquake ground shaking. Mitigation of fault rupture should be brought into balance with other socially and technically accepted levels of risk management for other kinds of earthquake and geologic hazards.
12. Acceptable risk is a concept used in engineering design to reduce risk to an acceptable level. Structural and geotechnical engineering mitigation solutions for surface faulting should be permitted if they demonstrate adequate safety factors and protection of the public—in the same manner as all other routinely accepted engineering solutions.
13. How much paleoseismic information (earthquake timing, recurrence, displacement) is sufficient to adequately characterize fault activity in support of performance-based (engineering) surface-faulting mitigation for normal-slip faults in the Basin and Range Province?
14. In property rights states (most, if not all, Basin and Range Province states), when a city or county approves a project, it accepts future liability (taxpayers pay for developers' mistakes). Recommend that jurisdictions in the Basin and Range Province with potential geologic hazards adopt laws, ordinances, and regulatory-review requirements to reduce future damage from geologic hazards.
15. Based upon the 2008 M 6.0 Wells, Nevada, earthquake experience, jurisdictions in seismically hazardous areas of the Basin and Range Province should specifically plan not only for emergency response, but also for post-earthquake recovery. Recovery plans should include immediate, intermediate, and long-term phases.

AGENDA

BASIN AND RANGE PROVINCE SEISMIC HAZARDS SUMMIT III

January 12–17, 2015

Utah Department of Natural Resources Building, Auditorium

Salt Lake City, Utah

The Utah Geological Survey and the Western States Seismic Policy Council, in conjunction with the Utah Division of Emergency Management, the Utah Professional Geologists Licensing Board, the Utah Professional Engineers and Land Surveyors Licensing Board, the U.S. Geological Survey (USGS), the Intermountain Section of the Association of Environmental and Engineering Geologists (AEG), the University of Utah Seismograph Stations, and the Utah Seismic Safety Commission will convene a Basin and Range Province Seismic Hazards Summit III (BRPSHSIII) to bring together geologists, seismologists, geodesists, engineers, emergency managers, and policy makers to present and discuss the latest earthquake-hazards research, and to evaluate research implications for hazard reduction and public policy in the Basin and Range Province.

Monday, January 12

7:30 a.m. Breakfast

8:00 a.m. **Short Course—Characterizing Hazardous Faults - Techniques, Data Needs, and Analysis**
Instructors: Christopher DuRoss, U.S. Geological Survey (formerly Utah Geological Survey) and others

The BRPSHSIII short course will describe and discuss the components of a successful paleoseismic investigation—from how to choose a site to interpreting and presenting data. Topics will include 1) site selection and trench design, 2) performing the field investigation, 3) radiocarbon and luminescence dating, 4) data analysis, and 5) reporting the results. The course will be geared toward students with no previous paleoseismic experience and consulting geologists with limited experience. However, more experienced geologists will benefit from discussions on the state and direction of the practice, such as probabilistic earthquake time determinations in OxCal. Participants will benefit from presentations from local experts on recent paleoseismic studies and specific tools and techniques, such as creating photomosaics and using and interpreting LiDAR data. Course materials will include hands-on materials (e.g., uninterpreted trench data) and exercises that will encourage discussion and collaboration. A breakfast, morning break, lunch, afternoon break, and short course booklet is provided as part of the registration fee.

8:00 a.m. **Workshop—U.S. Geological Survey Evaluation of Hazardous Faults in the Intermountain West (IMW) Region—2015 Update**
Leader: Richard Briggs, U.S. Geological Survey

In June 2008, a two-day workshop was convened at the USGS offices in Golden, Colorado, to identify important active faults in the IMW region for future studies. Knowledgeable state representatives and regional experts created a priority list that allows program managers to guide limited resources toward features that potentially pose the most serious hazard and/or risk in the IMW. The results of this workshop were published as USGS Open-File Report 2009-1140 (<http://pubs.usgs.gov/of/2009/1140/>).

This one-day workshop, led by the USGS Earthquake Hazards Program, will reexamine and update the priority list developed in 2008, to help maintain a balanced perspective of priorities throughout the entire IMW region. Because working groups have already been convened to specifically deal with Quaternary fault priorities in Utah and Nevada, this workshop will emphasize structures outside of these two states. A breakfast, morning break, lunch, and afternoon break are provided as part of the registration fee.

2:00 p.m. Registration/Poster Set Up

4:00 p.m. Short Course and Workshop Ends

6:00 p.m. **Off-Site Icebreaker**

Hosted by the Intermountain Section of the Association of Environmental and Engineering Geologists at Maxwell's East Coast Eatery, 357 South Main Street, Salt Lake City.

Tuesday, January 13

7:30 a.m. Registration/Breakfast

8:00 a.m. **Summit Opening (Welcome, Summit Objectives, and Overall Agenda)**

8:15 a.m. Keynote Address—Earthquake Early Warning in the Intermountain West: Keith Koper, Director, University of Utah Seismograph Stations

8:30 a.m. **First Session—Perspectives and Overview of User Needs**
Moderator: William Lund, Utah Geological Survey

8:30 a.m. Basin and Range Province Earthquakes—Low Probability High Consequences: Ivan Wong, URS Corporation

9:00 a.m. What Emergency Managers Need from Geoscientists: Bob Carey, Utah Division of Emergency Management

9:30 a.m. What Engineers Need from Geoscientists: George Ghusn, Jr., BJG Architecture + Engineering

10:00 a.m. Break

10:30 a.m. What Local Governments Need from Geoscientists: David Dobbins, City Manager, Draper City

11:00 a.m. The National Seismic Hazard Maps in the Basin and Range Province—Thirty-Five Years in the Making: Mark Petersen, U.S. Geological Survey

11:30 a.m. Data and Tools for Seismic Hazard Investigations: Steve Bowman, Utah Geological Survey

12:00 p.m. Lunch

1:00 p.m. **Second Session— M_{\max} Issues in the Basin and Range Province (BRP)**
Moderator: Ivan Wong, URS Corporation

1:00 p.m. Issues and Approaches for Estimating M_{\max} for Earthquake Sources in the Basin and Range: Donald Wells, AMEC, Inc.

1:30 p.m. Analysis and Selection of M_{\max} Relations for the Working Group on Utah Earthquake Probabilities: Christopher DuRoss, U.S. Geological Survey (formerly Utah Geological Survey)

2:00 p.m. Estimating Surface Lengths for Prehistoric Ruptures in the Basin and Range Province: Craig dePolo, Nevada Bureau of Mines and Geology

2:30 p.m. Fault Linkage, Complexity, and Earthquake Displacement: Glenn Biasi, University of Nevada, Reno

3:00 p.m. Break

3:30 p.m. Slip at a Point Variability—Implications for Earthquake-Magnitude Distributions Near M_{\max} : Suzanne Hecker, U.S. Geological Survey

4:00 p.m. Estimating Magnitudes of Large Earthquakes from Geological Observations of Faults with Low Slip Rates: John Anderson, University of Nevada, Reno

4:30 p.m. M_{\max} and the National Seismic Hazard Maps: Mark Petersen, U.S. Geological Survey

- 5:00 p.m. **First and Second Sessions Discussion**
- 6:30 p.m. **Intermountain Section of the Association of Environmental & Engineering Geologists and Utah Geological Association Joint Meeting**
Separate registration includes dinner, contact aegintermountain@gmail.com for details.
- 7:00 p.m. Natural Hazards Identification, Impact Analysis, and Risk Assessment for Community Disaster Mitigation Planning: Eldon Gath, President, Earth Consultants International and 2014–2015 AEG Richard H. Jahns Distinguished Lecturer in Applied Geology

Wednesday, January 14

- 7:30 a.m. Breakfast
- 8:00 a.m. **Opening (Objectives and Agenda for the Day)**
- 8:15 a.m. Keynote Address—Making Hazards Real: Using Scenarios to Spur Preparedness Before Disaster Strikes: David Applegate, Associate Director, U.S. Geological Survey
- 8:30 a.m. **Third Session—Ground Motions from Normal-Faulting Earthquakes**
Moderator: Jim Pechmann, University of Utah Seismograph Stations
- 8:30 a.m. Ground Motion Prediction Equations for the BRP—Current Status: Norm Abrahamson, Pacific Gas and Electric Company
- 9:00 a.m. Numerical Simulations of Wasatch Fault Earthquakes: Daniel Roten, University of California, San Diego
- 9:30 a.m. Numerical Simulations of Rupture Propagation and Ground Motions in Normal-Faulting Earthquakes: Ralph Archuleta, University of California, Santa Barbara
- 10:00 a.m. Break
- 10:30 a.m. Clark County and Reno/Tahoe: Advancing Earthquake Hazard Assessment with Physics and Geology: John Louie, University of Nevada, Reno
- 11:00 a.m. Rupture Direction and Near Fault Effects on Ground Motions in the Basin and Range Province: Jennie Watson-Lamprey, Watson-Lamprey Consulting
- 11:30 a.m. Precariously Balanced Rock Constraints on Seismic Hazard from Known Faults and from Smoothed “Background” Seismicity: Jim Brune, University of Nevada, Reno
- 12:00 p.m. Lunch
- 1:00 p.m. **Fourth Session—Fault Segmentation and Rupture Patterns in the BRP**
Moderator: David Schwartz, U.S. Geological Survey
- 1:00 p.m. Current Understanding and Issues Regarding Fault Segmentation in the BRP: David Schwartz, U. S. Geological Survey
- 1:30 p.m. Fault Linkage and Multisegment Ruptures—A Structural Prospective: Ron Bruhn, University of Utah, retired
- 2:00 p.m. UCERF-3 Fault Methodology—Is It Applicable to the BRP Seismic Hazard Analysis?: Ned Field/Morgan Page, U.S. Geological Survey

- 2:30 p.m. Break
- 3:00 p.m. Paleoseismic Trenching and LiDAR Analysis Supports Non-Persistent Rupture Terminations at Central Wasatch Fault Zone Segment Boundaries, Utah: Scott Bennett, U.S. Geological Survey
- 3:30 p.m. Rupture Patterns and Recurrence along the West Tahoe Fault System: California and Nevada: Gordon Seitz, California Geological Survey
- 4:00 p.m. Characterizing Ruptures of Normal Faults in Italy: Daniela Pantosti, National Institute of Geophysics and Volcanology, Italy
- 4:30 p.m. **Third and Fourth Sessions Discussion**

Thursday, January 15

- 7:30 a.m. Breakfast
- 8:00 a.m. **Opening (Objectives and Agenda for the Day)**
- 8:15 a.m. Keynote Address—Preparing for the Inevitable: Major General Jefferson S. Burton, Adjutant General, Utah National Guard
- 8:30 a.m. **Fifth Session—Earthquake Engineering and Risk Mitigation**
Moderator: Pete McDonough, Questar Gas Company
- 8:30 a.m. Current Strategies for Mitigating Surface Faulting in the Basin and Range Province: William Lund, Utah Geological Survey
- 9:00 a.m. Engineering Mitigation of Surface-Fault Rupture: Jonathan Bray, University of California, Berkeley
- 9:30 a.m. Geologic Data Needs for Engineering Mitigation of Earthquake Hazards: Ross Boulanger, University of California, Davis
- 10:00 a.m. Break
- 10:30 a.m. Reviewing Fault Surface-Rupture and Earthquake-Hazard-Mitigation Reports for Regulatory Compliance: Robert Larson, Los Angeles County Department of Public Works
- 11:00 a.m. Addressing Seismic Vulnerabilities to Natural Gas Systems: Pete McDonough, Questar Gas Company
- 11:30 a.m. Protection of Pipelines from Permanent Ground Deformation Using EPS Geofoam: Steve Bartlett, University of Utah
- 12:00 p.m. Lunch
- 1:00 p.m. **Sixth Session—Emergency Management and Public Policy**
Moderator: Bob Carey, Utah Division of Emergency Management
- 1:00 p.m. Case Study of the 2008 M6 Wells, Nevada Earthquake
- 1:00 p.m. Scientific Response to the 2008 M6 Wells, Nevada Earthquake: Craig dePolo, Nevada Bureau of Mines and Geology
- 1:30 p.m. Emergency Response – 2008 M6 Wells, Nevada Earthquake: Rich Harvey, Deputy State Forester, Nevada Division of Forestry

- 2:00 p.m. Engineering Considerations – 2008 M6 Wells, Nevada Earthquake: Barry Welliver, Structural Engineers Association of Utah
- 2:30 p.m. The Recovery of Wells, Nevada from the 2008 M6 Earthquake: Craig dePolo, Nevada Bureau of Mines and Geology
- 3:00 p.m. Break
- 3:30 p.m. Hazardous Faults in the BRP—What Constitutes Acceptable Risk: Roy Shlemon, R.J. Shlemon & Associates
- 4:00 p.m. Building Policy Considerations in Seismically Vulnerable Areas of the Basin and Range: Ron Lynn, Clark County, Nevada Department of Development Services
- 4:30 p.m. Modernizing the 1972 California Alquist-Priolo Act's Fault Zoning for the Performance-Based Millennium: Eldon Gath, Earth Consultants International
- 5:00 p.m. **Fifth and Sixth Sessions Discussion**

Friday, January 16

- 7:30 a.m. Breakfast
- 8:00 a.m. **Opening (Objectives and Agenda for the Day)**
- 8:15 a.m. Keynote Address—Kinematics of the Wasatch Fault Zone from GPS Measurements, Block Modeling, and Fault Modeling: Christine Puskas, UNAVCO.
- 8:45 a.m. **Seventh Session—Using Geodesy to Characterize Seismic Hazard in the BRP**
Moderator: Bill Hammond, University of Nevada, Reno
- 8:45 a.m. Fault Slip Rates in the Western Great Basin from Geodetic and Geologic Data: Bill Hammond, Corné Kreemer, Jayne Bormann, and Geoff Blewitt, University of Nevada, Reno
- 9:15 a.m. InSAR Analysis of the 2008 Reno-Mogul M4.7 Earthquake Swarm: Implications for Seismic Hazard in the Western Basin and Range: John Bell, Falk Amelung, and Christopher Henry, Nevada Bureau of Mines and Geology
- 9:45 a.m. Break
- 10:15 a.m. The Geodetic Strain Rate Field for the Colorado Plateau and Southern Basin and Range: Corné Kreemer, Geoff Blewitt, Bill Hammond, James Broermann, and Rick Bennett, University of Nevada, Reno
- 10:45 a.m. Update of Deformation Rates in the Snake River Plain: Suzette Payne, Rob McCaffrey, and Bob King, Idaho National Laboratory
- 11:15 a.m. Geodetic Constraints on Kinematics and Strain Rates in the Northern Basin and Range: Rebecca Bendick, Dylan Schmeelk, Yelebe Birhanu, and Cody Bomberger, University of Montana
- 11:45 a.m. **Seventh Session Discussion**
- 12:00 p.m. Lunch
- 1:00 p.m. **BRPSHSIII Wrap Up and Policy Discussion**

Moderators: William Lund, Utah Geological Survey and Craig dePolo, Nevada Bureau of Mines and Geology

1:00 p.m. Summit session topics review and policy discussion.

3:00 p.m. Break

4:30 p.m. Summit Close

Saturday, January 17

8:00 a.m. **Field Trip—Salt Lake City’s Earthquake Threat and What Is Being Done About It**
Leader: Mike Hylland, Utah Geological Survey

Location: Meet in front of the Utah Department of Natural Resources Building, main visitor parking lot. The field trip bus will leave at 8:00 a.m.

The BRPSHSIII field trip will visit prominent fault scarps on the Salt Lake City segment of the Wasatch fault zone, review the Holocene surface-faulting history of the fault, discuss important fault issues, such as the potential for partial- and multiple-segment ruptures, consider Lake Bonneville deposits used for constraining timing of fault movement, observe earthquake risk reduction measures applied to several recent retrofit or new construction of buildings, and tour the University of Utah Seismograph Stations to discuss earthquake monitoring systems and ongoing seismological research. A morning break, lunch, afternoon break, and field trip booklet are provided as part of the registration fee.

4:00 p.m. Field trip bus returns to Utah Department of Natural Resources Building, main visitor parking lot.

Partial funding for this educational opportunity has been provided by the Utah Division of Occupational & Professional Licensing and the Education and Enforcement Fund.

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