FPL.

L-2011-496
10 CFR 52.3

November 16, 2011

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

Re: Florida Power & Light Company
Proposed Turkey Point Units 6 and 7
Docket Nos. 52-040 and 52-041
Response to NRC Request for Additional Information Letter No. 037
(eRAI 5896) SRP Section - 02.05.02 Vibratory Ground Motion

Reference:

1. NRC Letter to FPL dated September 29, 2011, Request for Additional Information Letter No.037 Related to SRP Section 02.05.02 - Vibratory Ground Motion for the Turkey Point Nuclear Plant Units 6 and 7 Combined License Application
2. FPL Letter to NRC dated October 31, 2011, Response and Response Schedule to NRC Request for Additional Information Letter No. 037 (eRAI 5896) SRP Section - 02.05.02 Vibratory Ground Motion

Florida Power & Light Company (FPL) provides, as attachments to this letter, its responses to the Nuclear Regulatory Commission's (NRC) Request for Additional Information (RAI) 02.05.02-2, RAI 02.05.02-5, RAI 02.05.02-8 and RAI 02.05.02-9 provided in Reference 1. FPL provided a schedule for the responses to RAI 02.05.02-2, RAI 02.05.02-5, RAI 02.05.02-8, and RAI 02.05.02-9 in Reference 2. The attachment identifies changes that will be made in a future revision of the Turkey Point Units 6 and 7 Combined License Application (if applicable).

If you have any questions, or need additional information, please contact me at 561-691-7490.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on November 16, 2011

Sincerely,

William Maher
Senior Licensing Director – New Nuclear Projects

WDM/RFB

Florida Power & Light Company
700 Universe Boulevard, Juno Beach, FL 33408

D097
NRO

Attachment 1: FPL Response to NRC RAI No. 02.05.02-2 (eRAI 5896)
Attachment 2: FPL Response to NRC RAI No. 02.05.02-5 (eRAI 5896)
Attachment 3: FPL Response to NRC RAI No. 02.05.02-8 (eRAI 5896)
Attachment 4: FPL Response to NRC RAI No. 02.05.02-9 (eRAI 5896)

cc:
PTN 6 & 7 Project Manager, AP1000 Projects Branch 1, USNRC DNRL/NRO
Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant 3 & 4

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-2 (eRAI 5896)

FSAR Subsection 2.5.2.4.5 describes new ground motion prediction equations (GMPEs) that the applicant developed for Caribbean region seismic sources. The basis of the new GMPEs is a scientific study conducted by Motazedian and Atkinson (2005) in the Puerto Rico area. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion":

a. Please explain why ground motion prediction models developed by Motazedian and Atkinson (2005) for the Puerto Rico region, which is primarily a subduction zone, provide an adequate basis for the larger Caribbean region, especially for the region between Cuba and Florida.

b. Please provide the complete Senior Seismic Hazard Analysis Committee (SSHAC) documentation for the Level 2 study conducted to develop the Caribbean GMPEs for the staff to specifically evaluate the makeup of the Technical Integrator (TI) team, the peer review panel, how the experts' opinions were integrated into the development of the final GMPE, whether any conflicting opinions among the experts were dealt with, and how the final GMPEs represent the consensus of the informed community.

c. Please provide copies of the following supporting calculations: Report #: 25409-000-K0C-0000-00009, Report#: 25409-000-K0C-0000-00024, Report #: 25409-000-K0C-0000-00034 to enable the staff to evaluate the technical details of the final GMPEs.

d. In order for the staff to be able to compare the new Caribbean GMPEs with the 2004/2006 EPRI mid-continent GMPEs, please provide plots showing both ground motion models for earthquake magnitudes of 6.0, 7.0, and 8.0 in the distance range of 200 km to 1000 km at all seven frequencies defined in the EPRI 2004 and 2006 GMPEs.

e. Discuss evidence, if any, that seismic source scaling varies regionally and/or between source types in the Caribbean. For example, is there any evidence that stress parameter varies systematically between the northern Hispaniola sources, the Caribbean plate-boundary transform fault sources, and the Cuba sources? If so, what are the implications for the attenuation models and hazard calculated at TPNPP?

FPL RESPONSE:

Part a:

As noted in Garcia et al. (FSAR Reference 255), there are currently no calibrated ground motion prediction equations (GMPEs) for Cuba and the surrounding region. Strong motion instruments have only recently been installed in 1998 and the amount of recorded empirical ground motion data from these instruments, which is operated by the Cuban agency (FSAR Reference 255), is limited or unavailable. In the absence of a local regionally based empirical GMPE, Garcia et al. (FSAR Reference 255) employed the use of other GMPEs from similar regions. One specific GMPE that was used in their probabilistic seismic hazard analysis (PSHA) study for the Cuba region was the Motazedian and Atkinson (FSAR Reference 287) GMPE, which was developed for Puerto Rico for soft rock site conditions.

As presented in the Motazedian and Atkinson (FSAR Reference 287) study, a dataset of approximately 300 earthquakes of magnitude 3.0-5.5 located on and around the island of Puerto Rico was used to develop regional ground motion attenuation and source parameters. These authors acknowledge that their ground motion dataset consisted of both crustal and subduction zone earthquakes, as one would expect based on the tectonic setting for the island of Puerto Rico. In addition, Motazedian and Atkinson (FSAR Reference 287) note that the separation of the earthquakes into crustal and subduction events used in their dataset was not possible based on the limited station coverage for the region.

To address this possible concern about the influence of using both subduction and crustal events to estimate the regional attenuation and source parameters, Motazedian and Atkinson (FSAR Reference 287) provide a comparison of their GMPE developed based on the Puerto Rico strong motion dataset of events with representative GMPEs for central and eastern United States (FSAR Reference 210), California (Atkinson and Silva, 2000), and an empirically-based subduction GMPE based on the global ground motion dataset for subduction zones (Atkinson and Boore, 2003). Based on the comparison of GMPEs from these different regions, they conclude that their GMPE developed for the Puerto Rico region is similar to the two crustal models for California and eastern North America, and shows a significant difference (i.e., the subduction zone attenuation curves are lower) to the empirically-based subduction models. This comparison and noted results provide a technical justification for using the source and attenuation parameters from the Puerto Rico ground motion dataset (FSAR Reference 287) for the development of applicable GMPEs for the Caribbean seismic sources.

Based on the lack of a region-specific GMPE for the Cuba region, the accepted practice of using an applicable GMPE from similar regions was used in the development of regional ground motion relationships for the Cuba and Caribbean region. In performing a literature review of applicable GMPEs, the regional attenuation and source parameters developed from the Puerto Rico dataset of earthquakes (FSAR Reference 287) were selected as an acceptable dataset to develop simulation-based ground motions for the estimation of a regional suite of empirical ground motion attenuation relationships in PSHA.

Part b:

A formal Senior Seismic Hazard Analysis (SSHAC) Level 2 study was not conducted for the development of the Caribbean GMPE. The development followed a SSHAC Level 1 study with the additional interaction between the Technical Integrator (TI) team and a resource expert and the Technical Advisory Group (TAG). The later interactions occurred during the three TAG meetings. The TI team consisted of two Bechtel seismologists:

Dr. Nick Gregor
Dr. Behrooz Tavakoli

The resource expert was,

Dr. Dariush Motazedian (Carleton University, Ottawa, Canada)

The TAG members were:

Dr. Robert Kennedy (RPK Structural Mechanics Consulting)
Dr. William McCann (Earth Scientific Consultants)
Mr. Donald Moore (Southern Nuclear Operating Company)
Dr. J. Carl Stepp (Earthquake Hazards Solutions)
Dr. Robert Youngs (Geomatrix Consultants, currently AMEC-Geomatrix)

These TAG meetings provided a forum for the TAG members to be participatory peer review members for the project and to offer guidance on the development of the Caribbean GMPEs. Initially a literature review was performed with the goal of retrieving acceptable ground motion prediction equations (GMPEs) for the Cuba and Caribbean region. However, this literature review only retrieved one GMPE developed recently by Motazedian and Atkinson (FSAR Reference 287). In addition to the participatory interaction with the TAG members, correspondence was conducted with Professor Motazedian during the initial development of the Caribbean GMPEs. These initial technical discussions were for the possible application of the published Motazedian and Atkinson (FSAR Reference 287) GMPE for the PSHA study. However, based on the limitations of this GMPE (e.g., incomplete suite of necessary spectral frequencies, limited application for distances greater than 500 km, and site-specific ground conditions of soft rock), it was determined that this published GMPE was not acceptable for use in the PSHA.

For the development of the GMPEs for the Cuba and Caribbean region, the regionally determined source and attenuation parameters from Motazedian and Atkinson (FSAR Reference 287) were used with a point-source stochastic ground motion methodology to develop an applicable large-distance GMPE for the magnitude and distance range needed for the PSHA.

There was agreement amongst the TAG members on the methodology and results performed for the development of the GMPEs for the Caribbean seismic sources. As part

of the TAG feedback and to resolve any technical concerns from the TAG members, a sensitivity analysis was performed to examine the ground motion effects, if any, on epistemic uncertainty of alternative GMPEs for use in the PSHA.The alternative attenuation relationships considered an adopted double corner (2C) seismic source model that might be expected to occur in a more active tectonic environment such as the western United States (WUS) rather than the less active tectonic environment of the central and eastern United States (CEUS). In addition a Gulf Coast region anelastic attenuation factor (Q) model rather than the Puerto Rico region-specific Q model from Motazedian and Atkinson (FSAR Reference 287) was analyzed, recognizing that much of the propagation path from the Caribbean sources to the Turkey Point site is through the Gulf Coast crust.

It was found that adoption of these alternatives (i.e., different suite of regional attenuation and seismic source parameter values) led to ground motion values that were equal to (at large distances based on the anelastic attenuation rates) or lower than (based on the different magnitude scaling from the WUS based double corner model) the suite of original nine new ground motion attenuation models adopted for the Cuba and Caribbean region. A comparison of the weighted combination of the original nine GMPE models and the inclusion of these additional sensitivity models resulted in a slightly lower weighted mean ground motion attenuation curve over the magnitude and distance range needed for the PSHA. Thus, their incorporation into the final PSHA results would have slightly lowered the already low hazards and thus the use of the original nine GMPE models was accepted by the TAG members with the understanding that the inclusion of these additional GMPE models would be expected to lead to lower ground motion results.

The development of the GMPEs used in the PSHA for the Caribbean seismic sources followed a SSHAC Level 1 methodology with the additional interaction of a resource expert for the region. This methodology was approved by the TAG members during the multiple workshop meetings. Based on the sensitivity analysis presented at the workshop, the final suite of GMPEs recommended for the PSHA was selected with the technical understanding that they represent more conservative (i.e., higher) ground motion prediction values than would be expected from the inclusion of other candidate GMPE models.

Part c:

The following three calculations are available for inspection in the Reading Room for eRAI 5896.

- Calculation 25409-000-K0C-0000-00009, Rev. 001
- Calculation 25409-000-K0C-0000-00024, Rev. 001
- Calculation 25409-000-K0C-0000-00034, Rev. 000

Part d:

Ground motion attenuation curve plots are provided for the EPRI (FSAR References 242 and 203) and Caribbean ground motion prediction equations (GMPEs). Note that EPRI (FSAR Reference 203) is only a recommendation for the associated aleatory uncertainty and therefore does not impact the comparison plots of the weighted mean ground motion

attenuation curve. The plotted mean attenuation curve is the weighted mean of the individual median attenuation curves as defined in EPRI (FSAR Reference 242). These attenuation plots are provided for three specific moment magnitude (M_w) values: 6, 7, and 8 for distances between 200 km and 1,000 km. Note that the EPRI (FSAR Reference 242) ground motion attenuation model is defined as a function of epicentral distance, whereas the Caribbean ground motion attenuation model is defined as a function of hypocentral distance. However, because the closest distance is 200 km, the difference between the epicentral and hypocentral distances would be less than 1% for a typical crustal depth of 10 km and even smaller for larger distances out to 1,000 km.

The weighted mean ground motion attenuation curves for the EPRI (FSAR Reference 242) model are given in Figures 1 through 7 for the three magnitudes and seven spectral frequencies requested in the RAI. The weighted mean Caribbean ground motion attenuation curve plots for the same suite of magnitudes, distances, and spectral frequencies are shown in Figures 8 through 14.

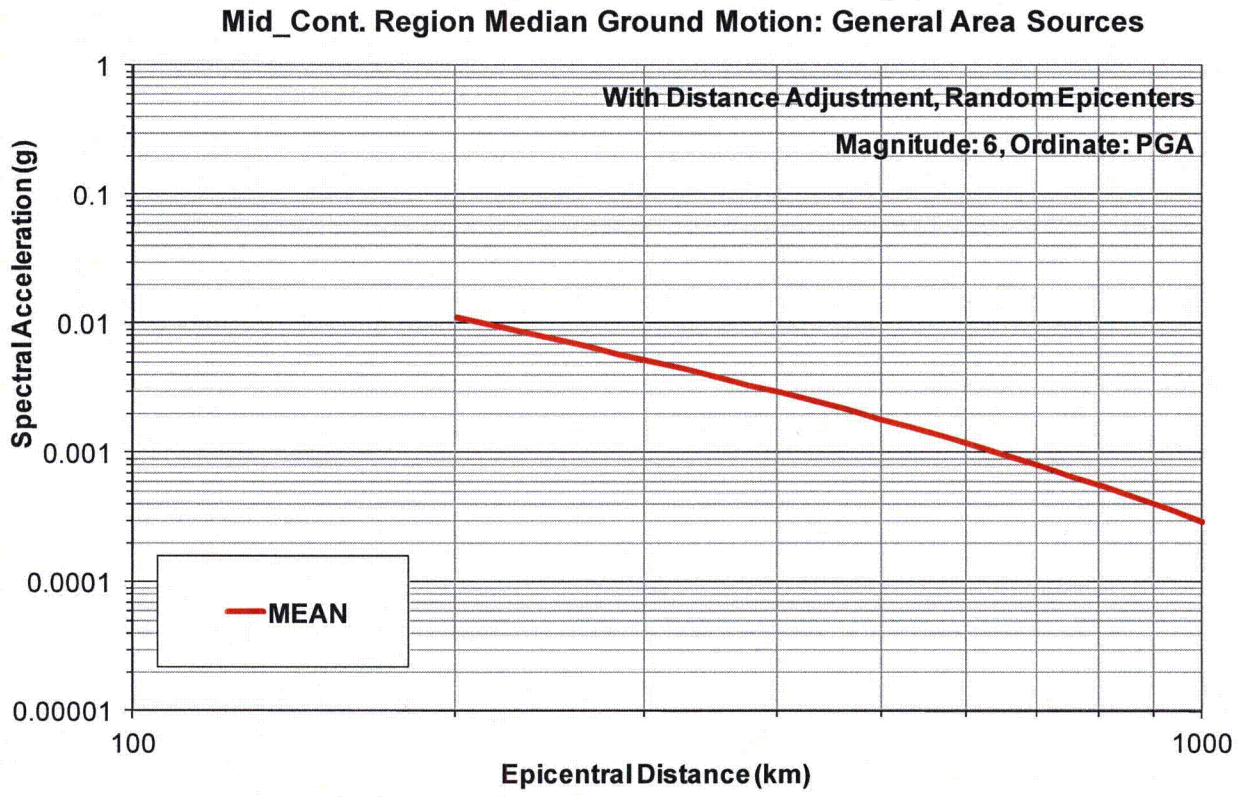


Figure 1a. EPRI (FSAR Reference 242) Mid Continent PGA weighted mean attenuation curve for a magnitude 6 earthquake.

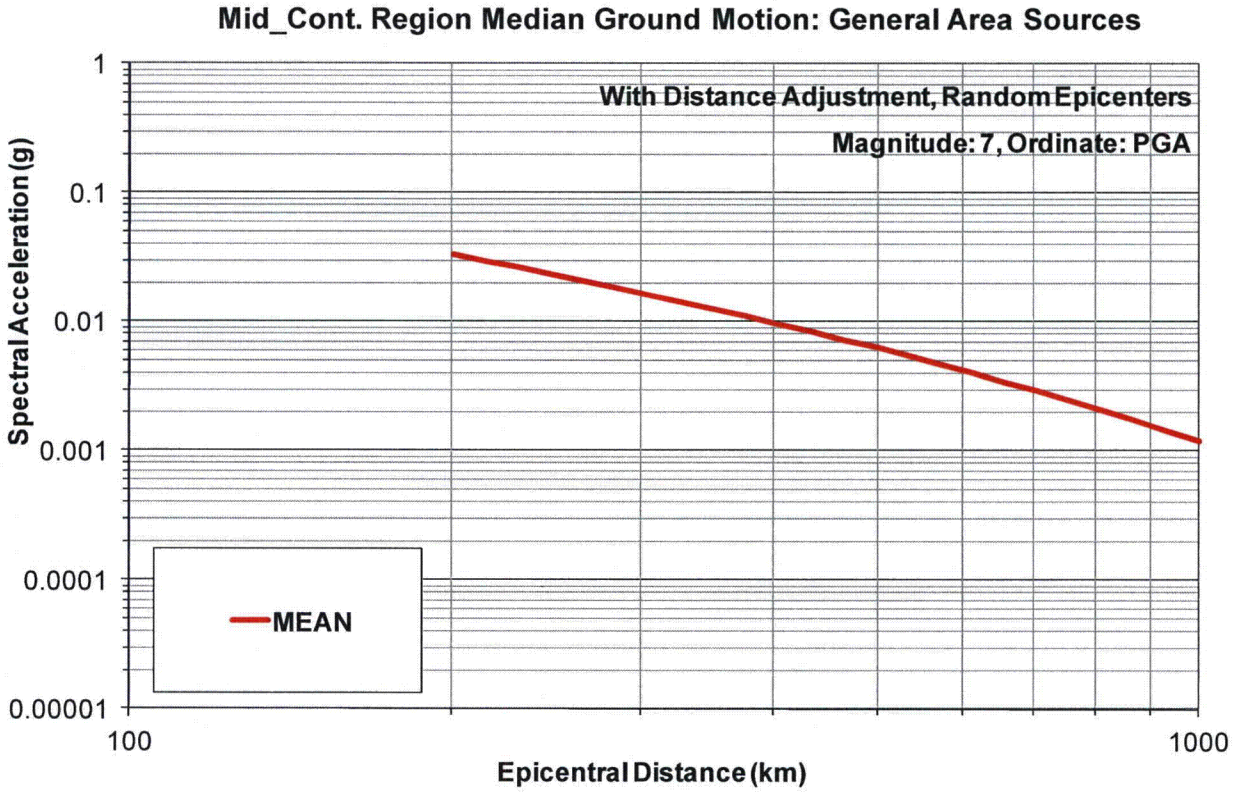


Figure 1b. EPRI (FSAR Reference 242) Mid Continent PGA weighted mean attenuation curve for a magnitude 7 earthquake.

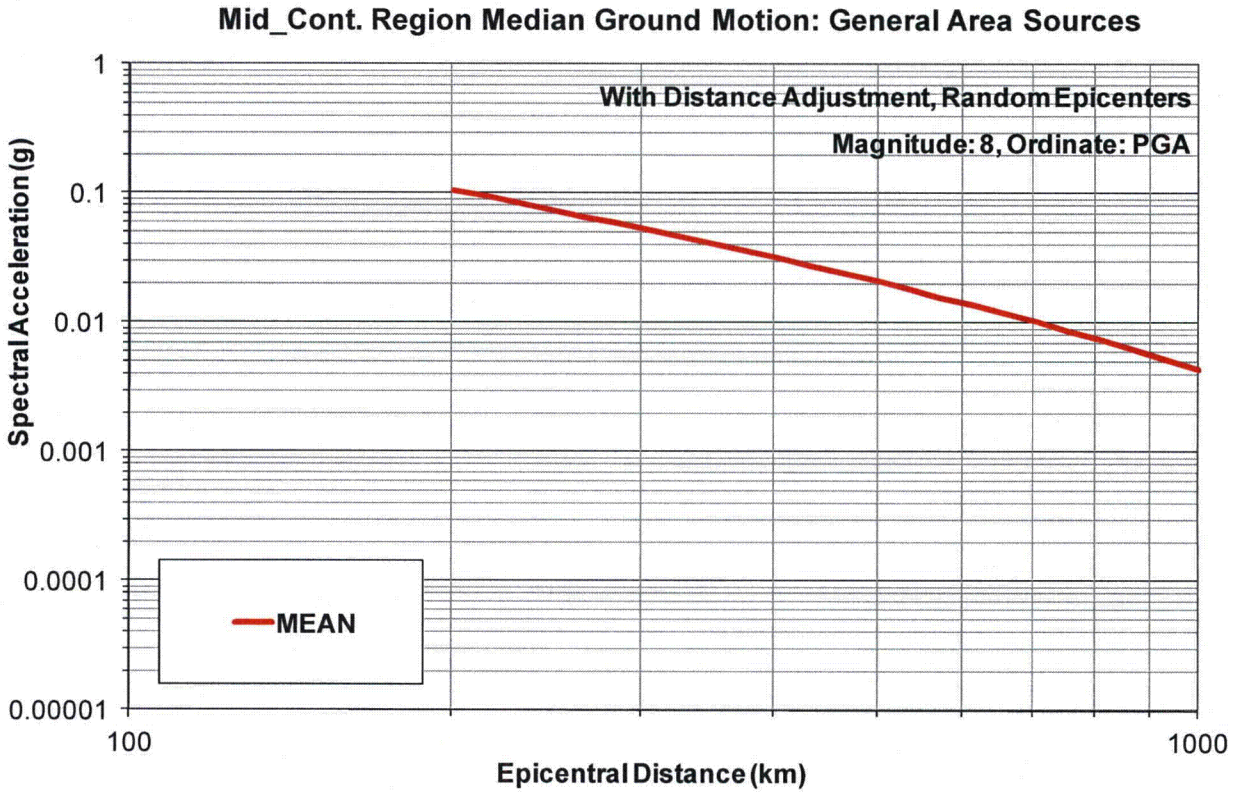


Figure 1c. EPRI (FSAR Reference 242) Mid Continent PGA weighted mean attenuation curve for a magnitude 8 earthquake.

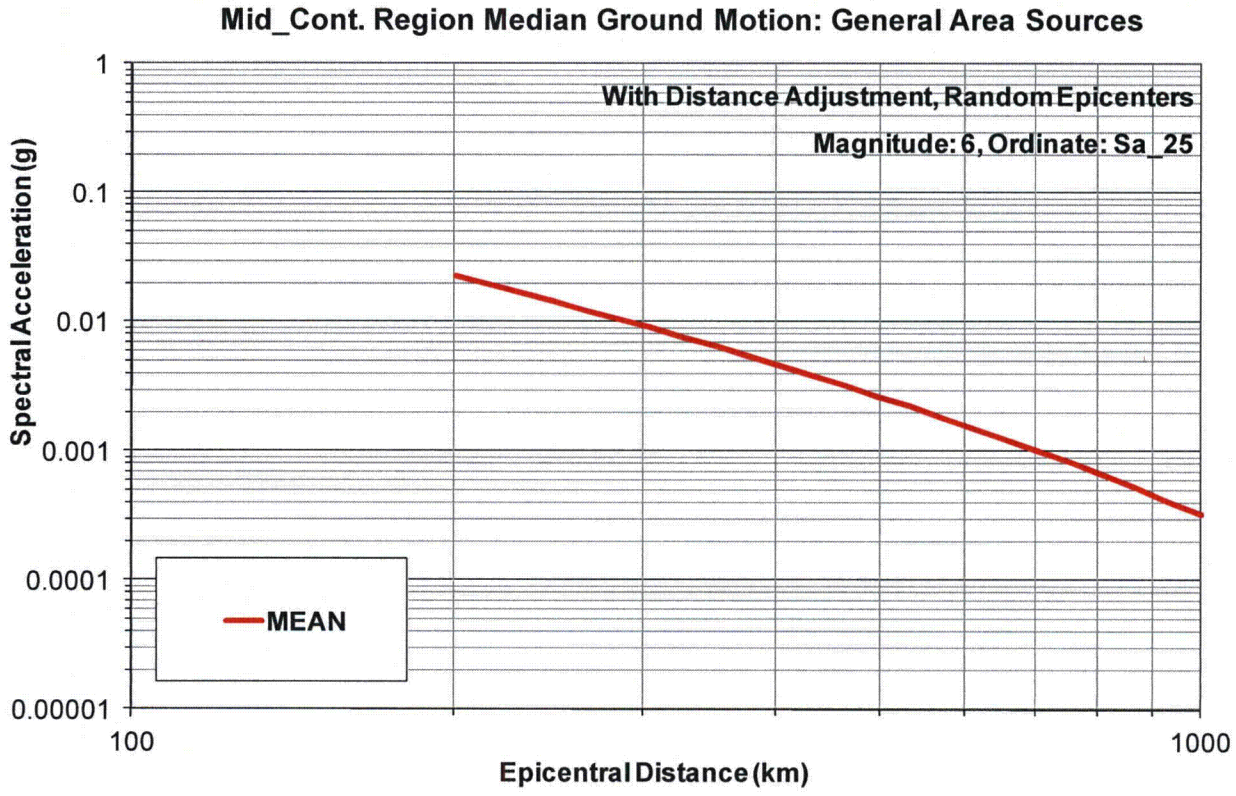


Figure 2a. EPRI (FSAR Reference 242) Mid Continent 25Hz weighted mean attenuation curve for a magnitude 6 earthquake.

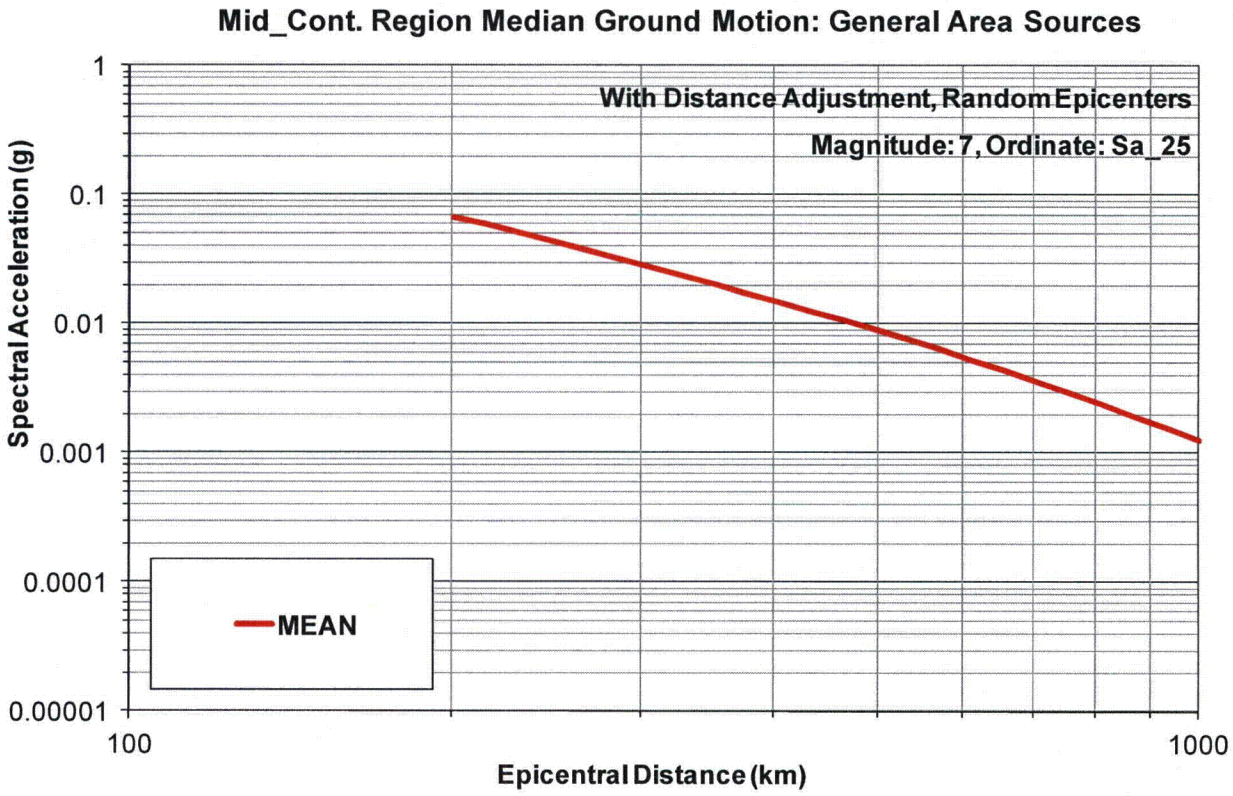


Figure 2b. EPRI (FSAR Reference 242) Mid Continent 25Hz weighted mean attenuation curve for a magnitude 7 earthquake.

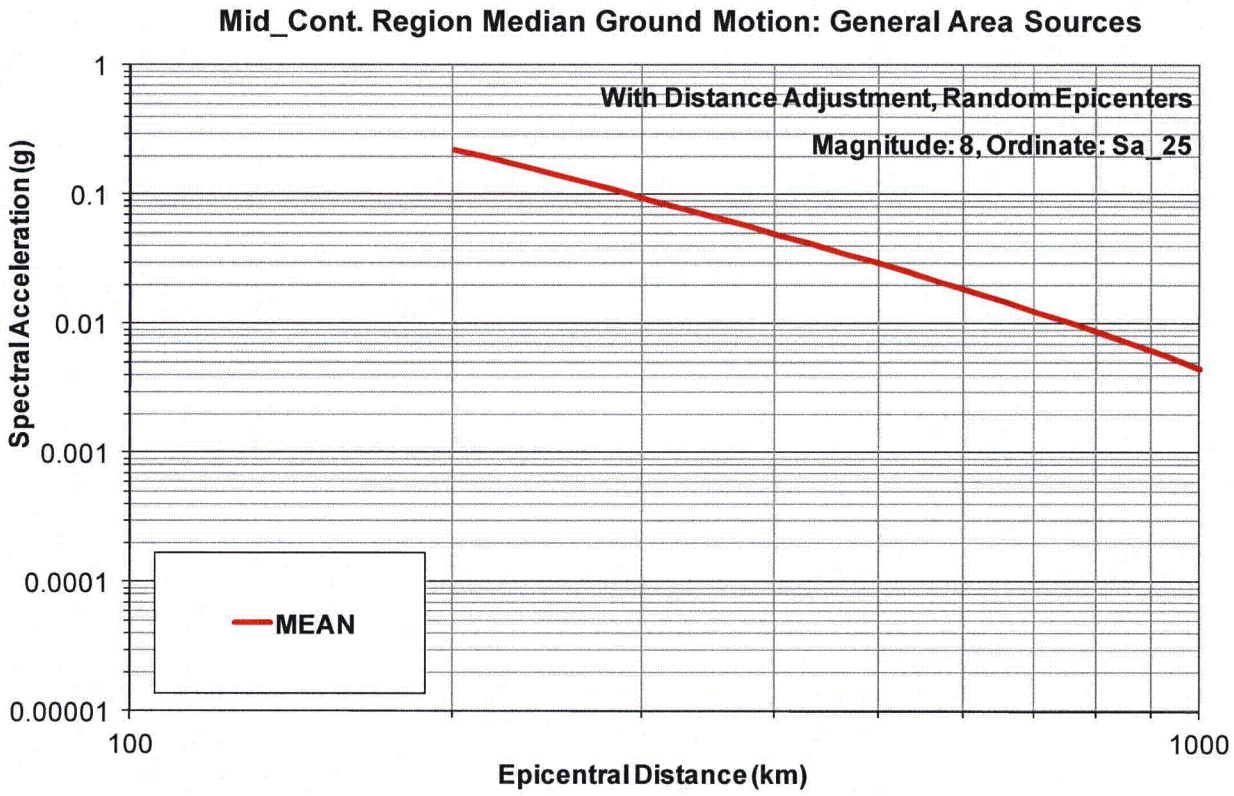


Figure 2c. EPRI (FSAR Reference 242) Mid Continent 25Hz weighted mean attenuation curve for a magnitude 8 earthquake.

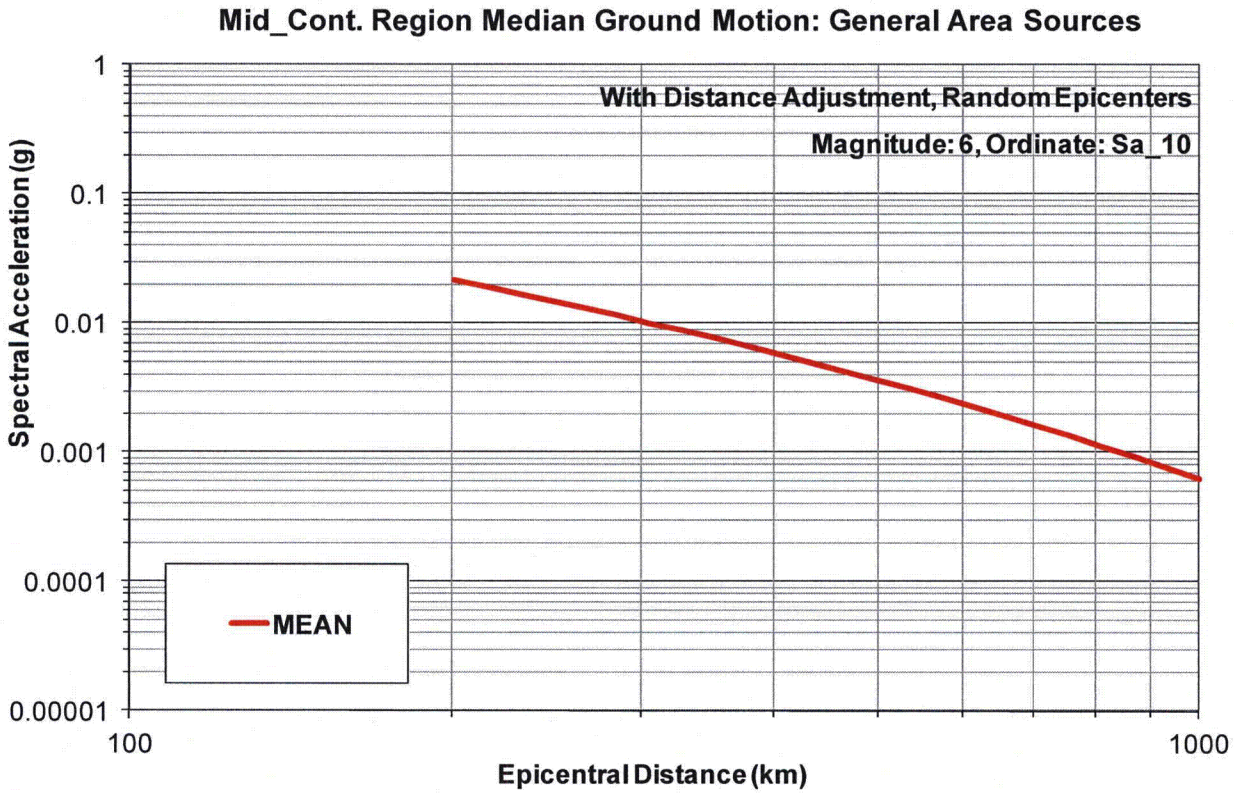


Figure 3a. EPRI (FSAR Reference 242) Mid Continent 10Hz weighted mean attenuation curve for a magnitude 6 earthquake.

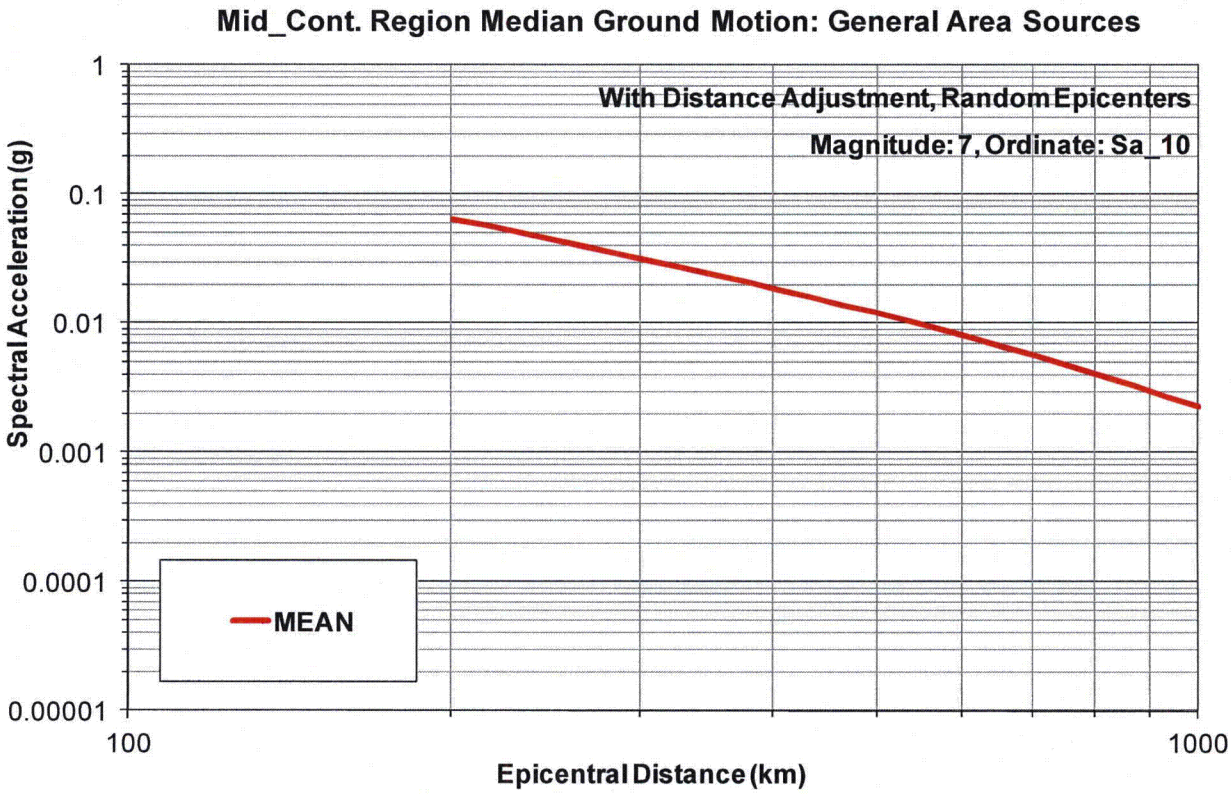


Figure 3b. EPRI (FSAR Reference 242) Mid Continent 10Hz weighted mean attenuation curve for a magnitude 7 earthquake.

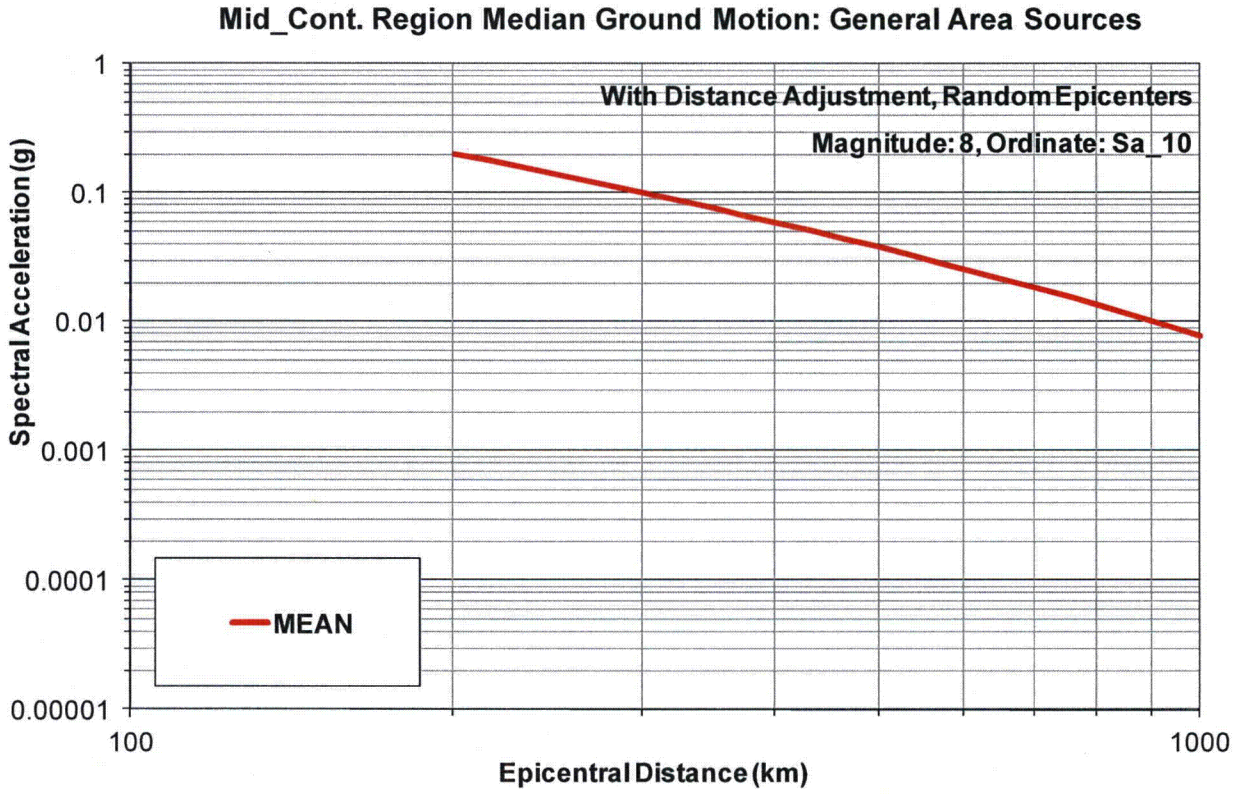


Figure 3c. EPRI (FSAR Reference 242) Mid Continent 10Hz weighted mean attenuation curve for a magnitude 8 earthquake.

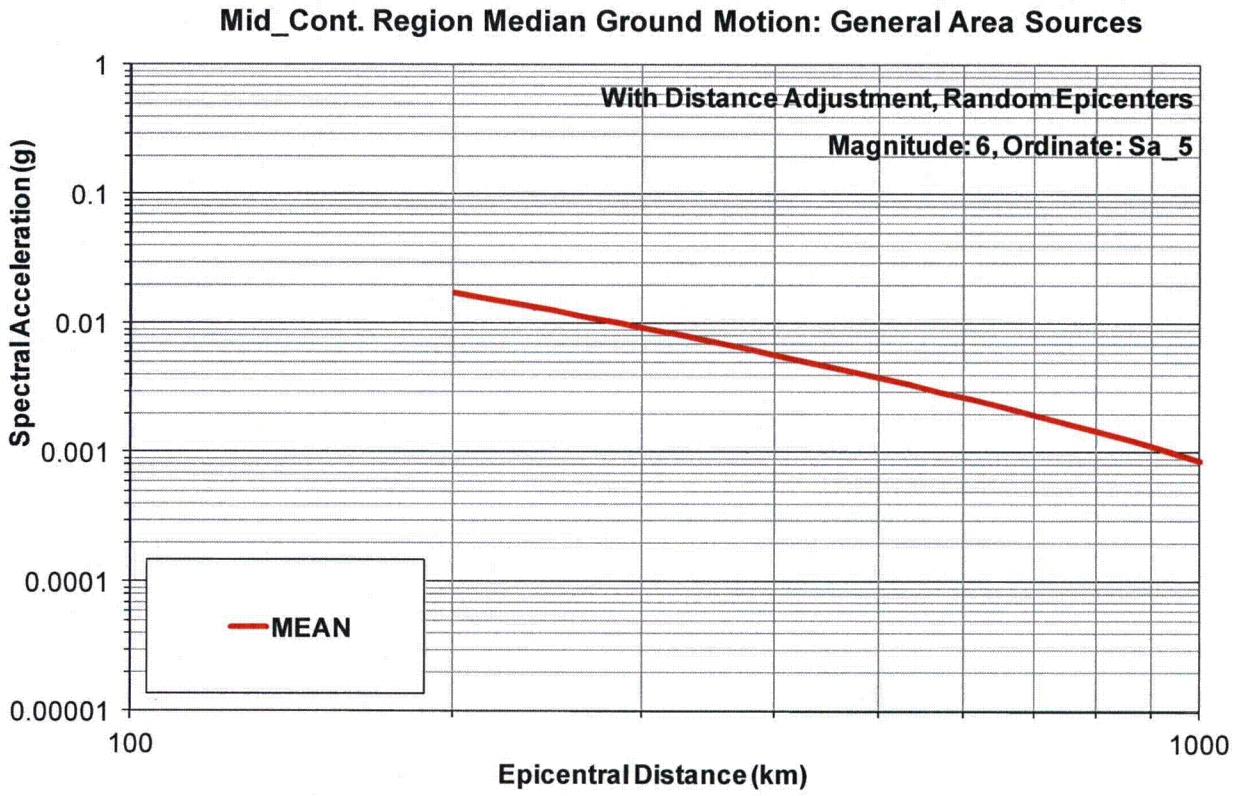


Figure 4a. EPRI (FSAR Reference 242) Mid Continent 5Hz weighted mean attenuation curve for a magnitude 6 earthquake.

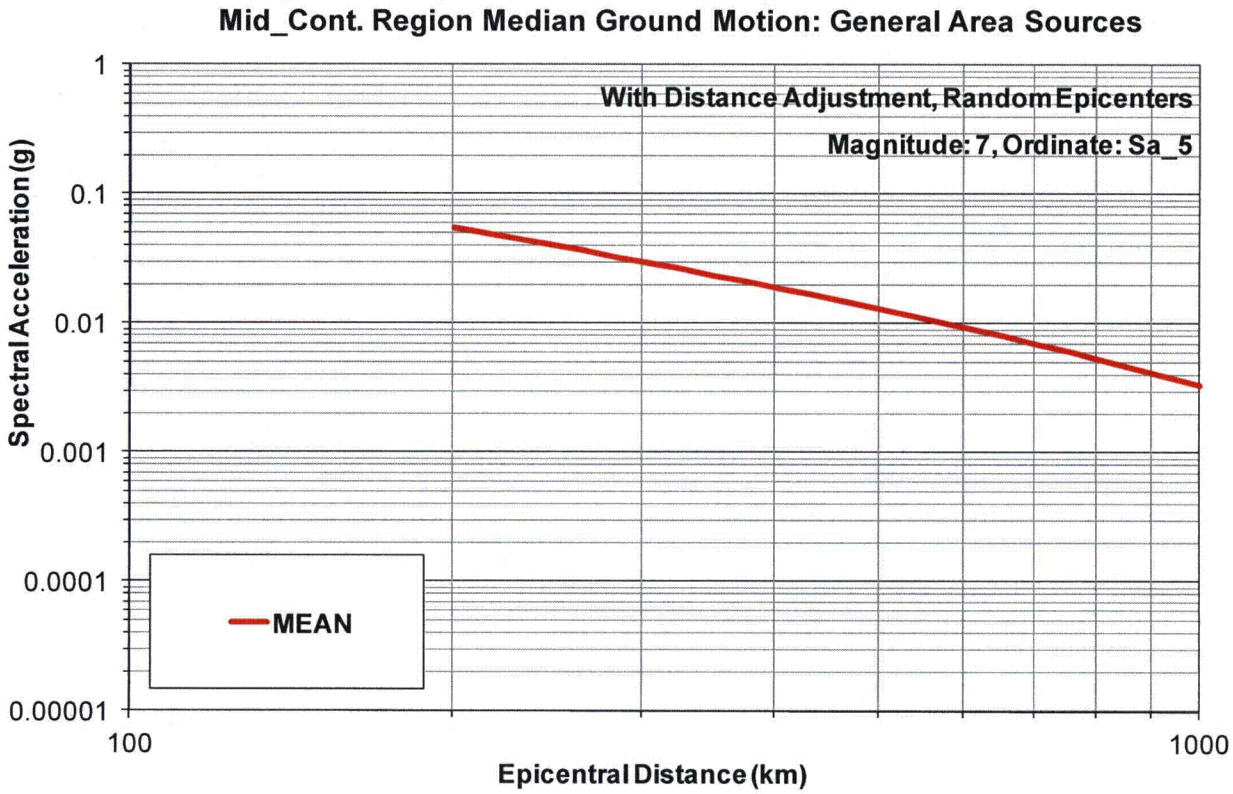


Figure 4b. EPRI (FSAR Reference 242) Mid Continent 5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

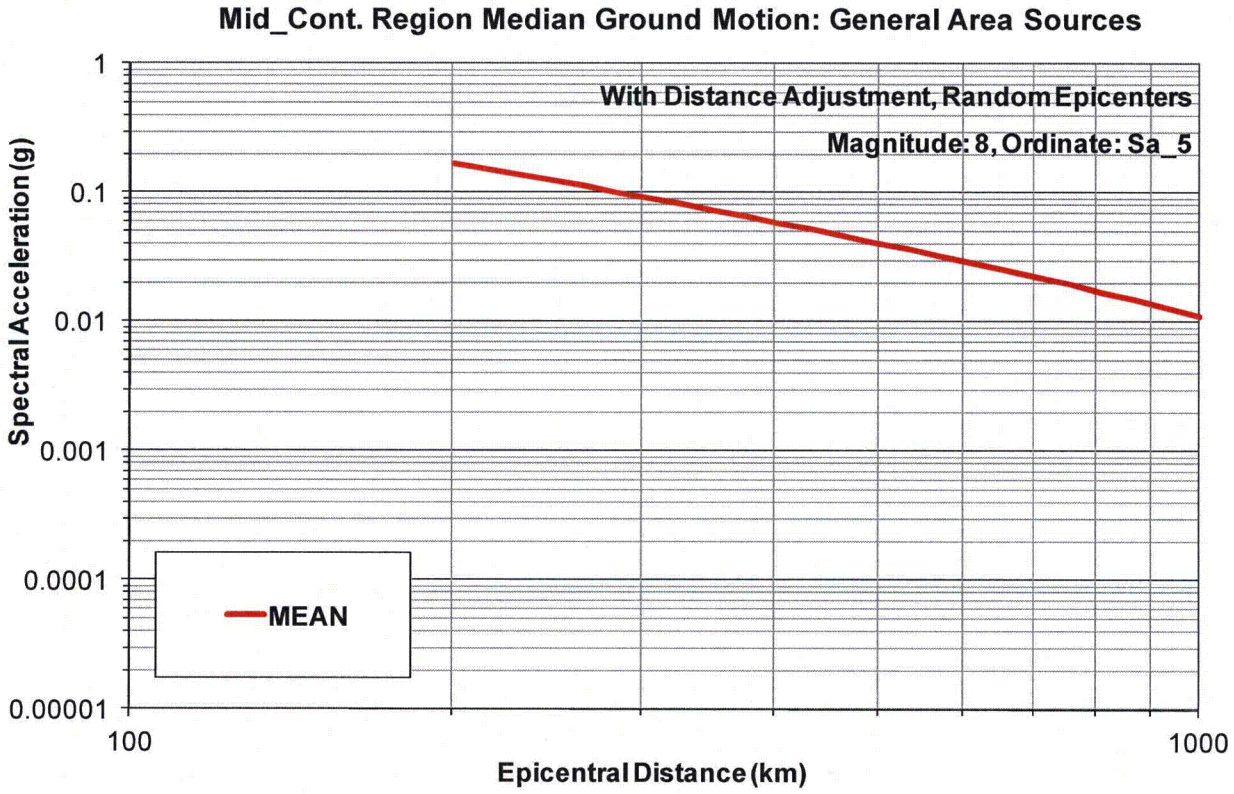


Figure 4c. EPRI (FSAR Reference 242) Mid Continent 5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

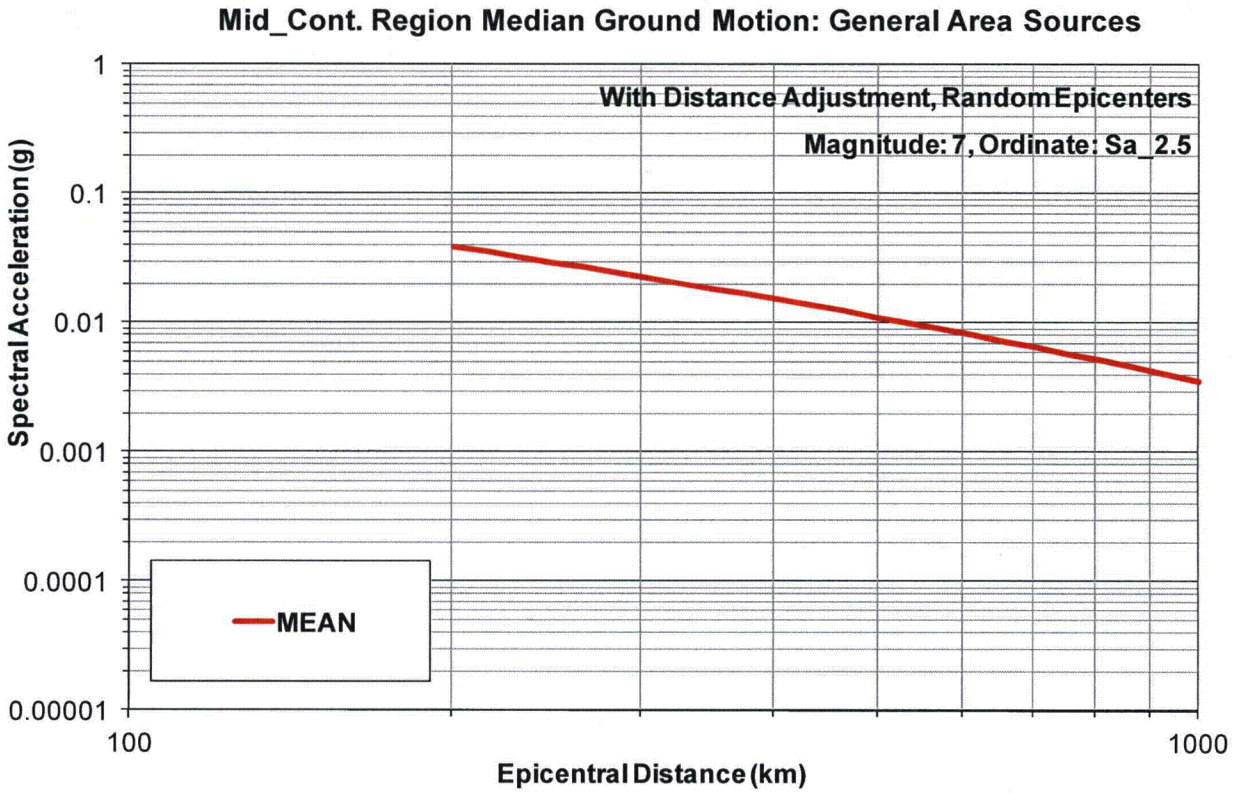


Figure 5b. EPRI (FSAR Reference 242) Mid Continent 2.5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

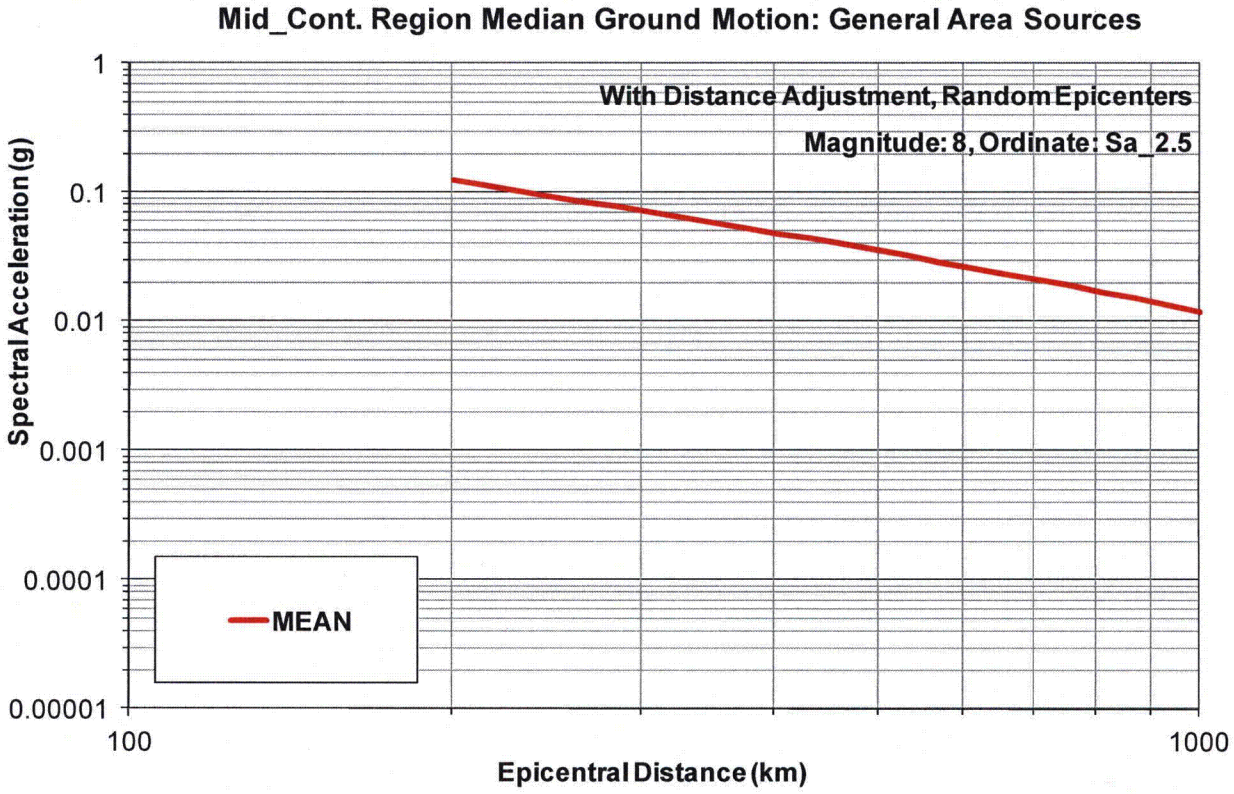


Figure 5c. EPRI (FSAR Reference 242) Mid Continent 2.5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

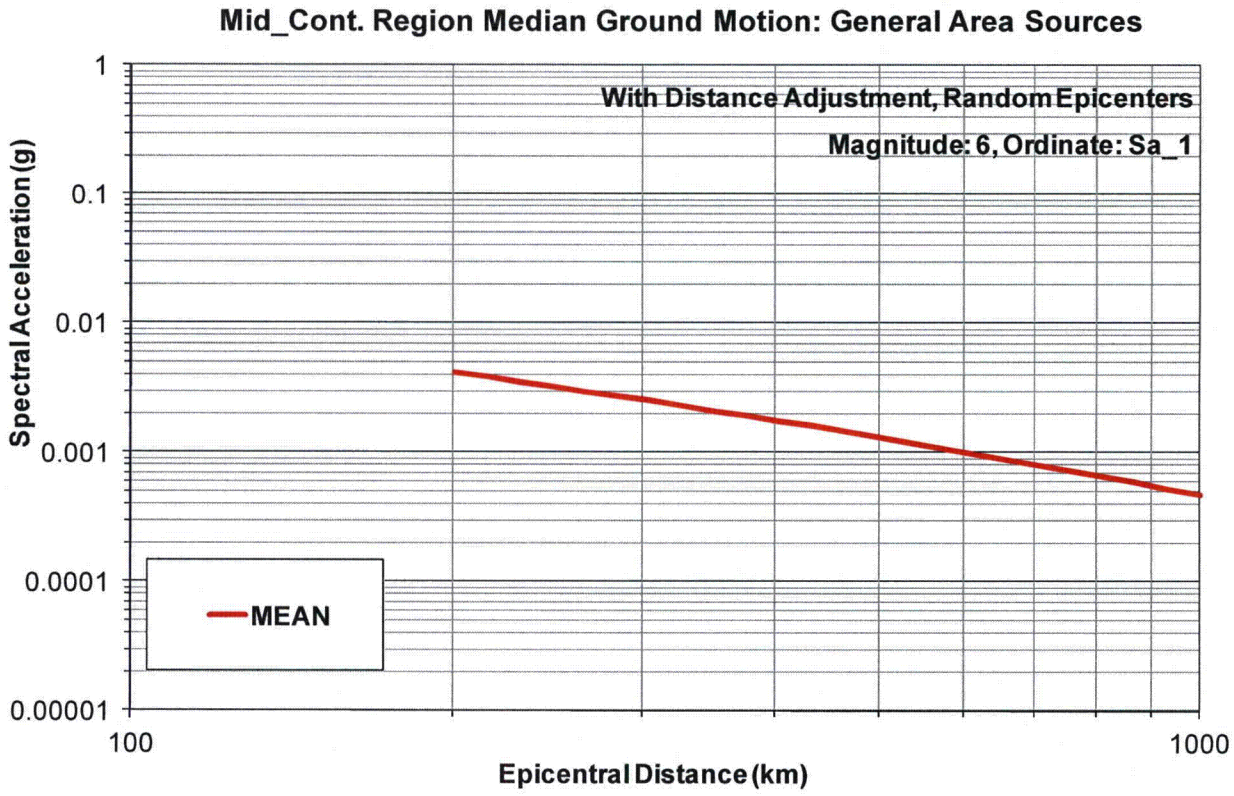


Figure 6a. EPRI (FSAR Reference 242) Mid Continent 1Hz weighted mean attenuation curve for a magnitude 6 earthquake.

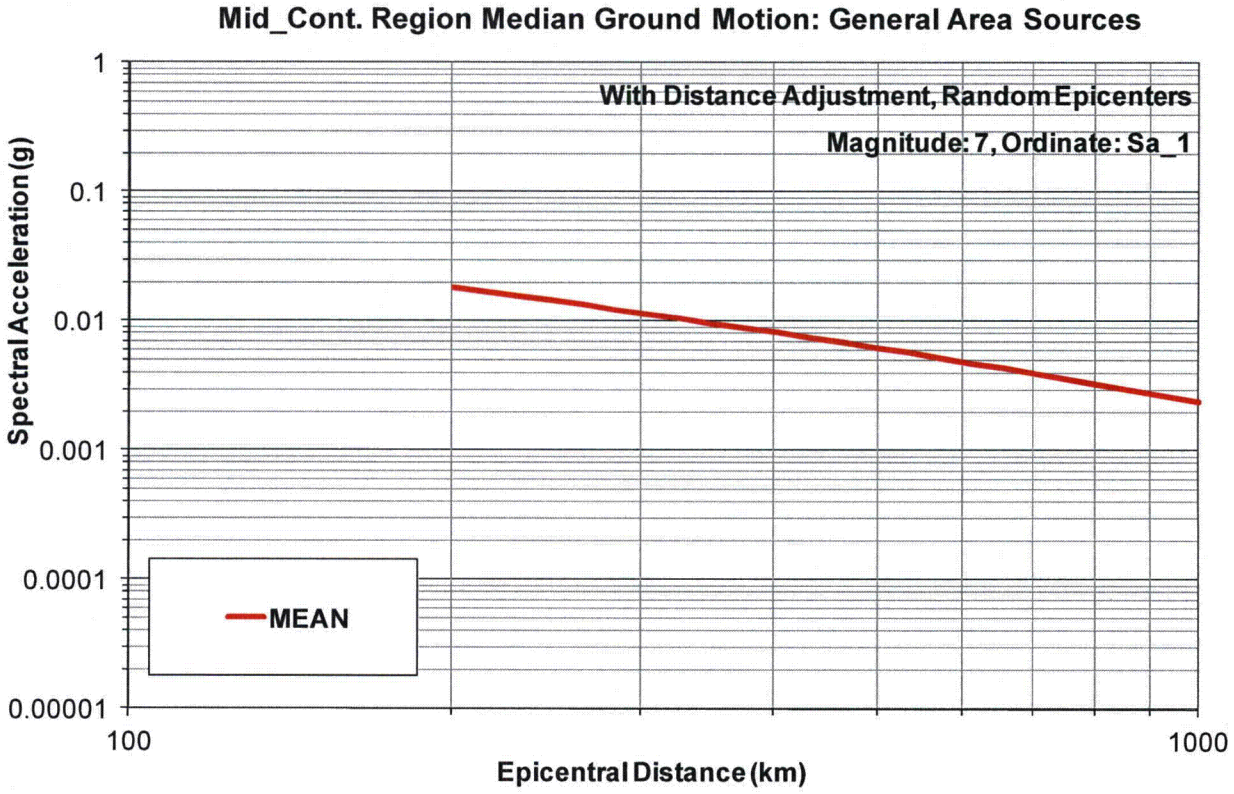


Figure 6b. EPRI (FSAR Reference 242) Mid Continent 1Hz weighted mean attenuation curve for a magnitude 7 earthquake.

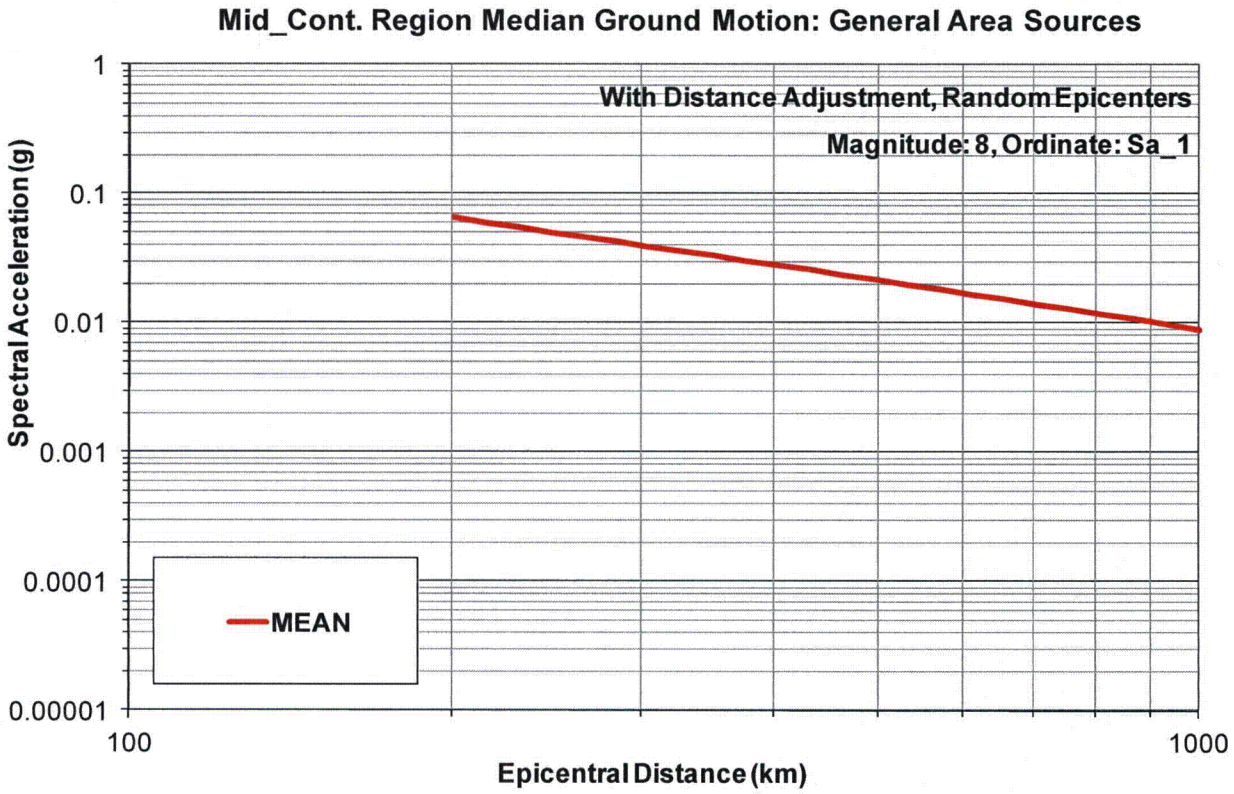


Figure 6c. EPRI (FSAR Reference 242) Mid Continent 1Hz weighted mean attenuation curve for a magnitude 8 earthquake.

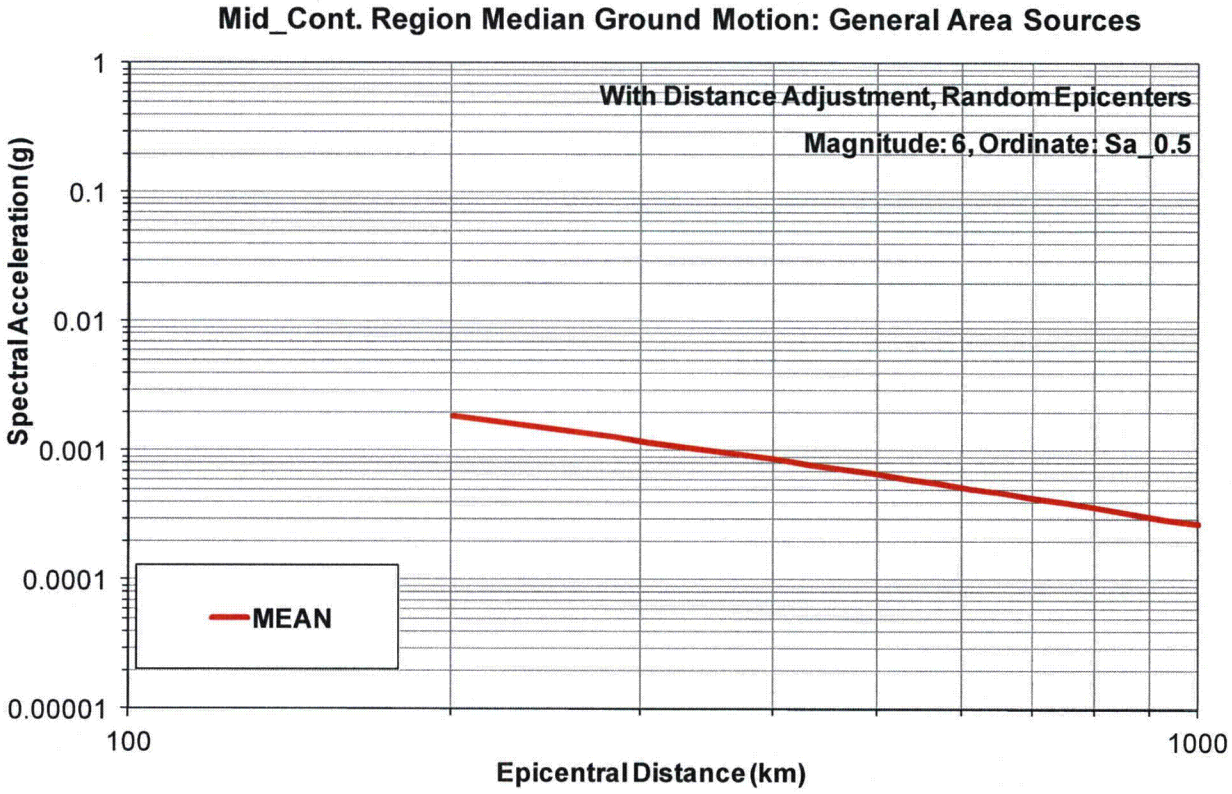


Figure 7a. EPRI (FSAR Reference 242) Mid Continent 0.5Hz weighted mean attenuation curve for a magnitude 6 earthquake.

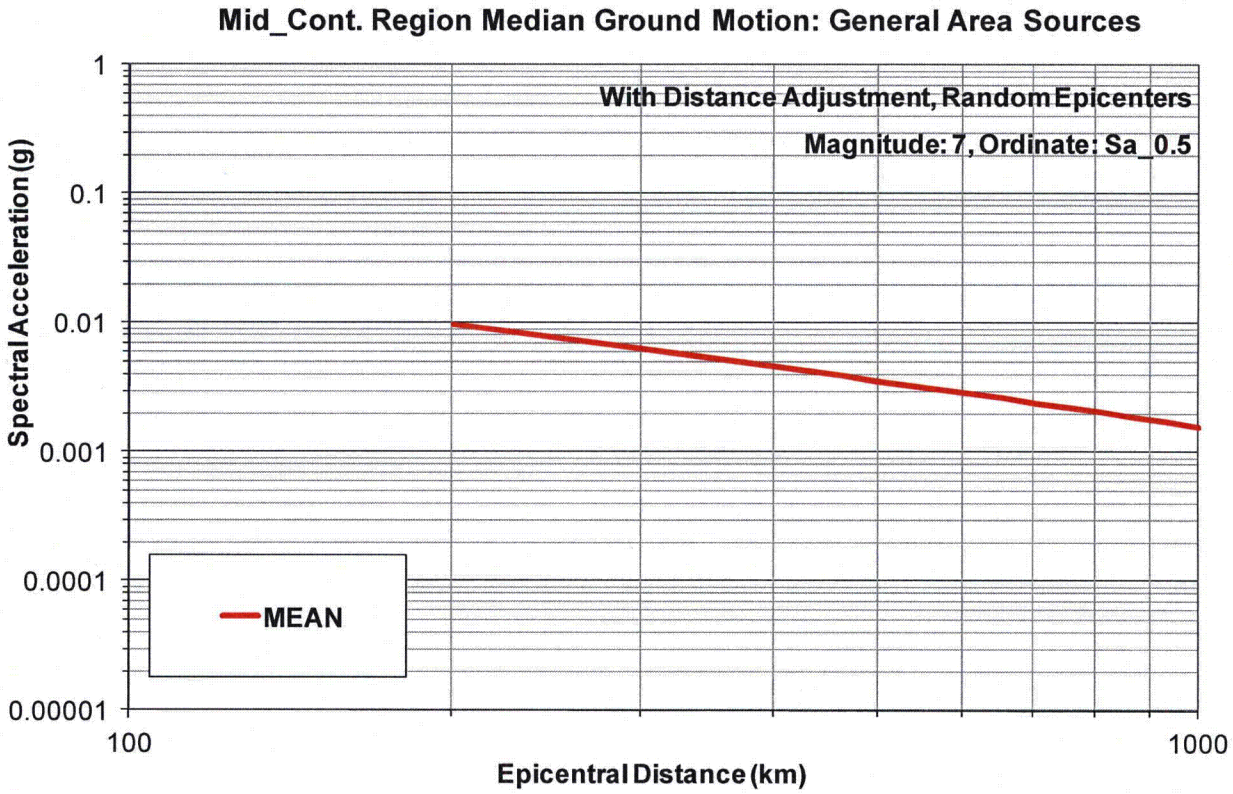


Figure 7b. EPRI (FSAR Reference 242) Mid Continent 0.5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

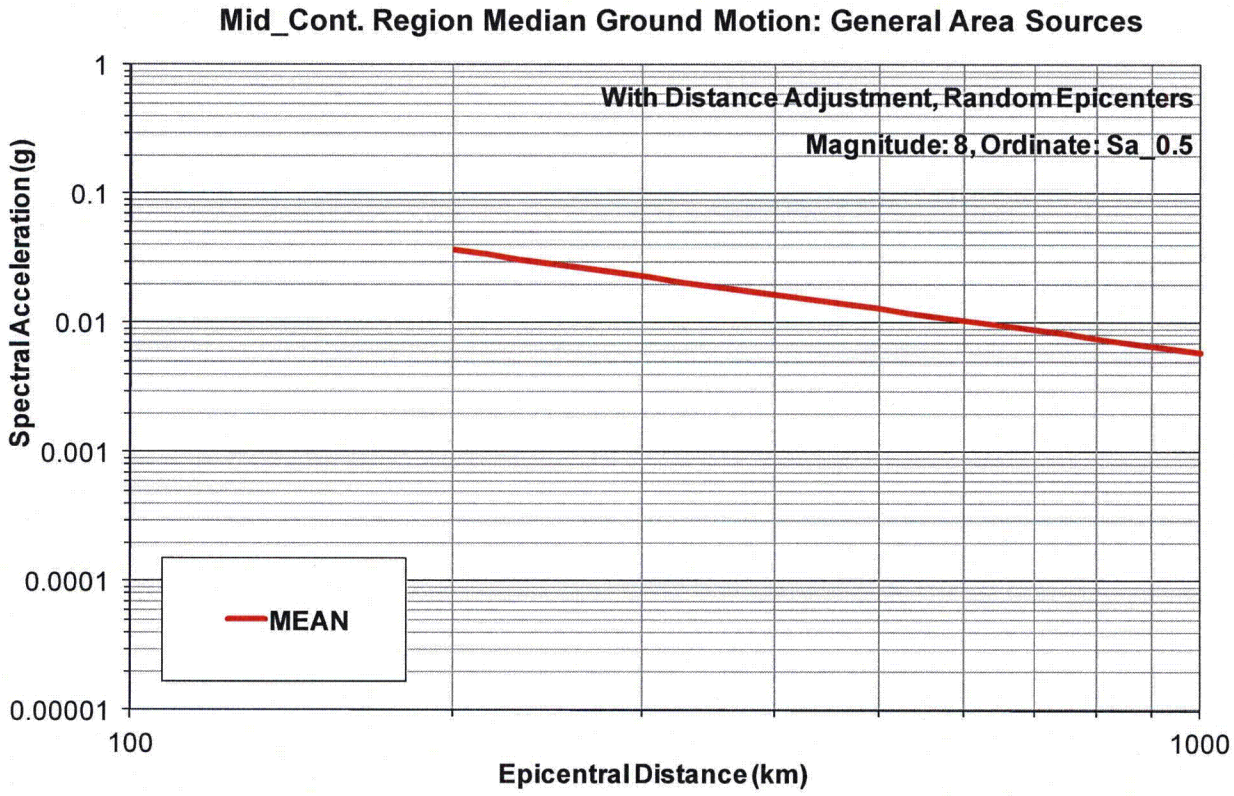


Figure 7c. EPRI (FSAR Reference 242) Mid Continent 0.5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

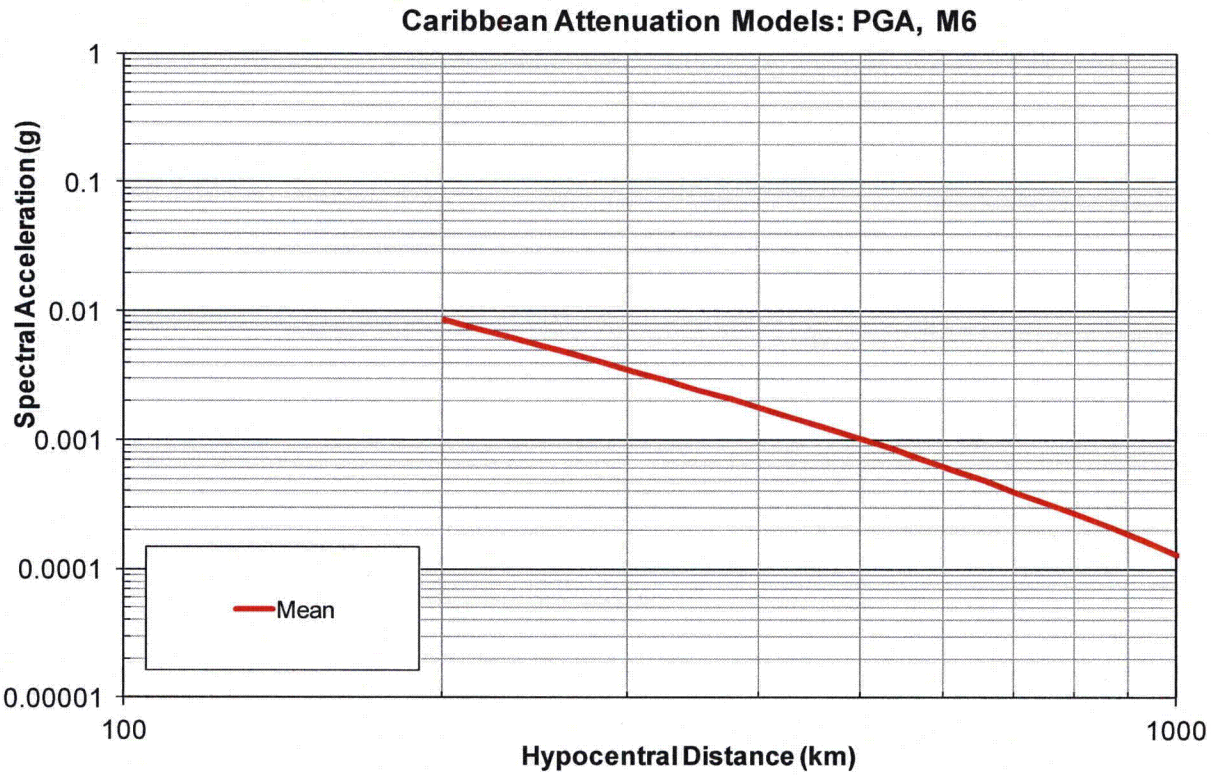


Figure 8a. Caribbean PGA weighted mean attenuation curve for a magnitude 6 earthquake.

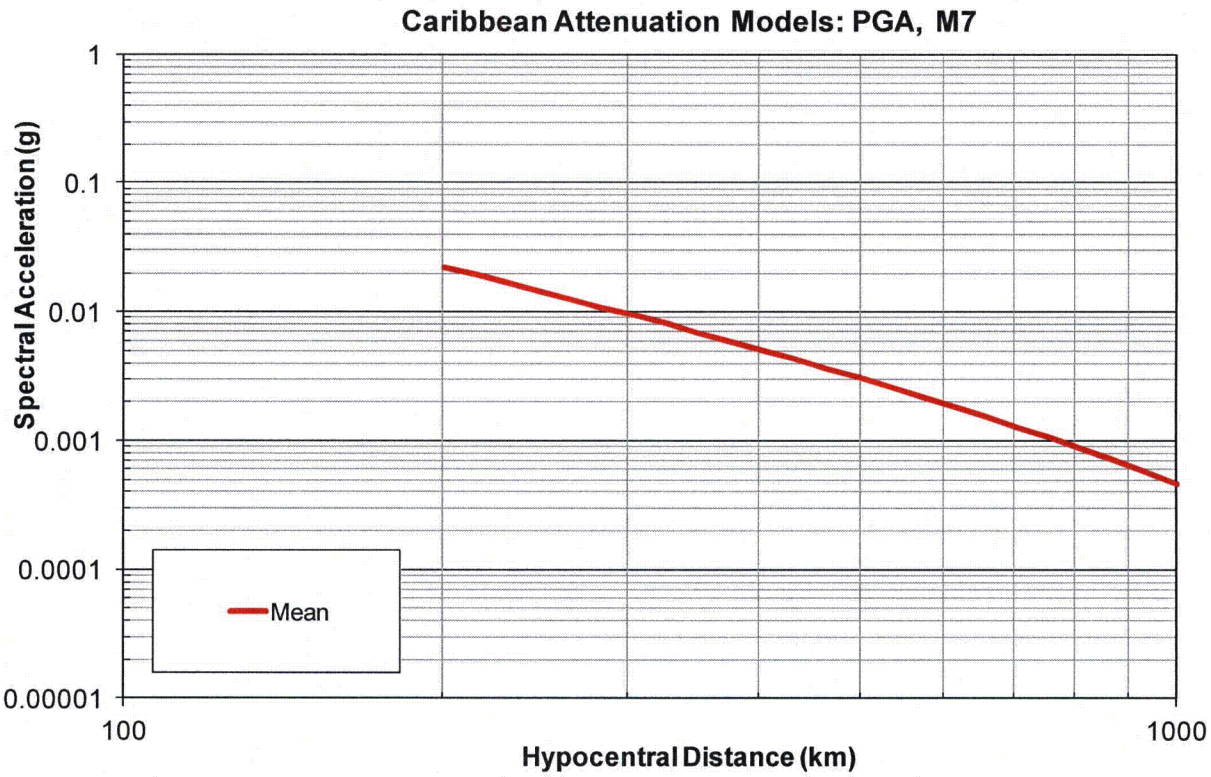


Figure 8b. Caribbean PGA weighted mean attenuation curve for a magnitude 7 earthquake.

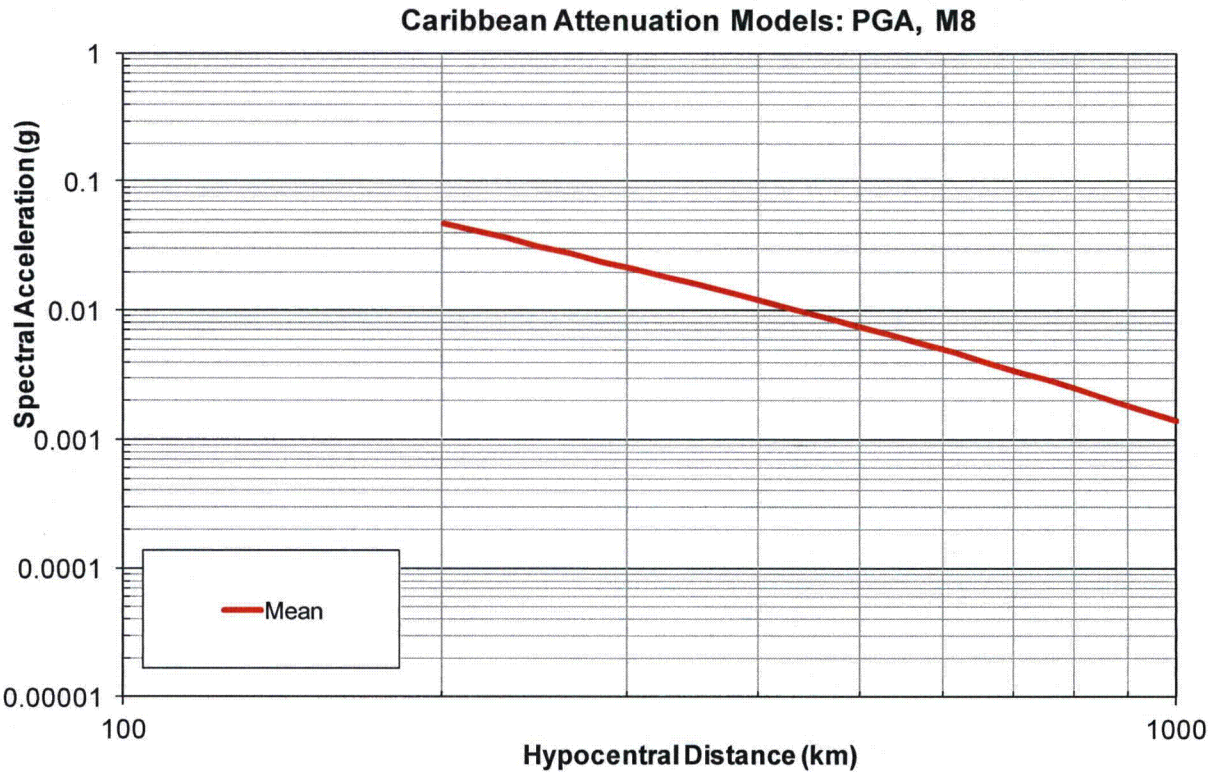


Figure 8c. Caribbean PGA weighted mean attenuation curve for a magnitude 8 earthquake.

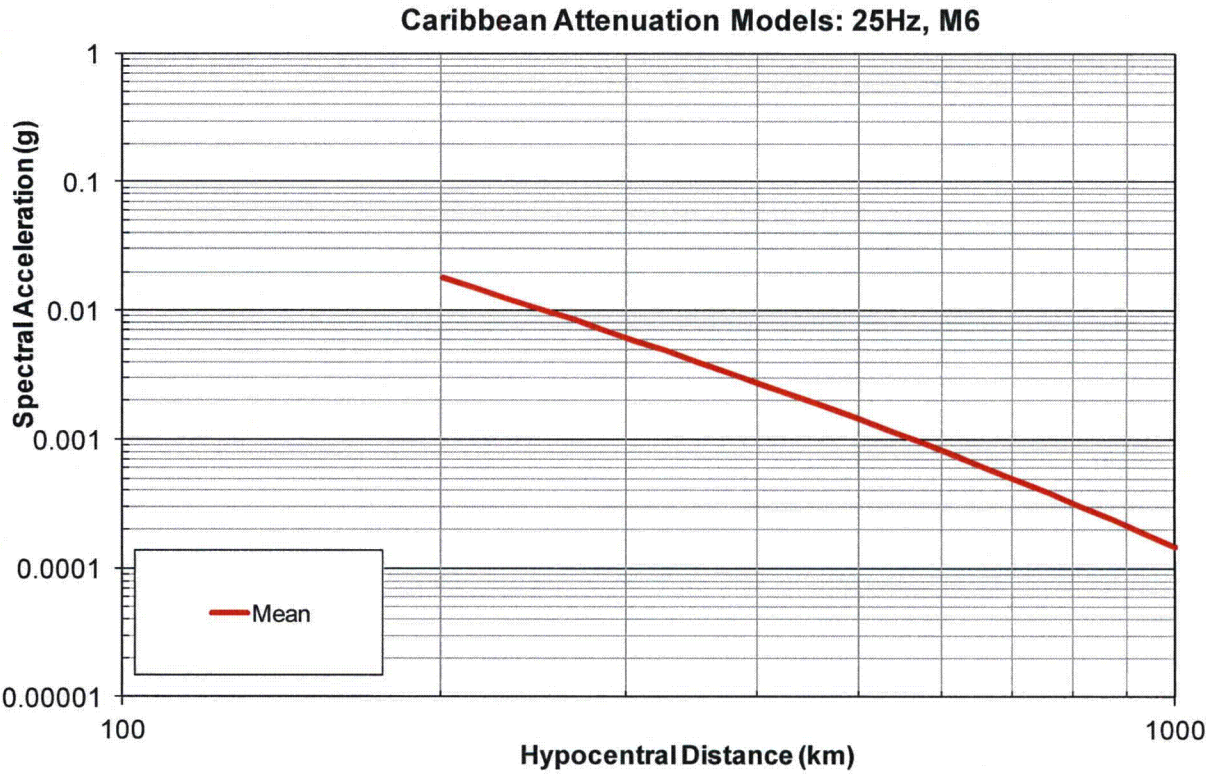


Figure 9a. Caribbean 25Hz weighted mean attenuation curve for a magnitude 6 earthquake.

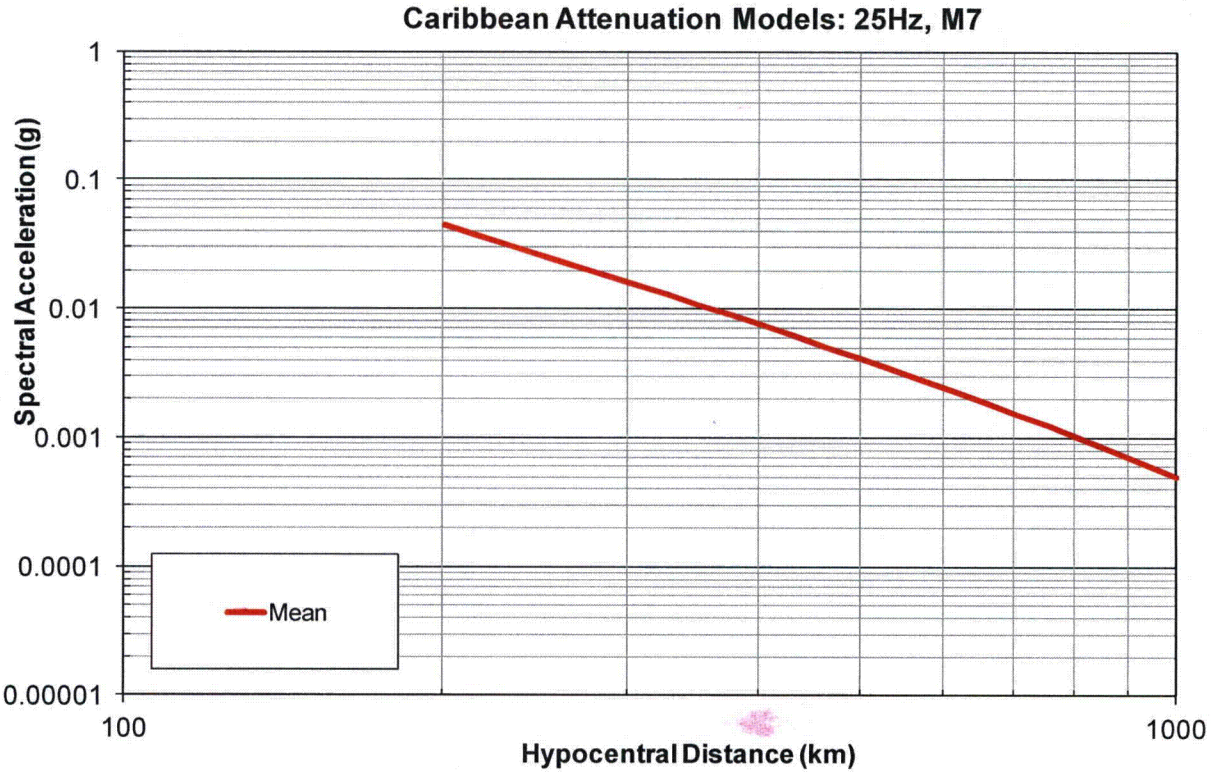


Figure 9b. Caribbean 25Hz weighted mean attenuation curve for a magnitude 7 earthquake.

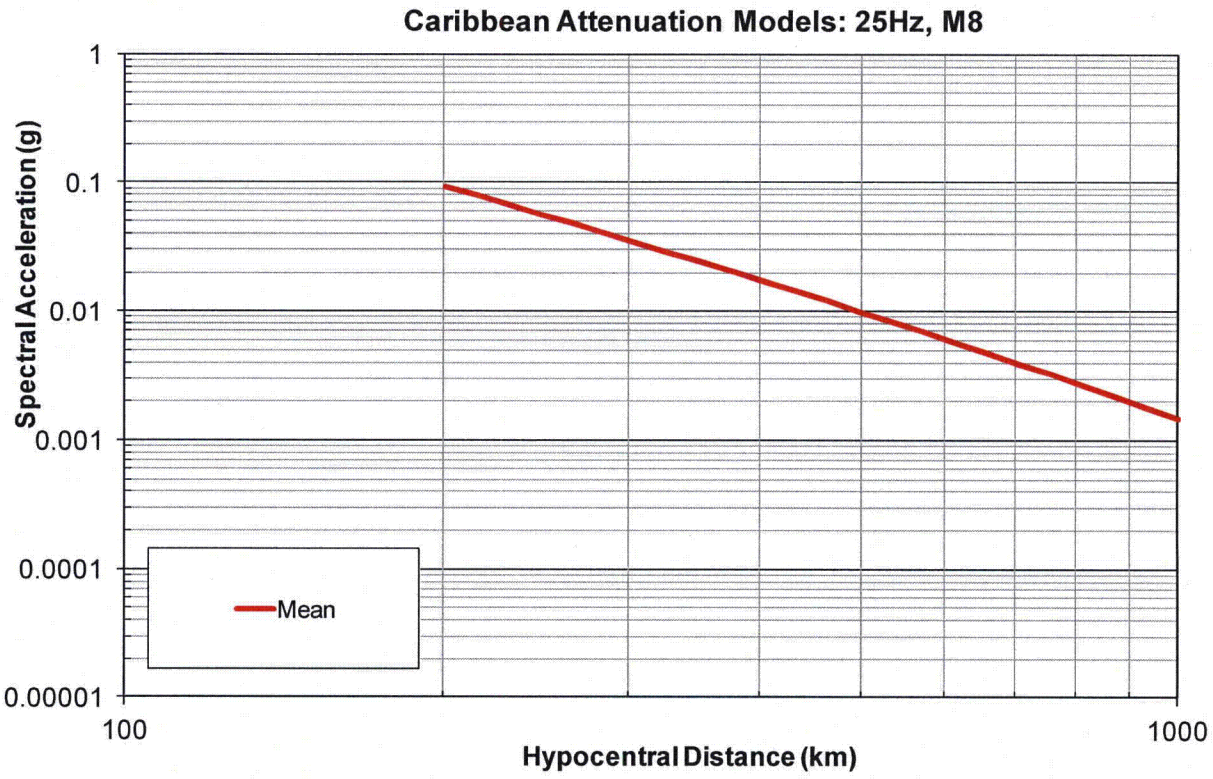


Figure 9c. Caribbean 25Hz weighted mean attenuation curve for a magnitude 8 earthquake.

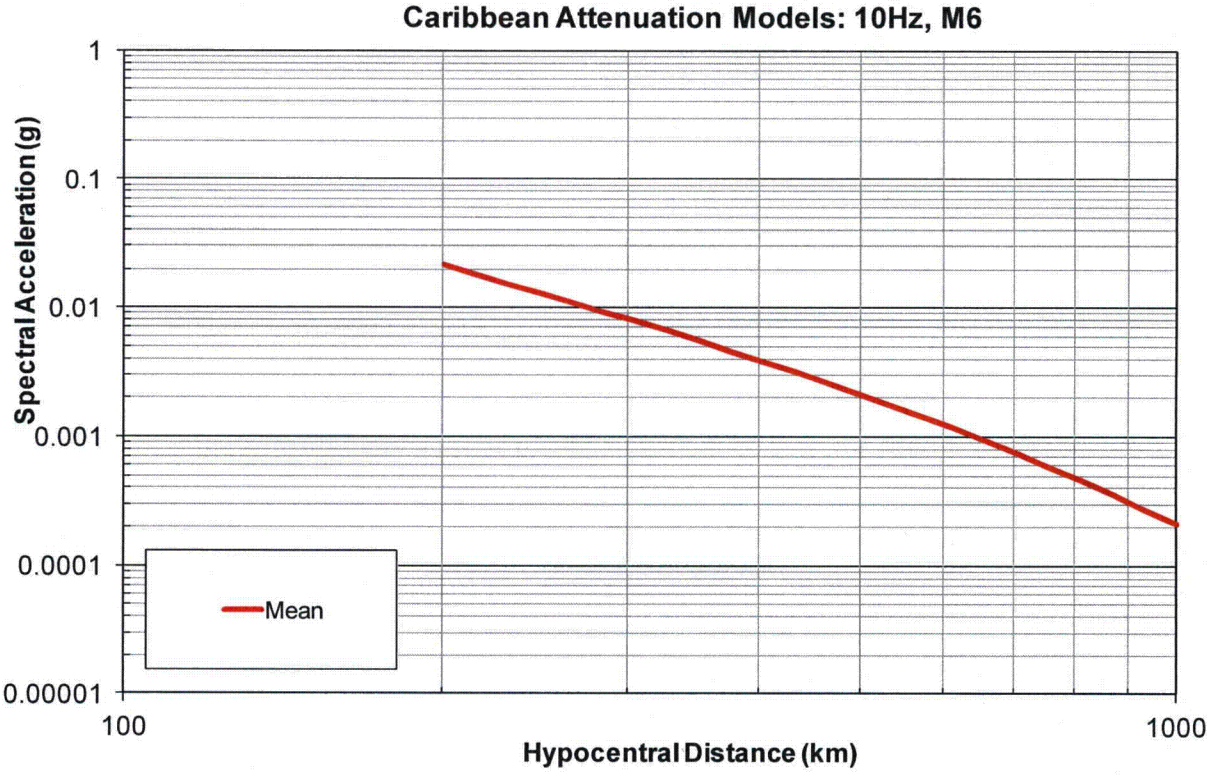


Figure 10a. Caribbean 10Hz weighted mean attenuation curve for a magnitude 6 earthquake.

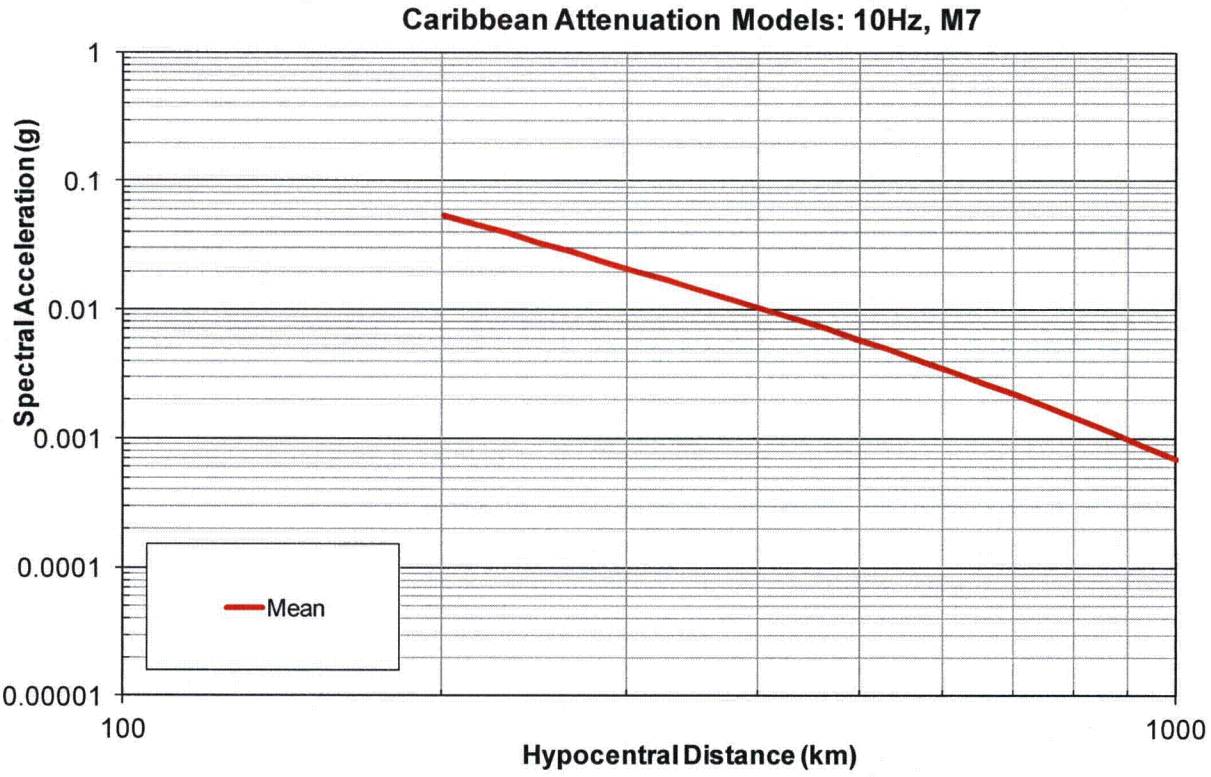


Figure 10b. Caribbean 10Hz weighted mean attenuation curve for a magnitude 7 earthquake.

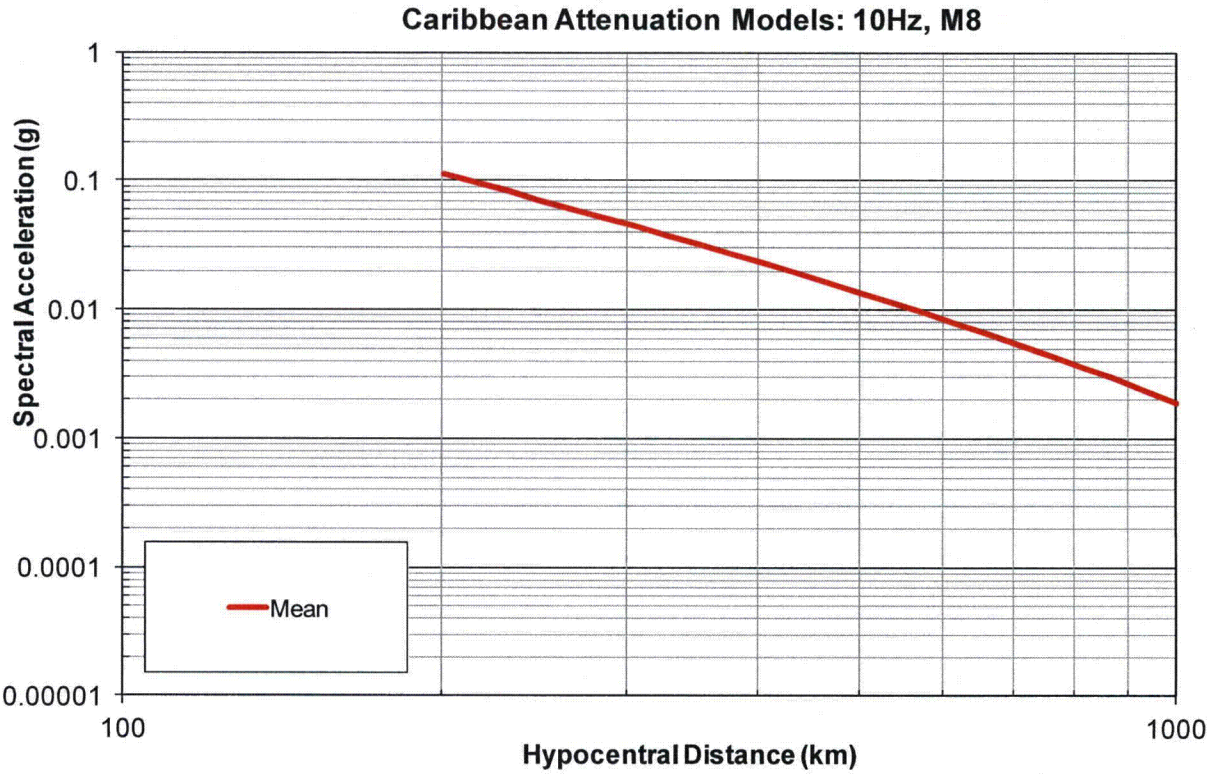


Figure 10c. Caribbean 10Hz weighted mean attenuation curve for a magnitude 8 earthquake.

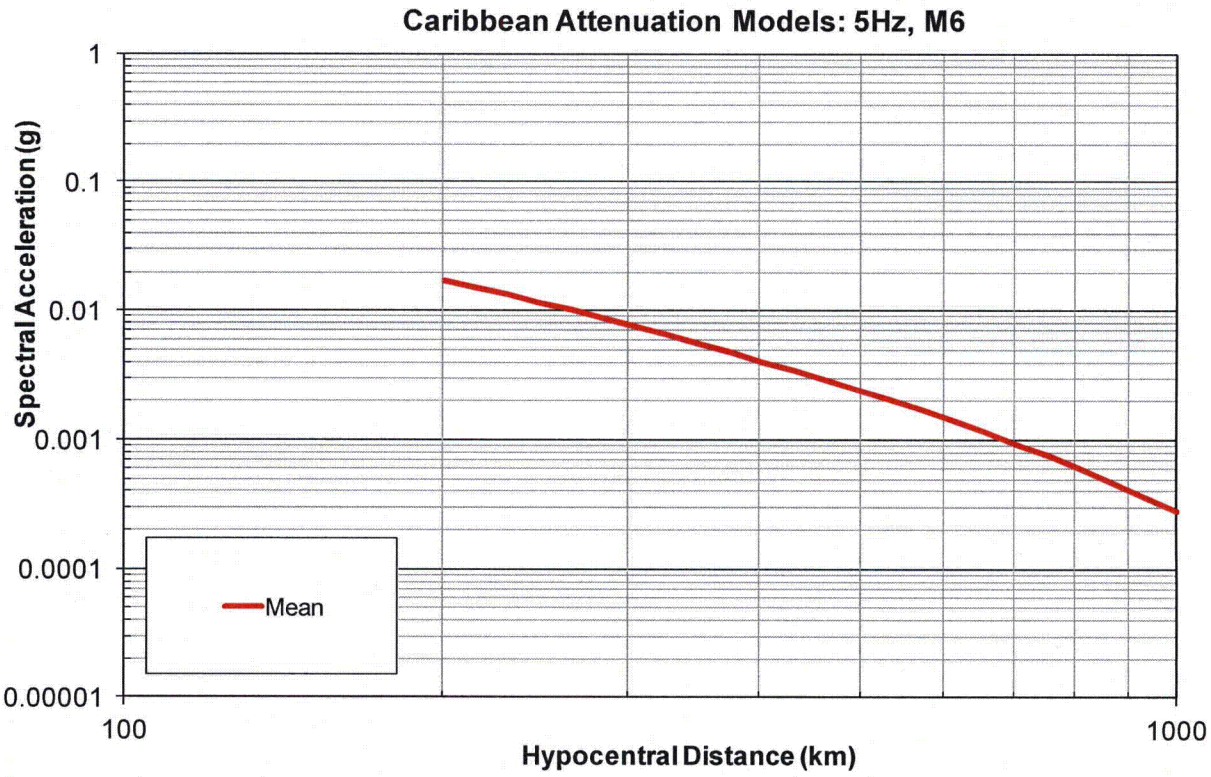


Figure 11a. Caribbean 5Hz weighted mean attenuation curve for a magnitude 6 earthquake.

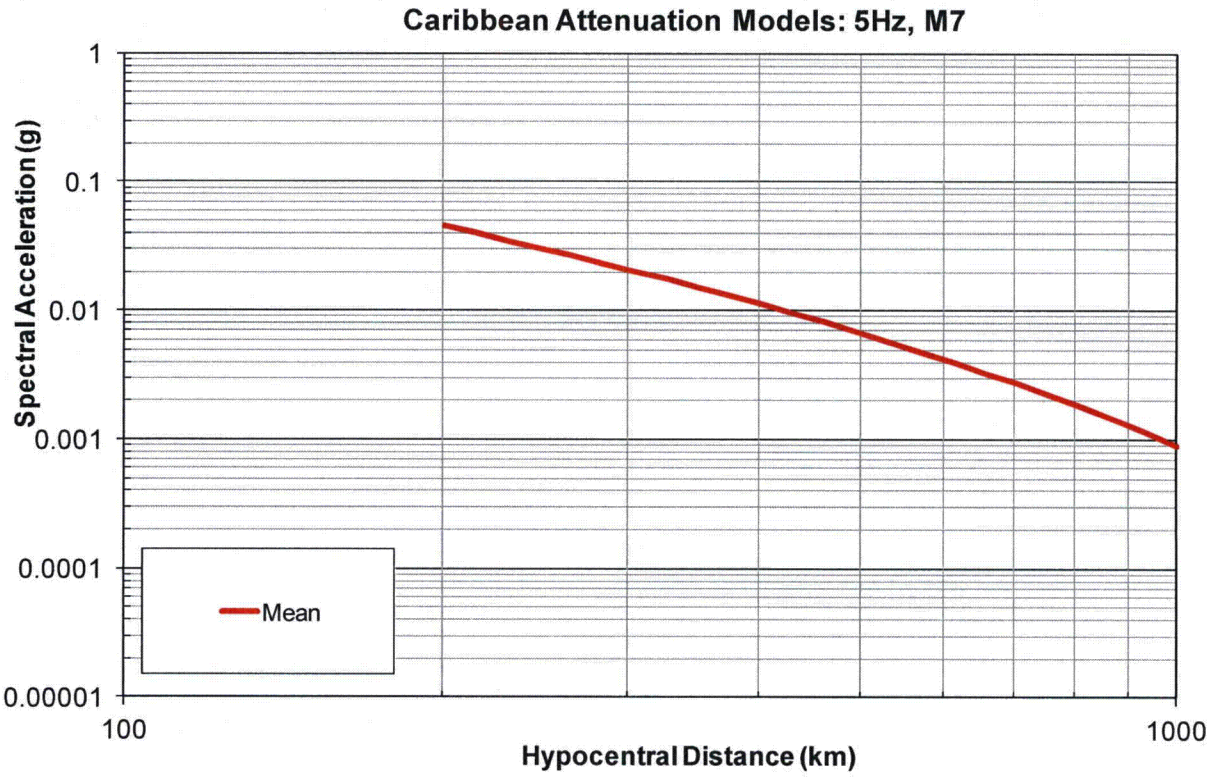


Figure 11b. Caribbean 5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

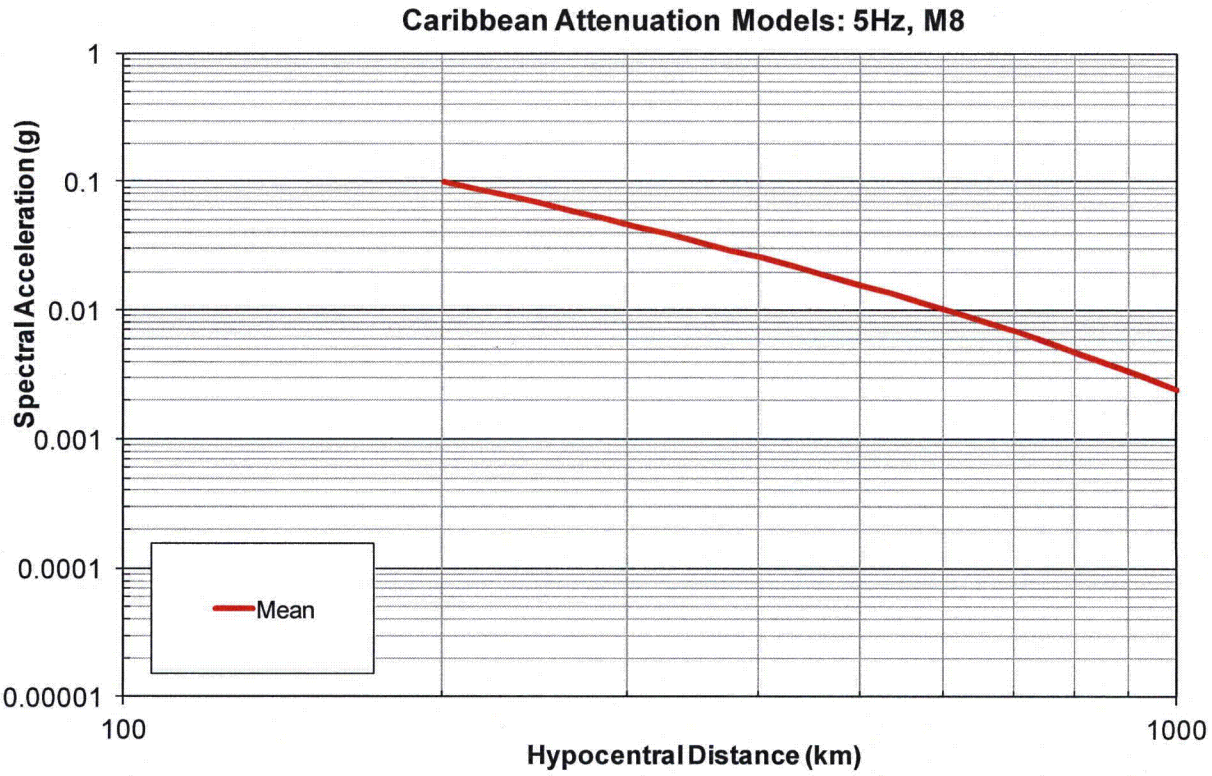


Figure 11c. Caribbean 5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

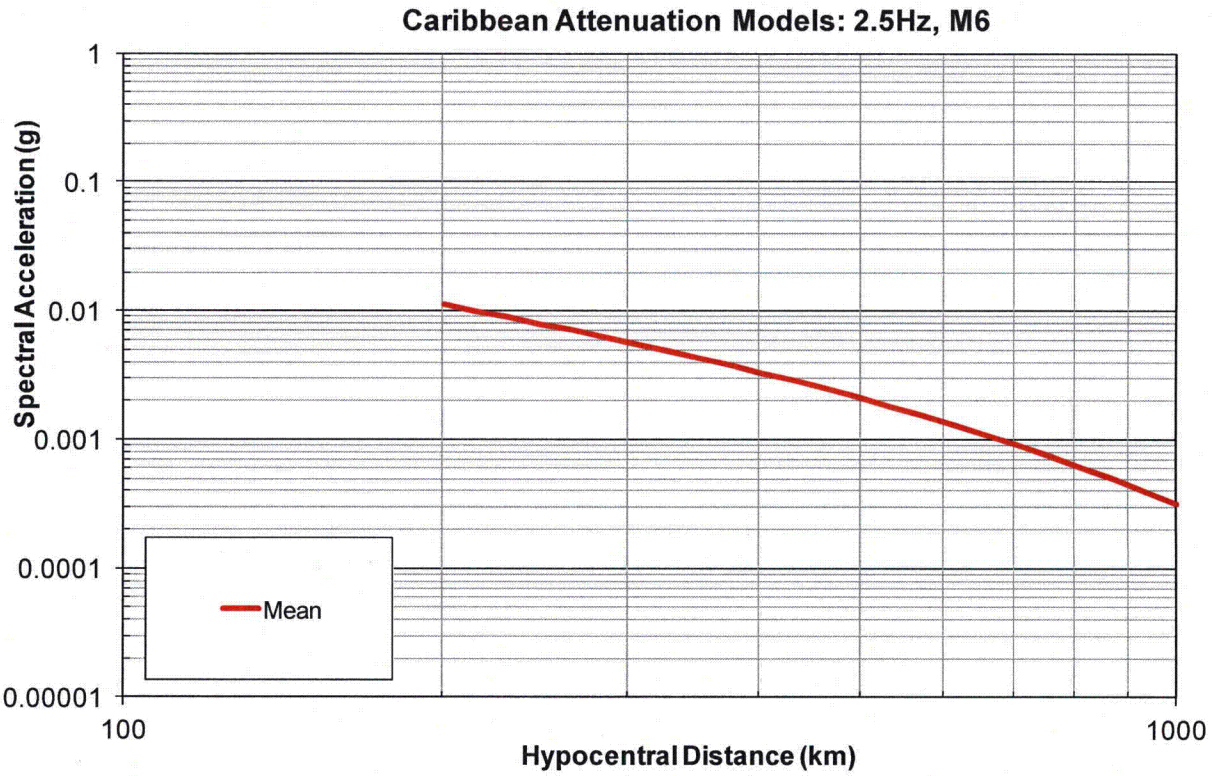


Figure 12a. Caribbean 2.5Hz weighted mean attenuation curve for a magnitude 6 earthquake.

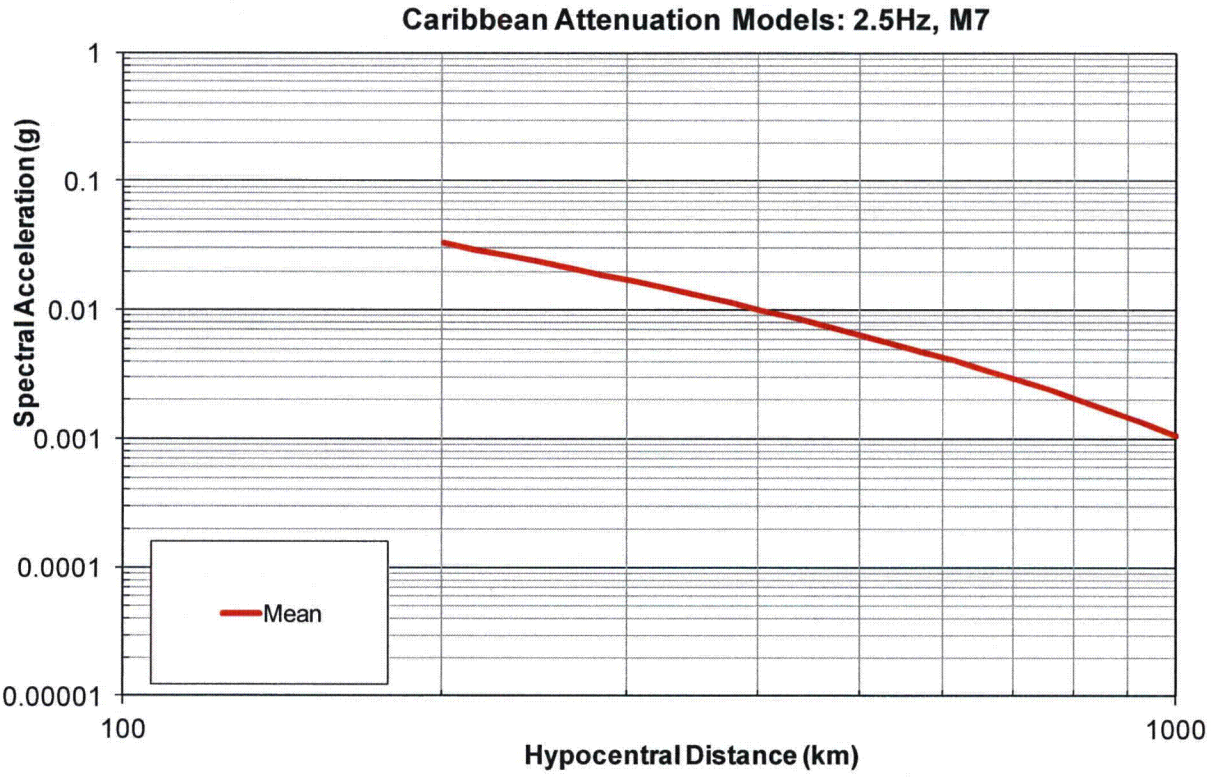


Figure 12b. Caribbean 2.5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

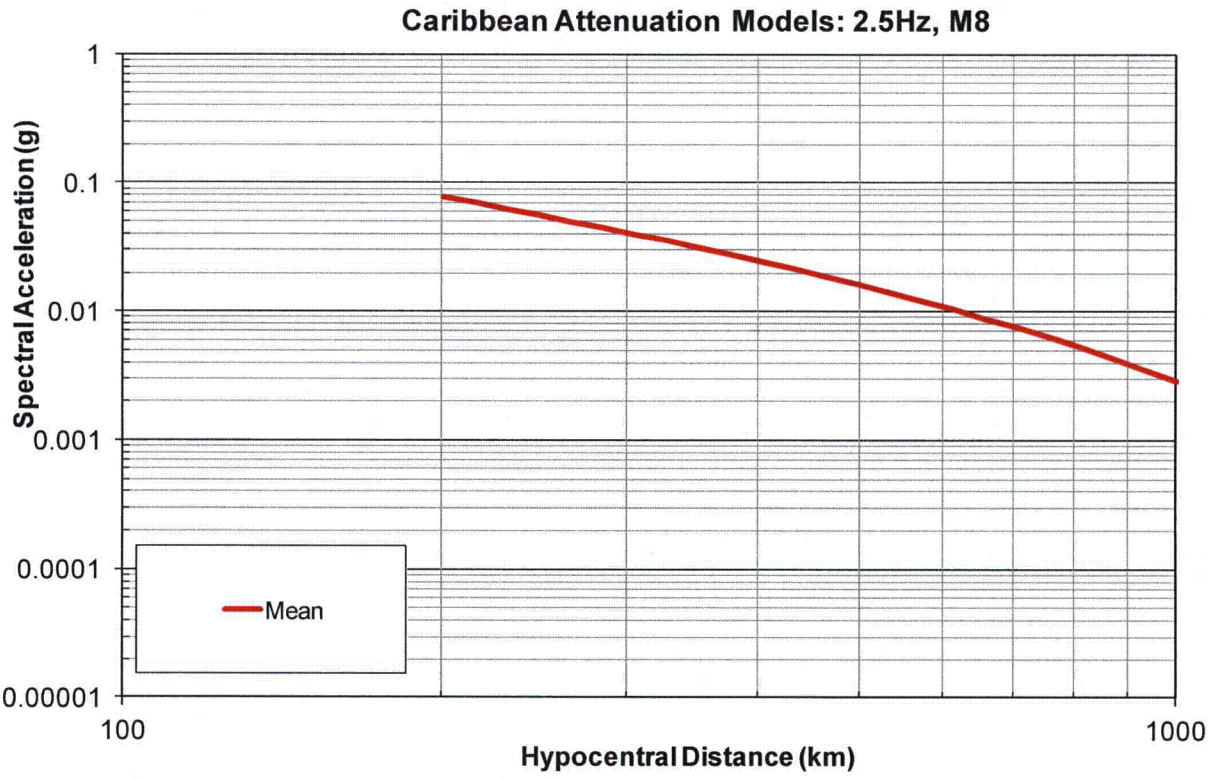


Figure 12c. Caribbean 2.5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

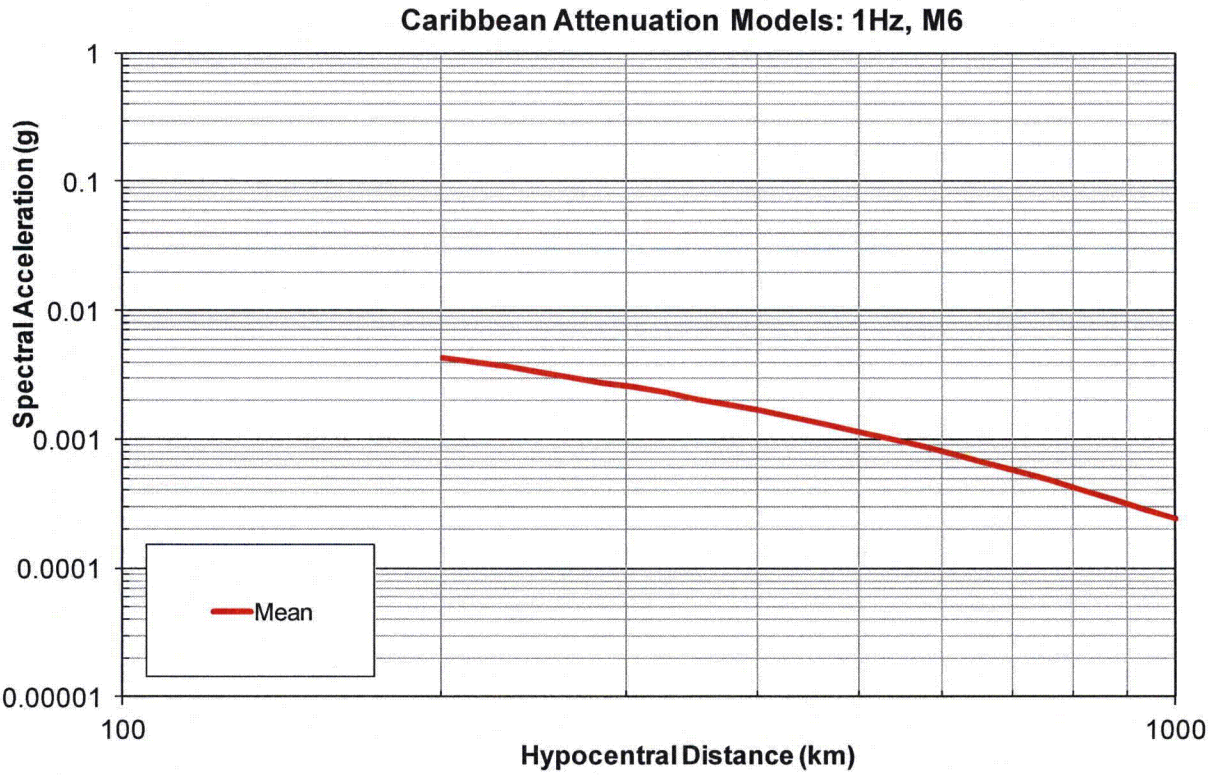


Figure 13a. Caribbean 1Hz weighted mean attenuation curve for a magnitude 6 earthquake.

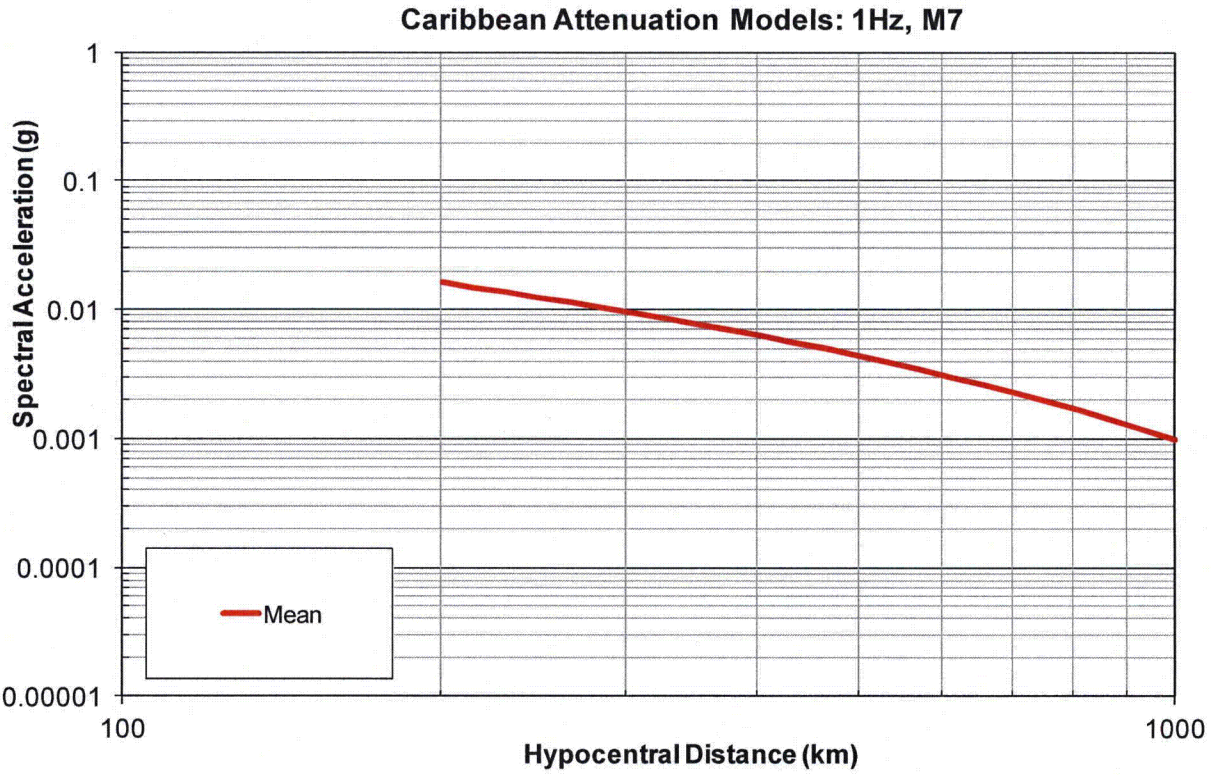


Figure 13b. Caribbean 1Hz weighted mean attenuation curve for a magnitude 7 earthquake.

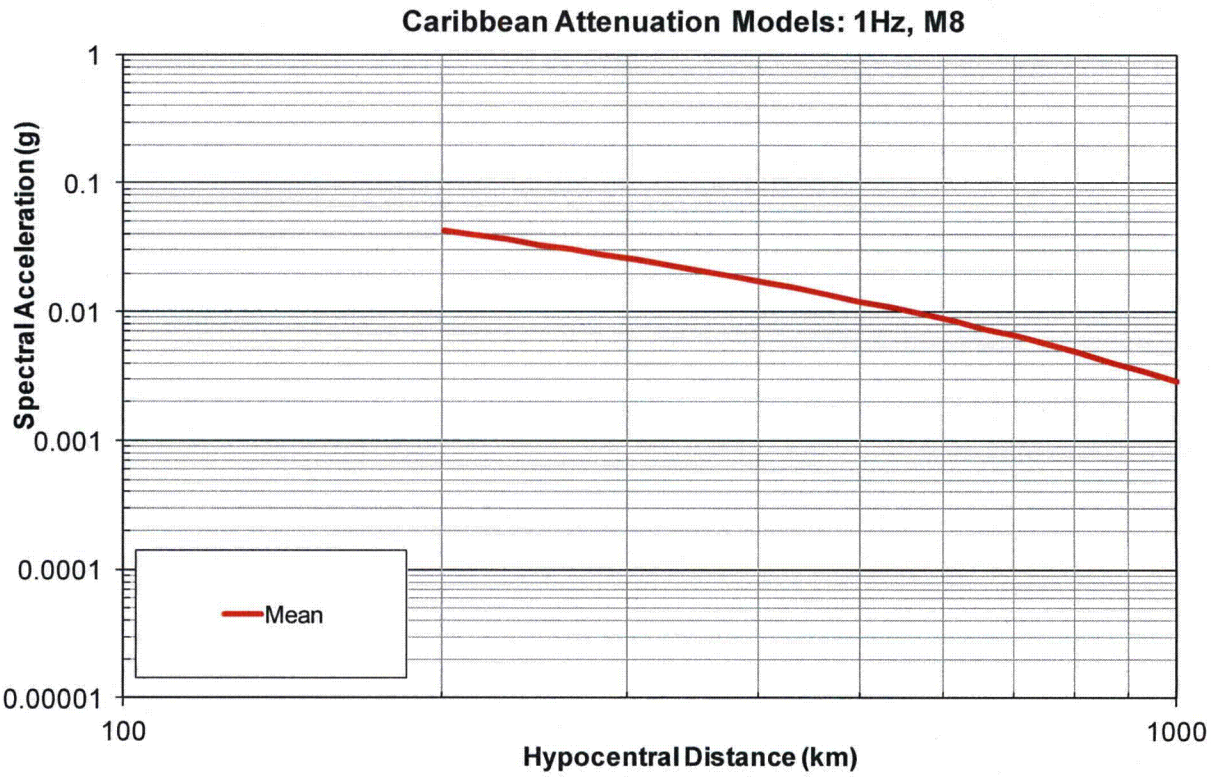


Figure 13c. Caribbean 1Hz weighted mean attenuation curve for a magnitude 8 earthquake.

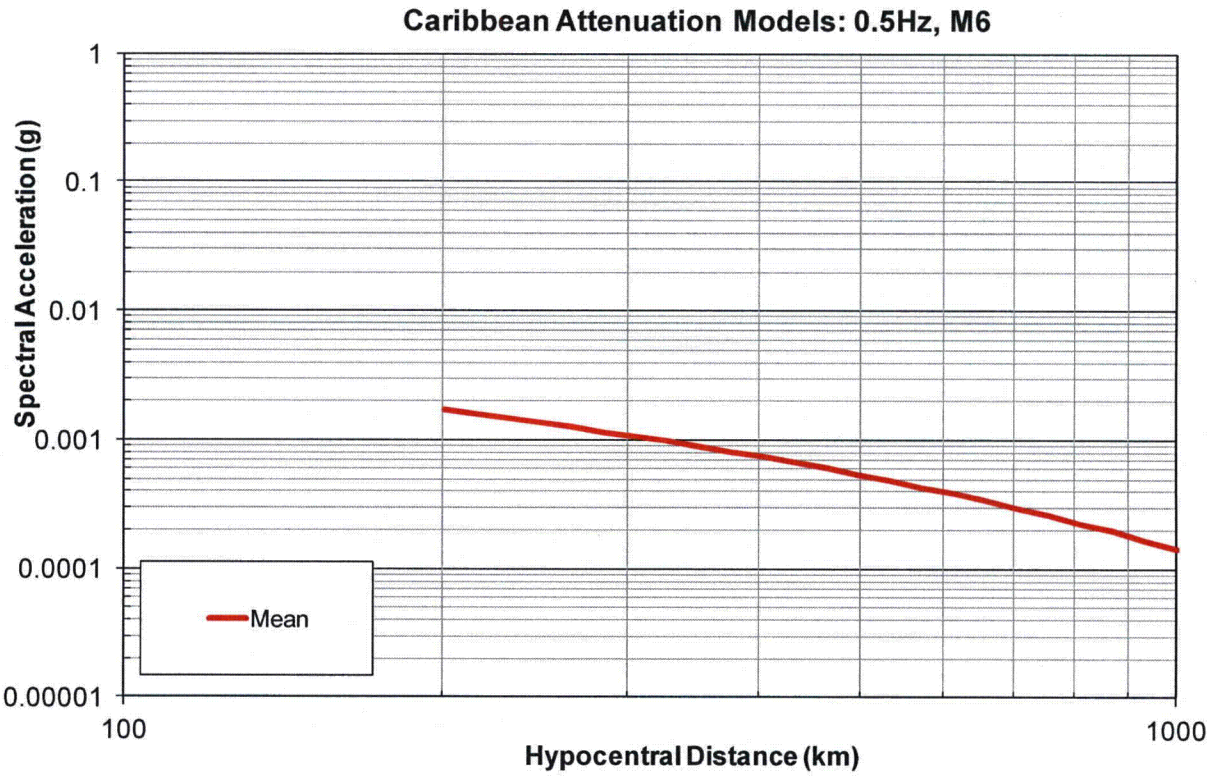


Figure 14a. Caribbean 0.5Hz weighted mean attenuation curve for a magnitude 6 earthquake.

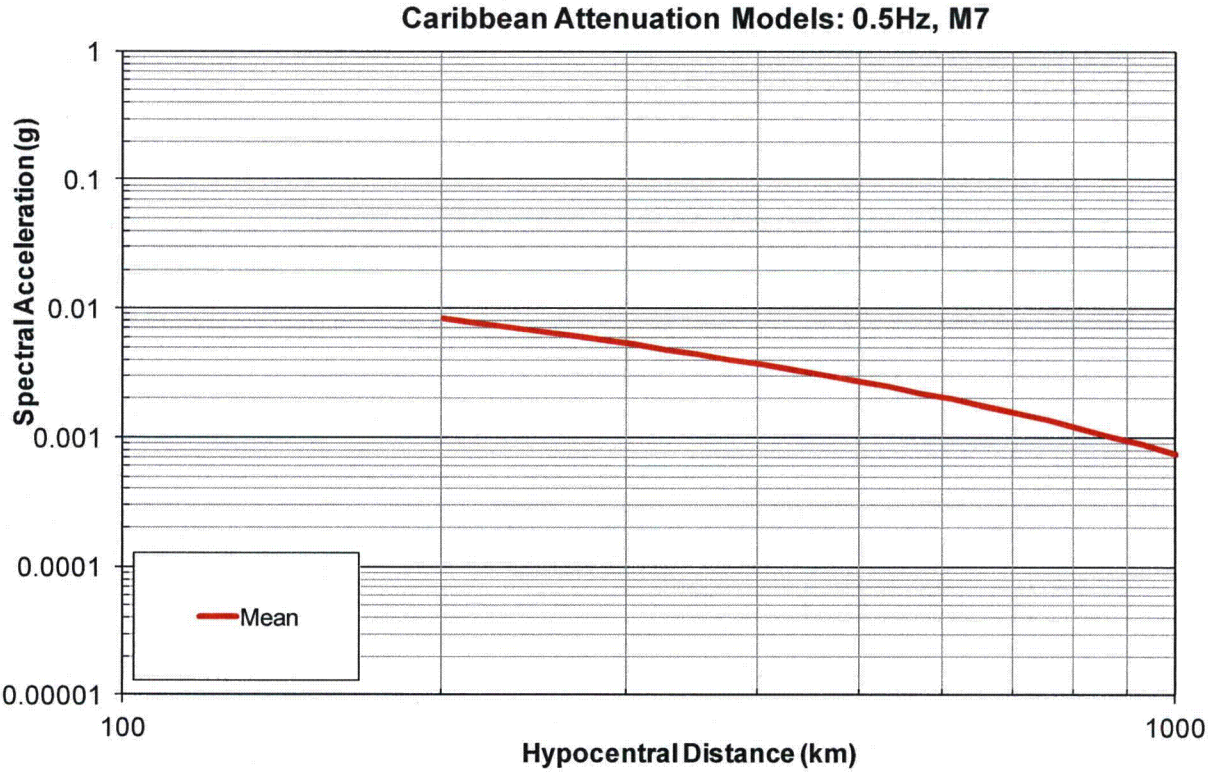


Figure 14b. Caribbean 0.5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

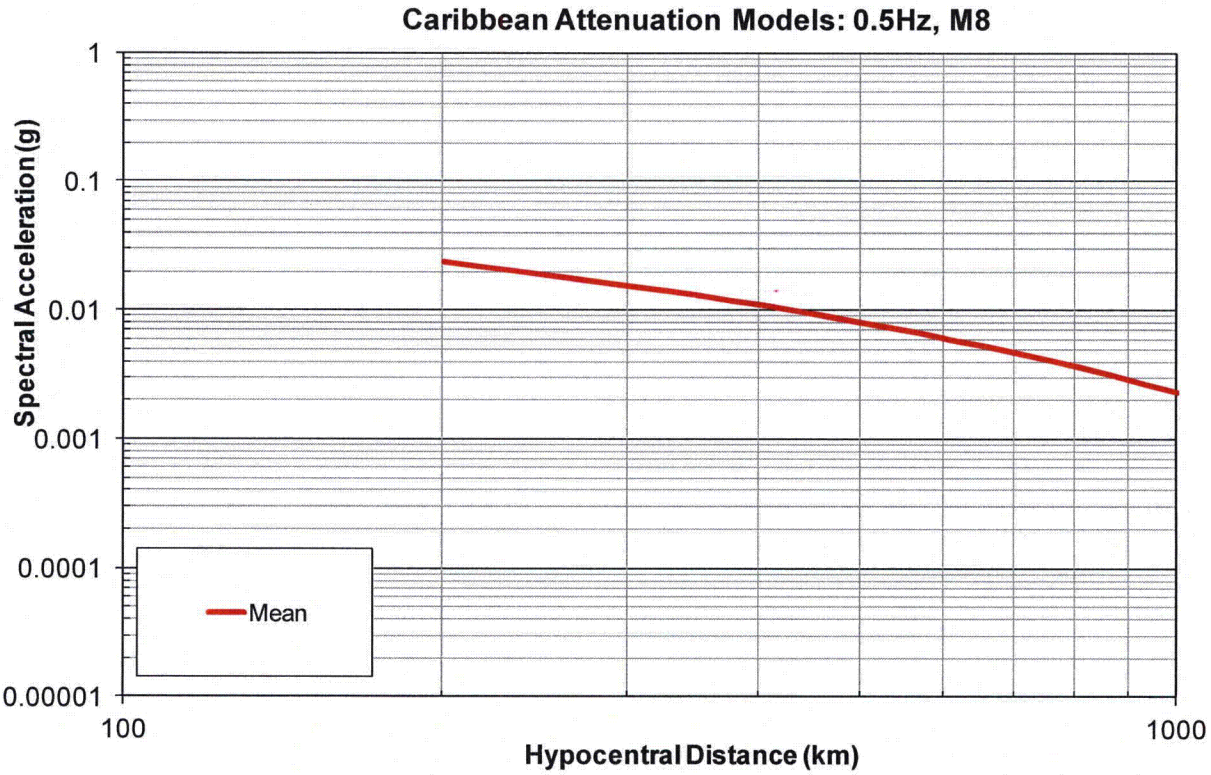


Figure 14c. Caribbean 0.5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

Part e:

Based on the relatively moderate to high levels of observed seismicity in the Caribbean region, the investigation into any potential seismic source variation on either a local or regional scale could, in theory, be studied. However, based on the limited seismic networks in the region, only one such study was discovered in the literature. This study by Motazedian and Atkinson (FSAR Reference 287) studied a dataset of ground motion recordings in and around the island of Puerto Rico to develop a seismic source model including the stress parameter for the region. As they note this ground motion dataset contains both crustal and subduction earthquakes but could not be subdivided based on the earthquake type. No studies were found during a literature review that specifically addresses any potential stress parameter variation between earthquakes associated with the Northern Hispaniola, Caribbean plate-boundary transform faults, and Cuba sources.

As part of this study, Motazedian and Atkinson (FSAR Reference 287) compared their attenuation model based on the Puerto Rico data and associated stress parameter with ground motion prediction equations (GMPEs) for central and eastern United States (CEUS), California, and subduction ground motion models. Note that the CEUS and California models are based on a similar stochastic ground motion methodology that was

used by Motazedian and Atkinson (FSAR Reference 287) whereas the subduction model is based on empirical data. Their conclusion was that the Puerto Rico based model is similar to the CEUS and California models and based on their attenuation curve plots, their model predicts significantly larger (i.e., larger by factors of 5 – 10 or greater) ground motions than the empirically-based subduction GMPE.

For the probabilistic seismic hazard analysis (PSHA) performed for Turkey Point site, a total of 10 seismic sources were considered for the Caribbean region. Of these 10 sources the two Northern Hispaniola sources (i.e., western and eastern) are identified as being associated with the tectonic subduction zone in the region. Based on the comparison plots given in the Motazedian and Atkinson study (FSAR Reference 287) and the large distance from the Turkey Point site to these individual subduction seismic sources, the use of an empirically derived GMPE for the subduction seismic source zones would lead to lower ground motions than the use of GMPEs based on the Motazedian and Atkinson (FSAR Reference 287) source and attenuation scaling. Thus the PSHA results are understood to have higher ground motion results than if a subduction GMPE was used for those specific Caribbean subduction seismic source zones.

References:

Atkinson, G., Boore, D., "Empirical Ground Motion Relation for Subduction Zone Earthquakes and their Application to Cascadia and other regions," Bulletin of the Seismological Society of America, v. 93, no. 4, pp. 1703-1729, 2003.

Atkinson, G., Silva, W., "Stochastic Modeling of California Ground Motions," Bulletin of the Seismological Society of America, v. 90, no. 2, pp. 255-274, 2000.

ASSOCIATED COLA REVISIONS:

None

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-5 (eRAI 5896)

FSAR Subsection 2.5.2.1.3.1 states that **M**w was used as the uniform magnitude measure in Phase II (Caribbean region) earthquake catalog development efforts. Phase I earthquake catalog (EPRI updates), on the other hand, uses mb as the uniform magnitude measure. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG)1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please explain the rationale for selecting **M**w as the uniform magnitude measure for the Caribbean earthquake catalog rather than mb. Discuss what impact, if any, this choice had on the number of earthquakes listed in the Caribbean earthquake catalog. Were there any earthquakes with mb of 3.0 (or perhaps larger) that did not make the **M**w >= 3.0 cut used in Phase II catalog development?

FPL RESPONSE:

Seismologists performing current conventional probabilistic seismic hazard analyses, as well as development of ground motion prediction equations (e.g., the 2008 USGS seismic hazard maps [FSAR Reference 300] and the 2008 Next Generation of Ground-Motion Attenuation models [Chiou et al., 2008]), prefer the use of moment magnitude (Mw) over other magnitude scales, including body-wave magnitude (m_b), as it is a more direct indication of the seismic energy associated with an earthquake, particularly for both shallow and deep focus earthquakes with large fault dimensions and/or complex rupture mechanisms that occur in the Caribbean. The m_b magnitude scale saturates or is progressively insensitive to very large earthquakes with magnitudes greater than about 7.5 due to the difference in the period and the seismic wave type used in determining the magnitude size. While the magnitudes of earthquakes within the central and eastern United States are adequately represented by the m_b scale, the largest events in the Caribbean are not. This rationale for selecting moment magnitude was the basis for its use in developing the Phase 2 earthquake catalog.

The update of the Phase 1 earthquake catalog was constrained to maintain the magnitude scale in m_b because both the EPRI-SOG seismicity catalog and recurrence characterization of the EPRI-SOG seismic sources already used the m_b scale.

It should be noted that both the SRP [NUREG-0800] Section 2.5.2 and Reg. Guide 1.206 specify that the "[earthquake catalog] should include all earthquakes having Modified Mercalli Intensity (MMI) greater than or equal to IV or magnitude greater than or equal to 3.0 that have been reported within 320 km (200 miles) of the site. Large earthquakes outside of this area that would impact the SSE, should be reported." The Phase 1 and Phase 2 catalogs were developed to meet these requirements. The magnitude scale is not explicitly specified in these requirements, however, both documents later state that "magnitude designations such as m_b, M_L, M_s, M_w should be identified." There is no specification of the magnitude scale for the earthquake catalog given in Reg. Guide 1.208.

The magnitude conversion relations between the moment magnitude scale and many other scales, such as m_b, show that the magnitudes less than about 4.5 (very short fault lengths) are assumed to be numerically equivalent to M_w and that the conversion relations are nonlinear at large magnitude values to reflect the saturation of some magnitude scales (Heaton et al., 1986). Therefore, in the development of the Phase 2 catalog, all small earthquakes of any magnitude scale less than 4.5 were retained to be numerically equivalent to M_w. As a result of this assumption for small events, the selected threshold magnitude scale $M_w \geq 3.0$ for the Phase 2 earthquake catalog and m_b (or (E)mb) ≥ 3.0 for the Phase 1 earthquake catalog presents no inconsistency in terms of minimum size or minimum seismic energy of a given earthquake considered in the two catalogs. Therefore, all earthquakes of magnitude 3.0 and larger, regardless of characterization as moment magnitude or body-wave magnitude, are included in both Phase 1 and Phase 2 earthquake catalogs, and there is no impact on the number of earthquakes in the two earthquake catalogs associated with the different magnitude scales used in the two earthquake catalogs.

This response is PLANT SPECIFIC.

References:

Chiou, B., R. Darragh, N. Gregor, and W. Silva (2008). NGA Project Strong-Motion Database, Earthquake Spectra v.24, pp.23-44.

Heaton, T., F. Tajima and A. W. Mori (1986). Estimating ground motions using recorded accelerograms. Surveys in Geophysics, v.8, p 25-83.

ASSOCIATED COLA REVISIONS:

None

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-8 (eRAI 5896)

FSAR Subsection 2.5.2.4.6 lists the Cuba areal source as one of the major contributing seismic sources to the total hazard. However, the deaggregation results shown in FSAR Figure 2.5.2-226 indicate only a minor contribution from the distance range of the Cuba areal source. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please explain this apparent discrepancy. What is the percentage of the Cuba areal source's hazard contribution (at 10E-04 and 10E-05 levels) to the total site hazard at all seven frequencies defined by the EPRI 2004 and 2006 GMPEs? Are these consistent with the deaggregation results?

FPL RESPONSE:

FSAR section 2.5.2.4.6 states that distant sources have the major contribution to low-frequency rock hazard and these sources include the Cuba areal source, Caribbean faults, and Charleston source. Table 1 shows the rock hazard from the Cuba areal source alone for the overall 10^{-4} and 10^{-5} amplitudes and also shows the percent contribution to the total 10^{-4} and 10^{-5} rock hazard. These percentages are consistent with the deaggregation plots (FSAR Figures 2.5.2-226 through 2.5.2-229). Note, for example, that at 10^{-4}, contributions from the Cuba areal source at 1 Hz and 2.5 Hz are 14.6% and 29.7% respectively, which average to approximately 22%. This contribution in FSAR Figure 2.5.2-226 (for 1 Hz and 2.5 Hz) is spread over about 25 magnitude-distance bins with magnitudes ranging from 6.0 to 7.5 and distances ranging from 210 km to about 480 km. This example illustrates that the percent contributions in Table 1 are consistent with the deaggregation plots (FSAR Figures 2.5.2-226 through 2.5.2-229).

Table 1. Percent contribution of total mean rock hazard from the Cuba areal source.

	% Contribution at 10^{-4}		% Contribution at 10^{-5}	
Frequency (Hz)	Mean Hazard (Cuba Areal Source)	% Contribution	Mean Hazard (Cuba Areal Source)	% Contribution
0.5	6.13E-06	6.1	4.33E-07	4.3
1	1.46E-05	14.6	1.21E-06	12.1
2.5	2.97E-05	29.7	1.45E-06	14.5
5	3.10E-05	31.0	5.82E-07	5.8
10	2.08E-05	20.8	1.52E-07	1.5
25	4.50E-06	4.5	6.97E-09	0.1
100 (PGA)	1.25E-05	12.5	4.49E-08	0.4

This response is PLANT SPECIFIC.

References:

None

ASSOCIATED COLA REVISIONS:

None

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-9 (eRAI 5896)

FSAR Subsection 2.5.2.5.1 states that P-wave velocities from eight deep wells were used to develop the deeper (>636 ft) sections of the site response model. The wells that provide the P-wave velocity information are approximately 100 km to 180 km away from the site. In accordance with Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground
Motion", please provide:

a. additional information on the applicability of seismic velocity information obtained at such great distances to the Turkey Point site. How was the variation in geology considered in these projections?

b. individual velocity profiles for each of the eight wells used in estimating the average profile shown in FSAR Figure 2.5.4-211

c. further details on how larger uncertainties in deeper layers' thicknesses/depths are taken into account in the randomization of the site profile

FPL RESPONSE:

Sonic logs 0001, 0002, 0005, 0007, 0008 and 0010 were derived from wells located approximately 66 miles, 62 miles, 81 miles, 110 miles, 82 miles, and 71 miles from the FPL Turkey Point site, respectively (FSAR Figure 2.5.4-210). The measurements recorded by the probe were depth, expressed in feet below the drill rig's Kelly bushing, and the interval travel time, Delta T (DT_p), expressed in microseconds (10^{-6} seconds) per foot. The logs were initiated at an upper depth of 3,610 ft to 4,100 ft below each drill rig's Kelly bushing and terminated at a lower depth of 11,600 ft to 11,920 ft below Kelly bushing.

Sonic logs LAB-TW and PBF-12 were derived from wells located approximately 115 miles and 64 miles from the FPL Turkey Point site, respectively (FSAR Figure 2.5.4-210). The measurements recorded by the probe were depth, expressed in feet below land surface, and interval travel time, expressed in microseconds per foot. The logs were initiated at an upper depth of 500 to 900 ft below land surface and terminated at a lower depth of 1,900 to 2,350 ft below land surface.

This response is structured to respond to parts a, b, and c of the RAI.

a) The well locations with the sonic logs used for this analysis are shown on FSAR Figure 2.5.4-210. FSAR Figure 2.5.1-232 shows a north-south geologic cross section (Section E-F) through the Upper Mesozoic and Lower Cenozoic rock in southern Florida. Point 39 on the profile (and on the Locator Map on FSAR Figure 2.5.1-232) is in the vicinity of the majority of the sonic log locations on

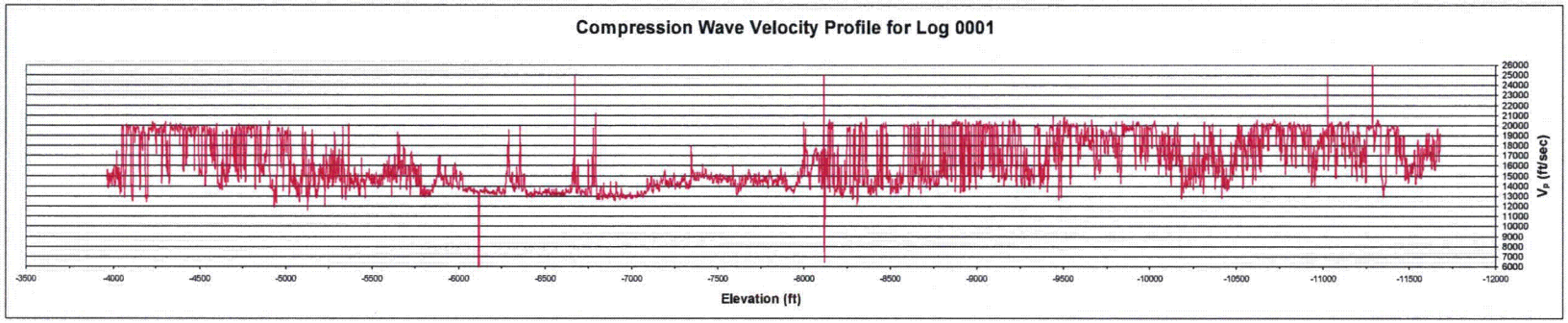
FSAR Figure 2.5.4-210. The distance from Point 39 to the Turkey Point site is about 80 miles. Based on the review of publications, regional geologic cross sections and the sonic logs, there is relatively little variation in the stratigraphy in the upper 6,000 ft between the Point 39 area and the Turkey Point site. Considering that stratigraphy generally shows less variation with increasing depth, it is reasonable to assume that the lack of stratigraphic variation on the scale shown in FSAR Figure 2.5.1-232 continues below 6,000 ft. This consistency of the stratigraphy and the gentle regional dip of the stratigraphic units confirms the appropriateness of using data from the eight deep wells to develop the site response model.

b) The velocity profiles for each of the 8 wells are shown in Figure 1.

c) The uncertainties in the dynamic properties of the deeper layers were taken into account by the following two steps.

1. The calculated logarithmic standard deviation of the converted shear-wave velocity (Vs) was increased to account for uncertainty in Poisson's ratio and to account for the number of profiles used to construct the deep portion of the base case profile.
2. The layer thicknesses of each synthetic profile were obtained using a randomization approach where the rate of layer boundaries at a given depth (which is closely related to the probability of having a layer boundary at that depth) is the sum of a smooth continuous function and a non-smooth function that takes non-zero values where the base case profiles has discontinuities in Vs. The value of the latter function is proportional to the relative change in Vs and inversely proportional to the logarithmic standard deviation of Vs. Because the size of the steps in the base case Vs profile is relatively small compared to the logarithmic standard deviation of Vs, these discontinuities tend to occur at different depths in different synthetic profiles, as can be verified in FSAR Figure 2.5.2-239. This implies that the layer thicknesses are strongly randomized in the lower portion of the profile.

Figure 1. Compression Wave Velocity Profiles for Sonic Logs 0001, 0002, 0005, 0007, 0008, 0010, LAB-TW and PBF-12



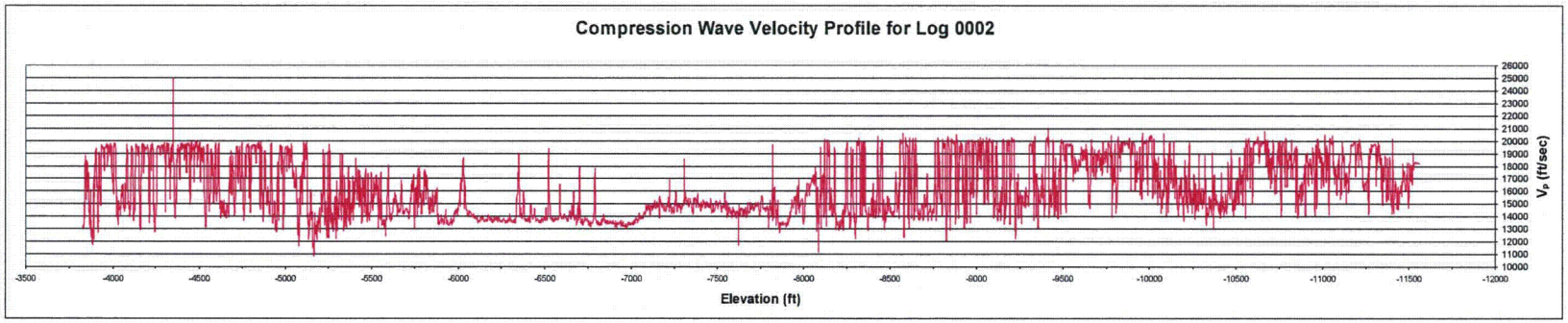
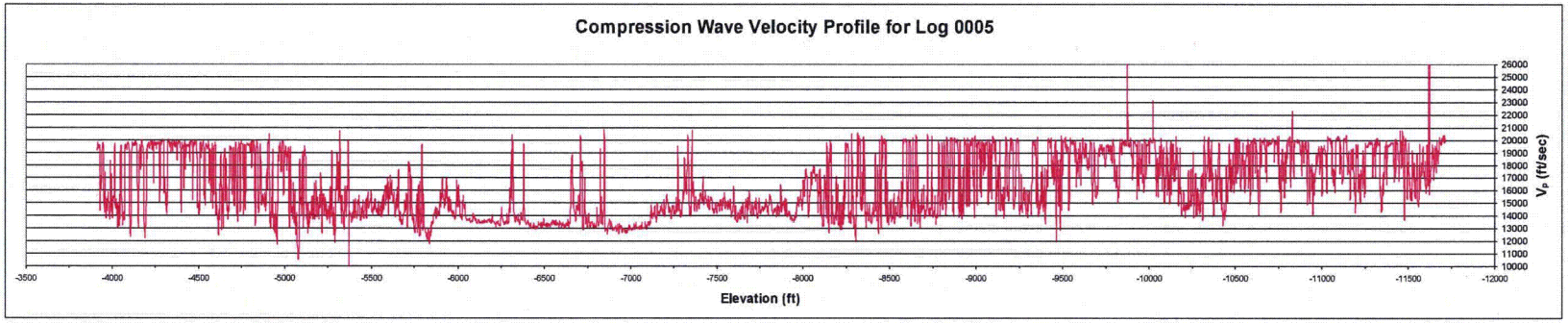
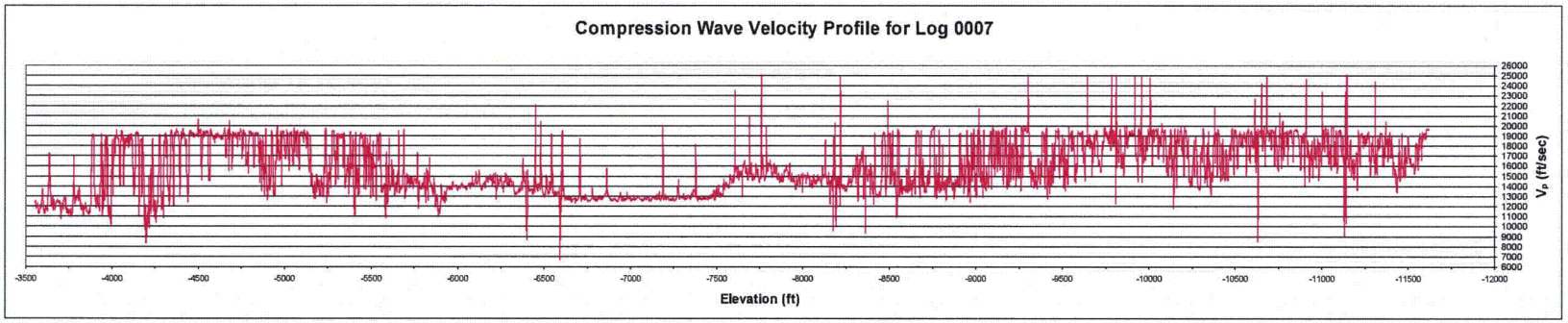


Figure 1. Compression Wave Velocity Profiles for Sonic Logs 0001, 0002, 0005, 0007, 0008, 0010, LAB-TW and PBF-12 Cont'd





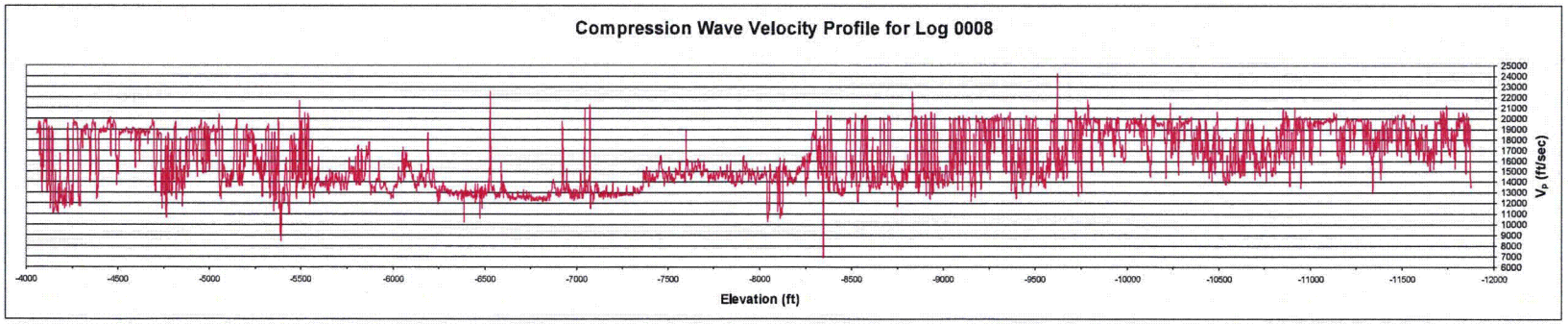
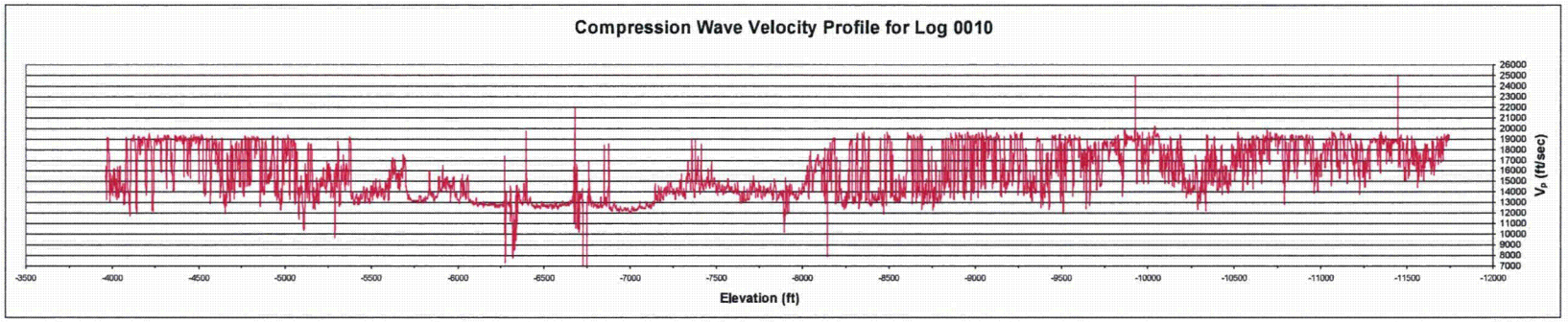
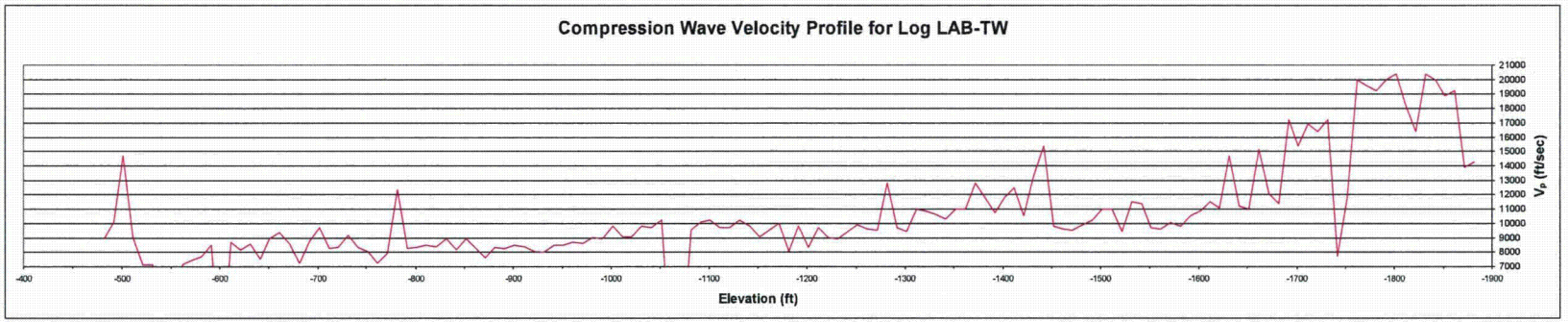
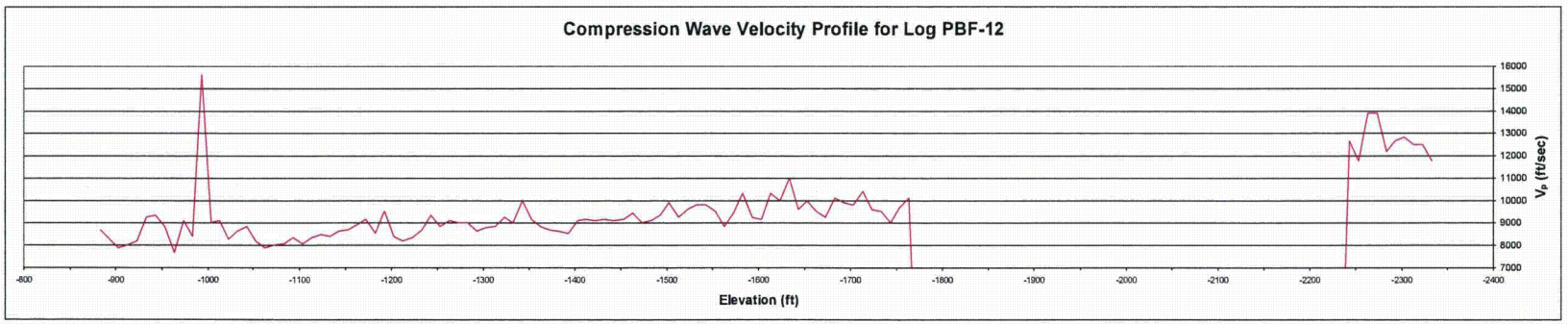


Figure 1. Compression Wave Velocity Profiles for Sonic Logs 0001, 0002, 0005, 0007, 0008, 0010, LAB-TW and PBF-12 Cont'd







This response is PLANT SPECIFIC.

References:

None

ASSOCIATED COLA REVISIONS:

None

ASSOCIATED ENCLOSURES:

None