2.5S.2 Vibratory Ground Motion

The following site-specific supplement addresses COL License Information Items 2.24, 2.26, and 2.30.

This section provides a detailed description of the vibratory ground motion assessment for the STP 3 & 4 site. This assessment was performed under the guidance in Regulatory Guide (RG) 1.208. RG 1.208 incorporates developments in ground motion estimation models; updated models for earthquake sources; methods for determining site response; and new methods for defining a site-specific, performance-based earthquake ground motion that satisfy the requirements of 10 CFR 100.23 and lead to the establishment of the safe shutdown earthquake ground motion (SSE). The purpose of this section is to develop the site-specific ground motion response spectrum (GMRS) characterized by horizontal and vertical response spectra determined as free-field motions on the ground surface using performance-based procedures.

The GMRS represents the first part in development of an SSE for a site as a characterization of the regional and local seismic hazard. The GMRS will be used to determine the adequacy of the Certified Seismic Design Response Spectra (CSDRS) for the GE ABWR Design Certification Document (DCD). The CSDRS will be the SSE for the site, the vibratory ground motion for which certain structures, systems, and components are designed to remain functional, pursuant to Appendix S to 10 CFR Part 50.

The starting point for the GMRS assessment is the seismicity, seismic source models, and ground motion attenuation relations of EPRI-SOG probabilistic seismic hazard analysis (PSHA) evaluation (Reference 2.5S.2-1).

Subsections 2.5S.2.1 through 2.5S.2.4 document the review and update of the available EPRI seismicity, seismic source, and ground motion models. Subsection 2.5S.2.5 summarizes information about the seismic wave transmission characteristics of the STP 3 & 4 site with reference to more detailed discussion of all engineering aspects of the subsurface in Subsection 2.5S.4.

Subsection 2.5S.2.6 describes development of the horizontal GMRS ground motion for the STP 3 & 4 site. Following RG 1.208, the selected ground motion is based on the risk-consistent/performance-based approach. Site-specific horizontal ground motion amplification factors are developed using site-specific estimates of sub-surface soil and rock properties. These amplification factors are then used to scale the hard rock spectra to develop Uniform Hazard Response Spectra (UHRS) accounting for site-specific conditions using Approach 2A of NUREG/CR-6769 (Reference 2.5S.2-2).

Subsection 2.5S.2.6 also describes vertical GMRS, developed by scaling the horizontal GMRS by a frequency-dependent vertical-to-horizontal (V/H) factor.

2.5S.2.1 Seismicity

The seismic hazard analysis conducted by EPRI (Reference 2.5S.2-1) relied on an analysis of historical seismicity in the Central and Eastern United States (CEUS) to estimate seismicity parameters (rates of activity and Richter b-values) for individual seismic sources. The historical earthquake catalog used in the EPRI analysis was complete through 1984. The earthquake data for the site region since 1984 were reviewed and used to update the EPRI catalog. The EPRI methodology did not originally incorporate contributions from seismic sources in the Gulf of Mexico except along its immediate coast. Special attention was paid to earthquakes in the Gulf of Mexico because two moderate earthquakes occurred recently in the Gulf of Mexico and the STP 3 & 4 site borders it.

2.5S.2.1.1 Regional Seismicity Catalog Used for EPRI Seismic Hazard Analysis Study

Many seismic networks record earthquakes in the CEUS. An effort was made during the EPRI seismic hazard analysis study to combine available data on historical earthquakes and to develop a homogeneous earthquake catalog that contained all recorded earthquakes for the region. “Homogeneous” means that estimates of body-wave magnitude (mb) for all earthquakes are consistent, duplicate earthquakes have been removed, non-earthquakes (e.g., mine blasts and sonic booms) have been eliminated, and significant events in the historical record have not been missed. The EPRI catalog (Reference 2.5S.2-3) forms a strong basis on which to estimate seismicity parameters such as recurrence rate and maximum magnitude.

2.5S.2.1.2 Updated Seismicity Data

The earthquake catalog was updated to determine whether regional earthquake patterns and parameters developed from the EPRI catalog (Reference 2.5S.2-3) remained unchanged. RG 1.206 specifies that earthquakes of Modified Mercalli Intensity (MMI) greater than or equal to IV or magnitude greater than or equal to 3.0 should be listed “that have been reported within 200 miles (320 km) of the site.” In updating the EPRI catalog, a latitude-longitude window of 24° to 40° N, 107° to 83° W was used. This window incorporates the 200 mi (320 km) radius “site region” and all seismic sources contributing significantly to STP 3 & 4 site earthquake hazard. Figure 2.5S.1-1 shows the site and its associated site region. Figures 2.5S.2-1 through 2.5S.2-6 show the site, this site region, the defined latitude-longitude window, both the original EPRI catalog earthquakes and updated seismicity data, and the original EPRI source zones.

Seismicity catalogs used to update the EPRI catalog are described below:

ANSS Catalog. The ANSS catalog (Reference 2.5S.2-4) was searched on November 28, 2006, for all records within the site region latitude-longitude window, resulting in 8229 records from February 1931 to November 2006. Of these, 5202 records are for events which occurred in 1985 or later.

ISC Catalog. The International Seismological Centre (ISC) catalog (Reference 2.5S.2-5) was searched on November 28, 2006, for all records within the site region latitude-longitude window, resulting in 841 records from November 1928 to September 2006. 643 records are for events which occurred in 1985 or later.

Stover and Coffman. The catalog from Stover and Coffman (Reference 2.5S.2-6), referred to USHIS, was searched on November 30, 2006, for all records within the site region latitude-longitude window, resulting in 182 records. Of these, eight records are for events which occurred in 1985 or later.

Stover et al. A search was made on November 30, 2006 using the catalog from Stover et al. (Reference 2.5S.2-7), also referred to as SRA, for all records within the site region latitude-longitude window, resulting in 2572 records. 119 records are for events which occurred in 1985 or later.

Rinehart et al. A search was made on November 30, 2006 using the catalog from Rinehart et al. (Reference 2.5S.2-8), also known as Mexico, Central America, and Caribbean or MCAC, for all records within the site region latitude-longitude window. There were no records recovered from this catalog due to its temporal coverage.

PDE Catalog. The catalog of Preliminary Determination of Epicenters (PDE) (Reference 2.5S.2-9), available from the National Earthquake Information Center (NEIC), was searched on November 30, 2006, resulting in 1080 records within the site region latitude-longitude window. 800 records are for events which occurred in 1985 or later.

In the event of duplicate entries in these six catalogs, the preference order chosen was: ANSS, ISC, USHIS, SRA, MCAC, and PDE. Non-preferred duplicate entries were deleted from the final catalog.

The magnitudes given in the catalogs were converted to EPRI best, or expected, estimates of body wave magnitude (E[mb], also referred to as Emb in Reference 2.5S.2-3) using the conversion factors given as equation 4-1 and Table 4-1 in Reference 2.5S.2-3:

$$Emb = 0.253 + 0.907 \cdot Md \qquad \text{Equation 2.5S.2-1}$$

$$Emb = 0.655 + 0.812 \cdot ML \qquad \text{Equation 2.5S.2-2}$$

where Md is duration (or coda) magnitude and ML is “local” magnitude.

The EPRI PSHA study expressed maximum magnitude (M_{max}) values in terms of body-wave magnitude (m_b), whereas most modern seismic hazard analyses describe M_{max} in terms of moment magnitude (**M**). To provide a consistent comparison between magnitude scales, body-wave magnitude was related to moment magnitude using the arithmetic average of three equations, or their inversions, presented by Reference 2.5S.2-10, 2.5S.2-11, and 2.5S.2-12. Throughout the discussion below in Subsections 2.5S.2.2 and 2.5S.2.3, the largest values of M_{max} distributions assigned by the Earth Science Teams (Reference 2.5S.2-13) to seismic sources are presented for both magnitude scales (m_b and **M**). For example, EPRI mb values of M_{max} are followed by the equivalent **M** value. Conversion values from m_b to **M** and **M** to m_b are provided in Table 2.5S.2-1.

Events reported in Ms (surface wave magnitude) were translated to M from the relationship illustrated in Reference 2.5S.2-14. The moment magnitude was then converted to mb using conversion values from Table 2.5S.2-1.

The EPRI-SOG methodology modifies the Emb values to develop unbiased estimates of seismicity recurrence parameters. The modified Emb magnitudes are designated uniform magnitude m_b* (referred to as Rmb in Reference 2.5S.2-3). Equation 4-2 of Reference 2.5S.2-3 indicates that the equation from which mb* is estimated from $E[m_b]$ and the standard deviation of m_b, σ_{mb}, (referred to as Smb in Reference 2.5S.2-3) is:

$$m_b^* = E[m_b] + (1/2)\cdot ln(10)\cdot b\cdot\sigma^2_{mb} \qquad \text{Equation 2.5S.2-3}$$

where b = 1.0.

Values for σ_{mb} [Smb] were estimated for the six catalogs, and m_b* [Rmb] were calculated for each event added to the updated catalog.

The result of the above process was an update of the EPRI catalog (Reference 2.5S.2-3) for the site region latitude-longitude window. For the purpose of recurrence analysis, all events added for the update are assumed to be independent events.

2.5S.2.1.3 Gulf of Mexico Seismicity

Two observations suggested that additional examination of earthquakes in the Gulf of Mexico was needed. First, earthquakes commonly cataloged as located within the Gulf of Mexico are often reported by so few nearby stations that determination of their epicenters may not be considered reliable (Reference 2.5S.2-15). This indicated that locations of Gulf of Mexico seismicity needed to be evaluated. Second, an examination of the original EPRI analysis (Reference 2.5S.2-16) indicated that earthquake recurrence parameters had not been evaluated for much of the Gulf of Mexico (see Figure 5-2 of EPRI [Reference 2.5S.2-13] and Figure 2.5S.2-7). The occurrence of two recent moderate earthquakes in the Gulf of Mexico (see below) indicated the potential for a significant contribution to seismic hazard at the STP 3 & 4 site from this area. This required a careful evaluation of Gulf of Mexico seismicity, both before and after the development of the EPRI earthquake catalog.

The seismicity was therefore re-evaluated with specific emphasis on the southeast portion of the project investigation region (24°N to 32°N, 100°W to 83°W) referred to as the “Gulf of Mexico investigation region.” The objective was to develop an improved characterization of seismicity for all time within the Gulf of Mexico investigation region for events of a minimum size (EPRI recurrence magnitude Rmb ≥ 3.0 or intensity ≥ IV). When combined with the seismicity catalog described in 2.5S.2.1.2 the EPRI catalog MAIN events (Reference 2.5S.2-3) and re-evaluated Gulf of Mexico seismicity, would constitute an improved characterization of the seismicity within the project investigation window (107°W to 83°W, 24°N to 40°N).

In the process of developing the updated seismicity catalog, a very large area was initially considered (14°N to 40°N, 107°W to 79°W), but particular care was taken with the characterization of earthquake parameters in the Gulf of Mexico where there were no EPRI (Reference 2.5S.2-16) recurrence parameters. This sub-area of the Gulf of Mexico investigation region is referred to herein as the “Re-Focus Zone” (see Figure 2.5S.2-7). The seismicity within the Re-Focus Zone is used to develop estimates for periods of completeness of records of earthquakes within the Gulf of Mexico as a function of magnitude and location. These values (see Subsection 2.5S.2.1.5) are then used in subsection 2.5S.2.4 to supplement the EPRI (Reference 2.5S.2-16) seismicity recurrence parameterization to include seismic sources within the Gulf of Mexico. These parameters provide contributions to seismic hazard at the STP 3 & 4 site from the Gulf of Mexico sources to be included in the PSHA analysis.

Ten significant regional, national, international, and global seismicity catalogs were considered in the development of the re-evaluated seismicity catalog for the Gulf of Mexico:

- Electric Power Research Institute (EPRI) (Reference 2.5S.2-3)
- Frohlich and Davis (DPC, FDNC, PDEf) (Reference 2.5S.2-17)
- Engdahl et. al. (EHB98) (Reference 2.5S.2-18)
- Perez (PEREZ) (Reference 2.5S2-19)
- Advanced National Seismic System (ANSS) (Reference 2.5S.2-20)
- International Seismological Centre (ISC) (Reference 2.5S.2-21)
- Significant U.S. Earthquakes (USHIS) (Reference 2.5S.2-6)
- Mexico, Central America and Caribbean, 1900 – 1979 (NGDC) (Reference 2.5S.2-8)
- Eastern, Central, And Mountain States of The United States (SRA) (Reference 2.5S.2-7)
- NEIC Preliminary Determination of Epicenters (PDE, PDE-W, PDE-Q) (Reference 2.5S.2-22)

The preference order chosen among the catalogs was initially: EPRI, DPC, FDNC, PDEf, EHB98, PEREZ, ANSS, ISC, USHIS, NGDC, SRA, PDE, PDE-W, and PDE-Q. Later, ISC entries were given preference over ANSS entries for events in the Gulf of Mexico if event-specific ISC evaluations had been made. A few ANSS locations for events in the Gulf of Mexico were found to have few recordings from nearby stations and to have unacceptably large travel time residuals for these few nearby stations. This was the sole change of catalog preference and all other portions of the preference order remain the same.

A detailed review of all duplicate information (more than one record per event) was made for the Gulf of Mexico investigation region. The review included examining phase data for events. Events that were reported only at distant networks and not re-evaluated by ISC were scrutinized and removed if warranted. Manmade and spurious events, as listed in Reference 2.5S.2-17, were also removed.

For the purpose of developing recurrence statistics in the Gulf of Mexico investigation region, it was necessary to eliminate dependent events (e.g., foreshock, aftershocks, and secondary events of an apparent seismicity cluster). As discussed earlier, the EPRI catalog has MAIN (independent) events distinguished from dependent events. Guided by the EPRI characterization of MAIN vs. non-MAIN, as well as by apparent spatial and temporal similarity between events, dependent events were identified and removed. Further, certain or likely non-seismic events (e.g., blasts) were identified and eliminated. The remaining events in the Gulf of Mexico investigation region were assessed to be equivalent to EPRI MAIN events.

In the development of the revised composite project seismicity catalog, the magnitudes given in all catalogs were converted to best, or expected, estimates of m_b (Emb), using the same conversion equations discussed above with the following additions:

Surface wave magnitudes [Ms] given in the catalogs were converted to EPRI best, or expected, estimates of body wave magnitude (E[mb], also referred to as Emb in Reference 2.5S.2-3) using the conversion factors given as equation 4-1 and Table 4-1 in Reference 2.5S.2-3:

$$Emb = 2.302 + 0.618 \cdot Ms \qquad \text{Equation 2.5S.2-4}$$

where Ms is surface wave magnitude.

If no explicit magnitudes are available for an event, an available maximum intensity value [Io] was converted to Emb, using a relationship from Table 4-1 in Reference 2.5S.2-3:

$$Emb = 0.709 + 0.599 \cdot Io \qquad \text{Equation 2.5S.2-5}$$

2.5S.2.1.4 Final Seismicity Catalog

The final seismicity catalog for the project investigation region (24°N to 40°N, 107°W to 83°W) is in Tables 2.5S.2-2 and 2.5S.2-3. Table 2.5S.2-2 is a catalog of pre-1985 earthquakes in the Gulf of Mexico Investigation Region (100°W to 83°W, 24°N to 32°N) with an Rmb magnitude 3.0 or greater or intensity IV or greater. These six earthquakes supplement EPRI data for this important subarea of the project investigation region. The seismicity presented in Table 2.5S.2-3 updates the EPRI catalog temporally as described above. Outside the Gulf of Mexico investigation region (24°N to 32°N, 100°W to 83°W) earthquakes compiled for the events in Table 2.5S.2-3 were assumed to be independent and equivalent to EPRI MAIN events. Updated catalog earthquake recurrence rates will be conservative compared to recurrence rates developed from the original EPRI MAIN events.

Tables 2.5S.2-2 and 2.5S.2-3, along with the EPRI MAIN events constitute a characterization of the mainshock seismicity within the project investigation window.

Within the updated seismicity catalog (1985 to present) there are two new moderate seismic events in the Gulf of Mexico that are significant for an updated characterization of the regional seismicity. These are (a) a **M** 5.1 (m_b 5.5) event occurred on February 10, 2006, offshore of the Louisiana coast within the Gulf of Mexico and (b) a magnitude **M** 5.8 (m_b 6.1) event occurred on September 10, 2006 offshore of the Florida coast and within the Gulf of Mexico.

A moment-tensor source can be used to model the surface waves generated by the February 10, 2006 earthquake if the earthquake centroid is placed within a few miles of the earth's surface in a medium with a very low shear modulus. The explanation for the February 10th earthquake that is currently in best agreement with the observed seismic data is a gravity-driven displacement surface within a thick shallow sedimentary wedge (Reference 2.5S.2-23).

The focal mechanism for the September 10, 2006 event indicates a reverse sense of motion, and the event depth is reported as 13 to 19 mi (22 to 31 km) (Reference 2.5S.2-24). This mechanism is that of an earthquake caused by tectonically driven stresses within the earth's crust.

The implications of these events for the characterization of earthquake potential in the Gulf of Mexico are discussed in Subsection 2.5S.2.3.

2.5S.2.1.5 Periods of Completeness for the Reporting of Gulf of Mexico Earthquakes

The EPRI methodology (Reference 2.5S.2-3) uses estimates of periods of completeness for the reporting of earthquakes as a function of magnitude. This methodology employs a matrix of probability of detection of earthquakes for an area for selected ranges of time-before-present and magnitude. The purpose of this section is to develop a matrix of detection probability for the Gulf of Mexico Re-Focus Zone (see Figure 2.5S.2-7) where such information is not available in the original EPRI parameterization (Reference 2.5S.2-16). This matrix is used later in Subsection 2.5S.2.4 to develop EPRI-consistent recurrence parameters for the Gulf of Mexico for use in the PSHA analysis of the STP 3 & 4 site.

Table 2.5S.2-4 lists the 22 events within the Gulf of Mexico Re-Focus Zone, considered EPRI MAIN or equivalent events, that were used to develop the matrix of detection probability for this area. This matrix was prepared to be consistent with the EPRI (Reference 2.5S.2-3) methodology of evaluating seismicity completeness considering various seismologically sound assumptions. Generation of the matrix of detection probability used, as a conservative guideline, the adjacent EPRI matrices of detection probability available onshore. The regional b-value based on the Gulf of Mexico seismicity catalog was reasonable and compatible with the Gulf of Mexico detection probability matrix developed for this study.

EPRI (Reference 2.5S.2-3) used a detailed analysis of United States demographics and history, number, and quality and distribution of seismographic instruments to develop matrices of probability of completeness as a function of time period, gridded area, and magnitude interval. Given uneven population distributions over time and uneven deployment of seismographic networks these completeness probability matrices also vary by location. EPRI “Incompleteness Regions” 2 and 3 are closest to the part of the Gulf of Mexico that is nearest the STP 3 & 4 site (see Reference 2.5S.2-3, Figure 5-2).

It was assumed that the probabilities of earthquake detection for the Gulf of Mexico would be less than those given for onshore coastal locations for comparable time periods. The procedure followed for estimating detection probabilities for the Gulf of Mexico was, therefore, to start with the available EPRI matrix suggesting the lowest probabilities along the shoreline (EPRI Incompleteness Region 2) and to assume lower probabilities of detection within the Gulf. The very detailed analysis performed by EPRI was not attempted.

Table 2.5S.2-5 is a version of the EPRI Incompleteness Region 2 matrix, modified to add additional years since 1984 (the last complete year in the Reference 2.5S.2-3 earthquake catalog). The latest bin time of the Incompleteness Region 2 matrix (1973 – 1983) has detection probabilities of 1.00 for all magnitude bins. Therefore, given that detection probability would not be expected to decrease with time, additional time bins with detection probabilities of 1.00 for all magnitudes were appended to the Incompleteness Region 2 table.

The matrix of detection probability shown in Table 2.5S.2-5 is appropriate for onshore sites of seismic activity near the project site. This matrix may be used for seismicity occurring through the year 2006.

In developing a matrix of detection probability appropriate for the Gulf of Mexico region, Table 2.5S.2-5 was qualitatively modified in consideration of the following constraints:

- For a given magnitude bin, detection probability for a given time bin would be expected to be the same or more than the detection probability of an adjacent earlier time bin. That is, the overall trend is for detection probabilities for a given magnitude interval to increase with time.
- For a given time bin, the detection probability for a given magnitude bin would be the same or more than the detection probability an adjacent smaller magnitude bin. That is, the overall trend is for detection probabilities for a given time interval to increase with magnitude.

Given the lack of regional seismographic stations in the Gulf of Mexico, as well as the obvious lack of felt or damage reports in the Gulf, detection probabilities for the Gulf of Mexico are expected to be no higher for any magnitude and time bin than that corresponding to the nearest onshore location of lowest detection probabilities.

It was assumed that after the advent of the World-Wide Standardized Seismograph Network in the mid-1960s most earthquakes of magnitude 5.5 and greater would be detectable and recorded (Reference 2.5S.2-25).

Preliminary analysis of Gulf of Mexico seismicity found a slope for the Gutenberg-Richter recurrence relation (the b-value) of about 0.5, which is notably less than typical b global values of ~1 (see Table 2 of Reference 2.5S.2-25; Table 4-7 of Reference 2.5S.2-26 for stable continental regions). It was judged that there was no known reason for which a low value should occur in this region when a more typical value for the CEUS is ~1 as used in previous EPRI recurrence model characterizations (Reference 2.5S.2-16).

Following these elements of expert judgment, the EPRI Incompleteness Region 2 matrix of detection probability given in Table 2.5S.2-5 was modified for the Gulf of Mexico, as presented in Table 2.5S.2-6. The probability of detection estimates in this matrix are governed by the considerations described above (unshaded bins), while the values in the blue shaded bins are also the results of a modest parametric variation of "b".

In general, global "b" values tend to average about 0.8 to 1.2. Using the detection probability matrix of Table 2.5S.2-6 with the seismicity of the Gulf of Mexico, results in a b value of 1.055. The b value of 1.055 and maximum-likelihood fit to the data are both good and reasonable evaluations, allowing the conclusion that the matrix of detection probability presented in Table 2.5S.2-6 is a reasonable characterization of the completeness of the seismicity in the Gulf of Mexico.

2.5S.2.1.5.1 Central American Seismicity

An area of more frequent seismicity occurs to the southwest along the west coast of Mexico and northern Central America, located approximately 800 miles (1300 km) from the STP site. The largest event in this century from this source was the Michoacan earthquake of 1985 with an approximate magnitude **M** 8.0 (Reference 2.5S.2-19).

Felt effects from Michoacan earthquake of 1985 were reported at several locations in Texas. The intensity observations for the Michoacan event are approximately a MMI II and include: vibrations in tall buildings and bridges and residential and commercial pool seiches. Minor disturbances of industrial and laboratory equipment were also observed and include slight movement of laboratory scales and vibrations in tools used to make crystals (Reference 2.5S.2-17).

As discussed in FSAR Section 2.5S.2.4.8, a sensitivity study was performed to evaluate the contribution to seismic hazard from the Middle America Trench (MAT), a major source of Central America Seismicity (CAS), to the overall STP earthquake hazard. It is concluded that the hazard contribution to the STP 3 & 4 site is not significant.

2.5S.2.2 Geologic and Tectonic Characteristics of Site and Region

A comprehensive review of available geological, seismological, and geophysical data was performed for the STP 3 & 4 site region and adjoining areas. The following sections describe significant seismic sources from the 1986 EPRI study (Reference 2.5S.2-13) for the STP 3 & 4 site and modifications to the EPRI sources as parameterized in EQHAZARD Primer (Reference 2.5S.2-16).

In the EPRI study, six independent Earth Science Teams (ESTs) evaluated geologic, geophysical, and seismological data, and each team developed a seismic source model for the CEUS. The six EST source models were used in a PSHA (Reference 2.5S.2-1) to model strong vibratory ground motion hazards at nuclear power plant sites across the CEUS.

Based on new information developed since publication of the EPRI study, the EPRI source models have been modified for the STP 3 & 4 COLA as follows:

- Two moderate earthquakes have occurred within the Gulf of Mexico since the EPRI 1986 study. The magnitudes of these events exceed the upper and/or lower bound of the maximum magnitude (M_{max}) distributions originally proposed by some of the EPRI ESTs for large areal source zones that encompass large portions of the Gulf Coastal Plain and the Gulf of Mexico. The M_{max} distributions have been revised for five of the six EPRI EST source zones to account for these earthquakes in the hazard calculations.

- Research post-dating the 1986 EPRI study has developed new information regarding the earthquake behavior of the New Madrid Seismic Zone. In calculating ground motion hazard at the STP 3 & 4 site, an updated characterization of the New Madrid Seismic Zone developed by the Exelon Generation Company (Reference 2.5S.2-27) has been added to the EPRI EST source model to account for new data on the recurrence rates and M_{max} values for the characteristic earthquake behavior of the New Madrid Seismic Zone.

In addition, the following changes to the EPRI model parameters are implemented to more accurately model seismic hazard at the STP 3 & 4 site:

- The Dames & Moore EST characterized their areal source zone containing STP 3 & 4 (South Coastal Margin, zone 20) with no smoothing of seismicity parameters, resulting in no contribution to hazard at the STP 3 & 4 site from this source zone despite earthquakes occurring elsewhere within the zone (see Subsection 2.5S.2.4) (Reference 2.5S.2-16). The smoothing parameters for the Dames & Moore South Coastal Margin (zone 20) have been revised to ensure that seismicity within the South Coastal Margin source zone contributes to the seismic hazard at STP 3 & 4.

- The calculation of seismic hazard within the EPRI computational model developed following the 1986 study (i.e., EQHAZARD) (Reference 2.5S.2-16) from background source zones depends on the presence of a suite of seismicity parameters gridded throughout the source zone. Seismicity parameters in the original model within the Gulf of Mexico region were not calculated or gridded south of 28° N, and thus regions of background source zones that extend south of 28° N do contribute to the seismic hazard at STP 3 & 4 in the original parameterization of the EPRI 1986 model (References 2.5S.2-3 and 2.5S.2-16). For the EPRI source model used in the hazard analysis for STP 3 & 4, seismicity parameters were calculated for regions south of 28° N to ensure that seismicity parameters are gridded within the full extent of source zones within the Gulf Coastal Plain and Gulf of Mexico region.

2.5S.2.2.1 Summary of EPRI Seismic Sources

The six ESTs involved in the EPRI project (the Bechtel Group, Dames & Moore, Law Engineering, Rondout Associates, Weston Geophysical Corporation, and Woodward-Clyde Consultants) each produced a report providing detailed descriptions of their individual philosophy and methodology used in identifying tectonic features, evaluating tectonic features as seismic sources, and parameterizing seismic sources (Reference 2.5S.2-13). For the computation of hazard in the 1989 study (Reference 2.5S.2-1), some of the seismic source parameters were modified or simplified from the original parameters determined by the six ESTs (Reference 2.5S.2-13). These modifications are summarized in another EPRI report (Reference 2.5S.2-16), which is the primary source for the seismicity parameters evaluated in this study.

The seismic source zones from each of the six EPRI ESTs that contributed to 99% of the total hazard at STP 1 & 2 (Reference 2.5S.2-1) and contribute to 99% of the total hazard at STP 3 & 4 are shown on Figure 2.5S.2-1 through Figure 2.5S.2-6. The parameters assigned to each source zone by their respective EST are summarized in Table 2.5S.2-7 through Table 2.5S.2-12. The tables also indicate whether new information has been identified that requires a revision of the source's geometry, maximum earthquake magnitude, or recurrence parameters. For those source zones where revisions are required (see Subsection 2.5S.2.6.2 and 2.5S.2.6.3), the revised values used in the hazard analysis for STP 3 & 4 are given in Table 2.5S.2-13.

Earthquakes with Emb > 3.0 are also shown on Figure 2.5S.2-1 through Figure 2.5S.2-6 to demonstrate the spatial distribution of seismicity relative to the seismic sources. Earthquake epicenters include events from the EPRI earthquake catalog for the period between 1627 and 1984 and an updated seismicity catalog for the period from 1985 to 2006 (see Subsection 2.5S.2.1.2). As described in Subsection 2.5S.2.1.2, the updated catalog within the Gulf of Mexico was for all time and captured six events that occurred between 1847 and 1984 that were not included in the original EPRI catalog.

The following sections summarize the seismic sources and their characterization parameters in the EPRI study (References 2.5S.2-1 and 2.5S.2-13). The discussion is limited to those sources that were determined during a 1989 EPRI study to contribute to 99% of the seismic hazard at STP 1 & 2 (Reference 2.5S.2-1).

2.5S.2.2.2 Sources Used for EPRI PSHA – Bechtel Group

The Bechtel Group EST source model includes two seismic source zones that contribute to 99% of the hazard at the STP 3 & 4 site (Table 2.5S.2-7). Both of these sources are within the STP 3 & 4 site region (Figure 2.5S.2-1). No other source zones identified by the Bechtel Group occur within the site region.

Following is a brief discussion of each of the two seismic sources in the Bechtel Group source model that contributed to 99% of the site hazard:

(1) Gulf Coast (BZ1)

The STP 3 & 4 site is located within the Bechtel Group Gulf Coast Zone (BZ1). This zone is a large background source that extends from the continental shelf off eastern Florida to the western coastal plain of Texas and encompasses the majority of the site region (Figure 2.5S.2-1). The largest M_{max} assigned by the Bechtel Group to this zone was m_b 6.6 (Table 2.5S.2-7).

(2) Texas Platform (BZ2)

The STP 3 & 4 site is located approximately 51 miles (82 km) from the nearest extent of the Bechtel Group Texas Platform Zone (BZ2). This zone is a large areal source that extends from the northern edge of the Texas coastal plain to the northwest into New Mexico and encompasses a portion of the site region (Figure 2.5S.2-1). The largest M_{max} assigned by the Bechtel Group to this zone was m_b 6.6 (Table 2.5S.2-7).

2.5S.2.2.3 Sources Used for EPRI PSHA – Dames & Moore

The Dames & Moore EST source model includes three seismic source zones that contribute to 99% of the hazard at the STP 3 & 4 site (Table 2.5S.2-8): South Coastal Margin (20), Ouachitas Fold Belt (25), and Combination Zone (C08). All of these source zones are within the site region.

Dames & Moore identified one additional source zone within the site region that does not contribute to 99% of the hazard (Figure 2.5S.2-2), the New Mexico Zone (67).

Following is a brief discussion of each of the three seismic sources in the Dames & Moore source model that contributed to 99% of the site hazard:

(1) South Coastal Margin (20)

The STP 3 & 4 site is located within the Dames & Moore South Coastal Margin Zone (20). This zone is a large background source that extends from the continental shelf off eastern Florida, along the Texas coastal plain, and into Mexico (Figure 2.5S.2-2). This source zone encompasses the majority of the site region. The largest M_{max} assigned by Dames & Moore to this zone was m_b 7.2 (Table 2.5S.2-8).

(2) Ouachitas Fold Belt (25)

At its closest approach, the STP 3 & 4 site is located approximately 106 mi (171 km) from the nearest extent of the Dames & Moore Ouachitas Fold Belt Zone (25). This zone encompasses the Ouachita mountain belt extending from Arkansas, through Oklahoma, following the buried trend of the Ouachita belt beneath the Texas coastal plain, and westward into Mexico (Figure

2.5S.2-2). This source zone encompasses a portion of the STP 3 & 4 site region. The largest M_{max} assigned by Dames & Moore to this zone was m_b 7.2 (Table 2.5S.2-8).

(3) Combination Zone (C08)

The STP 3 & 4 site is located approximately 106 miles (171 km) from the nearest extent of the Dames & Moore Combination Zone C08. This zone is spatially equivalent to the Ouachitas Fold Belt Source Zone (25) with the exclusion of the kink in the Ouachita fold belt (25A) at the Texas-Oklahoma border (Figure 2.5S.2-2). Combination Zone (C08) encompasses a portion of the STP 3 & 4 site region. The largest M_{max} assigned by Dames & Moore to this zone was m_b 7.2 (Table 2.5S.2-8).

2.5S.2.2.4 Sources Used for EPRI PSHA – Law Engineering

The Law Engineering source model includes two seismic source zones that contribute to 99% of the hazard at the STP 3 & 4 site (Table 2.5S.2-9). Both of these source zones are within the site region (Figure 2.5S.2-3). No other source zones defined by Law Engineering extend into the site region.

Following is a brief discussion of the two seismic sources in the Law Engineering source model that contributed to 99% of the site hazard:

(1) New Mexico-Texas Block (124)

The closest approach of the STP 3 & 4 site to the Law Engineering New Mexico-Texas Block Source Zone (124) is approximately 76 miles (122 km). This zone is a large areal source defined by the boundaries of the Oklahoma Aulacogen, the Ouachita gravity high, and magnetic trend of the Rio Grande-Colorado Front Ranges. This zone encompasses the majority of Texas, excluding the Gulf Coastal Plain, and extends into eastern New Mexico (Figure 2.5S.2-3). The southeastern most extent of this zone occurs within the site region. The largest M_{max} assigned by Law Engineering to this zone was m_b 5.8 (Table 2.5S.2-9).

(2) South Coastal Block (126)

The STP 3 & 4 site is located within the Law Engineering South Coastal Block Source Zone (126) (Figure 2.5S.2-3). This zone is a large areal source that extends from the continental shelf off eastern Florida westward into Texas and Mexico (Figure 2.5S.2-3). The northern edge of the zone was defined to coincide with the Paleozoic edge of the North American craton. This source zone encompasses the majority of the site region. The largest M_{max} assigned by Law Engineering to this zone was m_b 4.9 (Table 2.5S.2-9).

2.5S.2.2.5 Sources Used for EPRI PSHA – Rondout Associates

The Rondout Associates source model includes one seismic source zone that contributes to 99% of the hazard at the STP 3 & 4 site (Table 2.5S.2-10), the Gulf Coast to Bahamas Fracture Zone (51). This source zone lies partially within the site region (Figure 2.5S.2-4).

Rondout Associates also identified one other source zone as occurring within the site region (Figure 2.5S.2-4) that does not contribute to 99% of the hazard at STP 3 & 4, the Background 50 (C02) Zone.

Following is a brief discussion of the one seismic source in the Rondout Associates source model that contributed to 99% of the site hazard:

(1) Gulf Coast to Bahamas Fracture Zone (51)

The Gulf Coast to Bahamas Fracture Zone (51) is a large areal source defined by the presence of Paleozoic crust along the Gulf coastal region, and a stress regime with the maximum horizontal tensile stress directed at a high angle to the coast (Reference 2.5S.2-13). The zone extends from southern Florida eastward to Texas and Mexico (Figure 2.5S.2-4) and encompasses the majority of the site region. The largest M_{max} assigned by Rondout Associates to this zone was m_b 5.8 (Table 2.5S.2-10).

2.5S.2.2.6 Sources Used for EPRI PSHA – Weston Geophysical

The Weston Geophysical source model includes one seismic source zone that contributes to 99% of the hazard at the STP 3 & 4 site (Table 2.5S.2-11), the Gulf Coast (107) Zone. This source zone is within the site region (Figure 2.5S.2-5).

Weston Geophysical also identified one combination source zone within the site region (Figure 2.5S.2-5) that does not contribute to 99% of the hazard at the STP 3 & 4 site, the Combination Zone C31.

Following is a brief discussion of the one seismic source in the Weston Geophysical source model that contributed to 99% of the site hazard:

(1) Gulf Coast (107)

The Weston Geophysical Gulf Coast Zone (107) is a large areal source that extends from Florida through Texas and into eastern Mexico (Figure 2.5S.2-5). The majority of the site region occurs within the source zone. The largest M_{max} assigned by Weston to this zone was m_b 6.0 (Table 2.5S.2-11).

2.5S.2.2.7 Sources Used for EPRI PSHA – Woodward-Clyde Consultants

The Woodward-Clyde Consultants source model includes one seismic source that contributes to 99% of the hazard at the STP 3 & 4 site (Table 2.5S.2-11), the Central United States Backgrounds (B43) Source Zone. This source zone encompasses nearly all of the site region (Figure 2.5S.2-6). Woodward-Clyde Consultants did not identify any other source zones within the site region.

Following is a brief discussion of the one seismic source in the Woodward-Clyde Consultants source model that contributed to 99% of the site hazard:

(1) Central United States Backgrounds (B43)

The Central United States Backgrounds (B43) Zone is a large areal background source centered on the STP 3 & 4 site, and it is a quadrilateral with sides approximately 6º in length (Figure 2.5S.2-6). The largest M_{max} assigned by Woodward Clyde Consultants to this zone was m_b 6.5 (Table 2.5S.2-11).

2.5S.2.2.8 Post-EPRI Seismic Source Characterization Studies

Since publication of the 1986 EPRI study (Reference 2.5S.2-13), only one major published study has been performed to characterize seismic sources within the STP 3 & 4 site region, The U.S. Geological Survey's National Seismic Hazard Mapping Project (Reference 2.5S.2-11 and 2.5S.2-28).The relevant content of this study is summarized in the following paragraphs.

In 2002, the USGS produced seismic hazard maps for the coterminous United States based on new seismological, geophysical, and geological information (Reference 2.5S.2-28). The 2002 maps reflect changes to the source model used to construct a previous version of the national seismic hazard maps made in 1996 (Reference 2.5S.2-11). The most significant changes to the CEUS portion of the source model included changes in the recurrence and geometry of the Charleston source as well as changes in the recurrence, M_{max}, and geometry of New Madrid sources.

Similar to the 1986 EPRI model, the USGS model for the CEUS uses historical seismicity to determine the rates and relative magnitudes of earthquakes. Both models used a weighted distribution of different methods to calculate the rates and relative magnitudes. The 1986 EPRI model incorporates many background zones and local sources each with individual M_{max} distributions. In contrast, the USGS source model in the CEUS defines only five M_{max} zones between which M_{max} values are allowed to vary. The vast majority of the STP 3 & 4 site region, including the site, is within the USGS Extended Margin M_{max} zone that includes all of the CEUS seaward of the limit of Precambrian crustal rifting associated with opening of the Iapetan ocean (Reference 2.5S.2-11 and 2.5S.2-28). The USGS assigned a M_{max} value of **M** 7.5 (m_b 7.2) to the Extended Margin M_{max} zones. The rationale for the relatively large M_{max} value used by the USGS for the Extended Margin M_{max} zone was based on an interpretation of the origin of the 1886 **M** 7.3 (m_b 7.1) Charleston earthquake, and the recognition that M_{max} over this broad area did not make a significant difference to hazard estimates at the periods of interest for the USGS study (Reference 2.5S.2-11).

During development of the 1986 EPRI model, the individual ESTs were aware of the 1886 **M** 7.3 (m_b 7.1) Charleston earthquake and chose to account for this seismicity by defining sources local to the Charleston area (Reference 2.5S.2-13). In so doing, the ESTs treated the Charleston event as one that occurred on a unique, fixed source in the Charleston area, rather than as a “floating” earthquake capable of occurring anywhere within the extended crust underlying the Atlantic and Gulf Coast margins.

Following the approach of the original ESTs, the high M_{max} values adopted in the more recent 1996 and 2002 USGS source models (Reference 2.5S.2-28) for the Extended Margin Background Zone do not justify changing any of the EPRI (Reference 2.5S.2-13) seismic source zone parameterizations that contribute to 99% of the hazard at STP 3 & 4.

2.5S.2.3 Correlation of Earthquake Activity with Seismic Sources

The distribution of earthquake epicenters from both the EPRI catalog (Reference 2.5S.2-3) and updated earthquake catalog (see discussion in Subsection 2.5S.2.1) relative to the seismic sources in the six EPRI EST source models is shown in Figures 2.5S.2-1 through 2.5S.2-6. Comparison of the updated earthquake catalog to the EPRI (Reference 2.5S.2-3) earthquake catalog yields the following observations:

- The updated catalog does not include any earthquakes in the site region that can be associated with a known tectonic structure.
- The updated catalog does not include a unique cluster of seismicity that would suggest a new seismic source not recognized or accounted for in the EPRI seismic source model.
- The updated catalog does not show a pattern of seismicity that would require significant revision to the EPRI seismic source geometry.

The updated catalog contains a concentration of seismicity in the New Madrid Seismic Zone (Figure 2.5S.2-9) that has a spatial pattern consistent with seismicity patterns apparent in the EPRI earthquake catalog (Reference 2.5S.2-3) and consistent with observations made in the original EPRI-SOG study (Reference 2.5S.2-13). In particular, the original EPRI (Reference 2.5S.2-3) and updated catalog both demonstrate the presence of two northeast trending bands of seismicity in the New Madrid region offset by a third northwest-trending band of seismicity (Figure 2.5S.2-9).

The updated catalog includes two earthquakes that are larger in magnitude than some of the upper- and/or lower-bound values used by ESTs to characterize the M_{max} distribution of source zones within which these earthquakes occurred. These earthquakes are the February 10, 2006 Emb 5.5 earthquake, and the September 10, 2006 Emb 6.11 earthquake. These events require revisions to some of the ESTs M_{max} distributions for background source zones, as described below in Subsection 2.5S.2.6.2. The February 10, 2006 Emb 5.5 earthquake has been potentially associated with specific geologic structures and is discussed in the paragraph below. The September 10, 2006 Emb 6.1 earthquake has not been tied to any unique geologic structure.

The February 10, 2006 Emb 5.5 earthquake reported in the updated catalog has been proposed by Reference 2.5S.2-23 to be related to gravity sliding on a low-angle normal fault at the edge of the continental shelf. This hypothesis suggests a potential association between seismicity in the Gulf of Mexico and normal growth faults at the edge of the continental shelf; however, no other events within the updated catalog have been attributed to such mechanisms. The edge of the continental shelf (Figure

2.5S.1-20) generally is encompassed by the various EST areal source zones for the Gulf of Mexico and environs (Figure 2.5S.1-1 and Figure 2.5S.2-1 to Figure 2.5S.2-6). As such, increases in M_{max} to account for the February 10, 2006 Emb 5.5, as well as the September 10, 2006 Emb 6.1 earthquake (both described in Subsection 2.5S.2.6.2), adequately account for any potential association between earthquakes within the Gulf of Mexico and normal faults along the edge of the continental shelf.

2.5S.2.4 Probabilistic Seismic Hazard Analysis and Controlling Earthquake

This section describes the PSHA conducted for the STP 3 & 4 site. Following the procedures outlined in RG 1.208, Subsection 2.5S.2.4.1 discusses the basis for the PSHA, which is the 1989 EPRI study (Reference 2.5S.2-1). Subsection 2.5S.2.4.2 presents sensitivity studies using the updated earthquake catalog of Subsection 2.5S.2.1 that includes an analysis of historical earthquakes through 2005. The significance of new information on maximum magnitudes and on seismic source characterization is discussed in Subsections 2.5S.2.4.3 and 2.5S.2.4.4, respectively. The effects of recent models to characterize earthquake ground motions in the central and eastern United States are presented in Subsection 2.5S.2.4.5. Subsection 2.5S.2.4.6 presents the results of these revisions to the PSHA in the form of uniform hazard response spectra (UHRS). Finally, Subsection 2.5S.2.4.7 develops vertical ground motions in the form of vertical UHRS that are consistent with the horizontal UHRS, to present a complete representation of earthquake shaking.

2.5S.2.4.1 EPRI seismic hazard study

The 1989 EPRI study (Reference 2.5S.2-1) was the starting point for probabilistic seismic hazard calculations. An underlying principle of this study was that expert opinion on alternative, competing models of earthquake occurrence (e.g., size, location, and rates of occurrence) and of ground motion amplitude and its variability should be used to weight alternative hypotheses. The result is a family of weighted seismic hazard curves from which mean and fractile seismic hazard can be derived.

The first task was to calculate seismic hazard using the assumptions on seismic sources and ground motion equations developed in the 1989 EPRI study to ensure that seismic sources were modeled correctly and that the software being used (Reference 2.5S.2-29) could accurately reproduce the 1989 study results. The results of this comparison are different depending on the EPRI EST. Table 2.5S.2-14 compares the mean annual frequencies of exceedance calculated for the STP site to published annual frequencies of exceedance from the 1989 EPRI project for this site for the Bechtel Group EST. All results are for hard rock conditions. The “% diff” row shows the percent difference of rock hazard recalculated at the STP site compared to the 1989 result. Comparisons are shown for peak ground acceleration (PGA) hazard for the 15th mean, median, and 85th fractile hazard curves. For the mean hazard curves, the current calculation indicates slightly higher hazard, with up to +3.1% difference at 500 cm/s2. For ground motions associated with typical seismic design levels (PGA <0.25g), the differences in mean hazard are less than 1%. Differences in hazard are also small for the 15%, 50%, and 85% hazard, less than 7.7%, with the highest differences occurring at the largest ground motions.

Comparisons with some of the EPRI EST results were problematic, because some teams adopted distributions of maximum magnitude (M_{max}) for sources in the region of the site that included values less than m_b 5.0. For these values of M_{max}, the current hazard calculations indicate an annual frequency of exceedance of zero, because the lower-bound magnitude for calculations was m_b 5.0. Thus, for some lower percentiles the indicated hazard is zero, yet the EPRI (Reference 2.5S.2-1) results indicate a finite hazard for that case. For one team (the Law team), the host source has all values of M_{max} below 5.0, and an adjacent source (about 100 km from the site) has a distribution of M_{max} values that extends below 5.0. For this team, the current calculations indicate very low hazard, but the published EPRI (Reference 2.5S.2-1) results are not as low as would be expected in comparison to the hazards from the other EST teams. All differences for these teams are attributable to cases in which M_{max} values extend below 5.0, or to cases where seismicity parameters were missing from EPRI computer files in degree cells adjacent to the site. These differences were not resolved in detail because the M_{max} values of all seismic sources are reassessed (increased above 5.0) in this project (see Subsection 2.5S.2.4.3) and new seismicity parameters are calculated for all degree cells adjacent to the site using an updated seismicity catalog (see Subsection 2.5S.2.1).

Given these considerations, the comparisons shown in Table 2.5S.2-14 are considered acceptable agreement, and indicate that, for a given set of assumptions on seismic sources, seismicity parameters, and ground motion equations, the same hazard results would be calculated today as in the original EPRI study.

Several types of new information on the sources of earthquakes may require changes in inputs to PSHA, resulting in changes in the level of seismic hazard at the STP site compared to what would be calculated based on the EPRI (Reference 2.5S.2-1) evaluation. Seismic source characterization data and information that could affect the calculated level of seismic hazard include:

- Effects caused by an updated earthquake catalog and resulting changes in the characterization of the rate of earthquake occurrence as a function of magnitude for one or more seismic sources
- Identification of possible new seismic sources in the site vicinity
- Changes in the characterization of the maximum magnitude for seismic sources
- Changes to models used to estimate strong ground shaking and its variability in the central and eastern United States

Possible changes to seismic hazard caused by changes in these areas are addressed in the following sections.

2.5S.2.4.2 Update of Seismicity Parameters

Subsection 2.5S.2.1 describes the development of an updated earthquake catalog. This updated catalog includes modifications to the EPRI evaluation by subsequent researchers, the addition of earthquakes that have occurred after completion of the

EPRI evaluation development (post 1985), and identification of additional earthquakes in the time period covered by the EPRI evaluation for the project region (1758 to 1984). In addition, the study region of the original EPRI catalog was extended to the south to include additional areas of the Gulf of Mexico that were outside the original study region. The impact of the new catalog information was assessed in two areas. First, investigation was made of the effect of the new earthquake data on earthquake recurrence estimates within a several-hundred-kilometer region around the STP site (Figure 2.5S.2-10). Second, the final seismicity catalog was used to estimate seismicity parameters for EPRI EST sources that extend into the Gulf of Mexico and adjacent on-shore regions that were not included in the original EPRI study region. This second step produced more complete estimates of seismicity parameters for coastal EPRI EST sources than were previously available.

2.5S.2.4.2.1 Local Region

The effect of the updated earthquake catalog on earthquake occurrence rates in the local region around the STP site was assessed by computing earthquake recurrence parameters for the test area shown in Figure 2.5S.2-10. This consisted of a rectangular area with dimensions 4o latitude by 4o longitude encompassing seismicity in the vicinity of the site, and because local events within 100 km of the site dominate the hazard (with the exception of the New Madrid Seismic Zone, which is treated separately). These dimensions were chosen to encompass historical seismicity in the vicinity of the site. The truncated exponential recurrence model was fit to historical seismicity data using the EPRI EQPARAM program, which uses the maximum likelihood technique. Earthquake recurrence parameters were computed first using the original EPRI catalog and periods of completeness and then using the updated catalog and extending the periods of completeness to 2006, assuming that the probability of detection for all magnitudes is unity for the time period 1985 to 2006. The resulting earthquake recurrence rates are compared in Figure 2.5S.2-11 for the test area. The comparison shows that the extended earthquake catalog results in earthquake recurrence rates that are comparable to, and slightly higher than, rates from the original earthquake catalog. The difference in calculated rates occurrence of earthquakes for all magnitude levels is about 4%.

On the basis of the comparison shown in Figure 2.5S.2-11, it is concluded that the earthquake occurrence rate parameters developed in the EPRI (Reference 2.5S.2-1) evaluation for seismic sources to the west and north of the site are comparable to the rate parameters that would be estimated with an updated catalog. Conclusions for sources with degree cells to the east and south of the site are addressed in the following section.

2.5S.2.4.2.2 Gulf of Mexico and Coastal Regions

For locations south and east of the site, the original EPRI (Reference 2.5S.2-1) study region was limited (see Figure 2.5S.2-7). Subsection 2.5S.2.1.3 describes how the seismicity catalog was extended, and Subsection 2.5S.2.1.5 describes how periods of complete reporting were developed for this region. With these inputs, the EPRI EQPARAM software was run to calculate seismicity parameters (a- and b-values) for degree cells that were not available from the original analysis. This unavailability was a result of the original EPRI analysis extending only as far south, as the site region shown in Figure 2.5S.2-1. Therefore no parameters were calculated south of the EPRI Incompleteness Regions shown in Figure 2.5S.2-7. The seismicity parameters of the following EPRI EST sources were recalculated.

- Bechtel Group: source -BZ1
- Dames & Moore: source 20
- Law Engineering: source 126
- Rondout: source 51
- Woodward-Clyde: source B43
- Weston Geophysical: source 107

The original EPRI EST smoothing assumptions were used for each source, except for that of Dames & Moore, where updated smoothing parameters (see Subsections 2.5S.2.2 and 2.5S.2.4.5.1) have been developed. These updated sources were adopted because they were based on a more complete earthquake catalog (through 2006), and because this catalog covered an extended region not included in the original EPRI (Reference 2.5S.2-1) study.

2.5S.2.4.2.3 New Madrid Region

As discussed in Subsection 2.5S.1.1.4.4.5.3, paleoliquefaction studies have been conducted in the region of the 1811-1812 New Madrid, Missouri earthquakes. These studies have identified several sequences of pre-historic earthquakes that allow estimation of recurrence intervals between major earthquakes in the region. These sequences have led to an estimated mean recurrence interval for large earthquakes in the New Madrid region of approximately 500 years. This mean recurrence interval represents a higher activity rate than was estimated by the EPRI ESTs. Therefore, an updated New Madrid seismic source model was included in the seismic source interpretation for each EPRI EST, as discussed in Subsection 2.5S.2.4.4 below.

2.5S.2.4.3 Updated Characterization of Gulf Coastal Source Zones

Geological and seismological data published since the 1986 EPRI seismic source model are summarized and discussed in Subsections 2.5S.1 and 2.5S.2.1 through 2.5S.2.3, respectively. Following the guidance of RG 1.208, these data were reviewed to determine whether the existing EPRI-SOG source characterizations for the STP 3 & 4 site (see Subsection 2.5S.2.2.1) adequately capture the new data. As part of this review, it was noted that two earthquakes within the Gulf of Mexico (10 February 2006 Emb 5.52 and 10 September 2006 Emb 6.11) had occurred since the EPRI-SOG study with magnitudes greater than the lower-bound Mmax values for some of the source zones that contain them. In general, these source zones encompass the Gulf Coastal region, extend into the Gulf of Mexico, and contain the STP 3 & 4 site (Figure 2.5S.2-8). For convenience, these zones are referred to here as Gulf Coastal Source Zones (GCSZs).

Based on the identification of new data potentially suggesting the need for revisions to the EPRI-SOG source characterizations of the GCSZs, the guidance of RG 1.208 was followed in developing updated source characterizations for the GCSZs. In particular, a Senior Seismic Hazard Analysis Committee (SSHAC) Level 2 process (Reference 2.5S.2-59) was used to develop the updates. The Technical Integrators (TIs) for this study were Dr. Christopher Fuller and Dr. Jeff Unruh from William Lettis & Associates, Inc. Experts queried for this update included the following academic and commercial geoscientists with expertise in tectonics and seismicity within the Gulf of Mexico (Dr. James Dewey, USGS; Dr. Frank Peel, BHP Billiton Petroleum; Dr. Meredith Nettles, Lamont-Doherty Earth Observatory; Dr. Joe Dellinger, British Petroleum; Dr. Goran Ekstrom, Lamont-Doherty Earth Observatory; Dr. Martin Chapman, Virginia Tech; Dr. James Pindell, Rice University) and members of the original EPRI-SOG ESTs (Dr. Joe Litehiser, Bechtel team; Mr. George Klimkiewicz, Weston team; and Mr. Jim McWhorter, Dames & Moore team). The peer review panel (PRP) consisted of the seismic Technical Advisory Group (TAG) members for the STP 3 & 4 project: Dr. Carl Stepp, independent Consultant; Dr. Robert Kennedy, RPK Consulting; Dr. Cliff Frohlich, University of Texas; Dr. Allin Cornell, Stanford University (deceased); and Mr. Donald Moore, Southern Company.

GCSZ Update Methodology Background

As discussed in the introduction to Section 2.5S.2, development of the PSHA used for STP 3 & 4 followed the guidelines of RG 1.208. The EPRI-SOG PSHA model (Reference 2.5S.2-60), considered an acceptable base model per RG 1.208, was used as the starting base model. Following the guidance of RG 1.208, this base model was evaluated in light of new data developed since the EPRI-SOG study to determine whether modifications needed to be made to the model to ensure that it adequately represents the most recent information. The key criteria specified by RG 1.208 for evaluation of the EPRI-SOG model is whether the model "adequately" describes, or is "consistent" with, the new data.

The decision to modify the GCSZs of the EPRI-SOG model resulted from an extensive review by the TIs of information and data published since the EPRI-SOG study, as recommended in RG 1.208 (see FSAR Sections 2.5S.1 and 2.5S.2.1 through 2.5S.2.3). The specific new data that triggered the update was the occurrence of the 10 February 2006 and 10 September 2006 earthquakes, hereafter referred to as the February and September earthquakes, which have magnitudes greater than the lower-bound maximum magnitude of some of the GCSZs that contain the earthquakes. Earthquakes with magnitudes greater than their host source zone's lower-bound maximum magnitude represent new data that require a revision to the EPRI-SOG model because the maximum magnitude for a source zone cannot be less than the largest observed historical earthquake within the zone.

SSHAC Process

As described in NUREG/CR-6372 (Reference 2.5S.2-59), SSHAC guidelines can be applied to any aspect or issue of a PSHA. The issues explicitly addressed in this investigation were:

(1) Does Gulf of Mexico seismicity, and in particular the February and September earthquakes, provide evidence that EPRI-SOG GCSZ characterizations need to be updated?

(2) What components of the characterizations (i.e., geometry, recurrence, Mmax) need to be updated?

(3) What methodology should be used to update those components, if required?

To address these issues, relevant available datasets were compiled and analyzed. This data compilation and analysis were conducted following the guidance of RG 1.208, as documented in FSAR Sections 2.5S.1 and 2.5S.2.1 through 2.5S.2.3.

Also as part of the data collection step, numerous experts were interviewed to help define the "legitimate range of technically supportable interpretations among the entire informed technical community" (Reference 2.5S.2-59, page 6) with respect to the geologic and seismotectonic setting of the two earthquakes. The interviews focused on determining: (1) whether the experts were familiar with the two earthquakes; and (2) if the experts knew of any distinguishable geologic features or structures that may have been sources for the earthquakes. The interviews demonstrated that there is no current consensus among the informed technical community as to whether a distinguishable geologic feature or structure is associated with either earthquake.

The TIs analyzed the interview results and data and determined that:

- The Mmax values of the GCSZs needed to be updated because the magnitudes of the February and September earthquakes were larger than the lower-bound Mmax for some of the zones;
- The earthquake recurrence model did not need to be updated because there has not been a significant change in seismicity rate (see Subsections 2.5S.2.1 and 2.5S.2.4); and,
- The geometry of the GCSZs needed to be considered for updating because the earthquakes occur in some of the zones and not others (Figure 2.5S.2-8).

The TIs evaluated whether the earthquakes implied that the GCSZ geometries needed to be updated separately for each of the earthquakes. For the September earthquake, the TIs concluded that the existing EPRI-SOG GCSZ geometries adequately characterize the community distribution of potential seismic sources that may have caused the earthquake. This conclusion was based on the expert opinions expressed in interviews that demonstrated there is significant uncertainty with respect to whether or not the earthquake is related to an identifiable feature (e.g., geologic structure), and the fact that the existing GCSZ geometries can be interpreted as representing both possibilities. For example, three of the ESTs source zones included the earthquake epicenter, and thus these source zones represent the interpretation that an earthquake similar to the September event can occur anywhere within a very broad region in the Gulf of Mexico (Bechtel, Weston, Rondout). The remaining three EPRI-SOG GCSZs do not include the earthquake epicenter, and thus represent the interpretation that the earthquake is related to a source outside of the existing source zones.

For the February earthquake, the TIs also concluded that the existing GCSZ geometries adequately encompass the community distribution of potential geologic features or structures that may have caused the earthquake. All of the new data, information, and interviews indicated that there is considerable uncertainty with respect to what geologic feature or structure may have been responsible for the earthquake. For example, some of the experts interviewed suggested that a large-scale landslide on the Sigsbee escarpment in the Gulf of Mexico may have caused the earthquake (Reference 2.5S.2-23). This hypothesis implies that similar earthquakes may occur along other segments of the Sigsbee escarpment, thus suggesting the presence of a potential localized seismic source along the escarpment. The TIs evaluated these opinions and concluded that:

- The hypothesis that the February earthquake was caused by a large-scale landslide is not uniformly accepted within the technical community and represents only a single model of the possible cause of the earthquake;
- The existing EPRI-SOG GCSZ geometries capture this hypothesized source as well as other potential sources (e.g., the hypothesis that the earthquake occurred in the basement beneath the sedimentary section) (Reference 2.5S.2-61); and
- The existing EPRI-SOG GCSZs adequately characterize the "legitimate range of technically supportable interpretations among the entire informed technical community" (Reference 2.5S.2-59, page 6) with respect to the source of the February earthquake.

Thus, following a SSHAC Level 2 process, the TIs concluded that the existing EPRI-SOG GCSZs are an adequate representation of the "legitimate range of technically supportable interpretations among the entire informed technical community" (Reference 2.5S.2-59, page 6) with respect to source geometry. Therefore, the TIs determined that only the Mmax values for the GCSZs did not adequately describe, or were not consistent with, the new data (i.e., the February and September earthquakes), and thus needed to be updated.

Through the process of interacting with the PRP, the final result of the SSHAC Level 2 study was the decision to update the Mmax values using the original EST methodology because this methodology would: (1) preserve one of the original goals of the EPRI-SOG study, and the goal of a SSHAC process, to represent the range of uncertainty in the informed technical community because interpretations from six different expert ESTs are used; and (2) result in revised Mmax distributions that are consistent with the latest data. The revised updates to the GCSZs Mmax values developed using this methodology are presented in the following paragraphs. The PRP endorsed both the TIs' approach of applying the EPRI-SOG EST's Mmax methodologies and the resultant updated Mmax distributions.

Updated Mmax Values

As described in the paragraphs above, the Mmax values for some of the EPRI-SOG GCSZs were updated to reflect the February and September earthquakes. A review of the original Mmax distributions for each EPRI EST is provided in Table 2.5S.2-7 through Table 2.5S.2-12 and a summary of original and modified Mmax distributions for GCSZs is provided in Table 2.5S.2-13. The GCSZs and the two earthquakes are shown in Figure 2.5S.2-8. For this update the Mmax distribution for a particular GCSZ was revised only if two conditions were met: (1) one or both of the 2006 moderate-magnitude earthquakes cannot be determined to have occurred outside the source zone with reasonable certainty; and (2) the observed Emb magnitude for the largest earthquake in the zone is greater than the minimum mb magnitude of the original EPRI-SOG 1986 Mmax distribution for the zone. Details on the revisions for each of the EST GCSZs,where required, are described in Subsections 2.5S.2.4.3.1 through 2.5S.2.4.3.6.

2.5S.2.4.3.1 Bechtel Group Gulf Coast Source Zone (Zone BZ1)

Bechtel Group assigned M_{max} values of 5.4, 5.7, 6.0, and 6.6 to the Gulf Coast Source Zone (Zone BZ1) (Table 2.5S.2-13). Because the Emb 5.5 and Emb 6.1 earthquakes from the updated catalog occur well within this zone (Table 2.5S.2-15) (Figure 2.5S.2-8), and because these magnitudes are greater than the lowest M_{max} values for the source zone, the M_{max} distribution for this source zone has been updated.

The updated M_{max} values of 6.1, 6.4, and 6.6 with weightings of 0.1, 0.4, and 0.5 used here (Table 2.5S.2-13) follow from the Bechtel Group's methodology of defining M_{max} distributions as follows (Reference 2.5S.2-13):

- The lower bound magnitude of the distribution is defined as the greater of either the largest observed earthquake magnitude within the zone, or m_b 5.4
- The next higher magnitude is 0.3 magnitude units greater than the minimum
- The third magnitude is 0.6 magnitude units above the minimum
- The fourth magnitude, and upper bound of the distribution, is m_b 6.6
- The weightings on the four M_{max} values are 0.1, 0.4, 0.4, and 0.1, assigned consecutively from the minimum M_{max} value

If these guidelines result in an upper bound magnitude or magnitudes greater than m_b 6.6, then the upper M_{max} distribution is truncated at m_b 6.6, and all weightings for magnitudes greater than or equal to 6.6 summed and collapsed onto the magnitude 6.6 upper bound.

2.5S.2.4.3.2 Dames & Moore South Coastal Margin (Zone 20)

Dames & Moore assigned M_{max} values of 5.3 and 7.2 to the South Coastal Margin Source Zone (Zone 20) (Table 2.5S.2-13). The Emb 5.5 and Emb 6.1 earthquakes from the updated catalog are 11 mi (18 km) and 152 mi (245 km) outside this zone, respectively (Table 2.5S.2-15) (Figure 2.5S.2-8). The Emb 6.1 earthquake was well recorded by regional and global seismograph networks, and its epicentral location is robust enough to conclude that it is outside the source zone (Reference 2.5S.2-30). The Emb 5.5 earthquake was not well recorded (Reference 2.5S.2-20 and 2.5S.2-21), and attempts at relocating the event by the U.S. Geological Survey using proprietary data from ocean bottom seismographs have resulted in significant variations (10s of km) in earthquake epicentral location (Reference 2.5S.2-30) relative to the location reported in the updated seismicity catalog (see Subsection 2.5S.2.1). This event is conservatively assumed to have occurred within the boundary of the source zone. Because the Emb 5.5 magnitude is larger than the lower bound M_{max} value, the M_{max} distribution for this source zone has been revised.

Documentation of the methodology used to determine the M_{max} distribution for the South Coastal Margin zone in the EPRI model is not explicitly provided in either the Dames & Moore EST volume from the EPRI study (Reference 2.5S.2-13), or the description of the EPRI PSHA model in the EQHAZARD Primer (Reference 2.5S.2-16). Given the lack of a well-documented methodology to follow, the M_{max} distribution used here results from increasing the lower M_{max} bound to match the magnitude of the observed Emb 5.5 earthquake while maintaining the same upper bound and weightings of the original M_{max} distribution for the source zone. The updated M_{max} values are m_b 5.5 and 7.2 with weightings of 0.8 and 0.2, respectively (Table 2.5S.2-13).

2.5S.2.4.3.3 Law Engineering South Coastal Block (Zone 126)

Law Engineering assigned M_{max} values of 4.6 and 4.9 to the South Coastal Block Source Zone (Zone 126) (Table 2.5S.2-13). The Emb 5.5 and Emb 6.1 earthquakes from the updated catalog are 39 mi (63 km) and 97.6 mi (157 km) outside this zone, respectively (Table 2.5S.2-15) (Figure 2.5S.2-8). The Emb 6.1 earthquake was well recorded and clearly lies outside the source zone (Reference 2.5S.2-30). The Emb 5.5 earthquake was not well recorded (Reference 2.5S.2-20 and 2.5S.2-21), and attempts at relocating the event from the position reported in the updated seismicity catalog (Subsection 2.5S.2.6.1) using proprietary data from ocean bottom seismographs have resulted in significant (10s of kilometers) variation in the position of the earthquake epicenter (Reference 2.5S.2-30). Although current published locations of the Emb 5.5 earthquake locate it outside the source zone boundaries, the uncertainty in the epicentral location of the earthquake is such that it could have occurred within the source zone. The earthquake is conservatively assumed to have occurred within the South Coastal Block Zone. Because the Emb 5.5 earthquake is larger than the lower bound M_{max} value of the South Coastal Block Source Zone, the M_{max} distribution has been revised accordingly.

The updated M_{max} values of 5.5 and 5.7, adopted here (Table 2.5S.2-13), are derived using Law Engineering's methodology for developing M_{max} distributions, as follows (Reference 2.5S.2-13):

(1) The lower bound M_{max} is the magnitude of the maximum observed earthquake in the zone

(2) The upper bound M_{max} magnitude defined by Law Engineering for regions with earthquakes occurring within 6.2 mi (10 km) of the surface is m_b 5.7

Weights for the original M_{max} distribution (0.9 on the lower bound M_{max} and 0.1 on the upper bound M_{max}) (Reference 2.5S.2-1 and 2.5S.2-13) are retained in the updated M_{max} distribution for the STP 3 & 4 hazard analysis (Table 2.5S.2-13).

2.5S.2.4.3.4 Rondout Associates Gulf Coast to Bahamas Fracture Zone (Zone 51)

Rondout Associates assigned M_{max} values of 4.8, 5.5, and 5.8 to the Gulf Coast to Bahamas Fracture Zone Source Zone (Zone 51) (Table 2.5S.2-13). Because both the Emb 5.5 and Emb 6.1 earthquakes from the updated catalog occur well within this zone (Table 2.5S.2-15) (Figure 2.5S.2-8), and because these magnitudes are greater than the lowest M_{max} values for the source zone, the M_{max} distribution for this source zone has been updated.

The updated M_{max} values of 6.1, 6.3, and 6.5 with weightings of 0.3, 0.55, and 0.15 (respectively) used here (Table 2.5S.2-13) follow from reclassifying the source zone as one capable of producing moderate earthquakes instead of the original classification of the source zone as one only capable of producing smaller than moderate earthquakes (Reference 2.5S.2-13). The original Rondout M_{max} distribution for moderate earthquake source zones is 5.2, 6.3, and 6.5 with weightings of 0.3, 0.55, and 0.15, respectively. The updated M_{max} distribution for the STP 3 & 4 COL application follows this distribution with the exception of an increase in the lower bound of the distribution to 6.1 to account for the observed Emb 6.1 earthquake within this zone.

2.5S.2.4.3.5 Weston Geophysical Corporation Gulf Coast Source Zone (Zone 107)

Weston Geophysical Corporation assigned M_{max} values of 5.4 and 6.0 to the Gulf Coast Source Zone (Zone 107) (Table 2.5S.2-13). Both the Emb 5.5 and Emb 6.1 earthquakes from the updated catalog occur well within this zone (Table 2.5S.2-15) (Figure 2.5S.2-8). Because these magnitudes are greater than the 1986 M_{max} values for the source zone, the M_{max} distribution for this source zone has been revised.

Weston Geophysical Corporation's (Reference 2.5S.2-13) methodology for defining M_{max} is based on developing discrete distributions for the probability of M_{max} being a particular value. For the Gulf Coast Source Zone, these M_{max} values and probabilities determined by the Weston Geophysical Corporation EST are: 3.6 (0.04628), 4.2 (0.11982), 4.8 (0.27542), 5.4 (0.34415), 6.0 (0.16169), 6.6 (0.04461), and 7.2 (0.00553) (Reference 2.5S.2-13). Following Weston Geophysical Corporation's methodology, this discrete probability distribution is truncated at the magnitude that is closest to, yet greater than, the maximum observed earthquake within the source zone. For this study the distribution is truncated at 6.6 because the Emb 6.1 earthquake occurred within the source zone, and the next highest discrete magnitude in the distribution is 6.6. The truncated distribution is then renormalized so that the sum of all the probabilities is 1.0. The final M_{max} values are the truncated distribution, and the weights are the renormalized probabilities.

2.5S.2.4.3.6 Woodward-Clyde Consultants Central United States Backgrounds Source Zone (Zone B43)

Woodward-Clyde Consultants assigned M_{max} values of 4.9, 5.4, 5.8, and 6.5 to the Central United States Background Source Zone (zone B43) (Table 2.5S.2-13). Because the Emb 5.5 and Emb 6.1 earthquakes are 170 mi (273 km) and 395 mi (635 km) from the boundary of the source zone, respectively (Table 2.5S.2-15) (Figure 2.5S.2-8), the M_{max} distribution for this source zone is not revised.

2.5S.2.4.4 Updated Seismic Source Characterization

Geological, geophysical, and seismological information developed since the 1986 EPRI study (Reference 2.5S.2-13) was reviewed to identify seismic sources not included in the original EPRI screening for STP 1 & 2 (Reference 2.5S.2-1), and which should be evaluated to determine their potential contribution to seismic hazard at STP 3 & 4. Two sources were re-evaluated as described below:

- The Mt. Enterprise-Elkhart Graben (MEEG), located to the northeast of STP 3 & 4 just inside the 200-mile site region radius (Figure 2.5S.1-17 and Figure 2.5S.1-25)
- The New Madrid Seismic Zone located in the border region of Missouri, Arkansas and Tennessee northeast of the STP 3 & 4 site region (Figure 2.5S.1-26 and Figure 2.5S.2-9)

2.5S.2.4.4.1 Mt. Enterprise-Elkhart Graben

The MEEG is comprised of a system of roughly east-west-striking normal faults of various length and width scales (Reference 2.5S.2-31, 2.5S.2-32, 2.5S.2-33, 2.5S.2-34, and 2.5S.2-35). The STP 1 & 2 UFSAR (Reference 2.5S.2-36) concluded that the most recent movement on the faults that comprise the MEEG system, referred to as the Mount Enterprise fault zone in the STP 1 & 2 UFSAR, was likely Eocene in age or younger. Several publications that predate the 1986 EPRI studies present multiple lines of evidence that document Quaternary motion and active creep along the MEEG (see detailed discussion in Subsection 2.5S.1.1.4.4.5.1). Subsurface structure, imaged by seismic reflection data, indicate that the MEEG is rooted in the Jurassic Louann Salt at maximum depths of 4.5 to 6 km (Reference 2.5S.2-32 and 2.5S.2-35). This suggests that late Quaternary displacement and contemporary creep across the MEEG may be driven by movement of salt at depth, indicating that the fault is not accommodating tectonic deformation and thus is not an independent source of moderate to large earthquakes. Presumably, this was the evaluation of the EPRI ESTs, which had access to the pre-1986 literature on the MEEG and did not specifically characterize it as a Quaternary tectonic fault and potentially capable structure (Reference 2.5S.2-13). Subsequent research and publications reflect uncertainty among some members of the informed technical community regarding the seismic potential of the fault system (Reference 2.5S.2-34). Although no new data have been published since the 1986 EPRI studies to support an interpretation that the MEEG is a capable tectonic structure (Subsection 2.5S.1.1.4.4.5.1), the MEEG is included here in a sensitivity analysis with a low probability of activity (Pa = 0.2) to account for this uncertainty. The source characterization is described as follows.

For the purpose of modeling hazard at the STP 3 & 4 site, MEEG is represented as a western and eastern line source spanning the extent of the normal fault system shown in Figure 2.5S.1-24. The lengths of the respective line sources are 56 mi (90 km) and 37 mi (59 km). Published cross sections based on borehole and seismic reflection data show MEEG faults as conjugate pairs dipping to the north and south at average dips of 60º, and with maximum widths of 2.9 to 4.4 miles (4.6 to 7 km) (Reference 2.5S.2-31, 2.5S.2-32, 2.5S.2-33, and 2.5S.2-34). Because no single, uniform dip direction characterizes the MEEG, we model the structure as a vertical fault. We emphasize that adopting a vertical fault approximation for the MEEG is intended to capture its average behavior as a source of strong ground motion only. Documented local observations of the magnitude and direction of dip on the MEEG are retained for the purposes of determining slip rate and maximum magnitude.

As discussed in Subsection 2.5S.1.1.4.4.5.1, there are two estimates of offset across the MEEG:

- A long-term average separation rate determined from offset Quaternary gravels of approximately 0.02 mm/yr (0.00079 in/yr) corresponding to 0.023 mm/yr (0.00091 in/yr) of dip slip on a 60º fault
- A short-term separation rate determined from geodetic leveling spanning 1920 to the 1950s of approximately 4.3 mm/yr (0.17 in/yr) corresponding to 5.0 mm/yr (0.20 in/yr) of dip slip on a 60º dipping fault

The apparent modern creep rate of 4.3 mm/yr (0.17 in/yr) documented by geodetic leveling (Reference 2.5S.2-31), if accurate, likely reflects movement of salt at depth and is not indicative of the rate of tectonic strain accumulation on the MEEG, so the offset Quaternary gravels are used as the basis for estimating the tectonic slip rate of the MEEG. Because only one slip rate estimate is available, the 0.023 mm/yr (0.00091 in/yr) is taken as the mean slip rate with an uncertainty of + 50%, resulting in a slip rate distribution of 0.012 mm/yr (0.00047244 in/yr), 0.023 mm/yr (0.00091 in/yr), and 0.035 mm/yr (0.0013780 in/yr) with weightings of 0.2, 0.6, and 0.2, respectively.

M_{max} values are estimated following two methods:

- Using empirical relations for magnitude and rupture area, as well as observations of rupture aspect ratios for normal faults
- Using empirical relations for the magnitude and maximum displacement during a single event

Data compiled worldwide from earthquakes associated with normal fault rupture demonstrates that the rupture length to width ratio for normal faulting earthquakes is generally less than 4:1 (Reference 2.5S.2-37) and usually closer to 1:1 (Reference 2.5S.2-38). These observations suggest that given the width of the MEEG faults, rupture of the full fault lengths of 56 mi (90 km) and 37 mi (59 km) in a single event is not likely. To take into account these observations, M_{max} values are calculated using the normal faulting relationship of Reference 2.5S.2-37 using a fault width of 4.6 and 7 km and an aspect ratio of 4:1. The resulting M_{max} values are:

M_{max} of **M** 5.9 for a fault area of 11 mi x 2.9 mi (18.4 km x 4.6 km)

M_{max} of **M** 6.3 for a fault area of 17 mi x 4.4 mi (28 km x 7 km)

Reference 2.5S.2-37 present relationships between the maximum coseismic displacement and earthquake magnitude. Using the relationship appropriate for normal faults and the 66 cm (26 inches) of observed offset in Quaternary gravels (see Subsection 2.5S.1.1.4.4.5.1), a third M_{max} value for MEEG is **M** 6.5.

The three M_{max} estimates presented above (**M** 5.9, 6.3, and 6.5) are used as the distribution of M_{max} values for the MEEG with weightings of 0.2, 0.6, and 0.2, respectively. These **M** magnitudes are converted to m_b magnitudes following the procedure outlined in Subsection 2.5S.2.1.2. The final distribution of M_{max} values with weights is m_b 6. (0.2), m_b 6.5 (0.6), m_b 6.6 (0.2).

2.5S.2.4.4.2 New Madrid Seismic Zone

The New Madrid Seismic Zone extends from southeastern Missouri to southwestern Tennessee and is located more than 500 mi (800 km) northeast of the STP 3 & 4 site (Figure 2.5S.1-26. The New Madrid Seismic Zone produced a series of large-magnitude earthquakes between December 1811 and February 1812 (Reference 2.5S.2-39). Subsection 2.5S.1.1.4.4.5.3 presents a detailed discussion of the New Madrid Seismic Zone. Several studies that post-date the 1986 EPRI EST assessments demonstrate that the source parameters for geometry, M_{max}, and recurrence of M_{max} in the New Madrid region need to be updated to capture a more current understanding of this seismic source (Reference 2.5S.2-28, 2.5S.2-39, 2.5S.2-40, 2.5S.2-41, 2.5S.2-42, and 2.5S.2-43).

The original EPRI screening study for the STP 1 & 2 UFSAR did not show any New Madrid Source Zones from the EPRI-SOG ESTs as contributing to 99% of the hazard (Reference 2.5S.2-1) because New Madrid was only considered as a potential source if it was within 500 miles of the site (Reference 2.5S.2-1). However, the updated geometry, M_{max} values, and recurrence intervals for the New Madrid source and updated ground motion attenuation relations developed for the CEUS require reevaluation of the New Madrid Seismic Zone as a potential contributor to 99% of the hazard at STP3 & 4. The updated New Madrid seismic source model described in Exelon's ESP Application (Reference 2.5S.2-27) (Figures 2.5S.2-12 and 2.5S.2-12) and ground motion attenuation models published in EPRI (Reference 2.5S.2-44) form the basis for determining the potential contribution from the New Madrid Seismic Zone to seismic hazard at STP 3 & 4. This model accounts for new information on recurrence intervals for large earthquakes in the New Madrid area, for recent estimates of possible earthquake sizes on each of the active faults, and for the possibility of multiple earthquake occurrences within a short period of time (earthquake clusters).

Three faults are identified in the New Madrid Seismic Zone, each with two alternative geometries, as follows (Figures 2.5S.2-12):

Fault	Geometry
Blytheville	Blytheville arch/Bootheel lineament Blytheville arch/Blytheville Fault Zone
Northern	New Madrid north New Madrid north with extension
Reelfoot	Reelfoot central section Reelfoot full length

Earthquakes are treated as characteristic events in terms of magnitudes, with the following sets of magnitudes modeled for each fault (Reference 2.5S.2-27):

Blytheville	Reelfoot	Northern	Weight
7.3	7.5	7.0	0.1667
7.2	7.4	7.0	0.1667
7.2	7.4	7.2	0.0833
7.6	7.8	7.5	0.25
7.9	7.8	7.6	0.1667
7.8	7.7	7.5	0.1667

The above magnitudes represent the centers of characteristic magnitude ranges that extend ±0.25 magnitude units above and below the indicated magnitude.

Seismic hazard is calculated considering the possibility of clustered earthquake occurrences. The modeling of earthquake clusters in the New Madrid Seismic Zone has undergone considerable study, and this model will continue to evolve as further field evidence on paleo-earthquakes is found and analyzed. In the adopted model, all three faults rupture during each “event,” and the hazard is computed using this simplified model. This simplified model results in slightly higher ground motion hazard than if the possibility of two fault ruptures is considered or if a smaller-magnitude earthquake is considered for one of the three ruptures. The occurrence rate of earthquake clusters is developed using two models, a Poisson model and a lognormal renewal model with a range of coefficients of variation (Reference 2.5S.2-27). Consistent with Reference 2.5S.2-27, all faults are assumed to be vertical and to extend from the surface to 20 km depth. A finite rupture model is used to represent an extended rupture on all faults. Because of the large distance between the New Madrid Seismic Zone and STP 3 & 4, the details of the geometrical representation of each fault are not critical to the seismic hazard calculations.

2.5S.2.4.5 Other Revisions to the EPRI Source Model

2.5S.2.4.5.1 Revised Smoothing Parameters for Dames & Moore’s South Coastal Margin Source Zone

In the 1986 EPRI model, there are no seismicity parameters calculated and assigned to the degree cells adjacent to STP 3 & 4 for the Dames & Moore South Coastal Margin Source Zone (zone 20) (Reference 2.5S.2-1). The lack of parameters in this region is due to the combination of Dames & Moore adopting zero smoothing for the source zone, and the absence of seismicity from the 1986 EPRI model seismicity catalog within the degree cells that would be used to make estimates of these parameters (Reference 2.5S.2-1). Without parameters for these degree cells, the geographic regions adjacent to STP 3 & 4 do not contribute to the hazard at STP 3 & 4.

The smoothing for Dames & Moore's South Coastal Margin Source Zone has been updated for STP 3 & 4 hazard calculations to ensure that seismicity parameters are defined for degree cells adjacent to the site, and thus that these cells contribute to the calculated hazard at the site. The updated smoothing options and associated weights are (Table 2.5S.2-13):

- Constant a, constant b, strong prior on b of 1.04 (weight 0.2)
- Medium smoothing on a, medium smoothing on b, strong prior on b of 1.04 (weight 0.4)
- High smoothing on a, high smoothing on b, strong prior on b of 1.04 (weight 0.4)

These smoothing options are based on those used within in the 1986 EPRI model (Reference 2.5S.2-13 and 2.5S.2-16). The use of a strong prior on b of 1.04 reflects the preference of the Dames & Moore EST for a prior on b of 1.04 for other background source zones within the 1986 model (Reference 2.5S.2-13 and 2.5S.2-16).

2.5S.2.4.5.2 Update of the EPRI Model Southern Extent

The calculation of seismic hazard within the EPRI computational model developed following the 1986 study (i.e., EQHAZARD) (Reference 2.5S.2-16) from background source zones depends on the presence of a suite of seismicity parameters gridded throughout the source zone. Seismicity parameters in the original model within the Gulf of Mexico region were not calculated or gridded south of 28º N near the site. (See Figure 2.5S.2-7 for the complete definition of this boundary.) Consequently, a sensitivity analysis performed for seismic hazard at STP 3 & 4 confirmed that regions of GCSZs that extend south of 28º N were not included in the calculation of vibratory ground motion hazard at the STP 3 & 4 (Reference 2.5S.2-16) when the original parameterization of the EPRI model (Reference 2.5S.2-1 and 2.5S.2-13) was used. In particular, regions of the Gulf of Mexico and western Texas that are within contributing GCSZs that encompass STP 3 & 4 did not contribute to the hazard at STP 3 & 4. For the EPRI source model used in the final rock hazard calculation for STP 3 & 4, seismicity parameters were calculated for regions south of 28º N using supplemental estimates of periods of incompleteness for this region (see Subsection 2.5S.2.1) to ensure that seismicity parameters are gridded within the full extent of source zones within the Gulf Coastal Plain and Gulf of Mexico region.

2.5S.2.4.6 New Ground Motion Models

Since the EPRI study (Reference 2.5S.2-1), ground motion models for CEUS have evolved. An EPRI project was conducted to summarize knowledge about CEUS ground motions, and results were published by EPRI (Reference 2.5S.2-44). These updated equations estimate median spectral acceleration and its uncertainty as a function of earthquake magnitude and distance. Epistemic uncertainty is modeled using multiple ground motion equations with weights, and multiple estimate of aleatory uncertainty, also with weights. Different sets of sources are recommended for seismic sources that represent rifted vs. non-rifted regions of the earth's crust. Equations are available for spectral frequencies at hard rock sites of 100 Hz (which is equivalent to peak ground acceleration, PGA), 25 Hz, 10 Hz, 5 Hz, 2.5 Hz, 1 Hz, and 0.5 Hz.

The aleatory uncertainties published in the EPRI (Reference 2.5S.2-44) 2004 model were re-examined by EPRI (Reference 2.5S.2-45) because it was thought that the EPRI (Reference 2.5S.2-44) 2004 aleatory uncertainties were probably too large, resulting in over-estimates of seismic hazard. The EPRI (Reference 2.5S.2-45) study recommends a revised set of aleatory uncertainties and weights that can be used to replace the original EPRI (Reference 2.5S.2-44) 2004 aleatory uncertainties.

In summary, the ground motion models used in the seismic hazard calculations consisted of the median equations from EPRI (Reference 2.5S.2-44) combined with the updated aleatory uncertainties of the EPRI study (Reference 2.5S.2-45).

2.5S.2.4.7 Updated Probabilistic Seismic Hazard Analysis and Deaggregation

The seismic hazard at the STP site was investigated with the changes described in Subsection 2.5S.2.4.2 through 2.5S.2.4.6 to seismic sources, seismicity parameters, maximum magnitudes, and ground motion equations. The PSHA was made first for hard rock conditions. A PSHA consists of calculating annual frequencies of exceeding various threshold ground motion amplitudes for all possible earthquakes that are hypothesized in a region. The seismic sources are characterized by the rates of occurrence of earthquakes as a function of magnitude and distance, and the ground motion model estimates the distribution of ground motions at the site for each event. Multiple weighted hypotheses on seismic sources, earthquake rates of occurrence, and ground motions (characterized by the median ground motion amplitude and its uncertainty) result in multiple weighted seismic hazard curves, and from these the mean and fractile seismic hazard can be determined. The calculation is made separately for each of the six EPRI ESTs, and the seismic hazard distributions for the teams are combined, weighting each team equally. This combination gives the overall mean and distribution of rock seismic hazard at the site. The effects of local site conditions on seismic ground motions are taken into account below.

As described in Subsection 2.5S.2.4.4, a review of geological, geophysical, and seismological information developed since the 1986 EPRI study (Reference 2.5S.2-13) identified the MEEG and the New Madrid Seismic Zone as two seismic sources that were not included in the in the original EPRI screening for STP 1 & 2 (Reference 2.5S.2-1). The review indicated these sources should be evaluated to determine their potential contribution to seismic hazard at STP 3 & 4. A sensitivity analysis was completed using these sources in conjunction with the EPRI (Reference 2.5S.2-44) ground motion equations and the aleatory uncertainty model to determine if the two new sources contribute to 99% of the hazard at STP 3 & 4. The results of the analysis showed that MEEG provided an insignificant contribution to hazard, well below 1% of the hazard, and that the New Madrid Seismic Zone was a significant contributor.

Based on the results of the sensitivity analysis, the final PSHA for hard rock conditions was calculated with the EPRI (Reference 2.5S.2-1) team sources, modified as discussed above for additional seismicity in the Gulf of Mexico, with the addition of the New Madrid Seismic Zone model to each team's interpretations. The following EPRI EST sources were included:

- Bechtel Group: sources BEC-BZ1, BEC-BZ2
- Dames & Moore: sources DAM-20, DAM-25, DAM-C08
- Law: sources LAW-124, LAW-126
- Rondout: source RND-51
- Woodward-Clyde: source WCC-B43
- Weston: source WGC-107

Figures 2.5S.2-14 and 2.5S.2-15 show mean rock hazard by team for 10 Hz and 1 Hz spectral accelerations, respectively. The team weights are not reflected in Figures 2.5S.2-14 and 2.5S.2-15, i.e. each team is effectively given a weight of 1.0 in those figures. The mean hazard curves are similar, particularly for 1 Hz, because the New Madrid seismic source is common to all teams and dominates the hazard for this frequency. This is further illustrated in Figures 2.5S.2-16 and 2.5S.2-17, where mean seismic hazard curves are plotted for individual sources for 10 Hz and 1 Hz, respectively. In these figures the probability of activity of each source is reflected in the hazard (the probability of exceedance of ground motion amplitudes), but the team weights (1/6 each) are not reflected. The New Madrid seismic source dominates the 1 Hz hazard for annual frequencies of exceedance down to 10^{-6}, and has a major contribution to 10 Hz hazard for annual frequencies of exceedance in the range 10^{-3} to 10^{-4}.

Figures 2.5S.2-18 through 2.5S.2-24 show total rock hazard as the mean, 5th, 16th, 50th, 84th, and 95th fractile curves. One of the characteristics of the low spectral frequency hazard curves (1 Hz and 0.5 Hz, in particular) is that the mean rock hazard curves exceed the 84th fractile at high ground motion amplitudes. This is the case when the New Madrid seismic source dominates the hazard, and is caused by a few EPRI (Reference 2.5S.2-44) ground motion equations indicating relatively high hazards for the large distance between the New Madrid seismic source and the STP 3 & 4 site. This is shown in Figure 2.5S.2-25, which plots the 1 Hz spectral acceleration hazard from the New Madrid seismic source only, for the 12 ground motion equations used for that source. The curve indicated as "F9" with a weight of 0.036, indicates the highest hazard, more than a factor of 10 above all other curves. This curve alone will cause the mean hazard to coincide with a very high fractile hazard curve for cases where the New Madrid seismic source dominates the hazard.

Figure 2.5S.2-26 shows the mean and median 10^{-4}, 10^{-5}, and 10^{-6} uniform hazard response spectra (UHRS) for hard rock conditions, based on the seven ground motion frequencies for which ground motion estimates are available. Numerical values for the mean UHRS are shown in Table 2.5S.2-16.

The seismic hazard was deaggregated following the guidelines of RG 1.208. Specifically, the mean contributions to seismic hazard for 1 Hz and 2.5 Hz were deaggregated by magnitude and distance for the mean 10^{-4} ground motions at 1 Hz and 2.5 Hz, and these deaggregations were combined. Figure 2.5S.2-27 shows this combined deaggregation. Similar deaggregations of the mean hazard were performed for 5 and 10 Hz spectral accelerations (Figure 2.5S.2-28). Deaggregations of the mean hazard for 10^{-5} and 10^{-6} ground motions are shown in Figures 2.5S.2-29 through 2.5S.2-32. Deaggregation of the mean seismic hazard is recommended in RG 1.206. The contribution of the New Madrid source to seismic hazard is plotted in the deaggregation figures in the last distance interval, which represents 248 mi or greater (400+ km); the New Madrid source is actually about 1000 km from the STP 3 & 4 site.

Figures 2.5S.2-27 through 2.5S.2-32 include the contribution to hazard by, which is the number of logarithmic standard deviations that the applicable ground motion (10^{-4}, 10^{-5}, or 10^{-6}) is above the logarithmic mean. These figures indicate that the largest contribution to hazard for 10^{-4} and 10^{-5} ground motions comes from values between 0 and 2 standard deviations above the mean, which is a common result.

The deaggregation plots in Figures 2.5S.2-27 through 2.5S.2-30 for 10^{-4} and 10^{-5} ground motions indicate that the New Madrid seismic source has a major contribution to seismic hazard at the STP 3 & 4 site. For 10^{-4} annual frequency of exceedance, this source is the largest contributor to seismic hazard for both 5 and 10 Hz (Figure 2.5S.2-27) and 1 and 2.5 Hz (Figure 2.5S.2-28). For an annual frequency of 10^{-5}, the contribution is smaller particularly for high frequencies (see Figures 2.5S.2-29 and 2.5S.2-30). For an annual frequency of 10^{-6}, virtually all hazard at high frequencies comes from local sources (Figure 2.5S.2-32), while low frequencies have about equal contributions from the New Madrid seismic source and from local sources (Figure 2.5S.2-31). All of these observations are confirmed qualitatively in Figures 2.5S.2-16 and 2.5S.2-17, which compare the hazard from the New Madrid source to the hazard from local sources for 10 Hz and 1 Hz.

Table 2.5S.2-17 summarizes the mean magnitude and distance resulting from these deaggregations, for all contributions to hazard and for contributions with distances exceeding 100 km. For the 1 and 2.5 Hz results, contributions from events with R>100 km exceed 5% of the total hazard. As a result, following the guidance of RG 1.208, the controlling earthquake for low frequencies (LF) ground motions was selected from the R>100 km calculation, and the controlling earthquake for high frequencies (HF) ground motions was selected from the overall calculation. The values of **M** and R selected in this way are shown in shaded cells in Table 2.5S.2-17.

Smooth rock UHRS were developed from the UHRS amplitudes in Table 2.5S.2-16, using controlling earthquake **M** and R values shown in Table 2.5S.2-17 and using the hard rock spectral shapes for CEUS earthquake ground motions recommended in NUREG/CR-6728 (Reference 2.5S.2-46). Separate spectral shapes were developed for HF and LF. In order to reflect accurately the UHRS values calculated by the PSHA as shown in Table 2.5S.2-16, the HF spectral shape was anchored to the UHRS values from Table 2.5S.2-16 at 100 Hz, 25 Hz, 10 Hz, and 5 Hz. In between these frequencies, the spectrum was calculated using shapes anchored to the next higher and lower frequency and weighting those shapes. The weighting was based on the inverse logarithmic difference between the intermediate frequency and the next higher or lower frequency. This technique provided a smooth, realistic spectral shape at these intermediate frequencies. Below 5 Hz, the HF shape was extrapolated from 5 Hz.

For the LF spectral shape a similar procedure was used except that the LF spectral shape was anchored to the UHRS values at all seven ground motion frequencies for which hazard calculations were made (100 Hz, 25 Hz, 10 Hz, 5 Hz, 2.5 Hz, 1 Hz, and 0.5 Hz). Anchoring the LF spectral shape to all frequencies was necessary because otherwise the LF spectral shape exceeded the HF spectral shape at high frequencies. This results from the contribution of extreme ground motions ($\varepsilon>1$, see for example Figures 2.5S.2-29) at low spectral frequencies, and a resulting UHRS shape that differs from the median shape predicted in NUREG/CR-6728.

Figures 2.5S.2-33 and 2.5S.2-34 show the horizontal HF and LF spectra calculated in this way for 10^{-4} and 10^{-5} annual frequencies of exceedance, respectively; see Tables 2.5S.2-18 and 2.5S.2-19 for sampled numerical values of these rock response spectra. As mentioned previously, these spectra accurately reflect the UHRS amplitudes in Table 2.5S.2-16 that were calculated for the seven spectral frequencies at which PSHA calculations were done. Because the HF and LF spectra were scaled to the same high-frequency amplitudes, they are very similar at high frequencies. These spectra were used in site amplification calculations.

2.5S.2.4.8 Middle America Trench Seismic Hazard Sensitivity

The Middle America Trench [MAT] along the western coast of Mexico is over 800 miles (1300 km) from the STP 3 & 4 site at its closest approach. However, due to the low levels of seismicity within Texas and the relatively frequent large magnitude earthquakes observed from subduction along the MAT, the possibility that earthquakes along the MAT off Mexico could contribute to hazard at the project site was examined. A seismic hazard sensitivity study was performed to assess the significance of that hazard relative to the hazard presented from the other seismic sources already being considered. Given the large distance and the average crustal attenuation characteristics between the MAT and the project site, it was assessed that longer period motions would be most likely to contribute to the seismic hazard at the STP 3 & 4 site. For this reason, the sensitivity study focused on 1 Hz ground motion. Further, for the purpose of the sensitivity study, focus was placed on the subduction interface earthquakes, the source of earthquakes observed as large as nearly **M**~8 and arguably with the potential of being as large as **M**~9. The sensitivity study required development of a seismic source model for the large magnitude MAT subduction interface earthquakes, as well as a long-distance 1 Hz ground motion attenuation relationship. Detailed assessment of uncertainties was considered in both the seismic source and ground motion models.

Seismic Source Model

The MAT off of the west coast of Mexico was divided into four distinct segments based on variations in the age of the subducted oceanic crust, dip of the subducting plate, extent of historic interplate earthquake ruptures, and the presence or absence of fracture zones and ridges on the subducting plate. While the historical record of seismicity within this region shows that the MAT has been characterized by single-segment ruptures roughly corresponding to the four segments, the MAT seismic source model also considered the possibility of multi-segment ruptures.

A logic-tree approach was used to parameterize the MAT seismic source model. Besides the possibility of single or multiple-segment ruptures, associated distributions of maximum magnitudes were considered. Plate convergence rates and a distribution of plate coupling – a measure of the portion of the plate motion that is manifested as seismicity as opposed to aseismic deformation – were considered to model a range of slip rates for each of the single and multiple segments.

1 Hz Ground Motion Attenuation Model

An assessment of seven published attenuation models for 1 Hz spectral acceleration attenuation from subduction zone interface earthquakes was made. The relationships are based on both empirical and modeled data. While only two of the published relations were presented as applicable to the large distances needed for the PSHA – both relationships based on modeling studies – all seven were evaluated as to their median attenuation behavior over a magnitude range 6.5 to 8.5 and for distances out to 2,000 km. As a result of the comparison, a representative model among the suite of relationships was chosen for a median 1 Hz ground motion estimate. Epistemic uncertainty was evaluated and a bounding value appropriate for the purposes of the sensitivity study was developed.

Seismic Hazard Sensitivity Assessment

A PSHA was performed using the seismic source and ground motion models, summarized above. Comparison of the resulting 1 Hz hazard curve was made to an early version of the total PSHA using the significant updated EPRI-SOG sources, discussed in this section. Note that the early version of the total PSHA was sufficiently similar to the final version, presented here, for the purposes of the sensitivity study. At the 1 Hz ground motion acceleration corresponding to the 10^{-4} hazard level of the total hazard curve (excluding MAT contribution), the MAT hazard curve was less than 1% of that given by the total hazard curve. As the MAT hazard curve decreases faster than the total hazard curve with increasing ground motion, the relative MAT hazard at the 10^{-5} hazard level of the total hazard would be even less. Given the specification of the subset of EPRI-SOG sources in the CEUS to be considered as those contributing to 99% of the total hazard, the MAT contribution to the total is too small for further PSHA consideration.

2.5S.2.4.9 Vertical ground motions

Vertical spectra were derived from horizontal spectra after accounting for site amplification. V/H ratios were used to estimate 10^{-4} and 10^{-5} vertical spectra from the consistent horizontal spectra. This process, and the resulting spectra, are described in Subsection 2.5S.2.6.

2.5S.2.5 Seismic Wave Transmission Characteristics of the Site

The UHRS described in the previous section are defined on hard rock characterized with shear wave velocity Vs = 9200 fps, which is located at more than 30,000 feet (9144 m) below the ground surface. This section describes the development of the site amplification factors that result from the transmission of the seismic waves through the thick soil column. The effect is modeled by a truncated soil column, extending from the ground surface to a depth of about 8100 feet (2469 meters), and an adjustment to the soil damping within the truncated soil column to represent the anelastic attenuation of ground motion by the entire soil column (the “kappa” value).

The development of the site amplification factors is performed in the following steps:

(1) Develop a model of the base case soil column using site-specific geotechnical and geophysical data to a depth of about 600 feet (182 meters), augmented to a depth of about 8100 feet (2469 meters) with deep velocity profiles obtained from available deep sonic log data. The model for the upper 600 feet (182 meters) is based on mean shear wave velocities measured at the site and shear modulus and damping strain dependencies taken from selected generic curves to match the Resonant Shear Column Torsional (RCTS) testing results (see Subsection 2.5S.4.7). The deeper soil layers are assumed to behave linearly. This model provides the base case representation of the dynamic properties of STP 3 & 4 site subsurface.

(2) Confirm that this model adequately captures the frequency-dependent response of the deep soil column over all frequencies of interest.

(3) Calculate strain-independent (linear-elastic) material damping values for the deep soil strata (600 to 8100 ft), which experience small levels of strain during the earthquake to ensure that the truncated site model accurately accounts for the dissipation of energy in the deep soil site. This is done by constraining the damping within these deeper strata to replicate an estimate of the total kappa for the site.

(4) Generate a set of 60 artificial “randomized” soil profiles by using the base soil column and developing a probabilistic model that describes the uncertainties in the above soil properties, location of layer boundaries, correlation between the velocities in adjacent layers and the overall dissipation of energy in the site. Use the 10^{-4} and 10^{-5} annual-frequency-of-exceedance smooth LF and HF hard rock spectra of Subsection 2.5S.2.4 for input into the base of the randomized soil columns, calculate dynamic response of the site for each of the 60 artificial profiles by using an equivalent-linear site-response formulation together with Random Vibration Theory (RVT), and calculate the mean of site response. Time histories for the site response analysis are not

required for the frequency-domain RVT approach to site response analysis. This step is repeated for each of the four input motions (10^{-4} and 10^{-5} annual frequencies, HF and LF smooth spectra).

These steps are described in detail in the following subsections. The resulting site-specific ARS are used to develop GMRS in Subsection 2.5S.2.6

2.5S.2.5.1 Base Case Soil Column and Uncertainties

Development of a base case soil column is described in detail in Subsection 2.5S.4. Summaries of the low strain shear wave velocity, material damping, and strain-dependent properties of the base case soil strata are provided below in this section. These parameters serve as input for the site response analyses.

The geology at the STP 3 & 4 site consists of deep marine and fluvial deposits overlying bedrock. The upper approximately 600 feet (182 m) of the site soils were investigated using test borings, Cone Penetration Testing (CPT), test pits, and geophysical methods. Based on the results from these tests, soils in the upper layers of the site can generally be divided into the following geotechnical strata:

- Stratum A: Clay (CH), medium stiff to very stiff
- Stratum B: loose to dense Silty Sand (SM) and sandy silt (ML), or medium stiff to stiff clay
- Stratum C: Silty Sand (SM), dense to very dense
- Stratum D: Silty Clay (CH), very stiff to hard
- Stratum E: Slightly Silty Fine Sand (SP-SM), dense to very dense
- Stratum F: Silty Clay (CH/CL), very stiff to hard
- Stratum H: Silty Sand (SM), very dense
- Stratum J: Silty Clay (CL/CH) with Interbedded Silt, Silty Sand, Clayey Sand, or Sand, hard
- Stratum K: Sandy Clay, with Interbedded Silt or Silty Sand, stiff to hard
- Stratum L: Silty Clay (CL/CH), very stiff to hard
- Stratum M: Silty Sand (SM), dense to very dense
- Stratum N: Silty Clay (CH) with Interbedded Sand or Silty sand, very stiff to hard

The Primary-Secondary (P-S) suspension measurements and CPT results provided shear and compression wave velocities of the soil at 1.6 feet (0.5 m) intervals. These data were used to develop mean shear wave profile for the upper 600 feet (182 m) of soil. Unit weights for the upper 600 feet (182 m) soil are in the range of 120 pounds per cubic foot (pcf) to 128 pcf.

The nonlinear degradation soil shear modulus and damping curves based on RCTS test results are described in Section 2.5S.4.7.3 and are used for the upper 600 feet (182 m) of soils. Numerical values of the recommended curves are provided in Table 2.5S.4-34b (degradation soil shear modulus) and Table 2.5S.4-34c (damping ratio).

Information on subsurface conditions for depths below approximately 600 feet (182 m) was assembled from available sonic log data and used to develop the shear-wave velocity profile as well as other properties such as Poisson's ratio, refer to Section 2.5S.4. Linear elastic properties are assigned to the soil at depths below 600 feet (182 m) by assuming that the strains in these deep soil layers remain small during the earthquakes. Unit weight of the deep soils (below approximately 600 feet, 182 meters) range from 129 pcf to 140 pcf. A value of 170 pcf was assigned for the bedrock unit weight.

Damping values were developed for the linear deep soil layers to maintain the total kappa for the site as described below.

Low-strain kappa (k) value, a near surface damping parameter for modeling site-dependent effects, is used as a measure of the total dissipation of energy of the site during the small strain events. The site kappa (k) value is directly related to damping of the soil layers and scattering of the waves at layer interface boundaries. The kappa associated for soil layer damping is additive for all layers. The following expression shows the relationship between kappa (ki) and the damping coefficient, (zi) of the soil layer (i):

$$\kappa_i = \frac{2H_i\xi_i}{Vs_i} \qquad \text{Equation 2.5S.2-6}$$

where: Hi is the thickness and Vsi is the shear wave velocity of the soil layer (i). Total kappa (k) value of the site associated with material damping equals the sum of the ki values of all soil layers included in the model:

$$\kappa = \sum_i \kappa_i \qquad \text{Equation 2.5S.2-7}$$

The value of total kappa (k) is directly evaluated from recordings of earthquakes. One of the nearest and most applicable measures of total kappa is a value of 0.058 sec based on inversions of regional earthquakes located and recorded within the deeper portions of the Mississippi Embayment in the area just south of Saint Louis, Missouri and Memphis, Tennessee (Reference 2.5S.2-49). For various other study areas in the Mississippi Embayment also lacking in direct measurements of total (k), a more conservative value (i.e., corresponding to lower damping) of 0.046 sec has been used (Reference 2.5S.2-48).

A kappa (k) value of 0.006 sec is assumed to apply to the central and eastern United States crystalline basement and below (Reference 2.5S.2-12), leaving a total soil kappa (k) value of 0.040 sec for the damping of the full depth of the Mississippi Embayment soils. EPRI (Reference 2.5S.2-12) presents a standard deviation of 0.4

natural log units to be appropriate for sites in the eastern United States. This is consistent with Reference 2.5S.2-48 in considering ±50% variation about the base case value of kappa (k) for Mississippi embayment sites. Therefore, a base case kappa (k) value of 0.040 sec is used for STP 3 & 4 site model with a standard deviation of 0.4 natural log units.

The following procedure is used to assign the damping to the models of the soil at depths below 600 feet (182 m) in order to match the assigned kappa (k) value:

(1) From Equations 2.5S.2-6 and 2.5S.2-7, kappa (k) associated with material damping is calculated for the top 600 feet (182 m) of soil strata by using small strain damping for each soil layer.

(2) The kappa (k) value of the top 600 feet (182 m) of soil is deducted from the total kappa (k) value, and a constant damping value is assigned to deep soil layers.

(3) The damping of each deep soil layer is randomized with consideration given to the mean and variation of the total kappa.

The input motion for soil amplification analysis was specified at the bottom of the soil profile, below which the halfspace was modeled with shear wave velocity of 9200 fps and a damping ratio of 0.2%.

The soil column was truncated at a depth of 8100 ft (2469 meter). This depth was selected such that the resulting soil column captures the site response in the range of frequency of interest, greater than 0.1 Hertz. The natural soil column frequency was therefore calculated, starting from the best estimate shear-wave velocity profile, as shown in Figure 2.5S.2.35a, for the full soil column and confirmed to be less than 0.1 Hertz at 8100 ft depth.

As described in Subsection 2.5S.2.5.2, the soil properties for each layer were randomized to account for the inherent natural variability of soil deposits, as well as the (epistemic) uncertainty associated with the choice of curves for variation of shear modulus and damping with strain level. Therefore, the actual site response analysis comprised a range of soil properties for each layer, and in particular, a range of initial small strain shear modulus and degradation curves. Because of different properties in each of the randomized profiles, the site response analysis generated a range of results, as reported in Subsection 2.5S.2.5.4.

2.5S.2.5.2 Site Properties Representing Uncertainties and Correlations

To account for variations in shear-wave velocity across the site, 60 artificial profiles were generated using the stochastic model discussed in Reference 2.5S.2-50, with some modifications to account for conditions at the STP 3 & 4 site. These randomized profiles represent the truncated soil column from the top of bedrock with shear-wave velocity of 9200 feet per second (fps) to the ground surface. This model uses as inputs the following quantities:

- A shear-wave velocity profile for the upper 600 feet (182 m) of soil, which is equal to the base-case soil profile described above.
- A shear-wave velocity profile for the deeper soil column at depths greater than 600 feet (182 m) obtained from available deep sonic log data.
- The standard deviation of ln(Vs) (the natural logarithm of the shear-wave velocity) as a function of depth, which was developed using available site and regional data (See Subsection 2.5S.4).
- The correlation coefficient between ln(Vs) in adjacent layers, which is taken from generic studies, using the inter-layer correlation model for category US Geological Survey “C” soils (Reference 2.5S.2-50).
- The probabilistic characterization of layer thickness consists of a function that describes the rate of layer boundaries as a function of depth. This study used a generic form of this function, taken from Reference 2.5S.2-50, and then modified to allow for sharp changes in the adopted base-case velocity profile.
- The profiles of the median and plus/minus one standard deviation of the shear wave velocity profile are shown in Figure 2.5S.2-35b for the upper 1000 ft. The variation was used in the randomization of the shear wave velocity profile.
- The assigned depth to bedrock of 8,100 ft to ensure the site response is captured in the frequency range of interest, greater than 0.1 Hertz.
- Median values of shear stiffness (G/GMAX) and damping for each geologic unit are described in Subsection 2.5S.4. Uncertainties in the strain-dependent properties for each soil unit are characterized using the values in Reference 2.5S.2-51. Figures 2.5S.2-37 and 2.5S.2-38 illustrate the shear stiffness and damping curves generated for one of the geologic units, Stratum C, described in Subsection 2.5S.4.

Figure 2.5S.2-36 illustrates the 60 Vs profiles generated, using the median, logarithmic standard deviation, and correlation model described above. The same figure compares the median of these 60 Vs profiles to the median Vs profile described in the previous section, indicating good agreement.

This set of 60 profiles, consisting of Vs versus depth, depth to bedrock, stiffness, and damping, are used to calculate and quantify site response and its uncertainty, as described in the following sections.

2.5S.2.5.3 Correction of Damping for Scattering Effects to Maintain Total Site Kappa

The process of the randomization of soil velocity profiles introduces additional scattering of upward propagating shear waves (S-waves) in such a manner that the median response of all randomized profiles is lower than the response obtained from the analyses of the median profile. These scattering effects are accounted for by decreasing the damping value of the deep soil layers in the randomized profiles by 15%. Due to this modification, the mean (log-average) damping value of deep soil layer changes from 0.60% to 0.51% and the median values of total kappa (k) coefficient of site is reduced by 0.005 sec.

2.5S.2.5.4 Site Response Analyses

The site response analysis performed for the STP 3 & 4 site is conducted using the program P-SHAKE (refer to Appendix 3C), which uses a procedure based on Random Vibration Theory (RVT) (References 2.5S.2-52 and 2.5S.2-53) with the following assumptions:

- Vertically-propagating shear waves are the dominant contributor to site response
- An equivalent-linear formulation of soil nonlinearity is appropriate for the characterization of site response

These are the same assumptions that are implemented in the SHAKE program (Reference 2.5S.2-54). With respect to RVT implementation, the major steps used in P-SHAKE are as follows:

(1) The input motion is provided in terms of acceleration response spectrum (ARS) and its associated spectral damping, instead of spectrum-compatible acceleration time histories. The input ARS is converted to acceleration power spectral density (PSD) using the RVT based procedure with the peak factor function.

(2) From the frequency domain solution of the soil profile (following SHAKE approach), the transfer function for shear strain in each layer is obtained and convolved with the power spectral density (PSD) of input motion to get the PSD and the maximum strain in each layer. The effective strain is obtained from the maximum strain and is used to obtain the new soil properties (soil shear modulus and damping) for the next iteration.

(3) The iterations are repeated until convergence is reached in all layers to the convergence limit set by the user.

(4) Once the final frequency domain solution is obtained, the acceleration response spectrum at each layer interface can be computed from the solution using an inverse process of obtaining PSD from the acceleration response spectrum.

The RVT site-response analysis requires the following additional parameters:

- Strong-motion duration. The RVT methodology requires this parameter, but results are not very sensitive to it. These are calculated from the mean magnitudes resulting from deaggregation. Table 2.3.1 in Reference 2.5S.2-58 provides strong motion duration values as a function of magnitude. Accordingly, strong motion durations were assigned for each of the cases considered (10^{-4} and 10^{-5} annual frequencies, HF and LF smooth spectra), presented in Table 2.5S.2-20.

- Effective strain ratio. A value of 0.65 is used. Effective strain ratio is defined as the ratio between the peak acceleration of earthquake time history and the equivalent harmonic wave going through the soil layers (Reference 2.5S.2-55).

Figure 2.5S.2-39 shows with thick red lines the logarithmic mean of site amplification factors at ground surface from the analysis of the 60 modified random profiles with the 10^{-4} LF input motion. As would be expected due to the large depth of sediments at the site, amplifications are largest at low frequencies (below 3 Hz) and small de-amplification occurs at high frequencies because of soil damping. The maximum strains in the soil column are low for this motion, and this is shown in Figure 2.5S.2-40, which plots the maximum strains versus depth that are calculated for the 60 profiles and their logarithmic mean (in red thick line). The logarithmic mean of maximum strains is less than 0.03%. The maximum strain calculated from the analyses of all profiles is 0.05% in the upper 600 feet (182 m) of soil. The maximum strains in the deep soil layer at depths below 600 feet (182 m) are very small and do not exceed value of 0.02%.

Figure 2.5S.2-41 and Figure 2.5S.2-42 show similar plots of amplification factors and maximum strains obtained from the analysis with 10^{-4} HF motion. The maximum strain results show that the soil column exhibits a lower level of straining under this earthquake with maximum strains being less than 0.025%. Figure 2.5S.2-43 through Figure 2.5S.2-46 show comparable plots of amplification factors and maximum strains from the analyses performed with the 10^{-5} input motion, both LF and HF. For this higher motion, larger maximum strains are observed, but the maximum logarithmic mean does not exceed 0.11%. From all of the 60 profiles, a maximum strain of 0.19% is calculated in the upper 600 feet (182 m) of soil. The maximum strain in the deep soil layers is very small, less than 0.06%.

Comparison of the profiles of logarithmic mean maximum strain in Figure 2.5S.2-47 clearly indicates that response of the site under the LF motions is stronger than under HF motions. Figure 2.5S.2-48 shows the logarithmic mean profiles for the strain-compatible damping that is a measure of energy dissipation in the soil profile during the shaking. Corresponding to the strains, a maximum damping value of 3.4% in the upper 600 feet (182 m) of soil is calculated for the analyses with the 10^{-5} LF motion. The strain compatible damping calculated for is the 10^{-4} LF motion small and does not exceed 1.9%. The small strain-compatible damping results in relatively small de-amplification of the site response at high frequencies.

A comparison of log-mean soil amplification factors at the ground surface level for LF and HF 10^{-4} and 10^{-5} input motions is shown in Figure 2.5S.2-49a. As shown in this figure, the amplifications at 10^{-4} level of input motion between the LF and HF input motions are about the same up to 7 Hz. De-amplification occurs at higher frequencies, larger than 10 Hz, followed by amplification of the peak ground acceleration at high frequencies (above 40 hz). The amplification due to 10^{-5} level of input motion follows the same trend compared to the amplification due to 10^{-4} motion indicating limited extent of soil nonlinearity in the soil column. The corresponding amplified ARS at ground surface are presented in Figure 2.5S.2-49b.

2.5S.2.6 Ground Motion Response Spectra

The following site-specific supplement addresses COL License Information Item 2.2.

The GMRS ground motion was developed starting from the 10^{-4} and 10^{-5} HF and LF rock UHRS shown in Figures 2.5S.2-33 and 2.5S.2-34. Site response was calculated for each of these rock input motions. Figure 2.5S.2-50 shows the resulting logarithmic mean spectra for surface conditions for each of these input rock motions; see Tables 2.5S.2-18 and 2.5S.2-19 for sampled numerical values of these rock response spectra. The broad-banded LF motion dominates the site response for the 10^{-4} rock input motion, but for 10^{-5} the HF rock motion indicates higher response in the frequency range 12.5 to 3.3 Hz. The envelope spectra for 10^{-4} and 10^{-5} were determined from these individual results, and these envelope spectra were smoothed with a running average filter to smooth out peaks and valleys that are not statistically significant. These envelope spectra are shown in Figure 2.5S.2-51; see Tables 2.5S.2-18 and 2.5S.2-19 for sampled numerical values of these rock response spectra.

This procedure corresponds to Approach 2A in NUREG/CR-6769 (Reference 2.5S.2-2), wherein the rock UHRS (for example, at 10^{-4}) is multiplied by a mean amplification factor at each frequency to estimate the 10^{-4} site UHRS.

The low-frequency character of the spectra in Figures 2.5S.2-33, 2.5S.2-34, and 2.5S.2-20 reflects the low-frequency amplification of the site. This is a deep soil site and there is a fundamental site resonance at about 0.6 Hz, with a dip in site response at about 0.7 Hz, and this dip occurs for all 60 of the site profiles that were used to characterize the site profile. As a result, there is a dip in the site spectra for 10^{-4} and 10^{-5} at 0.7 Hz that reflects the site characteristics.

The horizontal GMRS was developed from the horizontal UHRS using the approach described in ASCE/SEI Standard 43-05 (Reference 2.5S.2-56) and RG 1.208. The ASCE/SEI Standard 43-05 approach defines the GMRS using the site-specific UHRS, which is defined for Seismic Design Category SDC-5 at a mean 10^{-4} annual frequency of exceedance. The procedure for computing the GMRS is as follows.

For each spectral frequency at which the UHRS is defined, a slope factor AR is determined from:

$$A_R = SA(10^{-5})/SA(10^{-4}) \qquad \text{Equation 2.5S.2-8}$$

where $SA(10^{-4})$ is the spectral acceleration SA at a mean UHRS exceedance frequency of 10^{-4}/yr (and similarly for $SA(10^{-5})$). A Design Factor "DF" is defined based on A_R, which reflects the slope of the mean hazard curve between 10^{-4} and 10^{-5} mean annual frequencies of exceedance. The DF at each spectral frequency is given by:

$$DF = 0.6(A_R)^{0.80} \qquad \text{Equation 2.5S.2-9}$$

and

$$GMRS = \max[SA(10^{-4}) \times \max(1, DF), 0.45 \times SA(10^{-5})] \qquad \text{Equation 2.5S.2-10}$$

The derivation of DF is described in detail in the Commentary to ASCE/SEI Standard 43-05 (Reference 2.5S.2-56) and in RG 1.208. Table 2.5S.2-21 shows the values of AR and DF calculated at each structural frequency and the resulting GMRS. The horizontal GMRS is plotted in Figure 2.5S.2-52. This horizontal GMRS is enveloped at all frequencies by the CSDRS, defined as the horizontal RG 1.60 spectrum anchored at a PGA of 0.30g.

A vertical GMRS was calculated by deriving vertical-to-horizontal (V/H) ratios and applying them to the horizontal 10^{-4} AND 10^{-5} UHRS. The V/H ratios were obtained by the applying the following steps described below.

For CEUS soil sites NUREG/CR-6728 (Reference 2.5S.2-46) suggests a methodology for estimating V/H using available empirical Western United States (WUS) ground motion attenuation relations for both soil and rock, horizontal and vertical motions, and ground motion modeling to develop transfer functions to translate WUS V/H estimates to CEUS V/H estimates. This methodology results in several significant trends in the derived ratios that depend on the frequency of the ground motion, the magnitude and distance of an earthquake, and the subsurface material properties at a site. Among these trends are: the tendency for V/H to increase with frequency, and (for soil sites) to increase with higher magnitudes and smaller distances in the high-frequency range, but to decrease with higher magnitude and smaller distances in the low-frequency range.

Using the attenuation relations of Reference 2.5S.2-57 for WUS soil V/H values, and using the controlling earthquake magnitudes and conservative values for distance for low- and broad-band frequency characterization of site-specific UHRS (for R>100 km and “overall” hazard, respectively, see Table 2.5S.2-17), V/H ratios have been developed for the STP 3 & 4 site. Figure 2.5S.2-53 shows all three magnitude V/H ratios at 93 mi (150km) distance. The specification of the distance of 150 km is based on the far-distance limit of the data used by Reference 2.5S.2-57 in their ground motion attenuation relations. In the high-frequencies, where V/H varies the most, V/H decreases with greater distance, so use of the distance of 150km, compared to the greater controlling distances in Table 2.5S.2-17, gives reasonable, if not conservative guidance on appropriate V/H for the project site. To account for the WUS-to-CEUS high-frequency transformation, discussed in EPRI (Reference 2.5S.2-12) and NUREG/CR-6728, these V/H ratios have been shifted toward higher frequencies. The value of this frequency shift (by a factor of 3.74) is derived by considering the V/H ratios presented in NUREG/CR-6728, and dividing the peak frequency for CEUS [~62.5Hz] by the peak frequency for WUS [~16.7Hz].

The V/H values from RG 1.60 are also shown in the Figure 2.5S.2-53. They have been adopted for the STP 3 & 4 site because they are conservative, acceptable, and simple. Figure 2.5S.2-54 plots the resulting vertical UHRS, calculated in this manner from the horizontal UHRS. The vertical GMRS was developed from the vertical UHRS in a manner identical to that used for the horizontal GMRS, and the vertical GMRS is also plotted in Figure 2.5S.2-54. Table 2.5S.2-22 lists the vertical UHRS, factors AR and DF, and the vertical GMRS amplitudes. This vertical GMRS is enveloped at all frequencies by the vertical CSDRS, defined as the vertical RG 1.60 spectrum anchored at a PGA of 0.30g.

The Foundation Input Response Spectra (FIRS) are calculated using the same rock motions and the simulated (randomized) profiles for the full height soil column model used in calculating the GMRS, propagating the motion from bedrock to finished ground surface. The GMRS is calculated from the soil column responses at the finished ground surface level and the FIRS are generated at the foundation levels of the structures as “SHAKE Outcrop” responses. The FIRS for Category I structures are included in Appendices 3A and 3H.

2.5S.2.7 References

2.5S.2-1 “Probabilistic seismic hazard evaluation at nuclear plant sites in the central and eastern United States, resolution of the Charleston Earthquake issue,” EPRI Rept. 6395-D, Electric Power Research Institute (EPRI), April 1989.

2.5S.2-2 “Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Development of Hazard- and Risk-Consistent Seismic Spectra for Two Sites,” NUREG/CR-6769, Risk Engineering, Inc., U.S. Nuclear Regulatory Commission, 2001.

2.5S.2-3 “Seismic Hazard Methodology for the Central and Eastern United States,” Volume 1, Part 2: Methodology (Revision 1), EPRI NP-4726-A, Rev. 1, Electric Power Research Institute (EPRI), November 1988.

2.5S.2-4 “ANSS/CNSS Worldwide Earthquake Catalog files” [catsearch.27217.txt and ANSScatalogSearch(112806).pdf], Advanced National Seismic System [ANSS], 2006. Available at: http://www.ncedc.org/anss/catalog-search.html, accessed November 28, 2006.

2.5S.2-5 “International Seismological Centre [ISC] On-line Bulletin,” [ISC Regional Catalogue.pdf, SearchOutput.htm, and SearchOutput.out], International Seismological Centre (ISC). Available at http://www.isc.ac.uk, accessed November 28, 2006.

2.5S.2-6 “Seismicity of the United States, 1568-1989 (Revised),” U.S. Geological Survey Professional Paper 1527, Stover, C.W., and J.L. Coffman, 1993. Catalog files [NEIC_suse_031307search.htm, neic_suse_031307search.tif Search_SUSE.doc and SUSE.edb] downloaded March 13, 2007 and November 30, 2006 from the USGS website http://neic.usgs.gov/neis/epic/code_catalog.html.

2.5S.2-7 “United States earthquake data file: U.S. Geological Survey, Open-File Report 84-225,” 123 p. Stover, C.W., Reagor, G., and Algermissen, S.T., 1984. Catalog files [neic_ECM_031307search.tif, NEIC_ECM_031307search.htm, ECMSUS.stt and Search_ECMSUS.doc] were downloaded March 13, 2007 and November 30, 2006 from the USGS website http://neic.usgs.gov/neis/epic/code_catalog.html.

2.5S.2-8 "Seismicity of Middle America: National Geophysical Data Center and National Earthquake Information Service," Rinehart, W., Ganse, R., and Teik, P., National Geophysical Data Center (NGDC); Arnold, E., and Stover, C., U.S. Geological Survey (USGS), and Smith, R.H., (CIRES), 1982. Catalog files [NEIC_mcac_031307search.htm, neic_mcac_031307search.tif and Search_MCAC.doc] were downloaded March 13, 2007 and November 30, 2006 from the USGS website http://neic.usgs.gov/neis/epic/code_catalog.html.

2.5S.2-9 "Preliminary Determination of Epicenter (PDE)," National Earthquake Information Center (NEIC), 2006. Catalog files [PDE.edb and Search_PDE.doc] were downloaded November 30, 2006 from the website http://neic.usgs.gov/neis/epic/code_catalog.html, accessed on November 30, 2006.

2.5S.2-10 "Ground-Motion Relations for Eastern North America," Bull. Seism. Soc. Am., v. 85, n. 1, 17-30, Atkinson, G. M. and D. M. Boore, 1995.

2.5S.2-11 "National seismic-hazard maps: documentation," Open-File Report 96-532, Frankel, A., Barnhard, T., Perkins, D., Leyendecker, E. V., Dickman, N., Hanson, S., and Hopper, M., USGS, 1996.

2.5S.2-12 "Guidelines for Determining Design Basis Ground Motions," v. 5: Quantification of Seismic Source Effects, EPRI Report TR-102293, Project 3302, Final Report, Electric Power Research Institute (EPRI), November 1993.

2.5S.2-13 "Seismic Hazard Methodology for the Central and Eastern United States, Tectonic Interpretations," v. 5–10, Electric Power Research Institute (EPRI), July 1986.

2.5S.2-14 "Estimating Ground Motions Using Recorded Accelerograms," Surveys in Geophysics, v. 8, pp. 25-83, Heaton, T.H., F. Tajima, and A. W. Mori, 1986.

2.5S.2-15 "Seismicity of the central Gulf of Mexico," Geology, pp. 103-106, Frohlich, C., 1982.

2.5S.2-16 "EQHAZARD Primer," Prepared by Risk Engineering for Seismicity Owners Group and Electric Power Research Institute (EPRI), EPRI NP-6452-D 1989, EPRI, June 1989.

2.5S.2-17 "Texas Earthquakes," pp. 240-255 Frohlich, C. and S. D. Davis, 2002.

2.5S.2-18 "Global teleseismic earthquake relocation with improved travel times and procedures for depth procedures," Bull. Seism. Soc. Am., v. 88, n. 3, 722-743, Engdahl, E. R., R. v. d. Hilst, and R. Buland, 1998.

2.5S.2-19 "Revised world seismicity catalog (1950-1997) for strong (MS ≥ 6) shallow (h ≤ 70 km) earthquakes," Bull. Seism. Soc. Am., v. 89, n. 2, 335-341, Perez, O. J., 1999.

2.5S.2-20 "ANSS/CNSS Worldwide Earthquake Catalog." Advanced National Seismic System [ANSS], 2007. Catalog files [catalog-search2_pl_lat14-40_lon79-107_031307.htm, http_www.ncedc.org_anss_catalog-search.tif and catalog-search2_pl_lat21_32_lon_79_99_forblasts.htm] were downloaded March 13, 2007 from the website http://www.ncedc.org/anss/catalog-search.html.

2.5S.2-21 "On-line Bulletin," International Seismological Centre (ISC), 2007. Files [Rectangular_Selection_14_149999.pdf,SearchOutput_14_149999.out, Rectangular_Selection_15_159999.pdf,SearchOutput_15_159999.out, Rectangular_Selection_16_169999.pdf,SearchOutput_16_169999.out, Rectangular_Selection_17_199999.pdf,SearchOutput_17_199999.out, Rectangular_Selection_20_249999.pdf,SearchOutput_20_249999.out, Rectangular_Selection_25_40.pdf,SearchOutput_25_40.out and Rectangular_Selection_21_32_100_79_ALL.pdf] were downloaded March 6, 2007 from the International Seismological Centre website http://www.isc.ac.uk..

2.5S.2-22 "Preliminary Determination of Epicenter (PDE)," National Earthquake Information Center (NEIC), 2007. Catalog files [NEIC_pde_031307search.htm and neic_pde_031307search.tif] were downloaded March 13, 2007 from the NEIC website http://neic.usgs.gov/neis/epic/code_catalog.html, accessed on March 13, 2007.

2.5S.2-23 "Analysis of the 10 February 2006: Gulf of Mexico Earthquake From Global Regional Seismic Data," Offshore Technology Conference Paper No. 19099, Nettles, M., 2007.

2.5S.2-24 "Information regarding technical and scientific information on the September 10, 2006 earthquake in the Gulf of Mexico," National Earthquake Information Center (NEIC), 2007. Available at http://earthquake.usgs.gov/eqcenter/eqinthenews/ 2006/usslav/#scitech data files [http_neic.usgs_CMTsoln_down062907.tif and http_neic.usgs_harvard_CMTsoln_down062907.tif], accessed on June 29, 2007.

2.5S.2-25 "Chapter 41: Global Seismicity: 1900 – 1999," International Handbook of Earthquake & Engineering Seismology, pp. 665 – 690, Engdahl, E.R. and Villaseñor, A., 2002.

2.5S.2-26 “The Earthquakes of Stable Continental Regions,” Volume 1: Assessment of Large earthquake Potential, EPRI Final Report TR-102261-V1, Johnston, A.C., K.J. Coppersmith, L.R. Kanter, and C.A. Cornell, Electric Power Research Institute (EPRI), December 1994.

2.5S.2-27 “Early Site Permit ESP Application for the EGC ESP Site,” Revision 4, Exelon Generation Company (EGC), April 2006.

2.5S.2-28 “Documentation for the 2002 Update of the National Seismic Hazard Maps,” U.S. Geological Survey, Open-file Report 02-420, Frankel, A.D., Petersen, M.D., Muller, C.S., Haller, K.M., Wheeler, R.L., Leyendecker, E.V., Wesson, R.L., Harmsen, S.C., Cramer, C.H., Perkins, D.M., and Rukstales, K.S., 2002.

2.5S.2-29 “FRISK88 Software,” Risk Engineering, Inc. (REI) 2007.

2.5S.2-30 Dewey, J., U.S. Geological Survey, Personal Communication, Email from Dewey to Fuller and Lester, Subject: Re: February 2006 gulf of Mexico Earthquake, with attachment gcreport_lester_fuller.doc.

2.5S.2-31 “Quaternary faulting in east Texas, University of Texas at Austin,” Bureau of Economic Geology, Geological Circular 80-1, Collins, E., Hobday, D., and Kreitler, C., 1980.

2.5S.2-32 “Fault tectonics of the east Texas basin, Austin, TX,” University of Texas at Austin, Bureau of Economic Geology, Geological Circular, No. 82-4, 31 p., Jackson, M.P.A., 1982.

2.5S.2-33 “Jurassic salt tectonism within Mt. Enterprise fault system, Rusk Co., Texas,” AAPG Bulletin, v. 69, p. 254-254, Ferguson, J., 1985.

2.5S.2-34 “Structural framework,” in The Geology of North America: the Gulf of Mexico Basin, Volume J, p. 31-52, Ewing, T.E., Geological Society of America, 1991.

2.5S.2-35 “Syntectonic depositional systems within the Mt. Enterprise Fault zone [Masters' Thesis],” Stephen F. Austin State University, Lee, G.C., 2005.

2.5S.2-36 “STPEGS Updated Final Safety Analysis Report, Units 1 and 2,” Revision 13.

2.5S.2-37 “New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement: Bulletin of the Seismological Society of America,” v. 84, pp. 974-1002, Wells, D.L., and Coppersmith, K.J., 1994.

2.5S.2-38 “The shapes, major axis orientations and displacement patterns of fault surfaces,” J. Structural Geol., v. 18, p. 235-248, Nicol, A., Watterson, J.J., Walsh, J., and Childs, C., 1996.

2.5S.2-39 “On the Modified Mercalli intensities and magnitudes of the 1811-1812 New Madrid earthquakes,” J. Geophys. Res., v. 105, p. 23,839-23,864, Hough, S.E., J.G., A., Seeber, L., and Hough, J.F., 2000.

2.5S.2-40 “Seismic moment assessment of earthquakes in stable continental regions - III. New Madrid 1811-1812, Charleston 1886 and Lisbon 1755,” Geophysical Journal International, v. 126, p. 314-344, Johnston, A.C., 1996.

2.5S.2-41 “Magnitudes and locations of the 1811-1812 New Madrid, Missouri and the 1886 Charleston, South Carolina, earthquakes,” Bulletin of the Seismological Society of America, v. 94, p. 64-75, Bakun, W.H., and Hopper, M.G., 2004.

2.5S.2-42 “A Seismic Hazard Uncertainty Analysis for the New Madrid Seismic Zone,” Engineering Geology, v. 62, p. 251-266, Cramer, C. H., 2001.

2.5S.2-43 “The Earthquake Potential of the New Madrid seismic zone,” Bulletin of the Seismological Society of America, v. 92, p. 2080-2089, Tuttle, M.P., Schweig, E.G., Sims, J.D., Lafferty, R.H., Wolf, L.W., and Haynes, M.L., 2002.

2.5S.2-44 “CEUS Ground Motion Project Final Report,” EPRI Technical Report 1009684, Electric Power Research Institute (EPRI), Dominion Energy, Entergy Nuclear, and Exelon Generation Company, December 2004.

2.5S.2-45 “Program on Technology Innovation: Truncation of the Lognormal Distribution and Value of the Standard Deviation for Ground Motion Models in the Central and Eastern United States,” Electric Power Research Institute (EPRI) and U.S. Department of Energy, 2006. 1014381.

2.5S.2-46 “Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard and Risk-Consistent Ground Motion Spectra Guidelines,” NUREG CR-6728, McGuire, R. K., W. J. Silva, and C. J. Constantino, October 2001.

2.5S.2-47 “Description and Validation of the Stochastic Ground Motion Model,” Contract 770573, Report to Brookhaven National Laboratory, Associated Universities, Inc., Silva, W. J., N. A. Abrahamson, G. R. Toro, and C. J. Constantino, 1997.

2.5S.2-48 “Program on Technology Innovation: Assessment of a Performance-Based Approach for Determining Seismic Ground Motions for New Plant Sites,” Final Report, v. 2: Seismic Hazard Results at 28 Sites, EPRI Report TR-1012045, Electric Power Research Institute (EPRI) and U.S. Department of Energy, August 2005.

2.5S.2-49 "Scenario Earthquakes For Saint Louis, MO, And Memphis, TN, and Seismic Hazard Maps for the Central United States Region Including the Effect of Site Conditions," Toro, G. and W. Silva, 2001. Prepared under USGS External Grant Number 1434-HQ-97-GR-02981 (Scenario Earthquakes and Seismic Hazard Mapping for the New Madrid Region).

2.5S.2-50 "Probabilistic Models of Site Velocity Profiles for Generic and Site-Specific Ground Motion Amplification Studies, (appendix)," Silva, "Description and Validation of the Stochastic Ground Motion Model," Silva, W.J., N. Abrahamson, G. Toro and C. Costantino, 1996. Report submitted to Brookhaven National Laboratory, Associated Universities, Inc. Upton New York 11973, contract No. 770573.

2.5S.2-51 "Recommendations for Uncertainty Estimates in Shear Modulus Reduction and Hysteretic Damping Relationships, (appendix)," Description and Validation of the Stochastic Ground Motion Model by Silva, W.J., N. Abrahamson, G. Toro and C. Costantino, 1996.

2.5S.2-52 "Structural Response to Stationary Excitation," Journal of the Engineering Mechanics Division ASCE, v. 106, No. EM6, December, pp. 1195-1213, Der Kiureghian, A., 1980.

2.5S.2-53 "Site-Specific Validation of Random Vibration Theory-Based Seismic Site Response Analysis," Journal of Geotechnical and Geoenvironmental Engineering, Vo. 132, No. 7, July, pp. 911-922, Rathje, E. and Ozbey, C.M., 2006.

2.5S.2-54 "SHAKE91: A computer program for conducting equivalent linear seismic response analyses of horizontally layered soil deposits," Idriss, I. M., and Sun, J. I., Dept. of Civil and Environmental Engineering, Center for Geotechnical Modeling, Univ. of California, 1992.

2.5S.2-55 "Shake- A computer program for earthquake response analysis of horizontally layered sites, Earthquake Engineering Research Center (EERC) Report No. 72-12, Schnabel, S. and Seed, H.B., December 1972.

2.5S.2-56 "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities," Rept. ASCE/SEI 43-05, American Society of Civil Engineers, 2005.

2.5S.2-57 "Empirical response spectral attenuation relations for shallow crustal earthquakes," Seism. Res. Ltrs, 68, 1, 94-127, Abrahamson, N.A, and W.J. Silva, 1997.

2.5S.2-58 American Society of Civil Engineers (ASCE), (2000) *Seismic Analysis of Safety-Related Nuclear Structures and Commentary*, (Nonproprietary), ASCE 4-98.

2.5S.2-59 NUREG/CR-6372, Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts: Washington, D.C., U. S. Nuclear Regulatory Commission, Budnitz, R.J., Apostolakis, G., Boore, D.M., Cluff, L.S., Coppersmith, K.J., Cornell, C.A., and Morris, P.A., 1997.

2.5S.2-60 EPRI, 1986-1989, Seismic Hazard Methodology for the Central and Eastern United States (NP-4726), Vol. 1-3 & 5-10, EPRI.

2.5S.2-61 Dewey, J.W., and Dellinger, J.A., 2008, Location of the Green Canyon (Offshore Southern Louisiana) Seismic Event of February 10, 2006, U.S. Geological Survey, Open File Report 2008-1184, p. 30.

Table 2.5S.2-1 Conversion between body-wave (m_b) and moment (M) magnitudes [1]

Convert m_b	To M	Convert M	To m_b
4.00	3.77	4.00	4.28
4.10	3.84	4.10	4.41
4.20	3.92	4.20	4.54
4.30	4.00	4.30	4.66
4.40	4.08	4.40	4.78
4.50	4.16	4.50	4.90
4.60	4.24	4.60	5.01
4.70	4.33	4.70	5.12
4.80	4.42	4.80	5.23
4.90	4.50	4.90	5.33
5.00	4.59	5.00	5.43
5.10	4.69	5.10	5.52
5.20	4.78	5.20	5.61
5.30	4.88	5.30	5.70
5.40	4.97	5.40	5.78
5.50	5.08	5.50	5.87
5.60	5.19	5.60	5.95
5.70	5.31	5.70	6.03
5.80	5.42	5.80	6.11
5.90	5.54	5.90	6.18
6.00	5.66	6.00	6.26
6.10	5.79	6.10	6.33
6.20	5.92	6.20	6.40
6.30	6.06	6.30	6.47
6.40	6.20	6.40	6.53
6.50	6.34	6.50	6.60
6.60	6.49	6.60	6.66
6.70	6.65	6.70	6.73
6.80	6.82	6.80	6.79
6.90	6.98	6.90	6.85
7.00	7.16	7.00	6.91

Table 2.5S.2-1 Conversion between body-wave (m_b) and moment (M) magnitudes [1] (Continued)

Convert m_b	To M	Convert M	To m_b
7.10	7.33	7.10	6.97
7.20	7.51	7.20	7.03
7.30	7.69	7.30	7.09
7.40	7.87	7.40	7.15
7.50	8.04	7.50	7.20
-	-	7.60	7.26
-	-	7.70	7.32
-	-	7.80	7.37
-	-	7.90	7.43
-	-	8.00	7.49

[1] Average of relations given by References 2.5S.2-10, 2.5S.2-11, and 2.5S.2-12.

Table 2.5S.2-2 Seismicity Catalog for pre-1985 for the Gulf of Mexico

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Latitude (°N)	Longitude (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
DPC	1847	2	14	2	0	0.00	29.600	-98.000	0	5	3.60	0.56	3.96
DPC	1887	1	5	17	57	0.00	30.150	-97.060	0	5	4.10	0.56	4.46
DPC	1887	1	31	22	14	0.00	30.530	-96.300	0	4	3.30	0.56	3.66
DPC	1902	10	9	19	0	0.00	30.100	-97.600	0	4	3.90	0.56	4.26
SRA	1981	2	13	2	15	0.00	30.000	-91.800	0	4	3.11	0.56	3.47
ANSS	1984	1	23	0	11	59.38	26.716	-87.339	5		2.85	0.41	3.04

Investigation Region (100°W to 83°W, 24°N to 32°N) [1]

[1] Exclusive of EPRI events, for which the events are Rmb magnitude ≥ 3.0 or intensity ≥ IV and are equivalent to EPRI MAIN mainshock events (i.e., independent)

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	1985	2	10	14	16	52.20	36.450	-98.410	5		2.85	0.41	3.04
ANSS	1985	2	13	10	22	24.00	38.420	-87.500	18		3.09	0.41	3.28
ANSS	1985	2	15	15	56	10.00	37.230	-89.330	5		3.33	0.41	3.53
ANSS	1985	3	16	21	55	2.47	38.558	-105.850	5		3.33	0.41	3.53
ANSS	1985	5	1	1	16	27.80	37.780	-87.610	10		3.01	0.41	3.20
ANSS	1985	5	4	7	7	11.86	36.282	-90.879	10		2.85	0.41	3.04
SRA	1985	5	6	2	11	16.20	34.969	-97.482	5	5	2.30	0.1	2.31
ANSS	1985	6	5	10	36	0.60	32.562	-106.916	6		3.01	0.41	3.20
SRA	1985	6	27	18	20	0.00	33.621	-106.475	0		3.40	0.1	3.41
ANSS	1985	7	12	18	20	28.30	35.202	-85.148	20		2.97	0.3	3.08
ANSS	1985	7	21	21	22	11.80	37.980	-90.620	6		2.93	0.41	3.12
ANSS	1985	8	2	4	23	10.80	35.223	-92.213	7		2.85	0.41	3.04
ANSS	1985	8	3	4	23	11.00	35.210	-92.200	5		3.33	0.41	3.53
ANSS	1985	8	16	14	56	52.96	34.130	-106.832	7		3.98	0.41	4.18
ANSS	1985	9	6	22	17	2.85	35.814	-93.123	2		3.33	0.41	3.53
ANSS	1985	9	18	15	54	4.64	33.548	-97.051	5		3.30	0.1	3.31
ANSS	1985	10	12	6	43	42.50	38.510	-89.010	5		2.85	0.41	3.04
ANSS	1985	11	8	19	56	48.52	35.223	-92.188	4		3.17	0.41	3.37
ANSS	1985	11	12	6	50	35.03	29.438	-104.800	5		4.30	0.1	4.31
ANSS	1985	12	5	22	59	41.11	35.896	-89.995	6		3.50	0.41	3.69
ANSS	1985	12	15	7	14	52.23	35.281	-104.635	5		3.60	0.1	3.61
ANSS	1985	12	16	22	20	4.38	35.736	-90.245	11		2.85	0.41	3.04
ANSS	1985	12	22	0	56	5.00	35.701	-83.720	13		3.25	0.3	3.35
ANSS	1985	12	29	8	56	58.30	38.490	-89.020	1		3.25	0.41	3.45
ANSS	1986	1	1	14	13	22.65	35.886	-89.991	8		2.85	0.41	3.04
ANSS	1986	1	7	1	26	43.30	35.610	-84.761	23		3.06	0.3	3.17
ANSS	1986	1	29	8	16	7.80	38.350	-87.540	5		2.93	0.41	3.12
ANSS	1986	1	30	22	26	37.07	32.066	-100.693	5		3.30	0.1	3.31
ANSS	1986	2	15	11	1	12.80	38.250	-89.770	5		2.85	0.41	3.04
ANSS	1986	2	17	19	13	6.70	37.940	-90.400	4		2.93	0.41	3.12
ANSS	1986	2	26	15	3	0.50	38.390	-89.100	5		2.85	0.41	3.04
ANSS	1986	2	26	22	49	59.03	24.815	-100.190	33		4.40	0.1	4.41
SRA	1986	2	28	4	12	57.90	33.296	-83.245	1	4	1.79	0.27	1.88
ANSS	1986	3	3	11	45	17.48	35.308	-102.514	5		3.10	0.1	3.11
ANSS	1986	4	11	6	17	14.75	38.982	-106.940	5		3.01	0.41	3.20
ANSS	1986	4	19	7	40	53.00	35.187	-85.510	27		2.97	0.3	3.08
ANSS	1986	4	27	21	33	22.50	37.960	-90.190	4		2.93	0.41	3.12
ANSS	1986	5	7	2	27	0.46	33.233	-87.361	1		4.50	0.1	4.51
ANSS	1986	5	9	21	55	26.71	38.887	-106.884	5		2.85	0.41	3.04
ISC	1986	5	12	4	18	2.70	27.714	-88.726	10	.	3.50	0.1	3.51
ANSS	1986	5	12	4	18	48.30	30.900	-89.150	10		2.93	0.41	3.12
ANSS	1986	5	24	8	16	1.50	35.118	-92.217	4		3.17	0.41	3.37
ANSS	1986	5	24	12	48	14.43	36.484	-89.917	13		3.17	0.41	3.37
ANSS	1986	6	2	4	4	5.20	39.344	-99.781	5		3.00	0.1	3.01
ANSS	1986	6	4	4	38	10.68	25.211	-100.717	33		3.50	0.1	3.51
ANSS	1986	6	8	8	52	55.36	24.497	-100.015	10		3.70	0.1	3.71

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	1986	7	11	14	26	14.80	34.937	-84.987	13		3.74	0.41	3.93
ANSS	1986	8	26	16	41	24.80	38.320	-89.790	5		3.58	0.41	3.77
ANSS	1986	8	27	18	6	56.38	35.160	-105.094	5		3.25	0.41	3.45
ANSS	1986	10	20	4	32	49.00	37.918	-101.372	5		3.00	0.1	3.01
ANSS	1986	10	29	5	3	41.30	38.440	-89.040	5		3.09	0.41	3.28
ANSS	1986	11	6	19	21	47.20	38.110	-90.420	9		2.85	0.41	3.04
ANSS	1986	12	12	23	51	48.26	36.903	-89.128	12		2.85	0.41	3.04
ANSS	1986	12	30	7	15	19.09	36.418	-89.629	13		3.25	0.41	3.45
ANSS	1987	1	16	3	25	35.96	35.902	-90.012	8		2.93	0.41	3.12
ANSS	1987	1	24	16	8	17.00	35.828	-98.097	5		3.10	0.1	3.11
ANSS	1987	3	13	18	37	7.00	39.090	-89.410	1		3.25	0.41	3.45
ANSS	1987	3	14	11	51	1.29	36.117	-89.770	10		2.85	0.41	3.04
ANSS	1987	3	27	7	29	30.50	35.565	-84.230	19		4.07	0.41	4.26
ANSS	1987	4	16	10	55	9.49	38.358	-105.651	5		2.85	0.41	3.04
ANSS	1987	4	26	0	56	21.50	38.540	-89.410	5		3.17	0.41	3.37
ANSS	1987	5	2	19	51	28.81	36.290	-89.553	10		3.01	0.41	3.20
PDE	1987	5	14	15	59	58.46	33.545	-106.519	0		3.01	0.41	3.20
ANSS	1987	5	20	0	2	12.64	35.155	-92.244	3		3.01	0.41	3.20
ANSS	1987	5	23	19	8	23.82	36.614	-89.620	11		3.33	0.41	3.53
ANSS	1987	6	4	17	19	23.40	37.939	-85.800	8		3.06	0.3	3.17
ANSS	1987	6	10	23	48	53.90	38.710	-87.950	5		4.88	0.41	5.07
ANSS	1987	6	13	21	17	13.50	36.576	-89.735	10		3.98	0.41	4.18
ANSS	1987	6	15	15	5	16.41	36.547	-89.697	13		2.85	0.41	3.04
ANSS	1987	6	19	3	46	38.29	36.466	-89.587	19		3.09	0.41	3.28
ANSS	1987	6	23	0	0	19.40	38.720	-87.950	5		2.93	0.41	3.12
ANSS	1987	6	26	18	39	20.38	36.534	-89.674	13		3.09	0.41	3.28
ANSS	1987	7	7	19	19	6.30	36.941	-89.148	17		3.33	0.41	3.53
ANSS	1987	7	11	0	4	29.50	36.105	-83.816	25		3.66	0.41	3.85
ANSS	1987	7	11	2	48	5.90	36.103	-83.819	24		3.25	0.41	3.45
ANSS	1987	7	20	16	19	16.10	38.955	-106.507	5		2.93	0.41	3.12
ANSS	1987	8	14	18	27	56.67	35.706	-90.385	11		2.85	0.41	3.04
ANSS	1987	8	31	17	12	35.20	38.300	-89.680	0		3.33	0.41	3.53
ANSS	1987	9	1	23	2	49.40	35.515	-84.396	21		3.06	0.3	3.17
ANSS	1987	9	22	17	23	50.10	35.623	-84.312	19		3.33	0.41	3.53
ANSS	1987	9	29	0	4	56.13	36.953	-89.159	11		4.15	0.41	4.34
ANSS	1987	10	14	15	49	40.10	37.050	-88.780	2		3.74	0.41	3.93
ANSS	1987	11	17	15	52	21.10	38.720	-87.960	5		3.25	0.41	3.45
ANSS	1987	12	8	1	42	40.30	36.055	-98.024	5		3.70	0.1	3.71
ANSS	1988	1	5	14	39	18.20	38.720	-87.960	5		3.33	0.41	3.53
ANSS	1988	1	9	1	7	40.60	35.279	-84.199	12		3.16	0.3	3.26
ANSS	1988	1	15	7	33	29.20	37.515	-106.684	5		3.17	0.41	3.37
ANSS	1988	1	31	0	12	44.36	35.664	-90.440	15		3.33	0.41	3.53
ANSS	1988	1	31	9	24	36.30	29.945	-105.076	5		3.90	0.41	4.10
ANSS	1988	2	18	0	37	45.40	35.346	-83.837	2		3.50	0.41	3.69
ANSS	1988	2	27	15	17	6.50	36.680	-89.520	15		3.25	0.41	3.45
ANSS	1988	3	10	21	24	9.50	37.750	-88.830	4		3.09	0.41	3.28

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	1988	3	15	12	34	48.70	38.300	-89.000	12		2.93	0.41	3.12
ANSS	1988	4	14	9	39	31.47	39.093	-99.155	5		3.60	0.1	3.61
ANSS	1988	5	2	13	43	59.42	35.666	-90.351	8		2.85	0.41	3.04
ANSS	1988	5	20	23	6	23.90	37.310	-92.670	5		3.42	0.41	3.61
ANSS	1988	6	25	15	2	49.26	36.669	-89.593	5		2.85	0.41	3.04
ANSS	1988	9	7	2	28	9.54	38.143	-83.878	10		4.60	0.1	4.61
ANSS	1988	9	7	2	30	32.90	38.170	-83.756	8		3.74	0.41	3.93
ANSS	1988	9	18	16	16	1.00	37.310	-87.210	13		2.85	0.41	3.04
ANSS	1988	10	5	0	38	55.00	38.660	-88.020	5		3.33	0.41	3.53
ANSS	1988	12	25	15	57	57.83	34.206	-92.658	12		3.42	0.41	3.61
ANSS	1988	12	29	2	52	13.70	38.990	-87.730	5		3.01	0.41	3.20
ANSS	1988	12	31	14	24	20.68	36.193	-89.430	6		3.09	0.41	3.28
ANSS	1989	1	3	19	8	51.30	38.990	-87.720	5		2.93	0.41	3.12
ANSS	1989	1	29	5	7	15.33	35.221	-104.093	7		3.34	0.3	3.44
ANSS	1989	2	28	17	31	50.84	33.643	-87.092	0		3.50	0.1	3.51
ANSS	1989	4	15	16	39	51.66	36.558	-89.682	10		2.85	0.41	3.04
ANSS	1989	4	27	16	47	51.33	36.088	-89.775	12		4.15	0.41	4.34
ANSS	1989	6	8	18	18	43.37	39.165	-99.477	5		4.00	0.1	4.01
ANSS	1989	6	16	14	53	53.12	39.143	-99.457	5		3.80	0.1	3.81
ANSS	1989	6	28	9	35	0.20	37.810	-88.950	13		3.01	0.41	3.20
ANSS	1989	7	6	10	38	25.56	38.772	-102.635	5		2.93	0.41	3.12
ANSS	1989	7	13	18	35	22.90	39.168	-99.472	5		3.40	0.1	3.41
ANSS	1989	7	14	23	32	22.39	36.295	-89.494	11		2.85	0.41	3.04
ANSS	1989	7	15	0	8	2.64	38.607	-83.569	10		3.10	0.1	3.11
ANSS	1989	7	15	18	58	28.00	34.373	-87.323	14		2.93	0.41	3.12
ANSS	1989	7	20	6	7	50.42	36.434	-98.876	5		3.10	0.1	3.11
ANSS	1989	8	13	20	16	2.90	33.632	-87.086	0		3.40	0.1	3.41
ANSS	1989	8	20	0	3	18.30	34.803	-87.596	7		3.82	0.41	4.02
ANSS	1989	9	14	17	31	27.90	36.558	-89.630	12		3.25	0.41	3.45
ANSS	1989	10	9	1	43	33.19	35.794	-90.153	13		2.93	0.41	3.12
ANSS	1989	10	30	5	6	56.46	36.555	-89.696	8		2.85	0.41	3.04
ANSS	1989	11	29	6	54	38.50	34.455	-106.891	13		4.52	0.3	4.62
ANSS	1989	12	1	9	26	51.30	36.216	-89.440	9		2.85	0.41	3.04
ANSS	1989	12	2	13	31	45.60	35.993	-83.847	11		3.01	0.41	3.20
ANSS	1990	1	24	18	20	26.20	38.140	-86.490	10		3.82	0.41	4.02
ANSS	1990	1	27	14	5	51.67	38.184	-86.430	5		3.74	0.41	3.93
ANSS	1990	1	29	13	16	10.68	34.463	-106.879	12		4.80	0.1	4.81
ANSS	1990	1	31	1	8	19.29	34.445	-106.860	10		4.00	0.1	4.01
ANSS	1990	2	21	12	2	19.34	34.014	-106.544	5		3.58	0.41	3.77
ANSS	1990	2	27	13	23	22.00	33.953	-106.588	5		3.79	0.3	3.89
ANSS	1990	3	2	7	1	48.07	38.851	-89.170	0		3.42	0.41	3.61
ANSS	1990	3	9	21	2	54.80	38.140	-86.190	5		2.85	0.41	3.04
ANSS	1990	3	12	16	48	1.67	36.359	-92.251	0		2.93	0.41	3.12
ANSS	1990	3	18	16	22	33.19	36.692	-91.505	1		3.09	0.41	3.28
ANSS	1990	4	24	9	41	36.57	38.955	-88.201	18		3.01	0.41	3.20
ANSS	1990	5	5	16	26	22.89	34.449	-106.878	7		3.52	0.3	3.62

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	1990	6	23	20	44	2.74	33.762	-87.969	1		3.25	0.41	3.45
ANSS	1990	7	15	18	22	48.50	37.880	-90.840	3		2.85	0.41	3.04
ANSS	1990	7	21	19	28	22.79	34.458	-106.858	12		2.97	0.3	3.08
ANSS	1990	7	21	20	30	31.34	34.455	-106.856	7		3.06	0.3	3.17
ANSS	1990	7	21	23	48	4.92	34.453	-106.854	7		3.16	0.3	3.26
ANSS	1990	7	22	21	27	5.13	34.838	-106.006	10		3.61	0.3	3.71
ANSS	1990	7	28	7	53	33.75	34.600	-93.376	4		3.01	0.41	3.20
ANSS	1990	7	31	7	32	40.18	34.456	-106.862	8		3.25	0.3	3.35
ANSS	1990	8	7	5	5	56.22	36.857	-89.237	7		3.17	0.41	3.37
ANSS	1990	8	17	21	1	15.90	36.934	-83.384	1		3.90	0.41	4.10
ANSS	1990	8	24	19	43	50.60	37.200	-89.110	5		2.93	0.41	3.12
ANSS	1990	8	29	19	34	59.25	35.785	-89.644	15		3.42	0.41	3.61
ANSS	1990	9	2	4	35	40.20	33.758	-87.928	1		3.16	0.3	3.26
ANSS	1990	9	8	0	3	57.40	38.061	-83.731	5		3.30	0.1	3.31
ANSS	1990	9	12	21	38	57.62	39.701	-106.206	5		3.09	0.41	3.28
ANSS	1990	9	16	21	14	13.19	35.537	-92.275	2		2.93	0.41	3.12
ANSS	1990	9	26	13	18	51.71	37.152	-89.613	1		4.55	0.41	4.75
ANSS	1990	9	27	1	47	52.95	37.172	-89.594	15		2.93	0.41	3.12
ANSS	1990	10	24	8	20	3.67	38.346	-88.971	1		3.25	0.41	3.45
ANSS	1990	11	8	10	8	25.40	37.108	-83.031	0		3.16	0.3	3.26
ANSS	1990	11	8	10	46	53.77	34.449	-106.856	6		4.40	0.1	4.41
ANSS	1990	11	8	11	3	46.51	34.453	-106.861	9		3.06	0.3	3.17
ANSS	1990	11	9	3	39	15.92	36.537	-89.632	10		3.25	0.41	3.45
ANSS	1990	11	10	12	18	16.85	34.450	-106.851	7		3.06	0.3	3.17
ANSS	1990	11	15	7	25	24.38	34.457	-106.859	7		3.52	0.3	3.62
ANSS	1990	11	15	11	44	41.40	34.760	-97.590	5		3.90	0.1	3.91
ANSS	1990	11	15	11	45	35.06	35.603	-93.042	29		3.50	0.41	3.69
ANSS	1990	12	20	14	4	17.40	39.590	-86.630	5		3.66	0.41	3.85
ANSS	1991	1	23	9	25	23.20	37.940	-88.873	1		3.17	0.41	3.37
ANSS	1991	1	24	5	0	26.90	36.378	-97.300	5		3.00	0.1	3.01
ANSS	1991	1	28	11	43	55.70	37.349	-87.324	1		2.93	0.41	3.12
ANSS	1991	2	6	10	3	2.72	28.428	-106.332	5		3.90	0.1	3.91
ANSS	1991	2	11	0	0	12.70	35.950	-89.930	14		3.09	0.41	3.28
ANSS	1991	2	11	15	36	44.30	34.108	-90.599	12		2.85	0.41	3.04
ANSS	1991	3	23	10	5	54.70	36.074	-89.805	13		2.85	0.41	3.04
ANSS	1991	4	16	4	6	37.80	38.593	-88.007	7		2.85	0.41	3.04
ANSS	1991	5	4	1	18	54.60	36.575	-89.825	11		4.31	0.41	4.50
ANSS	1991	5	10	12	15	54.33	37.459	-106.578	5		3.42	0.41	3.61
ANSS	1991	5	30	22	7	44.00	39.200	-99.400	5		3.50	0.1	3.51
ANSS	1991	6	1	22	1	41.30	36.521	-89.616	2		2.85	0.41	3.04
ANSS	1991	6	5	18	44	14.90	34.447	-106.849	4		2.97	0.3	3.08
ISC	1991	6	20	16	5	0.00	33.619	-106.475	0		3.50	0.41	3.69
ANSS	1991	7	7	21	24	3.60	36.685	-91.567	8		3.82	0.41	4.02
ANSS	1991	7	22	3	31	0.30	36.468	-89.546	9		2.85	0.41	3.04
ANSS	1991	9	24	7	21	7.00	35.701	-84.117	13		3.09	0.41	3.28
ANSS	1991	10	3	11	46	4.90	36.856	-89.449	2		2.85	0.41	3.04

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	1991	10	30	14	54	12.60	34.904	-84.713	8		3.06	0.3	3.17
ANSS	1991	11	11	9	20	44.00	38.905	-87.710	0		3.74	0.41	3.93
ANSS	1991	11	13	9	43	15.70	35.728	-90.292	13		2.85	0.41	3.04
ANSS	1991	11	16	3	39	2.01	25.895	-100.581	5		3.60	0.1	3.61
ANSS	1991	12	9	12	47	16.50	34.850	-106.553	14		3.10	0.1	3.11
ANSS	1991	12	13	11	41	46.50	35.856	-90.085	14		3.01	0.41	3.20
ANSS	1992	1	2	11	45	35.61	32.336	-103.101	5		5.00	0.1	5.01
ANSS	1992	1	21	11	36	21.00	38.000	-92.670	5		3.06	0.3	3.17
ANSS	1992	2	23	16	17	52.51	30.646	-105.507	5		3.40	0.1	3.41
ISC	1992	3	31	14	59	43.60	26.311	-85.895	5	.	3.80	0.1	3.81
ANSS	1992	4	3	3	6	4.20	35.832	-89.499	8		3.01	0.41	3.20
ANSS	1992	4	15	22	46	5.08	37.335	-104.773	5		3.30	0.1	3.31
ANSS	1992	4	30	0	1	30.51	36.932	-90.439	10		2.85	0.41	3.04
ANSS	1992	5	2	10	19	29.81	37.378	-104.778	5		3.10	0.1	3.11
ANSS	1992	7	15	2	56	40.75	38.760	-99.549	5		3.30	0.1	3.31
ANSS	1992	7	30	14	40	55.87	24.705	-99.779	10		4.30	0.1	4.31
ANSS	1992	8	26	3	24	52.67	32.173	-102.708	5		3.00	0.1	3.01
ANSS	1992	8	26	5	41	39.06	37.641	-89.683	2		2.93	0.41	3.12
ANSS	1992	9	11	16	34	11.70	33.171	-87.501	7		2.97	0.3	3.08
ISC	1992	9	27	17	2	34.40	28.192	-88.431	10	.	3.58	0.41	3.77
ANSS	1992	10	1	1	31	48.97	27.832	-102.374	5		3.80	0.1	3.81
ANSS	1992	11	10	17	16	46.80	35.644	-84.132	10		2.97	0.3	3.08
ANSS	1992	12	17	7	18	4.27	34.744	-97.581	5		3.60	0.1	3.61
ANSS	1992	12	27	10	12	58.76	37.501	-89.616	10		3.25	0.41	3.45
ANSS	1993	1	3	21	14	54.14	35.194	-90.244	17		2.85	0.41	3.04
ANSS	1993	1	8	13	1	18.70	35.929	-90.036	22		3.50	0.41	3.69
ANSS	1993	1	14	17	6	10.45	36.595	-98.275	5		3.10	0.1	3.11
ANSS	1993	1	15	2	2	50.90	35.039	-85.025	8		3.17	0.41	3.37
ANSS	1993	1	21	19	46	20.07	36.229	-89.597	6		3.09	0.41	3.28
ANSS	1993	1	29	13	56	24.17	39.033	-89.030	5		3.25	0.41	3.45
ANSS	1993	2	6	2	9	45.63	36.664	-89.733	8		3.33	0.41	3.53
ANSS	1993	2	24	12	41	21.80	36.167	-89.473	13		2.93	0.41	3.12
ANSS	1993	2	28	21	48	1.33	26.063	-101.930	5		3.80	0.1	3.81
ANSS	1993	3	2	0	29	11.86	36.673	-89.494	9		3.09	0.41	3.28
ANSS	1993	3	16	7	38	10.27	35.605	-90.478	12		3.09	0.41	3.28
ANSS	1993	3	24	2	32	3.50	35.391	-104.195	5		3.00	0.1	3.01
ANSS	1993	3	29	15	37	21.13	36.555	-89.586	10		2.85	0.41	3.04
ANSS	1993	3	31	20	23	21.30	36.799	-89.423	4		3.17	0.41	3.37
ANSS	1993	4	28	22	40	1.96	36.196	-89.442	7		3.42	0.41	3.61
ISC	1993	6	10	15	10	0.00	33.619	-106.475	0		3.25	0.41	3.45
ANSS	1993	6	16	1	47	12.62	37.651	-89.756	10		2.85	0.41	3.04
ANSS	1993	7	8	4	3	52.25	39.227	-106.715	5		3.17	0.41	3.37
ANSS	1993	7	16	10	54	32.86	31.747	-88.341	5		3.70	0.1	3.71
ANSS	1993	8	5	7	21	37.45	36.009	-89.885	12		3.01	0.41	3.20
ANSS	1993	8	27	0	8	33.35	38.091	-90.437	22		3.33	0.41	3.53
ANSS	1993	9	24	18	27	15.04	36.564	-89.582	7		2.93	0.41	3.12

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	1993	9	29	2	1	19.06	35.868	-102.981	5		3.30	0.1	3.31
ANSS	1993	11	30	3	7	31.82	35.863	-103.026	5		3.30	0.1	3.31
ANSS	1993	12	5	0	58	20.23	27.831	-102.737	5		4.70	0.1	4.71
ANSS	1993	12	22	19	25	11.39	33.331	-105.682	10		3.16	0.3	3.26
ANSS	1994	1	5	23	0	56.00	25.887	-106.933	10		3.80	0.1	3.81
ANSS	1994	2	5	14	55	37.79	37.368	-89.188	16		4.07	0.41	4.26
ANSS	1994	2	28	18	29	49.07	37.833	-89.374	5		3.09	0.41	3.28
ANSS	1994	3	21	17	34	18.16	36.860	-89.172	5		3.01	0.41	3.20
ANSS	1994	4	5	22	22	0.40	34.969	-85.491	24		3.25	0.41	3.45
ANSS	1994	4	6	17	38	56.17	38.156	-89.214	15		3.25	0.41	3.45
ISC	1994	4	16	7	20	20.00	34.660	-97.710	5		3.17	0.23	3.23
ANSS	1994	4	23	19	46	47.90	35.965	-90.050	5		3.25	0.41	3.45
ANSS	1994	4	29	3	28	58.68	36.250	-98.090	5		3.00	0.1	3.01
ANSS	1994	5	4	9	12	3.40	34.222	-87.195	19		3.09	0.41	3.28
ANSS	1994	6	10	23	34	2.92	33.013	-92.671	5		3.20	0.1	3.21
ISC	1994	6	30	1	8	24.00	27.849	-90.123	10	.	3.70	0.1	3.71
ANSS	1994	8	19	16	3	30.65	35.508	-89.919	11		3.25	0.41	3.45
ANSS	1994	8	20	10	45	45.33	36.140	-91.063	10		3.50	0.41	3.69
ANSS	1994	9	26	14	23	22.84	36.960	-88.920	13		3.42	0.41	3.61
ANSS	1994	11	6	12	50	38.95	35.949	-89.060	11		3.17	0.41	3.37
ANSS	1994	11	20	23	31	48.98	36.437	-89.514	6		2.85	0.41	3.04
ANSS	1994	12	25	19	6	7.52	39.290	-104.811	10		4.00	0.1	4.01
FDNC	1995	1	4	1	46	14.10	29.450	-96.950	5	4	2.70	0.1	2.71
ANSS	1995	1	18	15	51	39.42	34.774	-97.596	5		4.20	0.1	4.21
ANSS	1995	1	31	11	33	52.17	27.739	-105.114	10		3.50	0.1	3.51
ANSS	1995	2	19	12	57	6.00	39.120	-83.470	10		3.52	0.3	3.62
ANSS	1995	3	11	8	15	52.32	36.959	-83.133	1		3.80	0.1	3.81
ANSS	1995	3	11	9	50	4.44	36.990	-83.180	1		3.30	0.1	3.31
ANSS	1995	3	18	22	6	20.80	35.422	-84.941	26		3.25	0.3	3.35
ANSS	1995	3	19	18	36	43.97	35.000	-104.212	5		3.30	0.1	3.31
ANSS	1995	4	5	5	31	16.23	35.200	-99.028	5		3.00	0.1	3.01
ANSS	1995	4	14	0	32	56.17	30.285	-103.347	18		5.60	0.1	5.61
ANSS	1995	4	14	2	19	38.50	30.300	-103.350	10		3.30	0.1	3.31
ANSS	1995	4	15	14	33	29.51	30.271	-103.324	10		4.00	0.1	4.01
ANSS	1995	4	27	0	42	35.00	36.690	-89.480	5		2.93	0.41	3.12
ANSS	1995	5	27	19	51	8.00	36.180	-89.390	10		3.09	0.41	3.28
ANSS	1995	5	28	15	28	36.95	33.191	-87.827	1		3.40	0.1	3.41
ANSS	1995	5	31	19	57	36.23	24.948	-103.869	10		3.80	0.1	3.81
ANSS	1995	6	1	1	6	15.70	30.300	-103.350	10		3.50	0.1	3.51
ANSS	1995	6	1	4	49	29.32	34.287	-96.732	5		3.00	0.1	3.01
ANSS	1995	6	6	21	27	8.00	36.180	-89.370	8		3.17	0.41	3.37
ANSS	1995	6	29	9	27	19.00	36.630	-89.780	12		3.09	0.41	3.28
ANSS	1995	6	29	20	7	48.00	36.580	-89.770	10		2.93	0.41	3.12
ANSS	1995	7	4	3	59	4.53	36.246	-104.814	5		3.74	0.41	3.93
ANSS	1995	7	5	14	16	44.70	35.334	-84.163	10		3.66	0.41	3.85
ANSS	1995	7	9	12	42	56.00	35.880	-91.400	5		2.93	0.41	3.12

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	1995	7	15	1	3	28.35	33.478	-87.665	1		3.30	0.1	3.31
ANSS	1995	7	20	2	10	34.00	36.540	-89.620	9		2.85	0.41	3.04
ANSS	1995	7	31	0	47	48.00	37.690	-90.810	5		2.93	0.41	3.12
ANSS	1995	8	17	23	18	52.00	36.110	-89.370	18		3.09	0.41	3.28
ANSS	1995	8	28	15	13	39.05	34.205	-106.942	4		2.93	0.41	3.12
ANSS	1995	9	5	23	1	21.00	38.360	-89.040	4		3.01	0.41	3.20
ANSS	1995	9	15	0	31	33.26	36.870	-98.690	5		3.98	0.41	4.18
ANSS	1995	10	2	18	0	54.00	35.340	-90.120	9		2.85	0.41	3.04
ANSS	1995	10	26	0	37	28.96	37.053	-83.121	1		3.90	0.41	4.10
ANSS	1995	11	12	17	45	59.40	30.300	-103.350	10		3.58	0.41	3.77
ANSS	1995	11	24	1	52	35.00	36.600	-89.820	18		2.93	0.41	3.12
ANSS	1995	12	1	14	37	40.44	35.061	-99.337	5		3.01	0.41	3.20
ANSS	1995	12	15	10	16	39.90	36.193	-83.694	10		2.93	0.41	3.12
ANSS	1995	12	23	6	51	48.88	38.732	-104.917	5		3.58	0.41	3.77
ANSS	1995	12	31	0	37	38.19	38.716	-104.910	5		2.93	0.41	3.12
ISC	1996	3	15	12	3	35.50	33.230	-104.740	0		3.50	0.41	3.69
ANSS	1996	3	15	13	17	57.22	33.586	-105.694	10		3.01	0.41	3.20
ANSS	1996	3	24	20	16	12.70	34.255	-105.681	10		3.50	0.41	3.69
ANSS	1996	3	24	20	19	23.10	34.270	-105.689	10		3.66	0.41	3.85
ANSS	1996	3	25	6	43	46.86	35.610	-102.601	5		3.50	0.41	3.69
ANSS	1996	3	25	14	15	50.55	32.131	-88.671	5		3.50	0.41	3.69
ISC	1996	3	31	18	39	42.60	37.077	-83.899	0		3.50	0.1	3.51
ANSS	1996	4	4	23	55	5.00	35.520	-90.540	9		2.85	0.41	3.04
ANSS	1996	4	11	21	54	56.00	34.900	-91.310	6		2.93	0.41	3.12
ANSS	1996	4	19	8	50	14.01	36.981	-83.018	0		3.90	0.1	3.91
ISC	1996	5	13	20	18	59.30	36.776	-83.004	13		3.40	0.1	3.41
ANSS	1996	7	5	21	37	9.60	35.200	-84.000	5		2.93	0.41	3.12
ANSS	1996	7	16	0	35	6.00	35.760	-90.200	7		2.93	0.41	3.12
ANSS	1996	7	22	10	6	14.98	34.204	-105.711	10		3.50	0.41	3.69
ANSS	1996	8	1	5	44	22.75	37.398	-104.247	5		3.74	0.41	3.93
ANSS	1996	8	1	5	55	54.16	37.378	-104.196	5		3.25	0.41	3.45
ANSS	1996	8	11	18	17	49.88	33.577	-90.874	10		3.50	0.41	3.69
ANSS	1996	10	13	18	57	46.00	38.410	-89.380	23		2.85	0.41	3.04
ANSS	1996	11	1	3	9	28.35	37.349	-104.232	5		3.25	0.41	3.45
ANSS	1996	11	5	19	48	19.00	37.330	-90.220	4		2.93	0.41	3.12
ANSS	1996	11	23	10	54	18.50	35.040	-100.504	5		3.09	0.41	3.28
ANSS	1996	11	29	5	41	34.00	35.930	-89.930	20		4.15	0.41	4.34
ANSS	1996	11	29	10	47	10.00	36.240	-89.450	4		3.42	0.41	3.61
ANSS	1996	12	15	7	19	57.00	36.030	-89.830	8		2.93	0.41	3.12
ANSS	1996	12	16	1	58	31.35	39.500	-87.400	5		3.17	0.41	3.37
ANSS	1997	1	9	3	7	25.99	33.200	-92.600	5		2.93	0.41	3.12
ANSS	1997	1	18	22	4	39.00	39.100	-105.100	5		3.30	0.1	3.31
ANSS	1997	1	19	4	36	15.00	39.100	-105.100	5		2.85	0.41	3.04
ANSS	1997	2	12	23	53	10.77	34.947	-100.890	5		3.09	0.41	3.28
ANSS	1997	2	15	9	8	55.46	34.973	-100.569	5		3.25	0.41	3.45
ANSS	1997	3	16	19	7	28.00	34.270	-93.490	5		3.42	0.41	3.61

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ISC	1997	4	18	14	57	46.30	26.922	-87.284	33	.	3.80	0.1	3.81
ANSS	1997	5	4	3	39	12.99	31.000	-87.400	5		3.17	0.41	3.37
ANSS	1997	5	19	19	45	35.80	34.622	-85.353	3		3.01	0.41	3.20
ANSS	1997	5	20	9	41	5.82	34.188	-105.742	10		3.25	0.41	3.45
ANSS	1997	5	31	3	26	41.34	33.182	-95.966	5		3.42	0.41	3.61
ANSS	1997	7	19	17	6	34.40	34.953	-84.811	3		3.50	0.41	3.69
ANSS	1997	7	30	12	29	25.30	36.512	-83.547	23		3.74	0.41	3.93
ANSS	1997	9	6	23	38	0.91	34.660	-96.435	5		4.31	0.41	4.50
ANSS	1997	9	13	19	50	32.00	38.290	-89.710	16		2.93	0.41	3.12
ANSS	1997	9	17	18	16	32.00	35.670	-90.490	7		3.74	0.41	3.93
ANSS	1997	9	24	4	20	26.00	36.580	-89.890	12		2.93	0.41	3.12
ANSS	1997	9	27	12	14	10.00	36.200	-89.420	9		3.01	0.41	3.20
ISC	1997	10	19	11	12	12.10	32.332	-103.395	0		3.58	0.1	3.59
EHB98	1997	10	24	8	35	18.83	31.126	-87.283	3	.	4.80	0.1	4.81
ISC	1997	12	6	11	11	23.60	34.895	-95.968	5		3.01	0.1	3.02
ANSS	1997	12	11	11	34	57.00	37.101	-98.480	5		2.85	0.41	3.04
ANSS	1997	12	12	8	42	20.25	33.466	-87.306	1		3.90	0.41	4.10
ANSS	1997	12	31	13	28	30.05	34.533	-106.154	5		3.50	0.41	3.69
ANSS	1997	12	31	13	32	6.60	34.550	-106.150	5		3.50	0.41	3.69
ANSS	1997	12	31	13	33	58.90	34.550	-106.150	5		3.42	0.41	3.61
ANSS	1998	1	2	15	47	16.43	37.828	-103.408	5		3.42	0.41	3.61
ANSS	1998	1	4	8	5	31.87	34.553	-106.191	5		3.90	0.41	4.10
ANSS	1998	1	28	22	5	12.00	36.100	-89.770	8		2.85	0.41	3.04
ANSS	1998	2	12	9	37	49.00	36.140	-89.710	9		3.09	0.41	3.28
ANSS	1998	2	19	14	5	27.00	36.530	-89.580	8		2.85	0.41	3.04
ANSS	1998	4	8	18	16	49.00	36.940	-89.010	8		3.25	0.41	3.45
ANSS	1998	4	9	5	13	41.00	36.400	-89.500	7		2.85	0.41	3.04
ANSS	1998	4	15	10	33	42.42	30.188	-103.303	10		3.58	0.41	3.77
ANSS	1998	4	18	22	45	43.10	39.100	-105.100	5		2.85	0.41	3.04
ANSS	1998	4	27	15	22	46.25	35.453	-102.383	5		3.25	0.41	3.45
ANSS	1998	4	28	14	13	1.68	34.782	-98.416	5		4.07	0.41	4.26
ANSS	1998	5	7	12	24	41.40	32.370	-88.110	10		2.85	0.41	3.04
ANSS	1998	6	17	8	0	23.90	35.944	-84.392	11		3.58	0.41	3.77
ISC	1998	6	18	17	21	5.90	25.183	-106.684	0		4.50	0.1	4.51
ANSS	1998	6	24	15	20	1.39	32.502	-87.954	5		3.42	0.41	3.61
ISC	1998	7	6	6	54	4.10	25.035	-93.626	10	.	3.40	0.1	3.41
ANSS	1998	7	7	18	44	44.46	34.719	-97.589	5		3.25	0.41	3.45
ANSS	1998	7	14	5	38	48.75	35.344	-103.473	5		3.01	0.41	3.20
ANSS	1998	7	15	4	24	51.00	36.690	-89.520	14		3.17	0.41	3.37
ANSS	1998	7	22	22	11	57.00	37.670	-90.020	5		2.85	0.41	3.04
ISC	1998	8	14	17	5	11.80	27.744	-99.864	0		3.90	0.1	3.91
ANSS	1998	10	15	9	47	22.00	35.630	-90.430	4		3.01	0.41	3.20
ANSS	1998	10	30	17	41	22.20	36.800	-97.600	5		3.50	0.41	3.69
ANSS	1999	1	7	5	16	26.96	38.674	-99.378	5		3.09	0.41	3.28
ANSS	1999	1	17	18	38	5.10	36.893	-83.799	1		3.06	0.3	3.17
ANSS	1999	1	18	7	0	53.47	33.405	-87.255	1		4.80	0.1	4.81

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	1999	2	25	2	11	31.00	34.180	-89.810	5		3.01	0.41	3.20
ANSS	1999	3	1	8	0	23.50	32.573	-104.656	1		3.01	0.41	3.20
ANSS	1999	3	14	22	43	17.97	32.591	-104.630	1		3.90	0.41	4.10
ANSS	1999	3	17	12	29	23.11	32.582	-104.672	1		3.43	0.3	3.53
ANSS	1999	5	13	14	18	22.75	39.100	-94.700	5		3.09	0.41	3.28
ANSS	1999	5	30	19	4	25.60	32.575	-104.664	10		3.82	0.41	4.02
ANSS	1999	8	23	12	12	41.00	36.260	-89.500	9		3.17	0.41	3.37
ANSS	1999	10	21	8	17	59.00	36.540	-91.100	11		3.82	0.41	4.02
ANSS	1999	10	21	8	49	49.00	36.500	-90.990	9		3.17	0.41	3.37
ANSS	1999	10	25	23	19	58.37	36.846	-99.659	26		3.09	0.41	3.28
ANSS	1999	11	26	6	54	59.00	36.480	-92.400	5		3.01	0.41	3.20
ANSS	1999	11	28	11	0	9.30	33.416	-87.253	1		3.74	0.41	3.93
ISC	2000	1	14	10	39	34.90	34.674	-95.095	18		3.09	0.23	3.15
ANSS	2000	1	18	22	19	32.20	32.920	-83.465	19		3.50	0.41	3.69
ANSS	2000	2	2	7	14	20.26	32.582	-104.629	5		2.85	0.41	3.04
ANSS	2000	2	4	1	36	26.88	39.092	-99.417	5		2.93	0.41	3.12
ANSS	2000	2	26	3	1	0.83	30.243	-103.612	5		2.93	0.41	3.12
ANSS	2000	3	6	15	2	28.00	38.100	-87.570	5		2.85	0.41	3.04
ANSS	2000	4	14	3	54	20.00	39.760	-86.750	5		3.58	0.41	3.77
ANSS	2000	4	28	23	36	26.00	37.690	-88.460	5		3.01	0.41	3.20
ANSS	2000	5	28	11	32	7.02	33.809	-87.820	5		3.09	0.41	3.28
ANSS	2000	6	15	23	17	14.63	25.450	-100.999	33		4.60	0.1	4.61
ANSS	2000	6	27	1	28	45.00	35.800	-92.750	0		3.82	0.41	4.02
ANSS	2000	6	27	6	2	57.00	37.130	-88.870	4		3.01	0.41	3.20
ANSS	2000	8	2	12	21	30.06	35.200	-101.900	5		2.85	0.41	3.04
ANSS	2000	8	7	17	19	8.00	35.392	-101.812	5		3.33	0.41	3.53
ANSS	2000	8	7	18	34	9.00	35.392	-101.812	5		3.09	0.41	3.28
ANSS	2000	8	7	21	36	21.00	35.392	-101.812	5		3.09	0.41	3.28
ANSS	2000	8	10	13	39	50.00	35.392	-101.812	5		3.09	0.41	3.28
ANSS	2000	8	17	1	8	5.45	35.390	-101.814	5		3.82	0.41	4.02
ANSS	2000	8	22	20	12	15.00	36.490	-91.110	11		3.82	0.41	4.02
ANSS	2000	9	20	6	24	59.00	24.622	-99.933	33		4.20	0.1	4.21
ANSS	2000	12	7	14	8	50.00	38.010	-87.680	5		3.82	0.41	4.02
ISC	2000	12	9	6	46	9.20	28.017	-90.134	10	.	3.90	0.1	3.91
ANSS	2000	12	16	22	8	54.00	35.400	-101.800	5		3.82	0.41	4.02
ANSS	2001	3	3	10	46	13.00	33.190	-92.660	5		3.09	0.41	3.28
ANSS	2001	3	7	17	12	23.80	35.552	-84.850	7		3.25	0.41	3.45
ISC	2001	3	16	4	39	9.30	28.545	-88.946	10	.	3.70	0.1	3.71
ANSS	2001	3	21	23	35	34.90	34.847	-85.438	0		3.16	0.3	3.26
ANSS	2001	3	30	17	13	55.60	37.933	-93.327	5		3.17	0.41	3.37
ISC	2001	4	4	10	27	19.80	24.145	-106.838	137		3.20	0.1	3.21
ANSS	2001	4	13	16	36	20.70	36.526	-83.342	0		2.97	0.3	3.08
ANSS	2001	5	4	6	42	12.00	35.240	-92.250	10		4.23	0.41	4.42
ANSS	2001	5	4	8	31	43.00	35.250	-92.230	0		2.85	0.41	3.04
ANSS	2001	5	5	7	38	44.00	35.210	-92.230	7		2.85	0.41	3.04
ANSS	2001	6	2	1	55	53.72	32.334	-103.141	5		3.33	0.41	3.53

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	2001	7	7	20	45	43.00	36.270	-89.400	14		3.17	0.41	3.37
ANSS	2001	7	14	22	40	28.00	36.260	-89.420	7		2.85	0.41	3.04
ANSS	2001	7	22	19	22	45.57	39.022	-105.129	5		3.17	0.41	3.37
ANSS	2001	7	24	14	2	35.00	37.700	-97.000	5		3.09	0.41	3.28
ANSS	2001	7	26	5	26	46.00	35.971	-83.552	14		3.25	0.41	3.45
ANSS	2001	8	4	1	13	28.00	34.420	-93.230	0		3.25	0.41	3.45
ANSS	2001	8	28	14	16	9.52	37.088	-104.692	5		3.42	0.41	3.61
ANSS	2001	8	28	14	22	0.33	37.091	-104.655	5		3.50	0.41	3.69
ANSS	2001	9	4	12	22	44.97	37.107	-104.622	5		3.42	0.41	3.61
ANSS	2001	9	4	12	45	53.22	37.143	-104.650	5		3.90	0.41	4.10
ANSS	2001	9	5	10	52	7.89	37.143	-104.618	5		4.31	0.41	4.50
ANSS	2001	9	5	14	48	58.26	37.112	-104.611	5		3.66	0.41	3.85
ANSS	2001	9	6	9	41	43.59	37.110	-104.628	5		3.58	0.41	3.77
ANSS	2001	9	6	11	28	26.49	37.140	-104.585	5		3.50	0.41	3.69
ANSS	2001	9	10	18	56	0.37	37.108	-104.602	5		3.42	0.41	3.61
ANSS	2001	9	13	11	22	16.48	37.108	-104.703	5		2.93	0.41	3.12
ANSS	2001	9	13	16	39	5.44	37.091	-104.593	5		3.09	0.41	3.28
ANSS	2001	9	21	19	10	59.67	37.121	-104.706	5		3.42	0.41	3.61
ANSS	2001	11	13	1	56	13.13	39.996	-100.208	5		3.33	0.41	3.53
ANSS	2001	11	22	0	7	8.02	31.786	-102.631	5		3.17	0.41	3.37
ANSS	2001	12	8	1	8	22.40	34.710	-86.231	0		3.82	0.41	4.02
ANSS	2001	12	15	7	58	31.36	36.859	-104.797	5		3.33	0.41	3.53
ANSS	2001	12	17	1	54	44.76	33.200	-92.700	10		2.93	0.41	3.12
ANSS	2002	1	26	1	6	3.86	36.860	-104.784	5		3.42	0.41	3.61
ANSS	2002	2	7	5	19	55.41	36.857	-104.744	5		2.93	0.41	3.12
ANSS	2002	2	8	16	7	13.60	34.727	-98.361	5		3.74	0.41	3.93
ANSS	2002	2	17	23	1	41.00	36.540	-89.640	8		3.01	0.41	3.20
ANSS	2002	3	12	8	30	47.00	37.250	-89.960	10		3.17	0.41	3.37
ANSS	2002	3	31	2	54	8.13	35.359	-101.824	5		2.93	0.41	3.12
ANSS	2002	4	14	3	35	2.13	39.939	-100.320	5		2.93	0.41	3.12
ANSS	2002	4	20	20	0	0.00	36.130	-89.390	7		2.93	0.41	3.12
ANSS	2002	4	27	2	33	43.00	35.960	-89.960	5		2.85	0.41	3.04
ANSS	2002	5	21	20	35	34.43	32.797	-88.102	5		3.17	0.41	3.37
ISC	2002	5	27	0	28	22.00	27.664	-94.530	10	.	3.90	0.1	3.91
ANSS	2002	5	31	9	57	10.02	34.025	-97.619	5		3.33	0.41	3.53
ANSS	2002	6	18	9	12	36.66	36.881	-104.779	5		3.50	0.41	3.69
ANSS	2002	6	18	17	37	15.17	37.987	-87.780	5		5.01	0.1	5.02
ANSS	2002	6	19	12	14	20.30	36.568	-103.028	5		3.66	0.41	3.85
ANSS	2002	7	29	11	28	7.00	35.920	-90.030	8		2.93	0.41	3.12
ANSS	2002	8	11	23	19	47.00	34.340	-90.180	5		2.93	0.41	3.12
ANSS	2002	9	8	9	3	24.00	35.670	-89.640	6		2.85	0.41	3.04
ANSS	2002	9	17	15	45	14.47	32.581	-104.630	10		3.50	0.41	3.69
ANSS	2002	9	17	23	34	19.35	32.576	-104.631	10		3.33	0.41	3.53
ISC	2002	9	19	14	44	36.20	27.820	-89.131	10	.	3.80	0.1	3.81
ANSS	2002	10	13	22	18	54.59	39.203	-106.654	5		2.93	0.41	3.12
ANSS	2002	10	20	2	18	13.00	34.274	-96.079	5		3.42	0.41	3.61

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	2002	10	26	14	8	39.00	36.470	-89.550	8		3.01	0.41	3.20
ANSS	2002	10	26	20	5	55.00	33.950	-90.720	5		3.17	0.41	3.37
ANSS	2002	11	1	11	8	56.28	39.119	-99.089	5		3.09	0.41	3.28
ANSS	2002	11	1	14	19	56.16	39.077	-99.101	5		2.93	0.41	3.12
ANSS	2002	11	14	4	56	52.26	36.917	-104.768	5		3.25	0.41	3.45
ANSS	2002	12	11	14	25	23.54	39.360	-99.403	5		2.93	0.41	3.12
ISC	2002	12	31	19	2	29.10	37.034	-104.620	0		4.66	0.1	4.67
ANSS	2003	1	1	7	43	37.91	39.155	-106.759	5		3.01	0.41	3.20
ANSS	2003	1	3	16	17	7.00	37.830	-88.090	5		3.01	0.41	3.20
ISC	2003	1	4	23	25	5.90	24.344	-100.159	10		3.30	0.1	3.31
ANSS	2003	1	10	10	29	22.46	38.256	-102.622	5		3.01	0.41	3.20
ANSS	2003	4	1	13	9	49.61	39.244	-99.487	5		2.93	0.41	3.12
ANSS	2003	4	7	10	2	12.51	33.892	-97.695	5		3.01	0.41	3.20
ISC	2003	4	13	4	52	53.90	26.096	-86.080	10	.	3.50	0.1	3.51
ANSS	2003	4	17	17	31	59.07	39.255	-99.482	5		3.09	0.41	3.28
ANSS	2003	4	28	7	32	26.04	36.844	-104.923	5		3.58	0.41	3.77
ANSS	2003	4	29	8	59	38.10	34.445	-85.620	9		4.39	0.41	4.58
ANSS	2003	4	29	9	45	45.00	34.440	-85.640	3		3.01	0.41	3.20
ANSS	2003	4	30	4	56	22.00	35.920	-89.920	24		3.90	0.41	4.10
ANSS	2003	5	2	3	25	3.00	36.730	-89.680	2		2.85	0.41	3.04
ANSS	2003	5	2	8	10	13.00	37.960	-88.650	1		3.25	0.41	3.45
ANSS	2003	5	2	10	48	44.00	34.490	-85.610	15		3.17	0.41	3.37
ANSS	2003	5	30	2	18	24.00	36.130	-89.390	6		2.93	0.41	3.12
ANSS	2003	6	3	18	9	27.84	36.994	-104.768	5		3.33	0.41	3.53
ANSS	2003	6	6	12	29	34.00	36.870	-88.980	3		3.90	0.41	4.10
ANSS	2003	6	10	7	46	31.00	36.020	-91.390	5		2.85	0.41	3.04
ANSS	2003	6	15	0	22	17.97	36.910	-104.763	5		3.58	0.41	3.77
ANSS	2003	6	21	2	3	9.56	32.665	-104.505	5		3.58	0.41	3.77
ANSS	2003	7	8	5	55	5.00	38.150	-91.500	3		3.17	0.41	3.37
ANSS	2003	7	29	21	52	46.86	24.595	-105.120	10		4.33	0.3	4.44
ANSS	2003	7	30	2	50	19.00	36.520	-89.530	4		2.93	0.41	3.12
ANSS	2003	8	14	0	11	8.96	36.945	-104.870	5		3.33	0.41	3.53
ANSS	2003	8	26	2	26	58.00	37.100	-88.680	2		3.17	0.41	3.37
ANSS	2003	9	8	11	2	49.31	37.369	-104.685	5		3.09	0.41	3.28
ANSS	2003	9	13	15	22	40.99	36.831	-104.907	5		3.74	0.41	3.93
ANSS	2003	9	16	2	22	45.00	36.100	-89.760	7		2.85	0.41	3.04
ISC	2003	9	19	18	14	25.40	36.982	-104.751	0		4.50	0.1	4.51
ANSS	2003	9	24	15	2	9.09	35.277	-101.742	5		3.33	0.41	3.53
ANSS	2003	9	30	2	28	3.38	31.115	-87.520	5		3.33	0.41	3.53
ANSS	2003	10	25	12	55	55.58	37.031	-104.836	5		3.01	0.41	3.20
ANSS	2003	11	24	7	5	57.72	36.958	-104.828	5		3.17	0.41	3.37
ANSS	2003	12	14	10	16	41.00	35.200	-92.250	5		2.93	0.41	3.12
ANSS	2003	12	15	5	57	18.00	35.200	-92.240	5		2.85	0.41	3.04
ANSS	2003	12	21	5	20	6.00	36.290	-89.500	9		2.85	0.41	3.04
ANSS	2003	12	28	2	55	2.32	37.596	-105.280	5		3.50	0.41	3.69
ANSS	2003	12	28	3	57	3.21	37.584	-105.298	5		3.17	0.41	3.37

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	2003	12	29	9	2	8.00	38.130	-90.170	5		3.09	0.41	3.28
ANSS	2003	12	31	15	8	5.68	33.668	-91.695	5		2.93	0.41	3.12
ANSS	2004	1	14	1	14	15.47	37.018	-104.842	5		3.01	0.41	3.20
ANSS	2004	2	3	14	34	22.57	36.932	-104.861	5		3.42	0.41	3.61
ANSS	2004	2	8	5	56	45.00	39.490	-91.880	5		3.01	0.41	3.20
ANSS	2004	2	9	18	21	49.00	36.350	-90.750	13		3.01	0.41	3.20
ANSS	2004	3	20	10	40	35.47	33.232	-87.008	5		2.93	0.41	3.12
ANSS	2004	3	22	12	9	56.46	36.855	-104.851	5		4.40	0.1	4.41
ANSS	2004	3	30	1	2	55.40	36.892	-104.876	5		3.09	0.41	3.28
ANSS	2004	3	30	2	23	37.86	36.876	-104.831	5		3.17	0.41	3.37
ANSS	2004	3	30	2	41	4.15	37.036	-104.931	5		3.50	0.41	3.69
ANSS	2004	4	6	19	1	2.70	25.172	-99.532	38		4.33	0.3	4.44
ANSS	2004	4	22	16	13	2.25	34.804	-97.677	5		3.01	0.41	3.20
ANSS	2004	5	3	19	25	48.00	36.280	-89.450	3		2.85	0.41	3.04
ANSS	2004	5	9	8	56	10.43	33.231	-86.960	5		3.33	0.41	3.53
ANSS	2004	5	23	9	22	5.28	32.525	-104.566	5		4.00	0.1	4.01
ANSS	2004	5	24	21	36	28.56	34.465	-106.899	5		3.50	0.41	3.69
ANSS	2004	5	31	3	27	43.77	36.935	-104.835	5		3.33	0.41	3.53
ANSS	2004	6	8	0	15	9.99	34.233	-97.254	5		3.50	0.41	3.69
ANSS	2004	6	10	12	30	9.86	34.236	-97.267	5		3.01	0.41	3.20
ANSS	2004	6	15	8	34	21.00	36.730	-89.680	5		3.42	0.41	3.61
ANSS	2004	6	16	4	7	21.00	36.730	-89.690	4		2.93	0.41	3.12
ISC	2004	6	18	19	20	56.40	27.027	-86.997	10		3.50	0.1	3.51
ANSS	2004	6	22	8	55	28.23	32.528	-104.584	5		3.66	0.41	3.85
ANSS	2004	7	16	3	25	17.00	36.860	-89.180	4		3.58	0.41	3.77
ANSS	2004	8	1	6	50	47.63	36.874	-105.104	5		4.66	0.1	4.67
ANSS	2004	8	19	23	51	49.42	33.203	-86.968	5		3.70	0.1	3.71
ANSS	2004	8	26	18	45	18.62	32.582	-104.505	5		3.42	0.41	3.61
ANSS	2004	8	28	5	6	43.67	33.221	-86.924	5		2.93	0.41	3.12
ANSS	2004	9	10	6	39	21.00	35.369	-98.048	5		2.93	0.41	3.12
ANSS	2004	9	12	13	5	19.00	39.590	-85.790	5		3.58	0.41	3.77
ANSS	2004	9	12	23	31	23.00	36.420	-89.920	5		2.85	0.41	3.04
ANSS	2004	9	17	15	21	43.60	36.933	-84.004	1		3.66	0.41	3.85
ANSS	2004	10	28	2	59	4.82	32.604	-104.499	5		3.09	0.41	3.28
ANSS	2004	11	7	11	20	21.43	32.649	-87.933	5		4.66	0.1	4.67
ANSS	2004	11	14	21	27	49.90	33.253	-106.201	5		3.50	0.41	3.69
ANSS	2004	11	22	23	42	13.45	34.864	-97.672	5		3.09	0.41	3.28
ANSS	2004	11	30	23	59	34.00	36.940	-93.890	9		3.01	0.41	3.20
ANSS	2004	11	30	23	59	34.20	36.936	-83.893	10		2.97	0.3	3.08
ANSS	2004	12	23	6	54	20.70	35.429	-84.204	8		2.97	0.3	3.08
ANSS	2005	1	5	3	37	56.76	27.750	-104.987	5		3.25	0.41	3.45
ANSS	2005	1	10	10	14	59.15	37.007	-104.675	5		3.42	0.41	3.61
ANSS	2005	1	27	17	52	55.00	35.200	-92.220	4		2.85	0.41	3.04
ANSS	2005	2	10	14	4	54.00	35.760	-90.250	16		3.98	0.41	4.18
ANSS	2005	3	18	1	2	16.00	35.720	-84.160	9		2.85	0.41	3.04
ANSS	2005	3	22	8	11	50.51	31.836	-88.060	5		3.33	0.41	3.53

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	2005	4	3	14	39	16.97	28.393	-100.305	5		3.50	0.41	3.69
ANSS	2005	4	5	20	37	43.00	36.150	-83.690	10		3.01	0.41	3.20
ANSS	2005	4	6	8	45	24.57	36.881	-104.794	5		3.01	0.41	3.20
ANSS	2005	4	14	15	38	16.00	35.470	-84.090	15		2.93	0.41	3.12
ANSS	2005	4	22	5	17	4.09	34.179	-95.192	5		3.09	0.41	3.28
ANSS	2005	4	24	11	2	35.90	36.920	-105.070	5		3.42	0.41	3.61
ANSS	2005	5	1	12	37	32.00	35.830	-90.150	10		3.98	0.41	4.18
ANSS	2005	5	16	22	29	46.84	35.250	-97.608	5		2.93	0.41	3.12
ANSS	2005	5	18	19	59	42.90	38.460	-93.967	5		3.33	0.41	3.53
ANSS	2005	6	2	11	35	11.00	36.150	-89.470	15		3.82	0.41	4.02
ANSS	2005	6	7	16	33	36.71	33.531	-87.304	5		2.93	0.41	3.12
ANSS	2005	6	20	2	0	32.00	36.930	-88.990	10		2.85	0.41	3.04
ANSS	2005	6	20	12	21	42.00	36.920	-89.000	19		3.58	0.41	3.77
ANSS	2005	6	27	15	46	52.00	37.630	-89.420	10		3.09	0.41	3.28
ANSS	2005	7	4	10	45	24.50	36.860	-105.097	5		3.09	0.41	3.28
ANSS	2005	7	8	6	24	1.12	36.938	-104.886	5		3.09	0.41	3.28
ANSS	2005	7	13	12	8	13.00	35.810	-90.160	11		2.93	0.41	3.12
ANSS	2005	7	31	7	7	7.97	38.718	-92.725	5		3.33	0.41	3.53
ANSS	2005	8	10	22	8	16.96	36.952	-104.822	5		4.10	0.1	4.11
ANSS	2005	8	10	22	24	33.94	36.982	-104.959	5		3.09	0.41	3.28
ANSS	2005	8	15	0	12	57.00	35.870	-90.010	6		3.01	0.41	3.20
ANSS	2005	10	12	6	27	30.00	35.510	-84.540	8		3.58	0.41	3.77
ANSS	2005	10	20	8	15	36.58	36.970	-104.849	5		3.09	0.41	3.28
ANSS	2005	11	16	3	11	32.64	37.099	-104.897	5		3.01	0.41	3.20
ANSS	2005	12	6	16	24	14.00	38.420	-89.200	4		2.85	0.41	3.04
ANSS	2005	12	19	20	27	40.37	32.528	-104.549	5		4.41	0.1	4.42
ANSS	2005	12	20	0	52	20.51	30.258	-90.708	5		3.09	0.41	3.28
ISC	2005	12	22	14	30	12.40	32.599	-104.390	0		3.25	0.1	3.26
ANSS	2005	12	25	14	33	45.00	36.530	-89.660	12		2.93	0.41	3.12
ANSS	2006	1	2	21	48	57.00	37.840	-88.420	11		3.58	0.41	3.77
ANSS	2006	1	27	16	7	45.84	32.551	-104.577	5		3.17	0.41	3.37
ANSS	2006	1	27	18	48	49.23	37.030	-104.968	5		3.33	0.41	3.53
ANSS	2006	2	4	19	55	10.68	32.575	-104.617	5		2.85	0.41	3.04
ANSS	2006	2	10	4	14	17.80	27.597	-90.163	5	.	5.52	0.41	5.71
ANSS	2006	2	11	13	3	50.48	37.076	-105.444	5		3.01	0.41	3.20
ANSS	2006	2	18	5	49	41.45	35.672	-101.794	5		3.50	0.41	3.69
ANSS	2006	3	1	17	42	42.00	37.500	-88.980	6		3.09	0.41	3.28
ANSS	2006	3	4	17	14	58.25	30.289	-103.674	5		2.85	0.41	3.04
ANSS	2006	3	11	2	37	20.00	35.200	-88.010	2		2.85	0.41	3.04
ANSS	2006	3	15	8	30	25.86	35.091	-96.300	5		2.97	0.3	3.08
ANSS	2006	3	20	17	55	29.12	32.600	-104.563	5		3.09	0.41	3.28
ANSS	2006	3	28	23	55	11.49	35.363	-101.871	5		3.09	0.41	3.28
ANSS	2006	4	5	18	46	23.14	34.069	-97.314	5		3.09	0.41	3.28
ANSS	2006	4	8	15	59	43.25	28.010	-105.123	10		3.58	0.41	3.77
ANSS	2006	4	8	18	8	35.23	31.954	-101.419	5		3.01	0.41	3.20
ANSS	2006	4	9	14	41	29.00	35.240	-92.240	8		2.93	0.41	3.12

Table 2.5S.2-3 Seismicity Catalog from 1985 to Present for the Project Investigation Region [107°W to 83°W, 24°N to 40°N] for which the Events are Rmb Magnitude ≥ 3.0 or Intensity ≥ IV (Continued)

Catalog Reference	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
ANSS	2006	4	11	3	29	21.00	35.360	-84.480	20		3.33	0.41	3.53
ANSS	2006	4	17	16	25	12.29	24.432	-100.091	17		4.10	0.1	4.11
ANSS	2006	5	6	17	7	1.34	37.014	-104.768	5		3.17	0.41	3.37
ANSS	2006	5	10	12	17	29.00	35.530	-84.400	25		3.25	0.41	3.45
ISC	2006	5	14	3	4	0.50	26.058	-106.944	33		4.10	0.1	4.11
ANSS	2006	5	18	13	1	15.00	38.050	-90.530	6		3.01	0.41	3.20
ANSS	2006	5	26	6	14	25.12	36.795	-104.832	5		3.17	0.41	3.37
ANSS	2006	6	16	0	57	27.00	35.510	-83.200	1		3.42	0.41	3.61
ANSS	2006	7	11	11	53	37.78	36.964	-104.929	5		3.25	0.41	3.45
ANSS	2006	8	7	8	44	28.00	34.940	-85.460	14		3.01	0.41	3.20
ANSS	2006	8	12	10	49	9.67	32.895	-100.894	5		2.93	0.41	3.12
ANSS	2006	8	24	14	4	25.88	37.014	-105.013	5		3.17	0.41	3.37
ANSS	2006	9	7	13	51	13.00	36.270	-89.500	8		3.33	0.41	3.53
ANSS	2006	9	9	9	54	6.65	37.296	-104.770	5		3.25	0.41	3.45
ANSS	2006	9	9	12	53	14.21	37.368	-104.865	5		3.09	0.41	3.28
ANSS	2006	9	9	18	5	41.79	37.374	-104.736	5		3.01	0.41	3.20
ANSS	2006	9	9	23	14	35.54	37.298	-104.794	5		3.58	0.41	3.77
ANSS	2006	9	10	14	56	8.16	26.319	-86.606	14		6.11	0.1	6.12
ANSS	2006	9	14	13	3	24.26	37.010	-104.867	5		3.09	0.41	3.28
ANSS	2006	9	30	12	40	0.12	37.061	-104.971	5		2.93	0.41	3.12
ANSS	2006	10	6	22	13	16.78	34.122	-97.625	5		3.50	0.41	3.69
ANSS	2006	10	17	5	18	4.00	35.230	-92.290	4		2.93	0.41	3.12
ANSS	2006	10	18	20	59	21.00	36.540	-89.640	8		3.42	0.41	3.61

Table 2.5S.2-4 Seismicity Events Recommended for Recurrence Analysis within the Gulf of Mexico

Catalog	Year	Month	Day	Hour	Minute	Second	Lat (°N)	Lon (°E)	Depth (km)	Intensity	Emb	Smb	Rmb
EPRI	1927	12	15	4	30	0.00	28.900	-89.400	0	4	3.80	0.30	3.90
EPRI	1929	7	28	17	0	0.00	28.900	-89.400	0	4	3.80	0.30	3.90
EPRI	1958	11	6	23	8	0.00	29.900	-90.100	0	4	3.11	0.56	3.47
EPRI	1963	11	5	22	45	3.40	27.490	-92.580	15	.	4.71	0.20	4.76
EPRI	1978	7	24	8	6	16.90	26.380	-88.720	15	.	4.88	0.10	4.89
EPRI	1980	1	10	19	16	23.50	24.130	-85.710	15	.	3.88	0.10	3.89
SRA	1981	2	13	2	15	0.00	30.000	-91.800	0	4	3.11	0.56	3.47
ANSS	1984	1	23	0	11	59.38	26.716	-87.339	5	.	2.85	0.41	3.04
ISC	1986	5	12	4	18	2.70	27.714	-88.726	10	.	3.50	0.10	3.51
ISC	1992	3	31	14	59	43.60	26.311	-85.895	5	.	3.80	0.10	3.81
ISC	1992	9	27	17	2	34.40	28.192	-88.431	10	.	3.58	0.41	3.77
ISC	1994	6	30	1	8	24.00	27.849	-90.123	10	.	3.70	0.10	3.71
ISC	1997	4	18	14	57	46.30	26.922	-87.284	33	.	3.80	0.10	3.81
ISC	1998	7	6	6	54	4.10	25.035	-93.626	10	.	3.40	0.10	3.41
ISC	2000	12	9	6	46	9.20	28.017	-90.134	10	.	3.90	0.10	3.91
ISC	2001	3	16	4	39	9.30	28.545	-88.946	10	.	3.70	0.10	3.71
ISC	2002	5	27	0	28	22.00	27.664	-94.530	10	.	3.90	0.10	3.91
ISC	2002	9	19	14	44	36.20	27.820	-89.131	10	.	3.80	0.10	3.81
ISC	2003	4	13	4	52	53.90	26.096	-86.080	10	.	3.50	0.10	3.51
ISC	2004	6	18	19	20	56.40	27.027	-86.997	10	.	3.50	0.10	3.51
ANSS	2006	2	10	4	14	17.80	27.597	-90.163	5	.	5.52	0.41	5.71
ANSS	2006	9	10	14	56	8.16	26.319	-86.606	14	.	6.11	0.10	6.12

Table 2.5S.2-5 Region 2 Matrix of Detection Probability Modified to Extend the Matrix to Recent Years [2006 being the last year incorporated]

Matrix of Detection Probability: EPRI (Reference 2.5S.2-3) Incompleteness Region 2 [Modified]								
Magnitude Intervals	Year Intervals							TOTAL YEARS
	1625-1779	1780-1859	1860-1909	1910-1949	1950-1974	1975-1984	1985 - 2006	
	155 years	80 years	50 years	40 years	25 years	10 years	22 years	
3.3-3.89	0.00	0.00	0.10	0.51	0.63	1.00	1.00	73.2
3.9-4.49	0.00	0.00	0.15	0.90	1.00	1.00	1.00	100.5
4.5-5.09	0.00	0.00	0.24	0.98	1.00	1.00	1.00	108.2
5.1-5.69	0.00	0.00	0.24	0.98	1.00	1.00	1.00	108.2
5.7-6.29	0.00	0.00	0.70	1.00	1.00	1.00	1.00	132.0
6.3-7.5	0.00	0.01	1.00	1.00	1.00	1.00	1.00	147.8

Table 2.5S.2-6 Matrix of Detection Probability for the Gulf of Mexico

Magnitude Intervals	Year Intervals											TOTAL YEARS
	1625-1779	1780-1859	1860-1899	1900-1924	1925-1949	1950-1959	1960-1964	1965-1969	1970-1974	1975-1979	1980-2006	
	155 years	80 years	40 years	25 years	25 years	10 years	5 years	5 years	5 years	5 years	27 years	
3.3-3.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	8.1
3.9-4.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.60	18.7
4.5-5.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.70	0.70	0.90	33.8
5.1-5.69	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.90	1.00	1.00	1.00	45.0
5.7-6.29	0.00	0.00	0.00	0.00	0.70	0.90	1.00	1.00	1.00	1.00	1.00	73.5
6.3-7.5	0.00	0.00	0.00	0.30	0.90	1.00	1.00	1.00	1.00	1.00	1.00	87.0

Note: see Subsection 2.5S.2.1.5 for explanation of shaded cells.

Table 2.5S.2-7 Summary of Bechtel Group Seismic Source Zones

Source	Description	Distance [1]		Pa [2]	M_{max} (m_b) and Wts. [3]	Smoothing Options and Wts. [4]	Contributes to 99% of Hazard [5]	New Information to Suggest Change in Source		
		(km)	(mi)					Geometry [6]	M_{max} [7]	RI [8]
BZ1	Gulf Coast	0	0	1.0	5.4 [0.1] 5.7 [0.4] 6.0 [0.4] 6.6 [0.1]	1 [0.33] 2 [0.34] 3 [0.33]	Yes	No	Yes	No
BZ2	Texas Platform	82	51	1.0	5.4 [0.1] 5.7 [0.4] 6.0 [0.4] 6.6 [0.1]	1 [0.33] 2 [0.34] 4 [0.33]	Yes	No	No	No

[1] Shortest distance between STP 3 & 4 and source zone
[2] Probability of activity
[3] Maximum earthquake magnitude (M_{max}) in body-wave magnitude (m_b) and weighting (Wts.)
[4] Smoothing options
1 = constant a, constant b, no b prior
2 = low smoothing on a, high smoothing on b, no b prior
3 = low smoothing on a, low smoothing on b, no b prior
4 = low smoothing on a, low smoothing on b, weak b prior of 1.05
Weights on magnitude intervals are [1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0]
[5] Whether or not the source contributes to 99% of the hazard at STP 3 & 4
[6] No, unless new geometry proposed in literature
[7] No, unless M_{max} exceeded in literature
[8] RI = recurrence interval; assumed no change if no new paleoseismic data or rate of seismicity has not significantly changed

Table 2.5S.2-8 Summary of Dames & Moore Seismic Source Zones

Source	Description	Distance [1]		Pa [2]	M_{max} (m_b) and Wts. [3]	Smoothing Options and Wts. [4]	Contributes to 99% of Hazard [5]	New Information to Suggest Change in Source		
		(km)	(mi)					Geometry [6]	M_{max} [7]	RI [8]
20	South Coastal Margin	0	0	1.0	5.3 [0.8] 7.2 [0.2]	1 [0.75] 2 [0.25]	Yes	No	Yes	No
25	Ouachitas Fold Belt	170	106	0.35	5.5 [0.8] 7.2 [0.2]	1 [0.75] 2 [0.25]	Yes	No	No	No
C08	Combination zone: 25 (Ouachitas Fold Belt) excluding 25A (Kink in Fold Belt)	170	106	NA	5.5 [0.8] 7.2 [0.2]	1 [0.75] 2 [0.25]	Yes	No	No	No
67	New Mexico	288	179	1.0	5.0 [0.8] 7.2 [0.2]	1 [0.75] 2 [0.25]	No	No	No	No

[1] Shortest distance between STP 3 & 4 and source zone

[2] Probability of activity

[3] Maximum earthquake magnitude (M_{max}) in body-wave magnitude (m_b) and weighting (Wts.).

[4] Smoothing options

1 = no smoothing on a, no smoothing on b, strong b prior of 1.04

2 = no smoothing on a, no smoothing on b, weak b prior of 1.04

Weights on magnitude intervals are [0.1, 0.2, 0.4, 1.0, 1.0, 1.0, 1.0]

[5] Whether or not the source contributes to 99% of the hazard at STP 3 & 4

[6] No, unless new geometry proposed in literature

[7] No, unless M_{max} exceeded in literature

[8] RI = recurrence interval; assumed no change if no new paleoseismic data or rate of seismicity has not significantly changed

Table 2.5S.2-9 Summary of Law Engineering Seismic Source Zones

Source	Description	Distance [1]		Pa [2]	M_{max} (m_b) and Wts. [3]	Smoothing Options and Wts. [4]	Contributes to 99% of Hazard [5]	New Information to Suggest Change in Source		
		(km)	(mi)					Geometry [6]	M_{max} [7]	RI [8]
124	New Mexico –Texas Block	123	76	1.0	4.9 [0.3] 5.5 [0.5] 5.8 [0.2]	1a [1.0]	Yes	No	No	No
126	South Coastal Block	0	0	1.0	4.6 [0.9] 4.9 [0.1]	1a [1.0]	Yes	No	Yes	No

[1] Shortest distance between STP 3 & 4 and source zone.

[2] Probability of activity

[3] Maximum earthquake magnitude (M_{max}) in body-wave magnitude (m_b) and weighting (Wts.).

[4] Smoothing options

1a = high smoothing on a, constant b, strong b prior of 1.05

Weights on magnitude intervals are all 1.0

[5] Whether or not the source contributes to 99% of the hazard at STP 3 & 4

[6] No, unless new geometry proposed in literature

[7] No, unless M_{max} exceeded in literature

[8] RI = recurrence interval; assumed no change if no new paleoseismic data or rate of seismicity has not significantly changed

Table 2.5S.2-10 Summary of Rondout Associates Seismic Source Zones

Source	Description	Distance [1]		Pa [2]	M_{max} (m_b) and Wts. [3]	Smoothing Options and Wts. [4]	Contributes to 99% of Hazard [5]	New Information to Suggest Change in Source		
		(km)	(mi)					Geometry [6]	M_{max} [7]	RI [8]
51	Gulf Coast to Bahamas Fracture Zone	0	0	1.0	4.8 [0.2] 5.5 [0.6] 5.8 [0.2]	3 [1.0]	Yes	No	Yes	No
C02	Background 50	206	128	NA	4.8 [0.2] 5.5 [0.6] 5.8 [0.2]	3 [1.0]	No	No	No	No

[1] Shortest distance between STP 3 & 4 and source zone

[2] Probability of activity

[3] Maximum earthquake magnitude (M_{max}) in body-wave magnitude (m_b) and weighting (Wts.)

[4] Smoothing options

3 = low smoothing on a, constant b, strong b prior of 1.0

[5] Whether or not the source contributes to 99% of the hazard at STP 3 & 4

[6] No, unless new geometry proposed in literature

[7] No, unless M_{max} exceeded in literature

[8] RI = recurrence interval; assumed no change if no new paleoseismic data or rate of seismicity has not significantly changed

Table 2.5S.2-11 Summary of Weston Geophysical Corporation Seismic Source Zones

Source	Description	Distance [1]		Pa [2]	M_{max} (m_b) and Wts. [3]	Smoothing Options and Wts. [4]	Contributes to 99% of Hazard [5]	New Information to Suggest Change in Source		
		(km)	(mi)					Geometry [6]	M_{max} [7]	RI [8]
107	Gulf Coast	0	0	1.0	5.4 [0.71] 6.0 [0.29]	1a [0.2] 2a [0.8]	Yes	No	Yes	No
C31	Combination zone: 109 (Southwest) excluding 37 (Delaware Basin)	206	128	NA	5.4 [0.33] 6.0 [0.49] 6.6 [0.18]	1a [0.7] 2a [0.3]	No	No	No	No

[1] Shortest distance between STP 3 & 4 and source zone
[2] Probability of activity (Pa)
[3] Maximum earthquake magnitude (M_{max}) in body-wave magnitude (m_b) and weighting (Wts.).
[4] Smoothing options
1b = constant a, constant b, medium b prior of 0.9
2a = medium smoothing on a, medium smoothing on b, medium b prior of 1.0
[5] Whether or not the source contributes to 99% of the hazard at STP 3 & 4
[6] No, unless new geometry proposed in literature
[7] No, unless M_{max} exceeded in literature
[8] RI = recurrence interval; assumed no change if no new paleoseismic data or rate of seismicity has not significantly changed

Table 2.5S.2-12 Summary of Woodward-Clyde Consultants Seismic Source Zones

Source	Description	Distance [1]		Pa [2]	M_{max} (m_b) and Wts. [3]	Smoothing Options and Wts. [4]	Contributes to 99% of Hazard [5]	New Information to Suggest Change in Source		
		(km)	(mi)					Geometry [6]	M_{max} [7]	RI [8]
B43	Central US Backgrounds	0	0	NA	4.9 [0.17] 5.4 [0.28] 5.8 [0.27] 6.5 [0.28]	1 [0.25] 6 [0.25] 7 [0.25] 8 [0.25]	Yes	No	No	No

[1] Shortest distance between STP 3 & 4 and source zone

[2] Probability of activity (Pa)

[3] Maximum earthquake magnitude (M_{max}) in body-wave magnitude (m_b) and weighting (Wts.)

[4] Smoothing options

1 = low smoothing on a, high smoothing on b, no b prior

6 = low smoothing on a, high smoothing on b, moderate b prior of 1.0

7 = low smoothing on a, high smoothing on b, moderate b prior of 0.9

8 = low smoothing on a, high smoothing on b, moderate b prior of 0.8

Weights on magnitude intervals are all 1.0

[5] Whether or not the source contributes to 99% of the hazard at STP 3 & 4

[6] No unless new geometry proposed in literature

[7] No, unless M_{max} exceeded in literature

[8] RI = recurrence interval; assumed no change if no new paleoseismic data or rate of seismicity has not significantly changed

Table 2.5S.2-13 Comparison of EPRI EST Characterizations of Gulf of Mexico Costal Source Zones and Modifications for STP 3 & 4

EPRI EST	Source	Description	EPRI Model		Updated Model for STP 3 & 4	
			M_{max} (m_b) and Wts. [1]	Contributes to 99% of Hazard [2]	M_{max} (m_b) and Wts [3]	Smoothing Options and Wts. [4]
Bechtel Group	BZ1	Gulf Coast	5.4 [0.1] 5.7 [0.4] 6.0 [0.4] 6.6 [0.1]	Yes	6.1 [0.10] 6.4 [0.40] 6.6 [0.50]	No Update
Dames & Moore	20	South Coastal Margin	5.3 [0.8] 7.2 [0.2]	Yes	5.5 [0.80] 7.2 [0.20]	I (0.2) II (0.4) III (0.4)
Law Engineering	126	South Coastal Block	4.6 [0.9] 4.9 [0.1]	Yes	5.5 [0.90] 5.7 [0.10]	No Update
Rondout Associates	51	Gulf Coast to Bahamas Fracture Zone	4.8 [0.2] 5.5 [0.6] 5.8 [0.2]	Yes	6.1 [0.30] 6.3 [0.55] 6.5 [0.15]	No Update
Weston Geophysical Corporation	107	Gulf Coast	5.4 [0.71] 6.0 [0.29]	Yes	6.6 [0.89] 7.2 [0.11]	No Update
Woodward-Clyde Consultants	B43	Central US Backgrounds	4.9 [0.17] 5.4 [0.28] 5.8 [0.27] 6.5 [0.28]	Yes	No Update	No Update

[1] Mmax distribution and weights from EPRI 1986 model (EPRI, Reference 2.5S.2-16)

[2] Whether or not the source contributes to 99% of the hazard at STP 3 & 4

[3] Updated Mmax distributions and weights as described in Subsection 2.5S.2.6.2

[4] Updated smoothing options and weights as described in Subsection 2.5S.2.6.2.7.1

I: Constant a, constant b, strong prior on b of 1.04

II: Medium smoothing on a, medium smoothing on b, strong prior on b of 1.04

III: high smoothing on a, high smoothing on b, strong prior on b of 1.04

Table 2.5S.2-14 Comparison of EPRI (Reference 2.5S.2-16) and current hazard results for Bechtel Group EST using EPRI (Reference 2.5S.2-16) assumptions

PGA amp, cm/s^2	Hazard	EPRI	Current results	% difference
100	mean	1.19E-05	1.20E-05	0.8%
	15%	4.22E-06	4.27E-06	1.2%
	50%	9.09E-06	9.12E-06	0.3%
	85%	1.82E-05	1.82E-05	0.0%
250	mean	1.35E-06	1.36E-06	0.7%
	15%	4.62E-07	4.68E-07	1.3%
	50%	9.58E-07	9.33E-07	-2.6%
	85%	2.28E-06	2.29E-06	0.4%
500	mean	1.30E-07	1.34E-07	3.1%
	15%	3.08E-08	3.16E-08	2.6%
	50%	8.87E-08	9.55E-08	7.7%
	85%	2.23E-07	2.34E-07	4.9%

Table 2.5S.2-15 Table 2.5S.2-15 Closest Approach of Gulf of Mexico Earthquakes with Emb > 5.5 to Boundary of EPRI EST Gulf Coastal Source Zones

	EPRI EST Gulf Coastal Source Zone					
Earthquake	Bechtel Group Gulf Coast (BZ1)	Dames & Moore South Coastal Margin (20)	Law Engineering South Coastal Block (126)	Rondout Associates Gulf Coast to Bahamas	Weston Geophysical Corporation Gulf Coast (107)	Woodward-Clyde Consultants Central US Backgrounds (B43)
2006-02-10 Emb 5.5	159 mi (256 km)	-11 mi (-18 km)	-39 mi (-63 km)	147 mi (236 km)	179 mi (288 km)	-170 mi (-273 km)
2006-09-10 Emb 6.1	73.3 mi (118 km)	-152 mi (-245 km)	-97.6 mi (-157 km)	70.8 mi (114 km)	85.8 mi (138 km)	-395 mi (-635 km)

Note: Negative values indicate that earthquake occurred outside the source zone

Table 2.5S.2-16 Mean Rock Uniform Hazard Response Spectral Accelerations (g)

Mean rock UHRS			
Freq, Hz	**10^{-4} mean**	**10^{-5} mean**	**10^{-6} mean**
100 [PGA]	0.0327	0.126	0.517
25	0.0784	0.340	1.408
10	0.0684	0.253	0.896
5	0.0620	0.200	0.583
2.5	0.0552	0.154	0.353
1	0.0414	0.114	0.235
0.5	0.0341	0.114	0.243

Table 2.5S.2-17 Controlling Magnitudes and Distances from Deaggregation

Struct. frequency	Annual Freq. Exceed.	Overall hazard		Hazard from R>100 km	
		M	R, km	M	R, km
1 & 2.5 Hz	1E-4	7.4	600	7.6	880
5 & 10 Hz	1E-4	6.7	230	7.5	790
1 & 2.5 Hz	1E-5	7.3	380	7.7	890
5 & 10 Hz	1E-5	6.1	46	7.7	850
1 & 2.5 Hz	1E-6	6.9	122	7.8	890
5 & 10 Hz	1E-6	5.6	10	7.8	860

Shaded cells indicate values used to construct UHRS

Table 2.5S.2-18 Horizontal 10^{-4} Rock and Site Specific UHRS (in g)

Freq. (Hz)	Rock UHRS LF Sa (g)	Rock UHRS HF Sa (g)	Transfer Functions LF Amp	Transfer Functions HF Amp	Surface UHRS LF Sa (g)	Surface UHRS HF Sa (g)	Raw Envelope Sa (g)	Smooth Spectrum Sa (g)
100	3.27E-02	3.27E-02	2.190	1.556	7.17E-02	5.09E-02	7.17E-02	7.17E-02
90	3.57E-02	3.57E-02	2.009	1.427	7.17E-02	5.10E-02	7.17E-02	7.17E-02
80	4.08E-02	4.09E-02	1.759	1.249	7.18E-02	5.11E-02	7.18E-02	7.18E-02
70	4.86E-02	4.88E-02	1.479	1.050	7.19E-02	5.12E-02	7.19E-02	7.19E-02
60	5.84E-02	5.87E-02	1.232	0.876	7.20E-02	5.14E-02	7.20E-02	7.20E-02
50	6.79E-02	6.83E-02	1.063	0.759	7.22E-02	5.18E-02	7.22E-02	7.22E-02
45	7.17E-02	7.22E-02	1.010	0.724	7.24E-02	5.22E-02	7.24E-02	7.25E-02
40	7.46E-02	7.51E-02	0.976	0.704	7.28E-02	5.28E-02	7.28E-02	7.29E-02
35	7.66E-02	7.71E-02	0.959	0.698	7.34E-02	5.38E-02	7.34E-02	7.35E-02
30	7.78E-02	7.82E-02	0.958	0.711	7.46E-02	5.56E-02	7.46E-02	7.46E-02
25	7.84E-02	7.84E-02	0.977	0.748	7.65E-02	5.86E-02	7.65E-02	7.67E-02
20	7.68E-02	7.78E-02	1.041	0.823	8.00E-02	6.40E-02	8.00E-02	8.02E-02
15	7.39E-02	7.52E-02	1.170	0.982	8.65E-02	7.38E-02	8.65E-02	8.66E-02
12.5	7.16E-02	7.25E-02	1.274	1.118	9.13E-02	8.11E-02	9.13E-02	9.14E-02
10	6.84E-02	6.84E-02	1.444	1.333	9.88E-02	9.12E-02	9.88E-02	9.86E-02
9	6.79E-02	6.81E-02	1.511	1.413	1.03E-01	9.63E-02	1.03E-01	1.02E-01
8	6.71E-02	6.74E-02	1.593	1.523	1.07E-01	1.03E-01	1.07E-01	1.08E-01
7	6.59E-02	6.63E-02	1.741	1.710	1.15E-01	1.13E-01	1.15E-01	1.15E-01
6	6.44E-02	6.46E-02	1.961	1.970	1.26E-01	1.27E-01	1.27E-01	1.26E-01
5	6.20E-02	6.20E-02	2.165	2.162	1.34E-01	1.34E-01	1.34E-01	1.35E-01
4	5.94E-02	5.48E-02	2.417	2.446	1.44E-01	1.34E-01	1.44E-01	1.43E-01
3	5.66E-02	4.58E-02	2.728	2.765	1.54E-01	1.27E-01	1.54E-01	1.56E-01
2.5	5.52E-02	4.01E-02	3.059	3.123	1.69E-01	1.25E-01	1.69E-01	1.64E-01
2	5.17E-02	3.31E-02	2.862	2.852	1.48E-01	9.45E-02	1.48E-01	1.52E-01
1.5	4.73E-02	2.46E-02	3.120	3.125	1.48E-01	7.69E-02	1.48E-01	1.46E-01
1.25	4.39E-02	1.98E-02	3.146	3.133	1.38E-01	6.21E-02	1.38E-01	1.39E-01
1	4.14E-02	1.49E-02	3.061	3.070	1.27E-01	4.58E-02	1.27E-01	1.26E-01
0.9	4.08E-02	1.30E-02	2.897	2.896	1.18E-01	3.76E-02	1.18E-01	1.22E-01
0.8	3.95E-02	1.11E-02	3.026	3.031	1.20E-01	3.36E-02	1.20E-01	1.16E-01
0.7	3.75E-02	9.28E-03	2.894	2.843	1.09E-01	2.64E-02	1.09E-01	1.16E-01
0.6	3.62E-02	7.54E-03	3.292	3.319	1.19E-01	2.50E-02	1.19E-01	1.11E-01
0.5	3.41E-02	5.88E-03	3.041	3.066	1.04E-01	1.80E-02	1.04E-01	1.04E-01
0.4	2.48E-02	4.31E-03	3.124	3.059	7.73E-02	1.32E-02	7.73E-02	7.94E-02
0.3	1.57E-02	2.85E-03	3.238	3.212	5.08E-02	9.16E-03	5.08E-02	5.05E-02
0.2	7.39E-03	1.53E-03	2.842	2.756	2.10E-02	4.22E-03	2.10E-02	2.25E-02
0.15	3.92E-03	9.48E-04	2.983	2.943	1.17E-02	2.79E-03	1.17E-02	1.18E-02
0.125	2.48E-03	6.86E-04	3.358	3.331	8.34E-03	2.28E-03	8.34E-03	8.25E-03
0.1	1.33E-03	4.50E-04	3.125	3.005	4.17E-03	1.35E-03	4.17E-03	4.17E-03

Table 2.5S.2-19 Horizontal 10^{-5} Rock and Site Specific UHRS (in g)

Freq. (Hz)	Rock UHRS		Transfer Functions		Surface UHRS		Raw Envelope Sa (g)	Smooth Spectrum Sa (g)
	LF Sa (g)	HF Sa (g)	LF Amp	HF Amp	LF Sa (g)	HF Sa (g)		
100	1.26E-01	1.26E-01	1.583	1.175	1.99E-01	1.48E-01	1.99E-01	1.99E-01
90	1.39E-01	1.39E-01	1.438	1.066	1.99E-01	1.48E-01	1.99E-01	1.99E-01
80	1.60E-01	1.61E-01	1.245	0.921	2.00E-01	1.48E-01	2.00E-01	2.00E-01
70	1.93E-01	1.95E-01	1.033	0.764	2.00E-01	1.49E-01	2.00E-01	2.00E-01
60	2.36E-01	2.38E-01	0.848	0.627	2.00E-01	1.49E-01	2.00E-01	2.00E-01
50	2.78E-01	2.82E-01	0.719	0.533	2.00E-01	1.51E-01	2.00E-01	2.00E-01
45	2.97E-01	3.01E-01	0.676	0.504	2.01E-01	1.52E-01	2.01E-01	2.01E-01
40	3.12E-01	3.16E-01	0.645	0.485	2.01E-01	1.54E-01	2.01E-01	2.01E-01
35	3.24E-01	3.28E-01	0.624	0.477	2.02E-01	1.57E-01	2.02E-01	2.02E-01
30	3.33E-01	3.37E-01	0.613	0.483	2.04E-01	1.62E-01	2.04E-01	2.04E-01
25	3.40E-01	3.40E-01	0.611	0.509	2.08E-01	1.73E-01	2.08E-01	2.08E-01
20	3.22E-01	3.29E-01	0.670	0.586	2.16E-01	1.93E-01	2.16E-01	2.16E-01
15	2.95E-01	3.03E-01	0.788	0.753	2.32E-01	2.28E-01	2.32E-01	2.33E-01
12.5	2.77E-01	2.82E-01	0.882	0.891	2.44E-01	2.51E-01	2.51E-01	2.52E-01
10	2.53E-01	2.53E-01	1.044	1.119	2.64E-01	2.83E-01	2.83E-01	2.83E-01
9	2.46E-01	2.47E-01	1.120	1.211	2.75E-01	2.99E-01	2.99E-01	2.98E-01
8	2.37E-01	2.38E-01	1.203	1.314	2.85E-01	3.13E-01	3.13E-01	3.16E-01
7	2.27E-01	2.28E-01	1.328	1.489	3.02E-01	3.40E-01	3.40E-01	3.41E-01
6	2.15E-01	2.15E-01	1.540	1.743	3.31E-01	3.75E-01	3.75E-01	3.72E-01
5	2.00E-01	2.00E-01	1.789	1.972	3.57E-01	3.94E-01	3.94E-01	3.89E-01
4	1.88E-01	1.70E-01	2.014	2.239	3.79E-01	3.81E-01	3.81E-01	3.86E-01
3	1.69E-01	1.36E-01	2.371	2.585	4.01E-01	3.52E-01	4.01E-01	4.01E-01
2.5	1.54E-01	1.16E-01	2.700	2.940	4.14E-01	3.41E-01	4.14E-01	4.13E-01
2	1.46E-01	9.26E-02	2.735	2.785	4.00E-01	2.58E-01	4.00E-01	4.04E-01
1.5	1.36E-01	6.60E-02	2.973	3.041	4.04E-01	2.01E-01	4.04E-01	3.99E-01
1.25	1.27E-01	5.20E-02	3.066	3.079	3.88E-01	1.60E-01	3.88E-01	3.85E-01
1	1.14E-01	3.82E-02	2.997	3.018	3.41E-01	1.15E-01	3.41E-01	3.48E-01
0.9	1.18E-01	3.28E-02	2.815	2.846	3.32E-01	9.34E-02	3.32E-01	3.41E-01
0.8	1.19E-01	2.77E-02	2.935	2.976	3.50E-01	8.24E-02	3.50E-01	3.37E-01
0.7	1.17E-01	2.27E-02	2.809	2.788	3.29E-01	6.34E-02	3.29E-01	3.51E-01
0.6	1.17E-01	1.81E-02	3.243	3.269	3.80E-01	5.90E-02	3.80E-01	3.54E-01
0.5	1.14E-01	1.37E-02	3.009	3.014	3.42E-01	4.12E-02	3.42E-01	3.46E-01
0.4	8.27E-02	9.61E-03	3.241	3.063	2.68E-01	2.94E-02	2.68E-01	2.70E-01
0.3	5.27E-02	5.97E-03	3.276	3.153	1.73E-01	1.88E-02	1.73E-01	1.72E-01
0.2	2.49E-02	2.89E-03	2.899	2.763	7.23E-02	7.98E-03	7.23E-02	7.72E-02
0.15	1.32E-02	1.64E-03	3.018	2.910	3.99E-02	4.76E-03	3.99E-02	4.03E-02
0.125	8.38E-03	1.11E-03	3.389	3.299	2.84E-02	3.66E-03	2.84E-02	2.81E-02
0.1	4.49E-03	6.67E-04	3.154	3.014	1.42E-02	2.01E-03	1.42E-02	1.42E-02

Table 2.5S.2-20 Input Rock Motion Durations

Set of Runs	Input Rock Spectra			
	Description	Recurrence	Magnitude	Duration [sec]
LF 10^{-4}	Low Freq.	10^{-4}	7.6	13
HF 10^{-4}	High Freq	10^{-4}	6.7	10
LF 10^{-5}	Low Freq.	10^{-5}	7.7	13
HF 10^{-5}	High Freq.	10^{-5}	6.1	7

Table 2.5S.2-21 Horizontal 10^{-4} and 10^{-5} Site Specific UHRS (in g) and Calculation of GMRS (in g)

Freq.	10^{-4} smooth spectrum	10^{-5} smooth spectrum	AR	DF	GMRS
100	7.17E-02	1.99E-01	2.78	1.36	9.75E-02
90	7.17E-02	1.99E-01	2.78	1.36	9.75E-02
80	7.18E-02	2.00E-01	2.78	1.36	9.76E-02
70	7.19E-02	2.00E-01	2.78	1.36	9.76E-02
60	7.20E-02	2.00E-01	2.78	1.36	9.78E-02
50	7.22E-02	2.00E-01	2.77	1.36	9.80E-02
45	7.25E-02	2.01E-01	2.77	1.35	9.82E-02
40	7.29E-02	2.01E-01	2.76	1.35	9.85E-02
35	7.35E-02	2.02E-01	2.75	1.35	9.91E-02
30	7.46E-02	2.04E-01	2.74	1.34	1.00E-01
25	7.67E-02	2.08E-01	2.72	1.34	1.02E-01
20	8.02E-02	2.16E-01	2.69	1.33	1.06E-01
15	8.66E-02	2.33E-01	2.69	1.32	1.15E-01
12.5	9.14E-02	2.52E-01	2.76	1.35	1.23E-01
10	9.86E-02	2.83E-01	2.87	1.39	1.37E-01
9	1.02E-01	2.98E-01	2.90	1.41	1.44E-01
8	1.08E-01	3.16E-01	2.93	1.42	1.53E-01
7	1.15E-01	3.41E-01	2.95	1.43	1.65E-01
6	1.26E-01	3.72E-01	2.95	1.43	1.80E-01
5	1.35E-01	3.89E-01	2.88	1.40	1.89E-01
4	1.43E-01	3.86E-01	2.69	1.33	1.90E-01
3	1.56E-01	4.01E-01	2.57	1.28	1.99E-01
2.5	1.64E-01	4.13E-01	2.53	1.26	2.06E-01
2	1.52E-01	4.04E-01	2.66	1.31	1.99E-01
1.5	1.46E-01	3.99E-01	2.74	1.34	1.96E-01
1.25	1.39E-01	3.85E-01	2.77	1.36	1.89E-01
1	1.26E-01	3.48E-01	2.76	1.35	1.70E-01
0.9	1.22E-01	3.41E-01	2.81	1.37	1.67E-01
0.8	1.16E-01	3.37E-01	2.92	1.41	1.63E-01
0.7	1.16E-01	3.51E-01	3.03	1.46	1.69E-01
0.6	1.11E-01	3.54E-01	3.18	1.51	1.68E-01
0.5	1.04E-01	3.46E-01	3.31	1.56	1.63E-01
0.4	7.94E-02	2.70E-01	3.40	1.60	1.27E-01
0.3	5.05E-02	1.72E-01	3.41	1.60	8.08E-02
0.2	2.25E-02	7.72E-02	3.44	1.61	3.62E-02
0.15	1.18E-02	4.03E-02	3.42	1.60	1.89E-02
0.125	8.25E-03	2.81E-02	3.41	1.60	1.32E-02
0.1	4.17E-03	1.42E-02	3.40	1.60	6.65E-03

Table 2.5S.2-22 Vertical 10^{-4} and 10^{-5} Site Specific UHRS (in g) and Calculation of GMRS (in g)

Freq	V/H ratio	10^{-4} vertical UHRS	10^{-5} vertical UHRS	AR	DF	DRS
100	1	7.17E-02	1.99E-01	2.78	1.36	9.75E-02
90	1	7.17E-02	1.99E-01	2.78	1.36	9.75E-02
80	1	7.18E-02	2.00E-01	2.78	1.36	9.76E-02
70	1	7.19E-02	2.00E-01	2.78	1.36	9.76E-02
60	1	7.20E-02	2.00E-01	2.78	1.36	9.78E-02
50	1	7.22E-02	2.00E-01	2.77	1.36	9.80E-02
45	1	7.25E-02	2.01E-01	2.77	1.35	9.82E-02
40	1	7.29E-02	2.01E-01	2.76	1.35	9.85E-02
35	1	7.35E-02	2.02E-01	2.75	1.35	9.91E-02
30	1	7.46E-02	2.04E-01	2.74	1.34	1.00E-01
25	1	7.67E-02	2.08E-01	2.72	1.34	1.02E-01
20	1	8.02E-02	2.16E-01	2.69	1.33	1.06E-01
15	1	8.66E-02	2.33E-01	2.69	1.32	1.15E-01
12.5	1	9.14E-02	2.52E-01	2.76	1.35	1.23E-01
10	1	9.86E-02	2.83E-01	2.87	1.39	1.37E-01
9	1.000	1.02E-01	2.98E-01	2.90	1.41	1.44E-01
8	1.000	1.08E-01	3.16E-01	2.93	1.42	1.53E-01
7	1.000	1.15E-01	3.41E-01	2.95	1.43	1.65E-01
6	0.999	1.26E-01	3.72E-01	2.95	1.43	1.80E-01
5	0.999	1.35E-01	3.88E-01	2.88	1.40	1.89E-01
4	0.999	1.43E-01	3.86E-01	2.69	1.33	1.90E-01
3	0.857	1.34E-01	3.44E-01	2.57	1.28	1.71E-01
2.5	0.715	1.17E-01	2.95E-01	2.53	1.26	1.47E-01
2	0.710	1.08E-01	2.87E-01	2.66	1.31	1.42E-01
1.5	0.704	1.03E-01	2.81E-01	2.74	1.34	1.38E-01
1.25	0.701	9.75E-02	2.70E-01	2.77	1.36	1.32E-01
1	0.696	8.79E-02	2.42E-01	2.76	1.35	1.19E-01
0.9	0.694	8.44E-02	2.37E-01	2.81	1.37	1.16E-01
0.8	0.691	8.00E-02	2.33E-01	2.92	1.41	1.13E-01
0.7	0.689	7.97E-02	2.42E-01	3.03	1.46	1.16E-01
0.6	0.686	7.64E-02	2.43E-01	3.18	1.51	1.15E-01
0.5	0.682	7.13E-02	2.36E-01	3.31	1.56	1.11E-01
0.4	0.678	5.38E-02	1.83E-01	3.40	1.60	8.58E-02
0.3	0.672	3.39E-02	1.16E-01	3.41	1.60	5.43E-02
0.2	0.668	1.50E-02	5.16E-02	3.44	1.61	2.42E-02
0.15	0.668	7.88E-03	2.69E-02	3.42	1.60	1.26E-02
0.125	0.668	5.51E-03	1.88E-02	3.41	1.60	8.83E-03
0.1	0.668	2.79E-03	9.46E-03	3.40	1.60	4.45E-03

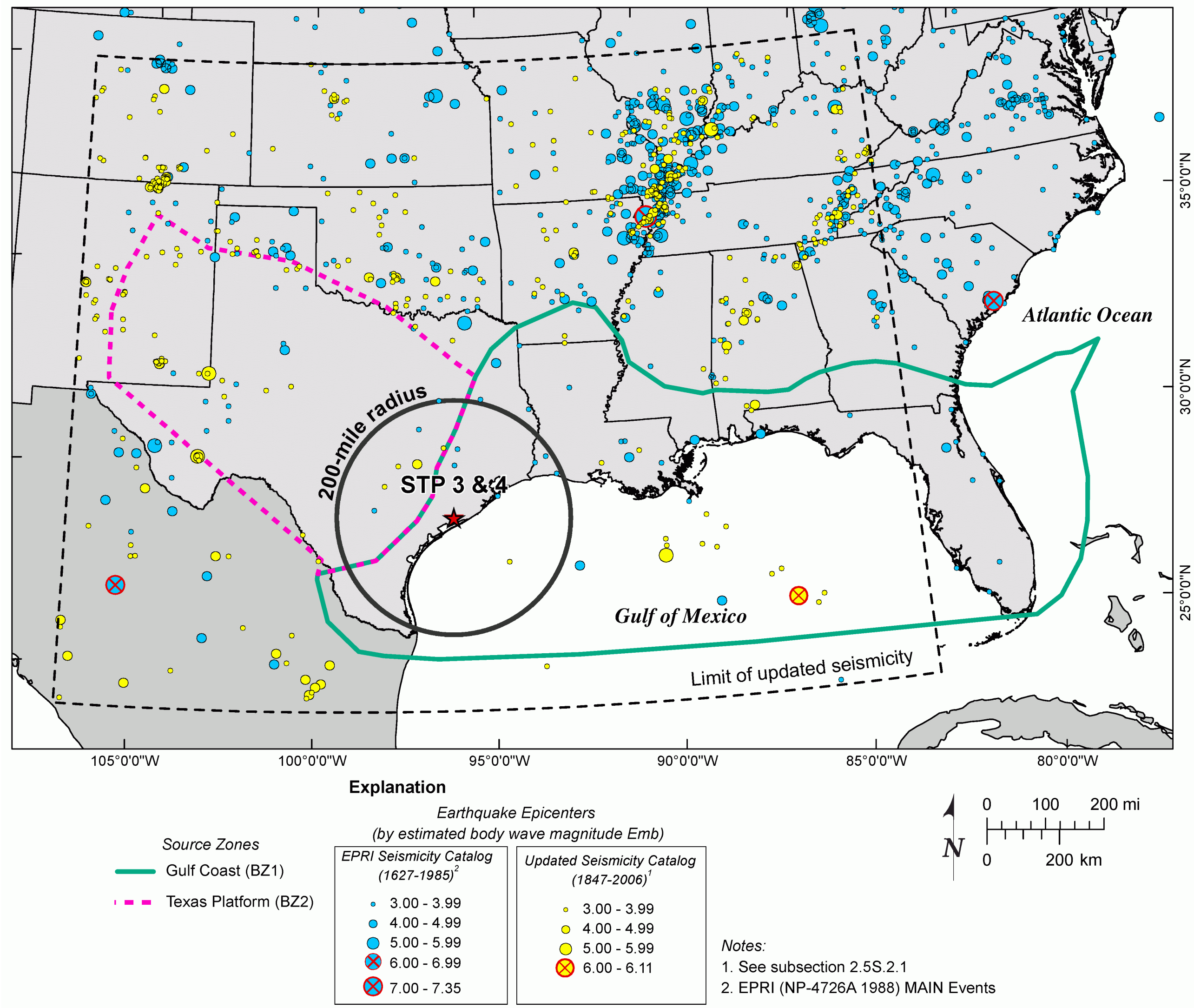

Figure 2.5S.2-1 Bechtel Group EPRI Source Zones

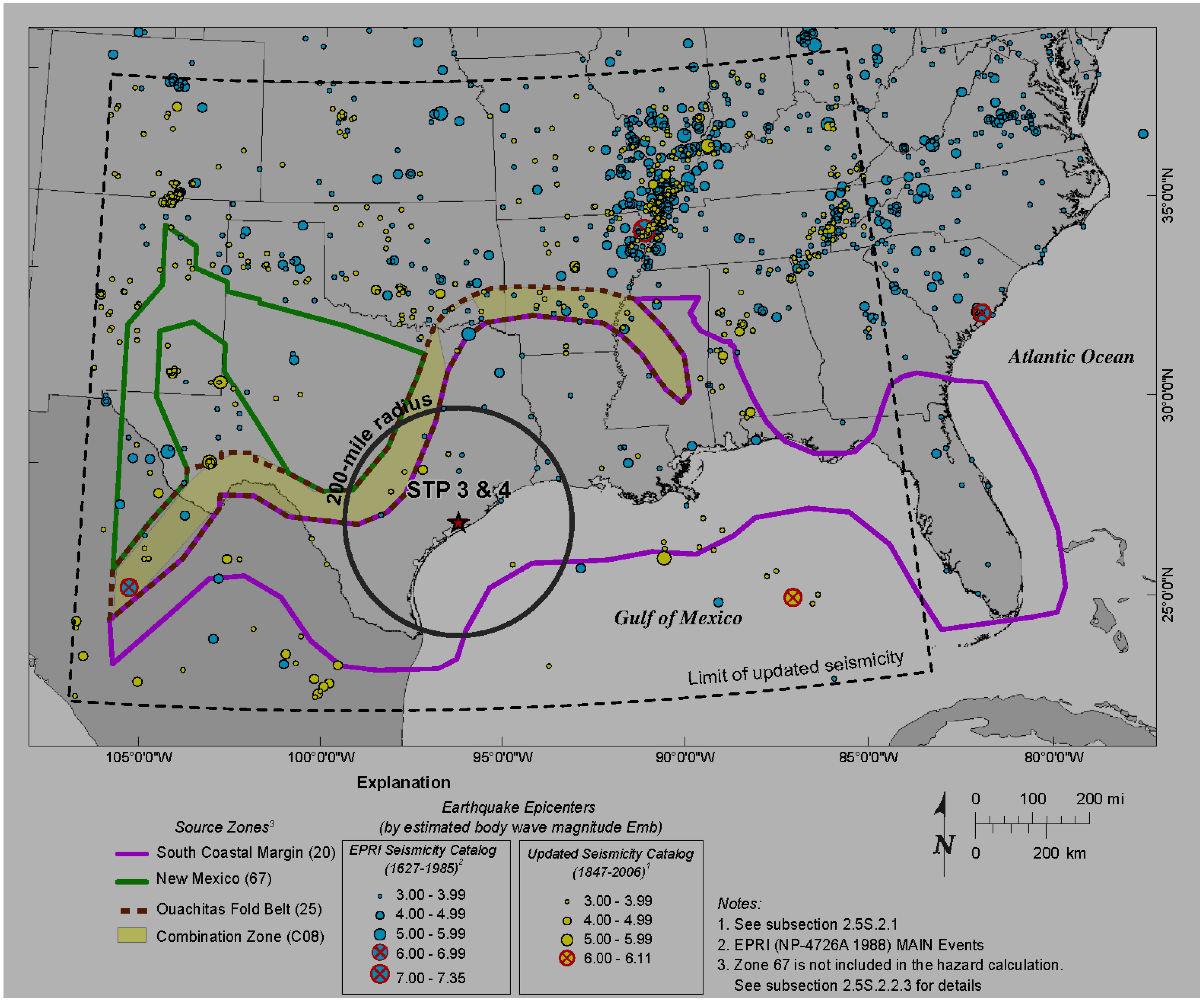

Figure 2.5S.2-2 Dames and Moore EPRI Source Zones

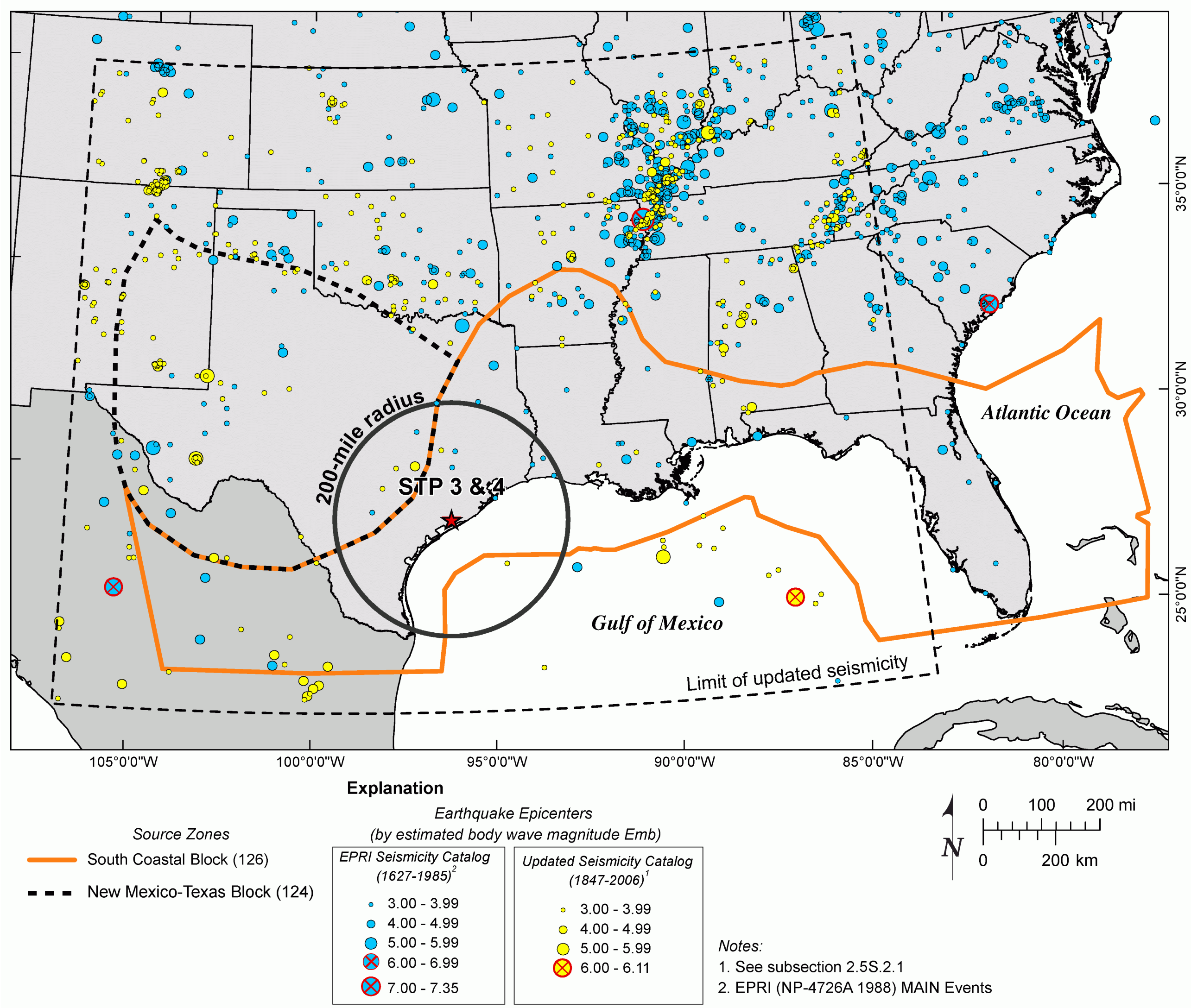

Figure 2.5S.2-3 Law Engineering EPRI (1988) Source Zones

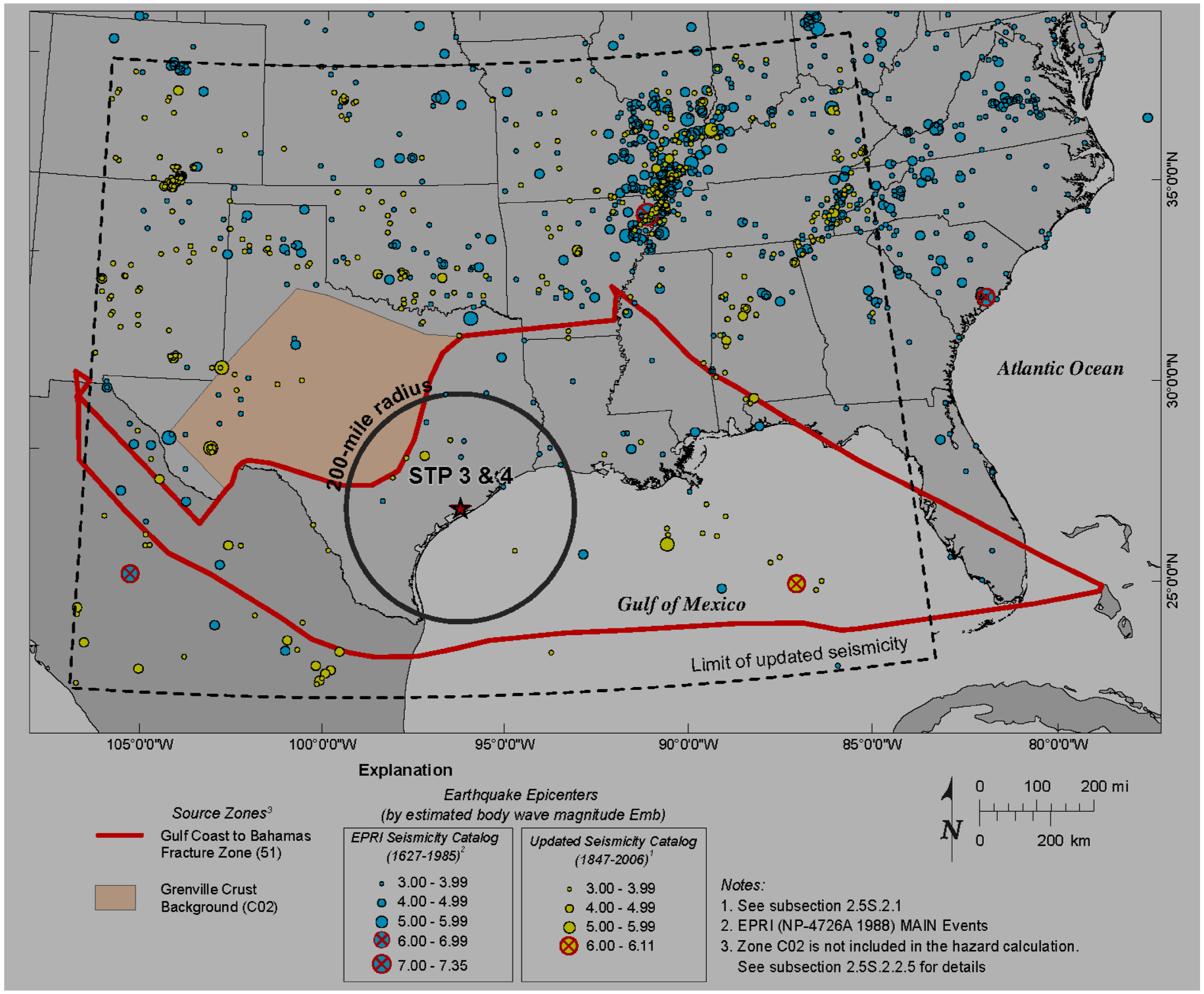

Figure 2.5S.2-4 Rondout Associates EPRI Source Zones

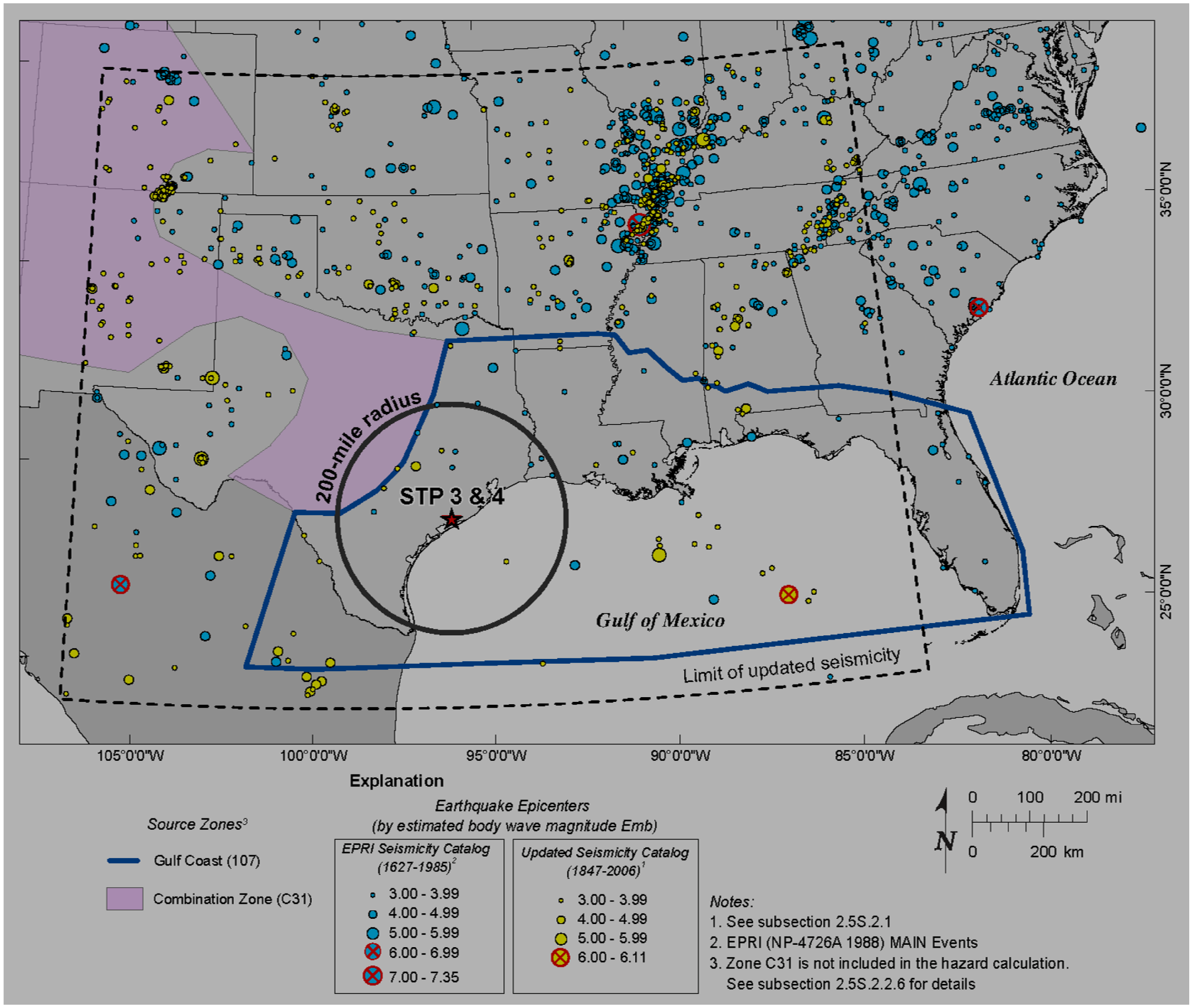

Figure 2.5S.2-5 Weston Geophysical Corporation EPRI (1989) Source Zones

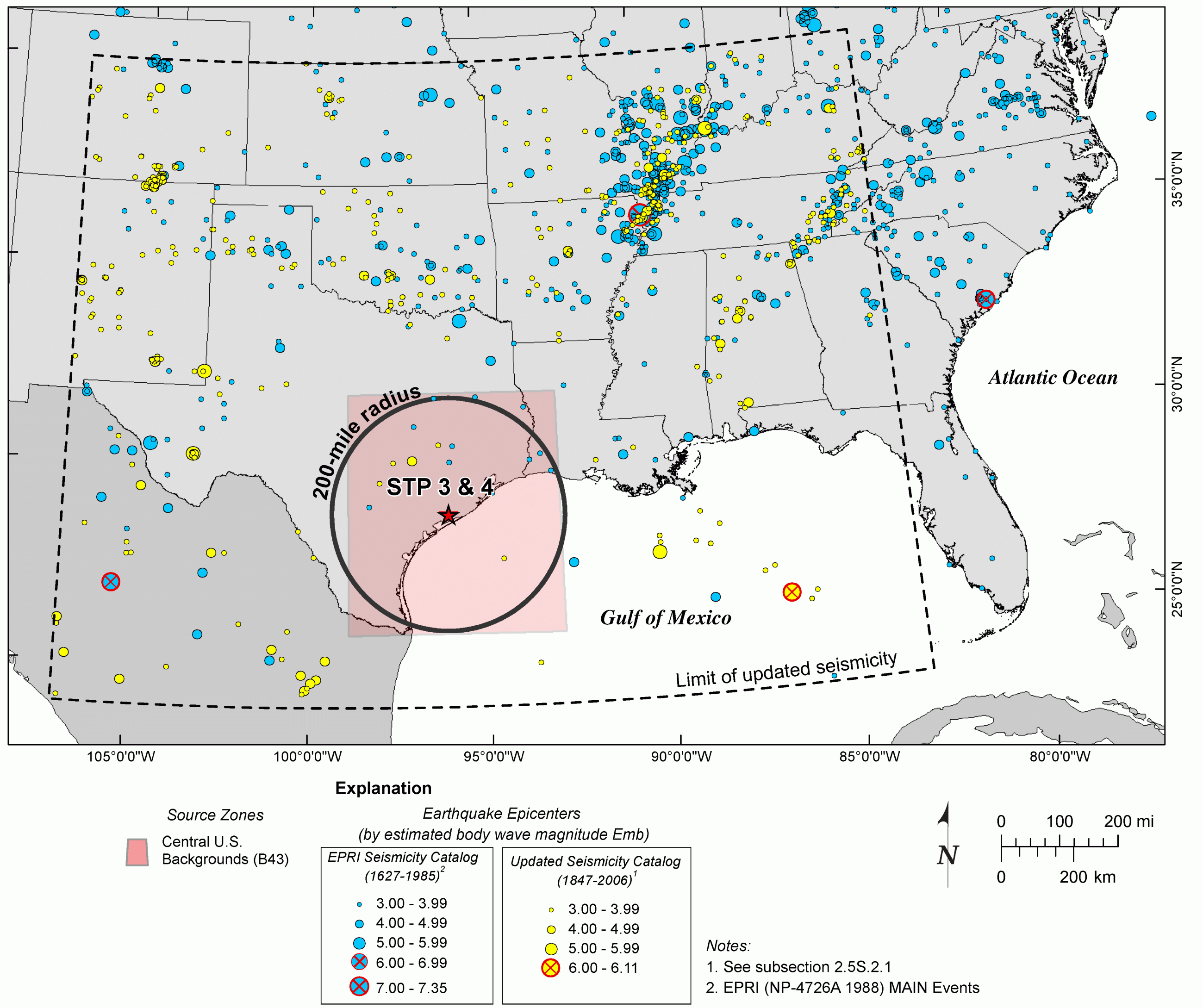

Figure 2.5S.2-6 Woodward-Clyde Consultants EPRI Source Zones

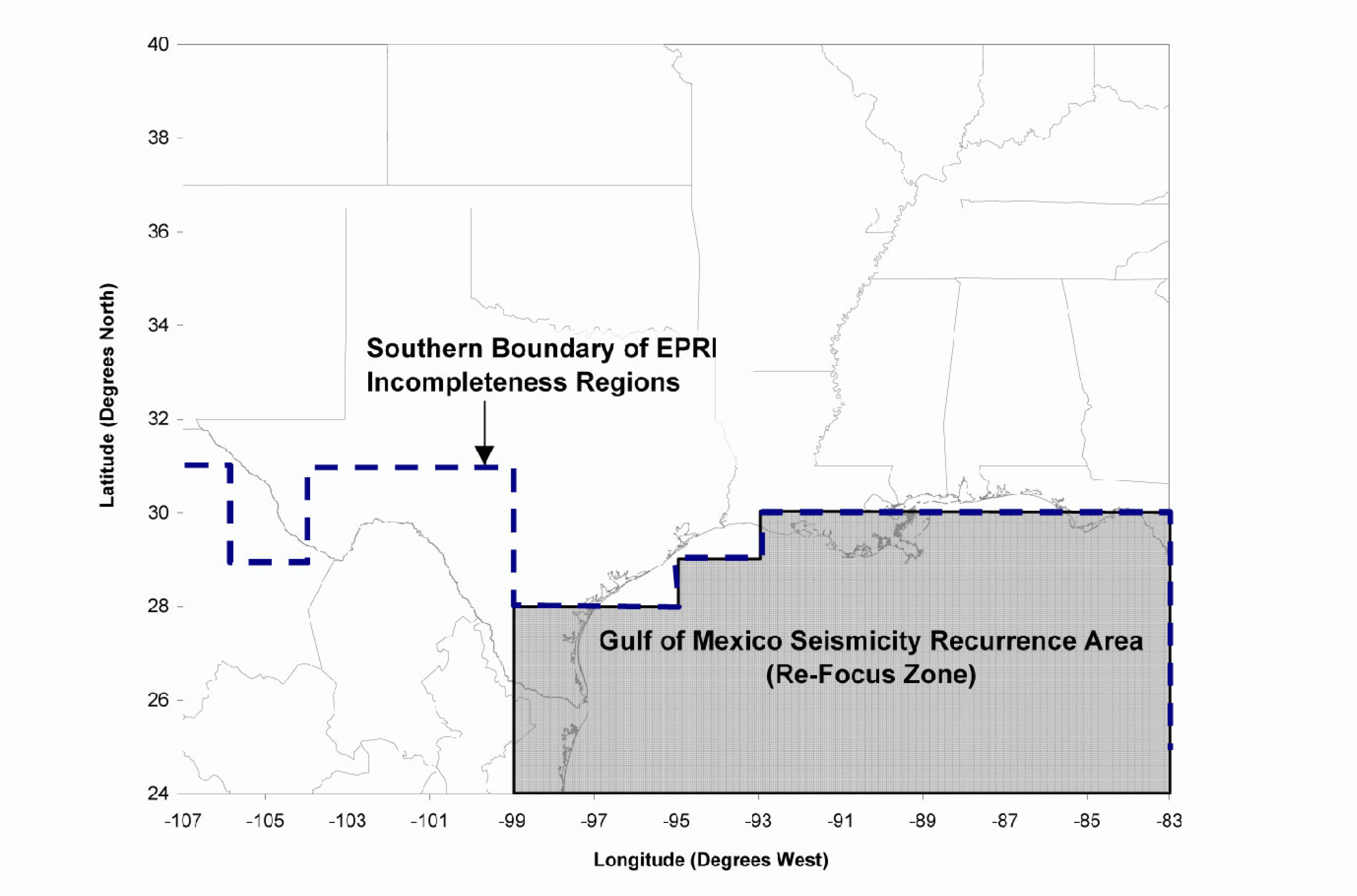

Figure 2.5S.2-7 Southern Boundary of EPRI Incompleteness Regions (Table 5-1 of Reference 2.5S.2-16) and Gulf of Mexico Seismicity Recurrence Area (Re-Focus Zone)

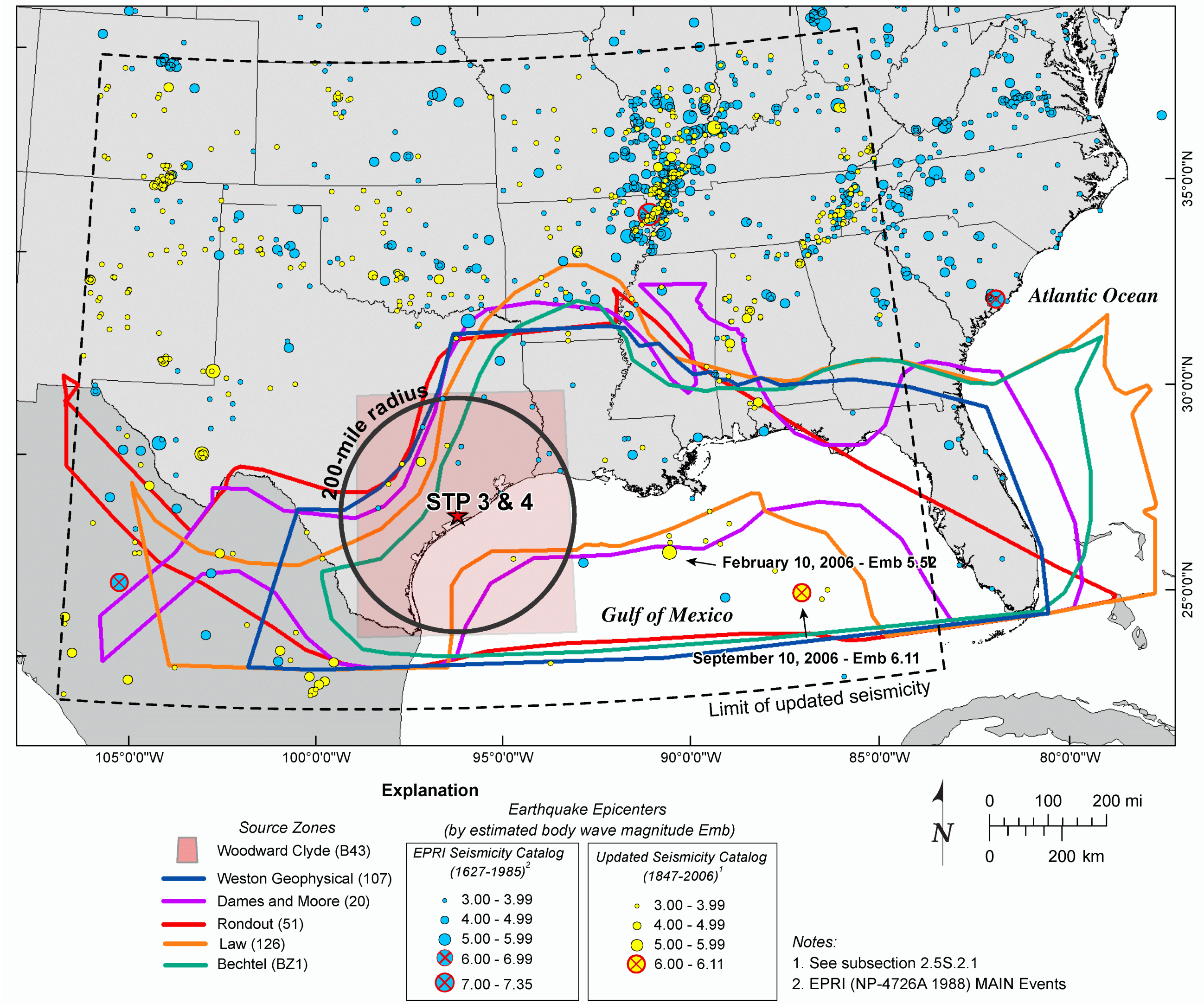

Figure 2.5S.2-8 EPRI EST Gulf Coast Background Source Zones

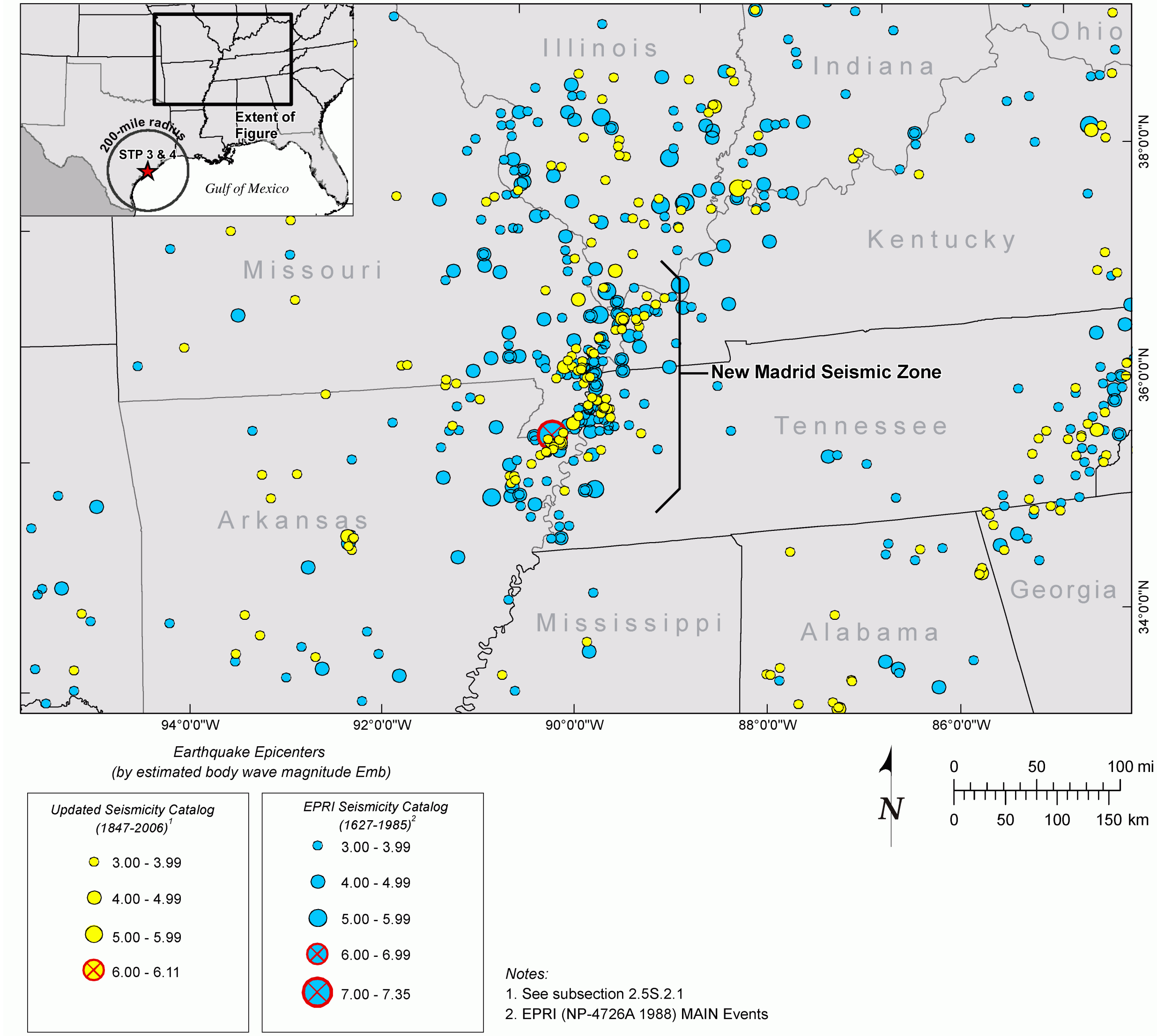

Figure 2.5S.2-9 New Madrid Seismic Zone Seismicity

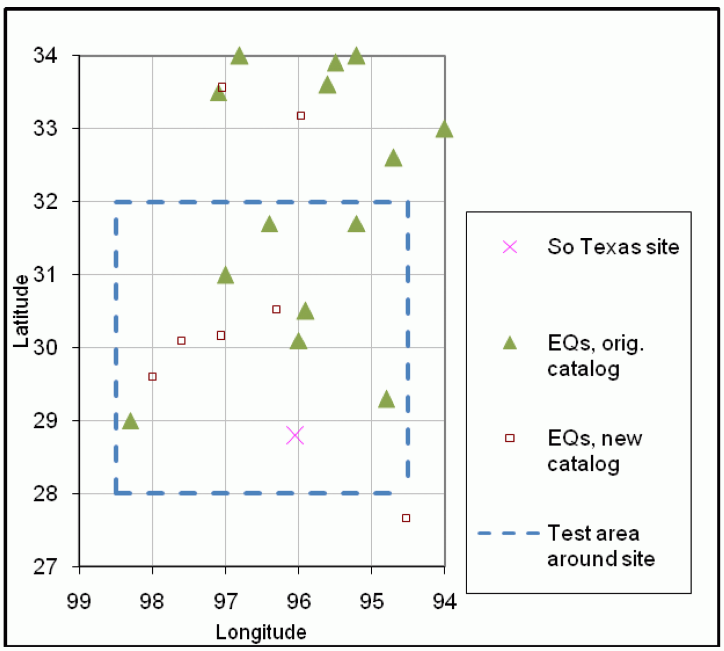

Figure 2.5S.2-10 Historical Seismicity in the Vicinity of South Texas Site and Test Area Used to Test the Effects of Additional Seismicity

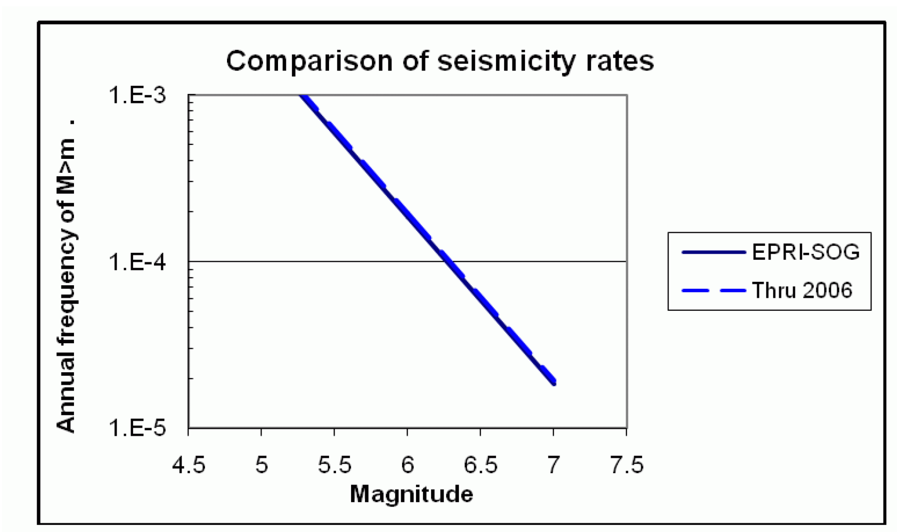

Figure 2.5S.2-11 Earthquake Occurrence Rates for EPRI (1989) Catalog and for Catalog Extended through 2006, for Test Area

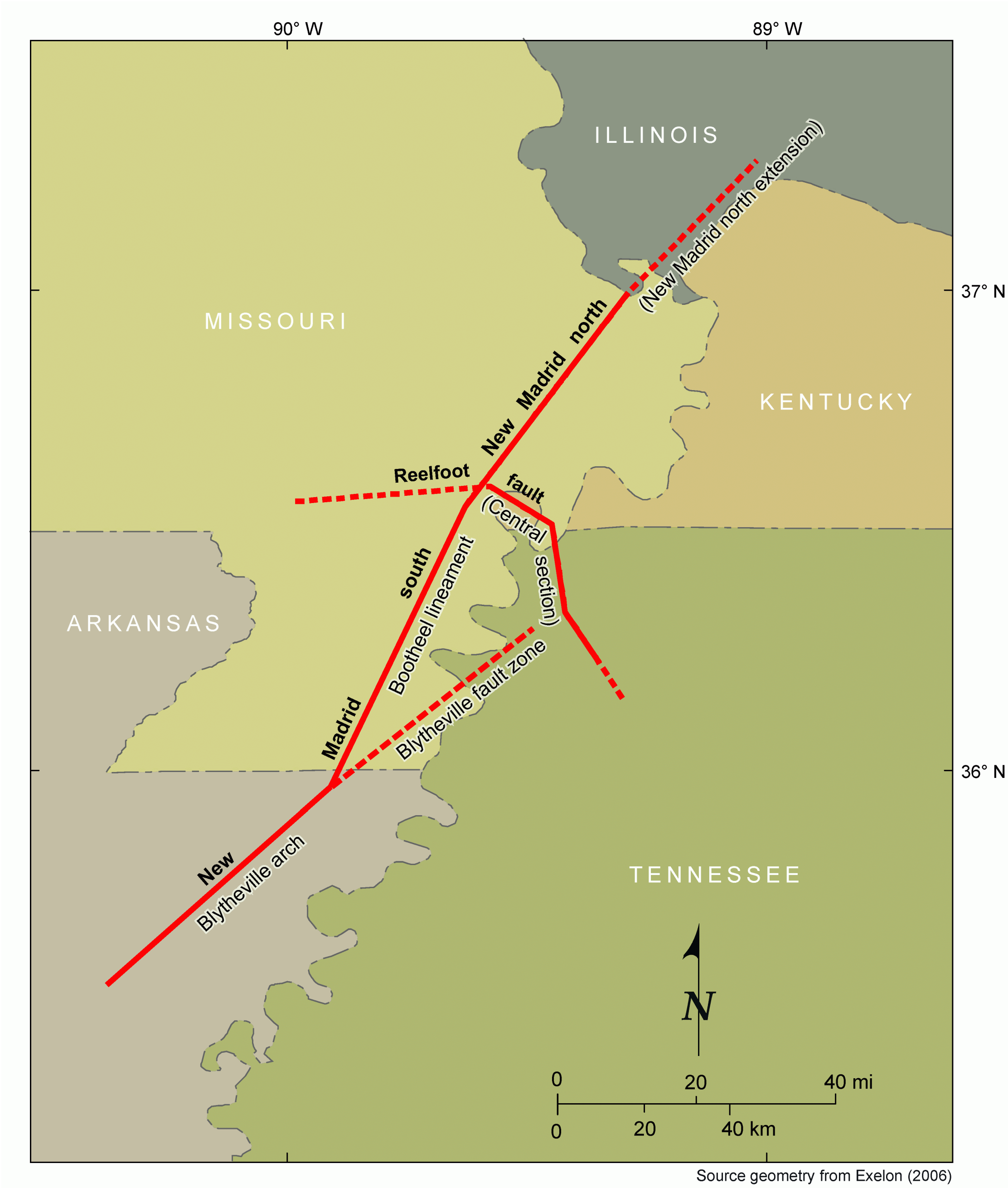

Figure 2.5S.2-12 New Madrid Faults from Clinton ESP Source Model

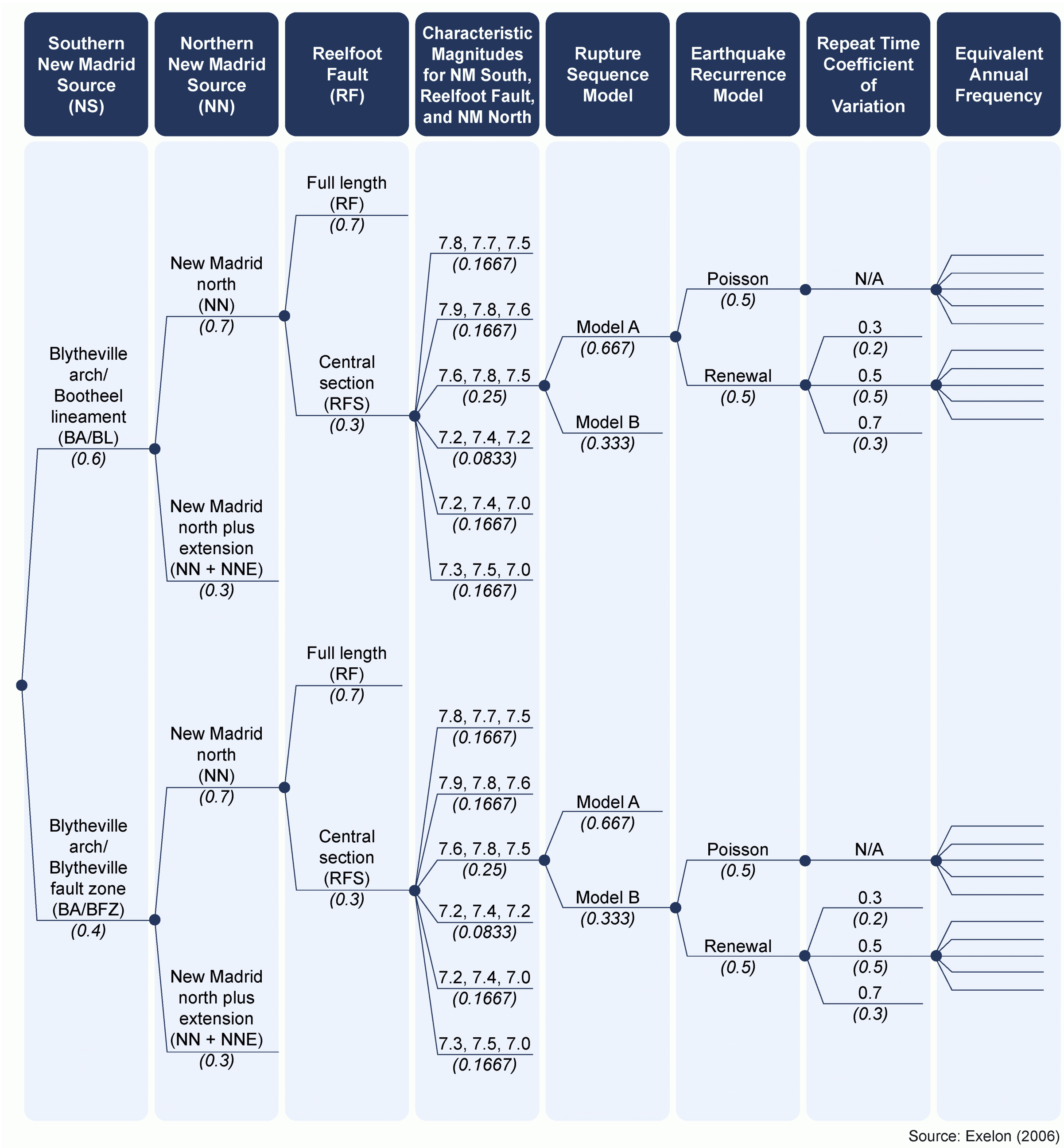

Figure 2.5S.2-13 Source Characterization Logic Tree for Characteristic New Madrid Earthquakes

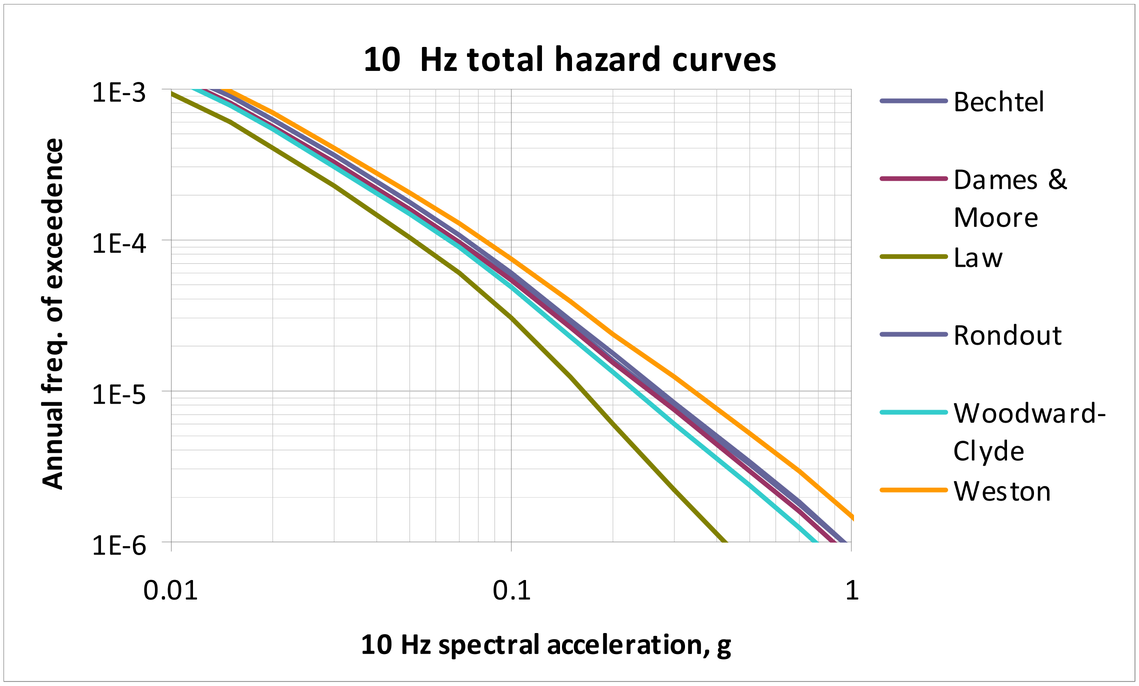

Figure 2.5S.2-14 Mean 10 Hz Rock Hazard Curves by EST

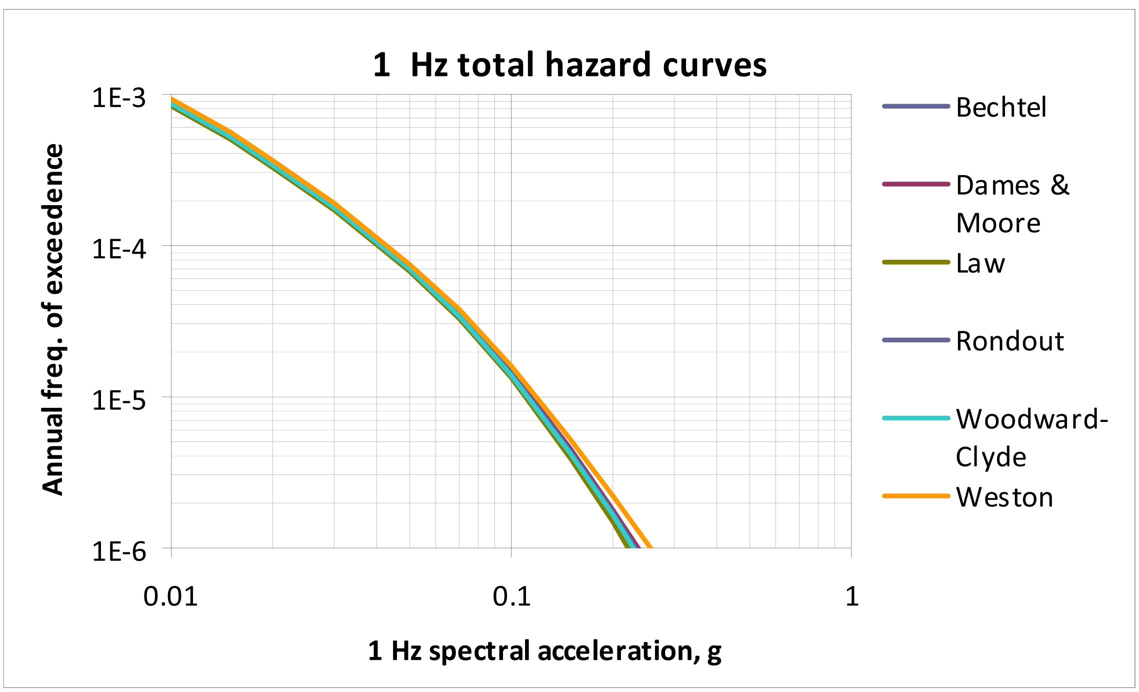

Figure 2.5S.2-15 Mean 1 Hz Rock Hazard Curves by EST

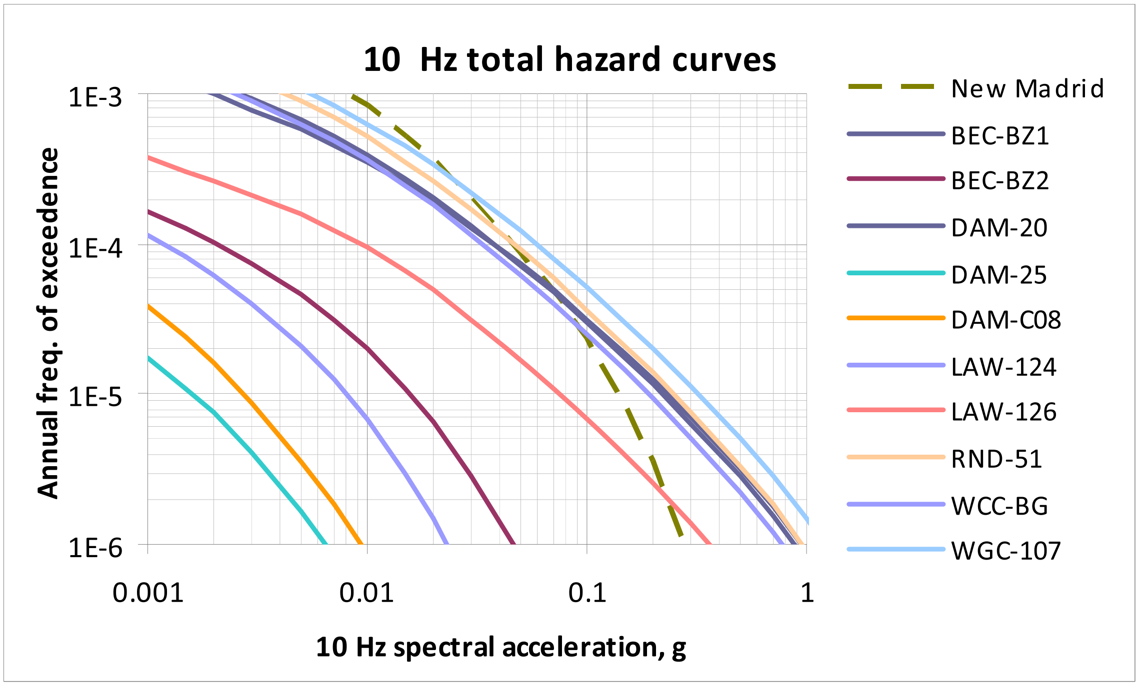

Figure 2.5S.2-16 Mean 10 Hz Rock Hazard Curves by Seismic Source

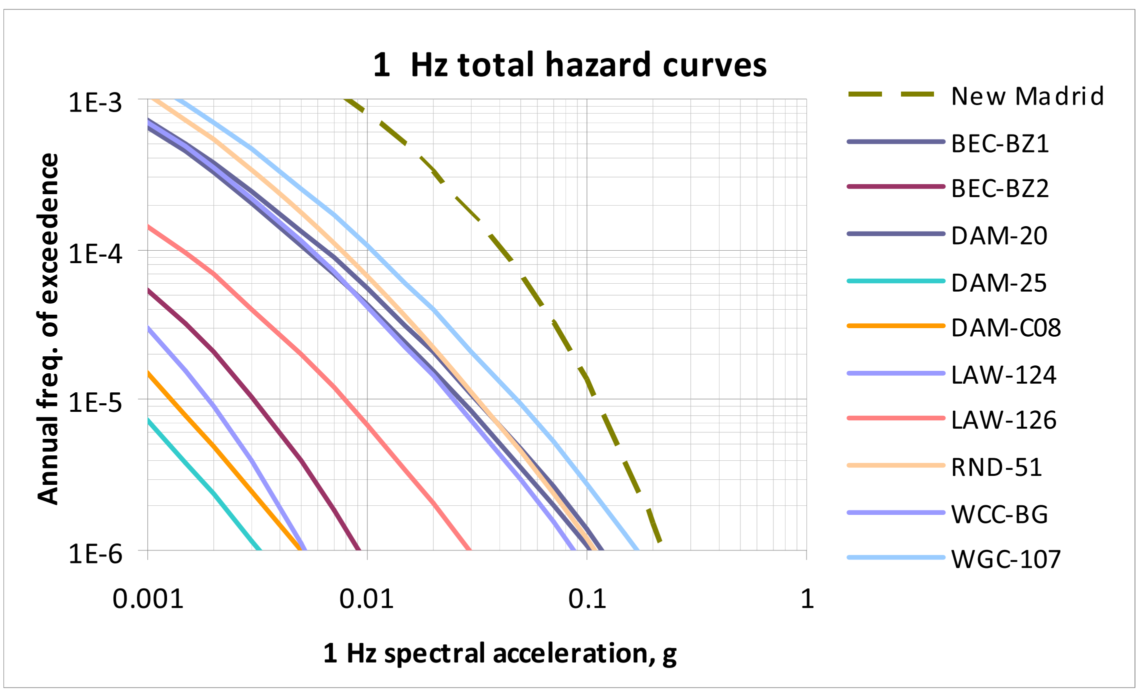

Figure 2.5S.2-17 Mean 1 Hz Rock Hazard Curves by Seismic Source

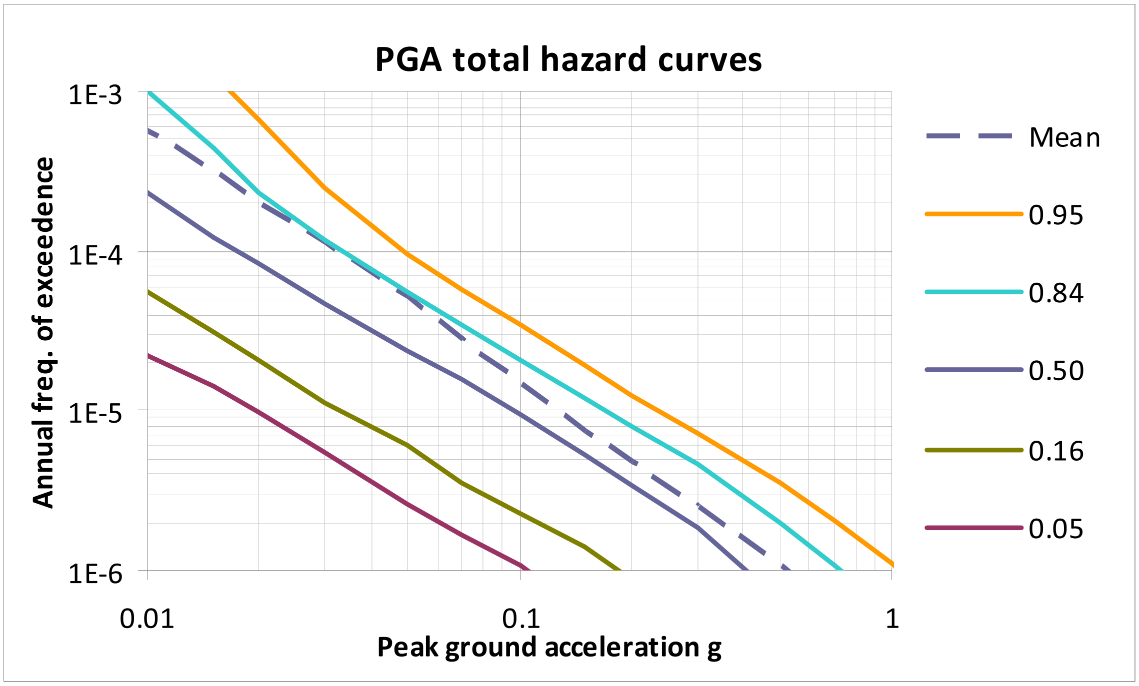

Figure 2.5S.2-18 Mean and Fractile PGA Rock Hazard Curves

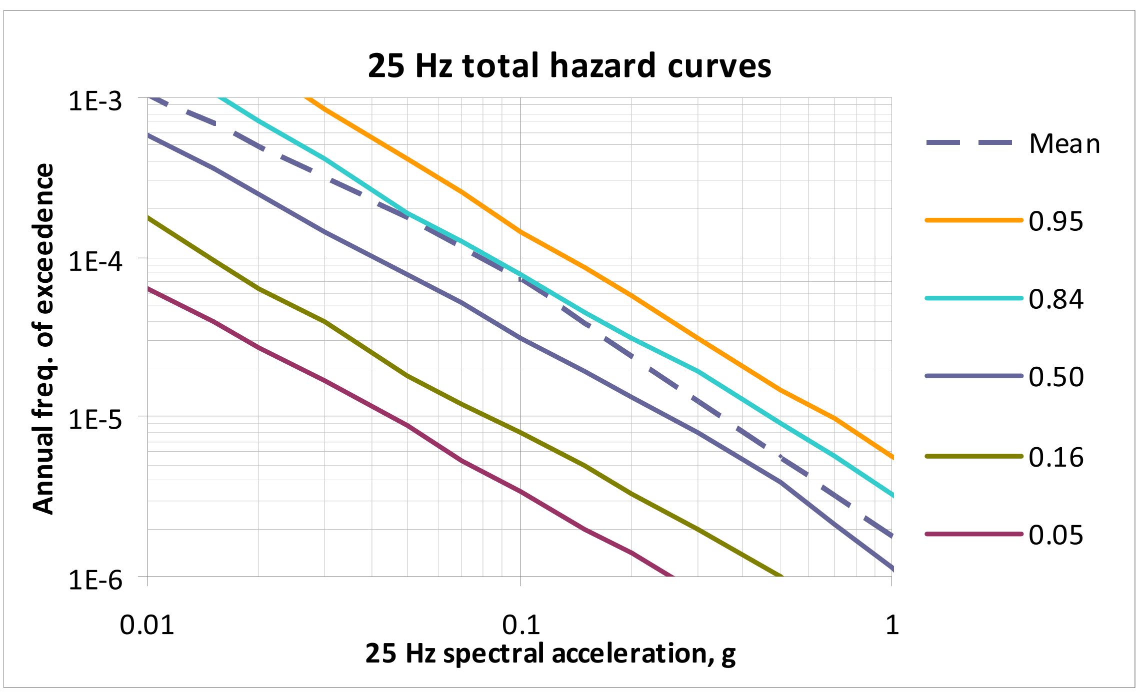

Figure 2.5S.2-19 Mean and Fractile 25 Hz Rock Hazard Curves

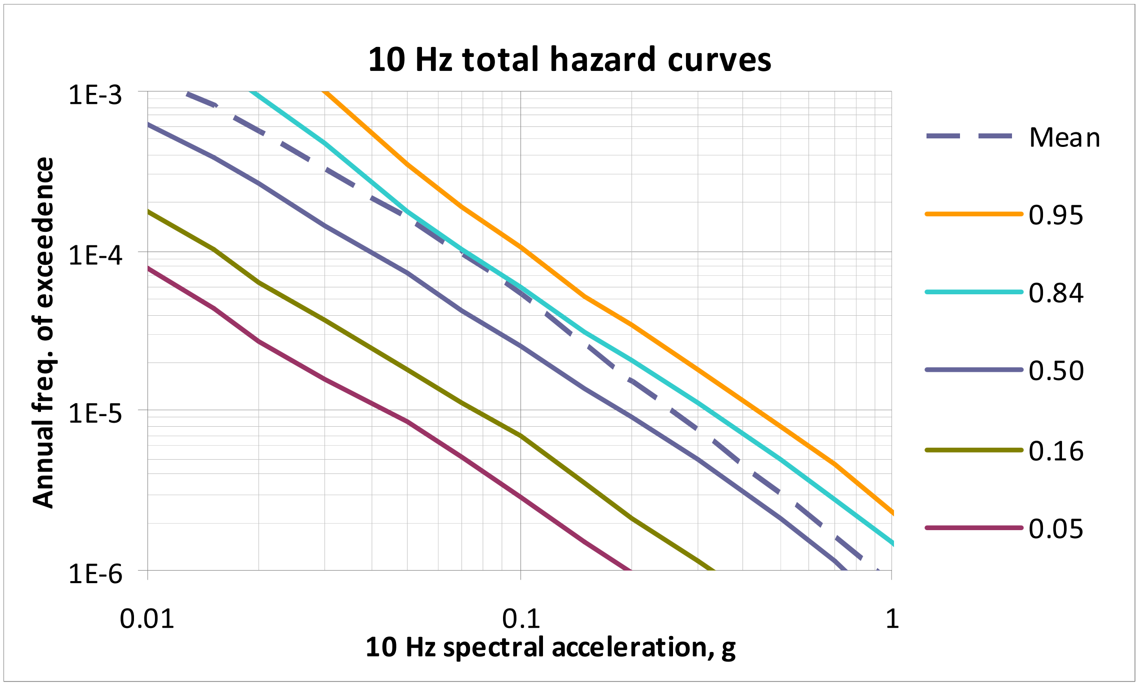

Figure 2.5S.2-20 Mean and Fractile 10 Hz Rock Hazard Curves

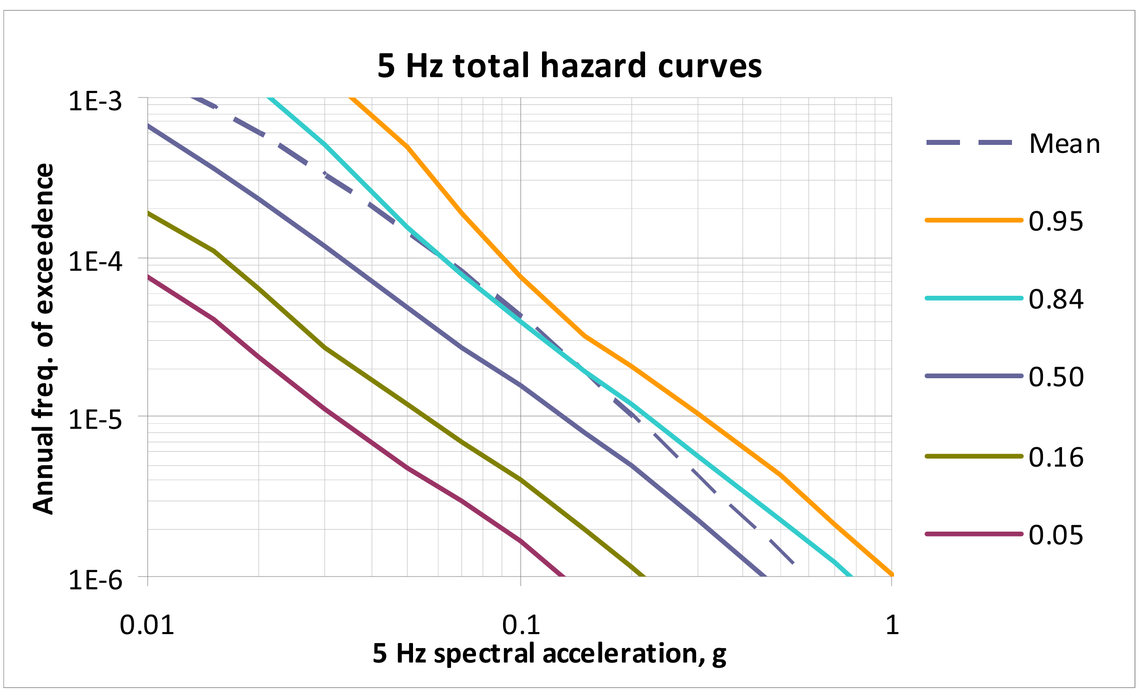

Figure 2.5S.2-21 Mean and Fractile 5 Hz Rock Hazard Curves

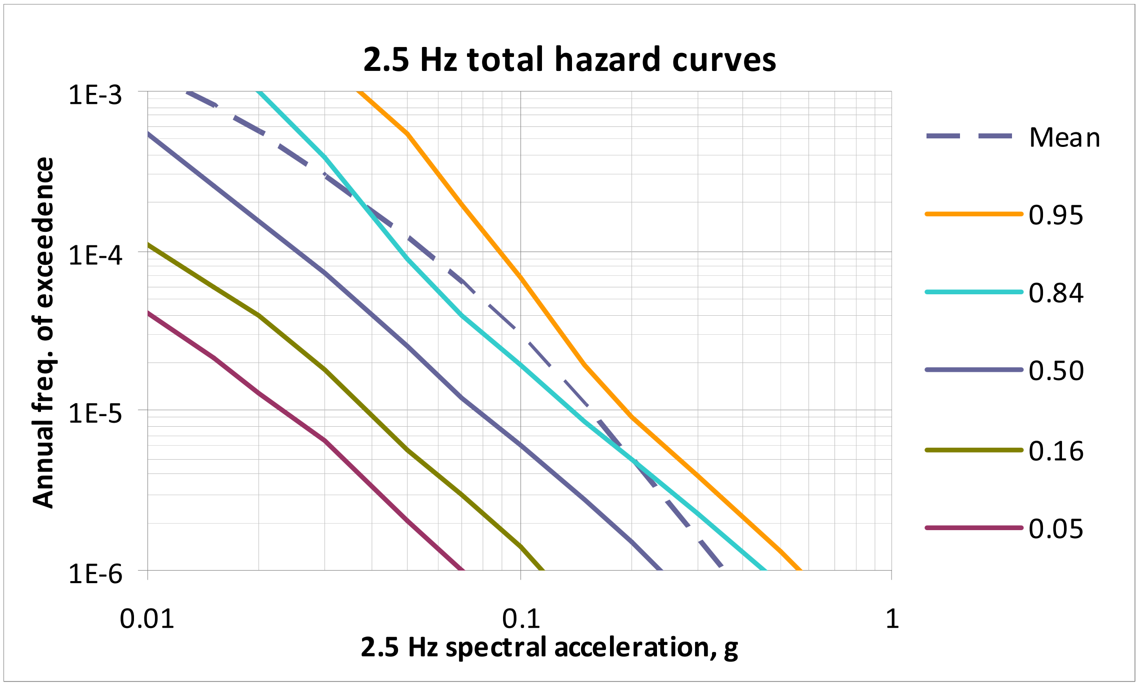

Figure 2.5S.2-22 Mean and Fractile 2.5 Hz Rock Hazard Curves

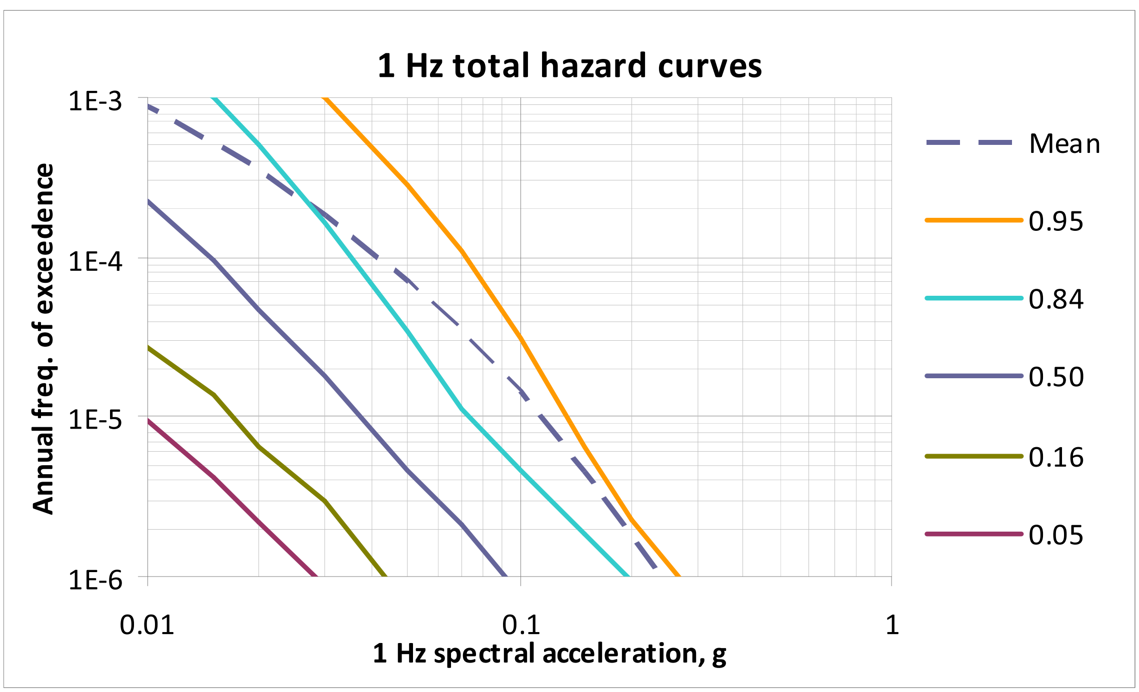

Figure 2.5S.2-23 Mean and Fractile 1 Hz Rock Hazard Curves

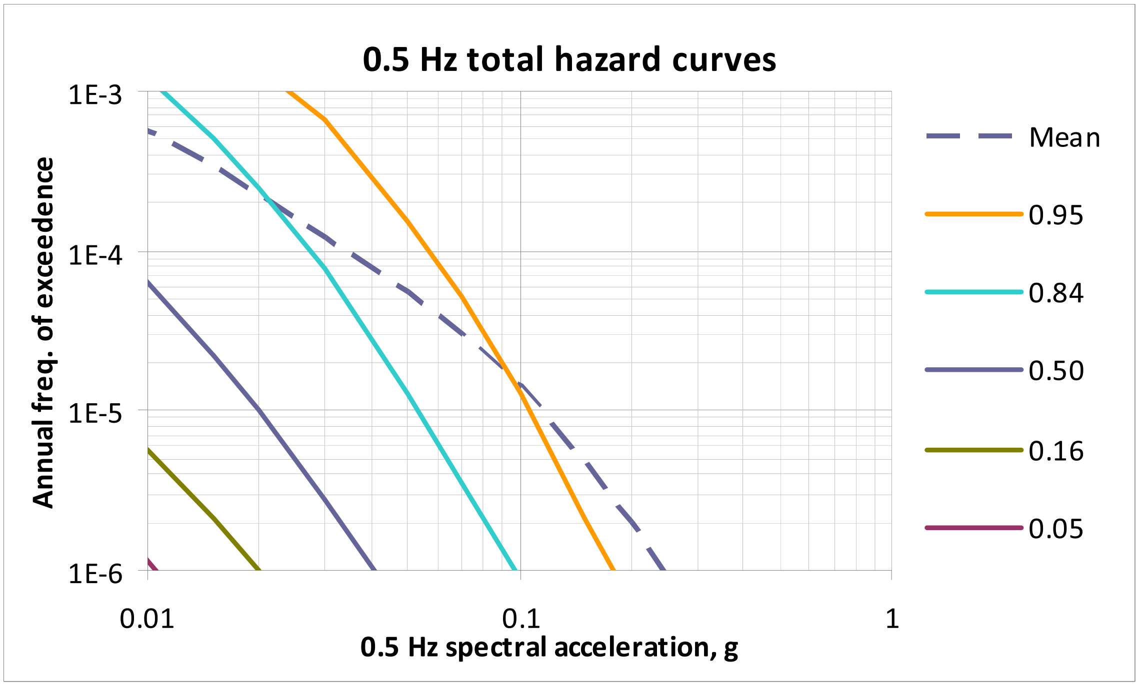

Figure 2.5S.2-24 Mean and Fractile 0.5 Hz Rock Hazard Curves

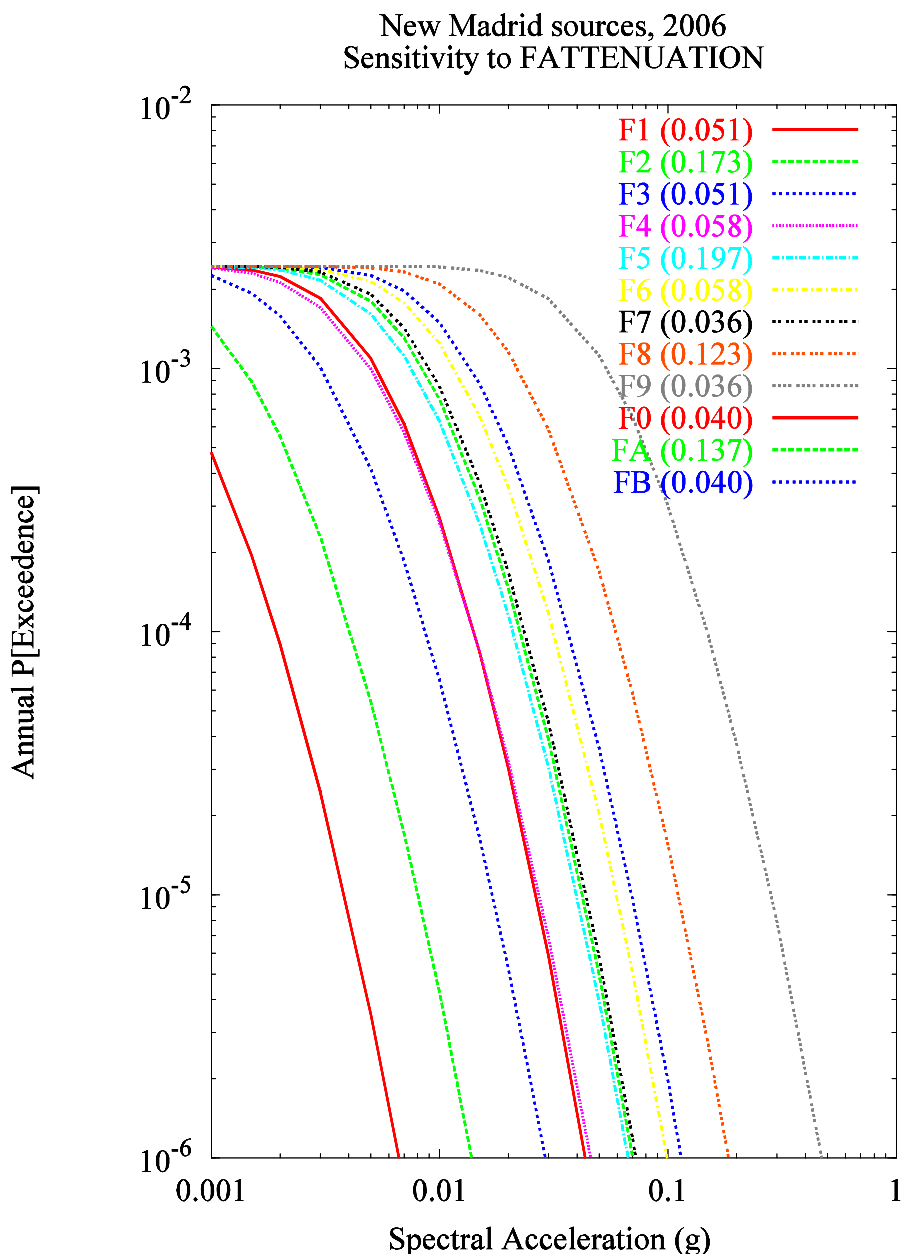

Figure 2.5S.2-25 1 Hz Rock Hazard Curves for the New Madrid Source, by Ground Motion Equation

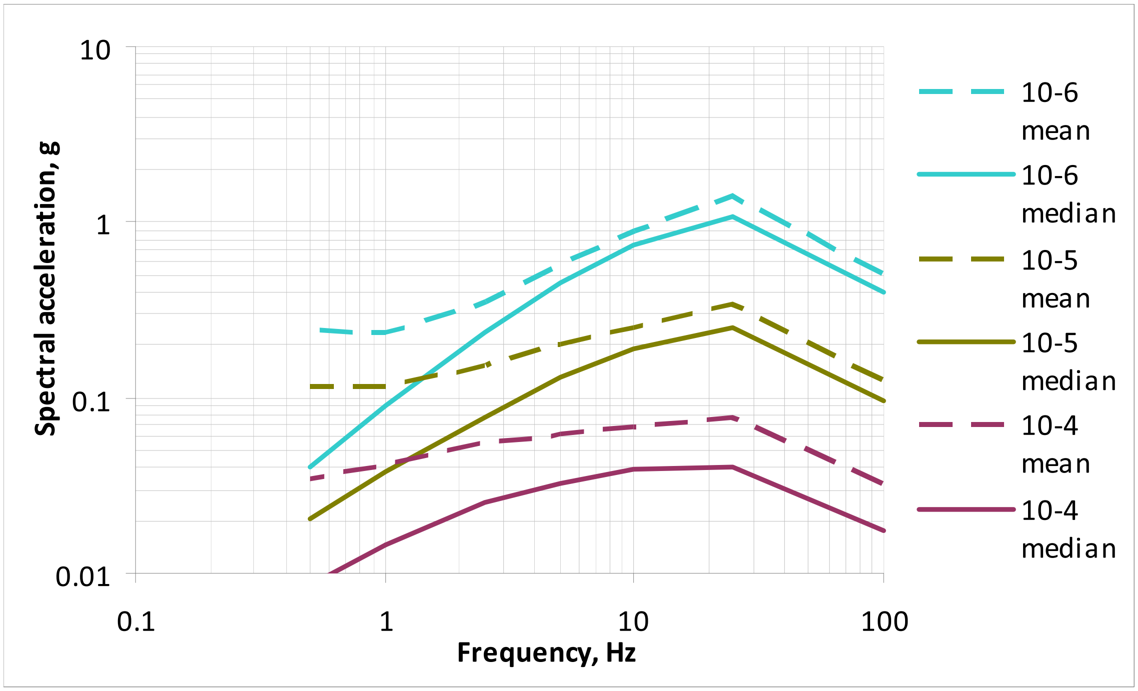

Figure 2.5S.2-26 Mean and Median Rock Uniform Hazard Response Spectra (UHRS)

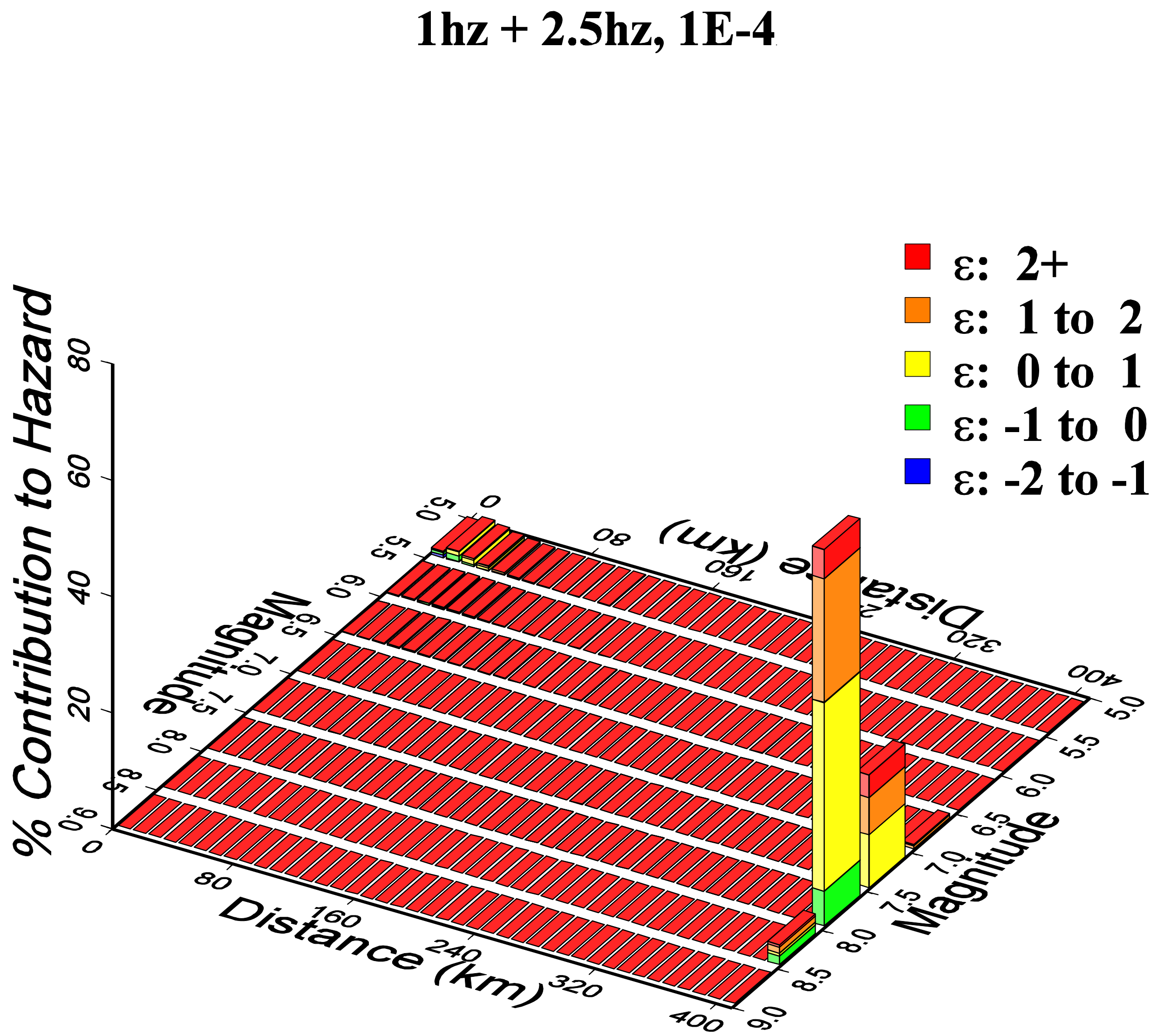

Figure 2.5S.2-27 M and R Deaggregation for 1 and 2.5 Hz at 10^{-4} Annual Frequency of Exceedence

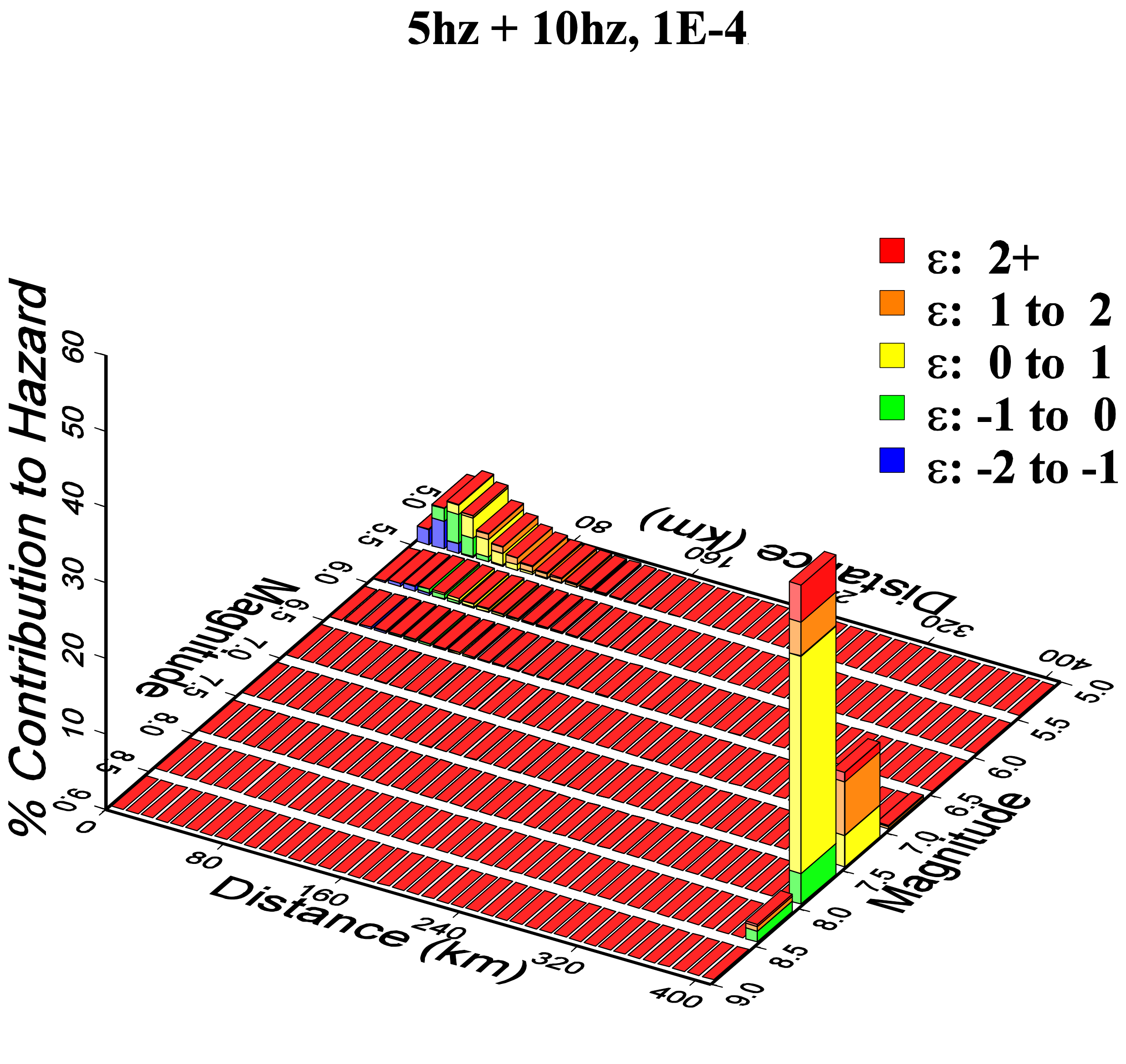

Figure 2.5S.2-28 M and R Deaggregation for 5 and 10 Hz at 10^{-4} Annual Frequency of Exceedence

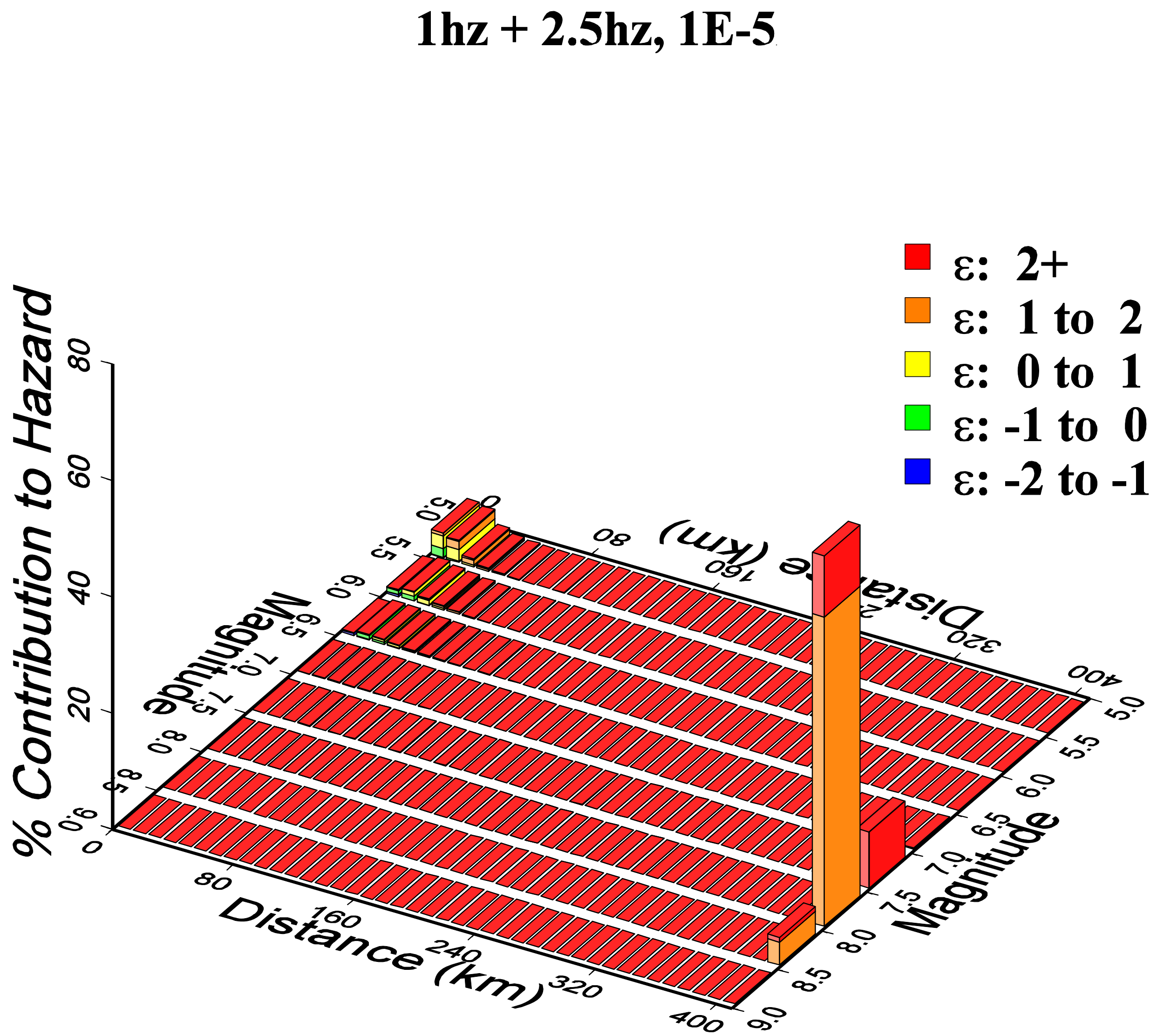

Figure 2.5S.2-29 M and R Deaggregation for 1 and 2.5 Hz at 10^{-5} Annual Frequency of Exceedence

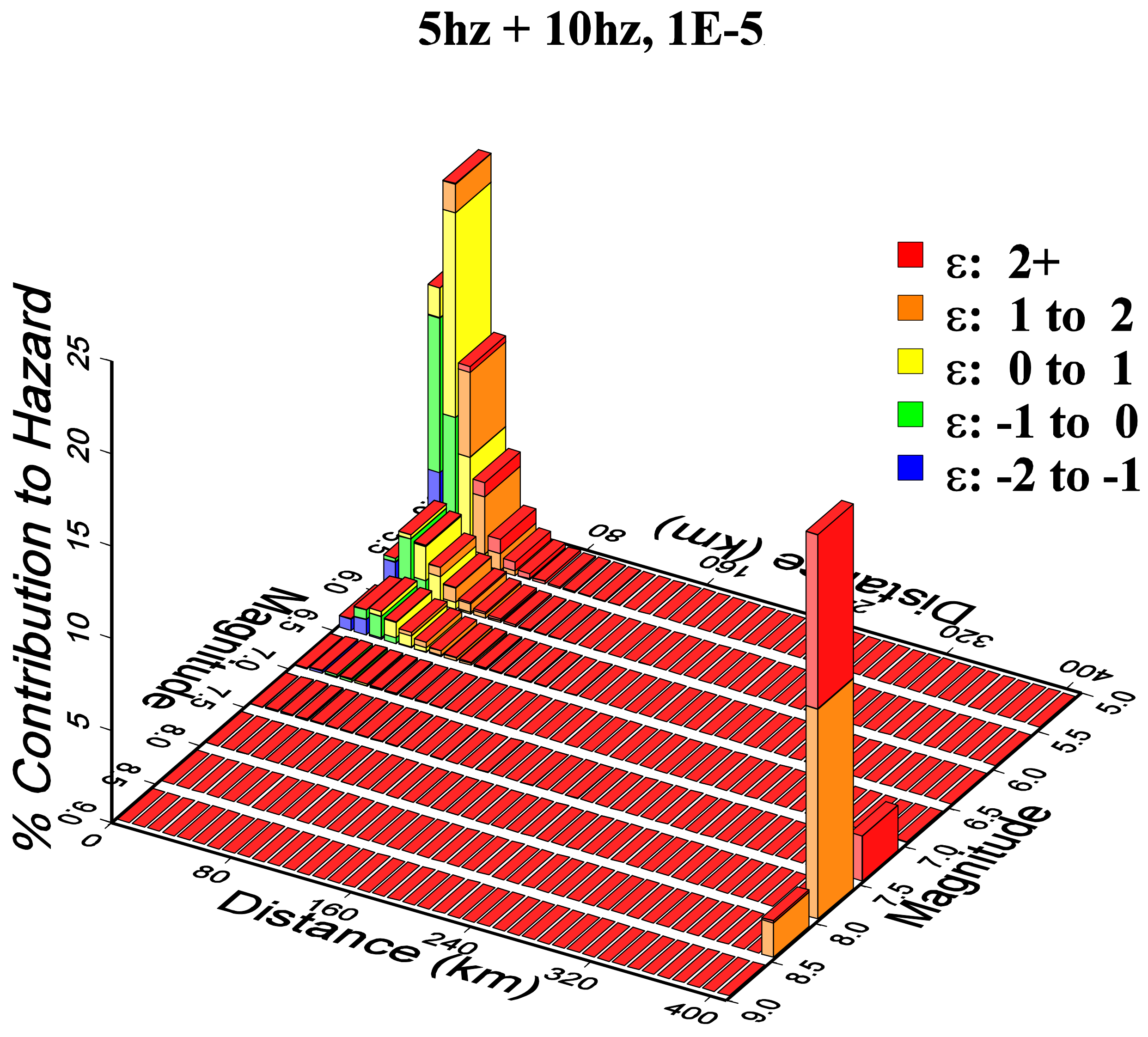

Figure 2.5S.2-30 M and R Deaggregation for 5 and 10 Hz at 10^{-5} Annual Frequency of Exceedence

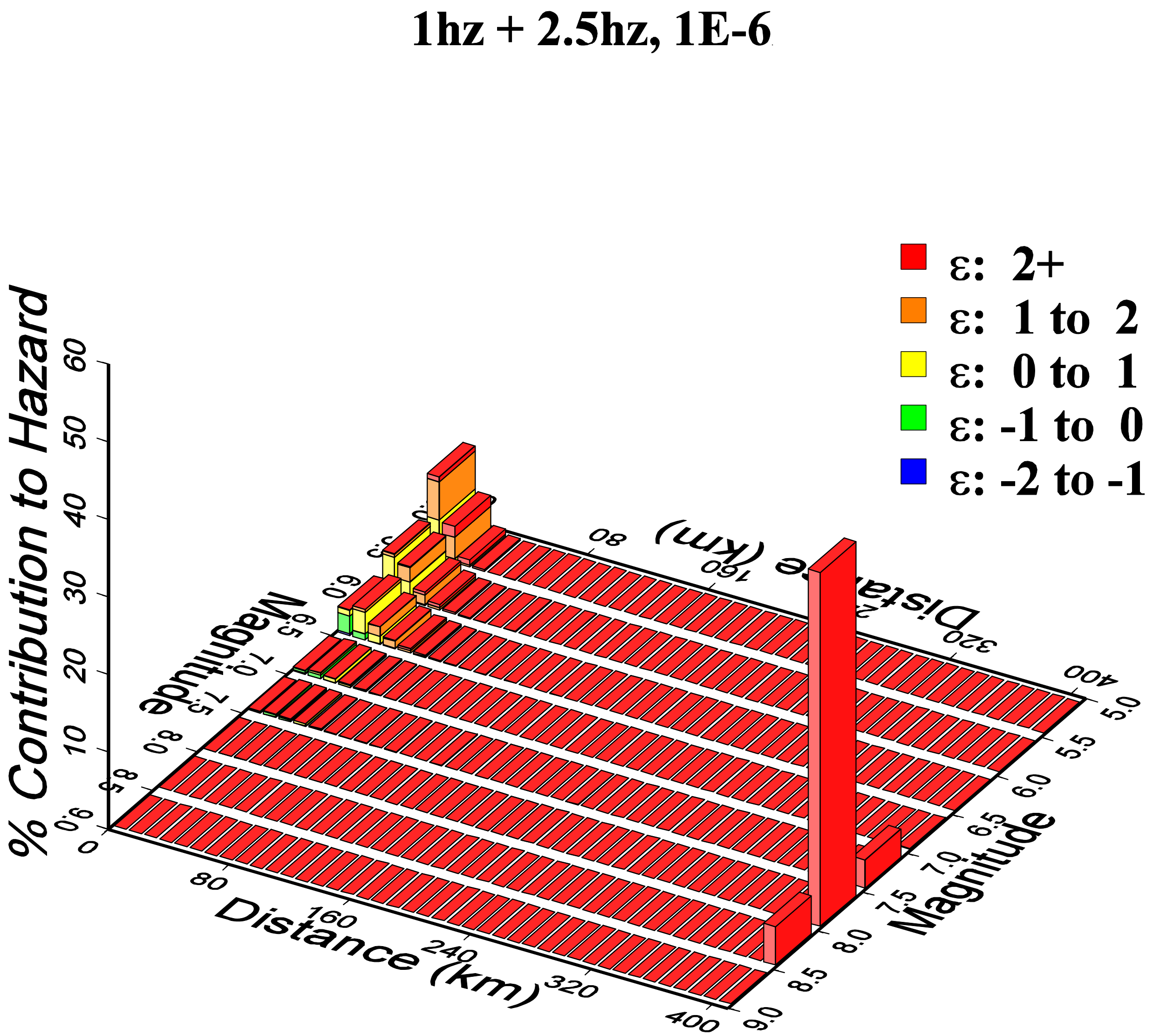

Figure 2.5S.2-31 M and R Deaggregation for 1 and 2.5 Hz at 10^{-6} Annual Frequency of Exceedence

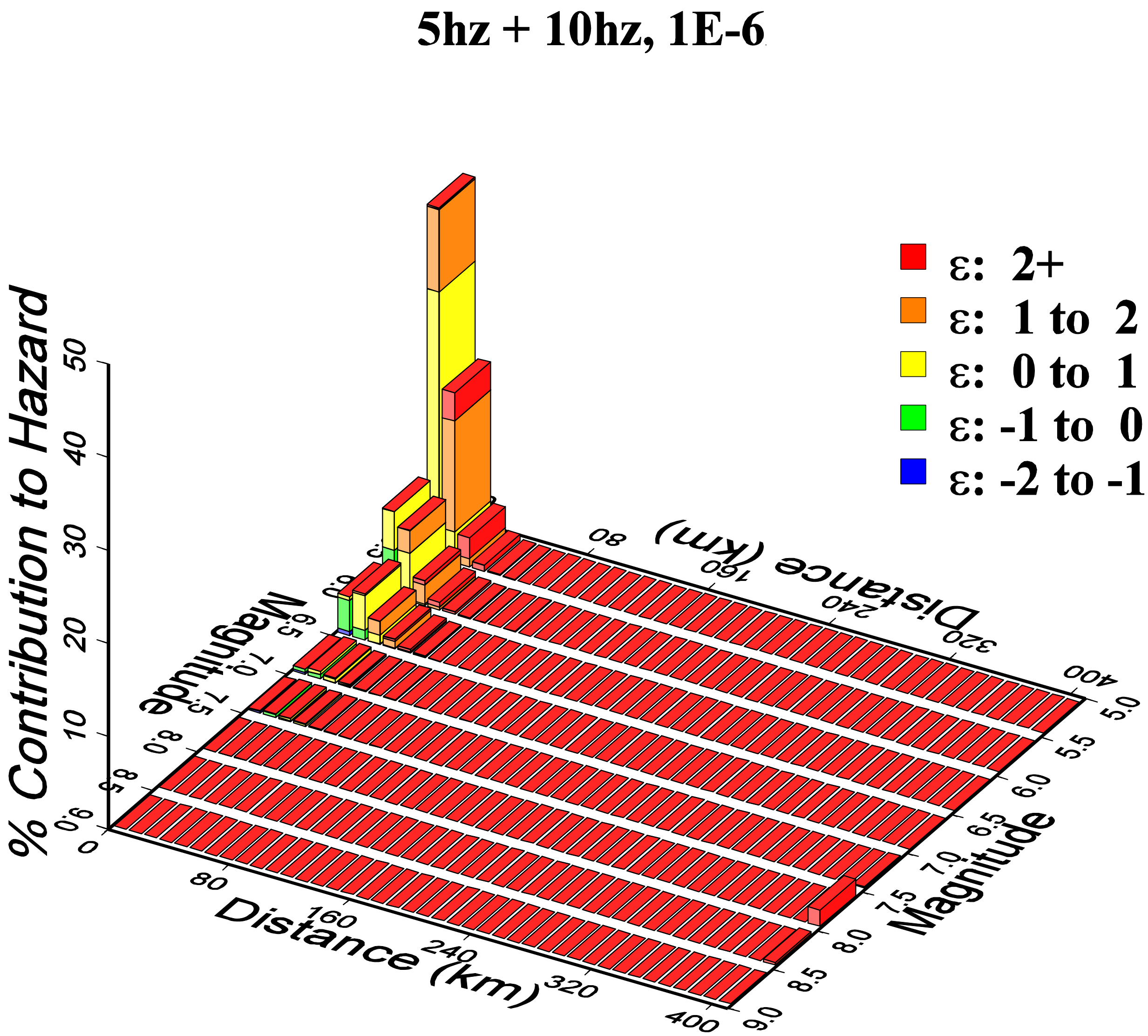

Figure 2.5S.2-32 M and R Deaggregation for 5 and 10 Hz at 10^{-6} Annual Frequency of Exceedence

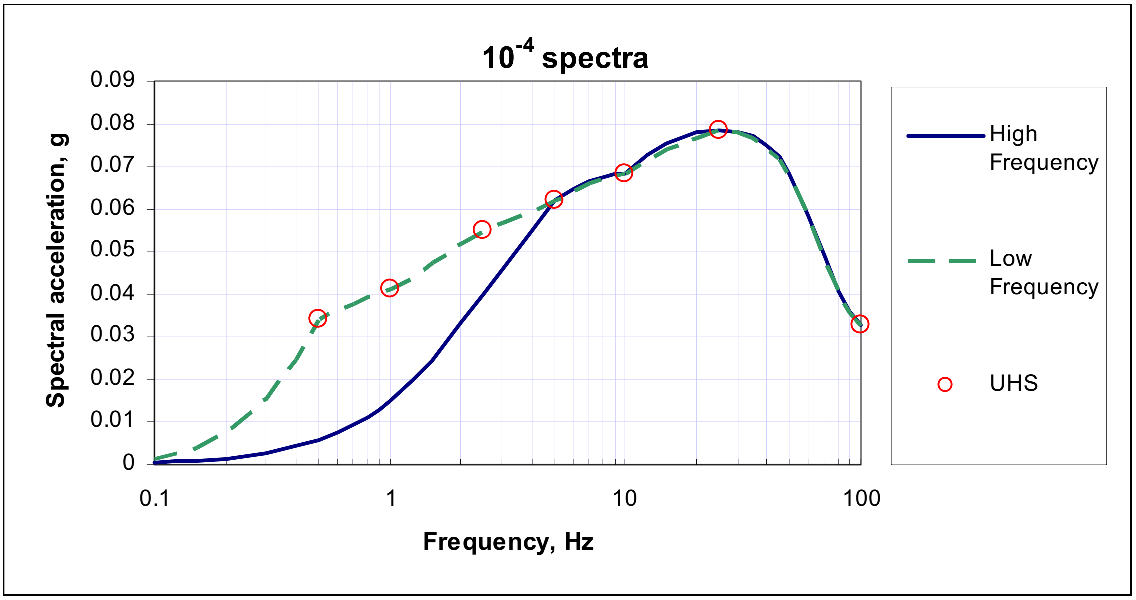

Figure 2.5S.2-33 Smooth 10^{-4} Rock UHRS for HF and LF Earthquakes

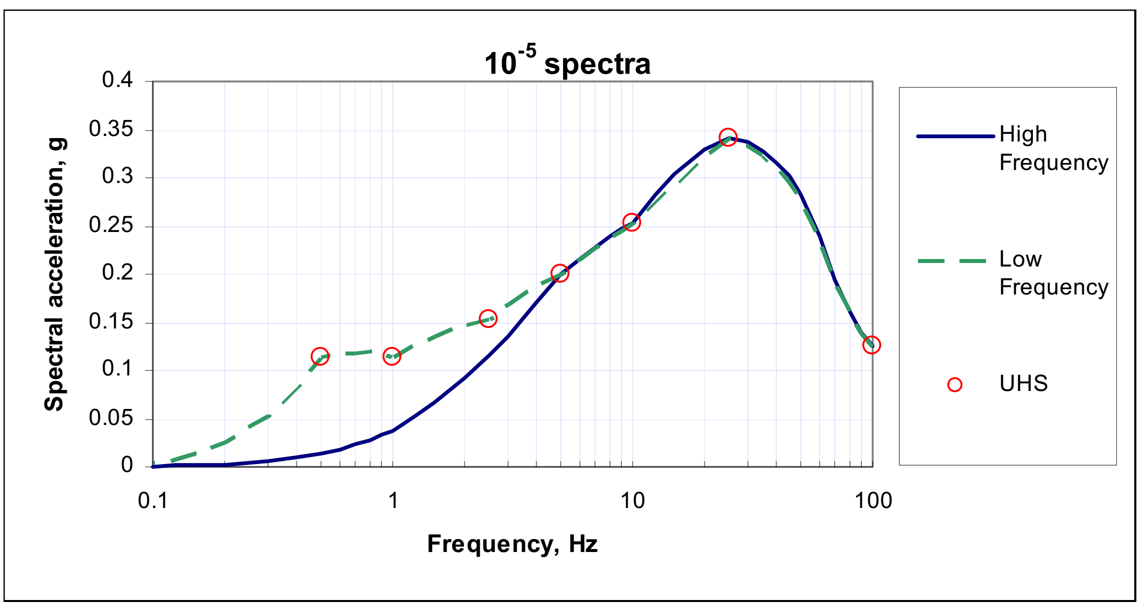

Figure 2.5S.2-34 Smooth 10^{-5} Rock UHRS for HF and LF Earthquakes

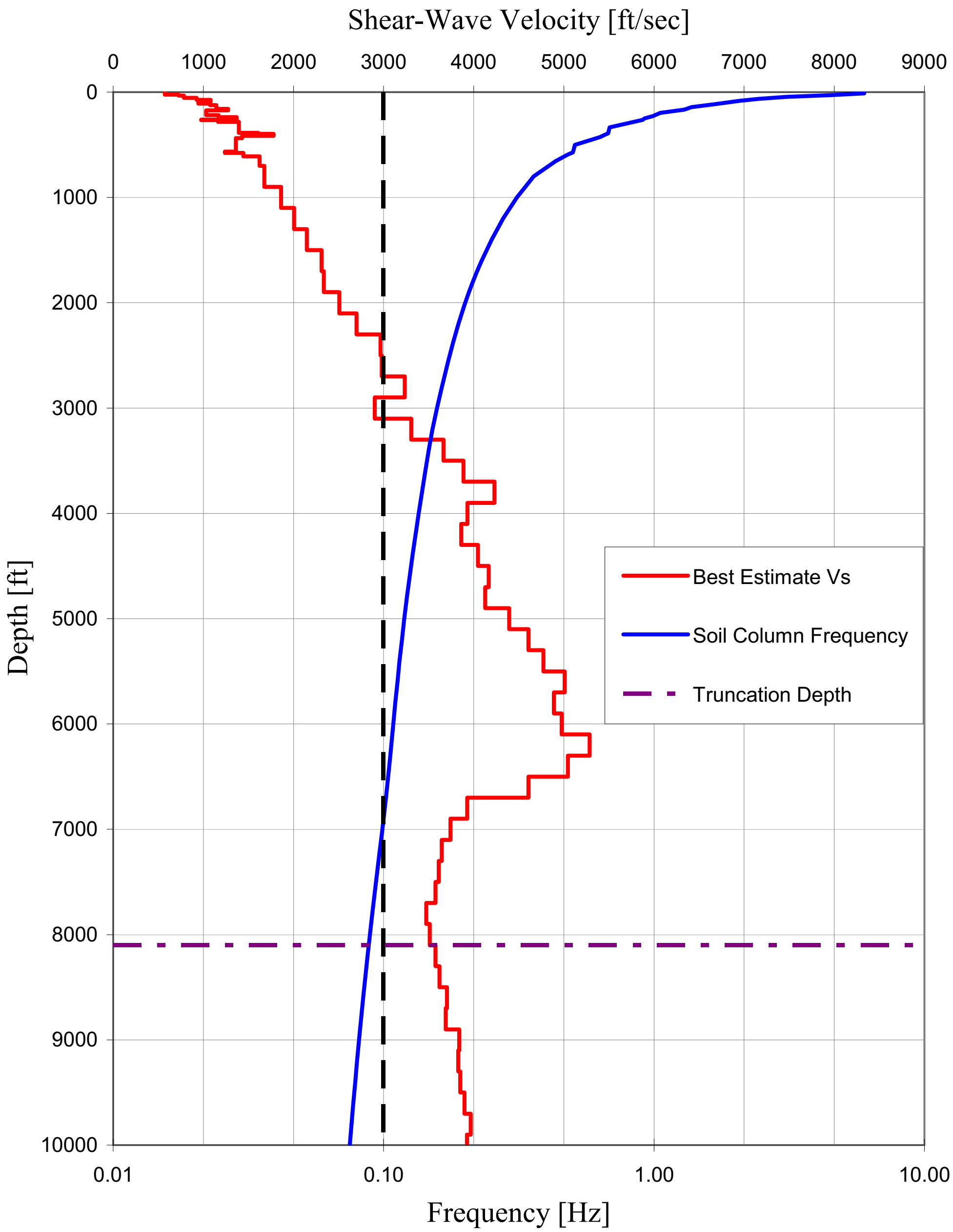

Figure 2.5S.2-35a Best Estimate Soil Column Frequency

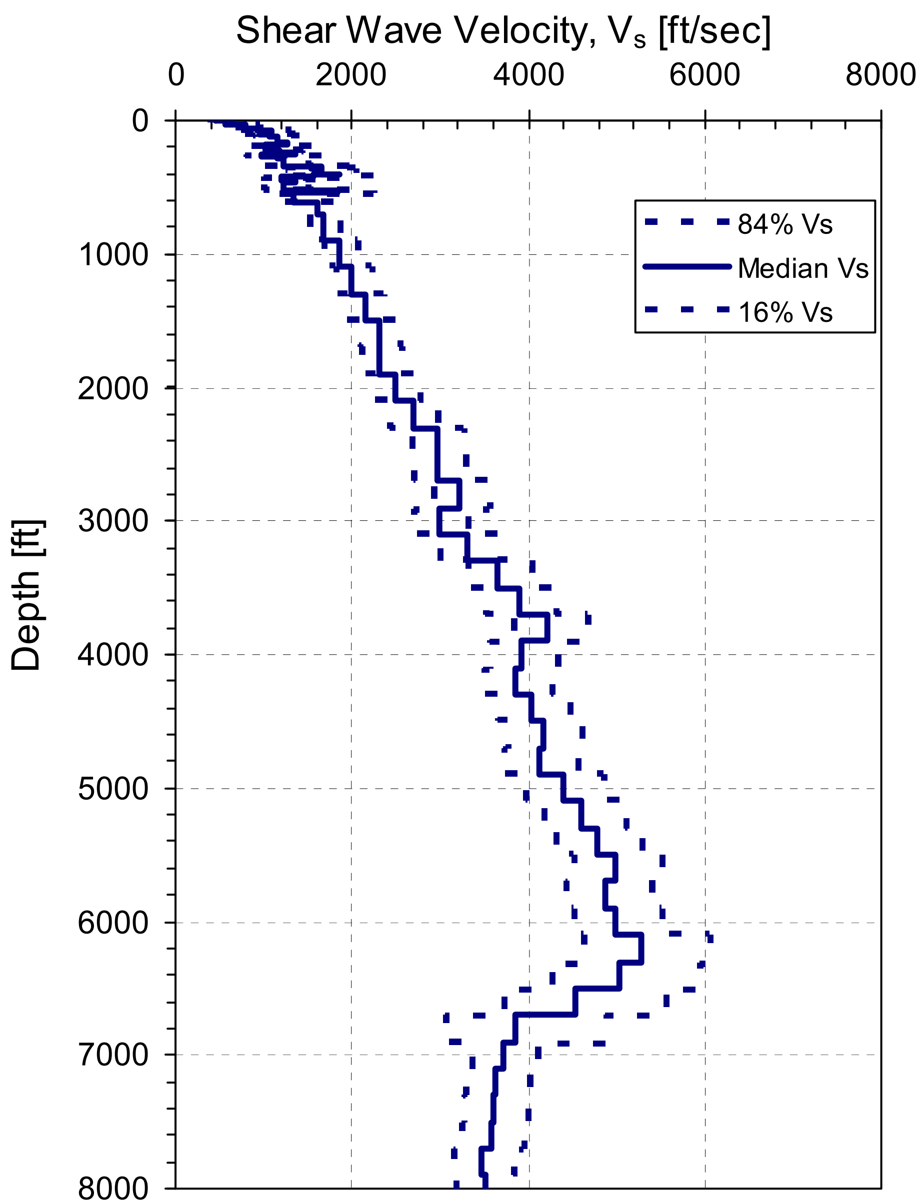

Figure 2.5S.2-35b Input Median Shear Wave Velocity Profile (+/- One Standard Deviation) for Randomization Process

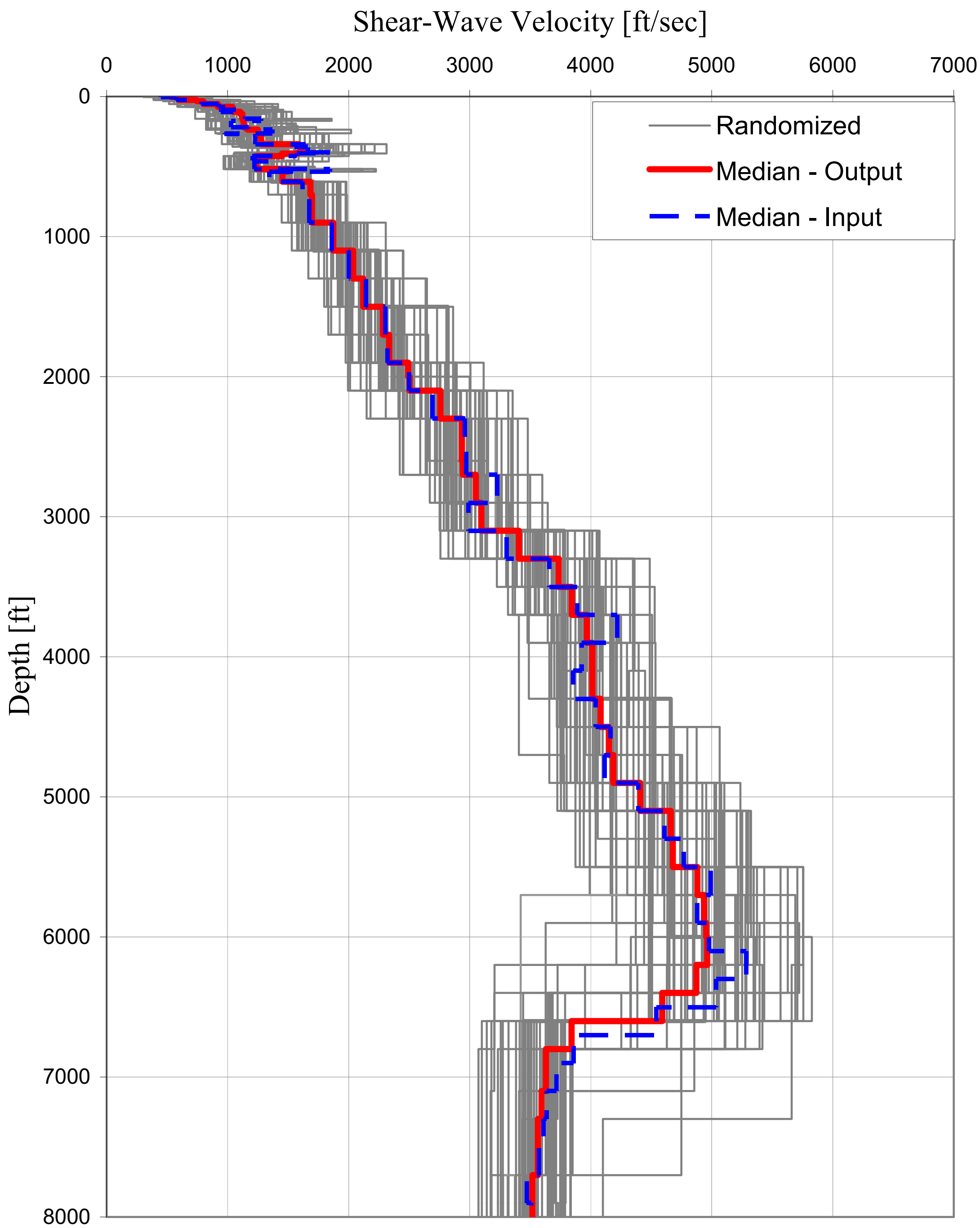

Figure 2.5S.2-36 Randomized Shear Wave Velocity Profiles, Median (Output) Shear Wave Velocity Profile and the Median (Input) Profile Used For Randomization

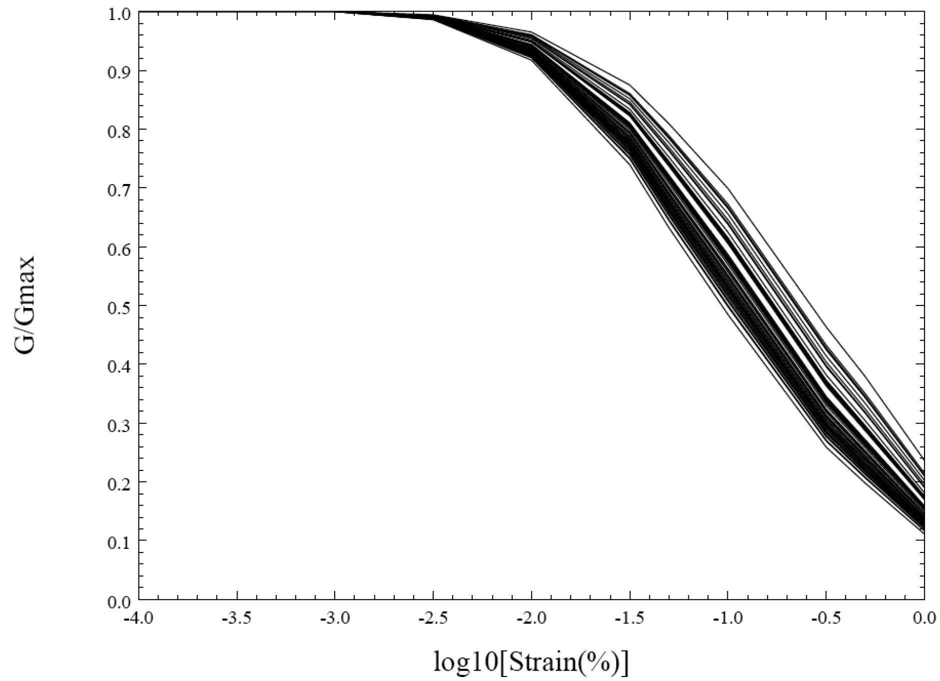

Figure 2.5S.2-37 Strain Dependent Degradation Curves for Stratum C

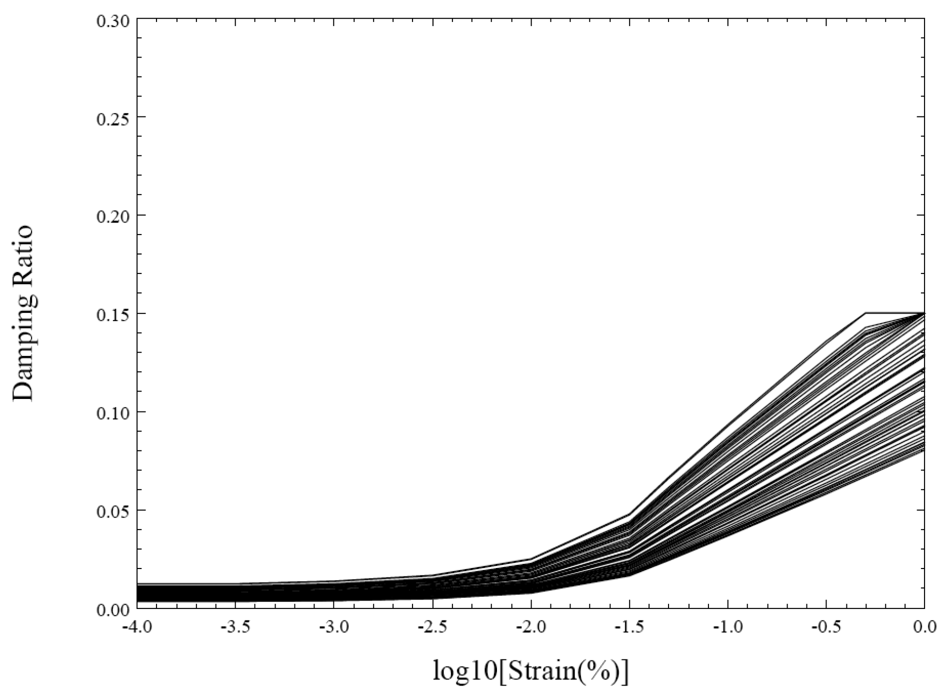

Figure 2.5S.2-38 Strain Dependent Damping Ratio Properties for Stratum C

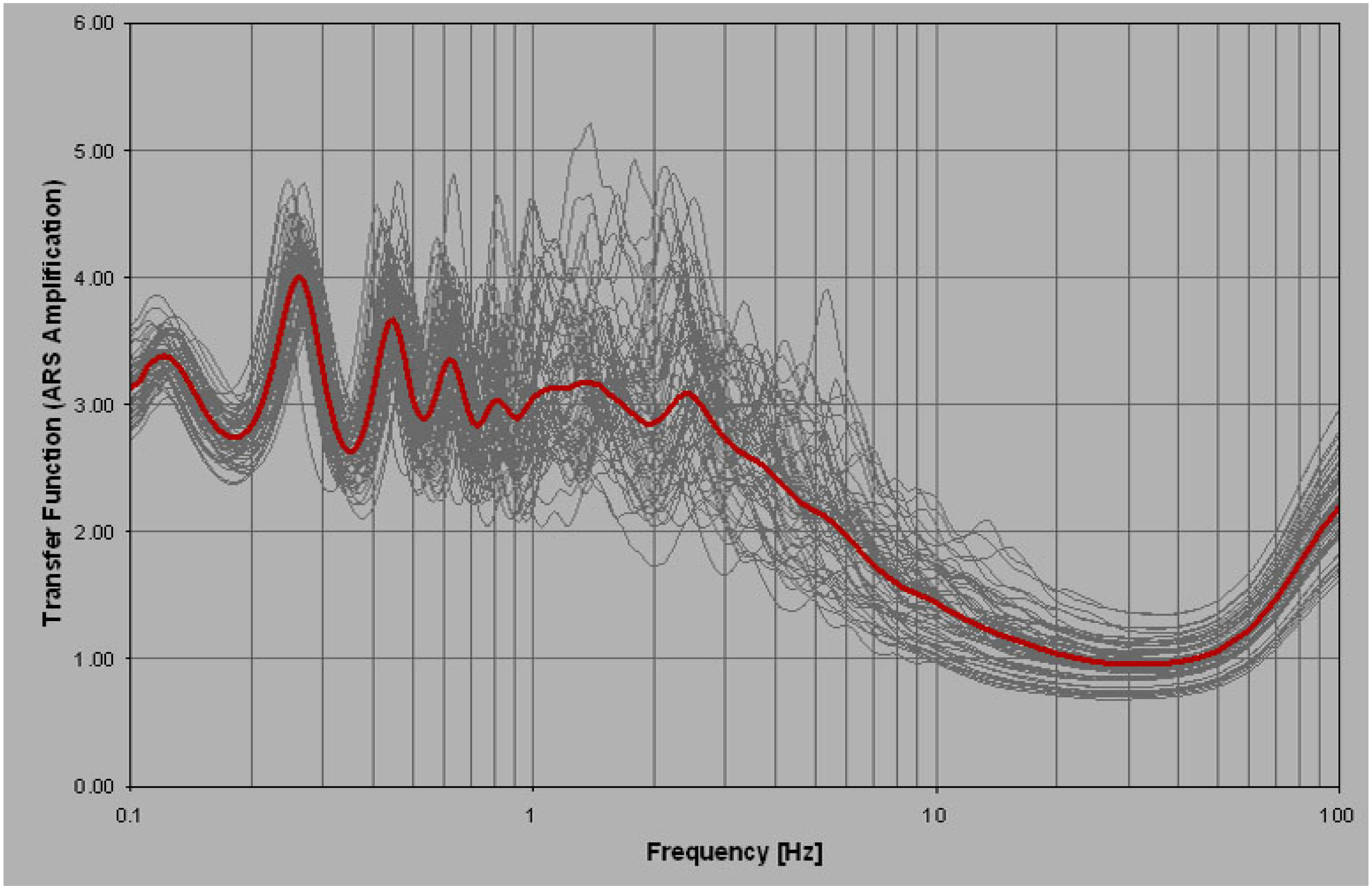

Figure 2.5S.2-39 Logarithmic Mean of Site Transfer Functions (Amplification Factors) at Ground Surface from Analysis of the 60 Modified Random Profiles with the 10^{-4} LF Input Motion

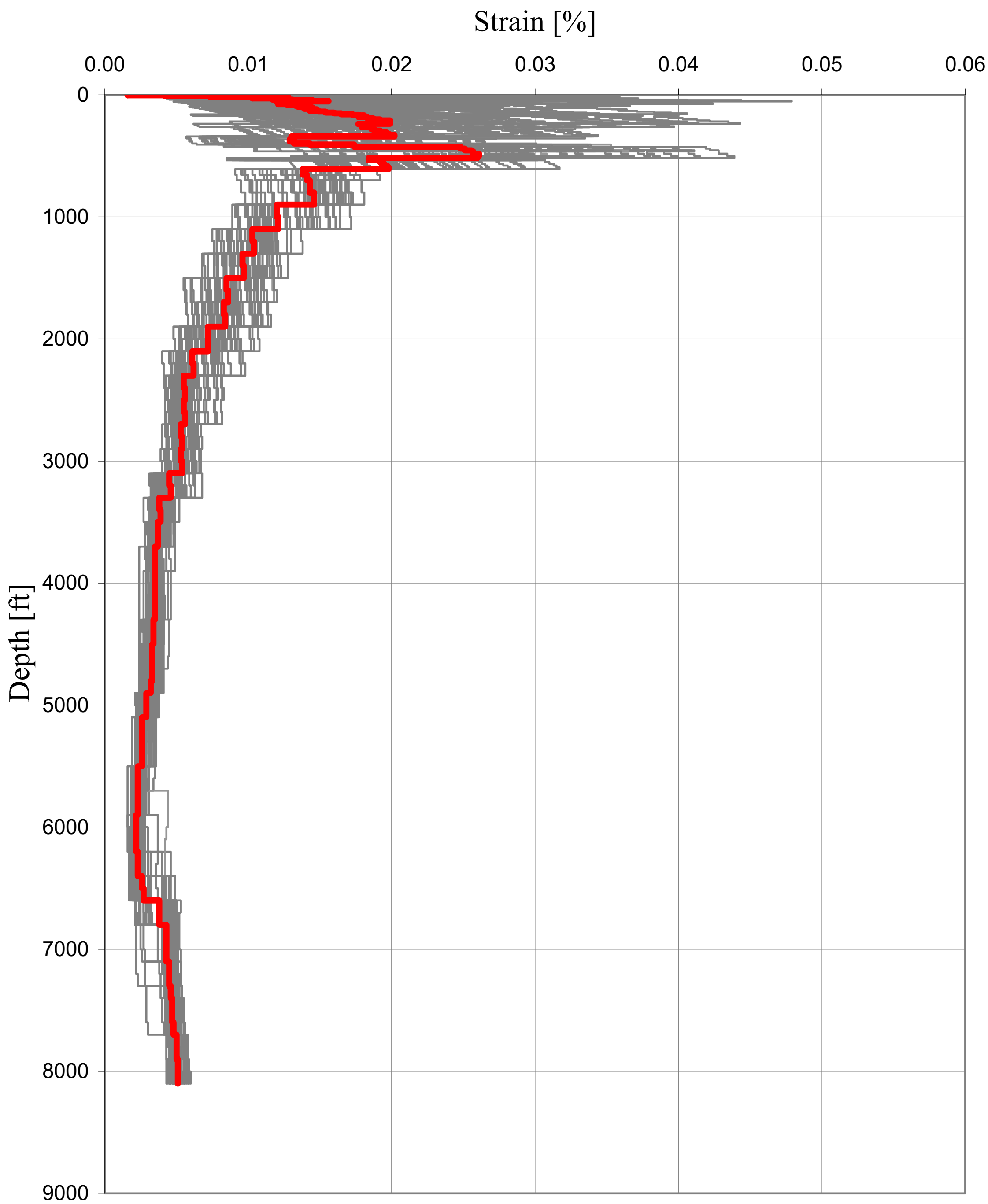

Figure 2.5S.2-40 Maximum Strains Versus Depth that are Calculated for the 60 Profiles and their Logarithmic Mean (Thick Red Line) with the 10^{-4} LF Input Motion

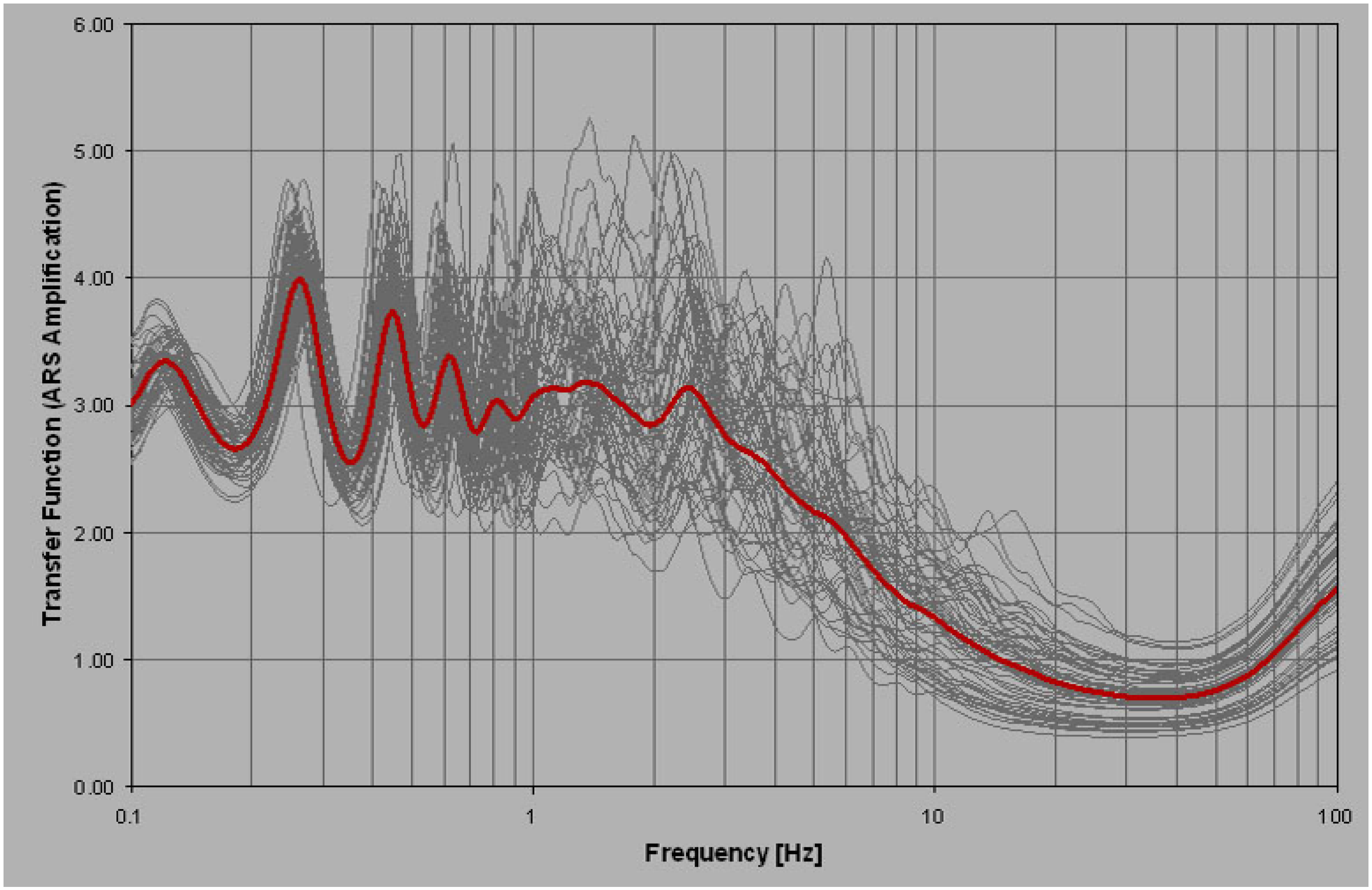

Figure 2.5S.2-41 Logarithmic Mean of Site Transfer Functions (Amplification Factors) at Ground Surface from Analysis of the 60 Modified Random Profiles with the 10^{-4} HF Input Motion

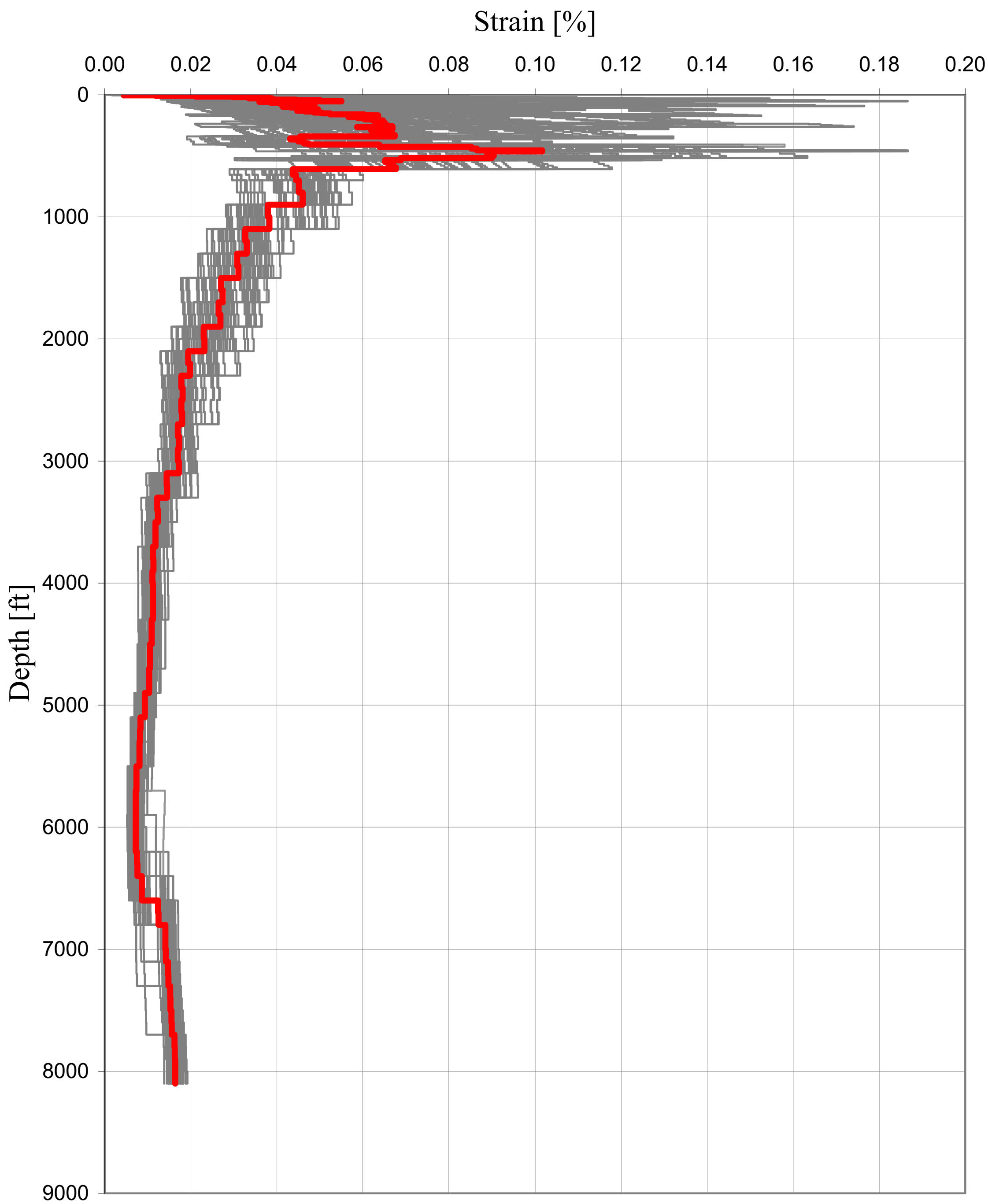

Figure 2.5S.2-42 Maximum Strains Versus Depth that are Calculated for the 60 Profiles and their Logarithmic Mean (Thick Red Line) with the 10^{-4} HF Input Motion

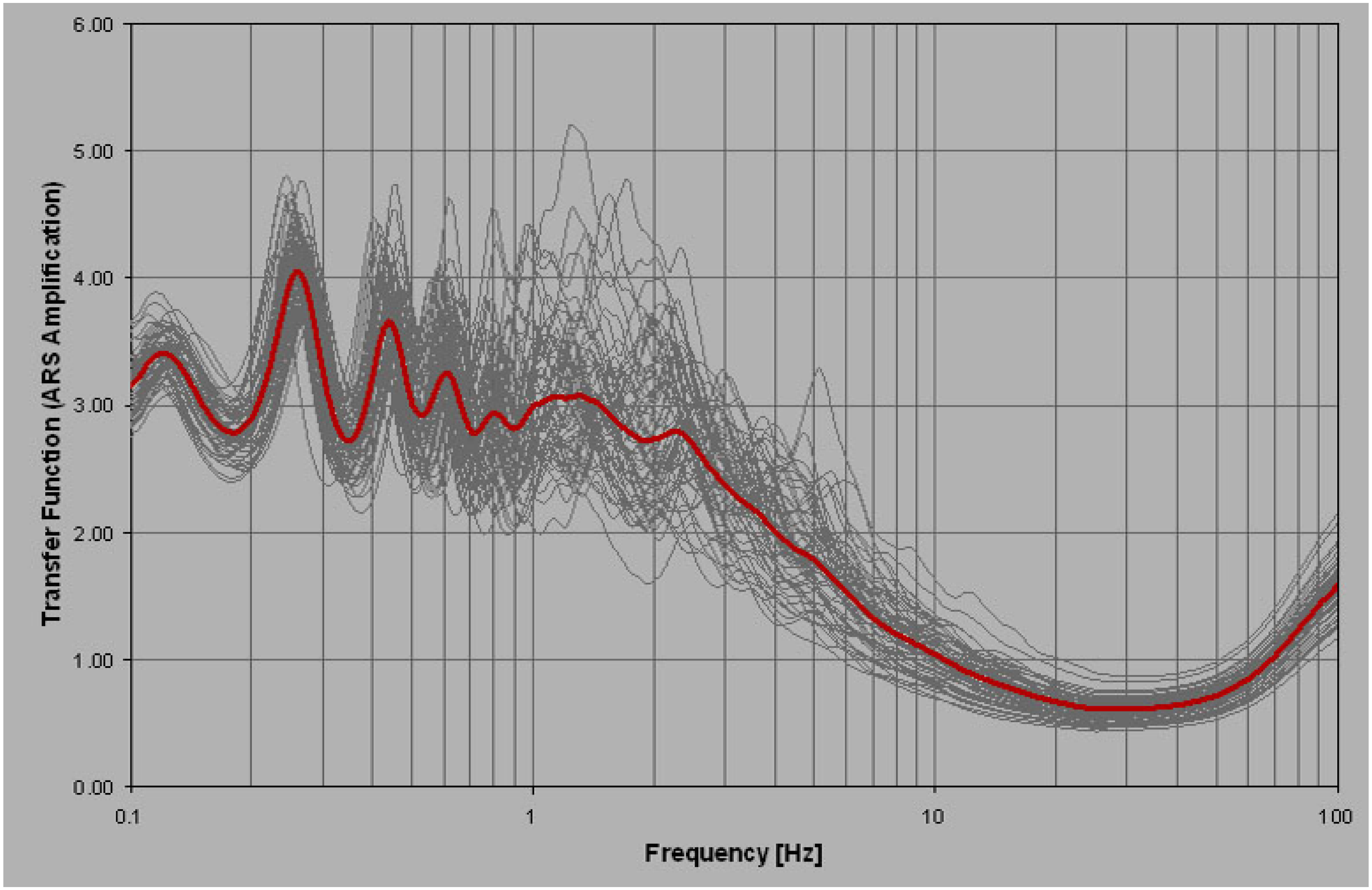

Figure 2.5S.2-43 Logarithmic Mean of Site Transfer Functions (Amplification Factors) at Ground Surface from Analysis of the 60 Modified Random Profiles with the 10^{-5} LF Input Motion

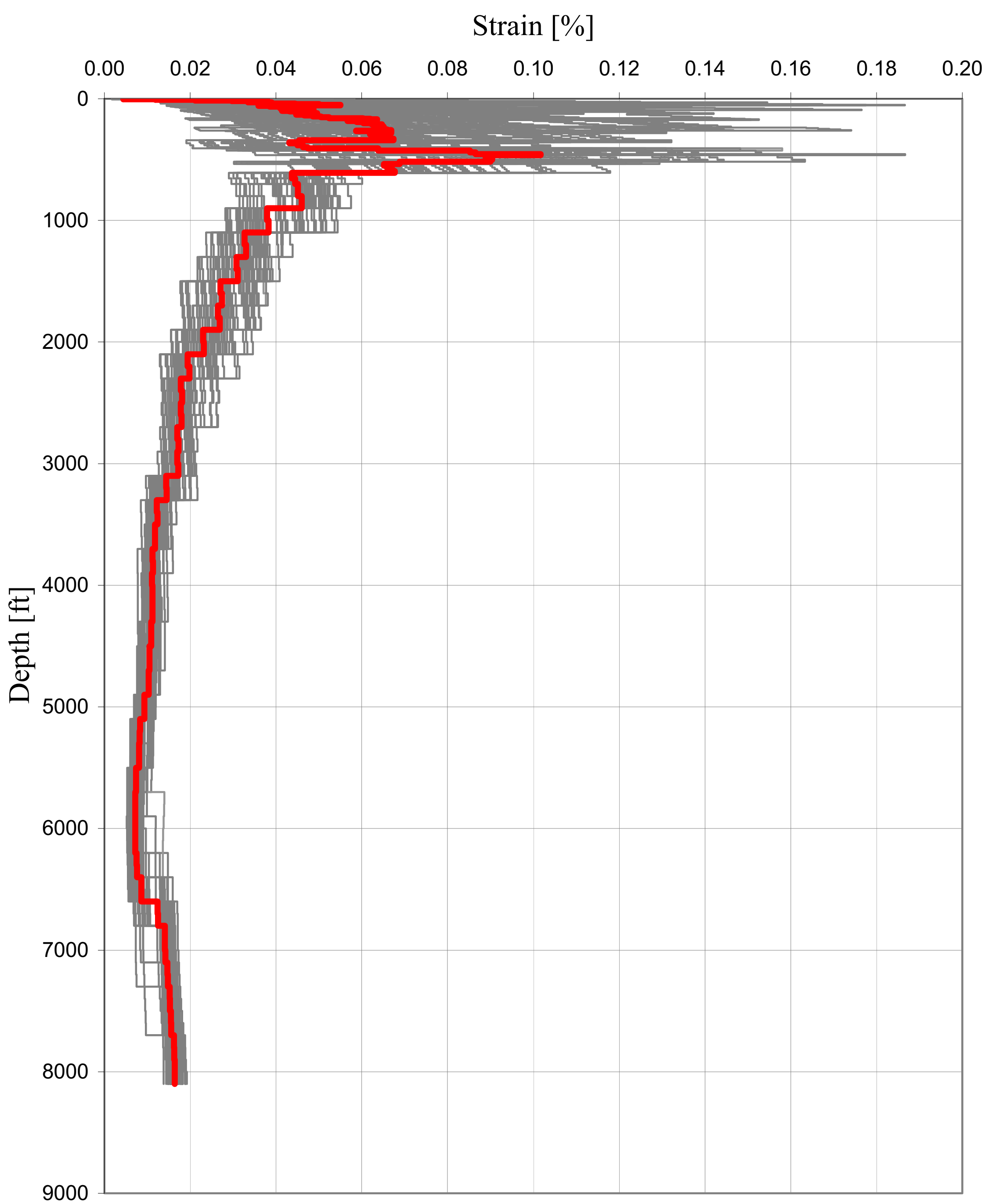

Figure 2.5S.2-44 Maximum Strains Versus Depth that are Calculated for the 60 Profiles and their Logarithmic Mean (Thick Red Line) with the 10^{-5} LF Input Motion

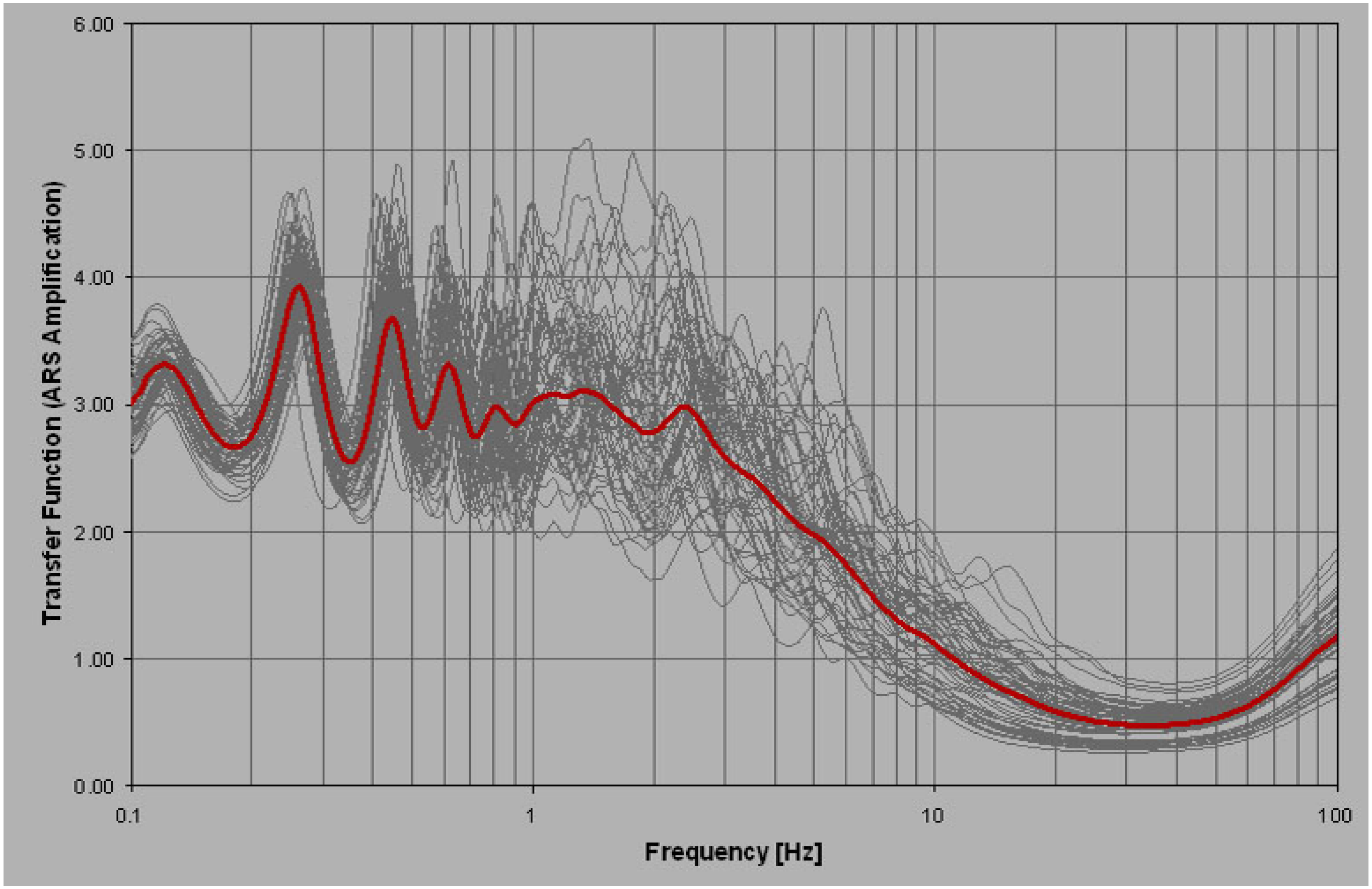

Figure 2.5S.2-45 Logarithmic Mean of Site Transfer Functions (Amplification Factors) at Ground Surface from Analysis of the 60 Modified Random Profiles with the 10^{-5} HF Input Motion

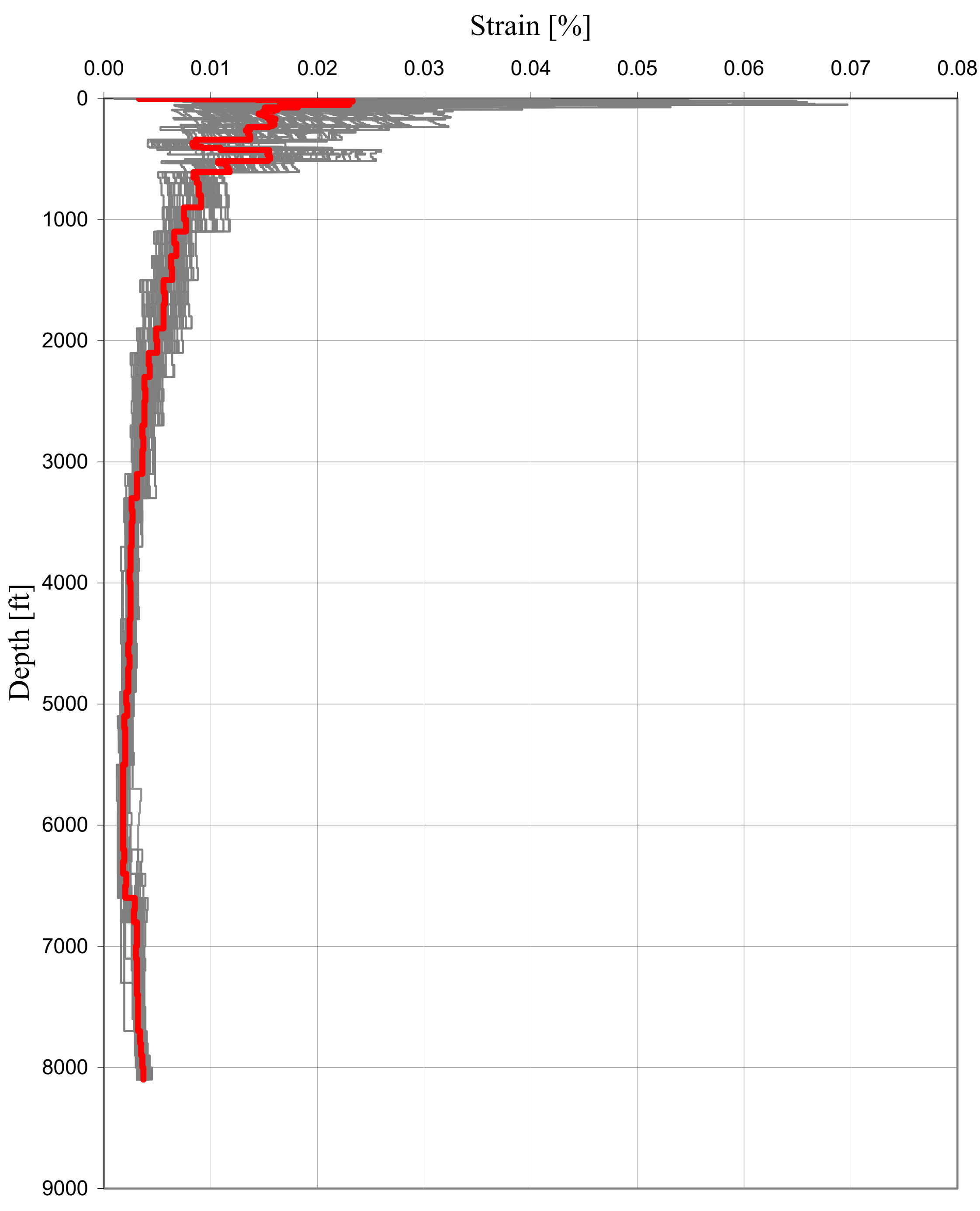

Figure 2.5S.2-46 Maximum Strains Versus Depth that are Calculated for the 60 Profiles and their Logarithmic Mean (Thick Red Line) with the 10^{-5} HF Input Motion

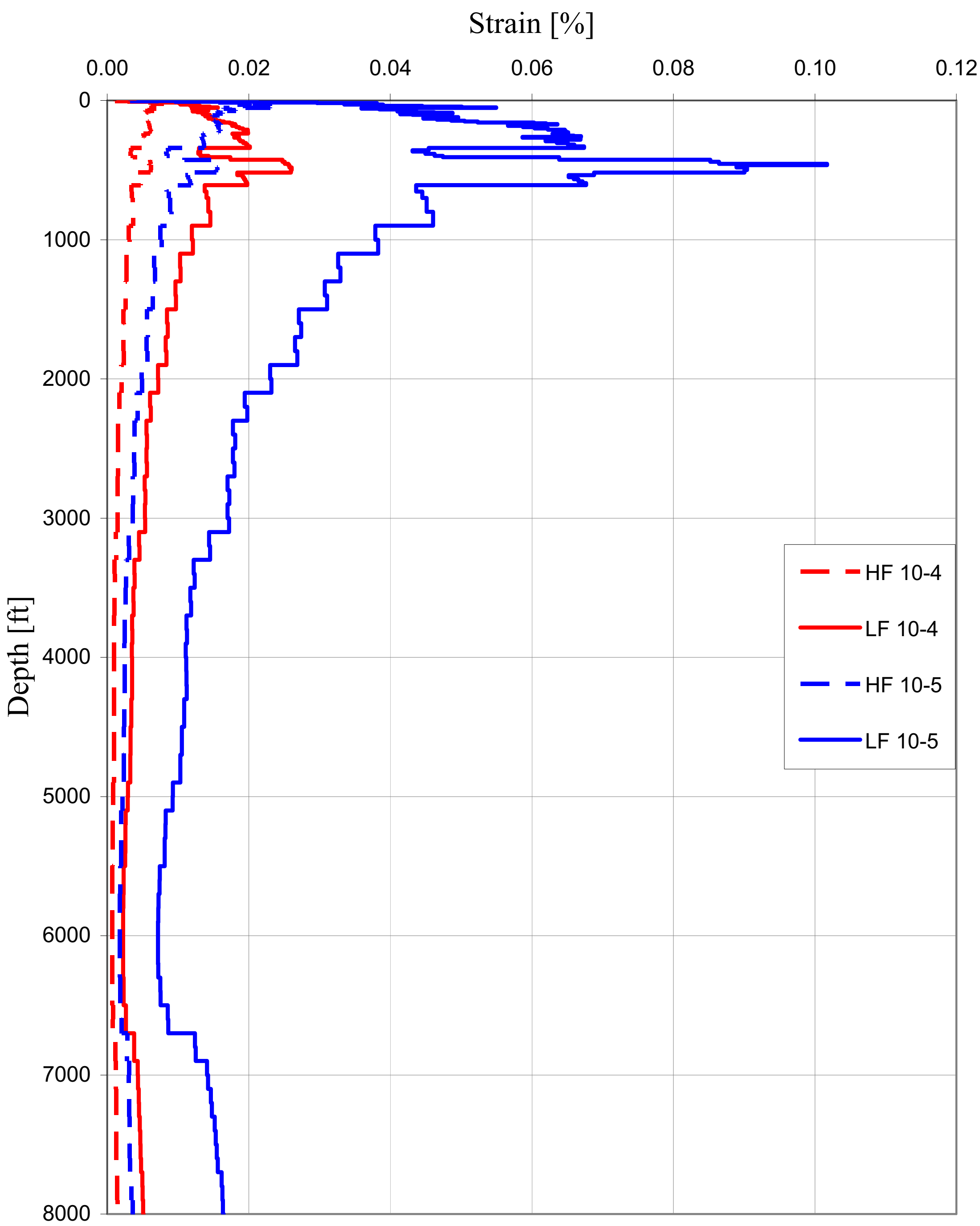

Figure 2.5S.2-47 Logarithmic Mean Maximum Strain Profiles

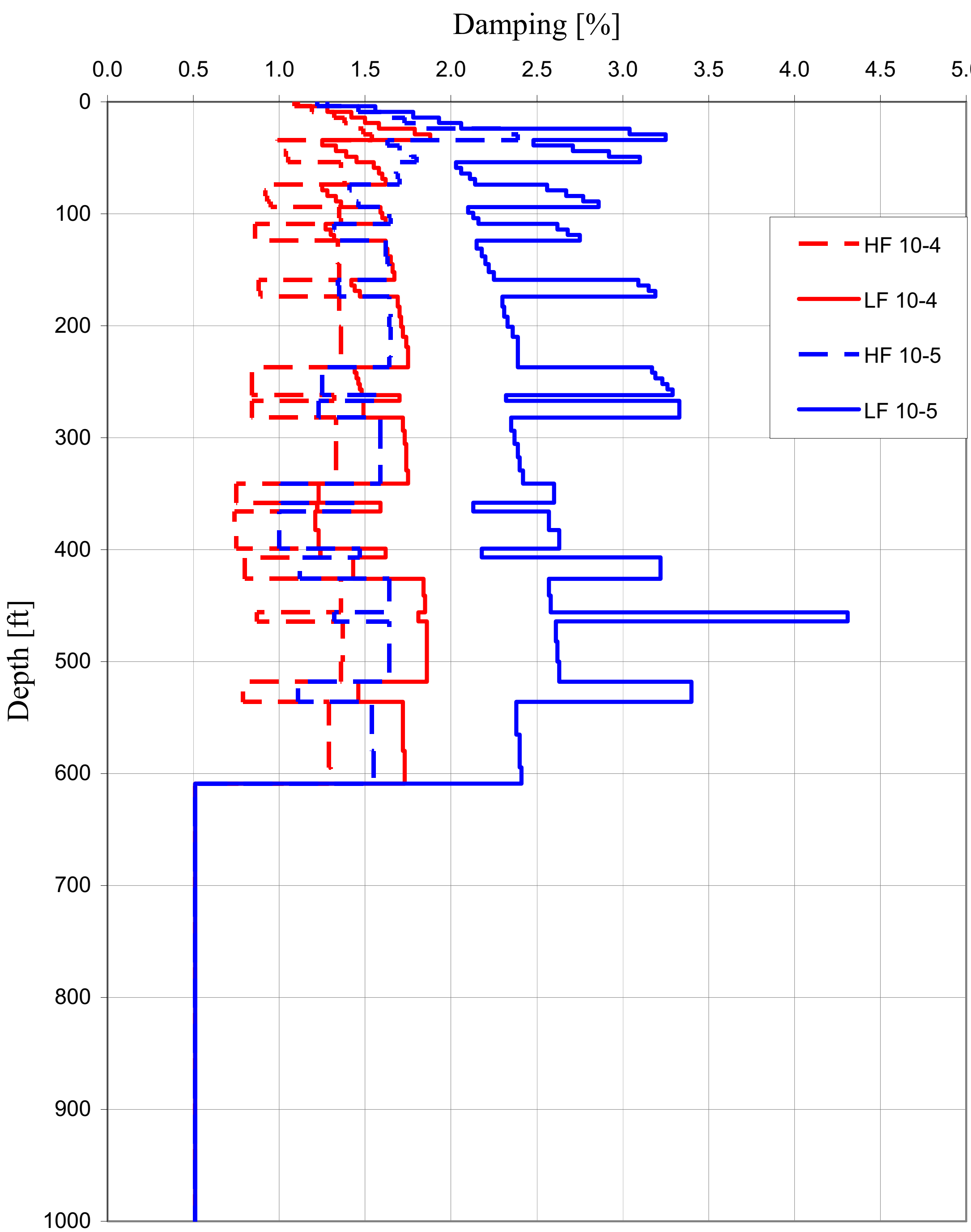

Figure 2.5S.2-48 Logarithmic Mean Profiles of Strain-Compatible Soil Damping (Top 1000 ft)

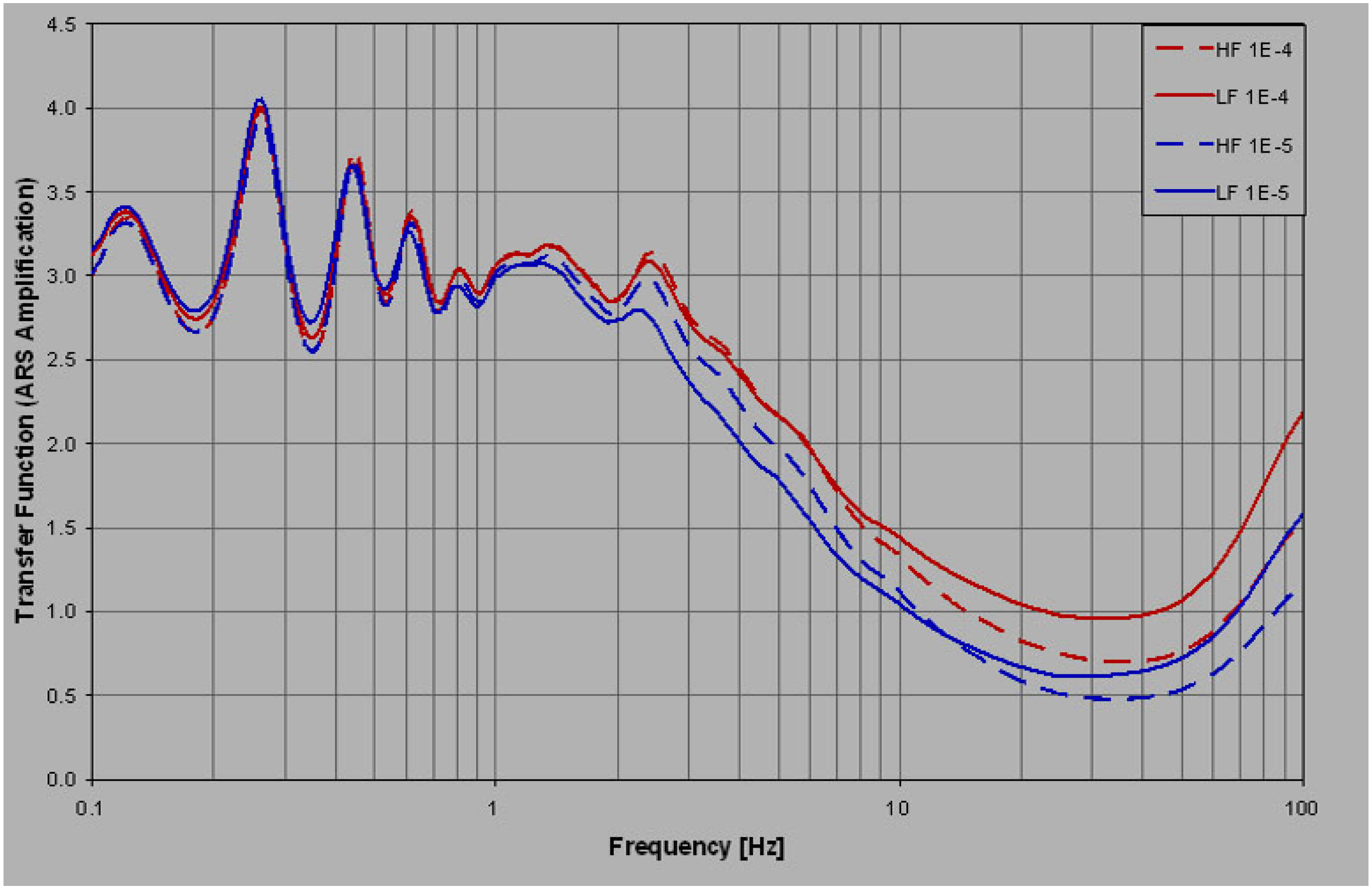

Figure 2.5S.2-49a Comparison of Log-Mean Soil Transfer Functions (Amplification Factors) at the Ground Surface Level for LF and HF 10^{-4} and 10^{-5} Input Motions

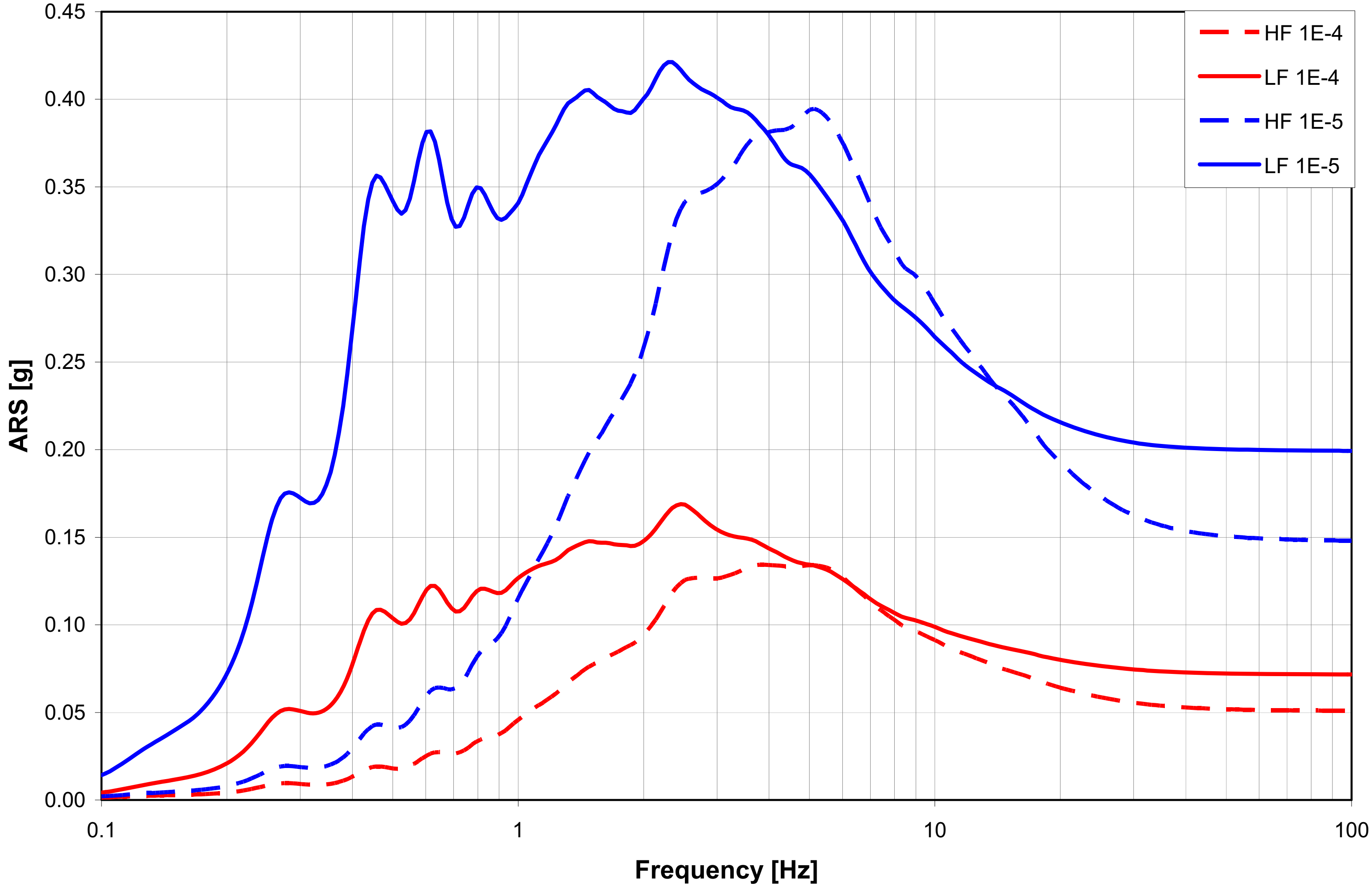

Figure 2.5S.2-49b Log-Mean ARS at the Ground Surface Level for LF and HF 10^{-4} and 10^{-5} Input Motions

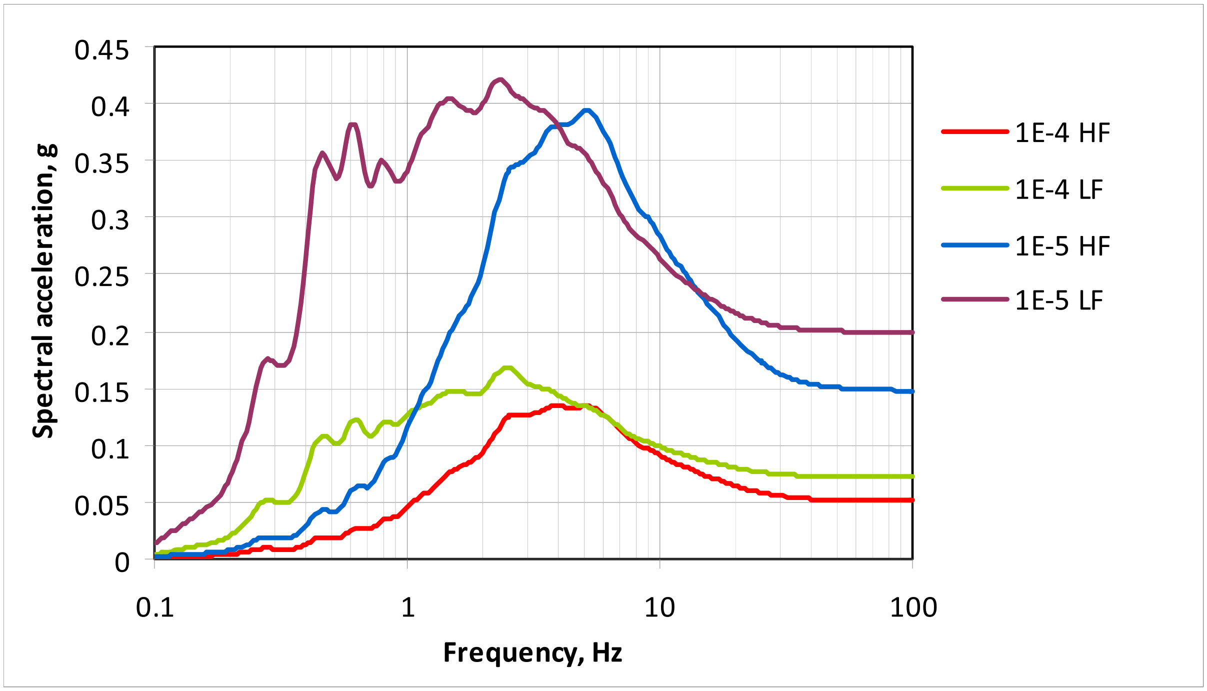

Figure 2.5S.2-50 Raw 10^{-4} and 10^{-5} Ground Surface UHRS for HF and LF Earthquakes

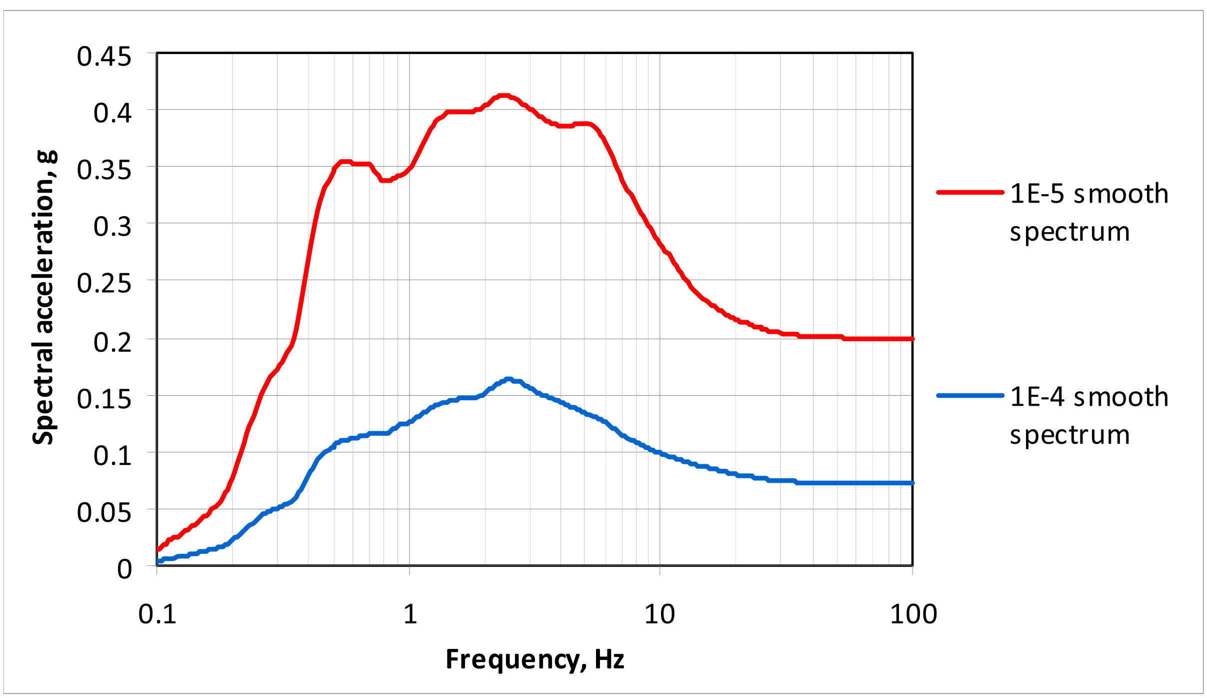

Figure 2.5S.2-51 Enveloped Smooth 10^{-4} and 10^{-5} Ground Surface UHRS for HF and LF Earthquakes

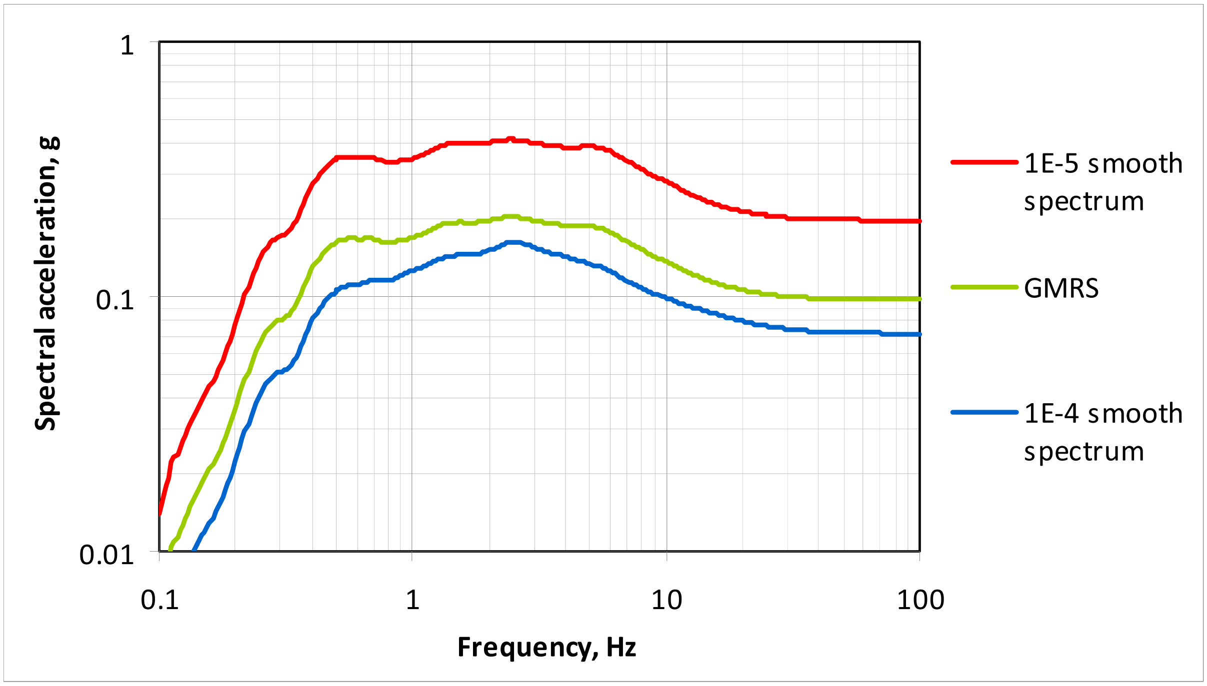

Figure 2.5S.2-52 Smooth 10^{-4} and 10^{-5} Soil UHRS, and Resulting GMRS

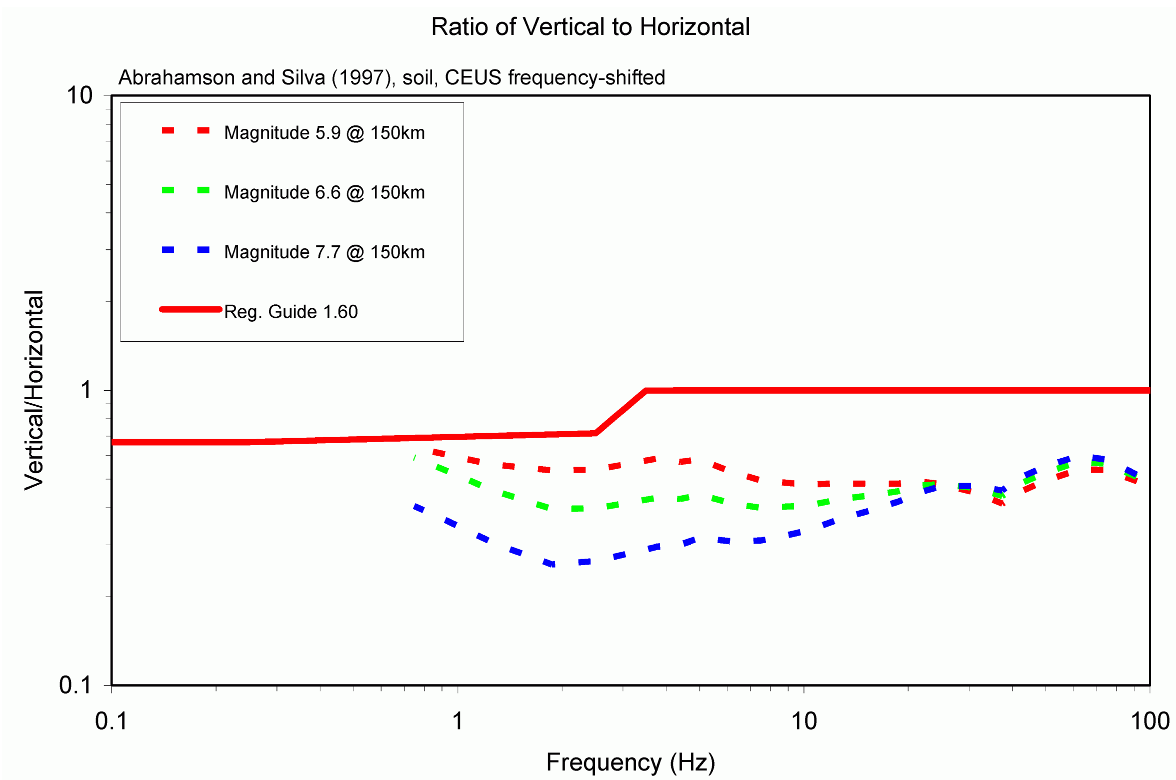

Figure 2.5S.2-53 The WUS Soil V/H Ratios at 150km for Magnitudes 5.9, 6.6, and 7.7 with the Frequencies Shifted by a Factor of (62.5/16.7) to Approximate a WUS-to-CEUS Transformation

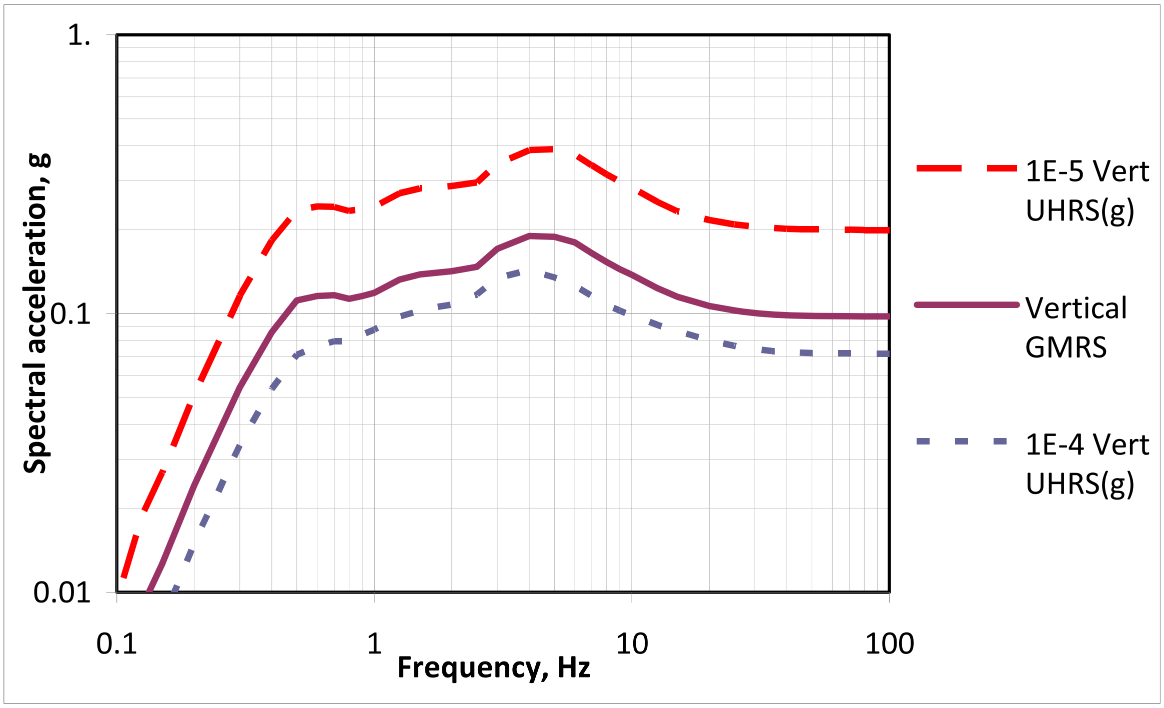

Figure 2.5S.2-54 Vertical 10^{-4} and 10^{-5} UHRS, and Vertical DRS