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From: Clifford Munson
Sent: Monday, March 03, 2008 11:09 AM
To: Niles Chokshi; Joseph Sebrosky
Subject: Fwd: Notes for further NRC discussions
Attachments: Notes on ETSZ.pdf

Joe,

Here is what we got from Leslie this morning. No scheduling items.

Cliff
>>> "KASS, Leslie" <lck@nei.org> 03/02/2008 10:02 PM >>>

Becky and team,

Attached please find the additional information that we discussed on Friday's call regarding the ETSZ.

We look forward to speaking to you again on Tuesday at 1pm EST. Please let me know if you have any questions. Thank you.

Leslie

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Hearing Identifier: Bellefonte_COL_NonPublic_EX
Email Number: 724

Mail Envelope Properties (C4A4C9A16294FB4CBA5A36312D05FFAC034CBD45C1)

Subject: Fwd: Notes for further NRC discussions
Sent Date: 3/3/2008 11:08:50 AM
Received Date: 3/3/2008 11:08:50 AM
From: Clifford Munson

Created By: Clifford.Munson@nrc.gov

Recipients:
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Tracking Status: None
"Joseph Sebrosky" <Joseph.Sebrosky@nrc.gov>
Tracking Status: None

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Files	Size	Date & Time
MESSAGE	1708	3/3/2008 11:08:50 AM
Notes on ETSZ.pdf	651494	

Options
Priority: Standard
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Sensitivity: Normal
Expiration Date:
Recipients Received:

Notes on seismic hazard sensitivity studies for Eastern Tennessee Seismic Zone

3 March 2008—R. McGuire

Maximum magnitude values

The TIP study (Ref. 1) and TVA Dam Safety study (Ref. 2) used distributions of maximum magnitude $M_{\max}$ that are somewhat higher than values used in the EPRI-SOG study. Figure 1 shows distributions of values used in the TIP and TVA studies, on the moment magnitude (M) scale.

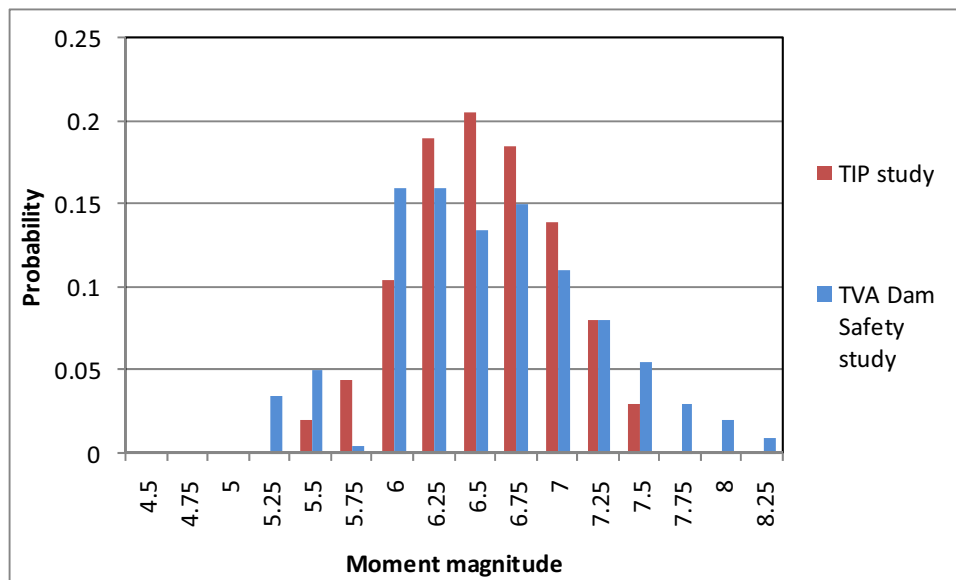


Figure 1: Distributions of $M_{\max}$ (on the moment magnitude scale) for the TIP and TVA studies.

These distributions have the following means and standard deviations (σ):

	<u>mean M</u>	<u>σ</u>
TIP study:	6.55	0.202
TVA Dam Safety study:	6.58	0.411
Composite:	6.56	0.307

Values for the composite distribution were determined by equally weighting the TIP and TVA distributions in Figure 1 and calculating the mean and σ .

For sensitivity studies on seismic hazard, the composite distribution can be represented with three magnitude values with weights, as follows:

<u>M value</u>	<u>equivalent m_b value</u>	<u>weight</u>
6.2	6.4	0.28
6.6	6.7	0.44

	7.0	6.9	0.28
Mean	6.60	6.67	
σ	0.299	0.190	

where the equivalent body-wave magnitude (m_b) values are computed by equally weighting the conversion equations from Atkinson and Boore (1995), Frankel et al. (1996), and EPRI (1993). The 3-point **M** distribution is one of many that could be chosen to represent the mean and σ of the composite distribution; the chosen values of **M** and m_b are on even tenths of a magnitude unit and will be consistent with the numerical integrations used for seismic hazard calculations. The distribution of **M** above (and the equivalent values of m_b) are referred to as the “composite distribution” in the next section.

EPRI-SOG source representations

The six EPRI-SOG teams represented seismicity in the region of eastern Tennessee with a range of seismic sources. These sources are summarized in Figure 2. They range from very localized sources capturing the seismicity in the eastern Tennessee region, to broad tectonic sources reflecting the geologic and tectonic structure, to large background sources that represent non-tectonic, “none-of-the-above” sources.

The specific EPRI-SOG interpretations, and the manner which they can be modified to determine the sensitivity to changes in $m_{\max}$ and seismicity for the eastern Tennessee region, are as follows. For sources that represent a tectonic explanation for the eastern Tennessee region, the $m_{\max}$ distribution will be modified to reflect the composite distribution described above. For sources that represent a background interpretation that is applicable when the tectonic sources are not active, the team’s original $m_{\max}$ distribution will not be modified to reflect the composite distribution. As summarized below, this occurs with a combined probability of about 0.21.

For these sensitivity studies, seismicity parameters will be updated using an extension of the EPRI-SOG catalog through 2007.

Bechtel team. Bechtel used 3 sources with mutually exclusive activity to represent seismicity in eastern Tennessee, as follows. (The original $m_{\max}$ values listed below are for the m_b magnitude scale, as published in the EPRI-SOG documents).

Source	Name	P[activity]	Seismicity	Orig. $m_{\max}$	Modified $m_{\max}$
BEC-24	Bristol Trends	0.25	Updated (2007)	5.7-6.6	Composite
BEC-25	NY-AL lineament	0.30	Updated (2007)	5.4-6.6	Composite
BEC-25A	Altern. geom. for 25	0.45	Updated (2007)	5.4-6.6	Composite
Total:		1.00			

The Bechtel team’s sources will be represented as 3 mutually exclusive sources with updated seismicity parameters (using the catalog extended through 2007) and the composite $m_{\max}$ distribution.

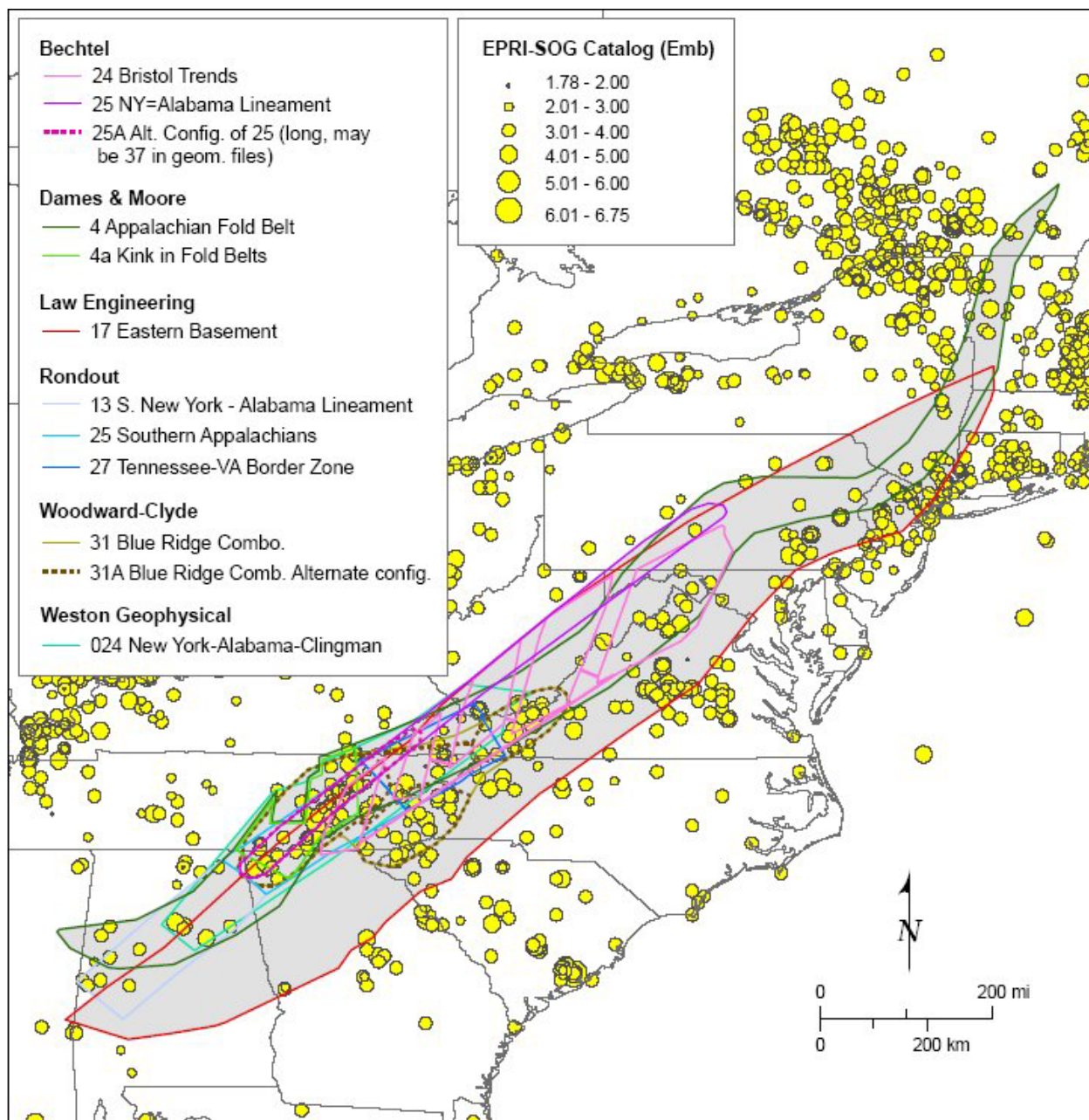


Figure 2: EPRI-SOG sources used to represent ETSZ, plotted with historical earthquakes from the EPRI-SOG catalog (figure courtesy of WLA).

Dames & Moore team. Dames & Moore used 2 sources with mutually exclusive activity to represent seismicity in eastern Tennessee, as follows.

Source	Name	P[activity]	Seismicity	Orig. $m_{\max}$	Modified $m_{\max}$
DAM-04	Appal. fold belts	0.35	Updated (2007)	6.0-7.2	Composite
DAM-4A	Kink in fold belts	0.65	Updated (2007)	6.8-7.2	Composite
	Total:	1.00			

The Dames & Moore team's sources will be represented as 2 mutually exclusive sources with updated seismicity parameters (using the catalog extended through 2007) and the composite $m_{\max}$ distribution. Note that for the area covered by source DAM-4A, the combined probability of activity is 1.0, so that for a site in the center of the ETSZ there is not an issue of missing seismicity.

Law Engineering team. The Law team used one source plus a background source to represent seismicity in eastern Tennessee, as follows.

Source	Name	P[activity]	Seismicity	Orig. $m_{\max}$	Modified $m_{\max}$
LAW-17	Eastern basement	0.62	Updated (2007)	5.7-6.8	Composite
LAW-217	Eastern base. BG	1.0 ($P_b=0.29$)*	Updated (2007)	4.9-5.7**	(not modified)
*--modified to $P_a=0.38$ and $P_b=1.0$ per nearby hazard studies					
**--modified to 5.2-5.7 per nearby hazard studies					

The LAW-217 source has the same geometry as the LAW-17 source and is identified as a background source with probability of background $P_b=0.29$. Both the LAW-17 and LAW-217 sources use spatial smoothing of seismicity. The difference between the two sources is in the $m_{\max}$ values. As done in hazard studies at a site in the vicinity of the ETSZ, the P_a of LAW-217 will be changed to 0.38 (with $P_b=1.0$), and the original $m_{\max}$ distribution will be modeled as 5.2-5.7. Thus there will be a total $P_a=1.0$ for the LAW sources.

Rondout team. Rondout used 3 separate sources with non-overlapping geometries to represent seismicity in eastern Tennessee, as follows.

Source	Name	P[activity]	Seismicity	Orig. $m_{\max}$	Modified $m_{\max}$
RND-25	So. Appalachians	0.99*	Updated (2007)	6.6-7.0	Composite
RND-13	So. NY-AL lineament	1.00	Updated (2007)	5.2-6.5	Composite
RND-27	TN-VA border zone	0.99*	Updated (2007)	5.2-6.5	Composite
*--will be changed to 1.00					

The RND-25 source is centered on the ETSZ, and the RND-13 and RND-27 sources represent seismicity to the southwest and northeast, respectively. All 3 sources will be used to compute hazard sensitivity with updated seismicity parameters (using the catalog extended through 2007) and the composite $m_{\max}$ distribution.

Weston Geophysical team. Weston used one source plus a background source to represent seismicity in eastern Tennessee, as follows.

Source	Name	P[activity]	Seismicity	Orig. $m_{\max}$	Modified $m_{\max}$
WGC-24	NY-AL Clingman	0.90	Updated (2007)	5.4-6.6	Composite
WGC-C17	So. Appalachians BG	0.10	Updated (2007)	5.4-6.6	(not modified)
	Total:	1.00			

Source WGC-24 is the Weston tectonic interpretation that incorporates the ETSZ. Background source C17 represents the remaining probability of 0.1 that earthquakes occur with some other explanation.

Woodward-Clyde team. Woodward-Clyde used 2 sources with mutually exclusive activity to represent seismicity in eastern Tennessee. The total probability of activity of these sources is 0.235. The remaining activity is represented by a Woodward-Clyde background source.

Source	Name	P[activity]	Seismicity	Orig. $m_{\max}$	Modified $m_{\max}$
WCC-31	Blue Ridge Comb.	0.024	Updated (2007)	5.9-7.0	Composite
WCC-31A	Blue Ridge Comb. Alt.	0.211	Updated (2007)	5.9-7.0	Composite
WCC-BG	Local background	<u>0.765</u>	Updated (2007)	5.8-6.6	(not modified)
	Total:	1.00			

The Woodward-Clyde team sources will be represented as 3 mutually exclusive sources with updated seismicity parameters (using the catalog extended through 2007). Two of these are tectonic sources and will be modified with the composite $m_{\max}$ distribution. The last source is a background source that will maintain the original $m_{\max}$ distribution. The total P[activity] for these sources is 1.0.

Summary. All of the six EPRI-SOG teams have interpretations of seismicity in the ETSZ with a total P[activity] of 1.0. Three of the six teams have alternative tectonic sources representing seismicity, and all of those sources will have $m_{\max}$ distributions modified to reflect the composite distribution. The remaining three teams have some sources representing tectonic interpretations, and alternative background sources representing the possibility that there is no specific tectonic basis in eastern Tennessee to explain historical seismicity there or to localize it there. These alternative background sources will not have their $m_{\max}$ distributions modified. These background sources have P[activity] of 0.38 (Law), 0.1 (Weston), and 0.765 (Woodward-Clyde), or a total probability (weighted by all team interpretations) of 0.2075.

The proposed seismic hazard sensitivity study using revised seismicity parameters and $m_{\max}$ value reflects the combined probability over all EPRI-SOG teams that seismicity in eastern Tennessee can be explained tectonically with about 79% confidence. For these interpretations, the $m_{\max}$ distribution will be modified to reflect the composite distribution. When tectonic interpretations do not apply (with about 21% confidence), the original EPRI-SOG $m_{\max}$ distributions will be used to represent the distributions of earthquake magnitudes in the eastern Tennessee region.

References

1. LLNL (2002). *Guidance for Performing Probabilistic Seismic Hazard Analysis for a Nuclear Plant Site: Example Application to the Southeastern United States*, USNRC Rept. NUREG/CR-6607, Oct.
2. Geomatrix Consultants (2004). *Dam Safety Seismic Hazard Assessment*, report prepared for Tennessee Valley Authority, 2 vol, September.