RESPONSE TO NRC QUESTIONS ON PALO VERDE SEISMIC HAZARD ANALYSIS

Prepared for

Arizona Public Service Company
Phoenix, Arizona

by

Risk Engineering, Inc.
Golden, Colorado

April 7, 1993

The report responds to questions raised by the U.S. Nuclear Regulatory Commission staff regarding seismic hazard estimates prepared by Risk Engineering, Inc., and documented in Reference A and B. The format followed is to restate each question individually, and to follow that with the response.

Question I-1: "What frequency ranges were used to evaluate ground motion and soil amplification (Ref. 3, Supplemental Report, P.11, 1-3)? It is stated that frequency content of ground motions in the western and eastern U.S. is different."

A very broad frequency range was used to evaluate ground motion and soil amplification, specifically 0.001 Hz to 140 Hz. After the Fourier Spectrum of soil response was computed, the response spectra for soil motion were computed using a frequency range of 0.1 Hz to 100 Hz. The use of these frequency ranges ensures that responses in the frequency band of interest (1 Hz to 25 Hz) is accurate.

The lowest frequencies of earthquake motion depend on the magnitude of the earthquake. The highest frequencies of the motions depend on the region. In the eastern U.S. there often is energy up to 40 Hz, while in the western U.S. the highest frequencies with significant energy are ordinarily 10 to 15 Hz. This upper limit on the frequency content depends on soil conditions, distance from the causative fault, characteristics of the recording instrument, and other factors, of course.

Question I-2: What is the reason for using DuBois et al. as a default catalog (Ref. 3, Supplemental Report, p. 4-1)? Some of the other references are more recent."

All available references on Arizona earthquakes were consulted and cross-checked to determine the most valid catalog to use for the analysis. This included earthquakes listed in the FSAR for Palo Verde, and the following references:

E.R. Engdahl and W.A. Rinehart. "Seismicity Map of North America." In *Observatory Seismology*, ed. by J.J. Litehiser, Univ. of Calif. Press, Berkeley, Calif., 1989.

C.W. Stover, B.G. Reagor, and S.T. Algermissen, *Seismicity Map of the State of Arizona.* Miscellaneous Field Studies Map MF-1852, US Geological Survey, 1986.

S.M. Dubois, A.W. Smith, N.K. Nye, and T.A. Novak. *Arizona Earthquakes, 1776-1980.* Bulletin 193, Arizona Bureau of Geology and Mineral Technology, 1982.

S.M. DuBois, M.L. Sbar, and T.A. Novak. *Historical Seismicity in Arizona.* Open-File Rept. 82-2, Arizona Bureau of Geology and Mineral Technology, 1982.

In addition, Prof. David Brumbaugh was retained as a consultant to Arizona Public Service Co. Prof. Brumbaugh, of Northern Arizona University, has studied the seismicity of Arizona over a period of years. He provided his best interpretations on sizes and locations of historical earthquakes, where ambiguities existed.

Question I-3: "What indication is there that the Stokoe measurements at Treasure Island (the damping and modulus-reduction curves for the clay layers) are valid at Palo Verde (Ref. 3, Supplemental Report, p. 5-11)?"

The current estimates of soil response at Palo Verde use damping and modulus reduction curves taken from Vucetic and Dobry, "Effect of Soil Plasticity on Cyclic Response," Journal of Geotechnical Engineering, Amer. Soc. of Civil Engrs., 1991. The Vucetic/Dobry study related damping and modulus reduction in clay to the plasticity index (PI) using a range of results from clay sites. In the opinion of Dr. Walter Silva, the Vucetic/Dobry curves shown in Figure 5-2 of the Revised Palo Verde Seismic Hazard Report (Reference C) are the best representation of material properties for the clay layers at Palo Verde.

Question I-4: "Should values other than logarithmic mean be considered (Ref. 3, Supplemental Report, p. 5-15, 5-16)?"

It has been observed empirically that ground motions (Fourier spectra, response spectra, and peak motions), when normalized by magnitude and distance are lognormally distributed (see for example, McGuire, June 1978 BSSA, p. 809; Campbell, Dec. 1981 BSSA, p. 2054). Therefore it is natural to plot predictions of response spectra (p 5-15, Figure 5-3) on a logarithmic scale, and to indicate the logarithmic mean. The plus or minus one standard deviation spectra in Figure 5-3 thus represent multiplicative and divisive factors applied to the logarithmic mean, and correspond approximately with the 15% and 85% fractile values. It is also natural to plot the ratio of the two spectra (e.g., a soil spectra divided by a rock spectra) as is done in Figures 5-4 through 5-9 of the Palo Verde Seismic Hazard Report.

Sensitivity Study II-1 (Seismic Zonation): "In the staff's review (Ref. 2) of the original probabilistic seismic hazard study, submitted by the licensee (Ref. 1), the staff stated that the seismic zonation used in the hazard analysis were not considered to be adequate. (The seismic source zones exclude higher seismicity to the southwest and northeast.) The supplemental hazard analysis submitted by the licensee on August 4, 1992 (Ref. 3), did not consider any additional seismic zonation. We have consulted studies published by the U.S. Geological Survey (USGS) and other investigators and we conclude that there are enough differences in expert opinion, with respect to the seismicity and zonation of the Palo Verde site region, to warrant additional sensitivity studies. To ascertain the sensitivity of the seismic hazard to variations in seismic zonation and activity rates we request that the licensee do an additional calculation using the zonation and activity rates specified in Table 1 and Figure 1 and include in this calculation, faults identified by the Geomatrix team together with their activity rates (Ref. 3, Supplemental Report, Table 4-2)."

Table 1

Seismicity Parameters for the Palo Verde Site
Recommended by NRC

Type	No.	Source	Range of Act. Rates *	Range of b-values	Range of Max. Mags.
Zone	Z1	Zone 1	0.0085-0.016	0.67-0.75	5.0-5.5
Zone	Z2	Zone 2	0.7000-1.110	0.80-1.20	6.5-8.0
Zone	Z3	Zone 3	0.0310-0.0670	0.70-0.85	5.5-6.0

* Activity rates shown are annual rates of $M_w \geq 5$ for each source.

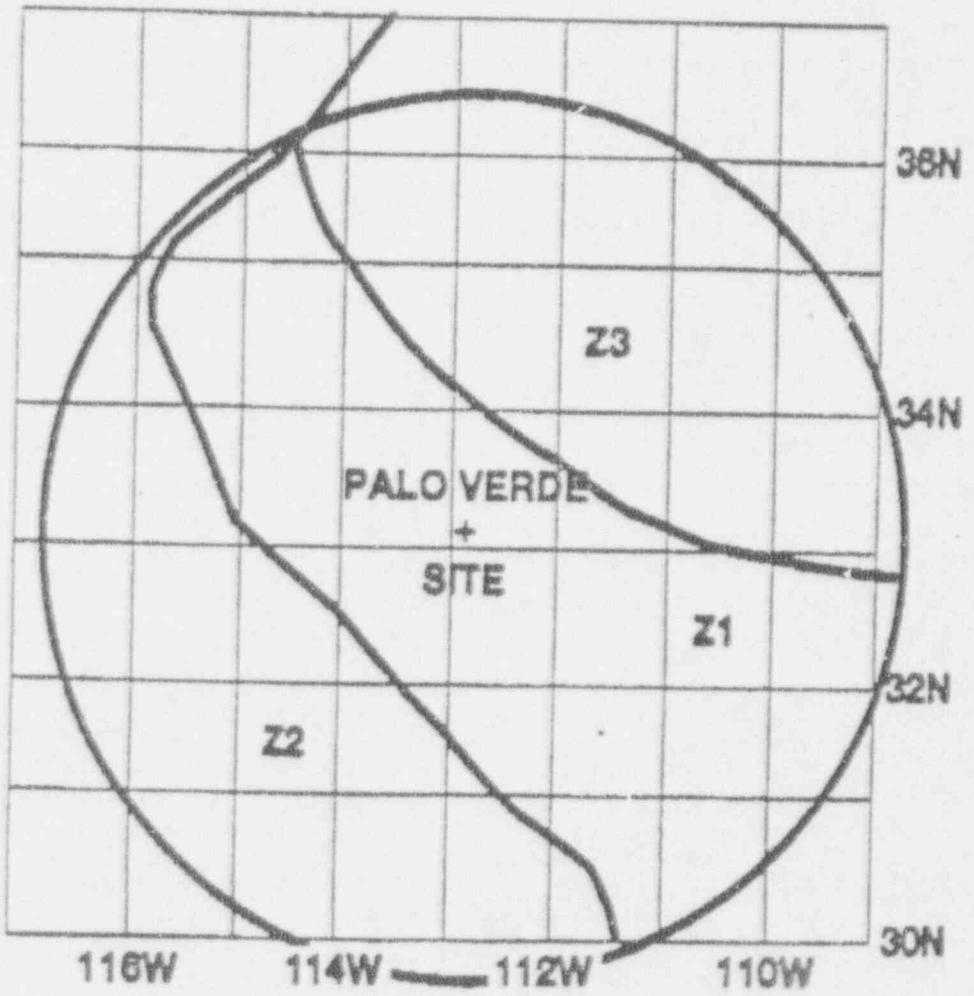

Figure 1. Seismic Source Zones (350 km radius) for the PALO VERDE Site recommended by NRC

The NRC sources and parameters were used to calculate seismic hazard at Palo Verde. In this calculation, the range indicated for the b-values was divided into three equally spaced representative values, each value being weighted equally. Table 2-1 summarizes the parameter values used and associated weights. Similarly, the range of activity rates was divided into four representative values, and the range of maximum magnitudes was divided into five representative values, all values being weighted equally. The base-case site amplification factors were used. The Geomatrix faults were not included in the calculation, in order not to obscure the comparison of hazard results. The calculated hazard from the NRC sources is shown in Figures 2-1 through 2-6 for PGA and the five frequencies considered. Specific hazard values are shown in Table 2-2, and the percent change in hazard (NRC sources divided by base case) is shown in Table 2-3. The NRC sources indicated lower hazard than the median base-case results at all frequencies, and the addition of the Geomatrix faults would not change this conclusion. This follows because the Geomatrix faults do not contribute significantly to the hazard for frequencies of 2.5 Hz and higher (see Figures 6-1 and 6-3 of the Revised Palo Verde Seismic Hazard Report; Reference C). At the frequency of 1 Hz (Figure 6-2 of Reference C) the Cerro Prieto fault and Laguna Salada faults are important contributors, but the combined mean hazard from the NRC sources and the Geomatrix faults is below the mean base-case hazard presented in Figure 6-27 of Reference C, for all amplitudes of interest. Therefore, we conclude that the use of the NRC sources and Geomatrix faults would lead to lower estimates of seismic hazard than have already been calculated in the Revised Palo Verde Seismic Hazard Report (Reference C).

Table 2-1

Seismicity Parameters Used
with NRC Zonation

Zone	Activity Rates (wt. = 1/4)	b Values (wt. = 1/3)	Maximum Magnitudes (wt. = 1/5)
Z1	0.0094,0.0113,0.0132,0.0151	0.67,0.71,0.75	5.1,5.2,5.3,5.4,5.5
Z2	0.75,0.85,0.96,1.06	0.80,1.00,1.20	6.5,6.875,7.25,7.625,8.0
Z3	0.036,0.045,0.054,0.063	0.70,0.77,0.85	5.5,5.625,5.75,5.875,6.0

Table 2-2

SPECTRAL VELOCITIES (cm/sec) FOR
VARIOUS EXCEEDANCE PROBABILITIES:
PALO VERDE SITE (SOIL)
(NRC SOURCES)

		Frequency (Hz)				
		25	10	5	2.5	1
Exceedance Probability	Percentile	Period (sec) 0.04	0.1	0.2	0.4	1
1.E−03	15	0.08	0.22	0.76	0.87	0.93
	50	0.22	0.80	2.08	2.61	3.89
	85	0.33	1.34	3.39	5.63	9.54
2.E−04	15	0.32	1.13	3.17	2.48	2.15
	50	0.49	1.95	4.87	5.25	6.73
	85	0.69	3.09	6.84	9.42	15.60
1.E−04	15	0.53	1.93	5.29	3.73	3.24
	50	0.72	2.86	7.09	7.68	8.66
	85	0.98	4.39	10.10	12.80	18.70
1.E−05	15	1.35	4.70	14.10	7.84	9.69
	50	1.84	7.48	19.40	22.00	19.50
	85	2.34	9.74	26.20	35.10	35.00

Table 2-3

PERCENT CHANGE IN SPECTRAL VELOCITIES FOR
PALO VERDE SITE (SOIL)
(NRC SOURCES)

		Frequency (Hz)				
		25	10	5	2.5	1
Exceedance		Period (sec)				
Probability	Percentile	0.04	0.1	0.2	0.4	1
1.E−03	15	-38	-37	-29	-40	-48
	50	-21	-26	-27	-40	-44
	85	-30	-28	-30	-31	-29
2.E−04	15	-18	-21	-14	-49	-54
	50	-25	-23	-26	-45	-47
	85	-37	-34	-41	-47	-34
1.E−04	15	-9	-9	-7	-49	-54
	50	-23	-19	-23	-44	-48
	85	-33	-29	-38	-49	-40
1.E−05	15	-4	-5	-1	-65	-49
	50	-14	-2	-8	-38	-49
	85	-23	-24	-25	-39	-48

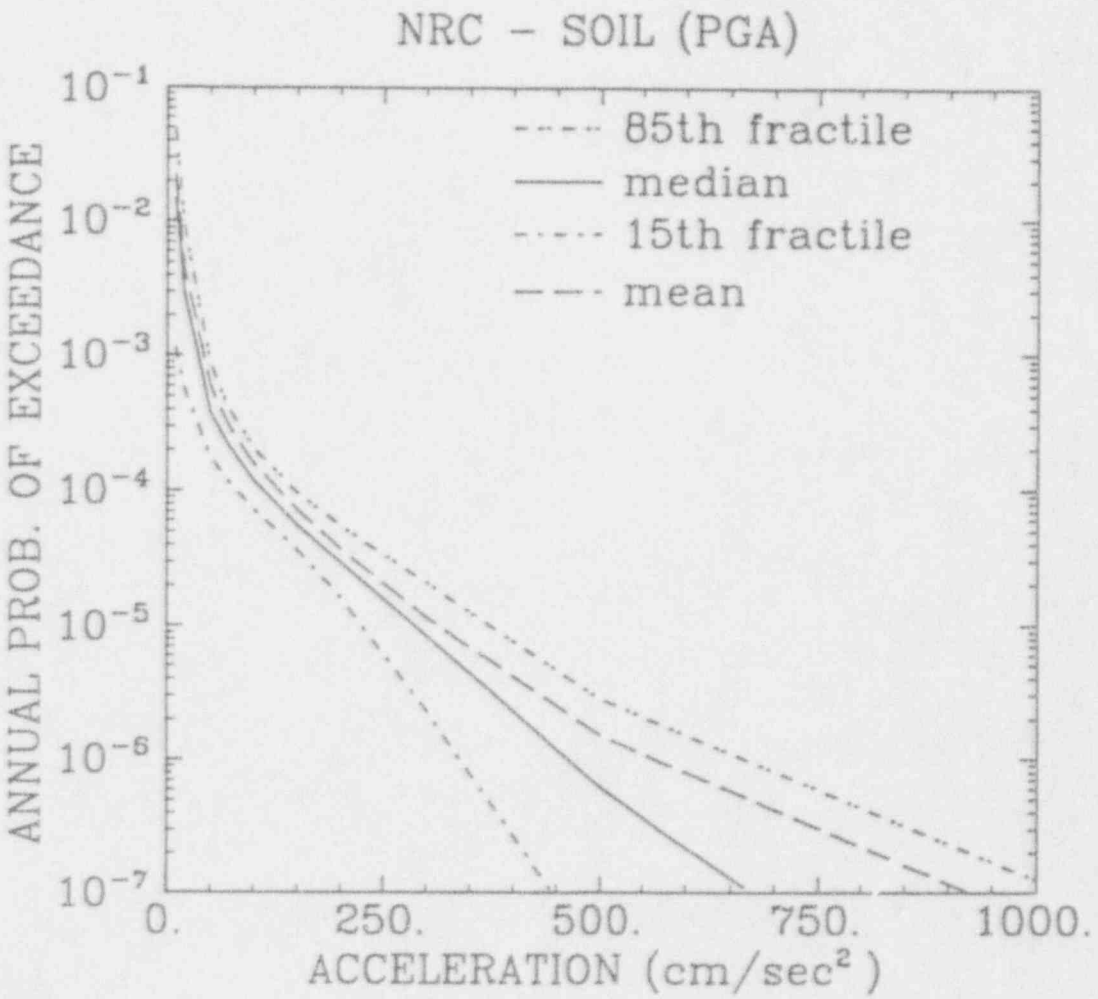

Figure 2-1: Hazard results using NRC sources; PGA

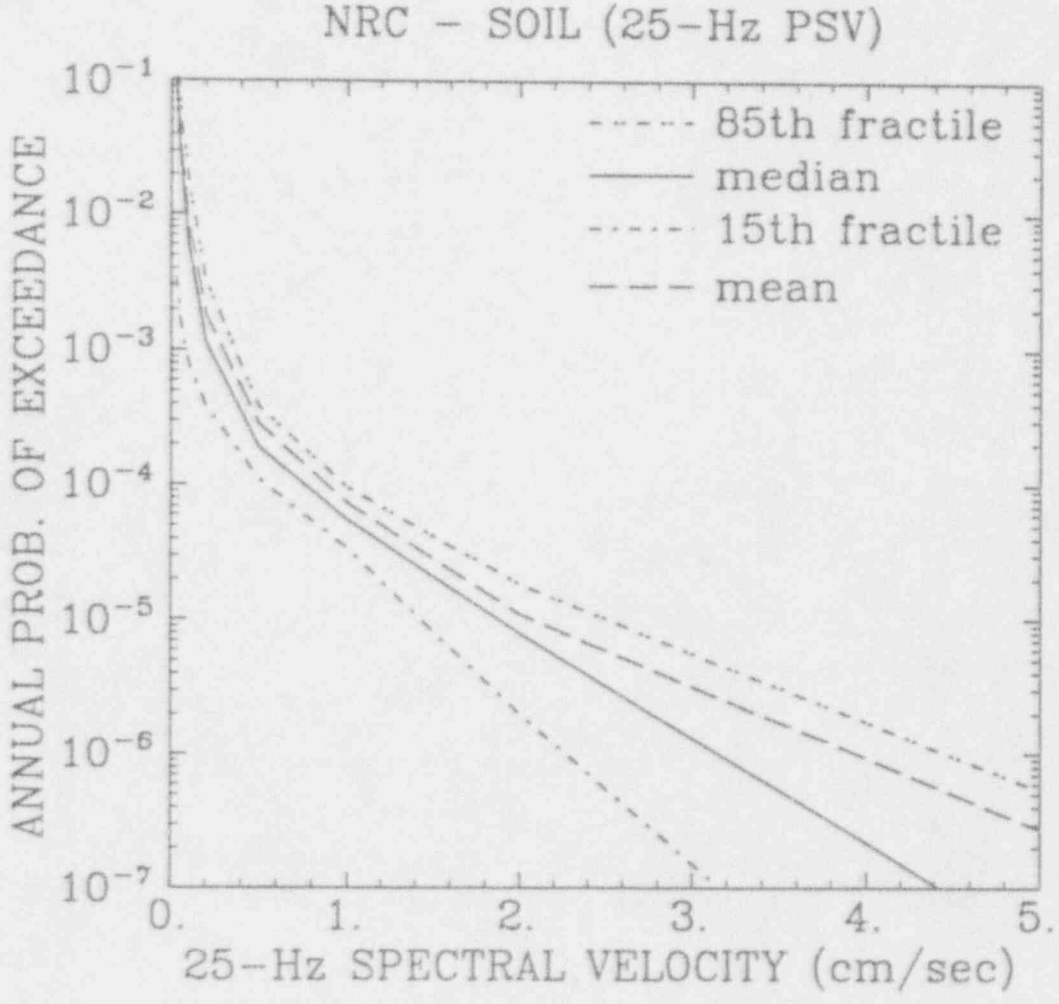

Figure 2-2: Hazard results using NRC sources; 25-Hz spectral velocity

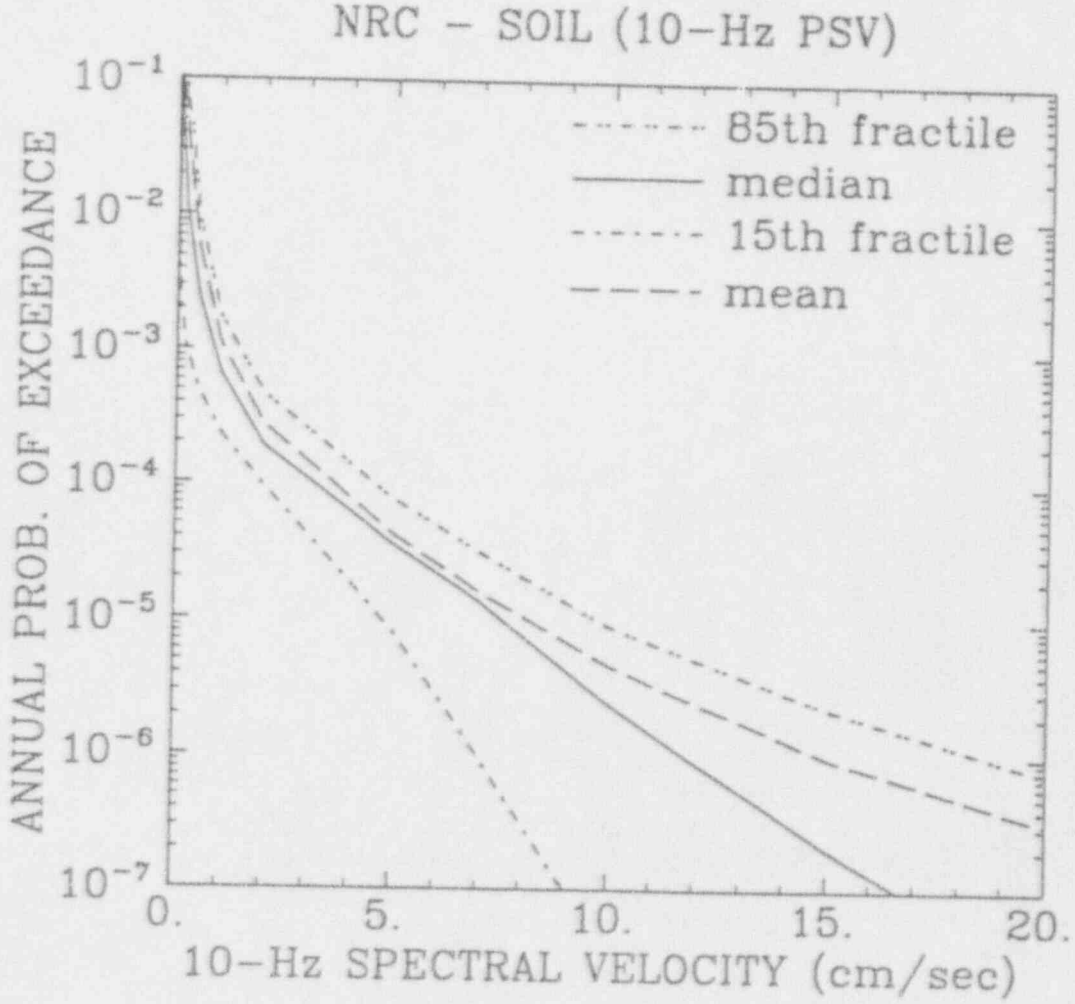

Figure 2-3: Hazard results using NRC sources; 10-Hz spectral velocity

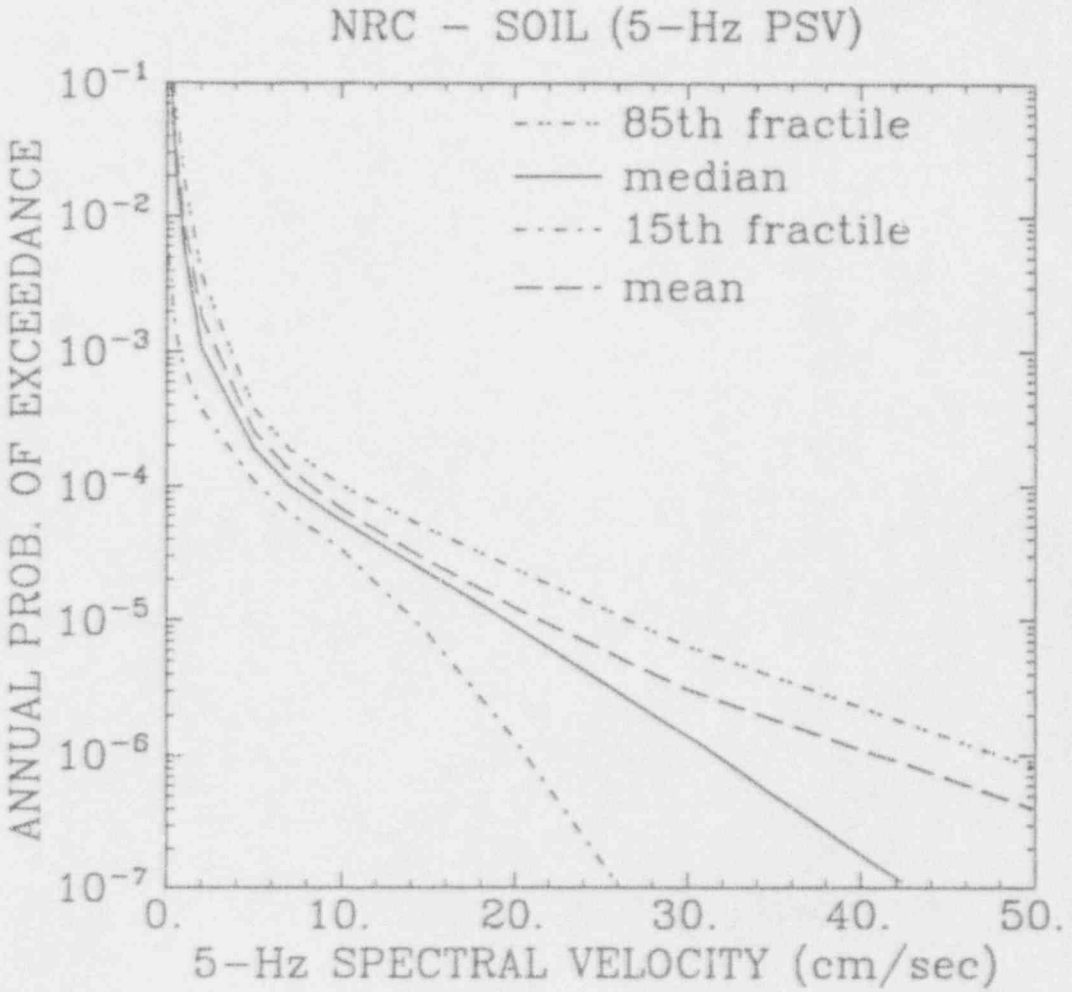

Figure 2-4: Hazard results using NRC sources; 5-Hz spectral velocity

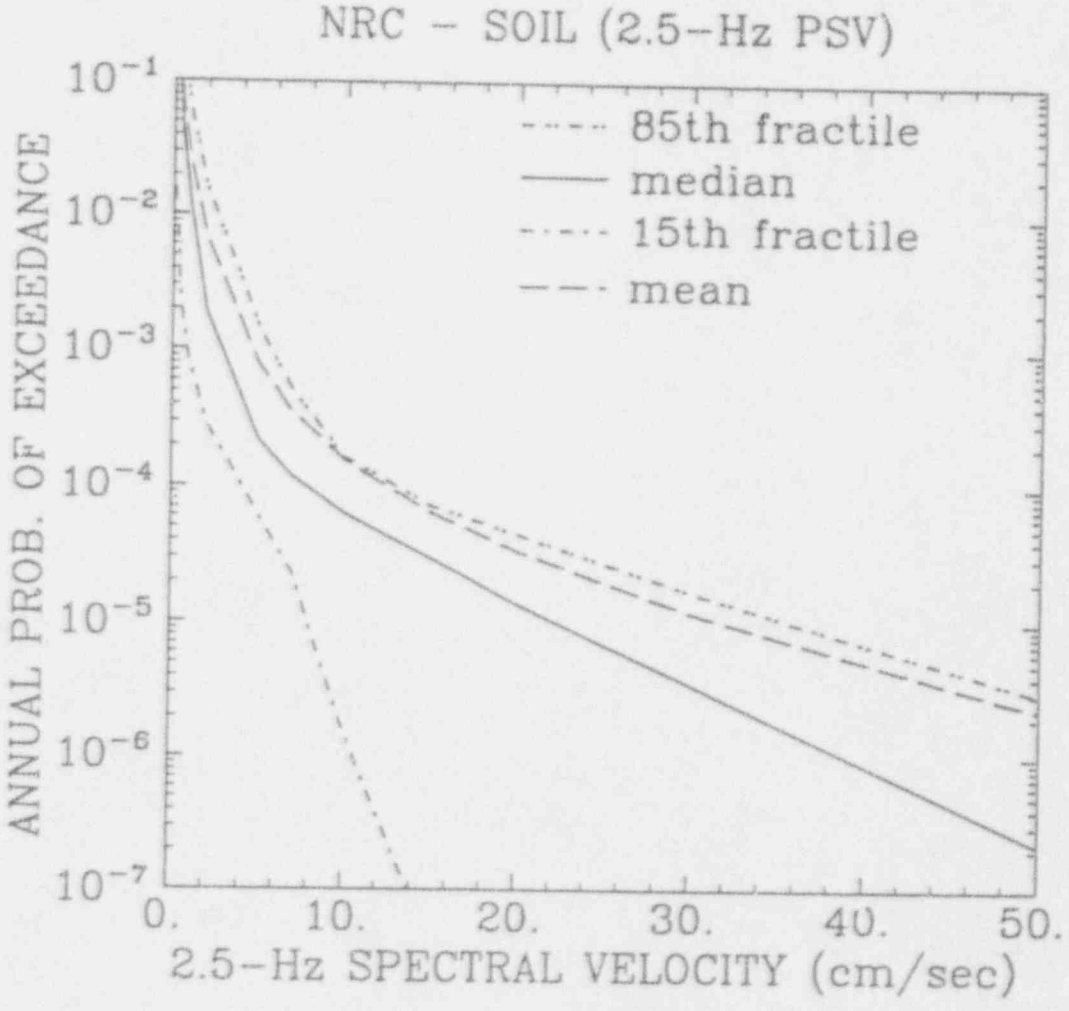

Figure 2-5: Hazard results using NRC sources; 2.5-Hz spectral velocity

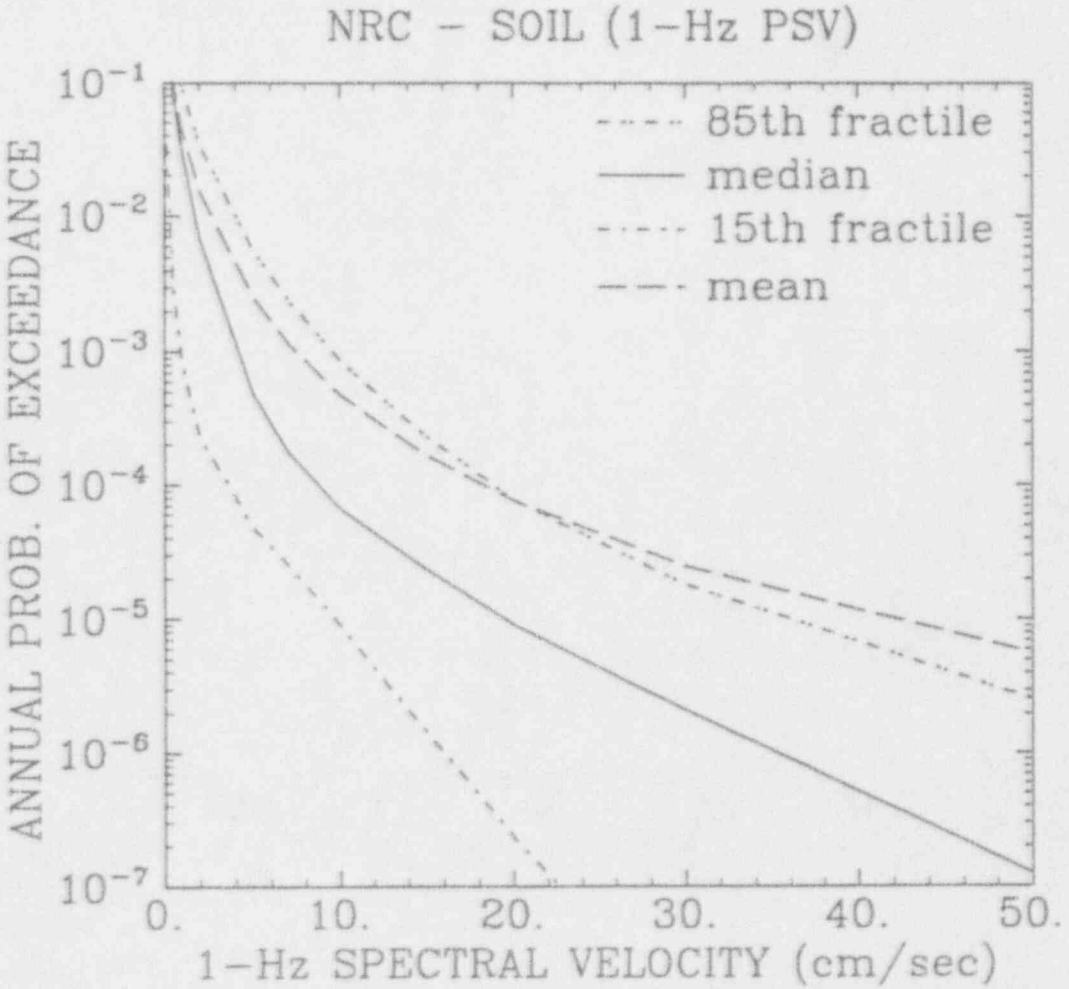

Figure 2-6: Hazard results using NRC sources; 1-Hz spectral velocity

Question II-2 (Seismic Wave Attenuation): "The supplemental study incorporated ground motion models proposed by K. Campbell and W. Joyner and D. Boore. These models are inappropriate in the form presented because they were derived from southern California (deep soil) ground motion records and do not reflect the seismic attenuation expected in southern Arizona. During a telephone conversation, Dr. Campbell said that he had recently revised his model and that of Joyner and Boore in an effort to simulate the southern Arizona geologic characteristics. Dr. Campbell believes that the resulting modified Campbell and modified Joyner and Boore ground motion models are more appropriate for the Palo Verde site, assuming a soil depth to basement rock of 250 m. Also the revised (supplemental) study utilizes the same ground motion model weighting scheme as the original study did. The staff recommends that a sensitivity analysis be performed using the modified Campbell model, the modified Joyner and Boore model, and the McGuire model with equal weights applied to all the models."

The Campbell (1991) attenuation equations are based on data that were considered representative of both soil and soft rock (see Campbell, Empirical Prediction of Near-Source Ground Motion for the Diablo Canyon Power Plant Site, San Luis Obispo, California, report to LLNL, September, 1990). The Joyner-Boore attenuation equations have a term that accounts for soil effects. This term was set to zero in order to predict outcrop ground motions. Differences in anelastic attenuation were accommodated by using γ terms appropriate for the Basin and Range Province. Therefore the Campbell and Joyner-Boore equations, as applied in the Palo Verde seismic hazard study, are appropriate methods for the prediction of outcrop ground motions at Palo Verde.

The Revised Palo Verde Seismic Hazard Report (Reference C) utilizes Dr. Campbell as a consultant in ground motion estimation, along with Dr. N. Abrahamson (consultant) and Dr. G.R. Toro of Risk Engineering, Inc. The resulting nine attenuation equations reflect the thinking of these attenuation experts on what might be reasonable ground motions for the Palo Verde study, and reflect the range of interpretations that are available. The sensitivity to choice of attenuation equation is presented in Figures 6-39 to 6-44 of Reference C.

As described in Section 5 of Reference C, five of the nine attenuation equations provide ground-motion estimates for rock conditions. These are then modified using the site-specific soil amplification factors. Four of the nine attenuation equations provide ground-motion estimates for generic soil sites, without explicitly considering the effect of the site-specific soil column on ground motions. It was the collective opinion of all ground-motion contributors that it was appropriate to assign a weight of 0.67 to the five attenuation equations that use site-specific amplification factors, and a weight of 0.33 to the generic-soil attenuation equations. Within each group, the attenuation equations are given approximately equal weights, as shown in Table 2-4. Although it is possible to propose various combinations and weighting schemes, it was not considered appropriate to arbitrarily neglect certain models or weighting factors, because the purpose of the base-case results is to obtain robust estimates that can be meaningfully compared to the EPRI results for plant sites in the central and eastern United States. Questions of sensitivity to the various attenuation functions are addressed in Figures 6-39 through 6-44 of Reference C.

Table 2-4

Attenuation Functions, Associated Weights, and Treatment of Site Effects

Attenuation-Function Type	Name	Weight
Applicable to soft rock; used with site-specific amplification factors (combined weight: 2/3)	Joyner-Boore (1982)	0.1333
	Joyner-Boore (1982; alternative Q)	0.1333
	Campbell (1991)	0.1333
	Campbell (1991; alternative Q)	0.1333
	Abrahamson (Model 3)	0.1333
Applicable to generic soil (combined weight: 1/3)	Abrahamson (Model 1)	0.0952
	Abrahamson (Model 2)	0.0476
	Campbell Model 1/2	0.0952
	Campbell Model 3/4	0.0952

Question II-3 (Soil Characteristics): "The supplemental study (Ref. 3) uses the modulus reduction and damping curves developed by Seed and Idriss and a "Standard Soil Profile." The staff recommends that a sensitivity study be performed using the range of shear degradation models shown in Figure 2 and that it assesses the influence of using the upper range and lower range of the soil profiles shown in the supplemental report (Ref. 3, Supplemental Report, Figure 2-2)."

Neither the supplemental study (NRC's Reference 3, our Reference B) nor the Revised Palo Verde Seismic Hazard Report (Reference C) use the Seed-Idriss curves or a standard velocity profile. In particular, Reference C uses the recently developed EPRI curves for sand and Vucetic-Dobry curves for clay, and a median velocity profile based on PVNGS Unit 2.

To investigate the effects of different assumptions on soil material properties, we have undertaken a number of sensitivity studies. These are described as follows.

To determine the effect of different modulus and damping curves, the soil/rock amplification was computed for the range of frequencies and amplitudes used in this study. Figures 3-1 through 3-6 compare these amplification factors. The solid line (labelled "EPRI") is the base case amplification used in the Revised Palo Verde Seismic Hazard Report (it makes use of soil material properties developed during a recent EPRI study, and uses the Unit-2 velocity profile as described in Reference C; Revised Palo Verde Seismic Hazard Report). The dashed curve uses the Geomatrix material properties; these amplifications are below or very close to the base case values at all frequencies, meaning that the use of the Geomatrix curves would not substantially change the results presented in the Revised Palo Verde Seismic Hazard Report.

The curves labeled EPRI/SOG Category IV in Figures 3-1 through 3-6 indicate the amplifications from the EPRI/SOG Category IV amplification factors (i.e., using the 1988 EPRI/SOG profiles, modulus, curve, and damping curve shown in Figures 2-2 and 2-3 of Reference D). The EPRI/SOG amplification factors are generally below the base case except for 2.5 and 5 Hz, where they indicate higher amplification (this is the profile referred to in Question II-3). To determine the effect on hazard, these amplification factors were used to compute hazards at Palo Verde, and the results are shown in Figures 3-7 through 3-12 for PGA and the five frequencies. Quantitative probabilities are presented in Table 3-1, and percent changes in hazard (probability) are presented in Table 3-2.

Additional analyses were made as requested, using the lower- and upper-bound EPRI/SOG shear wave profiles, together with the EPRI/SOG modulus and damping curves. Summary hazard results are presented in Tables 3-3 and 3-5 for the two profiles, and percent changes in hazard are presented in Tables 3-4 and 3-6. For these analyses, no uncertainty on shear wave velocity was assumed, as the intent was to examine the effects of lower-bound and upper-bound assumptions.

As a result of a further NRC requested sensitivity, the Unit 2 shear wave profile was used with an assumed 30% coefficient-of-variation in shear wave velocity and full correlation among velocities at different depths. The base-case modulus-reduction and damping curves were used. The resulting hazards are presented in Table 3-7, with percent changes in hazards from the base case presented in Table 3-8.

Some of these sensitivity studies indicate increases in hazard, but these results should not be viewed as realistic. The EPRI-SOG shear wave profile was developed as a generic model for deep soil sites in the eastern United States. The results from this model (Tables 3-1 and 3-2) are not appropriate to use at Palo Verde where site-specific velocities are available. In particular, the upper-bound EPRI/SOG velocity results (Tables 3-5 and 3-6) are not appropriate to use, to characterize the hazard at Palo Verde. The sensitivity study that assumed a 30% coefficient of variation is also not appropriate (Tables 3-7 and 3-8). Shear wave velocities do not vary in a perfectly-correlated way with depth, and the EPRI model of velocity correlation (which was used for the base case results, Reference C) is a more accurate and realistic model to determine soil response. Furthermore, it will be shown in pages 47 and 48 of this report that the conclusion of a 0.3g RLE would not be affected by the use of any of the site amplification factors considered in this sensitivity study.

As a final sensitivity, Figures 3-13 through 3-18 show the soil amplification factors for the three units at Palo Verde. The base case results used only the amplification factors for Unit 2, which are conservative (higher amplification) with respect to application at the other two units.

Table 3-1

SPECTRAL VELOCITIES (cm/sec) FOR
VARIOUS EXCEEDANCE PROBABILITIES:
PALO VERDE SITE (SOIL)
(EPRI/SOG PROFILE, MODULUS CURVE, AND DAMPING CURVE)

		Frequency (Hz)				
		25	10	5	2.5	1
Exceedance		Period (sec)				
Probability	Percentile	0.04	0.1	0.2	0.4	1
1.E−03	15	0.12	0.33	1.15	1.90	1.21
	50	0.27	1.08	3.02	5.16	5.00
	85	0.47	2.00	5.22	9.07	11.60
2.E−04	15	0.37	1.47	4.18	6.10	3.07
	50	0.64	2.56	7.08	10.80	9.34
	85	1.10	5.04	13.10	18.90	20.60
1.E−04	15	0.56	2.17	6.19	9.00	4.66
	50	0.94	3.60	10.10	15.20	12.40
	85	1.49	6.53	18.40	27.20	25.80
1.E−05	15	1.30	4.84	15.20	23.10	13.30
	50	2.06	7.97	23.40	37.60	30.40
	85	2.93	12.50	37.90	62.20	58.00

Table 3-2

PERCENT CHANGE IN SPECTRAL VELOCITIES FOR
PALO VERDE SITE (SOIL)
(EPRI/SOG PROFILE, MODULUS CURVE, AND DAMPING CURVE)

		Frequency (Hz)				
		25	10	5	2.5	1
Exceedance		Period (sec)				
Probability	Percentile	0.04	0.1	0.2	0.4	1
1.E−03	15	-8	-6	7	31	-32
	50	-4	0	6	19	-29
	85	0	8	8	12	-13
2.E−04	15	-5	3	14	27	-34
	50	-2	1	8	14	-26
	85	0	8	13	6	-13
1.E−04	15	-3	2	9	22	-34
	50	0	2	10	12	-26
	85	1	5	14	8	-17
1.E−05	15	-7	-2	7	5	-30
	50	-4	4	10	6	-21
	85	-3	-2	9	8	-14

Table 3-3

SPECTRAL VELOCITIES (cm/sec) FOR
VARIOUS EXCEEDANCE PROBABILITIES:
PALO VERDE SITE (SOIL)
(EPRI/SOG - LOWER BOUND)

		Frequency (Hz)				
		25	10	5	2.5	1
Exceedance		Period (sec)				
Probability	Percentile	0.04	0.1	0.2	0.4	1
1.E−03	15	0.16	0.53	1.59	1.49	1.48
	50	0.31	1.31	3.33	4.35	5.98
	85	0.48	2.15	5.46	7.71	11.90
2.E−04	15	0.44	1.72	4.85	5.06	3.73
	50	0.71	2.95	7.54	9.08	10.60
	85	1.12	5.04	12.20	16.30	21.10
1.E−04	15	0.64	2.37	6.84	7.61	5.52
	50	1.03	4.05	10.40	13.10	14.00
	85	1.47	6.53	16.00	22.70	26.40
1.E−05	15	1.54	5.48	15.70	20.70	16.90
	50	2.21	8.04	21.90	32.20	35.00
	85	2.95	11.80	34.20	50.60	62.50

Table 3-4

PERCENT CHANGE IN SPECTRAL VELOCITIES FOR
PALO VERDE SITE (SOIL)
(EPRI/SOG - LOWER BOUND)

		Frequency (Hz)				
		25	10	5	2.5	1
Exceedance		Period (sec)				
Probability	Percentile	0.04	0.1	0.2	0.4	1
1.E−03	15	23	51	49	3	-17
	50	11	21	17	1	-15
	85	2	16	13	-5	-11
2.E−04	15	13	20	32	5	-20
	50	9	16	15	-5	-17
	85	2	8	5	-9	-11
1.E−04	15	10	12	21	3	-22
	50	10	15	13	-4	-17
	85	0	5	-1	-10	-15
1.E−05	15	10	10	11	-6	-11
	50	3	5	3	-10	-9
	85	-3	-8	-2	-12	-7

Table 3-5

SPECTRAL VELOCITIES (cm/sec) FOR
VARIOUS EXCEEDANCE PROBABILITIES:
PALO VERDE SITE (SOIL)
(EPRI/SOG - UPPER BOUND)

		Frequency (Hz)				
		25	10	5	2.5	1
Exceedance		Period (sec)				
Probability	Percentile	0.04	0.1	0.2	0.4	1
1.E−03	15	0.14	0.39	0.87	2.31	0.96
	50	0.29	1.08	2.44	5.59	4.20
	85	0.48	1.85	4.39	9.07	11.10
2.E−04	15	0.43	1.47	3.06	7.09	2.64
	50	0.66	2.61	5.74	12.00	7.54
	85	1.10	4.67	10.50	19.60	18.70
1.E−04	15	0.62	2.13	4.85	10.80	3.88
	50	0.98	3.77	8.32	16.70	10.40
	85	1.47	6.83	15.10	29.20	23.80
1.E−05	15	1.56	5.31	13.60	29.00	10.90
	50	2.30	9.49	20.30	43.90	24.60
	85	3.11	15.70	34.40	68.20	51.60

Table 3-6

PERCENT CHANGE IN SPECTRAL VELOCITIES FOR
PALO VERDE SITE (SOIL)
(EPRI/SOG - UPPER BOUND)

		Frequency (Hz)				
		25	10	5	2.5	1
Exceedance		Period (sec)				
Probability	Percentile	0.04	0.1	0.2	0.4	1
1.E−03	15	8	11	-19	59	-46
	50	4	0	-14	29	-40
	85	2	-1	-9	12	-17
2.E−04	15	10	3	-17	47	-43
	50	2	3	-13	26	-41
	85	0	0	-9	10	-21
1.E−04	15	7	0	-14	46	-45
	50	4	7	-9	23	-38
	85	0	10	-7	16	-23
1.E−05	15	11	7	-4	31	-43
	50	7	24	-4	23	-36
	85	3	23	-11	18	-23

Table 3-7

SPECTRAL VELOCITIES (cm/sec) FOR
VARIOUS EXCEEDANCE PROBABILITIES:
PALO VERDE SITE (SOIL)
(UNIT-2 FULLY CORRELATED VELOCITIES - 30% COV)

		Frequency (Hz)				
		25	10	5	2.5	1
Exceedance		Period (sec)				
Probability	Percentile	0.04	0.1	0.2	0.4	1
1.E−03	15	0.14	0.36	1.07	1.62	1.86
	50	0.29	1.12	2.89	4.59	6.84
	85	0.47	1.92	4.84	8.12	12.80
2.E−04	15	0.41	1.51	3.99	5.28	4.67
	50	0.66	2.56	6.61	9.77	12.00
	85	1.10	4.86	11.90	17.50	22.20
1.E−04	15	0.60	2.19	5.98	7.99	6.83
	50	0.98	3.60	9.74	14.10	15.90
	85	1.47	6.65	17.20	24.60	28.20
1.E−05	15	1.48	5.27	15.60	22.40	17.60
	50	2.20	8.15	23.20	36.40	35.00
	85	3.06	12.60	36.00	58.00	64.90

Table 3-8

PERCENT CHANGE IN SPECTRAL VELOCITIES FOR
PALO VERDE SITE (SOIL)
(UNIT-2 FULLY CORRELATED VELOCITIES - 30% COV)

		Frequency (Hz)				
		25	10	5	2.5	1
Exceedance		Period (sec)				
Probability	Percentile	0.04	0.1	0.2	0.4	1
1.E−03	15	8	3	0	12	4
	50	4	4	2	6	-2
	85	0	3	0	0	-4
2.E−04	15	5	6	8	10	0
	50	2	1	1	3	-6
	85	0	4	3	-2	-6
1.E−04	15	3	3	6	8	-4
	50	4	2	6	4	-5
	85	0	7	6	-2	-9
1.E−05	15	6	6	10	1	-7
	50	3	6	9	2	-9
	85	1	-2	3	1	-4

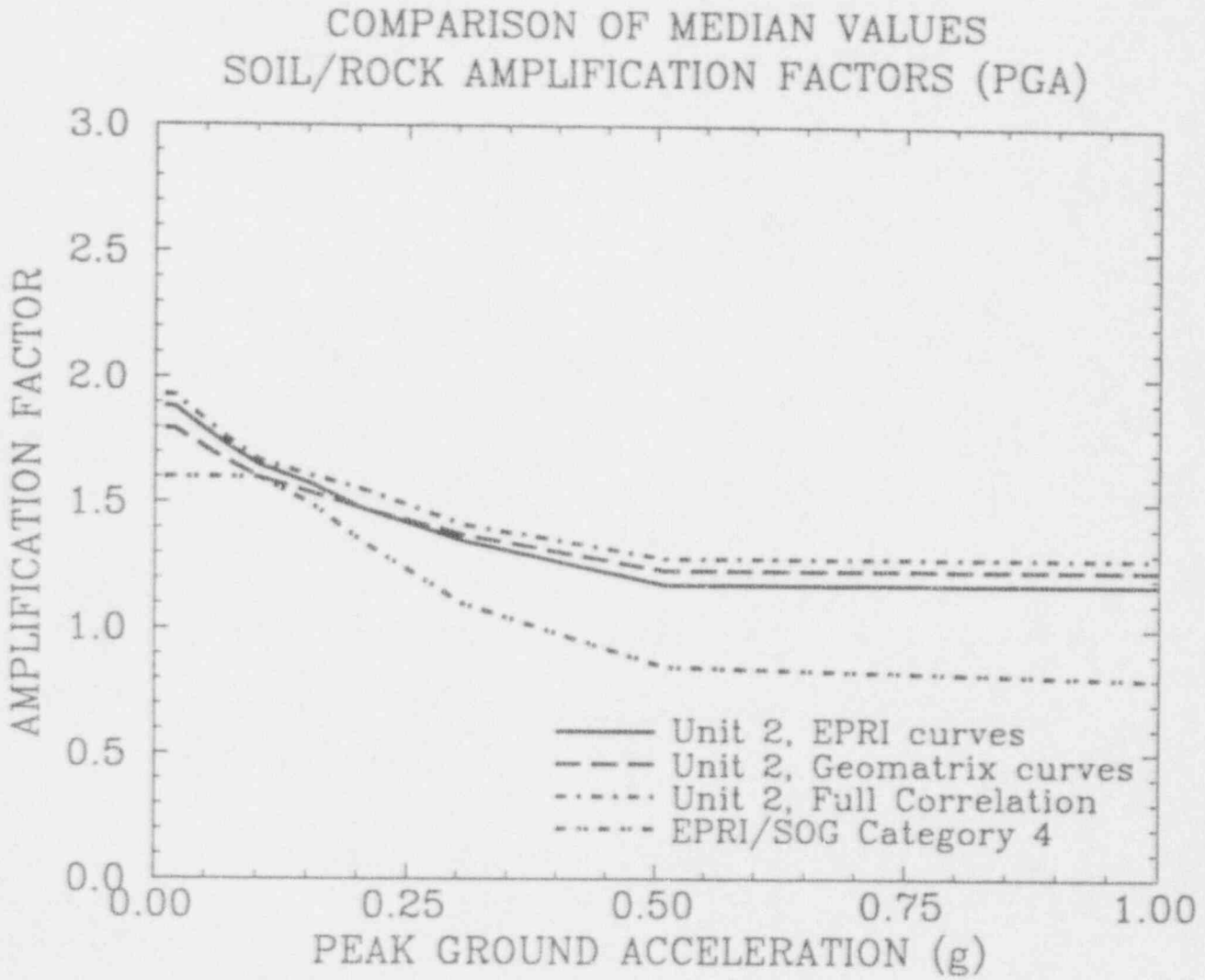

Figure 3-1: Soil amplification for various soil-property models; PGA

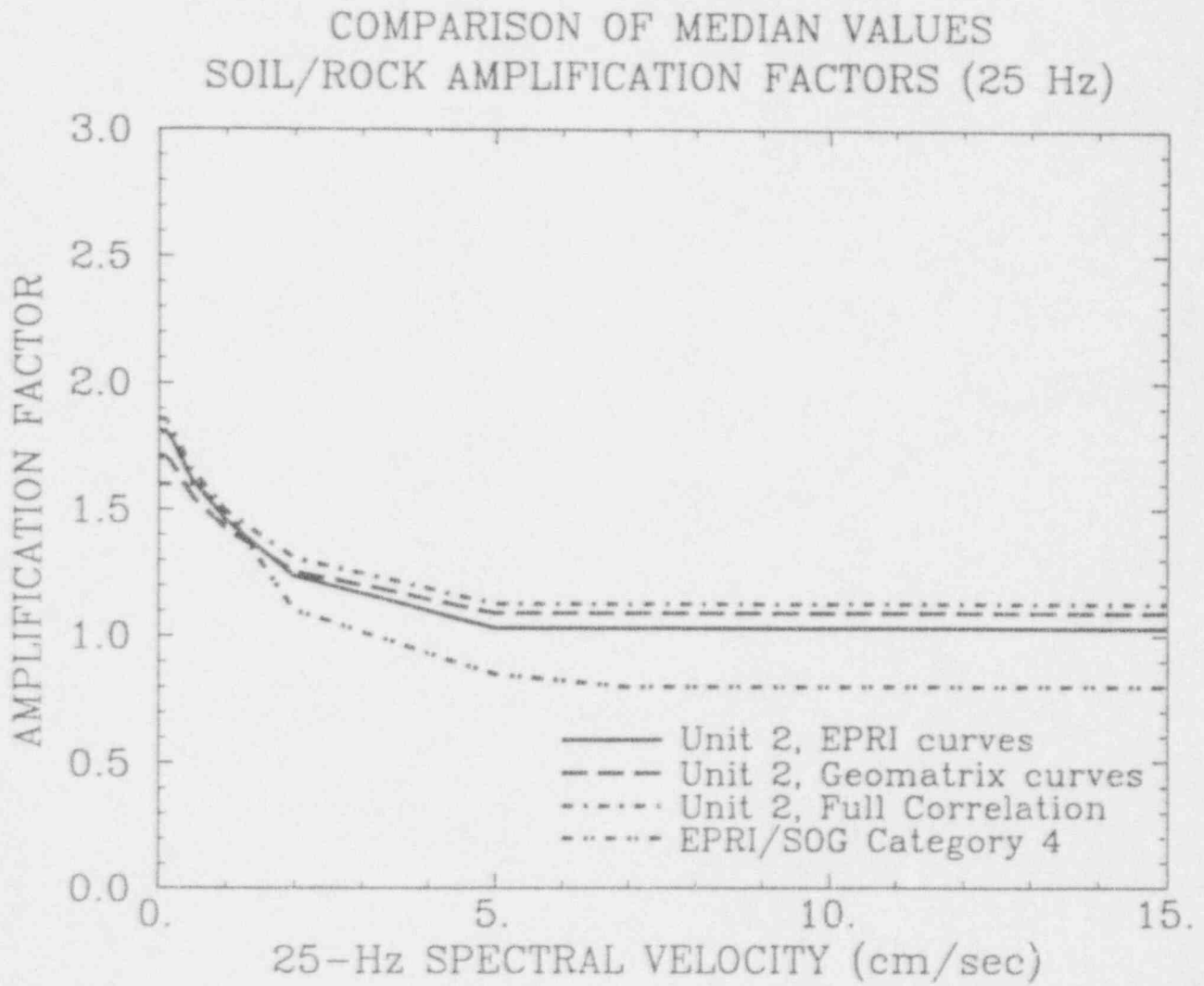

Figure 3-2: Soil amplification for various soil-property models; 25-Hz spectral velocity

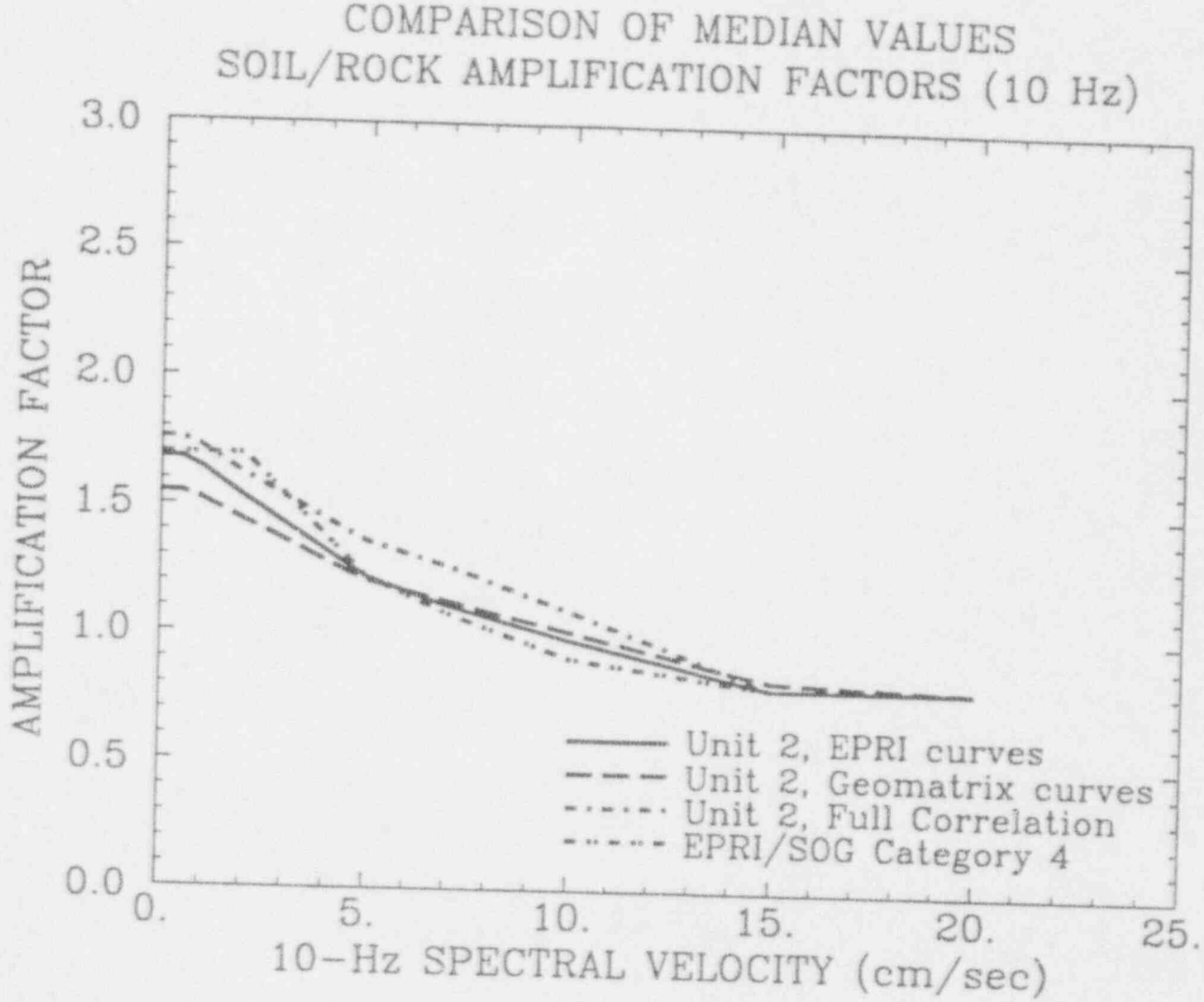

Figure 3-3: Soil amplification for various soil-property models, 10-Hz spectral velocity

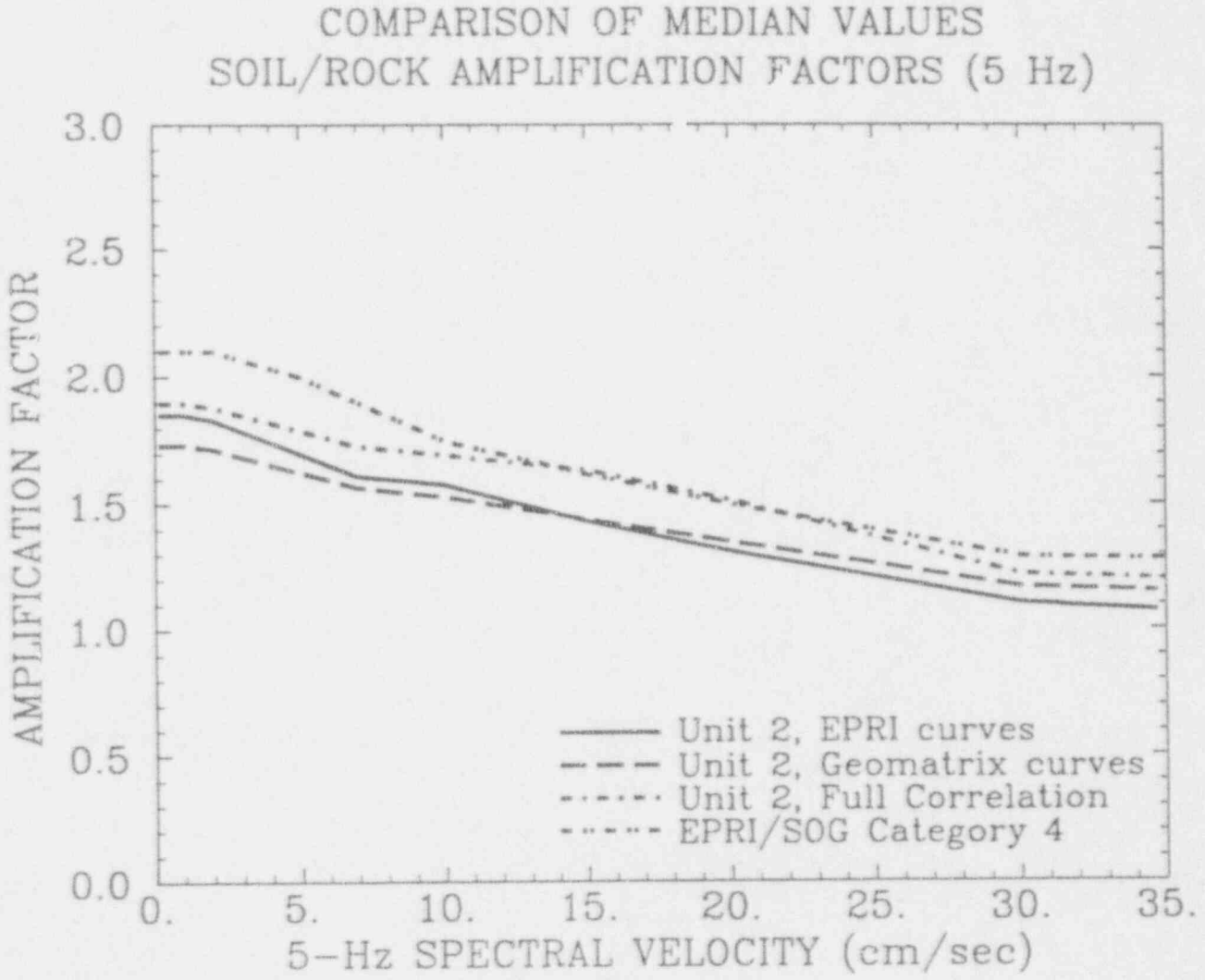

Figure 3-4: Soil amplification for various soil-property models; 5-Hz spectral velocity

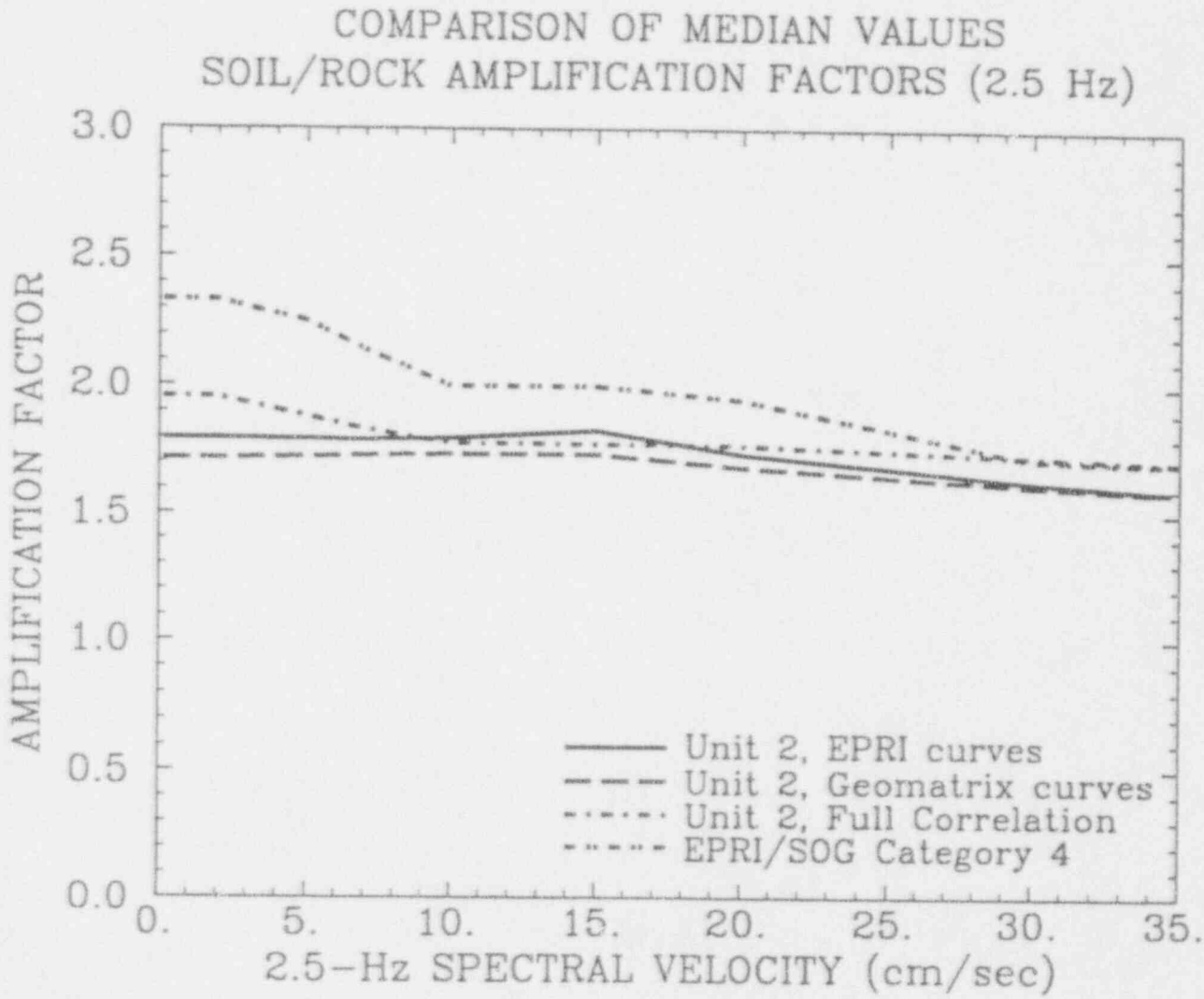

Figure 3-5: Soil amplification for various soil-property models; 2.5-Hz spectral velocity

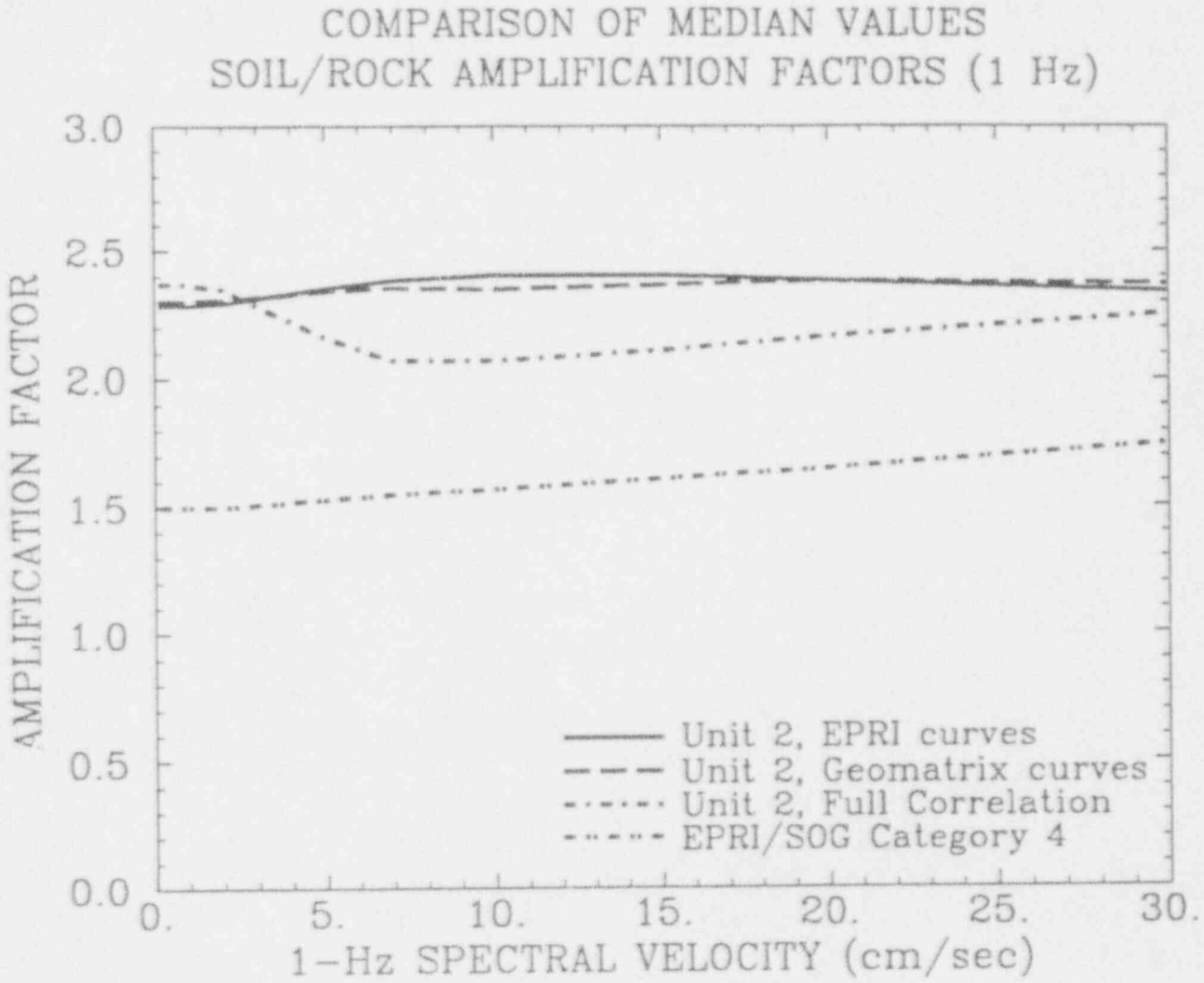

Figure 3-6: Soil amplification for various soil-property models; 1-Hz spectral velocity

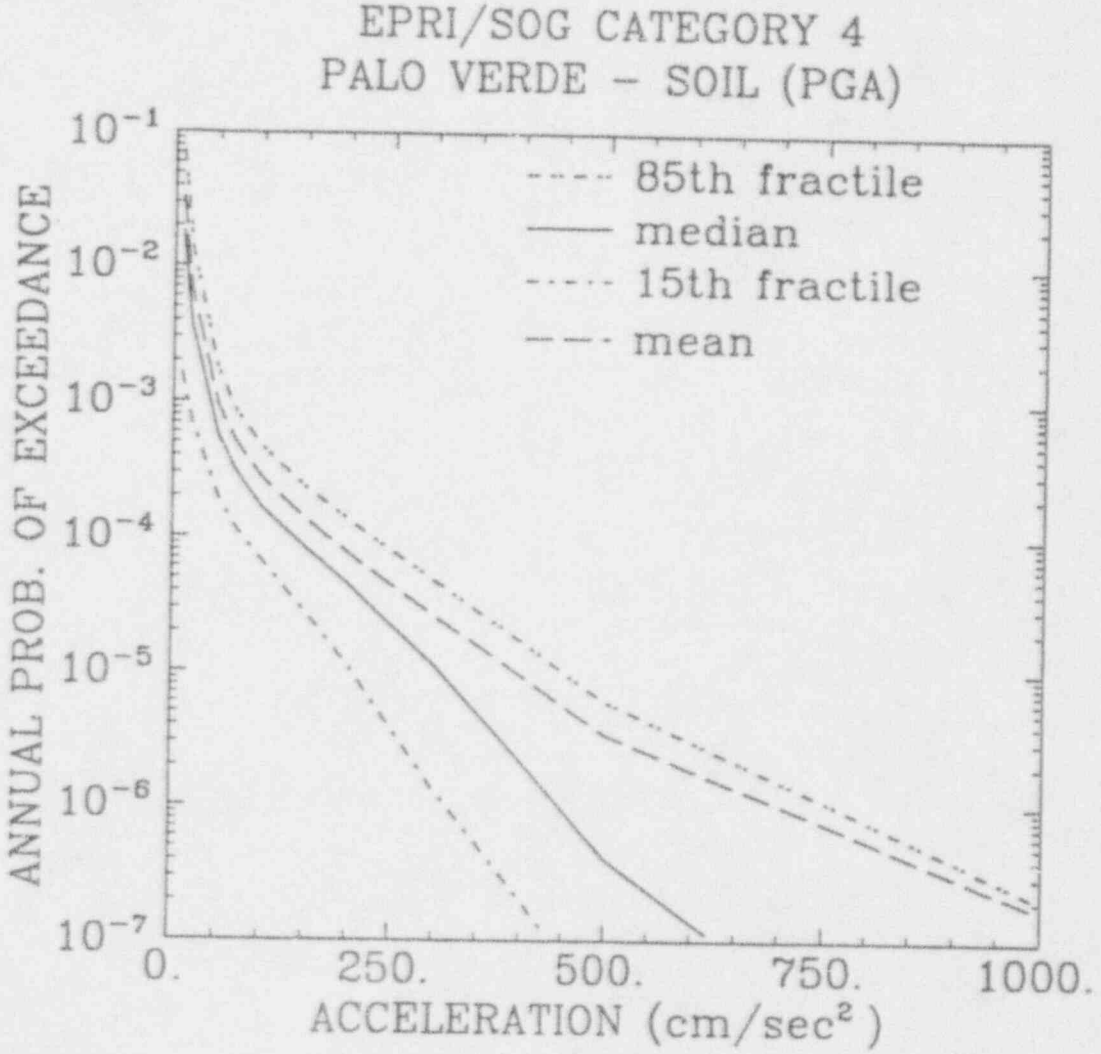

Figure 3-7: Hazard results using EPRI/SOG shear-wave velocity profile; PGA

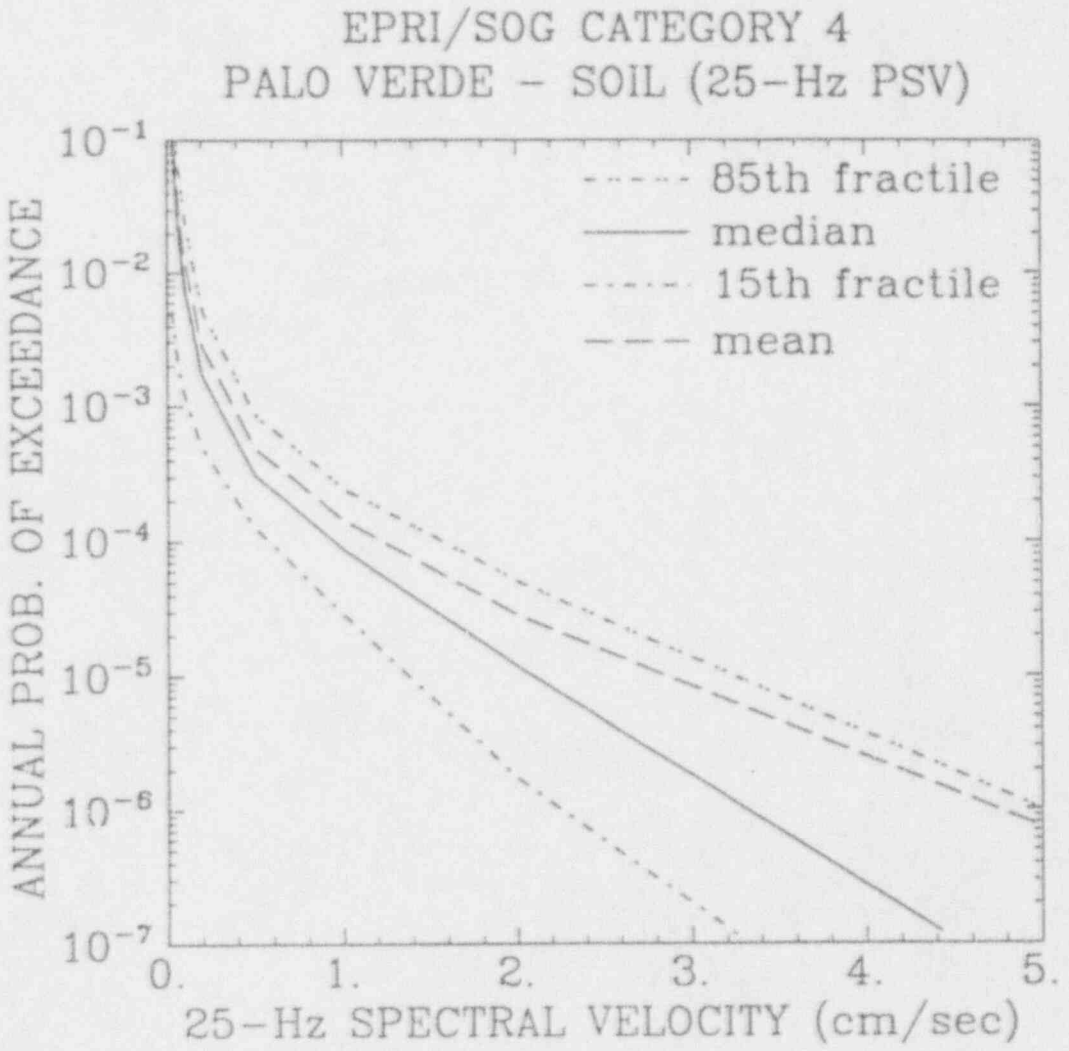

Figure 3-8: Hazard results using EPRI/SOG shear-wave velocity profile; 25-Hz spectral velocity

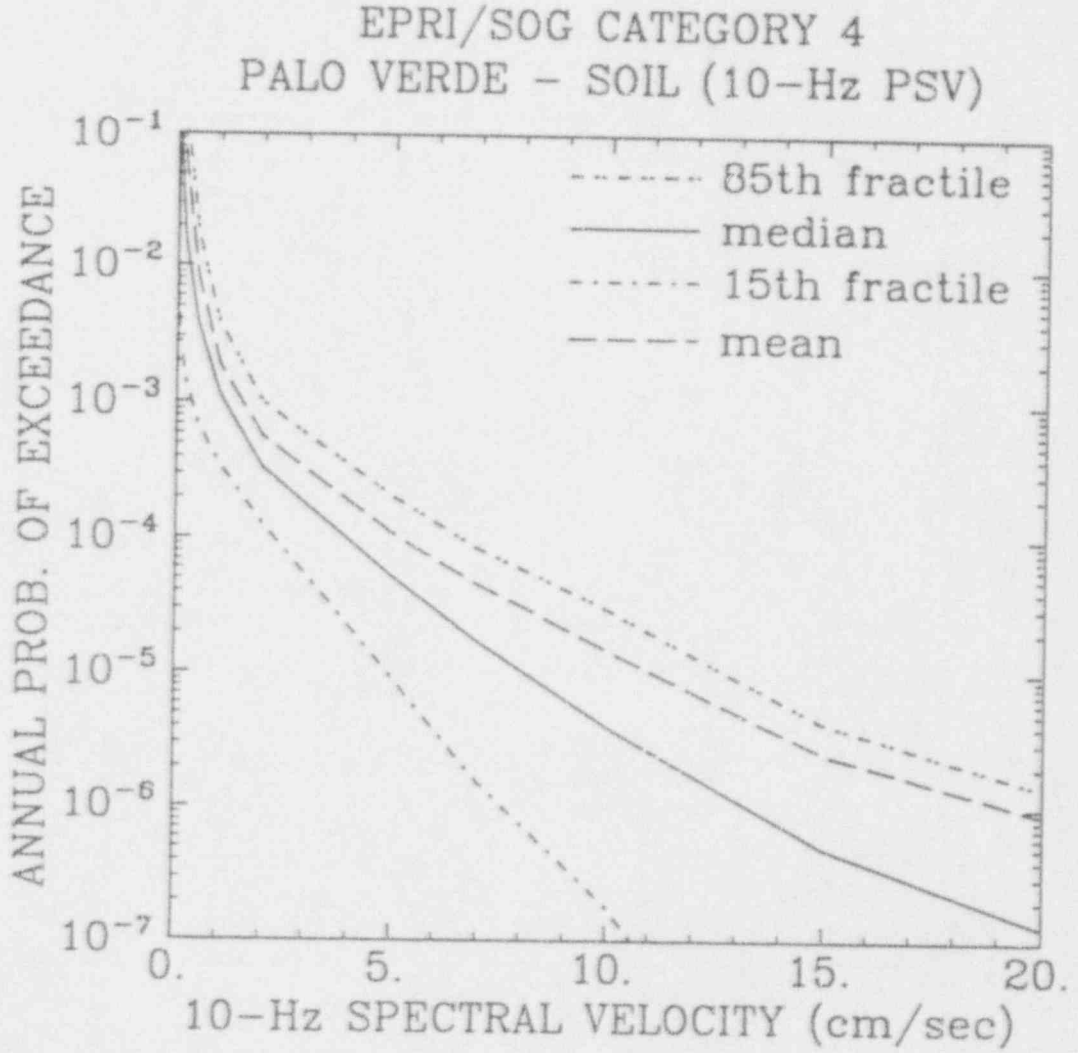

Figure 3-9: Hazard results using EPRI/SOG shear-wave velocity profile; 10-Hz spectral velocity

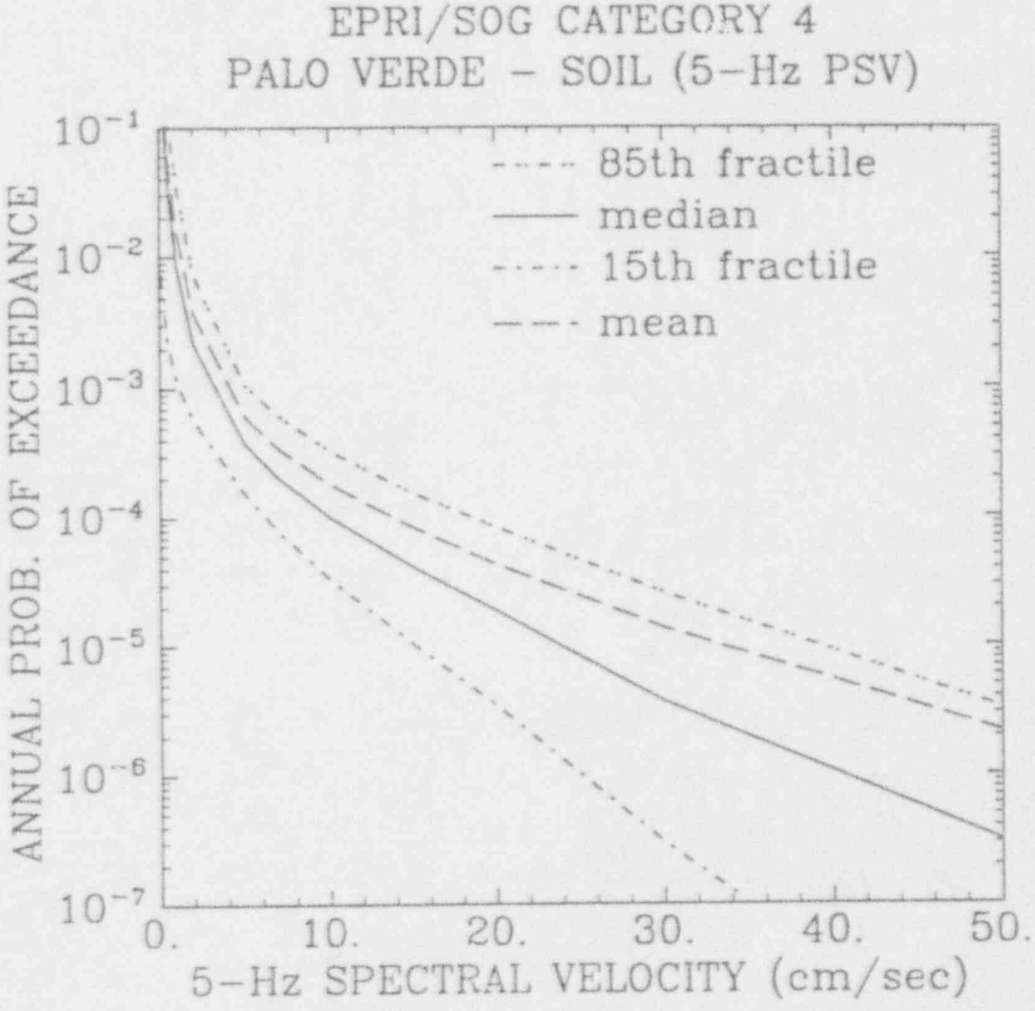

Figure 3-10: Hazard results using EPRI/SOG shear-wave velocity profile; 5-Hz spectral velocity

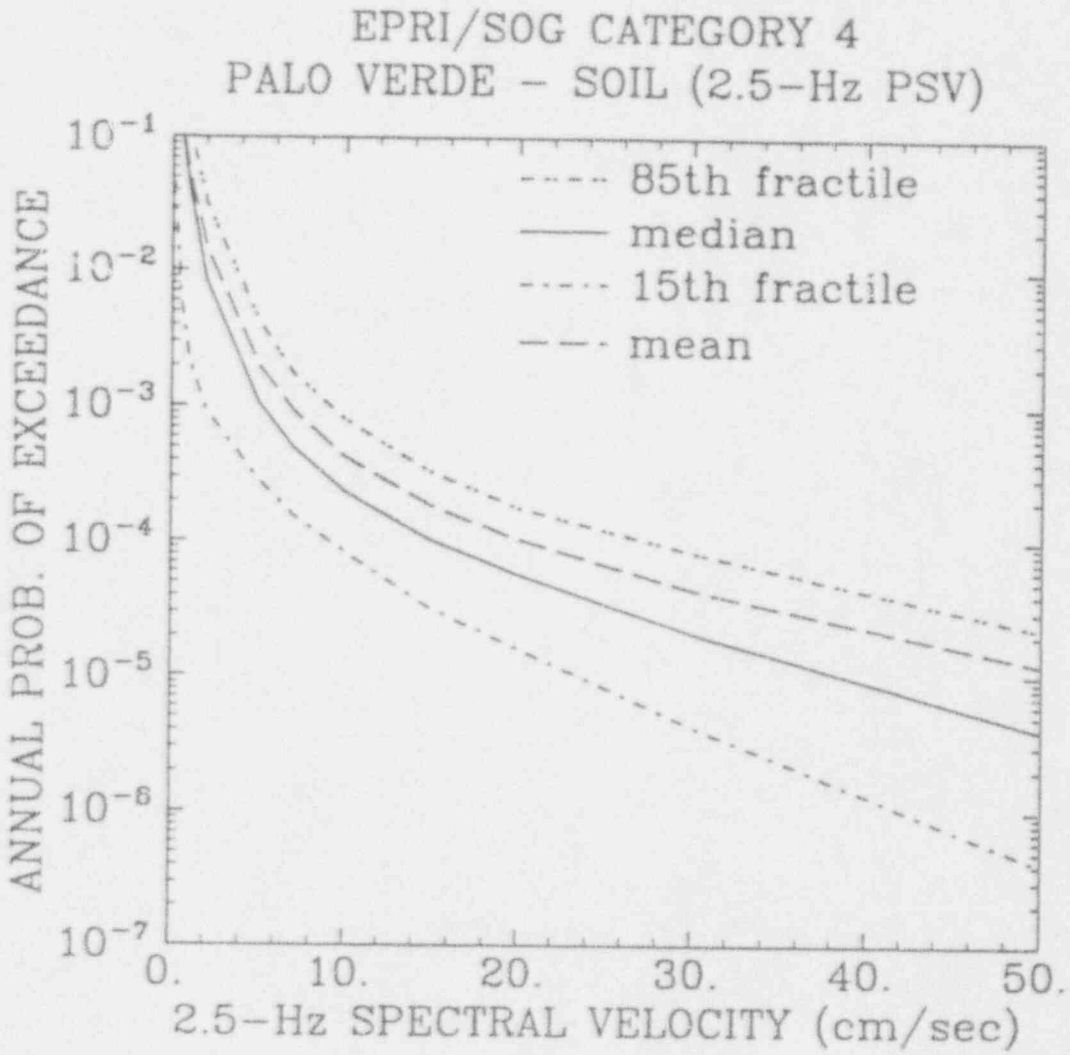

Figure 3-11: Hazard results using EPRI/SOG shear-wave velocity profile; 2.5-Hz spectral velocity

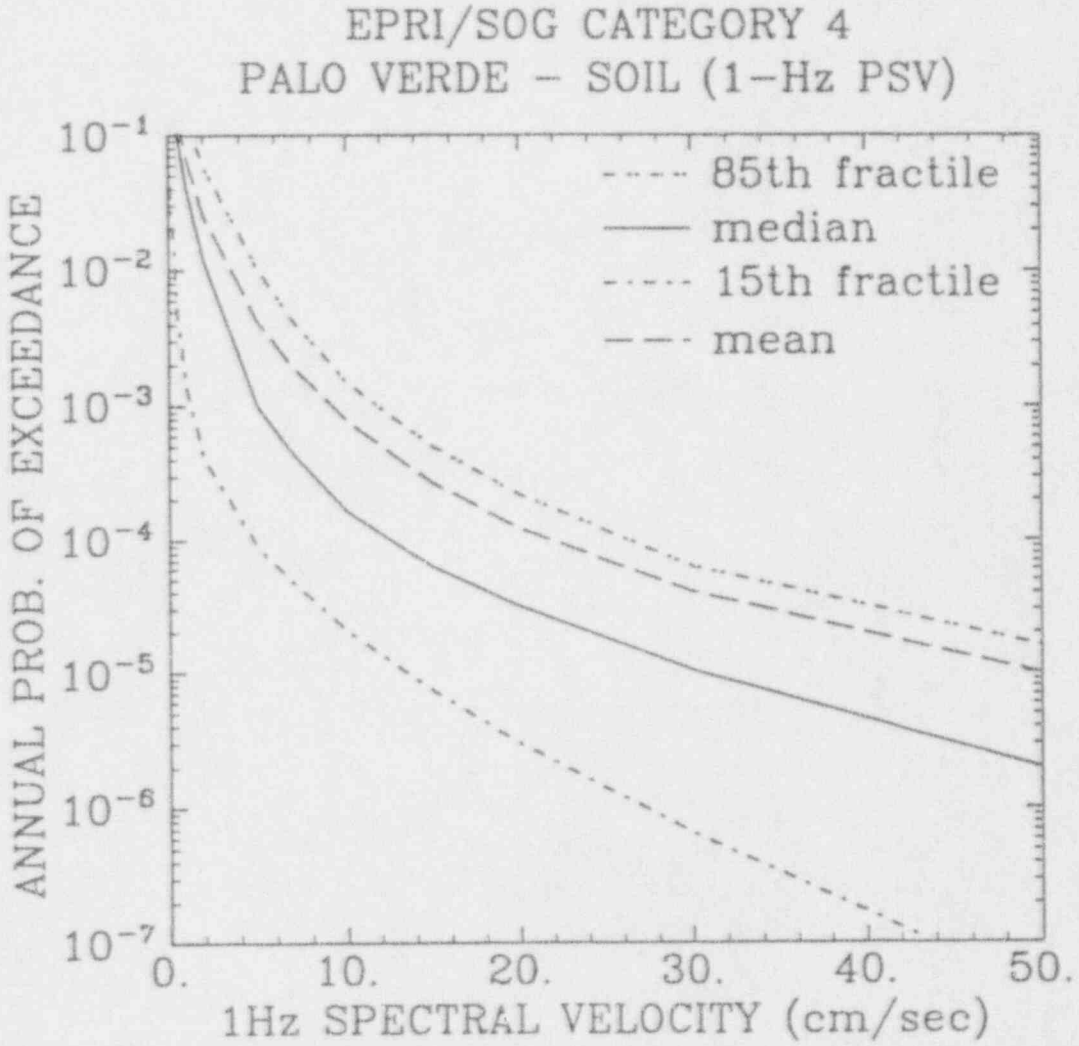

Figure 3-12: Hazard results using EPRI/SOG shear-wave velocity profile; 1-Hz spectral velocity

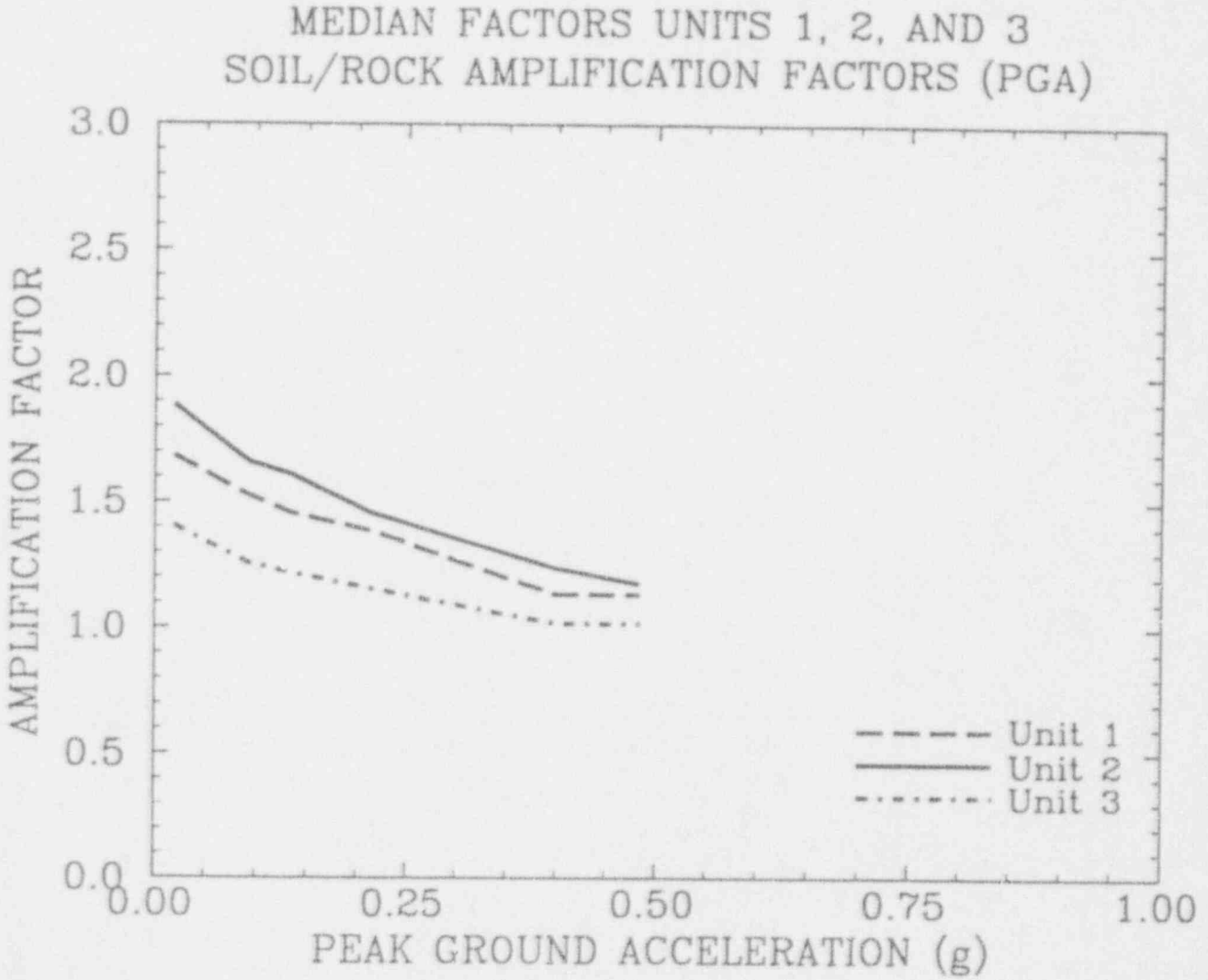

Figure 3-13: Soil amplification, Units 1,2, and 3; PGA

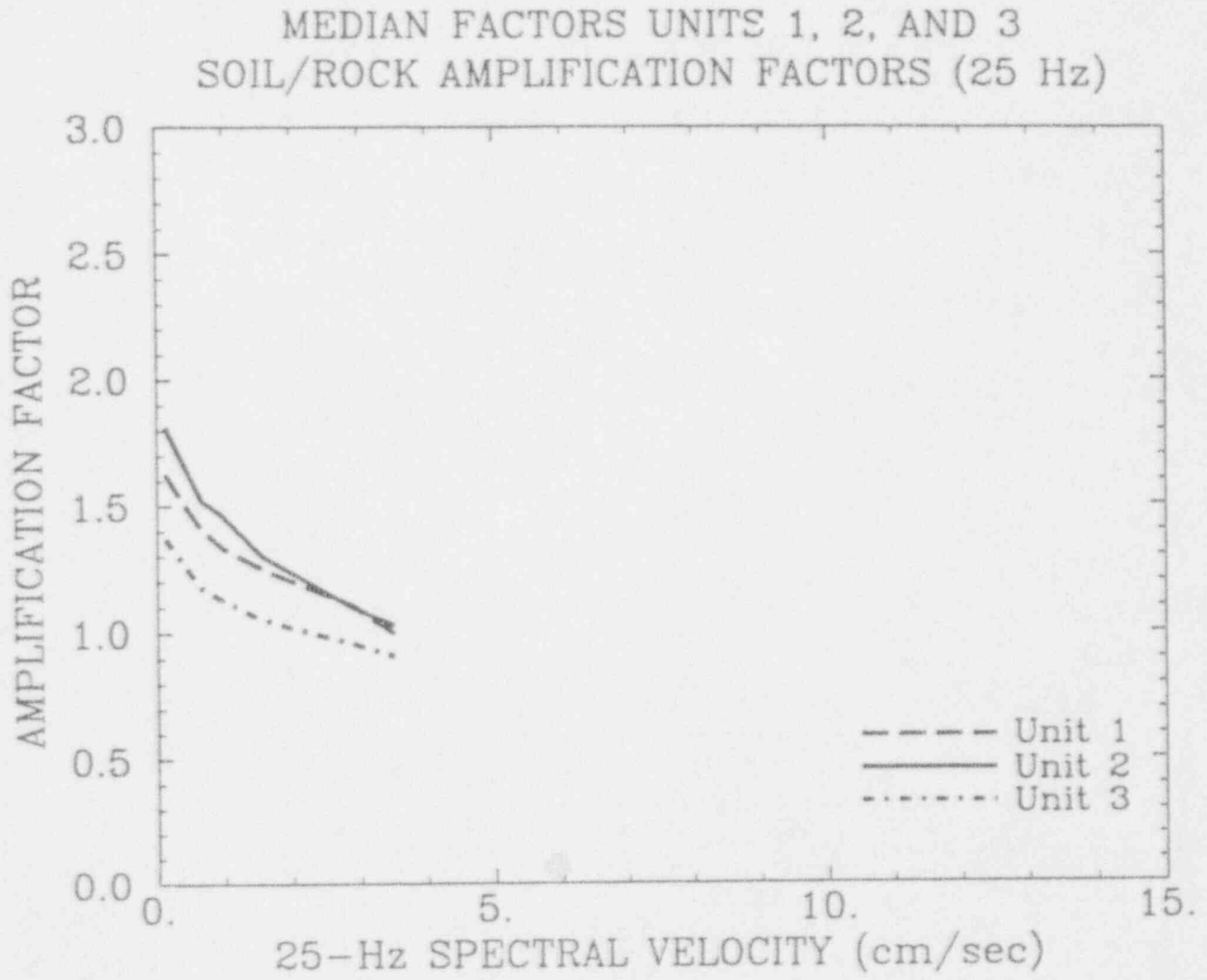

Figure 3-14: Soil amplification, Units 1,2, and 3; 25-Hz spectral velocity

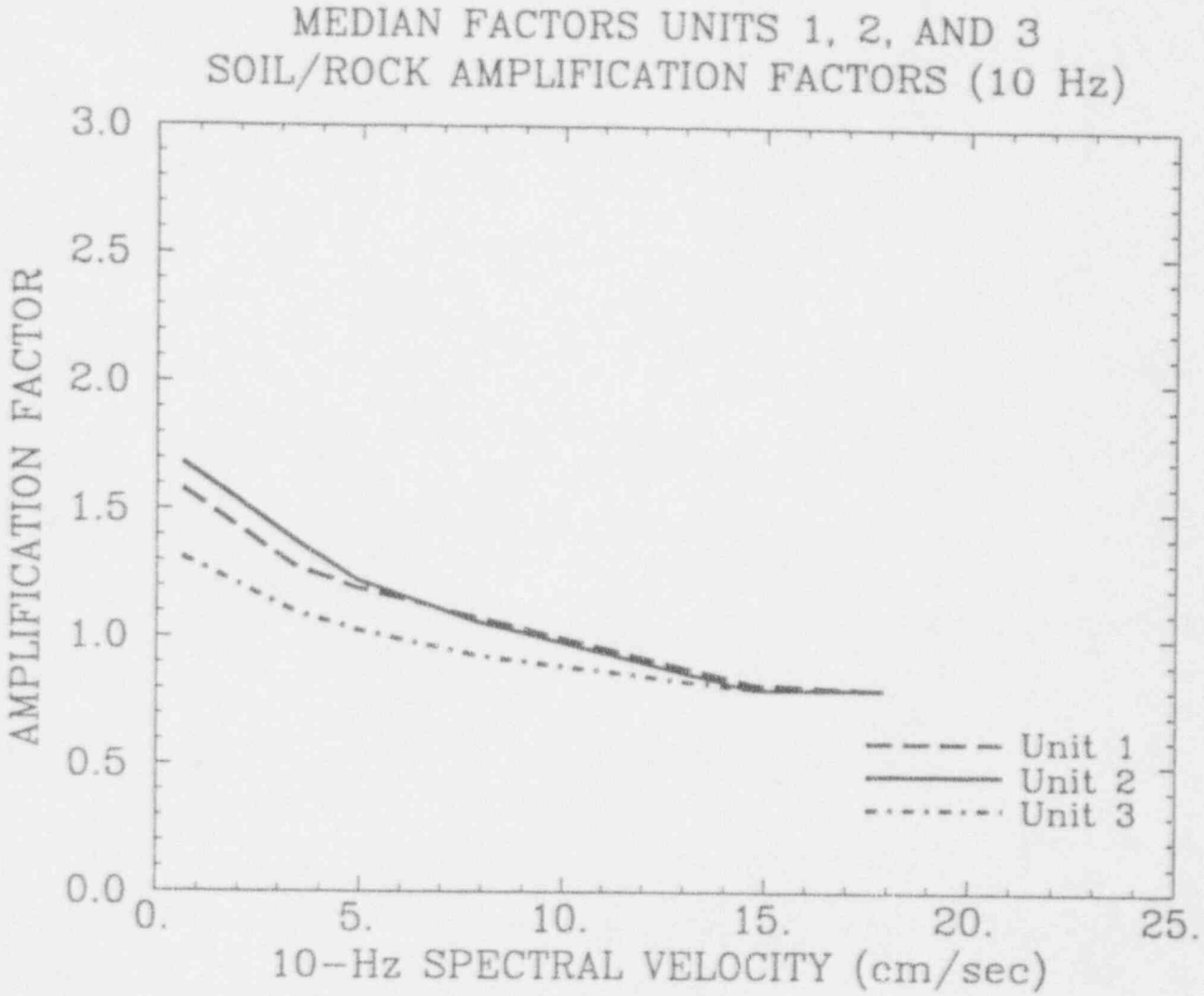

Figure 3-15: Soil amplification, Units 1,2, and 3; 10-Hz spectral velocity

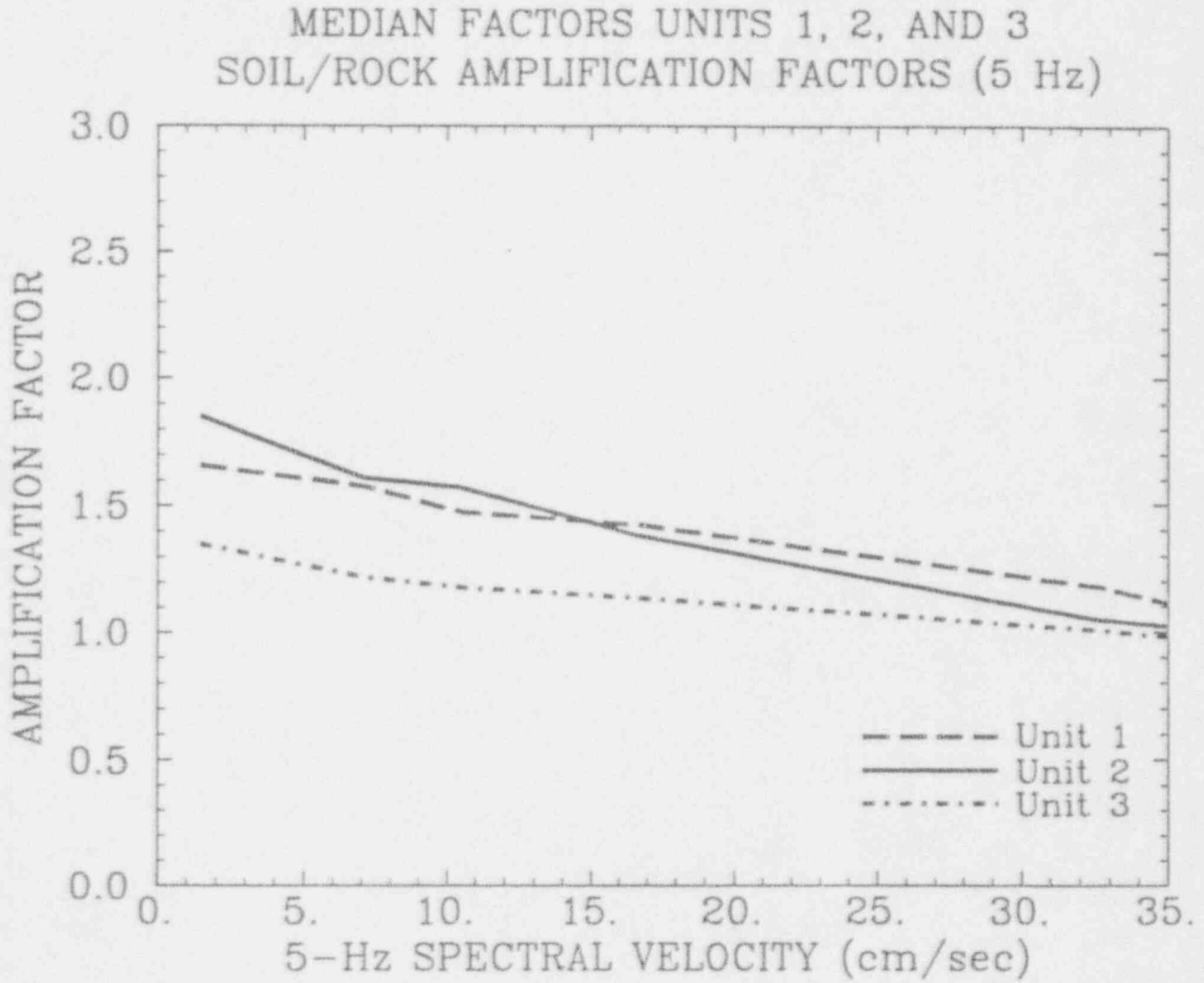

Figure 3-16: Soil amplification, Units 1,2, and 3; 5-Hz spectral velocity

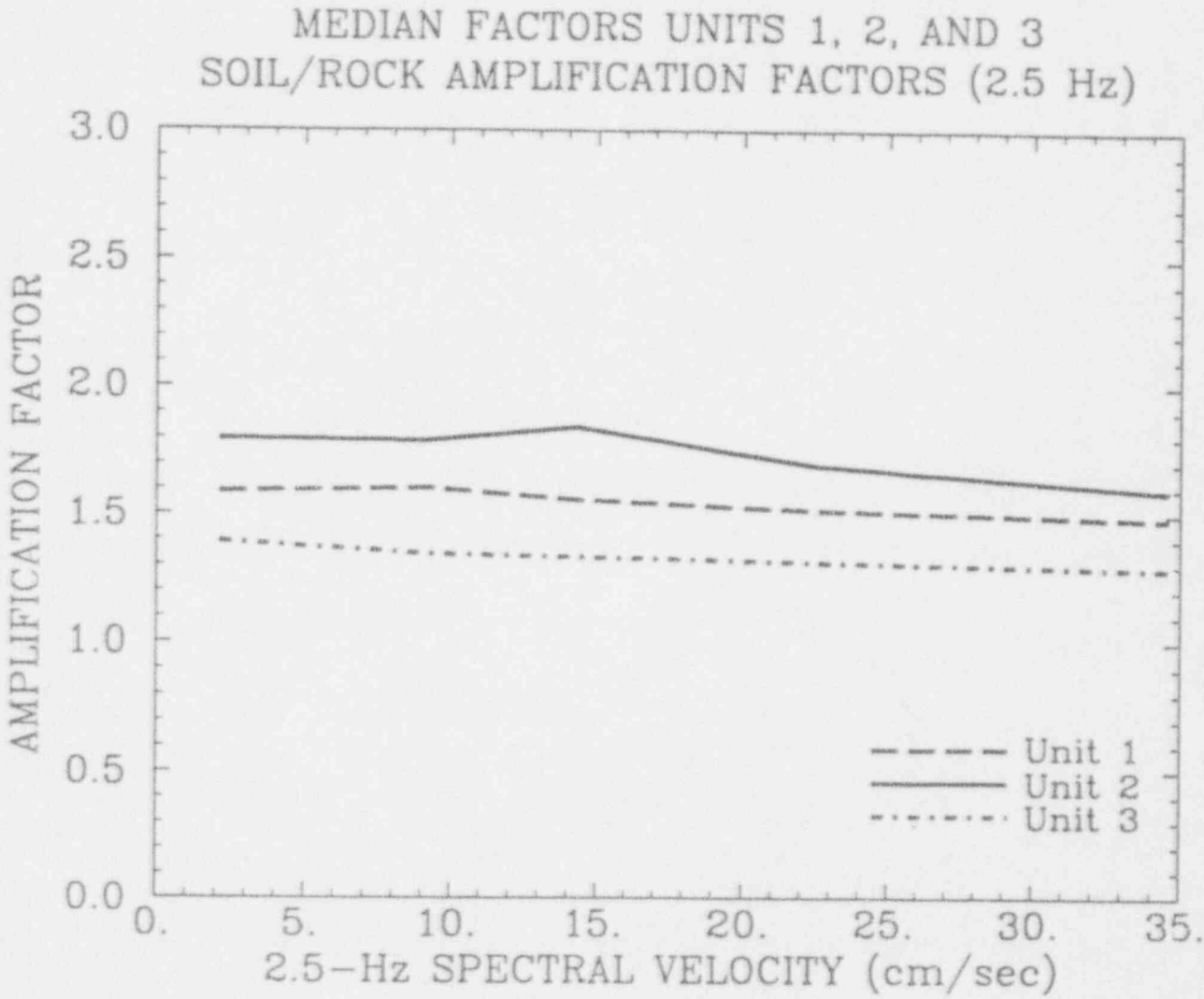

Figure 3-17: Soil amplification, Units 1,2, and 3; 2.5-Hz spectral velocity

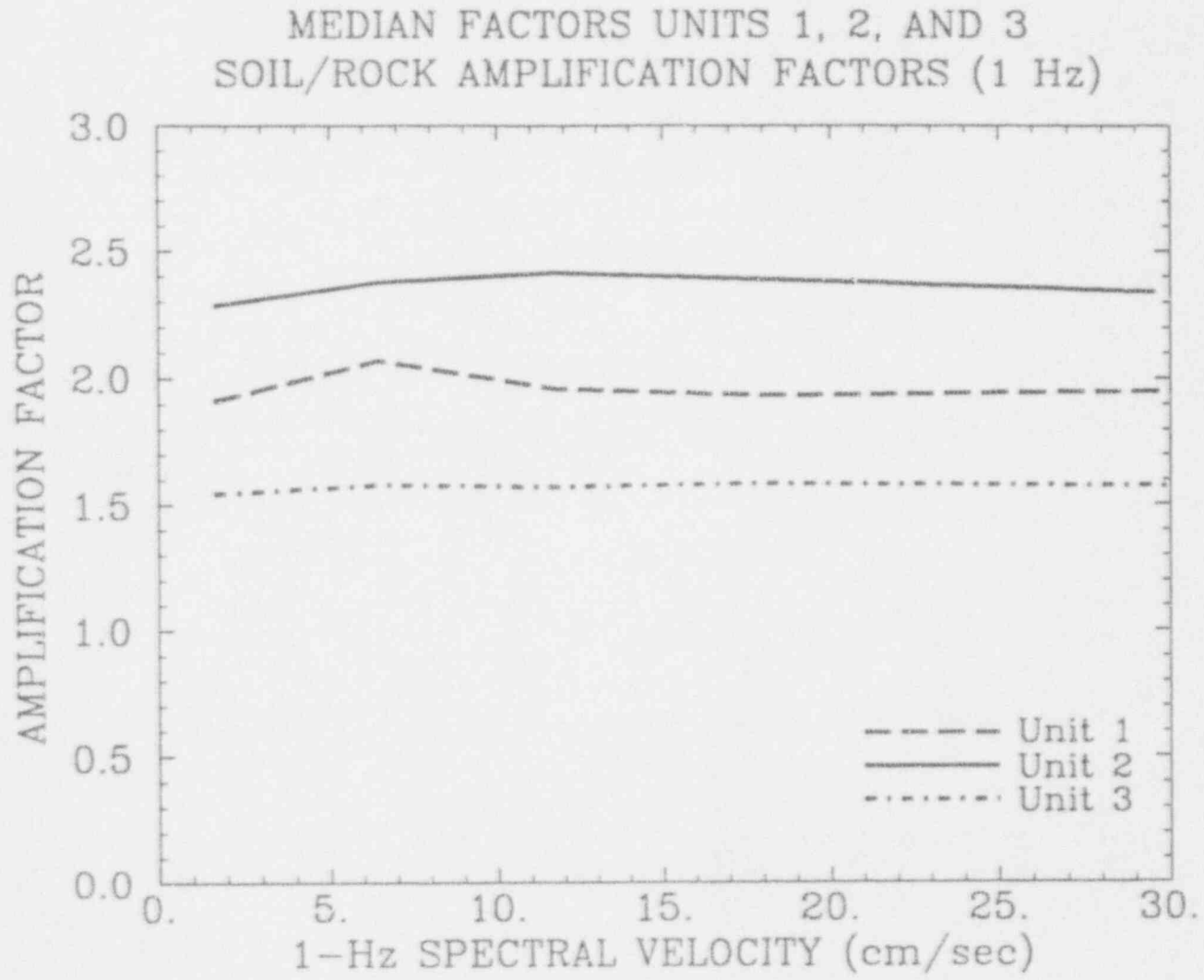

Figure 3-18: Soil amplification, Units 1,2, and 3; 1-Hz spectral velocity

Question II-4 (Comparison with Selected Sites in the Eastern United States): "In the original probabilistic seismic hazard study submitted by the licensee (Ref. 1), a comparison of the seismic hazard results with a selected site in the Eastern Unites States (Pilgrim) was provided (Ref. 1, Sec. 6.1). However, this comparison was deleted in the Supplemental Report (Ref. 3). It is important that such a comparison, to compare the seismic hazard results obtained for PVNGS to results obtained for sites in the Central and Eastern United States (CEUS), be provided for staff review. This comparison should use the results obtained from the above sensitivity studies which will enable the staff to verify that the site seismic hazard, in terms of frequencies and amplitudes of interest, is indeed, similar to that at sites in the CEUS."

Any earlier comparisons of seismic hazard measures for Palo Verde with CEUS plants have been superceded by results presented in Reference D. NUREG-1407 characterizes Palo Verde as "a site in the Western United States whose default bin is 0.5g, unless the licensee can demonstrate that the site hazard is similar to that at sites east of the Rocky Mountains that are found in the 0.3g bin." Reference D focuses on such comparisons among 0.3g plants, using the composite probability of exceeding the NUREG/CR-0098 spectrum (median, 5%-damped) as the key hazard parameter. To demonstrate the robustness of the study conclusions, Reference D also provides comparisons of seismic hazard among the two CEUS plants in the 0.5g bin (i.e., those plants where licensees have committed to performing a seismic PRA); these results (shown in both Appendix D and Tables 5-4 to 5-15 of Reference D) demonstrate that the hazard at Palo Verde is low with respect to that at the 0.5g (PRA) CEUS sites, and hence, that Palo Verde does not belong in the 0.5g bin. Reference D is based on the base-case hazard results and presents the most appropriate comparisons for evaluating the RLE for Palo Verde.

For informational purposes, as requested by the Staff, we have here developed comparisons of the seismic hazard results at Palo Verde, for the sensitivity cases previously discussed, with seismic hazard results at CEUS sites in the 0.3g and 0.5g (PRA) bins. These comparisons are similar in format to those presented in Section 5 of Reference D; results are ordered and tabulated separately for the mean, median and 85th-fractile statistics of hazard. Results of comparisons for the sensitivity variations are provided in the following Tables 4-1 to 4-15. Tables 4-1 to 4-3 provide comparisons for Palo Verde hazard based on EPRI/SOG soil amplification factors; Tables 4-4 to 4-6 provide comparisons for Palo Verde hazard based on the lower-bound EPRI/SOG shear wave velocity profile; Tables 4-7 to 4-9 present comparisons for Palo Verde hazard based on the upper bound EPRI/SOG shear wave velocity profile; Tables 4-10 to 4-12 present comparisons for Palo Verde hazard based on the Unit-2 shear wave velocity profile with 30% coefficient of variation in shear wave velocity and full correlation among velocities; and Tables 4-13 to 4-15 present comparisons for Palo Verde hazard based on the NRC model of seismic sources and parameters.

Each sensitivity variation, if substituted for the base-case hazard, would not alter the RLE conclusion developed in Reference D. However, being the most appropriate, representative, and realistic result for the seismic hazard at Palo Verde, the base case seismic hazard should be used in developing RLE conclusions, consistent with the manner in which plant binning was undertaken for NUREG-1407. Consequently, Reference D presents the most appropriate comparisons and RLE conclusion for the Palo Verde site. The results in Reference D show both that Palo Verde belongs with the 0.3g CEUS plants and that Palo Verde does not belong with the 0.5g (PRA) CEUS sites.

Table 4-1

Sensitivity Case: EPRI/SOG Shear-Wave Velocity Profile, Modulus Curve, and Damping Curve.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE MEAN PROBABILITY OF EXCEEDING NUREG/CR–0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	1.01E-04	MONTICELLO	0.3g Focused	9.39E-06
YANKEE ROWE	0.3g Full	4.33E-05	POINT BEACH	0.3g Focused	9.37E-06
SEABROOK	0.5g (PRA)	3.41E-05	CALVERT CLIFFS	0.3g Focused	8.40E-06
PALO VERDE	—	2.86E-05	BEAVER VALLEY	0.3g Focused	8.36E-06
INDIAN POINT	0.3g Full	2.55E-05	MCGUIRE	0.3g Focused	7.99E-06
SEQUOYAH	0.3g Full	2.54E-05	BELLEFONTE	0.3g Focused	7.84E-06
WATTS BAR	0.3g Focused	2.18E-05	THREE MILE ISLAND	0.3g Focused	7.44E-06
HADDAM NECK	0.3g Focused	2.18E-05	HATCH	0.3g Focused	5.76E-06
CLINTON	0.3g Focused	2.12E-05	FERMI	0.3g Focused	5.62E-06
NORTH ANNA	0.3g Focused	2.11E-05	VERMONT YANKEE	0.3g Focused	5.23E-06
VOGTLE	0.3g Focused	2.08E-05	GINNA	0.3g Focused	4.85E-06
BRUNSWICK	0.3g Focused	2.02E-05	ARKANSAS	0.3g Full	4.06E-06
HOPE CREEK	0.3g Focused	1.96E-05	BROWNS FERRY	0.3g Focused	3.88E-06
SALEM	0.3g Focused	1.96E-05	DAVIS BESSE	0.3g Focused	3.87E-06
LA SALLE	0.3g Focused	1.96E-05	PRAIRIE ISLAND	0.3g Focused	3.66E-06
ROBINSON	0.3g Full	1.77E-05	SUSQUEHANNA	0.3g Focused	3.14E-06
OCONEE	0.3g Full	1.72E-05	PERRY	0.3g Focused	2.99E-06
OYSTER CREEK	0.3g Focused	1.68E-05	BYRON	0.3g Focused	2.58E-06
ZION	0.3g Focused	1.67E-05	SHEARON HARRIS	0.3g Focused	2.37E-06
SURRY	0.3g Focused	1.42E-05	DRESDEN	0.3g Focused	2.33E-06
MILLSTONE	0.3g Focused	1.42E-05	BRAIDWOOD	0.3g Focused	2.05E-06
CATAWBA	0.3g Focused	1.32E-05	WOLF CREEK	0.3g Focused	1.94E-06
MAINE YANKEE	0.3g Full	1.26E-05	QUAD CITIES	0.3g Focused	1.73E-06
LIMERICK	0.3g Focused	1.22E-05	NINE MILE POINT	0.3g Focused	1.66E-06
SUMMER	0.3g Focused	1.12E-05	FITZPATRICK	0.3g Focused	1.66E-06
KEWAUNEE	0.3g Focused	9.73E-06	FARLEY	0.3g Focused	6.95E-07
PEACH BOTTOM	0.3g Focused	9.42E-06			

Table 4-2

Sensitivity Case: EPRI/SOG Shear-Wave Velocity Profile, Modulus Curve, and Damping Curve.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE MEDIAN PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	3.42E-05	BELLEFONTE	0.3g Focused	2.62E-06
SEABROOK	0.5g (PRA)	1.75E-05	MONTICELLO	0.3g Focused	2.41E-06
YANKEE ROWE	0.3g Full	1.21E-05	PEACH BOTTOM	0.3g Focused	2.28E-06
SEQUOYAH	0.3g Full	1.21E-05	OYSTER CREEK	0.3g Focused	2.18E-06
PALO VERDE	—	1.11E-05	VERMONT YANKEE	0.3g Focused	2.05E-06
NORTH ANNA	0.3g Focused	9.60E-06	BEAVER VALLEY	0.3g Focused	1.95E-06
WATTS BAR	0.3g Focused	9.45E-06	DAVIS BESSE	0.3g Focused	1.50E-06
INDIAN POINT	0.3g Full	7.73E-06	ARKANSAS	0.3g Full	1.49E-06
HADDAM NECK	0.3g Focused	7.19E-06	GINNA	0.3g Focused	1.41E-06
MAINE YANKEE	0.3g Full	7.00E-06	FERMI	0.3g Focused	1.37E-06
OCONEE	0.3g Full	6.82E-06	SURRY	0.3g Focused	1.24E-06
LA SALLE	0.3g Focused	5.59E-06	BROWNS FERRY	0.3g Focused	1.04E-06
MILLSTONE	0.3g Focused	5.29E-06	SUSQUEHANNA	0.3g Focused	9.98E-07
CATAWBA	0.3g Focused	5.22E-06	BYRON	0.3g Focused	9.19E-07
LIMERICK	0.3g Focused	5.05E-06	PERRY	0.3g Focused	8.74E-07
ZION	0.3g Focused	4.93E-06	WOLF CREEK	0.3g Focused	8.50E-07
SUMMER	0.3g Focused	4.58E-06	CALVERT CLIFFS	0.3g Focused	8.18E-07
BRUNSWICK	0.3g Focused	4.56E-06	DRESDEN	0.3g Focused	7.78E-07
VOGTLE	0.3g Focused	3.67E-06	BRAIDWOOD	0.3g Focused	7.34E-07
HOPE CREEK	0.3g Focused	3.43E-06	PRAIRIE ISLAND	0.3g Focused	6.75E-07
SALEM	0.3g Focused	3.43E-06	NINE MILE POINT	0.3g Focused	6.44E-07
MCGUIRE	0.3g Focused	3.34E-06	FITZPATRICK	0.3g Focused	6.44E-07
ROBINSON	0.3g Full	3.27E-06	HATCH	0.3g Focused	6.03E-07
CLINTON	0.3g Focused	3.00E-06	SHEARON HARRIS	0.3g Focused	5.51E-07
THREE MILE ISLAND	0.3g Focused	2.96E-06	QUAD CITIES	0.3g Focused	4.19E-07
KEWAUNEE	0.3g Focused	2.95E-06	FARLEY	0.3g Focused	1.21E-07
POINT BEACH	0.3g Focused	2.63E-06			

Table 4-3

Sensitivity Case: EPRI/SOG Shear-Wave Velocity Profile, Modulus Curve, and Damping Curve.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE 85TH-FRACTILE PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	1.72E-04	KEWAUNEE	0.3g Focused	1.50E-05
YANKEE ROWE	0.3g Full	7.09E-05	POINT BEACH	0.3g Focused	1.42E-05
SEABROOK	0.5g (PRA)	6.68E-05	MONTICELLO	0.3g Focused	1.39E-05
PALO VERDE	—	5.48E-05	THREE MILE ISLAND	0.3g Focused	1.33E-05
INDIAN POINT	0.3g Full	4.86E-05	BELLEFONTE	0.3g Focused	1.23E-05
SEQUOYAH	0.3g Full	4.74E-05	BEAVER VALLEY	0.3g Focused	1.18E-05
WATTS BAR	0.3g Focused	4.30E-05	CALVERT CLIFFS	0.3g Focused	9.41E-06
NORTH ANNA	0.3g Focused	3.82E-05	VERMONT YANKEE	0.3g Focused	9.08E-06
HADDAM NECK	0.3g Focused	3.14E-05	GINNA	0.3g Focused	7.58E-06
ROBINSON	0.3g Full	3.10E-05	FERMI	0.3g Focused	6.71E-06
VOGTLE	0.3g Focused	3.10E-05	HATCH	0.3g Focused	6.34E-06
LA SALLE	0.3g Focused	2.90E-05	DAVIS BESSE	0.3g Focused	6.28E-06
BRUNSWICK	0.3g Focused	2.78E-05	ARKANSAS	0.3g Full	5.89E-06
OCONEE	0.3g Full	2.76E-05	BROWNS FERRY	0.3g Focused	5.21E-06
CLINTON	0.3g Focused	2.66E-05	SUSQUEHANNA	0.3g Focused	5.12E-06
CATAWBA	0.3g Focused	2.66E-05	PERRY	0.3g Focused	4.71E-06
MAINE YANKEE	0.3g Full	2.52E-05	PRAIRIE ISLAND	0.3g Focused	4.12E-06
HOPE CREEK	0.3g Focused	2.27E-05	SHEARON HARRIS	0.3g Focused	3.82E-06
SALEM	0.3g Focused	2.27E-05	BYRON	0.3g Focused	3.72E-06
ZION	0.3g Focused	2.26E-05	DRESDEN	0.3g Focused	3.56E-06
MILLSTONE	0.3g Focused	2.11E-05	BRAIDWOOD	0.3g Focused	3.42E-06
SUMMER	0.3g Focused	2.08E-05	WOLF CREEK	0.3g Focused	3.39E-06
OYSTER CREEK	0.3g Focused	1.93E-05	FITZPATRICK	0.3g Focused	3.15E-06
LIMERICK	0.3g Focused	1.92E-05	NINE MILE POINT	0.3g Focused	3.15E-06
PEACH BOTTOM	0.3g Focused	1.63E-05	QUAD CITIES	0.3g Focused	2.56E-06
MCGUIRE	0.3g Focused	1.61E-05	FARLEY	0.3g Focused	8.06E-07
SURRY	0.3g Focused	1.52E-05			

Table 4-4

Sensitivity Case: Lower-Bound EPRI/SOG Shear Wave Velocity Profile.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE MEAN PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	1.01E-04	MONTICELLO	0.3g Focused	9.39E-06
YANKEE ROWE	0.3g Full	4.33E-05	POINT BEACH	0.3g Focused	9.37E-06
SEABROOK	0.5g (PRA)	3.41E-05	CALVERT CLIFFS	0.3g Focused	8.40E-06
INDIAN POINT	0.3g Full	2.55E-05	BEAVER VALLEY	0.3g Focused	8.36E-06
SEQUOYAH	0.3g Full	2.54E-05	MCGUIRE	0.3g Focused	7.99E-06
PALO VERDE	—	2.23E-05	BELLEFONTE	0.3g Focused	7.84E-06
WATTS BAR	0.3g Focused	2.18E-05	THREE MILE ISLAND	0.3g Focused	7.44E-06
HADDAM NECK	0.3g Focused	2.18E-05	HATCH	0.3g Focused	5.76E-06
CLINTON	0.3g Focused	2.12E-05	FERMI	0.3g Focused	5.62E-06
NORTH ANNA	0.3g Focused	2.11E-05	VERMONT YANKEE	0.3g Focused	5.23E-06
VOGTLE	0.3g Focused	2.08E-05	GINNA	0.3g Focused	4.85E-06
BRUNSWICK	0.3g Focused	2.02E-05	ARKANSAS	0.3g Full	4.06E-06
HOPE CREEK	0.3g Focused	1.96E-05	BROWNS FERRY	0.3g Focused	3.88E-06
SALEM	0.3g Focused	1.96E-05	DAVIS BESSE	0.3g Focused	3.87E-06
LA SALLE	0.3g Focused	1.96E-05	PRAIRIE ISLAND	0.3g Focused	3.66E-06
ROBINSON	0.3g Full	1.77E-05	SUSQUEHANNA	0.3g Focused	3.14E-06
OCONEE	0.3g Full	1.72E-05	PERRY	0.3g Focused	2.99E-06
OYSTER CREEK	0.3g Focused	1.68E-05	BYRON	0.3g Focused	2.58E-06
ZION	0.3g Focused	1.67E-05	SHEARON HARRIS	0.3g Focused	2.37E-06
SURRY	0.3g Focused	1.42E-05	DRESDEN	0.3g Focused	2.33E-06
MILLSTONE	0.3g Focused	1.42E-05	BRAIDWOOD	0.3g Focused	2.05E-06
CATAWBA	0.3g Focused	1.32E-05	WOLF CREEK	0.3g Focused	1.94E-06
MAINE YANKEE	0.3g Full	1.26E-05	QUAD CITIES	0.3g Focused	1.73E-06
LIMERICK	0.3g Focused	1.22E-05	NINE MILE POINT	0.3g Focused	1.66E-06
SUMMER	0.3g Focused	1.12E-05	FITZPATRICK	0.3g Focused	1.66E-06
KEWAUNEE	0.3g Focused	9.73E-06	FARLEY	0.3g Focused	6.95E-07
PEACH BOTTOM	0.3g Focused	9.42E-06			

Table 4-5

Sensitivity Case: Lower-Bound EPRI/SOG Shear Wave Velocity Profile.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE MEDIAN PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	3.42E-05	BELLEFONTE	0.3g Focused	2.62E-06
SEABROOK	0.5g (PRA)	1.75E-05	MONTICELLO	0.3g Focused	2.41E-06
YANKEE ROWE	0.3g Full	1.21E-05	PEACH BOTTOM	0.3g Focused	2.28E-06
SEQUOYAH	0.3g Full	1.21E-05	OYSTER CREEK	0.3g Focused	2.18E-06
PALO VERDE	—	9.98E-06	VERMONT YANKEE	0.3g Focused	2.05E-06
NORTH ANNA	0.3g Focused	9.60E-06	BEAVER VALLEY	0.3g Focused	1.95E-06
WATTS BAR	0.3g Focused	9.45E-06	DAVIS BESSE	0.3g Focused	1.50E-06
INDIAN POINT	0.3g Full	7.73E-06	ARKANSAS	0.3g Full	1.49E-06
HADDAM NECK	0.3g Focused	7.19E-06	GINNA	0.3g Focused	1.41E-06
MAINE YANKEE	0.3g Full	7.00E-06	FERMI	0.3g Focused	1.37E-06
OCONEE	0.3g Full	6.82E-06	SURRY	0.3g Focused	1.24E-06
LA SALLE	0.3g Focused	5.59E-06	BROWNS FERRY	0.3g Focused	1.04E-06
MILLSTONE	0.3g Focused	5.29E-06	SUSQUEHANNA	0.3g Focused	9.98E-07
CATAWBA	0.3g Focused	5.22E-06	BYRON	0.3g Focused	9.19E-07
LIMERICK	0.3g Focused	5.05E-06	PERRY	0.3g Focused	8.74E-07
ZION	0.3g Focused	4.93E-06	WOLF CREEK	0.3g Focused	8.50E-07
SUMMER	0.3g Focused	4.58E-06	CALVERT CLIFFS	0.3g Focused	8.18E-07
BRUNSWICK	0.3g Focused	4.56E-06	DRESDEN	0.3g Focused	7.78E-07
VOGTLE	0.3g Focused	3.67E-06	BRAIDWOOD	0.3g Focused	7.34E-07
HOPE CREEK	0.3g Focused	3.43E-06	PRAIRIE ISLAND	0.3g Focused	6.75E-07
SALEM	0.3g Focused	3.43E-06	NINE MILE POINT	0.3g Focused	6
MCGUIRE	0.3g Focused	3.34E-06	FITZPATRICK	0.3g Focused	6.44E-07
ROBINSON	0.3g Full	3.27E-06	HATCH	0.3g Focused	6.03E-07
CLINTON	0.3g Focused	3.00E-06	SHEARON HARRIS	0.3g Focused	5.51E-07
THREE MILE ISLAND	0.3g Focused	2.96E-06	QUAD CITIES	0.3g Focused	4.19E-07
KEWAUNEE	0.3g Focused	2.95E-06	FARLEY	0.3g Focused	1.21E-07
POINT BEACH	0.3g Focused	2.63E-06			

Table 4-6

Sensitivity Case: Lower-Bound EPRI/SOG Shear Wave Velocity Profile.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE 85TH-FRACTILE PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	1.72E-04	KEWAUNEE	0.3g Focused	1.50E-05
YANKEE ROWE	0.3g Full	7.09E-05	POINT BEACH	0.3g Focused	1.42E-05
SEABROOK	0.5g (PRA)	6.68E-05	MONTICELLO	0.3g Focused	1.39E-05
INDIAN POINT	0.3g Full	4.86E-05	THREE MILE ISLAND	0.3g Focused	1.33E-05
SEQUOYAH	0.3g Full	4.74E-05	BELLEFONTE	0.3g Focused	1.23E-05
WATTS BAR	0.3g Focused	4.30E-05	BEAVER VALLEY	0.3g Focused	1.18E-05
PALO VERDE	—	4.03E-05	CALVERT CLIFFS	0.3g Focused	9.41E-06
NORTH ANNA	0.3g Focused	3.82E-05	VERMONT YANKEE	0.3g Focused	9.08E-06
HADDAM NECK	0.3g Focused	3.14E-05	GINNA	0.3g Focused	7.58E-06
ROBINSON	0.3g Full	3.10E-05	FERMI	0.3g Focused	6.71E-06
VOGTLE	0.3g Focused	3.10E-05	HATCH	0.3g Focused	6.34E-06
LA SALLE	0.3g Focused	2.90E-05	DAVIS BESSE	0.3g Focused	6.28E-06
BRUNSWICK	0.3g Focused	2.78E-05	ARKANSAS	0.3g Full	5.89E-06
OCONEE	0.3g Full	2.76E-05	BROWNS FERRY	0.3g Focused	5.21E-06
CLINTON	0.3g Focused	2.66E-05	SUSQUEHANNA	0.3g Focused	5.12E-06
CATAWBA	0.3g Focused	2.66E-05	PERRY	0.3g Focused	4.71E-06
MAINE YANKEE	0.3g Full	2.52E-05	PRAIRIE ISLAND	0.3g Focused	4.12E-06
HOPE CREEK	0.3g Focused	2.27E-05	SHEARON HARRIS	0.3g Focused	3.82E-06
SALEM	0.3g Focused	2.27E-05	BYRON	0.3g Focused	3.72E-06
ZION	0.3g Focused	2.26E-05	DRESDEN	0.3g Focused	3.56E-06
MILLSTONE	0.3g Focused	2.11E-05	BRAIDWOOD	0.3g Focused	3.42E-06
SUMMER	0.3g Focused	2.08E-05	WOLF CREEK	0.3g Focused	3.39E-06
OYSTER CREEK	0.3g Focused	1.93E-05	FITZPATRICK	0.3g Focused	3.15E-06
LIMERICK	0.3g Focused	1.92E-05	NINE MILE POINT	0.3g Focused	3.15E-06
PEACH BOTTOM	0.3g Focused	1.63E-05	QUAD CITIES	0.3g Focused	2.56E-06
MCGUIRE	0.3g Focused	1.61E-05	FARLEY	0.3g Focused	8.06E-07
SURRY	0.3g Focused	1.52E-05			

Table 4-7

Sensitivity Case: Upper-Bound EPRI/SOG Shear Wave Velocity Profile.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE MEAN PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	1.01E-04	MONTICELLO	0.3g Focused	9.39E-06
YANKEE ROWE	0.3g Full	4.33E-05	POINT BEACH	0.3g Focused	9.37E-06
SEABROOK	0.5g (PRA)	3.41E-05	CALVERT CLIFFS	0.3g Focused	8.40E-06
PALO VERDE	—	2.81E-05	BEAVER VALLEY	0.3g Focused	8.36E-06
INDIAN POINT	0.3g Full	2.55E-05	MCGUIRE	0.3g Focused	7.99E-06
SEQUOYAH	0.3g Full	2.54E-05	BELLEFONTE	0.3g Focused	7.84E-06
WATTS BAR	0.3g Focused	2.18E-05	THREE MILE ISLAND	0.3g Focused	7.44E-06
HADDAM NECK	0.3g Focused	2.18E-05	HATCH	0.3g Focused	5.76E-06
CLINTON	0.3g Focused	2.12E-05	FERMI	0.3g Focused	5.62E-06
NORTH ANNA	0.3g Focused	2.11E-05	VERMONT YANKEE	0.3g Focused	5.23E-06
VOGTLE	0.3g Focused	2.08E-05	GINNA	0.3g Focused	4.85E-06
BRUNSWICK	0.3g Focused	2.02E-05	ARKANSAS	0.3g Full	4.06E-06
HOPE CREEK	0.3g Focused	1.96E-05	BROWNS FERRY	0.3g Focused	3.88E-06
SALEM	0.3g Focused	1.96E-05	DAVIS BESSE	0.3g Focused	3.87E-06
LA SALLE	0.3g Focused	1.96E-05	PRAIRIE ISLAND	0.3g Focused	3.66E-06
ROBINSON	0.3g Full	1.77E-05	SUSQUEHANNA	0.3g Focused	3.14E-06
OCONEE	0.3g Full	1.72E-05	PERRY	0.3g Focused	2.99E-06
OYSTER CREEK	0.3g Focused	1.68E-05	BYRON	0.3g Focused	2.58E-06
ZION	0.3g Focused	1.67E-05	SHEARON HARRIS	0.3g Focused	2.37E-06
SURRY	0.3g Focused	1.42E-05	DRESDEN	0.3g Focused	2.33E-06
MILLSTONE	0.3g Focused	1.42E-05	BRAIDWOOD	0.3g Focused	2.05E-06
CATAWBA	0.3g Focused	1.32E-05	WOLF CREEK	0.3g Focused	1.94E-06
MAINE YANKEE	0.3g Full	1.26E-05	QUAD CITIES	0.3g Focused	1.73E-06
LIMERICK	0.3g Focused	1.22E-05	NINE MILE POINT	0.3g Focused	1.66E-06
SUMMER	0.3g Focused	1.12E-05	FITZPATRICK	0.3g Focused	1.66E-06
KEWAUNEE	0.3g Focused	9.73E-06	FARLEY	0.3g Focused	6.95E-07
PEACH BOTTOM	0.3g Focused	9.42E-06			

Table 4-8

Sensitivity Case: Upper-Bound EPRI/SOG Shear Wave Velocity Profile.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE MEDIAN PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	3.42E-05	BELLEFONTE	0.3g Focused	2.62E-06
SEABROOK	0.5g (PRA)	1.75E-05	MONTICELLO	0.3g Focused	2.41E-06
PALO VERDE	—	1.31E-05	PEACH BOTTOM	0.3g Focused	2.28E-06
YANKEE ROWE	0.3g Full	1.21E-05	OYSTER CREEK	0.3g Focused	2.18E-06
SEQUOYAH	0.3g Full	1.21E-05	VERMONT YANKEE	0.3g Focused	2.05E-06
NORTH ANNA	0.3g Focused	9.60E-06	BEAVER VALLEY	0.3g Focused	1.95E-06
WATTS BAR	0.3g Focused	9.45E-06	DAVIS BESSE	0.3g Focused	1.50E-06
INDIAN POINT	0.3g Full	7.73E-06	ARKANSAS	0.3g Full	1.49E-06
HADDAM NECK	0.3g Focused	7.19E-06	GINNA	0.3g Focused	1.41E-06
MAINE YANKEE	0.3g Full	7.00E-06	FERMI	0.3g Focused	1.37E-06
OCONEE	0.3g Full	6.82E-06	SURRY	0.3g Focused	1.24E-06
LA SALLE	0.3g Focused	5.59E-06	BROWNS FERRY	0.3g Focused	1.04E-06
MILLSTONE	0.3g Focused	5.29E-06	SUSQUEHANNA	0.3g Focused	9.98E-07
CATAWBA	0.3g Focused	5.22E-06	BYRON	0.3g Focused	9.19E-07
LIMERICK	0.3g Focused	5.05E-06	PERRY	0.3g Focused	8.74E-07
ZION	0.3g Focused	4.93E-06	WOLF CREEK	0.3g Focused	8.50E-07
SUMMER	0.3g Focused	4.58E-06	CALVERT CLIFFS	0.3g Focused	8.18E-07
BRUNSWICK	0.3g Focused	4.56E-06	DRESDEN	0.3g Focused	7.78E-07
VOGTLE	0.3g Focused	3.67E-06	BRAIDWOOD	0.3g Focused	7.34E-07
HOPE CREEK	0.3g Focused	3.43E-06	PRAIRIE ISLAND	0.3g Focused	6.75E-07
SALEM	0.3g Focused	3.43E-06	NINE MILE POINT	0.3g Focused	6.44E-07
MCGUIRE	0.3g Focused	3.34E-06	FITZPATRICK	0.3g Focused	6.44E-07
ROBINSON	0.3g Full	3.27E-06	HATCH	0.3g Focused	6.03E-07
CLINTON	0.3g Focused	3.00E-06	SHEARON HARRIS	0.3g Focused	5.51E-07
THREE MILE ISLAND	0.3g Focused	2.96E-06	QUAD CITIES	0.3g Focused	4.19E-07
KEWAUNEE	0.3g Focused	2.95E-06	FARLEY	0.3g Focused	1.21E-07
POINT BEACH	0.3g Focused	2.63E-06			

Table 4-9

Sensitivity Case: Upper-Bound EPRI/SOG Shear Wave Velocity Profile.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE 85TH-FRACTILE PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	1.72E-04	KEWAUNEE	0.3g Focused	1.50E-05
YANKEE ROWE	0.3g Full	7.09E-05	POINT BEACH	0.3g Focused	1.42E-05
SEABROOK	0.5g (PRA)	6.68E-05	MONTICELLO	0.3g Focused	1.39E-05
PALO VERDE	—	5.28E-05	THREE MILE ISLAND	0.3g Focused	1.33E-05
INDIAN POINT	0.3g Full	4.86E-05	BELLEFONTE	0.3g Focused	1.23E-05
SEQUOYAH	0.3g Full	4.74E-05	BEAVER VALLEY	0.3g Focused	1.18E-05
WATTS BAR	0.3g Focused	4.30E-05	CALVERT CLIFFS	0.3g Focused	9.41E-06
NORTH ANNA	0.3g Focused	3.82E-05	VERMONT YANKEE	0.3g Focused	9.08E-06
HADDAM NECK	0.3g Focused	3.14E-05	GINNA	0.3g Focused	7.58E-06
ROBINSON	0.3g Full	3.10E-05	FERMI	0.3g Focused	6.71E-06
VOGTLE	0.3g Focused	3.10E-05	HATCH	0.3g Focused	6.34E-06
LA SALLE	0.3g Focused	2.90E-05	DAVIS BESSE	0.3g Focused	6.28E-06
BRUNSWICK	0.3g Focused	2.78E-05	ARKANSAS	0.3g Full	5.89E-06
OCONEE	0.3g Full	2.76E-05	BROWNS FERRY	0.3g Focused	5.21E-06
CLINTON	0.3g Focused	2.66E-05	SUSQUEHANNA	0.3g Focused	5.12E-06
CATAWBA	0.3g Focused	2.66E-05	PERRY	0.3g Focused	4.71E-06
MAINE YANKEE	0.3g Full	2.52E-05	PRAIRIE ISLAND	0.3g Focused	4.12E-06
HOPE CREEK	0.3g Focused	2.27E-05	SHEARON HARRIS	0.3g Focused	3.82E-06
SALEM	0.3g Focused	2.27E-05	BYRON	0.3g Focused	3.72E-06
ZION	0.3g Focused	2.26E-05	DRESDEN	0.3g Focused	3.56E-06
MILLSTONE	0.3g Focused	2.11E-05	BRAIDWOOD	0.3g Focused	3.42E-06
SUMMER	0.3g Focused	2.08E-05	WOLF CREEK	0.3g Focused	3.39E-06
OYSTER CREEK	0.3g Focused	1.93E-05	FITZPATRICK	0.3g Focused	3.15E-06
LIMERICK	0.3g Focused	1.92E-05	NINE MILE POINT	0.3g Focused	3.15E-06
PEACH BOTTOM	0.3g Focused	1.63E-05	QUAD CITIES	0.3g Focused	2.56E-06
MCGUIRE	0.3g Focused	1.61E-05	FARLEY	0.3g Focused	8.06E-07
SURRY	0.3g Focused	1.52E-05			

Table 4-10

Sensitivity Case: Unit-2 Fully Correlated Velocities — 30% Coefficient of Variation.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE MEAN PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	1.01E-04	MONTICELLO	0.3g Focused	9.39E-06
YANKEE ROWE	0.3g Full	4.33E-05	POINT BEACH	0.3g Focused	9.37E-06
SEABROOK	0.5g (PRA)	3.41E-05	CALVERT CLIFFS	0.3g Focused	8.40E-06
PALO VERDE	—	2.59E-05	BEAVER VALLEY	0.3g Focused	8.36E-06
INDIAN POINT	0.3g Full	2.55E-05	MCGUIRE	0.3g Focused	7.99E-06
SEQUOYAH	0.3g Full	2.54E-05	BELLEFONTE	0.3g Focused	7.84E-06
HADDAM NECK	0.3g Focused	2.18E-05	THREE MILE ISLAND	0.3g Focused	7.44E-06
WATTS BAR	0.3g Focused	2.18E-05	HATCH	0.3g Focused	5.76E-06
CLINTON	0.3g Focused	2.12E-05	FERMI	0.3g Focused	5.62E-06
NORTH ANNA	0.3g Focused	2.11E-05	VERMONT YANKEE	0.3g Focused	5.23E-06
VOGTLE	0.3g Focused	2.08E-05	GINNA	0.3g Focused	4.85E-06
BRUNSWICK	0.3g Focused	2.02E-05	ARKANSAS	0.3g Full	4.06E-06
LA SALLE	0.3g Focused	1.96E-05	BROWNS FERRY	0.3g Focused	3.88E-06
SALEM	0.3g Focused	1.96E-05	DAVIS BESSE	0.3g Focused	3.87E-06
HOPE CREEK	0.3g Focused	1.96E-05	PRAIRIE ISLAND	0.3g Focused	3.65E-06
ROBINSON	0.3g Full	1.77E-05	SUSQUEHANNA	0.3g Focused	3.14E-06
OCONEE	0.3g Full	1.72E-05	PERRY	0.3g Focused	2.99E-06
OYSTER CREEK	0.3g Focused	1.68E-05	BYRON	0.3g Focused	2.58E-06
ZION	0.3g Focused	1.67E-05	SHEARON HARRIS	0.3g Focused	2.37E-06
MILLSTONE	0.3g Focused	1.42E-05	DRESDEN	0.3g Focused	2.33E-06
SURRY	0.3g Focused	1.42E-05	BRAIDWOOD	0.3g Focused	2.05E-06
CATAWBA	0.3g Focused	1.32E-05	WOLF CREEK	0.3g Focused	1.94E-06
MAINE YANKEE	0.3g Full	1.26E-05	QUAD CITIES	0.3g Focused	1.73E-06
LIMERICK	0.3g Focused	1.22E-05	FITZPATRICK	0.3g Focused	1.66E-06
SUMMER	0.3g Focused	1.12E-05	NINE MILE POINT	0.3g Focused	1.66E-06
KEWAUNEE	0.3g Focused	9.73E-06	FARLEY	0.3g Focused	6.95E-07
PEACH BOTTOM	0.3g Focused	9.42E-06			

Table 4-11

Sensitivity Case: Unit-2 Fully Correlated Velocities — 30% Coefficient of Variation.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE MEDIAN PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	3.42E-05	BELLEFONTE	0.3g Focused	2.62E-06
SEABROOK	0.5g (PRA)	1.75E-05	MONTICELLO	0.3g Focused	2.41E-06
YANKEE ROWE	0.3g Full	1.21E-05	PEACH BOTTOM	0.3g Focused	2.28E-06
SEQUOYAH	0.3g Full	1.21E-05	OYSTER CREEK	0.3g Focused	2.18E-06
PALO VERDE	—	1.18E-05	VERMONT YANKEE	0.3g Focused	2.05E-06
NORTH ANNA	0.3g Focused	9.60E-06	BEAVER VALLEY	0.3g Focused	1.95E-06
WATTS BAR	0.3g Focused	9.45E-06	DAVIS BESSE	0.3g Focused	1.50E-06
INDIAN POINT	0.3g Full	7.73E-06	ARKANSAS	0.3g Full	1.49E-06
HADDAM NECK	0.3g Focused	7.19E-06	GINNA	0.3g Focused	1.41E-06
MAINE YANKEE	0.3g Full	7.00E-06	FERMI	0.3g Focused	1.37E-06
OCONEE	0.3g Full	6.82E-06	SURRY	0.3g Focused	1.24E-06
LA SALLE	0.3g Focused	5.59E-06	BROWNS FERRY	0.3g Focused	1.04E-06
MILLSTONE	0.3g Focused	5.29E-06	SUSQUEHANNA	0.3g Focused	9.98E-07
CATAWBA	0.3g Focused	5.22E-06	BYRON	0.3g Focused	9.19E-07
LIMERICK	0.3g Focused	5.05E-06	PERRY	0.3g Focused	8.74E-07
ZION	0.3g Focused	4.93E-06	WOLF CREEK	0.3g Focused	8.50E-07
SUMMER	0.3g Focused	4.58E-06	CALVERT CLIFFS	0.3g Focused	8.18E-07
BRUNSWICK	0.3g Focused	4.56E-06	DRESDEN	0.3g Focused	7.78E-07
VOGTLE	0.3g Focused	3.67E-06	BRAIDWOOD	0.3g Focused	7.34E-07
HOPE CREEK	0.3g Focused	3.43E-06	PRAIRIE ISLAND	0.3g Focused	6.75E-07
SALEM	0.3g Focused	3.43E-06	NINE MILE POINT	0.3g Focused	6.44E-07
MCGUIRE	0.3g Focused	3.34E-06	FITZPATRICK	0.3g Focused	6.44E-07
ROBINSON	0.3g Full	3.27E-06	HATCH	0.3g Focused	6.03E-07
CLINTON	0.3g Focused	3.00E-06	SHEARON HARRIS	0.3g Focused	5.51E-07
THREE MILE ISLAND	0.3g Focused	2.96E-06	QUAD CITIES	0.3g Focused	4.19E-07
KEWAUNEE	0.3g Focused	2.95E-06	FARLEY	0.3g Focused	1.21E-07
POINT BEACH	0.3g Focused	2.63E-06			

Table 4-12

Sensitivity Case: Unit-2 Fully Correlated Velocities — 30% Coefficient of Variation.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE 85TH-FRACTILE PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	1.72E-04	KEWAUNEE	0.3g Focused	1.50E-05
YANKEE ROWE	0.3g Full	7.09E-05	POINT BEACH	0.3g Focused	1.42E-05
SEABROOK	0.5g (PRA)	6.68E-05	MONTICELLO	0.3g Focused	1.39E-05
PALO VERDE	—	4.86E-05	THREE MILE ISLAND	0.3g Focused	1.33E-05
INDIAN POINT	0.3g Full	4.86E-05	BELLEFONTE	0.3g Focused	1.23E-05
SEQUOYAH	0.3g Full	4.74E-05	BEAVER VALLEY	0.3g Focused	1.18E-05
WATTS BAR	0.3g Focused	4.30E-05	CALVERT CLIFFS	0.3g Focused	9.41E-06
NORTH ANNA	0.3g Focused	3.82E-05	VERMONT YANKEE	0.3g Focused	9.08E-06
HADDAM NECK	0.3g Focused	3.14E-05	GINNA	0.3g Focused	7.58E-06
ROBINSON	0.3g Full	3.10E-05	FERMI	0.3g Focused	6.71E-06
VOGTLE	0.3g Focused	3.10E-05	HATCH	0.3g Focused	6.34E-06
LA SALLE	0.3g Focused	2.90E-05	DAVIS BESSE	0.3g Focused	6.28E-06
BRUNSWICK	0.3g Focused	2.78E-05	ARKANSAS	0.3g Full	5.89E-06
OCONEE	0.3g Full	2.76E-05	BROWNS FERRY	0.3g Focused	5.21E-06
CLINTON	0.3g Focused	2.66E-05	SUSQUEHANNA	0.3g Focused	5.12E-06
CATAWBA	0.3g Focused	2.66E-05	PERRY	0.3g Focused	4.71E-06
MAINE YANKEE	0.3g Full	2.52E-05	PRAIRIE ISLAND	0.3g Focused	4.12E-06
HOPE CREEK	0.3g Focused	2.27E-05	SHEARON HARRIS	0.3g Focused	3.82E-06
SALEM	0.3g Focused	2.27E-05	BYRON	0.3g Focused	3.72E-06
ZION	0.3g Focused	2.26E-05	DRESDEN	0.3g Focused	3.56E-06
MILLSTONE	0.3g Focused	2.11E-05	BRAIDWOOD	0.3g Focused	3.42E-06
SUMMER	0.3g Focused	2.08E-05	WOLF CREEK	0.3g Focused	3.39E-06
OYSTER CREEK	0.3g Focused	1.93E-05	FITZPATRICK	0.3g Focused	3.15E-06
LIMERICK	0.3g Focused	1.92E-05	NINE MILE POINT	0.3g Focused	3.15E-06
PEACH BOTTOM	0.3g Focused	1.63E-05	QUAD CITIES	0.3g Focused	2.56E-06
MCGUIRE	0.3g Focused	1.61E-05	FARLEY	0.3g Focused	8.06E-07
SURRY	0.3g Focused	1.52E-05			

Table 4-13

Sensitivity Case: NRC Model of Sources and Parameters.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE MEAN PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	1.01E-04	POINT BEACH	0.3g Focused	9.37E-06
YANKEE ROWE	0.3g Full	4.33E-05	PALO VERDE	—	8.76E-06
SEABROOK	0.5g (PRA)	3.41E-05	CALVERT CLIFFS	0.3g Focused	8.40E-06
INDIAN POINT	0.3g Full	2.55E-05	BEAVER VALLEY	0.3g Focused	8.36E-06
SEQUOYAH	0.3g Full	2.54E-05	MCGUIRE	0.3g Focused	7.99E-06
WATTS BAR	0.3g Focused	2.18E-05	BELLEFONTE	0.3g Focused	7.84E-06
HADDAM NECK	0.3g Focused	2.18E-05	THREE MILE ISLAND	0.3g Focused	7.44E-06
CLINTON	0.3g Focused	2.12E-05	HATCH	0.3g Focused	5.76E-06
NORTH ANNA	0.3g Focused	2.11E-05	FERMI	0.3g Focused	5.62E-06
VOGTLE	0.3g Focused	2.08E-05	VERMONT YANKEE	0.3g Focused	5.23E-06
BRUNSWICK	0.3g Focused	2.02E-05	GINNA	0.3g Focused	4.85E-06
SALEM	0.3g Focused	1.96E-05	ARKANSAS	0.3g Full	4.06E-06
HOPE CREEK	0.3g Focused	1.96E-05	BROWNS FERRY	0.3g Focused	3.88E-06
LA SALLE	0.3g Focused	1.96E-05	DAVIS BESSE	0.3g Focused	3.87E-06
ROBINSON	0.3g Full	1.77E-05	PRAIRIE ISLAND	0.3g Focused	3.66E-06
OCONEE	0.3g Full	1.72E-05	SUSQUEHANNA	0.3g Focused	3.14E-06
OYSTER CREEK	0.3g Focused	1.68E-05	PERRY	0.3g Focused	2.99E-06
ZION	0.3g Focused	1.67E-05	BYRON	0.3g Focused	2.58E-06
SURRY	0.3g Focused	1.42E-05	SHEARON HARRIS	0.3g Focused	2.37E-06
MILLSTONE	0.3g Focused	1.42E-05	DRESDEN	0.3g Focused	2.33E-06
CATAWBA	0.3g Focused	1.32E-05	BRAIDWOOD	0.3g Focused	2.05E-06
MAINE YANKEE	0.3g Full	1.26E-05	WOLF CREEK	0.3g Focused	1.94E-06
LIMERICK	0.3g Focused	1.22E-05	QUAD CITIES	0.3g Focused	1.73E-06
SUMMER	0.3g Focused	1.12E-05	NINE MILE POINT	0.3g Focused	1.66E-06
KEWAUNEE	0.3g Focused	9.73E-06	FITZPATRICK	0.3g Focused	1.66E-06
PEACH BOTTOM	0.3g Focused	9.42E-06	FARLEY	0.3g Focused	6.95E-07
MONTICELLO	0.3g Focused	9.39E-06			

Table 4-14

Sensitivity Case: NRC Model of Sources and Parameters.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE MEDIAN PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	3.42E-05	BELLEFONTE	0.3g Focused	2.62E-06
SEABROOK	0.5g (PRA)	1.75E-05	MONTICELLO	0.3g Focused	2.41E-06
YANKEE ROWE	0.3g Full	1.21E-05	PEACH BOTTOM	0.3g Focused	2.28E-06
SEQUOYAH	0.3g Full	1.21E-05	OYSTER CREEK	0.3g Focused	2.18E-06
NORTH ANNA	0.3g Focused	9.60E-06	VERMONT YANKEE	0.3g Focused	2.05E-06
WATTS BAR	0.3g Focused	9.45E-06	BEAVER VALLEY	0.3g Focused	1.95E-06
INDIAN POINT	0.3g Full	7.73E-06	DAVIS BESSE	0.3g Focused	1.50E-06
HADDAM NECK	0.3g Focused	7.19E-06	ARKANSAS	0.3g Full	1.49E-06
MAINE YANKEE	0.3g Full	7.00E-06	GINNA	0.3g Focused	1.41E-06
OCONEE	0.3g Full	6.82E-06	FERMI	0.3g Focused	1.37E-06
LA SALLE	0.3g Focused	5.59E-06	SURRY	0.3g Focused	1.24E-06
MILLSTONE	0.3g Focused	5.29E-06	BROWNS FERRY	0.3g Focused	1.04E-06
PALO VERDE	—	5.28E-06	SUSQUEHANNA	0.3g Focused	9.98E-07
CATAWBA	0.3g Focused	5.22E-06	BYRON	0.3g Focused	9.19E-07
LIMERICK	0.3g Focused	5.05E-06	PERRY	0.3g Focused	8.74E-07
ZION	0.3g Focused	4.93E-06	WOLF CREEK	0.3g Focused	8.50E-07
SUMMER	0.3g Focused	4.58E-06	CALVERT CLIFFS	0.3g Focused	8.18E-07
BRUNSWICK	0.3g Focused	4.56E-06	DRESDEN	0.3g Focused	7.78E-07
VOGTLE	0.3g Focused	3.67E-06	BRAIDWOOD	0.3g Focused	7.34E-07
HOPE CREEK	0.3g Focused	3.43E-06	PRAIRIE ISLAND	0.3g Focused	6.75E-07
SALEM	0.3g Focused	3.43E-06	NINE MILE POINT	0.3g Focused	6.44E-07
MCGUIRE	0.3g Focused	3.34E-06	FITZPATRICK	0.3g Focused	6.44E-07
ROBINSON	0.3g Full	3.27E-06	HATCH	0.3g Focused	6.03E-07
CLINTON	0.3g Focused	3.00E-06	SHEARON HARRIS	0.3g Focused	5.51E-07
THREE MILE ISLAND	0.3g Focused	2.96E-06	QUAD CITIES	0.3g Focused	4.19E-07
KEWAUNEE	0.3g Focused	2.95E-06	FARLEY	0.3g Focused	1.21E-07
POINT BEACH	0.3g Focused	2.63E-06			

Table 4-15

Sensitivity Case: NRC Model of Sources and Parameters.

RANKINGS, INDICATING PLANT NAMES, OF COMPOSITE 85TH-FRACTILE PROBABILITY OF EXCEEDING NUREG/CR-0098 SPECTRUM ANCHORED TO 0.3G; 50 0.3G SITES, TWO 0.5G SITES, AND THE PVNGS SITE

Plant Name	Review Type	Hazard	Plant Name	Review Type	Hazard
PILGRIM	0.5g (PRA)	1.72E-04	KEWAUNEE	0.3g Focused	1.50E-05
YANKEE ROWE	0.3g Full	7.09E-05	POINT BEACH	0.3g Focused	1.42E-05
SEABROOK	0.5g (PRA)	6.68E-05	MONTICELLO	0.3g Focused	1.39E-05
INDIAN POINT	0.3g Full	4.86E-05	THREE MILE ISLAND	0.3g Focused	1.33E-05
SEQUOYAH	0.3g Full	4.74E-05	BELLEFONTE	0.3g Focused	1.23E-05
WATTS BAR	0.3g Focused	4.30E-05	BEAVER VALLEY	0.3g Focused	1.18E-05
NORTH ANNA	0.3g Focused	3.82E-05	CALVERT CLIFFS	0.3g Focused	9.41E-06
HADDAM NECK	0.3g Focused	3.14E-05	VERMONT YANKEE	0.3g Focused	9.08E-06
VOGTLE	0.3g Focused	3.10E-05	GINNA	0.3g Focused	7.58E-06
ROBINSON	0.3g Full	3.10E-05	FERMI	0.3g Focused	6.71E-06
LA SALLE	0.3g Focused	2.90E-05	HATCH	0.3g Focused	6.34E-06
BRUNSWICK	0.3g Focused	2.78E-05	DAVIS BESSE	0.3g Focused	6.28E-06
OCONEE	0.3g Full	2.76E-05	ARKANSAS	0.3g Full	5.89E-06
CLINTON	0.3g Focused	2.66E-05	BROWNS FERRY	0.3g Focused	5.21E-06
CATAWBA	0.3g Focused	2.66E-05	SUSQUEHANNA	0.3g Focused	5.12E-06
MAINE YANKEE	0.3g Full	2.52E-05	PERRY	0.3g Focused	4.71E-06
HOPE CREEK	0.3g Focused	2.27E-05	PRAIRIE ISLAND	0.3g Focused	4.12E-06
SALEM	0.3g Focused	2.27E-05	SHEARON HARRIS	0.3g Focused	3.82E-06
ZION	0.3g Focused	2.26E-05	BYRON	0.3g Focused	3.72E-06
MILLSTONE	0.3g Focused	2.11E-05	DRESDEN	0.3g Focused	3.56E-06
SUMMER	0.3g Focused	2.08E-05	BRAIDWOOD	0.3g Focused	3.42E-06
OYSTER CREEK	0.3g Focused	1.93E-05	WOLF CREEK	0.3g Focused	3.39E-06
LIMERICK	0.3g Focused	1.92E-05	FITZPATRICK	0.3g Focused	3.15E-06
PEACH BOTTOM	0.3g Focused	1.63E-05	NINE MILE POINT	0.3g Focused	3.15E-06
MCGUIRE	0.3g Focused	1.61E-05	QUAD CITIES	0.3g Focused	2.56E-06
PALO VERDE	—	1.58E-05	FARLEY	0.3g Focused	8.06E-07
SURRY	0.3g Focused	1.52E-05			

REFERENCES

A. Risk Engineering, Inc., "Seismic Hazard Evaluation for the Palo Verde Nuclear Generating Station, Wintersburg, Arizona," Rept. to Arizona Public Service Co., December 1991.

B. Risk Engineering, Inc., "Updated Seismic Hazard Evaluation for the Palo Verde Nuclear Generating Station, Wintersburg, Arizona, Phase 2, Final Report," Rept. to Arizona Public Service Co., June 1992.

C. Risk Engineering, Inc., "Seismic Hazard Evaluation for the Palo Verde Nuclear Generating Station, Wintersburg, Arizona, Phase 2, Final Report," Rept. to Arizona Public Service Co., April 1993

D. Risk Engineering, Inc., "Review-Level Earthquake Evaluation: Recommendations for IPEEE Implementation at the Palo Verde Nuclear Generating Station near Wintersburg, Arizona, Final Report, Revision 2," Rept. to Arizona Public Service Co., April 1993.