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EPRI (2004,2006) Ground Motion Model (GMM) Review Project

Nuclear Regulatory Commission
Public Meeting
October 18, 2012

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REVIEW: OVERVIEW

Background:

- The EPRI (2004, 2006) Ground Motion Model (GMM) Review Project will provide industry information necessary specifically for an informed response to the NRC Request for Information (RFI) to Title 10 of the Code of Federal Regulation 50.54(f) Recommendation 2.1 of the Near-Term Task Force (NTTF) Review of Insights from the Fukushima Dai-Ichi Accident dated March 12, 2012.
- The project will provide information for developing site-specific ground motion response spectra (GMRS) for existing nuclear power plant sites and other seismic regulatory issues pending completion of the NGA-East Ground Motion Model.
- The industry position is to review and, if necessary, update the EPRI (2004, 2006) GMM: This position is prudent in light of guidance in NUREG-2117 (2012), input from ground motion experts and seismologists contacted from October 2011 to March 2012 and new data, models and methods that have become available since the SSHAC Level 3 EPRI (2004) workshops were held in 2002.

Purposes:

- Review and Update, if appropriate, the EPRI (2004, 2006) GMM for the need of calculating GMRS for existing nuclear power plant sites in response to the NRC RFI of the NTTF recommendation for seismic using an approach that can be accepted by the NRC
- Increase the accuracy of input to compute ground motion response spectra (GMRS) required in NTTF Recommendation 2.1 for seismic

CURRENT HIGHLIGHTS

- Task 1: Completed and Posted Project Plan on June 18, 2012;
- Task 2: Reviewed Ground-Motion Database, Reviewed New CEUS Ground Motion Prediction Equations (GMPEs), and Conducted Resource Expert and Proponent Interviews;
- Task 3: Obtained Shear Wave Velocity Measurements at Recording Stations;
- Task 4: Tested the EPRI (2004, 2006) Ground Motion Model (GMM);
- Task 5: Updating the EPRI (2004, 2006) Ground-Motion Model
- Task 6: Held Feedback Workshop on October 17, 2012
- Developed Project Schedule and Path Forward

Questions

Phase 1 - Decision Point 2:

- Is the EPRI (2004, 2006) Ground – Motion Model (GMM) consistent with current (2012) data, models and methods? NO

- Does the preponderance of evidence obtained from Phase 1 require that Phase 2 be completed to assess the seismic hazard differences between the old and updated model? YES

- Should the EPRI (2004, 2006) GMM be updated? YES

Questions (continued)

Phase 2 – Feedback Workshop:

- Is the Updated EPRI (2004, 2006) Ground – Motion Model (GMM) consistent with current (2012) data, models and methods?

- Are there any significant issues that have been overlooked?

- Can the Preliminary Updated EPRI (2004, 2006) Ground – Motion Model (GMM) be used to commence hazard calculations for 7 demonstration sites (Task 7)?

Basis for Recommendation to Proceed to Update the EPRI (2004, 2006) Ground-Motion Model

- Seven (7) of the thirteen (13) developers of the ground motion prediction equations (GMPEs) used in the EPRI (2004, 2006) GMM recommended that their GMPEs be replaced.
- There are three new GMPEs developed by ground motion experts during the past ten (10) years.
- Eighty percent (80%) of the earthquake records in a new ground motion database are from earthquakes that occurred after the development of the EPRI (2004) GMM.
- The EPRI (2004, 2006) GMM over-predicts ground motions at some magnitude-distance-frequency ranges important to nuclear power plant (NPP) probabilistic seismic hazard assessments (PSHAs).

EPRI (2004) GMM

Cluster	Model Type	Models
1	Single Corner Stochastic (0.275/0.351)	~~Hwang and Huo (1997)~~ ~~Silva et al (2002) - SC-CS~~ Silva et al (2002) - SC-CS-Sat Silva et al (2002) - SC-VS Toro et al (1997) Frankel et al (1996)
2	Double Corner Stochastic (0.312/0.399)	~~Atkinson and Boore (1995)~~ ~~Silva et al (2002) DC~~ Silva et al (2002) DC - Sat
3	Hybrid (0.196/0.250)	~~Abrahamon & Silva (2002)~~ ~~Atkinson (2001) & Sadigh et al (1997)~~ ~~Campbell (2003)~~
4	Finite Source /Greens Function (0.217/0.000)	Somerville et al. (2001)

Task 2 Results: Literature Reviews and Interviews

Models No Longer Recommended by Developers:

- Cluster No.1: Spectral, Single Corner:
  - Silva et al. (2002) – SC-CS
  - Hwang & Huo (1997)
- Cluster No. 2: Spectral, Double Corner
  - Atkinson & Boore (1995)
  - Silva et al. (2002) DC
- Cluster No. 3: Hybrid
  - Abrahamson & Silva (2002)
  - Atkinson (2001) & Sadigh et al. (1997)
  - Campbell (2003)
- Cluster No. 4: Finite Source/Greens Function
  - None

New Candidate Models

- Atkinson-Boore (2006 with 2011 revisions: AB06')
  - Replaces Atkinson-Boore 2-corner
  - Recommended by Atkinson and Boore
- Atkinson (2008, with 2011 revisions; A08')
  - Candidate for Hybrid Cluster, recommended by Atkinson
- Pezeshk et al. (2011)
  - Candidate for Hybrid Cluster, recommended by Campbell and Pezeshk
- Silva et al. (2003):
  - nearly identical to Silva et al. (2002); treat as equivalent

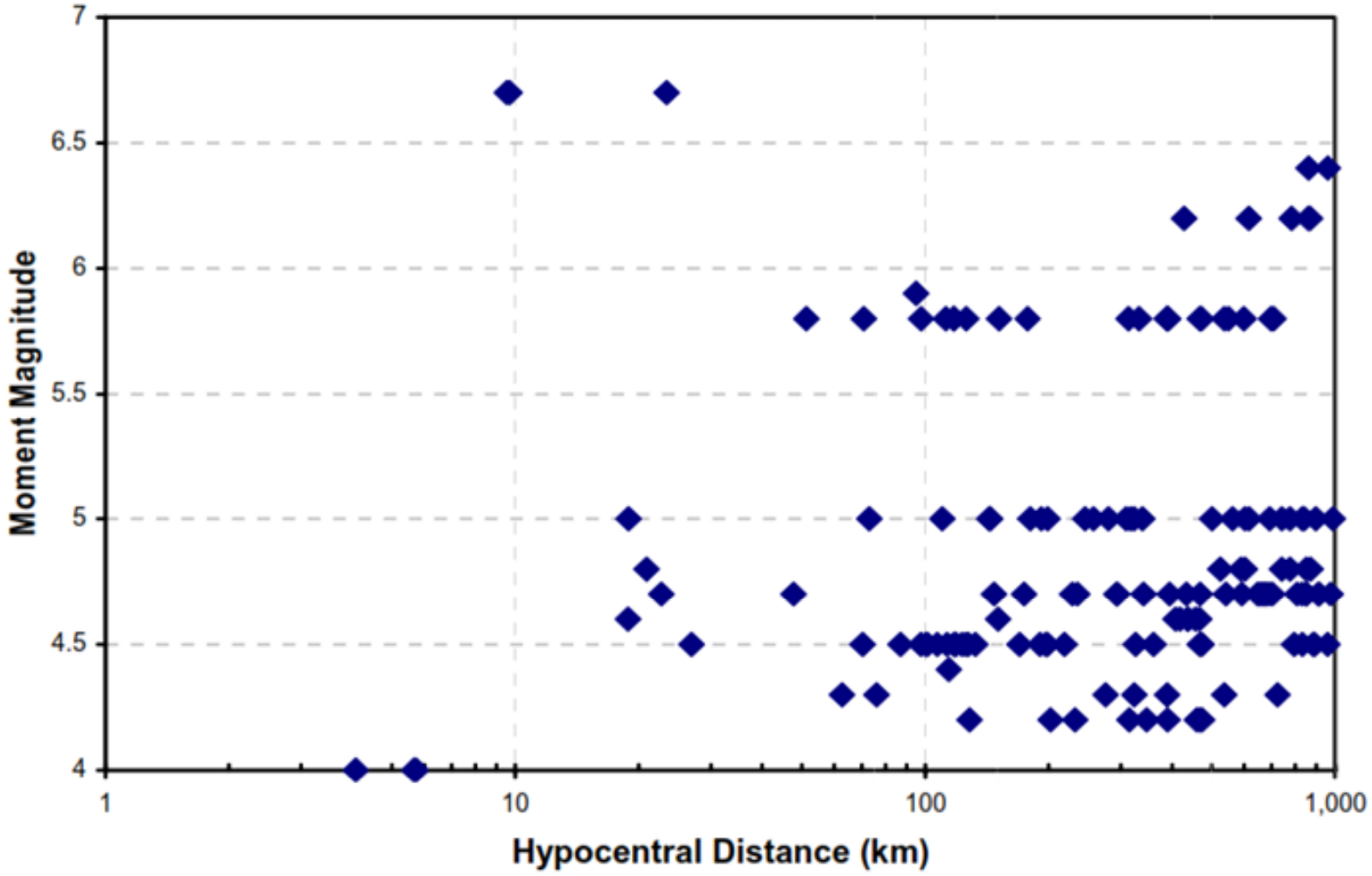
Task 2 Results: Summary

- Three (3) new ground motion prediction equations (GMPEs) are available
- Predictions are similar among the three for M5 and not too different for M7
- No new single–corner models
  - Should keep some of them (Frankel & Silva recommendations) but could down-weight if large residuals
- Proposal
  - AB06' →2-corner stochastic (replaces AB95)
  - A08' and PZT11 →hybrid (replace AS02, A01;S97, C03)

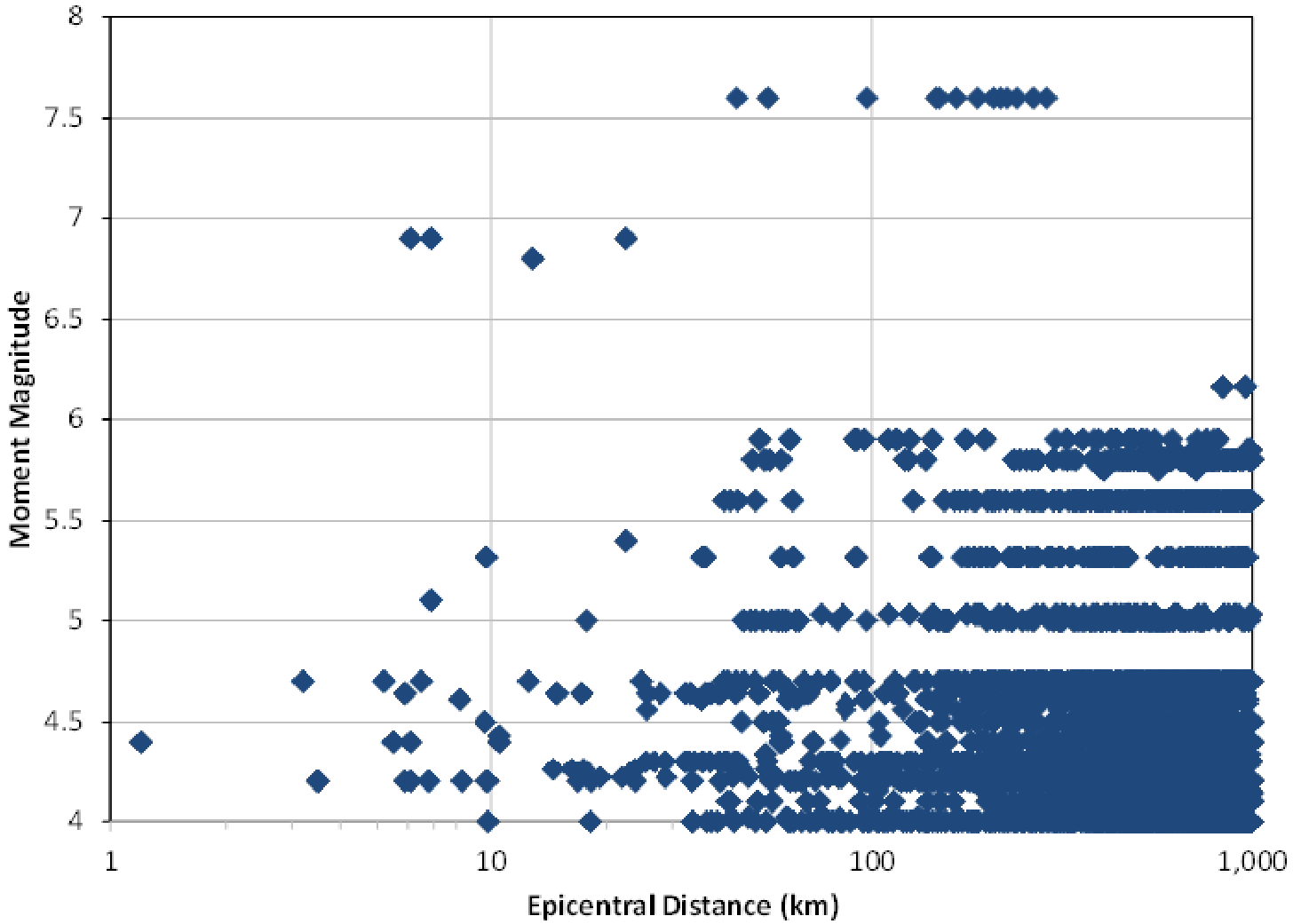
REVIEW: NGA-EAST DATABASE

- Data and metadata from earthquakes in CENA including some recent earthquakes:
  - M4 and greater with any records within 1000km
  - M2.5 to M4 with five or more recordings within 100km
- Number of records is nearly 28,000
- Each record has a flag indicating its quality
- Includes notable earthquakes not in EPRI (2004) study:
  - 2008 M5.3 Mt. Carmel, IL
  - 2010 M5.0 Val des Bois, Quebec
  - 2011 M5.8 Mineral VA earthquake (about 300 recordings) and one M4.5 aftershock
  - 2011 M5.6 Sparks Oklahoma
- Eighty Percent (80%) of the records are from earthquakes that occurred since 2004

REVIEW: EPRI (2004) GMM: MAGNITUDE-DISTANCE PLOT



REVIEW: MAGNITUDE-DISTANCE PLOT – NGA-EAST



Task 4: Comparisons to Site-Adjusted Ground-Motion Data using NGA-East Database

Comparisons to Site-Adjusted Ground-Motion Data:

- Sites with measured shear-wave velocity (this study, NGA-East, USGS)
- Analytically derived corrections

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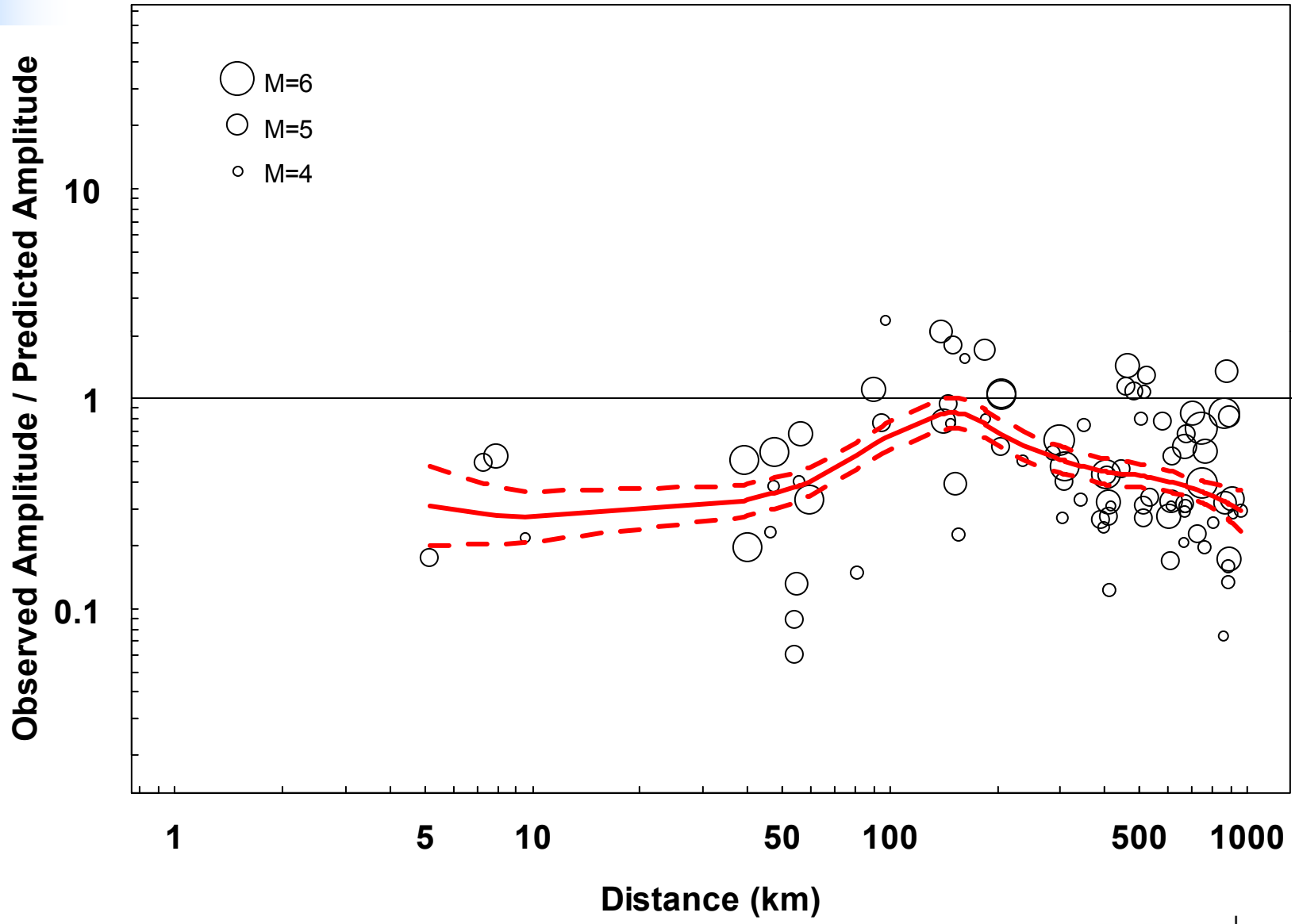
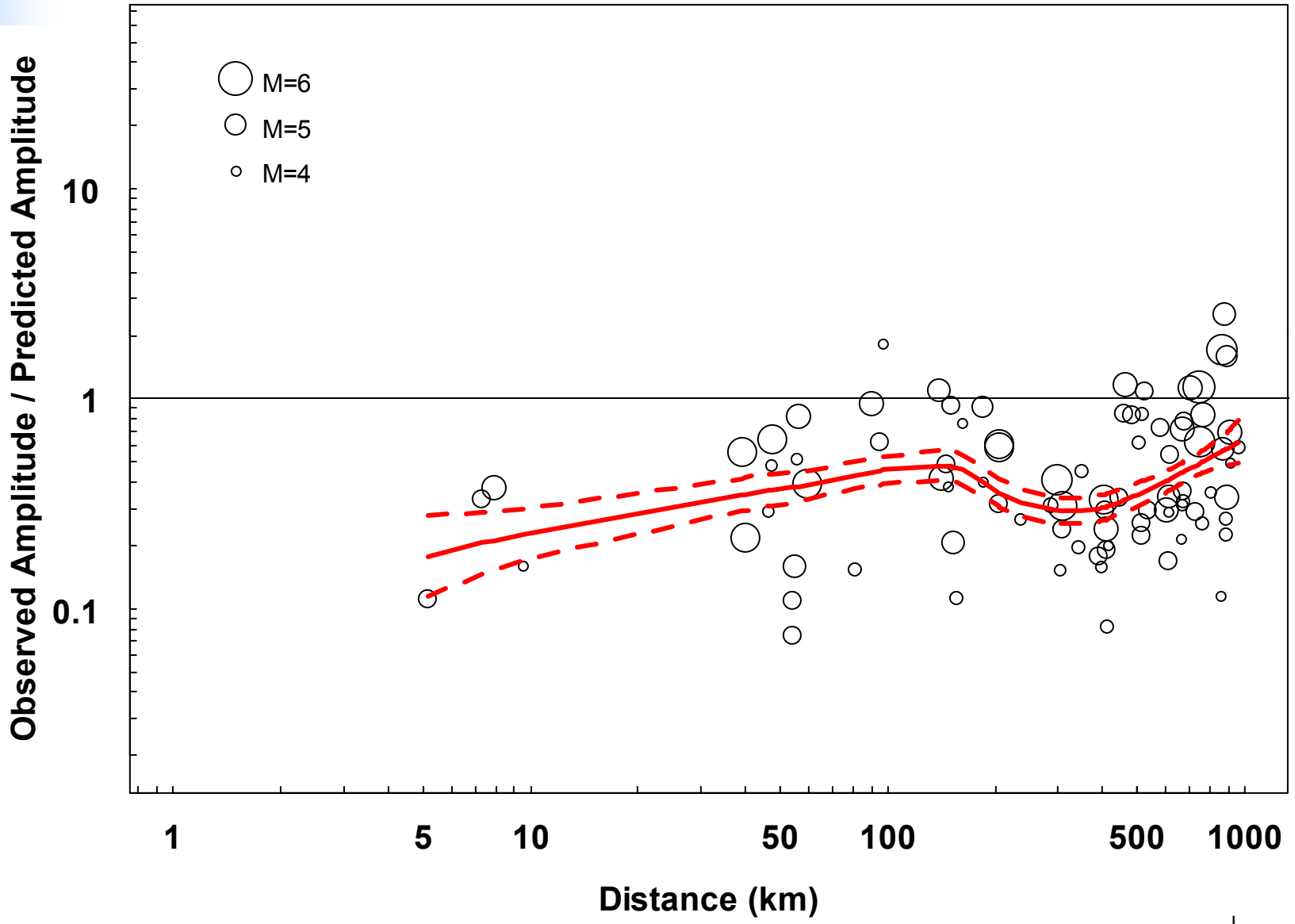
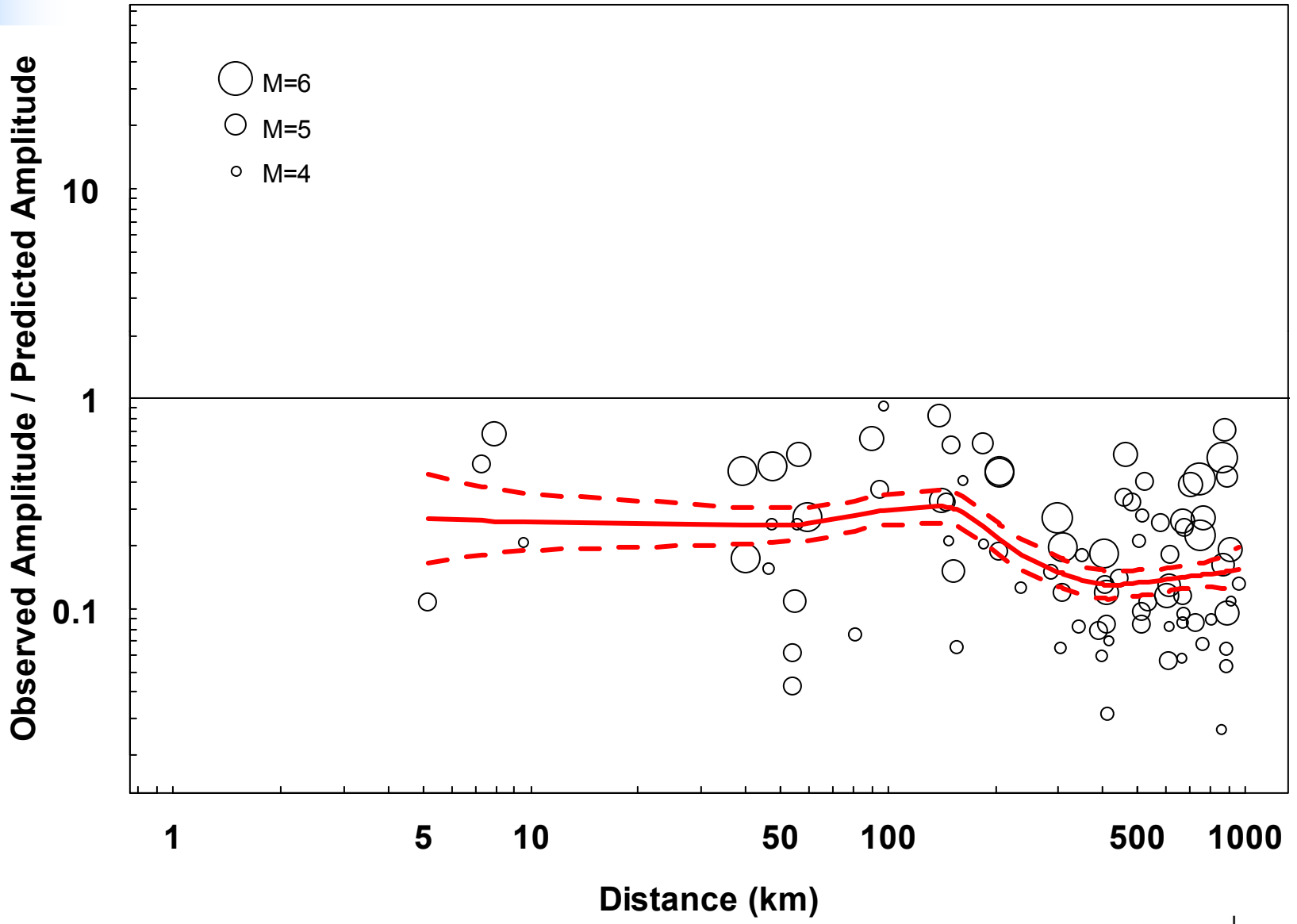
Corrected Residuals w.r.t. Cluster 1, 10 Hz



Corrected Residuals w.r.t. Cluster 2, 10 Hz



Corrected Residuals w.r.t. Cluster 3, 10 Hz



Task 5 Results

EPRI (2004) GMM

Cluster	Model Type	Models
1	Single Corner Stochastic (0.275/0.351)	~~Hwang and Huo (1997)~~ ~~Silva et al (2002) - SC-CS~~ Silva et al (2002) - SC-CS-Sat Silva et al (2002) - SC-VS Toro et al (1997) Frankel et al (1996)
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3	Hybrid (0.196/0.250)	~~Abrahamon & Silva (2002)~~ ~~Atkinson (2001) & Sadigh et al (1997)~~ ~~Campbell (2003)~~
4	Finite Source /Greens Function (0.217/0.000)	Somerville et al. (2001)

Weights for High Frequency (f>2.5 Hz)

Cluster	Model Type	Models
1	Single Corner Stochastic **0.15**	Silva et al (2002) - SC-CS-Sat – **0.53** Silva et al (2002) - SC-VS – **0.36** Toro et al (1997) – **0.08** Frankel et al (1996) – **0.03**
2	Double Corner Stochastic **0.50**	Atkinson and Boore (2006') – **0.36** Silva et al (2002) DC – Sat – **0.64**
3	Hybrid **0.15**	Atkinson (2008') – **0.79** Pezeshk et al. (2011) – **0.21**
4	Finite Source /Greens Function **0.20**	Somerville et al. (2001) – **1.00**

Weights for Low Frequency (f≤2.5 Hz)

Cluster	Model Type	Models
1	Single Corner Stochastic **0.00**	Silva et al (2002) - SC-CS-Sat – **0.40** Silva et al (2002) - SC-VS – **0.59** Toro et al (1997) – **0.00** Frankel et al (1996) – **0.01**
2	Double Corner Stochastic **0.54**	Atkinson and Boore (2006') – **1.00** Silva et al (2002) DC – Sat – **0.00**
3	Hybrid **0.45**	Atkinson (2008') – **0.32** Pezeshk et al. (2011) – **0.68**
4	Finite Source /Greens Function **0.01**	Somerville et al. (2001) – **1.00**

Update to EPRI (2006) Aleatory Variability Model

- Results of interviews with experts did not indicate a need to change the conclusions of EPRI (2006) with regard to differences between CENA and WNA aleatory variability
- Repeated analysis using final published values of aleatory variability from NGA (2008) papers for 4 models which provided both inter-event and intra-event aleatory components
- Increase WNA inter-event aleatory variability by 0.03 units, do not adjust WNA intra-event aleatory variability
- Will need to revisit this for final model based on preliminary results of NGA West 2 due in mid November

Review: Status

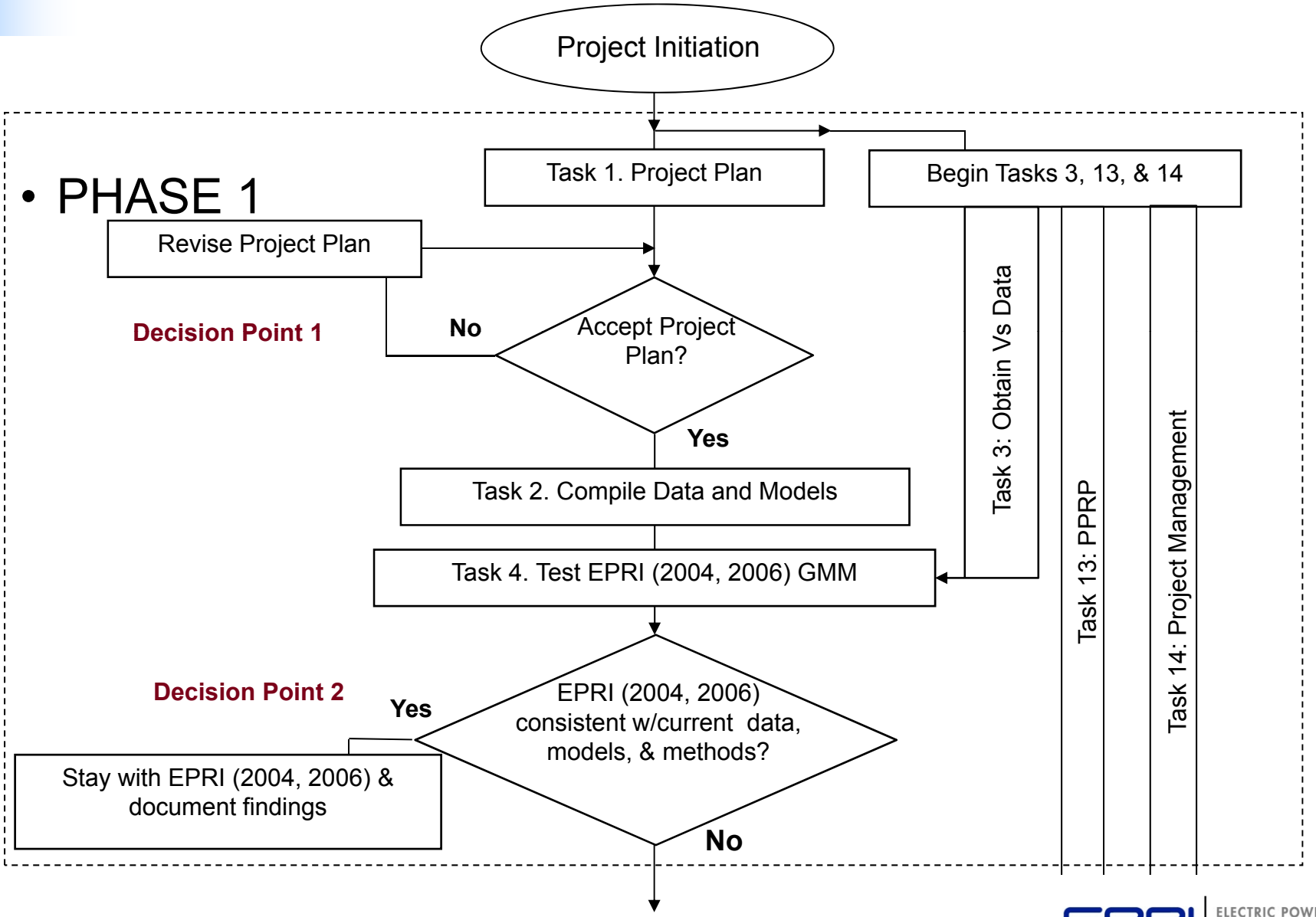
- Incorporate NRC comments into Project Plan (Completed – May 7, 2012);
- **Working Meetings:**
  - Working Meeting #1 (Conference Call) (Completed - March 8, 2012)
  - Working Meeting #2 (Completed – April 26, 2012)
  - Working Meeting #3 (Completed - May 24, 2012)
  - Working Meeting #4 (Completed - June 27, 2012)
  - Working Meeting #5 (Completed - August 14, 2012).
  - Feedback Workshop (Completed – October 17, 2012
- **PM and TI Team Conference Calls:** June 13, 2012; June 20, 2012, July 2, 2012; July 10, 2012; July 17, 2012; July 27, 2012; August 2, 2012; August 3, 2012 (Project Team); August 13, 2012; September 3, 2012; September 10, 2012; September 20, 2012 (Project Team); October 2, 2012; October 9, 2012 and October 16, 2012
- Publish EPRI (2004, 2006) GMM Review Project Plan as EPRI Technical Update (May 2012) Completed June 18, 2012);
- Project Shear Wave Velocity Measurements at Recording Stations (Completed field program July 12, 2012 – 33 recording stations plus two overlapping recording stations; Received all preliminary Vs data on August 7, 2012; Completed Vs Data Reports on August 2012; Obtained NGA-East database – Completed - June 11, 2012);
- Obtain NGA-East Ground Motion Database (Version 2.2) from NGA-East Project (Completed May 31, 2012);
- Identify Ground Motion Prediction Equations (GMPEs) developed after 2002 (Completed);
- Obtain Preliminary USGS Shear Wave Velocity Measurements at 25 Recording Stations (Completed September 28, 2012)

What's Next

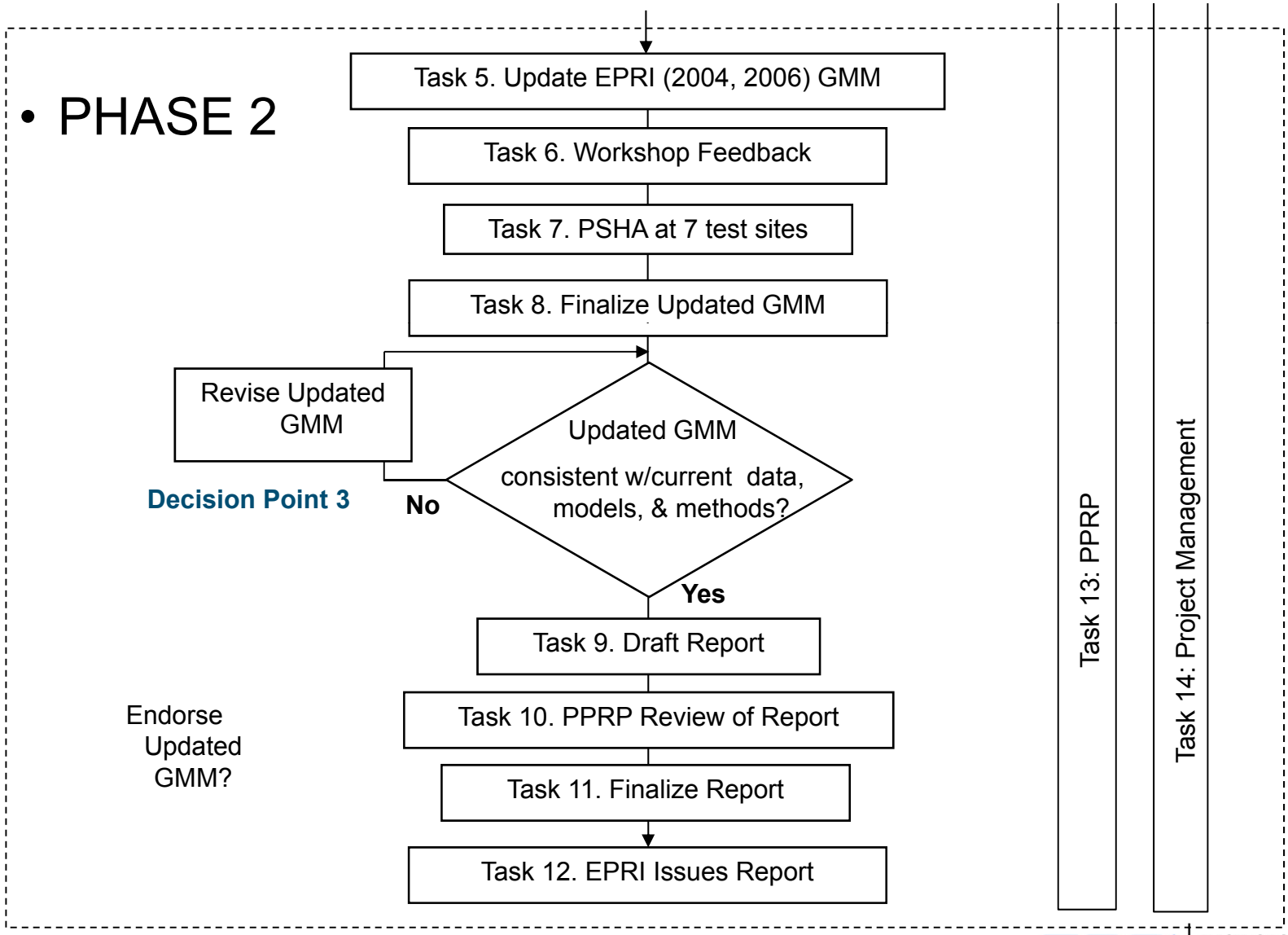
- Obtain Additional Feedback Following Workshop at EPRI:
  - Obtain Draft PPRP Feedback Report (October 23, 2012);
  - Obtain Final PPRP Feedback Report (October 26, 2012);
  - Obtain Any Additional Resource Expert and Proponent Feedback (October 26, 2012);
- Complete Comparison of Hazard Results Using Old and Updated GMM Model at 7 Test Sites (December 31, 2012);
- Closure Briefing at EPRI (February 13, 2013) and
- Publish EPRI (2004, 2006) GMM Review Project Report (April 2013)

SSHAC-Required Documentation

REVIEW: Project Plan: FLOW CHART



REVIEW: Project Plan: Flow Chart (continued)



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