

Figure 03.07.01-29 S1.278: Enveloped Scale Factors for Vertical Response Spectra, Reactor Service Water (RSW) Piping Tunnel

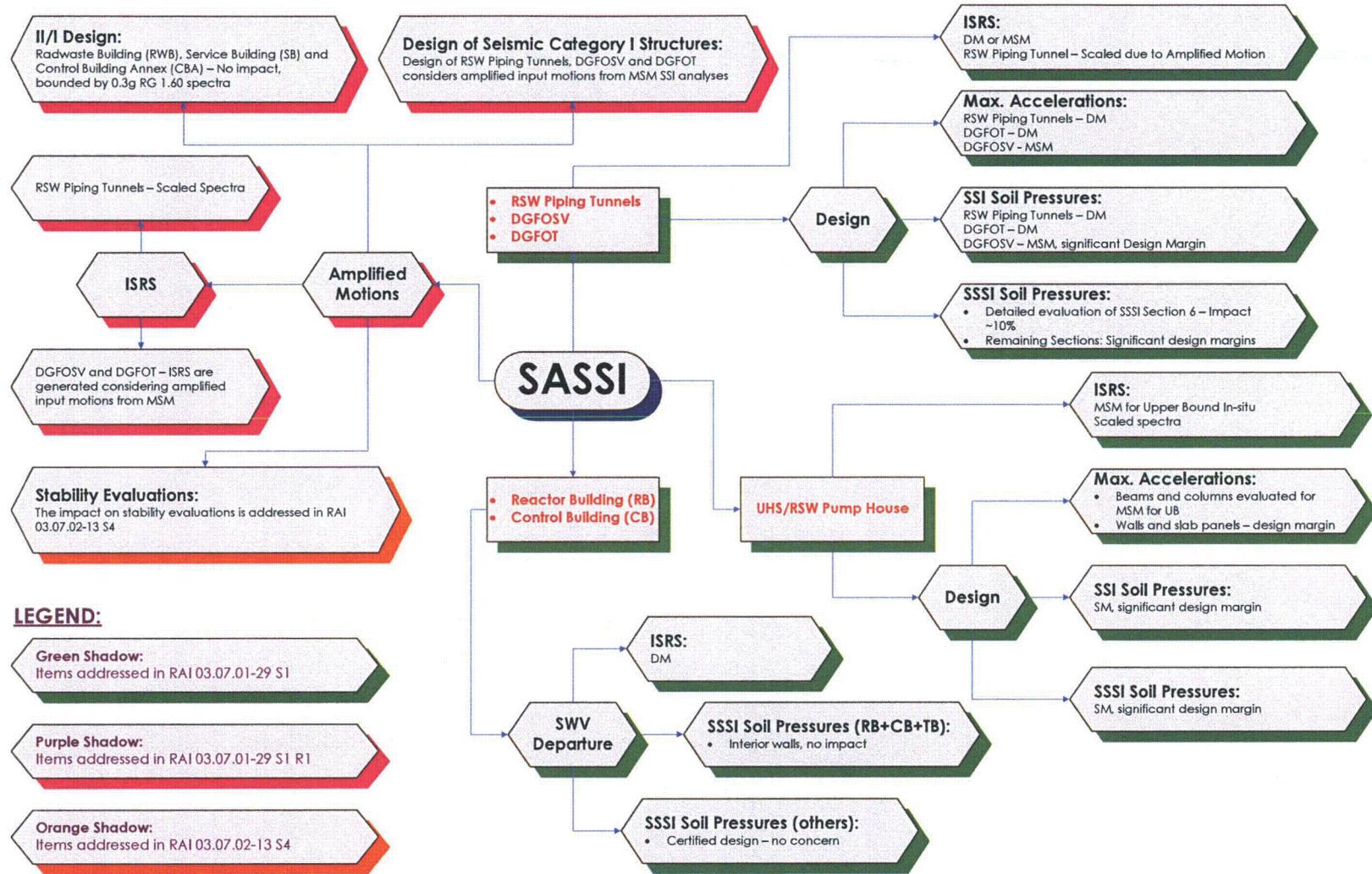


Figure 03.07.01-29 S1.279: Summary of STP 3&4 Evaluations/Actions for Addressing Issues Identified by DNFBS with SASSI Subtraction Method of Analysis

Enclosure 1

COLA will be revised as shown in this enclosure. These mark-ups are based on COLA Rev. 6 and replace those provided in RAI 03.07.01-29, Supplement 1 in their entirety.

3A.15 Site Conditions

Based on the site groundwater conditions originally described in FSAR Subsection 2.4S.12, the groundwater elevation of approximately eight feet below grade (26 feet MSL) was used in the analysis to determine the soil properties. Subsection 2.4S.12 and Table 2.0-2 now state the groundwater elevation as 28 feet MSL. Therefore, a sensitivity analysis of this change in groundwater elevation was performed using the Diesel Generator Fuel Oil Storage Vault SSI model, which showed no significant effect on the analysis results.

3A.21 Soil Pressure on Reactor and Control Building Walls Considering Structure-to-Structure Interaction (SSSI) Effect

To evaluate the effect of SSSI on soil pressures on the RB and CB walls, two dimensional (2D) analyses of RB and CB individually, and 2D SSSI analyses of RB and CB together with Turbine Building (TB) were performed using SASSI2000 software using the subtraction method of analysis. For resolution of issues with the subtraction method of analysis identified by the Defense Nuclear Facilities Safety Board (DNFSB) see Section 3H.10. Since the RB and CB and non-category I TB are closely spaced in the North-South (N-S) direction, the SSSI analysis was performed in the N-S direction. Both the RB and CB were analyzed individually in the N-S direction. The Soil-Structure Interaction (SSI) analysis was repeated for (1) the RB+CB model and (2) the RB+CB+TB model to consider the SSSI effects. The results of these analyses were enveloped. The 2D models used for these analyses are similar to the models described in DCD Tier 2, Section 3A.9.7 for considering SSSI effect on the RB and CB and soil pressures on the building walls. For soil properties variation effects, each analysis was performed using three site-specific SSE strain-compatible in-situ soil conditions: upper bound, mean and lower bound, and the results were enveloped. The site specific SSE input motion is defined at the grade elevation.

3H.6.5.1.3 Supporting Media for Seismic Category I Structures

Soil conditions at the STP 3 & 4 site are described in Subsection 2.5S.4. The soil at the site extends down several thousand feet and consists of alternating layers of clay, silt, and sand. Soil layering characteristics, geophysical shear wave velocity, unit weight, and Poisson's ratio are included in Table 2.5S.4-27. Based on the site groundwater conditions originally described in Section 2.4S.12, the groundwater elevation of approximately 8 ft below grade (26 feet MSL) was used in computing soil properties for the SSI analysis. Subsection 2.4S.12 and Table 2.0-2 now state the groundwater elevation as 28 feet MSL. Therefore, a sensitivity analysis of this change in groundwater elevation was performed, which showed no significant effect on the analysis results. The implementation of this change in the seismic analysis is discussed in Sections 3H.6.5.2.4.3 and 3H.6.5.3.

3H.6.5.2.4 Soil-Structure Interaction

The following describes the soil-structure-interaction (SSI) analysis for the UHS/RSW Pump House.

SSI effects were accounted for by the use of the SASSI2000 computer program using subtraction method of analysis, 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. For resolution of issues with the subtraction method of analysis identified by the Defense Nuclear Facilities Safety Board (DNFSB) see Section 3H.10. 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 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 for mean in-situ soil profile using the method in Section 3.3.1.9 of ASCE 4-98. Results of this analysis were enveloped with other SSI analyses.

3H.6.5.2.4.2 Additional Sensitivity Analysis for Refined Mesh

Additional SSI analyses were performed using a refined mesh for the soil and structural model. These analyses are described below.

Two additional UHS/RSW Pump House SSI analyses were performed for the upper bound soil profile case (UB soil case) considering both full and empty UHS basin, with a refined model shown in Figure 3H.6-15h.

The refined SSI model used for these analyses has the following passing frequency capability (passing frequency, $f = V_s / 5 h$, where V_s is the shear wave velocity of the soil layer and h is the vertical or horizontal distance between the adjacent interaction nodes):

Vertical direction: 40.4 Hz

Horizontal direction: 23.5 Hz

For soil layers below groundwater level, the Poisson's ratio was capped at 0.495 for determining the compression wave velocity. A cut-off frequency of 33 Hz was used in these analyses for transfer function calculation.

The passing frequency of about 24 Hz in the horizontal direction was selected since the site has a deep soil profile and the SSI frequencies are below 6 Hz. Also, as noted in SRP 3.7.1 Revision 3, Appendix A, the energy content of the earthquake time histories above 24 Hz is inconsequential.

Based on the results of the above refined SSI analyses, and additional structural mesh sensitivity analyses, envelope modification factors were determined for increase of the following in-structure response spectra obtained from the SSI analyses described in Section 3H.6.5.2.4 and 3H.6.5.2.4.1. were modified by multiplying them with the modification factors shown in Table 3H.6-17. Then, the results of the full and empty basin analyses were enveloped.

- Vertical direction spectra at the center of the Pump House Roof
- Vertical direction spectra at the center of the Pump House Operating Floor
- Vertical direction spectra of the Cooling Tower Walls
- Out-of-plane horizontal spectra of the Basin Walls

The final in-structure response spectra are shown in Figures 3H.6-16 through 3H.6-39.

3H.6.5.2.4.3 Final In-Structure Response spectra

In response to issues with the subtraction method of analysis identified by the Defense Nuclear Facilities Board (DNFSB) discussed in Section 3H.10, the SSI analysis for the upper bound in-situ soil case was repeated for both full and empty basin cases using the modified subtraction method of analysis. Also, in these analyses the groundwater table was changed to 6 ft below grade. Based on comparison of the resulting response spectra from these analyses to those from the subtraction method of analysis additional modification factors were determined for increase of in-structure response spectra from the subtraction method of analysis to account for the effect of using the modified subtraction method. The product of these modification factors and those described in Section 3H.6.5.2.4.2 as shown in Table 3H.6-17 were used to increase the in-structure response spectra described in Sections 3H.6.5.2.4 and 3H.6.5.2.4.1. Then, the results of the full and empty basin analyses were enveloped.

The final in-structure response spectra are shown in Figures 3H.6-16 through 3H.6-39.

3H.6.5.3 Seismic Analysis of RSW Piping Tunnels

SSI Analysis of the Typical 2D Section of RSW Tunnel (using the direct method of analysis)

Figure 3H.6-209 shows the structural part of the 2D plane-strain model of the reinforced concrete RSW Piping Tunnel with 2 ft thick mud mat under the base slab. The top of the tunnel is 1.75 ft below grade. The model uses 4-node plane-strain elements to model the 3 ft thick exterior walls, 3 ft thick base slab, two 2 ft thick intermediate floors, 2 ft thick mud mat and the 1.75 ft soil above the tunnel. As shown in Figure 3H.6-209, spring elements are added on the side walls of the tunnel to calculate the seismic soil pressures on the tunnel walls.

The Specifics of this 2D SSI model are as follows:

- The structural properties (i.e. mass and stiffness) for the 2D model correspond to per unit depth (1 ft dimension in the out-of-plane direction) of the tunnel.
- Layered soil is modeled up to 124 ft depth with half space below it (more than two times the horizontal dimension of RSW Piping Tunnel plus its embedment depth).
- Six cases of strain dependent soil properties representing in-situ lower bound, mean and upper bound; and backfill lower bound, mean and upper bound are considered.
- Analysis cases also include one case with cracked concrete (50% concrete modulus value) and one case with soil separation (20 ft depth). Backfill upper bound soil case was used in these analyses.
- Concrete and mud mat damping are assigned 4% for all cases, except 7% damping is assumed for the cracked case.
- Groundwater was considered at 8 ft depth (26 feet MSL). Subsection 2.4S.12 and Table 2.0-2 now state the site groundwater elevation as 28 feet MSL. Therefore, a sensitivity analysis of this change in groundwater elevation was performed using the Diesel Generator Fuel Oil Storage Vault SSI model, which showed no significant effect on the analysis results. The ground water effect is included by using minimum P-wave velocity of 5000 ft/sec except for cases where use of this minimum P-wave velocity results in Poisson's ratio in excess of 0.495.
- Model is capable of passing frequencies for both vertical and horizontal directions at least up to 32.9 Hz.
- Cut-off frequency for transfer function calculation is 33 Hz.

- Input motion is the amplified site specific SSE considering the effect of nearby heavy RB and UHS/RSW Pump House structures. These amplified motions were obtained from three dimensional (3D) SSI analyses of the RB and UHS/RSW PH SSI analyses as described below. For resolution of issues with the subtraction method of analysis identified by the Defense Nuclear Facilities Safety Board (DNFSB) see Section 3H.10.

SSSI Analysis of the East-West 2D section of the RSW piping tunnel between the RWB and RB

Figure 3H.6-210 shows the structural part of the 2D plane-strain model of RB + RSW Piping Tunnel + RWB. Specifics of this SSSI analysis are as follows:

- Subtraction method of analysis is used. For resolution of issues with the subtraction method of analysis identified by the Defense Nuclear Facilities Safety Board (DNFSB) see Section 3H.10.
- The structural properties (mass and stiffness) for the 2D model of the individual structures correspond to per unit depth (1 ft dimension in the out-of-plane direction) of the respective structure.
- Layered soil is modeled up to 551 ft depth with halfspace below it (more than two times the maximum horizontal dimension of any of the buildings plus their embedment depth).
- Lower bound in-situ, upper bound in-situ, and upper bound in-situ with upper bound backfill strain-dependent soil properties were used in the SSSI analysis.
- The damping of structural part of the model is 4%.
- Groundwater was considered at 8 ft depth (26 feet MSL). Subsection 2.4S.12 and Table 2.0-2 now state the site groundwater elevation as 28 feet MSL. Therefore, a sensitivity analysis of this change in groundwater elevation was performed using the Diesel Generator Fuel Oil Storage Vault SSI model, which showed no significant effect on the analysis results. The ground water effect is included by using minimum P-wave velocity of 5000 ft/sec except for cases where use of this minimum P-wave velocity results in Poisson's ratio in excess of 0.495.
- Model is capable of passing frequencies of at least up to 35.9 Hz in the vertical direction and 61.6 Hz in the horizontal direction.
- Cut-off frequency for transfer function calculation is 33 Hz.
- Input motion is site specific SSE motion.
- The horizontal (E-W) input motion is applied at the grade elevation.
- Figures 3H.6-212 and 3H.6-213 show the resulting soil pressures.

SSSI Analysis of the North-South 2D section of the RSW piping tunnel between the DGFOV and UHS/RSW Pump House

Figure 3H.6-211 shows the structural part of the 2D plane-strain model of RB + two DGFOVs + RSW Piping Tunnel (adjacent to UHS/RSW Pump House) + UHS/RSW Pump House. Specifics of this SSI analysis are as follows:

- Subtraction method of analysis is used. For resolution of issues with the subtraction method of analysis identified by the Defense Nuclear Facilities Safety Board (DNFSB) see Section 3H.10.
- The structural properties (mass and stiffness) for the 2D model of the individual structures correspond to per unit depth (1 ft dimension in the out-of-plane direction) of the respective structure.
- Layered soil is modeled up to 546 ft depth with halfspace below it (more than two times the maximum horizontal dimension of any of the buildings plus their embedment depth). Lower bound in-situ and upper bound in-situ strain-dependent soil properties were used in the SSSI analysis.
- The damping of structural part of the model is 4%.
- Groundwater was considered at 8 ft depth (26 feet MSL). Subsection 2.4S.12 and Table 2.0-2 now state the site groundwater elevation as 28 feet MSL. Therefore, a sensitivity analysis of this change in groundwater elevation was performed using the Diesel Generator Fuel Oil Storage Vault SSI model, which showed no significant effect on the analysis results. The ground water effect is included by using minimum P-wave velocity of 5000 ft/sec except for cases where use of this minimum P-wave velocity results in Poisson's ratio in excess of 0.495.
- Model is capable of passing frequencies of at least up to 35.9 Hz in the vertical direction and 61.6 Hz in the horizontal direction.
- Cut-off frequency for transfer function calculation is 33 Hz.
- Input motion is site specific SSE motion.
- The horizontal (N-S) input motion is applied at the grade elevation.
- Figures 3H.6-214 and 3H.6-215 show the resulting soil pressures.

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

3D SSI Analysis

The SSI analyses of the 3D model of DGFOSV are performed using SASSI2000 computer program (using the modified subtraction method).

Structural Model:

The structural part of the model consists of shell elements to model the exterior walls, and the roof slabs and 3D solid elements to model the basemat and the mud mat. Structure self weight and other applicable weights of equipment, live load, piping, metal decking, missile barrier cover are included in the structural model. The fuel tank is modeled with the fuel and tank weight lumped at the center of gravity of the tank and the tank lumped weight rigidly connected to the base mat at tank saddle locations. The fuel tank procurement specification will require that the fuel tank with fuel in it should have predominant frequencies greater than 33 Hz in horizontal and vertical directions. The fuel tank portion of the model has been assigned a damping value of 0.5%. For the other parts of the structure two damping values are used; 7% damping and 4% damping. The results from the 7% structural damping are used for design of the DGFOSV. The results from the 4% damping are used for generation of in-structure response spectra. Both full and empty fuel oil tank conditions are considered in the analysis. Figure 3H.6-222 shows the typical 3D structural model of the DGFOSV for various SSI analyses. The following provides the details of the SSI model and method of analysis.

Strain Dependent Soil Properties Used in SSI Analyses:

The strain dependent soil properties used in the model are in accordance with the properties provided in Table 3H.6-1 for the in-situ soil and Table 3H.6-2 for the backfill soil, with the exception that the groundwater table is changed to 6 ft below grade and for soil layers below the ground water table, the Poisson's ratio is capped at 0.495 for determining the compression wave velocity. The shear wave velocities in backfill are also adjusted as described in Section 3H.6.5.2.4 for groundwater table at 6 ft below grade. The thickness of soil layers are adjusted to provide a vertical direction passing frequency of at least 33 Hz (based on one fifth of shear wave length criterion).

Analysis Cases, Passing Frequency and Cutoff Frequency for the SSI Analyses:

- The following cases are analyzed for both 4% and 7% structural damping cases:

For full fuel oil tank case:

- Lower Bound (LB) in-situ soil
- Mean in-situ Soil
- Upper Bound (UB) in-situ soil

- LB backfill over LB in-situ soil
- Mean backfill over mean in-situ soil
- UB backfill over UB backfill
- UB in-situ soil with soil separation
- UB in-situ soil with cracked concrete

For Empty fuel oil tank case:

- UB in-situ soil with empty fuel tank

Note: For soil separation, cracked concrete and empty fuel oil tank cases, the UB in-situ soil is used because the UB in-situ soil case in general governed.

- A cut-off frequency of 33 Hz was used for all SSI analyses for transfer function calculation.
- Vertical direction passing frequencies (based on one fifth of shear wave length criterion and considering lower bound in-situ soil) are equal to or greater than 33 Hz.
- Horizontal direction passing frequencies are equal to or greater than 33 Hz, except at following locations:
 - For LB in-situ soil, the passing frequency for the top 4 ft soil layer is 30.3 Hz.
 - At the foundation toe, the passing frequencies for in-situ soil are 20 Hz for LB, 25.8 Hz for mean, 31.6 Hz for UB; and for backfill are 23.4 Hz for LB, 28.3 Hz for mean and 34.7 Hz for UB.

To evaluate the effect of 20 Hz passing frequency for LB in-situ case, the foundation toe was divided into two elements, thus increasing the passing frequency to 40 Hz. This refined model with LB in-situ soil properties was analyzed and 5% damped spectra from this model were compared with the spectra from the original model with passing frequency of 20 Hz. The comparison shows that:

- In the X direction, there is insignificant difference between the response spectra from the two models
- In the Y direction, the response spectra from the two models matched well except at frequency of about 3.8 Hz where the refined model produced higher spectra. However, spectra from both the models are enveloped by the spectra for UB in-situ soil case
- In the vertical direction, the spectra from the two models matched well (insignificant difference)

Based on the above evaluation it is concluded that the horizontal direction passing frequencies are acceptable.

Input Motion:

In the SSI analysis, acceleration time histories, consistent with 0.3g Regulatory Guide 1.60, are used as input at the grade elevation. The response spectra from these time histories envelop the amplified response spectra at the DGFOVS locations considering the effect of nearby heavy RB and UHS/RSW Pump House structures.

Response Combination, Enveloping and Spectra Peak Widening:

For all analysis cases, the responses due to two horizontal directions and vertical direction input motions are combined using square-root sum of squares (SRSS) method. Then, the responses from all analysis cases and all locations considered for spectra generation are enveloped to determine one set of un-widened horizontal and vertical response spectra. Finally, per Regulatory Guide 1.122, the enveloped un-widened response spectra are peak widened by plus-minus 15% on the frequency scale to obtain the final response spectra for DGFOVS. The resulting enveloping response spectra for DGFOVS are shown in Figures 3H.6-223 and 3H.6-224.

2D SSSI Analysis

Two 2D SSSI models are developed and analyzed to evaluate the effects of nearby structures on the three DGFOVS and to calculate the seismic soil pressures on the structures.

The first SSSI model is for a section cut in the North-South direction, consisting of UHS/RSW Pump house, RSW Piping Tunnel, DGFOVS 1B, DGFOVS 1C and RB. The details of this SSSI analysis are provided in Section 3H.6.5.3.

The second SSSI model is for a section cut in the East-West direction consisting of diesel generator fuel oil tunnel (DGFOT), DGFOVS 1A and the Crane Foundation Retaining Wall. The model for this SSSI analysis is shown in Figure 3H.6-225 and the details of the model are provided below.

Structural Models:**DGFOVS Model:**

East-West direction of 2D DGFOVS model is idealized by a stick model of beam elements. Axial, flexural, and shear deformation effects are included in beam element stiffness. The fuel oil tank is also modeled using beam elements and its mass is lumped at its CG. The basemat and the mud mat are modeled using four node plain strain elements. The model properties (stiffness and mass) for the 2D plane analysis correspond to per unit depth (one foot dimension in the out-of-plane direction) of the DGFOVS.

DGFOT Model:

Four node plane strain elements are used to model the exterior walls, base slab, the top slab and the mud mat. Applicable weights are included at appropriate locations in the model. The structural model properties (stiffness and mass), for the 2D plane strain model correspond to per unit depth (one foot dimension in out-of-plane direction).

Crane Wall:

The Crane Wall is modeled using beam elements with nodes located 17 ft away from the DGFOV east wall (clear distance between the DGFOV 1A exterior wall face and the west face of the Crane Wall). Beam section properties (stiffness and mass), for the 2D plane strain model correspond to per unit depth (one foot dimension in out-of-plane direction).

The SSSI analysis of the 2D model of DGFOV with other structures, which affects the DGFOV in the East-West direction is performed using SASSI2000 computer program, using subtraction method. For resolution of issues with the subtraction method of analysis identified by the Defense Nuclear Facilities Safety Board (DNFSB) see Section 3H.10. The following provides the details of this SSSI analysis.

Strain Dependent Soil Properties Used in SSSI Model:

The strain dependent soil properties used in the model are in accordance with the properties provided in Table 3H.6-1 for the in-situ soil, and Table 3H.6-2 for the backfill soil, with the exception that for soil layers below the ground water table, the Poisson's ratio is capped at 0.495 for determining the compression wave velocity. The thickness of soil layers are adjusted to provide a vertical direction passing frequency of at least 33 Hz (based on one fifth of shear wave length criterion).

Based on the site groundwater conditions originally described in FSAR Subsection 2.4S.12, the groundwater elevation of approximately eight feet below grade (26 feet MSL) was used in the analysis to determine the soil properties. Subsection 2.4S.12 and Table 2.0-2 now state the groundwater elevation as 28 feet MSL. Therefore, a sensitivity analysis of this change in groundwater elevation was performed using the Diesel Generator Fuel Oil Storage Vault SSI model, which showed no significant effect on the analysis results.

To evaluate the effects of the soil variation, six soil cases are considered:

- UB in-situ soil
- UB in-situ soil with UB backfill between the structures.
- LB in-situ soil with LB backfill between the structures.
- Mean in-situ soil with Mean backfill between the structures.
- Mean in-situ soil with LB backfill between the structures.
- Mean in-situ soil with UB backfill between the structures.

Passing Frequency and Cut-off Frequency for SSSI Model:

- Cut-off frequency of 33 Hz is used in the analysis.
- Vertical direction passing frequencies are equal to or greater than 33.5 Hz.
- Horizontal direction passing frequencies are equal to or greater than 30.48 Hz.

Input Motion:

STP 3&4 site specific SSE motion, as described in Subsection 3H.6.5.1.1.2, is applied at the grade elevation, in the East-West direction.

The incremental seismic soil pressures used in design, which envelope the incremental seismic soil pressures from the SSSI analyses and those computed per Subsection 3.5.3.2 of ASCE 4-98, are shown in Figures 3H.6-226 through 3H.6-231.

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

The effect of settlement due to the flexibility of the structure/basemat and supporting soil is accounted for through the use of finite element analysis in conjunction with foundation soil springs, as described in Section 3H.6.6.4. The resulting maximum calculated ratio of differential foundation settlements (between adjacent points in the mat finite element model) within the boundary of the DGFOVS is 1/4860.

Stability evaluations were performed for sliding, overturning, and flotation. For sliding and overturning evaluations, the 100%, 40%, 40% rule was used for consideration of the X, Y, and Z seismic excitations. Since the orientation of the DGFOVSs in the horizontal plane can be along the East-West or North-South axes, the horizontal seismic values used in the stability calculation envelope the SSI accelerations in the X and Y directions. The calculated factors of safety against sliding, overturning, and flotation for the DGFOVS are included in Table 3H.6-12.

The tornado missile impact evaluation results for the DGFOVS are included in Table 3H.6-13.

Lateral soil pressures used in design are shown in Figures 3H.6-241 through 3H.6-244.

The Large Equipment Access Building Foundation will be designed such that the surcharge load on the walls of the adjacent DGFOVS is insignificant.

3H.7.5.2.1 Seismic Analysis

A. 2D SSI Analysis of a Typical Cross section of DGFOVS

SASSI2000 computer code is used for the SSI analysis, using the direct method. Figure 3H.7-20 shows the structural part of the 2D plane-strain model of the DGFOVS

with 2 ft thick mud mat under the base mat. The top of the tunnel is at the grade elevation. The specifics of the 2D SSI model are as follows:

- The structural properties (i.e. mass and stiffness) for the 2D model correspond to per unit depth (1 ft dimension in out-of-plane direction) of the tunnel.
- Layered soil is modeled up to 74 ft depth (more than two times the horizontal cross section dimension of the tunnel plus its embedment depth) with halfspace below it.
- Sixteen cases of strain dependent soil properties representing the in-situ lower bound, mean and upper bound; lower bound backfill over in-situ lower bound, mean backfill over in-situ mean and upper bound backfill over in-situ upper bound; cracked concrete wall with in-situ upper bound soil, soil separation with in-situ upper bound soil; ABWR DCD/Tier 2 generic soil profiles UB1D, VP3D, VP4D, VP5D, VP7D, R, R with soil separation and R with cracked wall.
- Concrete and mud mat damping are assigned 4% for all cases (conservatively 4% damping is also used for cracked concrete cases).
- In accordance with Subsection 2.4S.12 and Table 2.0-2 groundwater was considered at 86 ft depth (286 feet MSL) for site-specific soil and backfill cases. Subsection 2.4S.12 and Table 2.0-2 now state the site groundwater elevation as 28 feet MSL. Therefore, a sensitivity analysis of this change in groundwater elevation was performed, which showed no significant effect on the analysis results. Groundwater was considered at 2 ft depth for DCD cases. In site-specific and backfill cases, the groundwater effect is included by using a minimum P-wave velocity of 5000 ft/sec, as explained in Section 3A.15, except that Poisson's ratio is capped at 0.495. In DCD cases, the groundwater effect is similarly included, except that, consistent with DCD Section 3A.3.3, a minimum P-wave velocity of 4800 ft/sec is used.

3H.10 STP 3 & 4 Resolution of Issues with Subtraction Method of Analysis Identified by DNFSB

The Defense Nuclear Facilities Safety Board (DNFSB) in its letter from Peter S. Winokur to Daniel B. Poneman of DOE, dated April 8, 2011, has identified a technical issue in SASSI that when the Subtraction Method (SM) is used to analyze embedded structures, the results may be non-conservative. To address this issue an extensive evaluation was performed and, where required, in-structure response spectra and/or structural designs based on SM were modified to ensure STP 3 & 4 designs are conservative. This evaluation took into account the recommendations for reviewing past SASSI SM analyses, and advice on avoiding SM errors in future analyses that DOE provided in a letter from Daniel B. Poneman to Peter S. Winokur dated July 29, 2011, responding to the DNFSB. The following is a summary of this evaluation.

Modified Subtraction Method:

For new analyses where use of the Direct Method (DM) of analysis is not feasible, in its July 29, 2011 letter to the DNFSB, DOE has recommended using the Modified Subtraction Method (MSM) of analysis. For analyses performed for STP 3 & 4, the interaction nodes for MSM are comprised of all those at the soil-structure interface and all those at the top of excavated soil elements. Based on a project specific validation and verification, in-structure response spectra, maximum accelerations, and forces from MSM were verified against those from DM.

Generation of In-structure Response Spectra (ISRS):

- Reactor Service Water (RSW) Piping Tunnel ISRS were generated using DM. Initially the amplified site specific SSE motions considering the effect of nearby heavy structures were obtained from SSI analyses of the Reactor Building (RB) and Ultimate Heat Sink (UHS)/RSW Pump House using SM. The SSI analyses of the RB (for all soil cases) and UHS/RSW Pump House (for upper bound in-situ soil case) were repeated using MSM. Based on the comparison of the RSW Piping Tunnel ISRS obtained from SSI analysis of RSW Piping Tunnel using amplified site specific SSE motions from MSM analyses to those from SM, increase scale factors were determined to account for the effect of MSM on amplified site specific SSE motions. The ISRS based on amplified site specific SSE motions from SM analyses were increased by these increase scale factors to obtain the final RSW Piping Tunnel ISRS.
- Diesel Generator Fuel Oil Tunnel (DGFOT) ISRS were generated using DM.
- Diesel Generator Fuel Oil Storage Vault (DGFOV) ISRS were initially generated using SM. DGFOV ISRS have been revised based on new SSI analysis using MSM.
- Ultimate Heat Sink (UHS)/RSW Pump House ISRS were initially generated using SM. The SSI analysis for the upper bound in-situ soil case was repeated using MSM. The ISRS from MSM were compared to the corresponding ISRS from SM to determine modification factors (only increases were considered, reductions were ignored) to

account for MSM effect. The product of the modification factors for MSM and envelope of the modification factors accounting for the cumulative effect of structural and SSI mesh refinements discussed in Section 3H.6.5.2.4.2 were used as the final modification factors for adjusting the ISRS from SM to obtain the final UHS/RSW Pump House ISRS.

SSSI Soil Pressures used in Structural Design:

Based on an extensive SSSI study, the following were concluded:

- The method of SSSI analysis (SM, MSM, or DM) has negligible impact on the total force due to seismic soil pressure.
- The method of SSSI analysis (SM, MSM, or DM) has negligible impact on location (i.e. C.G.) of the total force due to seismic soil pressure.
- DM analytical results show some changes in the distribution of seismic soil pressure for exterior walls.
- The method of SSSI analysis (SM, MSM, or DM) has negligible impact on the soil pressure distribution for interior walls (walls facing adjacent structure).

Considering the above and the available margins between the seismic soil pressures used for design and those from SM, the designs based on SM were found to be adequate for possible changes in soil pressure distribution due to use of DM.

SSI Soil Pressures used in Structural Design:

- RSW Piping Tunnel SSI soil pressures were obtained from DM.
- DGFOT SSI soil pressures were obtained from DM.
- DGFOVS SSI soil pressures were obtained from MSM. Based on available margin between the seismic soil pressures used for design and SSI soil pressures from MSM, the design was found to be adequate for possible changes in soil pressure distribution due to use of DM.
- UHS/RSW Pump House SSI soil pressures were obtained from SM. MSM SSI soil pressures for upper bound in-situ soil case were found to be comparable to those from SM. Based on available margin between the seismic soil pressures used for design and SSI soil pressures from SM, the design was found to be adequate for possible changes in soil pressure distribution due to use of DM.

Maximum Accelerations / Section Cut Forces used in Structural Design:

- RSW Piping Tunnel SSI is based on DM.
- DGFOT SSI is based on DM.

- DGFOV SSI is based on MSM.
- UHS/RSW Pump House SSI is based on SM. The maximum accelerations from MSM SSI analysis for upper bound in-situ soil case were used for evaluation of design which is based on SM. Based on the results of this evaluation, the conservative UHS/RSW Pump House design, using equivalent static method for determination of seismic loads, was found to have adequate margin to account for possible changes in maximum accelerations from MSM SSI analysis for all soil cases.

Table 3H.6-17: Response Spectra Modification Factors

Group	Direction	Damping	Frequency Range (Hz)							
			0-2	2-5	5-10	10-15	15-20	20-25	25-30	30-35
group1	X	0.005	1.255	1.255	1.472	2.195	2.195	1.837	1.837	1.047
group2			1.432	1.432	1.882	2.348	2.348	1.888	1.367	1.021
group3			1.321	1.321	1.868	2.083	2.083	1.775	1.697	1.097
group4			1.193	1.193	1.858	2.630	2.630	2.136	1.677	1.020
group5			1.195	1.195	1.864	1.838	1.838	1.317	1.219	1.000
group6			1.449	1.590	3.253	3.849	3.270	3.763	3.639	1.514
group7			1.230	1.230	1.814	1.582	1.553	2.234	1.202	1.003
group8			1.660	4.430	4.430	1.734	1.372	1.237	1.222	1.136
group9			1.660	2.138	1.859	1.734	1.413	1.237	1.192	1.117
group10			1.660	2.138	1.770	1.734	1.753	1.275	1.192	1.117
group1	X	0.01	1.273	1.273	1.423	1.754	1.754	1.340	1.298	1.047
group2			1.381	1.381	1.729	1.917	1.917	1.424	1.235	1.019
group3			1.285	1.285	1.734	1.728	1.728	1.384	1.184	1.097
group4			1.207	1.207	1.700	2.164	2.164	1.692	1.385	1.021
group5			1.166	1.166	1.760	1.567	1.567	1.216	1.059	1.000
group6			1.483	1.514	2.566	2.856	2.274	2.672	2.672	1.467
group7			1.192	1.192	1.727	1.347	1.532	1.553	1.110	1.002
group8			1.417	3.653	3.653	1.464	1.231	1.228	1.149	1.136
group9			1.417	2.072	1.662	1.464	1.301	1.149	1.149	1.117
group10			1.417	2.072	1.637	1.464	1.429	1.215	1.149	1.117
group1	X	0.02	1.264	1.264	1.363	1.505	1.505	1.181	1.181	1.047
group2			1.317	1.317	1.518	1.587	1.587	1.292	1.085	1.018
group3			1.252	1.252	1.535	1.377	1.377	1.113	1.097	1.097
group4			1.247	1.247	1.497	1.708	1.708	1.358	1.164	1.021
group5			1.151	1.151	1.576	1.348	1.348	1.118	1.016	1.000
group6			1.441	1.479	2.039	2.277	1.938	1.879	1.893	1.369
group7			1.205	1.205	1.561	1.303	1.334	1.158	1.078	1.001
group8			1.251	2.770	2.770	1.300	1.151	1.194	1.156	1.136
group9			1.251	1.843	1.483	1.300	1.197	1.122	1.123	1.117
group10			1.251	1.843	1.364	1.300	1.195	1.151	1.123	1.117
group1	X	0.03	1.227	1.227	1.326	1.342	1.312	1.152	1.152	1.048
group2			1.338	1.338	1.395	1.426	1.436	1.186	1.068	1.018
group3			1.274	1.274	1.413	1.272	1.272	1.054	1.097	1.097
group4			1.274	1.274	1.382	1.415	1.415	1.203	1.116	1.021
group5			1.123	1.123	1.459	1.217	1.217	1.055	1.000	1.000
group6			1.416	1.507	1.871	1.958	1.718	1.673	1.697	1.311
group7			1.181	1.181	1.456	1.247	1.247	1.104	1.073	1.000
group8			1.221	2.315	2.315	1.182	1.151	1.174	1.162	1.136
group9			1.221	1.672	1.317	1.182	1.151	1.117	1.120	1.117
group10			1.221	1.672	1.293	1.182	1.151	1.130	1.120	1.117
group1	X	0.04	1.202	1.202	1.269	1.256	1.233	1.122	1.122	1.047
group2			1.283	1.283	1.318	1.319	1.322	1.126	1.079	1.017
group3			1.236	1.236	1.336	1.239	1.239	1.061	1.097	1.097
group4			1.250	1.250	1.312	1.286	1.286	1.113	1.070	1.022
group5			1.102	1.102	1.379	1.121	1.121	1.012	1.000	1.000
group6			1.402	1.498	1.755	1.834	1.566	1.580	1.595	1.274
group7			1.159	1.159	1.381	1.223	1.207	1.048	1.045	1.000
group8			1.173	2.009	2.009	1.154	1.145	1.163	1.163	1.136
group9			1.173	1.595	1.282	1.154	1.145	1.115	1.118	1.116
group10			1.173	1.595	1.282	1.154	1.145	1.115	1.118	1.116

Table 3H.6-17: Response Spectra Modification Factors (Continued)

Group	Direction	Damping	Frequency Range (Hz)							
			0-2	2-5	5-10	10-15	15-20	20-25	25-30	30-35
group1	X	0.05	1.191	1.191	1.230	1.245	1.188	1.103	1.103	1.047
group2			1.245	1.245	1.267	1.241	1.248	1.089	1.081	1.017
group3			1.208	1.208	1.283	1.219	1.219	1.064	1.096	1.096
group4			1.240	1.240	1.265	1.244	1.244	1.058	1.036	1.022
group5			1.127	1.127	1.324	1.089	1.087	1.000	1.000	1.000
group6			1.391	1.476	1.692	1.732	1.460	1.515	1.520	1.248
group7			1.140	1.140	1.326	1.207	1.166	1.018	1.018	1.000
group8			1.157	1.809	1.809	1.146	1.141	1.161	1.161	1.135
group9			1.157	1.545	1.224	1.146	1.141	1.114	1.117	1.116
group10			1.157	1.545	1.224	1.146	1.141	1.114	1.117	1.116
group1	X	0.07	1.191	1.191	1.124	1.157	1.128	1.075	1.075	1.046
group2			1.212	1.212	1.177	1.140	1.140	1.090	1.039	1.016
group3			1.190	1.190	1.216	1.185	1.185	1.072	1.096	1.096
group4			1.234	1.234	1.198	1.187	1.187	1.055	1.024	1.022
group5			1.095	1.095	1.239	1.057	1.000	1.000	1.000	1.000
group6			1.383	1.457	1.604	1.597	1.373	1.404	1.404	1.223
group7			1.112	1.112	1.255	1.174	1.141	1.000	1.000	1.000
group8			1.147	1.582	1.582	1.138	1.135	1.152	1.152	1.135
group9			1.147	1.460	1.184	1.138	1.135	1.114	1.116	1.116
group10			1.147	1.460	1.184	1.138	1.135	1.114	1.116	1.116
group1	X	0.1	1.164	1.164	1.081	1.087	1.084	1.054	1.054	1.044
group2			1.163	1.163	1.118	1.080	1.091	1.086	1.032	1.014
group3			1.153	1.153	1.148	1.144	1.144	1.079	1.095	1.095
group4			1.182	1.182	1.109	1.155	1.150	1.037	1.022	1.021
group5			1.091	1.091	1.163	1.063	1.000	1.003	1.000	1.000
group6			1.362	1.401	1.559	1.486	1.393	1.306	1.306	1.217
group7			1.083	1.083	1.187	1.145	1.092	1.000	1.000	1.000
group8			1.135	1.416	1.416	1.151	1.130	1.141	1.141	1.134
group9			1.135	1.371	1.164	1.132	1.130	1.113	1.115	1.115
group10			1.135	1.371	1.164	1.132	1.130	1.113	1.115	1.115
group1	X	0.15	1.153	1.153	1.073	1.066	1.058	1.040	1.042	1.041
group2			1.130	1.130	1.079	1.055	1.058	1.058	1.008	1.010
group3			1.122	1.122	1.108	1.104	1.104	1.083	1.094	1.094
group4			1.152	1.152	1.100	1.086	1.086	1.021	1.021	1.020
group5			1.088	1.088	1.087	1.058	1.002	1.007	1.001	1.000
group6			1.324	1.339	1.493	1.390	1.373	1.259	1.260	1.211
group7			1.068	1.068	1.116	1.118	1.040	1.000	1.000	1.000
group8			1.122	1.350	1.350	1.180	1.124	1.134	1.134	1.132
group9			1.122	1.292	1.151	1.125	1.124	1.112	1.115	1.115
group10			1.122	1.292	1.151	1.125	1.124	1.112	1.115	1.115
group1	X	0.2	1.101	1.101	1.067	1.056	1.049	1.034	1.038	1.038
group2			1.111	1.111	1.054	1.028	1.040	1.034	1.007	1.009
group3			1.105	1.105	1.072	1.080	1.082	1.085	1.094	1.094
group4			1.116	1.116	1.090	1.053	1.052	1.019	1.020	1.020
group5			1.059	1.059	1.061	1.040	1.000	1.004	1.000	1.000
group6			1.300	1.308	1.481	1.350	1.341	1.246	1.242	1.209
group7			1.063	1.066	1.090	1.061	1.006	1.000	1.000	1.000
group8			1.122	1.305	1.305	1.201	1.120	1.130	1.131	1.131
group9			1.122	1.269	1.145	1.120	1.120	1.112	1.115	1.115
group10			1.122	1.269	1.145	1.120	1.120	1.112	1.115	1.115

Table 3H.6-17: Response Spectra Modification Factors (Continued)

Group	Direction	Damping	Frequency Range (Hz)							
			0-2	2-5	5-10	10-15	15-20	20-25	25-30	30-35
group1	Y	0.005	1.017	1.229	1.290	1.742	1.742	1.416	1.210	1.033
group2			1.051	1.116	2.071	2.424	2.424	5.938	3.282	1.055
group3			1.088	1.153	1.939	2.213	2.213	2.398	1.289	1.061
group4			1.082	1.113	2.647	1.855	1.687	2.427	1.666	1.031
group5			1.544	1.544	2.718	1.550	1.550	1.513	1.173	1.040
group6			1.394	1.639	5.529	3.093	3.093	3.693	2.794	1.370
group7			1.184	1.425	1.801	1.801	1.699	1.605	1.474	1.081
group8			2.327	9.258	1.967	2.941	1.801	1.495	1.485	1.485
group9			2.327	9.258	1.967	2.941	1.801	1.495	1.485	1.485
group10			2.327	9.258	1.967	2.941	2.357	1.495	1.485	1.485
group1	Y	0.01	1.020	1.203	1.280	1.513	1.513	1.275	1.153	1.033
group2			1.046	1.102	1.877	2.089	2.089	4.171	2.709	1.049
group3			1.091	1.134	1.788	1.793	1.753	1.764	1.209	1.062
group4			1.077	1.098	2.223	1.479	1.360	1.639	1.179	1.031
group5			1.303	1.303	2.137	1.348	1.348	1.241	1.096	1.040
group6			1.372	1.533	4.155	2.303	2.290	2.520	2.246	1.326
group7			1.250	1.318	1.456	1.512	1.512	1.362	1.153	1.081
group8			2.195	5.394	1.666	2.278	1.588	1.480	1.482	1.484
group9			2.195	5.394	1.666	2.278	1.588	1.480	1.482	1.484
group10			2.195	5.394	1.666	2.278	1.847	1.480	1.482	1.484
group1	Y	0.02	1.023	1.108	1.156	1.233	1.233	1.157	1.123	1.033
group2			1.044	1.079	1.575	1.736	1.807	2.625	2.053	1.038
group3			1.074	1.110	1.488	1.430	1.416	1.260	1.117	1.062
group4			1.078	1.078	1.653	1.284	1.142	1.214	1.053	1.031
group5			1.163	1.163	1.715	1.194	1.194	1.131	1.093	1.040
group6			1.317	1.422	2.837	1.931	1.931	1.820	1.752	1.237
group7			1.191	1.258	1.207	1.207	1.207	1.175	1.090	1.081
group8			1.962	3.812	1.647	1.697	1.552	1.487	1.483	1.485
group9			1.962	3.812	1.647	1.697	1.552	1.487	1.483	1.485
group10			1.962	3.812	1.647	1.697	1.552	1.487	1.483	1.485
group1	Y	0.03	1.014	1.077	1.138	1.132	1.132	1.101	1.101	1.033
group2			1.046	1.073	1.335	1.711	1.767	1.973	1.762	1.038
group3			1.073	1.091	1.279	1.313	1.285	1.113	1.058	1.062
group4			1.076	1.076	1.385	1.183	1.084	1.091	1.035	1.031
group5			1.117	1.117	1.447	1.132	1.132	1.104	1.098	1.040
group6			1.307	1.379	2.238	1.726	1.644	1.574	1.522	1.186
group7			1.163	1.221	1.154	1.130	1.069	1.124	1.101	1.081
group8			1.793	3.145	1.696	1.537	1.537	1.493	1.483	1.485
group9			1.793	3.145	1.696	1.537	1.537	1.493	1.483	1.485
group10			1.793	3.145	1.696	1.537	1.537	1.493	1.483	1.485
group1	Y	0.04	1.012	1.077	1.131	1.093	1.092	1.080	1.080	1.033
group2			1.047	1.068	1.210	1.691	1.691	1.641	1.542	1.038
group3			1.072	1.072	1.189	1.251	1.251	1.073	1.059	1.063
group4			1.071	1.071	1.243	1.157	1.059	1.059	1.034	1.031
group5			1.099	1.117	1.301	1.101	1.103	1.103	1.103	1.040
group6			1.283	1.383	1.953	1.632	1.458	1.473	1.430	1.153
group7			1.143	1.206	1.135	1.133	1.076	1.110	1.107	1.082
group8			1.770	2.845	1.710	1.521	1.521	1.494	1.483	1.485
group9			1.770	2.845	1.710	1.521	1.521	1.494	1.483	1.485
group10			1.770	2.845	1.710	1.521	1.521	1.494	1.483	1.485

Table 3H.6-17: Response Spectra Modification Factors (Continued)

Group	Direction	Damping	Frequency Range (Hz)							
			0-2	2-5	5-10	10-15	15-20	20-25	25-30	30-35
group1	Y	0.05	1.015	1.078	1.122	1.086	1.087	1.067	1.067	1.033
group2			1.055	1.055	1.140	1.571	1.571	1.449	1.398	1.038
group3			1.070	1.070	1.143	1.216	1.216	1.062	1.062	1.063
group4			1.067	1.067	1.177	1.157	1.057	1.053	1.033	1.031
group5			1.092	1.105	1.228	1.088	1.098	1.105	1.105	1.041
group6			1.260	1.394	1.791	1.570	1.452	1.386	1.363	1.129
group7			1.126	1.198	1.132	1.124	1.081	1.106	1.106	1.082
group8			1.751	2.636	1.720	1.512	1.512	1.495	1.484	1.485
group9			1.751	2.636	1.720	1.512	1.512	1.495	1.484	1.485
group10			1.751	2.636	1.720	1.512	1.512	1.495	1.484	1.485
group1	Y	0.07	1.022	1.075	1.101	1.089	1.089	1.059	1.059	1.034
group2			1.055	1.055	1.123	1.389	1.389	1.246	1.234	1.038
group3			1.068	1.088	1.135	1.163	1.163	1.072	1.072	1.064
group4			1.053	1.053	1.162	1.162	1.061	1.052	1.037	1.031
group5			1.048	1.087	1.168	1.083	1.086	1.097	1.097	1.041
group6			1.228	1.321	1.578	1.549	1.420	1.259	1.259	1.117
group7			1.134	1.168	1.124	1.116	1.086	1.097	1.097	1.082
group8			1.818	2.384	1.744	1.502	1.502	1.495	1.484	1.485
group9			1.818	2.384	1.744	1.502	1.502	1.495	1.484	1.485
group10			1.818	2.384	1.744	1.502	1.502	1.495	1.484	1.485
group1	Y	0.1	1.025	1.067	1.083	1.098	1.098	1.044	1.044	1.034
group2			1.049	1.062	1.092	1.250	1.250	1.116	1.115	1.038
group3			1.063	1.087	1.111	1.112	1.114	1.075	1.075	1.065
group4			1.048	1.087	1.114	1.110	1.052	1.051	1.039	1.032
group5			1.035	1.079	1.146	1.069	1.070	1.078	1.078	1.043
group6			1.190	1.231	1.466	1.467	1.379	1.241	1.177	1.112
group7			1.129	1.139	1.123	1.105	1.086	1.089	1.090	1.083
group8			1.886	2.277	1.741	1.550	1.503	1.498	1.484	1.486
group9			1.886	2.277	1.741	1.550	1.503	1.498	1.484	1.486
group10			1.886	2.277	1.741	1.550	1.503	1.498	1.484	1.486
group1	Y	0.15	1.017	1.055	1.066	1.082	1.082	1.049	1.033	1.035
group2			1.036	1.060	1.075	1.166	1.166	1.058	1.037	1.038
group3			1.028	1.068	1.084	1.081	1.081	1.070	1.070	1.066
group4			1.018	1.078	1.079	1.079	1.054	1.046	1.040	1.033
group5			1.029	1.062	1.093	1.056	1.056	1.062	1.062	1.045
group6			1.180	1.242	1.362	1.410	1.329	1.228	1.139	1.110
group7			1.105	1.114	1.090	1.090	1.075	1.085	1.085	1.083
group8			1.762	1.988	1.761	1.598	1.522	1.500	1.485	1.486
group9			1.762	1.988	1.761	1.598	1.522	1.500	1.485	1.486
group10			1.762	1.988	1.761	1.598	1.522	1.500	1.485	1.486
group1	Y	0.2	1.016	1.049	1.071	1.069	1.069	1.052	1.035	1.036
group2			1.017	1.028	1.068	1.119	1.119	1.055	1.036	1.038
group3			1.029	1.061	1.096	1.096	1.074	1.076	1.074	1.067
group4			1.015	1.048	1.062	1.062	1.055	1.045	1.039	1.033
group5			1.024	1.046	1.066	1.048	1.049	1.054	1.054	1.046
group6			1.187	1.233	1.354	1.381	1.289	1.218	1.125	1.113
group7			1.090	1.103	1.086	1.087	1.073	1.080	1.082	1.083
group8			1.659	1.812	1.692	1.607	1.537	1.503	1.487	1.487
group9			1.659	1.812	1.692	1.607	1.537	1.503	1.487	1.487
group10			1.659	1.812	1.692	1.607	1.537	1.503	1.487	1.487

Table 3H.6-17: Response Spectra Modification Factors (Continued)

Group	Direction	Damping	Frequency Range (Hz)							
			0-2	2-5	5-10	10-15	15-20	20-25	25-30	30-35
group1	Z	0.005	1.024	1.025	1.307	1.522	1.410	1.819	1.819	1.115
group2			1.009	1.024	1.458	2.802	2.802	2.301	1.480	1.093
group3			1.054	1.183	1.922	6.446	5.706	3.806	3.825	3.535
group4			1.043	1.126	2.323	4.021	3.146	4.902	3.262	1.346
group5			1.145	1.145	1.230	1.655	1.467	1.867	1.374	1.018
group6			1.027	1.042	1.210	1.562	2.041	2.041	1.589	1.145
group7			1.121	1.173	1.193	1.655	1.636	1.724	1.555	1.072
group8			1.109	1.534	2.401	4.285	3.959	3.979	2.855	1.919
group9			1.109	1.534	2.401	4.285	3.959	3.979	2.855	1.919
group10			1.109	1.534	2.401	4.285	3.959	3.979	2.855	1.919
group1	Z	0.01	1.021	1.025	1.244	1.489	1.274	1.308	1.308	1.113
group2			1.008	1.023	1.322	2.493	2.493	2.042	1.385	1.092
group3			1.052	1.196	1.826	5.703	4.015	3.481	3.326	3.099
group4			1.046	1.131	2.326	3.602	2.459	3.543	2.841	1.310
group5			1.109	1.109	1.187	1.521	1.391	1.471	1.387	1.018
group6			1.022	1.028	1.169	1.519	1.660	1.660	1.539	1.096
group7			1.094	1.094	1.155	1.571	1.456	1.406	1.395	1.036
group8			1.109	1.374	2.351	3.517	2.936	2.936	2.405	1.670
group9			1.109	1.374	2.351	3.517	2.936	2.936	2.405	1.670
group10			1.109	1.374	2.351	3.517	2.936	2.936	2.405	1.670
group1	Z	0.02	1.022	1.024	1.211	1.407	1.288	1.291	1.120	1.093
group2			1.008	1.026	1.228	2.051	2.051	1.621	1.219	1.092
group3			1.051	1.152	1.962	3.999	3.028	3.417	3.004	2.767
group4			1.042	1.121	2.180	2.856	1.873	2.338	1.979	1.286
group5			1.073	1.073	1.143	1.360	1.268	1.274	1.274	1.018
group6			1.013	1.020	1.169	1.352	1.473	1.473	1.420	1.065
group7			1.053	1.059	1.158	1.409	1.282	1.275	1.271	1.033
group8			1.107	1.213	1.836	3.179	2.113	2.248	2.248	1.607
group9			1.107	1.213	1.836	3.179	2.113	2.248	2.248	1.607
group10			1.107	1.213	1.836	3.179	2.113	2.248	2.248	1.607
group1	Z	0.03	1.019	1.024	1.197	1.330	1.293	1.307	1.099	1.093
group2			1.009	1.027	1.202	1.778	1.778	1.435	1.134	1.091
group3			1.048	1.166	2.136	3.599	2.822	3.220	2.737	2.571
group4			1.042	1.128	1.901	2.413	1.755	1.986	1.808	1.278
group5			1.064	1.064	1.132	1.274	1.204	1.164	1.164	1.018
group6			1.012	1.020	1.184	1.305	1.449	1.449	1.396	1.055
group7			1.039	1.049	1.162	1.292	1.217	1.243	1.220	1.036
group8			1.101	1.144	1.685	2.767	1.878	2.120	2.120	1.557
group9			1.101	1.144	1.685	2.767	1.878	2.120	2.120	1.557
group10			1.101	1.144	1.685	2.767	1.878	2.120	2.120	1.557
group1	Z	0.04	1.016	1.023	1.210	1.277	1.294	1.294	1.093	1.093
group2			1.009	1.027	1.194	1.606	1.606	1.359	1.112	1.091
group3			1.047	1.166	2.248	3.545	2.811	3.012	2.626	2.439
group4			1.039	1.115	1.712	2.124	1.640	1.832	1.661	1.275
group5			1.054	1.054	1.123	1.224	1.180	1.112	1.096	1.017
group6			1.010	1.021	1.194	1.301	1.411	1.411	1.375	1.051
group7			1.031	1.041	1.165	1.235	1.210	1.205	1.205	1.036
group8			1.096	1.125	1.571	2.496	1.870	1.793	1.793	1.519
group9			1.096	1.125	1.571	2.496	1.870	1.793	1.793	1.519
group10			1.096	1.125	1.571	2.496	1.870	1.793	1.793	1.519

Table 3H.6-17: Response Spectra Modification Factors (Continued)

Group	Direction	Damping	Frequency Range (Hz)							
			0-2	2-5	5-10	10-15	15-20	20-25	25-30	30-35
group1	Z	0.05	1.014	1.024	1.219	1.270	1.288	1.288	1.092	1.092
group2			1.009	1.028	1.196	1.515	1.515	1.300	1.090	1.090
group3			1.046	1.163	2.285	3.504	2.739	2.855	2.564	2.344
group4			1.039	1.117	1.614	1.944	1.586	1.728	1.571	1.274
group5			1.043	1.043	1.125	1.194	1.138	1.091	1.058	1.017
group6			1.009	1.021	1.203	1.301	1.362	1.362	1.304	1.051
group7			1.026	1.035	1.167	1.242	1.158	1.181	1.181	1.034
group8			1.090	1.132	1.556	2.306	1.791	1.679	1.676	1.491
group9			1.090	1.132	1.556	2.306	1.791	1.679	1.676	1.491
group10			1.090	1.132	1.556	2.306	1.791	1.679	1.676	1.491
group1	Z	0.07	1.011	1.024	1.225	1.253	1.256	1.256	1.109	1.092
group2			1.009	1.029	1.192	1.400	1.400	1.266	1.091	1.089
group3			1.046	1.167	2.487	3.422	2.724	2.767	2.378	2.220
group4			1.056	1.125	1.521	1.776	1.524	1.594	1.497	1.273
group5			1.029	1.029	1.134	1.198	1.080	1.064	1.047	1.016
group6			1.010	1.021	1.214	1.280	1.268	1.268	1.165	1.051
group7			1.023	1.028	1.166	1.231	1.116	1.138	1.138	1.031
group8			1.062	1.137	1.554	2.248	1.724	1.586	1.586	1.451
group9			1.062	1.137	1.554	2.248	1.724	1.586	1.586	1.451
group10			1.062	1.137	1.554	2.248	1.724	1.586	1.586	1.451
group1	Z	0.1	1.010	1.023	1.199	1.214	1.226	1.226	1.133	1.092
group2			1.009	1.030	1.181	1.314	1.314	1.231	1.111	1.089
group3			1.066	1.188	2.418	3.274	2.734	2.633	2.254	2.120
group4			1.063	1.140	1.421	1.623	1.471	1.487	1.417	1.271
group5			1.022	1.023	1.135	1.207	1.065	1.049	1.036	1.016
group6			1.009	1.021	1.219	1.259	1.207	1.211	1.122	1.049
group7			1.019	1.022	1.142	1.189	1.112	1.093	1.064	1.028
group8			1.047	1.148	1.553	2.218	1.718	1.531	1.497	1.416
group9			1.047	1.148	1.553	2.218	1.718	1.531	1.497	1.416
group10			1.047	1.148	1.553	2.218	1.718	1.531	1.497	1.416
group1	Z	0.15	1.009	1.025	1.099	1.144	1.220	1.217	1.155	1.093
group2			1.009	1.032	1.118	1.217	1.217	1.192	1.095	1.088
group3			1.093	1.226	2.344	2.887	2.672	2.514	2.092	2.042
group4			1.083	1.169	1.354	1.478	1.414	1.398	1.354	1.275
group5			1.016	1.017	1.098	1.166	1.045	1.045	1.023	1.016
group6			1.006	1.022	1.152	1.183	1.195	1.197	1.129	1.048
group7			1.014	1.017	1.090	1.128	1.103	1.081	1.026	1.027
group8			1.056	1.160	1.470	2.138	1.885	1.516	1.472	1.429
group9			1.056	1.160	1.470	2.138	1.885	1.516	1.472	1.429
group10			1.056	1.160	1.470	2.138	1.885	1.516	1.472	1.429
group1	Z	0.2	1.010	1.025	1.089	1.191	1.220	1.217	1.152	1.095
group2			1.009	1.032	1.088	1.153	1.165	1.165	1.097	1.088
group3			1.117	1.298	2.125	2.705	2.643	2.440	2.032	2.007
group4			1.100	1.184	1.330	1.398	1.363	1.342	1.327	1.278
group5			1.014	1.017	1.100	1.120	1.039	1.039	1.017	1.016
group6			1.006	1.023	1.118	1.201	1.189	1.190	1.143	1.056
group7			1.011	1.017	1.091	1.111	1.079	1.071	1.026	1.028
group8			1.063	1.177	1.620	1.985	1.940	1.537	1.463	1.450
group9			1.063	1.177	1.620	1.985	1.940	1.537	1.463	1.450
group10			1.063	1.177	1.620	1.985	1.940	1.537	1.463	1.450

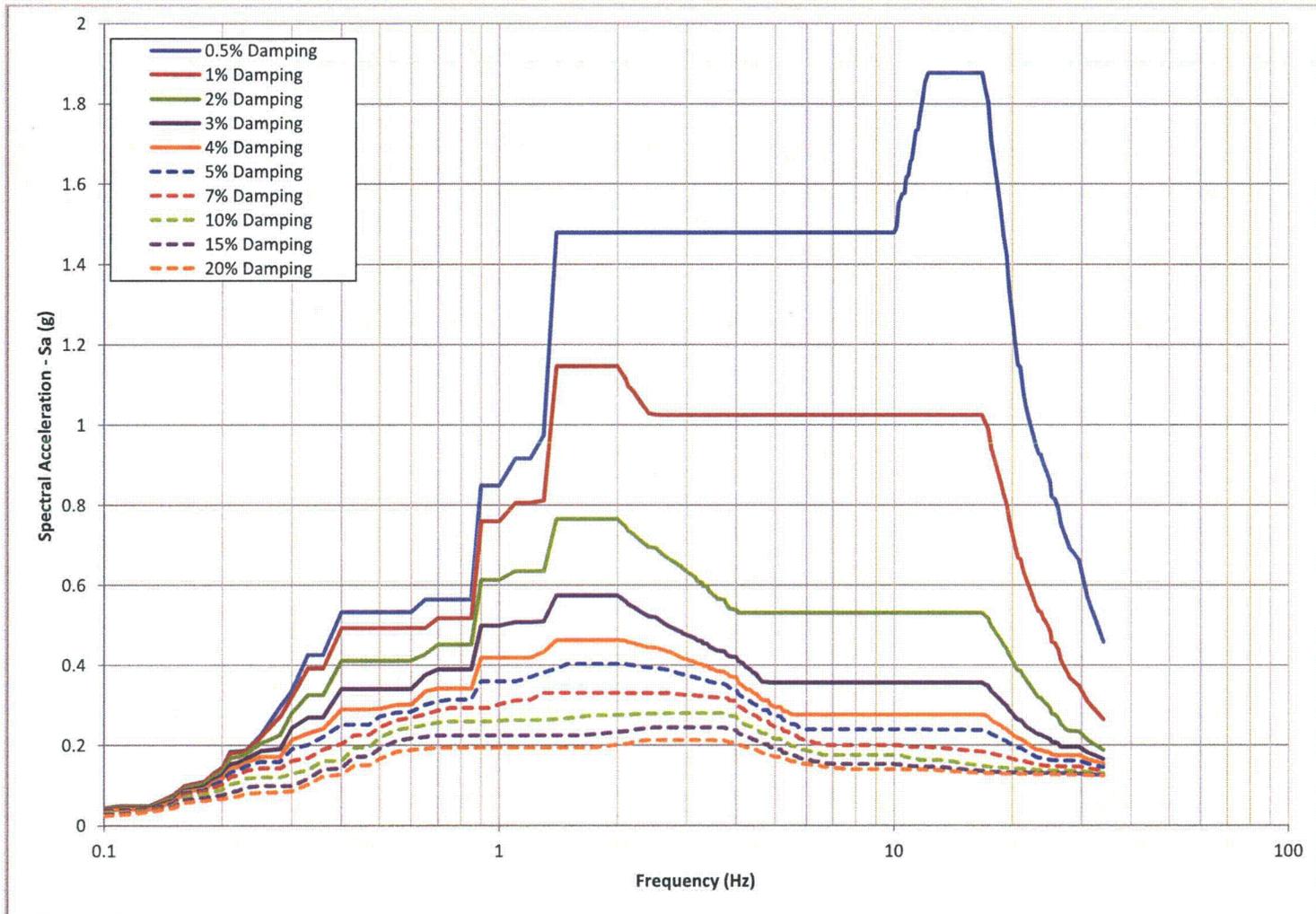


Figure 3H.6-16: Broadened FRS in E-W (X) Direction at the Top of RSW Pump House Mat (Elevation 18 ft MSL)

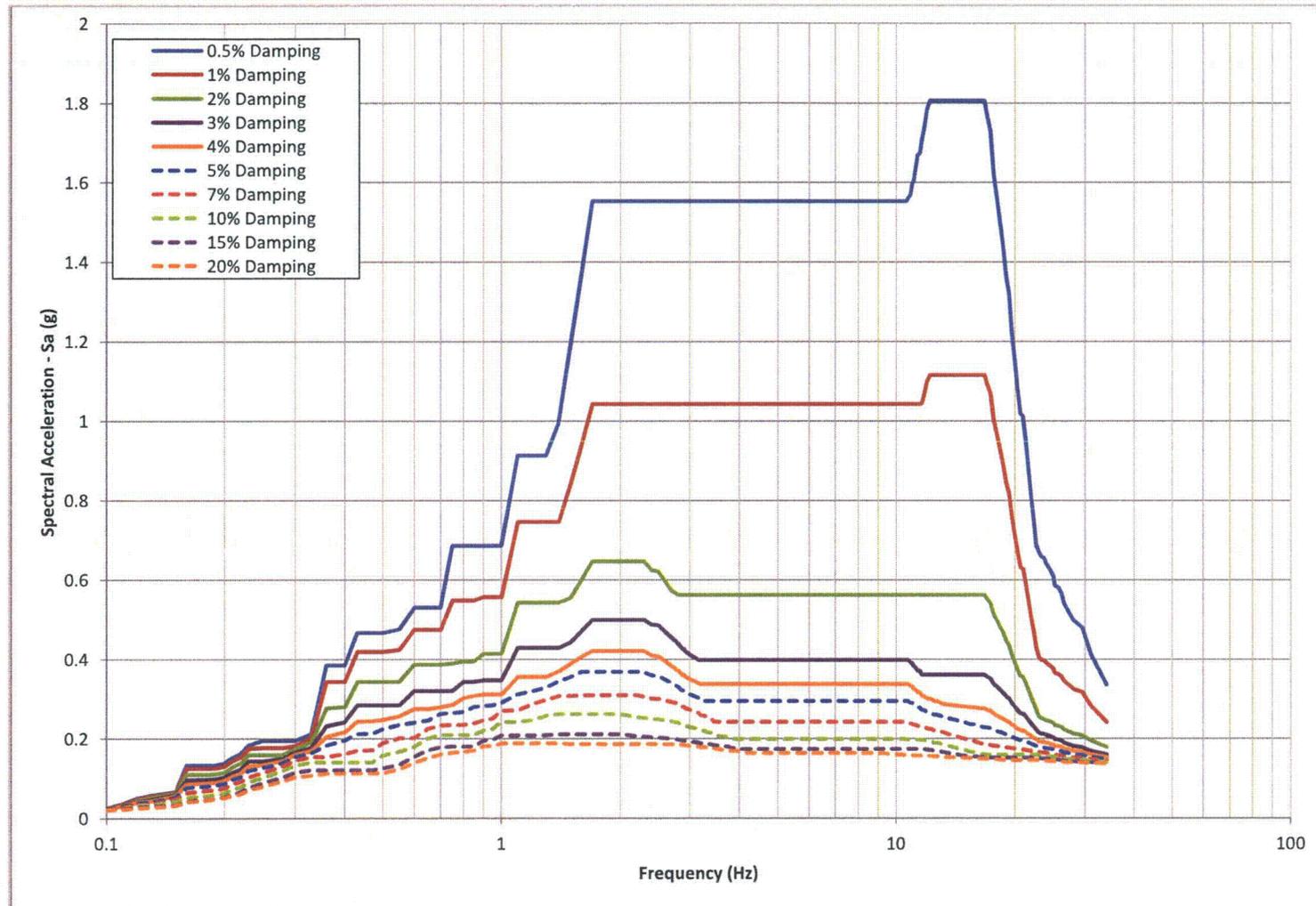


Figure 3H.6-17: Broadened FRS in N-S (Y) Direction at the Top of RSW Pump House Mat (Elevation 18 ft MSL)

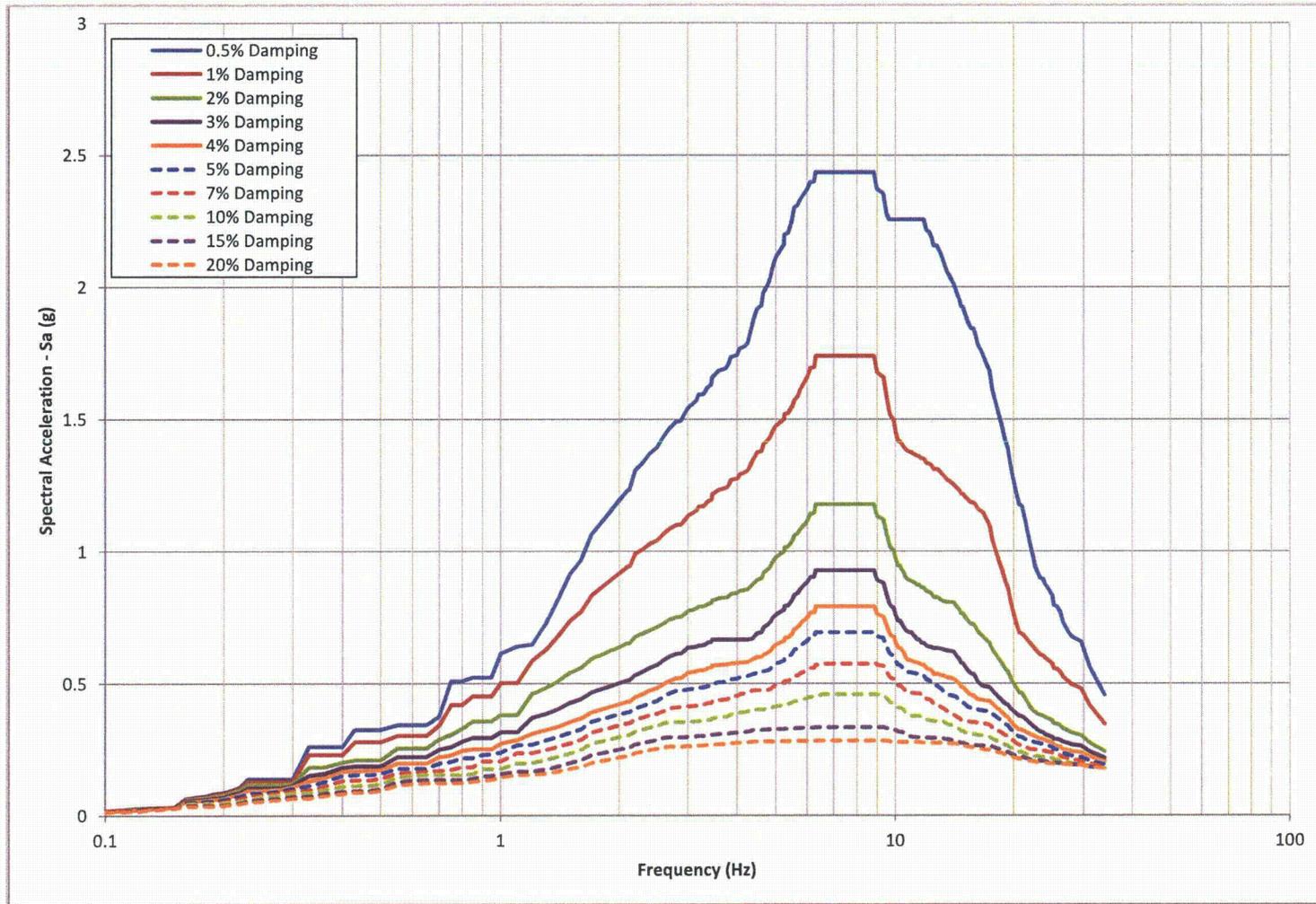


Figure 3H.6-18: Broadened FRS in Vertical (Z) Direction at the Top of RSW Pump House Mat (Elevation 18 ft MSL)

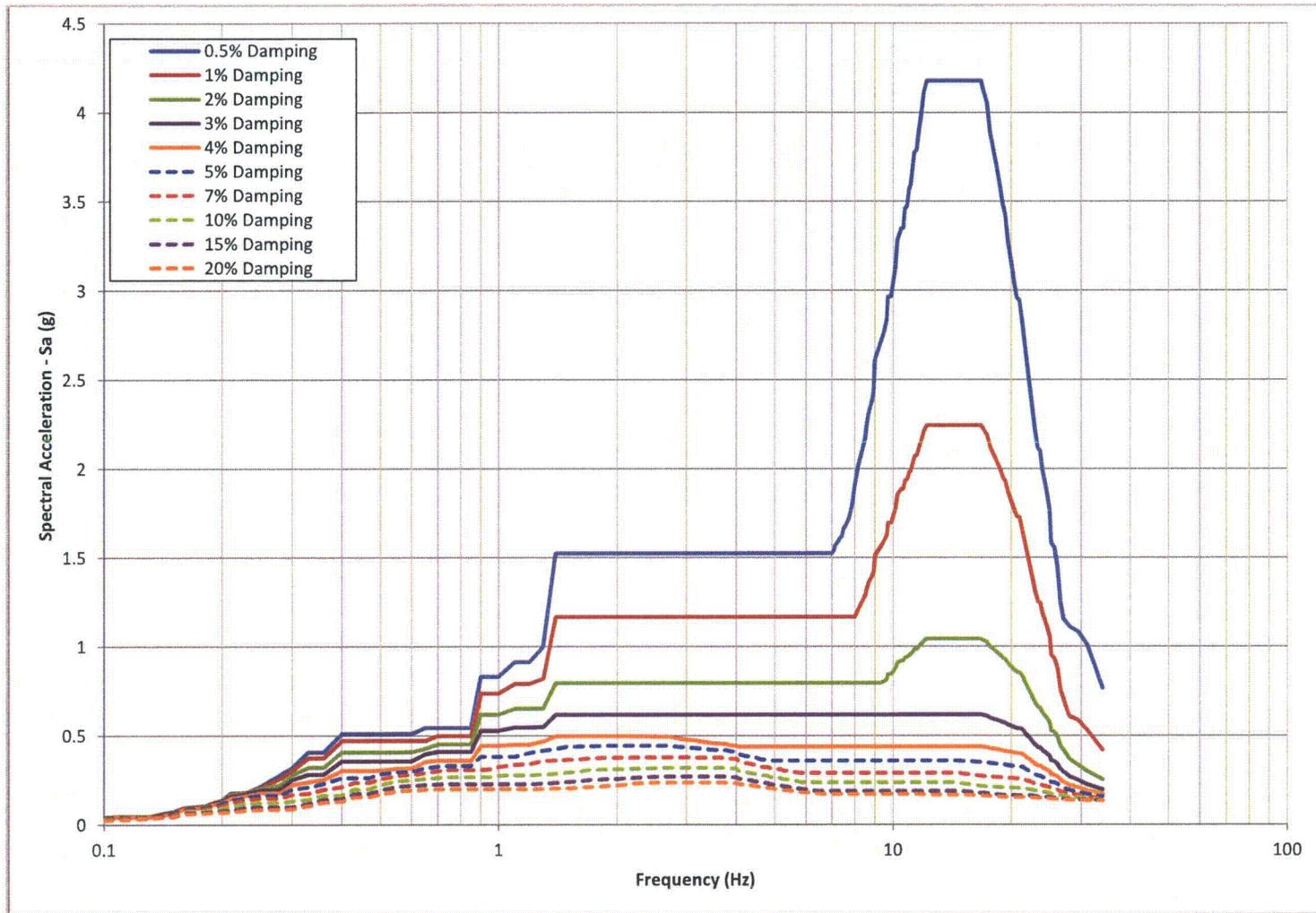


Figure 3H.6-19: Broadened FRS in E-W (X) Direction at the RSW Pump House Operating Floor (Elevation 14 ft MSL)

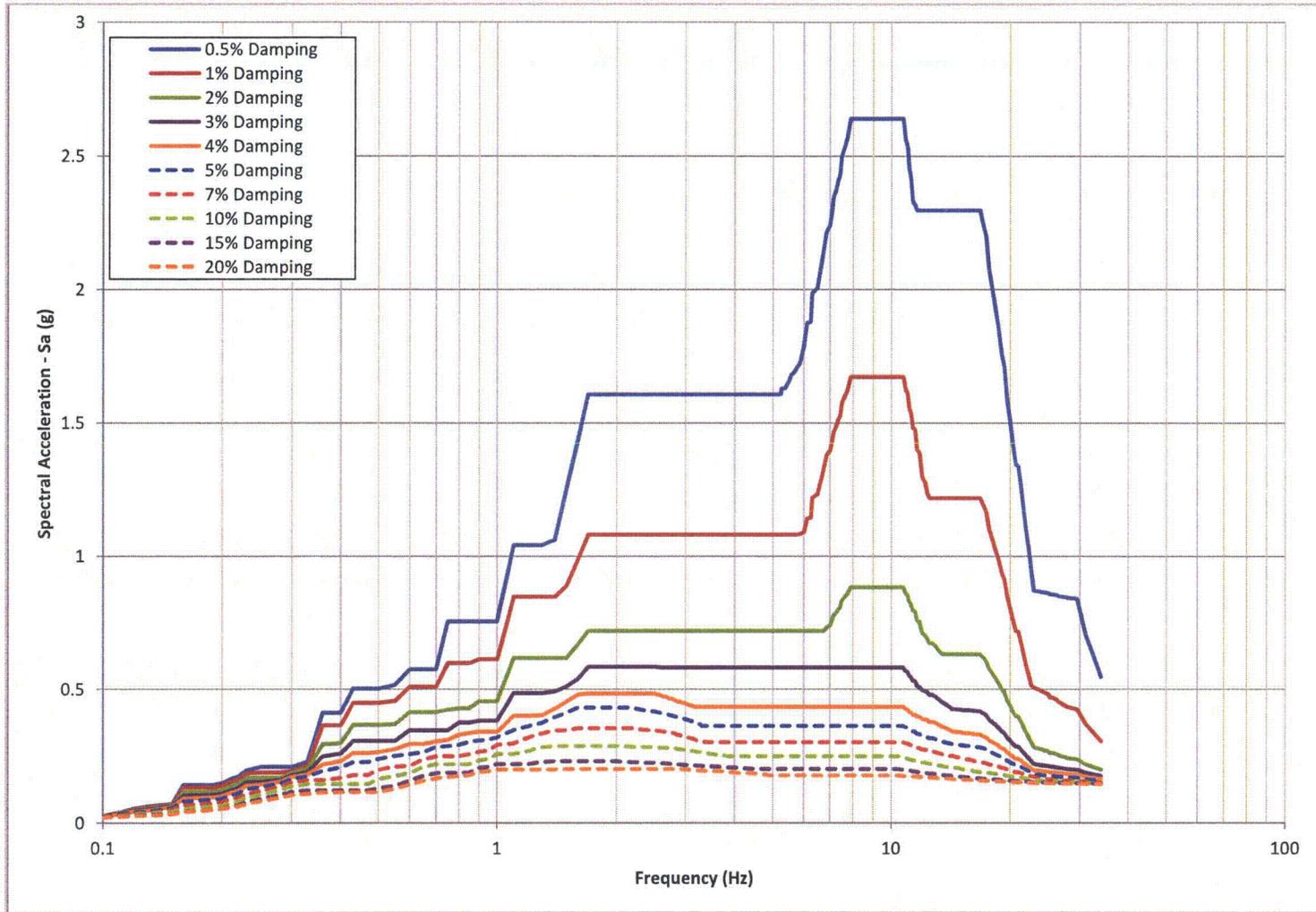


Figure 3H.6-20: Broadened FRS in N-S (Y) Direction at the RSW Pump House Operating Floor (Elevation 14 ft MSL)

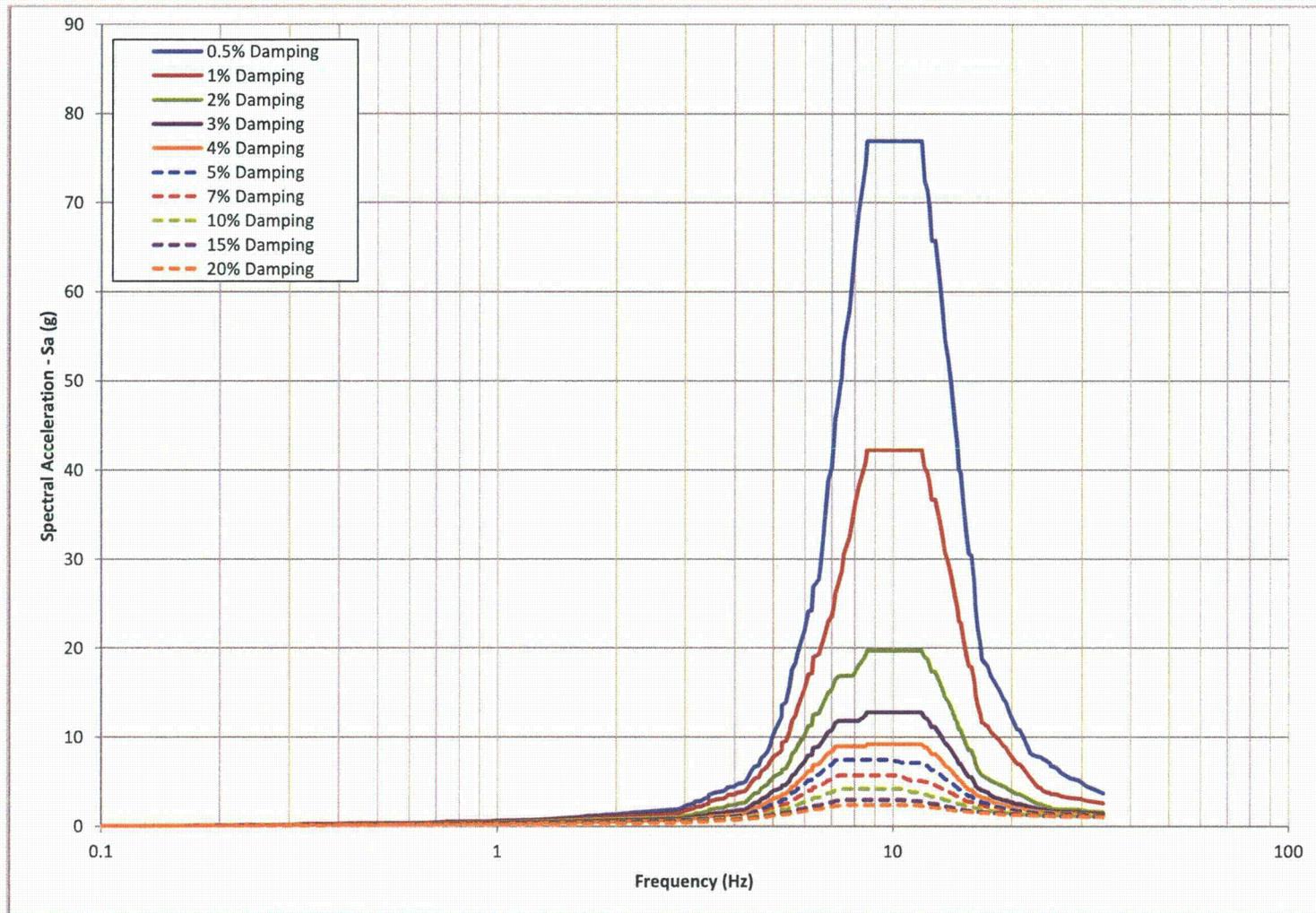


Figure 3H.6-21: Broadened FRS in Vertical (Z) Direction at the RSW Pump House Operating Floor (Elevation 14 ft MSL)

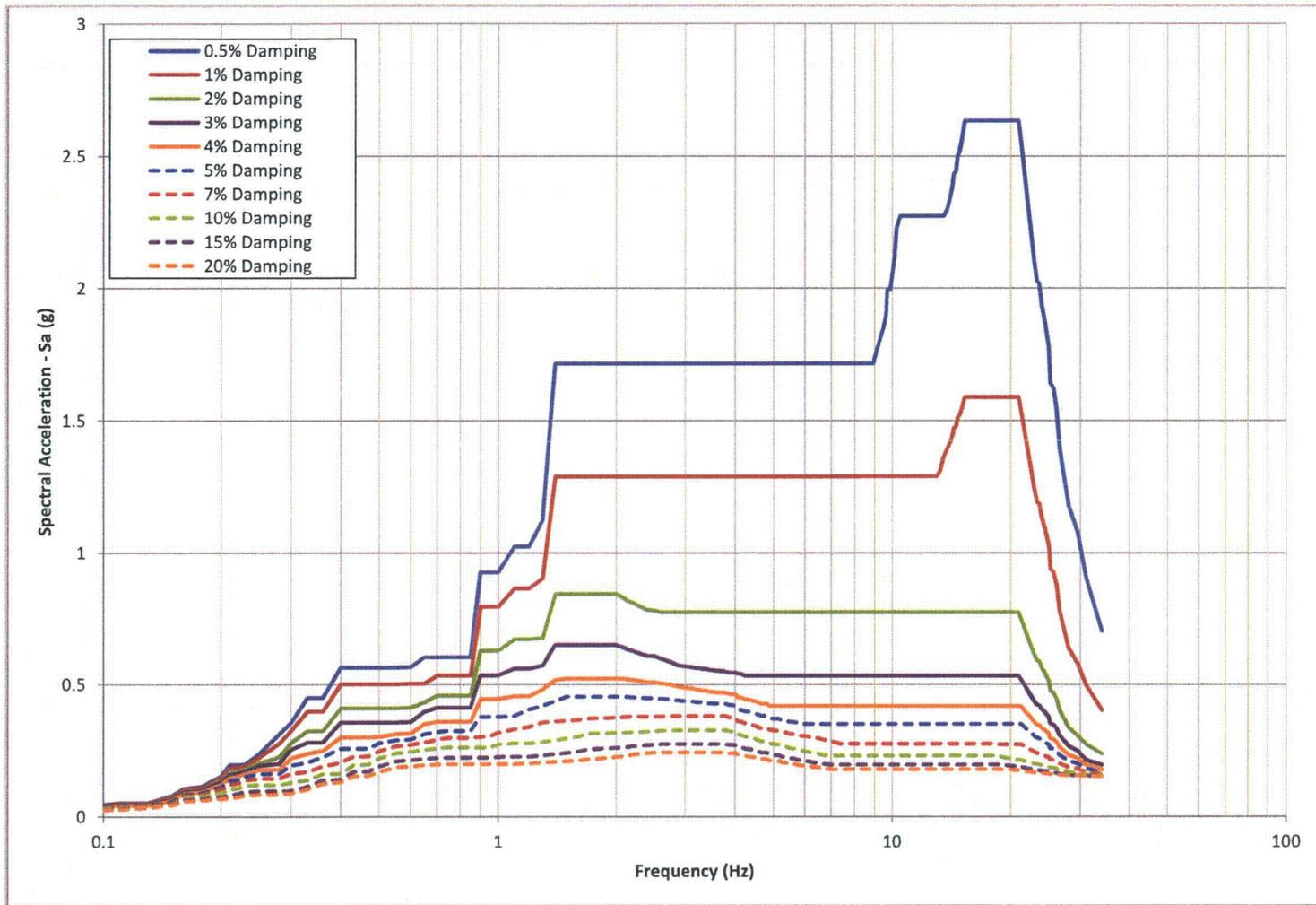


Figure 3H.6-22: Broadened FRS in E-W (X) Direction at the RSW Pump House Roof (Elevation 50 ft MSL)

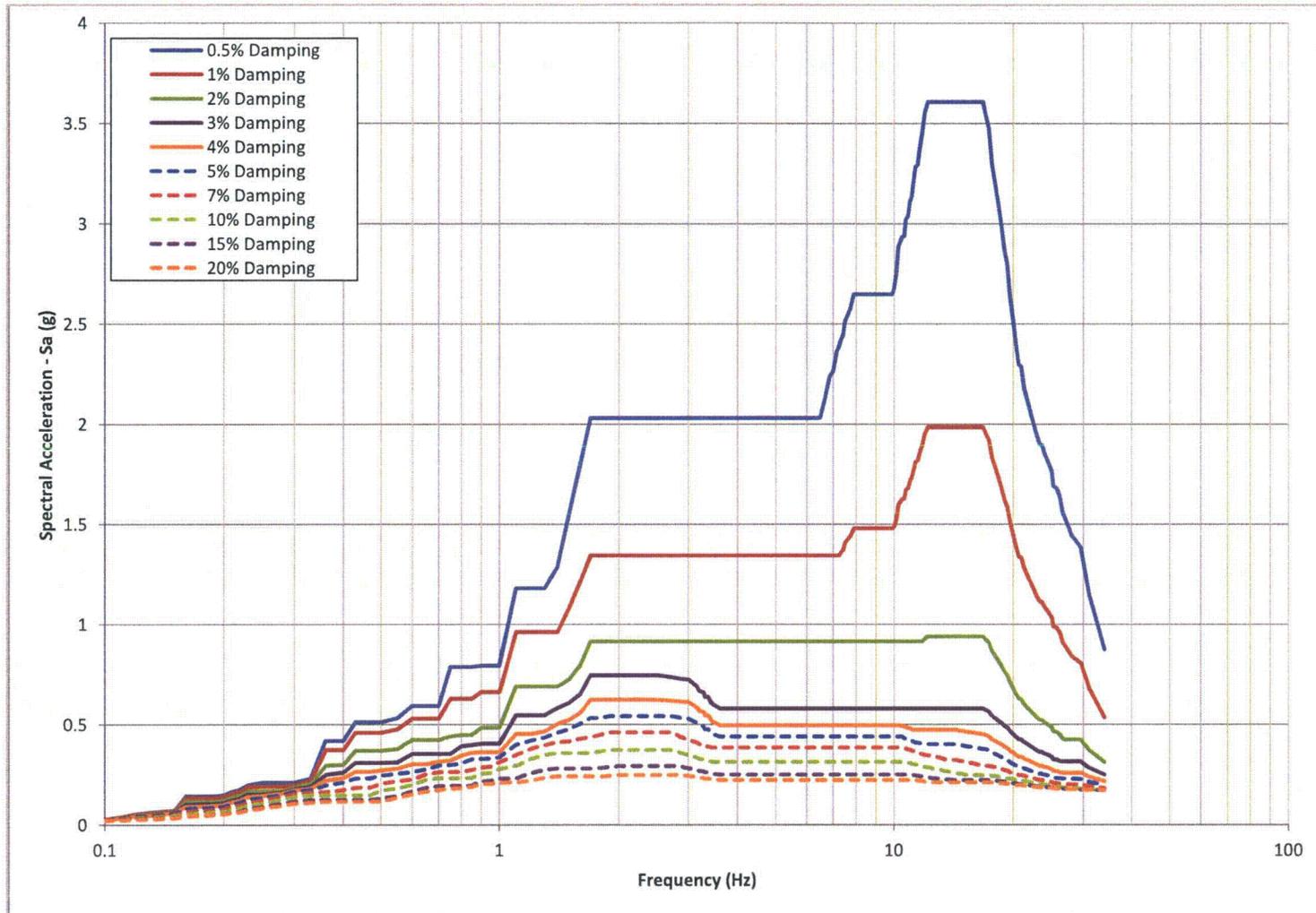


Figure 3H.6-23: Broadened FRS in N-S (Y) Direction at the RSW Pump House Roof (Elevation 50 ft MSL)

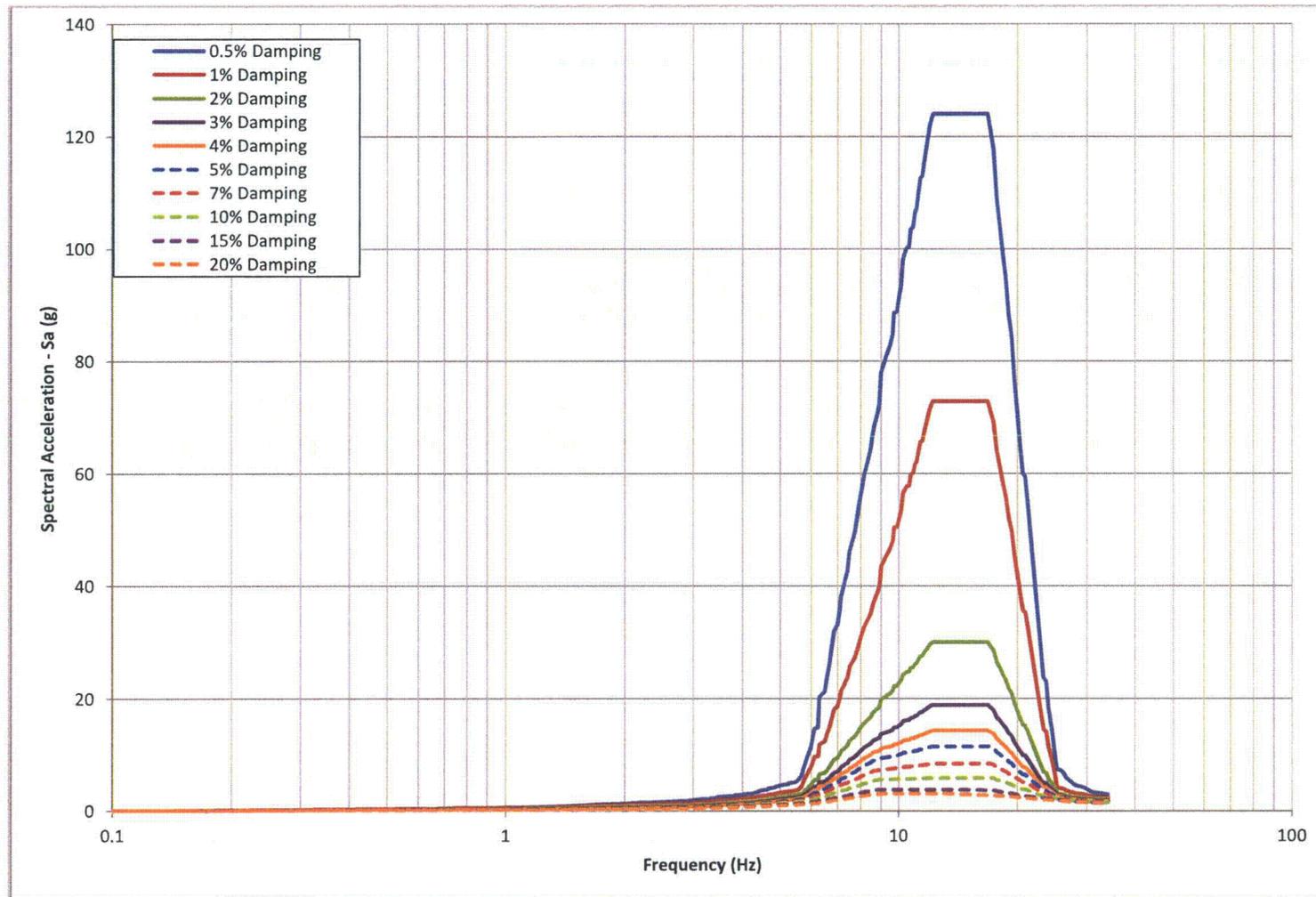


Figure 3H.6-24: Broadened FRS in Vertical (Z) Direction at the RSW Pump House Roof (Elevation 50 ft MSL)

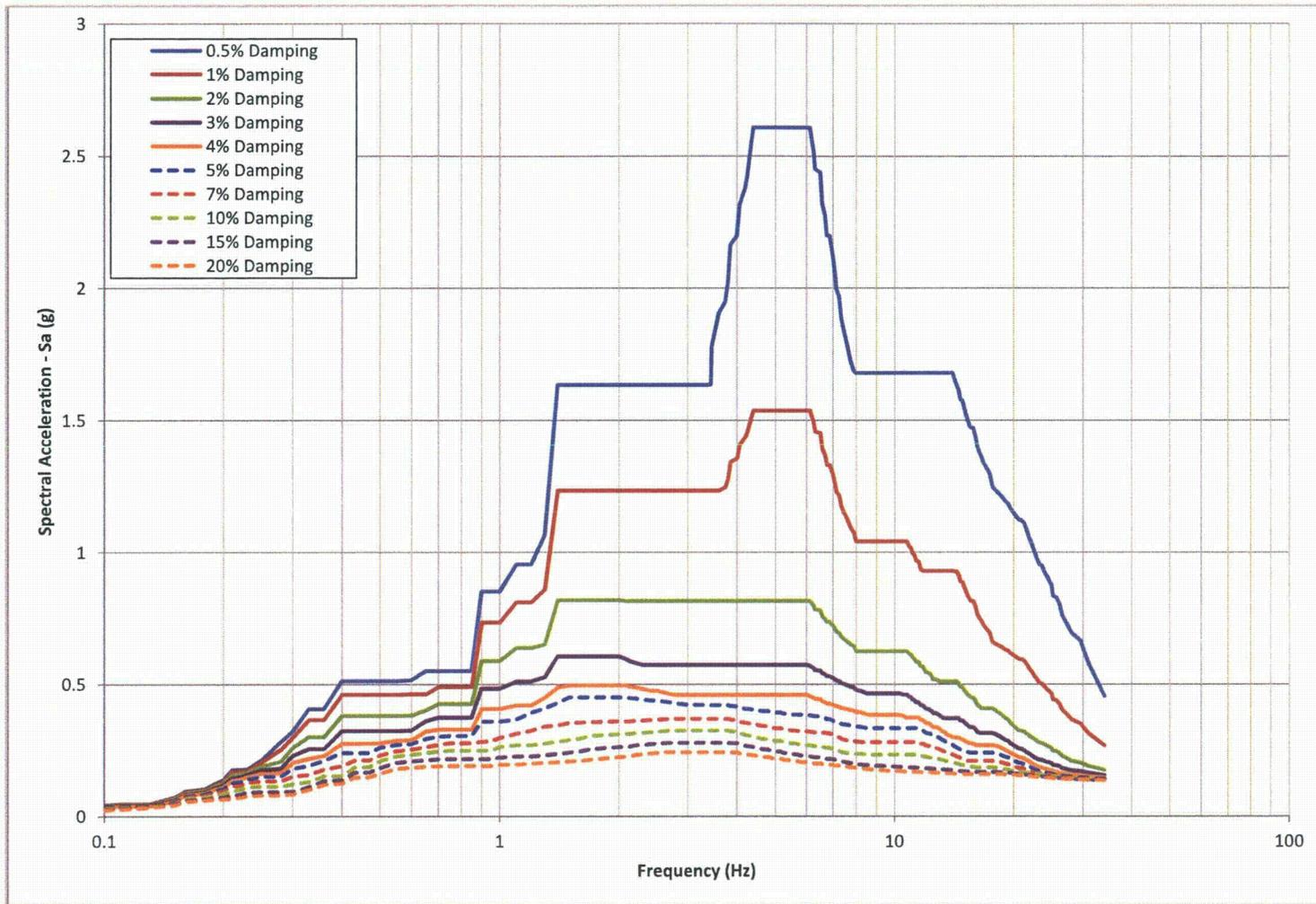


Figure 3H.6-25: Broadened FRS in E-W (X) Direction at the Top of UHS Basin Mat (Elevation 14 ft MSL)

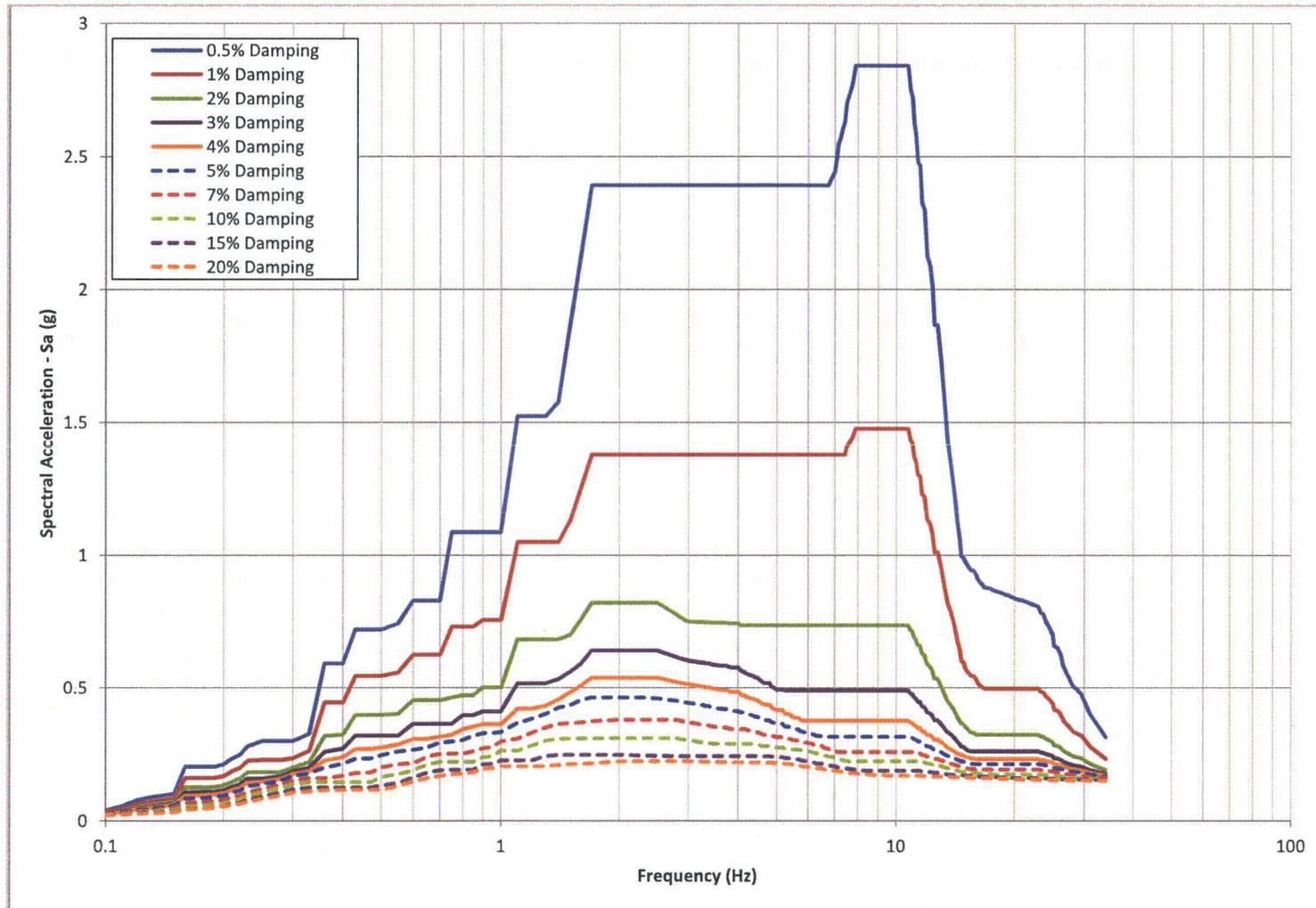


Figure 3H.6-26: Broadened FRS in N-S (Y) Direction at the Top of UHS Basin Mat (Elevation 14 ft MSL)

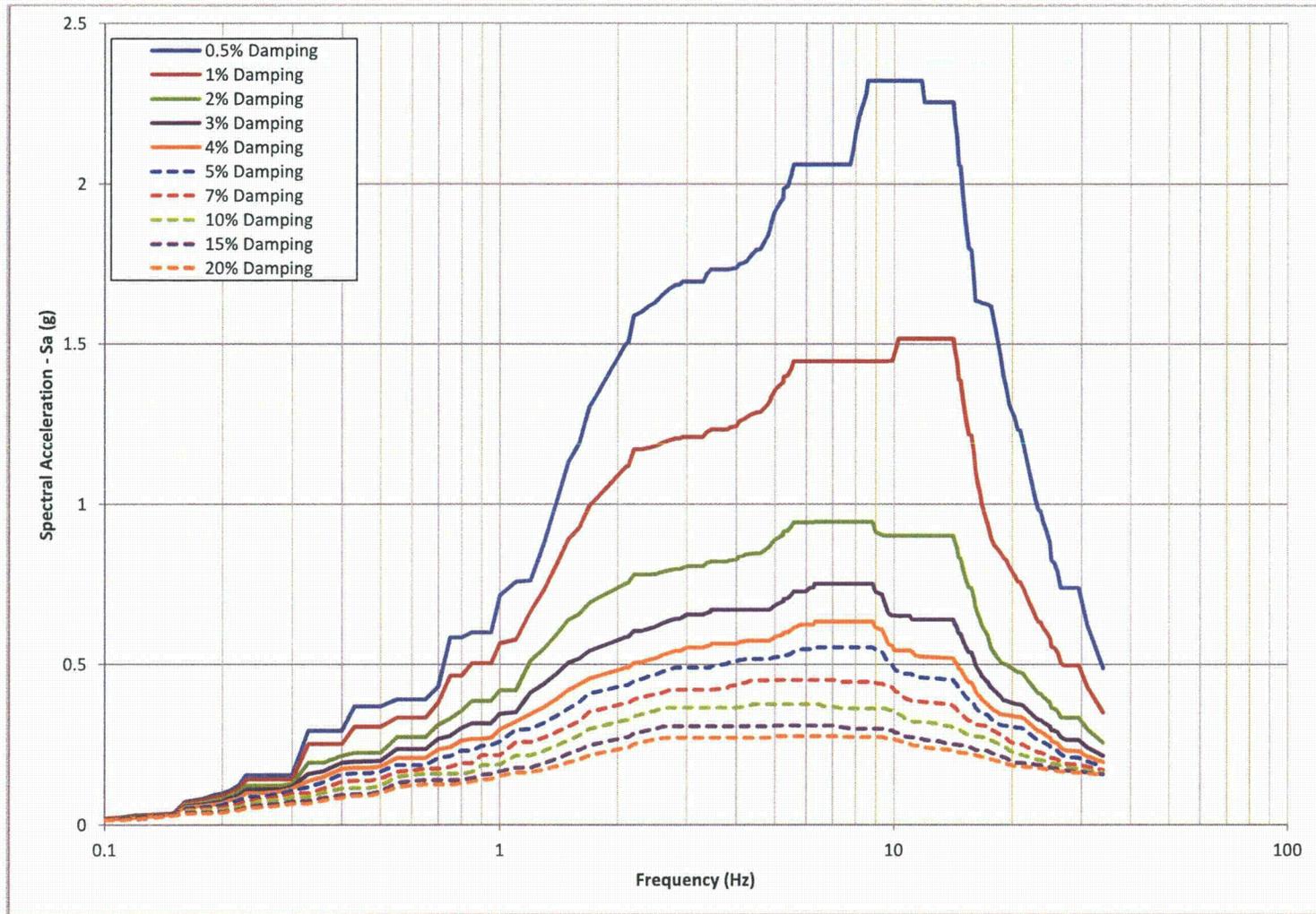


Figure 3H.6-27: Broadened FRS in Vertical (Z) Direction at the Top of UHS Basin Mat (Elevation 14 ft MSL)

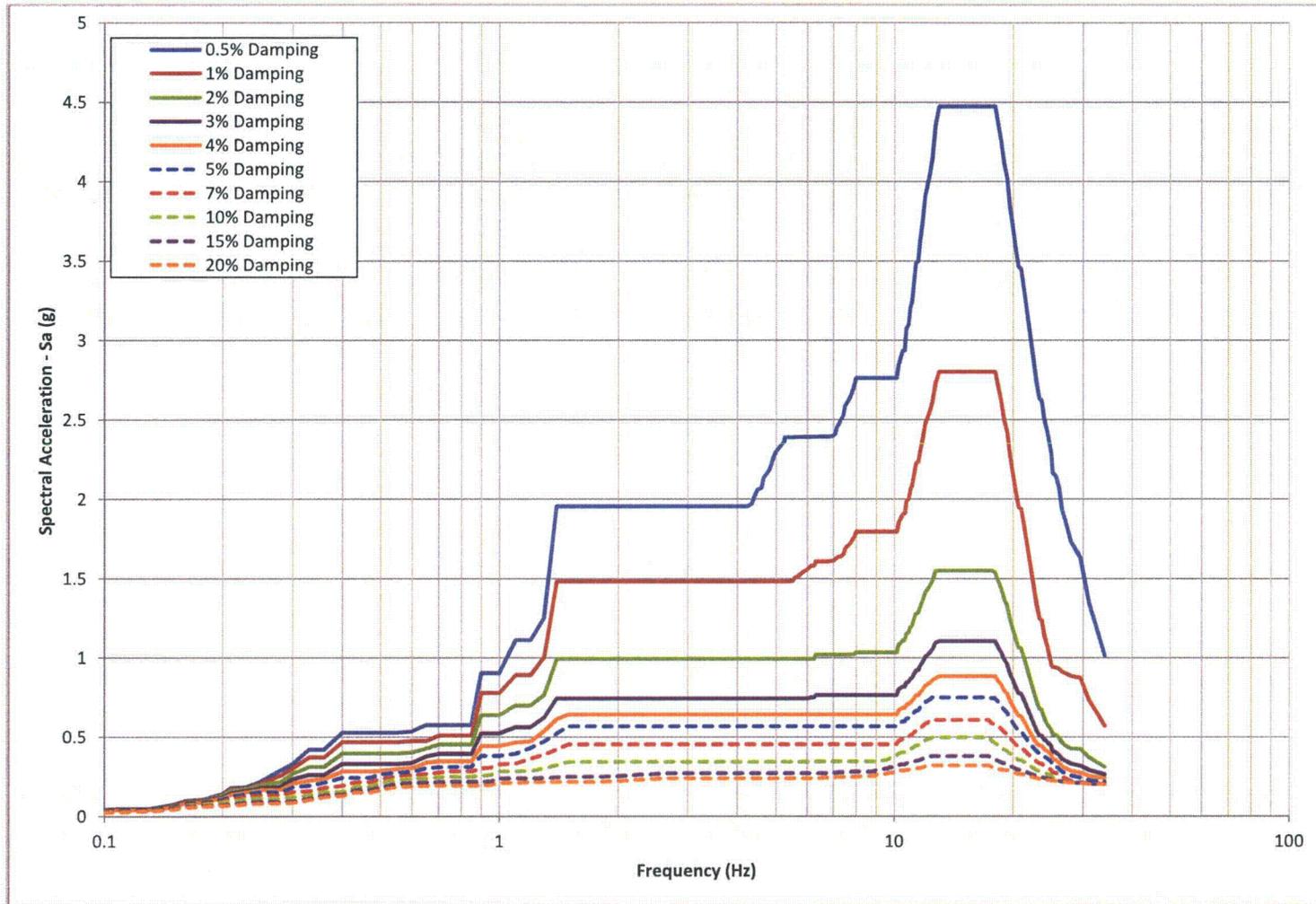


Figure 3H.6-28: Broadened FRS in E-W (X) Direction at the Top of UHS Basin Walls (Elevation 97.5 ft MSL)

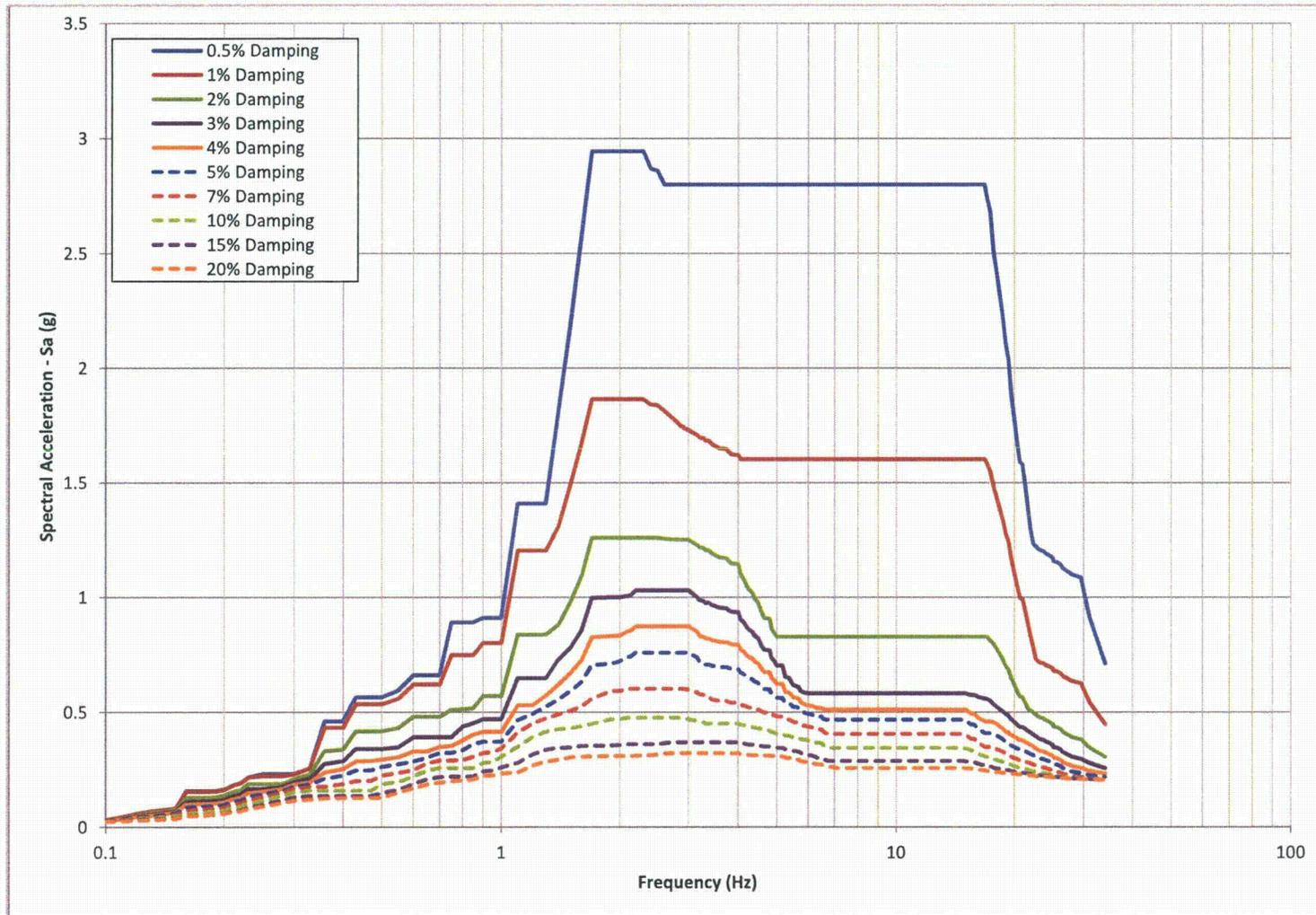


Figure 3H.6-29: Broadened FRS in N-S (Y) Direction at the Top of UHS Basin Walls (Elevation 97.5 ft MSL)

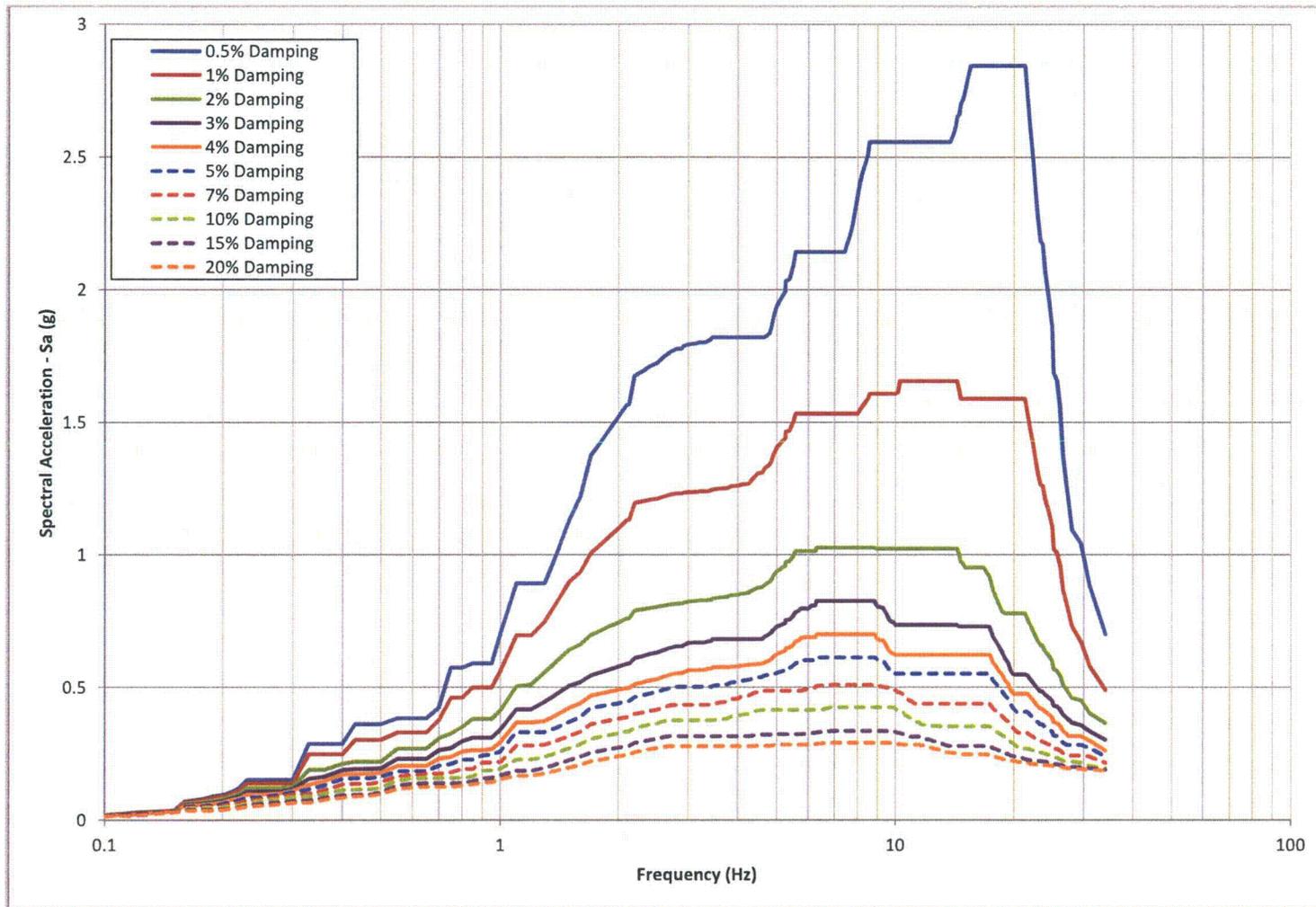


Figure 3H.6-30: Broadened FRS in Vertical (Z) Direction at the Top of UHS Basin Walls (Elevation 97.5 ft MSL)

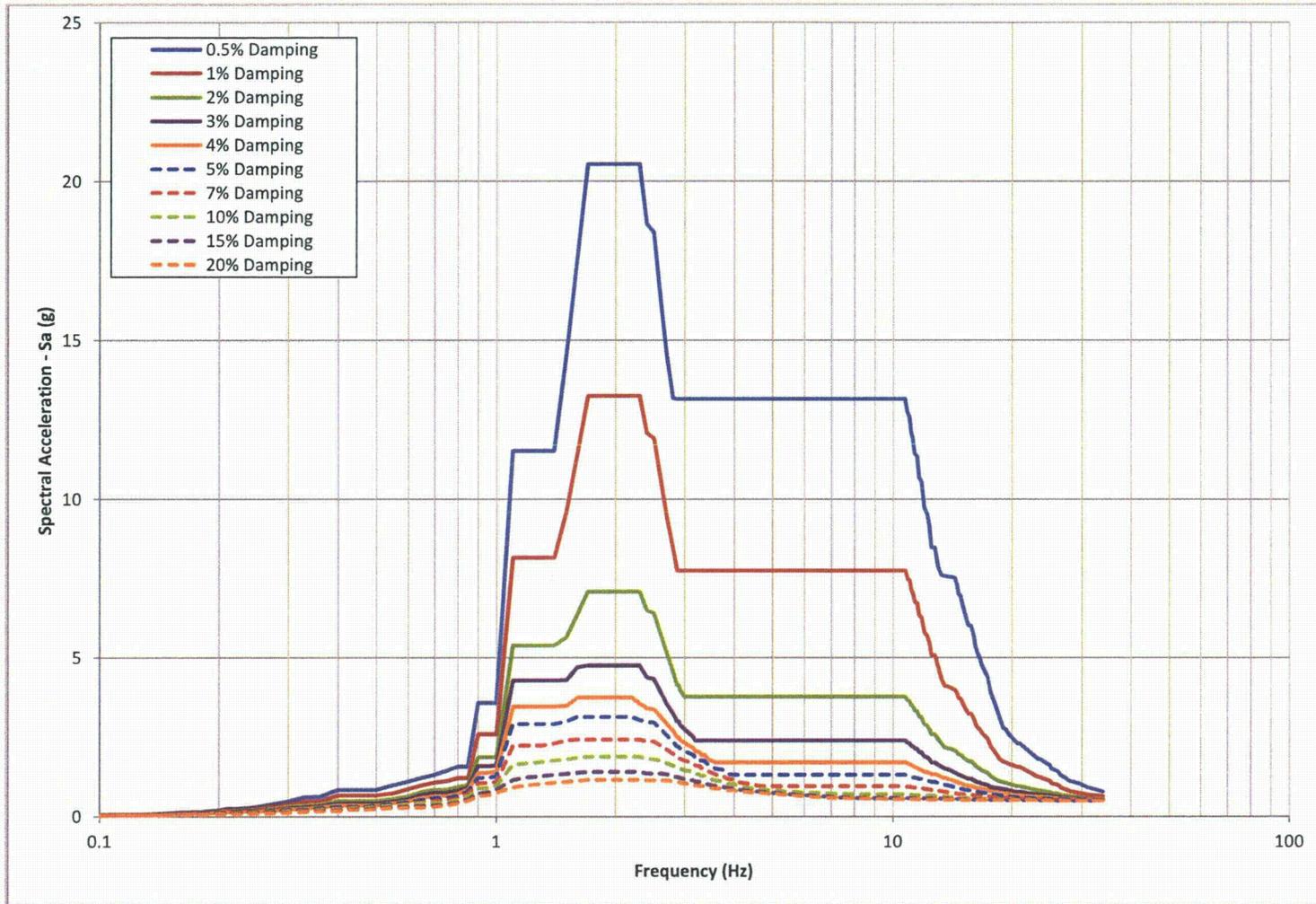


Figure 3H.6-31: Broadened FRS in E-W (X) Direction at the Bottom of Cooling Towers (Elevation 97.5 ft MSL)

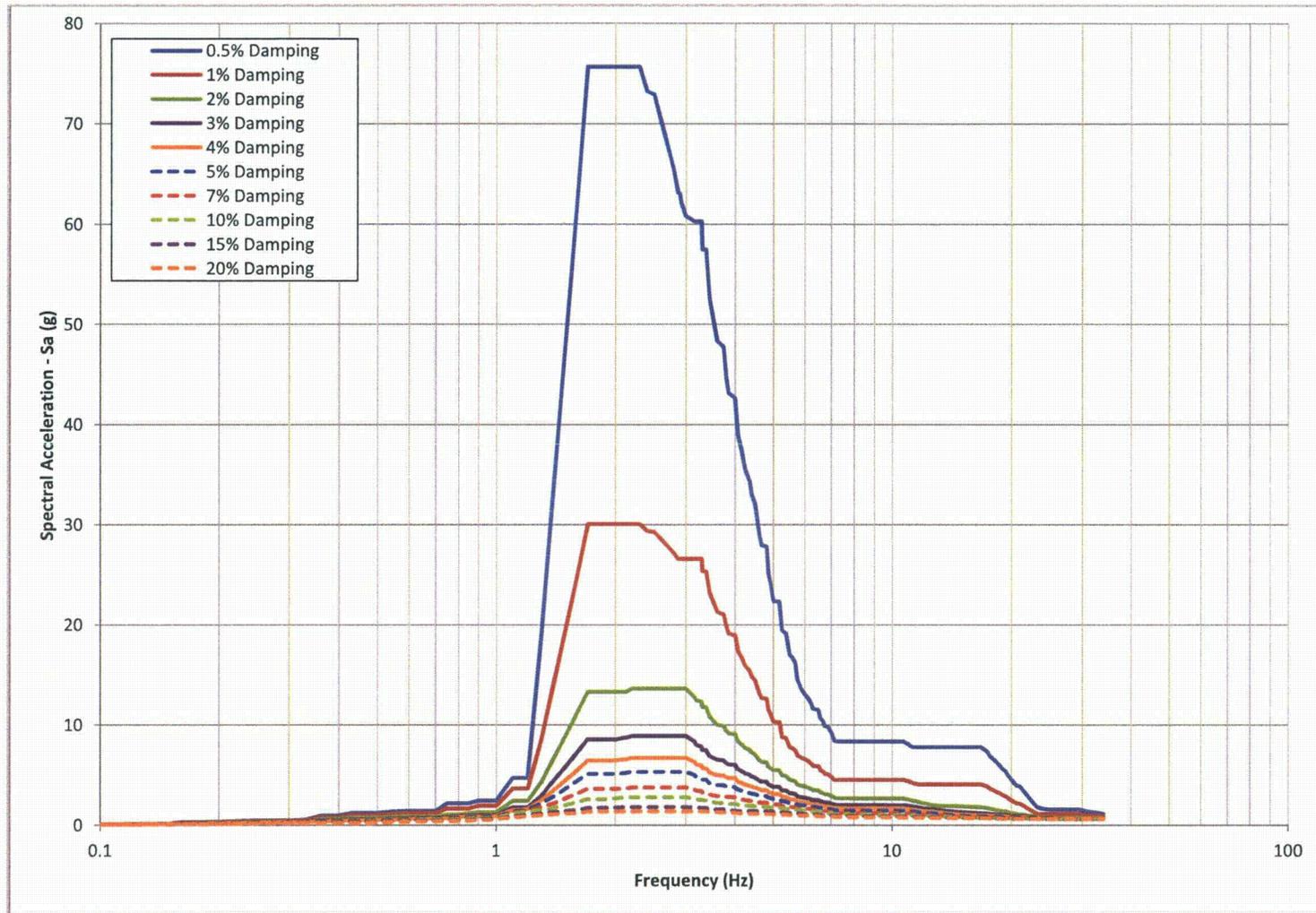


Figure 3H.6-32: Broadened FRS in N-S (Y) Direction at the Bottom of Cooling Towers (Elevation 97.5 ft MSL)

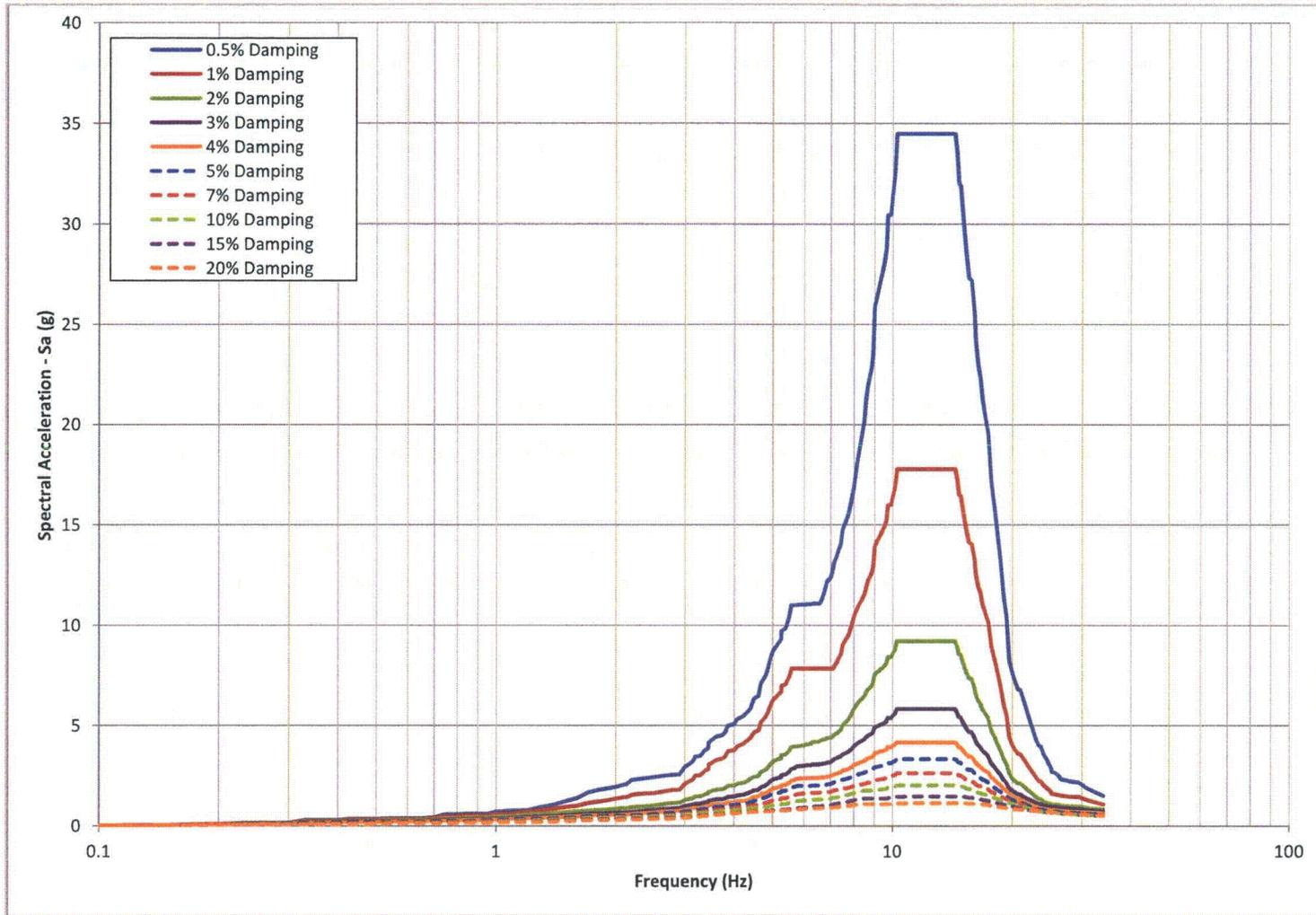


Figure 3H.6-33: Broadened FRS in Vertical (Z) Direction at the Bottom of Cooling Towers (Elevation 97.5 ft MSL)

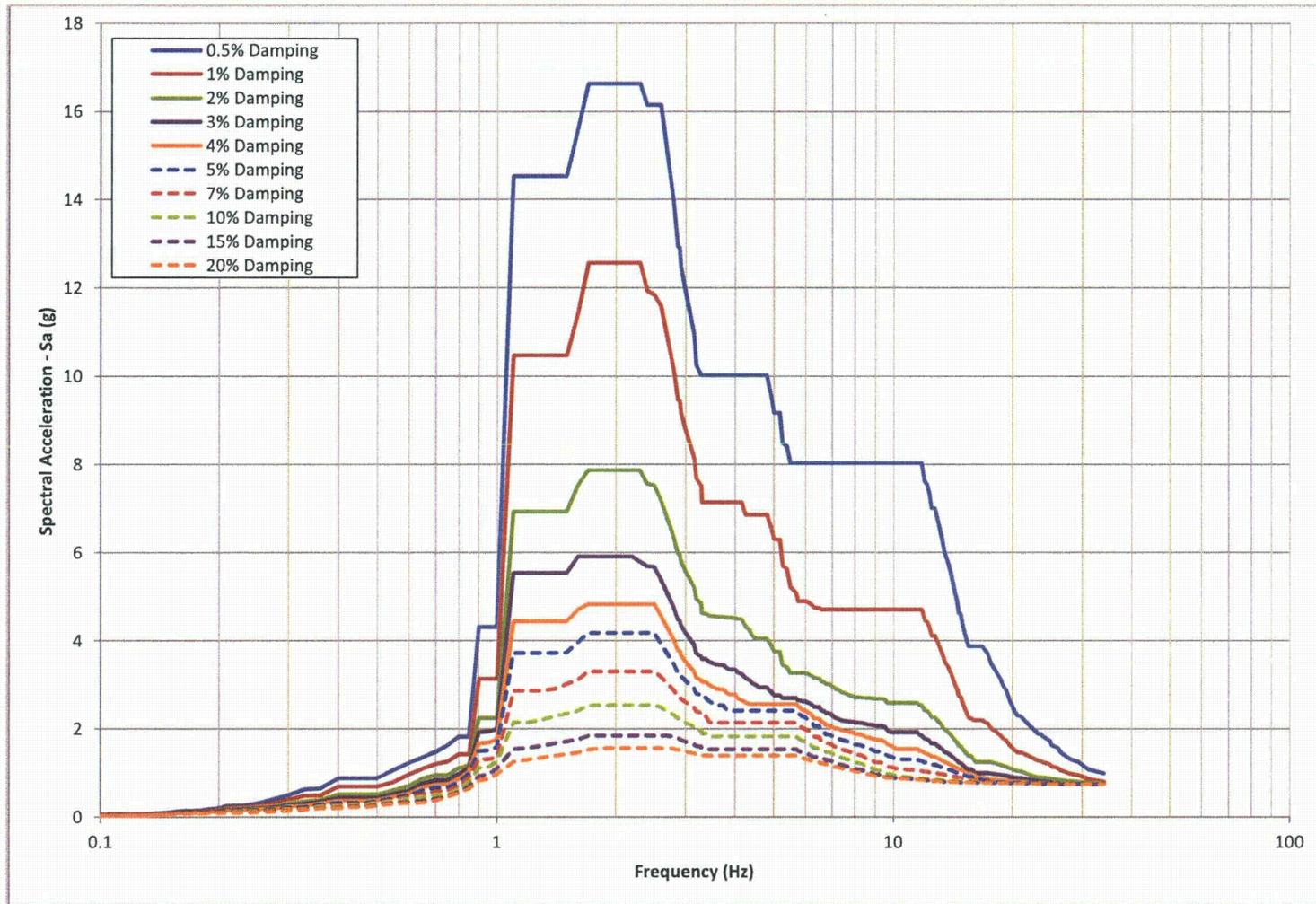


Figure 3H.6-34: Broadened FRS in E-W (X) Direction at the Mid-Level of Cooling Towers (Elevation 125.25 ft MSL)

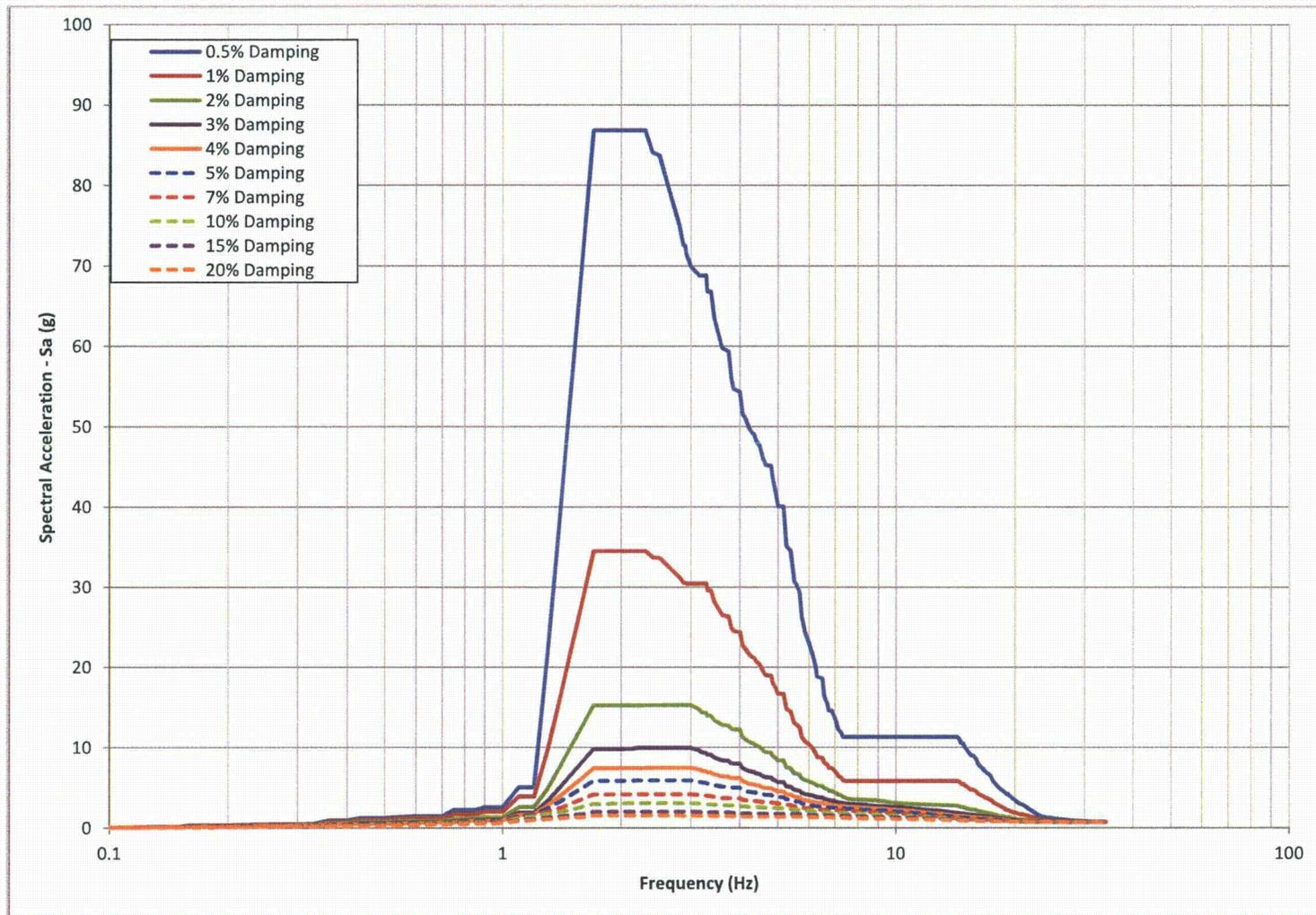


Figure 3H.6-35: Broadened FRS in N-S (Y) Direction at the Mid-Level of Cooling Towers (Elevation 125.25 ft MSL)

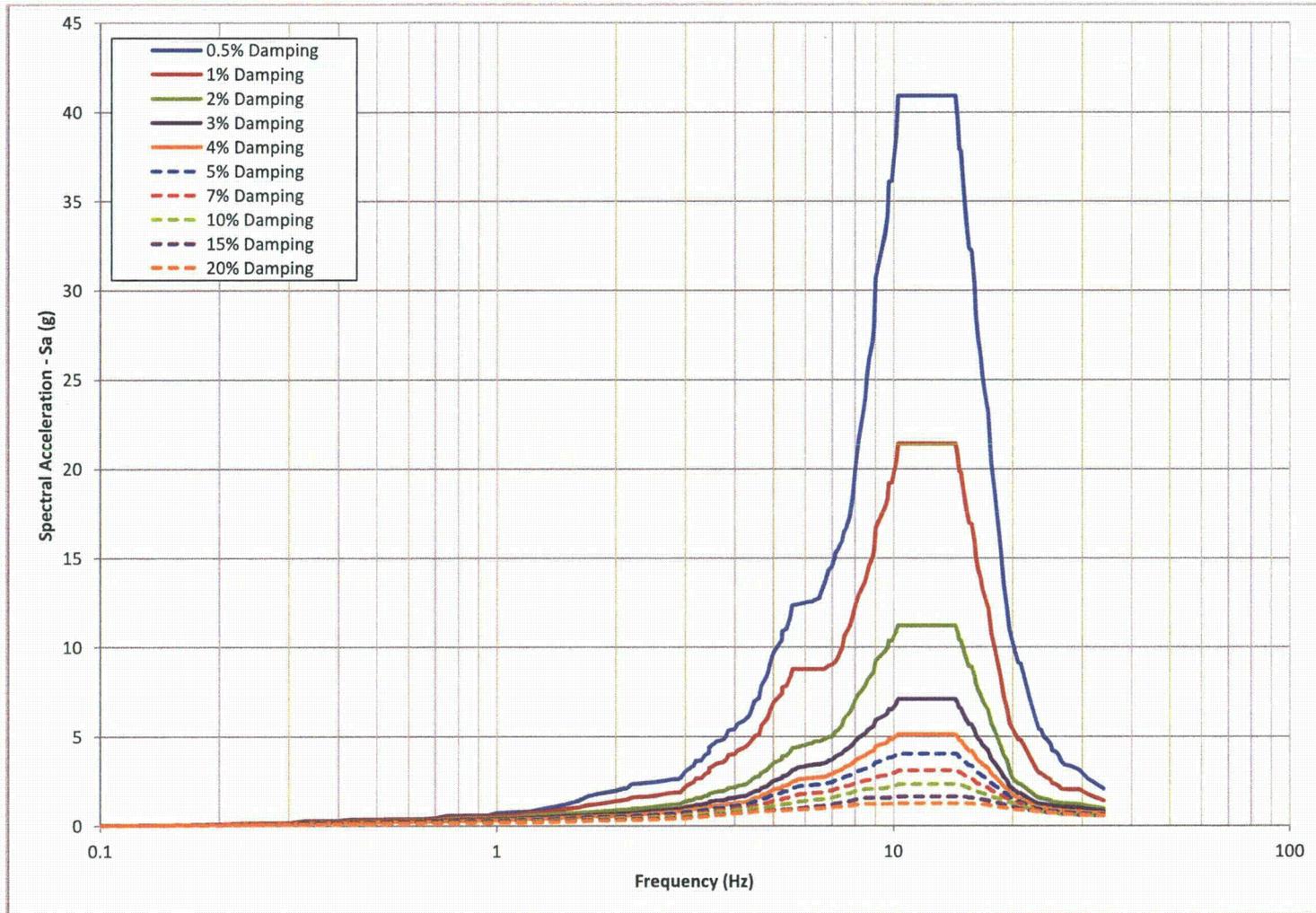


Figure 3H.6-36: Broadened FRS in Vertical (Z) Direction at the Mid-Level of Cooling Towers (Elevation 125.25 ft MSL)

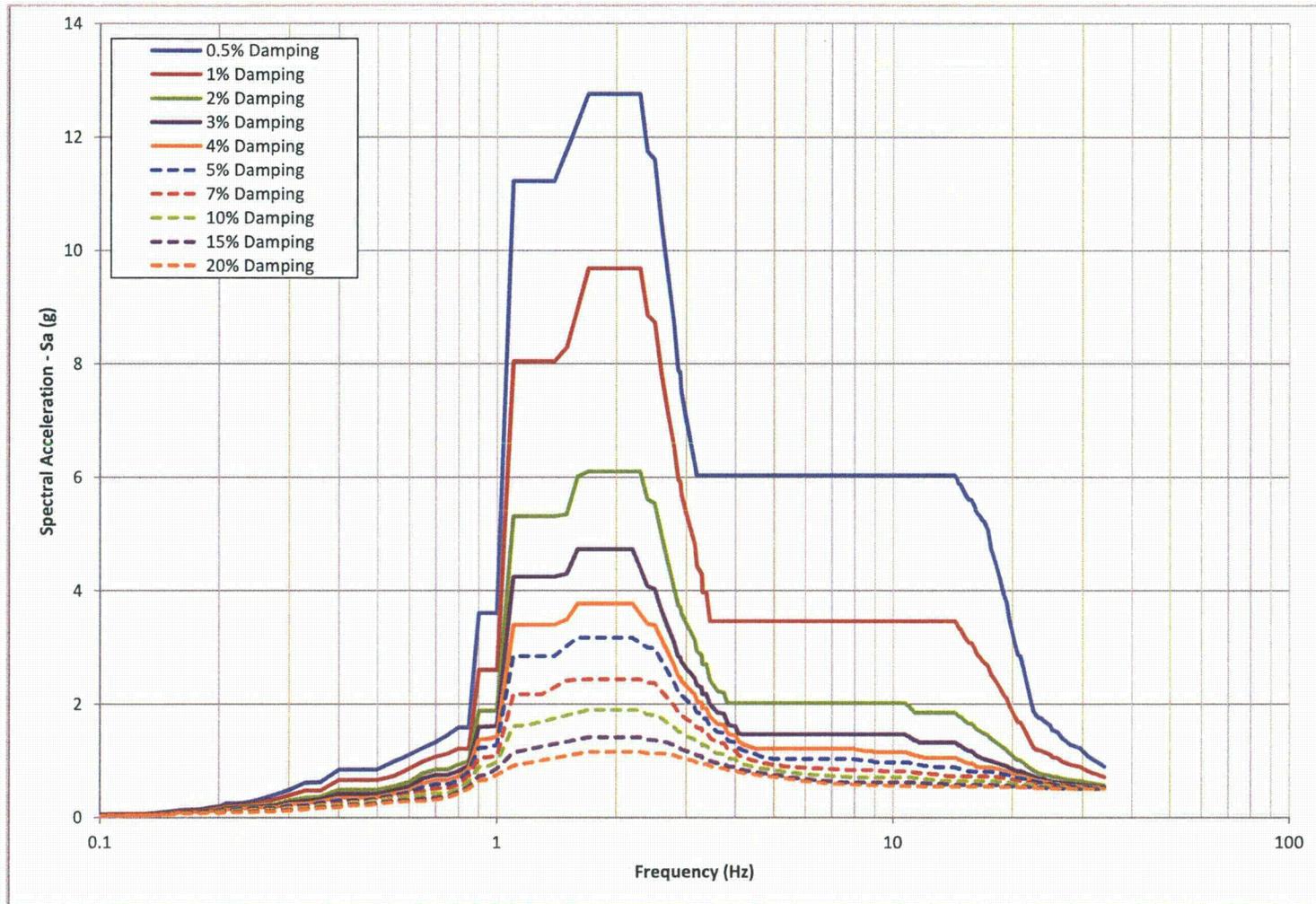


Figure 3H.6-37: Broadened FRS in E-W (X) Direction at the Top of Cooling Towers (Elevation 153 ft MSL)

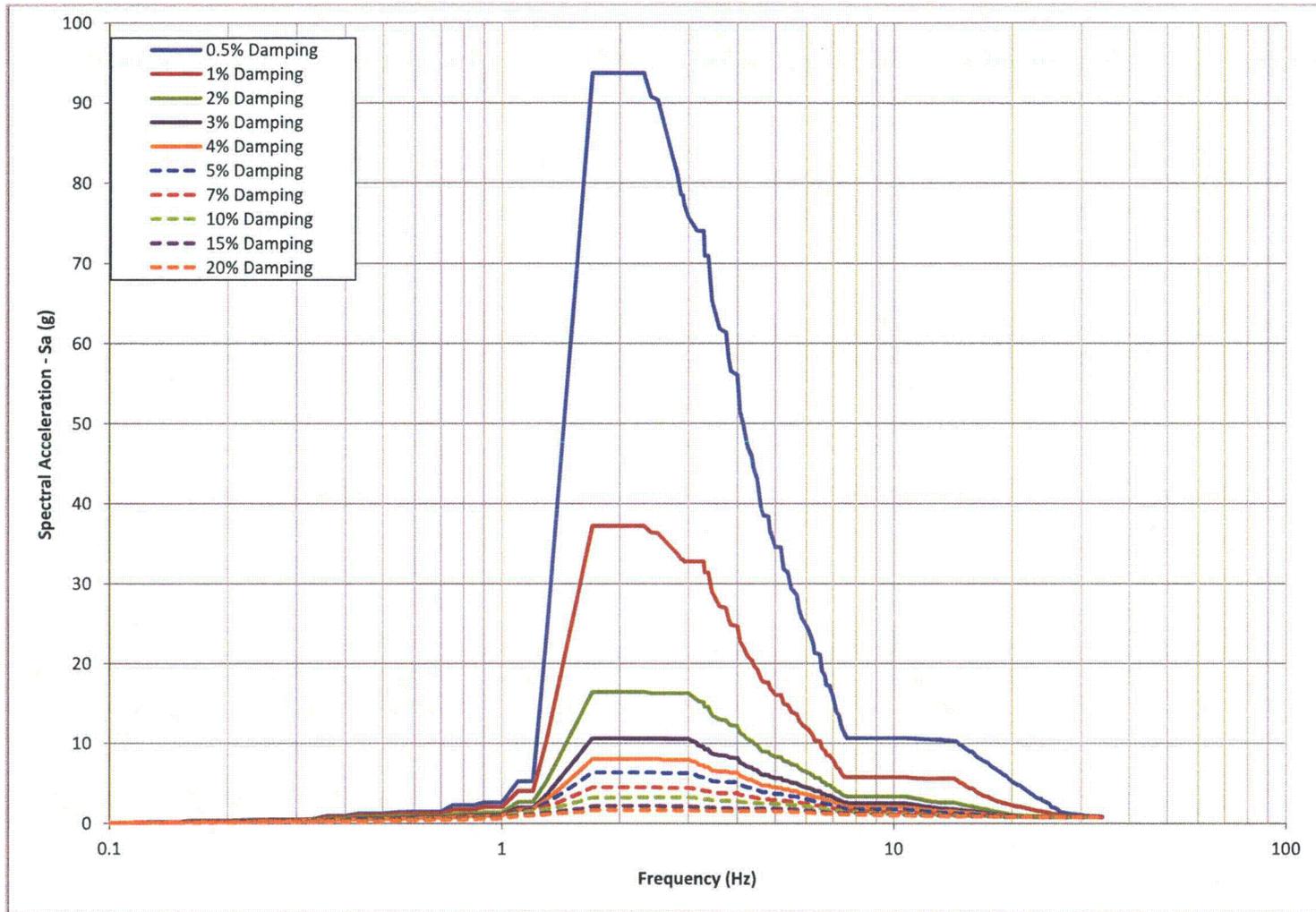


Figure 3H.6-38: Broadened FRS in N-S (Y) Direction at the Top of Cooling Towers (Elevation 153 ft MSL)

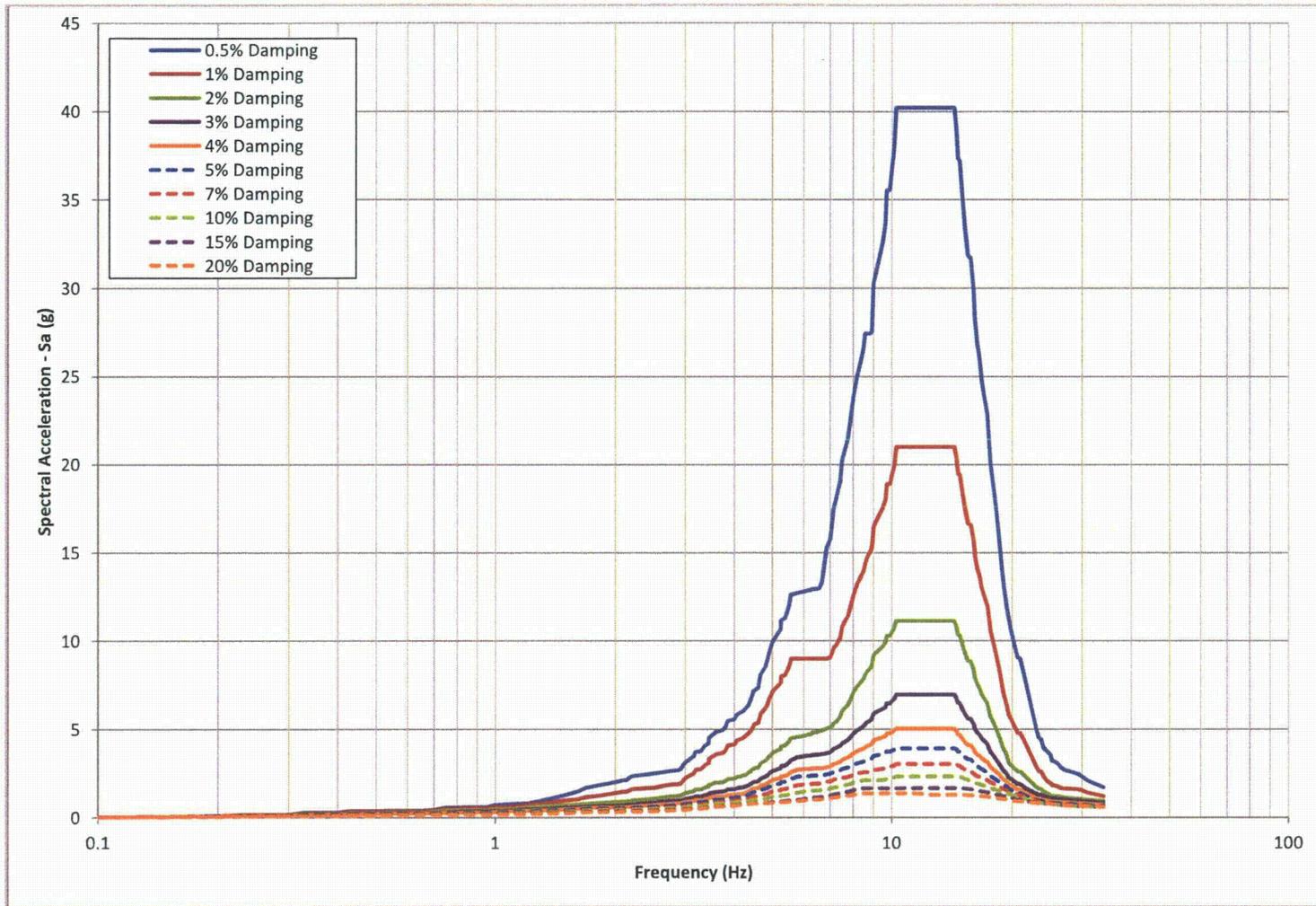


Figure 3H.6-39: Broadened FRS in Vertical (Z) Direction at the Top of Cooling Towers (Elevation 153 ft MSL)

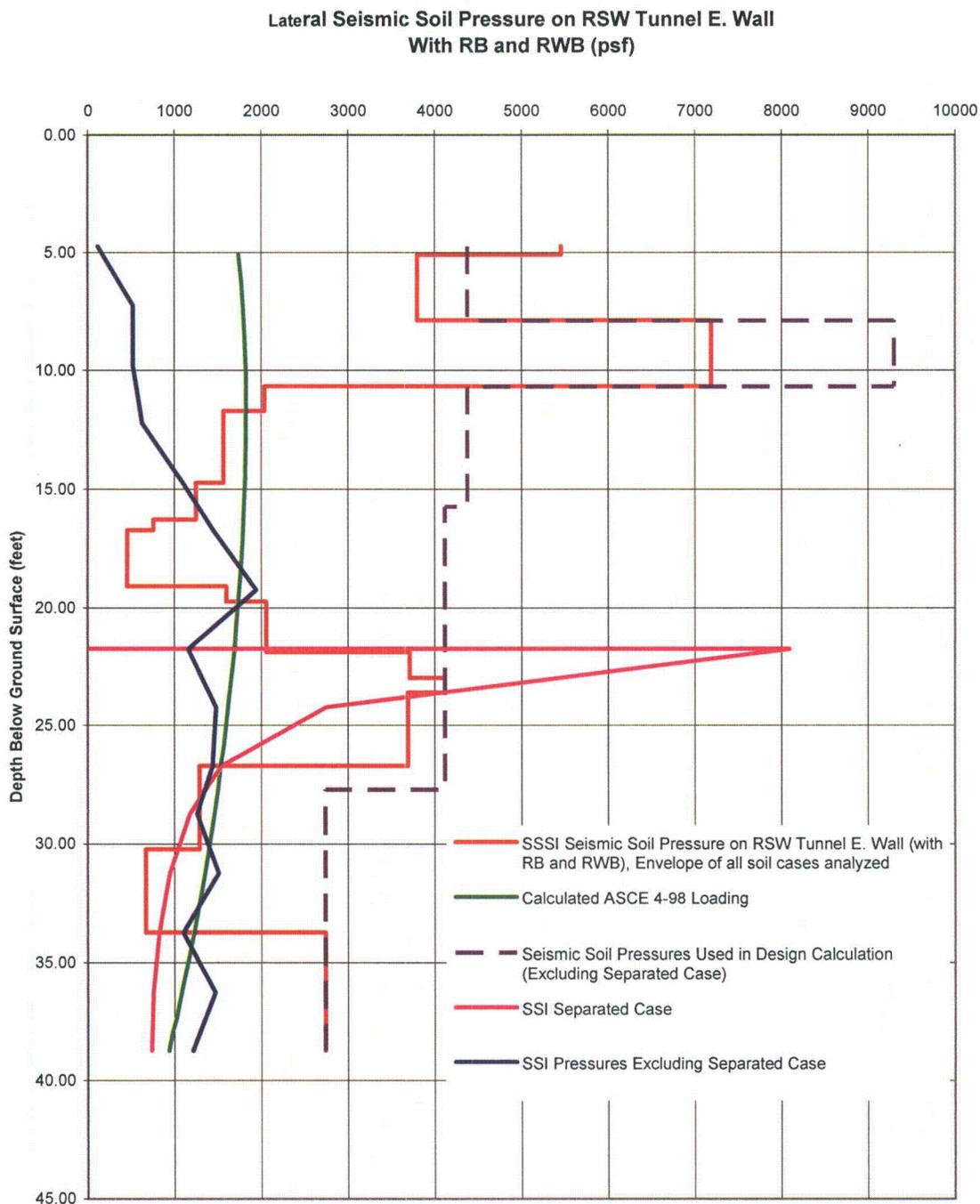
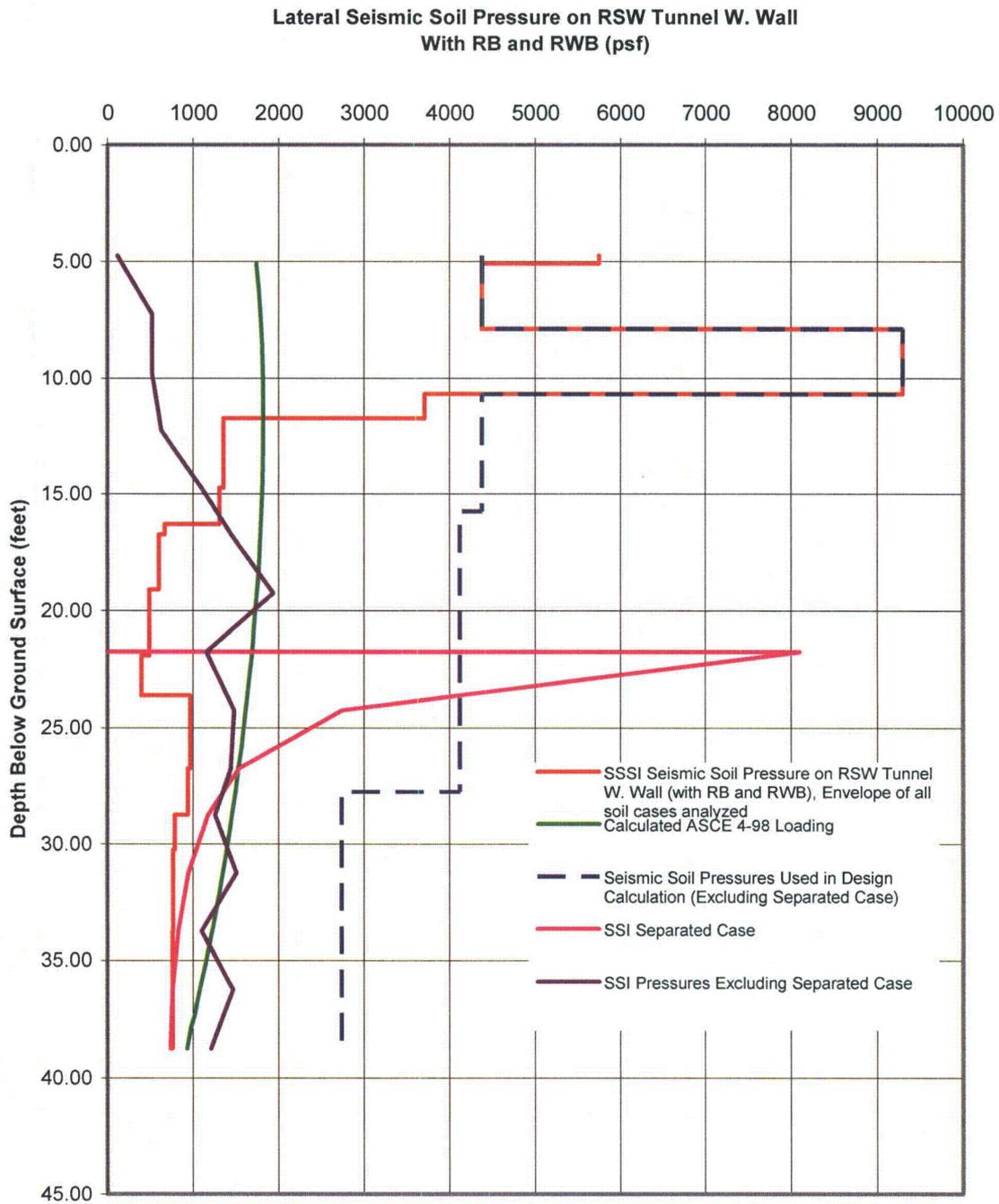


Figure 3H.6-212: Lateral Seismic Soil Pressure (psf) on RSW Piping Tunnel East Wall (Main Cross Section of RSW Piping Tunnel)



**Figure 3H.6-213: Lateral Seismic Soil Pressure (psf) on RSW Piping Tunnel West Wall
(Main Cross Section of RSW Piping Tunnel)**

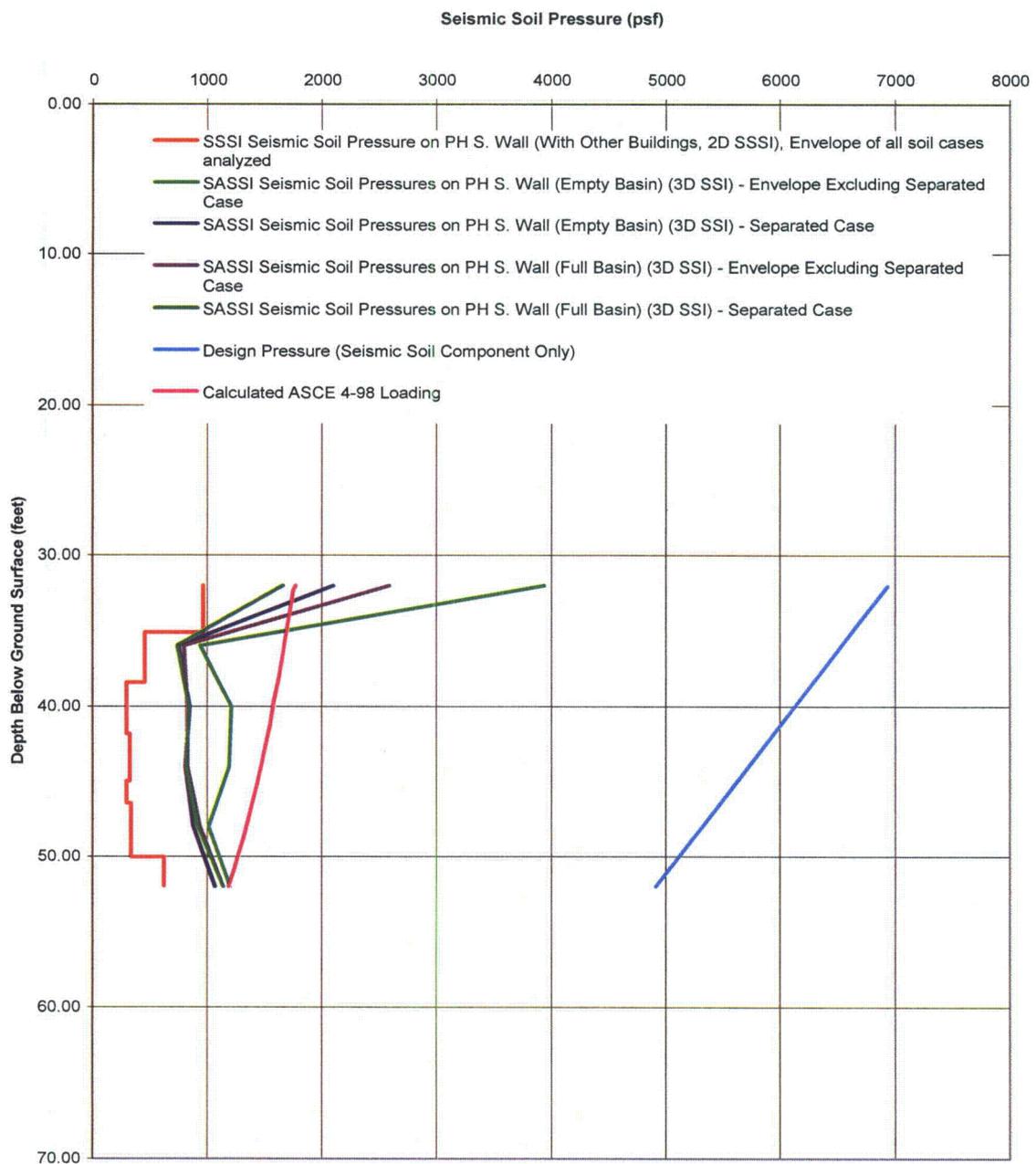


Figure 3H.6-218: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on RSW Pump House South Wall

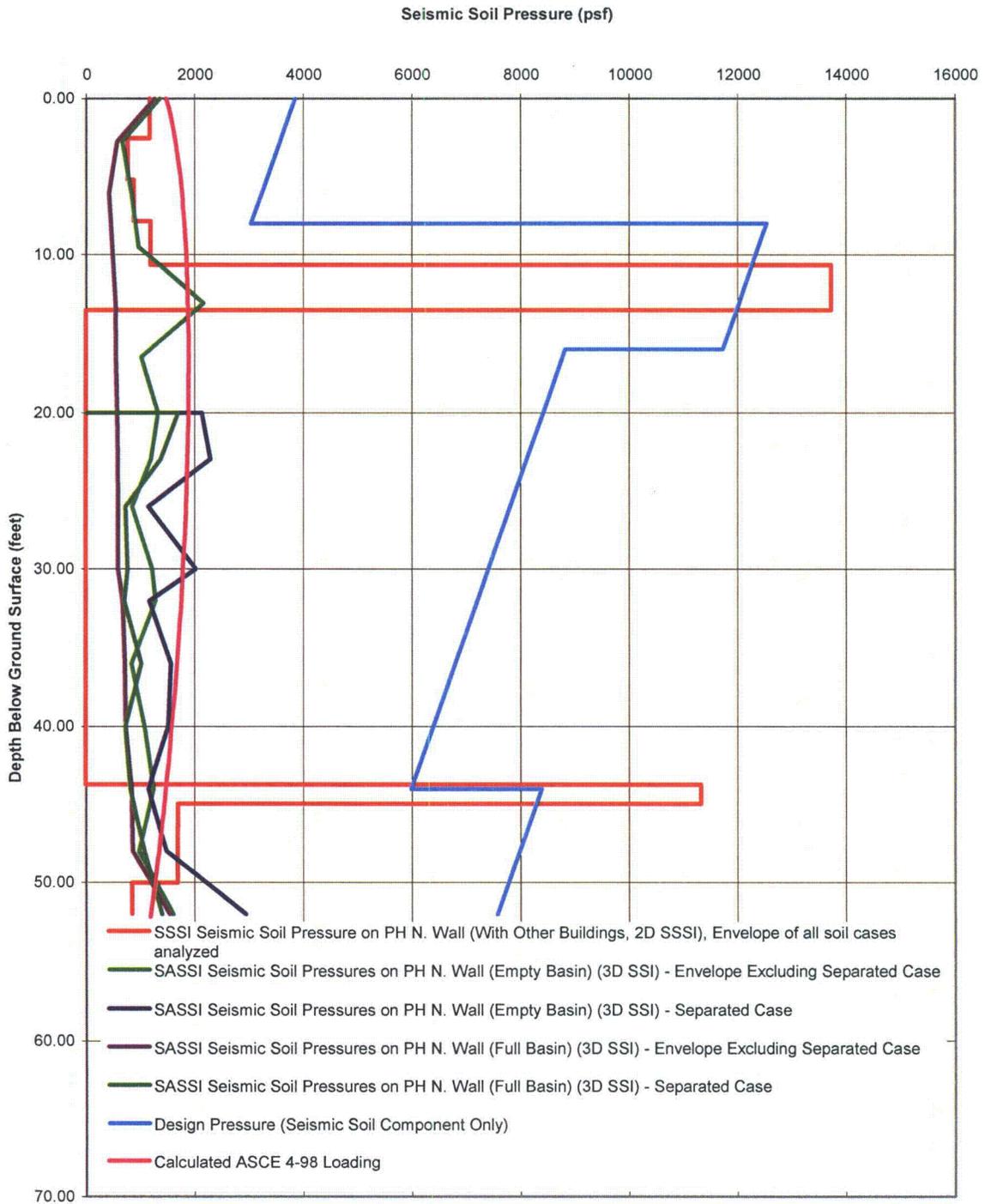


Figure 3H.6-219: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on RSW Pump House North Wall

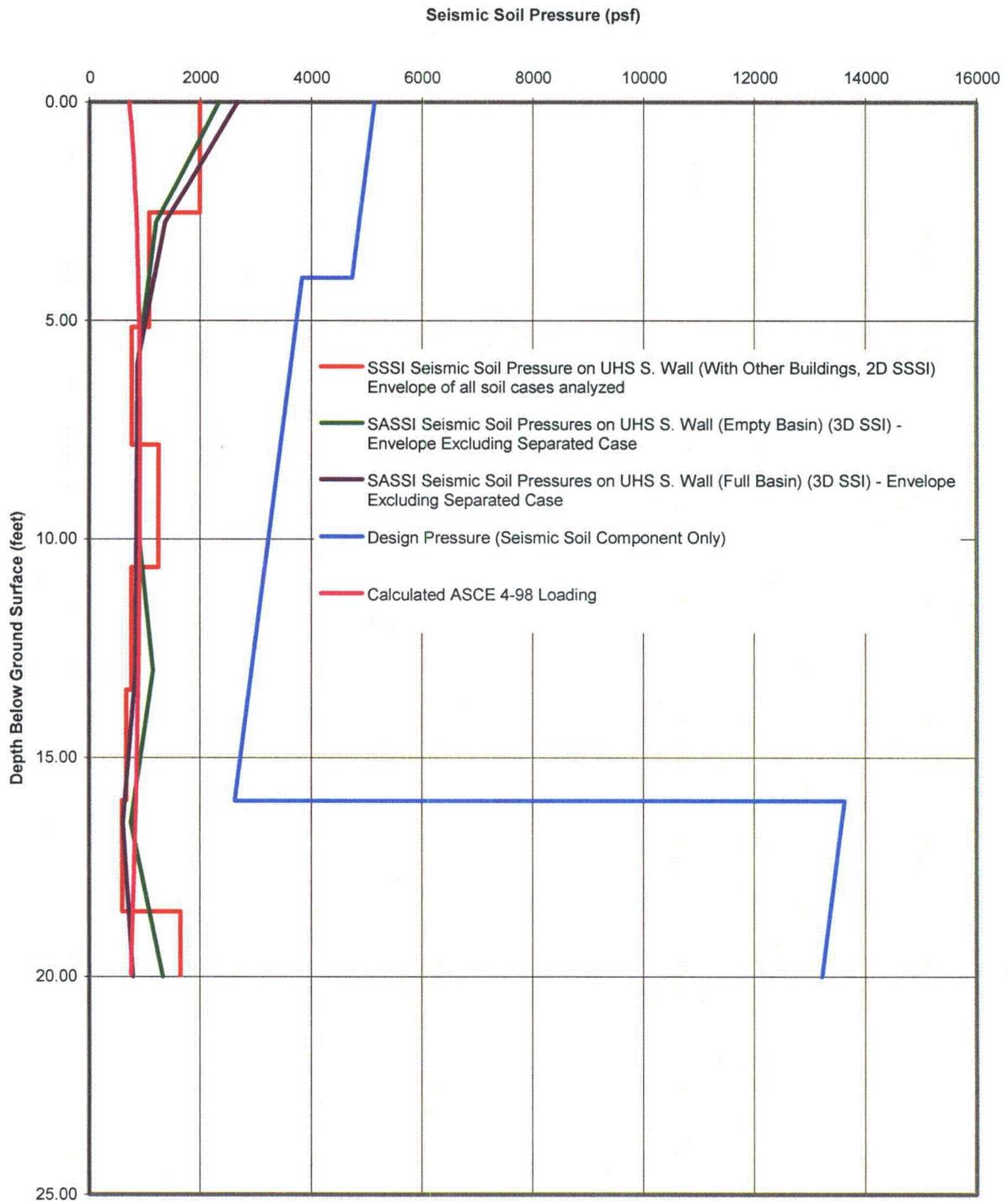


Figure 3H.6-220: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Ultimate Heat Sink Basin South Wall

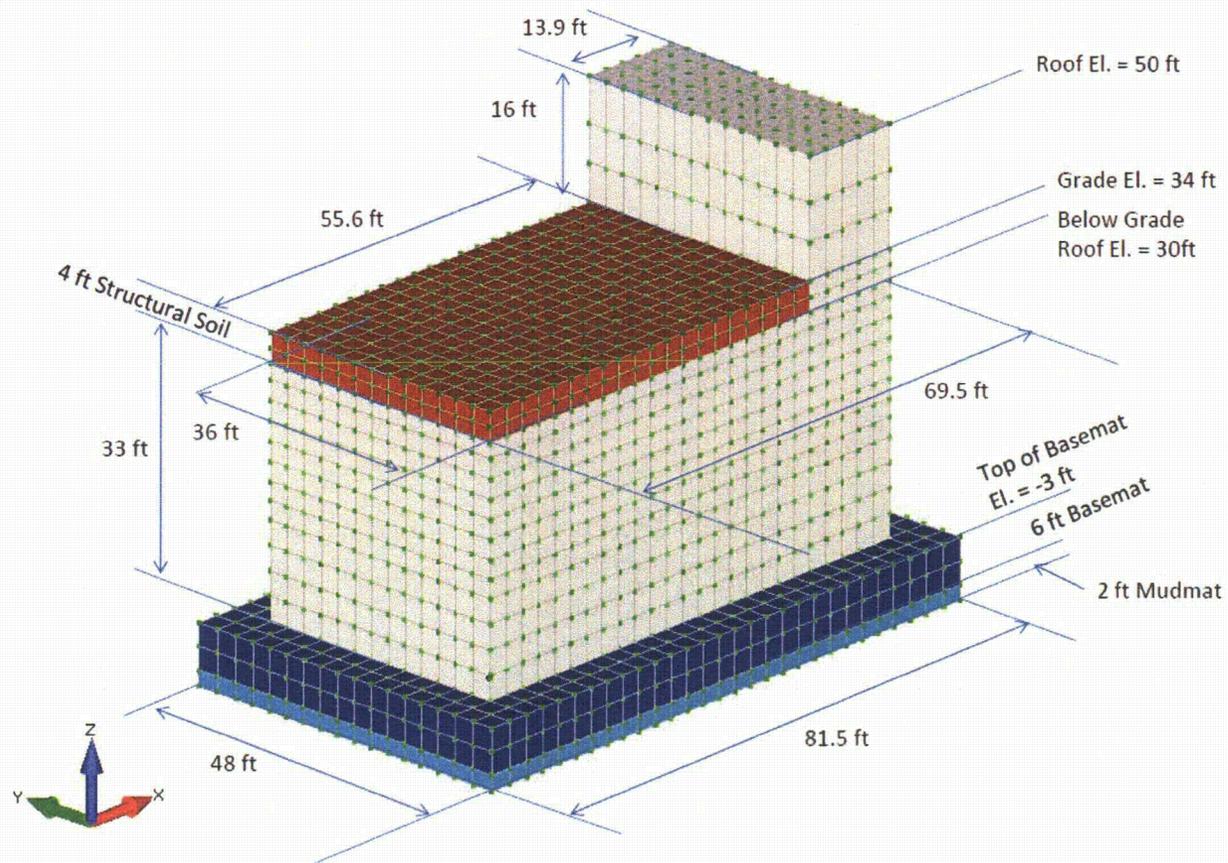


Figure 3H.6-222: 3D Model of DGFOSV for SSI Analysis

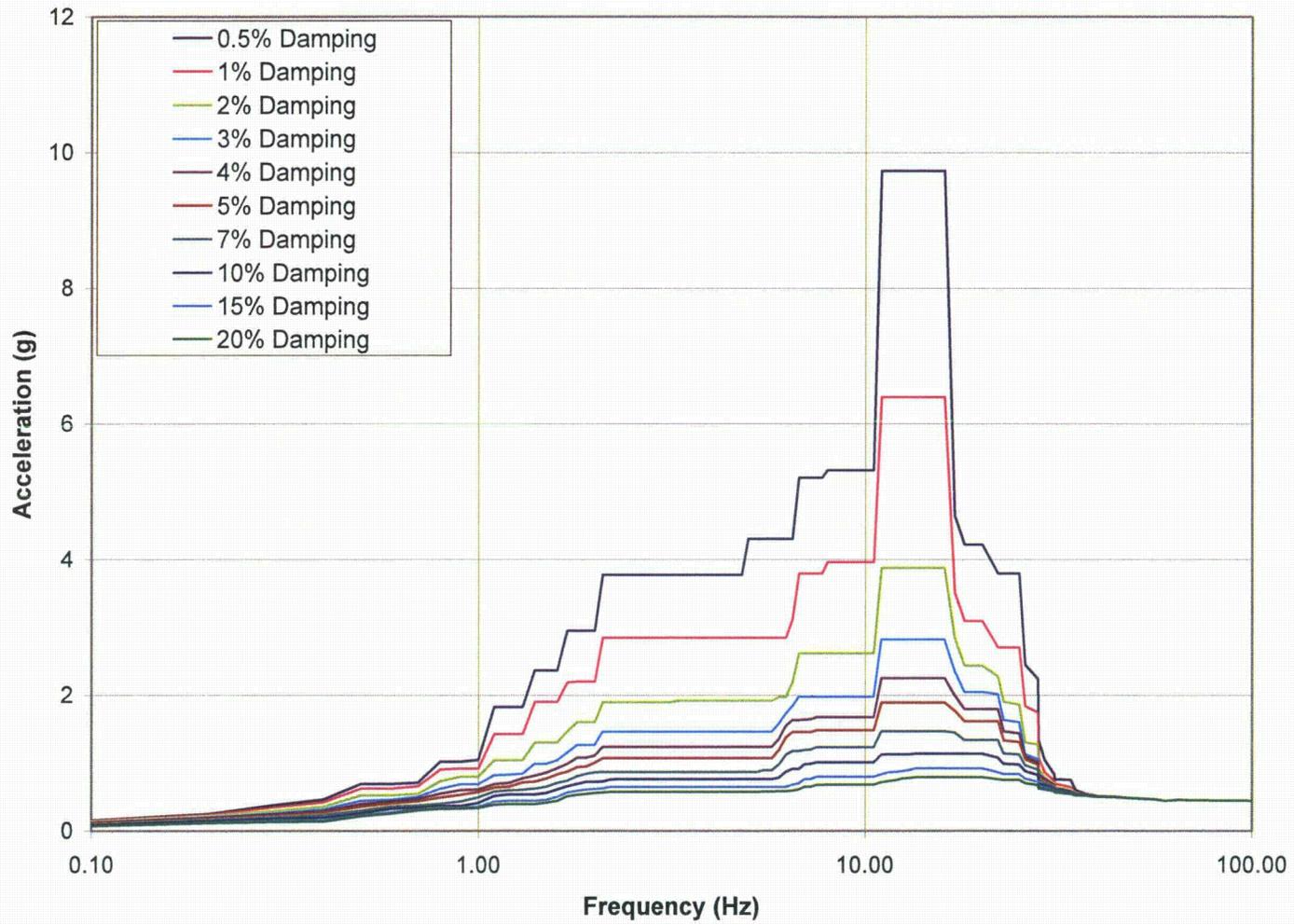


Figure 3H.6-223: Enveloped Broadened Horizontal Direction Response Spectra for DGFOVS

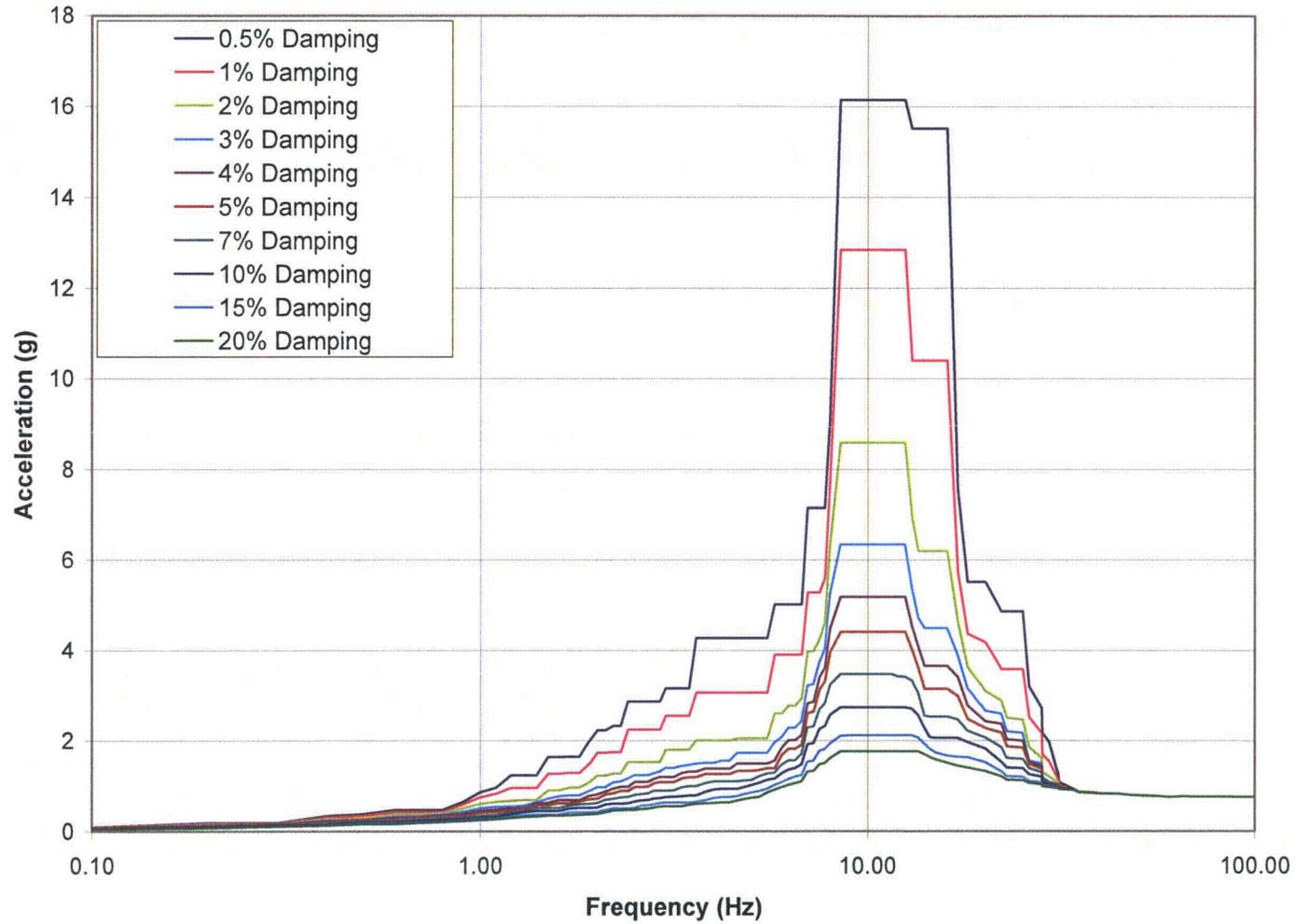


Figure 3H.6-224: Enveloped Broadened Vertical Direction Response Spectra for DGFO SV

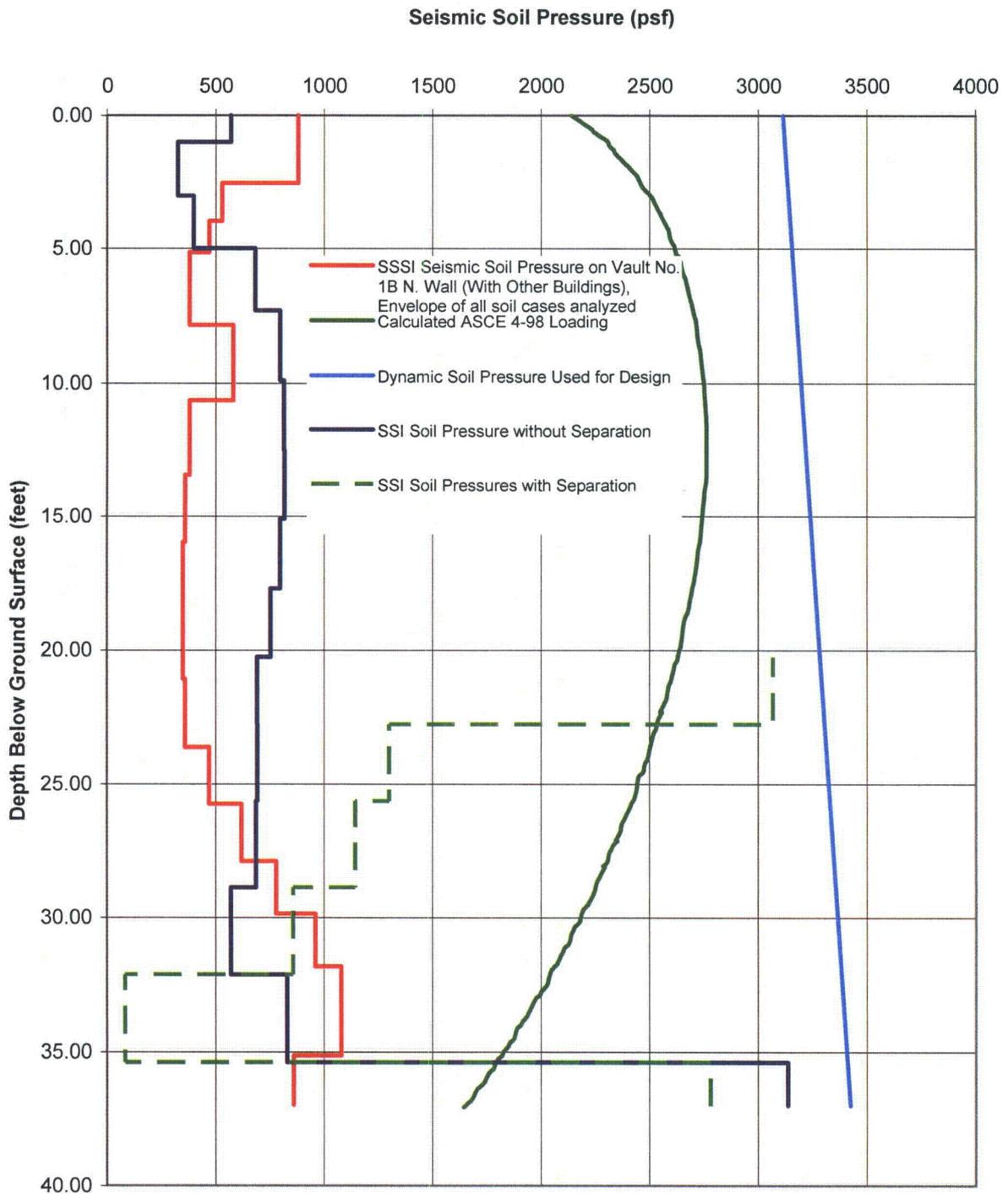


Figure 3H.6-226: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1B North Wall

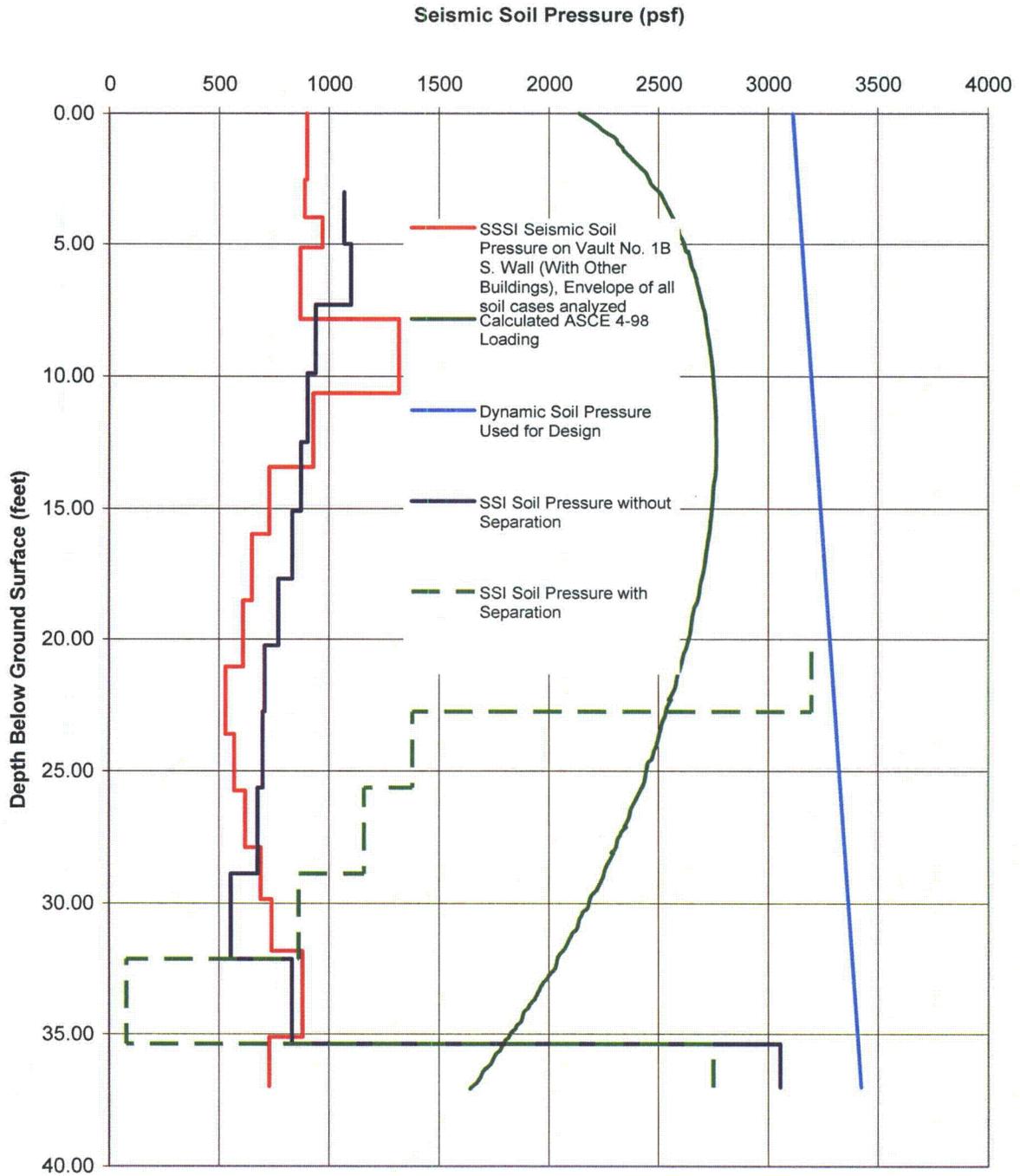


Figure 3H.6-227: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1B South Wall

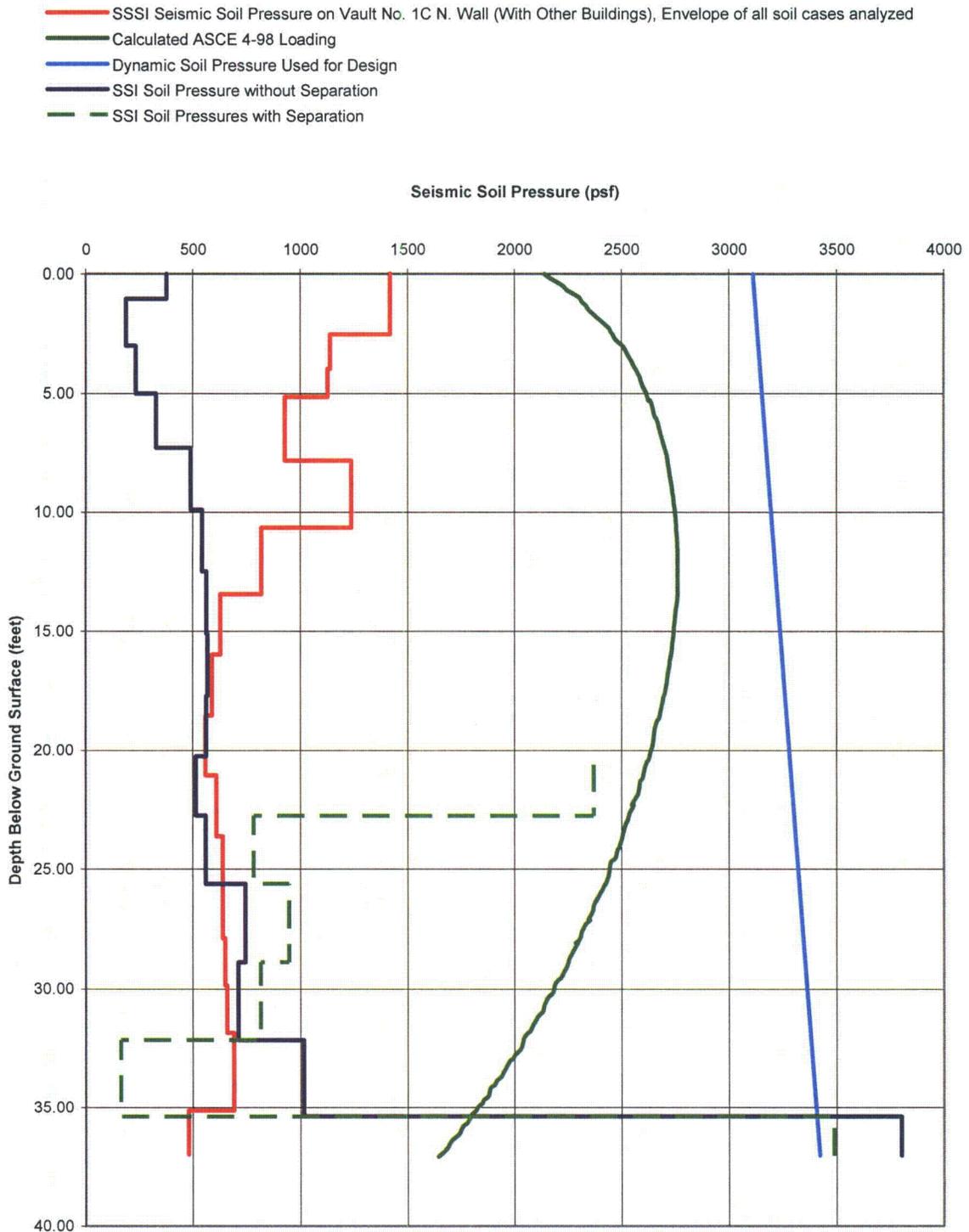


Figure 3H.6-228: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1C North Wall

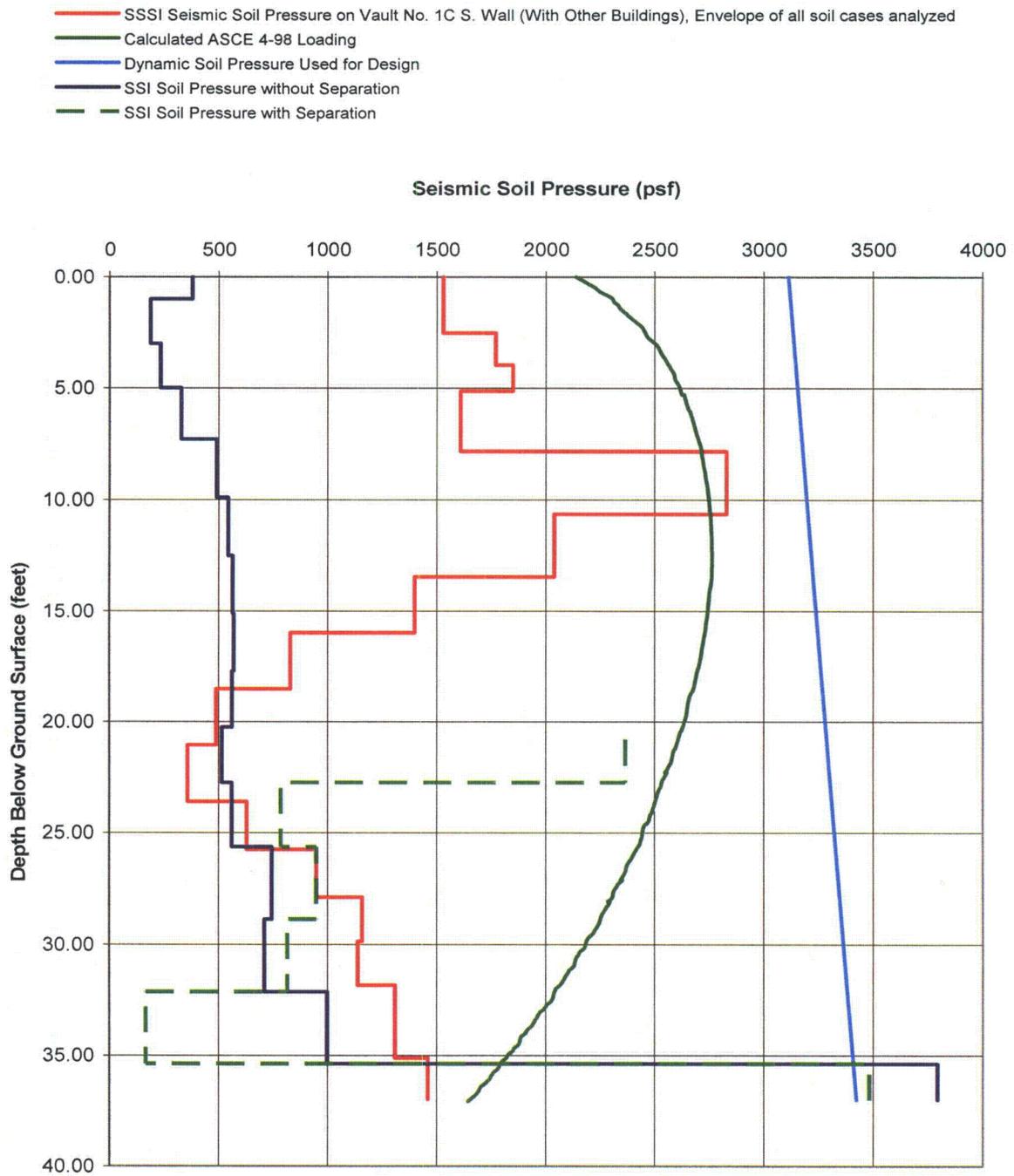


Figure 3H.6-229: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1C South Wall

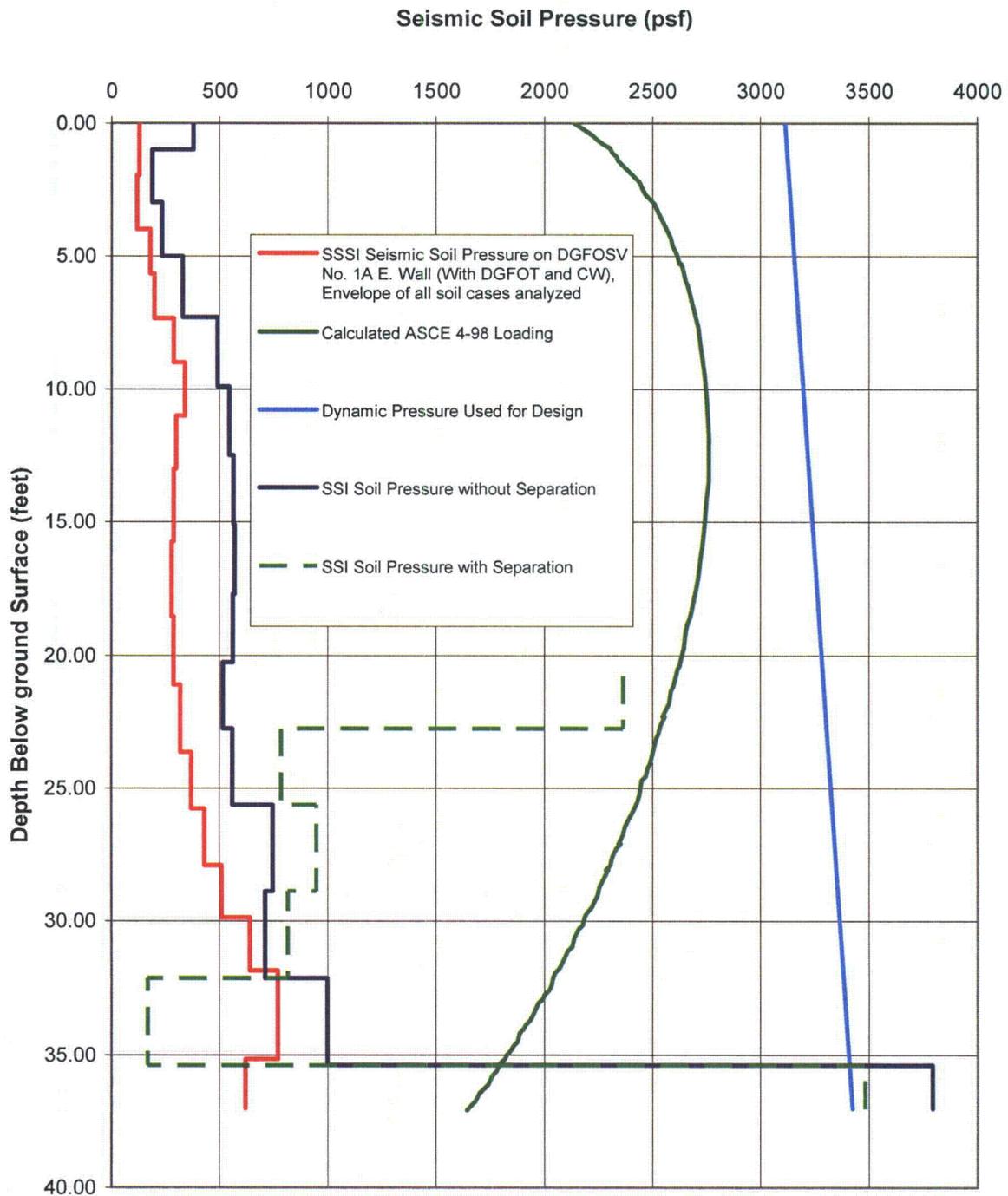


Figure 3H.6-230: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1A East Wall

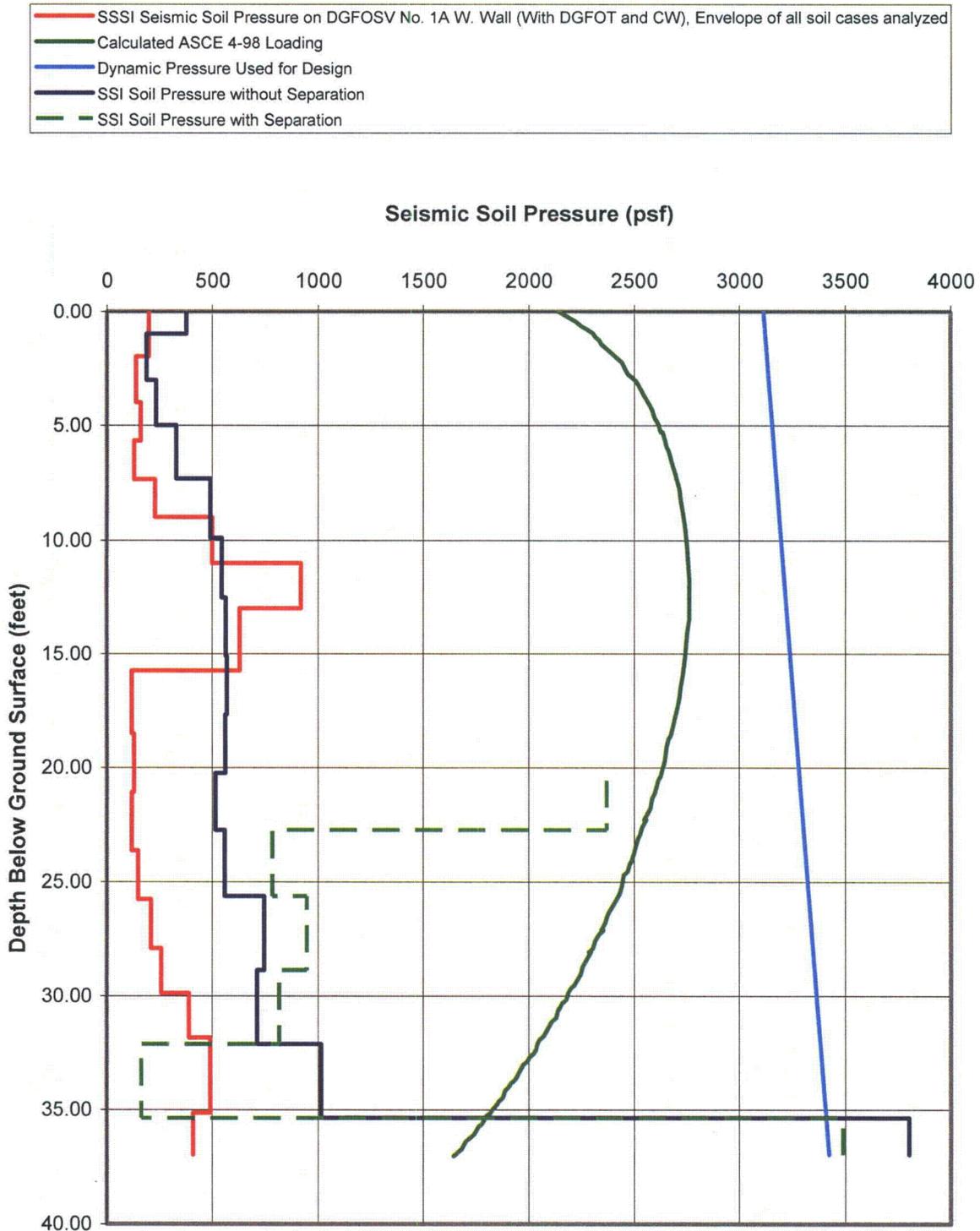


Figure 3H.6-231: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1A West Wall

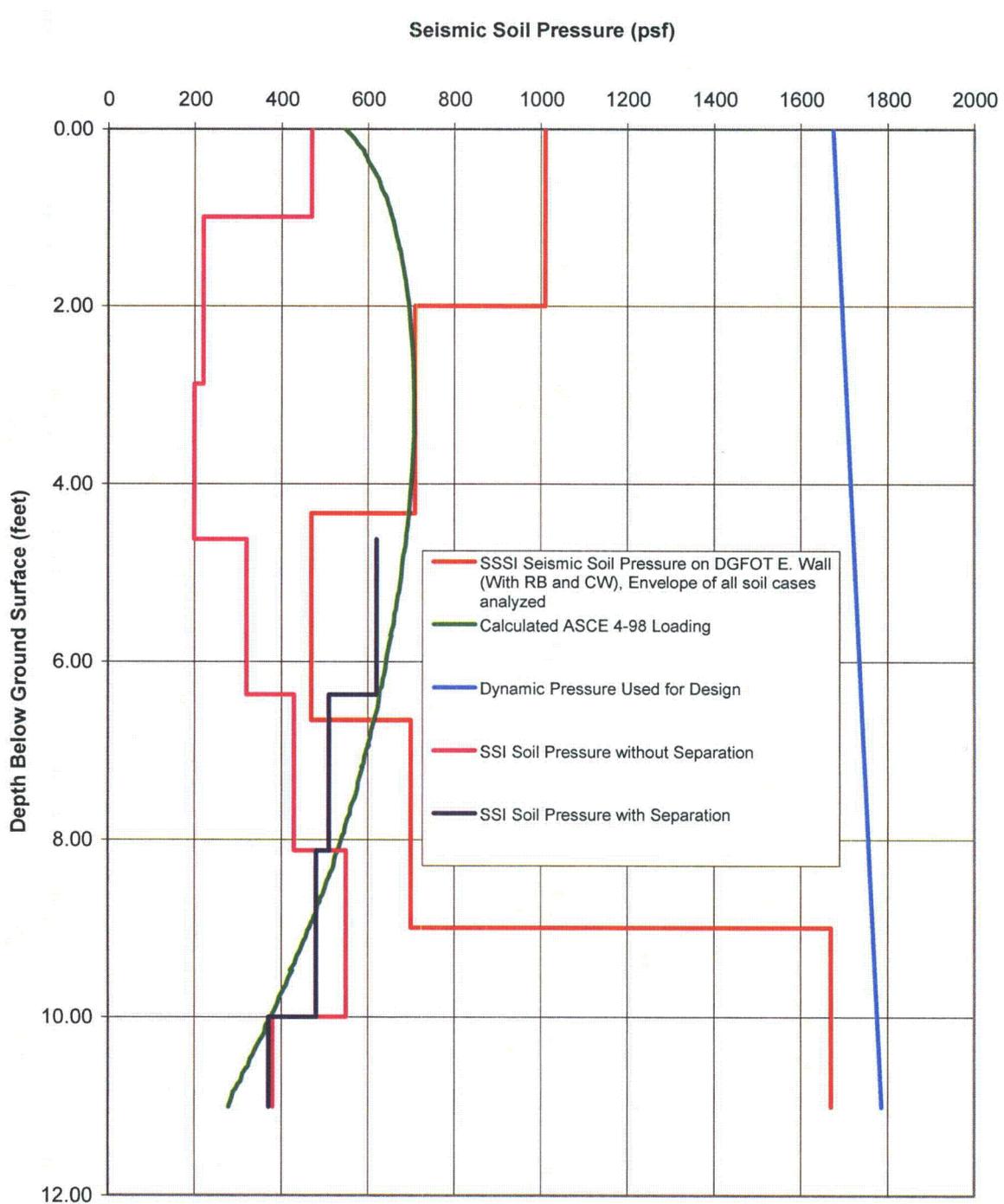


Figure 3H.7-5: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures (psf) on Fuel Oil Tunnel East Wall with Reactor Building and Crane Wall

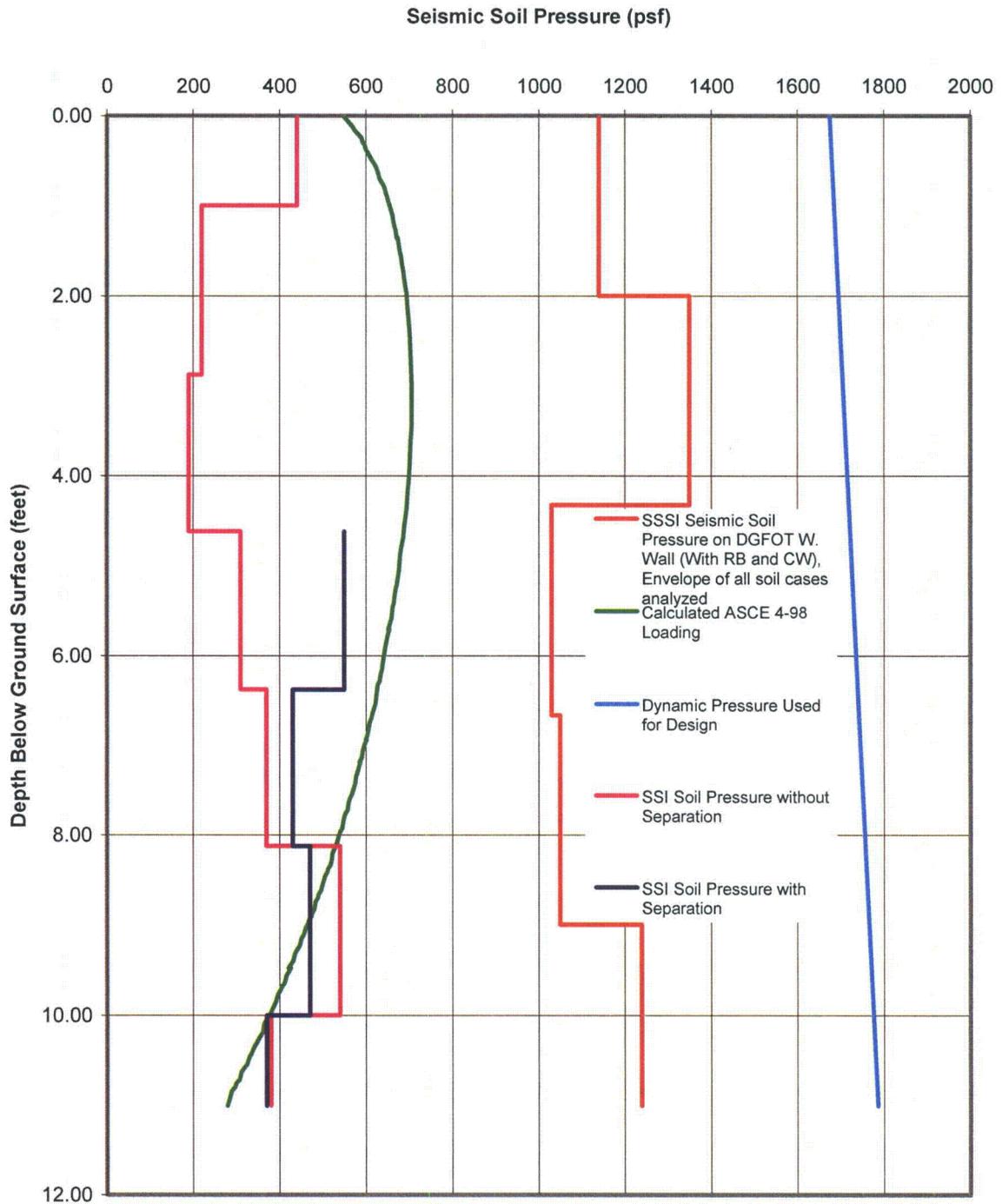


Figure 3H.7-6: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures (psf) on Fuel Oil Tunnel West Wall with Reactor Building and Crane Wall

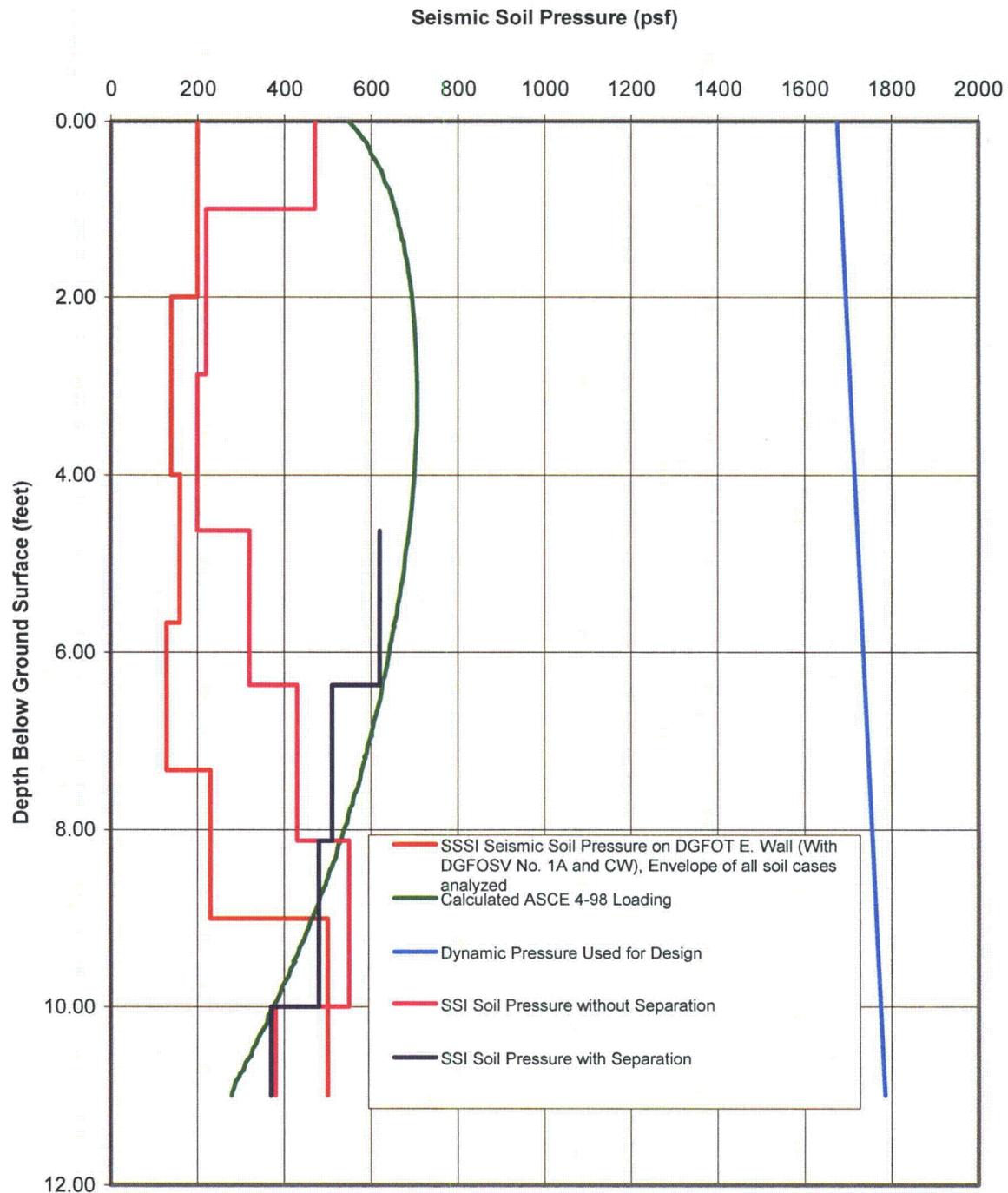


Figure 3H.7-7: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures (psf) on Fuel Oil Tunnel East Wall with Diesel Generator Fuel Oil Storage Vault and Crane Wall

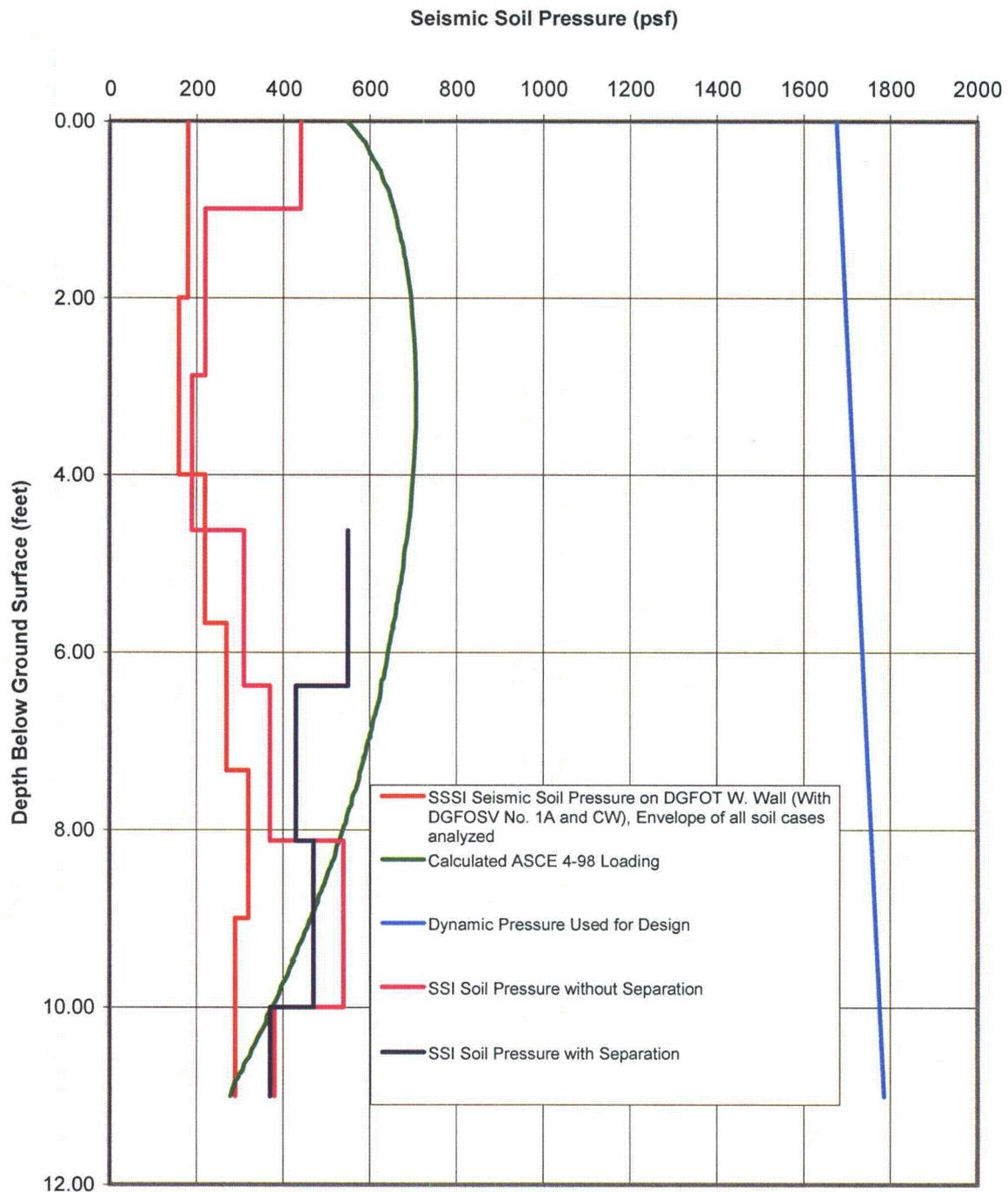


Figure 3H.7-8: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures (psf) on Fuel Oil Tunnel West Wall with Diesel Generator Fuel Oil Storage Vault and Crane Wall

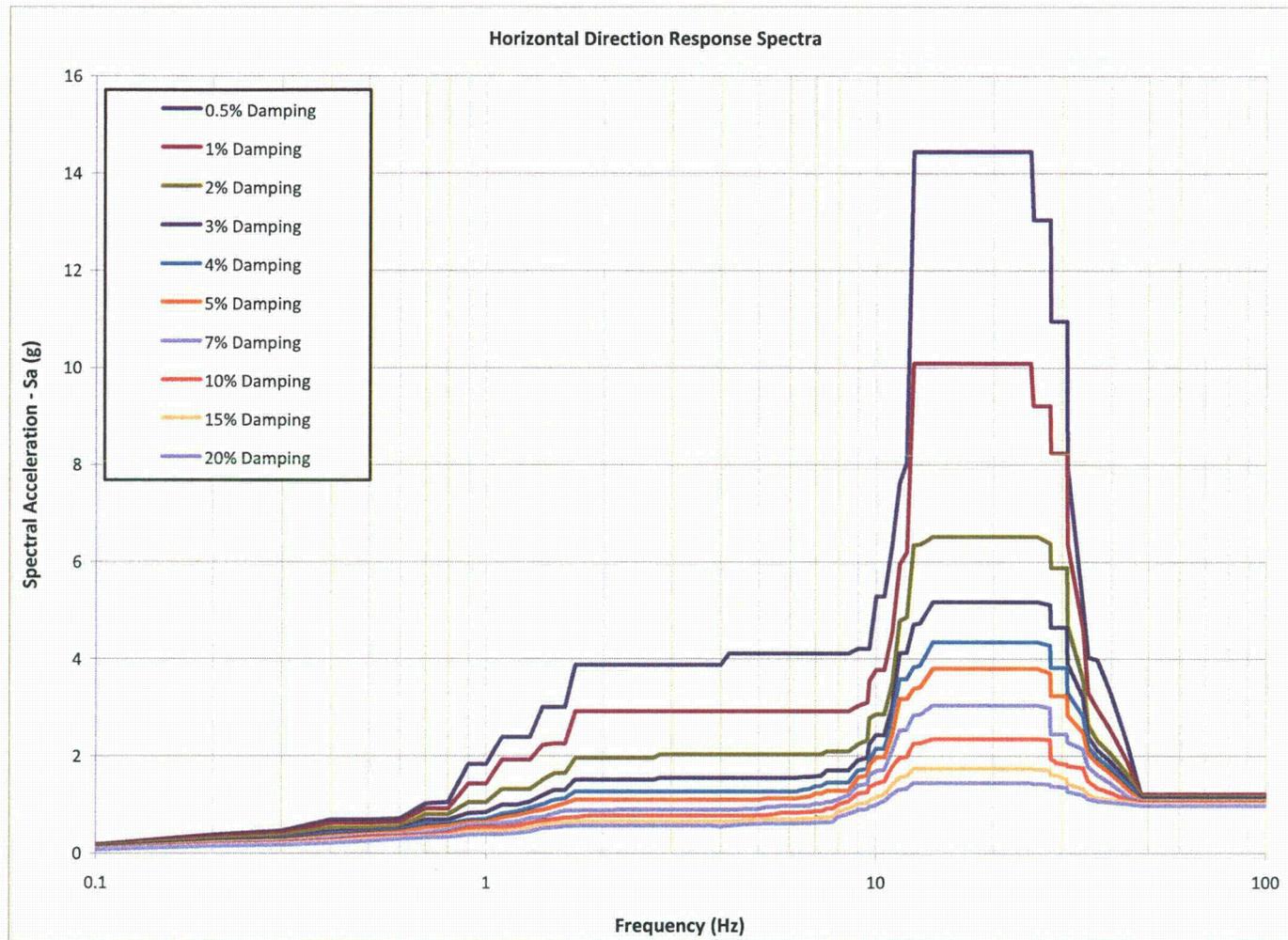


Figure 3H.7-31: Enveloped, Broadened Horizontal Response Spectra for DGFOTs

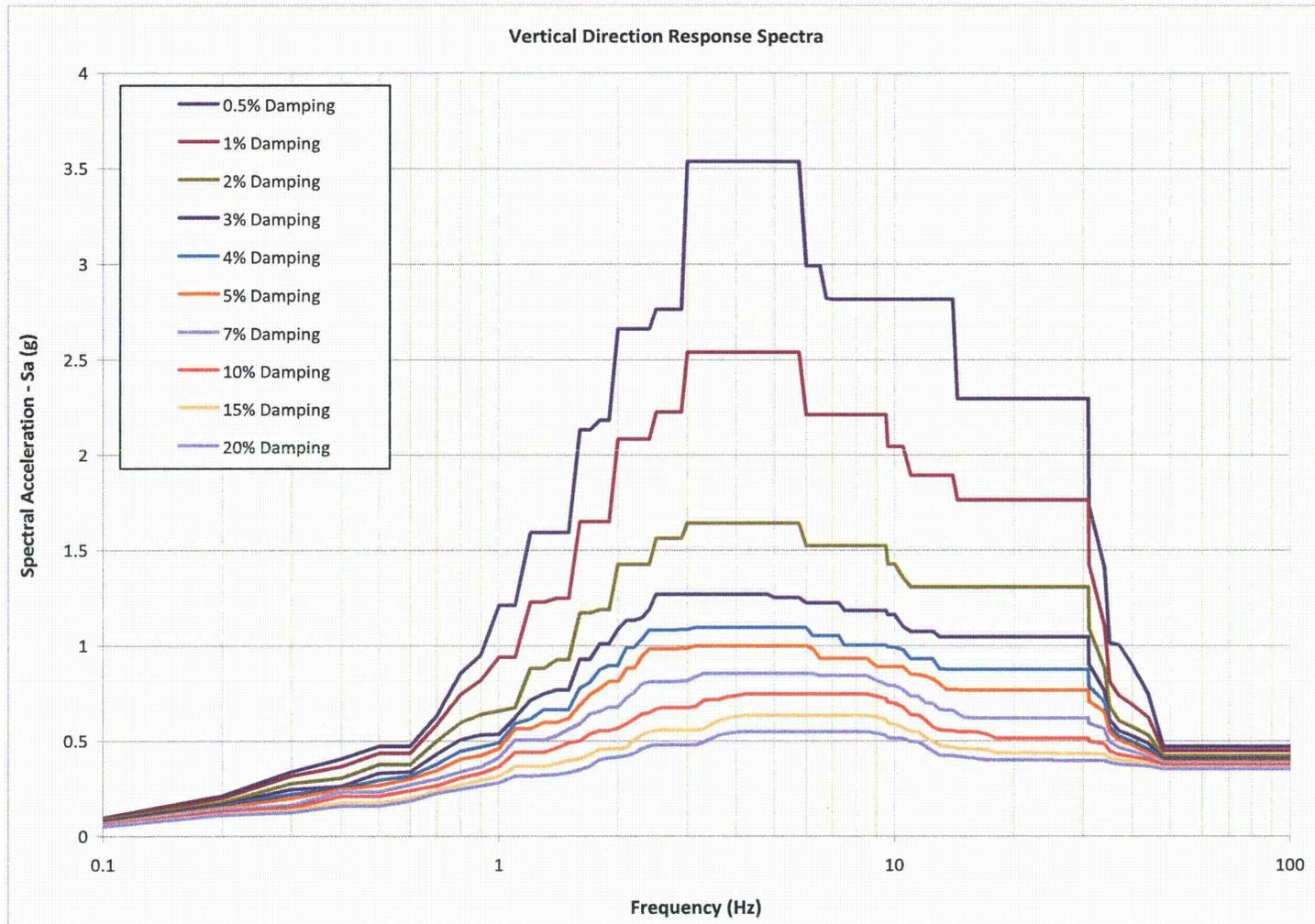


Figure 3H.7-32: Enveloped, Broadened Vertical Response Spectra for DGFOTs

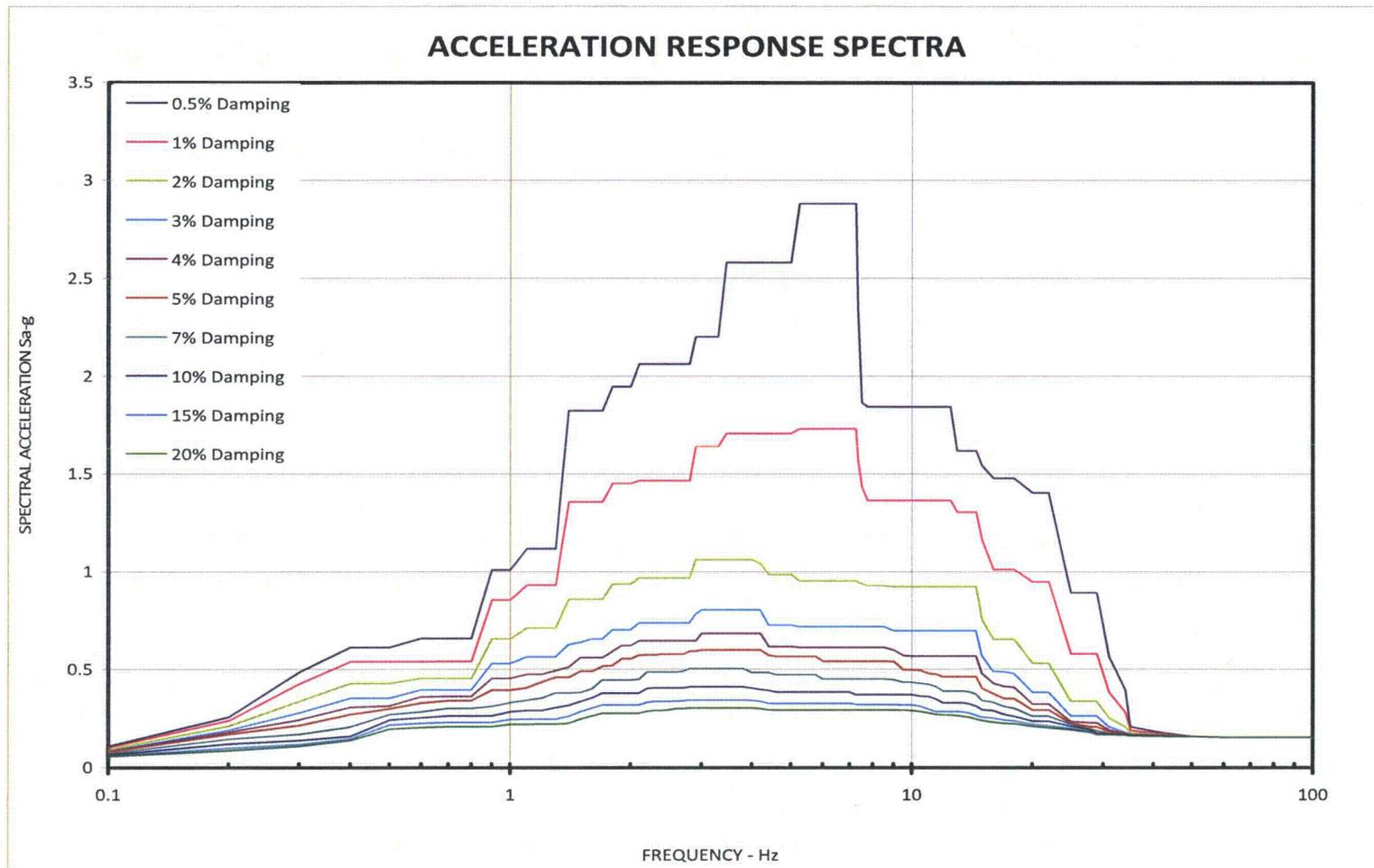


Figure 3H.6-138: RSW Piping Tunnel, Horizontal Response Spectra

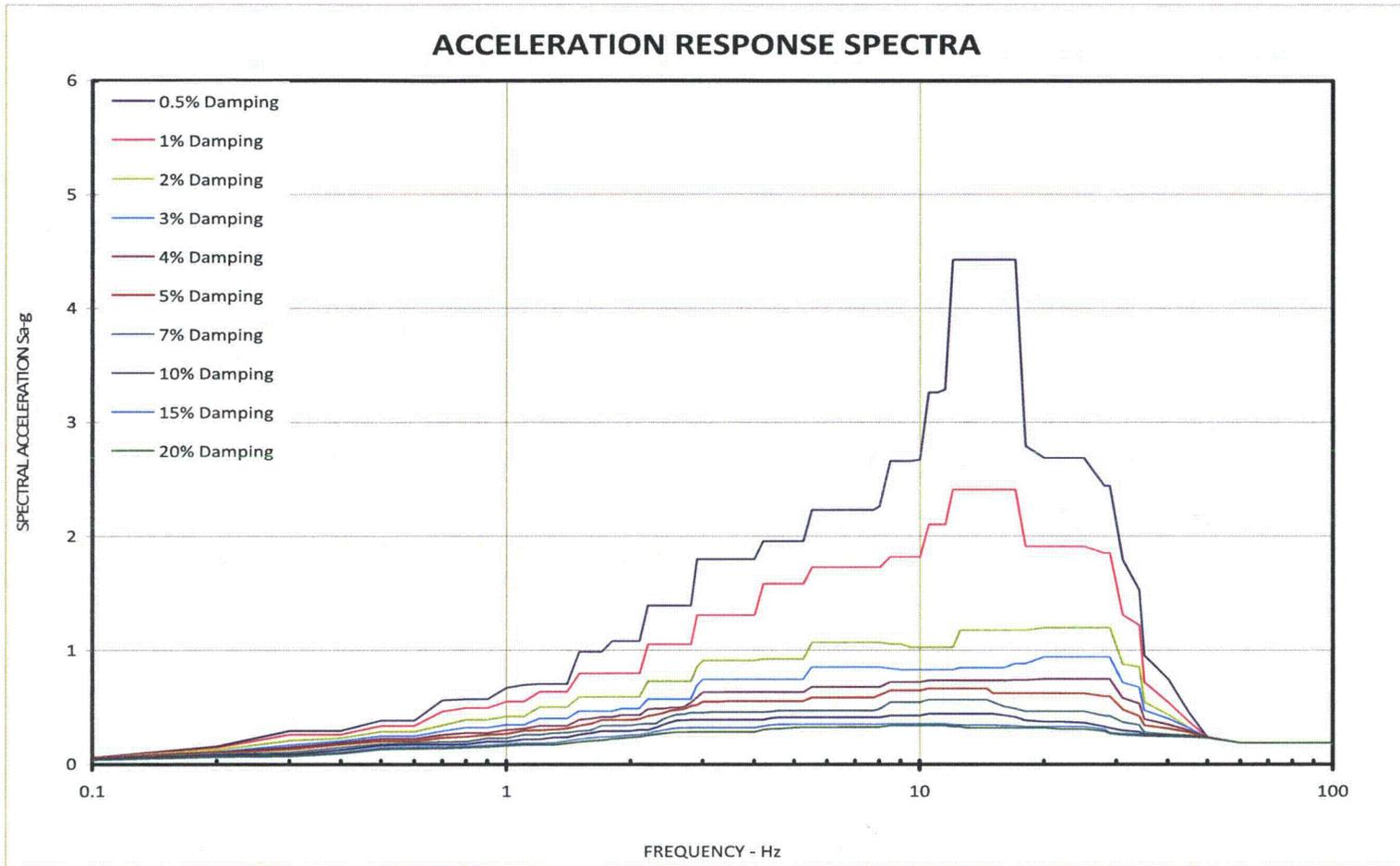


Figure 3H.6-139: RSW Piping Tunnel, Vertical Response Spectra