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CP-200801589
Log # TXNB-08028

Ref. # 10CFR52

November 5, 2008

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555
ATTN: David B. Matthews, Director
Division of New Reactor Licensing

SUBJECT: COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 3 AND 4
RESOLUTION OF DOCKETING ISSUES REGARDING FSAR SUBSECTIONS 2.5.1, 2.5.2, AND 2.5.4 (PARTIAL)
PROJECT NO. 0754

Dear Sir:

Luminant Generation Company LLC (Luminant) submits this resolution of docketing issues for Comanche Peak Nuclear Power Plant (CPNPP), Units 3 and 4. The issues regarding FSAR Subsection 2.5.2 were raised by NRC reviewers conducting the acceptance review of the CPNPP Units 3 and 4 Combined License (COL) application and Luminant has discussed them with the NRC in conference calls over the last few weeks. Luminant is confident that this resolution provides the NRC with adequate information to determine that the COL application is acceptable regarding these issues. These resolutions supplement the CPNPP Units 3 and 4 COL application.

The issues regarding FSAR Subsections 2.5.1 and 2.5.4 were characterized by the NRC as not being acceptance review completeness or sufficiency issues, but are issues that if not addressed could adversely affect the COLA review schedule. For that reason, Luminant is submitting the attached resolution.

Please address any correspondence relating to this resolution to Don Woodlan, Manager, Nuclear Regulatory Affairs, P.O. Box 1002, 6322 North FM 56, Glen Rose, TX 76043. You may also contact Mr. Woodlan directly at 254-897-6887 or by email at Donald.Woodlan@luminant.com.

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

Executed on November 5, 2008.

Sincerely,

Luminant Generation Company LLC

M. L. Lucas

Attachment - Resolution of Docketing Issues
c - See Attached

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ATTACHMENT

RESOLUTION OF DOCKETING ISSUES

FSAR Subsection 2.5.1 (Schedule Issue)

10 CFR 100.23 requires that the applicant properly characterize the site subsurface. The applicant indicates that karst formations exist at the site, and refers to a petrographic analysis that describes the extent of the karst, but has not provided that analysis, or the geotechnical boring logs, with the application. As submitted, the application does not provide sufficient information on potential dissolution of the karst, or justify the applicant's decision to not grout the karst.

Resolution

The geology within the Comanche Peak site region (200 mi. radius) does include two instances of limestone that exhibit karstic dissolution. These are

1. Some calcareous units exhibiting karstitic dissolution within the Edwards Plateau physiographic province (FSAR Subsection 2.5.1.1.1.4), and
2. The top of the Ellenburger limestone is a regional unconformity which exhibits limestone dissolution (FSAR Subsections 2.5.1.1.2.1, 2.5.1.2.2, and 2.5.1.2.3.1).

Neither of these instances affects the foundation conditions at the site. The site is located within the Grand Prairie physiographic province, more than 25 miles from the Edwards Plateau province. The Ellenburger Group is not exposed at the surface within 100 miles of the site and occurs at a depth of more than 4000 feet below the surface at the site. Also, the dissolution of the Ellenburger group occurred in the early Paleozoic and is no longer active today.

The investigation presented in the FSAR included a geotechnical drilling program, aerial photo investigation, and field reconnaissance which assessed the potential of karst hazard at the site. These studies, which demonstrated that no karst hazard exists within the site area, were summarized and discussed in FSAR with the following conclusions.

> There is no evidence of active karst conditions and related subsidence within the CPNPP site or in the surrounding area. (Subsection 2.5.1.2.5.4)
>
> The CPNPP Units 3 and 4 site is founded on Glen Rose Formation limestone, a "dirty" limestone not favorable for dissolution or karst-related hazard (Subsection 2.5.3.8.2.1)
>
> The findings indicate that karst and dissolutioning are not significant hazards for CPNPP Units 3 and 4. (Subsection 2.5.4.1.3)

The Engineering and Stratigraphy Calculation (TXUT-001-FSAR-2.5-CALC-004) was provided to the NRC as part of Enclosure 1 to Luminant letter TXBN-08027 on November 4, 2008. The calculation concludes that:

The irregular and minimal occurrence of calcareous rock dissolution along with the high ROD of fine grained limestone prove it unlikely for karstic terrane to form in the subsurface below Units 3 & 4 at CPNPP.

In summary, the investigations in support of the COL application adequately characterized the subsurface and evaluated karst hazard for the CPNPP Units 3 and 4 site, in accordance with 10 CFR 100.23. While karstitic dissolution has occurred in the past within the site region (200 mi radius), the aerial photograph analysis, field reconnaissance, and geotechnical program (including petrographic analysis of limestone samples) indicated no current karst activity exists within the site area (5 mi radius) and none is reported within the site vicinity (25 mi radius). Occasional limestone dissolution features (151 vugs in all of the borings) are noted within the Glen Rose Formation, and each one has been cataloged in Appendix 3 of the Engineering Stratigraphy Calculation. The minimal extent of these small (< 1 inch) unconnected features does not indicate a karst hazard or require a grouting program. These conclusions are supported by the Boring Log Data Report (TXUT-001-PR-005), which was also provided in Enclosure 1 to TXBN-08027.

FSAR Subsection 2.5.4 (Schedule Issues)

Issue 5 – The applicant mentioned in Section 2.5.4.5.4 of the FSAR that concrete fill may be used as backfill to replace unsuitable rock removed below elevation 782ft. as part of foundation preparations. However, the applicant did not provide any details regarding the properties of the concrete, such as compressive strength parameters or the concrete standard to be used. (RG1.206 C.I.2.5.4.5 *Excavations and Backfill*)

Resolution

Luminant will change FSAR Subsection 2.5.4.5.4 to include the following information in a future revision of the COLA.

As stated in FSAR Subsection 3.7.1.3, all major seismic category I and II buildings and structures are founded directly on solid limestone or fill concrete. The fill concrete has a design compressive strength of 3,000 psi that corresponds to a shear wave velocity of 6,400 ft/sec. The fill concrete mix design is required to be approved in advance to ensure it meets minimum strength requirements. The fill concrete will generally conform to ASTM C94/C94M-07, "Standard Specification for Ready-Mixed Concrete." A systematic quality control sampling and testing program ensures that material properties are in compliance with design specifications. Field inspections verify that the required mix is used and that test specimens are collected for testing.

Testing of fill concrete will be performed by a qualified testing laboratory that has an established quality assurance program that conforms to NQA-1 requirements. The testing laboratory will implement a concrete fill quality control program that will include all aspects of the fill concrete program from the qualification of materials to confirmatory strength testing. Field testing will utilize preapproved procedures that conform to ASTM C31/C31M-08a, "Standard Practice for Making and Curing Concrete Test Specimens in the Field."

Strength verification laboratory tests will be performed to confirm that the compressive strength of the fill concrete is satisfactory. The tests will be conducted using cylindrical test specimens molded during construction and will conform to ASTM C39/C39M-05e2, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens." The specimens will be taken from different batches of fill concrete. The strength of the fill concrete will be considered satisfactory if the average compressive strength from three cylinders molded at a location equals or exceeds the required strength and no individual strength test falls below the required value by more than 500 psi. If these acceptance criteria are not met, an evaluation of the acceptability of the fill concrete for its intended function will be performed before acceptance.

The fill concrete testing results, non-conformances related to fill concrete, and QA audits of fill concrete activities will be reviewed and dispositioned to ensure that the fill concrete meets the specified strength requirements.

These measures will ensure that the design properties of fill concrete are achieved during construction activities.

Issue 6 - Engineered backfill is planned to be placed adjacent to Category I structures. Calculations of critical parameters assume certain properties for the backfill. However, the applicant did not provide a description of the sources and quantities of backfill (RG 1.206 C.I.2.5.4.5 *Excavations and Backfill*), or a description of tests and acceptance criteria to demonstrate that the installed backfill meets the parameters assumed in the calculations.

Resolution

FSAR Subsection 2.5.4.5.4 states that backfill is required between the foundation excavation sidewalls and lower structural walls of seismic category I and II facilities, the main power block structures, and the UHS. The volume of backfill is minimized by using steep or vertical excavation cuts. No exclusions are placed on the use of limestone or sandstone derived from the mass grading to develop plant grade or foundation excavations. The total volume of excavation in the Units 3 and 4 power block and UHS areas greatly exceeds the volume of required backfill.

It is anticipated that the source of backfill to be used adjacent to Category I structures will be the limestone and sandstone removed from the excavation and that there will be a sufficient quantity of material from the excavation for that purpose.

A discussion of the materials for engineered fill is provided in Subsection 2.5.4.5.4.1.1. The acceptance criteria, test methods, and frequency of verification for field placement are provided for each fill application in FSAR Subsection 2.5.4.5.4.5. Continuous geotechnical engineering observation and inspection of all fill placement and compaction operations is required to certify and ensure that the fill is properly placed and compacted in accordance with the project plans and specifications.

FSAR Subsection 2.5.2

Issue 1 - The applicant provided the results of the Site Response Analysis calculations in Subsection 2.5.2.6. However, the subsection lacks the details of the methodology used for the staff to be able to review the procedures. The staff considers this lack of critical information an acceptance issue since the complete documentation is essential for the staff to be able to reach a final conclusion regarding the

applicant's findings. (Reference: RG 1.206 C.I.2.5.2.5 *Seismic Wave Transmission Characteristics of the Site)*

Resolution

Luminant will change FSAR Subsection 2.5.2.5 to include the following information in a future revision of the COLA.

DESCRIPTION OF SITE RESPONSE ANALYSIS

The site response analysis was conducted in three steps that are common to analyses of this type. First, the site geology and geotechnical properties were reviewed and used to generate multiple synthetic profiles of site characteristics. Second, sets of rock spectra were selected to represent rock ground motions corresponding to mean annual exceedence frequencies of 10^{-4}, 10^{-5}, and 10^{-6}. Finally, site response was calculated using an equivalent-linear technique, using the multiple synthetic profiles and the sets of rock spectra representing input motions. These three steps are described in detail in the following sections.

Generation of Synthetic Profiles

To account for the epistemic and aleatory uncertainties in the site's dynamic properties, as described in Subsection 2.5.2.5, multiple sets of 60 synthetic profiles were generated using the stochastic model developed by Toro (1996), with some modifications to account for the conditions at the Comanche Peak site. These synthetic profiles represent the site column from the top of bedrock to the elevations where the GMRS and the various FIRS are defined (see Subsection 2.5.6.2). Bedrock is defined as having a shear-wave velocity of 9,200 fps, in order to achieve consistency with the new EPRI attenuation equations used for the rock hazard calculations (Reference 2.5-401). For each site column, this stochastic model uses as inputs the following quantities: (1) the median shear-wave velocity profile, which is equal to the base-case profile given in Table 2.5.2-227; (2) the standard deviation of ln(Vs) (the natural logarithm of the shear-wave velocity) as a function of depth, which is calculated from the values in Table 2.5.2-227; (3) the correlation coefficient between ln(Vs) in adjacent layers, which is taken from generic results for rock in Toro (1996). Layer thickness was not randomized because the site's stratigraphy is very uniform.

The correlation coefficient between ln(Vs) in adjacent layers is estimated using the inter-layer correlation model from Toro (1996) for USGS category A. In the log-normal randomization model used to calculate the synthetic Vs for each layer, it is possible for the synthetic Vs in the deeper formations to be greater than 9,200 fps. When this happens for a certain synthetic profile, the randomization scheme sets that Vs to 9,200 fps and defines the corresponding depth to be the depth to bedrock for that synthetic profile.

Figure 1 illustrates the Vs values for the first 10 synthetic profiles for the GMRS/FIRS1 site column. Figure 2 compares the median of these 60 Vs profiles to the Vs $\pm$ Variability values given in Table 2.5.2-227, indicating excellent agreement. The difference in the mean+sigma values below 800 m is a consequence of imposing the 9200 fps upper bound dictated by the bedrock Vs (see above). Figures 3 and 4 show analogous results for top portion the FIRS4 site column.

The best-estimate values for the damping ratio and for the stiffness degradation (G/Gmax) are given in Table 2.5.2-227. Except for the fill at the top of the FIRS4 soil column, materials are assumed to behave linearly, with constant damping and G/Gmax=1. The uncertainty in damping is specified as 35%, (following the generic values in EPRI, 1993) and the uncertainty in G/Gmax for fill is specified as 15% at $3x10^{-3}$ % strain (following the generic values given by Constantino (1996). The correlation coefficient between ln(G/Gmax) and ln(damping) in the fill is specified as -0.75. This implies that in synthetic profiles where the fill has higher than average G/Gmax, the fill tends to have lower than average damping. The degradation and damping properties are treated as fully correlated among layers in the same geological unit, but independent between different units. Figure 5 shows the damping ratios for the Strawn formation in the 60 synthetic profiles corresponding to FIRS1. Similarly, Figure 6 shows the G/Gmax and damping ratios for the 60 synthetic profiles corresponding to FIRS4.

Each set of 60 synthetic profiles, consisting of Vs and unit weight vs. depth, depth to bedrock, stiffness, and damping curves, is used to calculate and quantify site response and its uncertainty, as described below.

Selection of Rock Input Motions

Rock input motions were selected for input to the site response calculations using the seismic hazard results presented in Subsection 2.5.2. Uniform hazard response spectra (UHRS) for rock conditions corresponding to mean annual exceedence frequencies of 10^{-4}, 10^{-5}, and 10^{-6} were used. The base spectrum for each mean annual exceedence frequency was a broad-banded (BB) spectrum, because deaggregation and fitting of high- and low-frequency (HF and LF) spectra indicated the same high-frequency amplitudes. These spectra are plotted in Figures 2.5.2-229 through 2.5.2-231 and are given in tabular form in Table 2.5.2-219. The development of these spectra is documented in Subsection 2.5.2.4.4. The effect of choosing a broad-banded spectrum was investigated by also computing response to the 10^{-4} HF spectrum, and comparing that response to the 10^{-4} BB spectrum, as described in the next section.

Site Response Calculations

The site response calculations for Comanche Peak were performed using the Random Vibration Theory (RVT) approach. In many respects, the inputs and assumptions are the same for an RVT analysis and for a time-history based analysis (e.g., an analysis with the program SHAKE). Both the RVT and time-history (SHAKE) procedures use a horizontally-layered half-space representation of the site and use an equivalent-linear representation of dynamic response to vertically propagating shear waves. Starting from the same inputs (in the form of response spectra), both procedures will lead to similar estimates of site response (see, for example, Rathje and Ozbey, 2006). The main advantage of the RVT approach is that it does not require the spectral matching of multiple time histories to a given rock response spectrum. Instead, the RVT approach uses a probabilistic representation of the ensemble of all input motions corresponding to that given response spectrum and then calculates the response spectrum of the ensemble of dynamic responses.

Site-response calculations were performed for the three broad-banded (BB) bedrock motions, and for the 10^{-4} HF motion, as described in the previous section.

In addition to the rock response spectra, the RVT site-response calculations require the following inputs: (1) the strong-motion duration associated with each rock spectrum; and (2) the equivalent-strain ratio to use in the equivalent-linear calculations (this input is required for both the time-history and RVT approaches) and depends on magnitude. The duration is calculated from the de-aggregation results in Subsection 2.5.2.4.4 (Table 2.5.2-220), using standard seismological relations between magnitude, seismic moment, corner frequency, and duration (see, for example, Rathje and Ozbey, 2006), and using stress-drop and crustal Vs values typical of the eastern United States. The effective strain ratio is calculated using the expression (M-1)/10 (Idriss and Sun, 1992). Values smaller than 0.5 or greater than 0.65 were brought into the 0.5-0.65 range, which is the range recommended by Kramer (1996). The calculated values of duration and effective strain ratio are given in Table 1.

For each site column and each rock-motion input, separate site response calculations were performed for the corresponding 60 synthetic profiles. These results for each combination of input motion and site column were then used to calculate the logarithmic mean and standard deviation of the amplification factor. Results for the various site columns, and for the 10^{-4}, 10^{-5}, and 10^{-6} BB inputs, are given in Figures 2.5.2-233 and 2.5.2-235 through 2.5.2-238. Tabular results are provided in Tables 2 through 6.

No graphs showing peak strain vs. depth are included here because all materials, except the fill at the top of the FIRS4 and FIRS4_CoV50 columns, are treated as behaving linearly (see "Generation of Synthetic Profiles" above). The logarithmic-mean (over the 60 synthetic profiles) values of the peak strain in the fill are approximately 0.004%, 0.01%, and 0.03%, for the 10^{-4}, 10^{-5}, and 10^{-6} inputs, respectively.

In addition, Figure 7 compares the median amplification factors obtained for GMRS/FIRS1 site column using the 10^{-4} HF and BB rock inputs. Although Figure 7 shows that the BB spectrum gives larger amplification factors for frequencies above 3 Hz, the effect of this difference on the 10^{-4} site hazard will be negligible because most of the 10^{-4} hazard at all frequencies comes from distant events (see Figures 2.5.2-221 and 2.5.2-222). These distant events will generate a BB rock spectrum. The effect of a difference in amplification factors at 10^{-5} would be somewhat larger (and would result in lower mean site spectra) because roughly 40% of the 10^{-5} rock hazard comes from local, small-magnitude events (see Figures 2.5.2-223 and 2.5.2-224). As a result, use of the BB amplification factors for all magnitude-distance combinations in the soil-hazard calculations (Subsection 2.5.2.6.1.1) yields slightly conservative hazard results at 10^{-5}, resulting in slightly conservative estimates of the design spectrum.

References

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Idriss, I. M., and Sun, J. I. (1992). *SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analyses of Horizontally Layered Soil Deposits*, Dept. of Civil and Environmental Engineering, Center for Geotechnical Modeling, Univ. of California, Davis, Calif.

Kramer, Steven L. (1996). *Geotechnical Earthquake Engineering*. Prentice-Hall.

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Toro, G.R. (1996). *Probabilistic Models of Site Velocity Profiles for Generic and Site-Specific Ground Motion Amplification Studies*. Published as an appendix in Silva, W.J., N. Abrahamson, G. Toro and C. Costantino. (1997). "Description and validation of the stochastic ground motion model." Report Submitted to Brookhaven National Laboratory, Associated Universities, Inc. Upton, New York 11973, Contract No. 770573.

Table 1. Calculation of duration and effective strain ratio for rock input motions considered in site response calculations

Case	Magnitude M	Distance R (km)	Seismic Moment Mo (dyn-cm)	Corner Frequency fc (Hz)	Duration T (sec)	Eff Strain Ratio
1E-4 HF	7.2	450	7.08E+26	0.09	33.04	0.62
1E-4 BB	7.6	820	2.82E+27	0.06	57.70	0.65
1E-5 BB	7.7	860	3.98E+27	0.05	61.74	0.65
1E-6 BB	7.8	860	5.62E+27	0.05	64.02	0.65

Table 2. Amplification factors for the GMRS/FIRS1 site column

	Amplification Factor for 10^{-4}		Amplification Factor for 10^{-5}		Amplification Factor for 10^{-6}	
Freq (Hz)	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.
0.1	1.13	0.06	1.13	0.07	1.13	0.07
0.125	1.16	0.08	1.16	0.09	1.16	0.09
0.15	1.20	0.11	1.20	0.11	1.20	0.11
0.2	1.31	0.17	1.31	0.16	1.31	0.16
0.3	1.47	0.18	1.46	0.17	1.46	0.17
0.4	1.45	0.17	1.43	0.17	1.43	0.17
0.5	1.39	0.18	1.37	0.18	1.37	0.18
0.6	1.38	0.16	1.36	0.16	1.36	0.16
0.7	1.40	0.15	1.37	0.14	1.38	0.14
0.8	1.43	0.12	1.40	0.12	1.40	0.12
0.9	1.43	0.11	1.39	0.10	1.39	0.10
1	1.45	0.12	1.37	0.11	1.37	0.11
1.25	1.66	0.17	1.61	0.17	1.61	0.17
1.5	1.82	0.19	1.75	0.19	1.74	0.19
2	1.80	0.13	1.72	0.13	1.72	0.13
2.5	1.53	0.14	1.42	0.14	1.41	0.14
3	1.22	0.15	1.14	0.16	1.12	0.16
4	0.94	0.13	0.86	0.14	0.83	0.15
5	0.87	0.12	0.78	0.13	0.74	0.14
6	0.85	0.14	0.75	0.15	0.71	0.18
7	0.80	0.16	0.69	0.17	0.64	0.21
8	0.74	0.15	0.63	0.17	0.56	0.21
9	0.71	0.15	0.59	0.17	0.52	0.21
10	0.72	0.16	0.58	0.17	0.50	0.23
12.5	0.74	0.21	0.57	0.23	0.49	0.31
15	0.73	0.19	0.55	0.22	0.47	0.29
20	0.63	0.14	0.45	0.16	0.34	0.24
25	0.58	0.12	0.39	0.14	0.28	0.20
30	0.55	0.11	0.38	0.12	0.26	0.17
35	0.55	0.11	0.38	0.11	0.26	0.16
40	0.55	0.11	0.39	0.11	0.26	0.14
45	0.56	0.10	0.40	0.10	0.27	0.13
50	0.58	0.10	0.42	0.10	0.28	0.13
60	0.66	0.09	0.49	0.09	0.33	0.12
70	0.78	0.08	0.60	0.09	0.40	0.11
80	0.91	0.08	0.72	0.09	0.48	0.11
90	1.03	0.08	0.83	0.09	0.56	0.11
100	1.12	0.08	0.91	0.09	0.62	0.11

Table 3. Amplification factors for the FIRS2 site column

	Amplification Factor for 10^{-4}		Amplification Factor for 10^{-5}		Amplification Factor for 10^{-6}	
Freq (Hz)	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.
0.1	1.12	0.06	1.12	0.07	1.12	0.06
0.125	1.14	0.08	1.14	0.08	1.14	0.08
0.15	1.18	0.11	1.18	0.11	1.18	0.11
0.2	1.27	0.16	1.27	0.16	1.27	0.16
0.3	1.43	0.18	1.43	0.18	1.43	0.18
0.4	1.44	0.17	1.44	0.17	1.44	0.17
0.5	1.40	0.18	1.40	0.18	1.40	0.18
0.6	1.37	0.15	1.38	0.15	1.38	0.15
0.7	1.37	0.13	1.37	0.13	1.38	0.13
0.8	1.39	0.10	1.39	0.10	1.39	0.10
0.9	1.41	0.11	1.41	0.11	1.40	0.11
1	1.45	0.14	1.41	0.13	1.41	0.13
1.25	1.64	0.19	1.65	0.19	1.65	0.19
1.5	1.83	0.18	1.83	0.18	1.83	0.18
2	1.73	0.14	1.73	0.13	1.72	0.13
2.5	1.39	0.16	1.37	0.15	1.36	0.15
3	1.10	0.17	1.10	0.17	1.08	0.17
4	0.85	0.14	0.84	0.14	0.81	0.15
5	0.80	0.15	0.78	0.16	0.74	0.17
6	0.79	0.17	0.76	0.18	0.72	0.20
7	0.73	0.19	0.70	0.21	0.64	0.25
8	0.67	0.20	0.63	0.22	0.56	0.28
9	0.65	0.20	0.60	0.23	0.52	0.29
10	0.65	0.20	0.60	0.23	0.51	0.29
12.5	0.67	0.25	0.61	0.29	0.52	0.37
15	0.64	0.23	0.56	0.27	0.48	0.36
20	0.55	0.15	0.45	0.20	0.34	0.28
25	0.52	0.14	0.40	0.17	0.28	0.25
30	0.51	0.14	0.39	0.18	0.27	0.25
35	0.50	0.14	0.39	0.17	0.27	0.25
40	0.51	0.13	0.40	0.15	0.27	0.20
45	0.52	0.12	0.41	0.13	0.28	0.18
50	0.54	0.11	0.43	0.13	0.29	0.17
60	0.61	0.11	0.50	0.12	0.34	0.15
70	0.72	0.10	0.61	0.11	0.41	0.14
80	0.85	0.10	0.73	0.11	0.49	0.14
90	0.97	0.10	0.84	0.11	0.57	0.14
100	1.05	0.10	0.93	0.11	0.63	0.14

Table 4. Amplification factors for the FIRS3 site column

	Amplification Factor for 10^{-4}		Amplification Factor for 10^{-5}		Amplification Factor for 10^{-6}	
Freq (Hz)	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.
0.1	1.12	0.08	1.12	0.08	1.12	0.08
0.125	1.14	0.11	1.14	0.11	1.14	0.11
0.15	1.18	0.14	1.18	0.14	1.18	0.14
0.2	1.27	0.19	1.27	0.19	1.27	0.19
0.3	1.39	0.19	1.39	0.19	1.39	0.19
0.4	1.39	0.16	1.39	0.16	1.39	0.16
0.5	1.37	0.17	1.36	0.18	1.36	0.18
0.6	1.35	0.16	1.35	0.16	1.35	0.17
0.7	1.35	0.13	1.35	0.13	1.36	0.13
0.8	1.40	0.12	1.40	0.12	1.40	0.12
0.9	1.44	0.12	1.44	0.12	1.43	0.12
1	1.46	0.14	1.41	0.13	1.41	0.13
1.25	1.60	0.20	1.60	0.20	1.60	0.20
1.5	1.78	0.18	1.78	0.18	1.78	0.18
2	1.66	0.15	1.66	0.15	1.66	0.15
2.5	1.37	0.22	1.35	0.20	1.34	0.20
3	1.13	0.21	1.12	0.20	1.10	0.21
4	0.89	0.16	0.87	0.17	0.85	0.17
5	0.84	0.18	0.83	0.18	0.79	0.20
6	0.84	0.20	0.83	0.21	0.79	0.23
7	0.82	0.25	0.80	0.26	0.75	0.30
8	0.80	0.28	0.77	0.30	0.72	0.34
9	0.83	0.32	0.79	0.35	0.74	0.39
10	0.88	0.33	0.84	0.36	0.79	0.41
12.5	0.94	0.29	0.90	0.33	0.86	0.38
15	0.81	0.30	0.76	0.34	0.69	0.41
20	0.68	0.25	0.59	0.31	0.51	0.40
25	0.59	0.19	0.48	0.24	0.37	0.33
30	0.55	0.16	0.43	0.19	0.32	0.27
35	0.53	0.16	0.43	0.18	0.31	0.26
40	0.54	0.15	0.43	0.18	0.31	0.25
45	0.55	0.15	0.45	0.17	0.32	0.23
50	0.57	0.14	0.47	0.16	0.34	0.22
60	0.65	0.13	0.55	0.15	0.39	0.20
70	0.77	0.13	0.67	0.14	0.47	0.20
80	0.91	0.13	0.80	0.14	0.57	0.19
90	1.03	0.13	0.92	0.14	0.66	0.19
100	1.12	0.12	1.01	0.14	0.73	0.19

Table 5. Amplification factors for the FIRS4 site column

	Amplification Factor for 10^{-4}		Amplification Factor for 10^{-5}		Amplification Factor for 10^{-6}	
Freq (Hz)	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.
0.1	1.12	0.06	1.13	0.06	1.13	0.06
0.125	1.15	0.08	1.15	0.08	1.15	0.08
0.15	1.19	0.10	1.19	0.10	1.19	0.10
0.2	1.29	0.15	1.29	0.15	1.29	0.15
0.3	1.45	0.18	1.46	0.18	1.46	0.18
0.4	1.44	0.17	1.44	0.17	1.45	0.17
0.5	1.37	0.17	1.37	0.18	1.38	0.18
0.6	1.35	0.16	1.36	0.16	1.38	0.17
0.7	1.38	0.14	1.39	0.14	1.43	0.16
0.8	1.45	0.13	1.46	0.14	1.50	0.17
0.9	1.49	0.14	1.49	0.14	1.54	0.19
1	1.54	0.15	1.51	0.15	1.57	0.21
1.25	1.79	0.19	1.82	0.19	1.92	0.24
1.5	1.98	0.22	2.02	0.23	2.14	0.29
2	1.92	0.15	1.99	0.19	2.14	0.26
2.5	1.62	0.23	1.69	0.28	1.80	0.31
3	1.42	0.30	1.52	0.35	1.58	0.35
4	1.50	0.47	1.53	0.44	1.52	0.40
5	1.85	0.48	1.77	0.43	1.57	0.40
6	2.04	0.40	1.82	0.39	1.44	0.45
7	1.87	0.38	1.61	0.42	1.24	0.49
8	1.63	0.40	1.38	0.44	1.06	0.52
9	1.41	0.40	1.19	0.42	0.90	0.45
10	1.23	0.32	1.04	0.33	0.79	0.36
12.5	1.09	0.26	0.93	0.27	0.71	0.31
15	1.05	0.27	0.87	0.28	0.65	0.34
20	0.91	0.26	0.70	0.29	0.49	0.35
25	0.82	0.22	0.61	0.24	0.41	0.29
30	0.78	0.20	0.58	0.21	0.38	0.25
35	0.77	0.20	0.58	0.20	0.38	0.23
40	0.77	0.19	0.59	0.19	0.38	0.21
45	0.78	0.18	0.60	0.18	0.40	0.20
50	0.81	0.18	0.64	0.18	0.42	0.19
60	0.92	0.17	0.74	0.17	0.49	0.18
70	1.09	0.17	0.90	0.16	0.60	0.18
80	1.29	0.17	1.08	0.16	0.72	0.18
90	1.46	0.17	1.25	0.16	0.83	0.17
100	1.58	0.16	1.37	0.16	0.92	0.17

Table 6. Amplification factors for the FIRS4_CoV50 site column

	Amplification Factor for 10^{-4}		Amplification Factor for 10^{-5}		Amplification Factor for 10^{-6}	
Freq (Hz)	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.
0.1	1.13	0.06	1.14	0.06	1.14	0.06
0.125	1.15	0.08	1.16	0.08	1.16	0.08
0.15	1.19	0.10	1.20	0.10	1.20	0.10
0.2	1.29	0.15	1.30	0.15	1.31	0.15
0.3	1.46	0.18	1.47	0.18	1.48	0.19
0.4	1.44	0.17	1.45	0.17	1.48	0.20
0.5	1.38	0.18	1.39	0.18	1.44	0.23
0.6	1.36	0.16	1.39	0.18	1.45	0.25
0.7	1.40	0.15	1.43	0.18	1.51	0.25
0.8	1.47	0.14	1.52	0.20	1.60	0.27
0.9	1.51	0.15	1.56	0.22	1.65	0.28
1	1.57	0.17	1.59	0.23	1.69	0.30
1.25	1.84	0.21	1.94	0.28	2.04	0.33
1.5	2.06	0.28	2.13	0.32	2.20	0.30
2	2.05	0.28	2.11	0.30	2.10	0.28
2.5	1.76	0.36	1.75	0.35	1.73	0.33
3	1.55	0.44	1.51	0.39	1.48	0.38
4	1.47	0.49	1.40	0.44	1.31	0.47
5	1.61	0.50	1.48	0.48	1.21	0.44
6	1.66	0.45	1.42	0.42	1.12	0.48
7	1.52	0.41	1.31	0.45	1.02	0.50
8	1.40	0.39	1.18	0.42	0.93	0.51
9	1.33	0.36	1.12	0.42	0.87	0.52
10	1.27	0.35	1.06	0.40	0.80	0.51
12.5	1.13	0.30	0.92	0.33	0.69	0.43
15	1.04	0.28	0.84	0.31	0.61	0.41
20	0.88	0.25	0.67	0.28	0.46	0.36
25	0.82	0.23	0.60	0.25	0.40	0.35
30	0.79	0.23	0.58	0.25	0.38	0.31
35	0.76	0.21	0.57	0.21	0.37	0.27
40	0.76	0.21	0.58	0.20	0.37	0.24
45	0.78	0.20	0.60	0.19	0.38	0.22
50	0.81	0.20	0.63	0.18	0.41	0.21
60	0.92	0.20	0.73	0.18	0.48	0.19
70	1.09	0.19	0.89	0.18	0.58	0.19
80	1.28	0.19	1.06	0.18	0.70	0.19
90	1.45	0.19	1.23	0.18	0.81	0.18
100	1.57	0.19	1.35	0.18	0.90	0.18

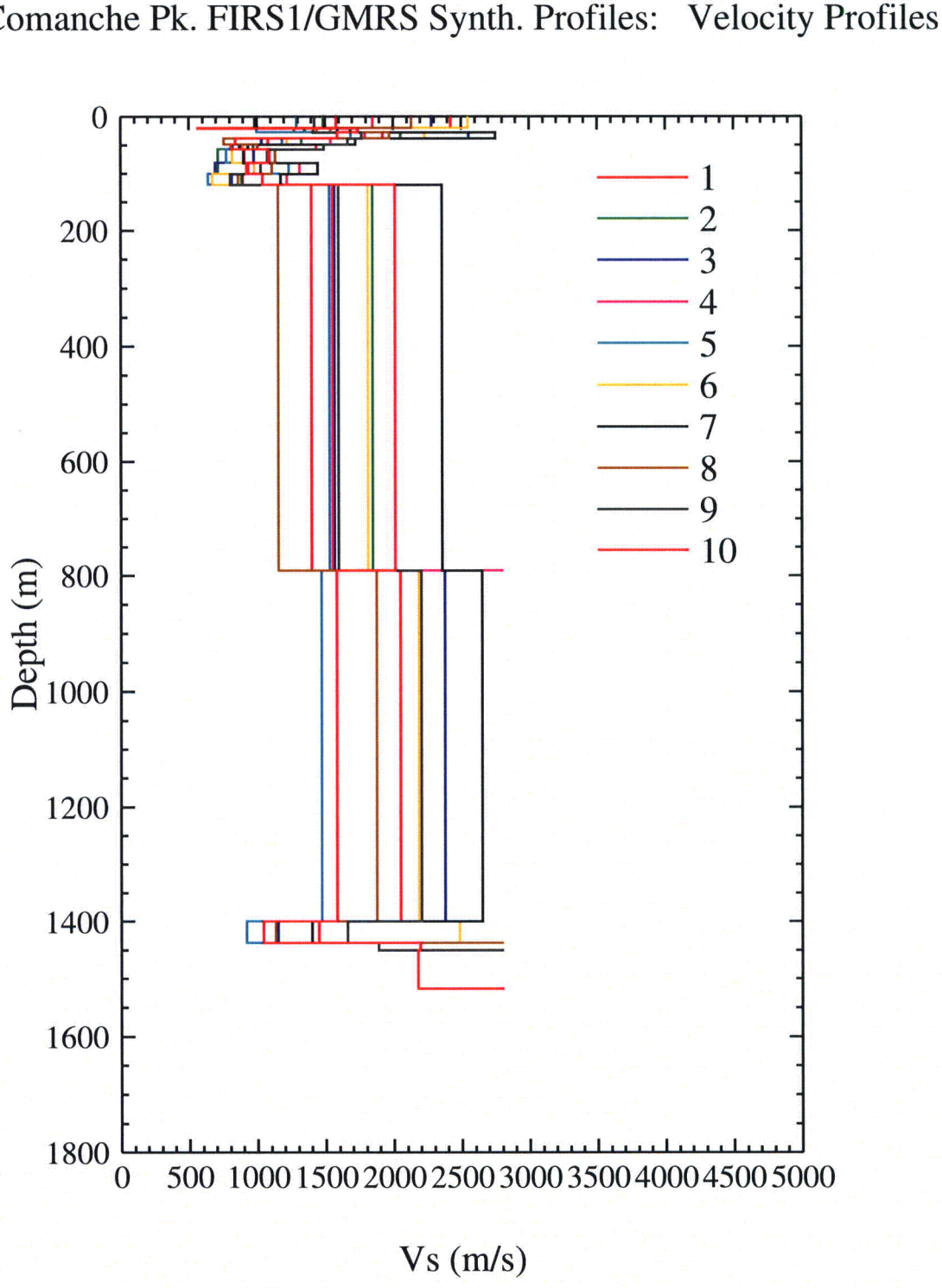

Figure 1. Graph of Vs vs. depth for the first 10 synthetic profiles generated for the GMRS/FIRS1 site column.

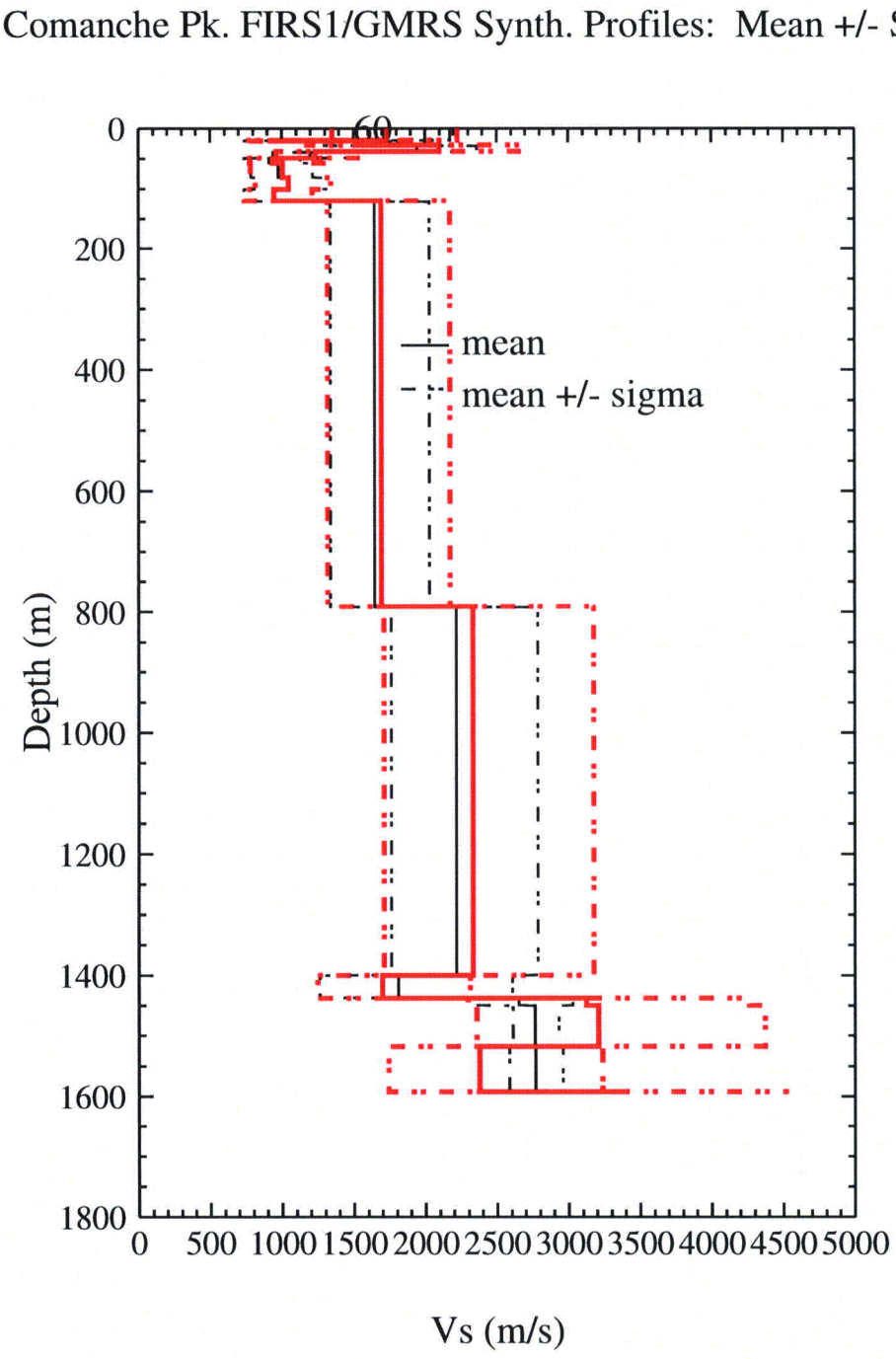

Figure 2. Summary statistics from synthetic profiles for GMRS/FIRS1 site column are compared to values in Table 2.5.2-227. Note: the calculated median+sigma from the artificial profiles (black dashed line) is lower than the target median+sigma at depths greater than 800 m because the distribution of Vs is truncated by the Vs of bedrock (9200 fps or 2,804 m/s) implicit in the EPRI attenuation equations.

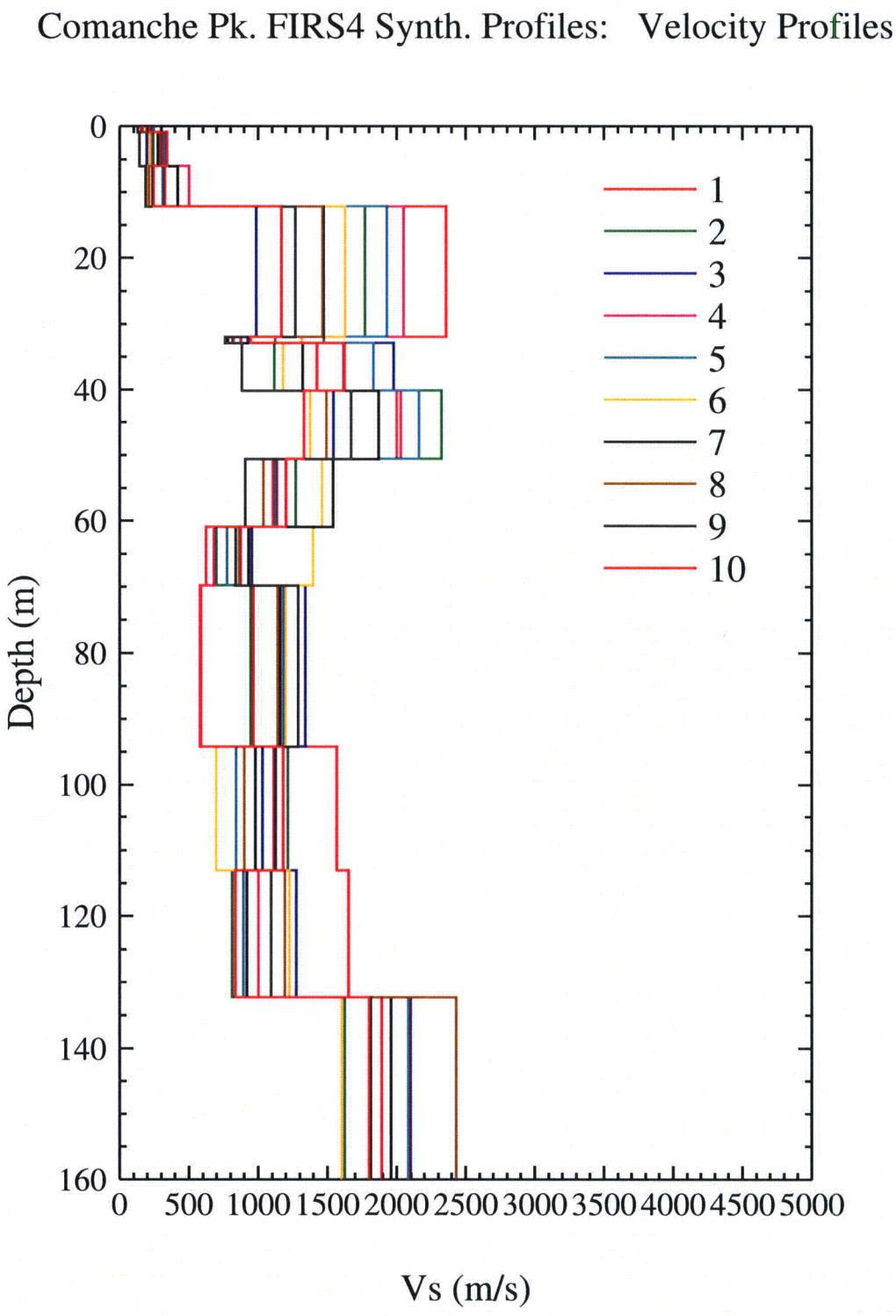

Figure 3. Graph of Vs vs. depth for the first 10 synthetic profiles generated for the top portion of the FIRS4 site column.

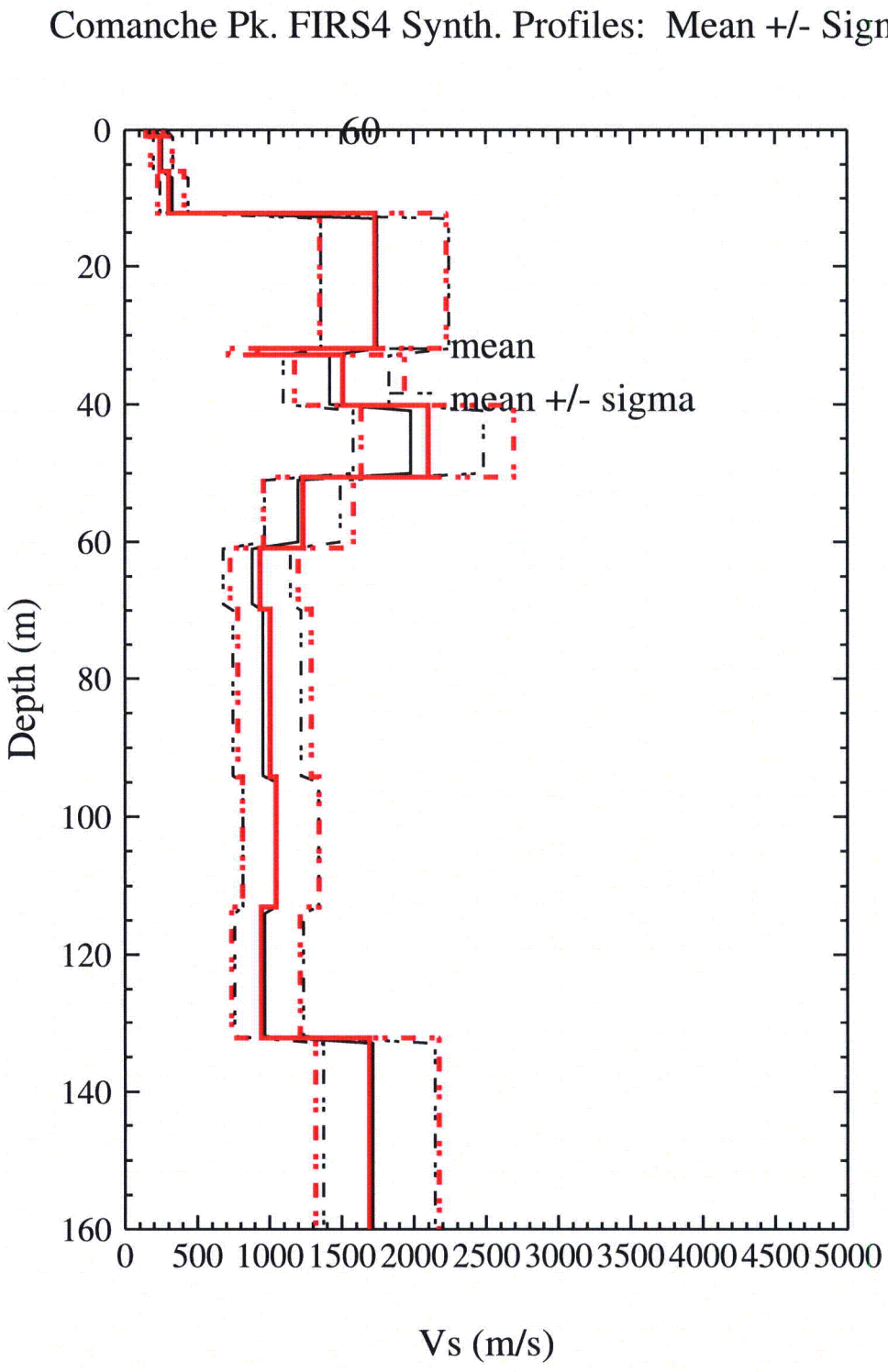

Figure 4. Summary statistics from synthetic profiles for the top portion of the FIRS4 site column are compared to values in Table 2.5.2-227.

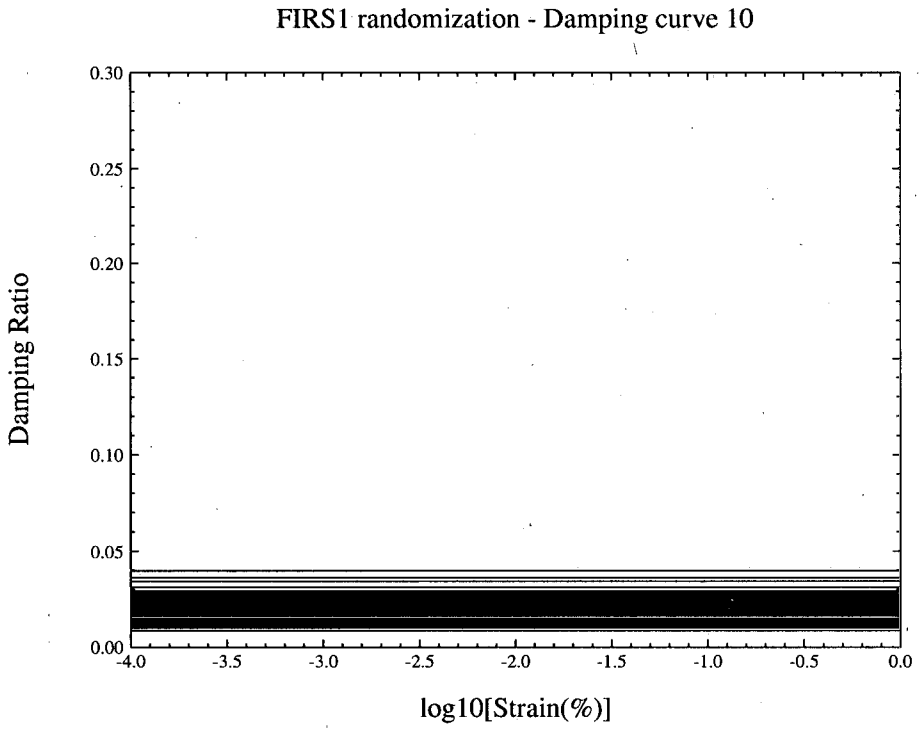

Figure 5. Damping ratios vs. strain for the Strawn formation in the 60 synthetic profiles for GMRS/FIRS1 site column. Note: damping ratios are given as fraction of critical, not as percentage of critical.

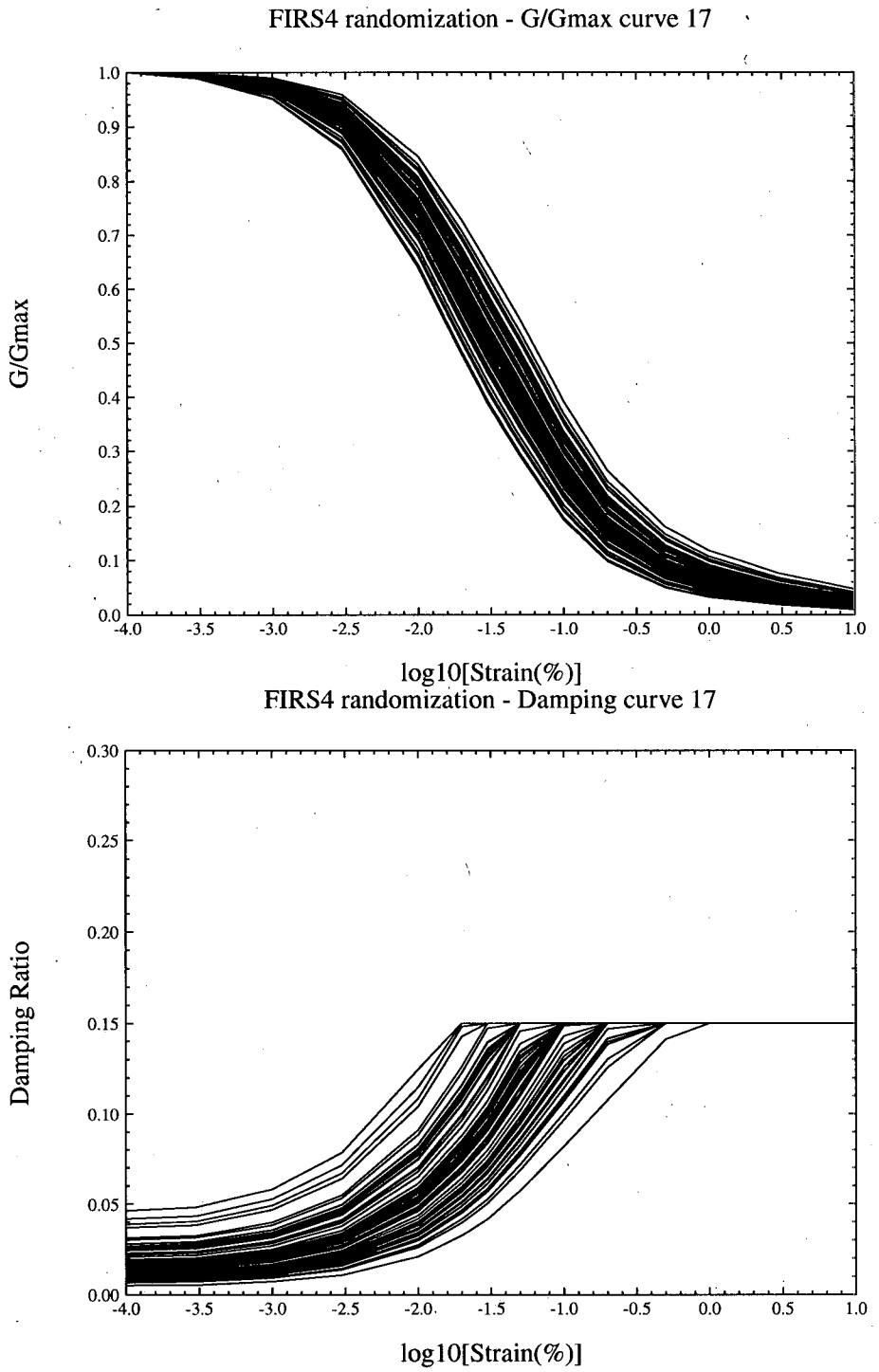

Figure 6. G/Gmax and damping ratios vs. strain for the fill (0-20 ft depth) in the 60 synthetic profiles for FIRS4 site column. Note: damping ratios are given as fraction of critical, not as percentage of critical.

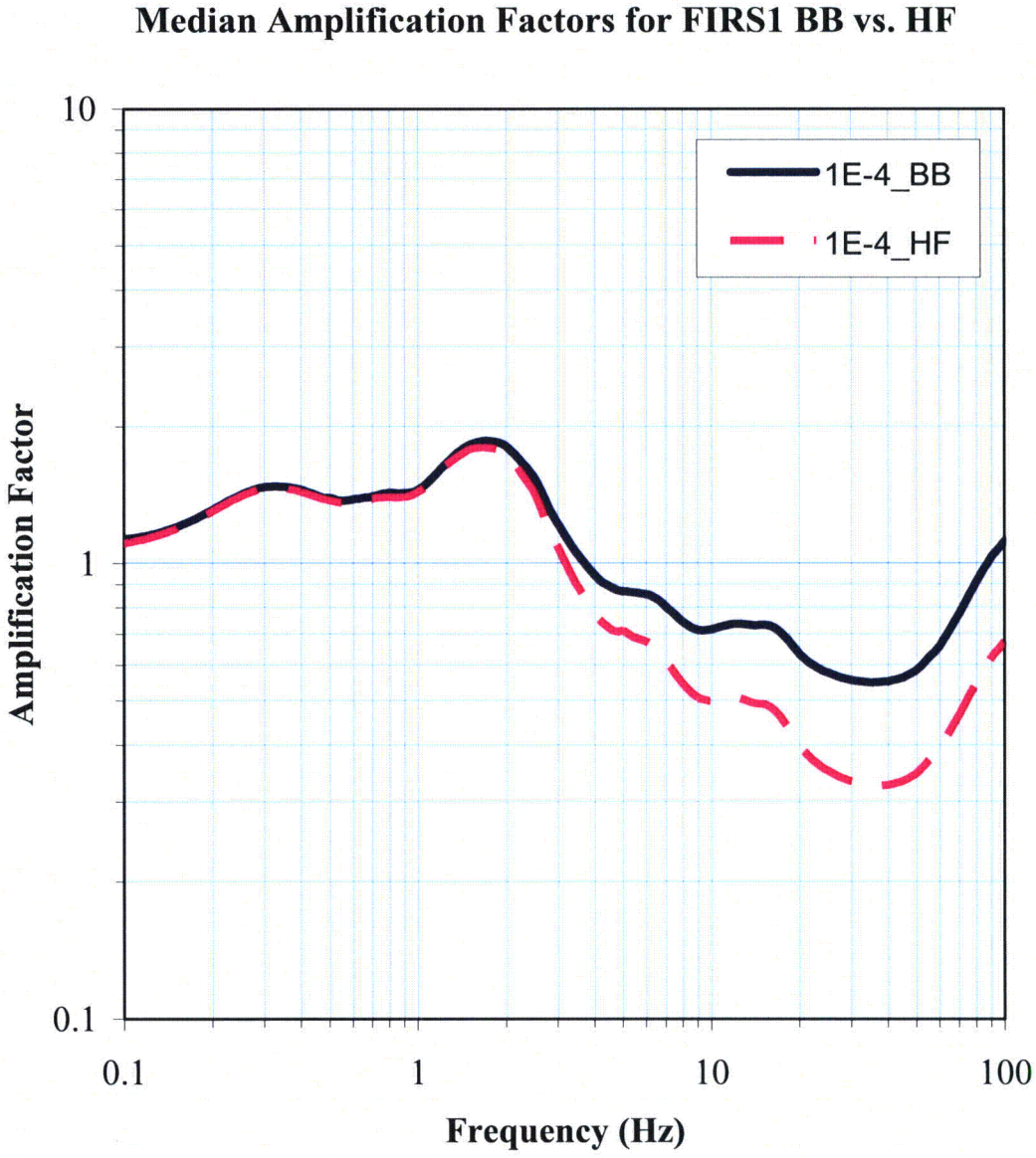

Figure 7. Comparison of amplification factors for GMRS/FIRS1 site column: HF vs BB inputs

Issue 2 - The FSAR does not include vertical GMRS. The subsection 2.5.2.6.1.2 entitled "Vertical GMRS Spectrum" only briefly discusses the vertical GMRS qualitatively, and states that vertical GMRS will be enveloped by the DCD CSDRS. The staff considers this issue an acceptance issue since the FSAR does not provide proper calculations to represent this critical safety parameter. (Reference: RG 1.206 -- C.I.2.5.2.6 *Ground Motion Response Spectrum)*

Resolution

Luminant will change FSAR Subsection 2.5.2.6 to include the following information in a future revision of the COLA.

Description of Horizontal GMRS and FIRS Spectra

The horizontal GMRS and FIRS spectra were developed as follows. A seismic hazard calculation was made using the site amplification factors for the GMRS and four FIRS conditions (FIRS2, FIRS3, FIRS4, and FIRS4-CoV50). These calculations were made at the seven spectral frequencies at which ground motion equations were available from the EPRI (2004) study (100 Hz, 25 Hz, 10 Hz, 5 Hz, 2.5 Hz, 1 Hz, and 0.5 Hz). The CAV filter was applied for these calculations, and at all spectral frequencies, the 1E-4 amplitudes were zero (i.e., the highest hazard at low amplitudes was less than 1E-4). As a result, the GMRS and FIRS amplitudes were determine from (for example) GMRS = 0.45 × SA(10^{-5}), where SA(10^{-5}) is the spectral acceleration for 10^{-5} annual frequency of exceedence.

The horizontal 1E-5 and GMRS spectra were calculated at 39 frequencies between 0.1 Hz and 100 Hz for the GMRS elevation. Because of the very flat appearance of the spectra at the seven spectral frequencies at which hazard calculations were made, log-log interpolation between available hazard values was used, with the exception of the following frequency ranges.

1 Hz to 5 Hz: Within this frequency range, a peak in site spectra occurs at 2.5 Hz, reflecting a site amplification at about 2 Hz. To reflect this amplification, the 1E-5 spectral amplitude at 2.5 Hz was broadened using rock spectral shapes from Ref. 1 and using the broad-banded values of M=7.7 and R=890 km for 1E-5 (on which the site amplification calculations were based). This is an acceptable approximation given that the rock spectrum is decreasing between 2.5 and 1 Hz.

0.5 Hz to 0.1 Hz: Below 0.5 Hz, the assumption was made that spectral accelerations are proportional to f down to 0.125 Hz (where f is frequency), and are proportional to f^2 between 0.125 Hz and 0.1 Hz. This is a common assumption for spectral shapes at low frequencies (Ref. 2).

Spectra for the four FIRS conditions (FIRS2, FIRS3, FIRS4, and FIRS4-CoV50 were calculated in a similar way. Note that the FIRS3 spectra have peaks at about 2 Hz and 10 Hz, and that the FIRS4 and FIRS4-CoV50 spectra have peaks at about 1.5 Hz and 5 Hz. These peaks were broadened in an approximate way similar to the procedure used for the GMRS.

These GMRS and FIRS spectra are plotted in Figures 1 through 5, with the 1E-5 spectrum for each condition also plotted. Table 1 shows the numerical values for the 1E-5 and GMRS spectra, and Table 2 shows the numerical values for the 1E-5 and FIRS spectra.

Description of Vertical GMRS and FIRS Spectra

Vertical GMRS and FIRS spectra were developed using vertical-to-horizontal (V/H) ratios. Ref. 1 and 3 indicate proposed V/H ratios for design spectra for nuclear facilities, and these V/H ratios are plotted in Figure 6. The V/H ratios in Figure 6 taken from Ref. 1 (the blue curve) are recommended for hard rock sites in the CEUS. The Comanche Peak site is a deep, soft-rock site with shales and limestones near the surface having shear-wave velocities of about 2600 fps, and the V/H ratios for this site condition will be similar to those for hard rock sites.

Based on these comparisons, it is concluded that the applicable V/H ratios at the Comanche Peak site will be $\leq$1.0 at all spectral frequencies between 100 Hz and 0.1 Hz. As a conservative assumption, the V/H ratio is assumed to be equal to 1.0 at all spectral frequencies. This assumption is also plotted in Figure 6.

The result of this assumption is that the spectra plotted in Figures 1 through 5 for the GMRS and four FIRS conditions apply to both the horizontal and vertical motions.

Tables 1 and 2 document (respectively) the 10^{-5} UHRS and GMRS, and the 10^{-5} UHRS and FIRS. Because V/H is assumed to be equal to unity, these spectra apply to both horizontal and vertical motions.

References

1. Risk Engineering, Inc. (2008). *Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines*, US Nuc. Reg. Comm. Rept. NUREG/CR-6728.
2. Building Seismic Safety Council (2004). *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures (FEMA 450) 2003 Edition*, Fed. Emerg. Manag. Agency Rept. 450.
3. US Atomic Energy Comm (1973). *Regulatory Guide 1.60 Design Response Spectra for Seismic Design of Nuclear Power Plants*, Wash. DC, Dec.
4. Risk Engineering, Inc. (2008). *Calculation of Site Response for Comanche Peak Units 2 and 3*, REI QA record 0737-ACR-030 Rev. 1.
5. Risk Engineering, Inc. (2008). *High Frequency and Low Frequency Horizontal Rock Spectra*, REI QA record 0737-ACR-026.

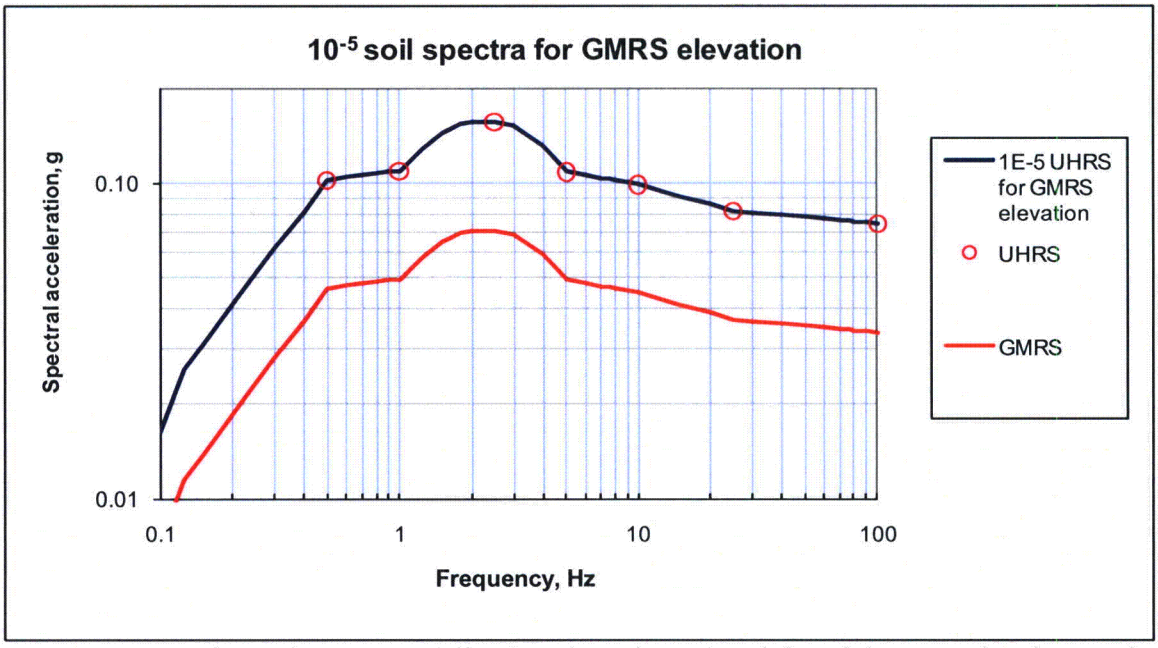

Figure 1: Comanche Peak 1E-5 UHRS (for GMRS conditions) and GMRS, horizontal and vertical.

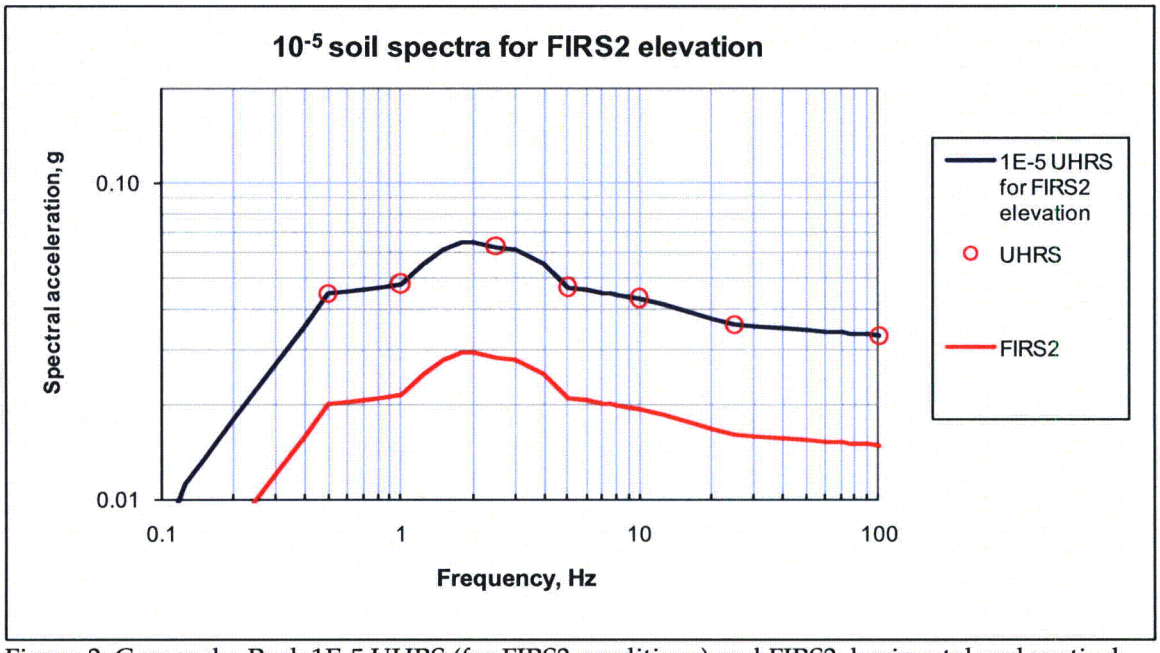

Figure 2: Comanche Peak 1E-5 UHRS (for FIRS2 conditions) and FIRS2, horizontal and vertical.

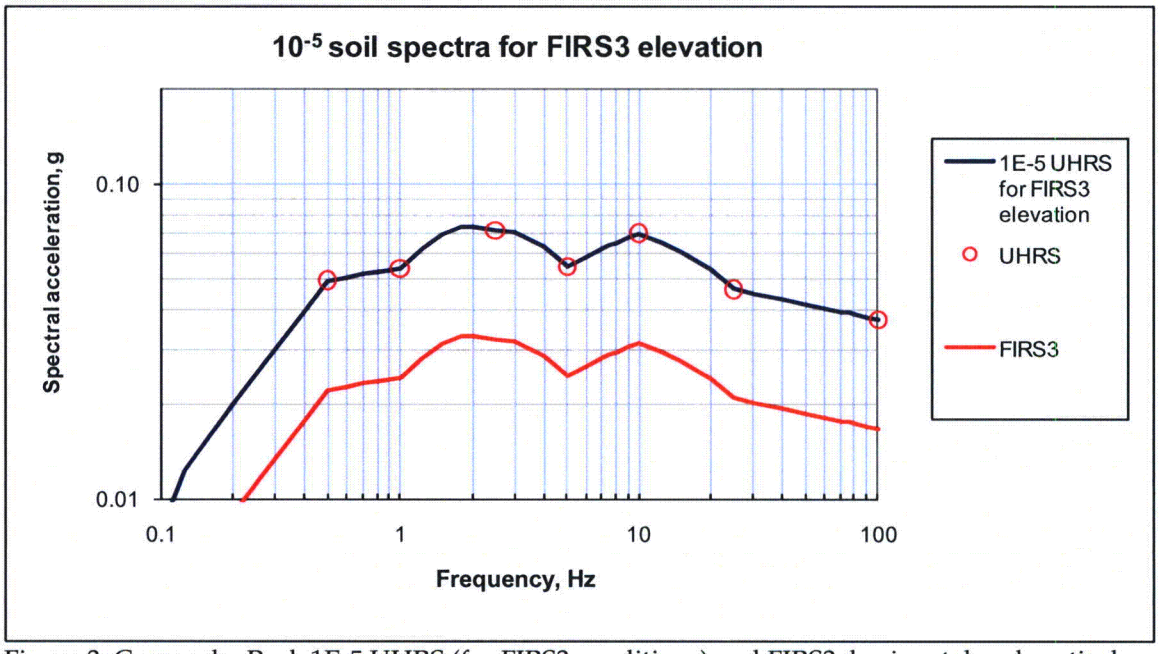

Figure 3: Comanche Peak 1E-5 UHRS (for FIRS3 conditions) and FIRS3, horizontal and vertical.

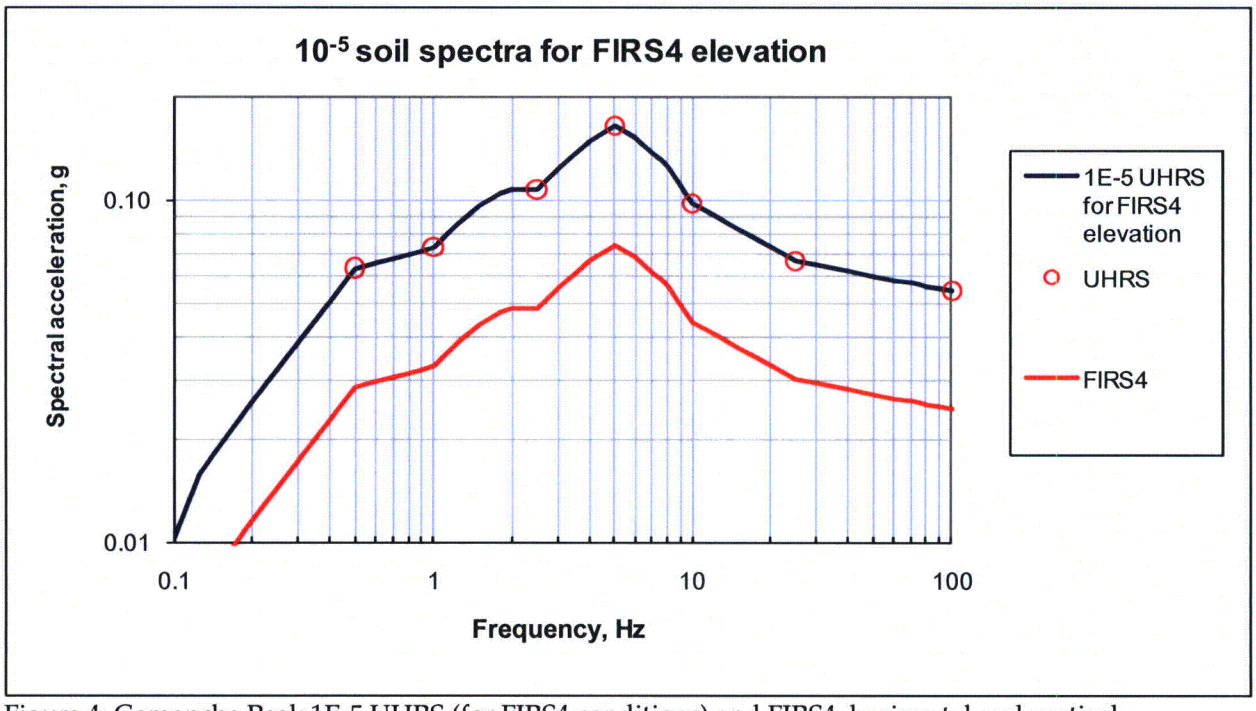

Figure 4: Comanche Peak 1E-5 UHRS (for FIRS4 conditions) and FIRS4, horizontal and vertical.

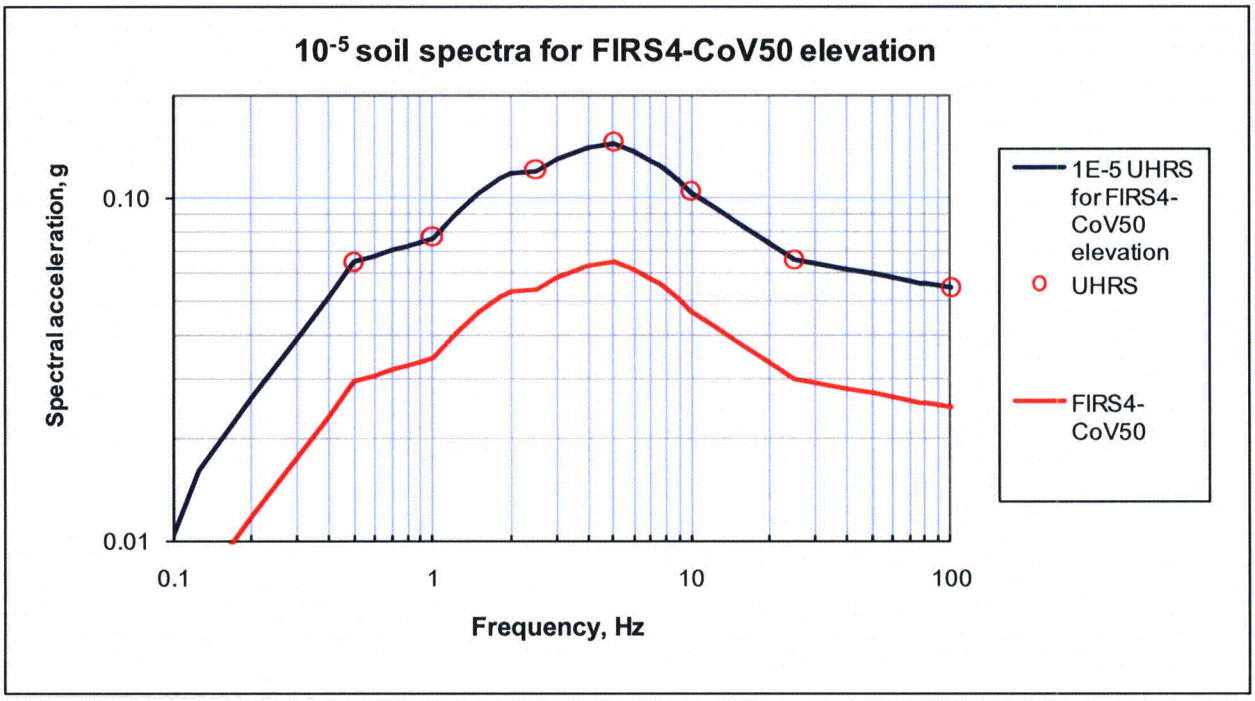

Figure 5: Comanche Peak 1E-5 UHRS (for FIRS4-COV50 conditions) and GMRS-COV50, horizontal and vertical.

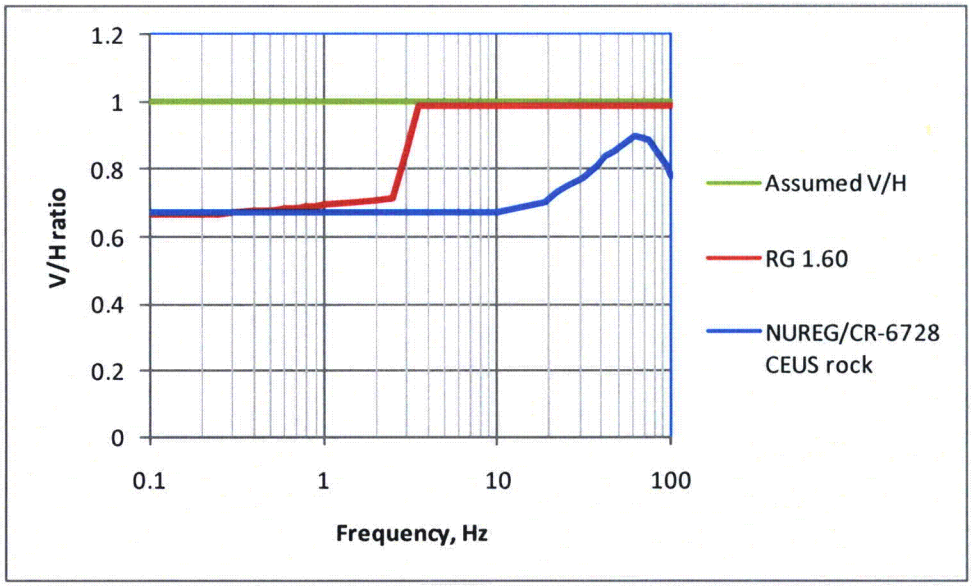

Figure 6: V/H ratios from two references, and assumed V/H ratio

Table 1: 1E-5 and GMRS amplitudes for GMRS elevation, horizontal and vertical.

Horizontal and vertical amplitudes for GMRS elevation		
Frequency	1E-5 UHRS	GMRS
100	7.43E-02	3.34E-02
90	7.48E-02	3.37E-02
80	7.54E-02	3.39E-02
75	7.57E-02	3.41E-02
70	7.61E-02	3.42E-02
60	7.68E-02	3.46E-02
50	7.78E-02	3.50E-02
40	7.89E-02	3.55E-02
30	8.04E-02	3.62E-02
25	8.14E-02	3.66E-02
20	8.53E-02	3.84E-02
15	9.05E-02	4.07E-02
12.5	9.40E-02	4.23E-02
10	9.85E-02	4.43E-02
9	9.99E-02	4.49E-02
8	1.01E-01	4.57E-02
7.5	1.02E-01	4.61E-02
7	1.03E-01	4.65E-02
6	1.05E-01	4.74E-02
5	1.08E-01	4.86E-02
4	1.31E-01	5.91E-02
3	1.51E-01	6.78E-02
2.5	1.55E-01	6.98E-02
2	1.55E-01	6.99E-02
1.8	1.54E-01	6.92E-02
1.5	1.43E-01	6.42E-02
1.25	1.28E-01	5.76E-02
1	1.09E-01	4.91E-02
0.9	1.08E-01	4.86E-02
0.8	1.07E-01	4.80E-02
0.7	1.05E-01	4.74E-02
0.6	1.04E-01	4.67E-02
0.5	1.02E-01	4.59E-02
0.4	8.16E-02	3.67E-02
0.3	6.12E-02	2.75E-02
0.2	4.08E-02	1.84E-02
0.15	3.06E-02	1.38E-02
0.125	2.55E-02	1.15E-02
0.1	1.63E-02	7.34E-03

Table 2: 1E-5 and FIRS amplitudes for FIRS elevations, horizontal and vertical.

	FIRS2		FIRS3		FIRS4		FIRS4-CoV50	
Frequency	1E-5 UHRS	FIRS2	1E-5 UHRS	FIRS3	1E-5 UHRS	FIRS4	1E-5 UHRS	FIRS4-CoV50
100	3.31E-02	1.49E-02	3.73E-02	1.68E-02	5.45E-02	2.45E-02	5.45E-02	2.45E-02
90	3.33E-02	1.50E-02	3.79E-02	1.71E-02	5.53E-02	2.49E-02	5.53E-02	2.49E-02
80	3.35E-02	1.51E-02	3.86E-02	1.74E-02	5.63E-02	2.53E-02	5.62E-02	2.53E-02
75	3.36E-02	1.51E-02	3.90E-02	1.76E-02	5.68E-02	2.56E-02	5.67E-02	2.55E-02
70	3.38E-02	1.52E-02	3.95E-02	1.78E-02	5.74E-02	2.58E-02	5.72E-02	2.57E-02
60	3.40E-02	1.53E-02	4.04E-02	1.82E-02	5.87E-02	2.64E-02	5.84E-02	2.63E-02
50	3.44E-02	1.55E-02	4.16E-02	1.87E-02	6.02E-02	2.71E-02	5.98E-02	2.69E-02
40	3.48E-02	1.57E-02	4.31E-02	1.94E-02	6.22E-02	2.80E-02	6.17E-02	2.77E-02
30	3.53E-02	1.59E-02	4.51E-02	2.03E-02	6.49E-02	2.92E-02	6.41E-02	2.88E-02
25	3.57E-02	1.61E-02	4.64E-02	2.09E-02	6.66E-02	3.00E-02	6.57E-02	2.96E-02
20	3.74E-02	1.68E-02	5.32E-02	2.40E-02	7.33E-02	3.30E-02	7.35E-02	3.31E-02
15	3.98E-02	1.79E-02	6.11E-02	2.75E-02	8.29E-02	3.73E-02	8.49E-02	3.82E-02
12.5	4.13E-02	1.86E-02	6.54E-02	2.94E-02	8.96E-02	4.03E-02	9.30E-02	4.18E-02
10	4.33E-02	1.95E-02	6.98E-02	3.14E-02	9.86E-02	4.44E-02	1.04E-01	4.68E-02
9	4.38E-02	1.97E-02	6.77E-02	3.04E-02	1.11E-01	5.00E-02	1.12E-01	5.04E-02
8	4.44E-02	2.00E-02	6.52E-02	2.93E-02	1.24E-01	5.59E-02	1.20E-01	5.42E-02
7.5	4.47E-02	2.01E-02	6.38E-02	2.87E-02	1.31E-01	5.90E-02	1.25E-01	5.61E-02
7	4.51E-02	2.03E-02	6.23E-02	2.80E-02	1.38E-01	6.20E-02	1.29E-01	5.80E-02
6	4.59E-02	2.06E-02	5.88E-02	2.65E-02	1.52E-01	6.83E-02	1.37E-01	6.18E-02
5	4.68E-02	2.11E-02	5.45E-02	2.45E-02	1.65E-01	7.43E-02	1.45E-01	6.53E-02
4	5.51E-02	2.48E-02	6.33E-02	2.85E-02	1.48E-01	6.64E-02	1.40E-01	6.32E-02
3	6.17E-02	2.77E-02	7.01E-02	3.16E-02	1.24E-01	5.57E-02	1.30E-01	5.87E-02
2.5	6.28E-02	2.83E-02	7.11E-02	3.20E-02	1.08E-01	4.84E-02	1.21E-01	5.45E-02
2	6.49E-02	2.92E-02	7.34E-02	3.30E-02	1.08E-01	4.84E-02	1.18E-01	5.31E-02
1.8	6.50E-02	2.93E-02	7.34E-02	3.30E-02	1.05E-01	4.71E-02	1.14E-01	5.12E-02
1.5	6.13E-02	2.76E-02	6.91E-02	3.11E-02	9.65E-02	4.34E-02	1.04E-01	4.66E-02
1.25	5.57E-02	2.51E-02	6.27E-02	2.82E-02	8.61E-02	3.87E-02	9.13E-02	4.11E-02
1	4.80E-02	2.16E-02	5.40E-02	2.43E-02	7.29E-02	3.28E-02	7.65E-02	3.44E-02
0.9	4.75E-02	2.14E-02	5.33E-02	2.40E-02	7.14E-02	3.21E-02	7.46E-02	3.36E-02
0.8	4.69E-02	2.11E-02	5.25E-02	2.36E-02	6.97E-02	3.14E-02	7.25E-02	3.26E-02
0.7	4.63E-02	2.08E-02	5.16E-02	2.32E-02	6.79E-02	3.06E-02	7.02E-02	3.16E-02
0.6	4.55E-02	2.05E-02	5.06E-02	2.28E-02	6.58E-02	2.96E-02	6.77E-02	3.05E-02
0.5	4.47E-02	2.01E-02	4.95E-02	2.23E-02	6.35E-02	2.86E-02	6.48E-02	2.92E-02
0.4	3.58E-02	1.61E-02	3.96E-02	1.78E-02	5.08E-02	2.29E-02	5.18E-02	2.33E-02
0.3	2.68E-02	1.21E-02	2.97E-02	1.34E-02	3.81E-02	1.71E-02	3.89E-02	1.75E-02
0.2	1.79E-02	8.05E-03	1.98E-02	8.91E-03	2.54E-02	1.14E-02	2.59E-02	1.17E-02
0.15	1.34E-02	6.03E-03	1.49E-02	6.68E-03	1.91E-02	8.57E-03	1.94E-02	8.75E-03
0.125	1.12E-02	5.03E-03	1.24E-02	5.57E-03	1.59E-02	7.14E-03	1.62E-02	7.29E-03
0.1	7.15E-03	3.22E-03	7.92E-03	3.56E-03	1.02E-02	4.57E-03	1.04E-02	4.67E-03

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