Nuclear Operating Company

South Texas Project Electric Generating Station 4000 Avenue F – Suite A Bay City, Texas 77414

February 4, 2010
U7-C-STP-NRC-100035

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville MD 20852-2738

South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
<u>Response to Request for Additional Information</u>

Attached are the responses to the NRC staff questions included in Request for Additional Information (RAI) letter numbers 299 and 302 related to Combined License Application (COLA) Part 2, Tier 2, Sections 3.7.1, 3.7.2 and 3.8.4.

Attachments 1 through 15 address the responses to the RAI questions listed below:

RAI 03.07.01-15
RAI 03.07.01-16
RAI 03.07.01-17
RAI 03.07.01-18
RAI 03.07.01-19
RAI 03.07.01-21
RAI 03.07.01-22
RAI 03.07.01-23
RAI 03.07.02-17
RAI 03.07.02-19
RAI 03.07.02-20
RAI 03.08.04-20
RAI 03.08.04-21
RAI 03.08.04-24
RAI 03.08.04-26

There are no commitments in this letter.

If you have any questions, please contact me at (361) 972-7136, or Bill Mookhoek at (361) 972-7274.

D091
NRO

STI 32607768

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

Executed on 2/4/10

Scott Head
Manager, Regulatory Affairs
South Texas Project Units 3 & 4

jep

Attachments:

1. RAI 03.07.01-15
2. RAI 03.07.01-16
3. RAI 03.07.01-17
4. RAI 03.07.01-18
5. RAI 03.07.01-19
6. RAI 03.07.01-21
7. RAI 03.07.01-22
8. RAI 03.07.01-23
9. RAI 03.07.02-17
10. RAI 03.07.02-19
11. RAI 03.07.02-20
12. RAI 03.08.04-20
13. RAI 03.08.04-21
14. RAI 03.08.04-24
15. RAI 03.08.04-26

cc: w/o attachment except*
(paper copy)

Director, Office of New Reactors
U. S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

Regional Administrator, Region IV
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, Texas 76011-8064

Kathy C. Perkins, RN, MBA
Assistant Commissioner
Division for Regulatory Services
Texas Department of State Health Services
P. O. Box 149347
Austin, Texas 78714-9347

Alice Hamilton Rogers, P.E.
Inspections Unit Manager
Texas Department of State Health Services
P.O. Box 149347
Austin, TX 87814-9347

C. M. Canady
City of Austin
Electric Utility Department
721 Barton Springs Road
Austin, TX 78704

*Steven P. Frantz, Esquire
A. H. Gutterman, Esquire
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Ave. NW
Washington D.C. 20004

*George F. Wunder
*Tom Tai
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852

(electronic copy)

*George F. Wunder
*Tom Tai
Loren R. Plisco
U. S. Nuclear Regulatory Commission

Steve Winn
Joseph Kiwak
Eli Smith
Nuclear Innovation North America

Jon C. Wood, Esquire
Cox Smith Matthews

J. J. Nesrsta
Kevin Pollo
L. D. Blaylock
CPS Energy

RAI 03.07.01-15

QUESTION:

(Follow-up Question to RAI 03.07.01-2)

1. In the response to item 1 of RAI 03.07.01-2, STP made reference to Enclosure 1 to this RAI response and also to revised Appendix 3H enclosed to response to RAI 03.07.01-13. In Enclosure 1, STP included the "input spectrum" only for 5% damping for horizontal and vertical direction. "Input Spectra" for other damping ratios were not provided. Enclosure 1 also included the response spectra for SSE design synthetic time histories for 2, 3, 4, 5, and 7% damping levels for horizontal and vertical directions. Marked-up Appendix 3H submitted in response to RAI 03.07.01-13 provided a comparison of GMRS with the "Input Spectrum" in the vertical direction only. The comparison of GMRS with the "Input Spectrum" in the horizontal direction is not included in the Marked-up Appendix 3H (Enclosure to RAI 03.07. 01-13). In addition, Figure 3H.6-2 included in the marked-up Appendix 3H (Enclosure to RAI 03.07.01-13) does not agree with the same figure shown in the revised Section 3H.6.5.1.1 of FSAR Rev 3. As such, the applicant is requested to review Figures 3H.6-1 and 3H.6-2 in the response to RAI 03.07.01-13 as well as in Section 3H.6.5.1.1 of the FSAR to reconcile the discrepancies in the figures.

   The applicant is further requested to provide in the FSAR the target "Input Spectra" for horizontal and vertical directions for 2, 3, 4, and 7% damping ratios developed as per guidance of Appendix C to SRP Section 3.7.1.

2. In the response to RAI 03.07.01-2, the time histories shown in Figs. 3A-251 through 3A-259 indicates that the selected duration of the synthetic time histories (using the 1952 Taft Earthquake as the seed) does not provide sufficient time for these time histories to attenuate to low residual ground motion values (zero acceleration and velocity levels) at the end of the earthquake duration. The applicant is requested to provide further justification for selecting duration of the synthetic time history which does not reflect real earthquake characteristics. In addition, the applicant is requested to provide in the FSAR the following information:

   (a) Comparisons between the target design spectra and response spectra of design time histories for both horizontal and vertical directions for damping values of 2, 3, 4, and 7% in accordance with the enveloping guidelines of SRP Section 3.7.1;

   (b) The time increment of the synthetic time history records;

   (c) The range of frequencies at which spectral accelerations were compared; and

   (d) Confirmation that 5% damped response spectrum of the synthetic time history does not fall more than 10% below the target response spectrum at any one frequency.

RESPONSE:

1. COLA Part 2, Tier 2, Figure 3H.6-1, Comparison of GMRS with the Input Spectrum in the horizontal direction, was inadvertently omitted from the enclosure to RAI 03.07.01-13 (submitted with Letter U7-C-STP-NRC-090112, dated August 20, 2009). However, this figure was included in COLA Revision 3 (see Letter U7-C-NRC-090130, dated September 16, 2009), and therefore is not being resubmitted.

   During RAI response development, some figures were found to be mislabeled. Specifically, COLA Revision 3 Figures 3H.6-2 through 3H.6-14 were inadvertently labeled with incorrect figure numbers and titles. The affected figures have been corrected, and the corrected figures included in the enclosure to this response. These figures, as well as additional figures that provide a complete set showing comparisons for three directions and three sets of soil properties, are indicated in the table below. These figures will be included in a future revision of the STP Units 3 and 4 COLA.

Figure	**Explanation**
Figure 3H.6-2	Replaces Figure 3H.6-2 due to mislabeling
Figure 3H.6-3a	Replaces Figure 3H.6-3 due to mislabeling
Figures 3H.6-3b and 3H.6-3c	Added for upper bound and lower bound soil properties
Figure 3H.6-4a	Replaces Figure 3H.6-4 due to mislabeling
Figures 3H.6-4b and 3H.6-4c	Added for upper bound and lower bound soil properties
Figure 3H.6-5a	Replaces Figure 3H.6-5 due to mislabeling
Figures 3H.6-5b and 3H.6-5c	Added for upper bound and lower bound soil properties
Figure 3H.6-6a	Replaces Figure 3H.6-6 due to mislabeling
Figures 3H.6-6b and 3H.6-6c	Added for upper bound and lower bound soil properties
Figure 3H.6-7a	Replaces Figure 3H.6-7 due to mislabeling
Figures 3H.6-7b and 3H.6-7c	Added for upper bound and lower bound soil properties
Figure 3H.6-8a	Replaces Figure 3H.6-8 due to mislabeling
Figures 3H.6-8b and 3H.6-8c	Added for upper bound and lower bound soil properties
Figure 3H.6-9a	Replaces Figure 3H.6-9 due to mislabeling
Figures 3H.6-9b and 3H.6-9c	Added for upper bound and lower bound soil properties
Figure 3H.6-10a	Replaces Figure 3H.6-10 due to mislabeling
Figures 3H.6-10b and 3H.6-10c	Added for upper bound and lower bound soil properties
Figure 3H.6-11a	Replaces Figure 3H.6-11 due to mislabeling
Figures 3H.6-11b and 3H.6-11c	Added for upper bound and lower bound soil properties
Figure 3H.6-12	Replaces Figure 3H.6-12 due to mislabeling
Figure 3H.6-13	Replaces Figure 3H.6-13 due to mislabeling
Figure 3H.6-14	Replaces Figure 3H.6-14 due to mislabeling

In addition, incorrect versions of Figures 3A-231 and 3A-232, Comparison of GMRS with DCD Design Spectrum in Horizontal and Vertical Direction, respectively, were included in COLA Revision 3. The correct figures are included in the enclosure to this response and will be included in a future revision of the STP Units 3 and 4 COLA.

The "Input Spectra" for 2%, 3%, 4%, and 7% damping for the horizontal and vertical directions, developed using Appendix C to Standard Review Plan (SRP) Section 3.7.1, are shown in Figures 3.7-1b and 3.7-2b, respectively. These figures are included in the enclosure to this response and will replace Figures 3.7-1b and 3.7-2b submitted with Letter U7-C-STP-NRC-090105, dated August 20, 2009. These figures will be included in a future revision of the STP Units 3 and 4 COLA.

2. The time histories are being used for linear elastic analyses. For linear analysis, the duration of the time histories is not critical provided the duration is comparable to recorded strong motion earthquakes and the time history spectra match the target response spectra complying with requirements of SRP Section 3.7.1. The synthetic time histories were developed using the initial 22 seconds of the recorded Taft earthquake recorded time history. The ground motions for Taft earthquake after 22 seconds are small. The duration of design time histories is consistent with the strong motion duration of Taft Earthquake and the spectra meet the requirements of SRP 3.7.1 related to matching the target spectra.

   In the SSI analysis, trailing zeros (quiet period) are added to the synthetic time history, making the total duration of the time history 40.96 seconds. This longer duration adequately models the attenuation of earthquake motion. RAI response Figures 03.07.01-15a and 03.07.01-15b (included below) show the acceleration and displacement response time histories from the soil-structure interaction (SSI) analysis for the Ultimate Heat Sink (UHS) base slab. These figures show that the responses smoothly decay after 22 seconds, and the peak responses occur at times earlier than the end of time history record. Therefore, the results of analyses are not affected by the time history not attenuating to residual values.

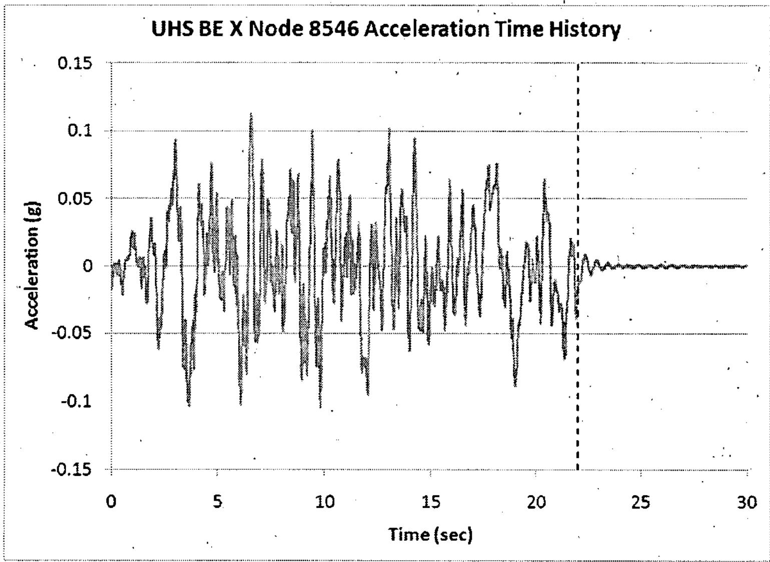


Figure 03.07.01-15a: Acceleration Time History Response in the UHS Base Slab for Mean Soil Case X-Acceleration (SASSI node 8546.)

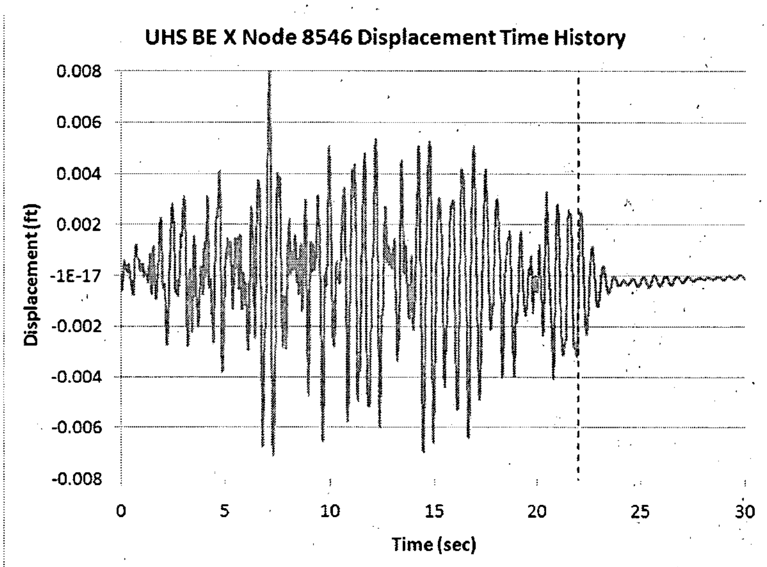


Figure 03.07.01-15b: Displacement Time History Response Relative to Input Motion in the UHS Base Slab for Mean Soil Case X-Acceleration (SASSI node 8546.)

The specific information requested in the RAI is as follows:

a) The comparisons between the design spectra and response spectra of design time histories for both horizontal and vertical directions for damping values of 2, 3, 4, and 7% are provided in the enclosure to this response as new COLA Part 2, Tier 2 Figures 3H.6-12a through 12d, 3H.6-13a through 13d, and 3H.6-14a through 14d. It should be noted, however, that, as stated in COLA Part 2, Tier 2 Section 3H.6.5.1.1.2, the time histories (two horizontal and one vertical) were developed satisfying the enveloping requirements of Option 1, Approach 2 of SRP Section 3.7.1, Revision 3, Section II (Acceptance Criteria). In this approach the enveloping requirements are applicable to spectra for 5% damping only.

b) The time increment of the synthetic time histories used is 0.005 seconds.

c) The range of frequencies and the frequencies at which spectral accelerations were compared are presented in Tables 3H.6-2d through 3H.6-2f provided in the enclosure to this response.

d) The 5% damped response spectrum of the synthetic time histories does not fall more than 10% below the target response spectrum at any one frequency, as shown in the enclosed Tables 3H.6-2d through 3H.6-2f.

The STP Units 3 and 4 COLA will be revised as follows as a result of this response.

a. COLA Tier 2 Figures 3H.6-2 through 3H.6-14 will be replaced with the enclosed Figures 3H.6-2 through 3H.6-14. Note that these figures now include the comparisons for three directions and three sets of soil properties.

b. COLA Tier 2 Figures 3A-231 and 3A-232, Comparison of GMRS with DCD Design Spectrum in Horizontal and Vertical Direction, respectively, will be replaced with corresponding figures included in the enclosure to this response.

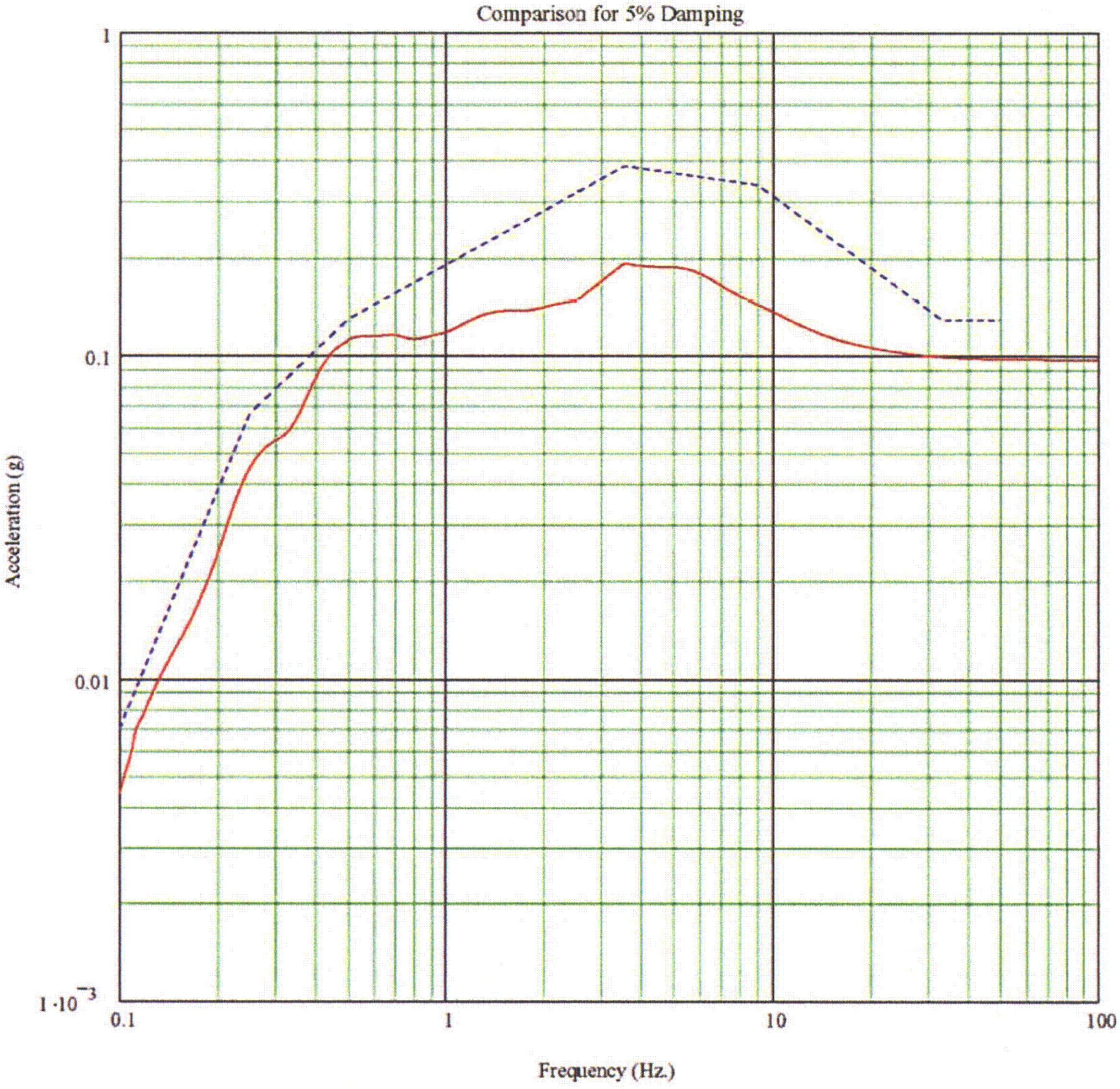
c. COLA Tier 2 Figures 3.7-1b and 3.7-2b submitted with Letter U7-C-STP-NRC-090105, dated August 20, 2009 will be replaced with the enclosed new Figures 3.7-1b and 3.7-2b, showing the Input Spectra for 2%, 3%, 4%, and 7% damping.

d. Enclosed new Figures 3H.6-12a through 12d, 3H.6-13a through 13d, and 3H.6-14a through 14d showing the comparison of Input Spectra and synthetic time history spectra for 2%, 3%, 4%, and 7% damping will be included in the COLA.

e. Enclosed new Tables 3H.6-2d through 3H.6-2f showing the comparison of spectral acceleration values for the Input Spectrum and synthetic time history spectrum of 5% damping will be included in the COLA.

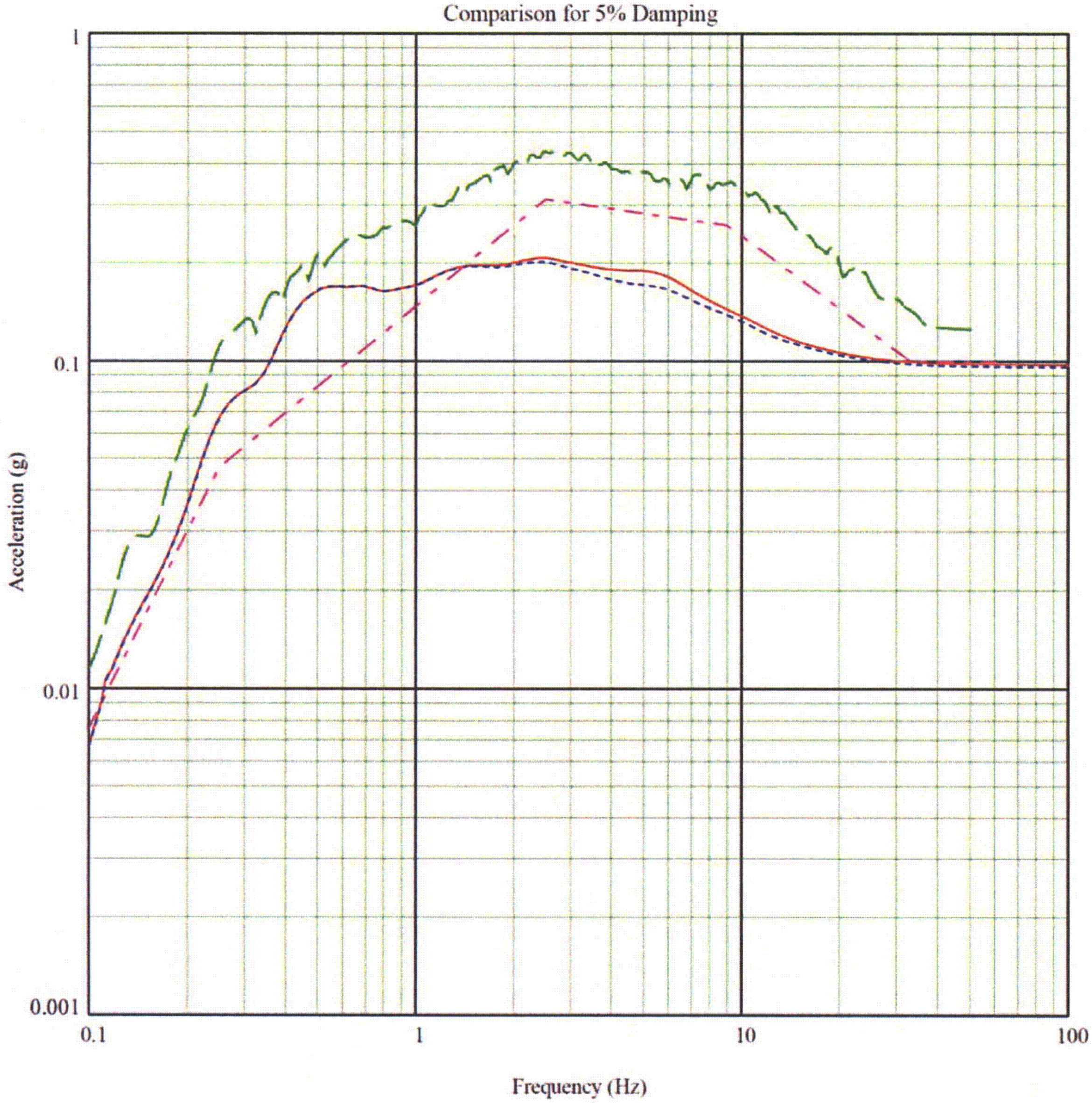
Enclosure to Response to RAI 03.07.01-15

Figure	Explanation
Figure 3H.6-2	Replaces Figure 3H.6-2 due to mislabeling
Figure 3H.6-3a	Replaces Figure 3H.6-3 due to mislabeling
Figures 3H.6-3b and 3H.6-3c	Added for upper bound and lower bound soil properties
Figure 3H.6-4a	Replaces Figure 3H.6-4 due to mislabeling
Figures 3H.6-4b and 3H.6-4c	Added for upper bound and lower bound soil properties
Figure 3H.6-5a	Replaces Figure 3H.6-5 due to mislabeling
Figures 3H.6-5b and 3H.6-5c	Added for upper bound and lower bound soil properties
Figure 3H.6-6a	Replaces Figure 3H.6-6 due to mislabeling
Figures 3H.6-6b and 3H.6-6c	Added for upper bound and lower bound soil properties
Figure 3H.6-7a	Replaces Figure 3H.6-7 due to mislabeling
Figures 3H.6-7b and 3H.6-7c	Added for upper bound and lower bound soil properties
Figure 3H.6-8a	Replaces Figure 3H.6-8 due to mislabeling
Figures 3H.6-8b and 3H.6-8c	Added for upper bound and lower bound soil properties
Figure 3H.6-9a	Replaces Figure 3H.6-9 due to mislabeling
Figures 3H.6-9b and 3H.6-9c	Added for upper bound and lower bound soil properties
Figure 3H.6-10a	Replaces Figure 3H.6-10 due to mislabeling
Figures 3H.6-10b and 3H.6-10c	Added for upper bound and lower bound soil properties
Figure 3H.6-11a	Replaces Figure 3H.6-11 due to mislabeling
Figures 3H.6-11b and 3H.6-11c	Added for upper bound and lower bound soil properties
Figure 3H.6-12	Replaces Figure 3H.6-12 due to mislabeling
Figure 3H.6-13	Replaces Figure 3H.6-13 due to mislabeling
Figure 3H.6-14	Replaces Figure 3H.6-14 due to mislabeling
Figures 3A-231 and 3A-232	Corrected
Figures 3.7-1b and 3.7-2b	Replaced
Figures 3H.6-12a through -12d	New
Figures 3H.6-13a through 13d	New
Figures 3H.6-14a through 14d	New
Tables 3H.6-2d through 3H.6-2f	New



___ (Red): GMRS in the vertical direction
...... (Blue): Input Spectrum in the vertical direction

Figure 3H.6-2: Comparison of GMRS with the Input Spectrum (Vertical)



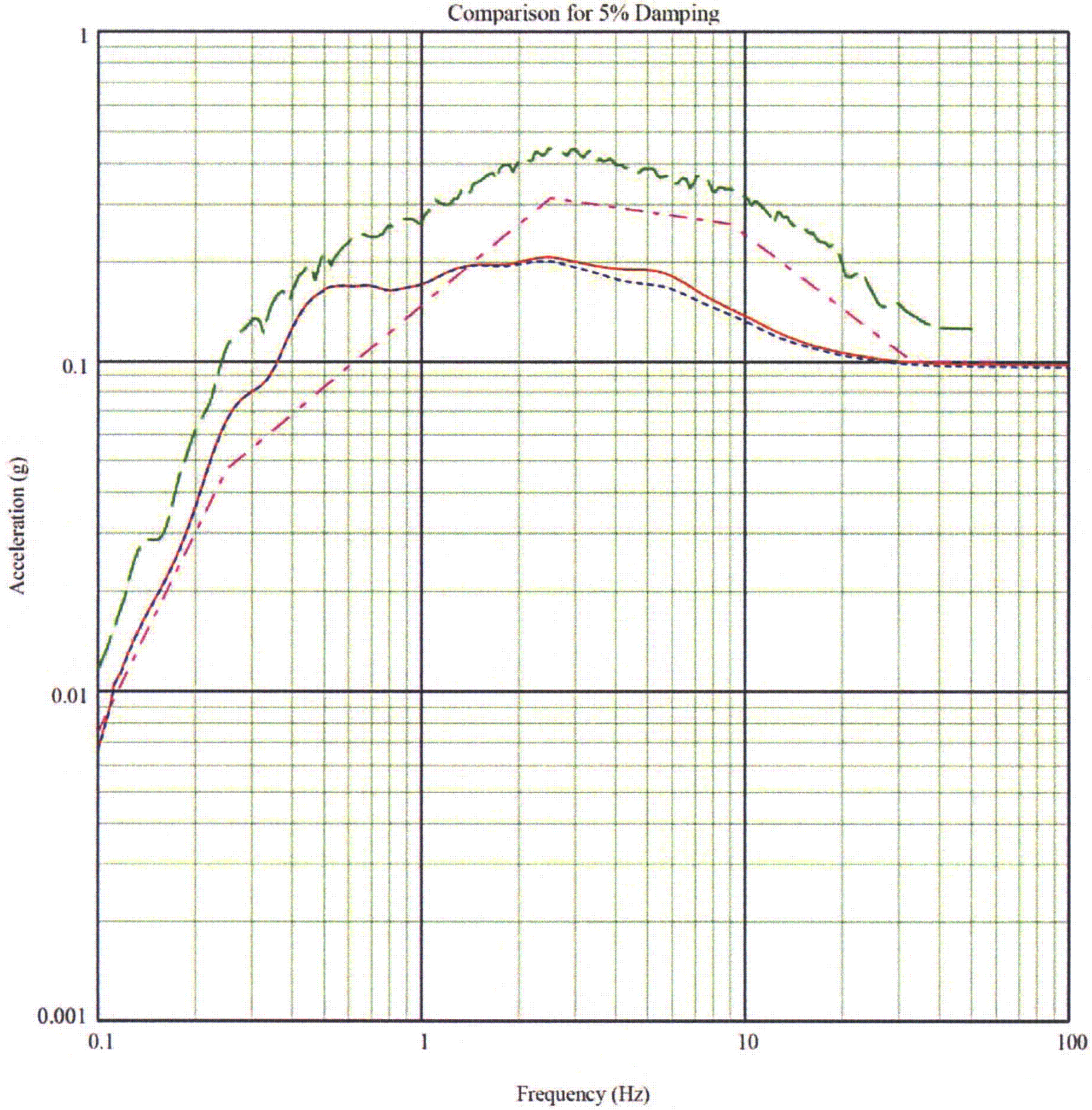
___(Red): GMRS

...... (Blue): FIRS at 32 ft below ground surface

___(Green): Outcrop spectrum at 32 ft below ground surface resulting from synthetic time history applied at ground surface

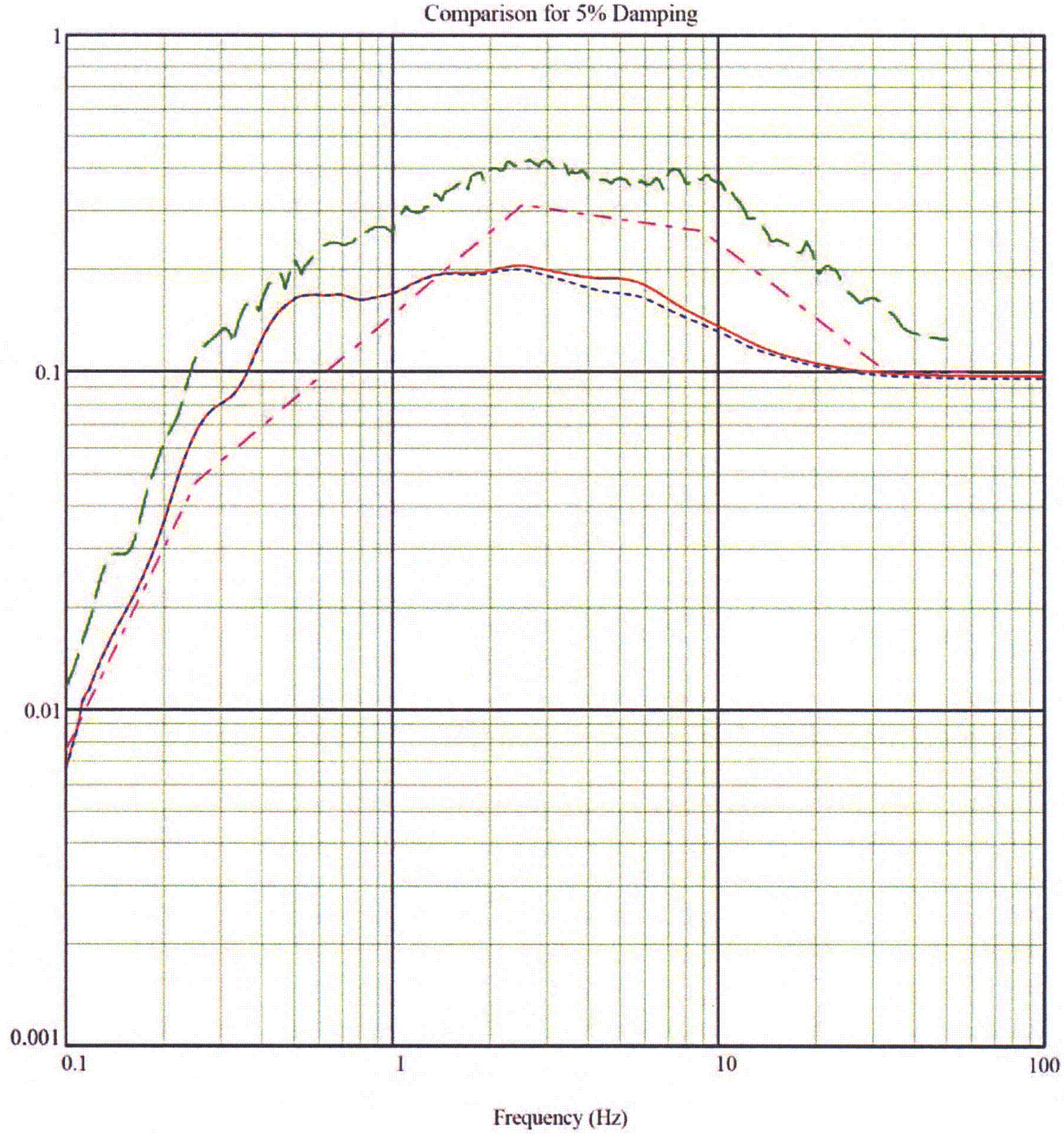
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-3a: Comparison of Spectra at Foundation of UHS Basin (Mean Soil Properties, E-W Direction)



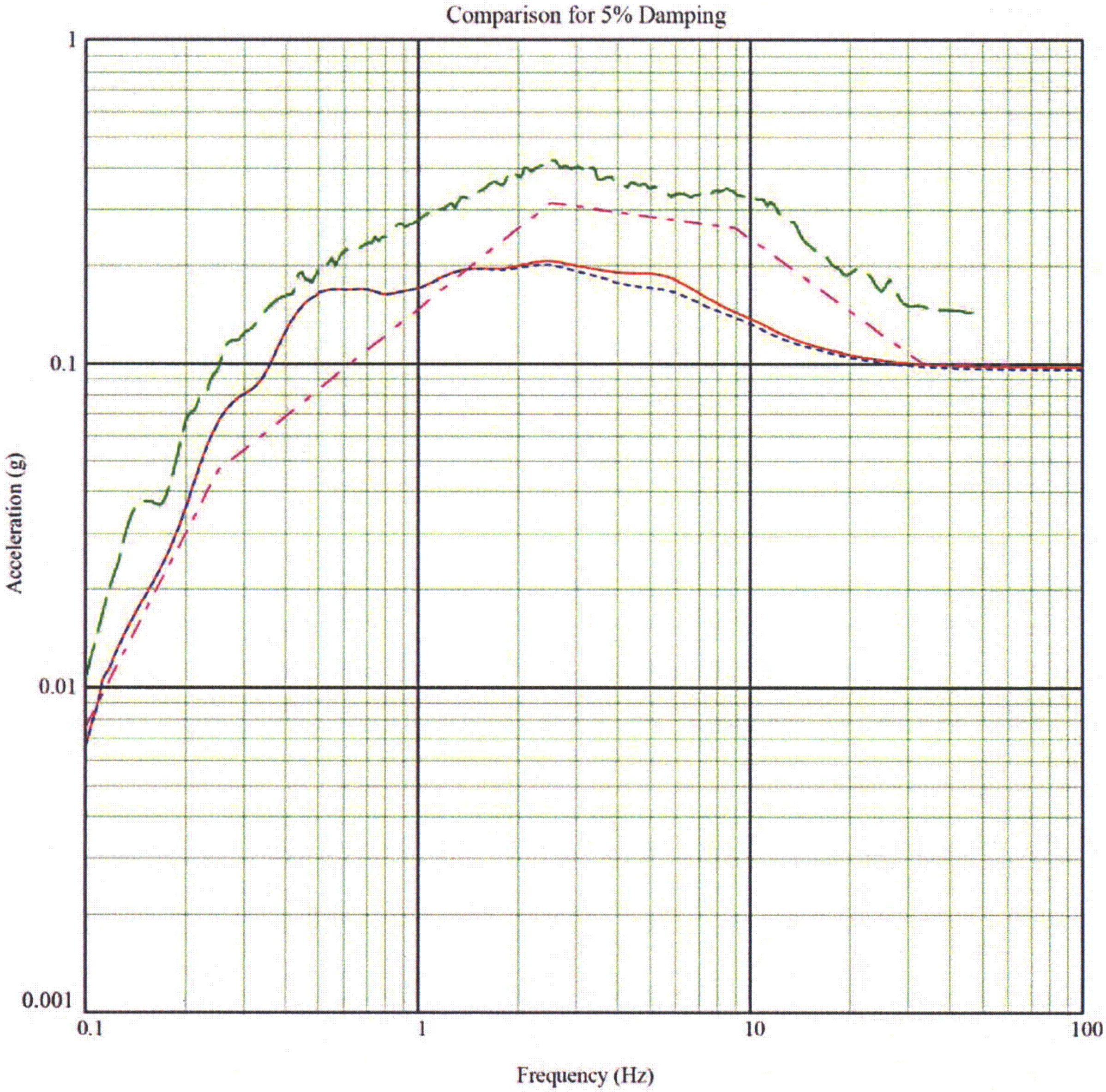
___(Red): GMRS
...... (Blue): FIRS at 32 ft below ground surface
___(Green): Outcrop spectrum at 32 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-3b: Comparison of Spectra at Foundation of UHS Basin (Upper Bound Soil Properties, E-W Direction)



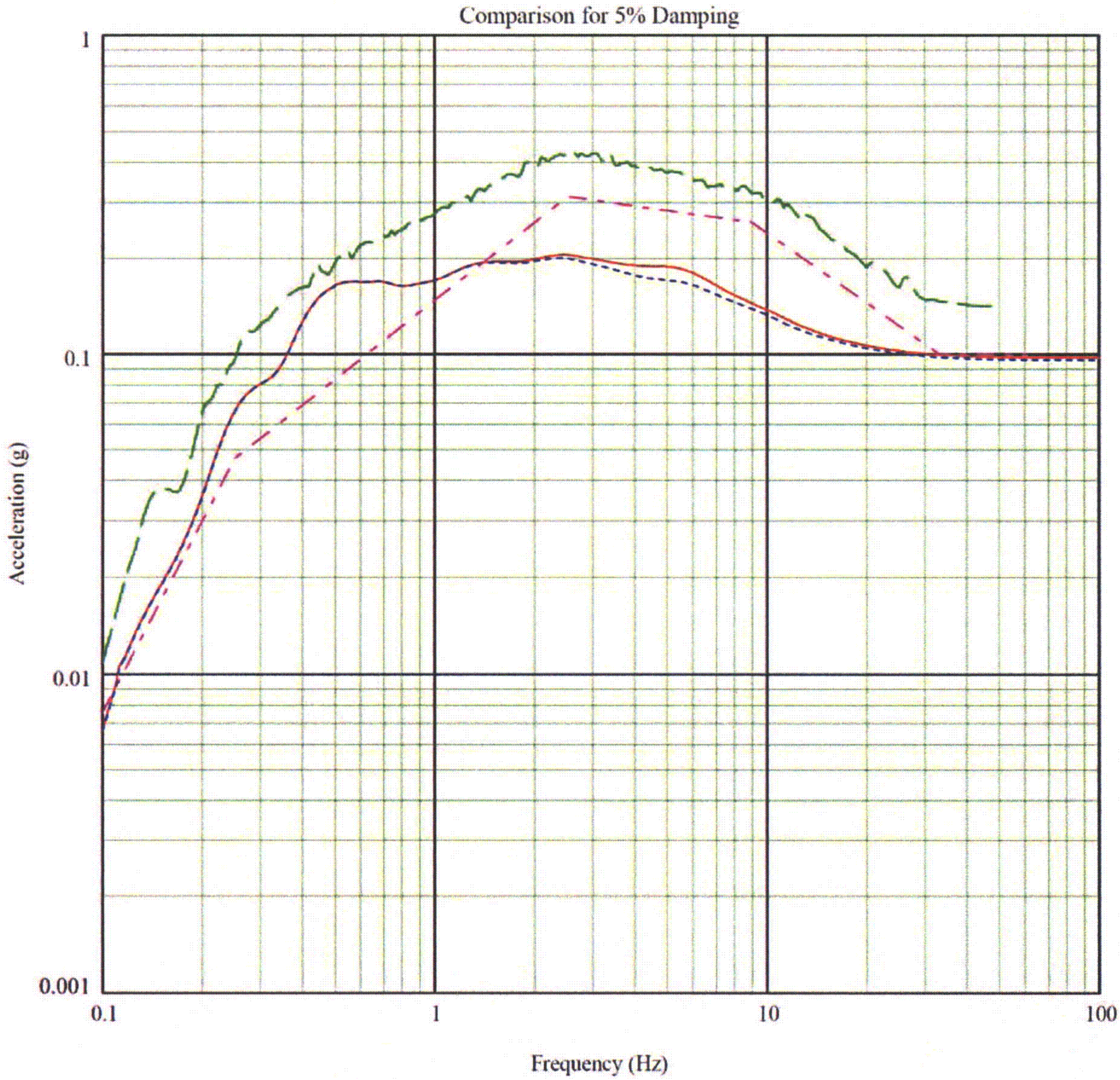
___(Red): GMRS
...... (Blue): FIRS at 32 ft below ground surface
___(Green): Outcrop spectrum at 32 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-3c: Comparison of Spectra at Foundation of UHS Basin (Lower Bound Soil Properties, E-W Direction)



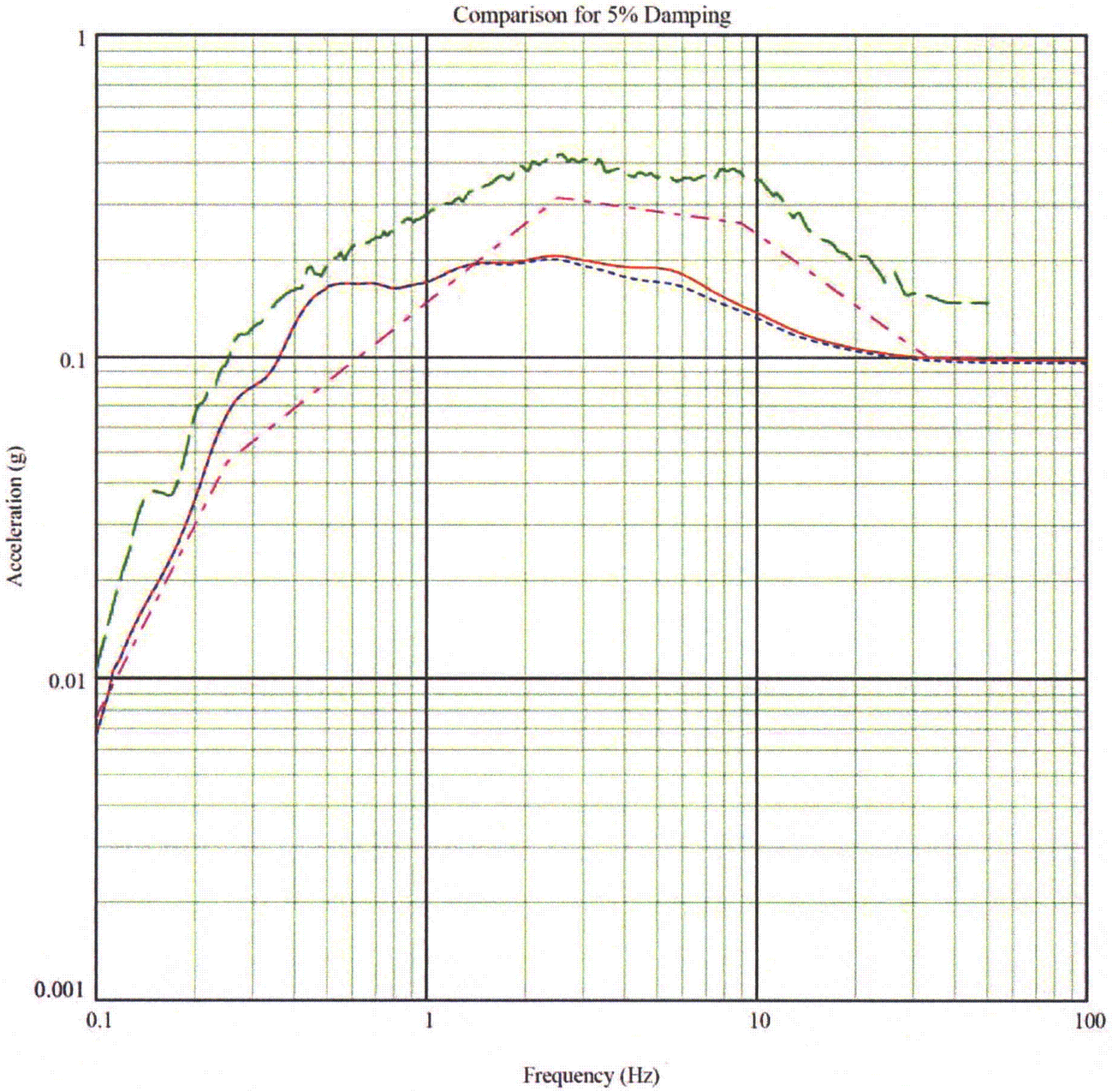
___(Red): GMRS
...... (Blue): FIRS at 32 ft below ground surface
___(Green): Outcrop spectrum at 32 ft below ground surface resulting from synthetic time history applied at ground surface
_·_· (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-4a: Comparison of Spectra at Foundation of UHS Basin (Mean Soil Properties, N-S Direction)



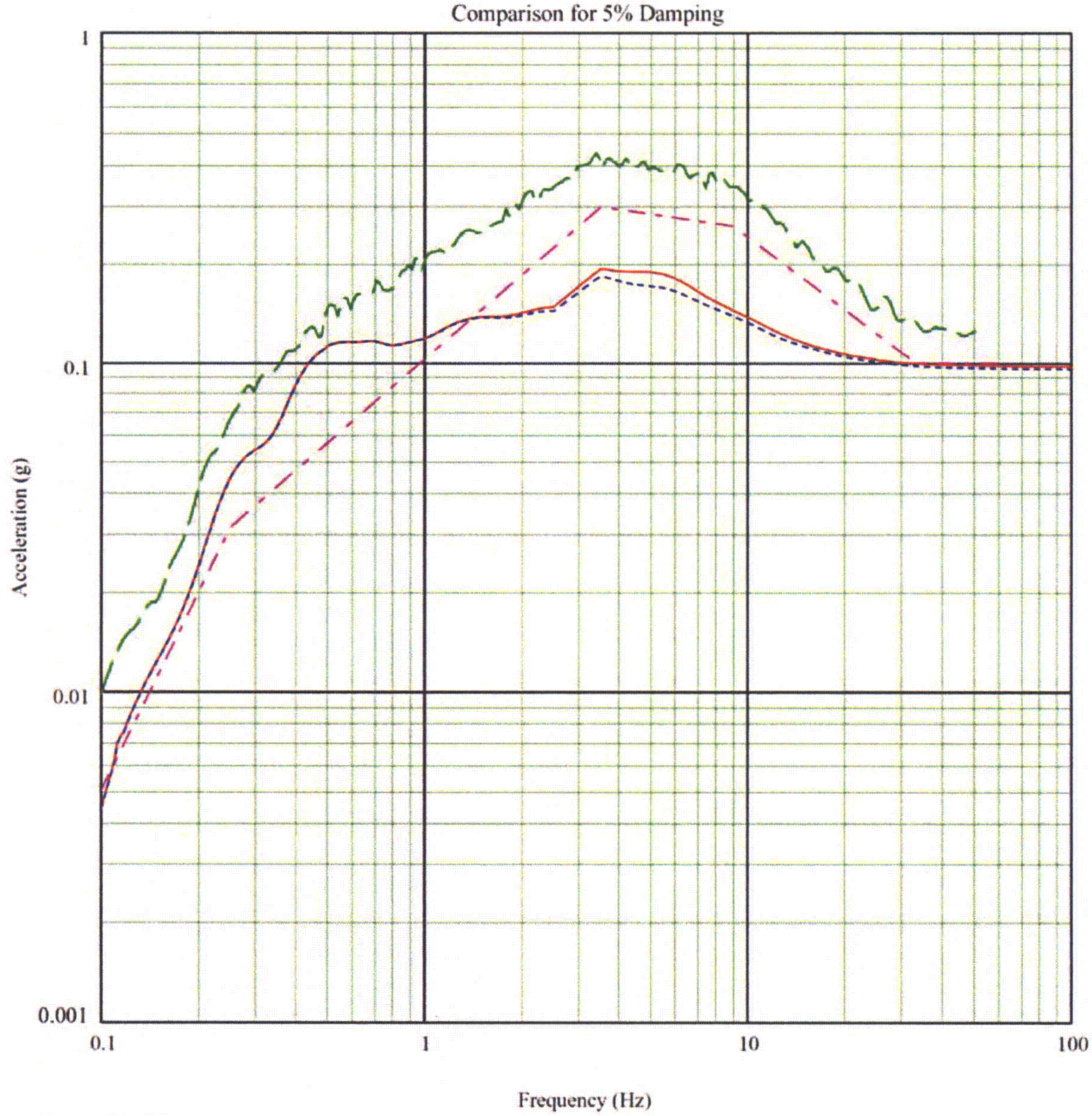
___(Red): GMRS
...... (Blue): FIRS at 32 ft below ground surface
___(Green): Outcrop spectrum at 32 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-4b: Comparison of Spectra at Foundation of UHS Basin (Upper Bound Soil Properties, N-S Direction)



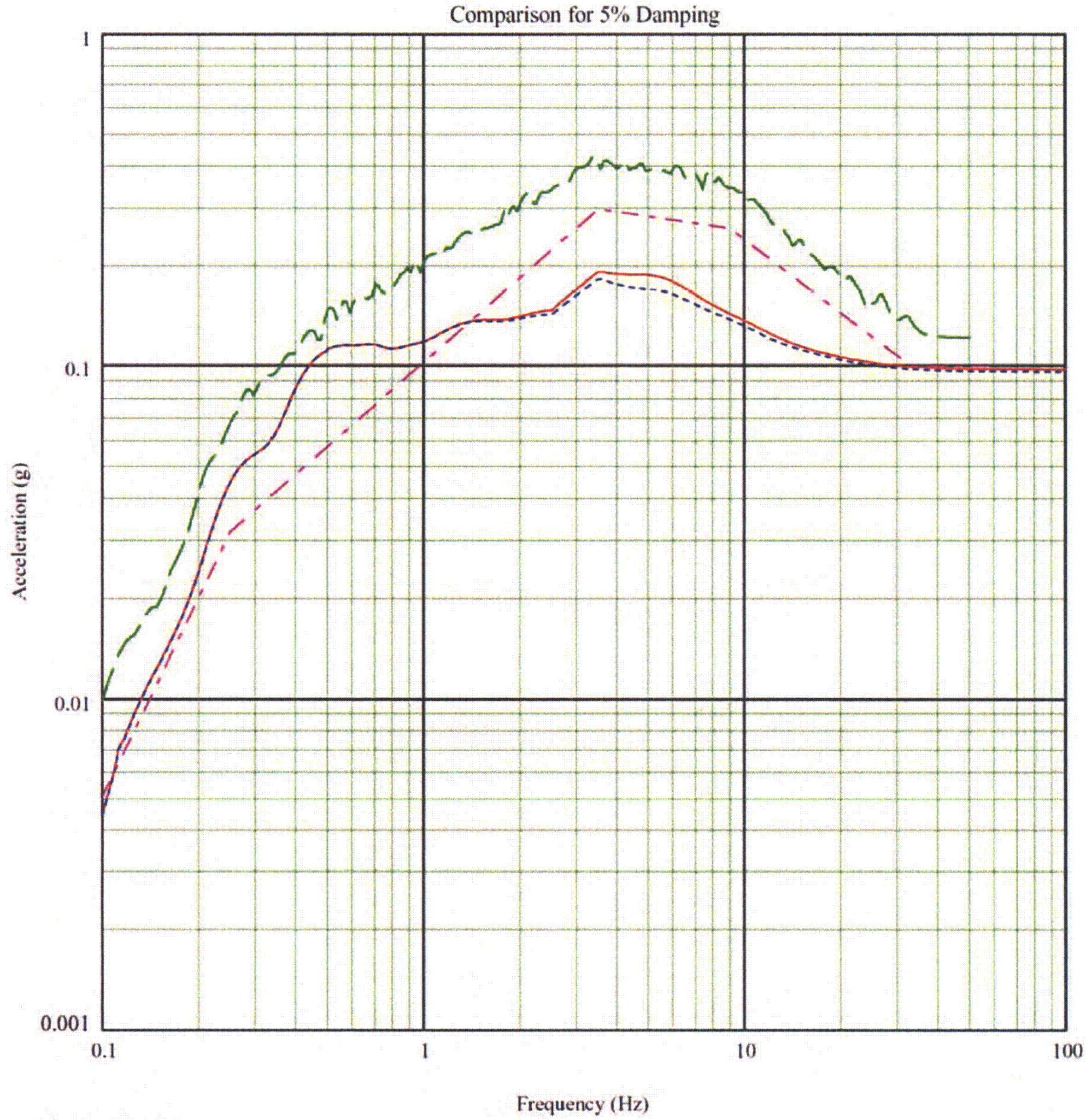
___(Red): GMRS
...... (Blue): FIRS at 32 ft below ground surface
___(Green): Outcrop spectrum at 32 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-4c: Comparison of Spectra at Foundation of UHS Basin (Lower Bound Soil Properties, N-S Direction)



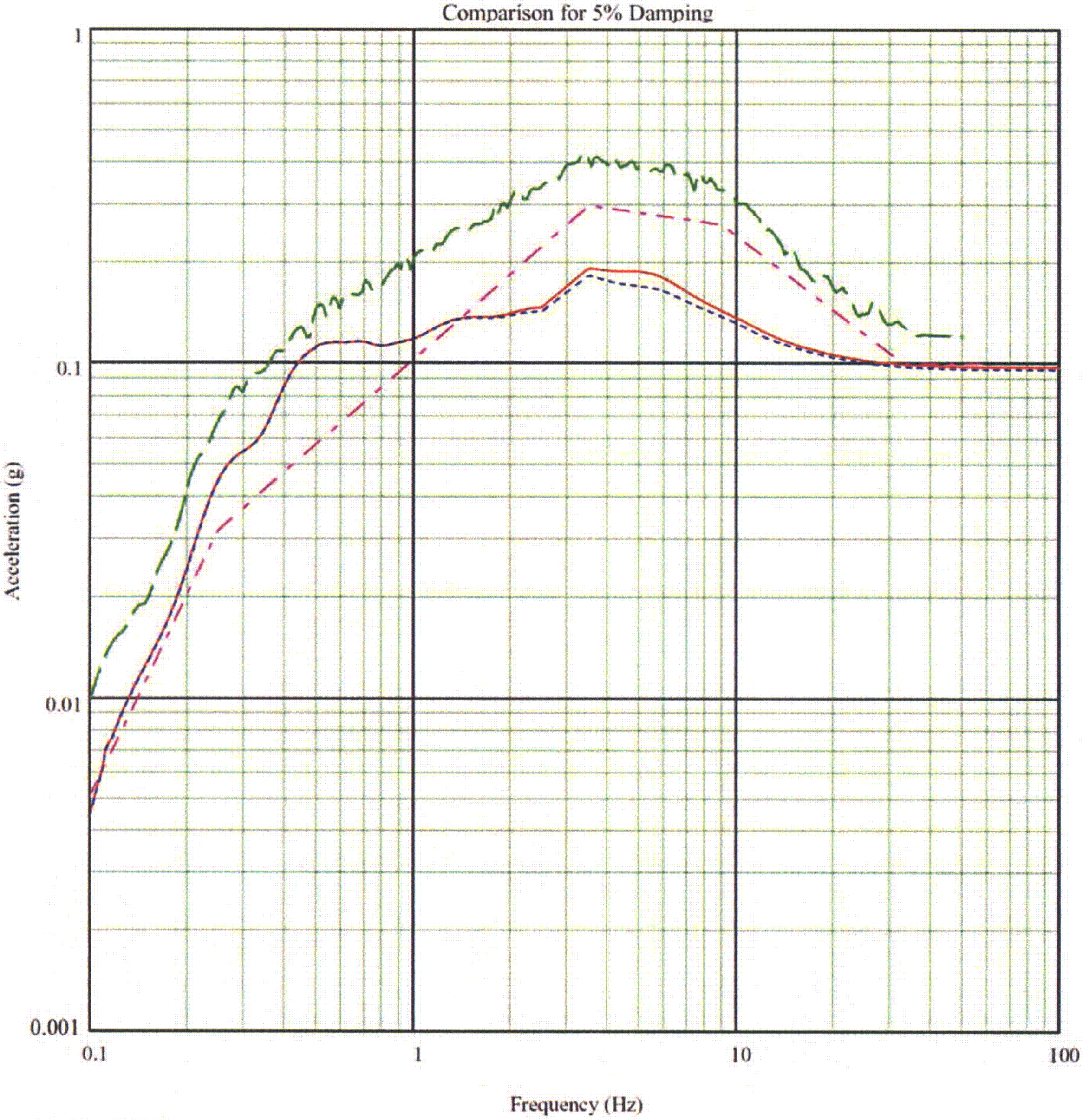
___(Red): GMRS
...... (Blue): FIRS at 32 ft below ground surface
___(Green): Outcrop spectrum at 32 ft below ground surface resulting from synthetic time history applied at ground surface
_._ (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-5a: Comparison of Spectra at Foundation of UHS Basin (Mean Soil Properties, Vertical Direction)



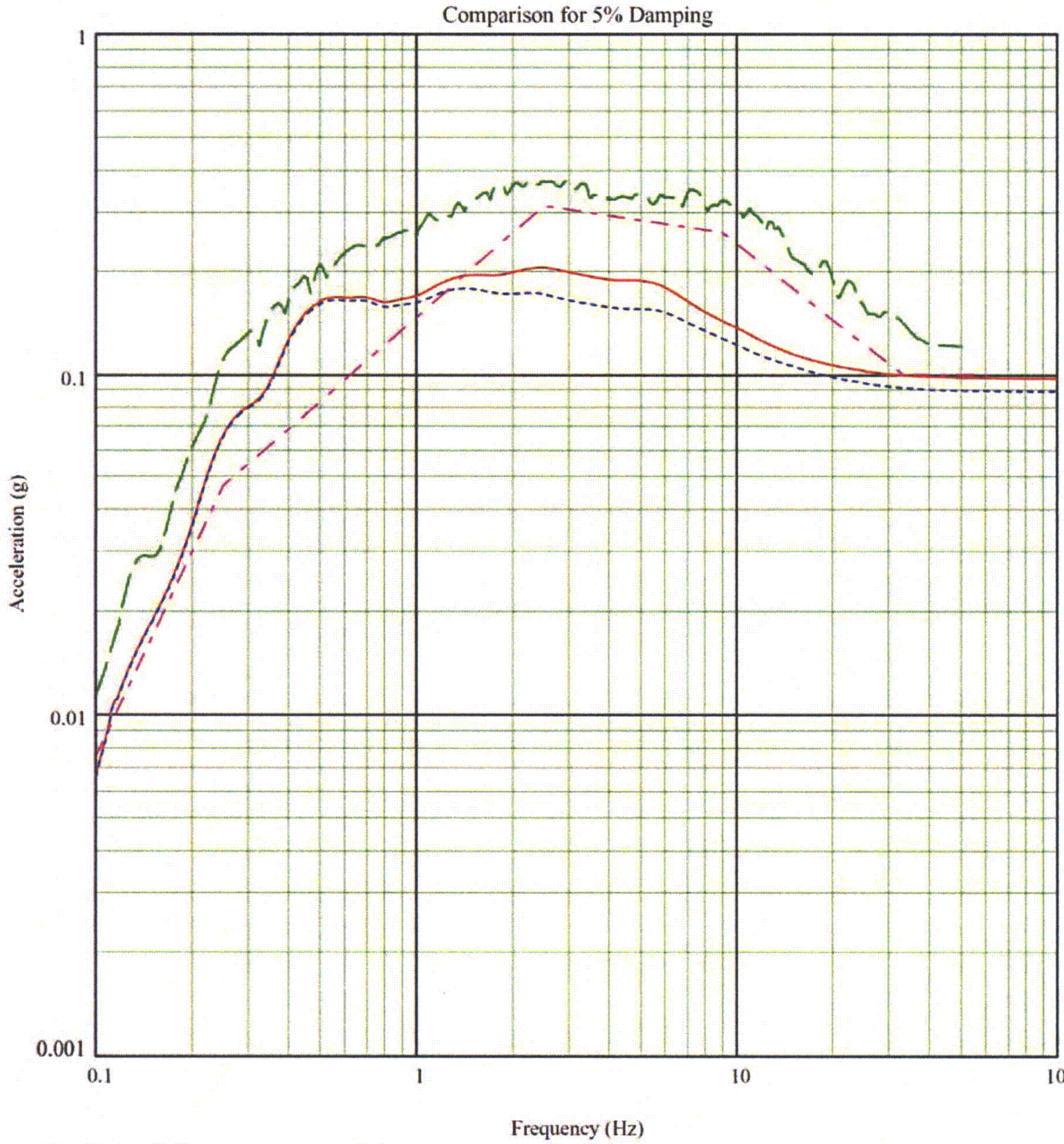
___(Red): GMRS
...... (Blue): FIRS at 32 ft below ground surface
___(Green): Outcrop spectrum at 32 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-5b: Comparison of Spectra at Foundation of UHS Basin (Upper Bound Soil Properties, Vertical Direction)



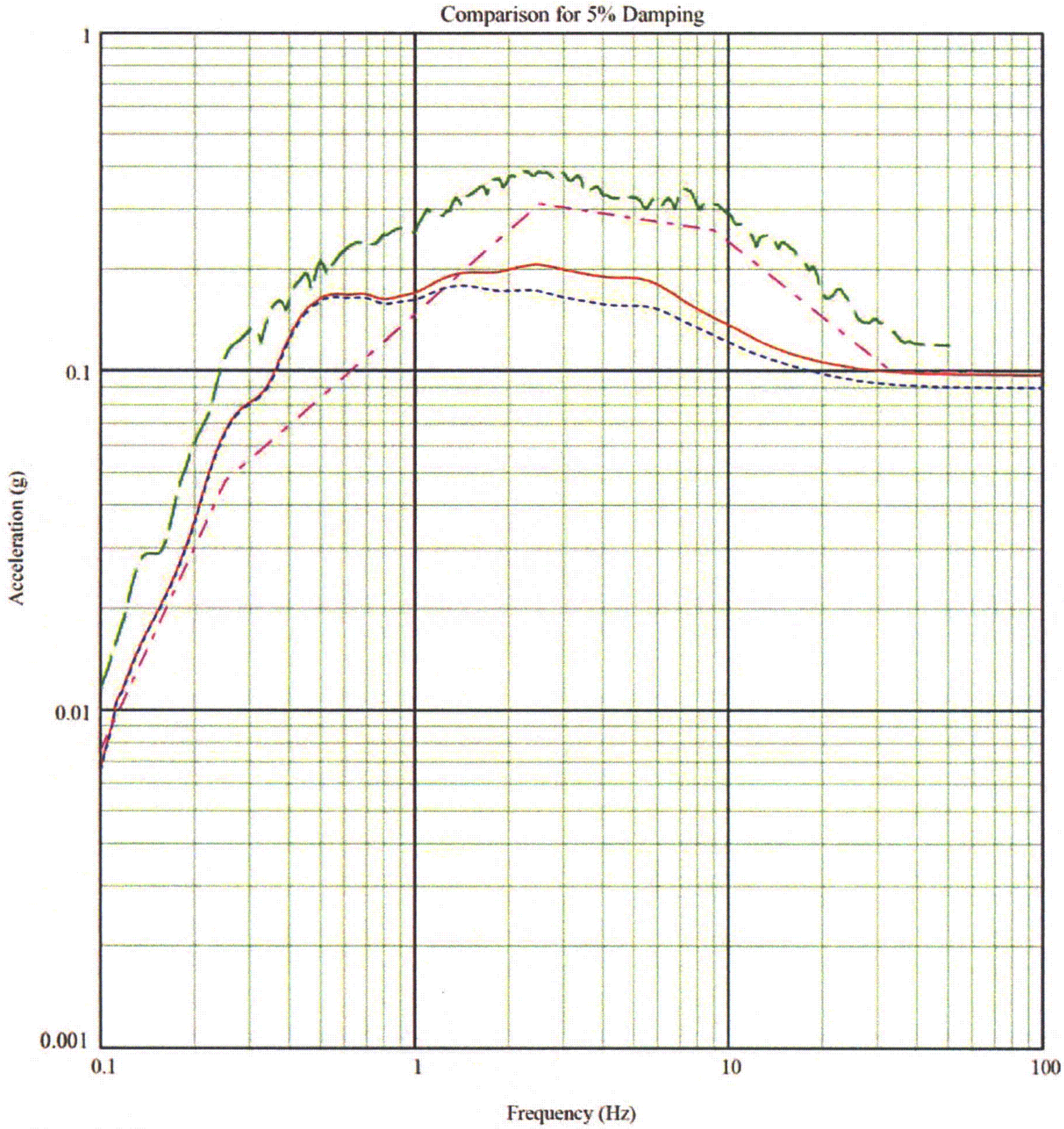
___(Red): GMRS
...... (Blue): FIRS at 32 ft below ground surface
___(Green): Outcrop spectrum at 32 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-5c: Comparison of Spectra at Foundation of UHS Basin (Lower Bound Soil Properties, Vertical Direction)



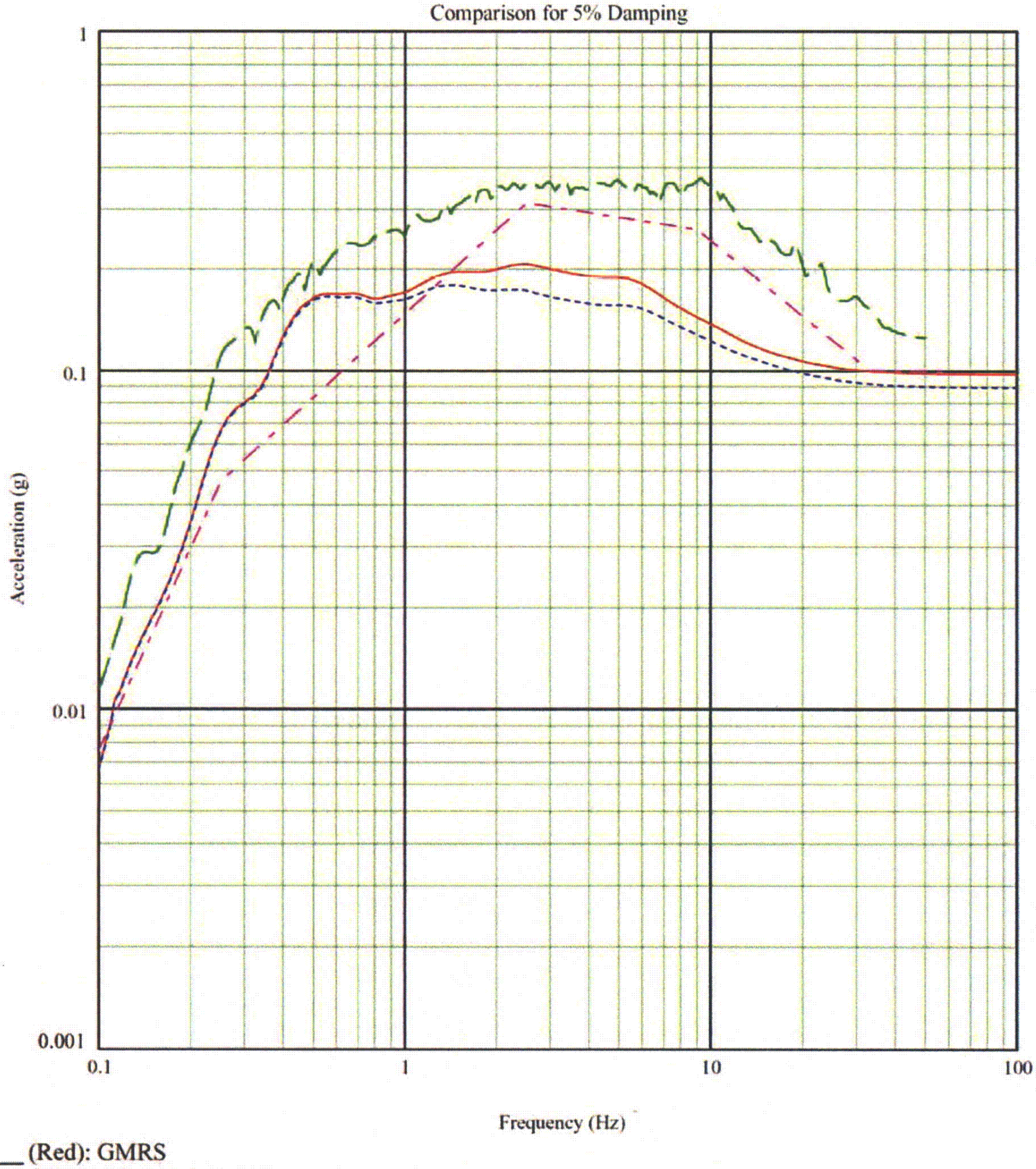
___(Red): GMRS
...... (Blue): FIRS at 57 ft below ground surface
___(Green): Outcrop spectrum at 57 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-6a: Comparison of Spectra at Foundation of RSW Piping Tunnel (Mean Soil Properties, E-W Direction)



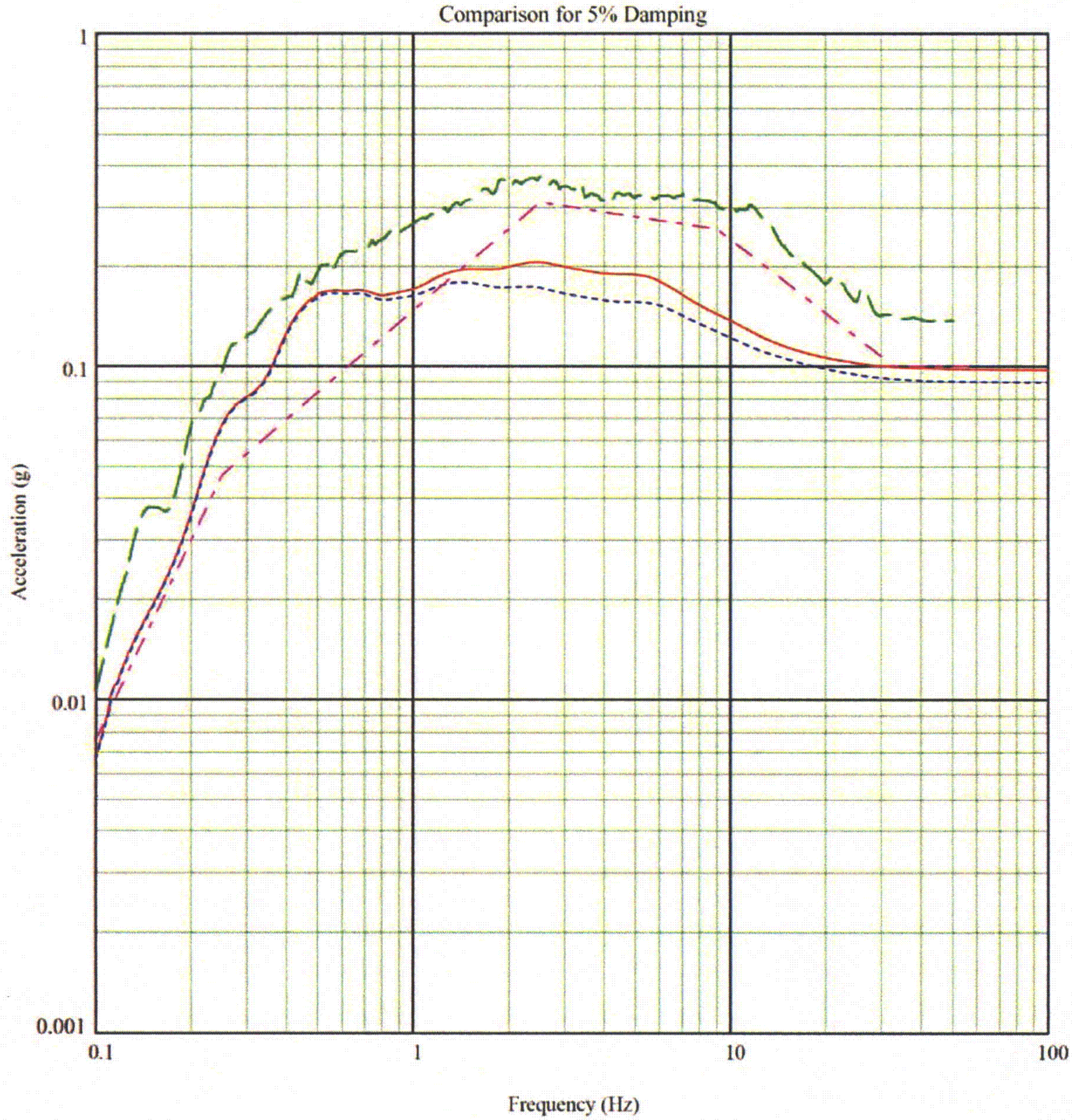
___(Red): GMRS
...... (Blue): FIRS at 57 ft below ground surface
___(Green): Outcrop spectrum at 57 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-6b: Comparison of Spectra at Foundation of RSW Piping Tunnel (Upper Bound Soil Properties, E-W Direction)



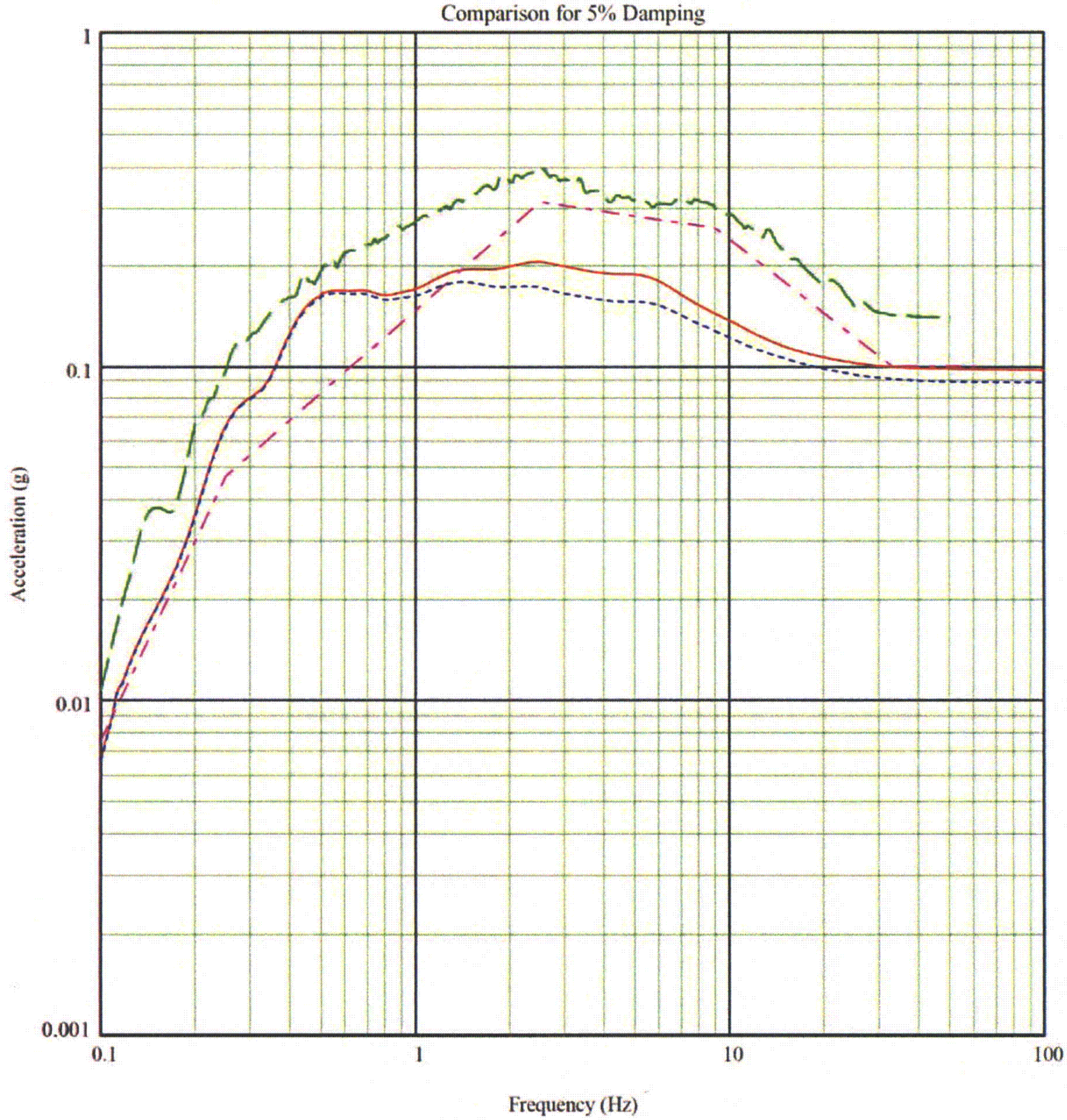
___ (Red): GMRS
...... (Blue): FIRS at 57 ft below ground surface
___ (Green): Outcrop spectrum at 57 ft below ground surface resulting from synthetic time history applied at ground surface
_-_- (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-6c: Comparison of Spectra at Foundation of RSW Piping Tunnel (Lower Bound Soil Properties, E-W Direction)



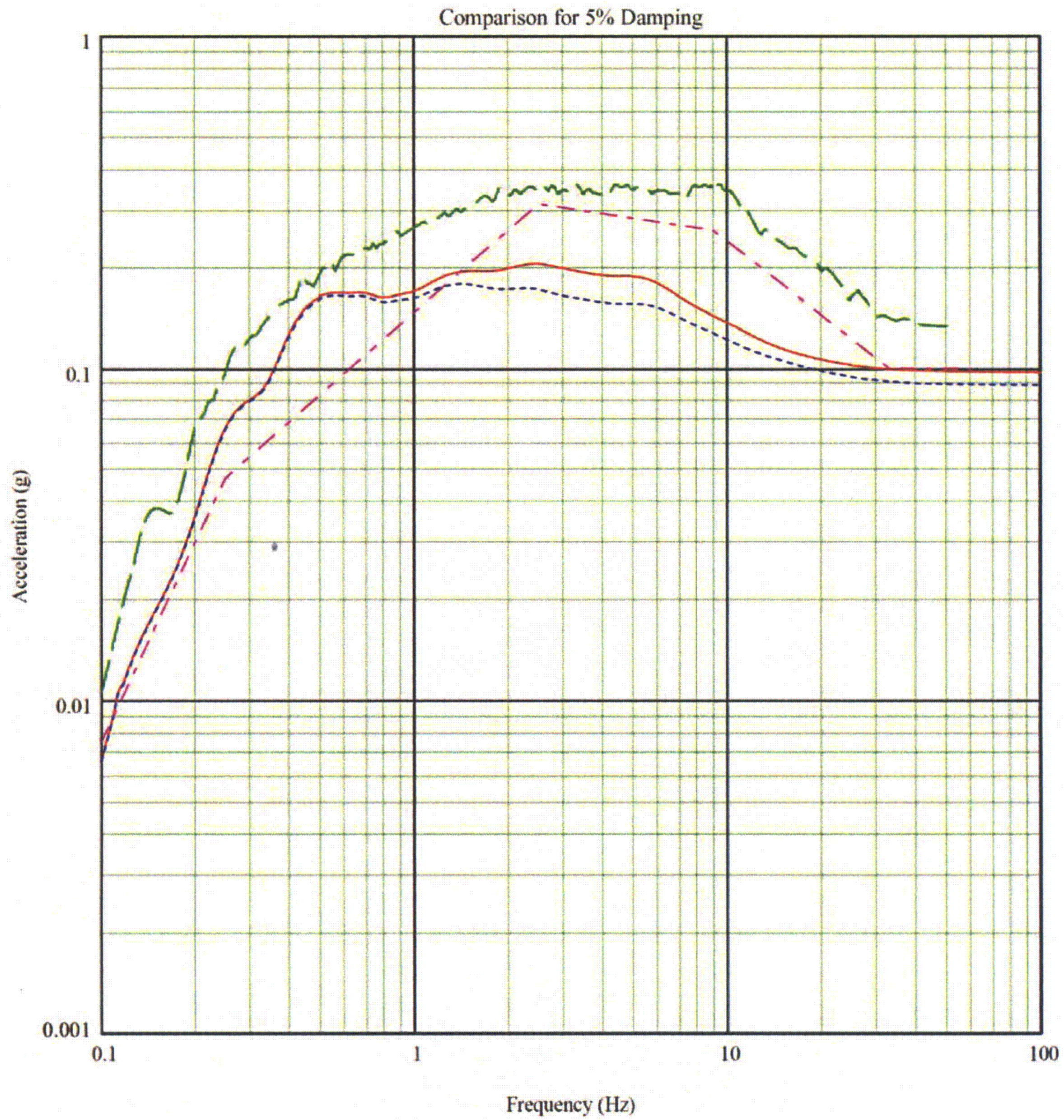
___ (Red): GMRS
...... (Blue): FIRS at 57 ft below ground surface
___ (Green): Outcrop spectrum at 57 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-7a: Comparison of Spectra at Foundation of RSW Piping Tunnel (Mean Soil Properties, N-S Direction)



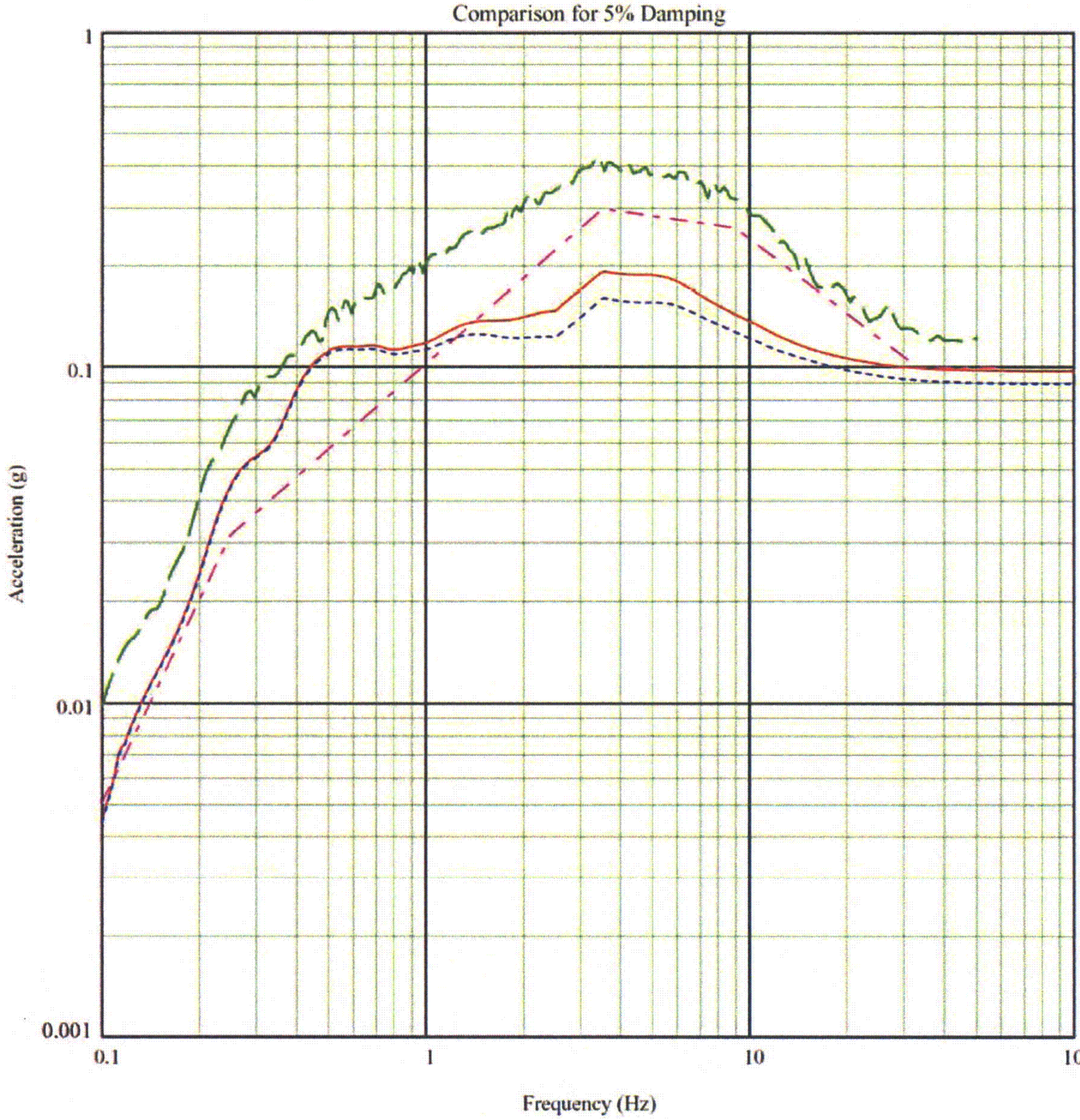
___ (Red): GMRS
...... (Blue): FIRS at 57 ft below ground surface
___ (Green): Outcrop spectrum at 57 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-7b: Comparison of Spectra at Foundation of RSW Piping Tunnel (Upper Bound Soil Properties, N-S Direction)



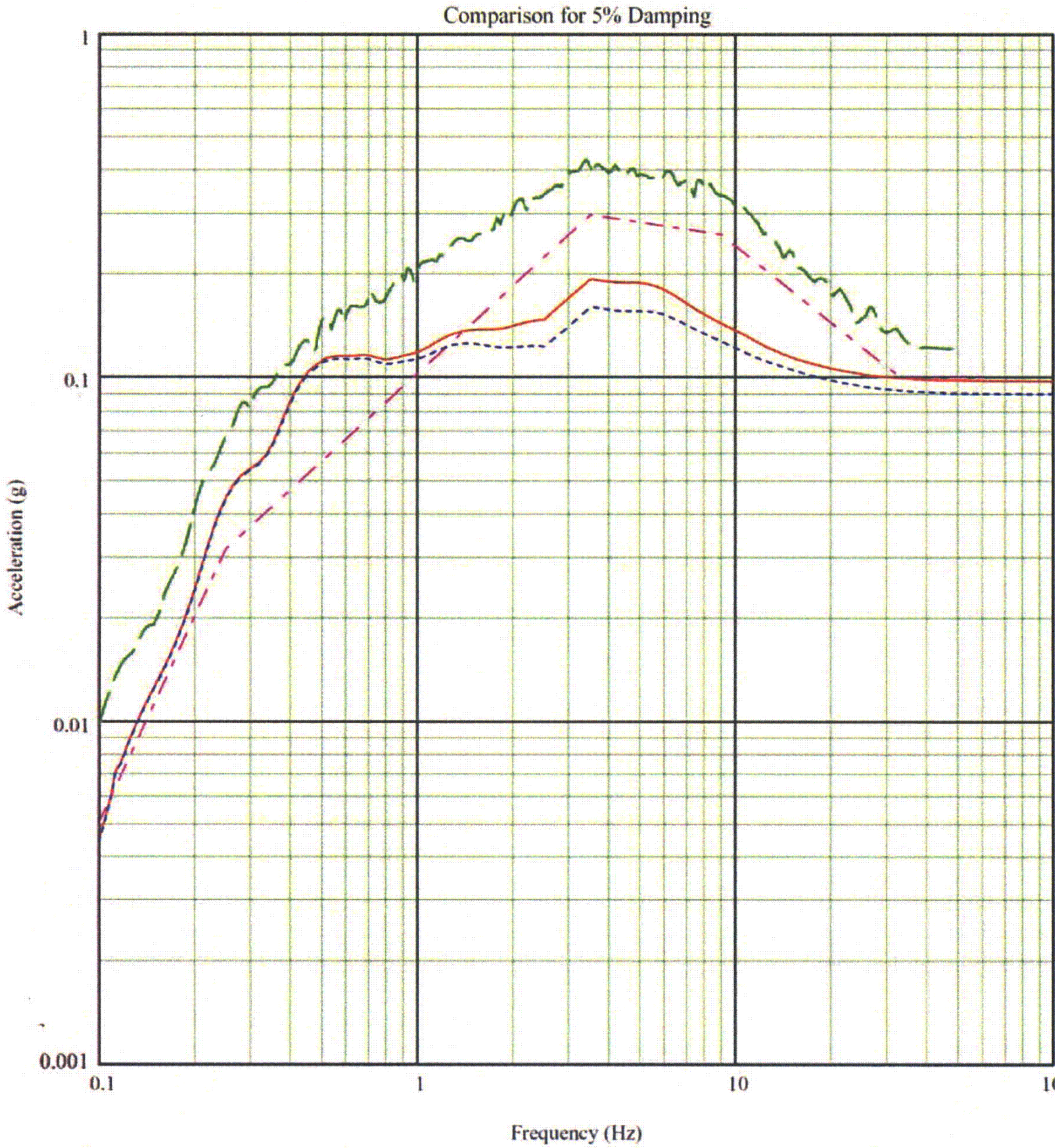
___ (Red): GMRS
...... (Blue): FIRS at 57 ft below ground surface
___ (Green): Outcrop spectrum at 57 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-7c: Comparison of Spectra at Foundation of RSW Piping Tunnel (Lower Bound Soil Properties, N-S Direction)



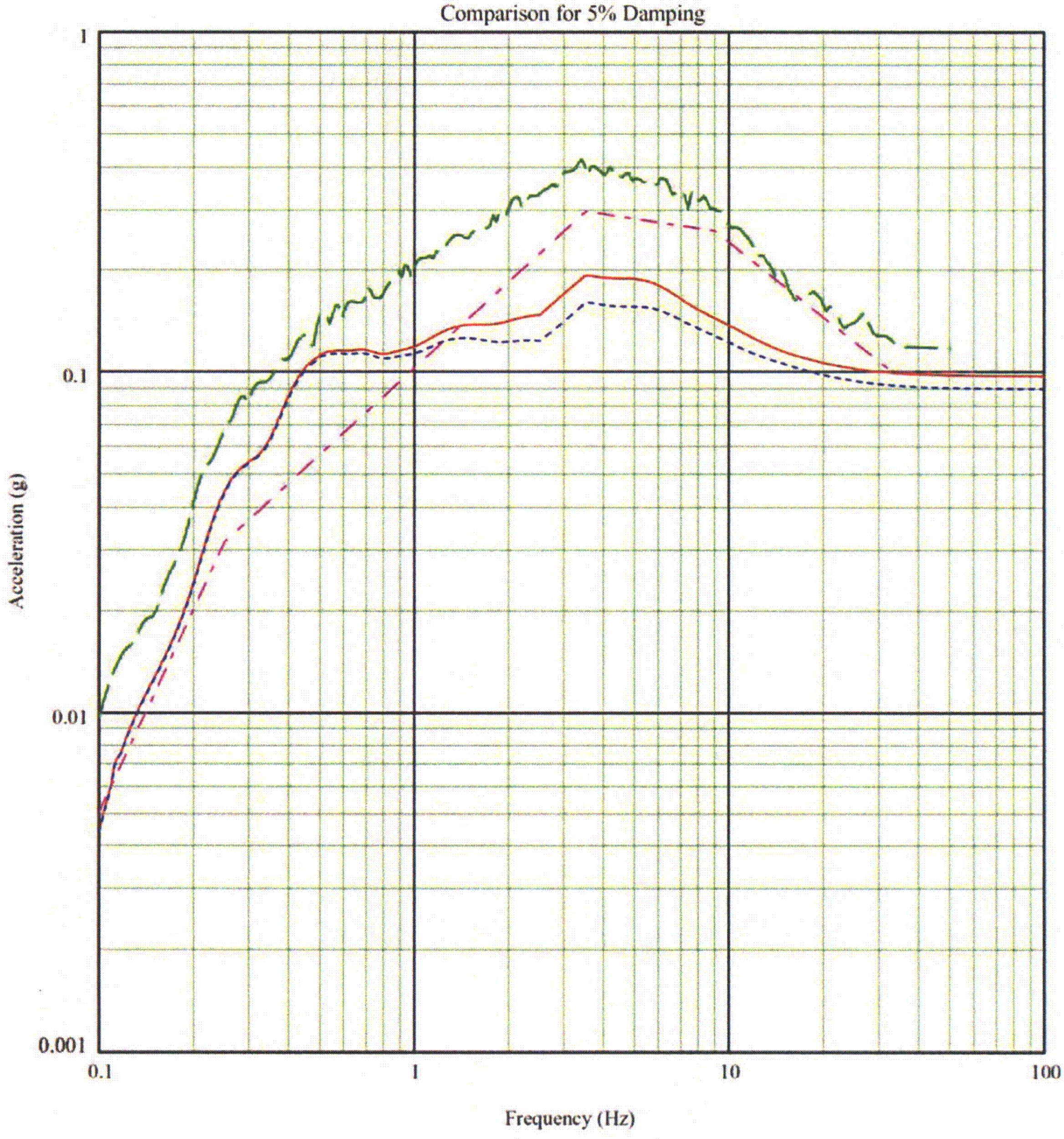
___ (Red): GMRS
...... (Blue): FIRS at 57 ft below ground surface
___ (Green): Outcrop spectrum at 57 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-8a: Comparison of Spectra at Foundation of RSW Piping Tunnel (Mean Soil Properties, Vertical Direction)



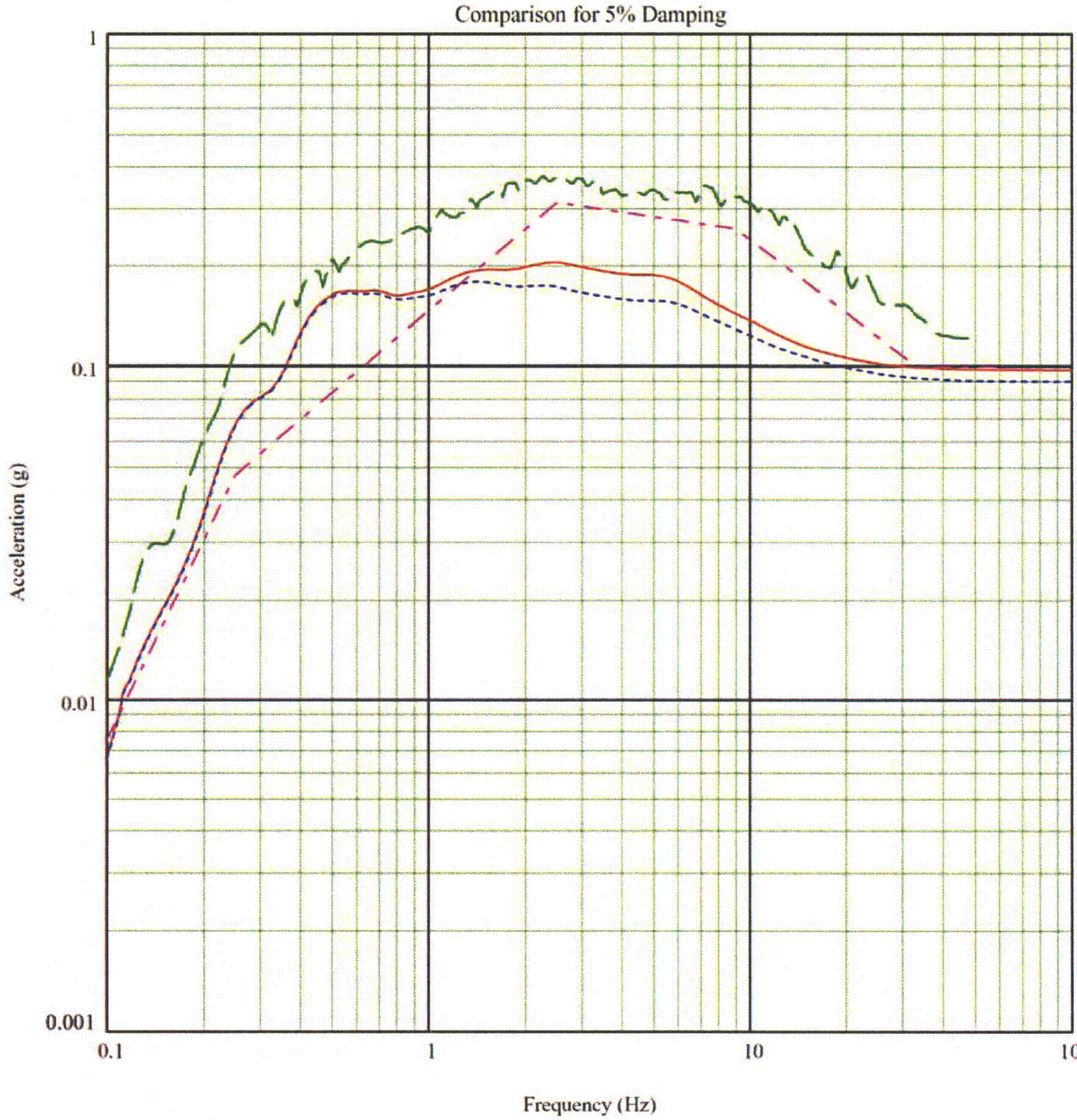
___(Red): GMRS
......(Blue): FIRS at 57 ft below ground surface
___(Green): Outcrop spectrum at 57 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-8b: Comparison of Spectra at Foundation of RSW Piping Tunnel (Upper Bound Soil Properties, Vertical Direction)



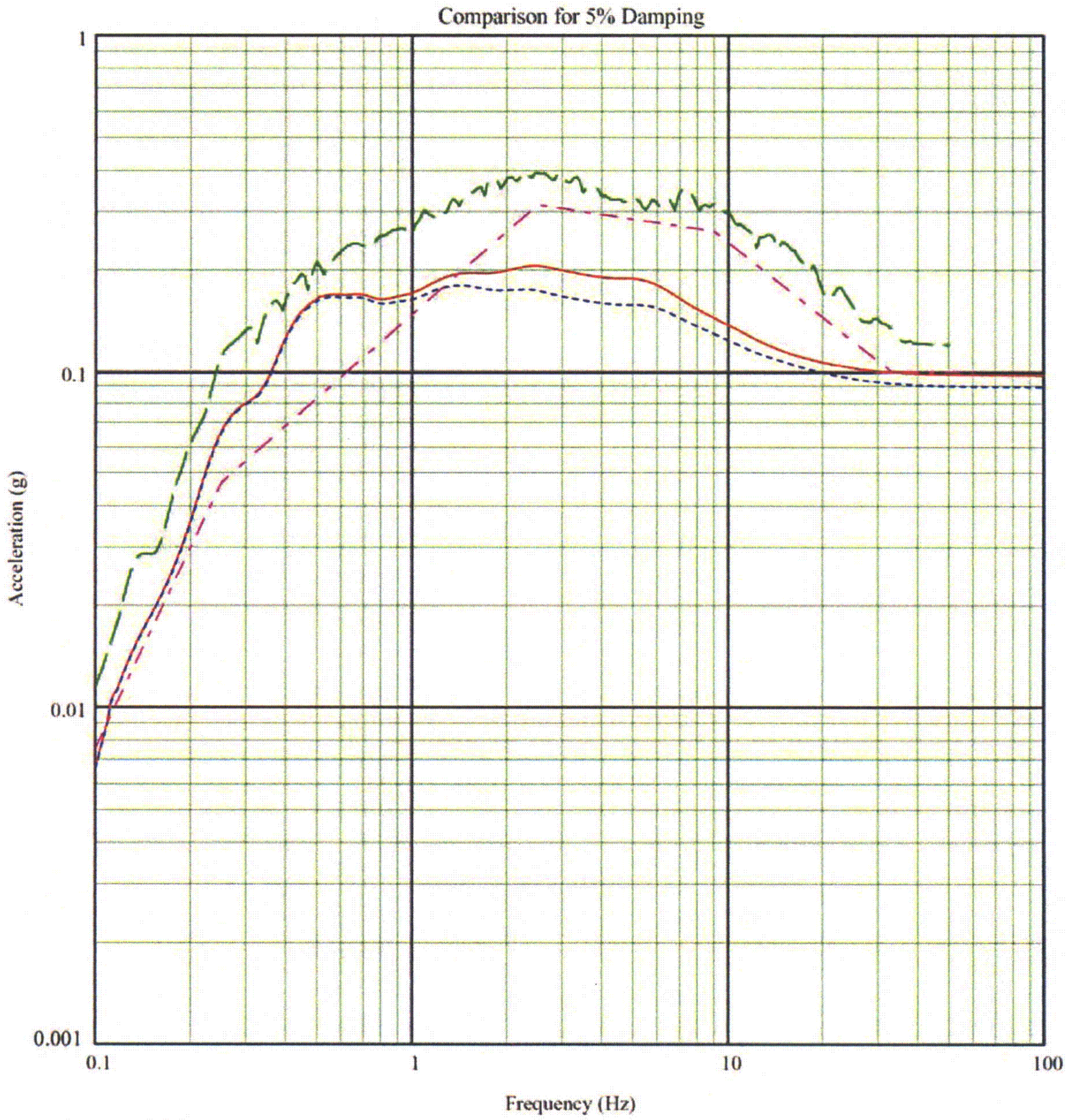
___(Red): GMRS
...... (Blue): FIRS at 57 ft below ground surface
___(Green): Outcrop spectrum at 57 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-8c: Comparison of Spectra at Foundation of RSW Piping Tunnel (Lower Bound Soil Properties, Vertical Direction)



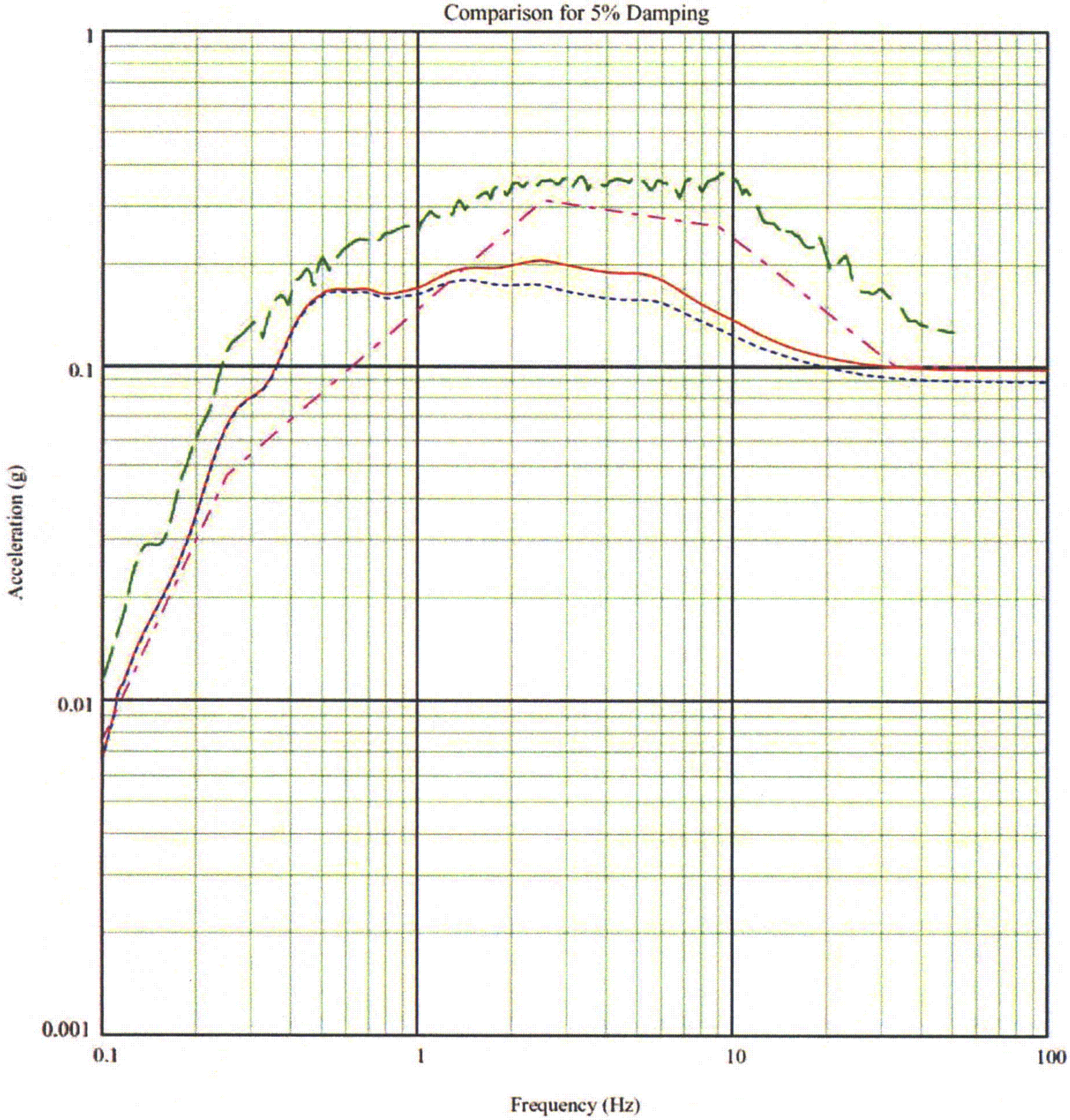
___(Red): GMRS
...... (Blue): FIRS at 68 ft below ground surface
___(Green): Outcrop spectrum at 68 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-9a: Comparison of Spectra at Foundation of RSW Pump House (Mean Soil Properties, E-W Direction)



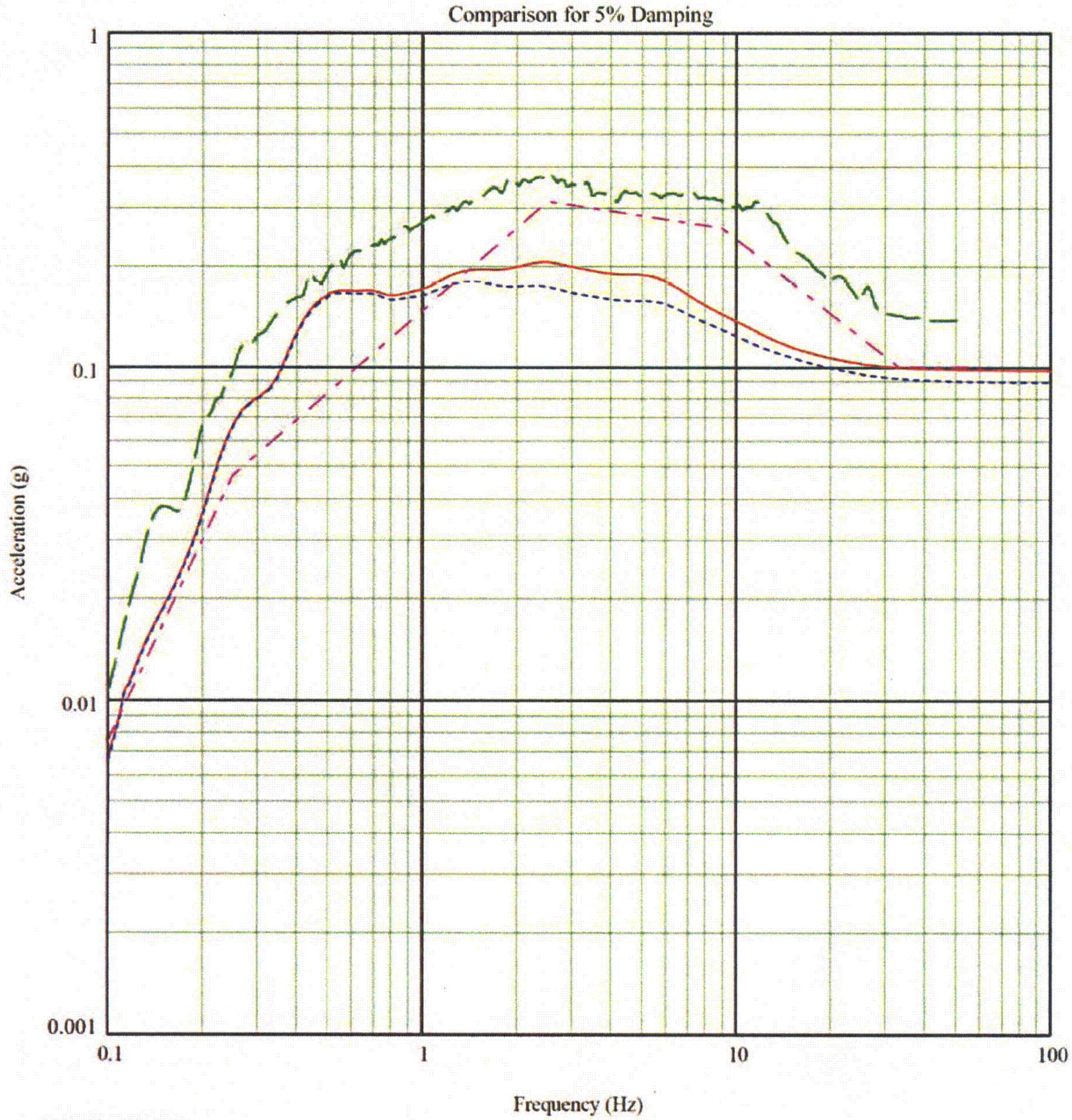
___ (Red): GMRS
...... (Blue): FIRS at 68 ft below ground surface
___ (Green): Outcrop spectrum at 68 ft below ground surface resulting from synthetic time history applied at ground surface
_._ (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-9b: Comparison of Spectra at Foundation of RSW Pump House (Upper Bound Soil Properties, E-W Direction)



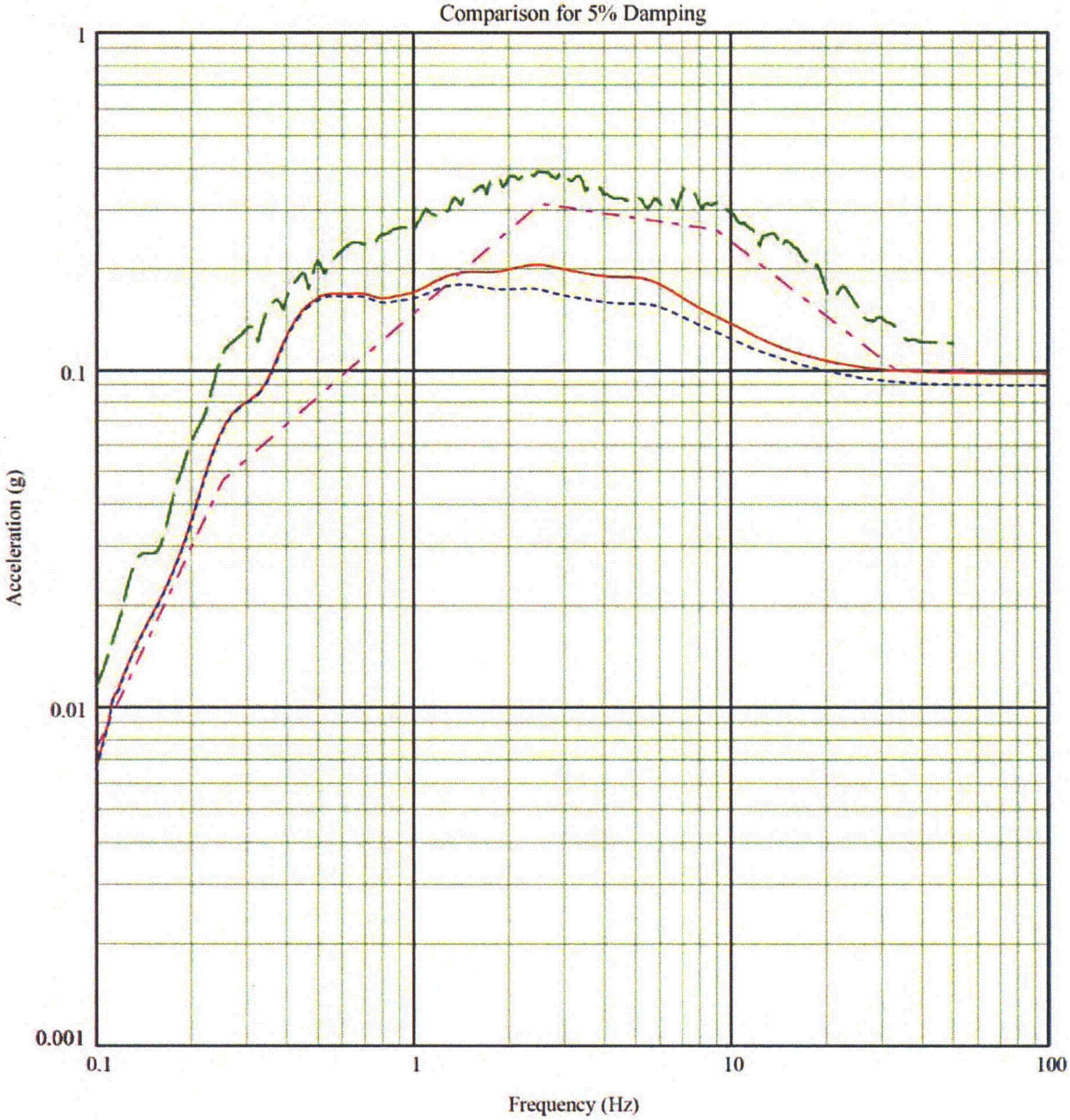
___ (Red): GMRS
...... (Blue): FIRS at 68 ft below ground surface
___ (Green): Outcrop spectrum at 68 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-9c: Comparison of Spectra at Foundation of RSW Pump House (Lower Bound Soil Properties, E-W Direction)



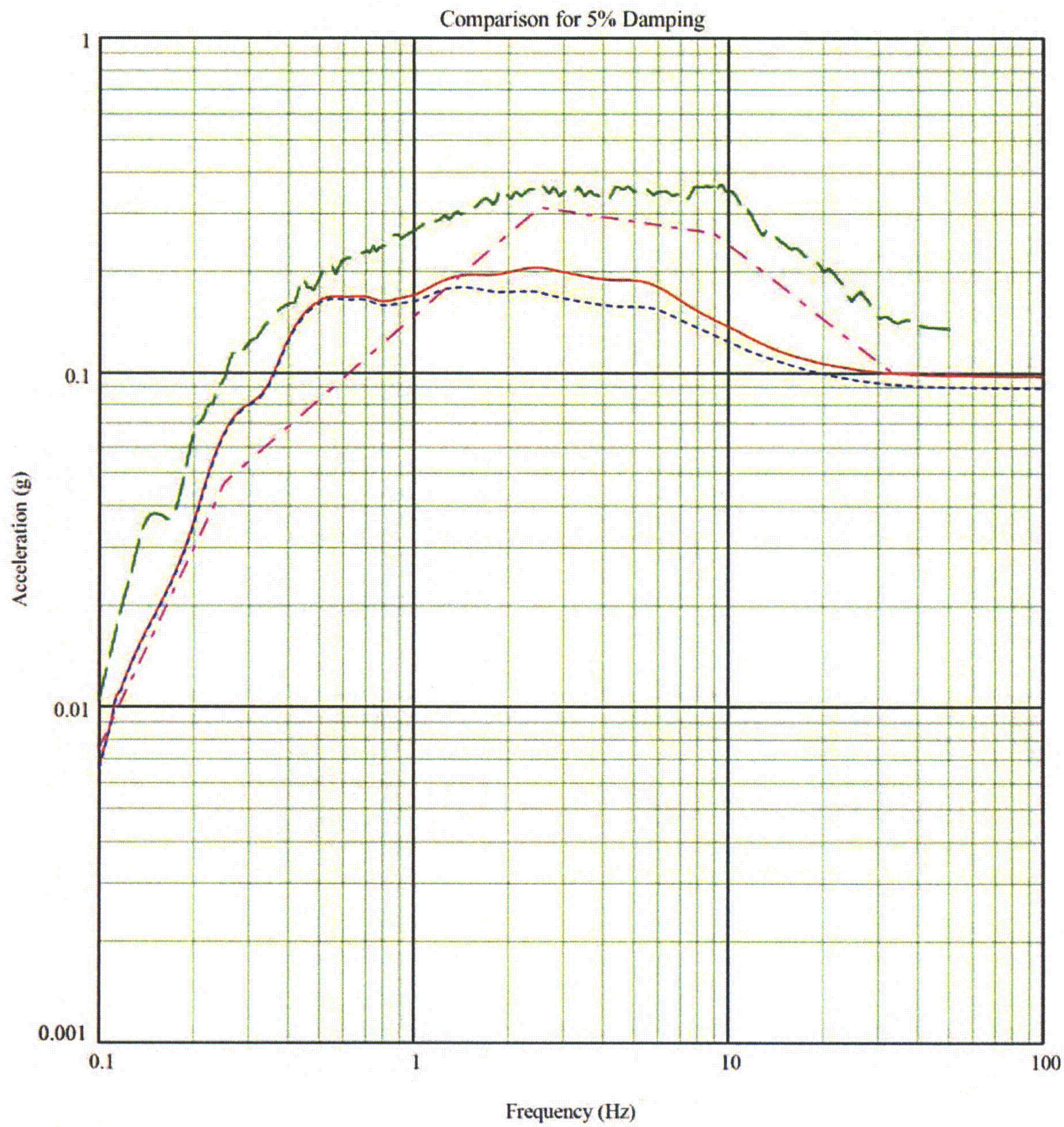
___(Red): GMRS
...... (Blue): FIRS at 68 ft below ground surface
___(Green): Outcrop spectrum at 68 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-10a: Comparison of Spectra at Foundation of RSW Pump House (Mean Soil Properties, N-S Direction)



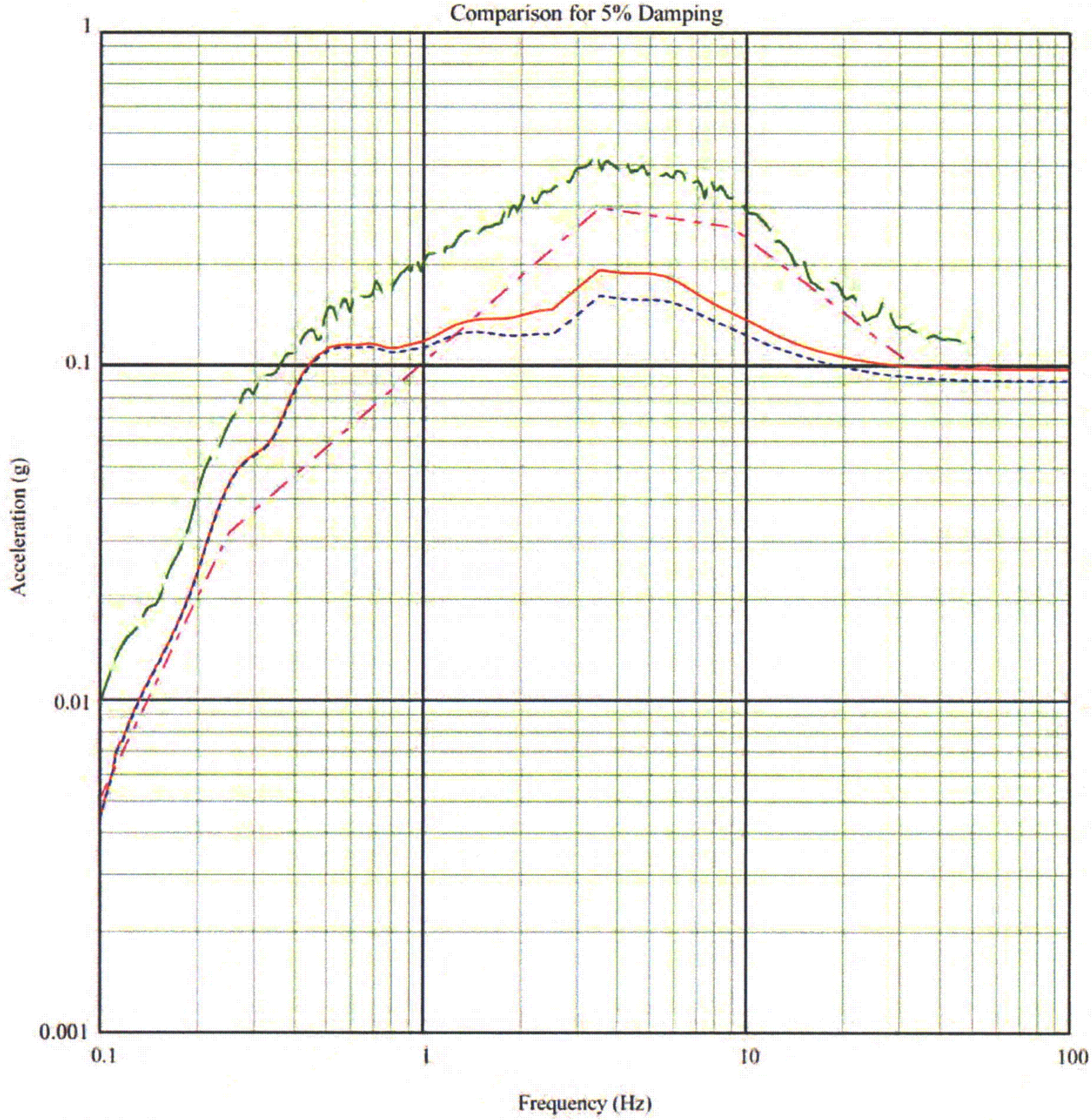
___(Red): GMRS
...... (Blue): FIRS at 68 ft below ground surface
___(Green): Outcrop spectrum at 68 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-10b: Comparison of Spectra at Foundation of RSW Pump House (Upper Bound Soil Properties, N-S Direction)



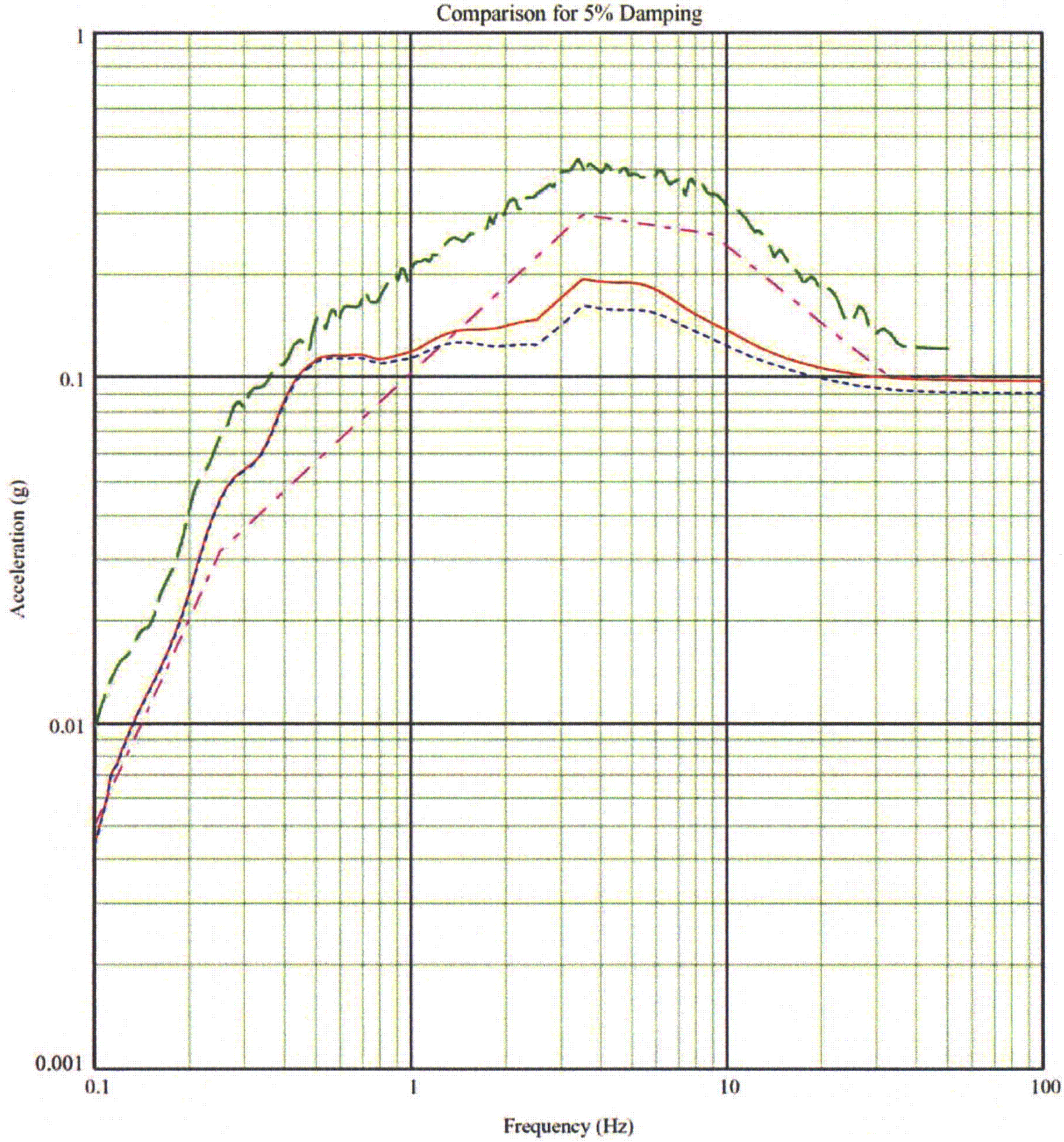
___(Red): GMRS
...... (Blue): FIRS at 68 ft below ground surface
___(Green): Outcrop spectrum at 68 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-10c: Comparison of Spectra at Foundation of RSW Pump House (Lower Bound Soil Properties, N-S Direction)



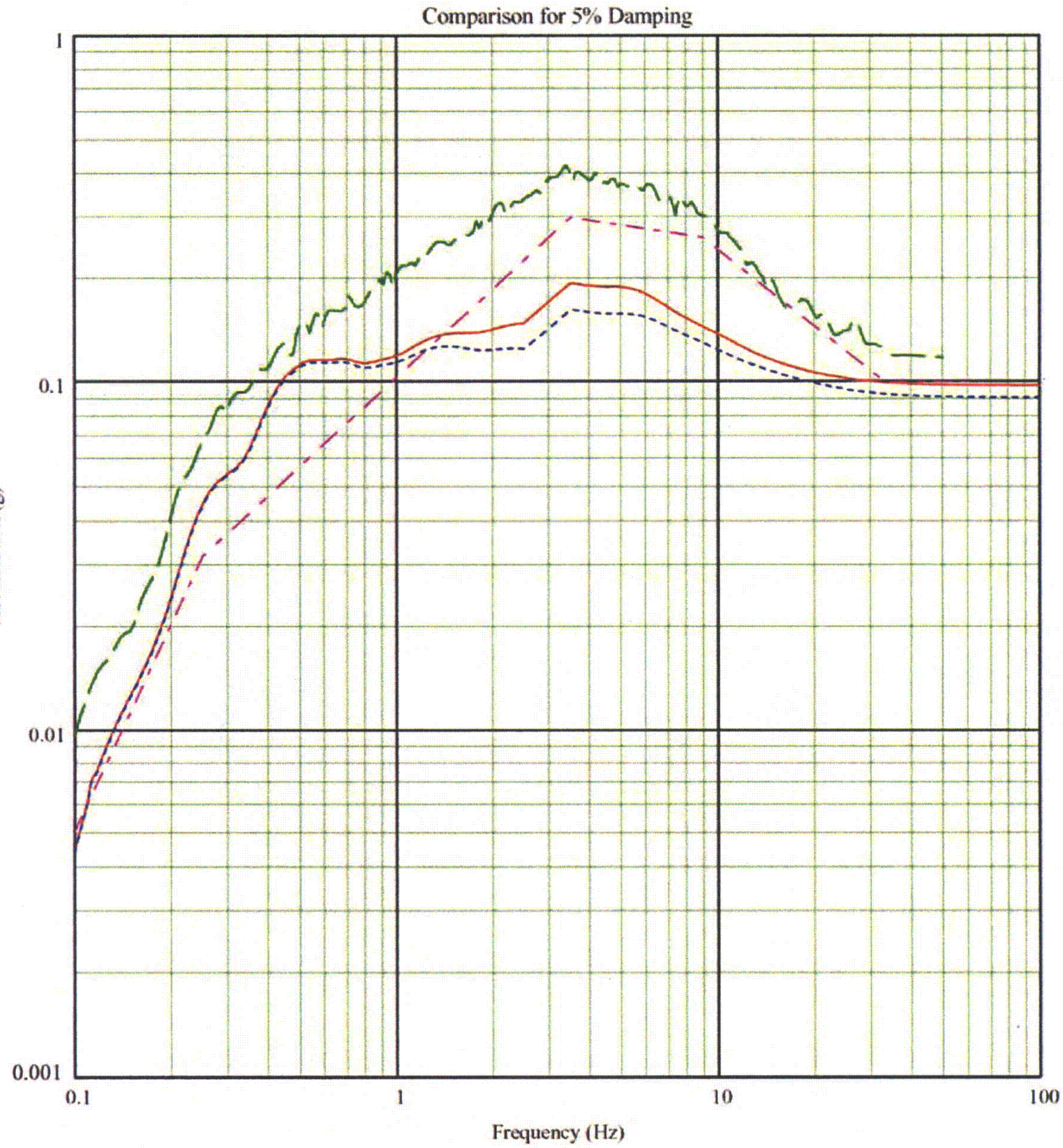
___(Red): GMRS
...... (Blue): FIRS at 68 ft below ground surface
___(Green): Outcrop spectrum at 68 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-11a: Comparison of Spectra at Foundation of RSW Pump House (Mean Soil Properties, Vertical Direction)



___ (Red): GMRS
...... (Blue): FIRS at 68 ft below ground surface
___ (Green): Outcrop spectrum at 68 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-11b: Comparison of Spectra at Foundation of RSW Pump House (Upper Bound Soil Properties, Vertical Direction)



___(Red): GMRS
...... (Blue): FIRS at 68 ft below ground surface
___(Green): Outcrop spectrum at 68 ft below ground surface resulting from synthetic time history applied at ground surface
_._. (Magenta): RG 1.60 spectrum scaled to 0.10g

Figure 3H.6-11c: Comparison of Spectra at Foundation of RSW Pump House (Lower Bound Soil Properties, Vertical Direction)

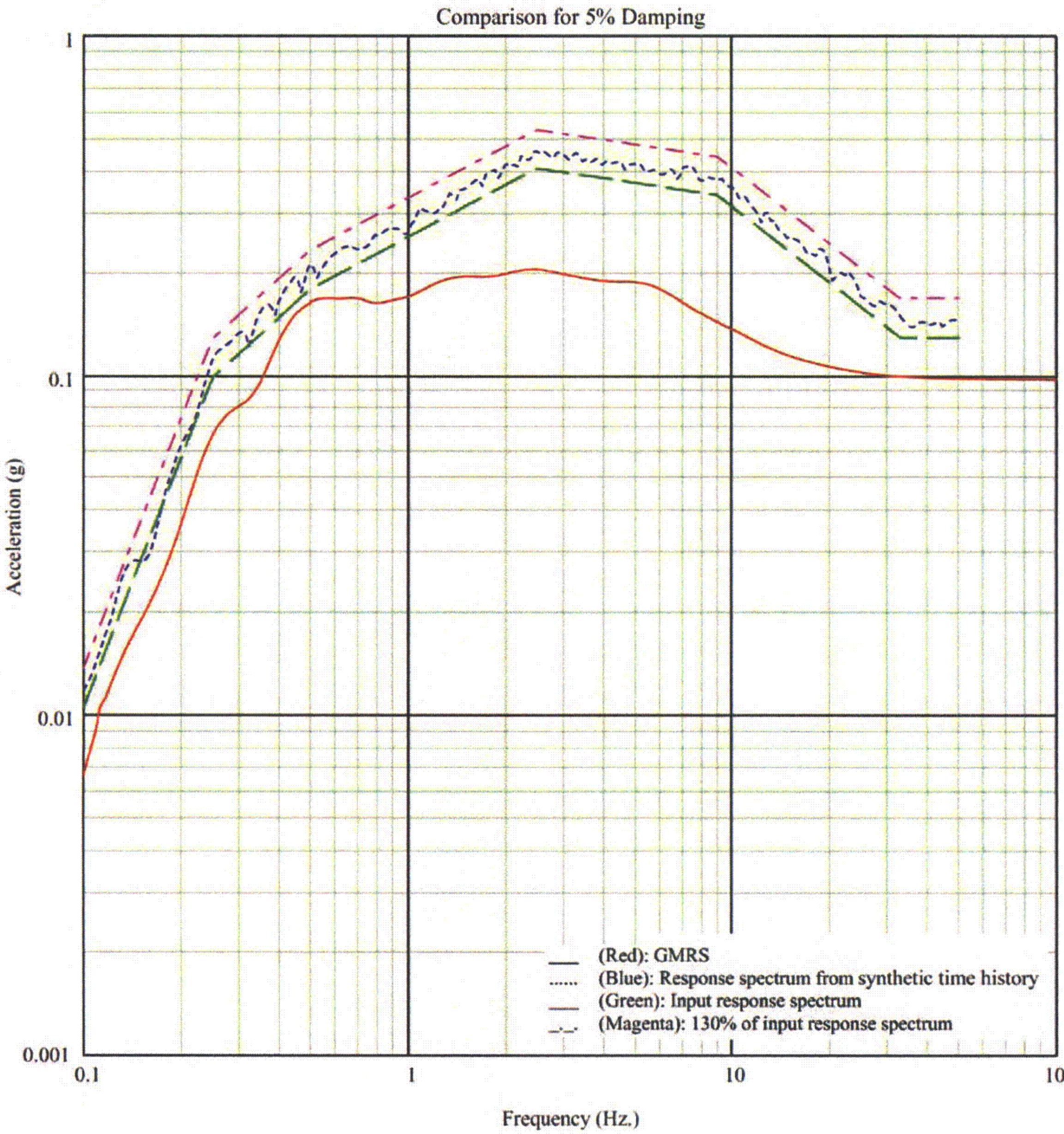


Figure 3H.6-12: Comparison of Spectrum from Synthetic Time History, Input Spectrum, 130% of Input Spectrum, and GMRS (E-W Direction)

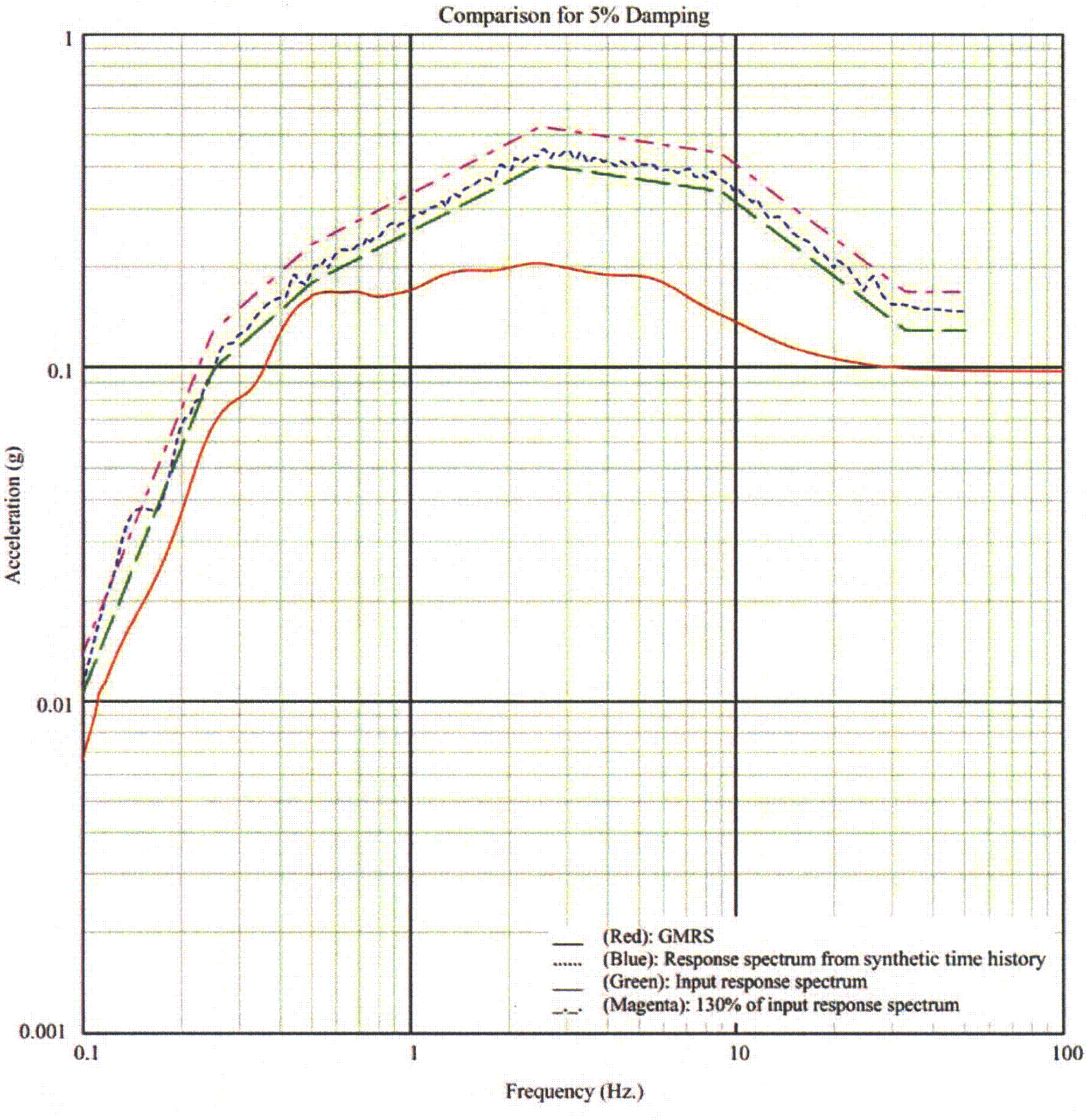


Figure 3H.6-13: Comparison of Spectrum from Synthetic Time History, Input Spectrum, 130% of Input Spectrum, and GMRS (N-S Direction)

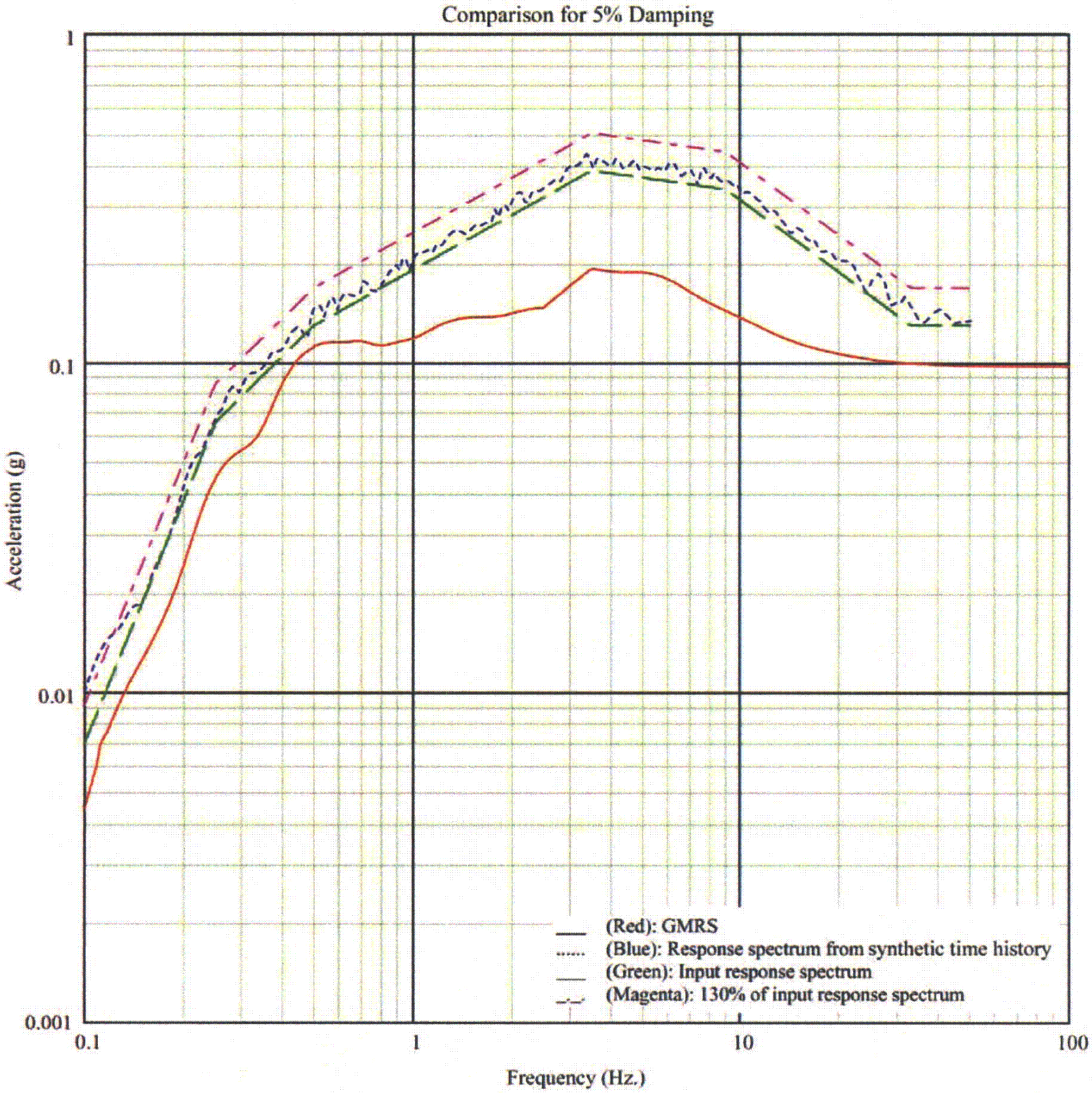


Figure 3H.6-14: Comparison of Spectrum from Synthetic Time History, Input Spectrum, 130% of Input Spectrum, and GMRS (Vertical Direction)

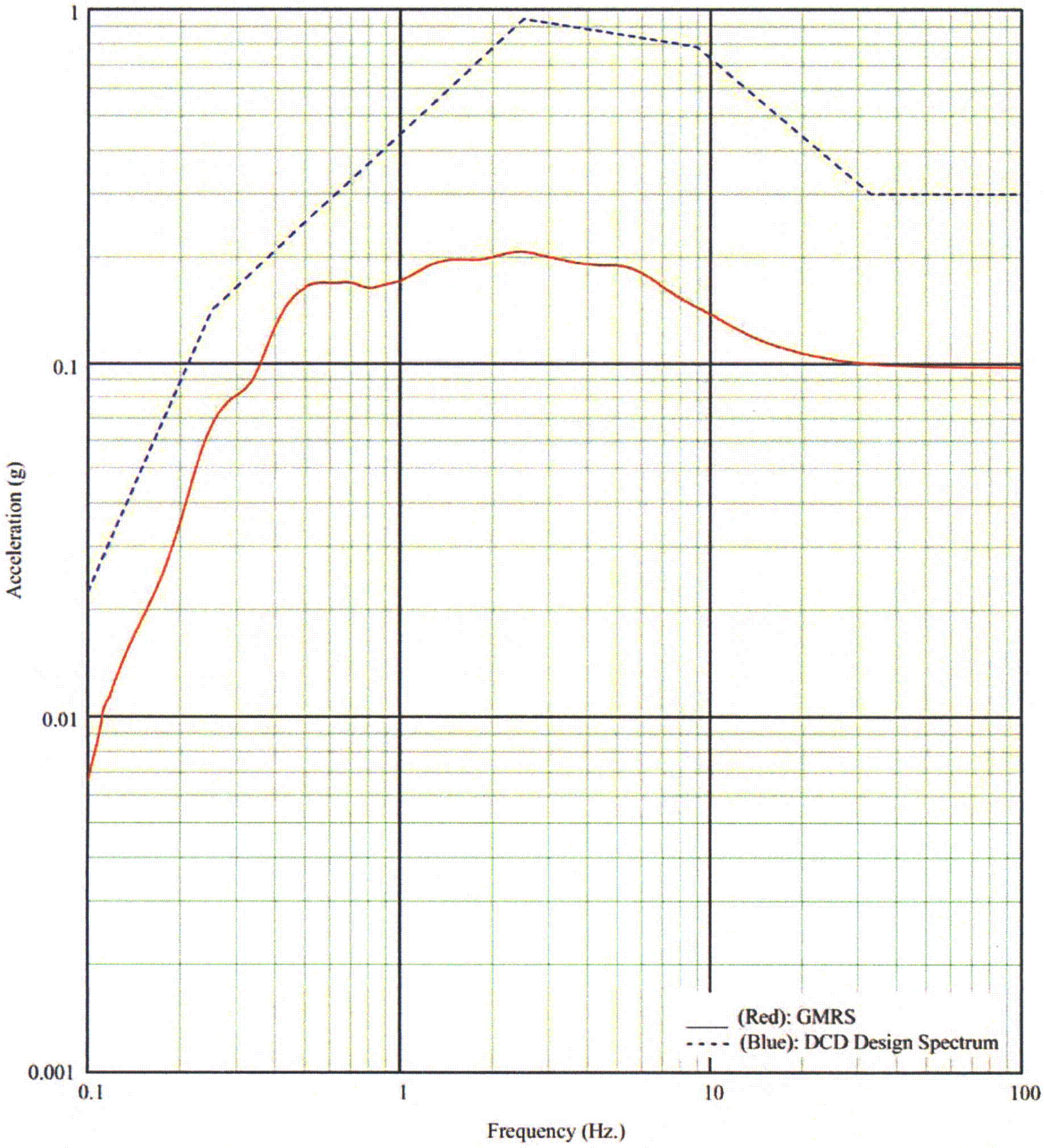


Figure 3A-231: Comparison of GMRS with DCD Design Spectrum (CSDRS) - Horizontal (5% damping)

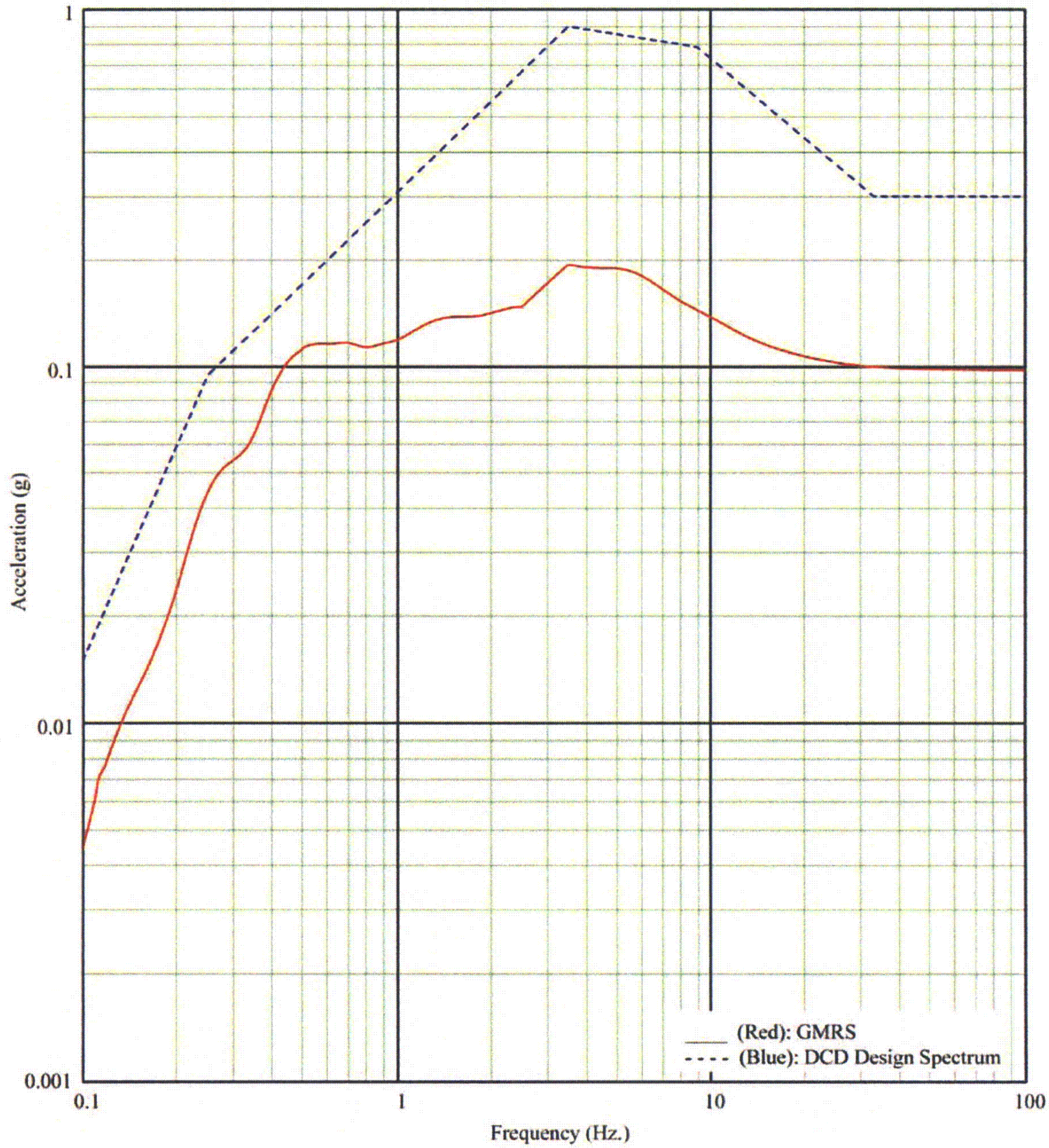


Figure 3A-232: Comparison of GMRS with DCD Design Spectrum (CSDRS) - Vertical (5% damping)

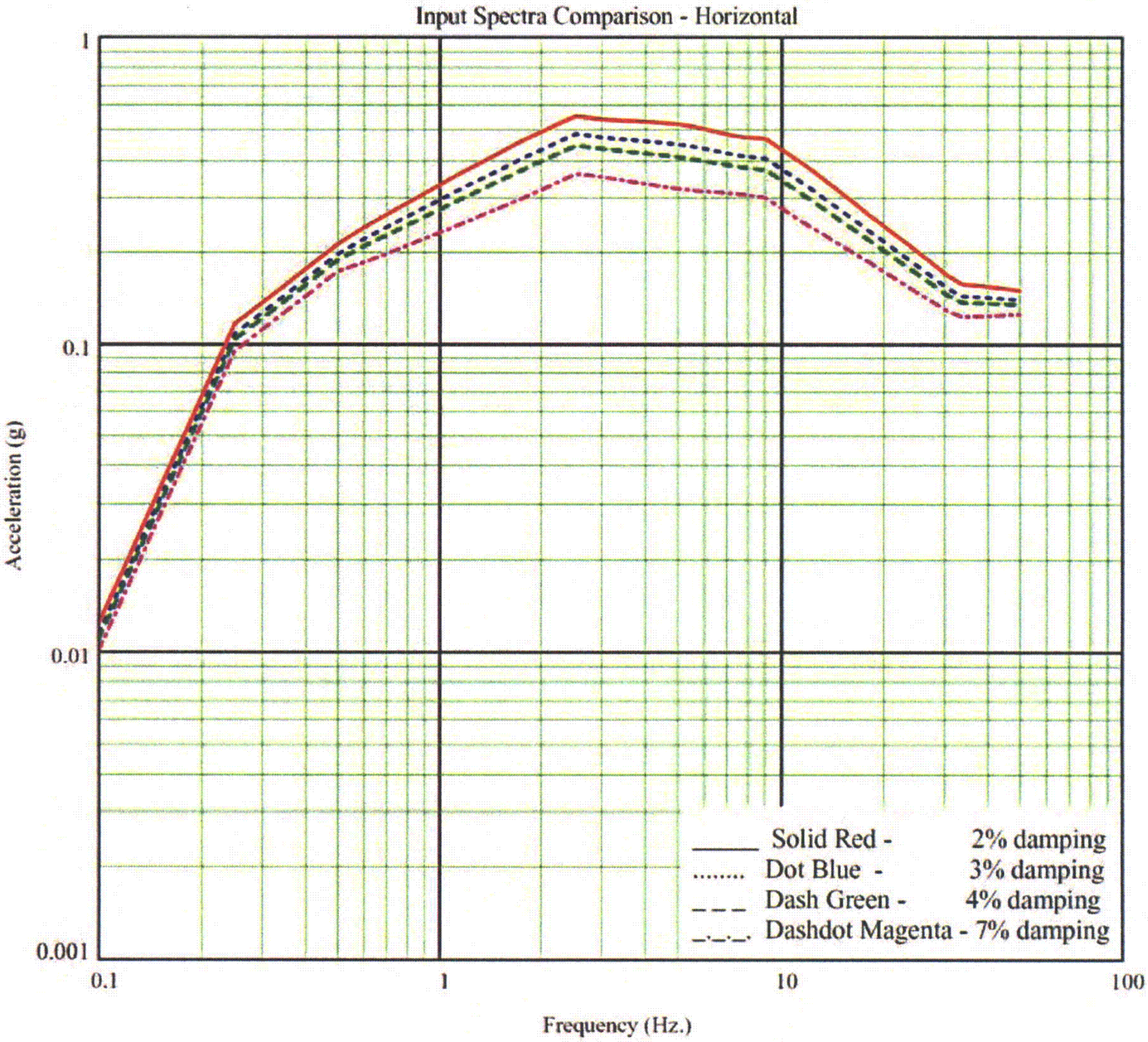


Figure 3.7-1b: Plots of 2%, 3%, 4% and 7% Damped Input Response Spectrum – Horizontal Direction

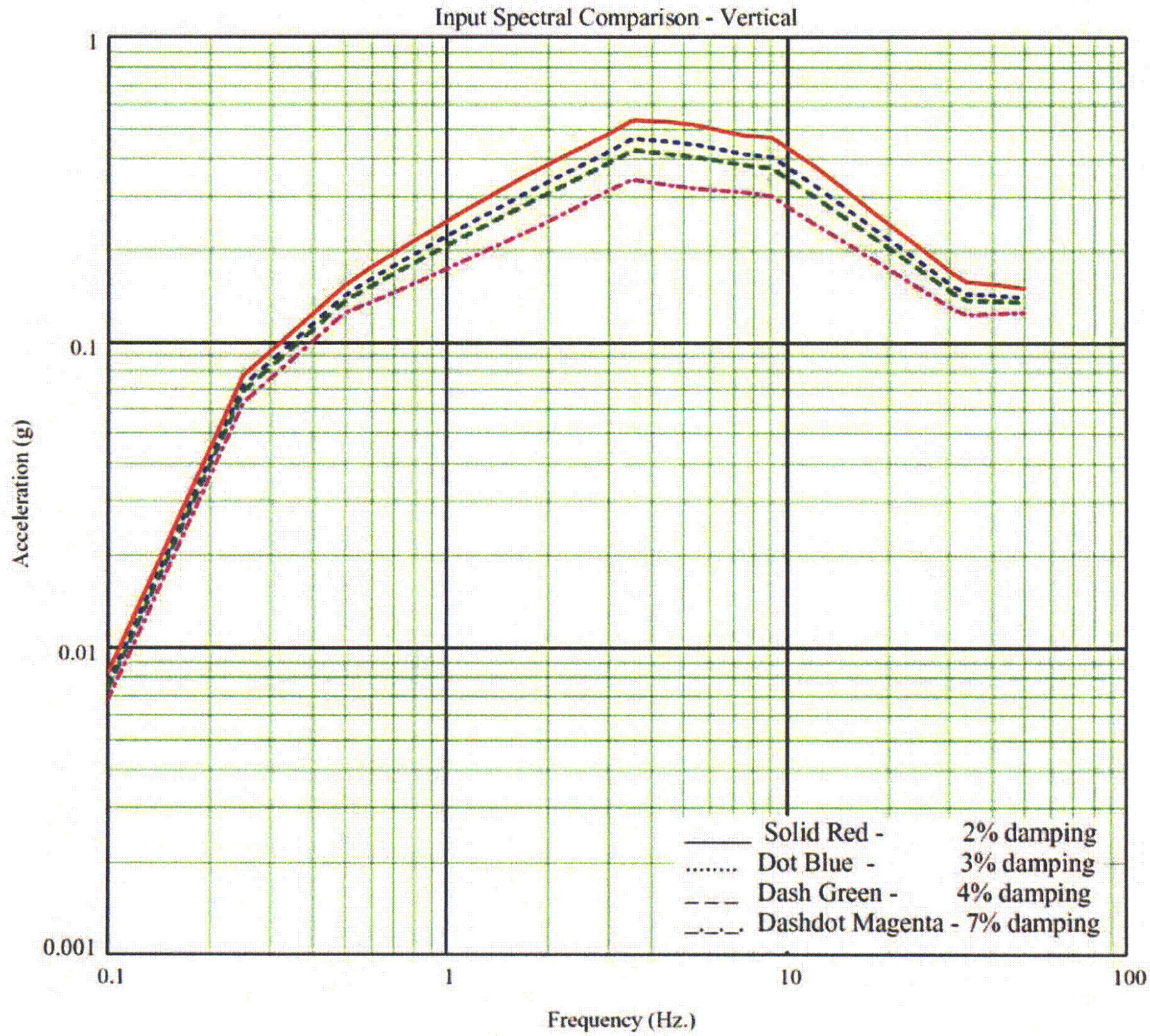
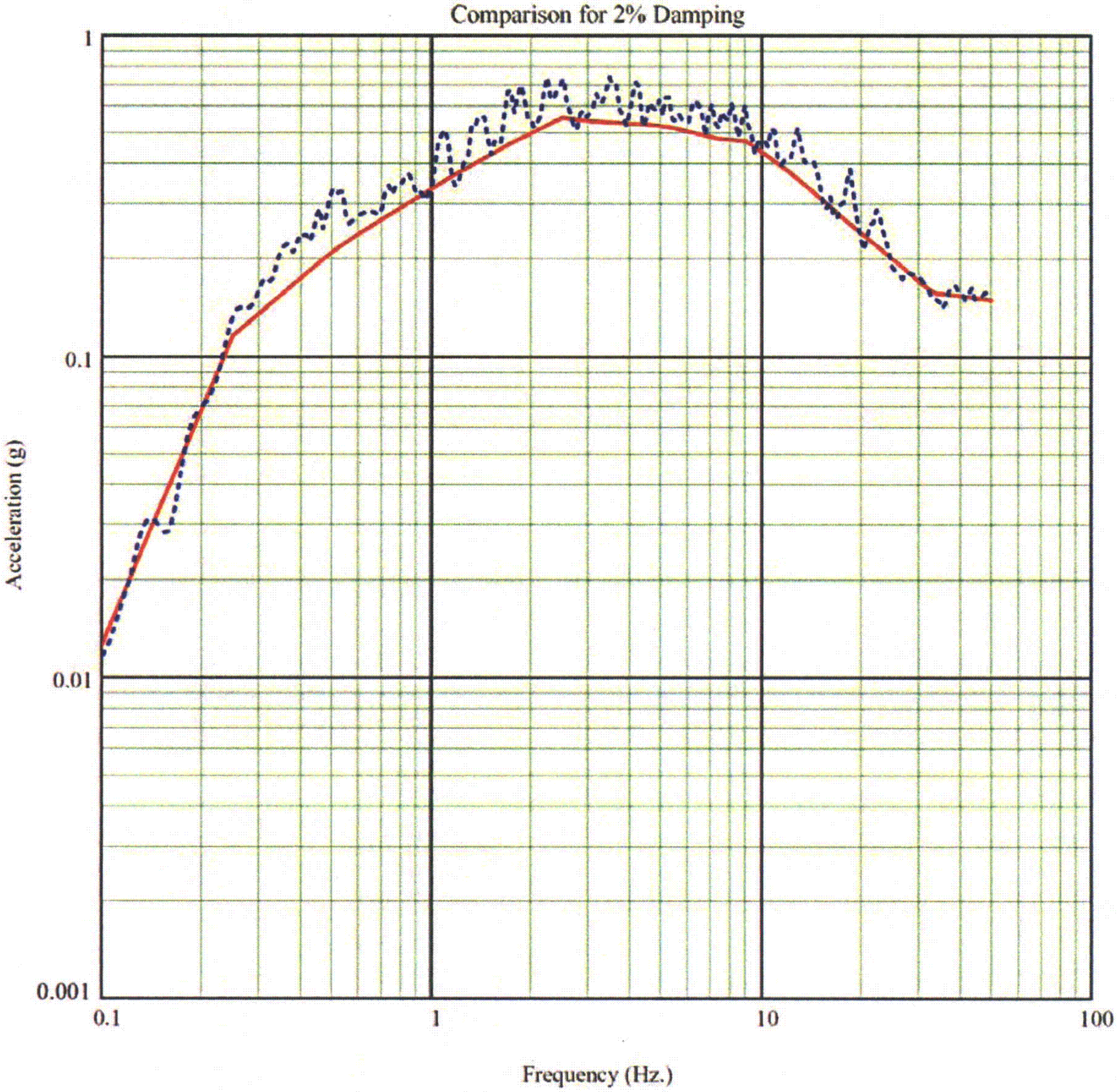
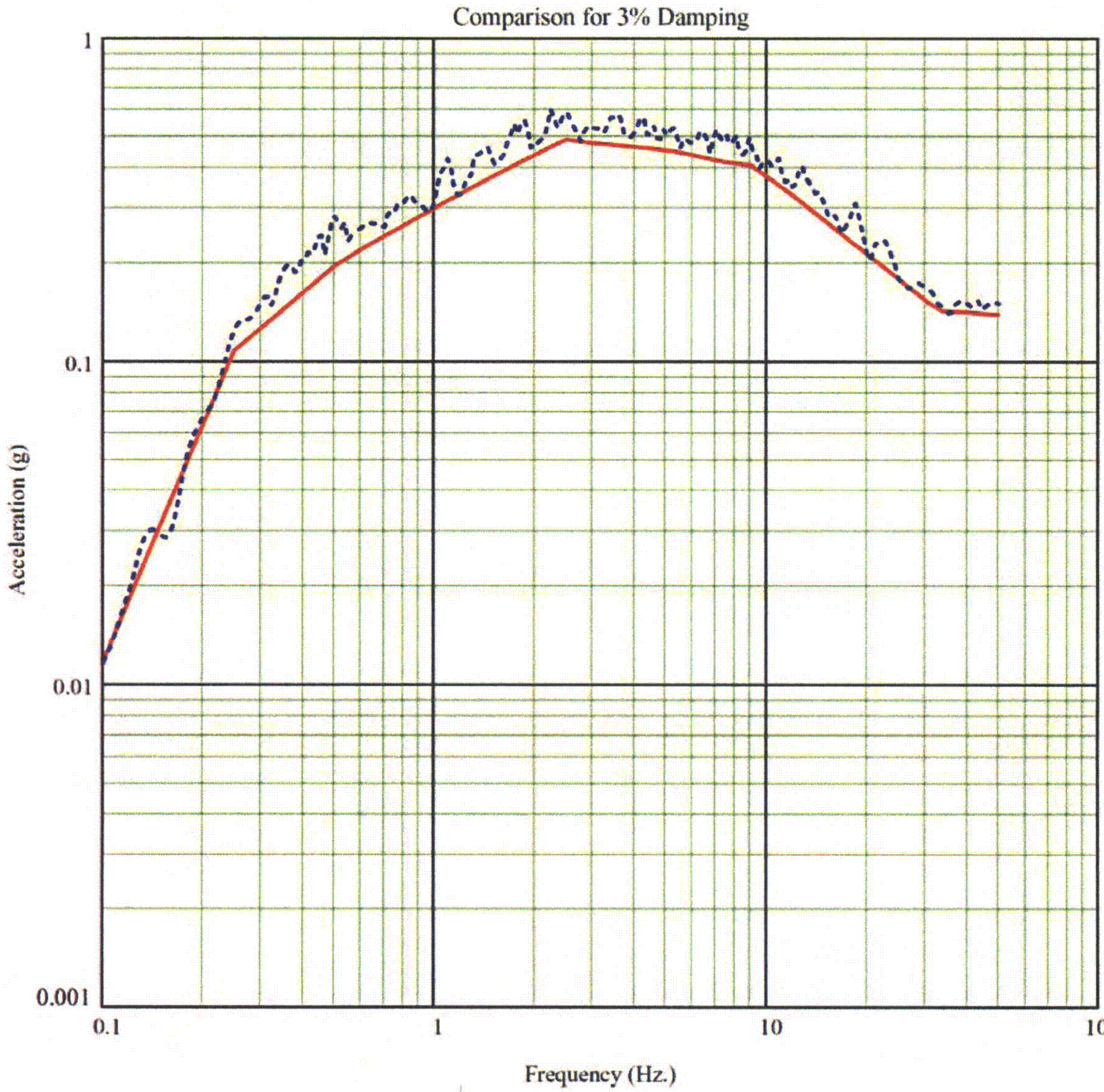


Figure 3.7-2b: Plots of 2%, 3%, 4% and 7% Damped Input Response Spectrum – Vertical Direction



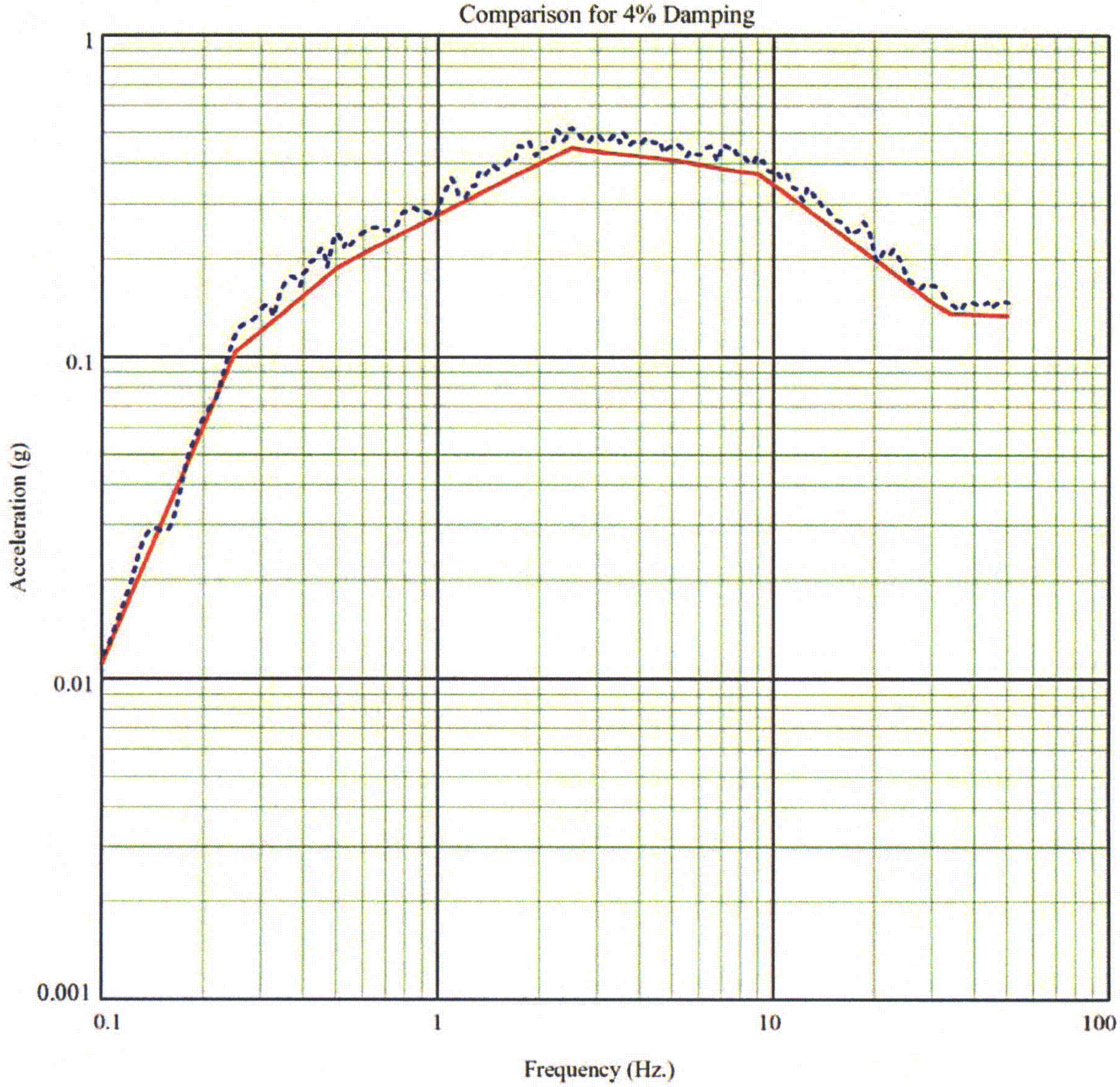
______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-12a: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Horizontal (E-W) – 2% Damping



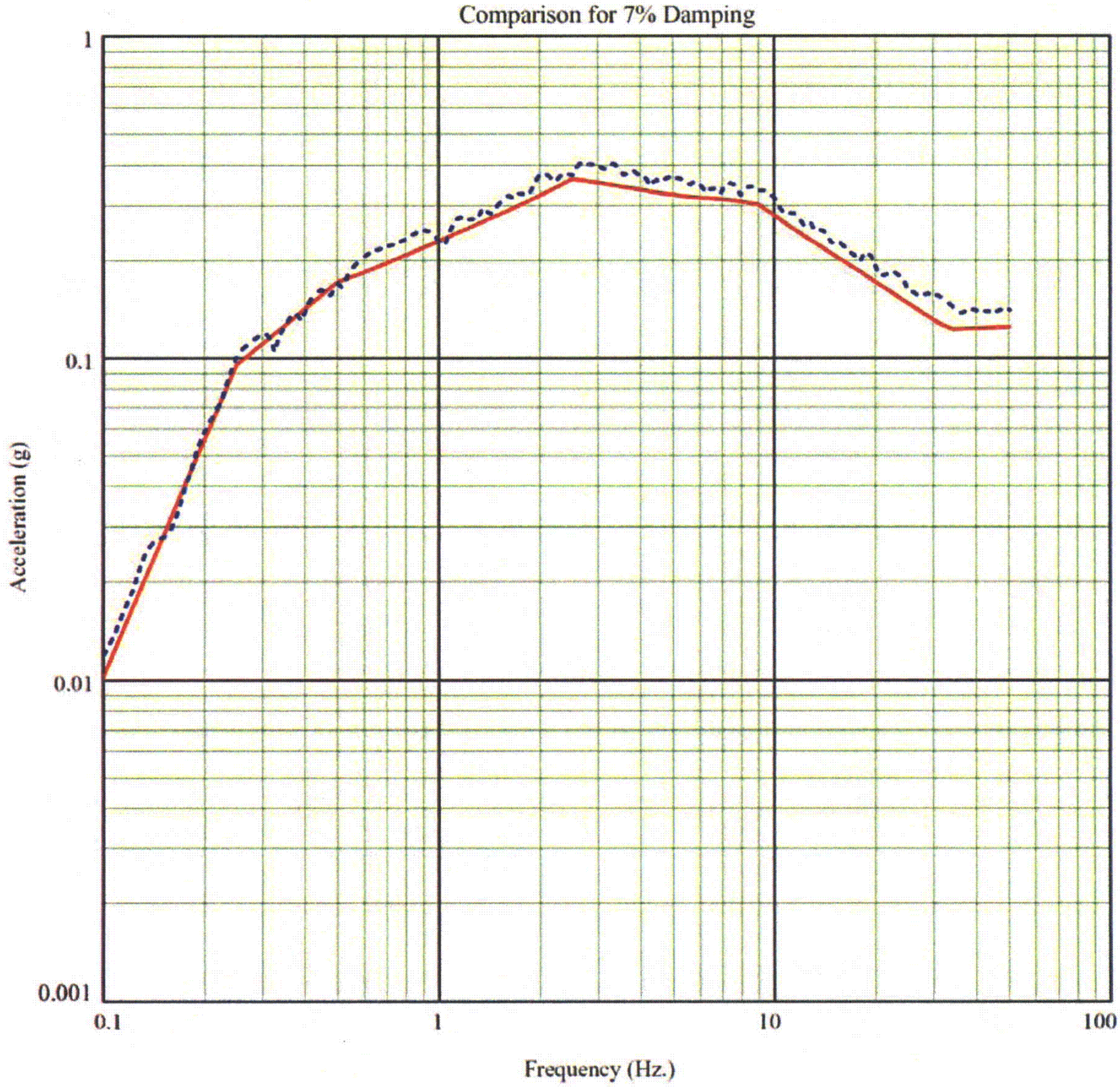
______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-12b: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Horizontal (E-W) – 3% Damping



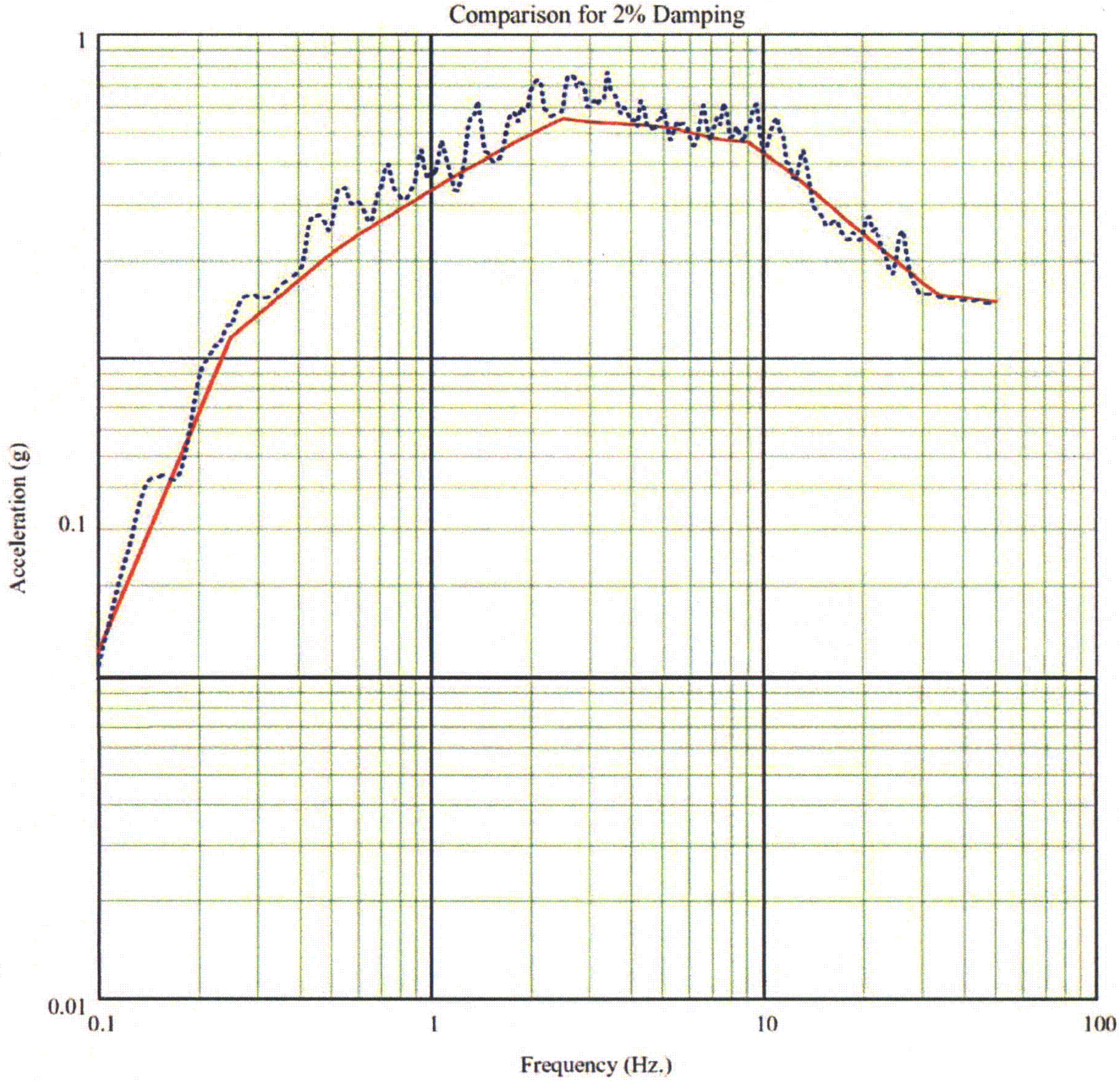
______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-12c: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Horizontal (E-W) – 4% Damping



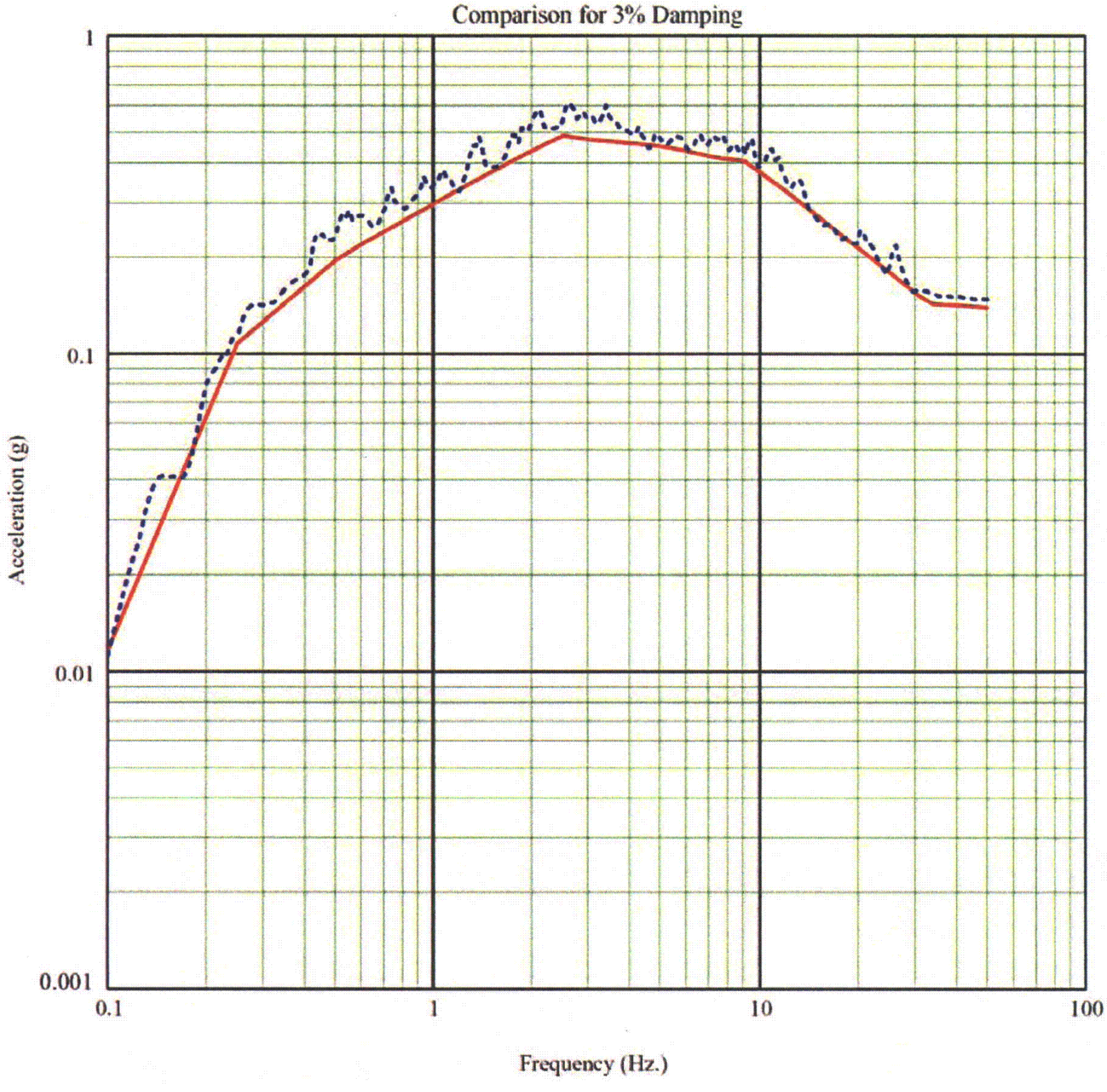
______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-12d: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Horizontal (E-W) – 7% Damping



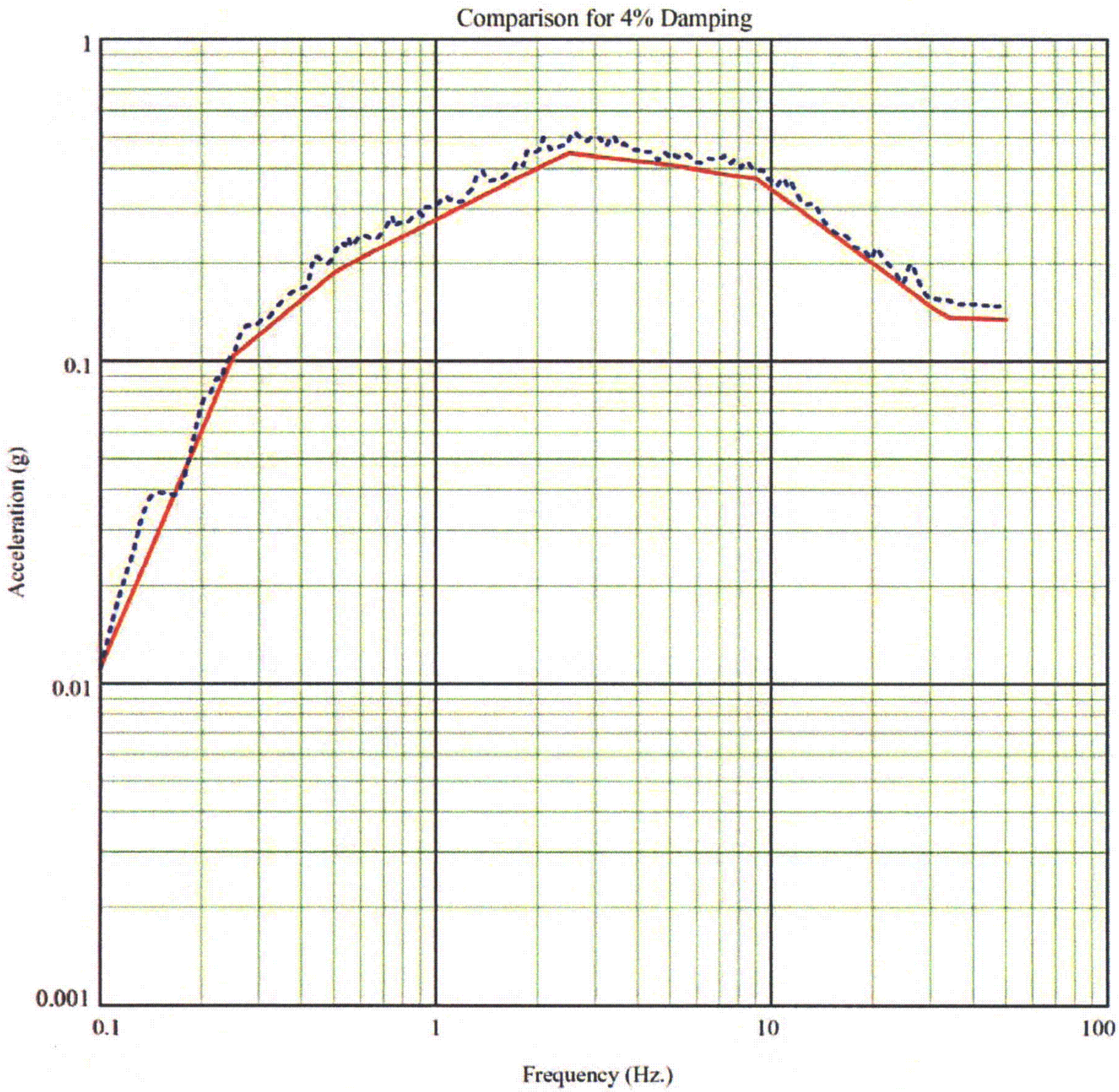
______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-13a: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Horizontal (N-S) – 2% Damping



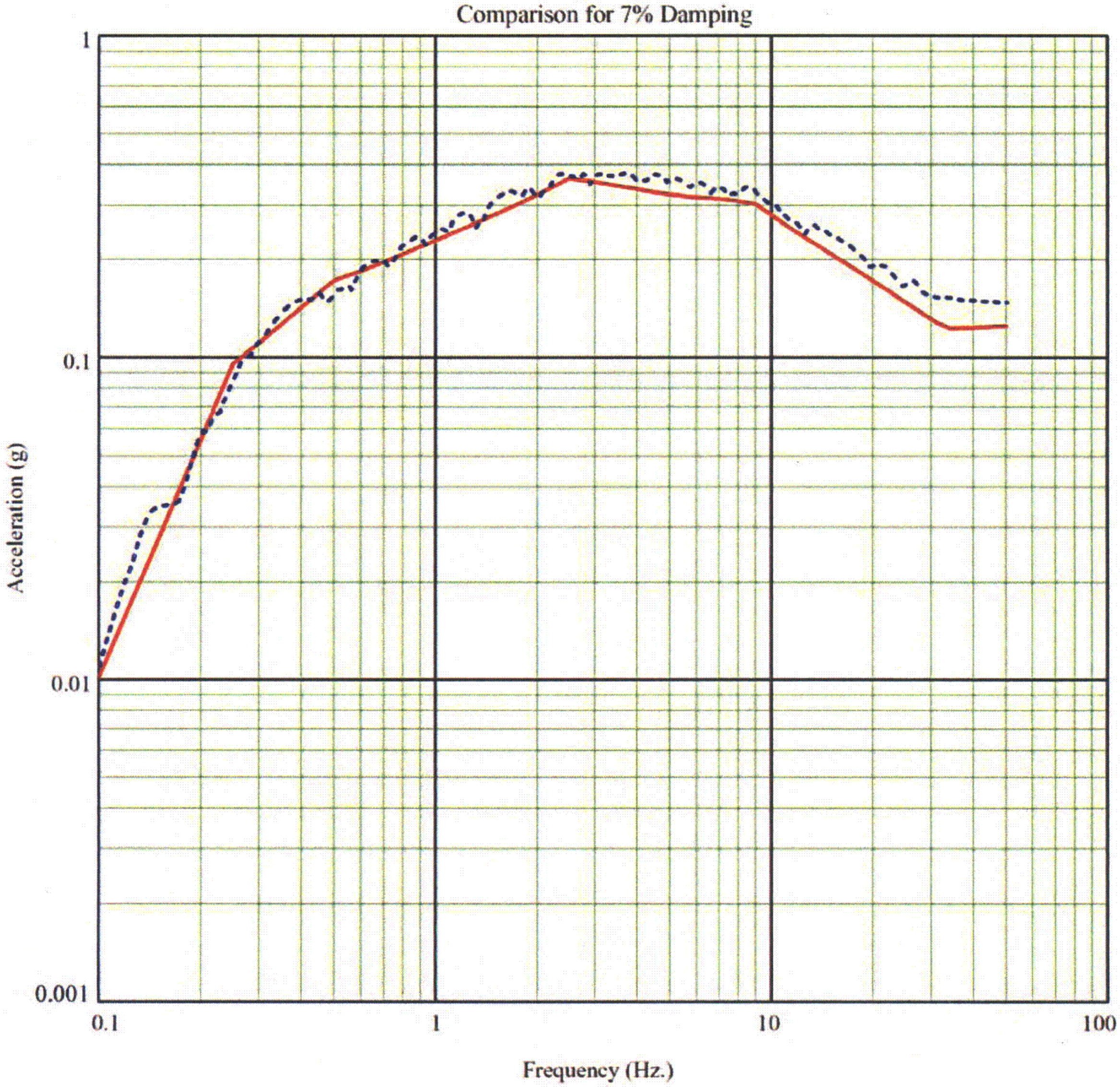
______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-13b: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Horizontal (N-S) – 3% Damping



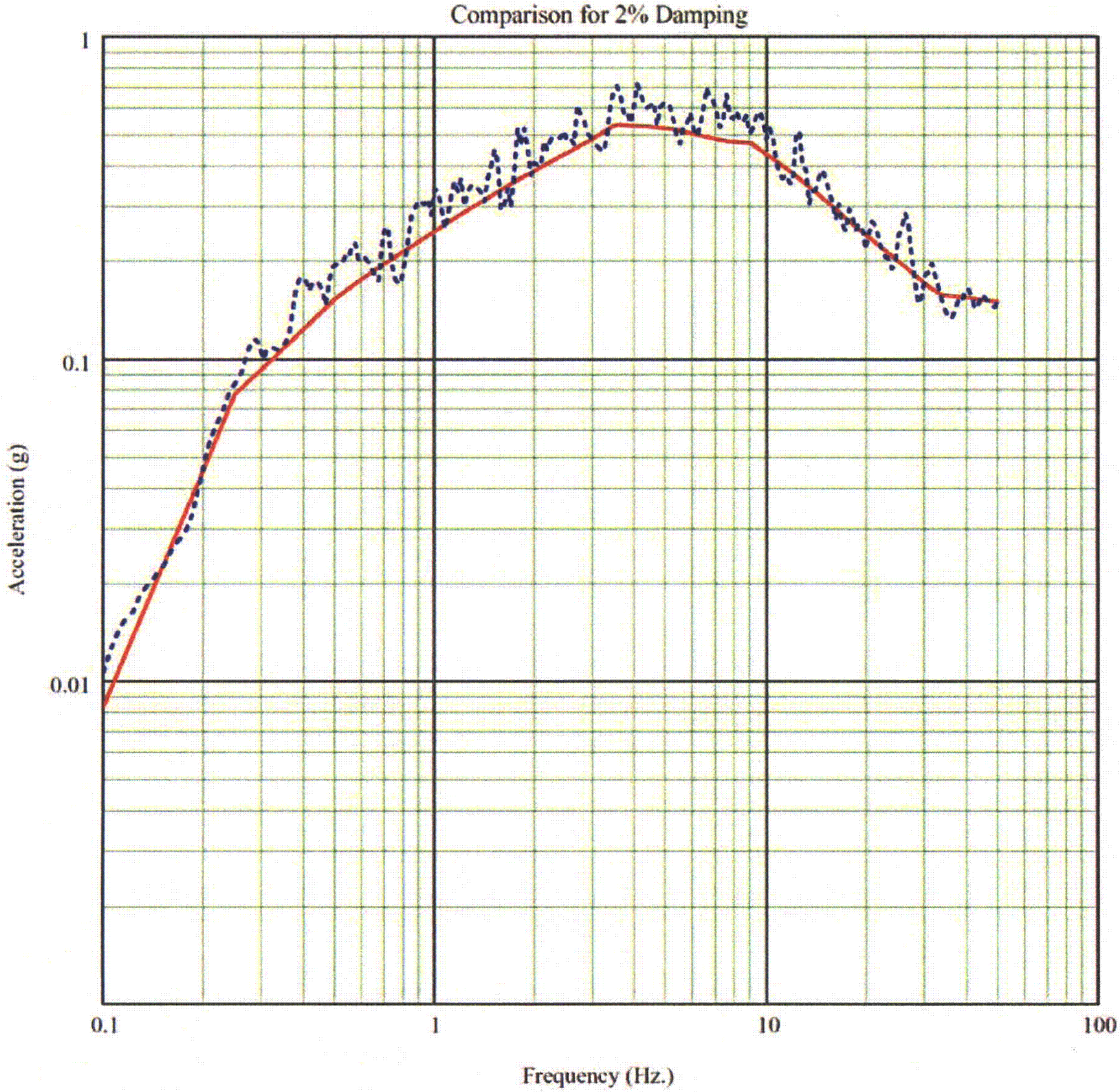
______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-13c: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Horizontal (N-S) – 4% Damping



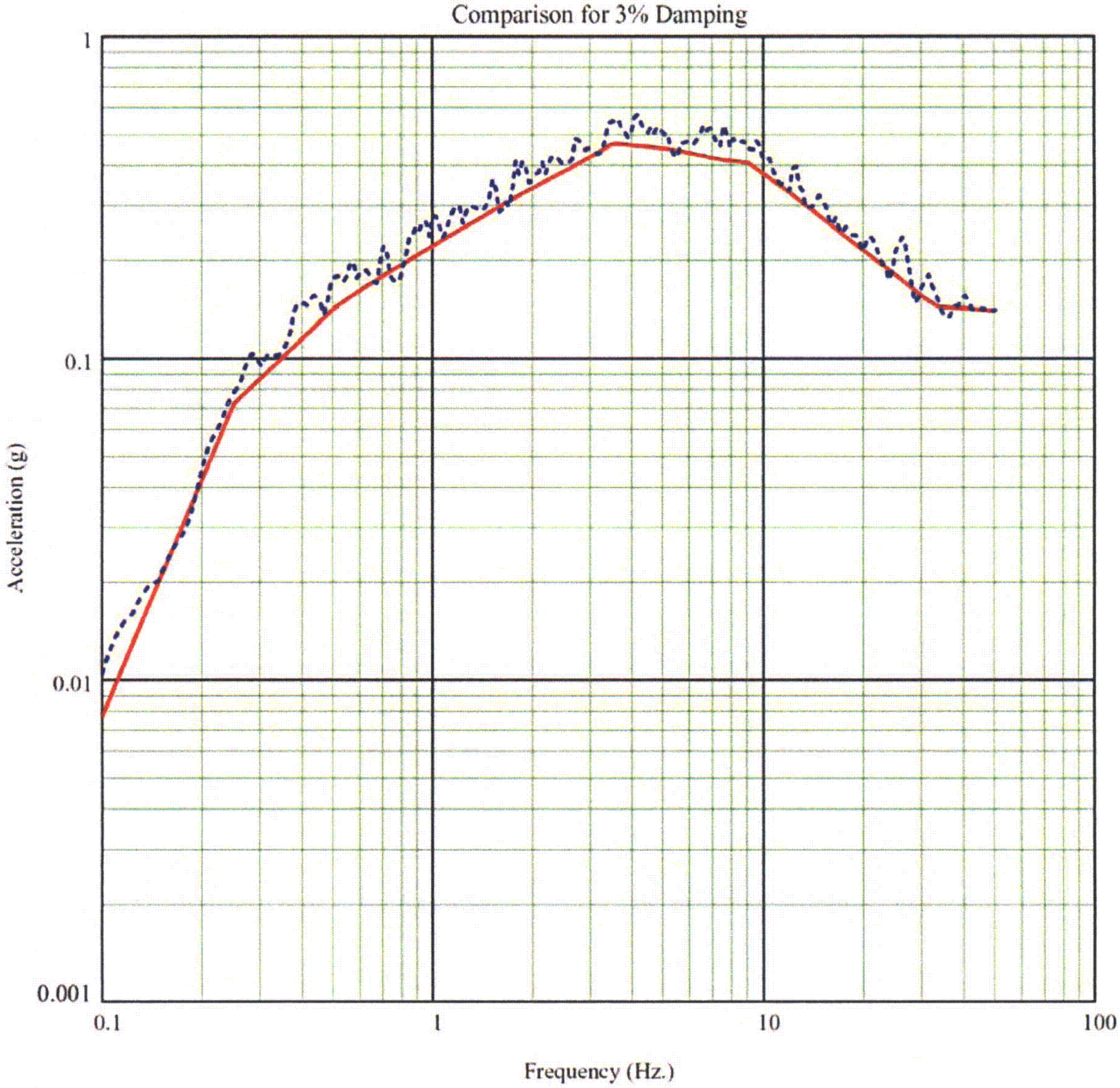
______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-13d: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Horizontal (N-S) – 7% Damping



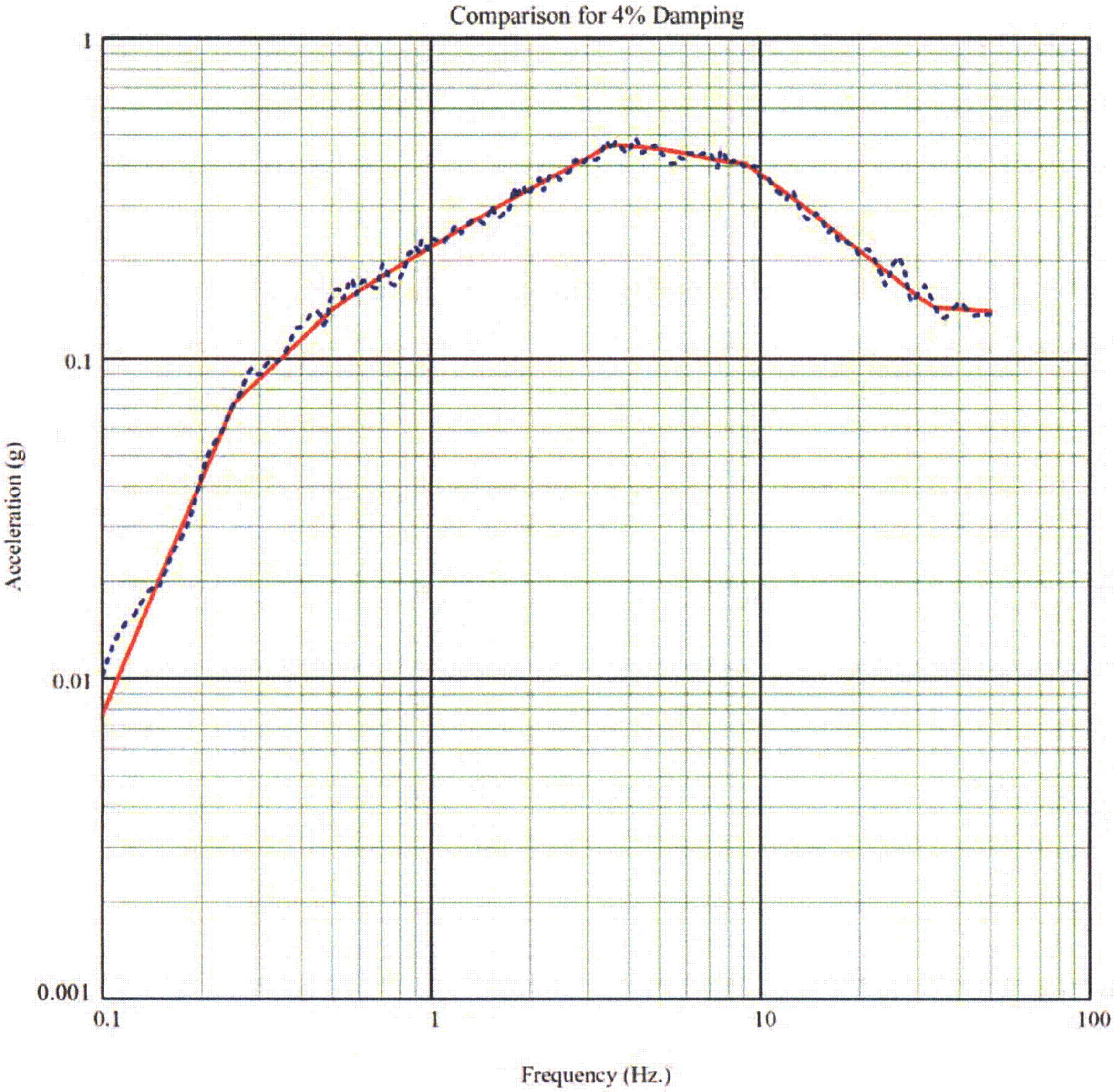
______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-14a: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Vertical – 2% Damping



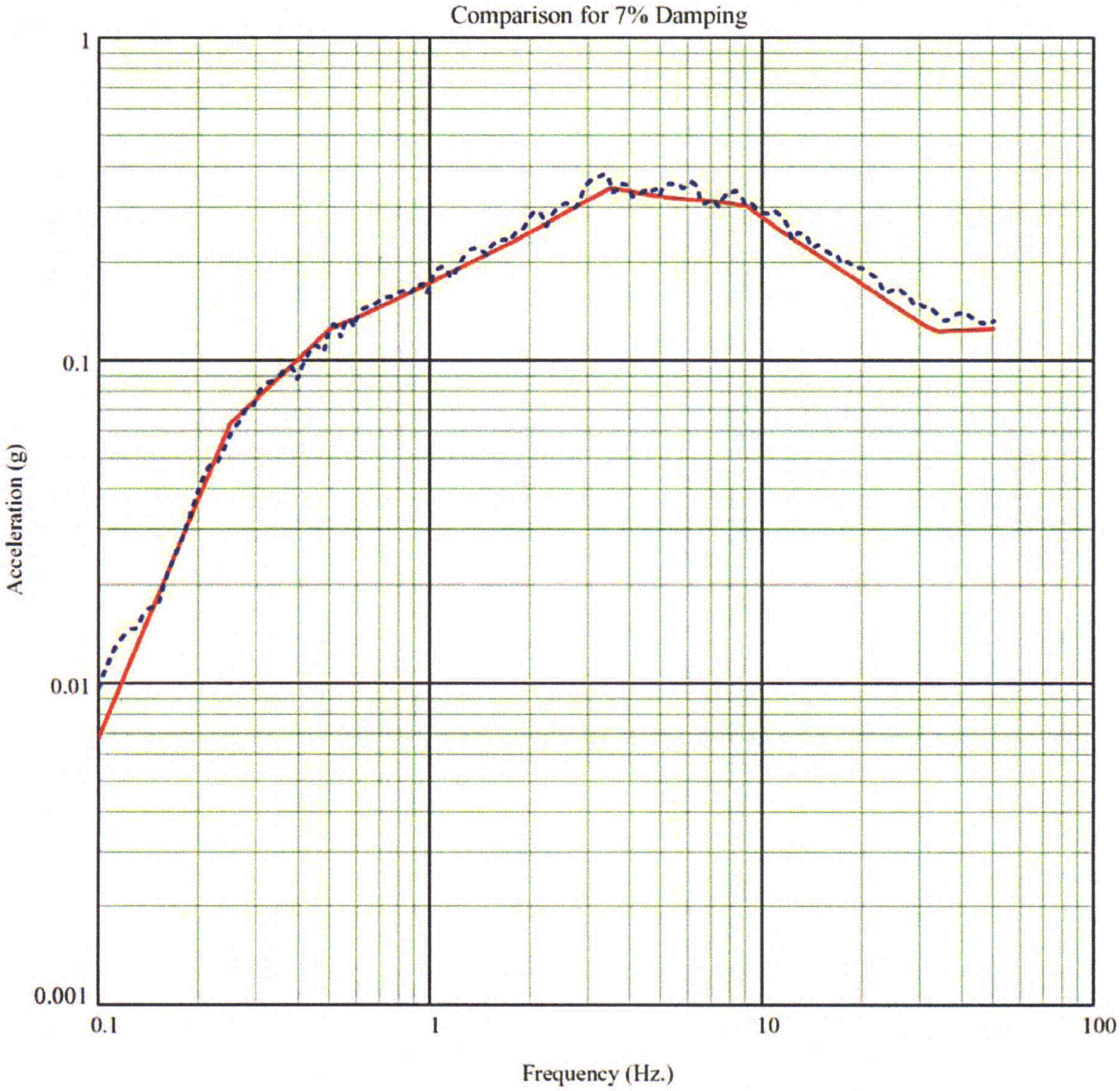
______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-14b: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Vertical – 3% Damping



______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-14c: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Vertical – 4% Damping



______ Solid Red - Input Spectrum
.... Dot Blue - Response Spectrum from Synthetic Time History

Figure 3H.6-14d: Comparison of Input Spectrum and Spectrum from Synthetic Time History, Vertical – 7% Damping

Table 3H.6-2d: Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (E-W Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (E-W)	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (E-W)	Percentage Less than Target
0.1	0.0106	0.0119	-	0.224	0.0757	0.0777	-
0.102	0.0112	0.0123	-	0.229	0.08	0.0845	-
0.105	0.0119	0.0129	-	0.234	0.0846	0.0919	-
0.107	0.0126	0.0136	-	0.24	0.0895	0.0996	-
0.11	0.0133	0.0147	-	0.246	0.0947	0.107	-
0.112	0.014	0.016	-	0.251	0.0994	0.113	-
0.115	0.0148	0.0175	-	0.257	0.1014	0.1171	-
0.118	0.0157	0.0193	-	0.263	0.1034	0.1195	-
0.12	0.0166	0.0211	-	0.269	0.1055	0.1215	-
0.123	0.0176	0.0231	-	0.275	0.1076	0.1235	-
0.126	0.0186	0.025	-	0.282	0.1098	0.1255	-
0.129	0.0196	0.0268	-	0.288	0.112	0.1281	-
0.132	0.0208	0.0283	-	0.295	0.1142	0.1314	-
0.135	0.022	0.0295	-	0.302	0.1165	0.1344	-
0.138	0.0232	0.0302	-	0.309	0.1189	0.1349	-
0.141	0.0246	0.0305	-	0.316	0.1212	0.1318	-
0.145	0.026	0.0305	-	0.324	0.1237	0.1219	1.5%
0.148	0.0275	0.0303	-	0.331	0.1261	0.1329	-
0.151	0.0291	0.0302	-	0.339	0.1287	0.1436	-
0.155	0.0308	0.0305	1.0%	0.347	0.1313	0.1513	-
0.159	0.0326	0.0313	4.2%	0.355	0.1339	0.1573	-
0.162	0.0345	0.033	4.5%	0.363	0.1366	0.1606	-
0.166	0.0365	0.0354	3.1%	0.371	0.1393	0.1622	-
0.17	0.0385	0.0385	-	0.38	0.1421	0.1583	-
0.174	0.0408	0.042	-	0.389	0.145	0.1508	-
0.178	0.0431	0.0453	-	0.398	0.1479	0.1641	-
0.182	0.0457	0.0483	-	0.407	0.1509	0.1779	-
0.186	0.0483	0.0511	-	0.417	0.1539	0.1824	-
0.191	0.051	0.055	-	0.427	0.157	0.1842	-
0.195	0.054	0.059	-	0.436	0.1601	0.1897	-
0.2	0.0571	0.0622	-	0.447	0.1633	0.1956	-
0.204	0.0604	0.065	-	0.457	0.1666	0.1925	-
0.209	0.0639	0.0674	-	0.468	0.1699	0.1756	-
0.214	0.0676	0.07	-	0.479	0.1733	0.1889	-
0.219	0.0715	0.073	-	0.49	0.1768	0.2054	-

Table 3H.6-2d (Continued): Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (E-W Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (E-W)	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (E-W)	Percentage Less than Target
0.5	0.18	0.2133	-	1.096	0.268	0.3131	-
0.501	0.1802	0.2133	-	1.122	0.2712	0.306	-
0.513	0.1823	0.2061	-	1.148	0.2743	0.304	-
0.525	0.1845	0.194	-	1.175	0.2776	0.3014	-
0.537	0.1866	0.2049	-	1.202	0.2808	0.2998	-
0.55	0.1888	0.2104	-	1.23	0.2841	0.3034	-
0.562	0.191	0.2173	-	1.259	0.2874	0.3143	-
0.575	0.1933	0.2228	-	1.288	0.2908	0.3137	-
0.589	0.1956	0.2271	-	1.318	0.2942	0.3295	-
0.603	0.1979	0.2313	-	1.349	0.2977	0.3442	-
0.617	0.2002	0.2354	-	1.38	0.3012	0.3366	-
0.631	0.2025	0.2385	-	1.412	0.3047	0.3276	-
0.646	0.2049	0.2402	-	1.445	0.3083	0.3508	-
0.661	0.2073	0.2402	-	1.479	0.3119	0.3524	-
0.676	0.2097	0.2387	-	1.514	0.3156	0.3555	-
0.692	0.2122	0.2364	-	1.549	0.3193	0.3626	-
0.708	0.2147	0.2353	-	1.585	0.323	0.3688	-
0.724	0.2172	0.237	-	1.622	0.3268	0.3755	-
0.741	0.2198	0.2393	-	1.659	0.3307	0.377	-
0.759	0.2224	0.2429	-	1.698	0.3345	0.3599	-
0.776	0.225	0.2527	-	1.738	0.3385	0.3894	-
0.794	0.2276	0.2595	-	1.778	0.3425	0.3968	-
0.813	0.2303	0.2569	-	1.82	0.3465	0.3994	-
0.832	0.233	0.2622	-	1.862	0.3505	0.4027	-
0.851	0.2357	0.2669	-	1.905	0.3547	0.3804	-
0.871	0.2385	0.2702	-	1.95	0.3588	0.3969	-
0.891	0.2413	0.2711	-	1.995	0.363	0.4157	-
0.912	0.2441	0.2703	-	2.042	0.3673	0.42	-
0.933	0.247	0.2697	-	2.089	0.3716	0.4167	-
0.955	0.2499	0.2664	-	2.138	0.376	0.4158	-
0.977	0.2528	0.2605	-	2.188	0.3804	0.4123	-
1	0.2558	0.2614	-	2.239	0.3848	0.4421	-
1.023	0.2588	0.279	-	2.291	0.3894	0.442	-
1.047	0.2618	0.2846	-	2.344	0.3939	0.4312	-
1.071	0.2649	0.3019	-	2.399	0.3986	0.4344	-

Table 3H.6-2d (Continued): Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (E-W Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (E-W)	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (E-W)	Percentage Less than Target
2.455	0.4032	0.4561	-	5.249	0.3661	0.4155	-
2.5	0.407	0.458	-	5.371	0.3649	0.3992	-
2.512	0.4067	0.4548	-	5.495	0.3637	0.3969	-
2.571	0.4054	0.4526	-	5.624	0.3625	0.4013	-
2.63	0.4041	0.4573	-	5.754	0.3613	0.4031	-
2.692	0.4027	0.4499	-	5.889	0.3602	0.3971	-
2.754	0.4014	0.4415	-	6.024	0.359	0.3893	-
2.818	0.4001	0.437	-	6.165	0.3578	0.3906	-
2.884	0.3988	0.4532	-	6.309	0.3566	0.3964	-
2.952	0.3975	0.4547	-	6.456	0.3555	0.4052	-
3.02	0.3962	0.449	-	6.605	0.3543	0.3992	-
3.09	0.3949	0.4376	-	6.761	0.3531	0.3775	-
3.163	0.3936	0.4301	-	6.92	0.352	0.3885	-
3.236	0.3923	0.4464	-	7.077	0.3508	0.4094	-
3.311	0.391	0.4537	-	7.246	0.3497	0.4119	-
3.389	0.3897	0.4431	-	7.413	0.349	0.4112	-
3.467	0.3884	0.4255	-	7.587	0.347	0.4092	-
3.549	0.3872	0.434	-	7.764	0.346	0.3939	-
3.631	0.3859	0.4236	-	7.943	0.345	0.3753	-
3.715	0.3846	0.4266	-	8.13	0.344	0.3744	-
3.802	0.3834	0.4346	-	8.319	0.343	0.3821	-
3.891	0.3821	0.4275	-	8.511	0.342	0.3825	-
3.981	0.3809	0.416	-	8.711	0.341	0.3792	-
4.073	0.3796	0.4262	-	8.913	0.339	0.3773	-
4.168	0.3784	0.426	-	9.124	0.336	0.3774	-
4.266	0.3771	0.4199	-	9.328	0.33	0.3785	-
4.365	0.3759	0.4244	-	9.551	0.324	0.3648	-
4.466	0.3746	0.4249	-	9.775	0.319	0.3598	-
4.57	0.3734	0.421	-	10	0.314	0.3565	-
4.677	0.3722	0.4029	-	10.235	0.308	0.3522	-
4.787	0.371	0.4141	-	10.471	0.303	0.3331	-
4.897	0.3698	0.4194	-	10.718	0.298	0.3288	-
5	0.3687	0.4188	-	10.965	0.293	0.3356	-
5.013	0.3685	0.4181	-	11.223	0.288	0.324	-
5.128	0.3673	0.4196	-	11.481	0.283	0.3146	-

Table 3H.6-2d (Continued): Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (E-W Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (E-W)	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (E-W)	Percentage Less than Target
11.751	0.278	0.3073	-	25.707	0.1563	0.1683	-
12.019	0.274	0.2985	-	26.316	0.1537	0.1658	-
12.3	0.269	0.2821	-	26.882	0.1511	0.1622	-
12.594	0.265	0.3001	-	27.548	0.1485	0.1599	-
12.887	0.26	0.3014	-	28.169	0.146	0.1643	-
13.175	0.256	0.2846	-	28.818	0.1436	0.1656	-
13.495	0.252	0.2863	-	29.499	0.1412	0.1628	-
13.812	0.247	0.2711	-	30.211	0.1388	0.1631	-
14.124	0.243	0.2659	-	30.864	0.1365	0.1616	-
14.451	0.239	0.2621	-	31.646	0.1342	0.1585	-
14.793	0.235	0.2534	-	32.362	0.1319	0.1542	-
15.129	0.231	0.2577	-	33.113	0.13	0.1496	-
15.48	0.227	0.253	-	33.898	0.13	0.1454	-
15.848	0.223	0.251	-	34.722	0.13	0.1426	-
16.207	0.22	0.2464	-	35.461	0.13	0.1398	-
16.584	0.216	0.2412	-	36.364	0.13	0.1394	-
16.978	0.212	0.2305	-	37.175	0.13	0.1434	-
17.391	0.209	0.2316	-	38.023	0.13	0.1438	-
17.794	0.205	0.2273	-	38.911	0.13	0.1444	-
18.182	0.202	0.2253	-	39.841	0.13	0.143	-
18.622	0.198	0.2368	-	40.816	0.13	0.1419	-
19.048	0.195	0.2353	-	41.667	0.13	0.1428	-
19.493	0.1917	0.2275	-	42.735	0.13	0.1436	-
19.96	0.1884	0.2073	-	43.668	0.13	0.1449	-
20.408	0.1853	0.1903	-	44.643	0.13	0.1399	-
20.877	0.1821	0.1951	-	45.662	0.13	0.1425	-
21.368	0.1791	0.1997	-	46.729	0.13	0.1447	-
21.882	0.176	0.2008	-	47.847	0.13	0.1461	-
22.371	0.1731	0.1974	-	49.02	0.13	0.146	-
22.883	0.1702	0.2031	-	50.251	0.13	0.1454	-
23.419	0.1673	0.1967	-				-
23.981	0.1645	0.1908	-				-
24.57	0.1617	0.1788	-				-
25	0.1595	0.1709	-				-
25.126	0.159	0.1705	-				-

Table 3H.6-2e: Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (N-S Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (N-S)	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (N-S)	Percentage Less than Target
0.1	0.0106	0.0111	-	0.224	0.0757	0.0801	-
0.102	0.0112	0.0121	-	0.229	0.08	0.08	-
0.105	0.0119	0.0133	-	0.234	0.0846	0.0864	-
0.107	0.0126	0.0145	-	0.24	0.0895	0.0916	-
0.11	0.0133	0.0158	-	0.246	0.0947	0.0933	1.5%
0.112	0.014	0.0173	-	0.251	0.0994	0.0981	1.3%
0.115	0.0148	0.0187	-	0.257	0.1014	0.1062	-
0.118	0.0157	0.0203	-	0.263	0.1034	0.1128	-
0.12	0.0166	0.0217	-	0.269	0.1055	0.1168	-
0.123	0.0176	0.0232	-	0.275	0.1076	0.1182	-
0.126	0.0186	0.025	-	0.282	0.1098	0.118	-
0.129	0.0196	0.0277	-	0.288	0.112	0.1189	-
0.132	0.0208	0.0303	-	0.295	0.1142	0.1235	-
0.135	0.022	0.0326	-	0.302	0.1165	0.1265	-
0.138	0.0232	0.0345	-	0.309	0.1189	0.1279	-
0.141	0.0246	0.036	-	0.316	0.1212	0.1294	-
0.145	0.026	0.037	-	0.324	0.1237	0.1342	-
0.148	0.0275	0.0374	-	0.331	0.1261	0.1387	-
0.151	0.0291	0.0374	-	0.339	0.1287	0.1429	-
0.155	0.0308	0.0375	-	0.347	0.1313	0.147	-
0.159	0.0326	0.0373	-	0.355	0.1339	0.1507	-
0.162	0.0345	0.0371	-	0.363	0.1366	0.154	-
0.166	0.0365	0.0369	-	0.371	0.1393	0.1569	-
0.17	0.0385	0.0373	3.2%	0.38	0.1421	0.1592	-
0.174	0.0408	0.0394	3.6%	0.389	0.145	0.1609	-
0.178	0.0431	0.0421	2.4%	0.398	0.1479	0.1621	-
0.182	0.0457	0.0457	-	0.407	0.1509	0.1628	-
0.186	0.0483	0.0502	-	0.417	0.1539	0.163	-
0.191	0.051	0.0557	-	0.427	0.157	0.1748	-
0.195	0.054	0.0617	-	0.436	0.1601	0.1886	-
0.2	0.0571	0.0668	-	0.447	0.1633	0.1903	-
0.204	0.0604	0.0702	-	0.457	0.1666	0.1804	-
0.209	0.0639	0.0708	-	0.468	0.1699	0.1804	-
0.214	0.0676	0.073	-	0.479	0.1733	0.1773	-
0.219	0.0715	0.0782	-	0.49	0.1768	0.1868	-

Table 3H.6-2e (Continued): Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (N-S Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (N-S)	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (N-S)	Percentage Less than Target
0.5	0.18	0.1939	-	1.096	0.268	0.2904	-
0.501	0.1802	0.1948	-	1.122	0.2712	0.2979	-
0.513	0.1823	0.2027	-	1.148	0.2743	0.3035	-
0.525	0.1845	0.2028	-	1.175	0.2776	0.3031	-
0.537	0.1866	0.2029	-	1.202	0.2808	0.3058	-
0.55	0.1888	0.2112	-	1.23	0.2841	0.313	-
0.562	0.191	0.1992	-	1.259	0.2874	0.3161	-
0.575	0.1933	0.2094	-	1.288	0.2908	0.3043	-
0.589	0.1956	0.218	-	1.318	0.2942	0.3225	-
0.603	0.1979	0.2219	-	1.349	0.2977	0.3322	-
0.617	0.2002	0.2257	-	1.38	0.3012	0.3329	-
0.631	0.2025	0.2263	-	1.412	0.3047	0.3266	-
0.646	0.2049	0.2249	-	1.445	0.3083	0.3396	-
0.661	0.2073	0.2251	-	1.479	0.3119	0.3465	-
0.676	0.2097	0.228	-	1.514	0.3156	0.3497	-
0.692	0.2122	0.2327	-	1.549	0.3193	0.3526	-
0.708	0.2147	0.2359	-	1.585	0.323	0.3577	-
0.724	0.2172	0.2348	-	1.622	0.3268	0.3644	-
0.741	0.2198	0.247	-	1.659	0.3307	0.3702	-
0.759	0.2224	0.2383	-	1.698	0.3345	0.3723	-
0.776	0.225	0.2463	-	1.738	0.3385	0.3694	-
0.794	0.2276	0.2468	-	1.778	0.3425	0.365	-
0.813	0.2303	0.2496	-	1.82	0.3465	0.3724	-
0.832	0.233	0.2574	-	1.862	0.3505	0.4028	-
0.851	0.2357	0.2647	-	1.905	0.3547	0.4082	-
0.871	0.2385	0.2705	-	1.95	0.3588	0.4003	-
0.891	0.2413	0.2718	-	1.995	0.363	0.3918	-
0.912	0.2441	0.2646	-	2.042	0.3673	0.393	-
0.933	0.247	0.2701	-	2.089	0.3716	0.4265	-
0.955	0.2499	0.2714	-	2.138	0.376	0.422	-
0.977	0.2528	0.2732	-	2.188	0.3804	0.4103	-
1	0.2558	0.279	-	2.239	0.3848	0.4202	-
1.023	0.2588	0.2851	-	2.291	0.3894	0.4271	-
1.047	0.2618	0.2907	-	2.344	0.3939	0.4331	-
1.071	0.2649	0.294	-	2.399	0.3986	0.4345	-

Table 3H.6-2e (Continued): Comparison of Spectral Accelerations for Target 5%-Damped Spectrum and Synthetic Time History Spectrum (N-S Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (N-S)	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (N-S)	Percentage Less than Target
2.455	0.4032	0.4309	-	5.249	0.3661	0.4074	-
2.5	0.407	0.4462	-	5.371	0.3649	0.4083	-
2.512	0.4067	0.4494	-	5.495	0.3637	0.4079	-
2.571	0.4054	0.4537	-	5.624	0.3625	0.4027	-
2.63	0.4041	0.4421	-	5.754	0.3613	0.3928	-
2.692	0.4027	0.4258	-	5.889	0.3602	0.3905	-
2.754	0.4014	0.4424	-	6.024	0.359	0.3932	-
2.818	0.4001	0.4351	-	6.165	0.3578	0.3929	-
2.884	0.3988	0.4337	-	6.309	0.3566	0.3938	-
2.952	0.3975	0.445	-	6.456	0.3555	0.3905	-
3.02	0.3962	0.4484	-	6.605	0.3543	0.3839	-
3.09	0.3949	0.4447	-	6.761	0.3531	0.3916	-
3.163	0.3936	0.4247	-	6.92	0.352	0.3922	-
3.236	0.3923	0.4246	-	7.077	0.3508	0.3964	-
3.311	0.391	0.4452	-	7.246	0.3497	0.3951	-
3.389	0.3897	0.4372	-	7.413	0.349	0.3768	-
3.467	0.3884	0.4171	-	7.587	0.347	0.375	-
3.549	0.3872	0.4115	-	7.764	0.346	0.38	-
3.631	0.3859	0.428	-	7.943	0.345	0.3788	-
3.715	0.3846	0.425	-	8.13	0.344	0.3709	-
3.802	0.3834	0.4256	-	8.319	0.343	0.386	-
3.891	0.3821	0.4153	-	8.511	0.342	0.3889	-
3.981	0.3809	0.4184	-	8.711	0.341	0.3783	-
4.073	0.3796	0.4156	-	8.913	0.339	0.3706	-
4.168	0.3784	0.4101	-	9.124	0.336	0.3642	-
4.266	0.3771	0.4034	-	9.328	0.33	0.3599	-
4.365	0.3759	0.4171	-	9.551	0.324	0.359	-
4.466	0.3746	0.4159	-	9.775	0.319	0.3422	-
4.57	0.3734	0.4077	-	10	0.314	0.344	-
4.677	0.3722	0.4088	-	10.235	0.308	0.3423	-
4.787	0.371	0.4147	-	10.471	0.303	0.3321	-
4.897	0.3698	0.4036	-	10.718	0.298	0.3252	-
5	0.3687	0.3998	-	10.965	0.293	0.3213	-
5.013	0.3685	0.4018	-	11.223	0.288	0.3137	-
5.128	0.3673	0.4093	-	11.481	0.283	0.3232	-

Table 3H.6-2e (Continued): Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (N-S Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (N-S)	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History – (N-S)	Percentage Less than Target
11.751	0.278	0.3143	-	25.707	0.1563	0.1846	-
12.019	0.274	0.3016	-	26.316	0.1537	0.1887	-
12.3	0.269	0.2917	-	26.882	0.1511	0.1815	-
12.594	0.265	0.2816	-	27.548	0.1485	0.1703	-
12.887	0.26	0.2812	-	28.169	0.146	0.1643	-
13.175	0.256	0.2844	-	28.818	0.1436	0.1599	-
13.495	0.252	0.2854	-	29.499	0.1412	0.1563	-
13.812	0.247	0.2787	-	30.211	0.1388	0.1556	-
14.124	0.243	0.2722	-	30.864	0.1365	0.1554	-
14.451	0.239	0.2643	-	31.646	0.1342	0.1549	-
14.793	0.235	0.2558	-	32.362	0.1319	0.1553	-
15.129	0.231	0.2519	-	33.113	0.13	0.1548	-
15.48	0.227	0.2476	-	33.898	0.13	0.1538	-
15.848	0.223	0.2449	-	34.722	0.13	0.1529	-
16.207	0.22	0.2422	-	35.461	0.13	0.1517	-
16.584	0.216	0.2401	-	36.364	0.13	0.1506	-
16.978	0.212	0.2359	-	37.175	0.13	0.1501	-
17.391	0.209	0.2288	-	38.023	0.13	0.1502	-
17.794	0.205	0.2221	-	38.911	0.13	0.1505	-
18.182	0.202	0.2195	-	39.841	0.13	0.1502	-
18.622	0.198	0.2181	-	40.816	0.13	0.1502	-
19.048	0.195	0.2124	-	41.667	0.13	0.1499	-
19.493	0.1917	0.2048	-	42.735	0.13	0.1493	-
19.96	0.1884	0.1989	-	43.668	0.13	0.1491	-
20.408	0.1853	0.2104	-	44.643	0.13	0.1489	-
20.877	0.1821	0.2076	-	45.662	0.13	0.1485	-
21.368	0.1791	0.2035	-	46.729	0.13	0.1483	-
21.882	0.176	0.2014	-	47.847	0.13	0.1482	-
22.371	0.1731	0.1952	-	49.02	0.13	0.1482	-
22.883	0.1702	0.1882	-	50.251	0.13	0.148	-
23.419	0.1673	0.184	-				-
23.981	0.1645	0.1778	-				-
24.57	0.1617	0.1704	-				-
25	0.1595	0.1742	-				-
25.126	0.159	0.1767	-				-

Table 3H.6-2f: Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (Vertical Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History –V1	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History –V1	Percentage Less than Target
0.1	0.0071	0.0101	-	0.224	0.0506	0.0534	-
0.102	0.0075	0.0108	-	0.229	0.0535	0.0552	-
0.105	0.0079	0.0115	-	0.234	0.0566	0.0582	-
0.107	0.0084	0.0123	-	0.24	0.0599	0.0617	-
0.11	0.0088	0.0129	-	0.246	0.0633	0.0652	-
0.112	0.0094	0.0135	-	0.251	0.0665	0.0683	-
0.115	0.0099	0.0141	-	0.257	0.068	0.071	-
0.118	0.0105	0.0146	-	0.263	0.0695	0.073	-
0.12	0.0111	0.0149	-	0.269	0.0711	0.0778	-
0.123	0.0117	0.0152	-	0.275	0.0727	0.0822	-
0.126	0.0124	0.0154	-	0.282	0.0744	0.0847	-
0.129	0.0131	0.016	-	0.288	0.0761	0.0845	-
0.132	0.0139	0.0166	-	0.295	0.0778	0.0812	-
0.135	0.0147	0.0173	-	0.302	0.0796	0.0854	-
0.138	0.0155	0.018	-	0.309	0.0814	0.0895	-
0.141	0.0164	0.0184	-	0.316	0.0832	0.0921	-
0.145	0.0174	0.0186	-	0.324	0.0851	0.0932	-
0.148	0.0184	0.0186	-	0.331	0.087	0.0935	-
0.151	0.0194	0.0195	-	0.339	0.089	0.0939	-
0.155	0.0206	0.0206	-	0.347	0.091	0.0959	-
0.159	0.0217	0.0222	-	0.355	0.0931	0.099	-
0.162	0.023	0.0236	-	0.363	0.0952	0.103	-
0.166	0.0243	0.0249	-	0.371	0.0974	0.1069	-
0.17	0.0257	0.026	-	0.38	0.0996	0.109	-
0.174	0.0272	0.0272	-	0.389	0.1018	0.1092	
0.178	0.0288	0.0287	0.35%	0.398	0.1041	0.1096	-
0.182	0.0305	0.0305	-	0.407	0.1065	0.1124	-
0.186	0.0322	0.0327	-	0.417	0.1089	0.1183	-
0.191	0.0341	0.0354	-	0.427	0.1114	0.1238	-
0.195	0.0361	0.0385	-	0.436	0.1139	0.1264	-
0.2	0.0381	0.0418	-	0.447	0.1165	0.129	-
0.204	0.0404	0.0452	-	0.457	0.1191	0.1269	-
0.209	0.0427	0.0481	-	0.468	0.1218	0.1199	1.58%
0.214	0.0452	0.0506	-	0.479	0.1246	0.1203	3.57%
0.219	0.0478	0.0524	-	0.49	0.1274	0.1376	-

Table 3H.6-2f (Continued): Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (Vertical Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History –V1	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History –V1	Percentage Less than Target
0.5	0.13	0.1467	-	1.096	0.2019	0.2192	-
0.501	0.1302	0.1473	-	1.122	0.2045	0.2209	-
0.513	0.1319	0.1506	-	1.148	0.2072	0.2163	-
0.525	0.1336	0.1484	-	1.175	0.2099	0.2277	-
0.537	0.1353	0.138	-	1.202	0.2126	0.2264	-
0.55	0.1371	0.1486	-	1.23	0.2154	0.229	-
0.562	0.1388	0.1578	-	1.259	0.2182	0.238	-
0.575	0.1407	0.1568	-	1.288	0.221	0.2453	-
0.589	0.1425	0.1451	-	1.318	0.2239	0.2505	-
0.603	0.1443	0.1558	-	1.349	0.2268	0.2532	-
0.617	0.1462	0.1615	-	1.38	0.2297	0.2529	-
0.631	0.1481	0.1624	-	1.412	0.2327	0.2504	-
0.646	0.15	0.1613	-	1.445	0.2357	0.2466	-
0.661	0.152	0.1599	-	1.479	0.2388	0.2494	-
0.676	0.154	0.1597	-	1.514	0.2419	0.2577	-
0.692	0.156	0.1632	-	1.549	0.245	0.2626	-
0.708	0.158	0.1774	-	1.585	0.2482	0.2612	-
0.724	0.16	0.1746	-	1.622	0.2514	0.263	-
0.741	0.1621	0.1669	-	1.659	0.2547	0.2671	-
0.759	0.1642	0.1656	-	1.698	0.258	0.2677	-
0.776	0.1663	0.1654	0.54%	1.738	0.2614	0.271	-
0.794	0.1685	0.169	-	1.778	0.2648	0.2946	-
0.813	0.1707	0.1762	-	1.82	0.2682	0.2794	-
0.832	0.1729	0.1823	-	1.862	0.2717	0.2976	-
0.851	0.1752	0.19	-	1.905	0.2752	0.3047	-
0.871	0.1775	0.192	-	1.95	0.2788	0.2924	-
0.891	0.1798	0.1986	-	1.995	0.2824	0.3099	-
0.912	0.1821	0.1913	-	2.042	0.2861	0.3248	-
0.933	0.1845	0.2081	-	2.089	0.2898	0.3319	-
0.955	0.1868	0.205	-	2.138	0.2936	0.3319	-
0.977	0.1893	0.1905	-	2.188	0.2974	0.3102	-
1	0.1917	0.2056	-	2.239	0.3012	0.3101	-
1.023	0.1942	0.2134	-	2.291	0.3052	0.3294	-
1.047	0.1967	0.2171	-	2.344	0.3091	0.337	-
1.071	0.1993	0.2166	-	2.399	0.3131	0.335	-

Table 3H.6-2f (Continued): Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (Vertical Time History)

Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History –V1	Percentage Less than Target	Frequency (Hz)	Target Spectral Acceleration	Spectral Acceleration from Time History –V1	Percentage Less than Target
2.455	0.3172	0.3366	-	5.249	0.3656	0.3918	-
2.5	0.3205	0.3425	-	5.371	0.3645	0.387	-
2.512	0.3213	0.3443	-	5.495	0.3633	0.3886	-
2.571	0.3255	0.3509	-	5.624	0.3621	0.396	-
2.63	0.3297	0.3536	-	5.754	0.3609	0.3873	-
2.692	0.334	0.3613	-	5.889	0.3598	0.3866	-
2.754	0.3384	0.367	-	6.024	0.3586	0.4048	-
2.818	0.3427	0.3586	-	6.165	0.3575	0.406	-
2.884	0.3472	0.3755	-	6.309	0.3563	0.4029	-
2.952	0.3517	0.3927	-	6.456	0.3552	0.3828	-
3.02	0.3563	0.3983	-	6.605	0.354	0.3716	-
3.09	0.3609	0.3991	-	6.761	0.3529	0.3809	-
3.163	0.3656	0.4006	-	6.92	0.3517	0.3851	-
3.236	0.3703	0.4073	-	7.077	0.3506	0.3867	-
3.311	0.3752	0.4222	-	7.246	0.3495	0.3685	-
3.389	0.38	0.4347	-	7.413	0.348	0.3488	-
3.467	0.385	0.4162	-	7.587	0.347	0.3884	-
3.549	0.3863	0.3931	-	7.764	0.346	0.3934	-
3.631	0.385	0.419	-	7.943	0.345	0.3712	-
3.715	0.3838	0.4216	-	8.13	0.344	0.367	-
3.802	0.3825	0.4112	-	8.319	0.343	0.3804	-
3.891	0.3813	0.4072	-	8.511	0.342	0.3669	-
3.981	0.3801	0.3966	-	8.711	0.341	0.3589	-
4.073	0.3788	0.4033	-	8.913	0.339	0.3563	-
4.168	0.3776	0.4212	-	9.124	0.336	0.3603	-
4.266	0.3764	0.4112	-	9.328	0.33	0.3554	-
4.365	0.3752	0.3923	-	9.551	0.324	0.347	-
4.466	0.374	0.3998	-	9.775	0.319	0.3497	-
4.57	0.3728	0.4	-	10	0.314	0.3288	-
4.677	0.3716	0.4118	-	10.235	0.308	0.3309	-
4.787	0.3704	0.4134	-	10.471	0.303	0.3334	-
4.897	0.3692	0.3894	-	10.718	0.298	0.3315	-
5	0.3681	0.395	-	10.965	0.293	0.325	-
5.013	0.368	0.3967	-	11.223	0.288	0.3163	-
5.128	0.3668	0.3969	-	11.481	0.283	0.3117	-

Table 3H.6-2f (Continued): Comparison of Spectral Accelerations for Target 5% Damped Spectrum and Synthetic Time History Spectrum (Vertical Time History)

Frequency (Hz)	Design Spectral Acceleration	Spectral Acceleration from Time History –V1	Percentage Less than Target	Frequency (Hz)	Design Spectral Acceleration	Spectral Acceleration from Time History –V1	Percentage Less than Target
11.751	0.278	0.2999	-	25.707	0.1563	0.1818	-
12.019	0.274	0.2913	-	26.316	0.1537	0.1875	-
12.3	0.269	0.2869	-	26.882	0.1511	0.1815	-
12.594	0.265	0.2927	-	27.548	0.1485	0.1748	-
12.887	0.26	0.2874	-	28.169	0.146	0.16	-
13.175	0.256	0.275	-	28.818	0.1436	0.1496	-
13.495	0.252	0.2691	-	29.499	0.1412	0.1518	-
13.812	0.247	0.259	-	30.211	0.1388	0.1547	-
14.124	0.243	0.2489	-	30.864	0.1365	0.1535	-
14.451	0.239	0.25	-	31.646	0.1342	0.1592	-
14.793	0.235	0.2586	-	32.362	0.1319	0.1541	-
15.129	0.231	0.2559	-	33.113	0.13	0.1483	-
15.48	0.227	0.2509	-	33.898	0.13	0.143	-
15.848	0.223	0.2382	-	34.722	0.13	0.1367	-
16.207	0.22	0.2358	-	35.461	0.13	0.1336	-
16.584	0.216	0.239	-	36.364	0.13	0.1332	-
16.978	0.212	0.2318	-	37.175	0.13	0.1362	-
17.391	0.209	0.22	-	38.023	0.13	0.1393	-
17.794	0.205	0.2173	-	38.911	0.13	0.1423	-
18.182	0.202	0.2192	-	39.841	0.13	0.1447	-
18.622	0.198	0.2165	-	40.816	0.13	0.1461	-
19.048	0.195	0.2141	-	41.667	0.13	0.1425	-
19.493	0.1917	0.2073	-	42.735	0.13	0.1389	-
19.96	0.1884	0.2038	-	43.668	0.13	0.1358	-
20.408	0.1853	0.2047	-	44.643	0.13	0.1318	-
20.877	0.1821	0.2039	-	45.662	0.13	0.1332	-
21.368	0.1791	0.2043	-	46.729	0.13	0.1337	-
21.882	0.176	0.1998	-	47.847	0.13	0.1338	-
22.371	0.1731	0.1925	-	49.02	0.13	0.1341	-
22.883	0.1702	0.1813	-	50.251	0.13	0.1346	-
23.419	0.1673	0.175	-				-
23.981	0.1645	0.165	-				-
24.57	0.1617	0.169	-				-
25	0.1595	0.1752	-				-
25.126	0.159	0.1783	-				-

RAI 03.07.01-16

QUESTION:

(Follow-up Question to RAI 03.07.01-3)

1. The applicant is requested to clarify whether CSDRS is the same as DCD SSE design spectra.

2. In item 2 of the response to RAI 03.07.01-3 regarding FIRS, the applicant states that, "—***the Foundation Input Response Spectra (FIRS) were developed using the same probabilistic models and analyses which were used for developing the Ground Motion Response Spectra (GMRS). A detailed description of the seismic wave transmission of the site, and the procedure to develop the GMRS, which are the same for the development of the FIRS, are provided in COLA Part 2, Tier 2, Sections 2.5S.2.5 and 2.5S.2.6, respectively***." Because Section 2.5S2 covers the development of the GMRS and not FIRS, it is not clear how FIRS was calculated from the site response soil column. As such, the applicant is requested to further provide information on the development of FIRS, more specifically, clarify whether FIRS at the foundation of Category I structures is developed as "SHAKE Outcrop" or "Geologic Outcrop."

RESPONSE:

1. The certified seismic design response spectra (CSDRS) are the same as DCD safe-shutdown earthquake (SSE) design spectra.

2. The foundation input response spectra (FIRS) are calculated using the same rock motions and the simulated (randomized) profiles for the full height soil column model used in calculating the GMRS, propagating the motion from bedrock to finished ground surface. The GMRS is calculated from the soil column responses at the finished ground surface level and the FIRS are calculated at the foundation levels of the structures as "SHAKE Outcrop" responses.

Please also see the response to RAI 03.07.01-19, Item 3, which provides additional information on the use of P-SHAKE and SHAKE programs.

COLA Part 2, Tier 2, Section 2.5S.2.6 will be revised to add the following paragraph at the end of the Section.

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

RAI 03.07.01-17

QUESTION:

(Follow-up Question to RAI 03.07.01-4)

1. In the response to RAI 03.07.01-4, the applicant stated that SSI analysis is described in Appendix 3A, as enclosed in the response to RAI 03.07.01-2. Section 3A.15 of this Appendix states, "***The backfill used along the walls of the structure will be granular soil compacted to 95% Modified Proctor. Based on this, the backfill modulus and damping values were calculated to lie between the upper bound and lower bound in situ soil properties, shown in Table 3H.6-1. Therefore, the effect of the backfill is considered to be bounded by the variation in soil properties used in the analysis.***" It is not clear whether the backfill properties used in the SSI confirmatory analysis of the RB and CB are the same as those shown in Table 3H.6-2. In addition, the method used to select the backfill strain-compatible material properties is not described. As such, the applicant is requested to provide the following:

   a. Backfill material properties used for the confirmatory SSI analysis of the RB and CB, if they are different from those listed in Table 3H.6-2. Provide the basis for selecting the backfill properties and describe how the backfill properties will be verified during construction.

   b. Plots showing that the strain-compatible shear modulus and damping properties of the backfill material are bounded by the lower-bound and upper-bound in-situ soil properties. This information should be included in the FSAR.

2. In the response to RAI 03.07.01-2, Appendix 3A.15 states, "***Based on the site groundwater conditions described in FSAR Subsection 2.4S.12, the groundwater elevation of approximately eight feet below grade was used in the analysis to determine the soil properties.***" In addition to the location of the groundwater table, the applicant is requested to describe how the groundwater effects on the soil properties are treated in the confirmatory SSI analysis. This information should be included in the FSAR.

3. The applicant references the tables and figures as enclosed in the response to RAI 03.07.01-2, which contains composite SSI models of RB and CB in Figures 3A-264 and 3A-266. In response to RAI 03.08.04-5, the applicant stated that "***The Reactor Building and the Control Building will be founded on structural concrete fill.***" As such, the applicant is requested to confirm whether the composite SSI model consists of the concrete backfill material and Table 3H.6-2 includes the corresponding concrete backfill properties. If the concrete backfill was not included in the composite SSI model the applicant is requested to provide justification.

RESPONSE:

1a. The method used to calculate the strain-compatible backfill properties is described in response to RAI 03.07.02-17, Part 3. Please refer to the response to RAI 02.05.04-33 (submitted with letter number U7-C-STP-NRC-100012 dated January 21, 2010) for explanation of how the backfill properties will be verified during construction.

1b. Based on the calculated strain-compatible backfill properties, enclosed Figure 3A-230a presents a comparison of the strain compatible backfill shear wave velocities (from revised Table 3H.6-2, attached with the response to RAI 03.07.02-17, Part 3), strain compatible in-situ soil shear wave velocities (from Table 3H.6-1), and strain compatible shear wave velocities for the UB1D150 case from the ABWR DCD, Appendix 3A. Similarly, enclosed Figure 3A-230b shows a comparison between the backfill damping profile and in-situ soil damping profile.

For Figure 3A-230a, the strain-compatible soil properties for DCD – UB1D150 case were obtained from the free-field response analysis of the UB soil profile provided in Table 3A-2 of the DCD. The free-field response analysis was performed using strain-dependent shear modulus and damping values provided in DCD Tables 3A-3 and 3A-4, respectively. The DCD soil profile was analyzed using two time histories, each compatible with the 0.3g Regulatory Guide R.G. 1.60 response spectra, applied at the ground surface. The strain compatible soil properties for the DCD – UB1D150 case, shown in Figure 3A-230a, are an average of the strain compatible soil properties obtained from these two analyses. The free-field response analysis was performed using computer program SHAKE.

Based on the comparisons shown in Figures 3A-230a and 3A-230b, the following is concluded:

- The lower bound backfill shear wave velocities are, in general, higher than, and therefore bounded by the lower bound in-situ soil properties (Figure 3A-230a). A small variation to this observation in the upper few feet and lower few feet is not significant in light of the overall trend of the comparison over the entire 90 feet depth of the backfill. Therefore, the SSI analysis performed for the lower bound in-situ soil properties bounds the higher properties of the backfill material.

- The upper bound backfill shear wave velocities are, in general, higher than the upper bound in-situ soil shear wave velocities (Figure 3A-230a). Therefore, the SSI analysis performed for the upper bound in-situ soil properties does not bound the lower bound properties of the backfill. However, the upper bound backfill shear wave velocity case is enveloped by the DCD Soil Profiles. This conclusion is based on the observation that the DCD Case UB1D150, which is the lowest shear wave velocity case in the DCD, used lower shear wave velocity than the upper bound backfill soil case (Figure 3A-230a). Variation to this observation in the upper few feet is not significant in light of the overall trend of the comparison over the entire 90 feet depth of the backfill. Since the DCD soil profile was used for the Reactor and Control Buildings design, it is concluded that a separate analysis including the upper bound backfill shear wave velocity is not required.

- The damping values for lower bound, mean, and upper bound in-situ soil profiles are in general lower than the damping values for the corresponding lower bound, mean, and upper bound backfill profiles.

Based on the above, it is concluded that the strain-compatible shear modulus and damping properties of the backfill material are bounded by the lower-bound and upper-bound in-situ soil properties (or the DCD soil properties in case of upper bound shear modulus).

2. The groundwater effect was included in the analysis by modifying the compression wave velocity, V_P, such that it is not less than 5000 ft/sec, except where Poisson's ratio, ν, calculated from the following Equation (1) is higher than 0.48. In those cases, ν is set to the maximum value of 0.48 and V_P is re-calculated using Equation (2). This information will be included in a future revision of the STP Units 3 and 4 FSAR as indicated below.

$$\nu = \frac{1}{2}\frac{(5000/V_S)^2-2}{(5000/V_S)^2-1} \le 0.48$$ Equation (1)

$$V_P = V_S\sqrt{\frac{2-2\nu}{1-2\nu}}$$ Equation (2)

3. The SSI model for the confirmatory analysis of the Reactor and Control Buildings did not include the concrete fill; the basemat was modeled as directly supported by the in-situ soil. The analysis was based on the standard plant models of the Reactor and Control Buildings as described in the DCD, with the use of site-specific soil properties and site-specific earthquake. Given the large margin between the site-specific in-structure response spectra and forces obtained from the analysis and DCD spectra and forces, as presented in Appendix 3A (see Supplement 1 to the Response to RAI 03.07.01-2 submitted with Letter U7-C-STP-NRC-090153 dated September 22, 2009), modeling the in-situ soil vs. concrete fill has no significant effect on the conclusion of the analysis, i.e., the site-specific responses are bounded by the DCD responses. In the SSI model, ten feet of in-situ soil has been modeled in place of concrete fill. In a model which includes approximately 450 to 500 feet of soil and a massive Reactor or Control Building, with a very stiff basemat, the difference in mass and stiffness of 10 feet of concrete fill vs. in-situ soil will not have a significant effect on the response of the structures, and these responses will still be bounded by the DCD responses with a significant margin. It should also be noted that the as-built analysis and design of the Reactor and Control Buildings will account for the concrete fill.

The STP Units 3 and 4 COLA will be revised as follows as a result of this response.

1. Attached Figures 3A-230a and 3A-230b will be added.

2. Section 3A.15 will be revised as follows:

3A.15 Site Conditions

SSI analyses were performed using the STP 3 & 4 site-specific soil properties. Both RB and CB are founded on in situ soil. Soil backfill is used only adjacent to the walls. The site-specific shear wave velocities are provided in FSAR Table 2.5S.4-27.

The strain-compatible soil properties for the SSI model were obtained from the same models and ground response analysis which were used to develop the GMRS, as described in Section 2.5S.25. A set of mean strain-compatible shear wave velocity and damping values, along with the associated standard deviations, was calculated. The calculated properties and associated standard deviations were used to develop the best estimate (BE), upper bound (UB), and lower bound (LB) profiles. While the BE profile is the mean profile, the UB and LB profiles are the mean +/- one standard deviation , respectively, maintaining the minimum variation of 1.5 on soil shear modulus, per the guidance provided in SRP 3.7.2. The corresponding compression wave velocity (VP) profiles were calculated using the shear wave velocity and the Poisson's ratio. The resulting strain-compatible properties for the three profiles are presented in Table 3H.6-1. ~~Based on these analyses, mean and standard deviation of strain-compatible soil properties were developed. For the SSI analysis, three sets of soil properties were used (i.e., mean, upper bound, and lower bound), and the responses from the three analyses were enveloped. The upper bound and lower bound properties were based on varying the mean properties by one standard deviation. Table 3H.6-1 shows the unit weight, shear wave velocity, compression wave velocity, and damping values of various soil layers used in the SSI analysis for the mean, upper bound and lower bound cases.~~ The backfill used along the walls of the structure will be granular soil compacted to 95% Modified Proctor. Based on this, the backfill modulus and damping values were calculated as described in Section 3H.6.5.2.4. Based on the following analysis, it was concluded that ~~to lie between the upper bound and lower bound in situ soil properties, shown in Table 3H.6-1. Therefore,~~ the effect of the backfill is considered to be bounded by the variation in soil properties used in the analysis.

Based on the calculated strain-compatible backfill properties, as explained in Section 3H.6.5.2.4, Figure 3A-230a presents a comparison of the strain compatible backfill shear wave velocities (from Table 3H.6-2), strain compatible in-situ soil shear wave velocities (from Table 3H.6-1), and strain compatible shear wave velocities for the UB1D150 case from DCD, Appendix 3A. Similarly, Figure 3A-230b shows a comparison between the backfill damping profile and in-situ soil damping profile.

For Figure 3A-230a, the strain-compatible soil properties for DCD – UB1D150 case were obtained from the free-field response analysis of the UB soil profile provided in Table 3A-2 of the DCD. The free-field response analysis was performed using strain-dependent shear modulus and damping values provided in DCD Tables 3A-3 and 3A-4.

respectively. The DCD soil profile was analyzed using two time histories, each compatible with the 0.3g Regulatory Guide R.G. 1.60 response spectra, applied at the ground surface. The strain compatible soil properties for the DCD – UB1D150 case, shown in Figure 3A-230a, are an average of the strain compatible soil properties obtained from these two analyses. The free-field response analysis was performed using computer program SHAKE.

Based on the comparisons shown in Figures 3A-230a and 3A-230b, the following is concluded:

- The lower bound backfill shear wave velocities are, in general, higher than the lower bound in-situ soil properties (Figure 3A-230a). A small variation to this observation in the upper few feet and lower few feet is not significant in light of the overall trend of the comparison over the entire depth of the backfill. Therefore, the SSI analysis performed for the lower bound in-situ soil properties bounds the higher properties of the backfill material.

- The upper bound backfill shear wave velocities are, in general, higher than the upper bound in-situ soil shear wave velocities (Figure 3A-230a). Therefore, the SSI analysis performed for the upper bound in-situ soil properties does not bound the lower bound properties of the backfill. However, the upper bound backfill shear wave velocity case is enveloped by the DCD Soil Profiles. This conclusion is based on the observation that the DCD Case UB1D150, which is the lowest shear wave velocity case in the DCD, used lower shear wave velocity than the upper bound backfill soil case (Figure 3A-230a). Variation to this observation in the upper few feet is not significant in light of the overall trend of the comparison over the entire depth of the backfill. Since the DCD soil profile was used for the Reactor and Control Buildings design, it is concluded that a separate analysis including the upper bound backfill shear wave velocity is not required.

- The damping values for lower bound, mean and upper bound in-situ soil profiles are in general lower than the damping values for the corresponding lower bound, mean and upper bound backfill profiles.

Based on the above it is concluded that the strain-compatible shear modulus and damping properties of the backfill material are bounded by the lower-bound and upper-bound in-situ soil properties (or the DCD soil properties in case of upper bound shear modulus).

Based on the site groundwater conditions described in FSAR Subsection 2.4S.12, the groundwater elevation of approximately eight feet below grade was used in the analysis to determine the soil properties.

The groundwater effect was included in the analysis by modifying the compression wave velocity, V_P, such that it is not less than 5000 ft/sec, except where Poisson's ratio, ν, calculated from the following Equation (1) is higher than 0.48. In those cases, ν is set to the maximum value of 0.48 and V_P is re-calculated using Equation (2).

$$\nu = \frac{1}{2}\frac{(5000/V_S)^2 - 2}{(5000/V_S)^2 - 1} \leq 0.48 \qquad \text{Equation (1)}$$

$$V_P = V_S\sqrt{\frac{2-2\nu}{1-2\nu}} \qquad \text{Equation (2)}$$

3. The last paragraph of COLA Tier 2 Section 3A.16.2 will be revised to refer to Figures 3H.6-12 through 3H.6-14 as shown below, and Figures 3A-260 through 3A-262 will be deleted since the same information is included in COLA Figures 3H.6-12 through 3H.6-14.

   Figures 3H.6-12 through 3H.6-14 show the comparison of the response spectra for the synthetic time history, the Input Spectrum, and 1.3 times the Input Spectrum, in the two horizontal and vertical directions for 5% damping.

Enclosure to Response to RAI 03.07.01-17

Figures 3A-230a and 3A-230b will be added to COLA
Figures 3A-260 through 3A-262 will be deleted from COLA

Figure 3A-230a: Comparison of Strain-Compatible Shear Wave Velocity Profiles for Backfill

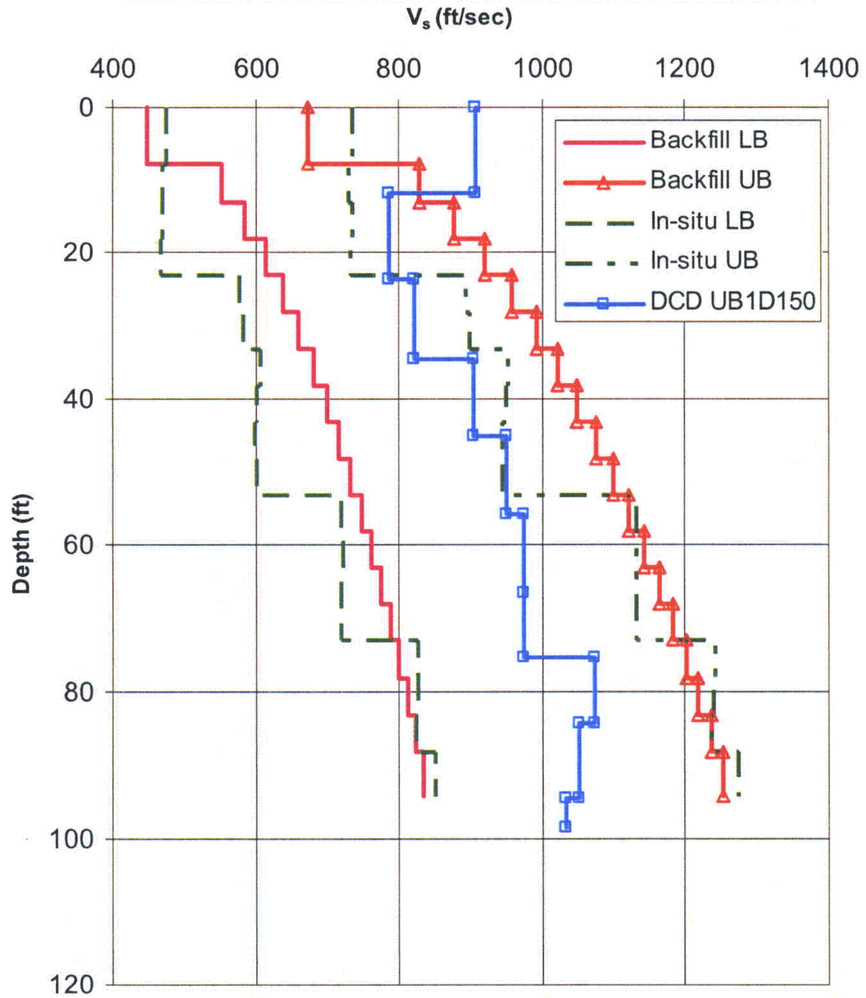
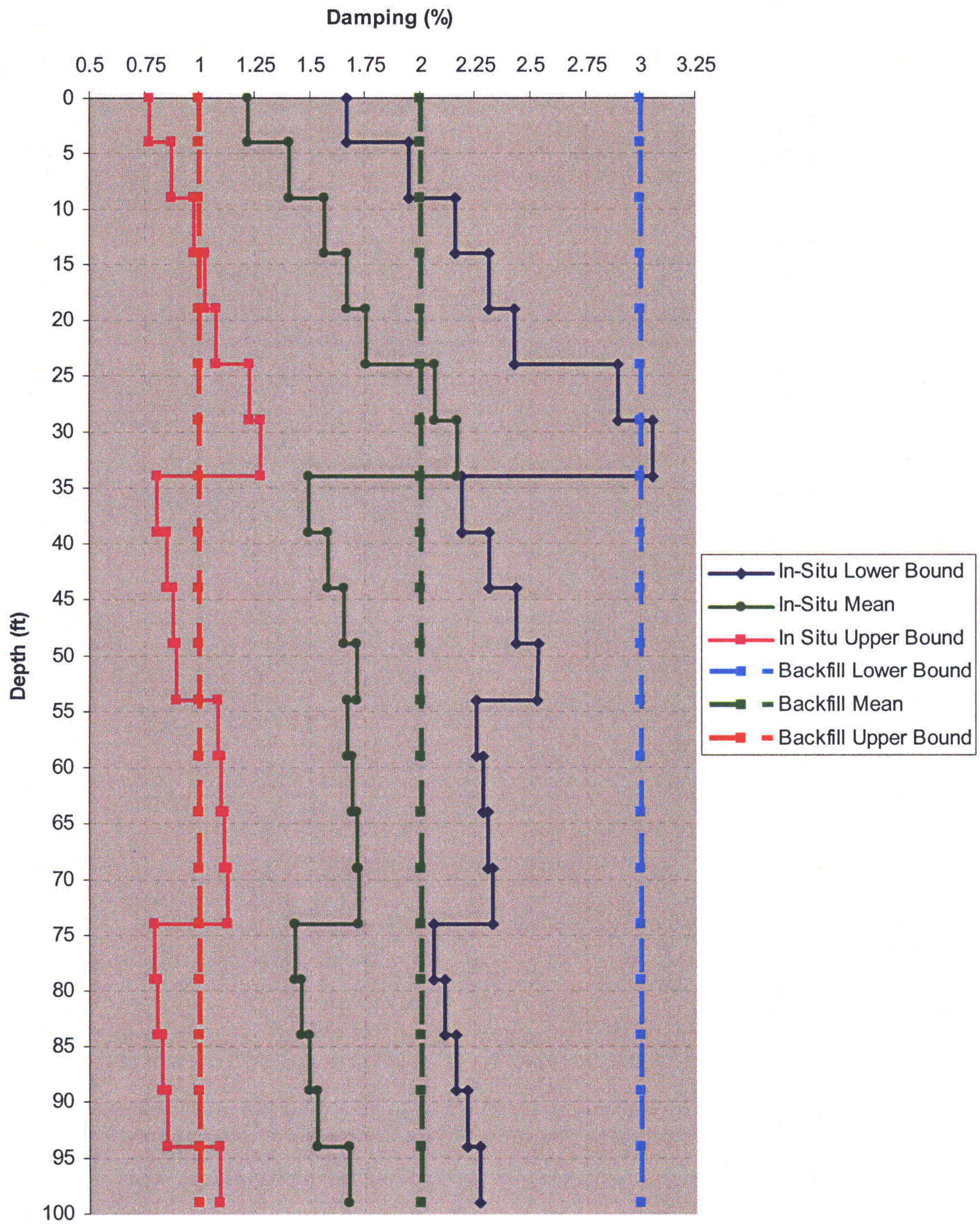


Figure 3A-230b: Comparison of Strain-Compatible Dampaing Profile for Backfill



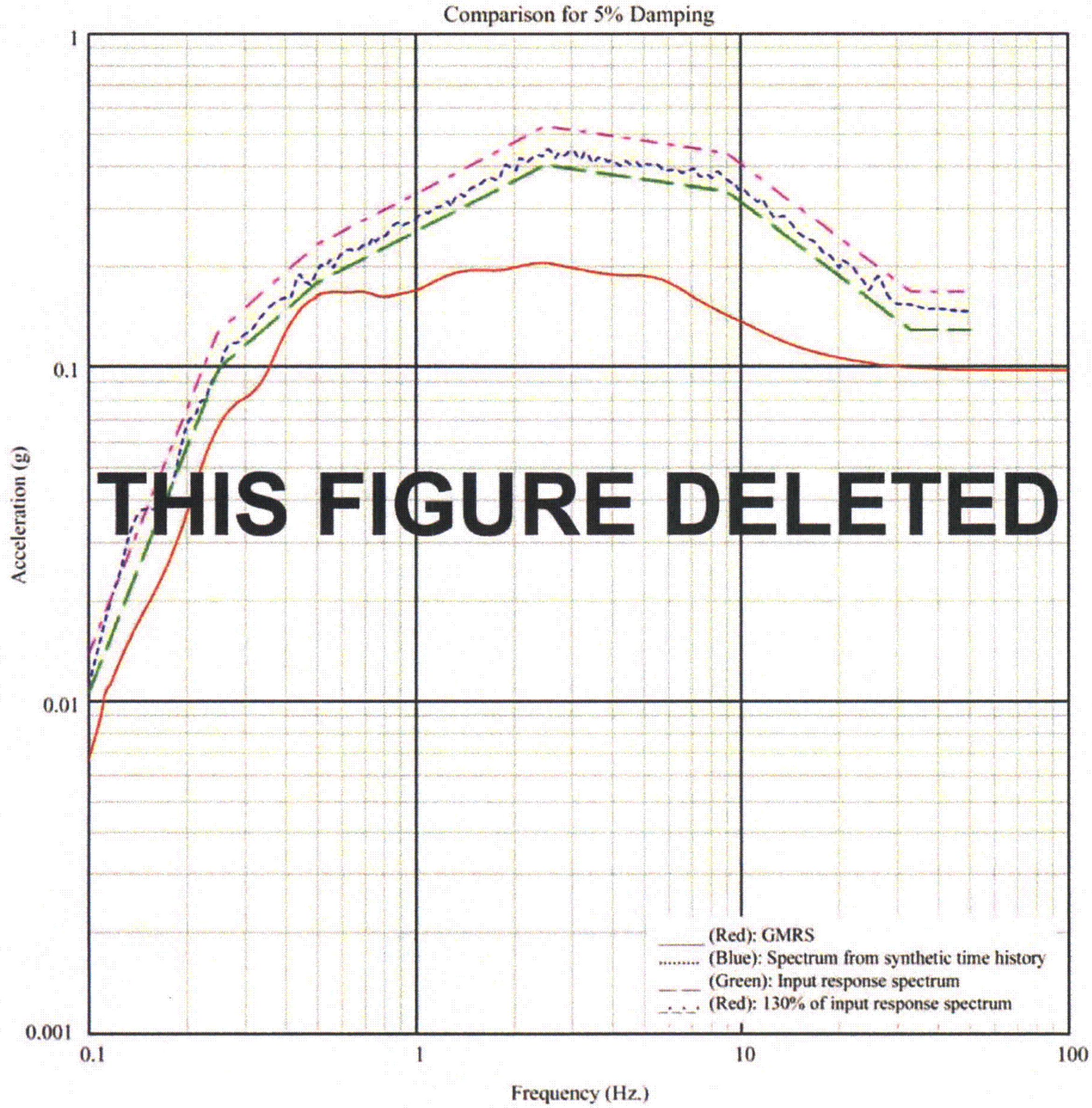


Figure 3A-260 ~~**Comparison of GMRS with Spectrum from Synthetic Time History (X Direction)**~~ **Not Used**

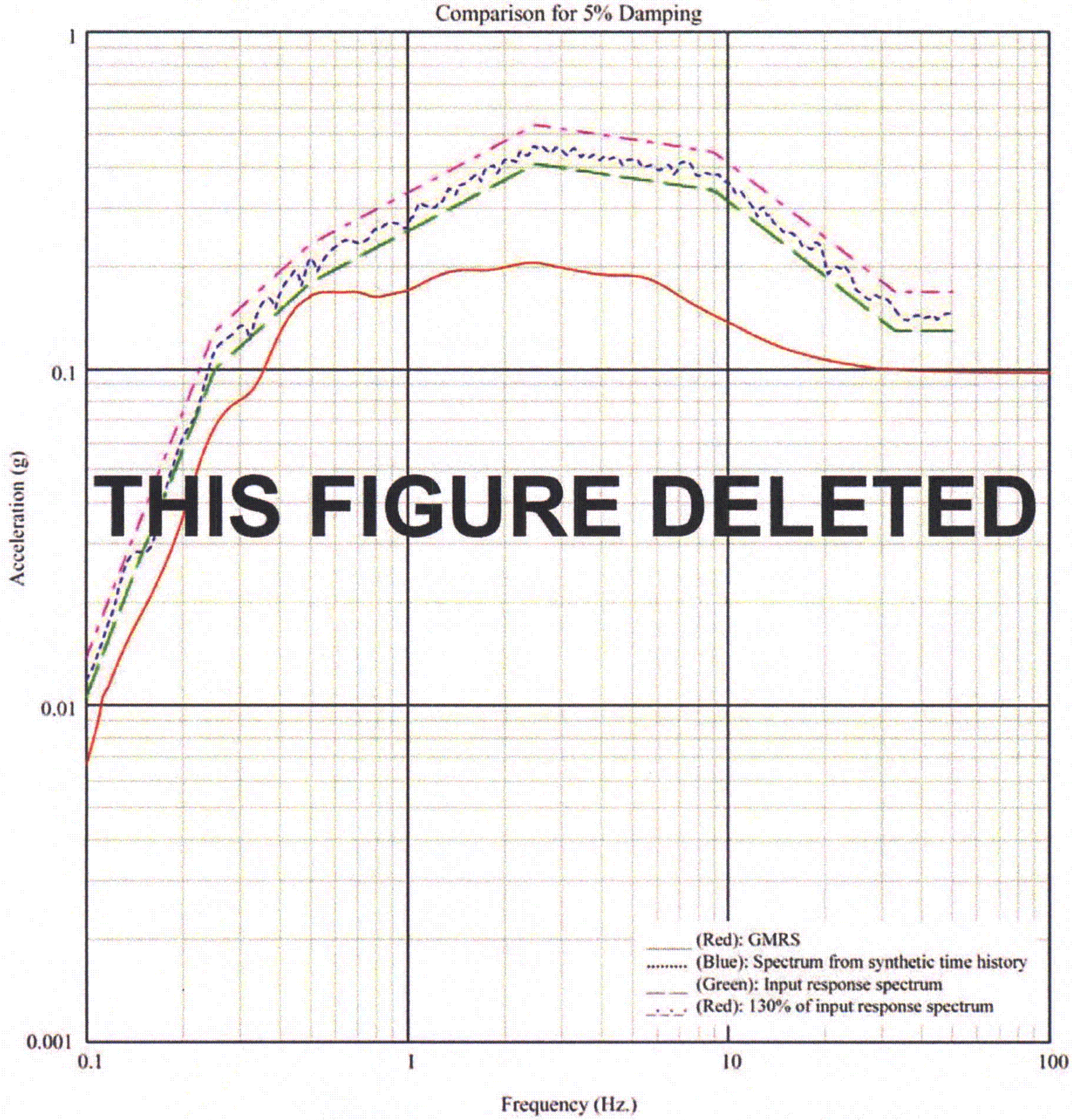


Figure 3A-261 ~~Comparison of GMRS with Spectrum from Synthetic Time History (Y Direction)~~ Not Used

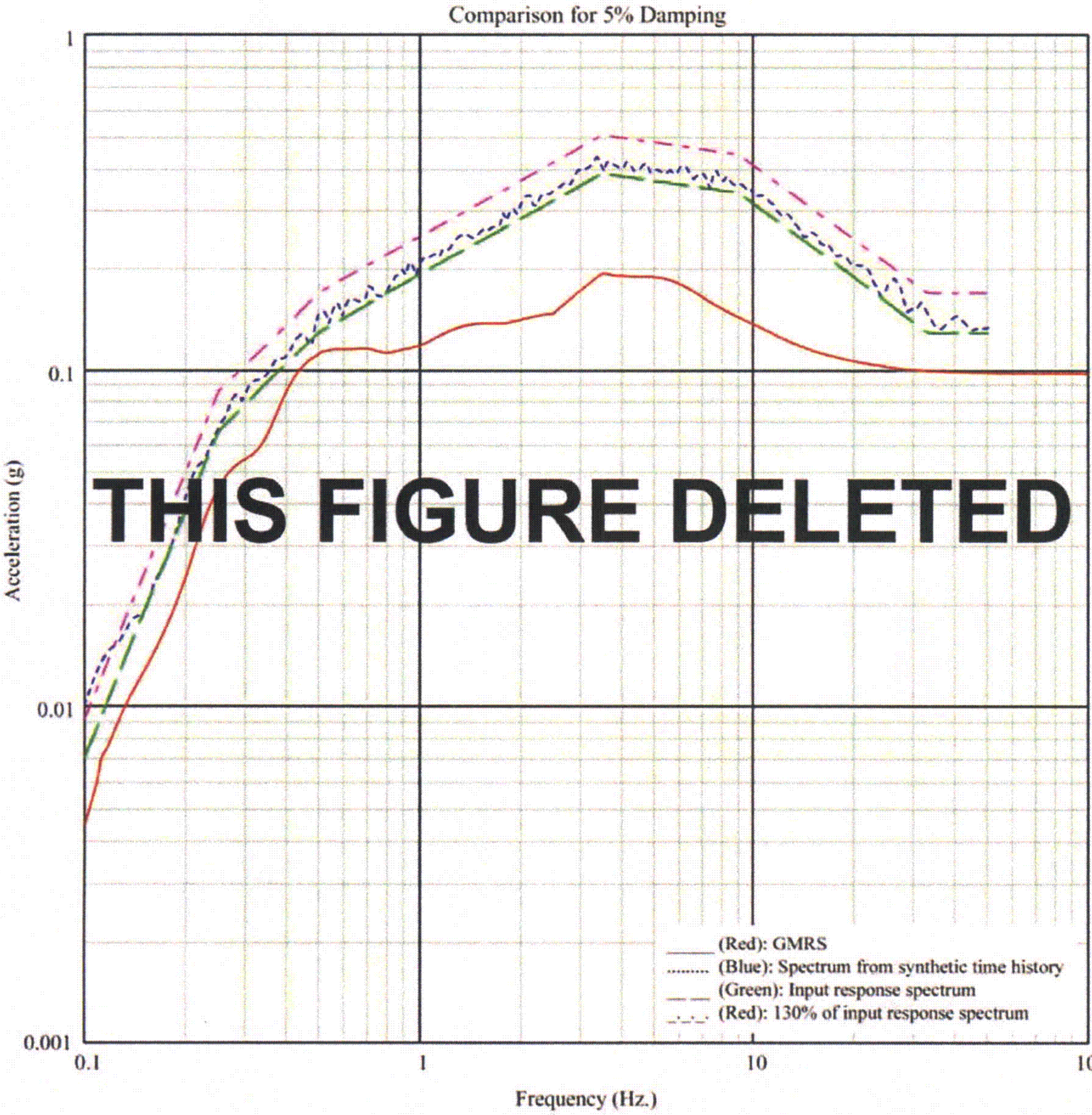


Figure 3A-262 ~~Comparison of GMRS with Spectrum from Synthetic Time History (Vertical Direction)~~ **Not Used**

RAI 03.07.01-18

QUESTION:

(Follow-up Question to RAI 03.07.01-5)

In the response to RAI 03.07.01-5, the applicant cited DCD Appendix 3A in concluding that "the potential effect of structure-to-structure interaction is relatively small." However, DCD (see DCD Section 3A.9.7, Effect of Adjacent Buildings) also concluded that seismic soil pressure in between the RB and CB increased due to structure-to-structure interaction (SSSI) effect. The applicant is requested to provide soil pressure profile between the RB and CB, and discuss how the potential effects of the increase in the seismic soil pressure in between the RB and CB due to SSSI effect has been addressed and bounded by the certified design.

RESPONSE:

It is recognized that the seismic soil pressure in between the Reactor Building (RB) and Control Building (CB) will increase due to structure-to-structure interaction effect. However, since the site-specific Safe Shutdown Earthquake (SSE) Input Spectra is only about 43% of DCD SSE Spectra (i.e., 0.13g modified RG 1.60 spectra vs. 0.3g RG 1.60 spectra), even with lower soil shear wave velocity the resulting soil pressure is expected to be bounded by the soil pressure reported in DCD Table 3A-18.

In response to this request, additional soil-structure interaction (SSI) analysis has been initiated to quantify the increased soil pressure profile between the RB and CB due to structure-to-structure interaction effect. The confirmatory analysis showing that the soil pressure profile is bounded by the certified design will be provided by April 30, 2010.

No COLA change is required for this response.

RAI 03.07.01-19

QUESTION:

(Follow-up Question to RAI 03.07.01-6)

In response to RAI 03.07.01-6, the applicant referred to COLA Part 2, Tier 2, Section 3A.17 for description of the supporting media, dimensions of the structural foundation, and total structural height for the Reactor Building (RB) and Control Building (CB). However, the referenced section does not include the requested information for the Diesel Generator Fuel Oil Storage Vaults (DGFOSV) which is listed as Seismic Category I structure in Revision 3 of the FSAR Section 2.5S.4.10.2. As such, the applicant was requested to provide information on supporting media for DGFOSV. Since the shear wave velocity parameter of the subgrade material (soil or backfill) supporting this structure may be less than 1000 fps, the applicant is also requested to provide quantitative results of the reconciliatory site specific seismic analysis (with appropriate consideration of dynamic soil or backfill properties) addressing the potential impact on FIRS, SSI, settlement calculations, and structural design concerning DGFOSV.

2. In the response to item 3 of RAI 03-07-01-6 it was stated that "The resulting strain-compatible properties for the three profiles are presented in COLA Part 2, Tier 2 Table 3H.6-1." A review of Table 3H.6-1 indicates that the S-wave and P-wave damping ratio used in the SSI analysis for an individual layer is the same. The applicant is requested to provide the basis for maintaining the S-wave and P-wave damping the same for an individual layer.

3. In response to RAI 03.07.01-6, Item 3, the applicant states that, "The seismic site response analysis was conducted, as described in Section 2.5S.2.5, using P-SHAKE to develop Ground Motion Response Spectrum (GMRS). ...." No reference to P-SHAKE program was found in Section 2.5S.2.5 of Revision 3, and no proposed FSAR markup is provided for future incorporation. As such, the applicant is requested to clarify whether P-SHAKE program has been used to develop GMRS and strain-compatible soil properties, as described in Section 2.5S.2.5, and if so, how P-SHAKE program performs site-response analysis (e.g. deterministic or probabilistic method, etc.). The applicant is further requested to clarify whether P-SHAKE program was also used to perform deconvolution of the SSE design motion specified at the freefield ground surface to calculate the foundation motion for the Seismic Category I structures.

RESPONSE:

(Paragraph 1)

The Diesel Generator Fuel Oil Storage Vaults (DGFOSV) are reinforced concrete structures, located below grade with an access room above grade. The DGFOSV house fuel oil tanks and transfer pumps. The DGFOSV are buried in the structural back-fill. The embedment depth to the bottom of the mud mat is approximately 43 ft, the maximum height from the bottom of the mudmat is approximately 59 ft, and the basemat dimensions are approximately

73 ft by 40 ft. Properties of the backfill are described in COLA Part 2, Tier 2 Section 3H.6.5.2.4. The DGFOSV will be analyzed using equivalent static method. The seismic induced dynamic soil pressures on DGFOSV walls will be computed using the method of ASCE 4-98, Subsection 3.5.3.2.

Two DGFOSV are located about 50 feet away from the south face of the Reactor Building (RB), which is a heavy multistory structure. The third DGFOSV is located approximately 28 feet away from the north face of the Reactor Service Water (RSW) Pump House. Considering the soil profile at the STP Units 3 & 4 site, the induced acceleration at the foundation level of the DGFOSV during a safe-shutdown earthquake (SSE) event may be amplified due to their close proximity to the RB (for the two) or the RSW Pump House (for the third). To establish the input motion for the soil-structure interaction (SSI) analysis of the DGFOSV, considering the impact of the nearby heavy RB (for the two) and RSW Pump House (for the third) structures, an analysis as described below will be performed.

Five interaction nodes at the ground surface and five at the depth corresponding to the bottom elevation of the DGFOSV foundations are added to the three dimensional SSI SASSI2000 model of the RB for obtaining free field responses for the two DGFOSV close to the RB. These five nodes correspond to the four corners and the center of the DGFOSV. This RB SSI model is analyzed for the STP site-specific SSE. Then, an average of the spectra at five nodes at the surface and foundation each is calculated. The envelope of these two average spectra and the 0.3g Regulatory Guide 1.60 response spectrum will be used as the input response spectrum for the SSI analysis of the DGFOSV. The DGFOSV and the equipment and components inside the vault will be designed using the results of the SSI analysis.

A similar SSI analysis, as described in the above paragraph, will be performed for the third DGFOSV close to the RSW Pump House. Then, the enveloped response spectra for the two DGFOSV close to the RB and the one close to the RSW Pump House will be used for the design of all DGFOSV.

The comparison of response spectra (the minimum required 0.1g Regulatory Guide 1.60 spectra, the FIRS, and the deconvolved SHAKE outcrop spectra) at the foundation level of the DGFOSV is presented in COLA Part 2, Tier 2 Figures 3H.6-11d through 3H.6-11L. As can be seen from these figures, the deconvolved SHAKE outcrop spectra envelop the minimum required spectra and FIRS for the three sets of soil properties.

The applicable codes, standards, and specifications from COLA Part 2, Tier 2 Section 3H.6.4 will be used for analysis and design of the DGFOSV.

The DGFOSV will be designed to the applicable loads and load combinations specified in COLA Part 2, Tier 2 Section 3H.6.4.

The settlement information on the DGFOSV is included in COLA Part 2, Tier 2, Section 2.5S.4.10.

The analysis and design results confirming that the DGFOSV design requirements are met will be available for review by April 30, 2010.

2. The P-wave damping ratios are assigned the same values as those calculated for the S-wave damping ratios. This is based on the recommendations of the upcoming ASCE 4-09 standards (see Reference below). The recommendation is based on the recent observation of earthquake data and the realization that the waves generated due to SSI effects are mainly surface and shear waves. It should be noted that the S-wave damping ratios for the best estimate profile are very low (around 1.5% and not exceeding 2%). Moreover, using the maximum strains, as shown in FSAR Figure 2.5S.2-47, and applying the effective strain ratio of 0.65, as described in FSAR Subsection 2.5S.2.5.4, the uniform strains for 1E-4 hazard level do not exceed 0.02%.

   Reference Used for this RAI Response:

   American Society of Civil Engineers (ASCE), Seismic Analysis of Safety-Related Nuclear Structures, ASCE 4-09, to be published in 2010.

3. The P-SHAKE program was used to develop the GMRS in Section 2.5S.2.5. A mark-up of COLA Part 2, Tier 2, Section 2.5S.2.5, that describes the P-SHAKE program and its use in site response analysis, is included as part of the response to RAI 02.05.02-23 submitted with STPNOC Letter U7-C-STP-NRC-090146, dated September 21, 2009.

   The SHAKE program was used to perform deconvolution of the SSE design motion specified at the free field ground surface to calculate the SHAKE outcrop motion at the foundation elevation of the Seismic Category I structures.

   The COLA mark-up for Section 2.5S.2.5 provided in response to RAI 02.05.02-23 is reproduced in the following for ready reference:

   "The description of the RVT approach in the STP COLA will be modified and expanded to include a more detailed discussion. The first and second paragraphs of FSAR Section 2.5S.2.5.4, COLA Revision 3 will be revised as follows:

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

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

These are the same assumptions that are implemented in the SHAKE program (Reference 2.5S.2-54)~~. and that constitute standard practice for site-response calculations. In this respect, RVT and SHAKE solve the same problem, but RVT works with ground-motion power spectral densities or response spectra (and its relation to peak values), while SHAKE works with individual time histories and their Fourier spectra.~~ With respect to RVT implementation, the major steps used in P-SHAKE are as follows:

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

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

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

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

References:

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

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

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

The STP Units 3 and 4 COLA will be revised as follows as a result of this response.

1. Revise Section 3H.6.1 to add Diesel Generator Fuel Oil Storage Vaults as follows:

3H.6.1 Objective and Scope

(3) Diesel Generator Fuel Oil Storage Vault for each unit.

2. Add the following new subsection in Section 3H.6, and revise the subsection number for the References:

3H.6.7 Diesel Generator Fuel Oil Storage Vaults (DGFOSV)

The Diesel Generator Fuel Oil Storage Vaults (DGFOSV) are reinforced concrete structures located below grade with an access room above grade. The DGFOSV house fuel oil tanks and transfer pumps. The DGFOSV are buried in the structural back-fill. The embedment depth to the bottom of the mud mat is approximately 43 ft, the maximum height from the bottom of the mudmat is approximately 59 ft, and the basemat dimensions are approximately 73 ft by 40 ft. Properties of the backfill are described in Section 3H.6.5.2.4. The DGFOSV will be analyzed using equivalent static method. The seismic induced dynamic soil pressures on DGFOSV walls and roof will be computed using the method of ASCE 4-98, Subsection 3.5.3.2.

Two DGFOSV are located about 50 feet away from the south face of the Reactor Building (RB), which is a heavy multistory structure. The third DGFOSV is located approximately 28 feet away from the north face of the Reactor Service Water (RSW) Pump House. Considering the soil profile at the STP Units 3 & 4 site, the induced acceleration at the foundation level of the DGFOSV during a safe-shutdown earthquake (SSE) event may be amplified due to their close proximity to the RB (for the two) or the RSW Pump House (for the third). To establish the input motion for the soil-structure interaction (SSI) analysis of the DGFOSV, considering the impact of the nearby heavy RB (for the two) and RSW Pump House (for the third) structures, an analysis as described below will be performed.

Five interaction nodes at the ground surface and five at the depth corresponding to the bottom elevation of the DGFOSV foundations are added to the three dimensional SSI SASSI2000 model of the RB for obtaining free field responses for the two DGFOSV close to the RB. These five nodes correspond to the four corners and the center of the DGFOSV. This RB SSI model is analyzed for the STP site-specific SSE. Then, an average of the spectra at five nodes at the surface and foundation each is calculated. The envelope of these two average spectra and the 0.3g Regulatory Guide 1.60 response spectrum will be used as the input response spectrum for the SSI analysis of the DGFOSV. The DGFOSV and the equipment and components inside the vault will be designed using the results of the SSI analysis.

A similar SSI analysis, as described in the above paragraph, will be performed for the third DGFOSV close to the RSW Pump House. Then, the enveloped response spectra for the two DGFOSV close to the RB and the one close to the RSW Pump House will be used for the design of all DGFOSV.

The comparison of response spectra (the minimum required 0.1g Regulatory Guide 1.60 spectra, the FIRS, and the deconvolved SHAKE outcrop spectra) at the foundation level of the DGFOSV is presented in Figures 3H.6-11d through 3H.6-11L. As can be seen from these figures, the deconvolved SHAKE outcrop spectra envelop the minimum required spectra and FIRS for the three sets of soil properties.

The applicable codes, standards, and specifications from Section 3H.6.4 will be used for analysis and design of the DGFOSV.

The DGFOSV will be designed to the applicable loads and load combinations specified in COLA Part 2, Tier 2 Section 3H.6.4.

The settlement information on the DGFOSV is included in Section 2.5S.4.10.

~~3H.6.6.6~~ 3H.6.8 References

3. Add enclosed Figures 3H.6-11d through 3H.6-11L.

Enclosure to Response to RAI 03.07.01-19

New COLA Figures 3H.6-11d through 3H.6-11L

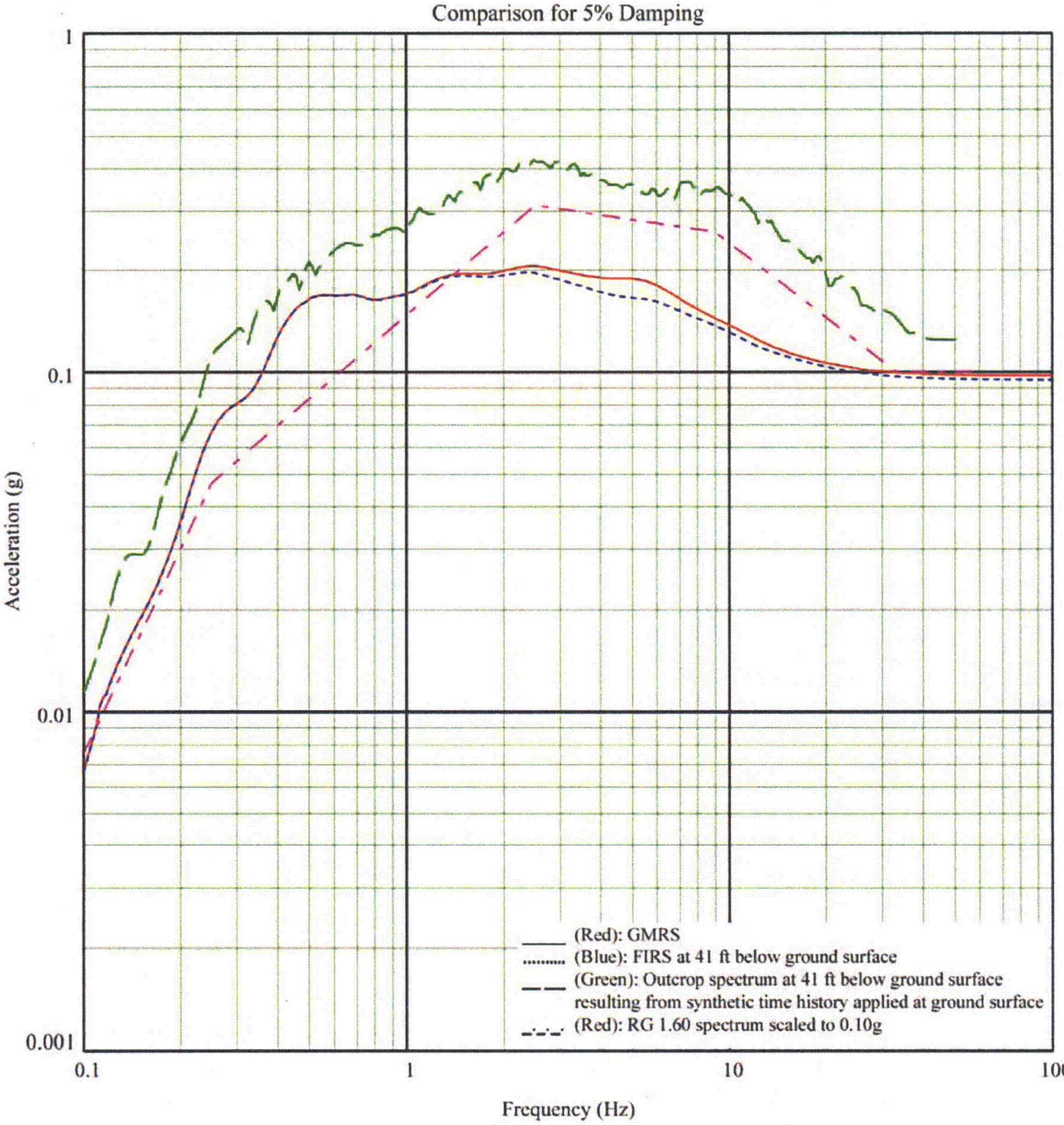


Figure 3H.6-11d: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Mean Soil Properties, E-W Direction

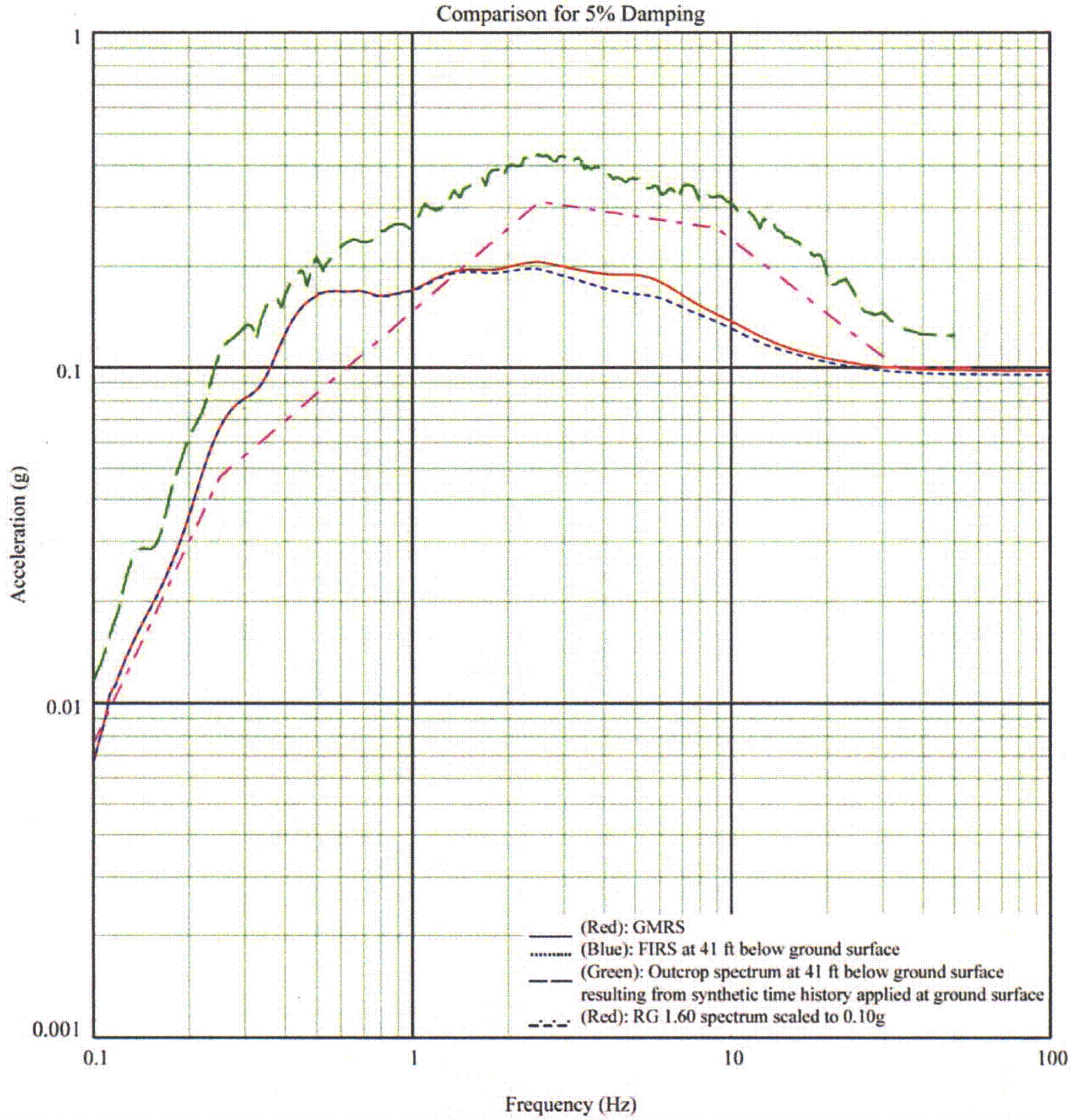


Figure 3H.6-11e: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Upper Bound Soil Properties, E-W Direction

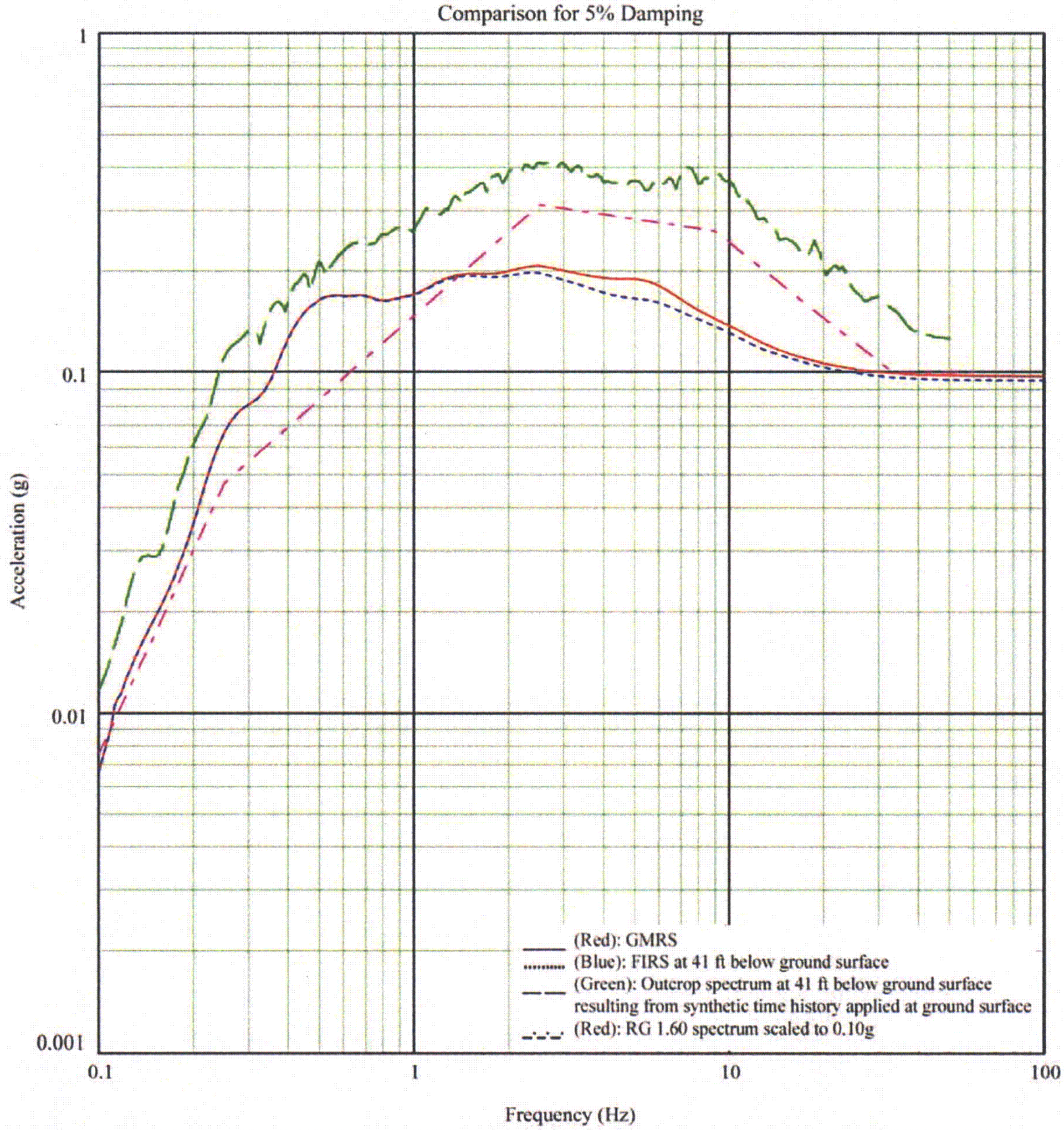


Figure 3H.6-11f: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Lower Bound Soil Properties, E-W Direction

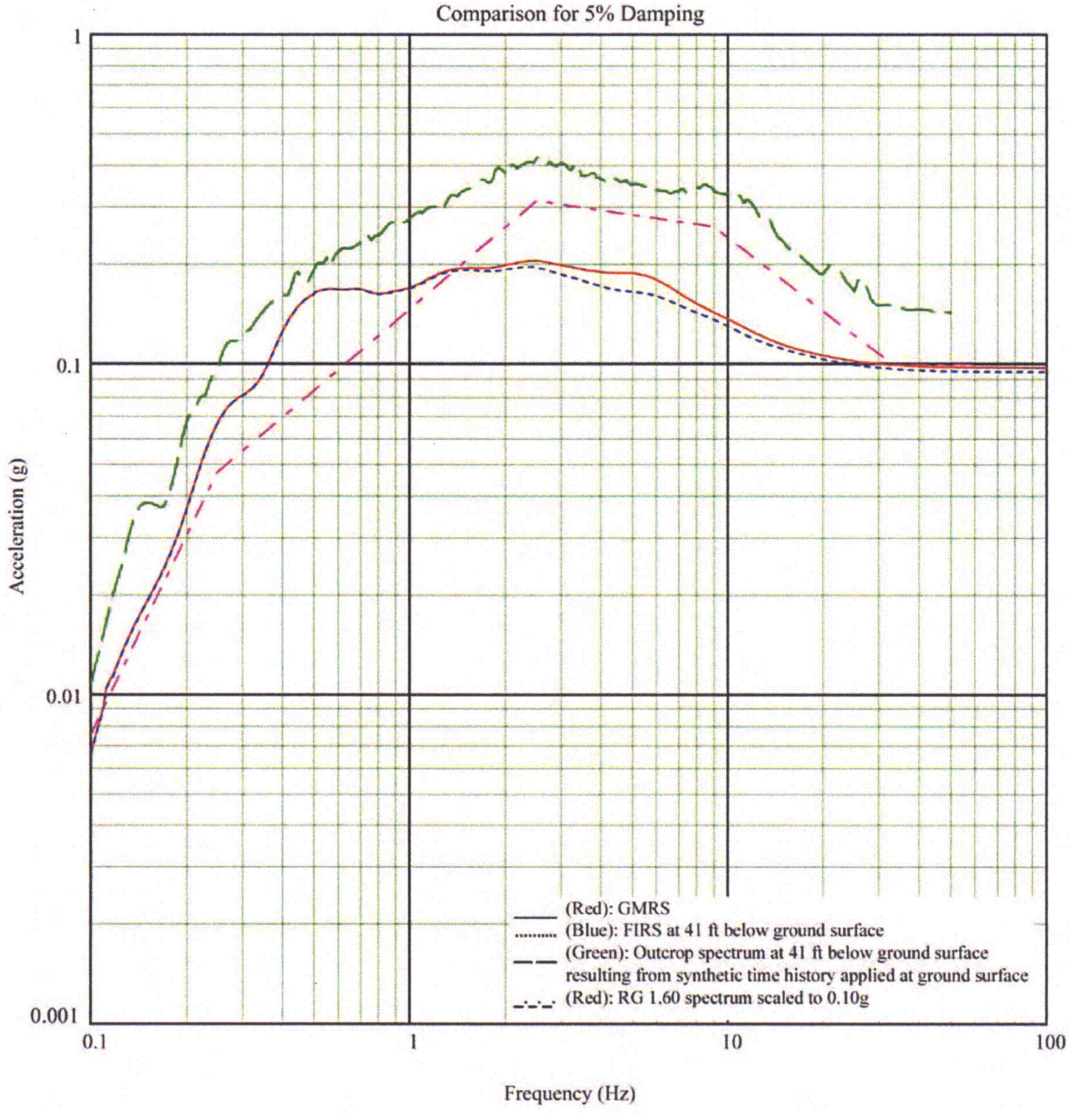


Figure 3H.6-11g: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Mean Soil Properties, N-S Direction

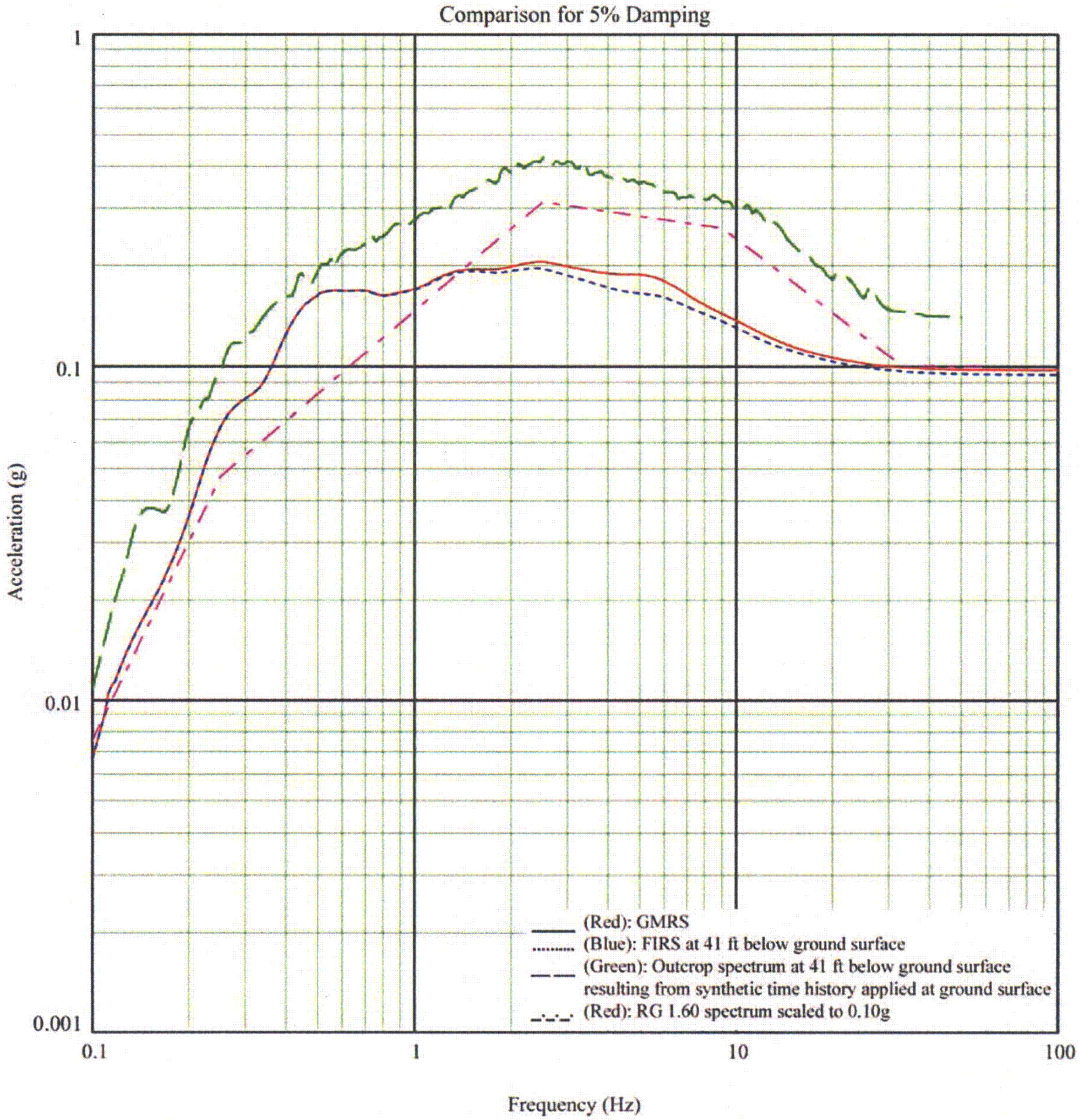


Figure 3H.6-11h: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Upper Bound Soil Properties, N-S Direction

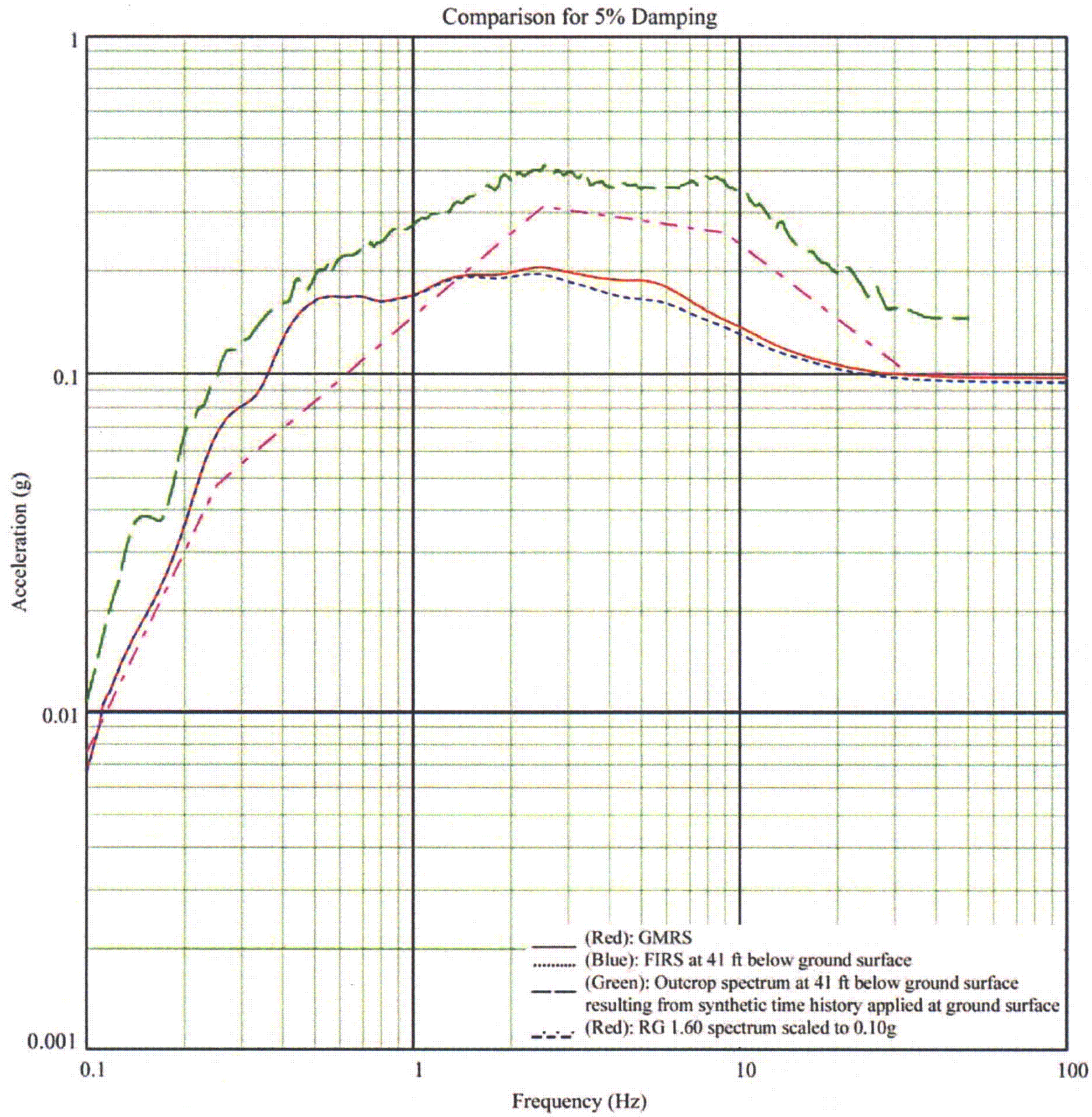


Figure 3H.6-11i: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Lower Bound Soil Properties, N-S Direction

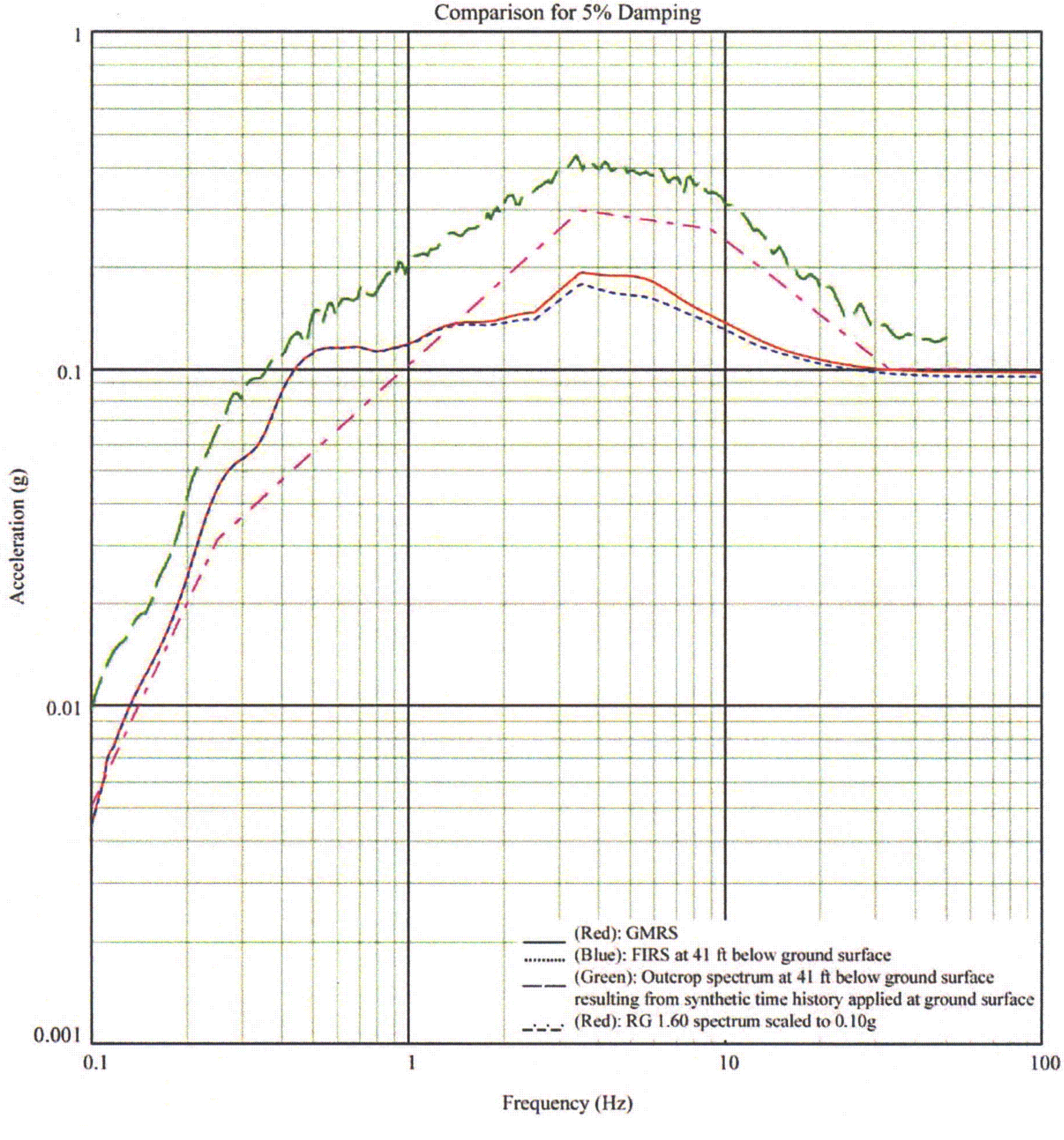


Figure 3H.6-11j: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Mean Soil Properties, Vertical Direction

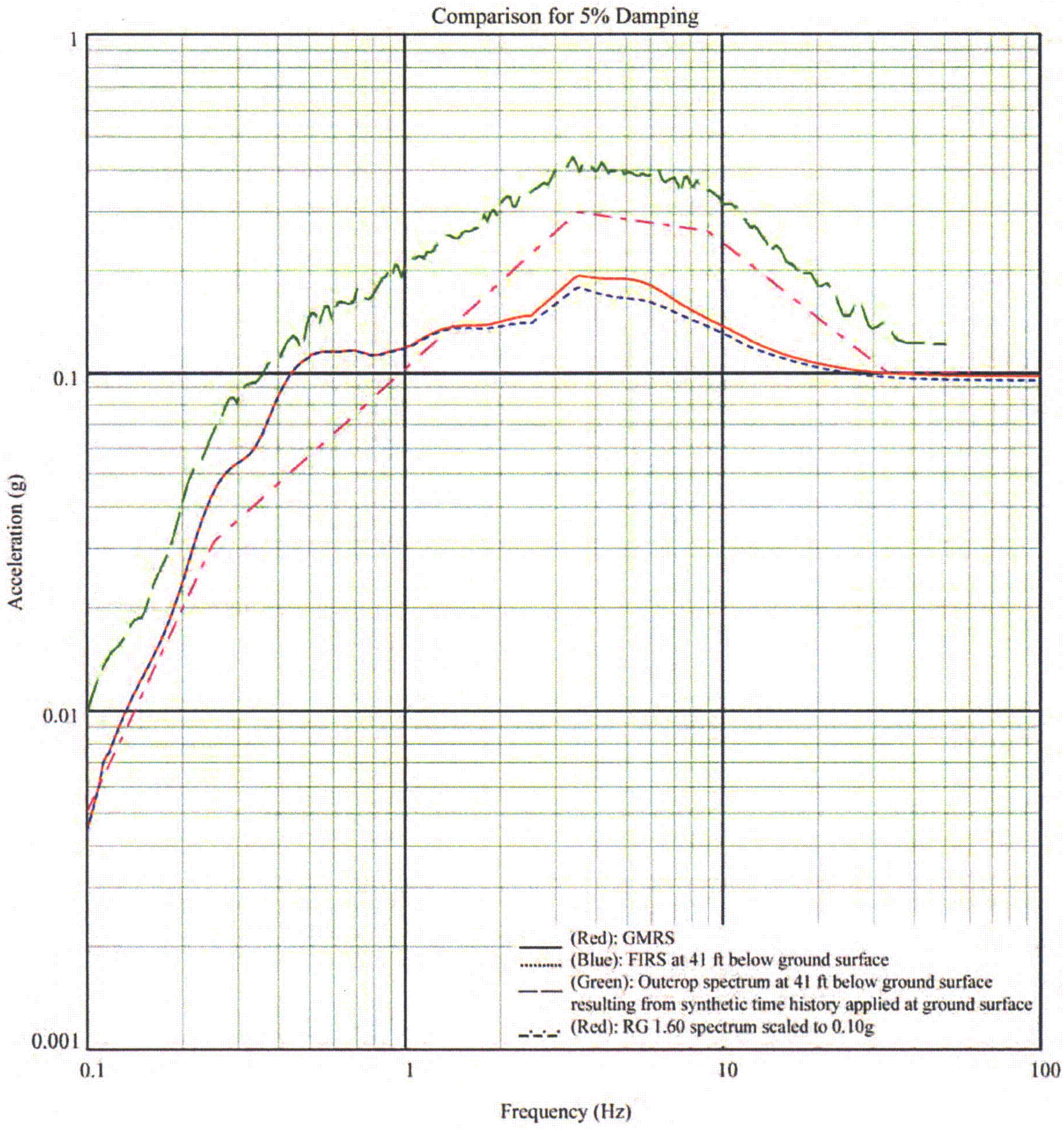


Figure 3H.6-11k: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Upper Bound Soil Properties, Vertical Direction

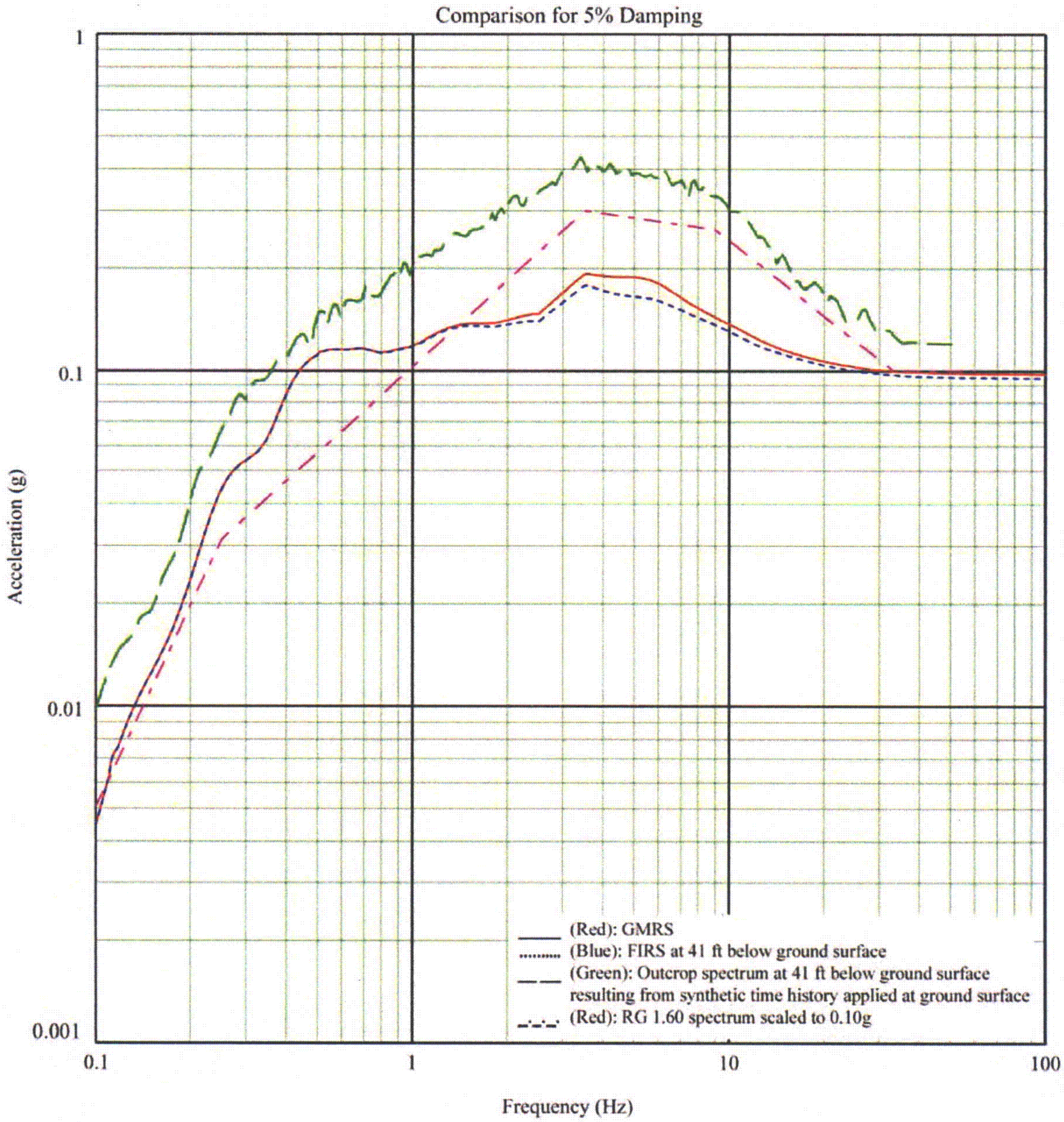


Figure 3H.6-11L: Comparison of Spectra at Foundation of Emergency Diesel Generator Fuel Storage Vault – Lower Bound Soil Properties, Vertical Direction

RAI 03.07.01-21

QUESTION:

(Follow-up Question to RAI 03.07.01-11)

1. In the response to RAI 03.07.01-11, Item 1, the applicant has not provided all the necessary information as per acceptance criteria of SRP 3.7.1.II.1B. The applicant stated that "***A single set of time histories (two horizontal and one vertical) was developed satisfying the enveloping requirements of Option 1, Approach 2 of SRP 3.7.1, Section II (Acceptance Criteria), Revision 3.***" As such, the applicant is requested to provide the following information: (a) the time step and total duration of record including trailing zeros, (b) how the response spectra of synthetic time histories were calculated for comparison with target spectra; i.e., number of frequency points and spacing, and (c) how the criteria, that the response spectrum of the synthetic time history at 5% damping shall not fall more than 10% below the target spectrum at any one frequency, was satisfied.

   The accompanying marked-up Section 3H.6.5.1.1.2 is not included in the updated FSAR, Rev 3. The applicant is requested to incorporate the mark-up Section 3H.6.5.1.1.2, "Design Time Histories," in response to this RAI in the next FSAR revision.

RESPONSE:

1. The information requested in the RAI is provided in the following:

(a) The time step and duration of the synthetic time histories are 0.005 seconds and 22 seconds respectively. When the time histories are input in SSI analysis using SASSI2000 program, trailing zeros are added at the end of 22 seconds to yield a total duration of 40.96 seconds (the time step of trailing zeros is also 0.005 seconds).

(b) The response spectra of synthetic time histories were calculated for comparison with target spectra at 275 frequency points with spacing as shown in Tables 3H.6-2d through 3H.6-2f provided with the response to RAI 03.07.01-15, Part 2c, submitted concurrently with this response.

(c) As shown in Tables 3H.6-2d through 3H.6-2f, provided with Response to RAI 03.07.01-15, Part 2c, the 5% damped response spectra of the synthetic time histories do not fall more than 10% below the target response spectrum at any frequency.

The COLA mark-up for Section 3H.6.5.1.1.2 submitted with the response to RAI 03.07.01-11 with letter 07-C-STP-NRC-090128 dated September 3, 2009 will be incorporated in a future revision of COLA.

COLA Part 2, Tier 2, Section 3H.6.5.1.1.2 will be revised as follows:

3H.6.5.1.1.2 Design Time Histories

Synthetic acceleration time histories consistent with the Input Spectra defined and discussed in Subsection 3H.6.5.1.1.1 were developed, using the 1952 Taft Earthquake Time Histories as seed, for use as input to the seismic analysis. A single set of time histories (two horizontal and one vertical) was developed satisfying the enveloping requirements of Option 1, Approach 2 of SRP 3.7.1, Section II (Acceptance Criteria), Revision 3. Per paragraph 2(d) of Approach 2, in lieu of the power spectrum density requirement, the requirement that the computed 5% damped response spectrum of the synthetic time history does not exceed the target response spectrum at any frequency by more than 30% was met. In the time history method of analysis, the two horizontal and the vertical time histories were applied separately (not applied simultaneously) and the maximum responses were combined using the square-root-of-the-sum-of-the-squares (SRSS) or the 100-40-40 percent spatial combination rule. Therefore, per Regulatory Guide 1.92, Revision 2, statistical independence of the three time histories (cross-correlation coefficient requirement) is not required.

Figures 3H.6-12 through 3H.6-14 show the comparison of the response spectrum for the synthetic time history, the Input Spectrum, and 1.3 times the Input Spectrum, in the two horizontal and vertical directions. The response spectra of synthetic time histories were calculated for comparison with target spectra at 275 frequency points with spacing as shown in Tables 3H.6-2d through 3H.6-2f. As shown in Tables 3H.6-2d through 3H.6-2f, the 5% damped response spectra of the synthetic time histories do not fall more than 10% below the target response spectrum at any frequency.

The time step and duration of the synthetic time histories are 0.005 seconds and 22 seconds, respectively. When the time histories are input in SSI analysis using SASSI2000 program, trailing zeros are added at the end of 22 seconds to yield a total duration of 40.96 seconds (the time step of trailing zeros is also 0.005 seconds).

The duration of the time histories for Arias Intensity to rise from 5% to 75% is 11.2 seconds for the two horizontal design time histories and 12.2 seconds for the vertical design time history.

RAI 03.07.01-22

QUESTION:

(Follow-up Question to RAI 03.07.01-12)

In the response to RAI 03.07.01-12, Item 3, the applicant stated that ***"—— (SSE) damping values are used for the generation of In-Structure Response Spectra since the Ultimate Heat Sink structure is highly stressed during the SSE event."*** As such, the applicant is requested to provide in the FSAR a table of stress levels for each of the site-specific structures within which the In-Structure Response Spectra (ISRS) is being generated. This should include representative examples of stresses in both walls and floors and a comparison of stress levels to code allowable stresses. Comparison should be provided for in-plane stresses as well as for out-of-plane stresses. Based on the comparison of actual and code allowable stresses, a technical justification should be provided for the selected damping value.

RESPONSE:

In the latest Soil-Structure Interaction (SSI) analysis of the Ultimate Heat Sink and Reactor Service Water Pump House (submitted with letter U7-C-STP-NRC-090208 dated November 19, 2009), OBE damping value of 4% was used for generation of In-Structure Response Spectra in accordance with Table 2 of Regulatory Guide 1.61, Revision 1. Since Safe-Shutdown Earthquake (SSE) damping is no longer used, there is no need for inclusion of a table in the FSAR for comparison of stress levels to code allowable stresses.

COLA Part 2, Tier 2, Section 3H.6.5.1.2 will be revised as shown below:

3H.6.5.1.2 Percentage of Critical Damping Values

The percentages of critical damping values considered in the seismic analysis for site-specific seismic Category I structures and associated systems and components are the same as listed in DCD Table 3.7-1. The damping values are the same as in Regulatory Guides 1.61 and 1.84, except for the cable trays and conduits, as explained in DCD Section 3.7.1.3. The OBE~~SSE~~ damping values were used for the generation of in-structure response spectra (ISRS)~~, since the UHS structure is highly stressed during the SSE event.~~

RAI 03.07.01-23

QUESTION:

(Follow-up Question to Partial Response to RAI 03.07.01-13)

With regard to Item c of the response to RAI 03.07.01-13, the applicant is requested to address the following:

1. The applicant is requested to provide all missing information in Tables 3H.6-3 through 3H.6-8 and Figures 3H.6-15 through 3H.6-40.

2. The applicant states that "***Development of strain-compatible soil properties for use in the SSI analysis is described in Section 3H.6.5.2.4;***" A number of inconsistencies were noted among some of the Figures included in Section 3H.6. For example, in revision 3 of FSAR, Figure 3H.6-2, "Comparison of GMRS with the input spectrum (vertical)," does not match with Figure 3H.6-1 for the same comparison provided for horizontal. In addition, Figures 3H.6-9, 3H.6-10, and 3H.6-11 for comparison of spectra at foundation of UHS basin, RSW Tunnel, and RSW Pump House, respectively, in the z direction do not match with similar figures provided for the same structures in the x and y directions in Figures 3H6-3 through 3H6-8. Similar discrepancies are found for Figures 3H.6-12, 3H.6-13 and 3H.6-14. The applicant is requested to correct, as appropriate Figure 3H.6-1 and 3H.6-2, as well as Figures 3H.6-9 through 3H.6-14.

3. Section 3H6.5.1.1.1 (b) states that "***When a deconvolution analysis is performed in the SHAKE program with the Input Spectrum applied at the free field ground surface, the resulting response spectrum at the outcrop of each Seismic Category I foundation will envelop the foundation input response spectrum (FIRS) developed using the same probabilistic approach and model which was used to develop the GMRS***." While this approach uses an ensemble of soil profiles to demonstrate that FIRS is enveloped with the Input Spectrum applied at the free field ground surface, the SSI analysis discussed in Section 3H.6.5.2.4 uses a deterministic approach with three soil profiles only. As such, the applicant is requested to provide at the foundations of each Category 1 structures a comparison of the FIRS and envelope of the three response spectra obtained (through deconvolution analysis with three SSI soil profiles) using the SHAKE program with the input design time history as applied at the free ground surface. The applicant is also requested to show that the FIRS are enveloped by the envelope of the three response spectra obtained above. Include this comparison in the FSAR.

4. Section 3H.6.5.2.4 states that "***The soil layer thicknesses used in the SSI model were sufficiently small to transmit frequency up to 33 Hz for mean soil properties***." Based on the shear wave velocities and layer thicknesses presented in Tables 3H.6-1 & 2 in the response, the applicant is requested to provide the criteria and its basis to justify that the model composed of soil and backfill material is capable of transmitting frequencies up to 33 Hz. Include this justification in the FSAR.

5. The response did not describe how the strain-compatible backfill properties are calculated. As such, the applicant is requested to describe in the FSAR as to how the lower bound, best estimate, and upper bound strain compatible backfill properties provided in Table 3H.6-2 were obtained.

RESPONSE:

1. The results of seismic analysis of the UHS/Pump House structure were provided in Supplement 1 to the response to RAI 03.07.01-13, submitted with Letter U7-C-STP-NRC-090208 dated November 19, 2009 (ML093270047). This response included Tables 3H.6-3 and 3H.6-4, and Figures 3H.6-15 through 3H.6-40. The results of the Ultimate Heat Sink (UHS) Pump House design were provided in the Supplement 2 response to RAI 03.07.01-13, submitted with Letter U7-C-STP-NRC-090230, dated December 30, 2009 (ML100050225). This response included Tables 3H.6-5 through 3H.6-8, and Figures 3H.6-41 through 3H.6-136.

2. The requested COLA Part 2, Tier 2 figure corrections are provided in the response to RAI 03.07.01-15, Part 1 provided concurrently with this response.

3. Figures 3A-233 through 3A-250, included in COLA Revision 3, provide, for the ABWR standard plant Category I structures (Reactor and Control Buildings), a comparison of the foundation input response spectrum (FIRS) and envelope of the three response spectra obtained (through deconvolution analysis with three soil-structure interaction (SSI) soil profiles) using the SHAKE program with the input design time history applied at the free field ground surface. The same information for the site-specific structures (UHS, RSW Pump House, RSW Piping Tunnel, and Diesel Generator Fuel Oil Storage Vaults) is provided in Figures 3H.6-3a through 11L, included with response to RAI 03.07.01-15 and RAI 03.07.01-19 being submitted concurrently. As can be seen from these figures, the FIRS are enveloped in all cases, including all three sets of soil properties, by the corresponding response spectra obtained from the deconvolution analyses.

4. The requested justification is provided in response to RAI 03.07.02-17, Part 1.

5. The requested information is provided in response to RAI 03.07.02-17, Part 3.

No additional COLA revision is required as a result of this response.

RAI 03.07.02-17

QUESTION:

(Follow-up Question to RAI 03.07.02-5)

1. In the response to Item 1 of RAI 03.07.02-5, the applicant states that, "***The soil layer thicknesses used in the SSI model were sufficiently small to transmit frequencies up to 33 Hz for mean in-situ soil properties. As described in the COLA markup for Section 3H.6.5.2.4 as provided in the response for RAI 03.07.01-3, in order to account for the backfill placed adjacent to the walls, an additional set of SSI analyses was performed by modeling the backfill as the soil horizon above the foundation level in the SASSI2000 model. The soil layer thicknesses used for the back fill were sufficiently small to transmit frequencies up to 33 Hz for the mean back fill soil properties.***" The applicant is requested to provide the criteria and quantitative basis that shows the soil and backfill layer thicknesses, as shown in Table 3H.6-1 and 3H.6-2 are sufficiently small to transmit frequencies up to 33 Hz for the SSI analysis using SASSI2000. Also provide justification for not using lower bound soil/back fill properties in determining the soil layer thickness to be able to transmit frequencies up to 33 Hz.

2. In the response to Item 2 of RAI 03.07.02-5, the applicant states that, "***SASSI2000 "Transmitting boundaries" were used at side boundaries of the model.***" SASSI is based on a substructure method that does not use lateral transmitting boundaries on the side, and half space boundary at the bottom of the SSI model, such as those used by the total SSI models in which the structure and soil domain are analyzed together in one step. As such, the applicant is requested to revise the statement in the response to this RAI.

3. In the response to Item 3 of RAI 03.07.02-5, the applicant refers to the response to RAI 03.07.01-3. However, the level of details is not sufficient. The applicant is requested to describe in sufficient details how the strain-compatible back fill properties for the lower bound, upper bound and best estimate cases are developed from the results of probabilistic site response analysis, as described in COLA Part 2, Tier 2, Section 2.5S.2.

4. In the response to Item 6 of RAI 03.07.02-5, the applicant has stated that the results of SSI analysis of the UHS basin, RSW Pump House and RSW Piping Tunnel will be provided at a later date by November 24, 2009. The applicant is requested to provide these results so that the review can be completed.

RESPONSE:

1. The layer thicknesses used in the soil-structure interaction (SSI) model for both in-situ soil and backfill soil were modified from those shown in Tables 3H.6-1 and 3H.6-2 to be sufficiently small to conservatively transmit frequencies up to 33 Hz for the corresponding mean soil properties. The attached Tables 3H.6-1a, b, and c provide the actual layer thicknesses used, along with the strain-compatible soil properties data and passing frequency

values for the three in-situ soil profiles, i.e., mean, upper bound, and lower bound, respectively. Similar data for the backfill are provided in Tables 3H.6-2a, b, and c. The layer thicknesses, H, were computed using the following equation:

$$H=V_s/(5^* F_{t\text{-}s})$$

where V_s is the shear wave velocity and $F_{t\text{-}s}$ is the transmittal frequency.

Where an adjusted in-situ soil layer in the SSI model crosses two or more soil layers in Table 3H.6-1, the adjusted shear and compression wave velocities are calculated to produce an equivalent speed of travel through the SSI model layer:

$$V = t / [(t_1 / V_1) + (t_2 / V_2) + \ldots+(t_n/V_n)]$$

where V is the wave velocity in the adjusted layer, t is the adjusted layer thickness, t_n is the thickness of soil layer n (from Table 3H.6-1) within the adjusted layer, and V_n is the wave velocity in soil layer n (from Table 3H 6-1) within the adjusted layer.

The adjusted unit weight γ and damping ratio d are calculated on a weighted average basis (with respect to layer thickness), as follows:

$$\gamma = [\gamma_1 t_1 + \gamma_2 t_2 + \ldots. +\gamma_n t_n] / t$$

$$d = [d_1 t_1 + d_2 t_2 + \ldots +d_n t_n] / t$$

where γ_n is the unit weight and d_n is the damping ratio of layer n from (Table 3H.6-1) within the adjusted layer.

The procedure used for the adjustment of the backfill soil properties is the same as provided above, except that the values from Table 3H.6-2 are used instead of Table 3H.6-1.

In the SSI model, the layer thicknesses used for the mean soil case were also used for the lower bound and upper bound in-situ and back fill soil, as shown in Tables 3H.6-1a, b, and c, and 3H.6-2a, b, and c. Based on the above equation, the transmittal frequencies for the lower bound soil layers are 26 Hz or higher. ASCE 4-98, Section 3.3.3.5 recommends that "The cutoff frequency may be taken as twice the highest dominant frequency of the coupled soil-structure system for the direction under consideration, but not less than 10 Hz." The dominant frequency of coupled soil-structure system has been calculated using the procedure recommended in ASCE 4-98, Section 3.3.3.5. Based on this calculation the highest frequency of the coupled soil-structure system is less than 6 Hz. Thus, the cutoff frequency is required to be at least 12 Hz. The lower bound soil model's lowest transmittal frequency of 26 Hz is larger than the required 12 Hz, and therefore is acceptable.

2. The statement will be revised to state that SASSI2000 implicitly considers transmitting boundaries in the formulation of impedance calculation. SASSI2000 sub-structuring method

has been used and no boundary condition besides the standard SASSI2000 elastic half space at the bottom of the site soil layering was used.

3. Based on the physical properties of the backfill described in Section 3H.6.5.2.4, its strain compatible dynamic soil properties are estimated using the following steps:

   A. Determine Safe Shutdown Earthquake (SSE) compatible soil shear strains in the backfill

   It is assumed that the strains in the backfill are same as in the surrounding soil (in-situ soil). This assumption is reasonable because the extent of the backfill is small as compared to the surrounding soil and the primary motion of the backfill will be about the same as the surrounding soil. The strain in the in-situ soil is calculated using the following steps:

   (a) The ratio G / Gmax for an in-situ stratum is calculated using the mean strain compatible shear wave velocity ($V_{\text{- strain}}$) in layers (from Table 3H.6-1) within the stratum and the average field measured shear wave velocity ($V_{\text{-field}}$, from Table 2.5S.4-27) in the following equation:

   $$G / Gmax = [V_{\text{- strain}} \ / \ V_{\text{-field}}\ ]^2$$

   (b) Using the shear modulus degradation curve (see Table 2.5S.4-32) of the soil stratum and the above calculated G / Gmax ratio, the SSE induced shear strain is calculated for the stratum.

   (c) An average value of shear strain is calculated for the entire backfill depth by averaging the strain values for all the strata.

   B. Determine the strain compatible shear modulus and damping values of the backfill

   The backfill is granular soil compacted to 95% Modified Proctor (85% relative density). Based on this, shear modulus degradation curve for the 85% relative density sand from Earthquake Engineering Research Center (EERC) Report 70-10 (Soil Moduli and Damping Factors for Dynamic Response Analysis, by Seed and Idriss) is used for calculating the strain compatible shear modulus, for the strain calculated in Step A. The strain compatible shear modulus of the backfill , $G_{backfill}$ is calculated using the following equation:

   $$G_{backfill} = 1000\ K_2\ \sigma_m^{1/2}\ \text{psf} \qquad \text{(EERC Report 70-10)}$$

   where the coefficient K_2 is from the EERC Report 70-10 degradation curve for the calculated shear strain, and σ_m is the effective mean principal stress in the soil.

   The damping value of the backfill is estimated using the sand strain dependent damping curve provided in EERC Report 70-10.

The above strain compatible shear modulus is the best estimate values (G_m). To consider the variability in shear modulus values, the lower bound (G_{LB}) and upper bound (G_{UB}) values are calculated using SRP Section 3.7.2 criteria.

$G_{LB} = G_m / 1.5$

$G_{UB} = 1.5 \times G_m$

The corresponding strain compatible shear wave velocities (V_S) and compression wave velocities (V_P) are calculated using the general equations:

$V_S = [G / \rho]^{1/2}$ where G is the shear modulus and ρ is the mass density of soil.

$V_P = V_S [(2 - 2\nu) / (1 - 2\nu)]^{1/2}$

where, ν is the Poisson's Ratio values equal to 0.42 and 0.47 for the backfill above groundwater and below groundwater table, respectively.

The strain compatible shear wave velocity, compression wave velocity and damping values calculated as above are used in the SSI analysis. These values are provided in the revised Table 3H.6-2.

4. Seismic analysis results for the UHS/RSW Pump House structure were provided in Letter U7-C-STP-NRC-090208, dated November 19, 2009.

The STP Units 3 and 4 COLA will be revised as follows as a result of this response.

1. Table 3H.6-2 will be replaced with the attached Table 3H.6-2.
2. Tables 3H.6-1a, b, and c, and 3H.6-2a, b, and c will be added.
3. Section 3H.6.5.2.4 will be revised as shown below.

3H.6.5.2.4 Soil-Structure Interaction

Soil-structure interaction (SSI) effects were accounted for by the use of the SASSI2000 computer program in conjunction with time histories described in Subsection 3H.6.5.1.1.2 and the structural model described in Subsection 3H.6.5.2.3 and shown in Figure 3H.6-15. The input ground motion time histories described in Section 3H.6.5.1.1.2 were applied at the finished grade in the free field. ~~SASSI2000 "Transmitting boundaries" were used at side boundaries of the model. For the bottom boundary, elastic half space was used.~~ SASSI2000 implicitly considers transmitting boundaries in the formulation of impedance calculation. SASSI2000 sub-structuring method was used and no boundary condition besides the standard SASSI2000 elastic half space at the bottom of the site soil layering was used. The SASSI2000 analysis addresses the embedment of the structure, groundwater effects, the layering of the soil, and variations of the strain-dependent soil properties. A separate SSI analysis for effects of side soil-wall separation during the seismic event was performed using the method in Section 3.3.1.9 of ASCE 4-98. Results of this analysis were enveloped with other SSI analyses.

The strain-compatible soil shear wave velocity and damping values for the SSI analysis were obtained from the same site response analysis which was used to develop the GMRS, as described in Section 2.5S.2.5. ~~Three sets of soil properties were used (i.e., mean, upper bound, and lower bound), and the responses from the three analyses were enveloped. The three sets of soil properties are shown in Table 3H.6-1.~~ The seismic site response analysis was conducted using P-SHAKE computer program, which also provided the strain-compatible soil properties for the SSI analysis. A set of mean strain-compatible shear wave velocity and damping profiles along with the associated standard deviations was calculated. The calculated mean properties and associated standard deviations were used to develop the best estimate (BE), upper bound (UB), and lower bound (LB) profiles. While the BE profile is the mean profile, the UB and LB profiles are the median +/- one standard deviation , respectively, maintaining the minimum variation of 1.5 on soil shear modulus, per the guidance provided in SRP 3.7.2. The corresponding compression wave velocity profiles were calculated using the shear wave velocity and the Poisson's ratio. The resulting strain-compatible properties for the three profiles, which were used in the SSI analysis, are presented in Table 3H.6-1._The soil layer thicknesses used in the SSI model were sufficiently small to transmit frequency up to 33 Hz for mean soil properties.

The layer thicknesses used for both in-situ soil and back fill soil, in the SSI model, were modified from those shown in Tables 3H.6-1 and 3H.6-2 to have thicknesses sufficiently small enough to conservatively transmit frequencies up to 33 Hz for the corresponding mean soil properties. Tables 3H.6-1a, b, and c provide the actual layer thicknesses, along with the strain-compatible soil properties data and passing frequency values for the three in-situ soil profiles, i.e., mean, upper bound, and lower bound, respectively. Similar data for the backfill are provided in Tables 3H.6-2a, b, and c. The layer thicknesses, H, were computed using the following equation:

$H=V_s /(5^* F_{t-s})$

where V_s is the shear wave velocity and F_{t-s} is the transmittal frequency.

In the SSI model, the layer thicknesses used for the mean soil case were also used for the lower bound in-situ and back fill soil. Based on the above equation, the transmittal frequencies for the lower bound soil layers are 26 Hz or higher. ASCE 4-98, Section 3.3.3.5 recommends that "The cutoff frequency may be taken as twice the highest dominant frequency of the coupled soil-structure system for the direction under consideration, but not less than 10 Hz." The dominant frequency of coupled soil-structure system has been calculated using the procedure recommended in ASCE 4-98, Section 3.3.3.5. Based on this calculation the highest frequency of the coupled soil-structure system is less than 6 Hz. Thus, the cutoff frequency is required to be at least 12 Hz. The lower bound soil model's lowest transmittal frequency of 26 Hz is larger than the required 12 Hz, and therefore is acceptable.

In order to account for the backfill placed adjacent to the walls, an additional set of SSI analyses was performed by modeling the backfill as the soil horizon above the foundation level in the SASSI2000 model. The soil layer thicknesses used for the back fill were sufficiently small to transmit the required frequencies ~~up to 33 Hz for the mean back fill soil properties~~ as explained in the above paragraph. The responses obtained from this set of SSI analyses and the analyses using in-situ soil as the horizon were enveloped.

The following properties were used for the backfill to obtain shear wave and compression wave velocities, and damping ratios used in the SSI analysis:

Unit Weight: ....120 pcf (1,922 kg/m^3)
Compaction: ....95% Modified Proctor
Poisson's Ratio: ....0.42 above water table, 0.47 below water table

Based on the physical properties of the backfill described above, its strain compatible dynamic soil properties are estimated using the following steps:

1. Determine SSE compatible soil shear strains in the backfill

   It is assumed that the strains in the backfill are same as in the surrounding soil (in-situ soil). This assumption is reasonable because the extent of the backfill is small as compared to the surrounding soil and the primary motion of the backfill will be about the same as the surrounding soil. The strain in the in-situ soil is calculated using the following steps:

(a) The ratio G / Gmax for an in-situ stratum is calculated using the mean strain compatible shear wave velocity ($V_{-strain}$) in layers (from Table 3H.6-1) within the stratum and the average field measured shear wave velocity (V_{-field}, from Table 2.5S.4-27) in the following equation:

$G / Gmax = [V_{-strain} / V_{-field}]^2$

(b) Using the shear modulus degradation curve (see Table 2.5S.4-32) of the soil stratum and the above calculated G / Gmax ratio, the SSE induced shear strain is calculated for the stratum.

(c) An average value of shear strain is calculated for the entire backfill depth by averaging the strain values for all the strata.

2. Determine the strain compatible shear modulus and damping values of the backfill

The backfill is granular soil compacted to 95% Modified Proctor (85% relative density). Based on this, shear modulus degradation curve for the 85% relative density sand from Earthquake Engineering Research Center (EERC) Report 70-10 (Soil Moduli and Damping Factors for Dynamic Response Analysis, by Seed and Idriss) is used for calculating the strain compatible shear modulus, for the strain calculated in Step 1. The strain compatible shear modulus of the backfill , $G_{backfill}$ is calculated using the following equation:

$G_{backfill} = 1000\ K_2\ \sigma_m^{1/2}$ psf (EERC Report 70-10)

Where the coefficient K_2 is from the EERC Report 70-10 degradation curve for the calculated shear strain, and σ_m is the effective mean principal stress in the soil.

The damping value of the backfill is estimated using the sand strain dependent damping curve provided in EERC Report 70-10.

The above strain compatible shear modulus is the best estimate values (G_m). To consider the variability in shear modulus values, the lower bound (G_{LB}) and upper bound (G_{UB}) values are calculated using SRP Section 3.7.2 criteria.

$G_{LB} = G_m / 1.5$

$G_{UB} = 1.5 \times G_m$

The corresponding strain compatible shear wave velocities (V_S) and compression wave velocities (V_P) are calculated using the general equations:

$V_S = [G / \rho]^{1/2}$ where G is the shear modulus and ρ is the mass density of soil.

$V_P = V_S [(2 - 2v) / (1 - 2v)]^{1/2}$

Where, v is the Poisson's Ratio values equal to 0.42 and 0.47 for the backfill above groundwater and below groundwater table, respectively.

The strain-compatible shear wave and compression wave velocities, and damping ratios calculated as above are used in the three backfill models (mean, upper bound, and lower bound) and are shown in Table 3H.6-2.

Enclosure to Response to RAI 03.07.02-17

Replacement Table 3H.6-2
New Tables 3H.6-1a, b, and c
New Tables 3H.6-2a, b, and c

Table 3H.6-2: Strain-Compatible Properties of Backfill Material

Soil Depth (ft)	Lower Bound Soil			Mean Soil			Upper Bound Soil		
	Vs (ft/sec)	Vp (ft/sec)	Damping (%)	Vs (ft/sec)	Vp (ft/sec)	Damping (%)	Vs (ft/sec)	Vp (ft/sec)	Damping (%)
0 to 8	449	1208	3	550	1480	2	673	1813	1
8 to 13	553	2323	3	677	2845	2	829	3485	1
13 to 18	586	2462	3	717	3015	2	879	3693	1
18 to 23	614	2580	3	752	3160	2	921	3870	1
23 to 28	639	2684	3	782	3288	2	958	4027	1
28 to 33	661	2778	3	809	3402	2	991	4166	1
33 to 38	681	2862	3	834	3506	2	1021	4294	1
38 to 43	699	2940	3	857	3601	2	1049	4410	1
43 to 48	717	3012	3	878	3689	2	1075	4518	1
48 to 53	733	3079	3	897	3771	2	1099	4619	1
53 to 58	748	3142	3	916	3849	2	1121	4714	1
58 to 63	762	3202	3	933	3922	2	1143	4803	1
63 to 68	775	3258	3	949	3991	2	1163	4888	1
68 to 73	788	3312	3	965	4056	2	1182	4968	1
73 to 78.25	800	3364	3	980	4120	2	1201	5046	1
78.25 to 83.25	812	3414	3	995	4182	2	1218	5121	1
83.25 to 88.25	823	3461	3	1009	4239	2	1235	5192	1
88.25 to 94.25	835	3510	3	1023	4299	2	1253	5266	1

Table 3H.6-1a: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Mean)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
1	2.75	56.0	53.3	0.124	548.1	1475.9	1.22	39.9
2	3.25	53.3	50.0	0.124	579.0	1559.0	1.34	35.6
3	3.50	50.0	46.5	0.124	599.6	1731.8	1.43	34.3
4	3.50	46.5	43.0	0.124	596.5	3041.5	1.57	34.1
5	3.50	43.0	39.5	0.124	598.4	3051.3	1.64	34.2
6	3.50	39.5	36.0	0.124	598.9	3054.0	1.69	34.2
7	3.00	36.0	33.0	0.124	598.3	3050.9	1.75	39.9
8	3.00	33.0	30.0	0.122	680.1	3468.0	1.96	45.3
9	4.00	30.0	26.0	0.121	730.8	3726.7	2.09	36.5
10	2.00	26.0	24.0	0.121	733.4	3739.4	2.17	73.3
11	4.00	24.0	20.0	0.122	755.1	3850.4	1.83	37.8
12	4.00	20.0	16.0	0.122	777.3	3963.5	1.52	38.9
13	4.00	16.0	12.0	0.122	774.6	3949.6	1.58	38.7
14	4.00	12.0	8.0	0.122	771.2	3932.2	1.66	38.6
15	4.00	8.0	4.0	0.122	771.7	3935.0	1.70	38.6
16	5.00	4.0	-1.0	0.122	856.8	4368.6	1.69	34.3
17	5.00	-1.0	-6.0	0.122	924.8	4715.5	1.68	37.0
18	2.00	-6.0	-8.0	0.122	925.0	4716.5	1.69	92.5
19	5.50	-8.0	-13.5	0.122	924.2	4712.6	1.71	33.6
20	5.60	-13.5	-19.1	0.122	939.9	4763.9	1.67	33.6
21	6.10	-19.1	-25.2	0.123	1012.5	5000.0	1.44	33.2
22	6.10	-25.2	-31.3	0.123	1010.3	5000.0	1.48	33.1
23	6.10	-31.3	-37.4	0.123	1008.2	5000.0	1.52	33.1
24	6.10	-37.4	-43.5	0.125	1037.9	5000.0	1.58	34.0
25	6.30	-43.5	-49.8	0.125	1040.8	5000.0	1.69	33.0
26	6.40	-49.8	-56.2	0.125	1062.3	5000.0	1.55	33.2
27	6.50	-56.2	-62.7	0.125	1084.5	5000.0	1.42	33.4
28	6.60	-62.7	-69.3	0.125	1090.3	5000.0	1.28	33.0
29	6.75	-69.3	-76.1	0.125	1119.9	5000.0	1.70	33.2
30	6.75	-76.1	-82.8	0.125	1119.3	5000.0	1.71	33.2

Table 3H.6-1a: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Mean) (Continued)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
31	6.75	-82.8	-89.6	0.125	1117.8	5000.0	1.72	33.1
32	6.75	-89.6	-96.3	0.125	1117.4	5000.0	1.73	33.1
33	6.75	-96.3	-103.1	0.125	1116.8	5000.0	1.74	33.1
34	6.50	-103.1	-109.6	0.125	1102.1	5000.0	1.55	33.9
35	6.50	-109.6	-116.1	0.125	1100.6	5000.0	1.57	33.9
36	6.75	-116.1	-122.8	0.125	1118.6	5000.0	1.70	33.1
37	6.75	-122.8	-129.6	0.125	1126.1	5000.0	1.76	33.4
38	6.75	-129.6	-136.3	0.125	1125.9	5000.0	1.76	33.4
39	6.75	-136.3	-143.1	0.125	1129.8	5000.0	1.77	33.5
40	6.75	-143.1	-149.8	0.125	1130.1	5000.0	1.78	33.5
41	6.75	-149.8	-156.6	0.125	1128.5	5000.0	1.78	33.4
42	6.75	-156.6	-163.3	0.125	1126.7	5000.0	1.79	33.4
43	6.80	-163.3	-170.1	0.124	1146.4	5000.0	1.79	33.7
44	6.90	-170.1	-177.0	0.124	1154.5	5000.0	1.79	33.5
45	7.10	-177.0	-184.1	0.125	1185.1	5059.6	1.68	33.4
46	7.40	-184.1	-191.5	0.127	1222.2	5137.0	1.48	33.0
47	7.30	-191.5	-198.8	0.127	1221.4	5133.7	1.56	33.5
48	7.30	-198.8	-206.1	0.127	1221.2	5133.0	1.55	33.5
49	7.50	-206.1	-213.6	0.126	1249.8	5252.9	1.67	33.3
50	7.40	-213.6	-221.0	0.127	1237.7	5202.1	1.53	33.5
51	7.50	-221.0	-228.5	0.126	1247.3	5242.4	1.61	33.3
52	7.60	-228.5	-236.1	0.123	1266.9	5324.9	1.75	33.3
53	7.60	-236.1	-243.7	0.123	1266.5	5323.4	1.76	33.3
54	7.60	-243.7	-251.3	0.123	1266.3	5322.6	1.76	33.3
55	7.60	-251.3	-258.9	0.123	1266.0	5321.2	1.77	33.3
56	7.60	-258.9	-266.5	0.123	1268.9	5333.3	1.77	33.4
57	7.60	-266.5	-274.1	0.123	1270.3	5339.0	1.77	33.4
58	7.60	-274.1	-281.7	0.123	1269.9	5337.6	1.78	33.4
59	8.70	-281.7	-290.4	0.126	1443.5	6067.4	1.48	33.2
60	9.50	-290.4	-299.9	0.128	1575.1	6620.6	1.29	33.2
61	9.50	-299.9	-309.4	0.124	1600.0	6725.1	1.54	33.7
62	9.50	-309.4	-318.9	0.128	1604.9	6745.6	1.29	33.8

Table 3H.6-1a: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Mean) (Continued)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
63	9.50	-318.9	-328.4	0.128	1604.5	6744.1	1.27	33.8
64	9.50	-328.4	-337.9	0.128	1603.7	6740.8	1.29	33.8
65	9.50	-337.9	-347.4	0.126	1592.9	6695.2	1.45	33.5
66	8.90	-347.4	-356.3	0.126	1479.0	6216.6	1.54	33.2
67	8.50	-356.3	-364.8	0.128	1417.2	5956.7	1.47	33.3
68	8.10	-364.8	-372.9	0.126	1339.3	5629.3	1.61	33.1
69	7.30	-372.9	-380.2	0.123	1219.2	5124.3	1.86	33.4
70	7.30	-380.2	-387.5	0.123	1219.1	5124.0	1.86	33.4
71	7.30	-387.5	-394.8	0.123	1218.9	5123.3	1.86	33.4
72	7.30	-394.8	-402.1	0.124	1209.9	5087.2	1.85	33.1
73	7.20	-402.1	-409.3	0.127	1192.6	5018.0	1.84	33.1
74	7.30	-409.3	-416.6	0.123	1213.6	5101.1	1.87	33.2
75	7.30	-416.6	-423.9	0.123	1213.6	5101.1	1.87	33.2
76	7.30	-423.9	-431.2	0.123	1213.4	5100.1	1.87	33.2
77	7.30	-431.2	-438.5	0.123	1213.3	5099.7	1.87	33.2
78	7.30	-438.5	-445.8	0.123	1215.9	5110.8	1.87	33.3
79	7.40	-445.8	-453.2	0.123	1224.1	5145.1	1.87	33.1
80	7.40	-453.2	-460.6	0.123	1224.1	5145.1	1.87	33.1
81	8.50	-460.6	-469.1	0.123	1419.0	5964.3	1.56	33.4
82	8.80	-469.1	-477.9	0.123	1465.0	6157.6	1.50	33.3
83	8.70	-477.9	-486.6	0.123	1442.8	6064.5	1.68	33.2
84	8.70	-486.6	-495.3	0.123	1435.9	6035.3	1.73	33.0
85	8.70	-495.3	-504.0	0.123	1435.6	6034.3	1.74	33.0
86	8.70	-504.0	-512.7	0.123	1435.5	6033.9	1.74	33.0
87	8.60	-512.7	-521.3	0.123	1435.4	6033.3	1.74	33.4
88	8.60	-521.3	-529.9	0.123	1435.3	6032.6	1.74	33.4
89	8.60	-529.9	-538.5	0.123	1435.2	6032.3	1.74	33.4
90	8.60	-538.5	-547.1	0.123	1435.0	6031.5	1.75	33.4
91	9.10	-547.1	-556.2	0.125	1515.0	6091.2	1.34	33.3
92	10.20	-556.2	-566.4	0.129	1688.6	6204.3	0.59	33.1
93	10.20	-566.4	-576.6	0.129	1688.6	6204.3	0.59	33.1
94	10.20	-576.6	-586.8	0.129	1688.6	6204.3	0.59	33.1

Table 3H.6-1a: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Mean) (Continued)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
95	10.20	-586.8	-597.0	0.129	1688.6	6204.3	0.59	33.1
96	10.20	-597.0	-607.2	0.129	1688.6	6204.3	0.59	33.1
97	10.20	-607.2	-617.4	0.129	1688.6	6204.3	0.59	33.1
98	10.20	-617.4	-627.6	0.129	1688.6	6204.3	0.59	33.1
99	10.20	-627.6	-637.8	0.129	1688.6	6204.3	0.59	33.1
100	10.20	-637.8	-648.0	0.129	1693.4	6221.8	0.59	33.2
Halfspace				0.129	1693.4	6221.8	0.588	-

Table 3H.6-1b: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Upper Bound)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
1	2.75	56.0	53.3	0.124	677.2	1823.4	0.77	49.3
2	3.25	53.3	50.0	0.124	711.6	1916.1	0.84	43.8
3	3.50	50.0	46.5	0.124	734.4	2121.0	0.89	42.0
4	3.50	46.5	43.0	0.124	730.5	3725.1	0.97	41.7
5	3.50	43.0	39.5	0.124	732.9	3737.1	1.01	41.9
6	3.50	39.5	36.0	0.124	733.5	3740.4	1.04	41.9
7	3.00	36.0	33.0	0.124	732.8	3736.6	1.08	48.9
8	3.00	33.0	30.0	0.122	833.0	4247.5	1.18	55.5
9	4.00	30.0	26.0	0.121	895.1	4564.3	1.24	44.8
10	2.00	26.0	24.0	0.121	898.2	4579.8	1.28	89.8
11	4.00	24.0	20.0	0.122	924.8	4715.7	1.04	46.2
12	4.00	20.0	16.0	0.122	952.0	4854.2	0.82	47.6
13	4.00	16.0	12.0	0.122	948.7	4837.3	0.85	47.4
14	4.00	12.0	8.0	0.122	944.5	4816.0	0.88	47.2
15	4.00	8.0	4.0	0.122	945.2	4819.3	0.89	47.3
16	5.00	4.0	-1.0	0.122	1049.3	4926.6	1.01	42.0
17	5.00	-1.0	-6.0	0.122	1132.7	5000.0	1.09	45.3
18	2.00	-6.0	-8.0	0.122	1132.9	5000.0	1.10	113.3
19	5.50	-8.0	-13.5	0.122	1131.9	5000.0	1.12	41.2
20	5.60	-13.5	-19.1	0.122	1151.2	5041.0	1.06	41.1
21	6.10	-19.1	-25.2	0.123	1240.1	5212.4	0.80	40.7
22	6.10	-25.2	-31.3	0.123	1237.4	5201.0	0.82	40.6
23	6.10	-31.3	-37.4	0.123	1234.7	5189.9	0.85	40.5
24	6.10	-37.4	-43.5	0.125	1271.2	5343.0	1.05	41.7
25	6.30	-43.5	-49.8	0.125	1274.6	5357.6	1.10	40.5
26	6.40	-49.8	-56.2	0.125	1301.1	5468.8	0.95	40.7
27	6.50	-56.2	-62.7	0.125	1328.2	5582.7	0.81	40.9
28	6.60	-62.7	-69.3	0.125	1335.3	5612.7	0.84	40.5
29	6.75	-69.3	-76.1	0.125	1371.6	5765.2	1.08	40.6
30	6.75	-76.1	-82.8	0.125	1370.9	5761.9	1.09	40.6

Table 3H.6-1b: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Upper Bound) (Continued)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
31	6.75	-82.8	-89.6	0.125	1369.1	5754.3	1.10	40.6
32	6.75	-89.6	-96.3	0.125	1368.5	5751.8	1.10	40.5
33	6.75	-96.3	-103.1	0.125	1367.8	5748.8	1.11	40.5
34	6.50	-103.1	-109.6	0.125	1349.7	5673.1	0.86	41.5
35	6.50	-109.6	-116.1	0.125	1347.9	5665.7	0.87	41.5
36	6.75	-116.1	-122.8	0.125	1370.0	5758.3	1.05	40.6
37	6.75	-122.8	-129.6	0.125	1379.1	5796.7	1.12	40.9
38	6.75	-129.6	-136.3	0.125	1378.9	5795.9	1.12	40.9
39	6.75	-136.3	-143.1	0.125	1383.7	5816.1	1.13	41.0
40	6.75	-143.1	-149.8	0.125	1384.1	5817.6	1.14	41.0
41	6.75	-149.8	-156.6	0.125	1382.2	5809.6	1.14	41.0
42	6.75	-156.6	-163.3	0.125	1379.9	5800.0	1.15	40.9
43	6.80	-163.3	-170.1	0.124	1404.0	5901.3	1.17	41.3
44	6.90	-170.1	-177.0	0.124	1414.0	5943.2	1.16	41.0
45	7.10	-177.0	-184.1	0.125	1451.5	6100.8	0.99	40.9
46	7.40	-184.1	-191.5	0.127	1496.8	6291.5	0.82	40.5
47	7.30	-191.5	-198.8	0.127	1495.9	6287.4	0.80	41.0
48	7.30	-198.8	-206.1	0.127	1495.7	6286.6	0.80	41.0
49	7.50	-206.1	-213.6	0.126	1530.6	6433.5	1.06	40.8
50	7.40	-213.6	-221.0	0.127	1515.8	6371.2	0.95	41.0
51	7.50	-221.0	-228.5	0.126	1527.5	6420.6	1.01	40.7
52	7.60	-228.5	-236.1	0.123	1551.6	6521.6	1.14	40.8
53	7.60	-236.1	-243.7	0.123	1551.1	6519.8	1.15	40.8
54	7.60	-243.7	-251.3	0.123	1550.9	6518.8	1.15	40.8
55	7.60	-251.3	-258.9	0.123	1550.5	6517.1	1.15	40.8
56	7.60	-258.9	-266.5	0.123	1554.1	6531.8	1.15	40.9
57	7.60	-266.5	-274.1	0.123	1555.7	6538.9	1.15	40.9
58	7.60	-274.1	-281.7	0.123	1555.3	6537.2	1.15	40.9
59	8.70	-281.7	-290.4	0.126	1767.9	7431.0	0.90	40.6
60	9.50	-290.4	-299.9	0.128	1929.1	8108.5	0.74	40.6
61	9.50	-299.9	-309.4	0.124	1959.6	8236.6	0.99	41.3
62	9.50	-309.4	-318.9	0.128	1965.6	8261.6	0.76	41.4

Table 3H.6-1b: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Upper Bound) (Continued)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
63	9.50	-318.9	-328.4	0.128	1965.2	8259.8	0.74	41.4
64	9.50	-328.4	-337.9	0.128	1964.2	8255.8	0.75	41.4
65	9.50	-337.9	-347.4	0.126	1950.9	8200.0	0.90	41.1
66	8.90	-347.4	-356.3	0.126	1811.4	7613.7	0.95	40.7
67	8.50	-356.3	-364.8	0.128	1735.7	7295.4	0.88	40.8
68	8.10	-364.8	-372.9	0.126	1640.3	6894.5	0.99	40.5
69	7.30	-372.9	-380.2	0.123	1493.2	6276.0	1.19	40.9
70	7.30	-380.2	-387.5	0.123	1493.1	6275.6	1.19	40.9
71	7.30	-387.5	-394.8	0.123	1492.8	6274.7	1.19	40.9
72	7.30	-394.8	-402.1	0.124	1481.8	6228.2	1.15	40.6
73	7.20	-402.1	-409.3	0.127	1460.7	6139.2	1.08	40.6
74	7.30	-409.3	-416.6	0.123	1486.4	6247.5	1.20	40.7
75	7.30	-416.6	-423.9	0.123	1486.4	6247.5	1.20	40.7
76	7.30	-423.9	-431.2	0.123	1486.1	6246.3	1.20	40.7
77	7.30	-431.2	-438.5	0.123	1486.0	6245.8	1.20	40.7
78	7.30	-438.5	-445.8	0.123	1489.2	6259.4	1.20	40.8
79	7.40	-445.8	-453.2	0.123	1499.2	6301.4	1.20	40.5
80	7.40	-453.2	-460.6	0.123	1499.2	6301.4	1.20	40.5
81	8.50	-460.6	-469.1	0.123	1737.9	7304.7	0.95	40.9
82	8.80	-469.1	-477.9	0.123	1794.2	7541.5	0.90	40.8
83	8.70	-477.9	-486.6	0.123	1767.1	7427.4	1.08	40.6
84	8.70	-486.6	-495.3	0.123	1758.6	7391.7	1.13	40.4
85	8.70	-495.3	-504.0	0.123	1758.3	7390.5	1.13	40.4
86	8.70	-504.0	-512.7	0.123	1758.2	7390.0	1.14	40.4
87	8.60	-512.7	-521.3	0.123	1758.0	7389.2	1.14	40.9
88	8.60	-521.3	-529.9	0.123	1757.8	7388.3	1.14	40.9
89	8.60	-529.9	-538.5	0.123	1757.7	7388.0	1.14	40.9
90	8.60	-538.5	-547.1	0.123	1757.5	7387.0	1.14	40.9
91	9.10	-547.1	-556.2	0.125	1855.5	7460.1	0.83	40.8
92	10.20	-556.2	-566.4	0.129	2068.1	7598.6	0.26	40.6
93	10.20	-566.4	-576.6	0.129	2068.1	7598.6	0.26	40.6
94	10.20	-576.6	-586.8	0.129	2068.1	7598.6	0.26	40.6

Table 3H.6-1b: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Upper Bound) (Continued)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
95	10.20	-586.8	-597.0	0.129	2068.1	7598.6	0.26	40.6
96	10.20	-597.0	-607.2	0.129	2068.1	7598.6	0.26	40.6
97	10.20	-607.2	-617.4	0.129	2068.1	7598.6	0.26	40.6
98	10.20	-617.4	-627.6	0.129	2068.1	7598.6	0.26	40.6
99	10.20	-627.6	-637.8	0.129	2068.1	7598.6	0.26	40.6
100	10.20	-637.8	-648.0	0.129	2073.9	7620.0	0.26	40.7
Halfspace				0.129	2073.9	7620.0	0.264	-

Table 3H.6-1c: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Lower Bound)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
1	2.75	56.0	53.3	0.124	419.1	1128.4	1.67	30.5
2	3.25	53.3	50.0	0.124	451.5	1215.7	1.84	27.8
3	3.50	50.0	46.5	0.124	473.9	1368.8	1.98	27.1
4	3.50	46.5	43.0	0.124	470.6	2399.5	2.16	26.9
5	3.50	43.0	39.5	0.124	470.2	2397.5	2.27	26.9
6	3.50	39.5	36.0	0.124	469.1	2392.1	2.35	26.8
7	3.00	36.0	33.0	0.124	466.9	2380.6	2.43	31.1
8	3.00	33.0	30.0	0.122	535.6	2731.0	2.74	35.7
9	4.00	30.0	26.0	0.121	578.9	2952.0	2.94	28.9
10	2.00	26.0	24.0	0.121	581.3	2964.2	3.05	58.1
11	4.00	24.0	20.0	0.122	593.7	3027.2	2.62	29.7
12	4.00	20.0	16.0	0.122	605.5	3087.4	2.22	30.3
13	4.00	16.0	12.0	0.122	602.2	3070.6	2.31	30.1
14	4.00	12.0	8.0	0.122	598.1	3049.7	2.43	29.9
15	4.00	8.0	4.0	0.122	599.5	3056.8	2.51	30.0
16	5.00	4.0	-1.0	0.122	666.6	3398.8	2.37	26.7
17	5.00	-1.0	-6.0	0.122	720.3	3672.8	2.27	28.8
18	2.00	-6.0	-8.0	0.122	720.6	3674.4	2.28	72.1
19	5.50	-8.0	-13.5	0.122	719.7	3670.1	2.31	26.2
20	5.60	-13.5	-19.1	0.122	738.1	3763.4	2.27	26.4
21	6.10	-19.1	-25.2	0.123	826.7	4215.5	2.08	27.1
22	6.10	-25.2	-31.3	0.123	824.9	4206.3	2.14	27.0
23	6.10	-31.3	-37.4	0.123	823.2	4197.3	2.20	27.0
24	6.10	-37.4	-43.5	0.125	847.5	4321.2	2.11	27.8
25	6.30	-43.5	-49.8	0.125	849.8	4332.9	2.28	27.0
26	6.40	-49.8	-56.2	0.125	861.8	4394.5	2.15	26.9
27	6.50	-56.2	-62.7	0.125	873.6	4454.6	2.03	26.9
28	6.60	-62.7	-69.3	0.125	880.2	4488.0	1.75	26.7
29	6.75	-69.3	-76.1	0.125	914.4	4662.7	2.31	27.1
30	6.75	-76.1	-82.8	0.125	913.7	4659.3	2.33	27.1

Table 3H.6-1c: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Lower Bound) (Continued)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
31	6.75	-82.8	-89.6	0.125	911.5	4647.6	2.34	27.0
32	6.75	-89.6	-96.3	0.125	910.9	4644.8	2.36	27.0
33	6.75	-96.3	-103.1	0.125	910.2	4641.2	2.37	27.0
34	6.50	-103.1	-109.6	0.125	883.2	4503.5	2.23	27.2
35	6.50	-109.6	-116.1	0.125	881.1	4492.6	2.26	27.1
36	6.75	-116.1	-122.8	0.125	908.0	4629.8	2.35	26.9
37	6.75	-122.8	-129.6	0.125	919.4	4688.2	2.39	27.2
38	6.75	-129.6	-136.3	0.125	919.3	4687.6	2.40	27.2
39	6.75	-136.3	-143.1	0.125	922.5	4703.8	2.41	27.3
40	6.75	-143.1	-149.8	0.125	922.7	4705.0	2.42	27.3
41	6.75	-149.8	-156.6	0.125	921.4	4698.5	2.43	27.3
42	6.75	-156.6	-163.3	0.125	919.3	4687.6	2.43	27.2
43	6.80	-163.3	-170.1	0.124	921.5	4698.6	2.41	27.1
44	6.90	-170.1	-177.0	0.124	928.7	4735.0	2.41	26.9
45	7.10	-177.0	-184.1	0.125	954.6	4855.4	2.36	26.9
46	7.40	-184.1	-191.5	0.127	985.8	5000.0	2.17	26.6
47	7.30	-191.5	-198.8	0.127	984.9	5000.0	2.32	27.0
48	7.30	-198.8	-206.1	0.127	984.7	5000.0	2.31	27.0
49	7.50	-206.1	-213.6	0.126	1020.4	5000.0	2.27	27.2
50	7.40	-213.6	-221.0	0.127	1010.5	5000.0	2.12	27.3
51	7.50	-221.0	-228.5	0.126	1018.3	5000.0	2.20	27.2
52	7.60	-228.5	-236.1	0.123	1034.4	5000.0	2.36	27.2
53	7.60	-236.1	-243.7	0.123	1034.1	5000.0	2.37	27.2
54	7.60	-243.7	-251.3	0.123	1033.9	5000.0	2.37	27.2
55	7.60	-251.3	-258.9	0.123	1033.7	5000.0	2.38	27.2
56	7.60	-258.9	-266.5	0.123	1036.0	5000.0	2.39	27.3
57	7.60	-266.5	-274.1	0.123	1037.2	5000.0	2.40	27.3
58	7.60	-274.1	-281.7	0.123	1036.9	5000.0	2.40	27.3
59	8.70	-281.7	-290.4	0.126	1160.9	5160.6	2.05	26.7
60	9.50	-290.4	-299.9	0.128	1252.4	5264.0	1.84	26.4
61	9.50	-299.9	-309.4	0.124	1290.5	5424.1	2.08	27.2

Table 3H.6-1c: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Lower Bound) (Continued)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
62	9.50	-309.4	-318.9	0.128	1309.8	5504.9	1.82	27.6
63	9.50	-318.9	-328.4	0.128	1310.1	5506.5	1.80	27.6
64	9.50	-328.4	-337.9	0.128	1309.5	5503.9	1.82	27.6
65	9.50	-337.9	-347.4	0.126	1300.6	5466.7	2.00	27.4
66	8.90	-347.4	-356.3	0.126	1206.9	5163.3	2.12	27.1
67	8.50	-356.3	-364.8	0.128	1156.1	5000.0	2.07	27.2
68	8.10	-364.8	-372.9	0.126	1092.9	5000.0	2.23	27.0
69	7.30	-372.9	-380.2	0.123	995.4	5000.0	2.53	27.3
70	7.30	-380.2	-387.5	0.123	995.3	5000.0	2.53	27.3
71	7.30	-387.5	-394.8	0.123	995.2	5000.0	2.53	27.3
72	7.30	-394.8	-402.1	0.124	987.8	4984.4	2.56	27.1
73	7.20	-402.1	-409.3	0.127	973.7	4955.8	2.61	27.0
74	7.30	-409.3	-416.6	0.123	990.9	5000.0	2.54	27.1
75	7.30	-416.6	-423.9	0.123	990.9	5000.0	2.54	27.1
76	7.30	-423.9	-431.2	0.123	990.7	5000.0	2.54	27.1
77	7.30	-431.2	-438.5	0.123	990.6	5000.0	2.54	27.1
78	7.30	-438.5	-445.8	0.123	992.8	5000.0	2.54	27.2
79	7.40	-445.8	-453.2	0.123	999.5	5000.0	2.54	27.0
80	7.40	-453.2	-460.6	0.123	999.5	5000.0	2.54	27.0
81	8.50	-460.6	-469.1	0.123	1158.6	5023.1	2.17	27.3
82	8.80	-469.1	-477.9	0.123	1196.2	5027.7	2.10	27.2
83	8.70	-477.9	-486.6	0.123	1178.1	5006.7	2.28	27.1
84	8.70	-486.6	-495.3	0.123	1172.4	5000.0	2.34	27.0
85	8.70	-495.3	-504.0	0.123	1172.2	5000.0	2.34	26.9
86	8.70	-504.0	-512.7	0.123	1172.1	5000.0	2.34	26.9
87	8.60	-512.7	-521.3	0.123	1172.0	5000.0	2.34	27.3
88	8.60	-521.3	-529.9	0.123	1171.9	5000.0	2.35	27.3
89	8.60	-529.9	-538.5	0.123	1171.8	5000.0	2.35	27.3
90	8.60	-538.5	-547.1	0.123	1171.7	5000.0	2.35	27.2
91	9.10	-547.1	-556.2	0.125	1237.0	5022.9	1.85	27.2
92	10.20	-556.2	-566.4	0.129	1378.7	5065.8	0.91	27.0
93	10.20	-566.4	-576.6	0.129	1378.7	5065.8	0.91	27.0

Table 3H.6-1c: Layer Thicknesses and Strain Compatible In-Situ Soil Properties Used for the SSI Analysis (Lower Bound) (Continued)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
94	10.20	-576.6	-586.8	0.129	1378.7	5065.8	0.91	27.0
95	10.20	-586.8	-597.0	0.129	1378.7	5065.8	0.91	27.0
96	10.20	-597.0	-607.2	0.129	1378.7	5065.8	0.91	27.0
97	10.20	-607.2	-617.4	0.129	1378.7	5065.8	0.91	27.0
98	10.20	-617.4	-627.6	0.129	1378.7	5065.8	0.91	27.0
99	10.20	-627.6	-637.8	0.129	1378.7	5065.8	0.91	27.0
100	10.20	-637.8	-648.0	0.129	1382.6	5080.1	0.91	27.1
Halfspace				0.129	1382.6	5080.1	0.913	-

Table 3H.6-2a: Layer Thicknesses and Strain-Compatible Backfill Soil Properties Used for the SSI Analysis (Mean)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
1	2.75	56.0	53.3	0.120	550.0	1480.0	2.00	40.0
2	3.25	53.3	50.0	0.120	550.0	1480.0	2.00	33.8
3	3.50	50.0	46.5	0.120	598.1	1863.1	2.00	34.2
4	3.50	46.5	43.0	0.120	677.0	2845.0	2.00	38.7
5	3.50	43.0	39.5	0.120	717.0	3015.0	2.00	41.0
6	3.50	39.5	36.0	0.120	736.6	3096.2	2.00	42.1
7	3.00	36.0	33.0	0.120	752.0	3160.0	2.00	50.1
8	3.00	33.0	30.0	0.120	782.0	3288.0	2.00	52.1
9	4.00	30.0	26.0	0.120	795.3	3344.0	2.00	39.8
10	2.00	26.0	24.0	0.120	809.0	3402.0	2.00	80.9
11	4.00	24.0	20.0	0.120	827.6	3479.4	2.00	41.4
12	4.00	20.0	16.0	0.120	845.3	3552.9	2.00	42.3
13	4.00	16.0	12.0	0.120	862.2	3622.6	2.00	43.1
14	4.00	12.0	8.0	0.120	878.0	3689.0	2.00	43.9
15	4.00	8.0	4.0	0.120	897.0	3771.0	2.00	44.9
16	5.00	4.0	-1.0	0.120	912.1	3833.1	2.00	36.5
17	5.00	-1.0	-6.0	0.120	929.5	3907.2	2.00	37.2
18	2.00	-6.0	-8.0	0.120	940.9	3956.2	2.00	94.1

Table 3H.6-2b: Layer Thicknesses and Strain-Compatible Backfill Soil Properties Used for the SSI Analysis (Upper Bound)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
1	2.75	56.0	53.3	0.120	673.0	1813.0	1.00	48.9
2	3.25	53.3	50.0	0.120	673.0	1813.0	1.00	41.4
3	3.50	50.0	46.5	0.120	732.0	2282.3	1.00	41.8
4	3.50	46.5	43.0	0.120	829.0	3485.0	1.00	47.4
5	3.50	43.0	39.5	0.120	879.0	3693.0	1.00	50.2
6	3.50	39.5	36.0	0.120	902.5	3792.1	1.00	51.6
7	3.00	36.0	33.0	0.120	921.0	3870.0	1.00	61.4
8	3.00	33.0	30.0	0.120	958.0	4027.0	1.00	63.9
9	4.00	30.0	26.0	0.120	974.2	4095.3	1.00	48.7
10	2.00	26.0	24.0	0.120	991.0	4166.0	1.00	99.1
11	4.00	24.0	20.0	0.120	1013.3	4261.3	1.00	50.7
12	4.00	20.0	16.0	0.120	1034.8	4351.2	1.00	51.7
13	4.00	16.0	12.0	0.120	1055.4	4436.5	1.00	52.8
14	4.00	12.0	8.0	0.120	1075.0	4518.0	1.00	53.8
15	4.00	8.0	4.0	0.120	1099.0	4619.0	1.00	55.0
16	5.00	4.0	-1.0	0.120	1116.5	4694.7	1.00	44.7
17	5.00	-1.0	-6.0	0.120	1138.5	4784.9	1.00	45.5
18	2.00	-6.0	-8.0	0.120	1152.9	4845.1	1.00	115.3

Table 3H.6-2c: Layer Thicknesses and Strain-Compatible Backfill Soil Properties Used for the SSI Analysis (Lower Bound)

Layer No.	Thickness (ft)	Top Elevation of Layer (ft)	Bottom Elevation of Layer (ft)	Unit Weight (kcf)	S-Wave Vel. (ft/sec)	P-Wave Vel. (ft/sec)	Damping (%)	Passing Freq. for S-Wave Vel. (Hz)
1	2.75	56.0	53.3	0.120	449.0	1208.0	3.00	32.7
2	3.25	53.3	50.0	0.120	449.0	1208.0	3.00	27.6
3	3.50	50.0	46.5	0.120	488.4	1520.8	3.00	27.9
4	3.50	46.5	43.0	0.120	553.0	2323.0	3.00	31.6
5	3.50	43.0	39.5	0.120	586.0	2462.0	3.00	33.5
6	3.50	39.5	36.0	0.120	601.7	2528.1	3.00	34.4
7	3.00	36.0	33.0	0.120	614.0	2580.0	3.00	40.9
8	3.00	33.0	30.0	0.120	639.0	2684.0	3.00	42.6
9	4.00	30.0	26.0	0.120	649.8	2730.2	3.00	32.5
10	2.00	26.0	24.0	0.120	661.0	2778.0	3.00	66.1
11	4.00	24.0	20.0	0.120	675.9	2840.5	3.00	33.8
12	4.00	20.0	16.0	0.120	689.9	2900.5	3.00	34.5
13	4.00	16.0	12.0	0.120	703.4	2957.7	3.00	35.2
14	4.00	12.0	8.0	0.120	717.0	3012.0	3.00	35.9
15	4.00	8.0	4.0	0.120	733.0	3079.0	3.00	36.7
16	5.00	4.0	-1.0	0.120	745.0	3129.2	3.00	29.8
17	5.00	-1.0	-6.0	0.120	759.2	3189.8	3.00	30.4
18	2.00	-6.0	-8.0	0.120	768.4	3229.8	3.00	76.8

RAI 03.07.02-19

QUESTION:

(Follow-up Question to RAI 03.07.02-11)

In the response to RAI 03.07.02-11, the applicant stated that, "***The analysis and design results will be available for review following the completion of the detailed design of the RWB currently scheduled for December 2010***." Since this is part of the seismic SSI analysis and RWB is classified as a non-Category I structure with the potential to interact with Category I structures, the applicant is requested to provide the seismic input motion incorporating the effects of SSSI for design of the RWB. The applicant also is requested to include the method proposed in the response for establishing the design response spectra for RWB together with the design spectra input for RWB in the FSAR.

RESPONSE:

Considering the method described in response to RAI 03.07.02-11 for development of the input motion for the Radwaste Building (RWB) II/I design, and based on analysis results from a representative Soil-Structure Interaction (SSI) analysis, the resulting input motion will be same as 0.3g Regulatory Guide 1.60 response spectra for frequencies above 1 Hz. For frequencies below 1 Hz (which are not of interest for structural evaluation), the resulting input motion may slightly exceed the 0.3g Regulatory Guide 1.60 response spectra. Attached Figures RAI 03.07.02-19a and RAI 03.07.02-19b show the input motion for II/I design of the RWB based on the representative SSI analysis.

The additional SSI analysis to confirm the attached results is in progress. The resulting input motion from this confirmatory SSI analysis will be provided by April 30, 2010.

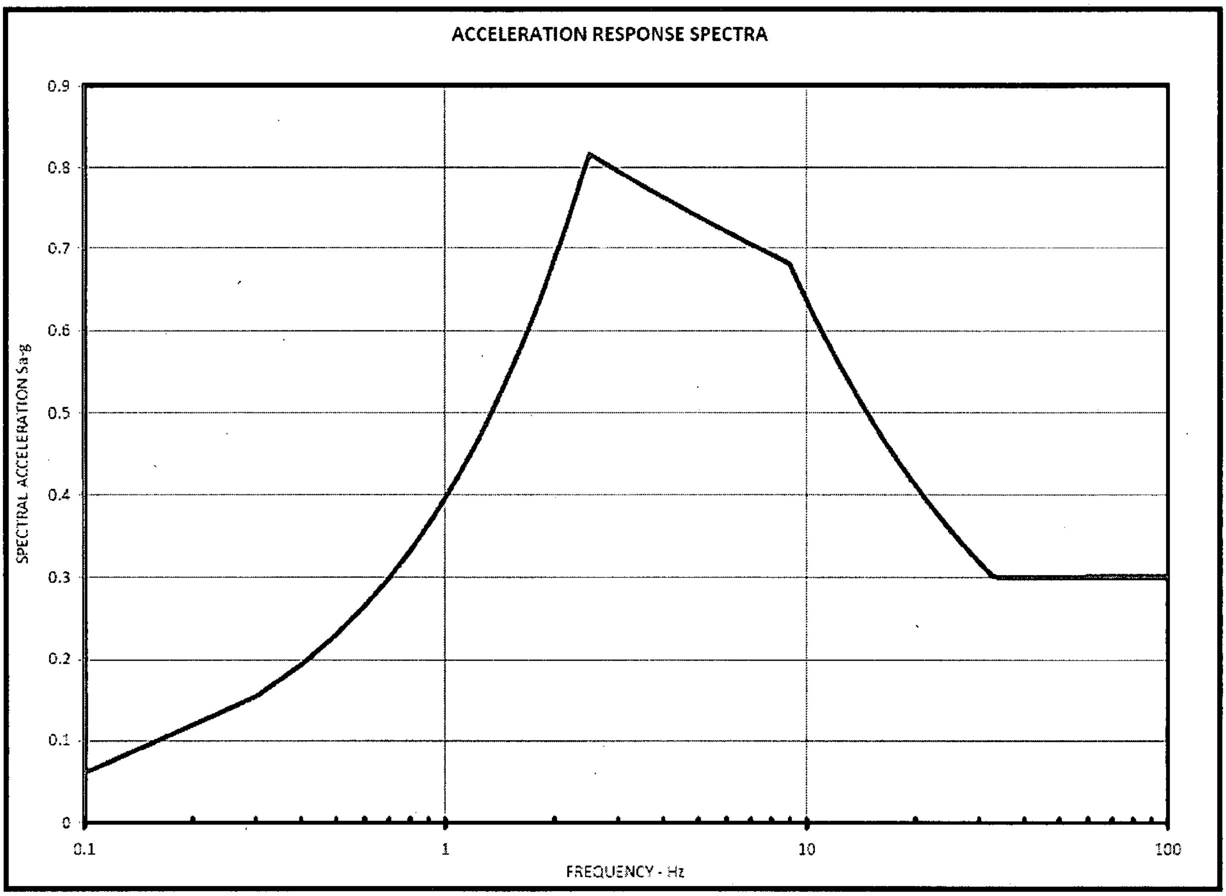


Figure RAI 03.07.02-19a: Horizontal (E-W) Radwaste Building Mat Foundation Response spectrum (7% Damping)

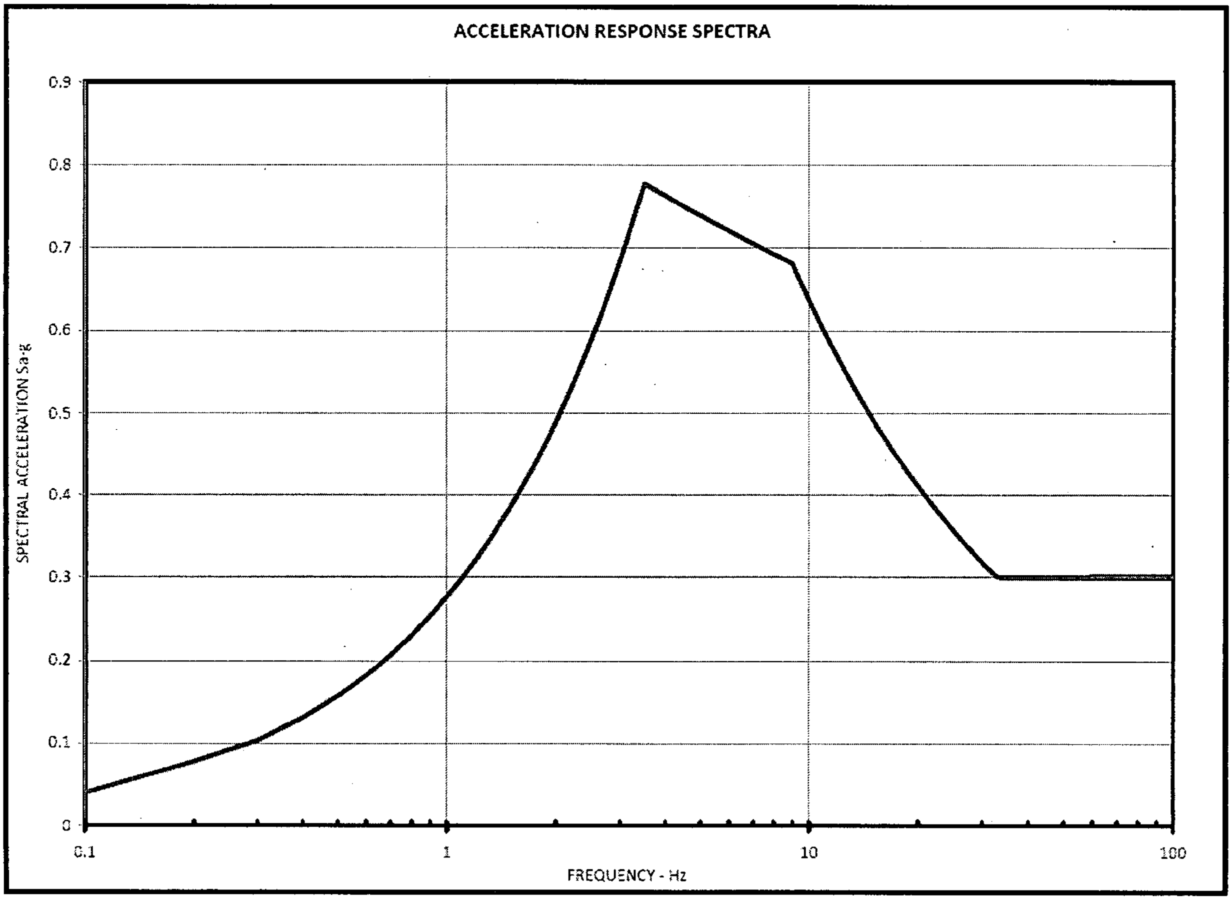


Figure RAI 03.07.02-19b: Vertical Radwaste Building Mat Foundation Response spectrum (7% Damping)

Previous COLA Section 3.7.3.16 revision provided in response to RAI 03.07.03-1 regarding the determination of the input motion for the Control Building Annex (see letter U7-C-STP-NRC-090136, dated September 15, 2009) will be supplemented as shown below:

3.7.3.16 Analysis Procedure for Non-Seismic Structures in Lieu of Dynamic Analysis

Add the following paragraph at the end of this section.

For the Radwaste Building (RWB), the SSE input at the foundation level is the envelope of 0.3g RG 1.60 response spectrum and the induced acceleration response spectrum due to site-specific SSE that is determined from an SSI analysis which accounts for the impact of the nearby Reactor Building (RB). In this SSI analysis, five interaction nodes at the depth corresponding to the bottom elevation of the RWB foundation are added to the three dimensional SSI model of the RB. These five interaction nodes correspond to the four corners and the center of the RWB foundation. The average response of these five interaction nodes is enveloped with the 0.3g RG 1.60 spectra to determine the SSE input at the foundation level.

RAI 03.07.02-20

QUESTION:

In response to COL License Information Item 3.22 the applicant in FSAR Section 3.7.5.4 states that ***"Nonsafety-related SSCs that are located in the same room as safety-related SSCs will be reviewed to determine if their failure will impact the ability of the safety-related SSC to perform its safety function. Non-seismic Category 1 SSCs whose failure could jeopardize the function of a safety-related SSC will be analyzed to demonstrate that structural integrity will be maintained in an SSE."*** Additional information is needed to determine how this review will be implemented. As such, the applicant is requested to describe in the FSAR in detail (a) the process for completing the design of balance-of-plant and non-safety-related systems to minimize II/I interactions, (b) criteria to be used for determining if the failure of non-safety-related SSCs will impact the ability of the safety-related SSCs to perform its safety function, and (c) the analysis/design criteria to be used for demonstrating structural integrity of non-seismic Category I SSCs.

RESPONSE:

The following response applies inside any Category I structure for non-seismic Category I structures, systems and components (SSCs) located in the same room as safety-related SSCs:

(a) Process for completing the design of balance-of-plant and non-safety-related systems to minimize II/I interactions

The following non safety-related commodities are routed on design drawings and designed to preclude failure under Safe-Shutdown Earthquake (SSE) seismic loading:

Large Bore Piping
Small Bore Piping
Cable Tray
Conduit (Except for field run conduit listed below)
HVAC Ducts
Instrumentation

This includes design of supports and support anchorages for SSE seismic loading. Layout guidelines specify minimum separation criteria between commodities. For analyzed commodities (i.e., piping), movements are calculated and are checked for interference on a case-by-case basis if they exceed the layout guidelines. For commodities routed by span criteria, maximum allowable movements corresponding to the separation guidelines are incorporated in the span calculations to ensure seismic movements do not exceed separation criteria.

Similarly, field run commodities are designed to preclude failure under SSE seismic loading. Field run commodities are limited to conduit and junction boxes for the following:

Communications
Security
Lighting
Fire Detection

This includes design of supports and support anchorages for SSE seismic loading. Layout guidelines specify minimum separation criteria between commodities. Maximum allowable movements corresponding to the separation guidelines are incorporated in the span calculations to ensure seismic movements do not exceed separation criteria.

The anchorages for individual non safety-related SSCs not discussed above such as equipment and components are designed to preclude failure under SSE seismic loading.

(b) <u>Criteria to be used for determining if the failure of non-safety-related SSCs will impact the ability of the safety-related SSCs to perform its safety function</u>

Non safety-related SSCs in the same room with safety-related SSCs are designed to preclude failure under SSE seismic loading. Therefore, no criteria has been developed for determining if the failure of non-safety-related SSCs will impact the ability of the safety-related SSCs to perform its safety function.

Note that if at the completion of detailed design, a limited number of non-safety-related SSCs cannot be shown to withstand an SSE event; failure of each SSC will be evaluated on case-by-case basis. Either adjacent safety-related SSCs will be shielded from the non-safety-related SSCs or an impact evaluation will be performed to demonstrate that the failure of the non-safety-related SSCs will not prevent safety-related SSCs from performing their safety function.

(c) <u>Analysis/design criteria to be used for demonstrating structural integrity of non-seismic Category I SSCs.</u>

1) Non-safety-related piping and instrument lines inside any Category I structures will be designed to withstand an SSE event with pipe stresses limited to faulted allowable stresses.

2) Support span criteria used for non-safety-related cable trays, conduits, and HVAC ducts inside any Category I structure will be the same as for safety-related SSCs.

3) Supports for non-safety-related piping, instrument lines, cable trays, conduits, and HVAC ducts inside any Category I structures will be designed for loads that include SSE loads and self-excitation loads during an SSE event.

4) Anchorages for non safety-related commodity supports, equipment, and components inside any Category I structure will be designed for loads that include SSE loads.

5) Within the Category I structures, both embedments and post installed anchors are safety-related. These are designed to the requirements for Category I components, regardless of the classification of the component attached to the structure.

COLA Part 2, Tier 2, Section 3.7.5.4 will be revised as follows as a result of this RAI response.

3.7.5.4 Assessment of Interaction Due to Seismic Effects

The following standard supplement addresses COL License Information Item 3.22. Inside Category I structures, non safety-related SSCs that are located in the same room as safety-related SSCs will be reviewed to determine if their failure will impact the ability of the safety-related SSC to perform its safety function. Non-seismic Category 1 SSCs whose failure could jeopardize the function of a safety related SSC will be analyzed to demonstrate that structural integrity will be maintained in an SSE.

Additional details are provided in the following paragraphs.

(a) The following non-safety-related commodities are routed on design drawings and designed to preclude failure under SSE seismic loading:

Large Bore Piping
Small Bore Piping
Cable Tray
Conduit (Except for field run conduit listed below)
HVAC Ducts
Instrumentation

This includes design of supports and support anchorages for SSE seismic loading. Layout guidelines specify minimum separation criteria between commodities. For analyzed commodities (i.e., piping), movements are calculated and are checked for interference on a case by case basis if they exceed the layout guidelines. For commodities routed by span criteria, maximum allowable movements corresponding to the separation guidelines are incorporated in the span calculations to ensure seismic movements do not exceed separation criteria.

Similarly, field run commodities are designed to preclude failure under SSE seismic loading. Field run commodities are limited to conduit and junction boxes for the following:

Communications
Security
Lighting
Fire Detection

This includes design of supports and support anchorages for SSE seismic loading. Layout guidelines specify minimum separation criteria between commodities. Maximum allowable movements corresponding to the separation guidelines are incorporated in the span calculations to ensure seismic movements do not exceed separation criteria.

The anchorages for individual non-safety-related SSCs not discussed above such as equipment and components are designed to preclude failure under SSE seismic loading.

(b) Criteria to be used for determining if the failure of non-safety-related SSCs will impact the ability of the safety-related SSCs to perform its safety function

Non-safety-related SSCs in the same room with safety-related SSCs are designed to preclude failure under SSE seismic loading. Therefore, no criteria has been developed for determining if the failure of non-safety-related SSCs will impact the ability of the safety-related SSCs to perform its safety function.

If at the completion of detailed design, a limited number of non-safety-related SSCs cannot be shown to withstand an SSE event; failure of each SSC will be evaluated on case by case basis. Either adjacent safety-related SSCs will be shielded from the non-safety-related SSCs or an impact evaluation will be performed to demonstrate that the failure of the non-safety-related SSCs will not prevent safety-related SSCs from performing their safety function.

(c) Analysis/design criteria to be used for demonstrating structural integrity of non-seismic Category I SSCs.

1. Non-safety-related piping and instrument lines inside any Category I structures will be designed to withstand an SSE event with pipe stresses limited to faulted allowable stresses.

2. Support span criteria used for non-safety-related cable trays, conduits, and HVAC ducts inside any Category I structure will be the same as for safety-related SSCs.

3. Supports for non-safety-related piping, instrument lines, cable trays, conduits, and HVAC ducts inside any Category 1 structures will be designed for loads that include SSE loads and self-excitation loads during an SSE event.

4. Anchorages for non-safety-related commodity supports, equipment, and components inside any Category I structure will be designed for loads that include SSE loads.

5. Within the Category I structures, both embedments and post installed anchors are safety-related. These are designed to the requirements for Category I components, regardless of the classification of the component attached to the structure.

A procedure to confirm that all nonsafety-related SSCs located in the same room as a safety related SSC have been evaluated and correctly dispositioned for inspection of the as-built plant for II/I interactions will be developed in accordance with Section 13.5 and will be made available for inspection prior to fuel load. (COM 3.7-2)

RAI 03.08.04-20

QUESTION:

Follow-up to Question 03.08.04-9 (RAI 2965)

In its response to Question 03.08.04-9, the applicant stated that for computation of global seismic loads, the live load is limited to the expected live load present during normal plant operation, Lo. This load has been defined as 25% of the operating floor and roof live loads. In FSAR Section 3H.6.4.3.4, the applicant has used a full live load for load combinations not involving a seismic load, and Lo for loading combinations involving seismic load. Although it is acceptable to consider 25% of design live load for computation of global seismic loads, the basis for considering only 25% of live load in loading combinations involving seismic load is not understood. The load combination that includes the seismic load needs to include the full live load effects per the guidance of SRP 3.8.4 and ACI 349. Therefore, the applicant is requested to clarify the use of a reduced live load (expected live load) in the seismic load combinations.

RESPONSE:

The seismic live load (L_o) will be replaced with the Live Load L in the load combinations in COLA Part 2, Tier 2 Sections 3H.6.4.3.4.2 and 3H.6.4.3.4.3, with appropriate note from Section 3H.6.4.3.1.2 (see proposed COLA mark-up).

The following sections of COLA, Part 2, Tier 2 will be revised as follows as a result of this response.

3H.6.4.3.4.2 Structural Steel Load Combinations

$S = D + L + H + F + R_o + T_o$

$S = D + L + W + R_o + H + F + T_o$

$1.6S = D + L + Wt + H + R_o + F + T_o$

$1.6S = D + L + FL + H + R_o + F + T_o$

$1.6S = D + \cancel{L_o}\ L + E' + H' + R_o + F + T_o$

$1.6S = D + L + S_E + R_o + H + F + T_o$

For the computation of global seismic loads the live load is limited to the expected live load present during normal plant operation which is defined as 25% of the operating floor and roof live loads. However, design of local elements such as beams and slabs is based on consideration of full normal live load.

3H.6.4.3.4.3 Reinforced Concrete Load Combinations

$U = 1.4D + 1.7F + 1.7L + 1.7H + 1.7\ R_o$

$U = 1.4D + 1.7F + 1.7L + 1.7H + 1.7W + 1.7\ R_o$

$U = D + F + L + H + Ta + E'$

$U = D + F + L + H + T_o + R_o + W_t$

$U = D + F + \cancel{L_o}\ L + H' + T_o + R_o + E'$

$U = 1.05D + 1.05F + 1.3L + 1.3H + 1.2T_o + 1.3R_o$

$U = 1.05D + 1.05F + 1.3L + 1.3H + 1.3W + 1.2T_o + 1.3R_o$

$U = D + F + L + H + T_o + R_o + FL$

$U = D + F + L + H + T_o + R_o + S_E$

For the computation of global seismic loads the live load is limited to the expected live load present during normal plant operation which is defined as 25% of the operating floor and roof live loads. However, design of local elements such as beams and slabs is based on consideration of full normal live load.

For the UHS basin, the required strength defined by the above load combinations are multiplied by the following Environmental Durability Factors (S) defined in ACI 350:

- Flexural strength..1.3
- Axial tension (including hoop tension)..1.65
- Excess shear strength carried by shear reinforcement..............................1.3

RAI 03.08.04-21

QUESTION:

Follow-up to Question 03.08.04-10 (RAI 2965)

In FSAR Subsection 3H.6.4.3.3.5, Revision 3, the applicant defines extreme snow load (SE) as 5.5 psf. The applicant has subsequently used this SE in loading combinations. However, for load combinations involving extreme snow, the roof load due to an extreme winter precipitation event per ISG-7 should be considered. According to the applicant's response to Question 03.08.04-14, this load was determined to be 47 lbs/ft^2 based on the maximum accumulated water on roof during an extreme winter precipitation event. Therefore, the applicant is requested to elaborate in this section how the extreme snow load used in load combination for roof design was determined following the guidance provided in ISG-7, and report the design load to be used in load combination for roof design. This information is needed to establish consistency between load definition and its use in corresponding load combination.

RESPONSE:

Per COLA Part 2, Tier 2, Section 2.3S.1.3.4, the ground snow load for both normal winter precipitation event and extreme frozen winter precipitation is 5.5 psf. ISG-7 provides guidance for converting the ground snow load to roof snow load using methodology provided in ASCE 7-05. ASCE 7-05 utilizes an exposure factor (C_e), a thermal factor (C_t), and an importance factor (I) as multipliers for converting ground snow load to roof snow load using Equation 7-1 in Section 7.3. ISG-7 also provides recommended values for these three coefficients to be used in Equation 7-1. As noted in ISG-7, pages 9 and 10, the coefficients to be used in Equation 7-1 of ASCE 7-05 are (C_e=1.1), (C_t=1.0), and (I=1.2). Using these values for the coefficients in Equation 7-1 of ASCE 7-05, and the limitation for minimum value provided in Section 7.3 of ASCE 7-05, the roof snow load is determined to be 6.6 psf, corresponding to a ground snow load of 5.5 psf.

Per ISG-7, the extreme winter precipitation shall be the larger of the following two cases:

Case 1: Normal winter precipitation + Extreme frozen winter precipitation
Case 2: Normal winter precipitation + Extreme liquid winter precipitation

Per COLA Part 2, Tier 2, Section 2.3S.1.3.4, the extreme liquid winter precipitation is 34 inches (or 177 psf). Assuming that both the roof drains and scuppers are clogged, Case 1 will yield a loading of 6.6 + 6.6 = 13.2 psf and Case 2 will yield a loading of 6.6 + 177 = 183.6 psf. However, since the roofs of site-specific structures are designed without parapets (see COLA Part 2, Tier 2, Section 3H.6.4.2.5), for site-specific Category I structures, the extreme winter precipitation can not exceed Case 1 loading of 13.2 psf. The parapet height of ABWR Standard Plant structures do not exceed 9 inches, the extreme winter precipitation for ABWR Standard Plant structures can not exceed 47 psf [i.e. 62.4 pcf x (9/12) = 47 psf].

COLA Sections 3H.6.4.2.4, 3H.6.4.3.1.3 and 3H.6.4.3.3.5 and Table 2.0-2 will be revised as shown below:

3H.6.4.2.4 Maximum Snow Load

~~Design snow load is 0 kPa (100-year return snow pack) and 0.263 kPa (5.5 psf) (Maximum ground level snow load) in accordance with Subsection 2.3S.1.3.4.~~ Normal roof snow load is 6.6 psf. Extreme roof snow load is 13.2 psf.

3H.6.4.3.1.3 Snow Loads

~~Design snow load is 0 kPa (100-year return snow pack) and 0.263 kPa (5.5 psf) (Maximum ground level snow load) in accordance with Subsection 2.3S.1.3.4.~~ The normal roof snow load is 6.6 psf.

3H.6.4.3.3.5 Extreme Snow Load (SE)

~~Maximum ground level snow load, in accordance with Subsection 2.3S.1.3.4, is 0.263 kPa (5.5 psf).~~ Per FSAR Section 2.3S.1.3.4, the ground snow load for both normal winter precipitation event and extreme frozen winter precipitation is 5.5 psf. ISG-7 provides guidance for converting the ground snow load to roof snow load using methodology provided in ASCE 7-05. ASCE 7-05 utilizes an exposure factor (C_e), a thermal factor (C_t), and an importance factor (I) as multipliers for converting ground snow load to roof snow load using Equation 7-1 in Section 7.3. ISG-7 also provides recommended values for these three coefficients to be used in Equation 7-1. As noted in ISG-7, pages 9 and 10, the coefficients to be used in Equation 7-1 of ASCE 7-05 are (C_e=1.1), (C_t=1.0), and (I=1.2). Using these values for the coefficients in Equation 7-1 of ASCE 7-05, and the limitation for minimum value provided in Section 7.3 of ASCE 7-05, the roof snow load is determined to be 6.6 psf, corresponding to a ground snow load of 5.5 psf.

Per ISG-7, the extreme winter precipitation shall be the larger of the following two cases:

Case 1: Normal winter precipitation + Extreme frozen winter precipitation
Case 2: Normal winter precipitation + Extreme liquid winter precipitation

Per FSAR Section 2.3S.1.3.4, the extreme liquid winter precipitation is 34 inches (or 177 psf). Assuming that both the roof drains and scuppers are clogged, Case 1 will yield a loading of 6.6+ 6.6 = 13.2 psf and Case 2 will yield a loading of 6.6 + 177 = 183.6 psf. However, since the roofs of site-specific structures are designed without parapets (see Section 3H.6.4.2.5), for site-specific Category I structures, the extreme winter precipitation can not exceed Case 1 loading of 13.2 psf.

Table 2.0-2 Comparison of ABWR Standard Plant Site Design Parameters and STP 3 & 4 Site Characteristics

Subject	ABWR Standard Plant Site Design Parameters	STP 3 & 4 Site Characteristics	Bounded (Yes/No)	Discussion
Precipitation (for Roof Design)	Maximum Snow Load: 2.394 kPa (50 psf)	~~0 kPa (0 psf) (100-year return snow pack)~~ ~~0.263 kpa (5.5 psf) (Maximum ground level snow load)~~ Normal roof snow load = 6.6 psf and Extreme winter precipitation roof load = 47 psf	Yes	Further information on maximum snow load is provided in Subsection ~~2.3S.1.~~ 3H.6.4.3.3.5. Parapet height of ABWR Standard Plant structures will be limited to 9 inches.

RAI 03.08.04-24

QUESTION:

Follow-up to Question 03.08.04-14 (RAI 3323)

The applicant's response to Question 03.08.04-14 explained that since the maximum parapet height for ABWR standard plant seismic category I structures is 9 inches, roof load during the extreme winter precipitation event may not exceed 47 lbs/ft^2, which is less than the roof design live load of 50 lbs/ft^2.

The applicant is requested to explain why any potential incidental live loads on the roof need not be considered concurrent with the extreme winter precipitation event. Also, since the maximum parapet height of 9 inches is used as the basis for computing the extreme winter precipitation load on the roof, the applicant is requested to include this information in the FSAR. The requested information will establish the adequacy of roof design live load, and include in the FSAR critical design information.

RESPONSE:

Per Sections 3.8.4.3.1.1 and 3.8.4.3.2 of DCD Tier 2, snow load and roof live load are considered non concurrent loads.

Therefore, for the ABWR standard plant seismic category I structures, there is no need to combine any roof live load with the extreme winter precipitation load.

Please see updated Table 2.0-2 in the response to RAI 03.08.04-21. No additional COLA changes are required as a result of this RAI.

RAI 03.08.04-26

QUESTION:

Follow-up to Question 03.08.04-16 (RAI 3323)

In the response to Question 03.08.04-16, the applicant provided details of how hydrodynamic loads were included in the Ultimate Heat Sink (UHS) finite element model following the guidance provided in SRP 3.7.3, but did not include any information in the FSAR. The applicant is requested to include in the FSAR a summary description about how hydrodynamic loads were included in the UHS structural model to meet the guidance provided in SRP 3.7.3, Acceptance Criterion 14.

RESPONSE:

See attached COLA revision.

COLA Part 2, Tier 2, Section 3H.6.6.2.1 will be revised as shown below:

3H.6.6.2.1 UHS Basin, UHS Cooling Tower Enclosure, and RSW Pump House

The analysis described in Subsection 3H.6.6.1 considers the following loads, combined in accordance with Subsection 3H.6.4.3.4:

- Dead and live loads on the UHS basin, UHS cooling tower enclosures, and RSW pump houses as specified in Subsection 3H.6.4.3.1, plus the weight of the UHS cooling tower fill, equipment and commodities in the RSW pump house.

- Hydrostatic and hydrodynamic (impulsive and convective) loads corresponding to the water in the basin, and on the walls and the piers of the UHS basin. These hydrodynamic loads are calculated in accordance with Subsection C3.5.4 of ASCE 4 and meet the guidance provided in SRP 3.7.3, Acceptance Criterion 14.

    - Specifically the "Housner method" described in TID-7024 is used to determine the hydrodynamic impulsive and convective masses.

    - The impulsive masses are applied to the walls of the UHS Soil-Structure Interaction (SSI) model. Therefore, the horizontal impulsive-mode spectral acceleration is based on consideration of the flexibility of the tank.

    - The seismically induced hydrodynamic pressures on the tank walls are determined by the modal and spatial combination methods outlined in SRP Section 3.7.2 including the effects of soil-structure interaction.

    - Since the fundamental sloshing (convective) frequency is so low (0.135 cycles per second in the N-S direction and 0.078 cycles per second in the E-W direction), the convective mass is not included in the SSI model but is considered in the design by employing the spectral acceleration of the horizontal convective frequency at 0.5 percent damping.

- The hydrodynamic pressure is added to the hydrostatic pressure to account for the induced tension and compression forces on basin walls in the design.

- At-rest lateral soil pressure on the walls of the UHS basin and RSW pump houses. Hydrostatic pressures on the walls of the UHS basin and RSW pump houses due to groundwater.

- Dynamic lateral soil pressures on the walls of the UHS basin and RSW pump houses due to an SSE, calculated using the methodology defined in Subsection 3.5.3.2.2 of ASCE 4.Surcharge pressure of 300 psf (14.4 kPa) applied to the access road to the UHS basin and RSW pump houses.

- SSE forces corresponding to the weight of the structures being acted on by the accelerations established by the SSI analysis.

- Wind loads on the UHS basin, UHS cooling tower enclosures, and RSW pump houses calculated as indicated in Subsection 3H.6.4.3.2. Tornado wind and pressure loads on the UHS basin, UHS cooling tower enclosures, and RSW pump houses calculated as specified in Subsection 3H.6.4.3.3.1. Overall global effects of applicable tornado missiles on the UHS basin walls and cooling tower enclosure walls.

- The design flood loads on the RSW pump houses and tunnels are as stated in Subsection 3H.6.4.2.3.