Blue Castle SSHAC Level 3 Study

Presentation to NRC Staff

William Lettis

October 27, 2011

Blue Castle Holdings – SSHAC Level 3 Seismic Source and Ground Motion Characterization Project

Presentation Overview

- SSHAC Seismic Overview
- SSHAC Project Plan, Organization and Schedule
- SSHAC Project Status
- NRC Discussion Items
- Closing/Questions/Concluding Remarks

Blue Castle SSHAC Level 3 Study

Seismic Overview

Blue Castle Site

Emery County, Utah

PRESENTED BY:

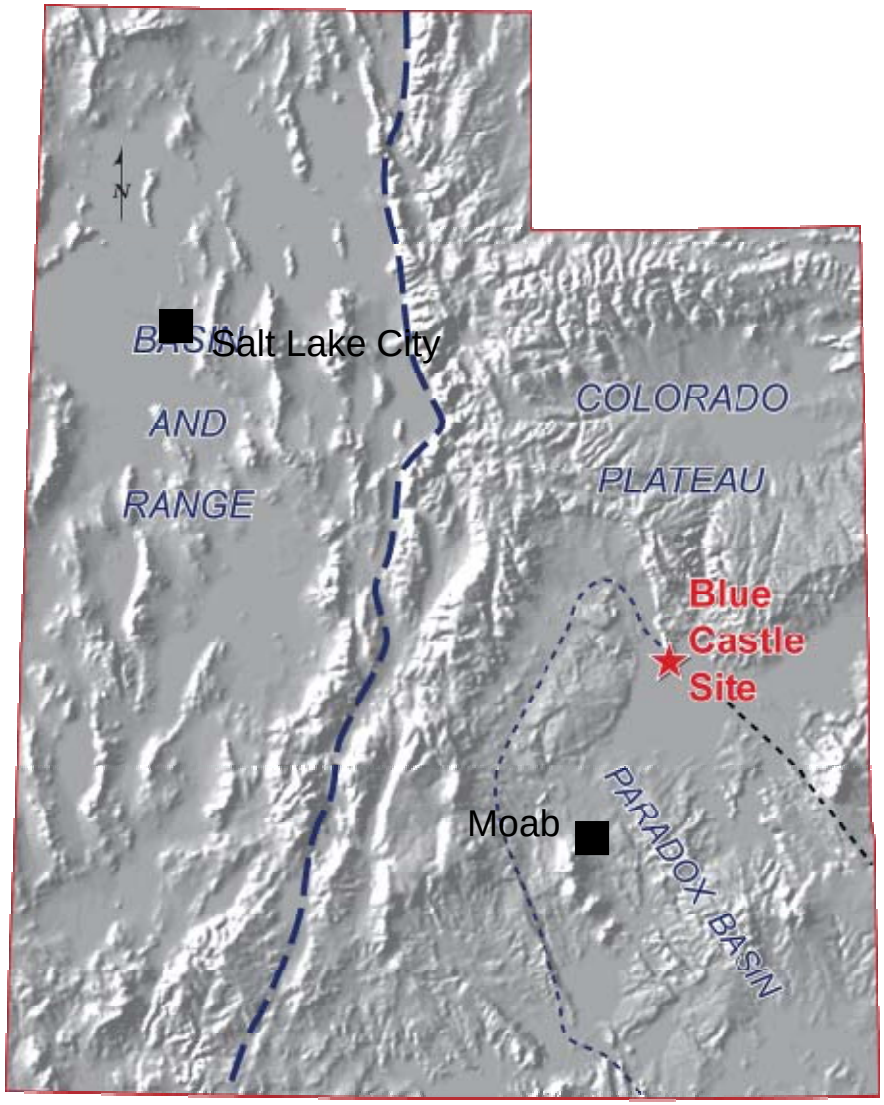
William R. Lettis

October 27, 2011

Seismic Characterization Study

Section 2.5.1, 2.5.2, 2.5.3, 2.5.4
-Blue Castle Site Studies

SSHAC Level 3 Study
- Develop SSC and GMC Models
- Input to PSHA for 2.5.2
- Identify significant issues to focus site studies



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Selection of SSHAC Level 3

(1) SSHAC Methodology defines four different levels of study distinguished by increasing level of sophistication, resources, and participation by technical experts

(2) NRC expectations are that a SSHAC Level 3 or 4 study will be performed for sites in the WUS in areas where a similar level study has not previously been performed and accepted by the NRC

(3) A SSHAC Level 3 or 4 study should be performed in regions of -
Active, complex tectonic settings

- Potential for significant public impact/scrutiny
- Significant Regulatory scrutiny

(4) Based on this guidance and the absence of an approved SSC or GMC model for the BCH region, a SSHAC Level 3 study has been selected for the BCH ESP

(5) A SSHAC Level 4 study is not being used because of the relatively minor increase in regulatory assurance associated with a Level 4 study “From the regulatory perspective of the NRC, there is no essential difference between Level 3 and Level 4 studies” (US NRC, 2011, Draft).

Blue Castle SSHAC Level 3 Objectives

(1) Develop fully hazard-informed SSC and GMC models for use in the Blue Castle PSHA for development of site GMRS

(2) Provide increased regulatory assurance that the site PSHA and GMRS adequately captures uncertainties in data and scientific knowledge

(3) Identify important data needs for reducing uncertainties in significant SSC and GMC parameters that can be fulfilled by the ongoing BCH field program

(4) Perform study under the BCH Quality Assurance Program and Project Instruction PI-05

Blue Castle SSHAC Level 3 Objectives

Goals of All PSHA Methodologies:
Stability and Longevity

Stability

- Enjoys public confidence that the views of the larger informed technical community have been considered and properly represented
- Public represented by regulator
- Not subject to significant change with each new scientific finding

Longevity

- Results will be valid for applications up to at least 10 years in the future
- The technical underpinnings will remain valid in the future, despite the development of new data

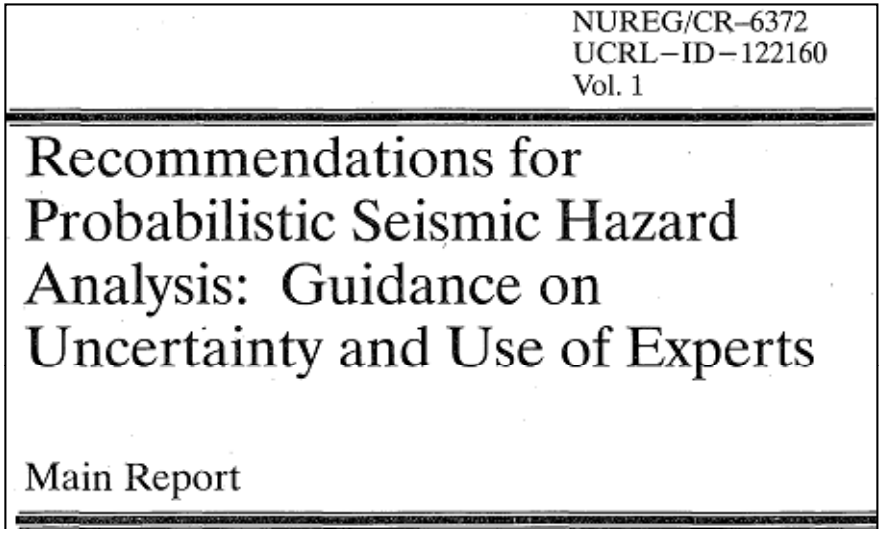
Blue Castle SSHAC Level 3 Objectives

Stability Comes from Identifying and Incorporating Uncertainties

- Views of the larger technical community are uncertain
- Alternative models for the locations and rates of future earthquakes
- Parameters that define the models are uncertain
- Likelihood that the community distribution is captured increases with SSHAC Study Level
- Increasing formalism and involvement of experts
- Increasing stability (regulatory confidence) that all hypotheses have been considered

The SSHAC Process

A structured framework and procedure for conducting multiple-expert assessments of input to PSHA



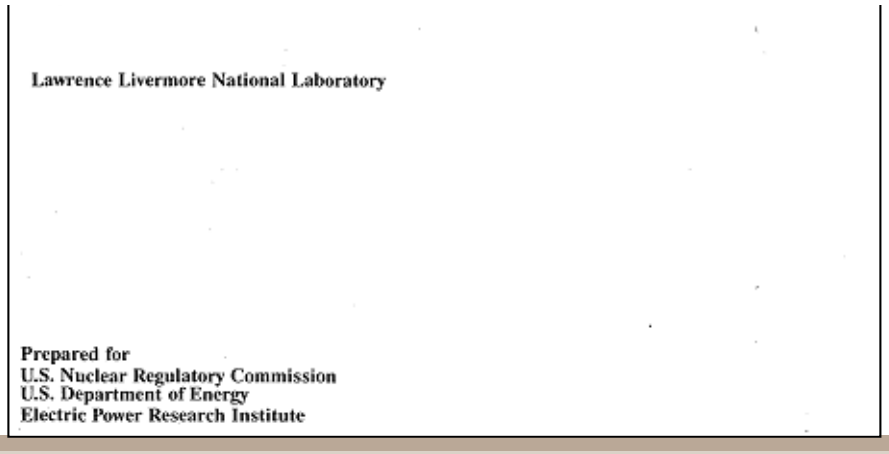
NUREG/CR–6372
UCRL–ID–122160
Vol. 1

Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts

Main Report

Prepared by
Senior Seismic Hazard Analysis Committee (SSHAC)
R. J. Budnitz (Chairman), G. Apostolakis, D. M. Boore, L. S. Cluff, K. J. Coppersmith, C. A. Cornell, P. A. Morris

Procedures defined by the Senior Seismic Hazard Analysis Committee (SSHAC)



Lawrence Livermore National Laboratory

Prepared for
U.S. Nuclear Regulatory Commission
U.S. Department of Energy
Electric Power Research Institute

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The SSHAC Process

Several more recent updates on SSHAC Guidance

(1) Hanks et al, 2009, Implementation of the SSHAC Guidelines for Level 3 and 4 PSHAs – Experience Gained from Actual Applications; USGS Open-File Report 2009-1093

(2) Coppersmith, Bommer, Kammerer and Ake, 2010, Implementation Guidance for SSHAC Level 3 and 4 Processes; June 10, 2010 Probabilistic Safety Assessment and Management Conference

(3) Munson and Ake, 2010, Seismic Considerations for Western U.S. Sites June 16, 2010 ANS Conference

(4) US NRC, 2011, Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies; Draft NUREG XXXX

NUREG/CR-6372 "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and the Use of Experts"

- Acknowledged instability of the PSHA process (at that time)
- NRC, DOE, and EPRI co-sponsored a study to provide methodological guidance for performing PSHA
- Project was carried out by the seven-member Senior Seismic Hazard Analysis Committee (SSHAC)
- Reviewed past studies, including landmark LLNL and EPRI studies
- Most important conclusion - Differences in PSHA are the result of procedural rather than technical differences
- Provides guidance on the process to incorporate uncertainty from the informed technical community for PSHA
- Defines four levels of study that represent **increasing** effort and budget (Level 1 to Level 4) with **increasing** confidence/certainty that TDI has been captured

SSHAC Objective

- Develop a methodology for obtaining reproducible, stable estimates of probabilistic seismic hazard at a site, including *explicit* quantification of uncertainty
  - Focused on **Process** for assessing uncertainty in the PSHA model input assessments and for quantifying the uncertainty in PSHA results
  - "Stability" is achieved by properly characterizing and quantifying uncertainty

SSHAC Basic Principles for a PSHA

- Principle 1: The goal of a SSHAC is "*to represent the center, the body, and the range of technical interpretations that the larger technical community would have if they were to conduct the study*"

- Termed the "informed technical community" (ITC) by Budnitz et al (1997)
- Termed the range of "technically defensible interpretations" (TDI) by US NRC (2011, Draft)

SSHAC Basic Principles for a PSHA (continued)

- Principle 2: *"It is absolutely necessary that there be a clear definition of ownership of the inputs into the PSHA, and hence ownership of the results of the PSHA"*

  – Ownership means intellectual responsibility
  – For SSHAC Level 3, Technical Integrator (TI) assumes ownership
    - TI Team (Intellectual ownership)
    - As opposed to Owner/Sponsor (Project owner)

Key Features of a SSHAC Process

- Define *specific roles* of all participants
- Develop and disseminate complete database
- Consider range of TDI in evaluating alternative models and uncertainties
- Encourage interactive debate and learning in structured setting
  - Documented Workshops and Information
    - Data Tables
- Evaluator experts (TI) build models to represent center, body, and range of technically defensible interpretations
- Provide feedback to understand implications of preliminary models and uncertainties (sensitivity)
- Conduct participatory (continual) peer review

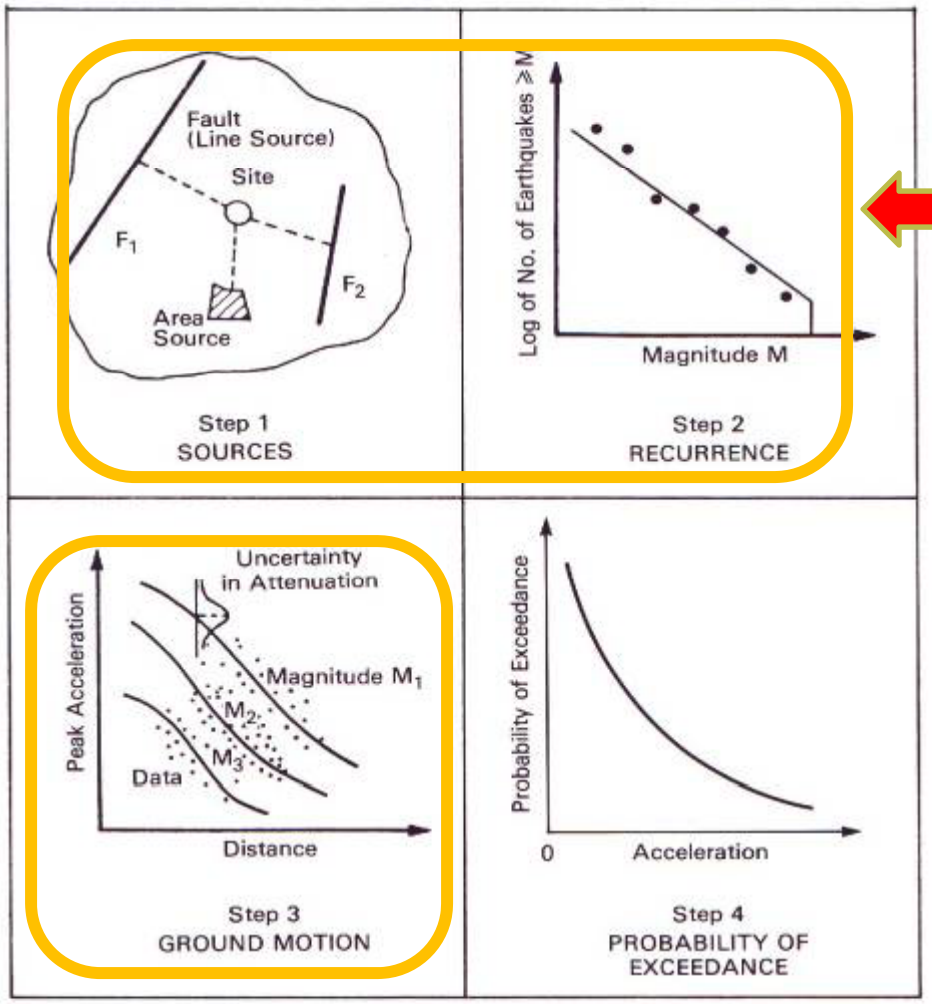
Probabilistic Seismic Hazard Analysis (PSHA)

Seismic Source Characterization: SSC Model

Source Geometry

Ground Motion Characterization: GMC Model

Earthquake Recurrence



Reiter (1990)

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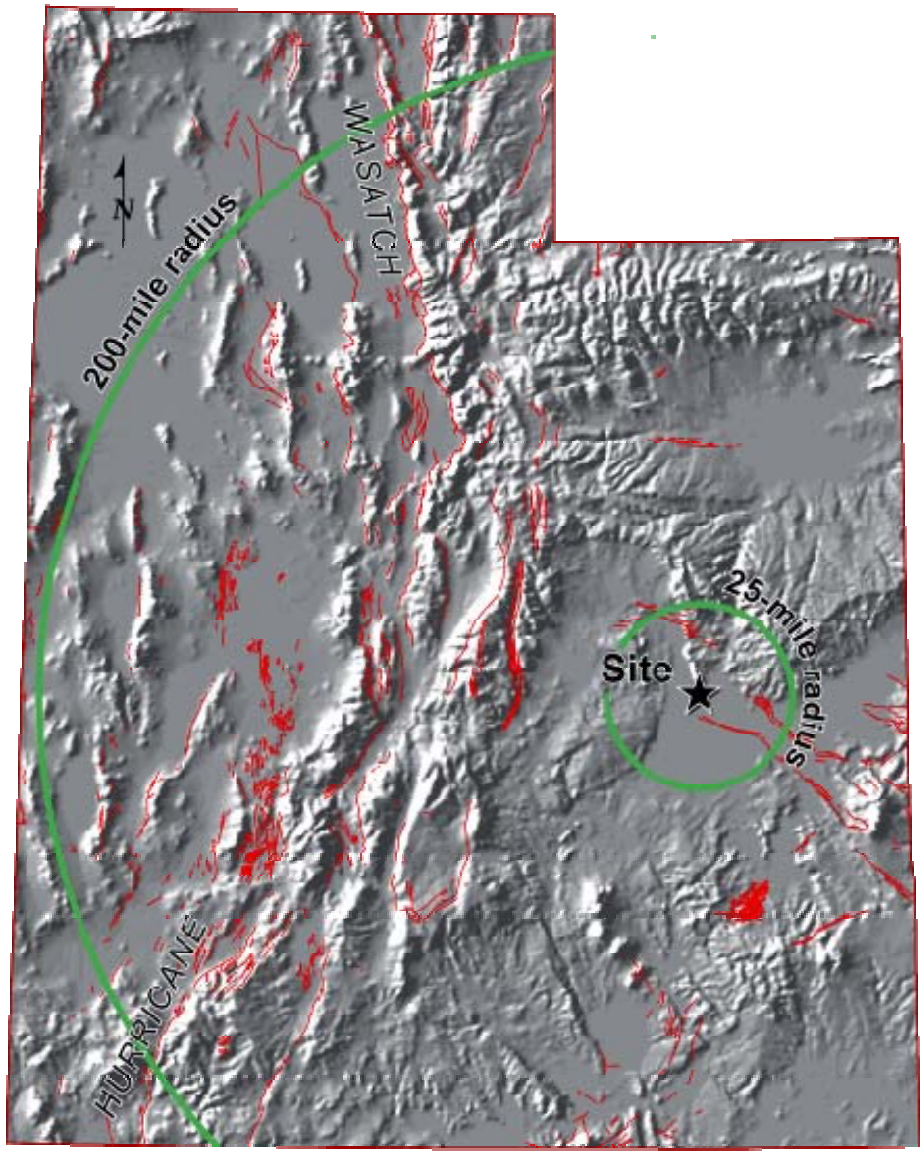
Regional Faults

- Active Wasatch Front Faults
- Basin and Range Faults
- Salt-related Faults



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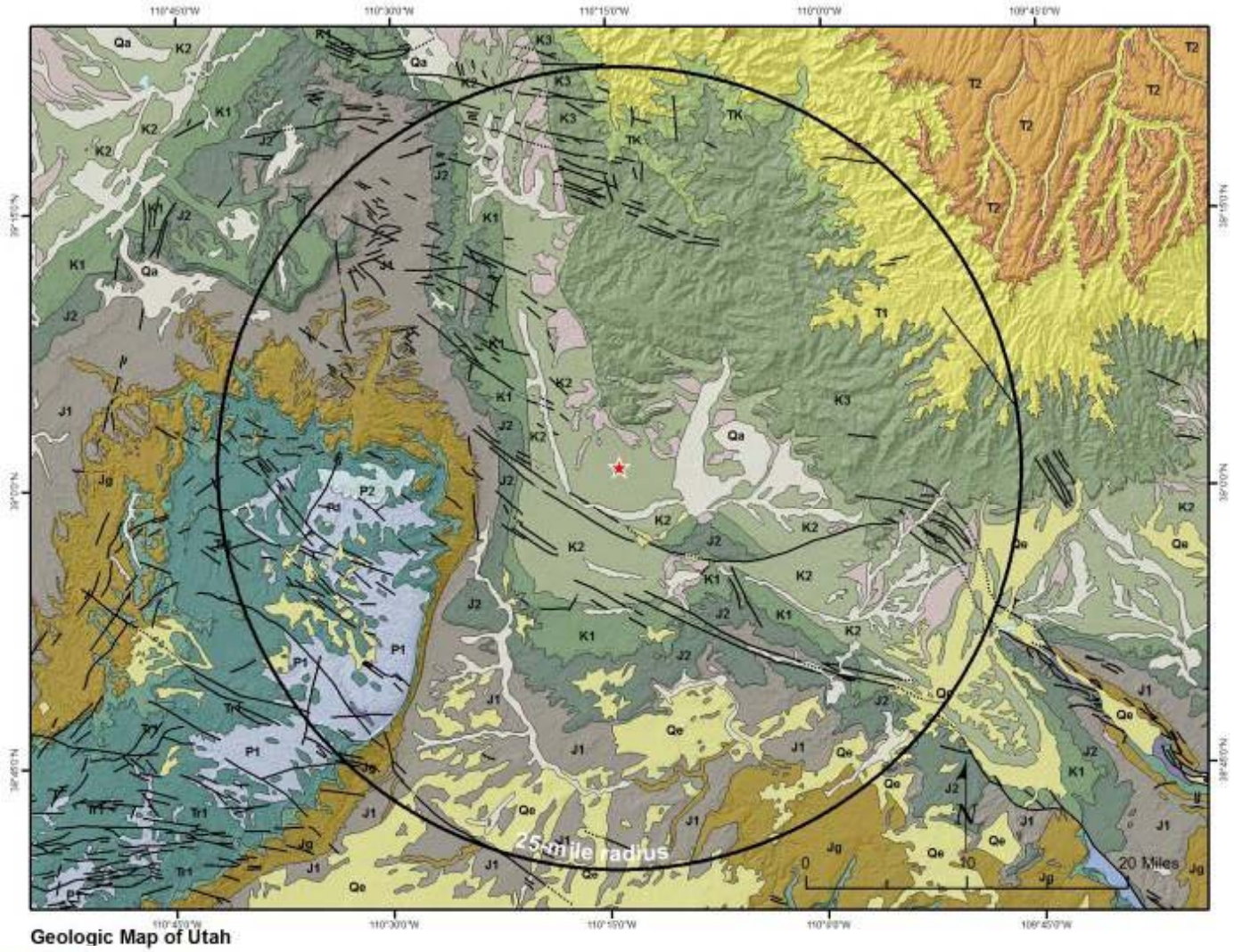
Blue Castle Site Area Geologic Map



Geologic Map of Utah

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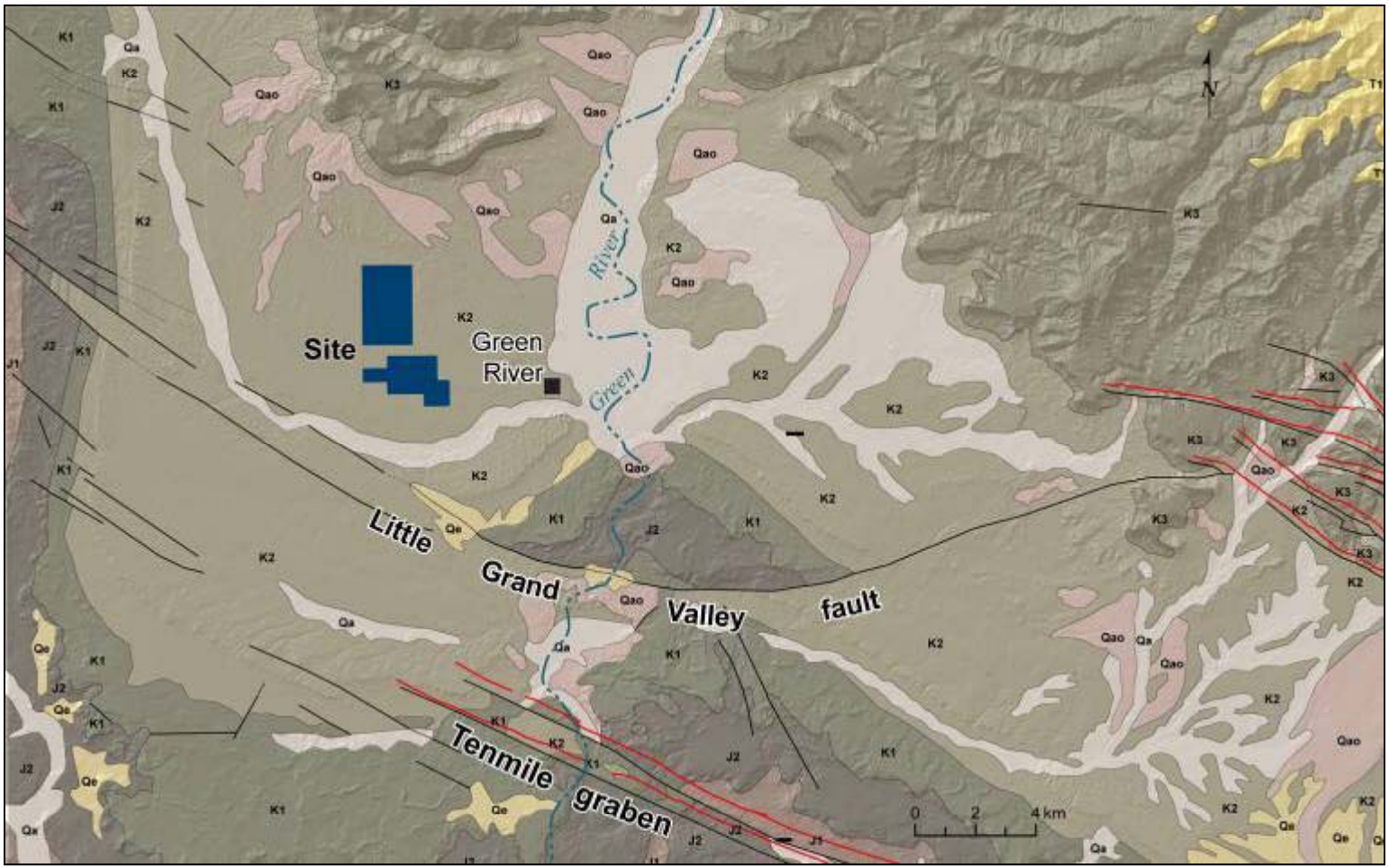
Blue Castle Site Geology Detail



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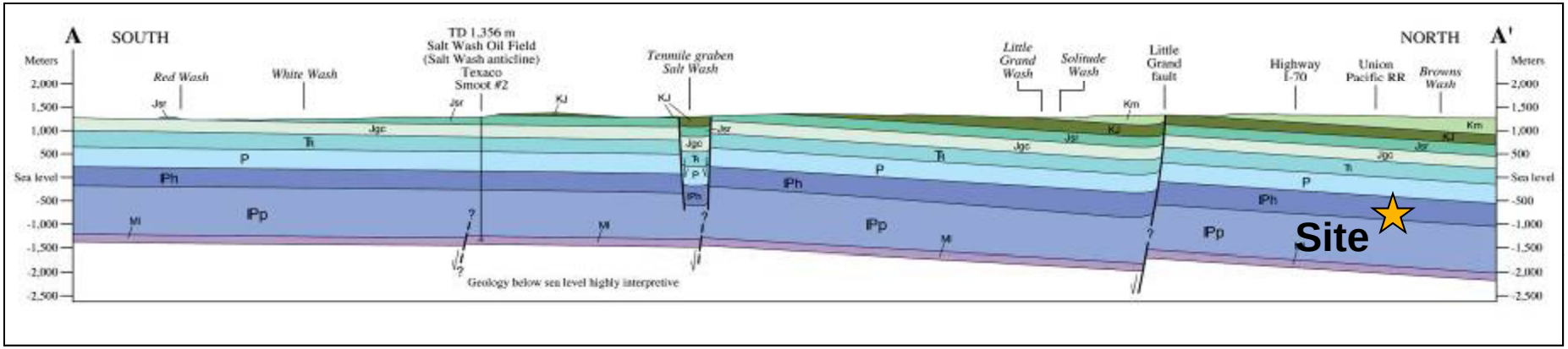
Blue Castle Site Subsurface Geology



- Geologic Cross-section A-A'
- Site is underlain by 500 ft of Mancos Shale (Km), then another 300 ft of Morrison Formation shale (KJ)
- South of the site, the Little Grand Valley fault has down-on-the-south displacement of Cretaceous bedrock, but no evidence of late Quaternary movement

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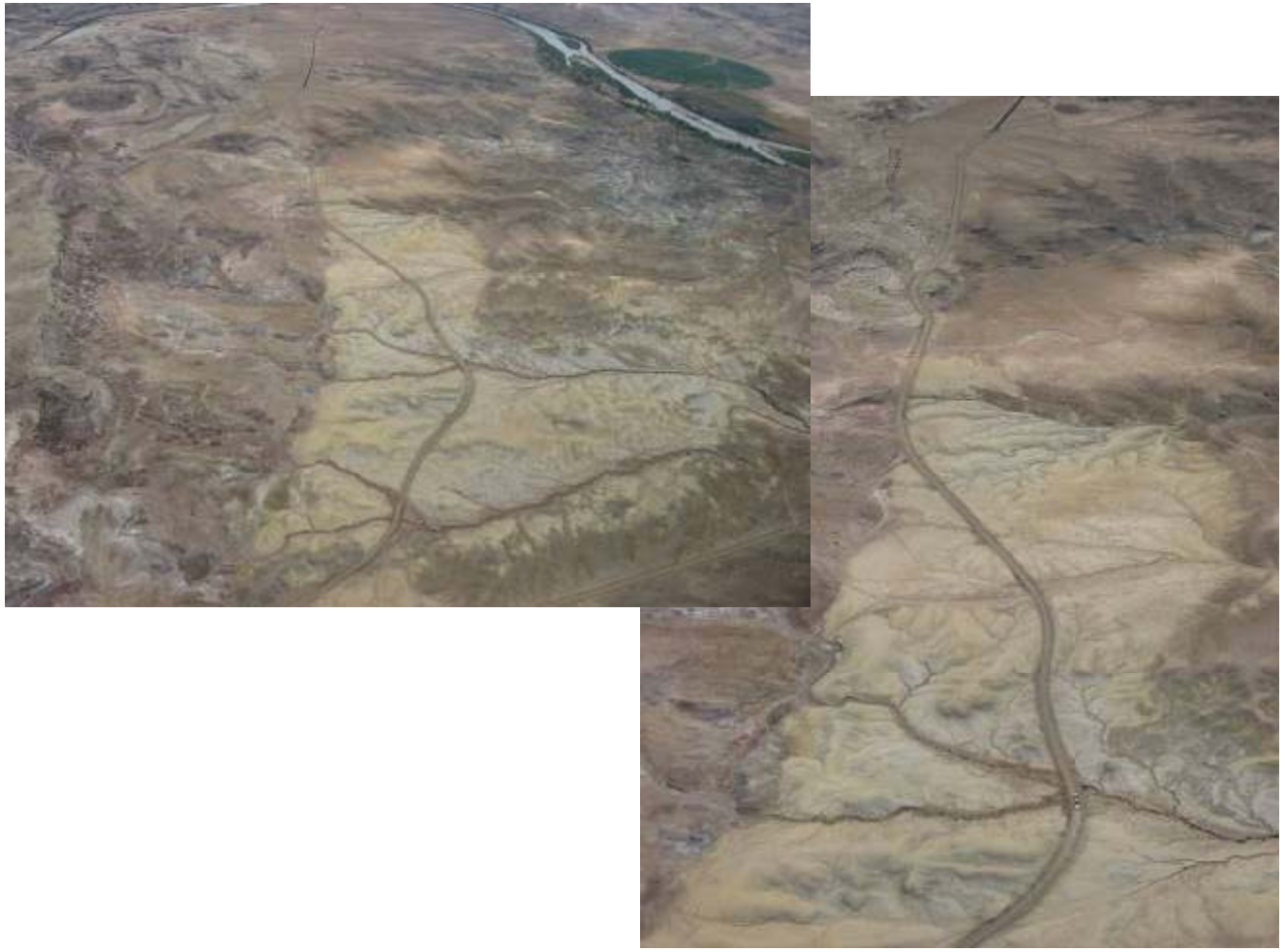
Little Grand Valley Wash fault

- South side down
- Offsets Cretaceous rocks, judged pre-Quaternary by USGS
- Associated with other Paradox basin faults



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Blue Castle SSHAC Schedule

Tasks	2011						2012												2013	
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
1: Preparation for Workshop 0																				
2: Workshop 0 - SSHAC Training and Data Needs																				
3: Data Collection and Initial Model Evaluation																				
4: Workshop 1 - Significant Issues and Data Needs																				
5: Data Evaluation and V1 Model Development																				
6: Workshop 2 - V1 Model Feedback and Alternative Models																				
7: V2 Model Development and Hazard Sensitivity																				
8: Workshop 3 - V2 Model and Hazard Sensitivity Feedback																				
9: V3 Model Development and hazard Sensitivity Feedback																				
10a: Conference Call - V3 GMC Model Presentation																				
10b: Workshop 4 - Final Briefing of V3 SSC and GMC Model																				
11a: GMC Report Preparation																				
11b: SSC Report Preparation																				

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Blue Castle SSHAC Level 3 Study

Project Status

William Lettis

October 27, 2011

Blue Castle SSHAC Level 3 Study

Activities Performed to Date

Completion of Draft and Final Project Plan
- Scope and Schedule
- Including PPRP Review and Comment

Identification of Project Participants/Contracts

Completion of Quality Assurance Project Instruction
- QA Training

Completion of Initial Data Compilation and Sensitivity Analysis

Completion of Workshop 0 – "Significant Issues and SSHAC Training"

Preparation for Workshop 1 – "Significant Issues, Available Data and Data Needs"
- Identify Resource Experts and Discussion Topics
- PPRP Review
- Convene several SSC and GMC Working Meetings

Blue Castle Holdings – SSHAC Level 3 Seismic Source and Ground Motion Characterization Project

Ground Rules for Workshops

- The workshops are an opportunity for the TI team to:
  - Exchange data
  - Present interpretations
  - Challenge and defend technical hypotheses
  - Gain information on the project
  - Interact and ask questions

Therefore, the focus of each workshop is for the TI Team

Conduct of the technical discussions at the workshops will be at the highest professional level.

- Discussions is among the TI team and the presenters.
- PPRP will be provided with opportunities to ask questions.
- Meeting with PPRP at end of workshop for informal comments; to be followed by written comments
- TI team runs the workshops and is responsible for keeping schedule, logistics, etc.

Blue Castle Holdings – SSHAC Level 3 Seismic Source and Ground Motion Characterization Project

Workshop 0 – SSHAC Training and Project Kick-off

Goals of the workshop

- Introduce participants
- Introduce projects goals, expectations, schedule
- Review Project Plan
- Identify key hazard-significant SSC and GMC issues
- Review available data, including availability, formats, quality, and uncertainties
- Identify Resource Experts for Workshop 1 and Tentative Proponent Experts for Workshop 2
- Identify the project path forward
- PPRP feedback and comments

Blue Castle Holdings – SSHAC Level 3 Seismic Source and Ground Motion Characterization Project

Workshop 1 – Significant Issues and Data Needs

Goals of the workshop

- Introduce projects goals, expectations, schedule
- Review SSHAC methodology
- Review workshop ground rules, Resource Expert roles
- Identify key hazard-significant SSC and GMC issues
- Review available data to address key issues, including formats, quality, and uncertainties
- Identify additional data needs to reduce uncertainties
- PPRP feedback and comments

Workshop 1 – Data Needs

Proposed GMC Resource Experts and Topics

Sinana Akkar (Data, Turkey)
David Brumbaugh (Data, Arizona)
Bidhi Deeno (Data, Italy)
Basil Margaris (Data, Greece)
Jim Peshmann (Data, Utah)
Suzette Payne (Data, INL)
Jon Stewart (Data, Italy)
Bob Smith (Data, Utah)
Ann Sheehan (Data, Colorado)
Dave Boore (GMPEs, Data Greece)
Mike Stickney (Data, Montana)

Workshop 1 – Data Needs

Proposed SSC Resource Experts and Topics

- **Able to Attend:**
  - Walter Arabasz [earthquake catalog issues, source characterization, mining-induced seismicity]
  - Jim Coogan [regional structure, industry data, detachment-related deformation]
  - Chris DuRoss [UT geologic and fault mapping, paleoseismology]
  - Kathy Haller [USGS fault database, paleoseismology]
  - Corne Kreemer [GPS geodesy]
  - Bob Kirkham [western CO faults and seismicity, CO salt tectonics]
  - Bill Lund [UT geologic and fault mapping]
  - Mike Machette [UT geologic and fault mapping, paleoseismology]
  - Jim Pechmann [earthquake catalog issues, UT data]
  - Doug Sprinkel [regional structure and geologic mapping, industry data]
  - Grant Willis [UT geologic and fault mapping]

Workshop 1 – Data Needs

Proposed SSC Resource Experts and Topics

- **May Attend:**
  - Susan Olig [UT faults, paleoseismology, source characterization]
  - Christine Puskas [GPS geodesy]
  - Bruce Trudgill [regional structure, salt tectonics]
  - Ivan Wong [source characterization, UT working group]

- **Unable to Attend:**
  - Chuck Mueller [earthquake catalog issues]
  - Mark Petersen [earthquake catalog issues]
  - Rus Wheeler [geologic basis for CEUS/WUS ground-motion boundary]

Workshop 2 – Alternative Models

Proposed SSC Proponent Experts and Topics

- James Coogan [Western State U., independent consultant] - detachment-related deformation
- Tony Crone [USGS] - paleoseismology
- Jesus Guerrero-Iturbe [U. Zaragosa] - Moab fault and salt tectonics (collaborator Ron Bruhn (U. Utah as possible alternate)
- Jim McCalpin [GEO-HAZ] - paleoseismology
- Mark Petersen [USGS] - fault classification and Pa decision-making
- Dave Schwartz [USGS] - paleoseismology, esp Wasatch and Bear River faults
- Bruce Trudgill [CO School Mines] - salt tectonics
- Ivan Wong [URS] - fault classification and Pa decision-making
- Walter Arabasz – Utah seismicity catalog
- Jim Peshman – Mining induced seismicity
- ? - Geodetic Data
- ? - Erosional unroofing isostatic rebound in Colorado Plateau

Workshop 2 – Alternative Models

Proposed GMC Proponent Experts and Topics

Rus Wheeler (CEUS vs WUS, Geologic Basis, USGS Perspective)
Paul Spudich (CEUS vs WUS, B&R GMPE)
Richard Stead (CEUS vs WUS Geologic Basis, LG Attenuation)
Gail Atkinson (CEUS vs WUS, Point Source Stochastic)
Dave Boore (CEUS vs WUS, NGA)
Mark Peterson (CEUS vs WUS, Geologic Basis, USGS Perspective)
Scott Phillips (CEUS vs WUS, LG Attenuation)
Andreas Reitbrok (CEUS vs WUS, Point Source Stochastic)
Linda Al-Atik (Site Correction)
Bob Herrmann (CEUS vs WUS, Geologic Basis)
Frank Scherbaum (Site Correction)
Bob Youngs (Sigma, CEUS vs WUS)
Richard Lee (Site Correction)
John Anderson (Site Correction, Kappa)
Ken Campbell (CEUS vs WUS, NGA))
Brian Chiou (CEUS vs WUS, Small Magnitude)
Adrian Rodriguez-Marek (Sigma)
Walt Silva (Site Correction)
Ivan Wond (CEUS vs WUS, WGUE Perspective)

Blue Castle SSHAC Level 3 Study

Project Plan, Organization and Schedule

William Lettis

October 27, 2011

Blue Castle SSHAC Level 3 Scope

Review of Project Plan, Organization and Schedule

- Outline of Project Plan
  - Objectives
  - Description of SSHAC Methodology
  - Selection of SSHAC Level
  - Project Organization
  - Work Plan
  - Schedule
  - Quality Assurance
- Conforms to NRC (2011) Draft NUREG
- Final Project plan incorporates PPRP comments

Blue Castle SSHAC Level 3 Objectives

(1) Develop fully hazard-informed SSC and GMC models for use in the Blue Castle PSHA for development of site GMRS

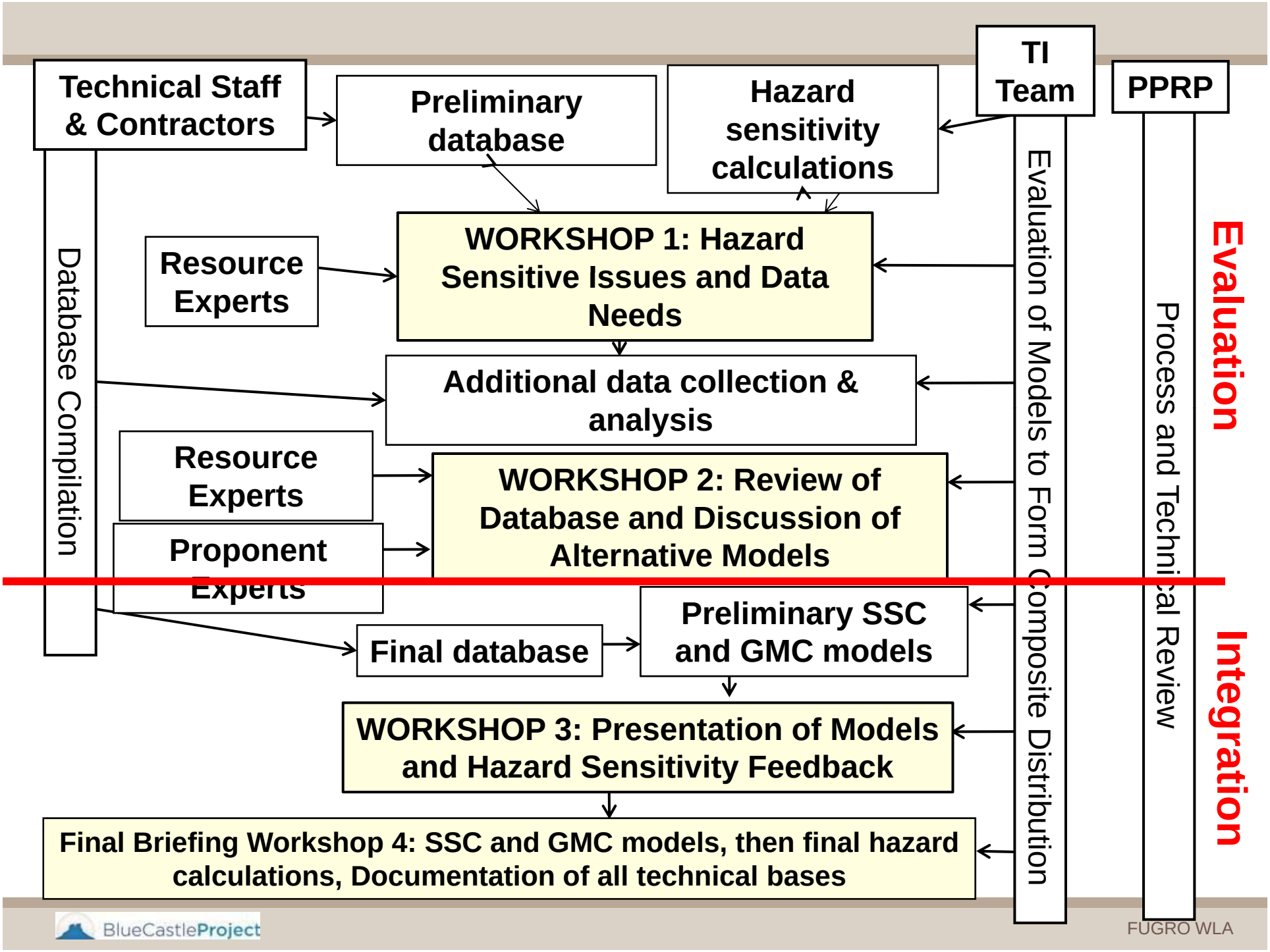
(2) Provide regulatory assurance that the site PSHA and GMRS adequately captures uncertainties in data and scientific knowledge

(3) Identify important data needs for reducing uncertainties in significant SSC and GMC parameters that can be fulfilled by the ongoing BCH field program

Description of SSHAC Level 3 Methodology

Basic Principals of the Blue Castle SSHAC Methodology

- Discussed Previously Under Seismic Overview
  - Process to obtain stable, reproducible PSHA with explicit assessment of uncertainty
  - Represent CBR of the TDI
  - Definition of Participants and Intellectual Ownership
  - Participatory Peer Review


Technical Staff & Contractors
Preliminary database
Hazard sensitivity calculations
TI Team
PPRP
Database Compilation
Evaluation of Models to Form Composite Distribution
Process and Technical Review
Evaluation
Resource Experts
WORKSHOP 1: Hazard Sensitive Issues and Data Needs
Additional data collection & analysis
Resource Experts
Proponent Experts
WORKSHOP 2: Review of Database and Discussion of Alternative Models
Integration
Final database
Preliminary SSC and GMC models
WORKSHOP 3: Presentation of Models and Hazard Sensitivity Feedback
Final Briefing Workshop 4: SSC and GMC models, then final hazard calculations, Documentation of all technical bases

Procedural Steps in SSHAC Level 3 Project

Essential Step	Discussion	Implementation
1. Select SSHAC Level	• Document decision criteria and process	• Justify in Project Plan
2. Develop Project Plan and QA PIs	• Includes all technical and process activities	• Discuss with NRC and PPRP
3. Select project participants	• Includes all management, technical, and peer review participants	• Identify and discuss with PPRP
4. Develop project database	• Includes compilation of existing, available data • Include focused new data collection • Data dissemination to all evaluator experts and TI Team members	• Comprehensive project database developed • Access by all project participants throughout project • Special development of geophysical data and paleoseismic data
5. Hold workshops	Workshop topics: • (1) Hazard-significant issues and available data • (2) Alternative interpretations • (3) Feedback	• Workshops held as required, plus: • PPRP briefings • NRC briefings

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Procedural Steps in SSHAC Level 3 Project

Essential Step	Discussion	Implementation
6. Develop preliminary model(s)	• Preliminary models developed prior to Feedback workshop	• Sensitivity model developed prior to WS3 Feedback • Preliminary SSC and GM model , Draft SSC and GM model also provide feedback
7. Perform preliminary hazard calculations and sensitivity analyses	• Hazard calculations should show the significance of all elements of the models • Sensitivity analyses should include the contributions to uncertainties	• Hazard calculations and sensitivity analyses conducted for Sensitivity, Preliminary, and Draft SSC models • Feedback used to identify key issues
8. Finalize models in light of feedback	• Feedback provides a basis for prioritizing and focusing the finalization process	• Progressive development of SSC and GM model through model-building cycles • TI Team working meetings for evaluation and integration process

Procedural Steps in SSHAC Level 3 Project

Essential Step	Discussion	Implementation
9. Perform final hazard calculations and sensitivity analyses	• Should be conducted to develop the required deliverables for subsequent use of the hazard results	• Hazard calculations and sensitivity analyses
10. Develop draft and final project report	• Fundamental documentation of SSHAC process, technical bases, and results	• Draft report reviewed by PPRP • Final report developed in light of reviewer comments and final model-building
1'. Participatory peer review of entire process	• Workshop review comments of key products and activities • Review of draft report • Final written review of technical evaluations and process used	• Active participatory review process • Written comments following workshops and briefings • Review of Final Report and final concurrence evaluation

SSHAC Participants and Roles

SSHAC defines several key concepts and roles

- Project Technical Integrator
- Technical Integrator (TI)
- Expert roles:
  - Evaluator expert
  - Resource expert
  - Proponent expert
  - Hazard analyst
- Participatory Peer Review Panel

Expert Roles

Project Technical Integrator

- An individual that serves as coordinator/facilitator of combined SSC and GMC SSHAC Study

Technical Integrator

- An individual or small team of evaluator experts that serves as integrator for the technical assessments
- Structures and documents information exchanges
- Stages effective debates and interactions in critical areas
- Responsible for capturing views of larger TDI and considering them in the evaluation process
- Responsible for documentation
- Intellectual ownership of final model

TI Team Responsibilities

- Evaluation
  - Identification of important issues and applicable data
  - Interaction with proponent and resource experts
  - Evaluate existing data, alternative models and methods from the larger technical community, and need for additional information
- Integration
  - Develop range of alternative models and uncertainties, given available data and proponent viewpoints, that represent the center, body, and range of the informed technical community
  - Imagine community's views if they had gone through the same evaluation process

Expert Roles (continued)

Resource Expert

- An expert with personal knowledge of a particular data set, interpretations and/or hypotheses
- Active participant in research of particular topic
- Participates in professional community through debates and literature
- Presents data and information without proponent bias

Expert Roles (continued)

Proponent Expert

- An expert who advocates a particular hypothesis or technical position
- Common role in science
- Peer review in professional debates and literature
- Ideas either gain support or fade with time
- Opinions may range from mainstream to extreme (or outlier) views

Expert Roles (continued)

Participatory Peer Review Panel (PPRP)

- Panel of individuals with SSHAC and PSHA experience that provide peer review of the SSHAC implementation process
- PPRP need not necessarily have technical knowledge of the site but provides technical review of the PSHA input parameters and uncertainties
- PPRP assures that views of the TDI are captured and documented through implementation of the SSHAC process

PPRP Responsibilities

- Continual review of technical and process aspects of the project
- Technical
  - Quality of the databases developed or compiled?
  - Have all data, models, and methods within the techncial community been considered?
  - Is the analysis of the available data reasonable?
  - Uncertainty tools appropriate and properly applied?
  - Models and assessments reasonable?
- Process
  - Activities consistent with SSHAC-3 process?
  - Considered available data, models, and methods?
  - Is documentation complete and clear?
- Endorsement

Selection of SSHAC Level 3

(1) SSHAC Methodology defines four different levels of study distinguished by increasing level of sophistication, resources, and participation by technical experts

(2) NRC expectations are that a SSHAC Level 3 or 4 study will be performed for sites in the WUS in areas where a similar level study has not previously been performed and accepted by the NRC

(3) A SSHAC Level 3 or 4 study should be performed in regions of
- Active, complex tectonic settings
- Potential for significant public impact/scrutiny
- Significant Regulatory scrutiny

(4) Based on this guidance and the absence of an approved SSC or GMC model for the BCH region, a SSHAC Level 3 study has been selected for the BCH ESP

(5) A SSHAC Level 4 study is not being used because of the significantly increased schedule requirement, and relatively minor increase in regulatory assurance associated with a Level 4 study

Blue Castle SSHAC Level 3 Project Organization

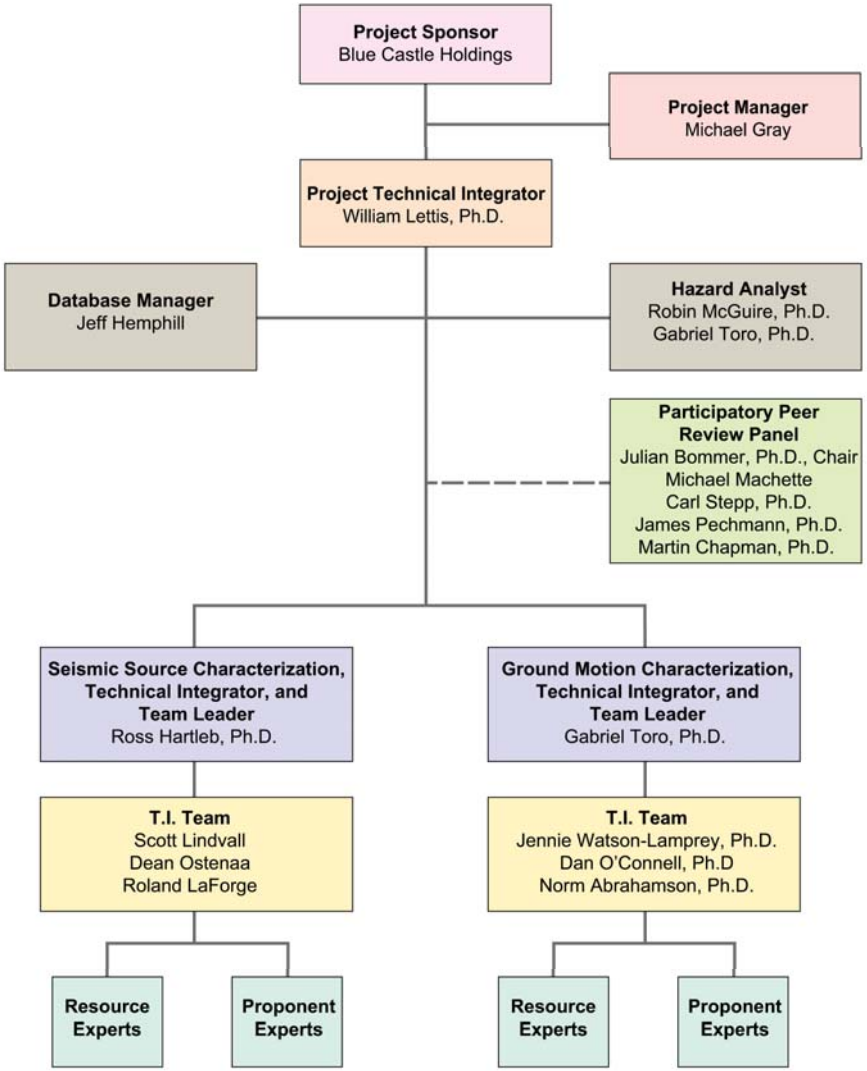
- The Blue Castle SSHAC Study will Involve Two Components
  - Seismic Source Model (SSC SSHAC)
  - Ground Motion Attenuation Model (GMC SSHAC)

- One Project Technical Integrator (PTI) will oversee both SSHAC studies

- One Participatory Peer Review Panel (PPRP)

- Each SSHAC Study will necessarily involve different professionals for the Technical Integrator Staff, Evaluator staff, and Resource and Proponent experts

Blue Castle SSHAC Organization



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Blue Castle SSHAC Level 3 Work Plan

Work Plan includes

(1) Formal Structured Workshops with Resource and Proponent Experts
(2) Working Meetings of the SSC and GMC TI Teams
(3) Interface opportunities between the GMC and SSC TI Teams and ongoing Blue Castle field investigations
(4) Comprehensive documented SSC and GMC database
(5) Explicit process of Evaluation and Integration
(6) Continual participatory peer review

Goals for Blue Castle SSHAC Level 3 Workshops

- Workshops are an opportunity for the TI Team to:
  - Exchange data
  - Understand viewpoints of technical community
  - Challenge and defend technical hypotheses
  - Gain information on the project
  - Interact and ask questions
- Therefore, the focus of the workshops is on the TI Team
- PPRP provides oversight on the SSHAC process and reviews technical information

SSHAC Level 3 Workshops

- **Workshop 0 – SSHAC Training and Significant Issues**

  - Review project SSHAC Level 3 Methodology and Processes
  - Assess data and information available
  - Initial Sensitivity Analysis
  - Identify key technical issues and questions
  - Identify key data needs and appropriate Resource and Proponent Experts

  Attendees: TI Staff, Evaluator team, PPRP

  Length: 2 days

  - Working Meetings to develop initial SSC and GMC V0 Conceptual Framework model

SSHAC Level 3 Workshops (cont'd)

Workshop 1 – Significant Issues and Data Needs

- Introduce projects goals, expectations, schedule
- Review SSHAC methodology
- Review workshop ground rules, Resource Expert roles
- Identify key hazard-significant SSC and GMC issues
- Review available data to address key issues, including formats, quality, and uncertainties
- Identify additional data needs to reduce uncertainties
- PPRP feedback and comments

Attendees: TI Staff, Evaluator team, PPRP, Resource Experts, Hazard Analyst

Length: 4 days

- *Working Meetings to develop preliminary SSC or GMC V1 Model*

SSHAC Level 3 Workshops (cont'd)

- **Workshop 2 – Alternative Models**
  - Goals
    - To provide an opportunity for the TI team to understand proponent views regarding important technical issues
    - To discuss the range of alternative models and uncertainties within the larger technical community

- Presentations of data, interpretations and models directly from the Proponent experts, including explanations of topics requested by the TI and Evaluator team

- Question/answer period

Attendees: TI Staff, Evaluator team, PPRP, Proponent Experts, Hazard Analyst. Length: 2 to 3 days.

- *Working Meetings to develop preliminary V2 SSC and GMC Model*

SSHAC Level 3 Workshops (cont'd)

- **Workshop 3 – V2 Model and Hazard Feedback Workshop**

  - Present SSC and GMC V2 logic tree of alternative models including discussion of epistemic uncertainty

  - Present Sensitivity Analyses by Hazard Analyst

  - Identify Additional Sensitivity Analyses to be performed by Hazard Analyst (if any)

  Attendees: Same as Workshop 2 (selected Resource and Proponent Experts only)

  Length: 1 to 2 days

  - *Working meetings to develop final models and for Hazard Analyst to perform sensitivity analyses*

SSHAC Level 3 Workshops (cont'd)

- **Workshop 4** - **Final V3 Model Workshop (also called Final Briefing)**

  - Present Final logic tree of alternative models for PPRP review and comment Attendees: TI Staff, Evaluator team, PPRP Length: 1 to 2 days

Blue Castle SSHAC Schedule

Tasks	2011						2012												2013	
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
1: Preparation for Workshop 0																				
2: Workshop 0 - SSHAC Training and Data Needs																				
3: Data Collection and Initial Model Evaluation																				
4: Workshop 1 - Significant Issues and Data Needs																				
5: Data Evaluation and V1 Model Development																				
6: Workshop 2 - V1 Model Feedback and Alternative Models																				
7: V2 Model Development and Hazard Sensitivity																				
8: Workshop 3 - V2 Model and Hazard Sensitivity Feedback																				
9: V3 Model Development and hazard Sensitivity Feedback																				
10a: Conference Call - V3 GMC Model Presentation																				
10b: Workshop 4 - Final Briefing of V3 SSC and GMC Model																				
11a: GMC Report Preparation																				
11b: SSC Report Preparation																				

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Blue Castle SSHAC Level 3 Study

NRC Discussion Topics

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Sensitivity Analysis

- Sources beyond 320 Kilometers
  - Sangre de Cristo Fault – not significant to hazard
- CEUS vs WUS GMPEs is significant
- Faults within 40 kilometers are significant
  - Tectonic vs Salt-Related Faults is Significant Topic
- Geometry and Mmax of Areal Source Zones are significant

Seismic Source Characterization

- **Process to identify and characterize areal and fault sources**
  - Evaluate existing data compilations
    - USGS Quaternary fault and fold database
    - Utah, Colorado and Arizona State Surveys
  - Evaluate published and unpublished literature and data
  - Interview technical community (SSHAC process - Resource and Proponent Experts)
  - Perform Sensitivity Analysis
    - Identify and focus additional study on hazard-significant issues
  - Perform directed studies
    - LIDAR, detailed mapping, paleoseismic trenching, seismic reflection

Recurrence Models

- Fault Sources
  - Truncated Exponential and Characteristic Models
- Areal Sources
  - Test Constant Seismicity with Maximum Likelihood
  - If not Valid:
    - Adaptive Kernel
    - Penalized-Likelihood (CEUS approach)

Earthquake Catalog

- Update to Utah Seismicity Catalog
  - Review USGS catalog
  - Evaluate/remove mining induced seismicity
  - Convert to uniform magnitude scale (M)

Significant GMC Issues

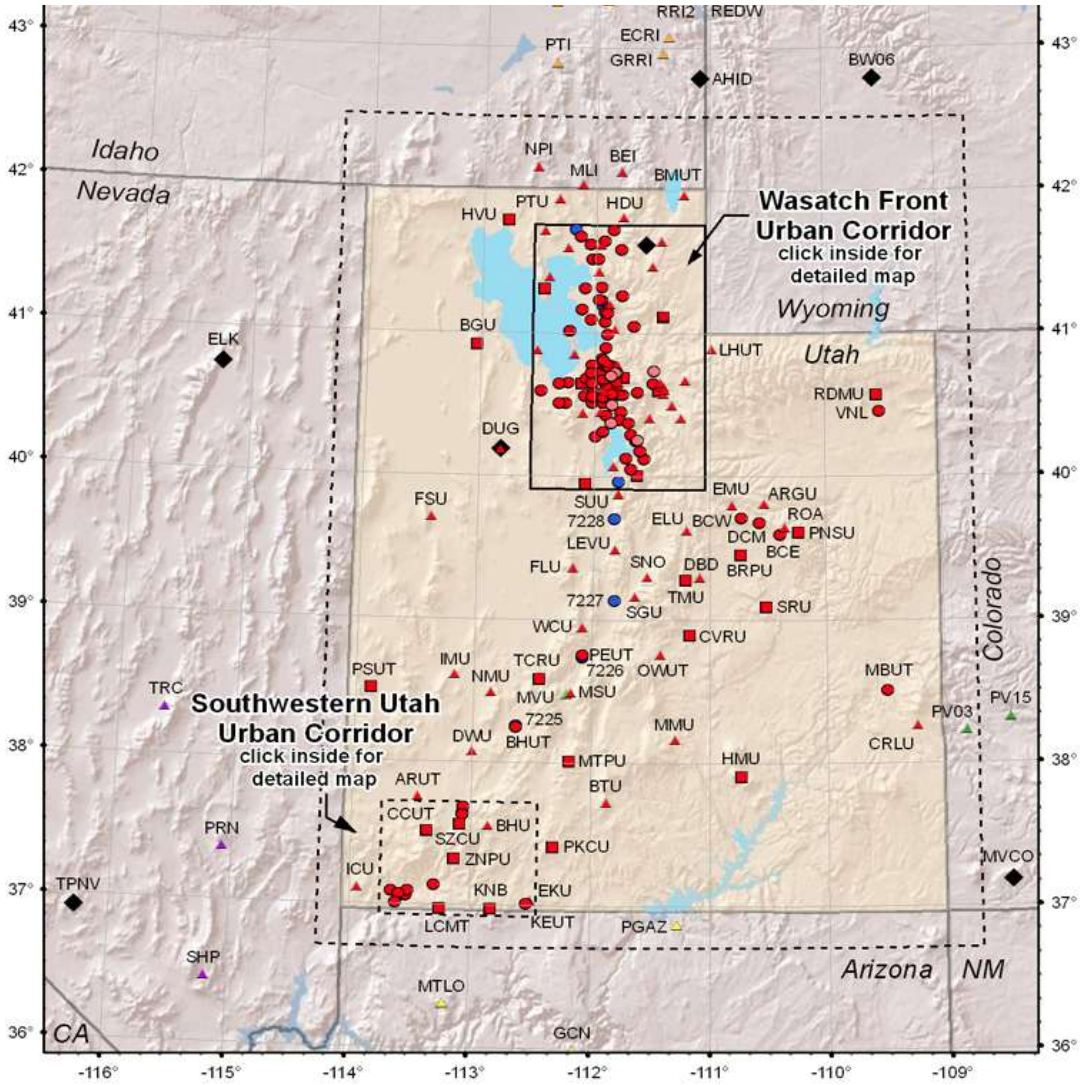
- Western US vs. Central and Eastern US ground motion attenuation relationships
- NGA West 2 models
- Small magnitude earthquakes: value and limitations
- Stress drop
- Kappa and Vs30 scaling
- Site-specific rock ground motion
- Sigma: single station?
- Addition of a point source stochastic model to list of GMPEs

Ground Motion Prediction Equations (GMPE's)

- Resolution of CEUS vs WUS
  - Definition – Geologic vs Ground Motion
    - Meet with Resource and Proponent Experts
- Independent Verification
  - Compare actual ground motion data from B&R and RM earthquakes recorded in CP at 4 or 5 frequencies
  - Are ground motions recorded in host region indicative of WUS or CEUS
- Available Data
  - Broadband Stations in Utah (1998-2011)
    - 46 recorded earthquakes M>4.0 (ANSS and IRIS Cataloges)
  - Earthscope Experiments (2007-2009)
    - 8 recorded earthquakes M>3.0 (ANSS and IRIS Cataloges)
- In Addition, INL and NGA West1 Data

Utah Broadband Data

Over 200 Stations



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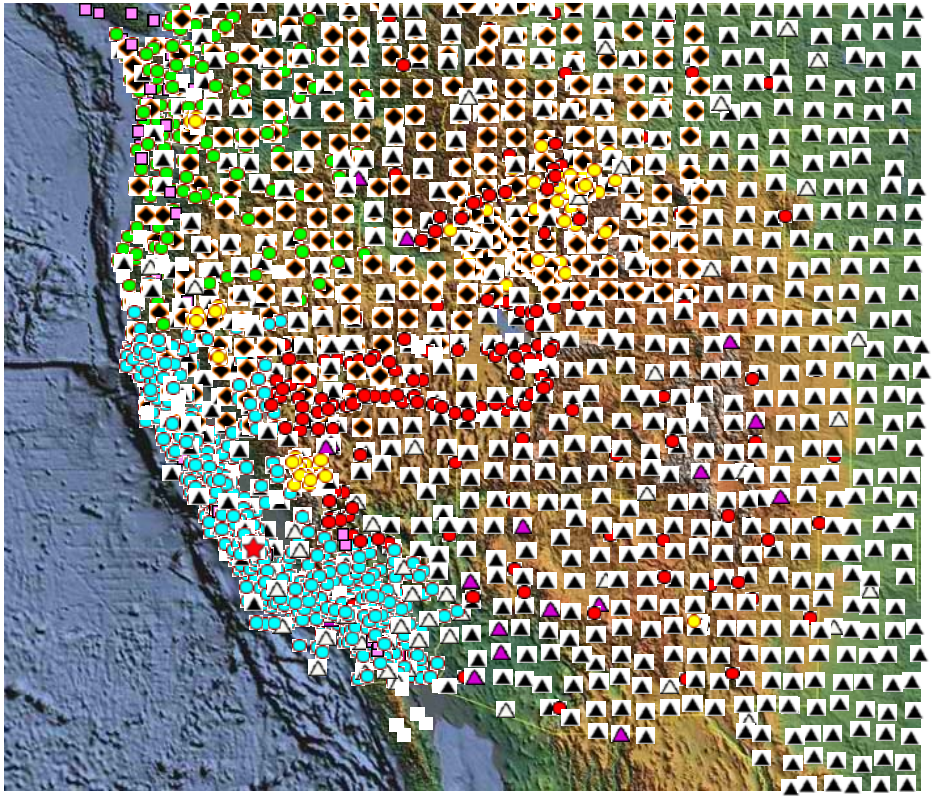
Earthscope Data



Site Response Analysis Methodology

- Approach will be to develop GMPE's directly for competent layer (~2000 m/s Vs30).
  - Avoid need for a separate site-response analysis.

Thank You

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