NINA

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May 16, 2011
U7-C-NINA-NRC-110076

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
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Rockville MD 20852-2738

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

During an audit on March 14-18, 2011, the NRC Staff requested that Nuclear Innovation North America LLC (NINA) provide additional information to support the review of the Combined License Application (COLA). Attached are supplemental responses to NRC staff questions included in Request for Additional Information (RAI) related to COLA Part 2, Tier 2, Sections 3.7 and 3.8. The attachments provide supplemental responses to the RAI questions listed below:

03.07.01-27
03.08.04-30

Where there are COLA markups, they will be made at the first routine COLA update following NRC acceptance of the RAI response.

There are no commitments in this letter.

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

D091
NRO

STI 32870073

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

Executed on 5/16/11

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

jep

Attachments:

1. RAI 03.07.01-27, Supplement 3
2. RAI 03.08.04-30, Supplement 2

cc: w/o attachment except*

(paper copy)

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RAI 03.07.01-27, Supplement 3

QUESTION:

Follow-up Question to RAI 03.07.01-19 (STP-NRC-100093)

1. 10CFR50, Appendix S requires that evaluation for SSE must take into account soil-structure interaction (SSI) effects and the expected duration of vibratory motion. In the response to the first paragraph of RAI 03.07.01-19, the applicant has presented its approach for developing the input motion for the SSI analysis and design of the DGFOSV that takes into account the impact of the nearby heavy RB and RSW Pump House structures. The applicant also stated that *"Conservatively, a 3-dimensional SAP2000 response spectrum analysis was used to obtain the safe-shutdown earthquake (SSE) design forces due to structure inertia. The seismic induced dynamic soil pressure on DGFOSV walls were computed using the method of ASCE 4-98, Subsection 3.5.3.2"* The response, however, does not provide details as to how the SSI analysis of the DGFOSV are performed and how the input motion developed are subsequently specified in the SSI analysis of DGFOSV to develop the structural response and in-structure response spectra for any equipment and subsystems within DGFOSV. From the response it appears that the applicant has not included explicitly DGFOSV structural model in the SASSI model of the RB and RSW Pump House structures to properly evaluate the SSSI effect on the DGFOSV. In order for the staff to determine if the evaluation of DGFOSV for SSE has appropriately accounted SSI effects, the applicant is requested to provide in the FSAR the following information:

   (a) Describe in detail the method used for the SSI analysis of DGFOSV including the procedures for treatment of strain dependent backfill material properties in the model, input motion used and how it is specified in the analysis, variation of soil properties, and the computer programs used for SSI analysis.

   (b) Describe in detail how SAP2000 analysis of DGFOSV was performed including, how foundation soil/backfill material was represented, how many modes were extracted, what modal damping values were used, how the input motion was specified, and what type of boundary conditions were used.

   (c) Demonstrate that the DGFOSV foundation response spectra and dynamic soil pressure (on DGFOSV basement walls using ASCE 4-98 criteria) used in the design of DGFOSV will envelop the results of structure to structure (SSSI) interaction analysis which explicitly models DGFOSV structure in the SSI model of RB and the RSW Pump House structure.

   (d) Describe in detail if there is any Category I tunnel structure for transporting Diesel Fuel Oil between DGFOSV and the Diesel Generator located in other buildings including its layout and configuration and seismic analysis and design method.

2. In the response to Item 2 of RAI 03.07.01-19, the applicant has stated that the P-wave damping ratios are assigned the same values as those calculated for the S-wave damping ratios because of the upcoming recommendations of ASCE 4-09 standards. It is further stated that this 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 is noted that the NRC has not endorsed ASCE 4-09 for estimating the P-wave damping. In general, the P-wave damping is primarily associated with the site response rather than SSI effects. Because the Pwave energy for the most part will travel in water within the saturated soil media at relatively high propagation speed and is not affected by shear strains of degraded soil, the P-wave damping will be small. As such, the applicant is requested to provide quantitative assessment by performing sensitivity analysis that shows that seismic responses of Category I structures are not adversely affected to a lower P-wave damping.

SUPPLEMENTAL RESPONSE:

Revision 1 to the Supplement 2 response to this RAI was submitted with Nuclear Innovation North America LLC (NINA) letter U7-C-NINA-NRC-110042, dated March 7, 2011. Supplement 3 to RAI 03.07.01-27 provides clarifications requested by NRC during the audit performed on March 14-18, 2011, and additional clarifications requested by NRC subsequent to the audit.

Item A - Input Motion for Soil-Structure Interaction (SSI) Analyses

NINA was requested to review the COLA description of how the input motion for the SSI analysis of the Reactor Service Water (RSW) Piping Tunnel, Diesel Generator Fuel Oil Storage Vault (DGFOSV), and Diesel Generator Fuel Oil Tunnels (DGFOTs) was determined, and clarify as necessary (Audit Action Items 3.7-3, 4, and 5). See the discussion provided in the following paragraphs.

Reactor Service Water (RSW) Piping Tunnel:

In order to account for amplification of input motion due to nearby heavy Reactor Building (RB) and Ultimate Heat Sink /Reactor Service Pump House (UHS/RSW Pump House) the following was done:

- In the three dimensional SSI analysis of the RB for site-specific SSE, one interaction node at the ground surface and one interaction node at the depth corresponding to the bottom elevation of the RSW Piping Tunnel were located at six locations along the centerline of the RSW Piping Tunnel.
- In the three dimensional SSI analysis of the UHS/RSW Pump House for site-specific SSE, one interaction node at the ground surface and one interaction node at the depth

corresponding to the bottom elevation of the RSW Piping Tunnel were located at one location at centerline of the Tunnel.

- The resulting amplified response spectra at the interaction nodes, representing the response of the RSW Piping Tunnel, from the above SSI analyses of RB and UHS/RSW Pump House were obtained. In order to find a reasonable envelop of these response spectra, to be used in the SSI analysis of the RSW Piping Tunnels, these spectra were compared to 1.15x site-specific SSE to identify those exceeding 1.15x site-specific SSE. New COLA Figures 3H.6-209a through 3H.6-209d includes the response spectra which exceed 1.15x site-specific SSE.

- Based on the comparison of the response spectra shown in Figures 3H.6-209a through 3H.6-209d, six motions were selected as envelop amplified motions for SSI analysis. These six motions correspond to 1.15x site-specific SSE and amplified motion time histories for Nodes 29378, 29379, 29390, 29392, and 15129.

- SSI analyses of the RSW Tunnel were performed, for each soil case, using 1.15x site-specific SSE input and acceleration time histories for the five nodes, noted above, obtained from the RB and UHS/RSW Pump House SSI analyses for the corresponding soil cases. The response spectra and maximum accelerations from these SSI analyses were enveloped to produce final response spectra and maximum accelerations for design.

Diesel Generator Fuel Oil Storage Vaults (DGFOSV):

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 three DGFOSV. 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. For each of the three DGFOSVs, first an average of the spectra at five nodes at the surface and foundation each is calculated and then envelope of the two average spectra is calculated. Similarly, in the SSI analysis for the RSW Pump House, interaction nodes are added in the model and amplified motion for the DGFOSV close to the RSW Pump House is obtained. Since the diesel oil tank is Standard Plant equipment, the input motion for the SSI analysis also considers the 0.3g Regulatory Guide 1.60 response spectra. Therefore, the envelope of the envelope average spectra for the three DGFOSV and the 0.3g Regulatory Guide 1.60 response spectra are used as the input response spectra for the SSI analysis of the DGFOSV. As shown in new COLA Figures 3H.6-222a through 3H.6-222c, the 0.3g Regulatory Guide 1.60 response spectra were found to be the bounding spectra.

Diesel Generator Fuel Oil Tunnels (DGFOT):

In the three dimensional SSI analysis of the RB for site-specific SSE, one interaction node at the ground surface and one interaction node at the depth corresponding to the bottom elevation of the DGFOT were located at several locations along each of the three DGFOTs. The envelope of the amplified motions at these interaction nodes and 0.3g Regulatory

Guide 1.60 response spectra were used for SSI analysis of the DGFOT. As shown in new COLA Figures 3H.7-30a through 3H.7-30c, the 0.3g Regulatory Guide 1.60 response spectra were found to be the bounding spectra.

COLA Part 2, Tier 2 Sections 3H.6.5.3, 3H.6.7, and 3H.7.5.2.1 will be revised, due to this response, as provided in the Enclosure. Figures 3H.6-209a through 3H.6-209d, Figures 3H.6-222a through 3H.6-222c, and Figures 3H.7-30a through 3H.7-30c will also be added to COLA to show the input motions used for the SSI analyses of the RSW Piping Tunnels, DGFOSV and DGFOT, respectively.

Item B - Amplified Site-specific Response Spectra for RSW Piping Tunnels, DGFOSV, and DGFOT

NINA was requested to include in COLA the amplified site-specific response spectra for RSW Piping Tunnel, DGFOSV, and DGFOT (Audit Action Item 3.7-22). See the discussion provided in the following paragraphs.

- **RSW Piping Tunnel:**

  See discussion for the RSW Piping Tunnel in Item A above. New COLA Figures 3H.6-209a through 3H.6-209d show the amplified motion response spectra which were used in the SSI analysis of the RSW Piping Tunnel, as explained in Item A above.

- **DGFOSV:**

  Amplified site-specific response spectra of DGFOSV for 5% damping are provided in new COLA Figures 3H.6-222a, 3H.6-222b, and 3H.6-222c. As shown in these figures, the 0.3g Regulatory Guide 1.60 spectra, which were used for the SSI analysis, envelop the amplified site-specific response spectra.

- **DGFOT:**

  Amplified site-specific response spectra of DGFOT for 5% damping are provided in new COLA Figures 3H.7-30a, 3H.7-30b, and 3H.7-30c. As shown in these figures, the 0.3g Regulatory Guide 1.60 spectra, which were used for the SSI analysis, envelop the amplified site-specific response spectra.

COLA revisions due to this response are provided in the Enclosure.

Item C - Soil Cases for the Structure-Soil-Structure Interaction (SSSI) Analyses

NINA was requested to discuss the soil cases for which the SSSI analyses for the RSW Piping Tunnel, DGFOSV, and DGFOT were performed. These cases should, as a minimum, include the upper bound in-situ and backfill soil cases. NINA was also requested to clarify the SSSI soil pressure figures in COLA to indicate that those represent envelop of all soil cases analyzed (Audit Action Items 3.7-6, 8, 10, and 36). Finally, NINA was requested to provide information regarding the following Clarification Issue 2, as provided by the NRC.

> **Issue 2** (Audit Action 3.7-8/3.7-36): *Why for SSSI of RSW Tunnel was UB in situ used vs. UB backfill soil?*
>
> *Review of responses to RAI 03.07.01-27, Supplements 1, Revision 1 indicates that two 2D SSSI models (East-West and North-South Sections) are analyzed to evaluate the effects of nearby structures on the three DGFOSVs and calculate the seismic soil pressures. In the East-West direction 2-D SSSI DGFOSV model (DGFOT 1C + DGFOSV 1A + CFRW), five cases of soil and backfill properties are considered to evaluate the effects of the soil and backfill properties variation. Also response to RAI 03.07.01-27, Supplement 2, Revision 2 indicates that in the East-West direction for DGFOT 1A (RB + DGFOT 1A + CFRW), five cases are run with various combinations of soil and backfill properties. However, in the North-South direction (UHS/RSWPH + RSW Tunnel + DGFOSV 1B + DGFOSV 1C + RB), only one case was run with UB soil properties. Also as discussed in response to RAI 03.07.02-24, Supplement 1, Revision 1, in the East-West direction for dynamic soil pressure evaluation for RSW Tunnel and RWB walls, the 2 D SSSI model (RB + RSW Tunnel + RWB) included only the UB in situ soil without any evaluation for backfill properties. As such, the applicant is requested to demonstrate that consideration of only UB soil profile instead of using a combination of UB soil and backfill parameters for the cited cases will still be conservative for the wall design of all site specific Category I and RWB structures (UHS/RSWPH, DGFOSV, RSW Tunnel, UHS/and RWB). The applicant is also requested to include this evaluation in the applicable sections of the FSAR.*

The following provides the requested clarification.

Subsequent to the March 14-18, 2011 audit, the structure-soil-structure-interaction (SSSI) analyses were expanded to include as a minimum the upper bound in-situ and backfill soil cases. Table 03.07.01-27 S3.C1 provides a summary of the soil cases used for various SSSI analyses of Reactor Service Water (RSW) Piping Tunnel, Ultimate Heat Sink (UHS)/RSW Pump House, Diesel Generator Fuel Oil Storage Vaults (DGFOSV), Diesel Generator Fuel Oil Tunnels (DGFOT), Reactor Building (RB), Control Building (CB), and Radwaste Building (RWB). As shown in this table, each SSSI analysis includes bounding upper bound and lower bound soil cases.

The following revised COLA figures showing SSSI soil pressures, based on envelope of all soil cases analyzed, are provided in the Enclosure.

Control Building:	Figure 3A-302
Reactor Building:	Figures 3A-301, and 3H.1-1 through 3H.1-6
Radwaste Building:	Figures 3H.3-50 and 3H.3-51
RSW Piping Tunnel:	Figures 3H.6-212 through 3H.6-217
UHS/RSW Pump House:	Figures 3H.6-218 through 3H.6-220
DGFOSV:	Figures 3H.6-226 through 3H.6-231
DGFOT:	Figures 3H.7-5 through 3H.7-8

Item D - <u>Groundwater Elevation</u>

NINA was requested to revise COLA Appendix 3A or 3H, as appropriate, to reconcile the inconsistency in the groundwater level used for SSI analysis and design (Audit Action Item 3.7-7). NINA was also requested to provide information regarding the following Clarification Issue 1, as provided by the NRC.

Issue 1 (Audit Action 3.7-7): *Revise Appendix 3A and 3H.6 to reconcile ground water elevation with Chapter 2*

Inconsistencies were noted among various Sections of the FSAR concerning the specified design ground water level and the ground water level used in the seismic analysis for Category I structures. For example in FSAR Section 2.4S.12.5, it is stated that "In summary, based on measured groundwater levels in observation wells and modeled post-construction groundwater levels, the maximum post-construction groundwater elevation at the STP Units 3 and 4 site is estimated to be 28 ft MSL, as reflected in Table 2.0-2. The nominal finished plant grade in the power block area is approximately 34 ft MSL, six feet higher than the site characteristic maximum groundwater level." Appendix 3H.6.4.2.2, Design Ground Water Level, also specified ground water level at 28 MSL establishing the depth of water table at six feet below the grade. However, in Section 3A.15, Site Conditions, it is stated that "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." It is also noted that SSI model for the seismic analysis of Category I structures considered the ground water table to be approximately at eight feet below the grade elevation. As such, the applicant is requested to address these inconsistencies among various sections of the FSAR and the seismic analysis model and revise the applicable FSAR sections on groundwater level and structural design criteria. The applicant is specifically requested to demonstrate that the FIRS, GMRS, and the results of seismic analysis of the Category I structures including the results of stability calculations as currently established in the COLA are not adversely affected and include this justification in the applicable FSAR sections.

The following provides the requested clarifications.

As stated in COLA Part 2, Tier 2 Section 3H.6.4.2.2, for design of structures, including the stability evaluations, 28 feet MSL was used as a conservative value for the groundwater level from the start of the Project. For seismic analysis work the maximum groundwater level measured during the geotechnical investigation of the site was used. The maximum groundwater level based on these geotechnical investigations was originally reported as 26 feet MSL in COLA Part 2, Tier 2 Section 2.4S.12.5, and was used in the seismic analyses. Subsequently, the site characteristic maximum groundwater level in the COLA was revised to 28 feet MSL. This difference of two feet in groundwater level is not considered significant for the seismic analysis work. In order to confirm this, the following work, related to the seismic analysis of structures, which had used approximately 26 feet MSL as the groundwater elevation, were reviewed for impact due to the change in the groundwater level to 28 feet MSL.

a. Development of Ground Motion Response Spectra (GMRS) and Foundation Input Response Spectra (FIRS)
b. Calculation of seismic foundation soil spring stiffness for use in mat design
c. Calculation of differential building settlement and tilt for use in calculation of seismic gaps and seismic movements of the buildings for commodity design
d. Soil properties used in the SSI analyses

Each of the above items is discussed in the following paragraphs.

a. Development of GMRS and FIRS

The vertical component of the GMRS and FIRS were calculated using the applicable vertical to horizontal (V/H) acceleration response spectral ratios, and not through site response analysis using P-wave velocity. Therefore, the change in the groundwater level does not affect the GMRS and FIRS.

b. Calculation of Seismic Foundation Soil Spring Stiffness for Use in Mat Design

An evaluation of the seismic foundation soil spring stiffness, which was used in the mat design, due to the change in the groundwater level was performed. The results of this evaluation confirmed that the small change in the groundwater level does not have any significant effect on the spring stiffness values; the maximum changes were less than 5% for the vertical springs and 2% for the horizontal springs.

c. Calculation of Differential Building Settlement and Tilt for use in Calculation of Seismic Gaps and Seismic Movements of the Buildings for Commodity Design

An evaluation of the differential building settlement and tilt, which were used in the calculation of seismic gaps and seismic movements of the buildings for commodity design, due to the change in the groundwater level was performed. The results of this evaluation confirmed that the small change in the groundwater level does not have any significant effect on these calculations.

The differential settlement values changed by approximately 0.01 inch to 0.02 inch, depending on the building, representing a maximum change of approximately 6%. Similarly, the maximum change in tilt values from the previously calculated values ranged from nearly zero to approximately 9%, depending on the building. It should be noted that the calculated seismic gaps and seismic movements for design of commodities are a function of movements due to the following:

- Building differential settlements
- Building tilts
- Relative seismic movements from SSI analysis
- Movements from sliding stability evaluations
- Movements from overturning stability evaluations

Therefore, since differential building settlement and tilt only comprise a portion of the movements used for calculation of seismic gaps and seismic movements for design of commodities, the impact on the calculated seismic gaps and seismic movements for design of commodities will be insignificant (i.e. less than 5%).

d. Soil Properties used in the SSI Analyses

As stated in COLA Part 2, Tier 2 Section 3A.15, a groundwater level of eight feet below grade (26 feet MSL) was used in the SSI analyses. In order to evaluate the impact of the change in the groundwater level from 26 feet MSL to 28 feet MSL, a sensitivity analysis was performed. For this analysis, the existing SSI analysis of the DGFOSVs was repeated after revising the compression wave velocities in the soil layers between 26 feet and 28 feet elevation to 5000 feet/sec, except that a Poisson's ratio cut-off of 0.495 was used. The following provides details of the SSI models, soil profiles used in the models, and results.

Two soil cases were considered in the analyses; (1) lower bound in-situ (LB) and (2) upper bound backfill (UB). These two soil cases were selected because they bound the shear wave velocities of various soil cases; the LB soil case represents the lower bound shear wave velocity of all soil cases and the UB soil case represents the upper bound shear wave velocity of all soil cases. The analysis models cover two orientations of DGFOSVs: (i) length of the Vault in East-West direction and (ii) length of the Vault in North-South direction. These two orientations of DGFOSVs are shown in COLA Figure 3H.6-221. The input motion corresponds to 0.3g Regulatory Guide 1.60 spectra. The results of this sensitivity analysis are presented, in terms of response spectra comparison, in Figures 03.07.01-27 S3.D1 through 03.07.01-27 S3.D25. All the response spectra shown in these figures are envelope of response spectra for the LB and UB soil profiles.

It can be seen from the response spectra comparisons presented in these figures that at some locations of the DGFOSV model, there are some differences at frequencies higher than about 8Hz, but these differences are small. Based on this sensitivity analysis it is concluded that the small change of two feet in groundwater level does not have any significant effect on the SSI results.

COLA Part 2, Tier 2 Sections 3A.15, 3H.6.5.1.3, 3H.6.5.3, and 3H.7.5.2.1 will be revised, due to this response, as provided in the Enclosure.

Item E - Spectra for Analysis of DGFOSV

NINA was requested to provide a figure in COLA showing that 0.3g Regulatory Guide 1.60 spectra envelop amplified motions for all three vaults. (Audit Action Item 3.7-19)

As discussed in Item B above, new COLA figures 3H.6-222a, 3H.6-222b, and 3H.6-222c show that the 0.3g Regulatory Guide 1.60 spectra, which were used for the SSI analysis, envelop the amplified site-specific response spectra.

Item F - Include Spectra Comparison Provided During the Audit for Cracked Concrete Cases

NINA was requested to include the spectra comparison, provided during the audit, for cracked concrete cases. (Audit Action Item 3.7-27)

The spectra comparisons provided during the March 14-18, 2011 audit are provided in Figures 03.07.01-27 S3.F1 through 03.07.01-27 S3.F59. These figures are as follows:

- Figures 03.07.01-27 S3.F1 through 03.07.01-27 S3.F12 provide spectra comparisons for UHS/RSW pump house for full UHS basin case
- Figures 03.07.01-27 S3.F13 through 03.07.01-27 S3.F24 provide spectra comparisons for UHS/RSW pump house for empty UHS basin case
- Figure 03.07.01-27 S3.F25 provides node locations for RSW piping tunnel soil-structure-interaction (SSI) model
- Figures 03.07.01-27 S3.F26 through 03.07.01-27 S3.F32 provide horizontal spectra comparisons for RSW piping tunnel
- Figures 03.07.01-27 S3.F33 through 03.07.01-27 S3.F39 provide vertical spectra comparisons for RSW piping tunnel
- Figures 03.07.01-27 S3.F40 and 03.07.01-27 S3.F41 provide spectra comparisons for impact of cross terms on the amplified site-specific spectra for RSW piping tunnel
- Figures 03.07.01-27 S3.F42 through 03.07.01-27 S3.F50 provide spectra comparisons for DGFOT
- Figures 03.07.01-27 S3.F51 through 03.07.01-27 S3.F59 provide spectra comparisons for DGFOSV

Table 03.07.01-27 S3 C.1: Soil Cases Analyzed in Various SSSI analyses

SSSI Model	LB In-Situ	M In-Situ	UB In-Situ	LB In-situ with LB Backfill	M In-situ with M Backfill	UB In-situ with UB Backfill	M In-situ with LB Backfill	M In-situ with UB Backfill
RB + RSW Piping Tunnel + RWB	X		X			X		
RB + DGFOT + CFRW			X	X	X	X	X	X
DGFOSV + DGFOT + CFRW			X	X	X	X	X	X
UHS/RSW Pump House + RSW Piping Tunnel + 2 DGFOSV + RB	X		X			X		
RB + CB + TB	X	X	X			X		

Notations:
M = Mean
LB = Lower Bound
UB = Upper Bound
RB = Reactor Building
CB = Control Building
TB = Turbine Building
RSW = Reactor Service Water
RWB = Radwaste Building
CFRW = Crane Foundation Retaining Wall
DGFOT = Diesel generator Fuel Oil Tunnel
DGFOSV = Diesel Generator Fuel oil Storage Vault

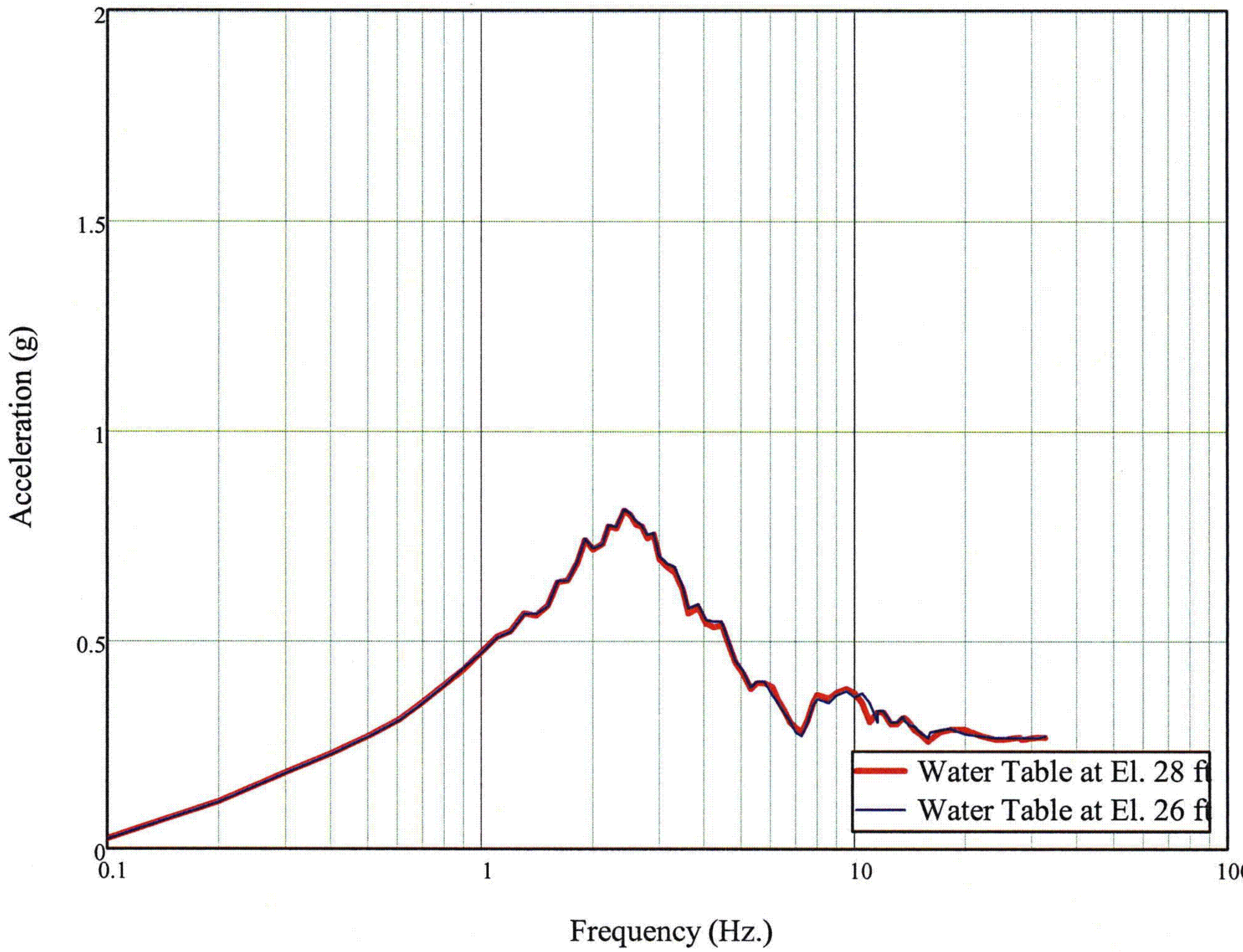


Figure 03.07.01-27 S3.D1: N-S Direction Response Spectra Comparison At Top of Foundation Mat, El. -3.0 ft (DGFOSV No. 1A and 1B)

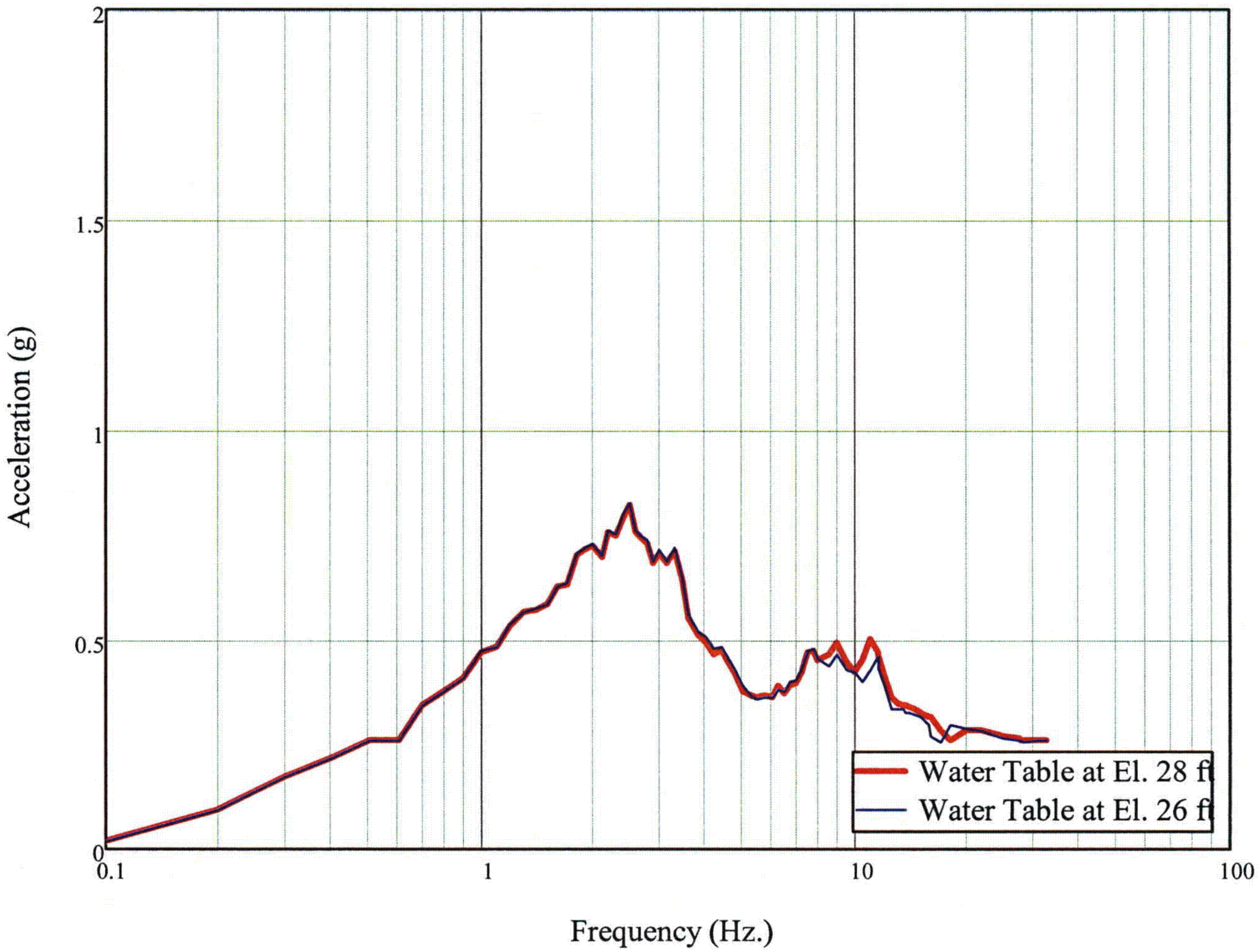


Figure 03.07.01-27 S3.D2: E-W Direction Response Spectra Comparison At Top of Foundation Mat, El. -3.0 ft (DGFOSV No. 1A and 1B)

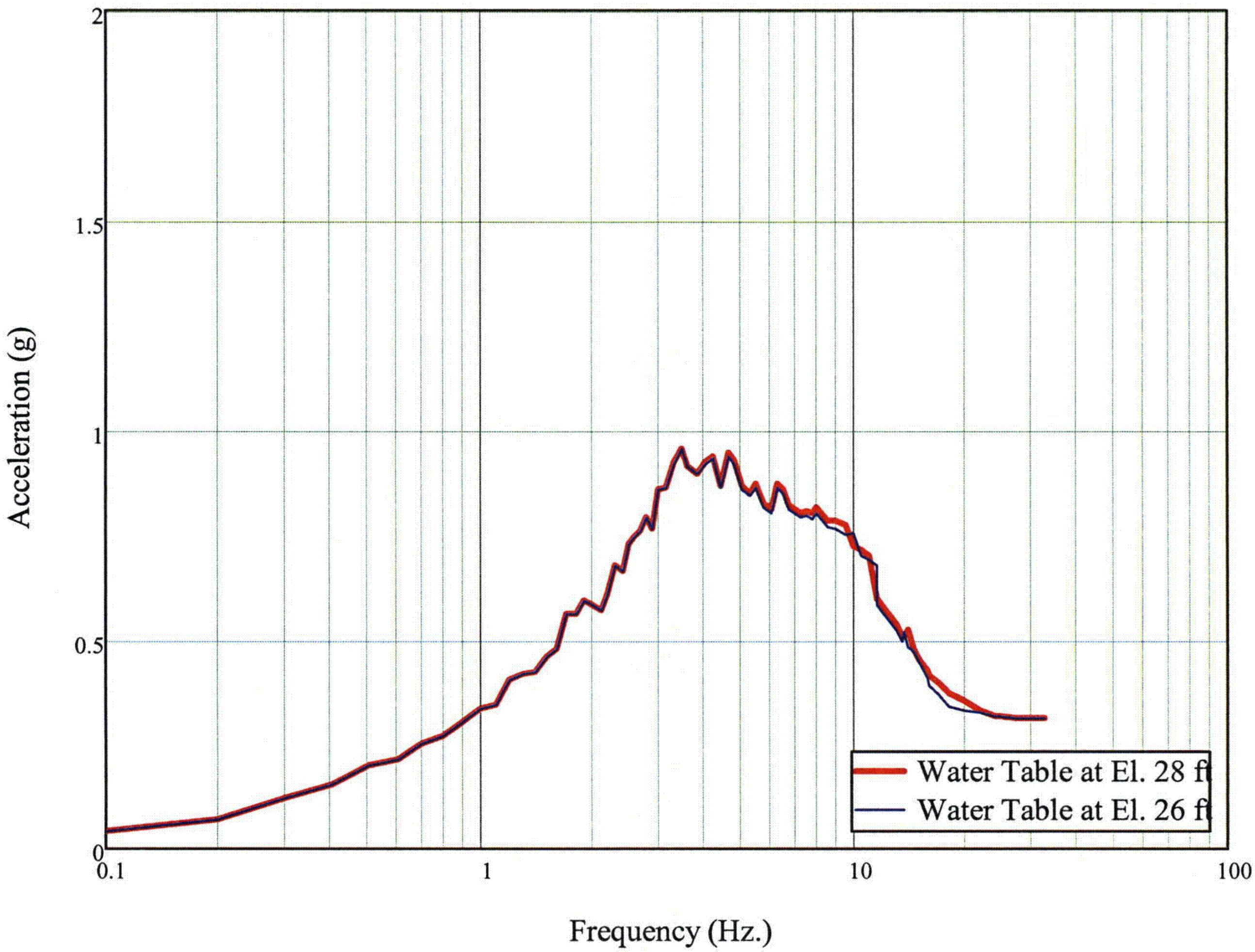


Figure 03.07.01-27 S3.D3: Vertical Direction Response Spectra Comparison At Top of Foundation Mat, El. -3.0 ft (DGFOSV No. 1A, 1B, and 1C)

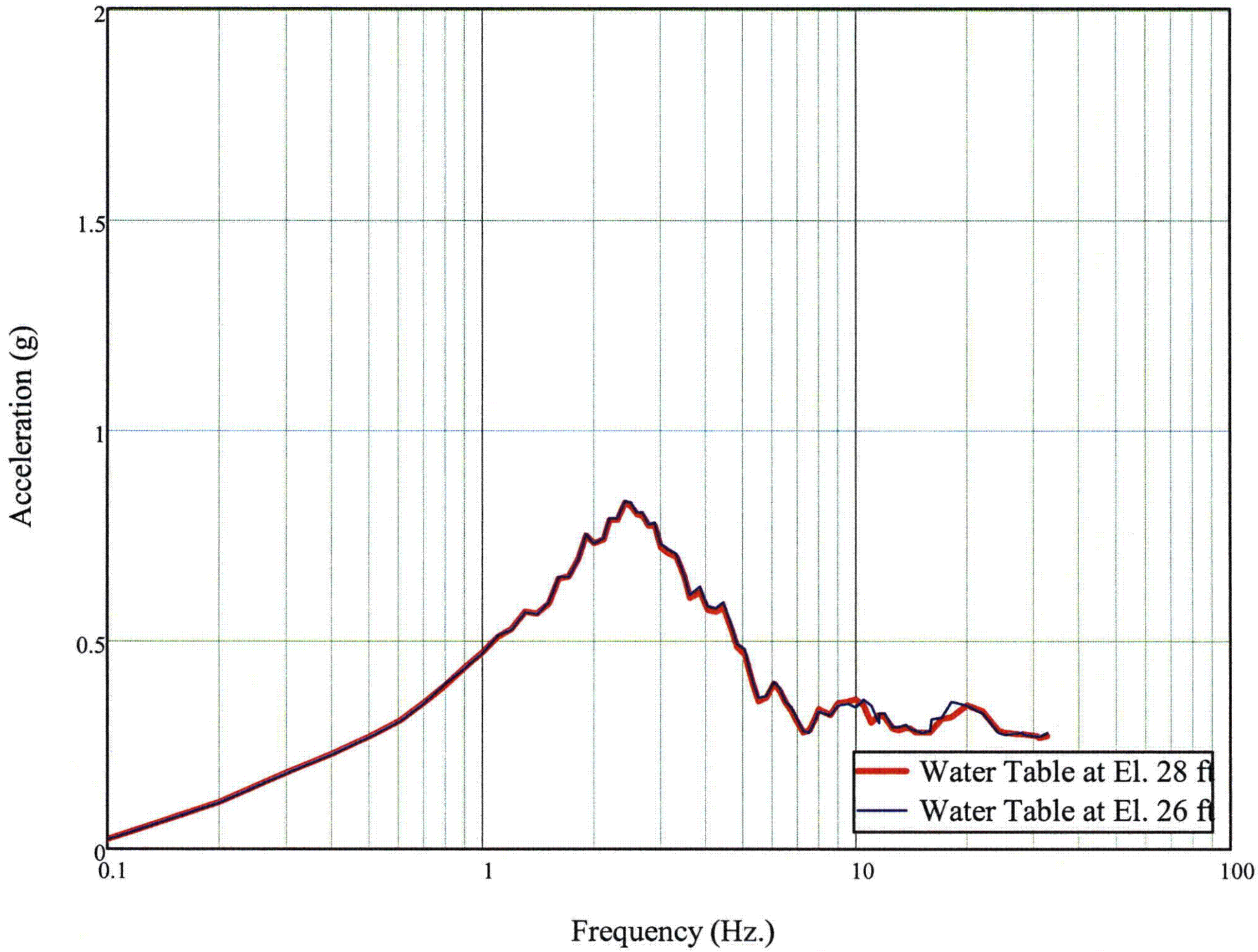


Figure 03.07.01-27 S3.D4: N-S Direction Response Spectra Comparison At Center of Gravity of Fuel Oil Tank (DGFOSV No. 1A and 1B)

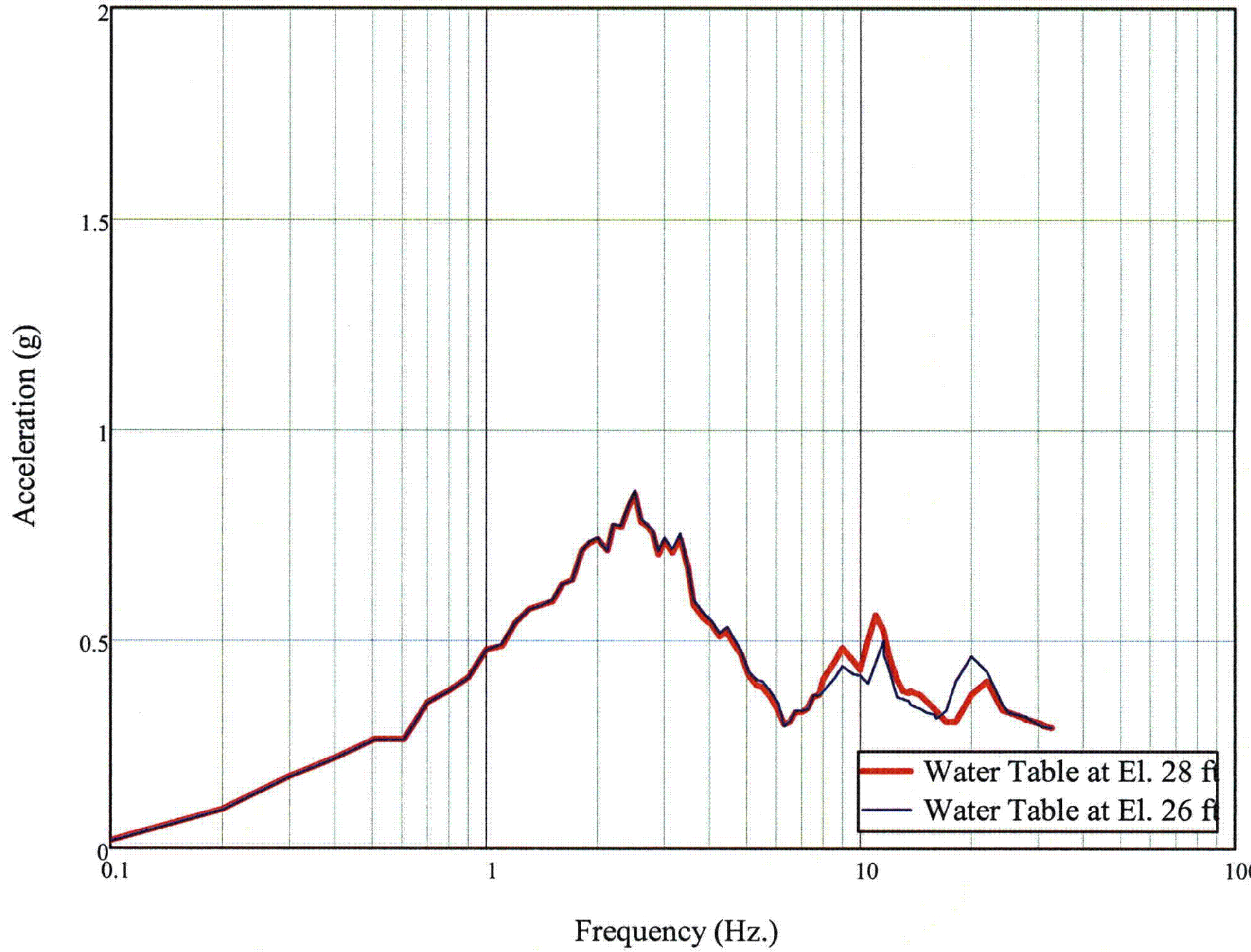


Figure 03.07.01-27 S3.D5: E-W Direction Response Spectra Comparison At Center of Gravity of Fuel Oil Tank (DGFOSV No. 1A and 1B)

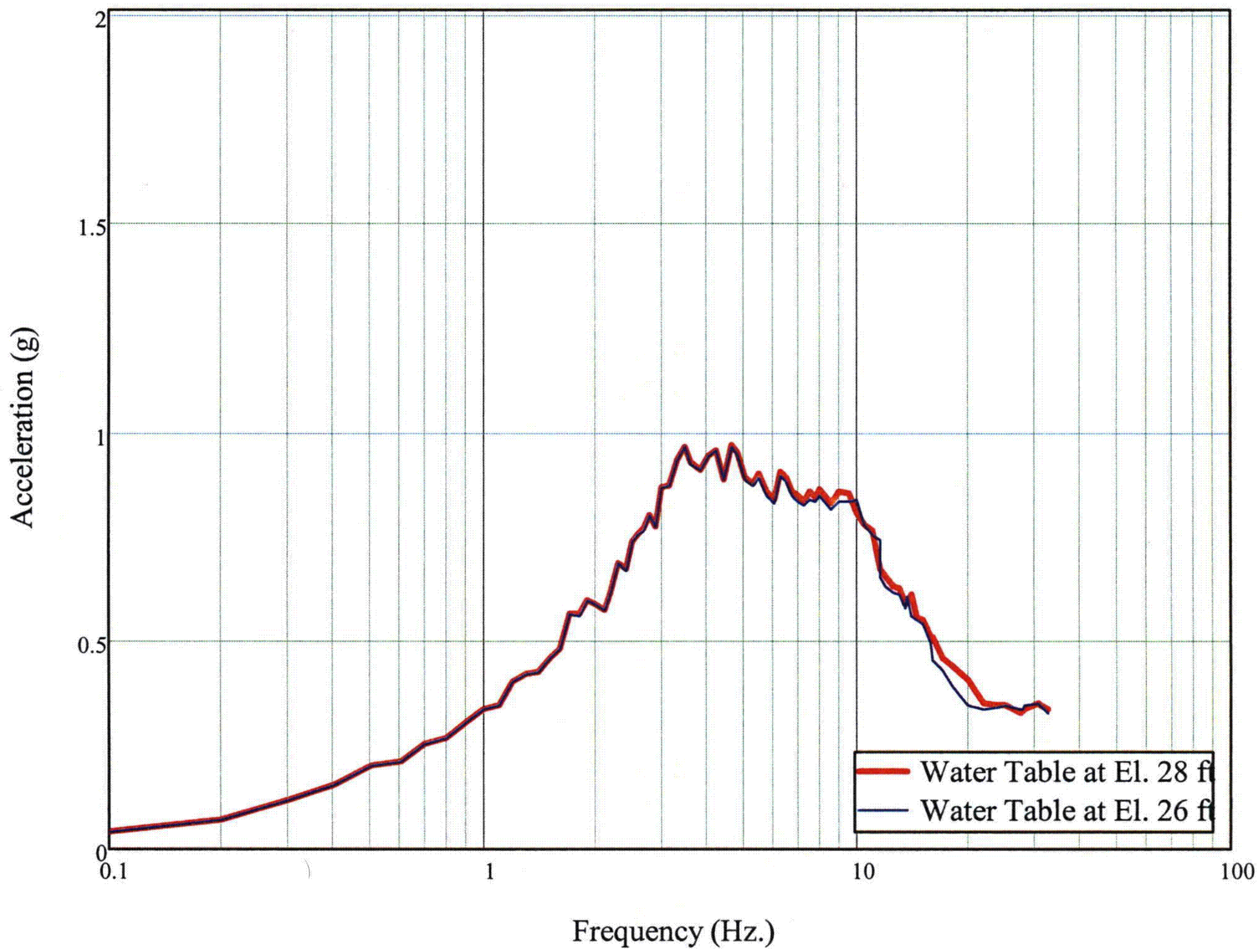


Figure 03.07.01-27 S3.D6: Vertical Direction Response Spectra Comparison At Center of Gravity of Fuel Oil Tank (DGFOSV No. 1A, 1B, and 1C)

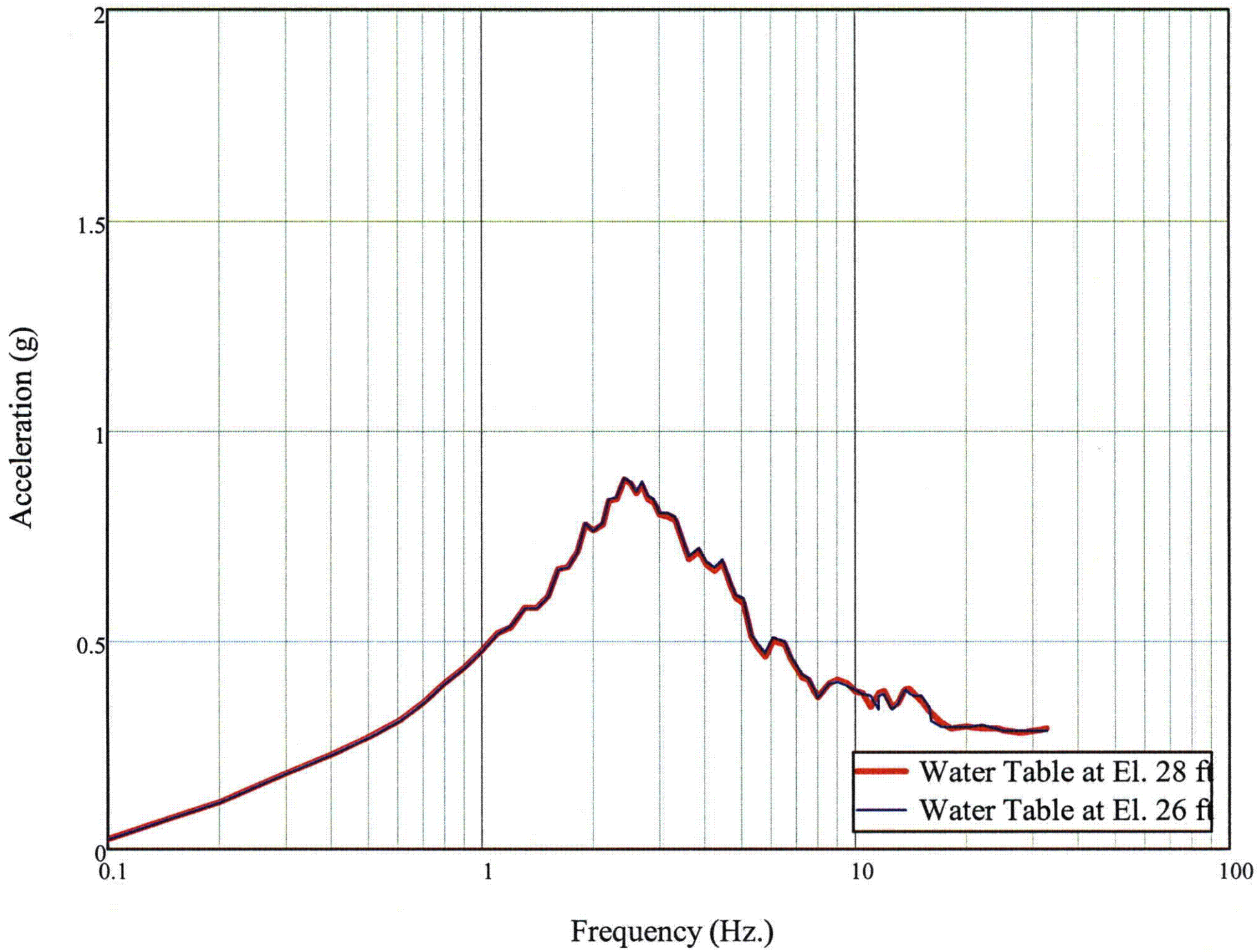


Figure 03.07.01-27 S3.D7: N-S Direction Response Spectra Comparison Out-of-plane of E-W Walls at El. 15 ft (DGFOSV No. 1A and 1B)

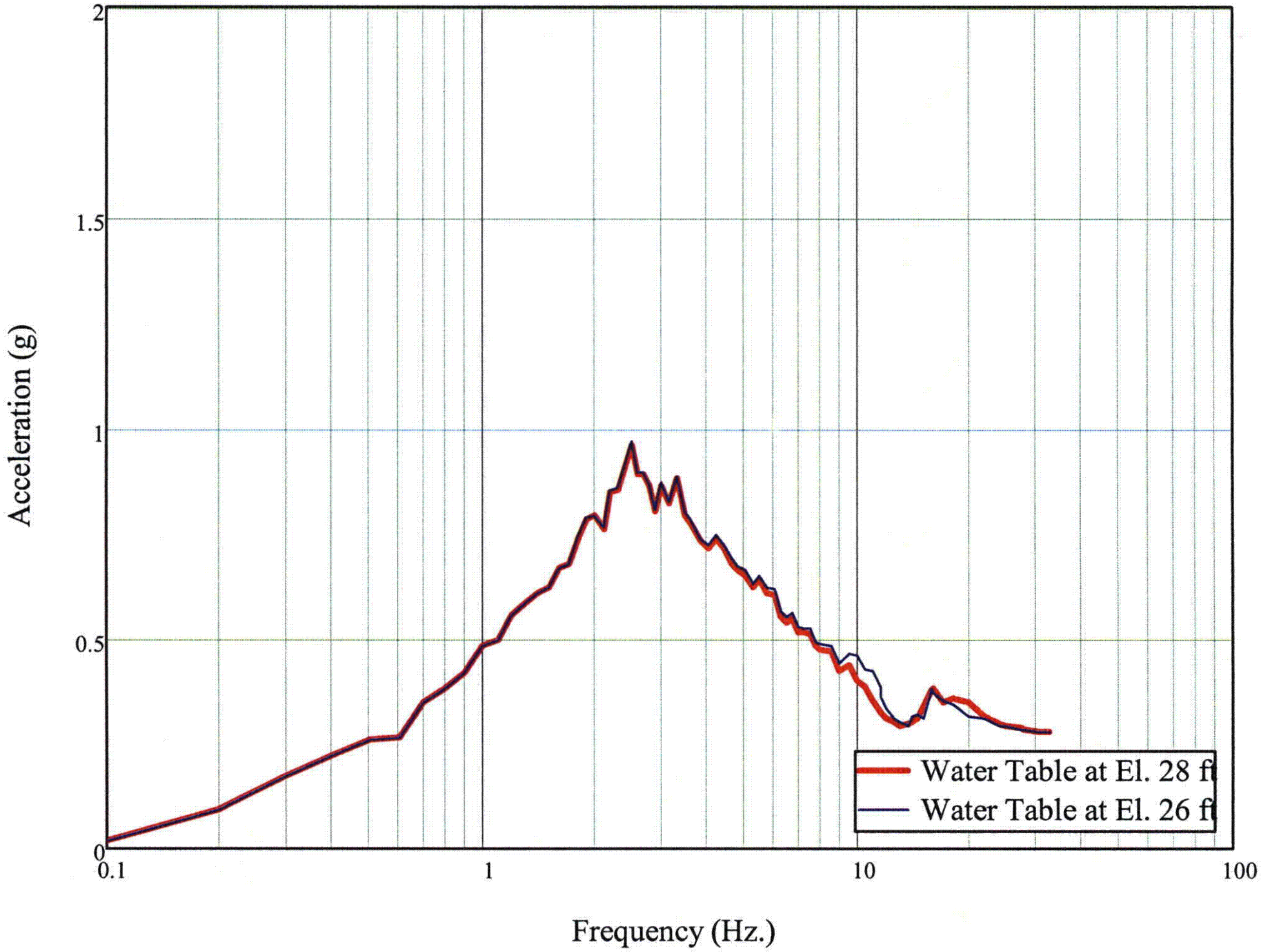


Figure 03.07.01-27 S3.D8: E-W Direction Response Spectra Comparison Out-of-plane of N-S Walls at El. 15 ft (DGFOSV No. 1A and 1B)

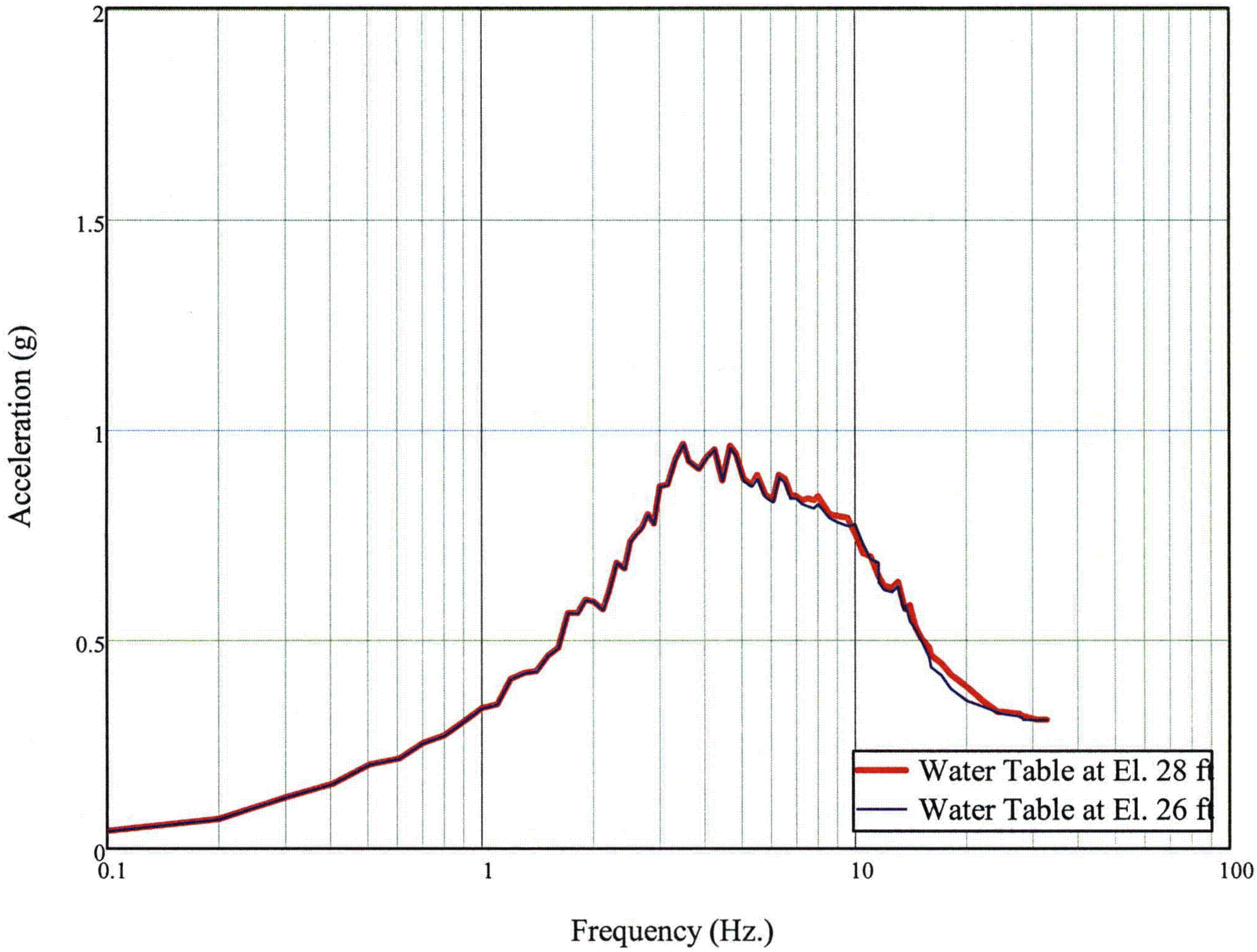


Figure 03.07.01-27 S3.D9: Vertical Direction Response Spectra Comparison at El. 15 ft (E-W Walls of DGFOSV No. 1A, 1B, and N-S Walls of DGFOSV No. 1C)

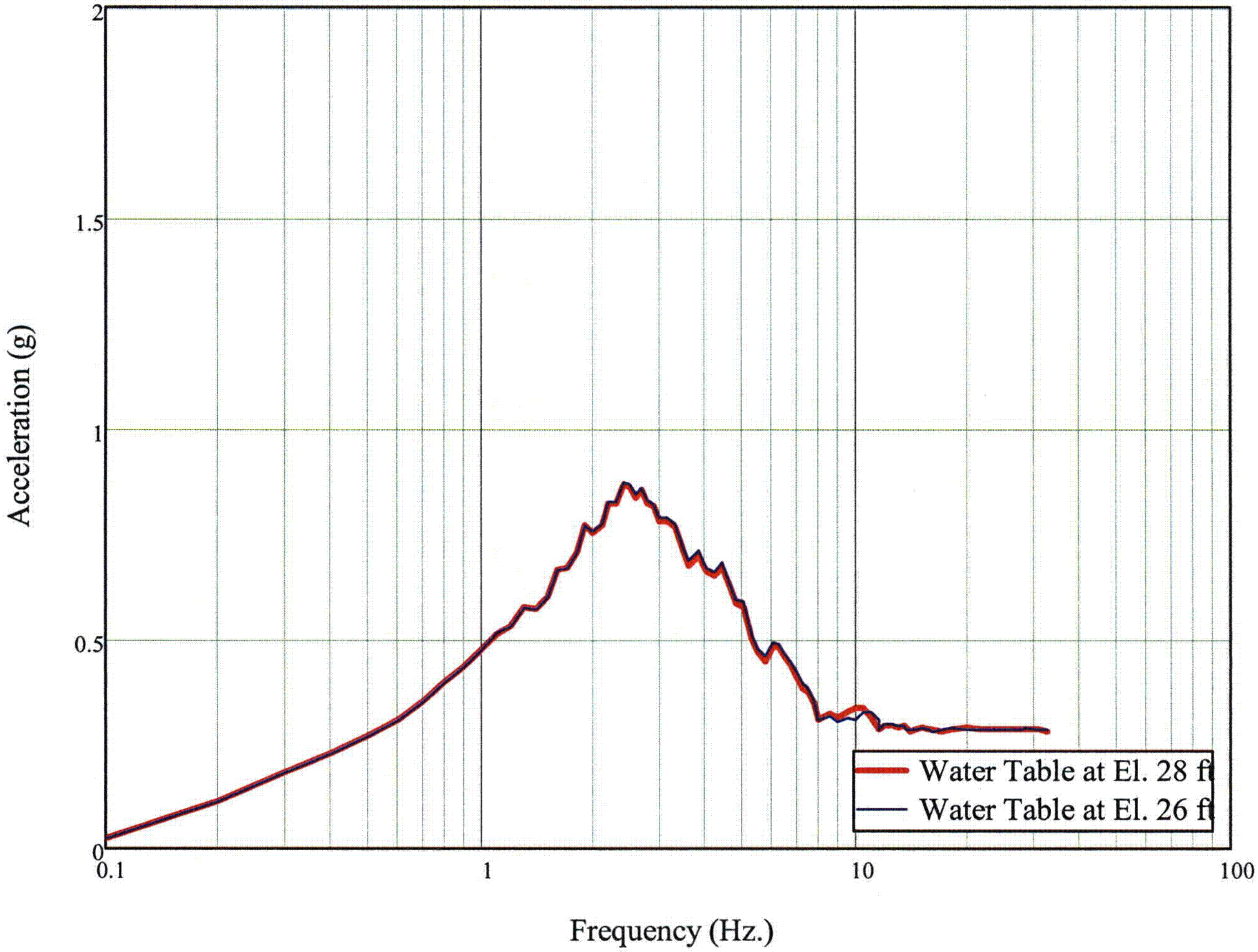


Figure 03.07.01-27 S3.D10: N-S Direction Response Spectra Comparison At Roof Slab El. 30 ft (DGFOSV No. 1A and 1B)

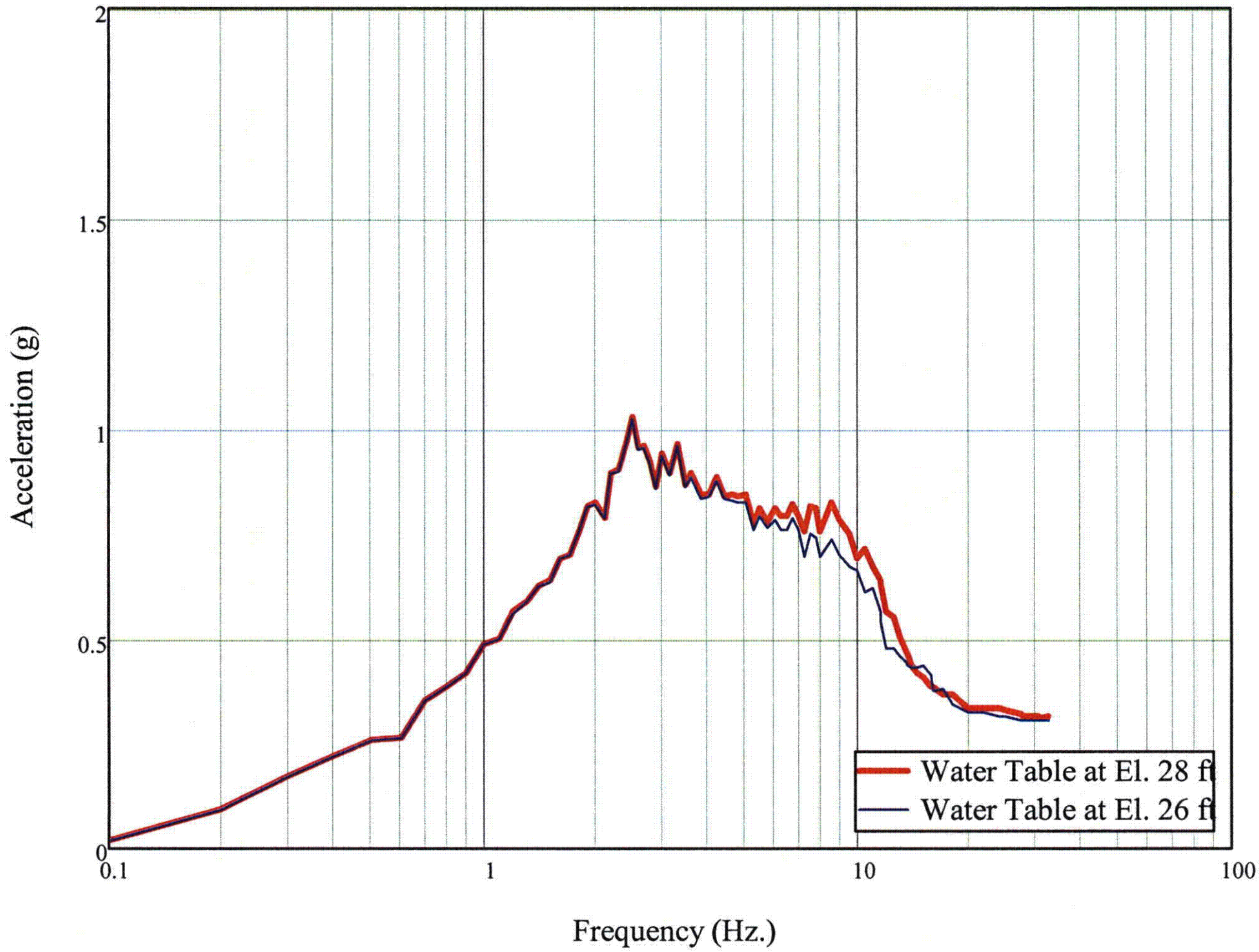


Figure 03.07.01-27 S3.D11: E-W Direction Response Spectra Comparison At Roof Slab El. 30 ft (DGFOSV No. 1A and 1B)

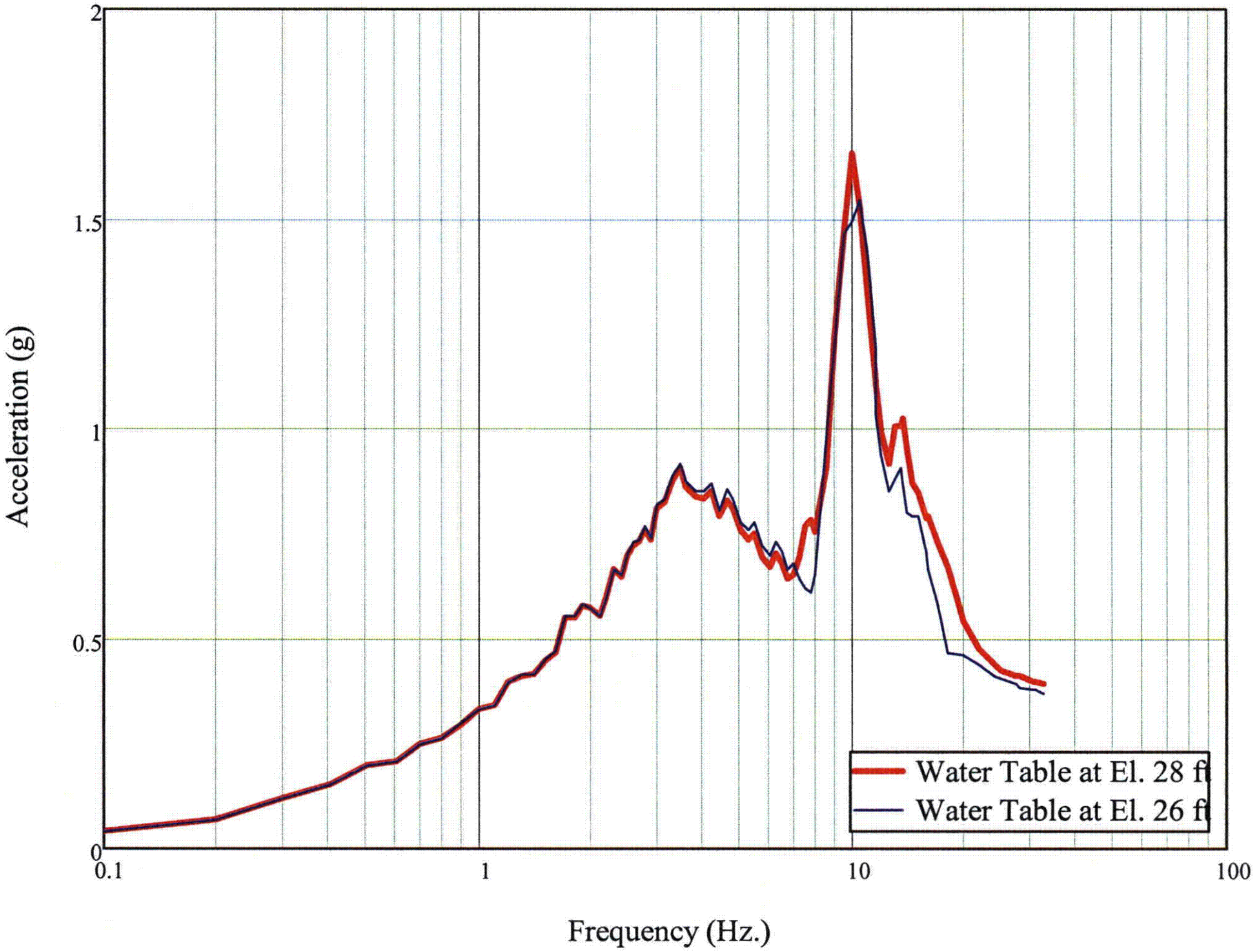


Figure 03.07.01-27 S3.D12: Vertical Direction Response Spectra Comparison At Roof Slab El. 30 ft (DGFOSV No. 1A, 1B and 1C)

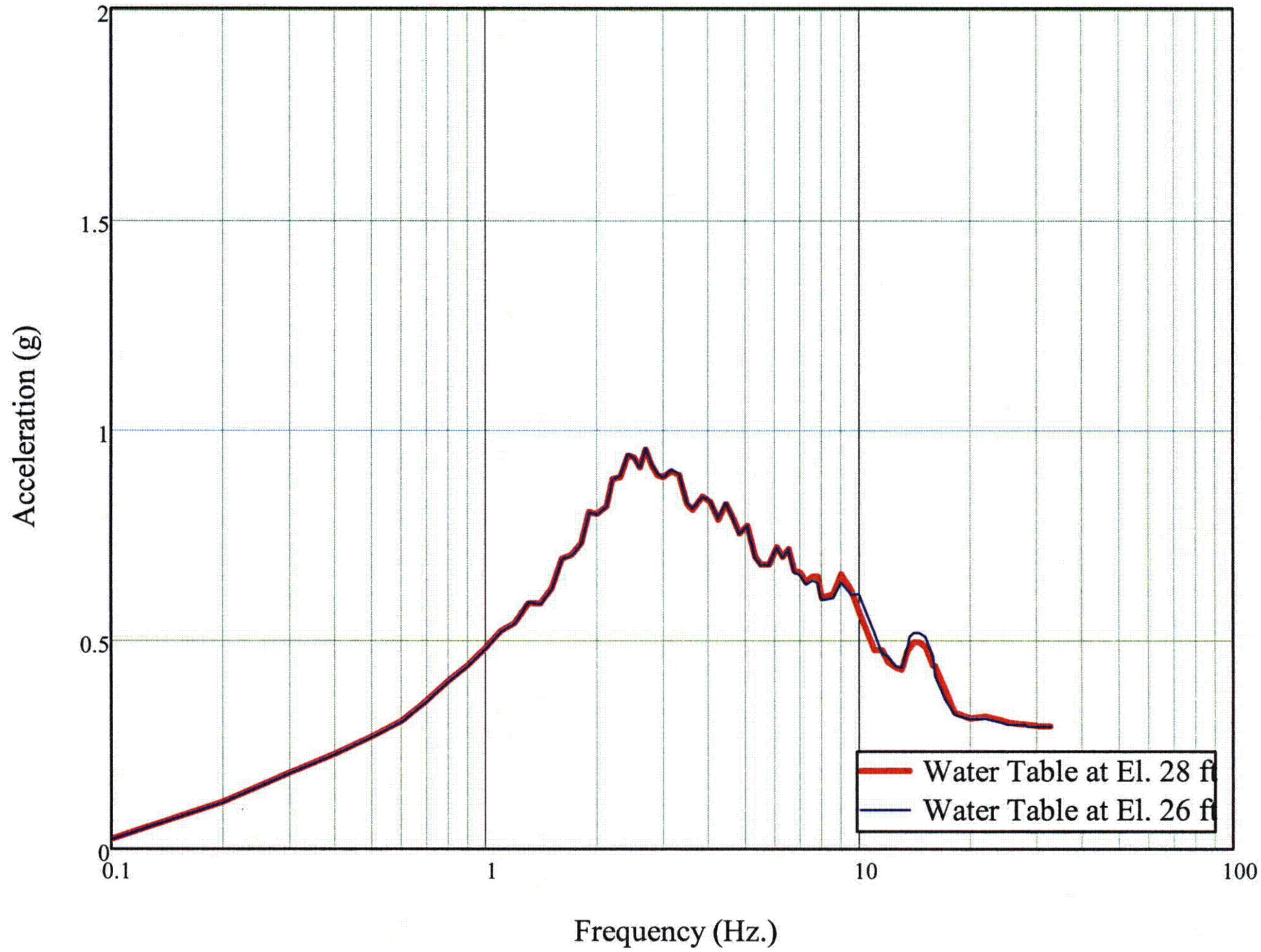


Figure 03.07.01-27 S3.D13: N-S Direction Response Spectra Comparison At Roof Slab El. 50 ft (DGFOSV No. 1A and 1B)

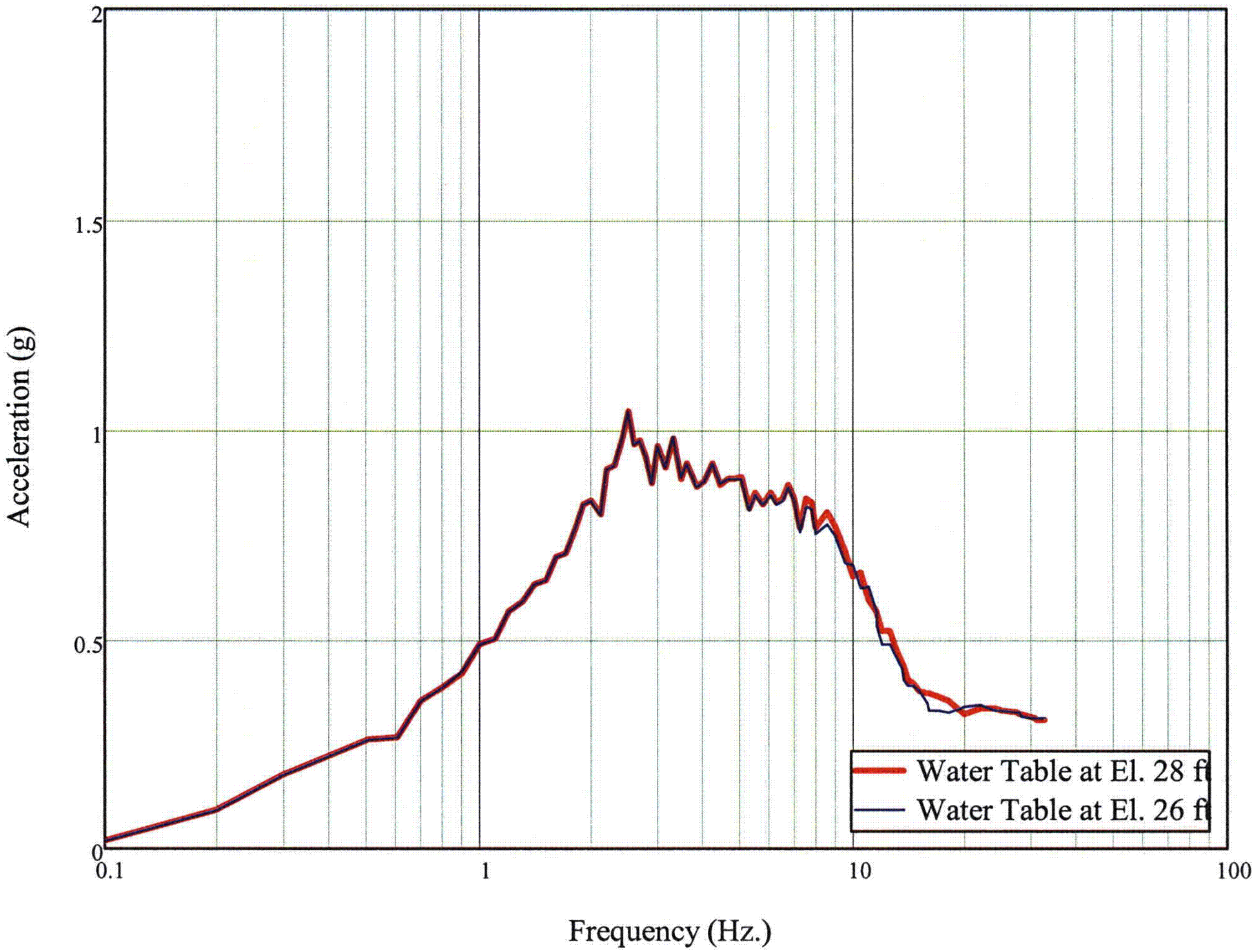


Figure 03.07.01-27 S3.D14: E-W Direction Response Spectra Comparison At Roof Slab El. 50 ft (DGFOSV No. 1A and 1B)

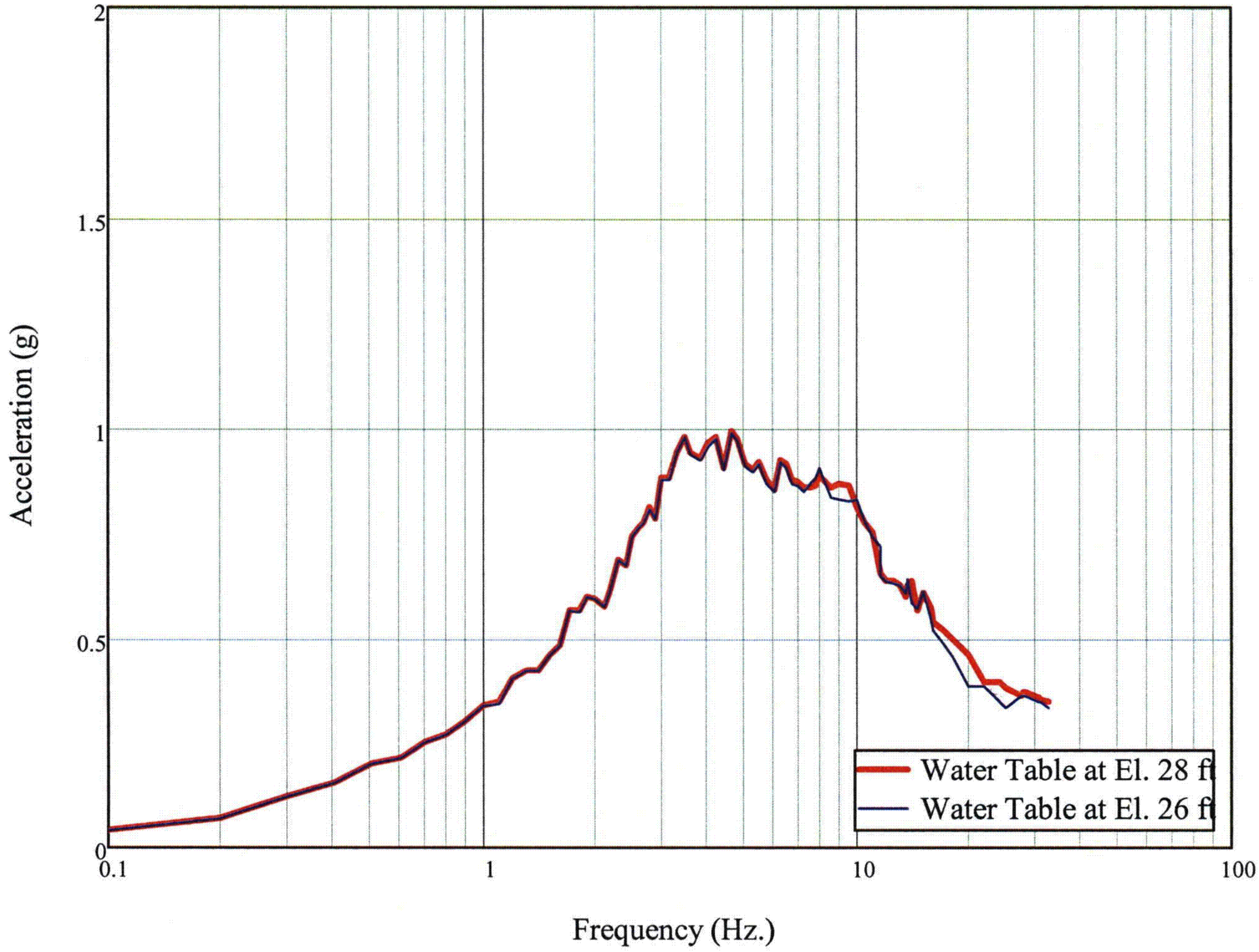


Figure 03.07.01-27 S3.D15: Vertical Direction Response Spectra Comparison At Roof Slab El. 50 ft (DGFOSV No. 1A, 1B and 1C)

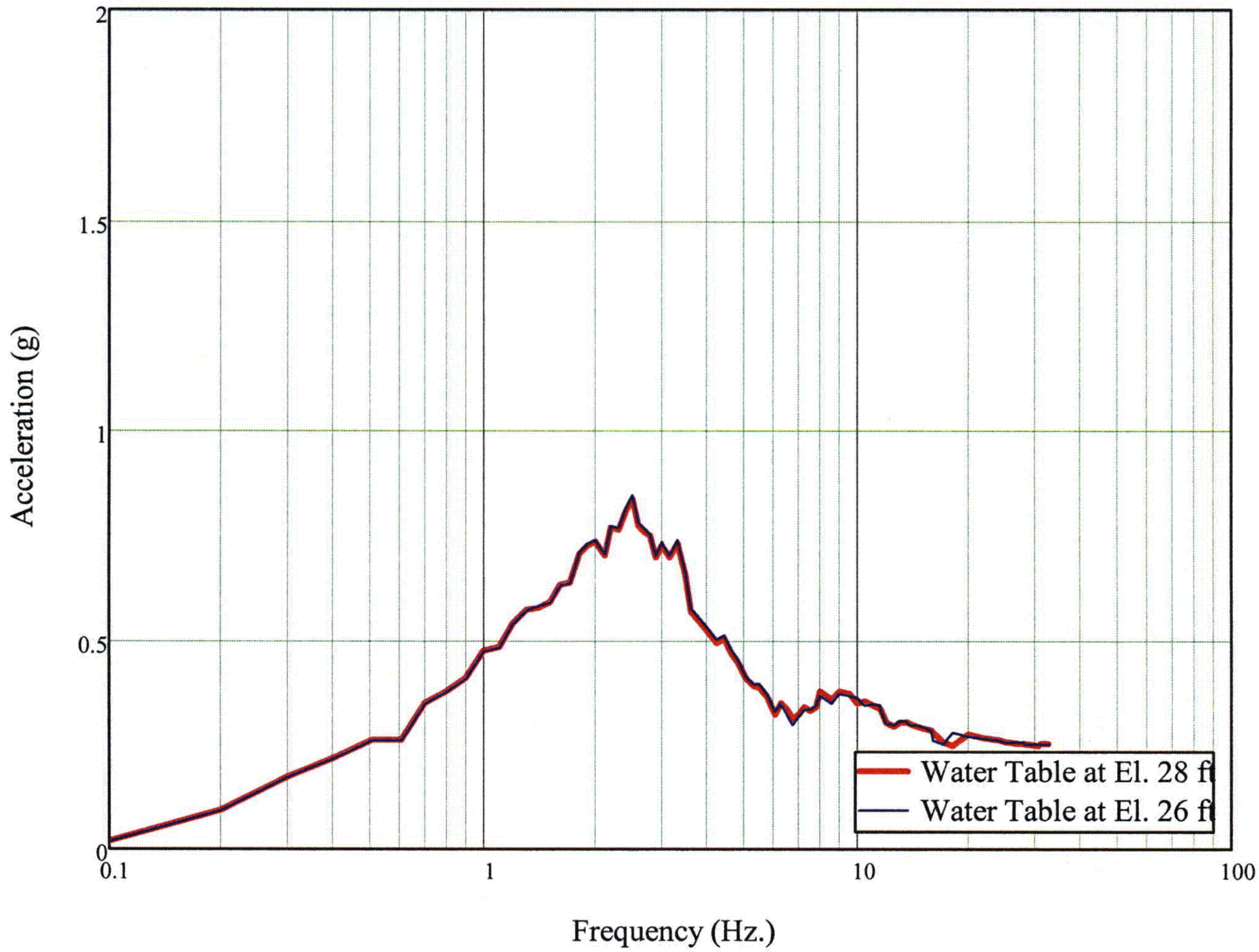


Figure 03.07.01-27 S3.D16: E-W Direction Response Spectra Comparison At Top of Foundation Mat El. -3 ft (DGFOSV No. 1C)

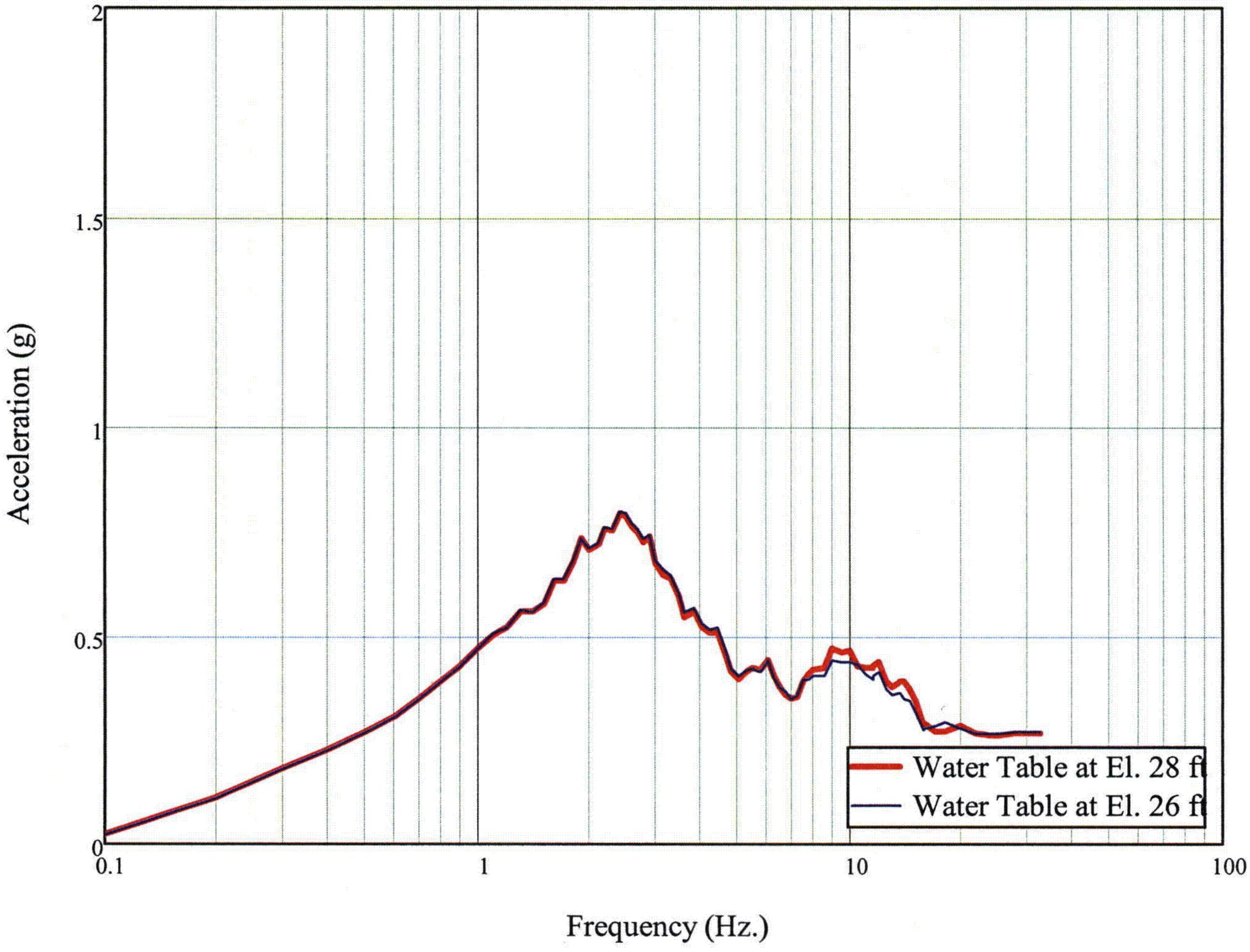


Figure 03.07.01-27 S3.D17: N-S Direction Response Spectra Comparison At Top of Foundation Mat El. -3 ft (DGFOSV No. 1C)

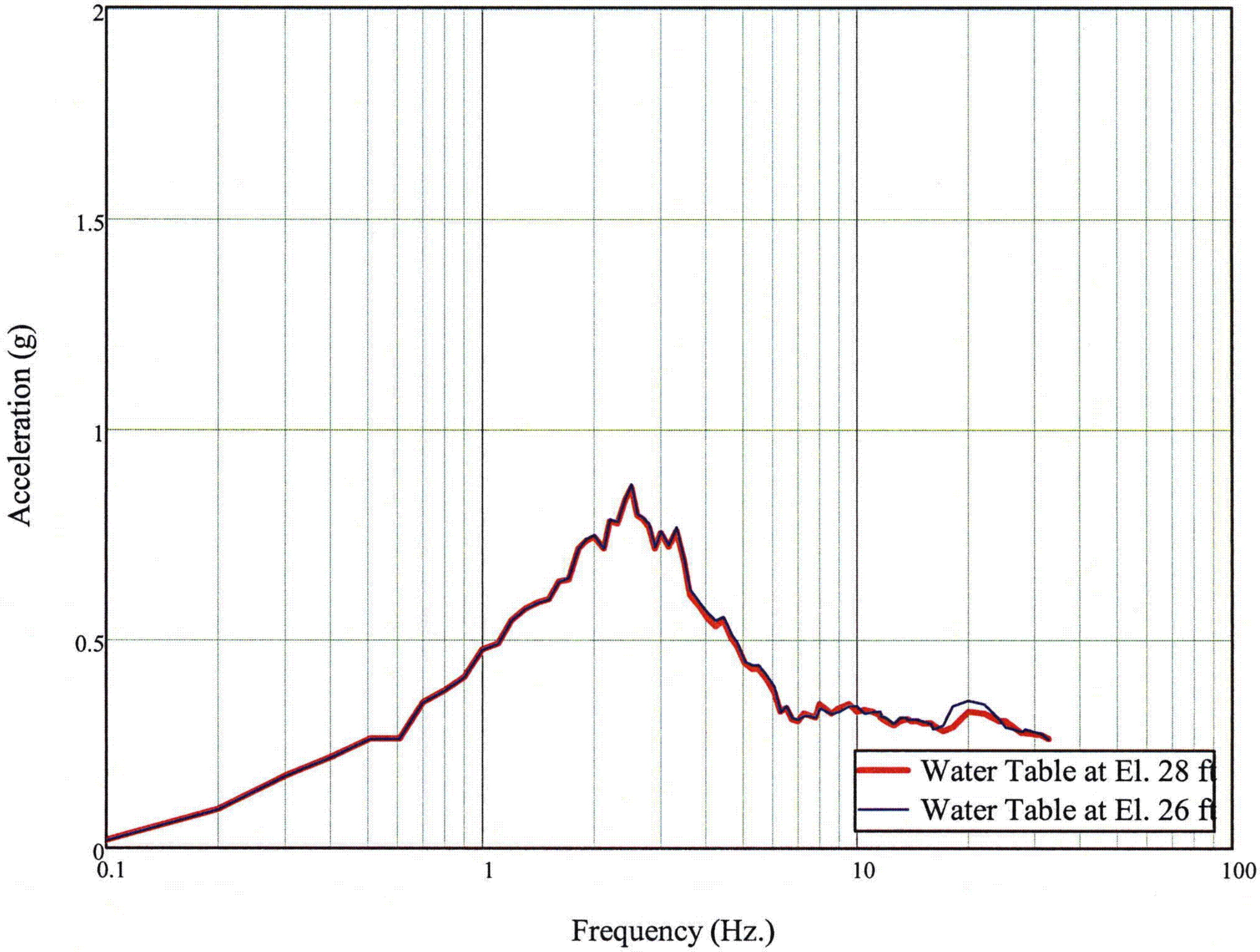


Figure 03.07.01-27 S3.D18: E-W Direction Response Spectra Comparison At Center of Gravity of Fuel Oil Tank (DGFOSV No. 1C)

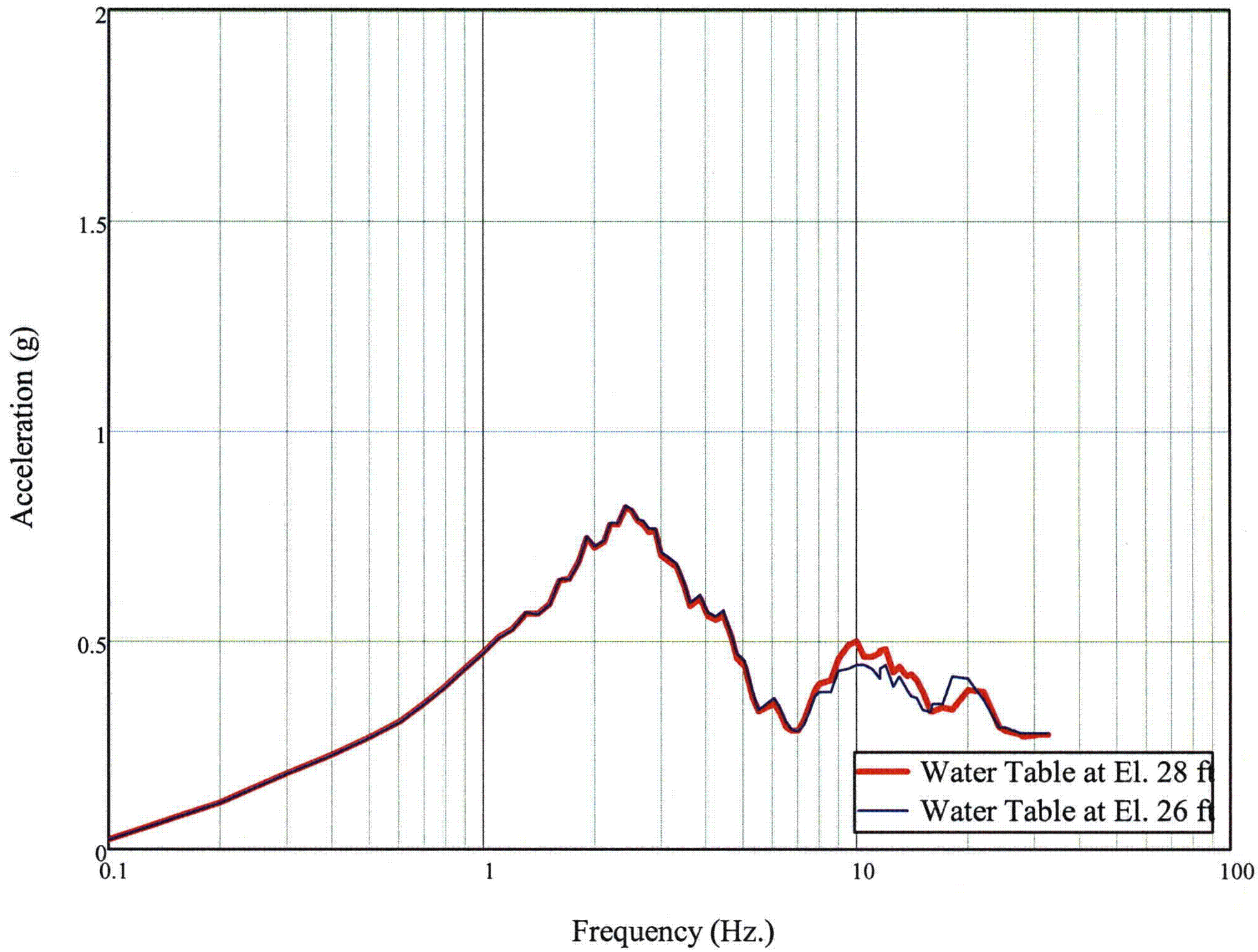


Figure 03.07.01-27 S3.D19: N-S Direction Response Spectra Comparison At Center of Gravity of Fuel Oil Tank (DGFOSV No. 1C)

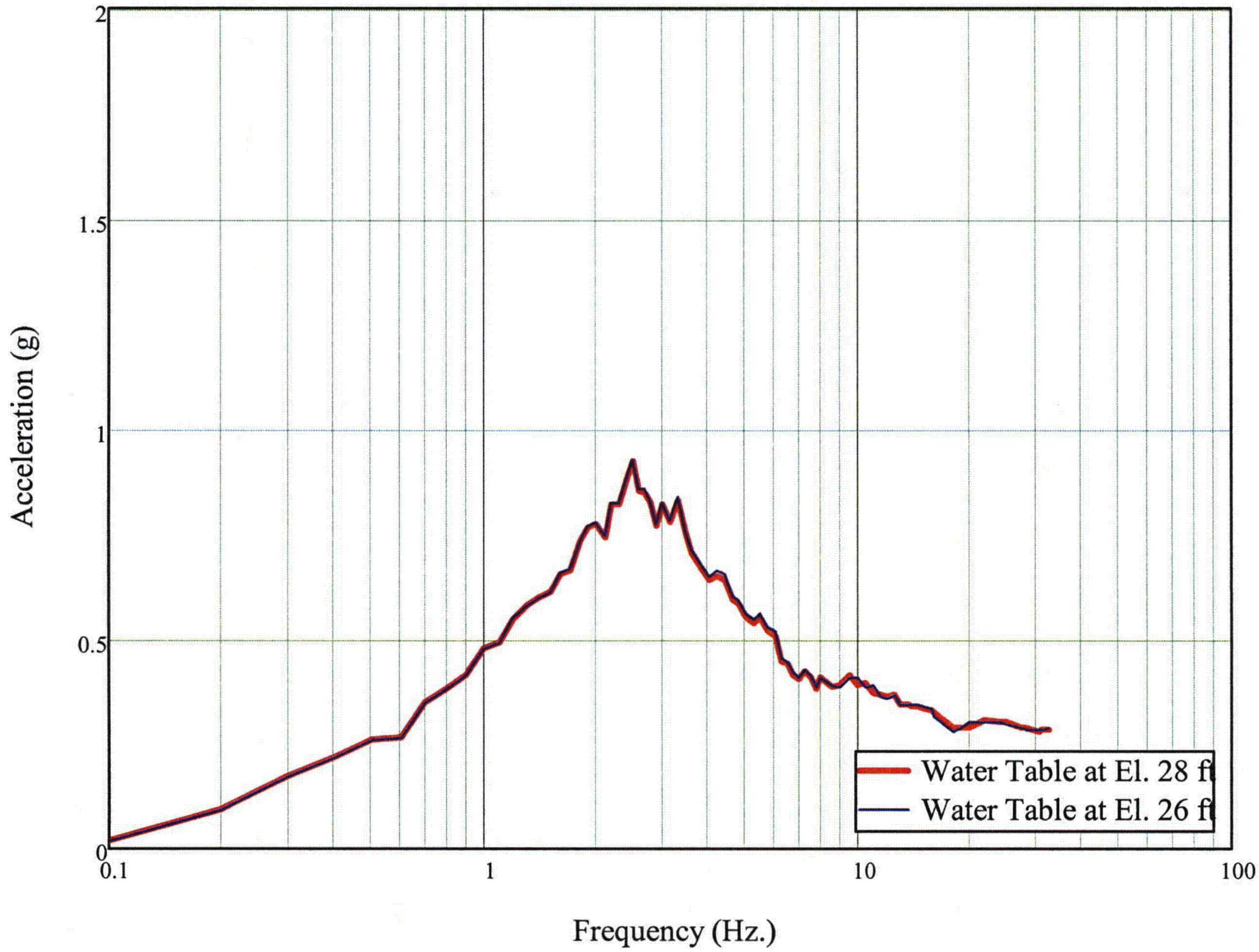


Figure 03.07.01-27 S3.D20: E-W Direction Response Spectra Comparison Out-of-plane of N-S Walls at El. 15 ft (DGFOSV No. 1C)

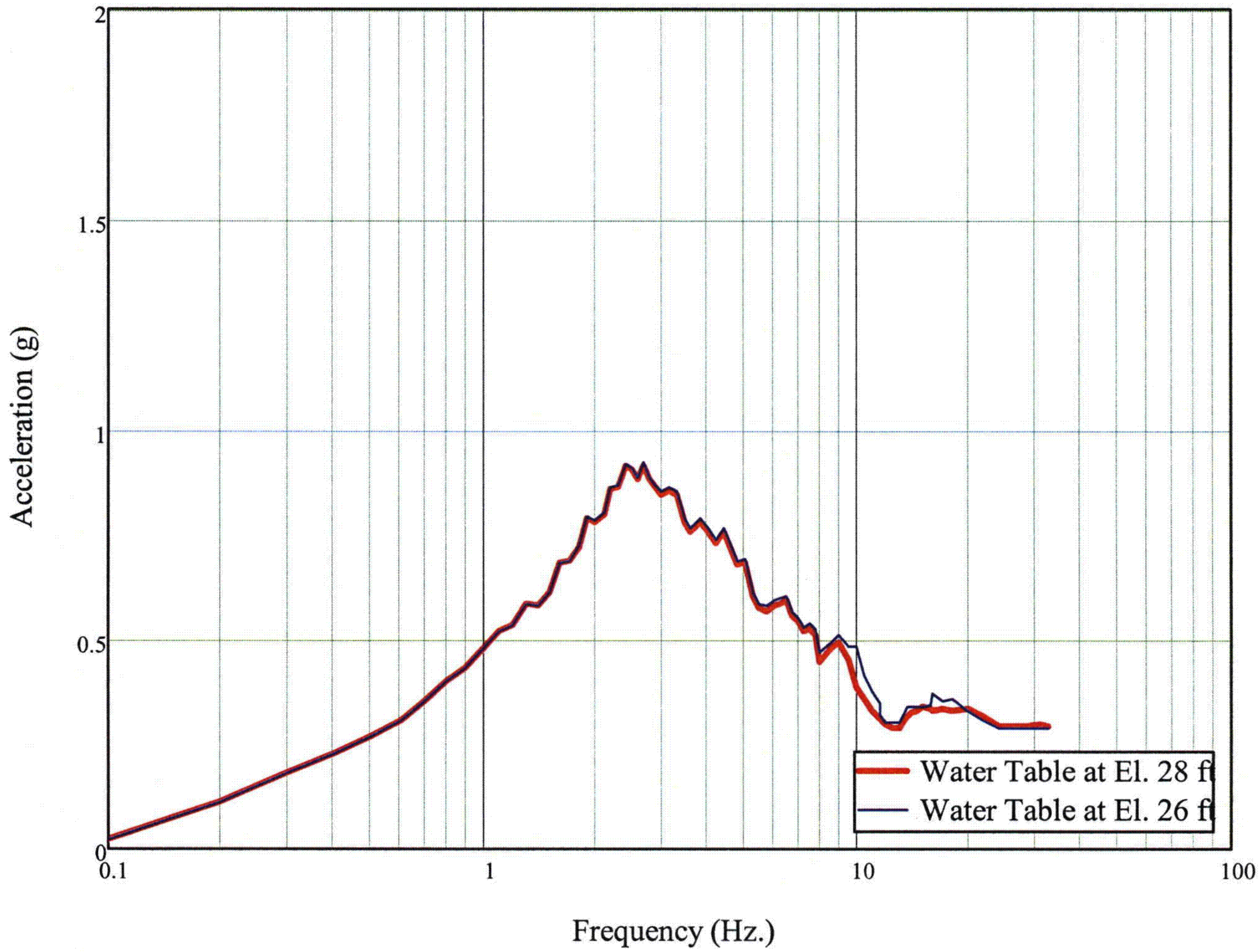


Figure 03.07.01-27 S3.D21: N-S Direction Response Spectra Comparison Out-of-plane of E-W Walls at El. 15 ft (DGFOSV No. 1C)

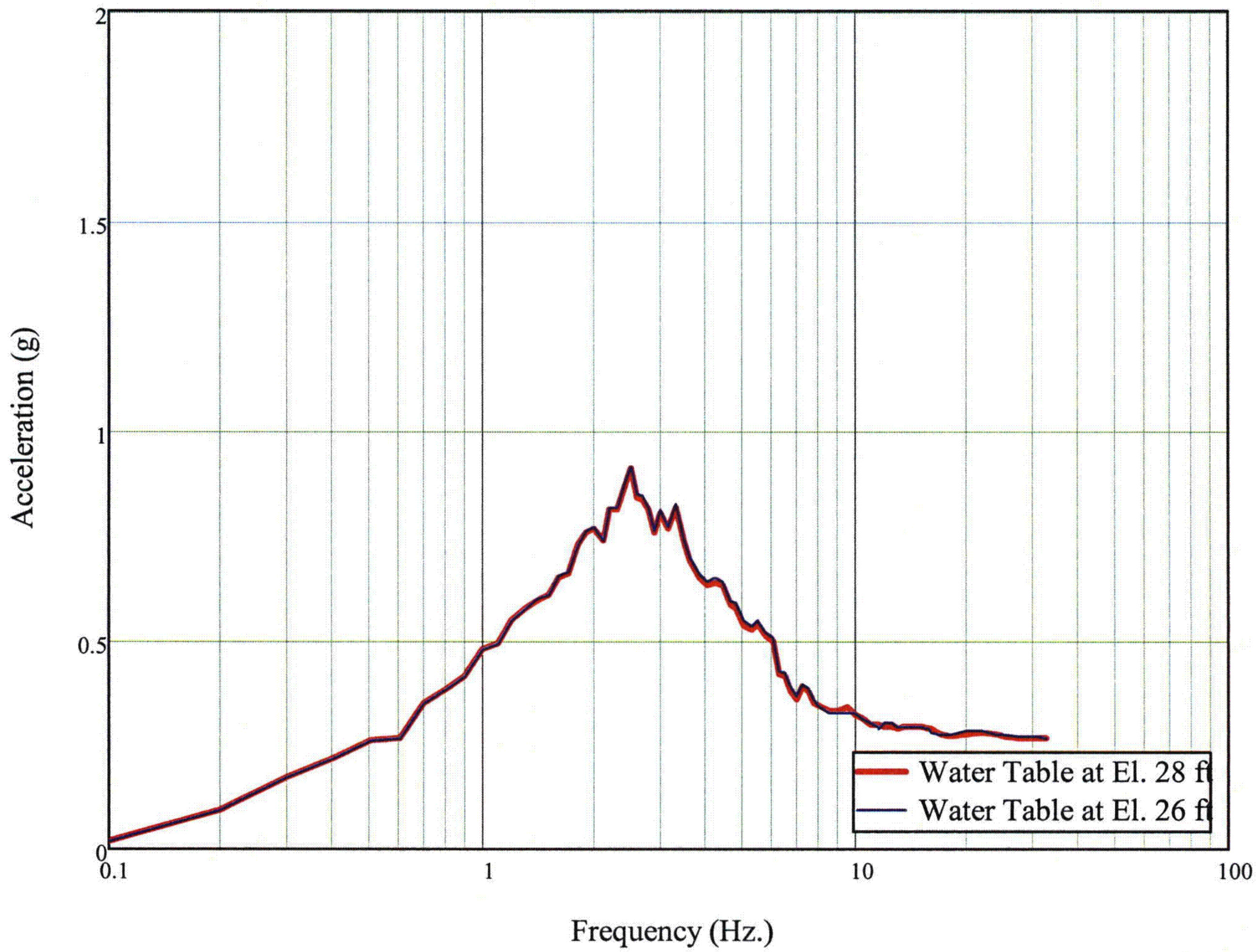


Figure 03.07.01-27 S3.D22: E-W Direction Response Spectra Comparison At Roof Slab El. 30 ft (DGFOSV No. 1C)

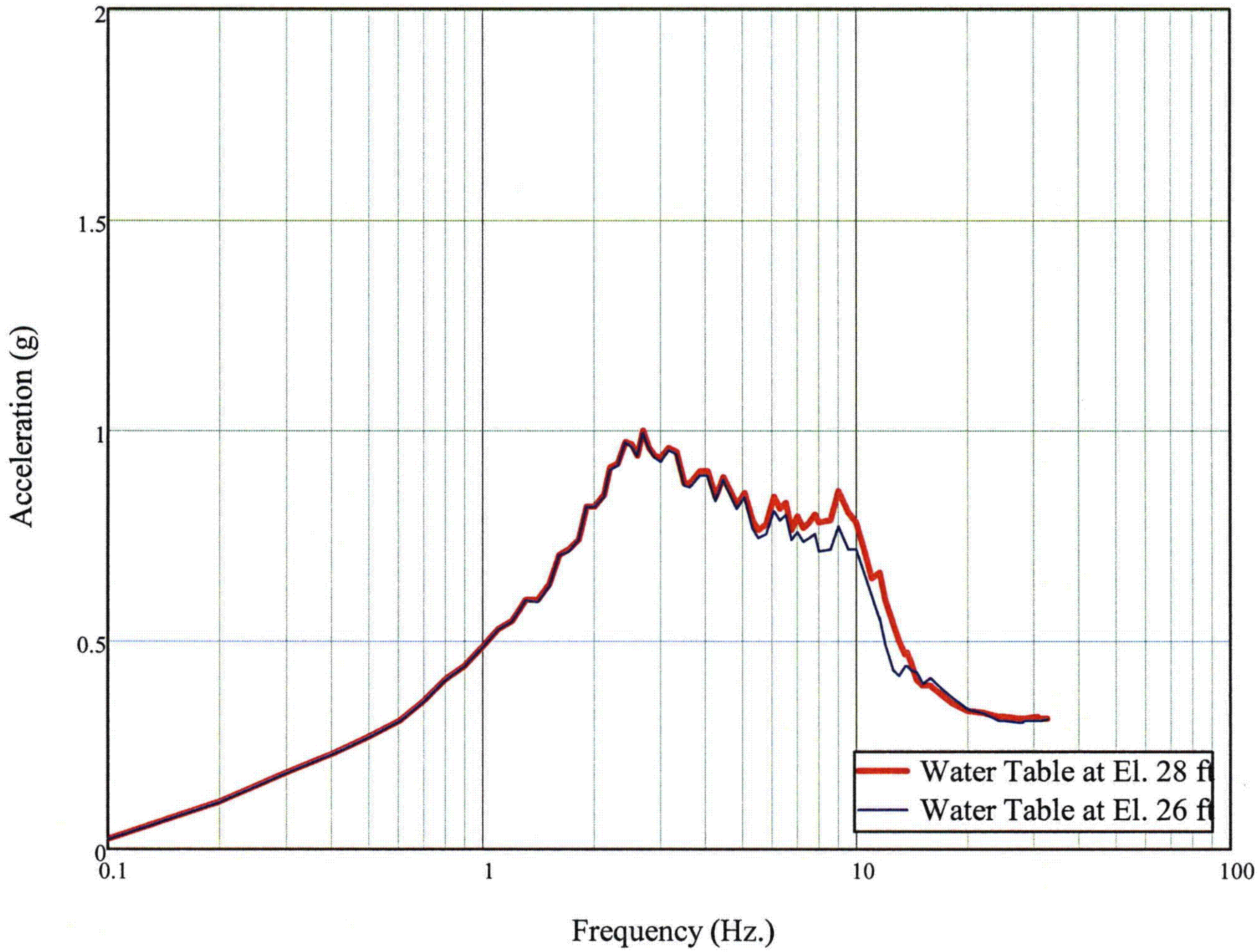


Figure 03.07.01-27 S3.D23: N-S Direction Response Spectra Comparison At Roof Slab El. 30 ft (DGFOSV No. 1C)

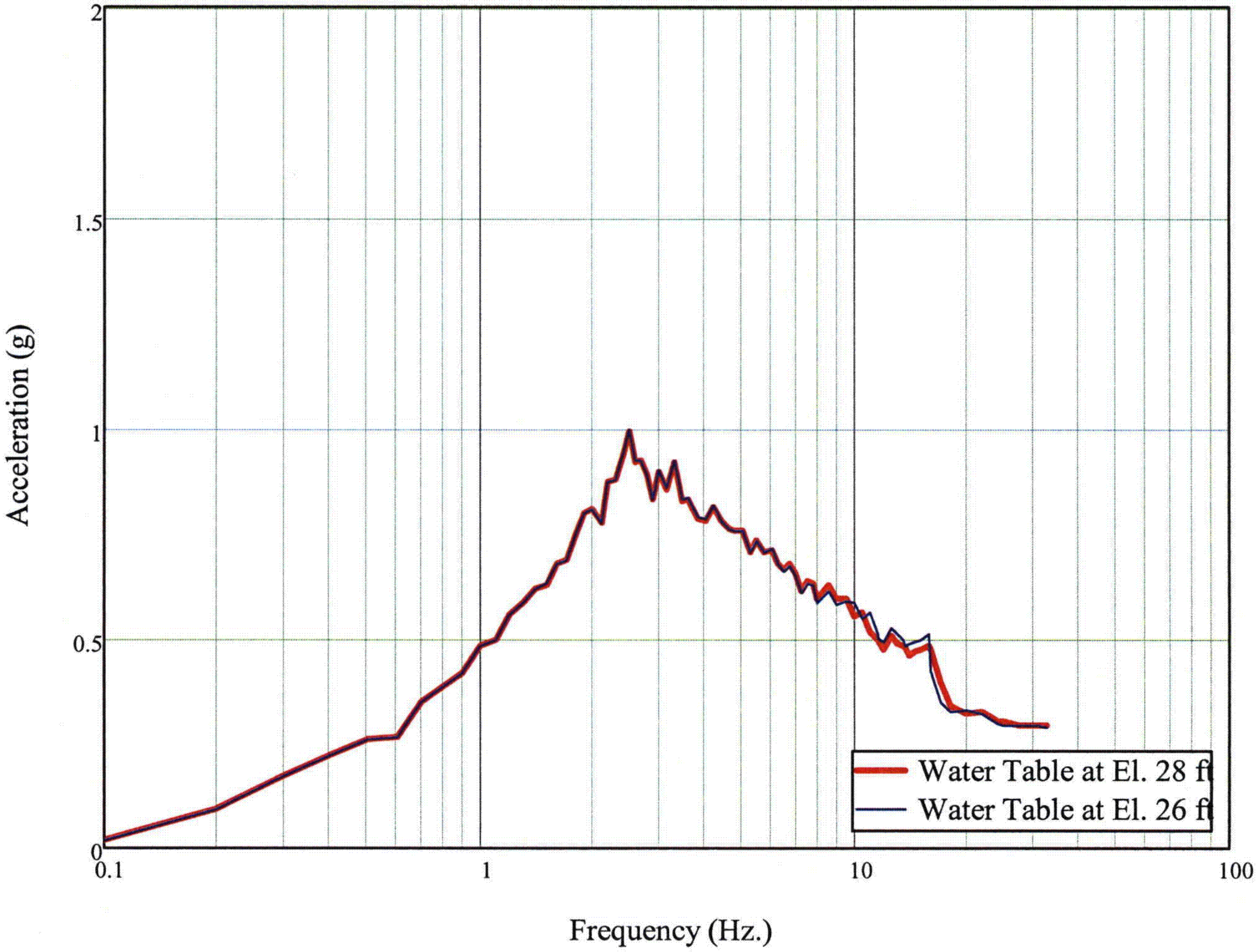


Figure 03.07.01-27 S3.D24: E-W Direction Response Spectra Comparison At Roof Slab El. 50 ft (DGFOSV No. 1C)

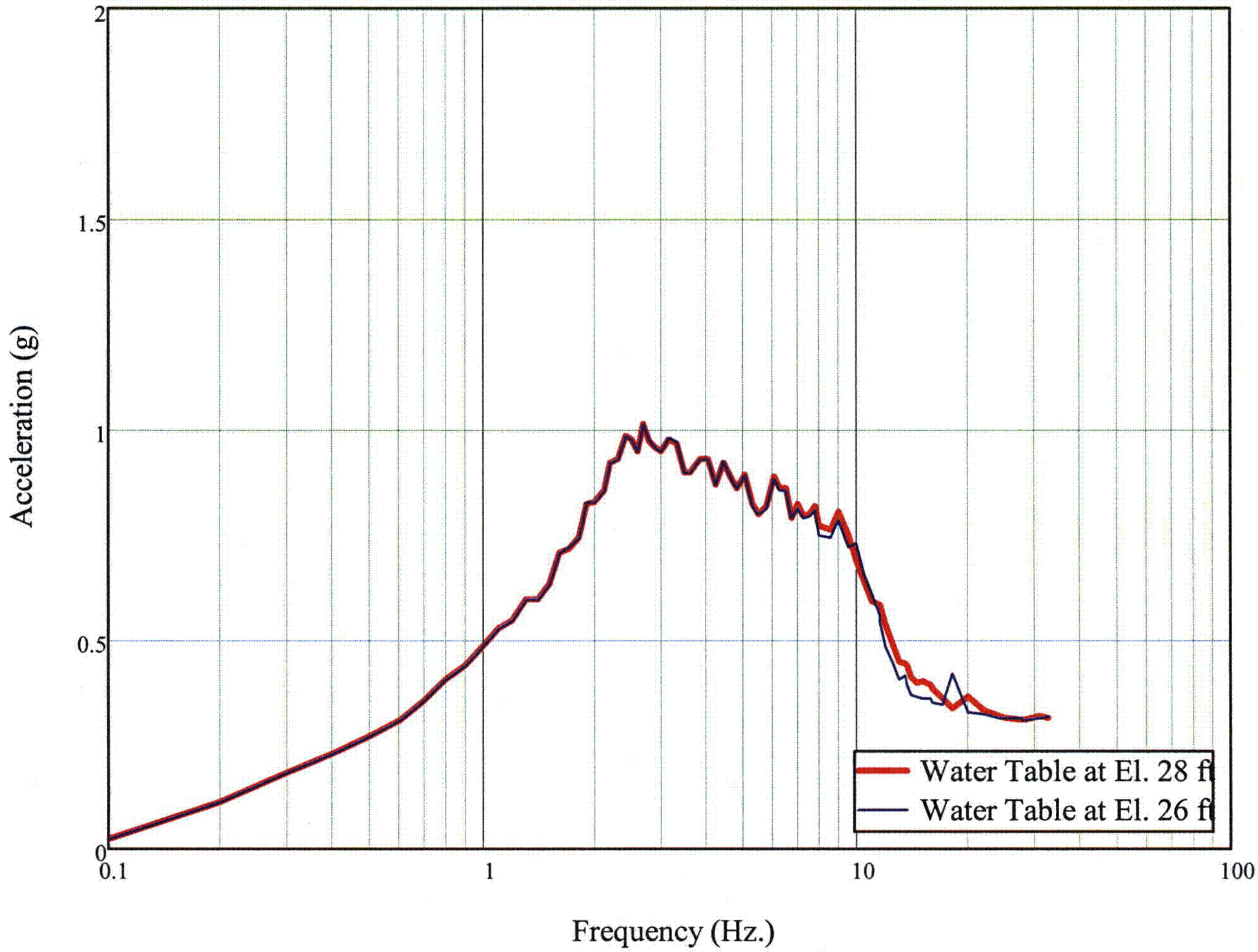


Figure 03.07.01-27 S3.D25: N-S Direction Response Spectra Comparison At Roof Slab El. 50 ft (DGFOSV No. 1C)

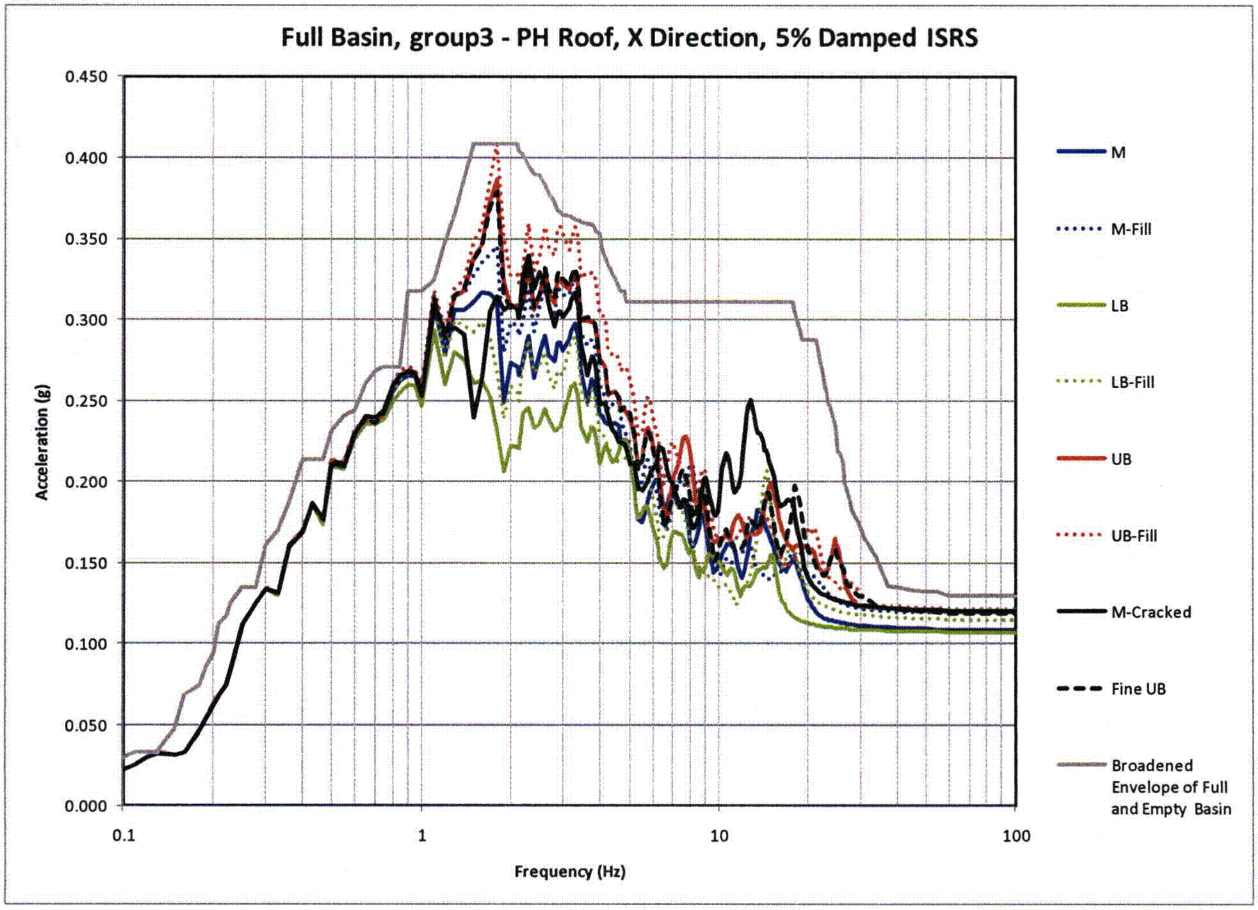


Figure 03.07.01-27 S3.F1: Full Basin, group3 - PH Roof, X Direction, 5% Damped ISRS

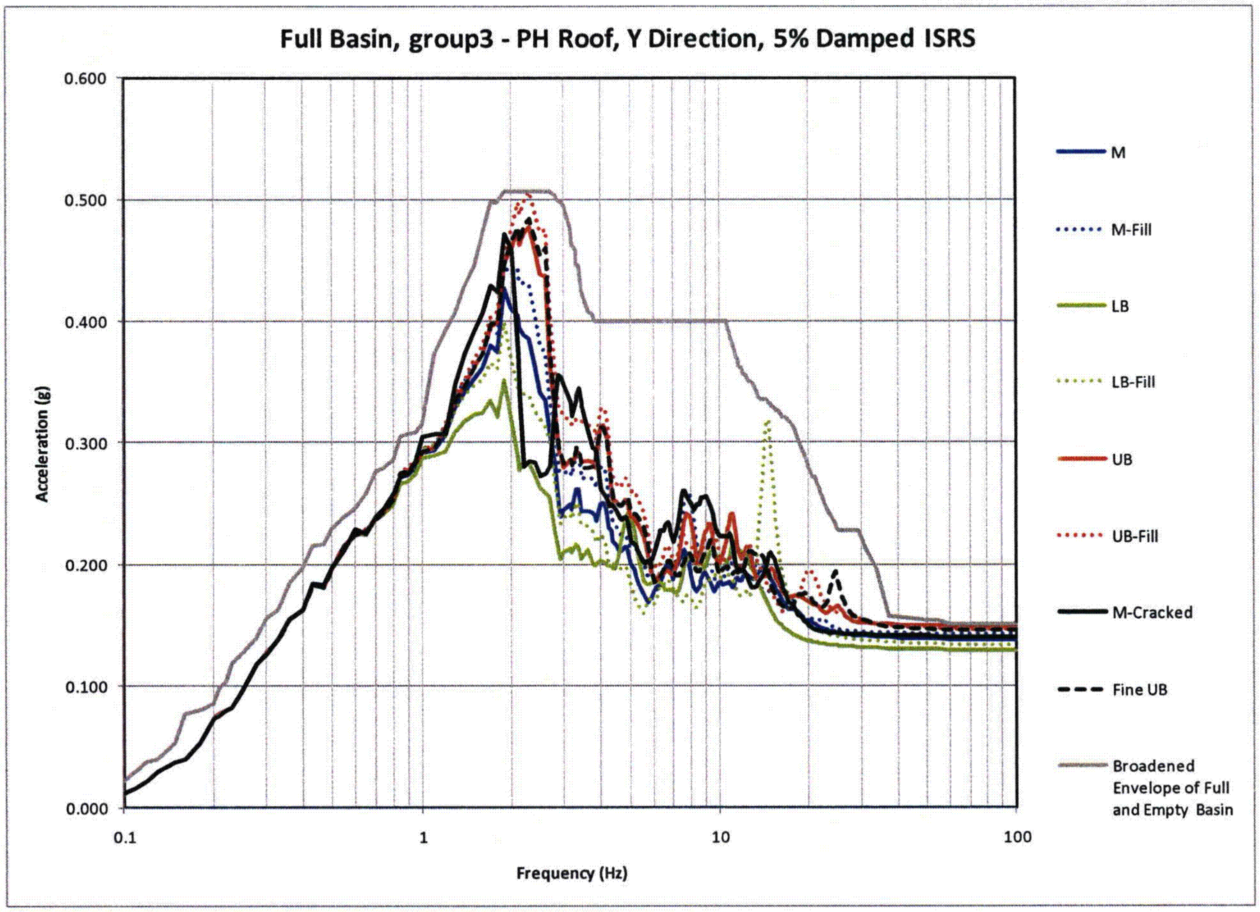


Figure 03.07.01-27 S3.F2: Full Basin, group3 - PH Roof, Y Direction, 5% Damped ISRS

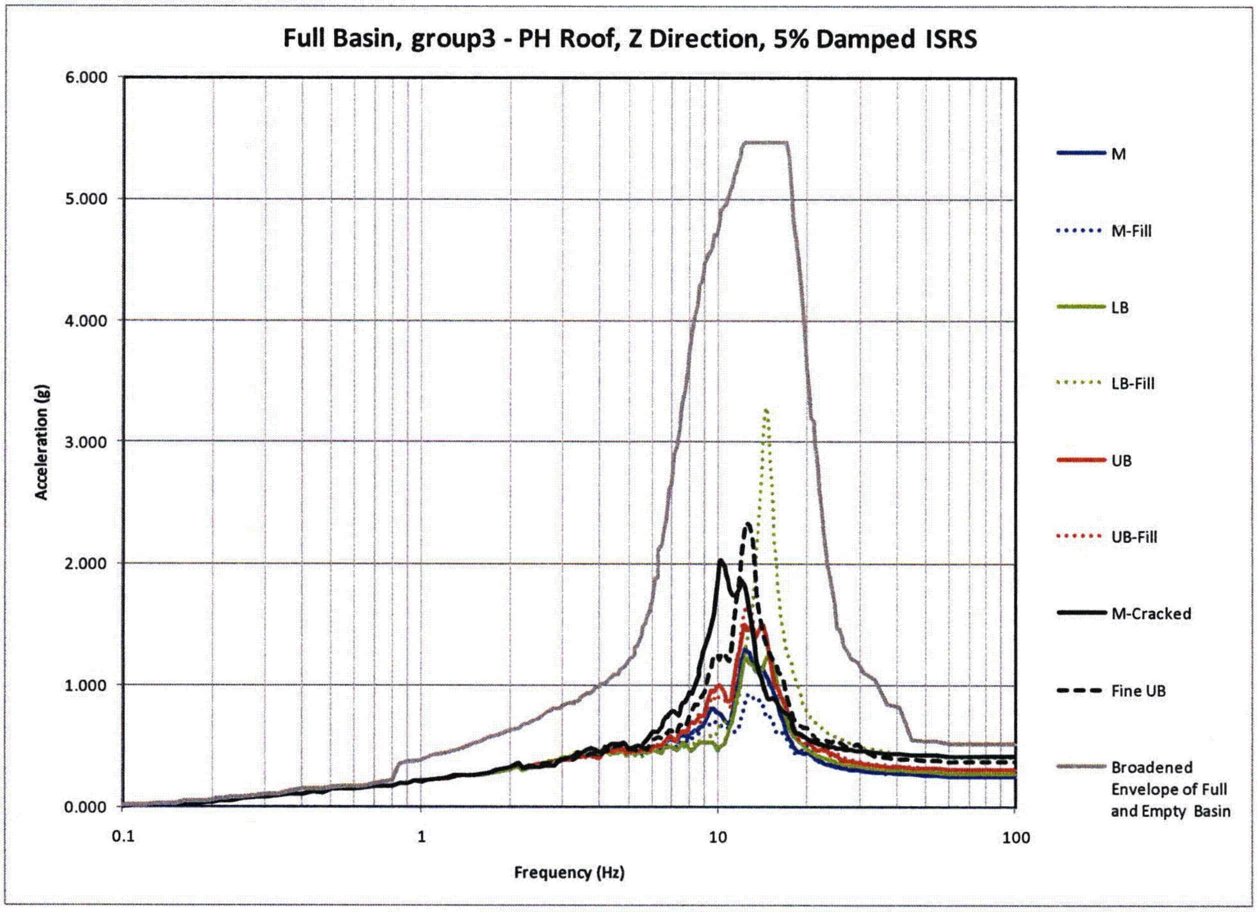


Figure 03.07.01-27 S3.F3: Full Basin, group3 - PH Roof, Z Direction, 5% Damped ISRS

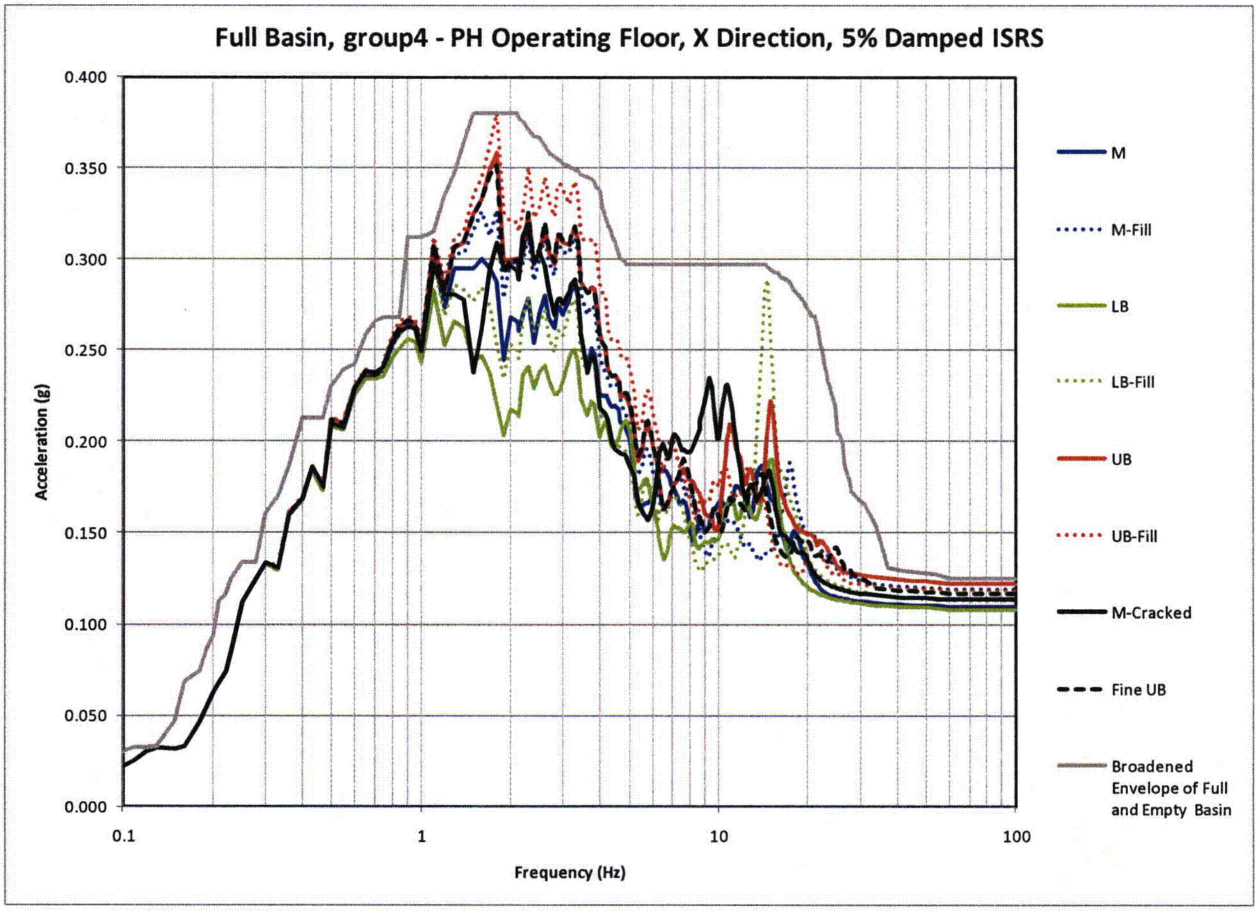


Figure 03.07.01-27 S3.F4: Full Basin, group4 - PH Operating Floor, X Direction, 5% Damped ISRS

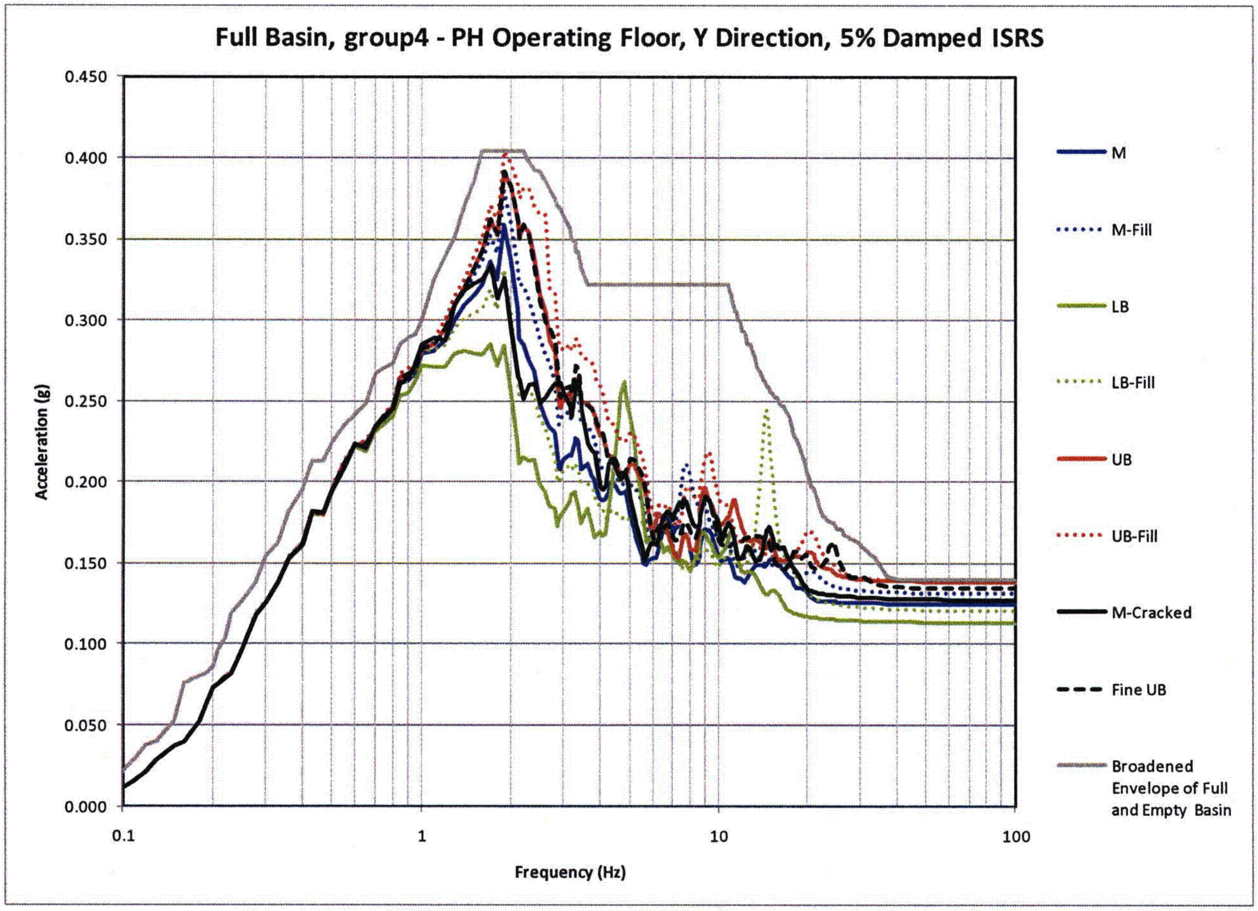


Figure 03.07.01-27 S3.F5: Full Basin, group4 - PH Operating Floor, Y Direction, 5% Damped ISRS

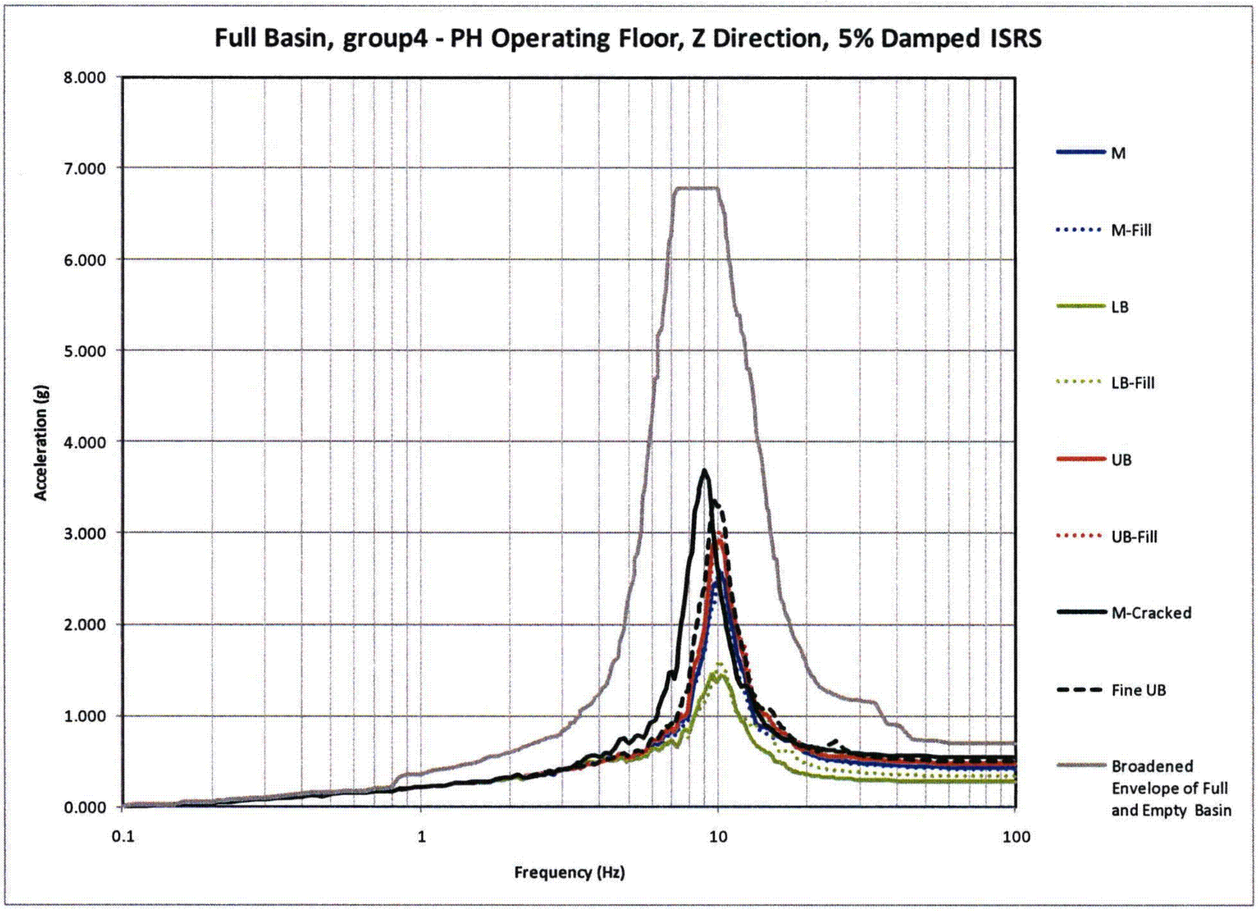


Figure 03.07.01-27 S3.F6: Full Basin, group4 - PH Operating Floor, Z Direction, 5% Damped ISRS

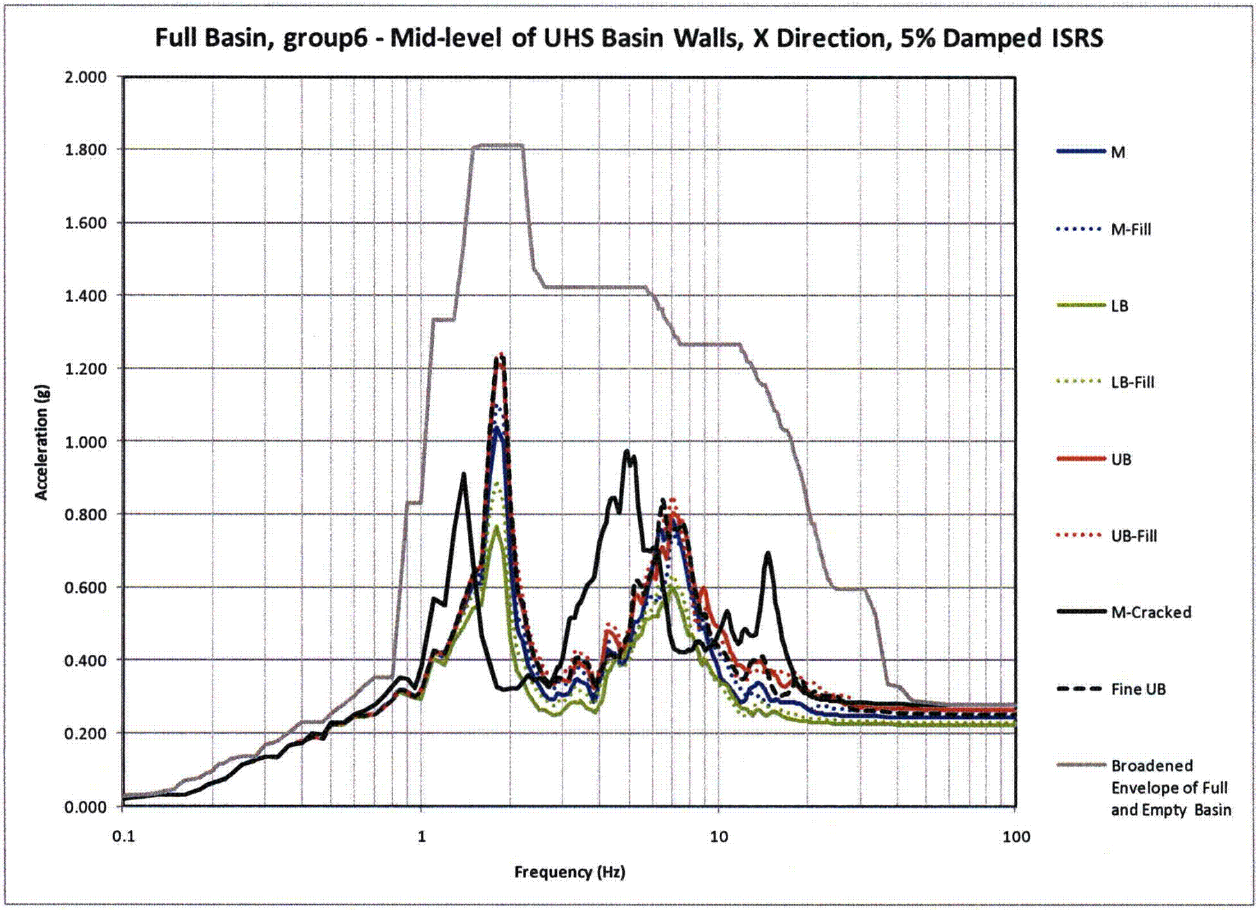


Figure 03.07.01-27 S3.F7: Full Basin, group6 - Mid-level of UHS Basin Walls, X Direction, 5% Damped ISRS

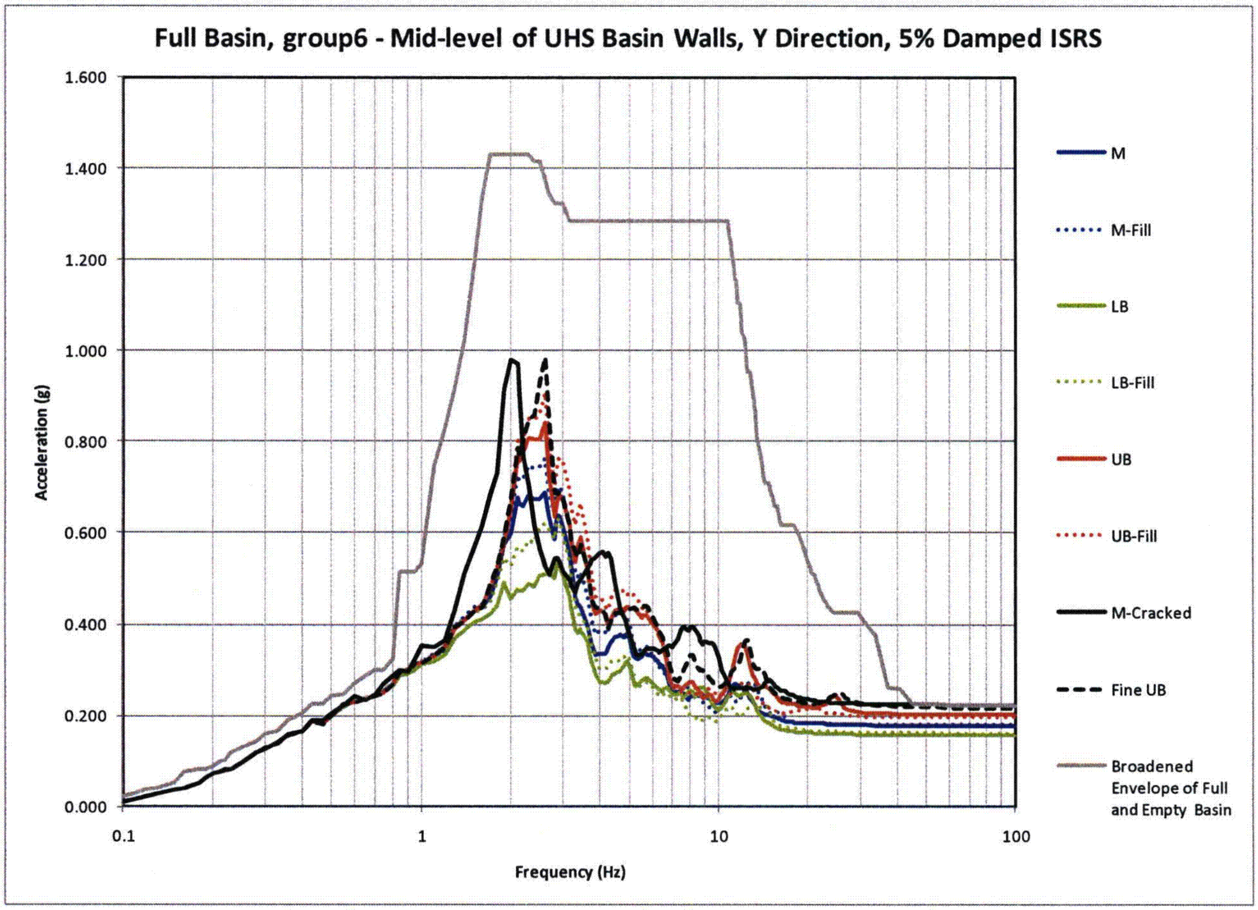


Figure 03.07.01-27 S3.F8: Full Basin, group6 - Mid-level of UHS Basin Walls, Y Direction, 5% Damped ISRS

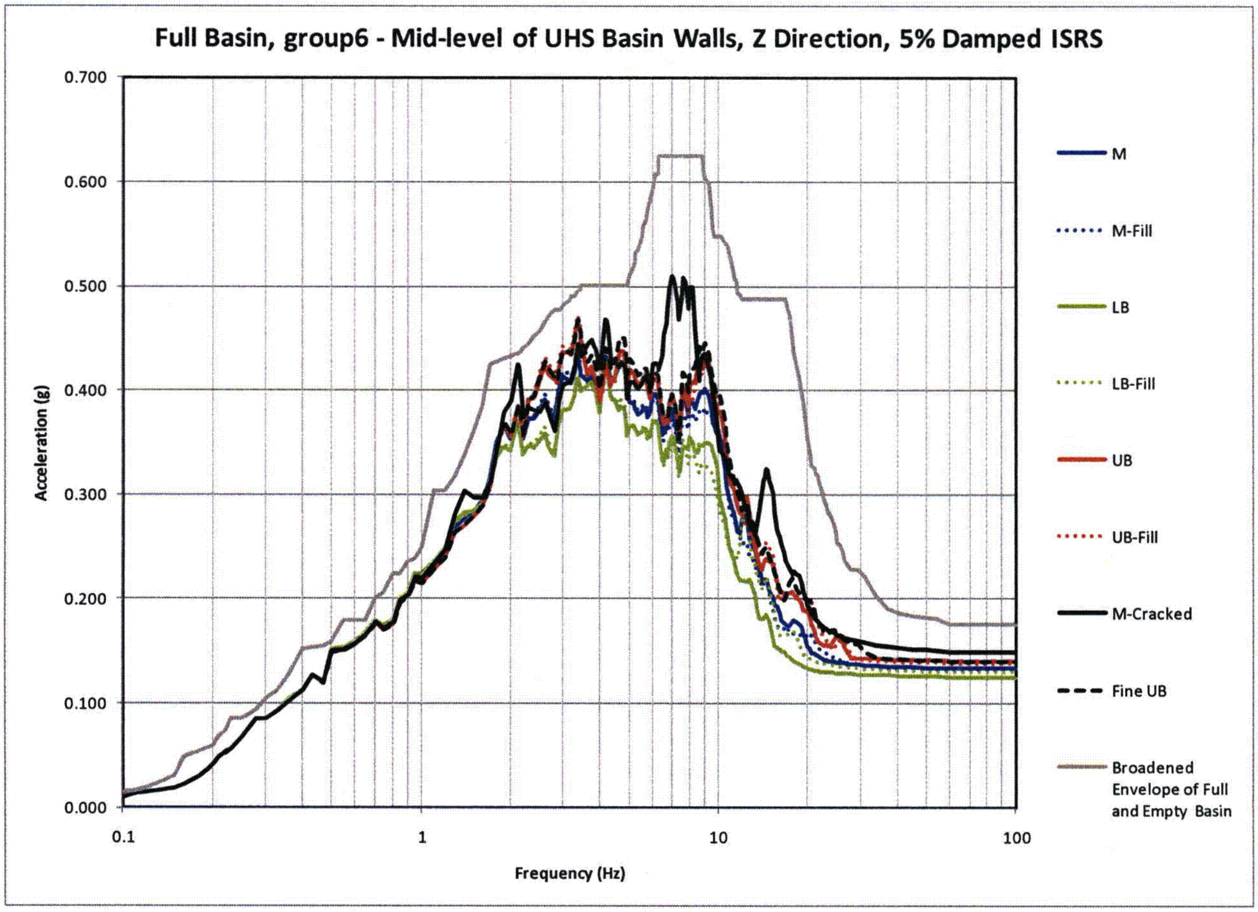


Figure 03.07.01-27 S3.F9: Full Basin, group6 - Mid-level of UHS Basin Walls, Z Direction, 5% Damped ISRS

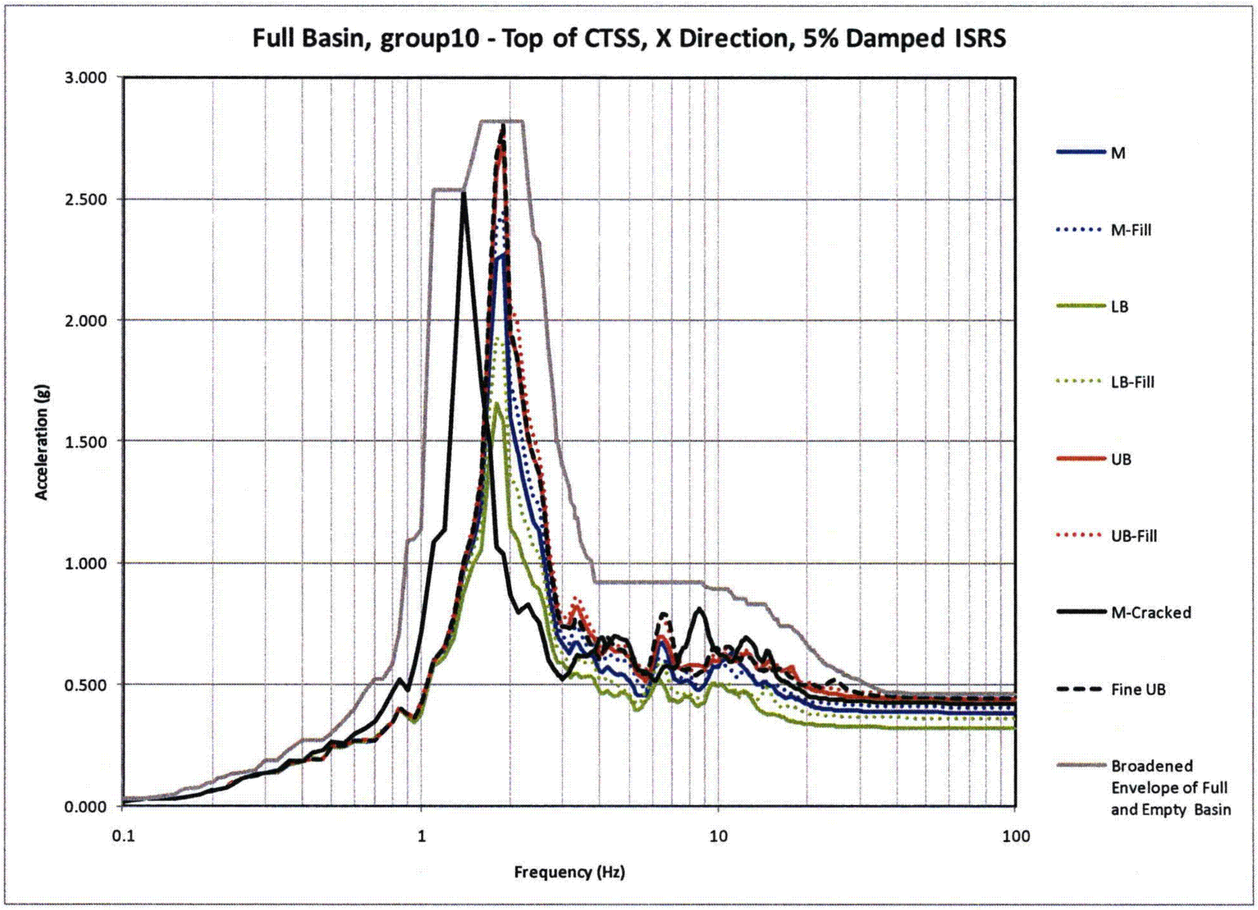


Figure 03.07.01-27 S3.F10: Full Basin, group10 - Top of CTSS, X Direction, 5% Damped ISRS

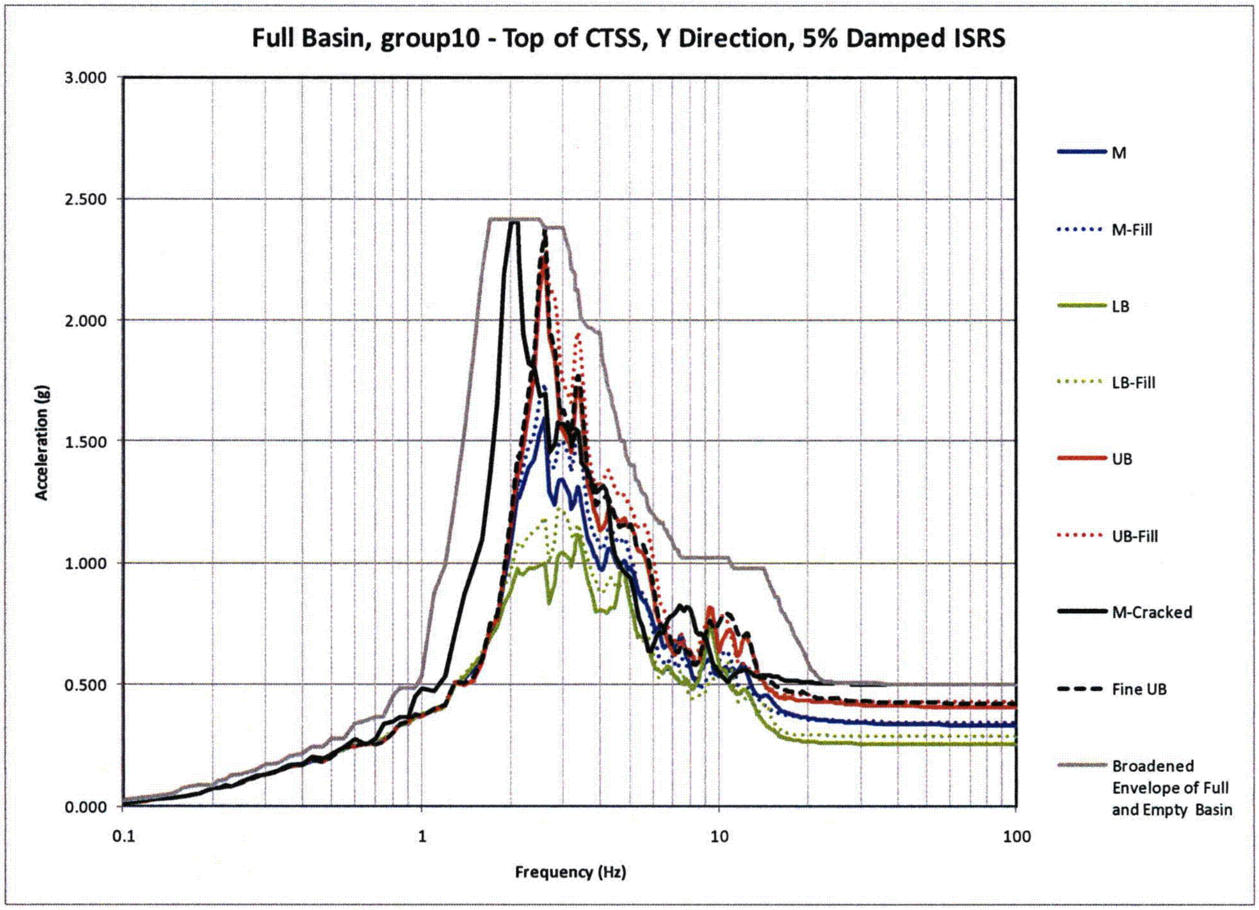


Figure 03.07.01-27 S3.F11: Full Basin, group10 - Top of CTSS, Y Direction, 5% Damped ISRS

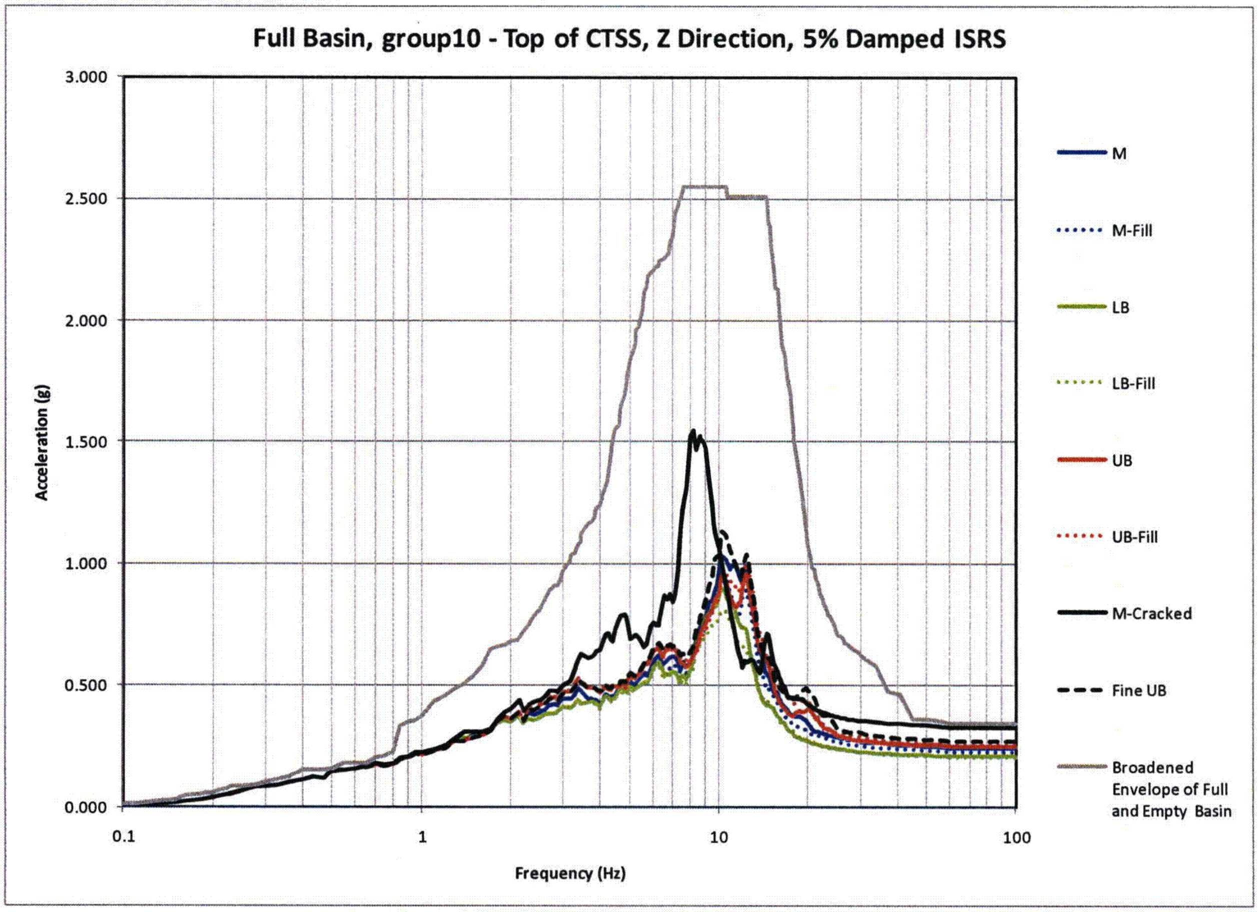


Figure 03.07.01-27 S3.F12: Full Basin, group10 - Top of CTSS, Z Direction, 5% Damped ISRS

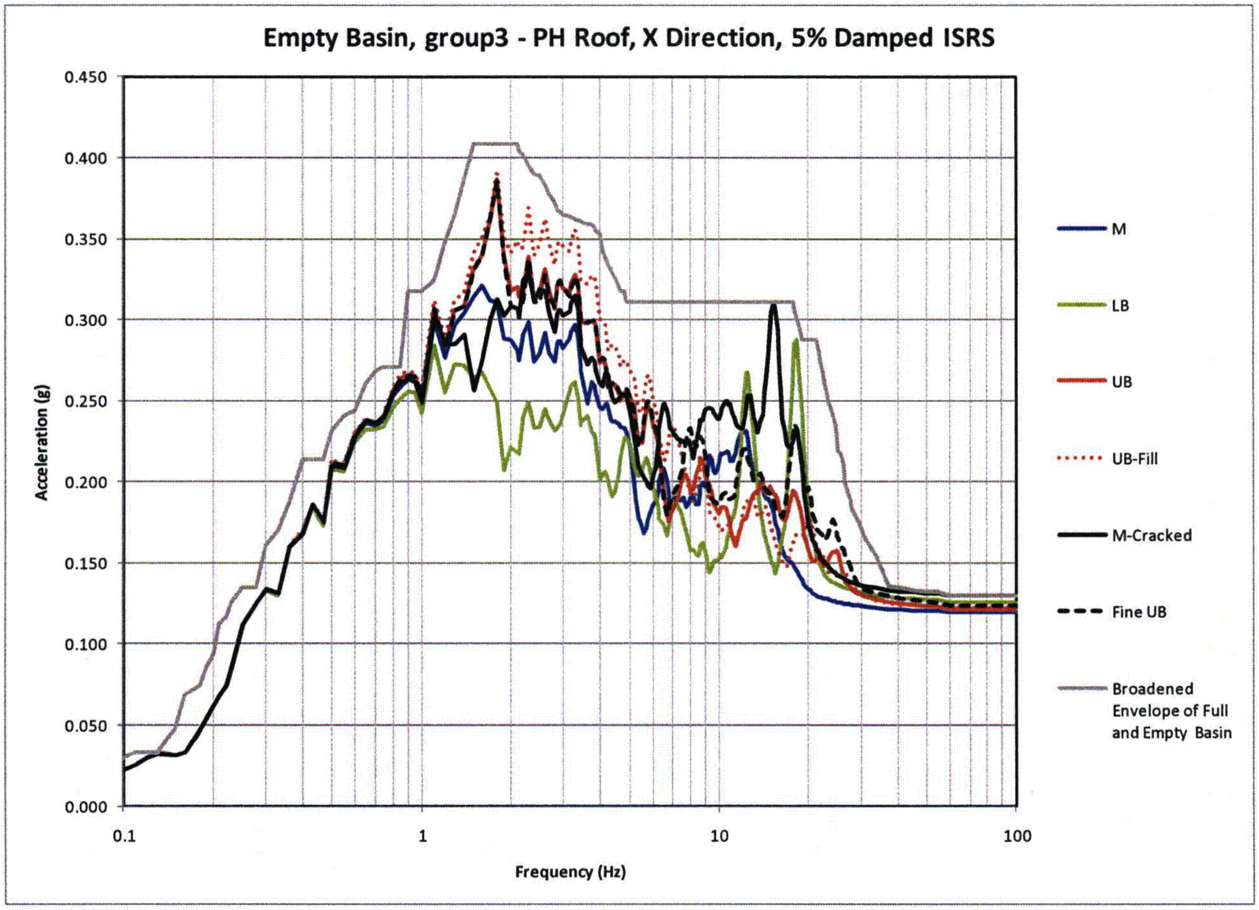


Figure 03.07.01-27 S3.F13: Empty Basin, group3 - PH Roof, X Direction, 5% Damped ISRS,

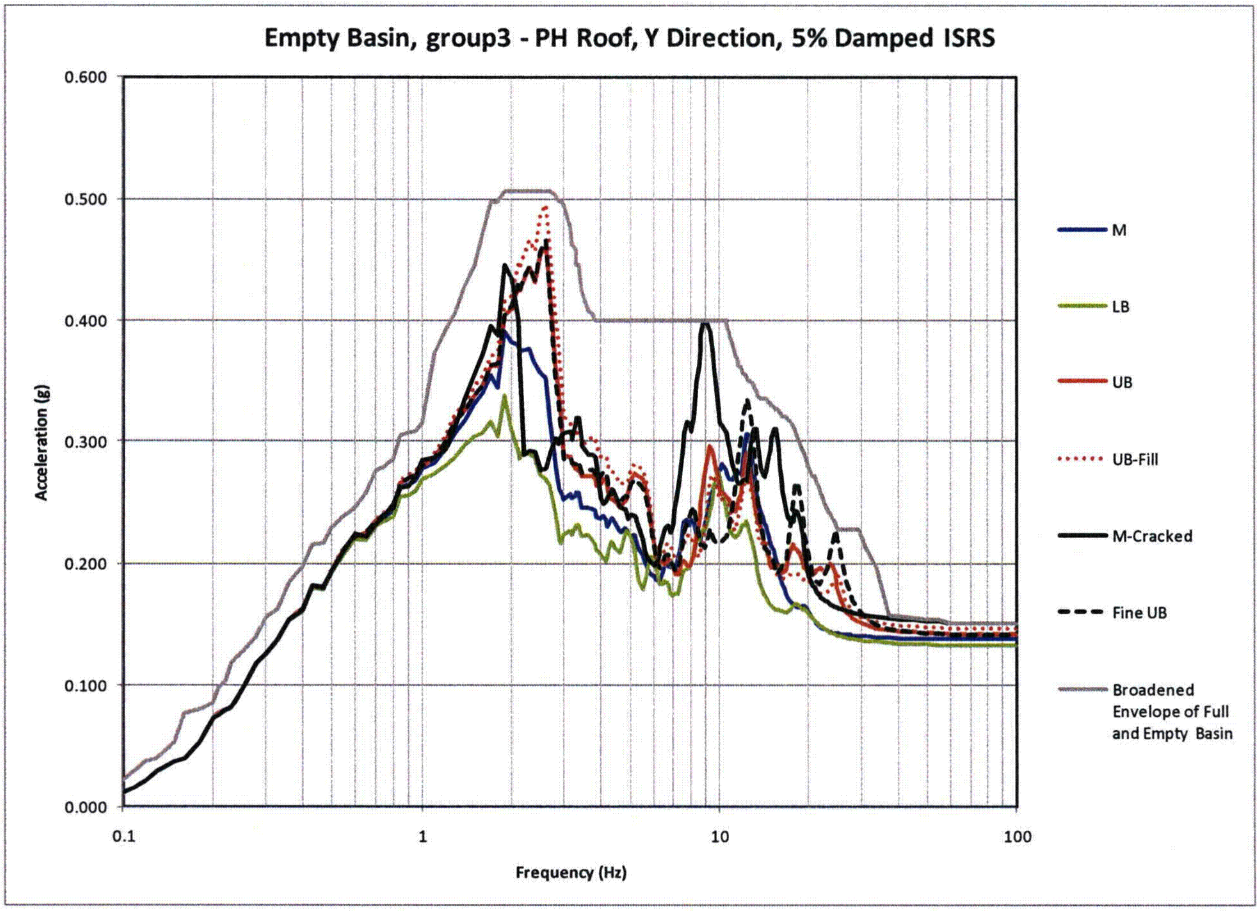


Figure 03.07.01-27 S3.F14: Empty Basin, group3 - PH Roof, Y Direction, 5% Damped ISRS,

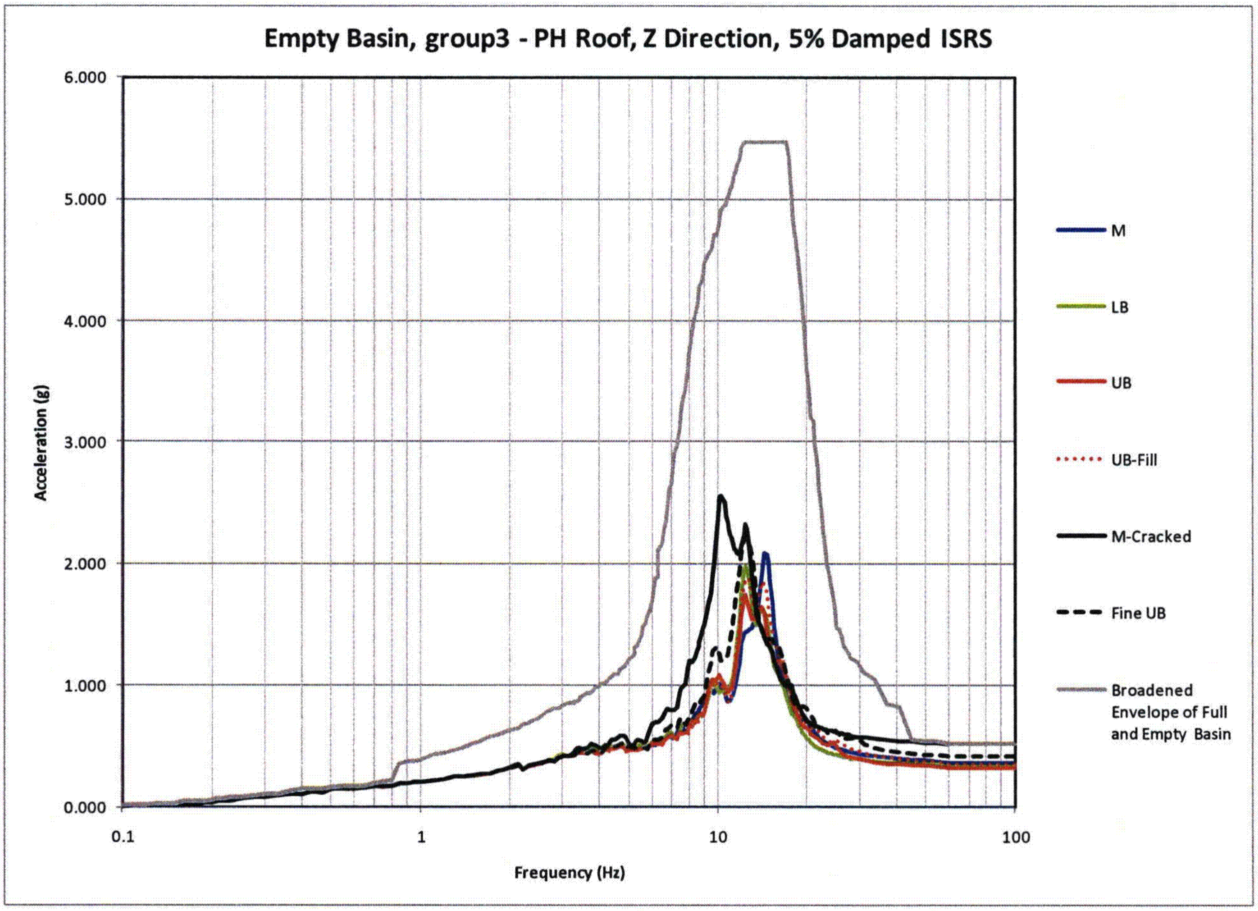


Figure 03.07.01-27 S3.F15: Empty Basin, group3 - PH Roof, Z Direction, 5% Damped ISRS,

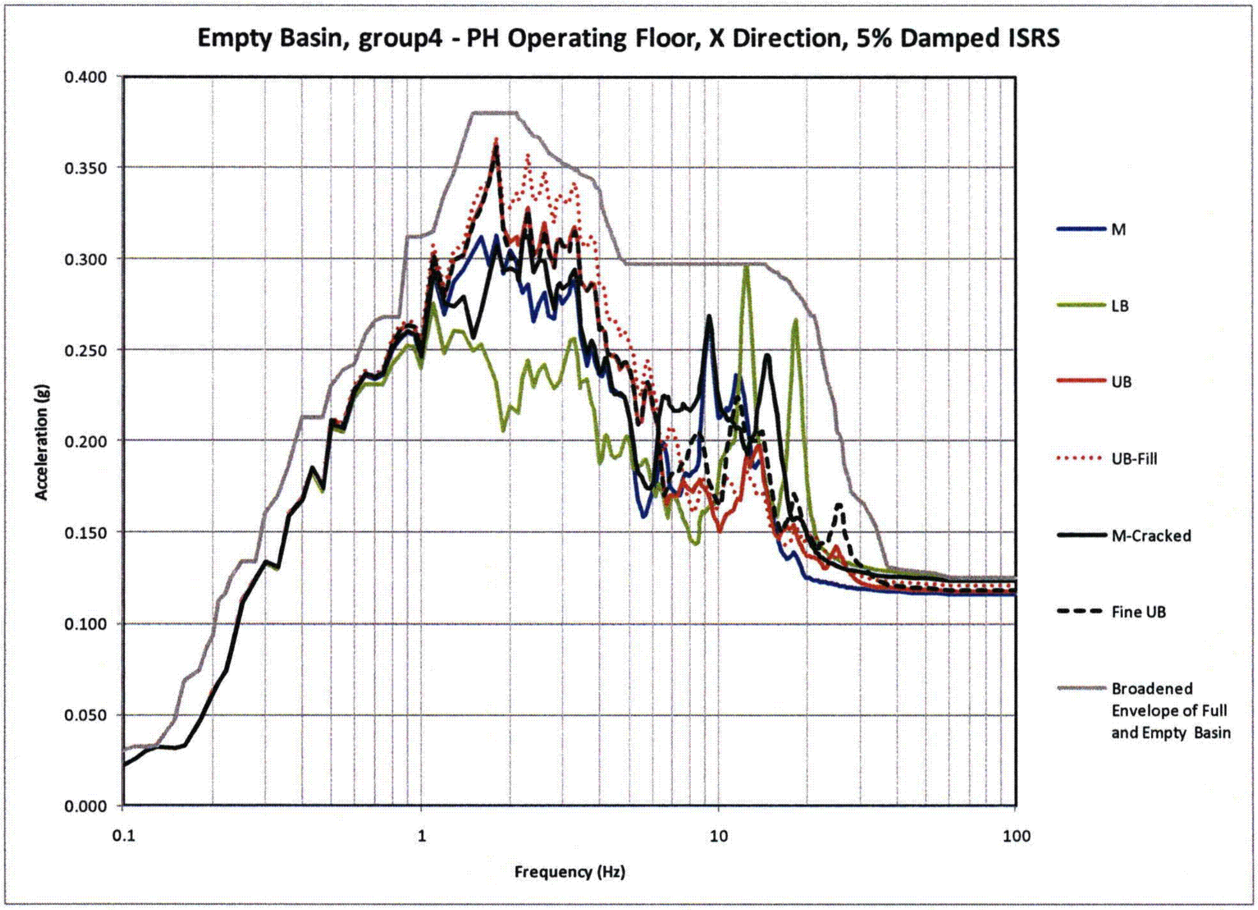


Figure 03.07.01-27 S3.F16: Empty Basin, group4 - PH Operating Floor, X Direction, 5% Damped ISRS,

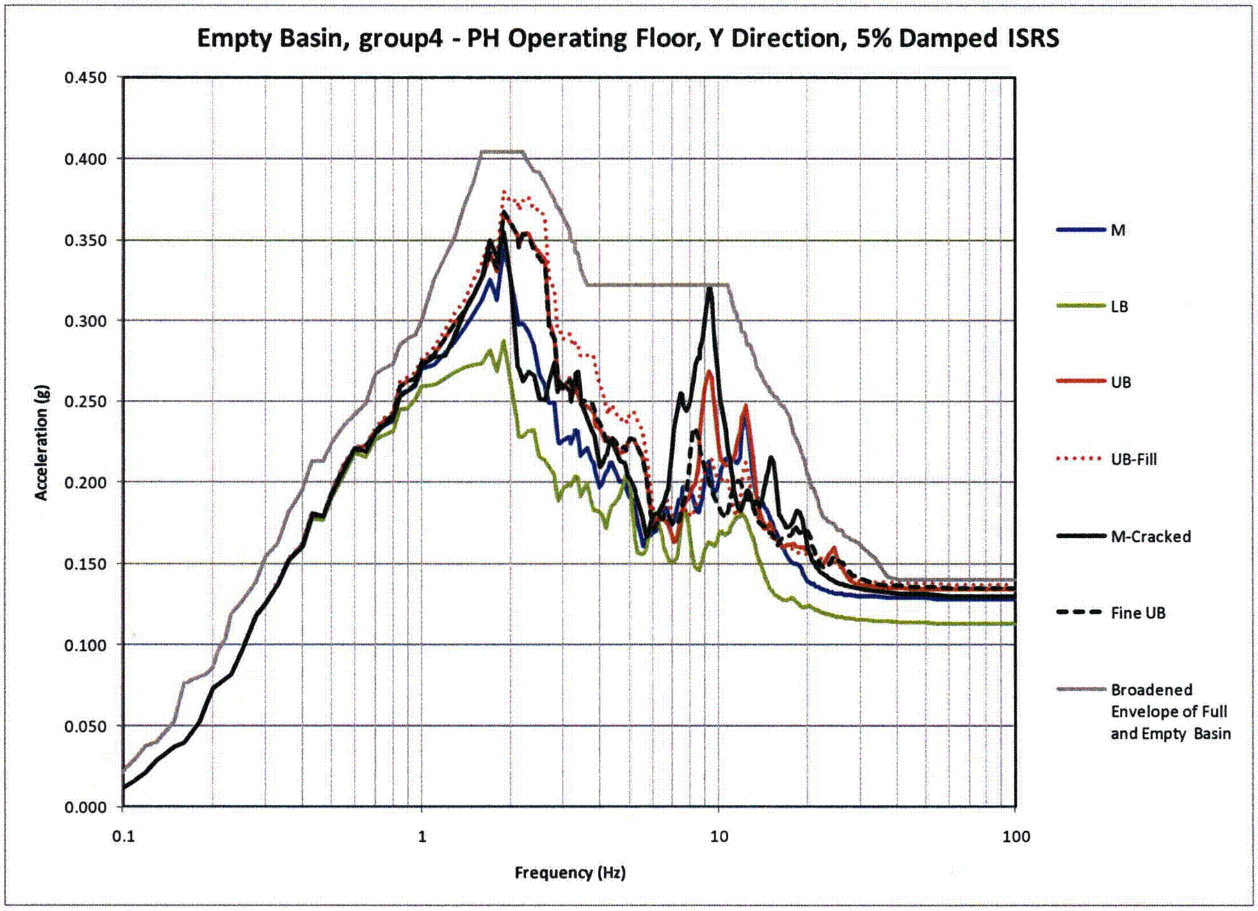


Figure 03.07.01-27 S3.F17: Empty Basin, group4 - PH Operating Floor, Y Direction, 5% Damped ISRS,

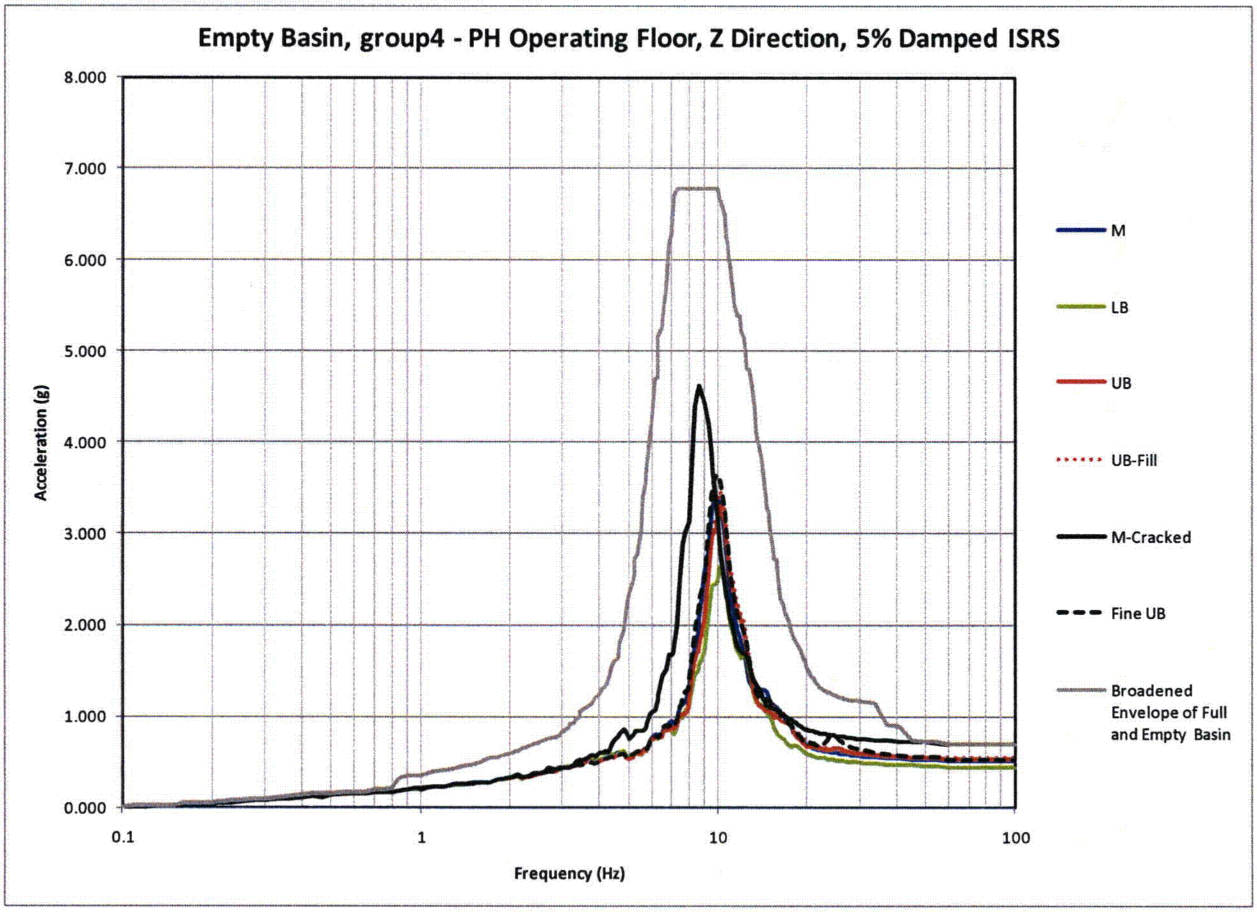


Figure 03.07.01-27 S3.F18: Empty Basin, group4 - PH Operating Floor, Z Direction, 5% Damped ISRS,

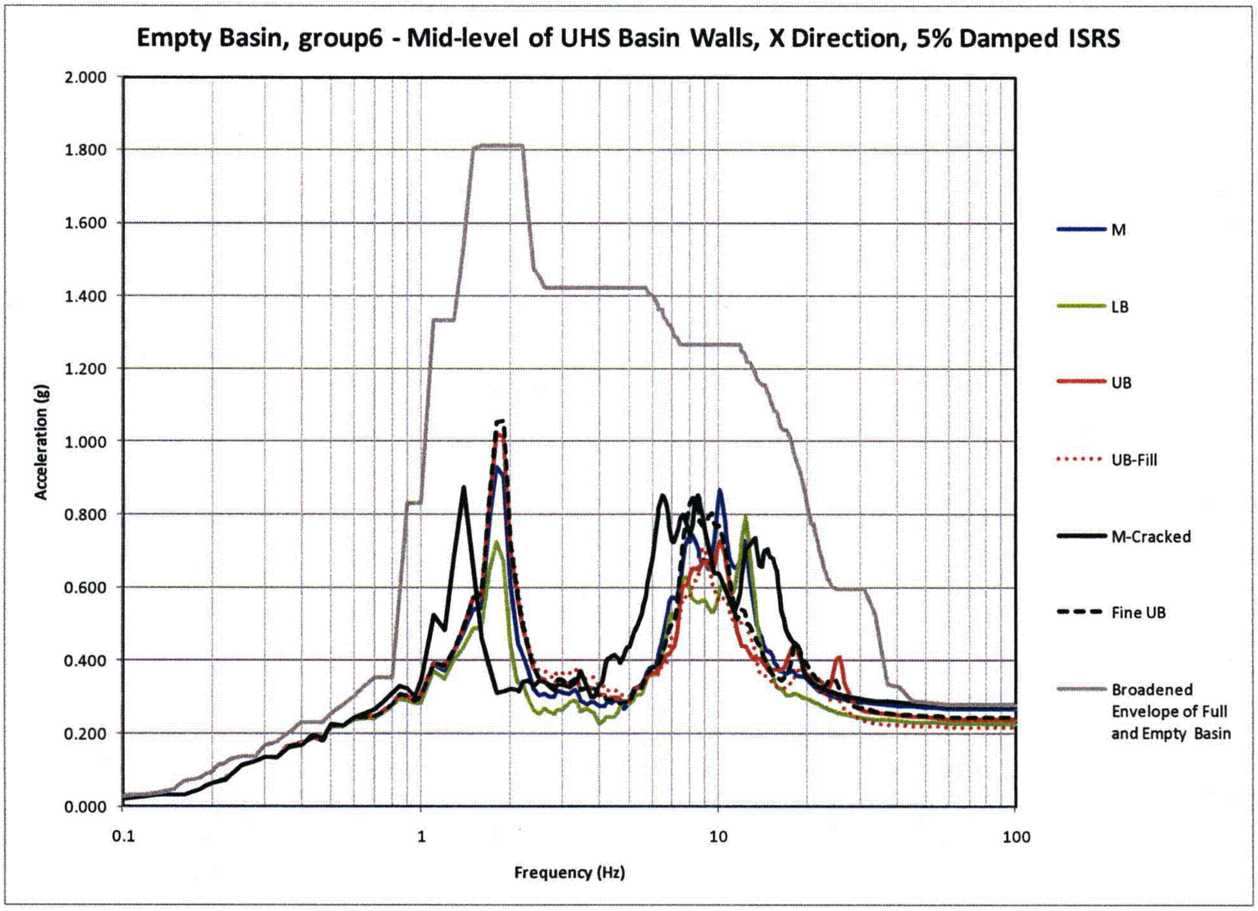


Figure 03.07.01-27 S3.F19: Empty Basin, group6 - Mid-level of UHS Basin Walls, X Direction, 5% Damped ISRS,

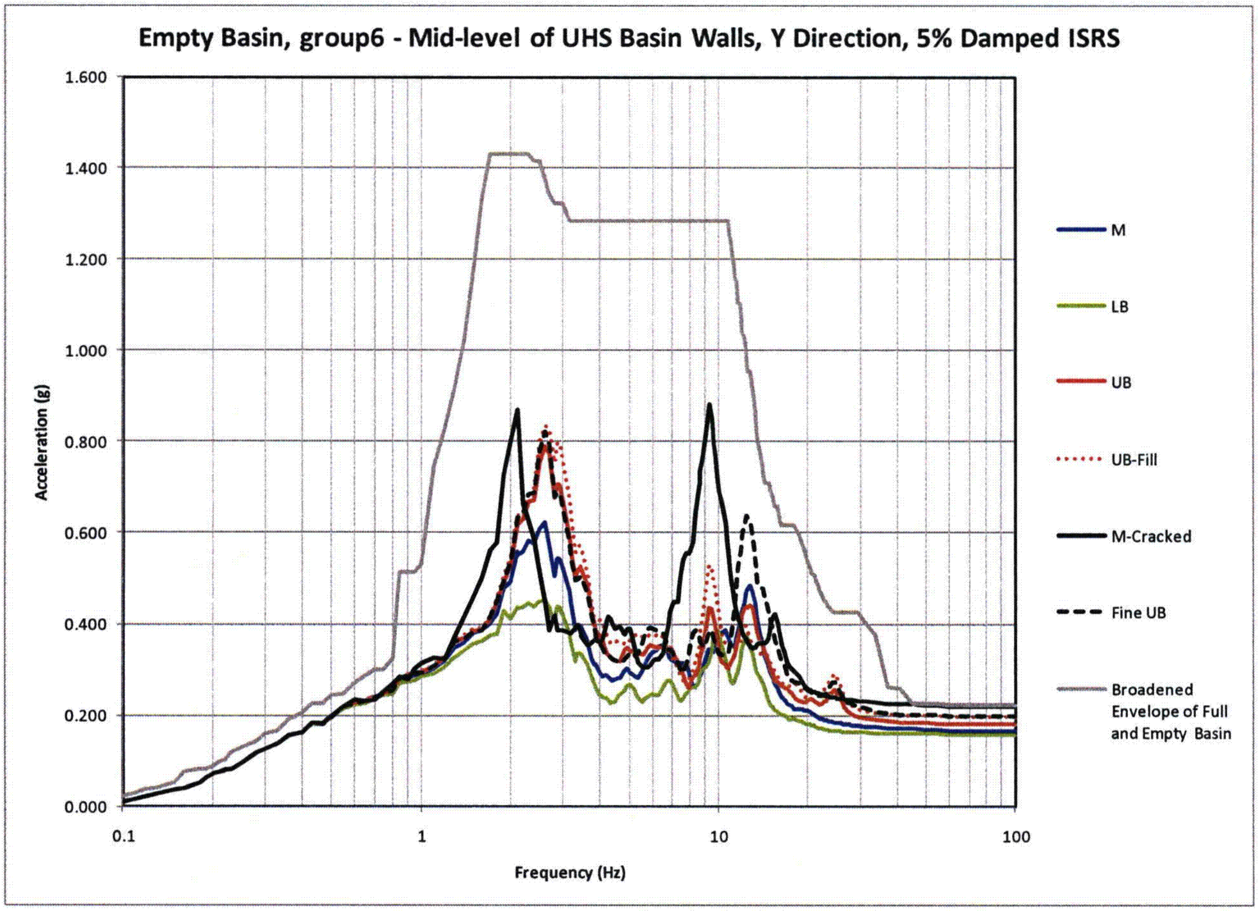


Figure 03.07.01-27 S3.F20: Empty Basin, group6 - Mid-level of UHS Basin Walls, Y Direction, 5% Damped ISRS,

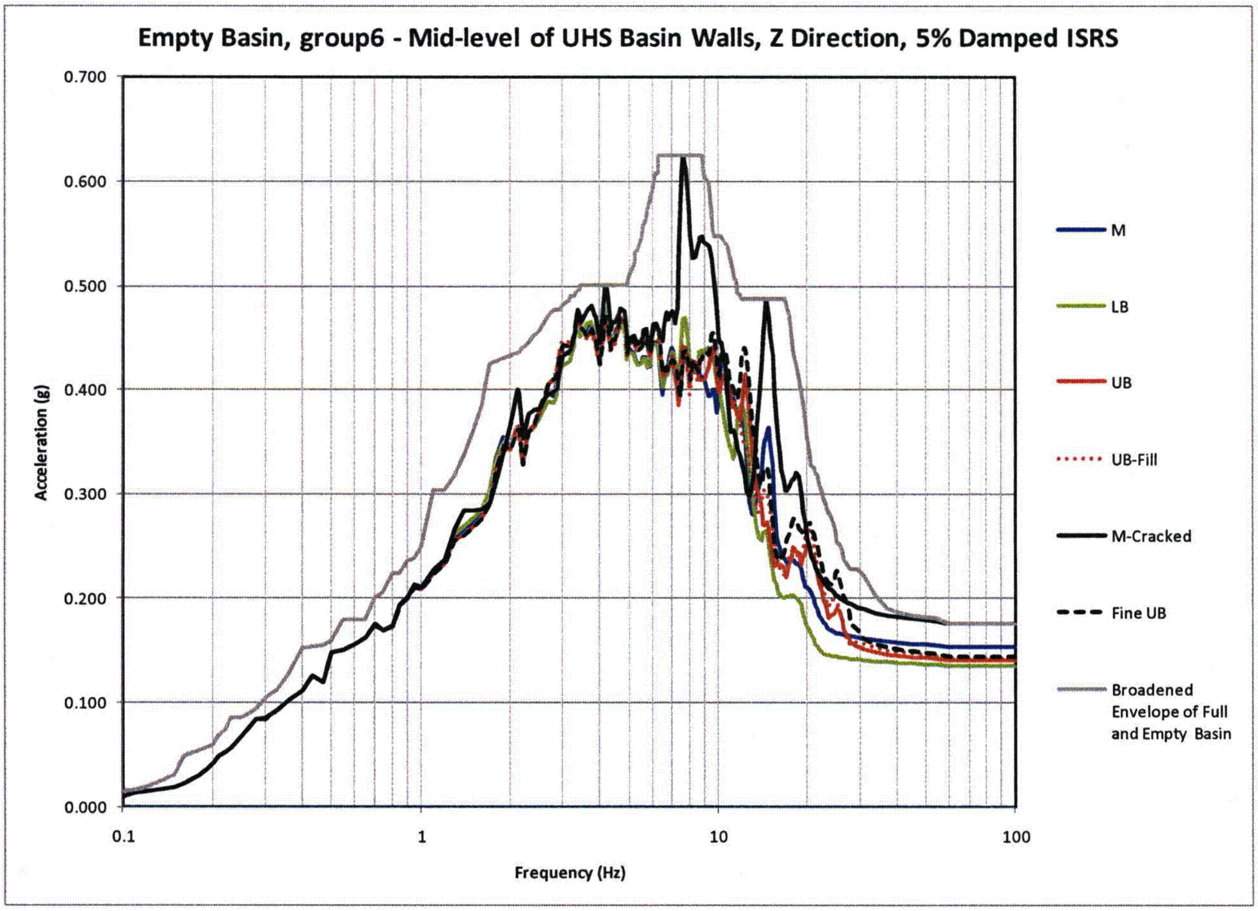


Figure 03.07.01-27 S3.F21: Empty Basin, group6 - Mid-level of UHS Basin Walls, Z Direction, 5% Damped ISRS,

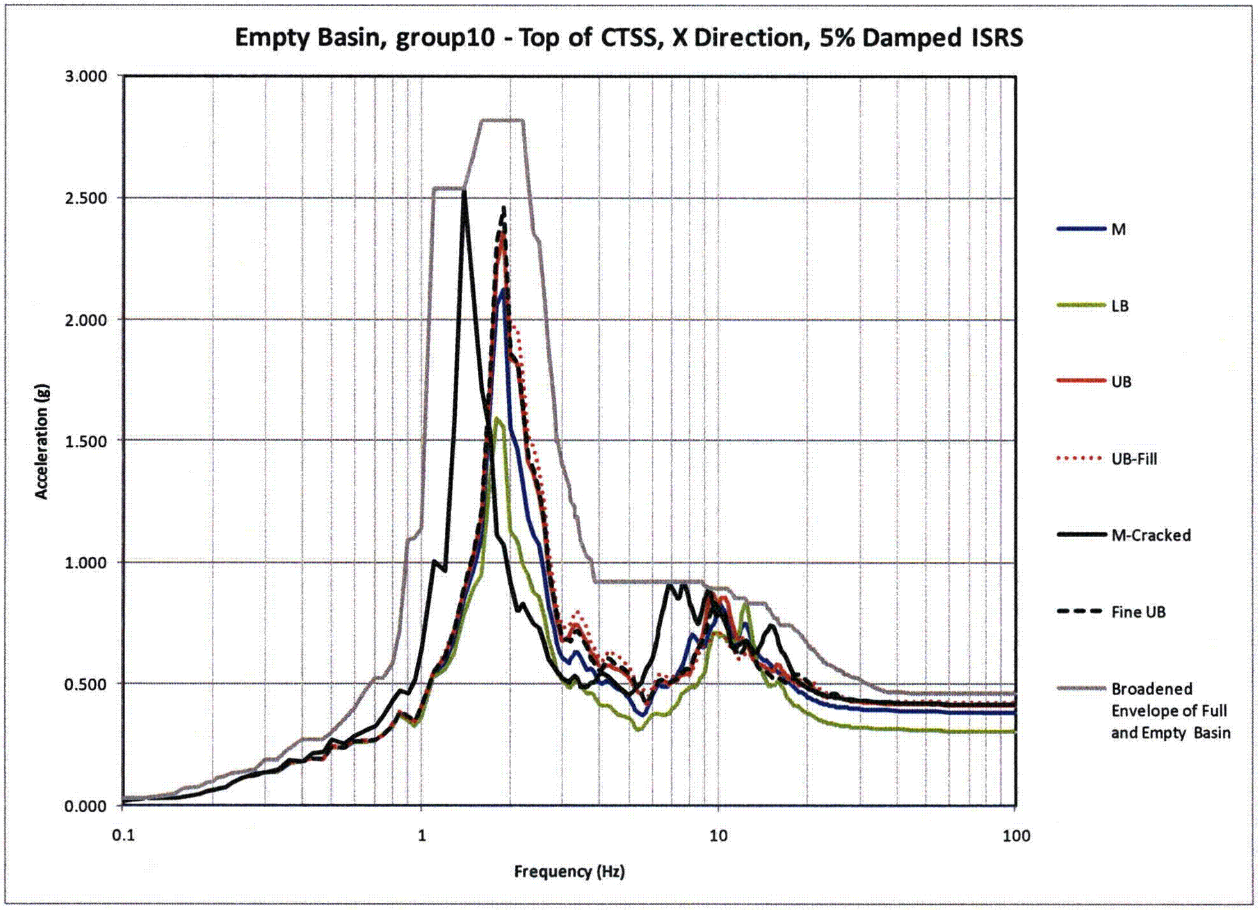


Figure 03.07.01-27 S3.F22: Empty Basin, group10 - Top of CTSS, X Direction, 5% Damped ISRS,

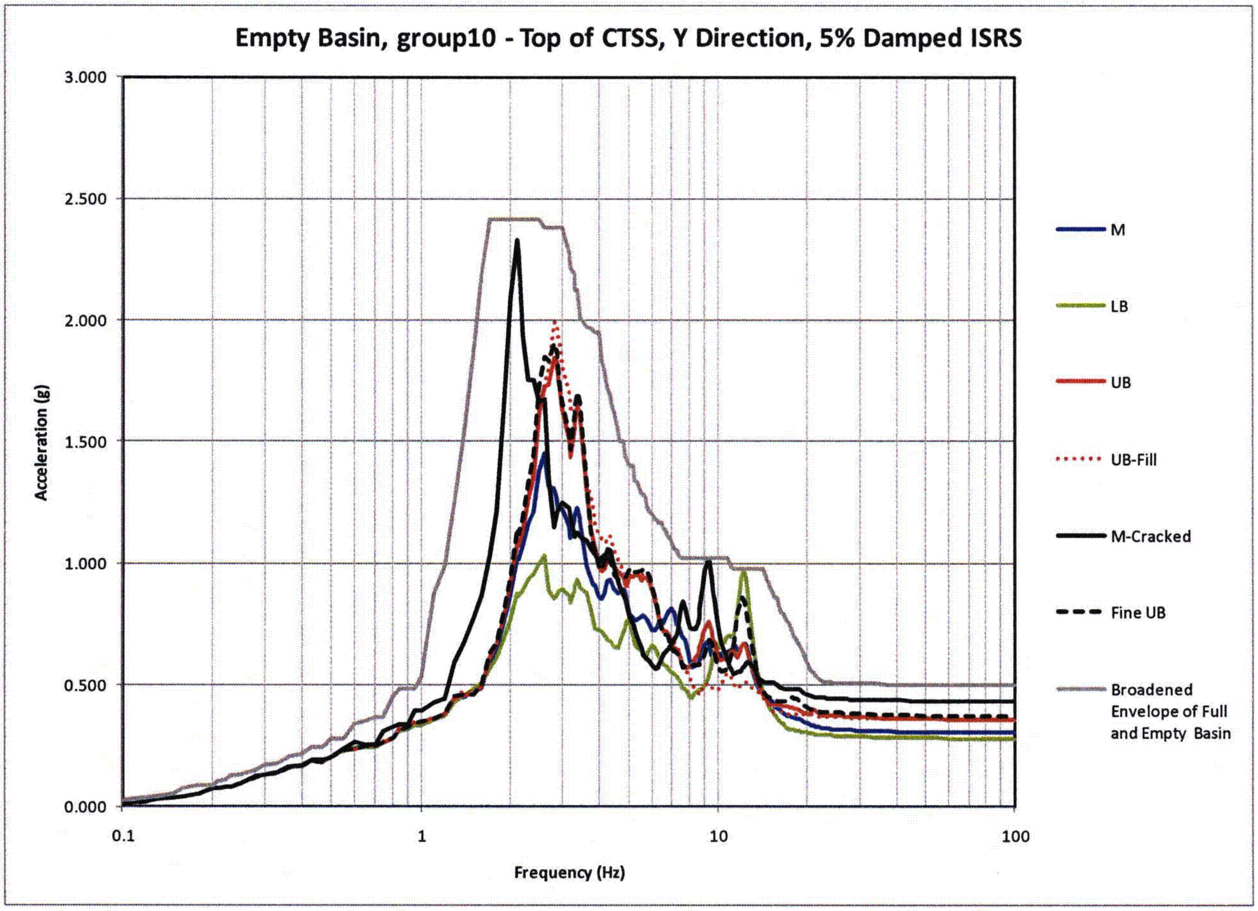


Figure 03.07.01-27 S3.F23: Empty Basin, group10 - Top of CTSS, Y Direction, 5% Damped ISRS,

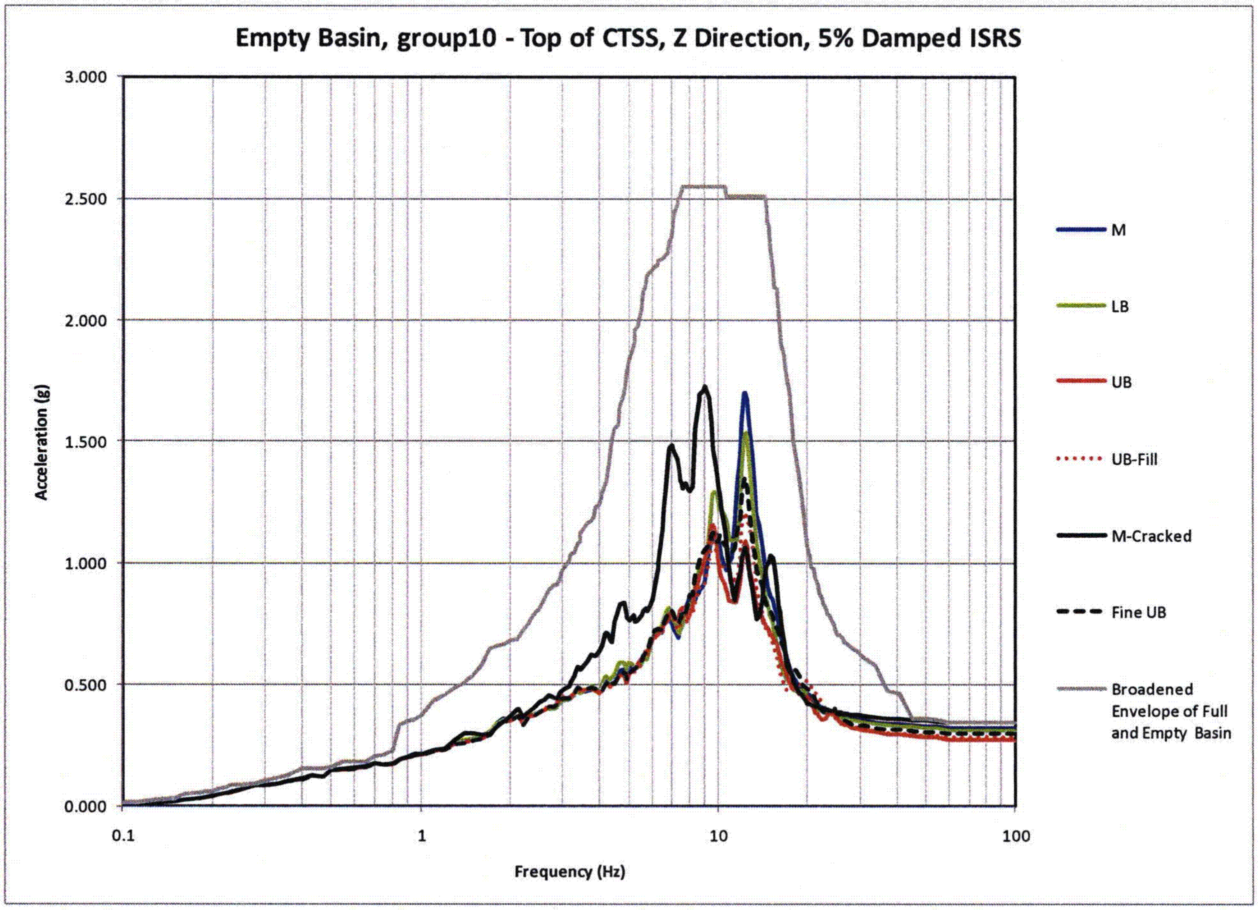
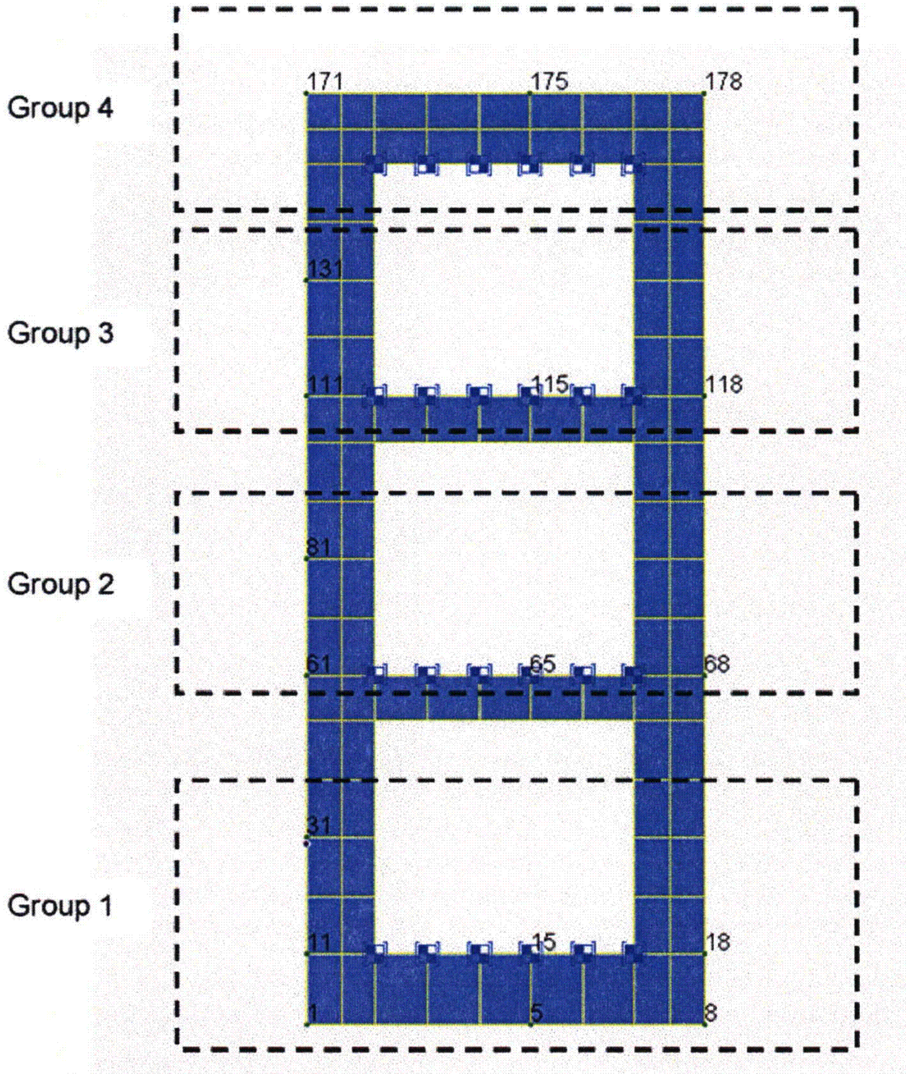


Figure 03.07.01-27 S3.F24: Empty Basin, group10 - Top of CTSS, Z Direction, 5% Damped ISRS,



NOTE: Group 5 is the group of all output nodes.

Figure 03.07.01-27 S3.F25: RSW Tunnel SSI Model – Structure Only, Output Nodes and Groups Labled.

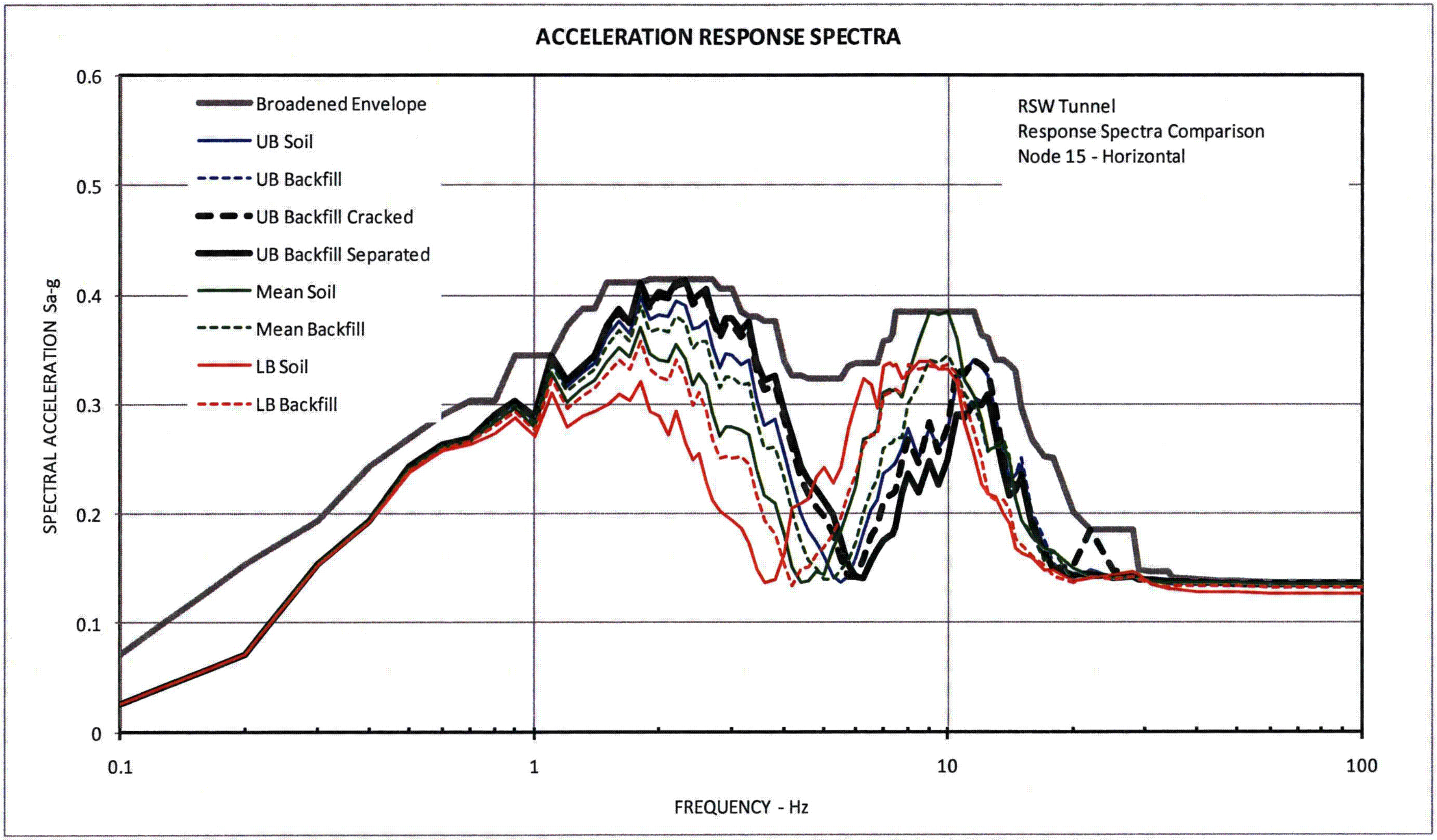


Figure 03.07.01-27 S3.F26: RSW Tunnel, Response Spectra Comparison, Node 15 - Horizontal

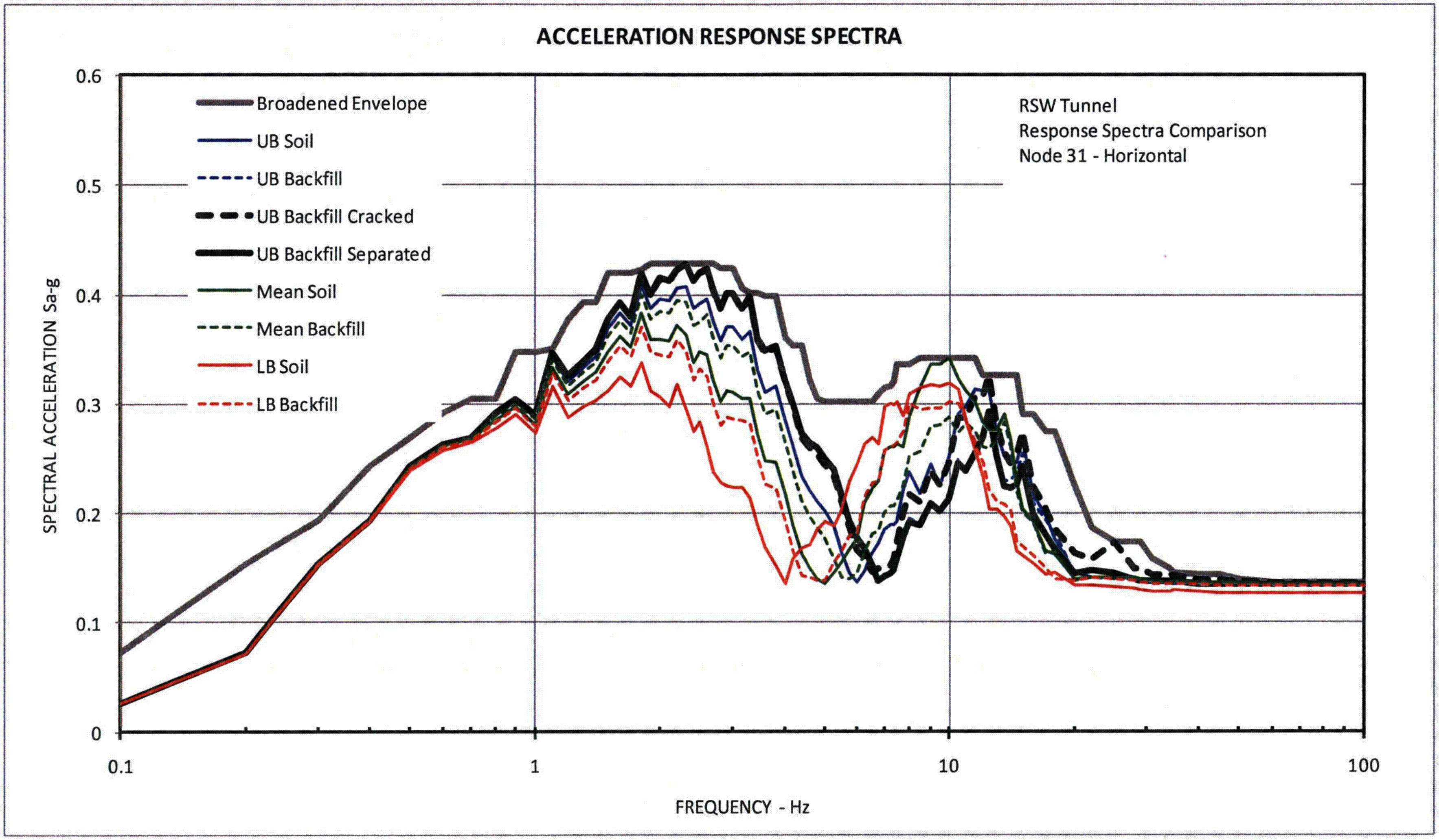


Figure 03.07.01-27 S3.F27: RSW Tunnel, Response Spectra Comparison, Node 31 - Horizontal

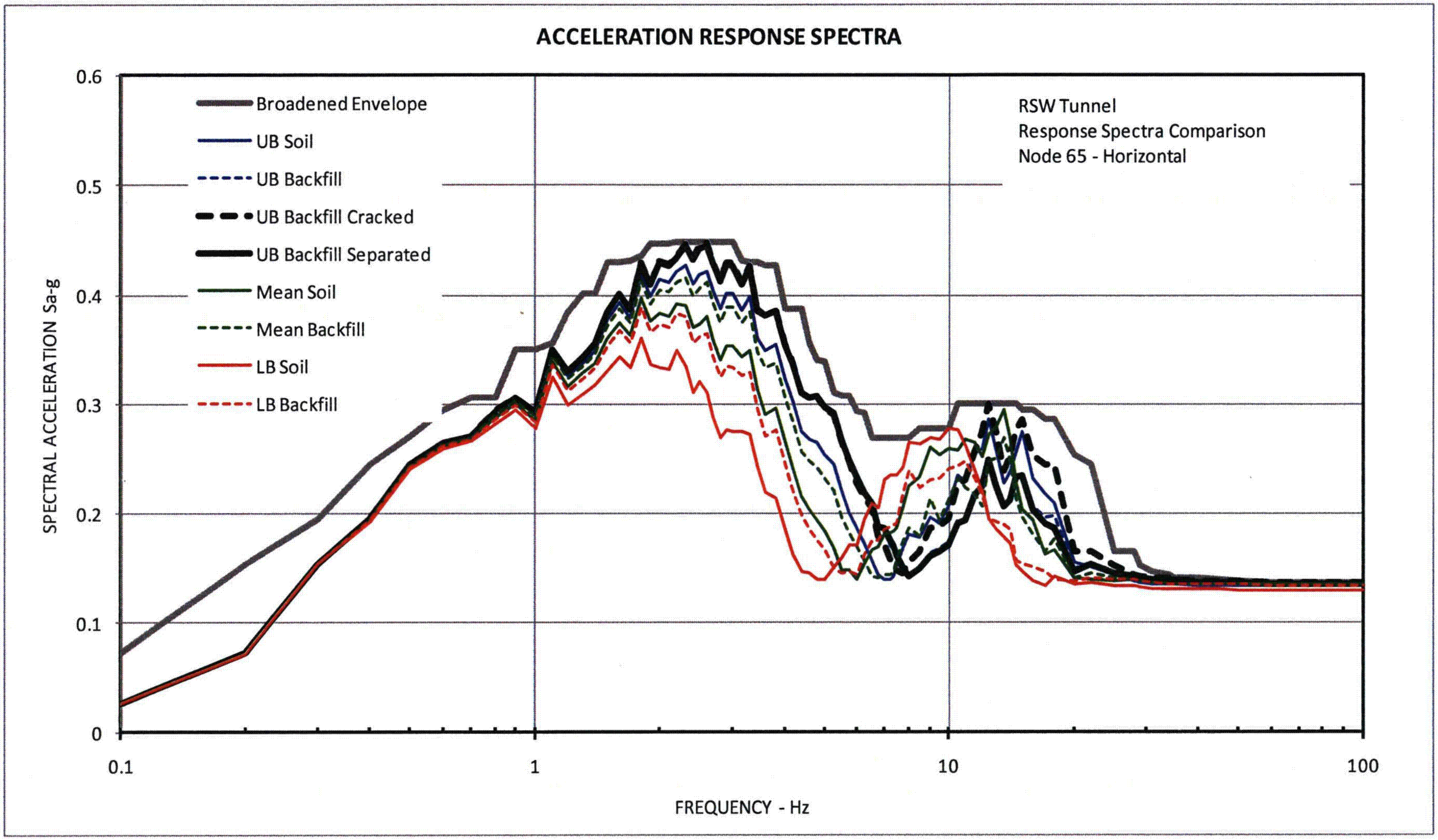


Figure 03.07.01-27 S3.F28: RSW Tunnel, Response Spectra Comparison, Node 65 - Horizontal

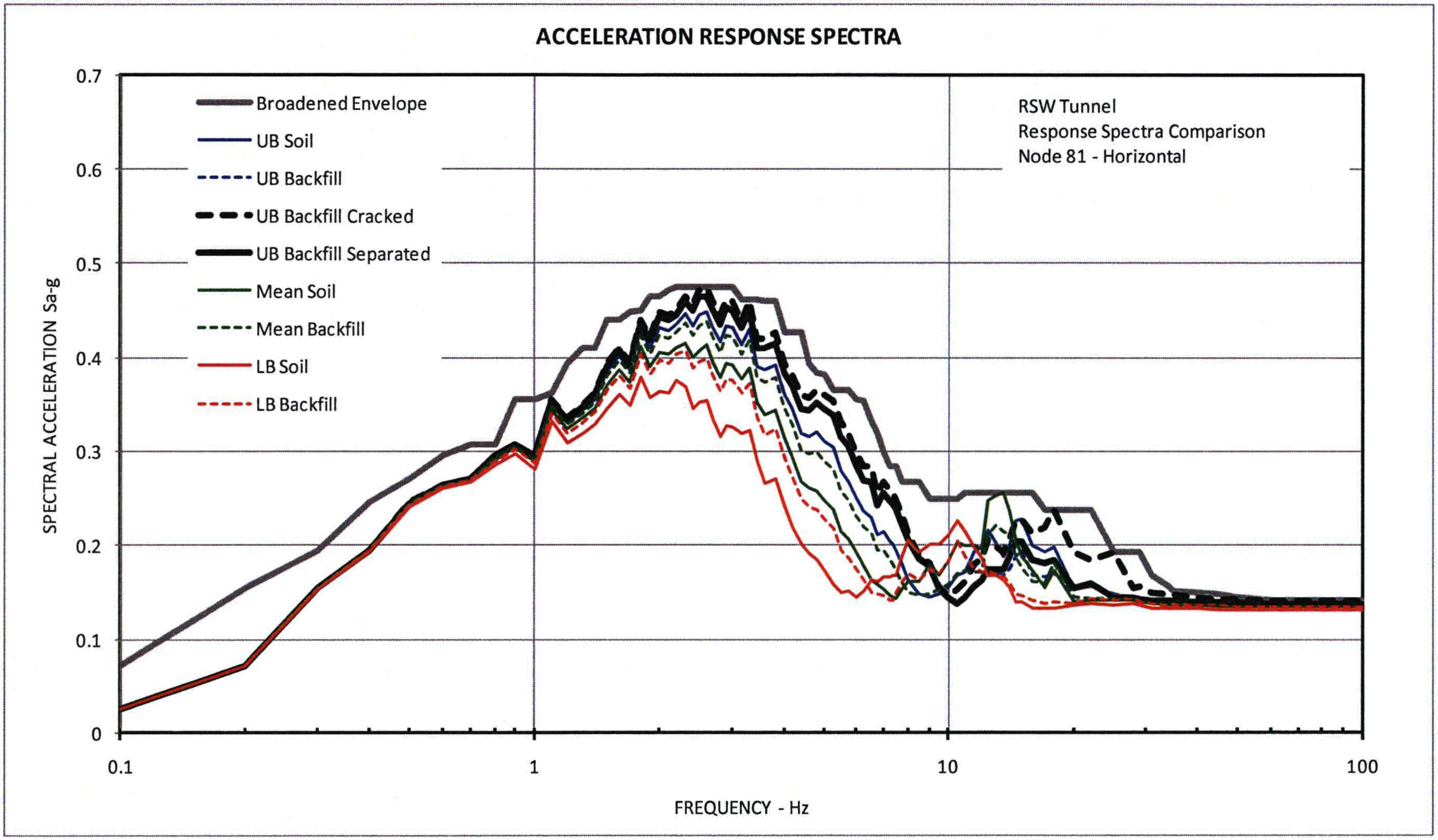


Figure 03.07.01-27 S3.F29: RSW Tunnel, Response Spectra Comparison, Node 81 - Horizontal

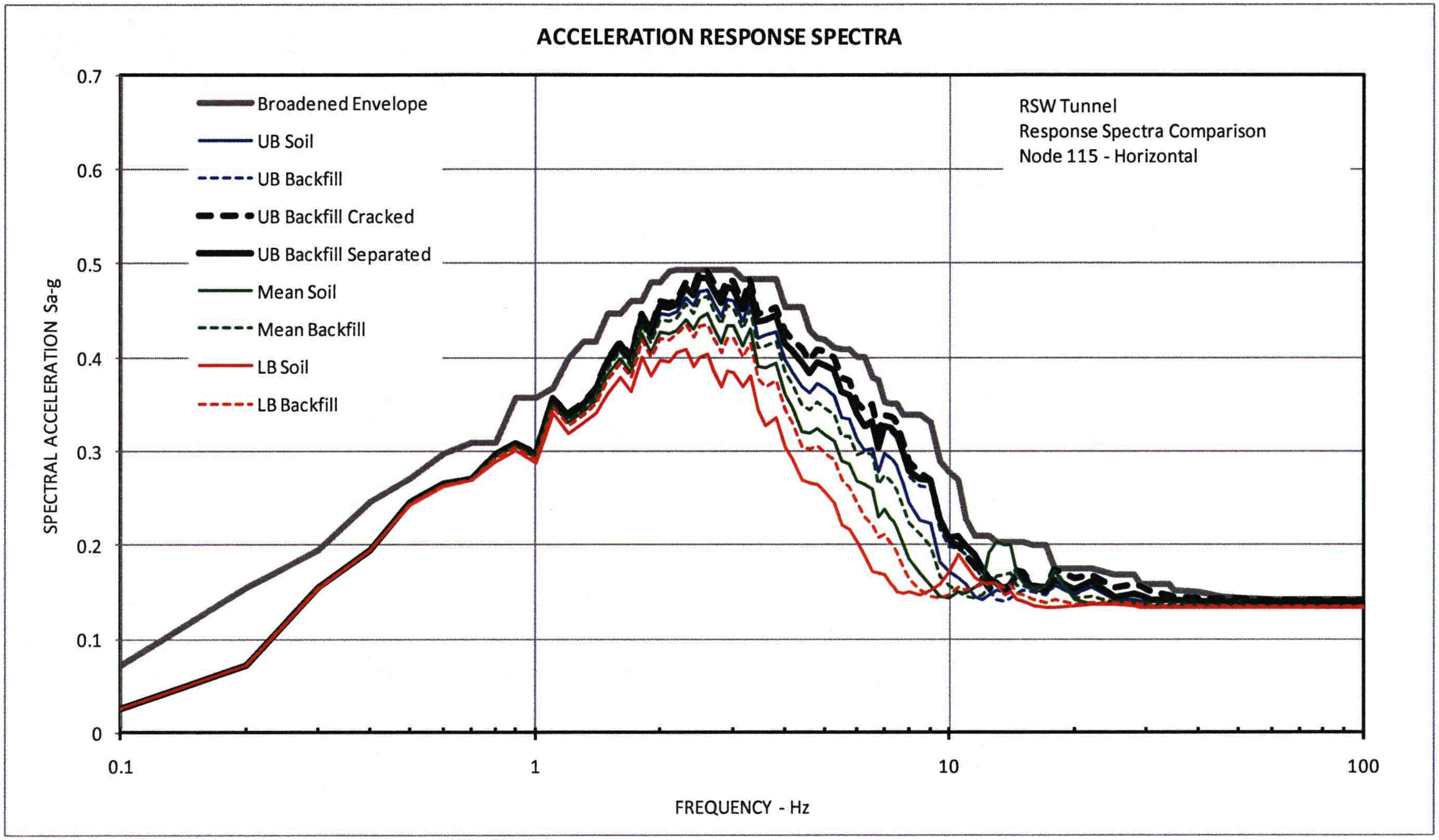


Figure 03.07.01-27 S3.F30: RSW Tunnel, Response Spectra Comparison, Node 115 - Horizontal

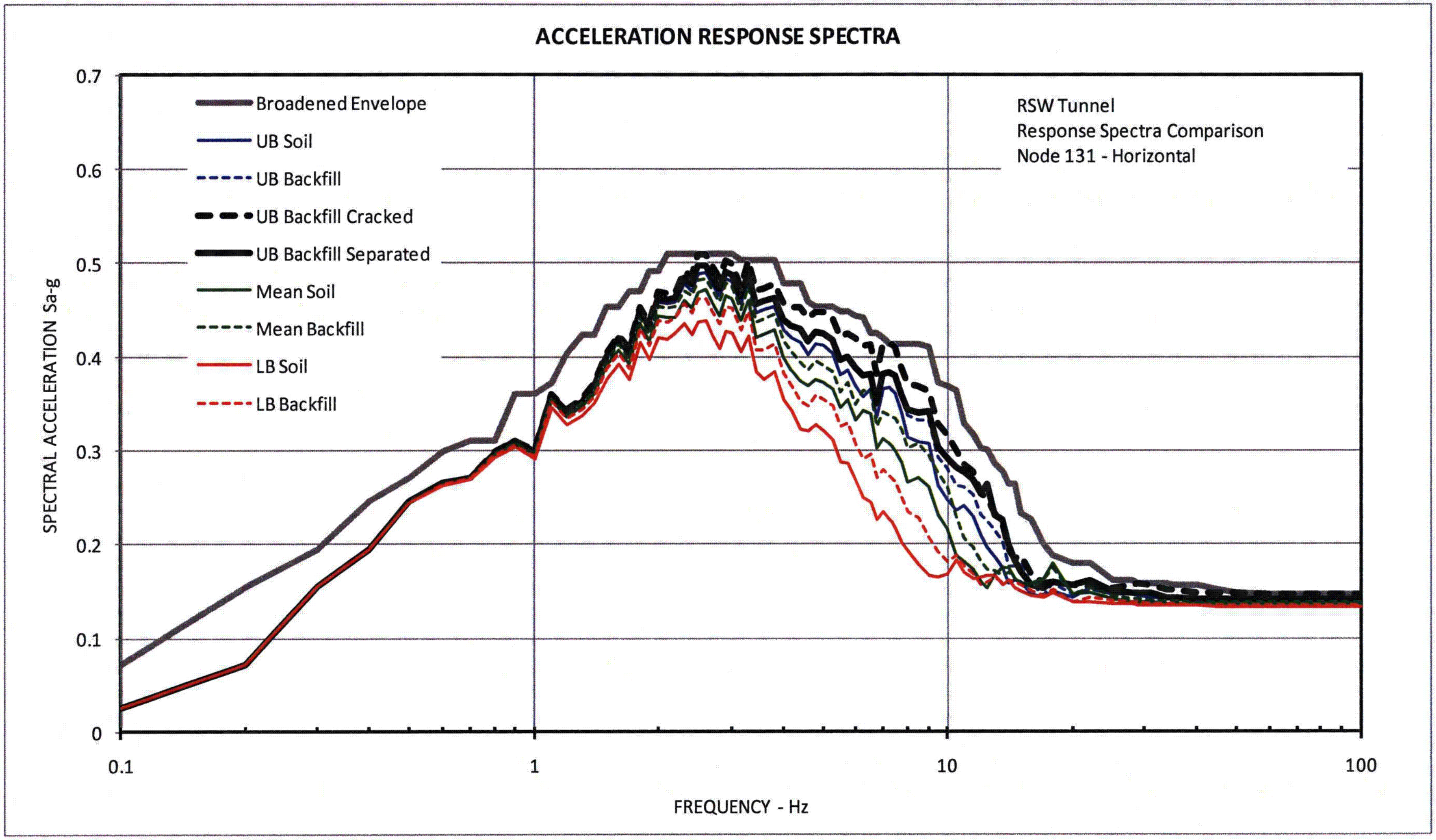


Figure 03.07.01-27 S3.F31: RSW Tunnel, Response Spectra Comparison, Node 131 - Horizontal

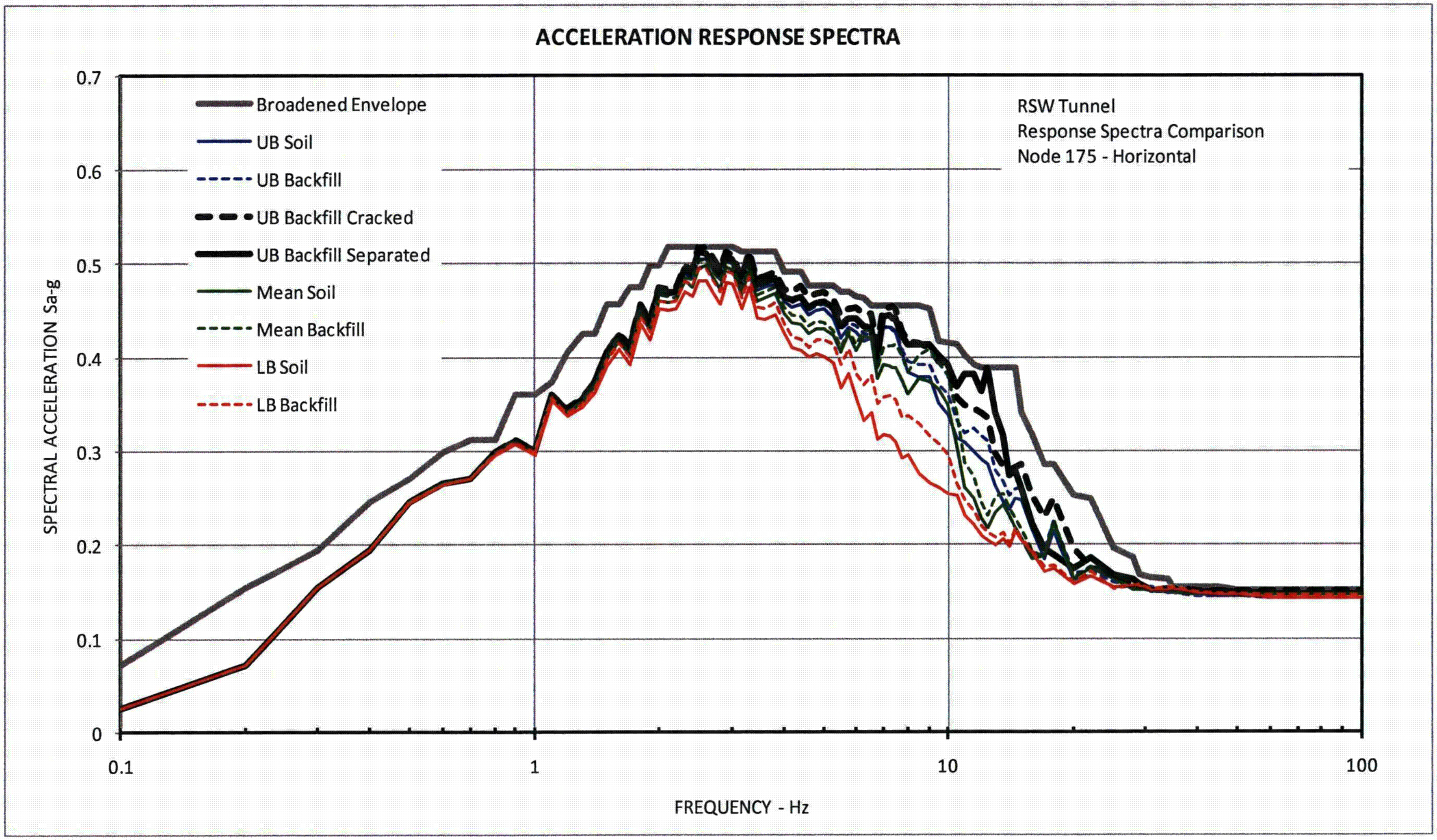


Figure 03.07.01-27 S3.F32: RSW Tunnel, Response Spectra Comparison, Node 175 - Horizontal

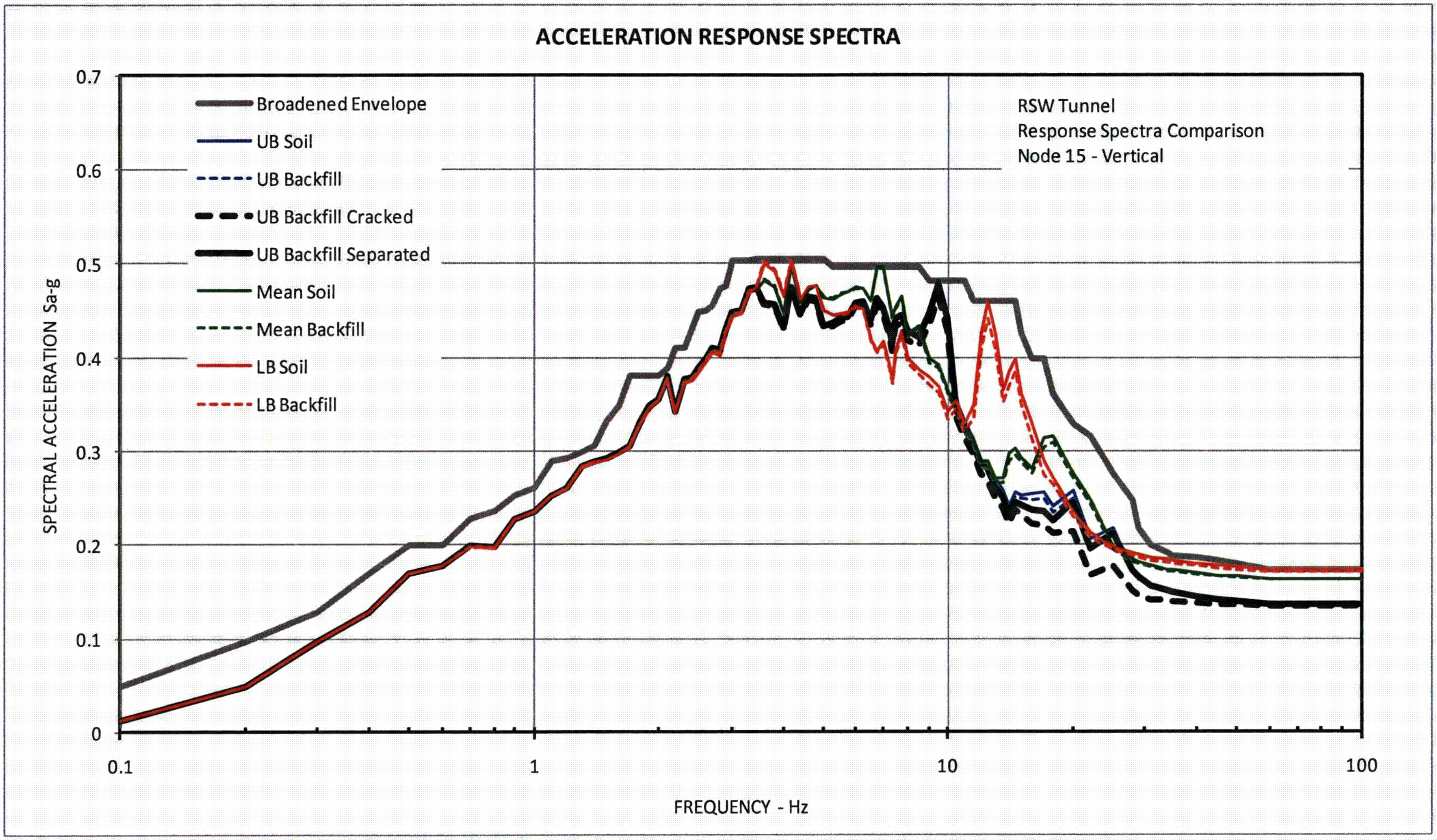


Figure 03.07.01-27 S3.F33: RSW Tunnel, Response Spectra Comparison, Node 15 - Vertical

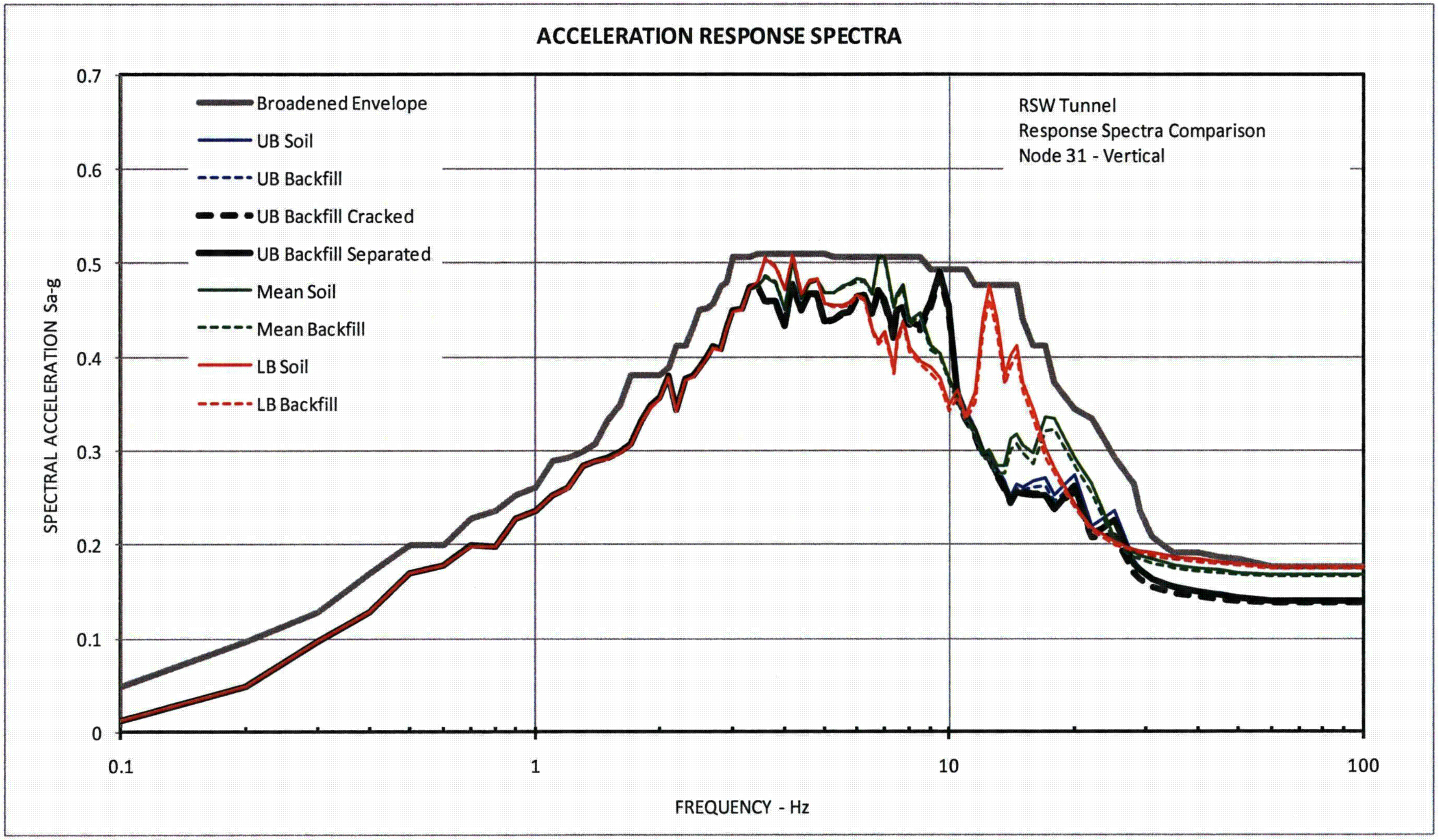


Figure 03.07.01-27 S3.F34: RSW Tunnel, Response Spectra Comparison, Node 31 - Vertical

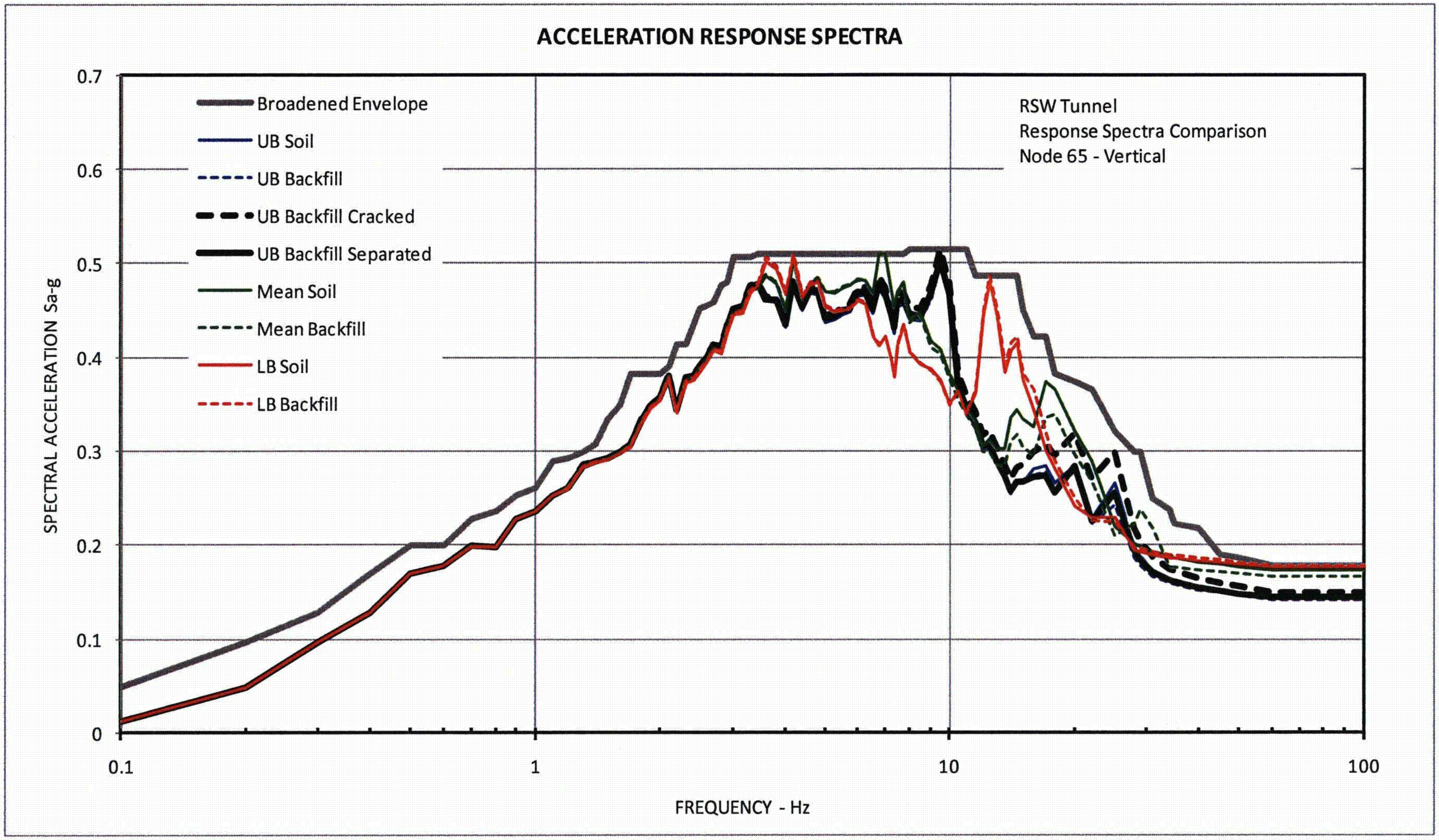


Figure 03.07.01-27 S3.F35: RSW Tunnel, Response Spectra Comparison, Node 65 - Vertical

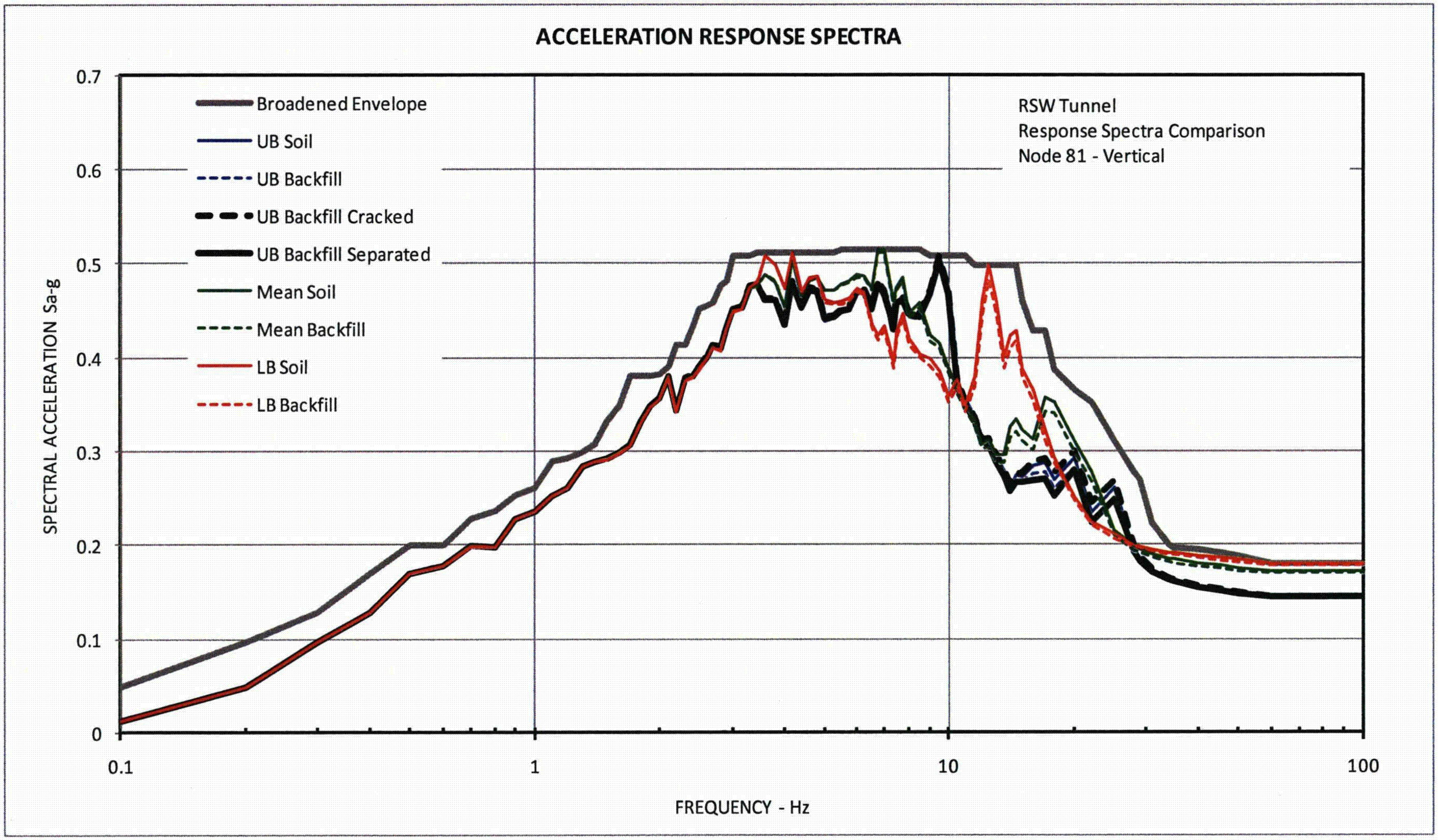


Figure 03.07.01-27 S3.F36: RSW Tunnel, Response Spectra Comparison, Node 81 - Vertical

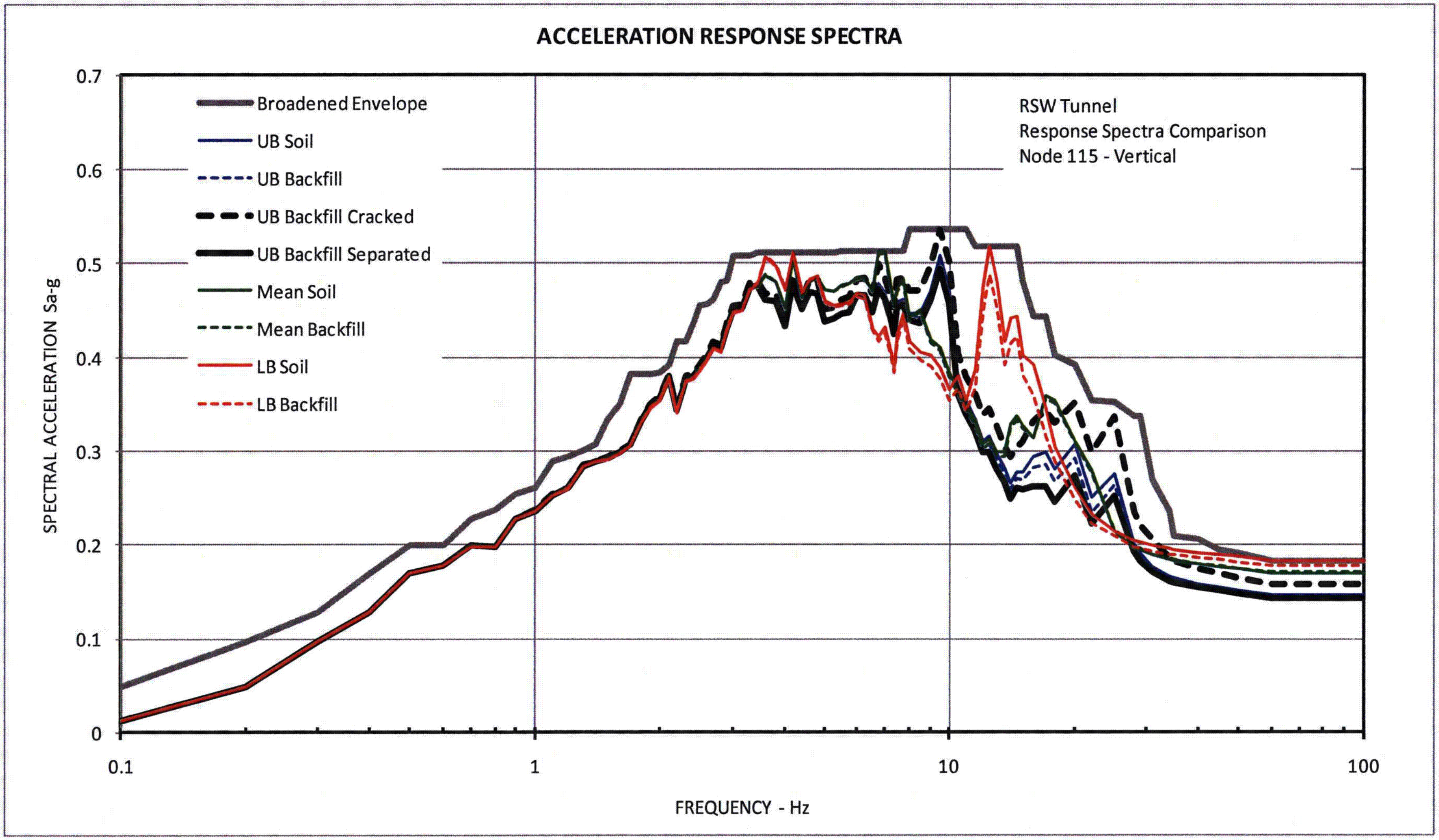


Figure 03.07.01-27 S3.F37: RSW Tunnel, Response Spectra Comparison, Node 115 - Vertical

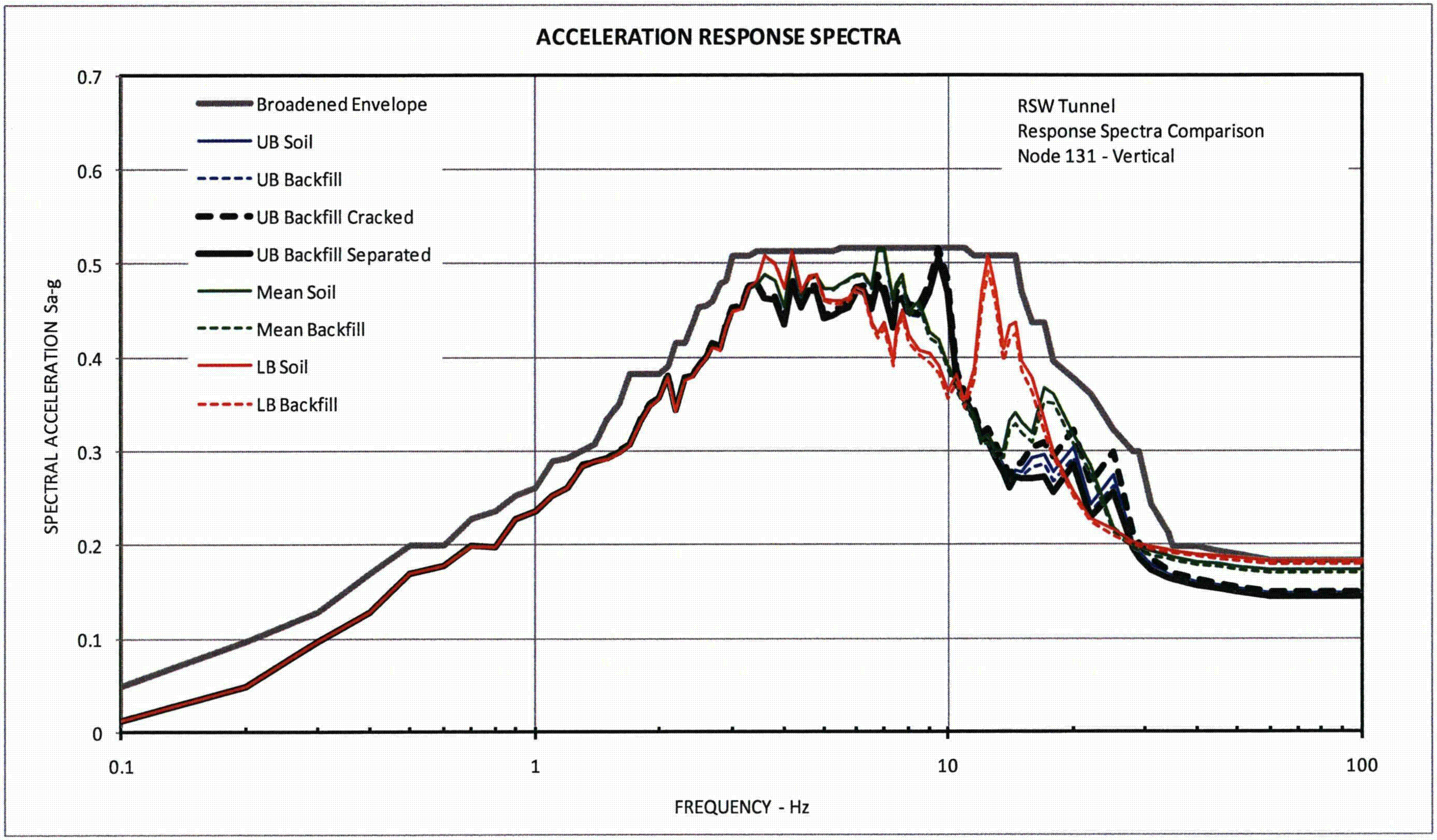


Figure 03.07.01-27 S3.F38: RSW Tunnel, Response Spectra Comparison, Node 131 - Vertical

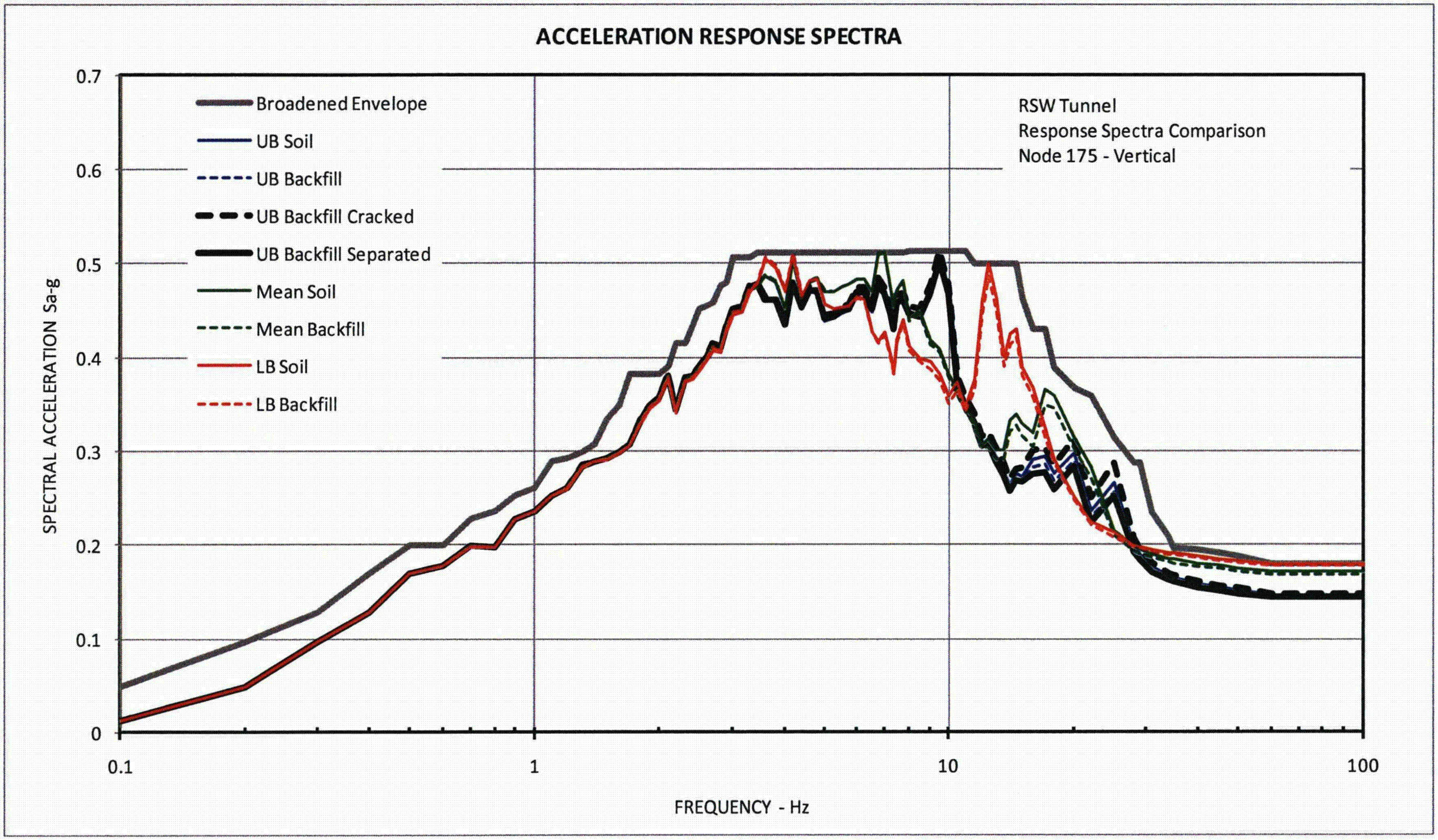


Figure 03.07.01-27 S3.F39: RSW Tunnel, Response Spectra Comparison, Node 175 - Vertical

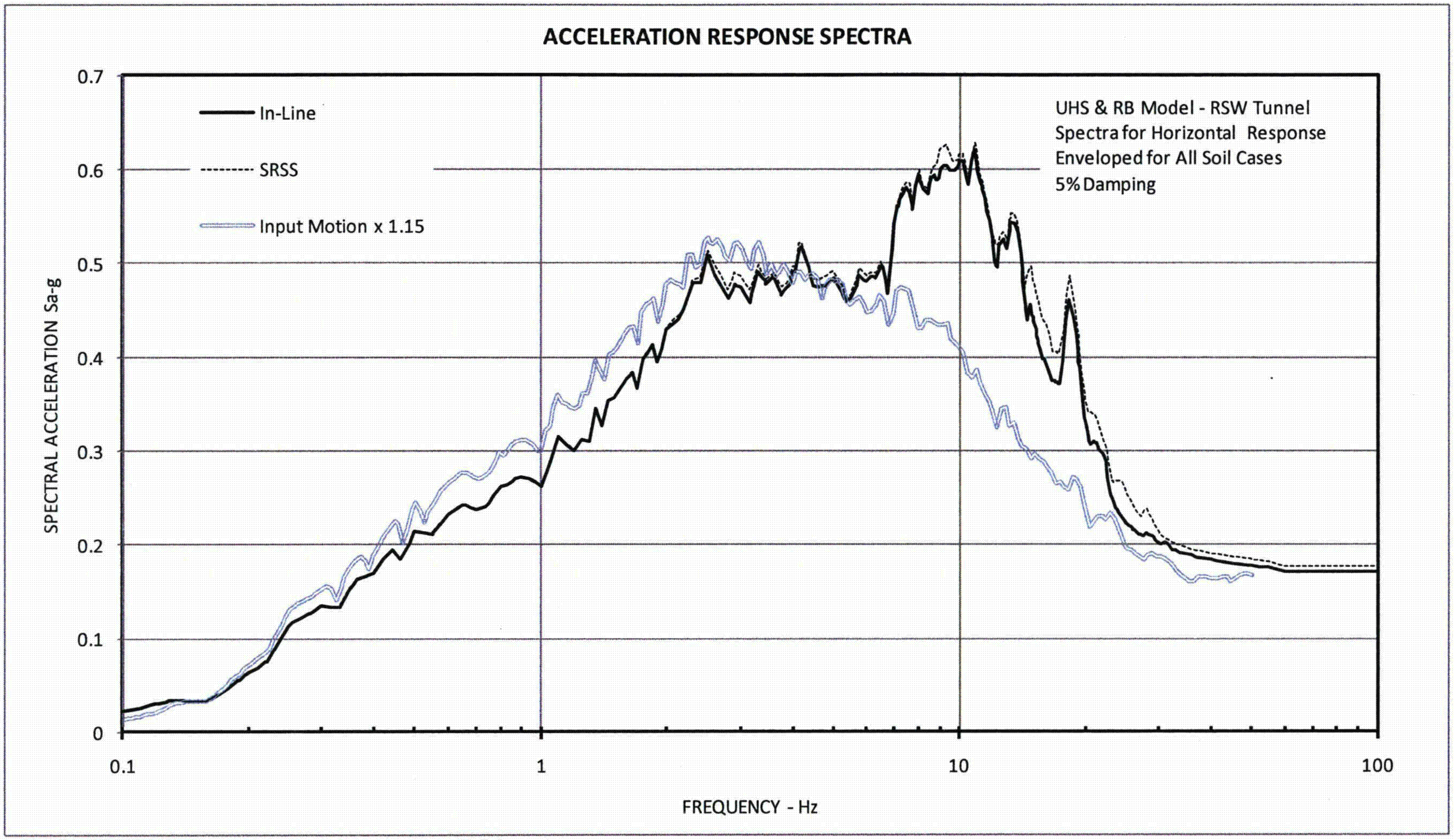


Figure 03.07.01-27 S3.F40 - Horizontal spectra, 5% damping, envelope of RSW Tunnel nodes from UHS and RB analyses.

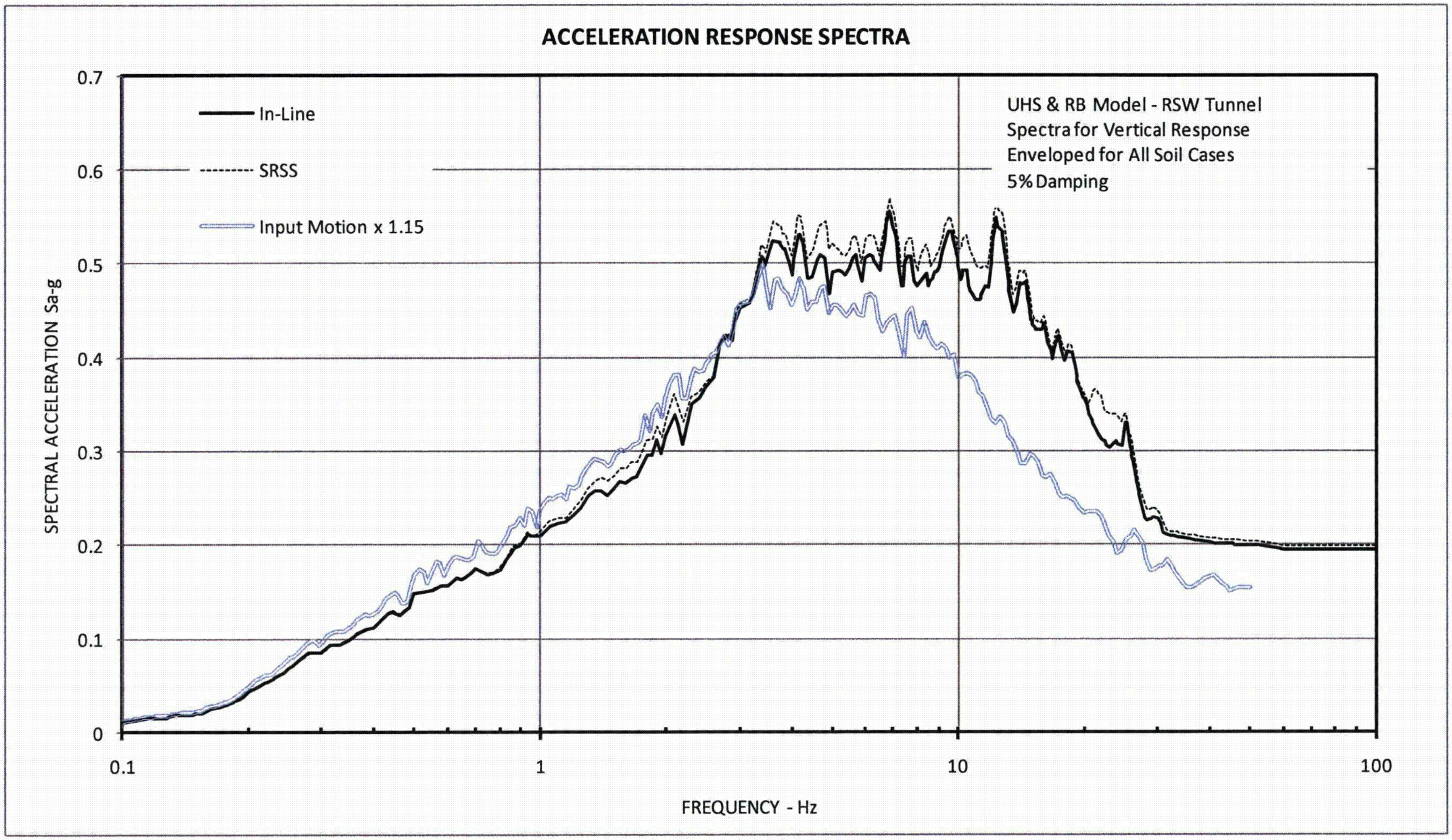


Figure 03.07.01-27 S3.F41 - Vertical spectra, 5% damping, envelope of RSW Tunnel nodes from UHS and RB analyses.

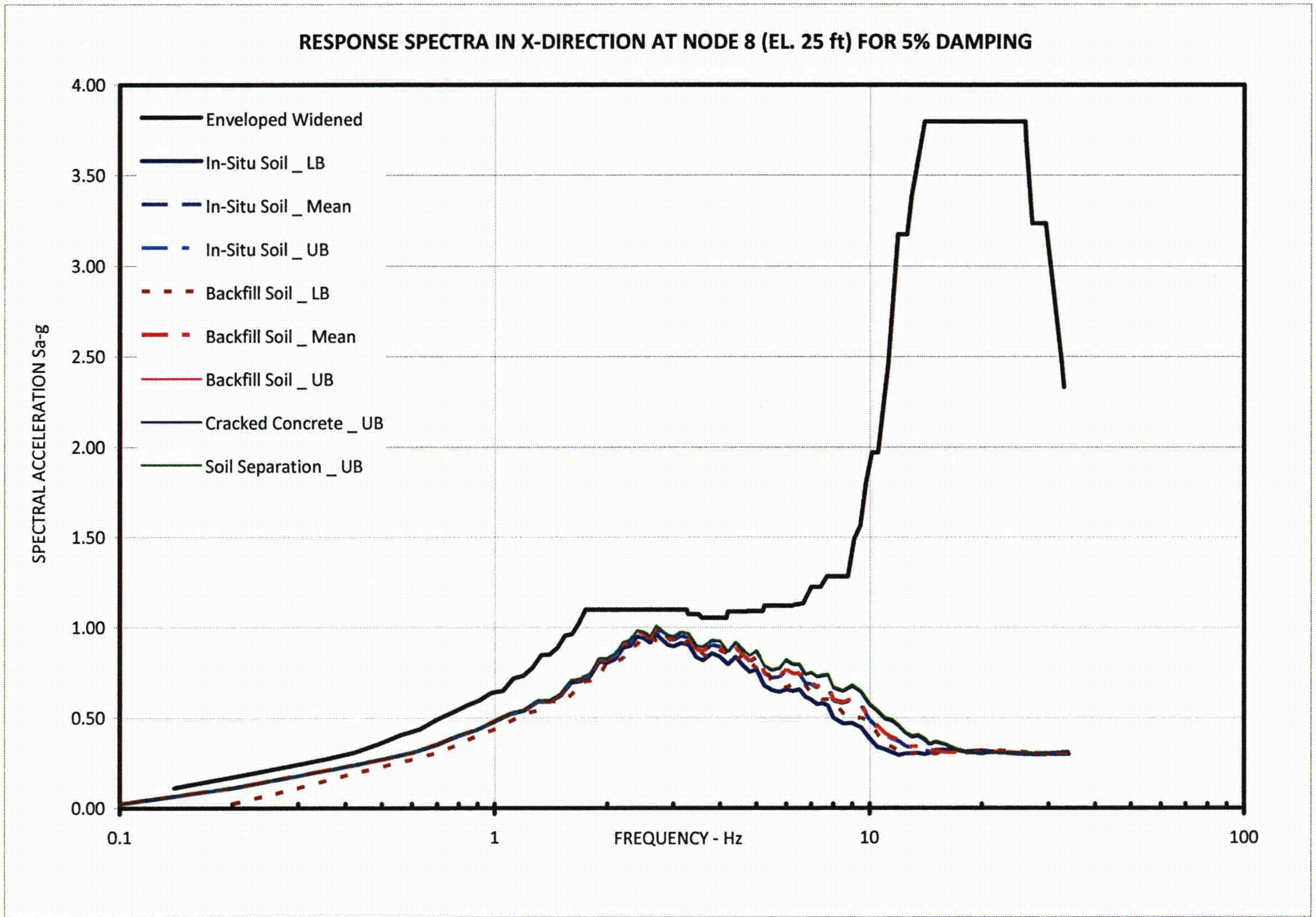


Figure 03.07.01-27 S3.F42: N-S Response Spectra Comparison for DGFOT, Top of Basemat

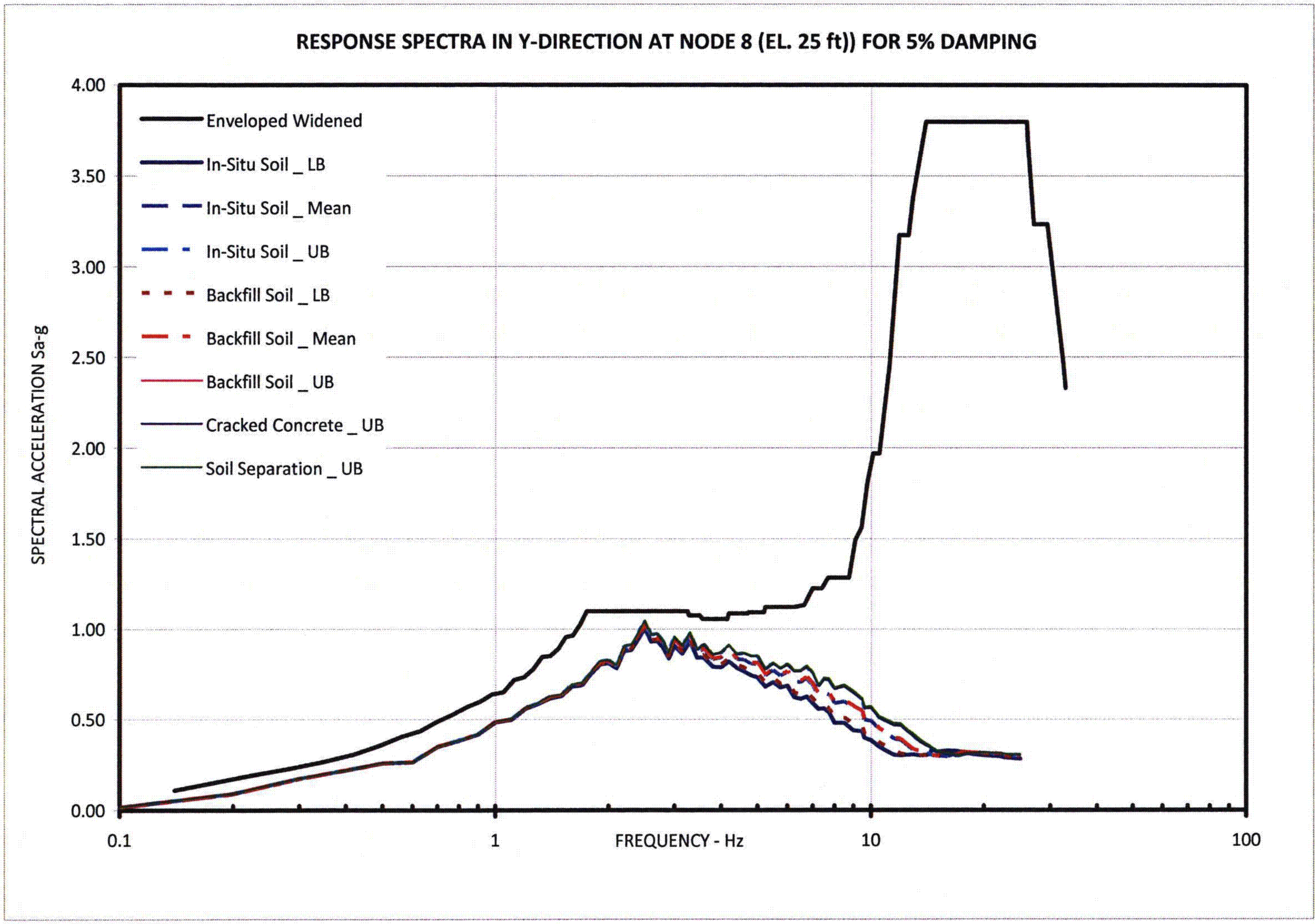


Figure 03.07.01-27 S3.F43: E-W Response Spectra Comparison for DGFOT, Top of Basemat

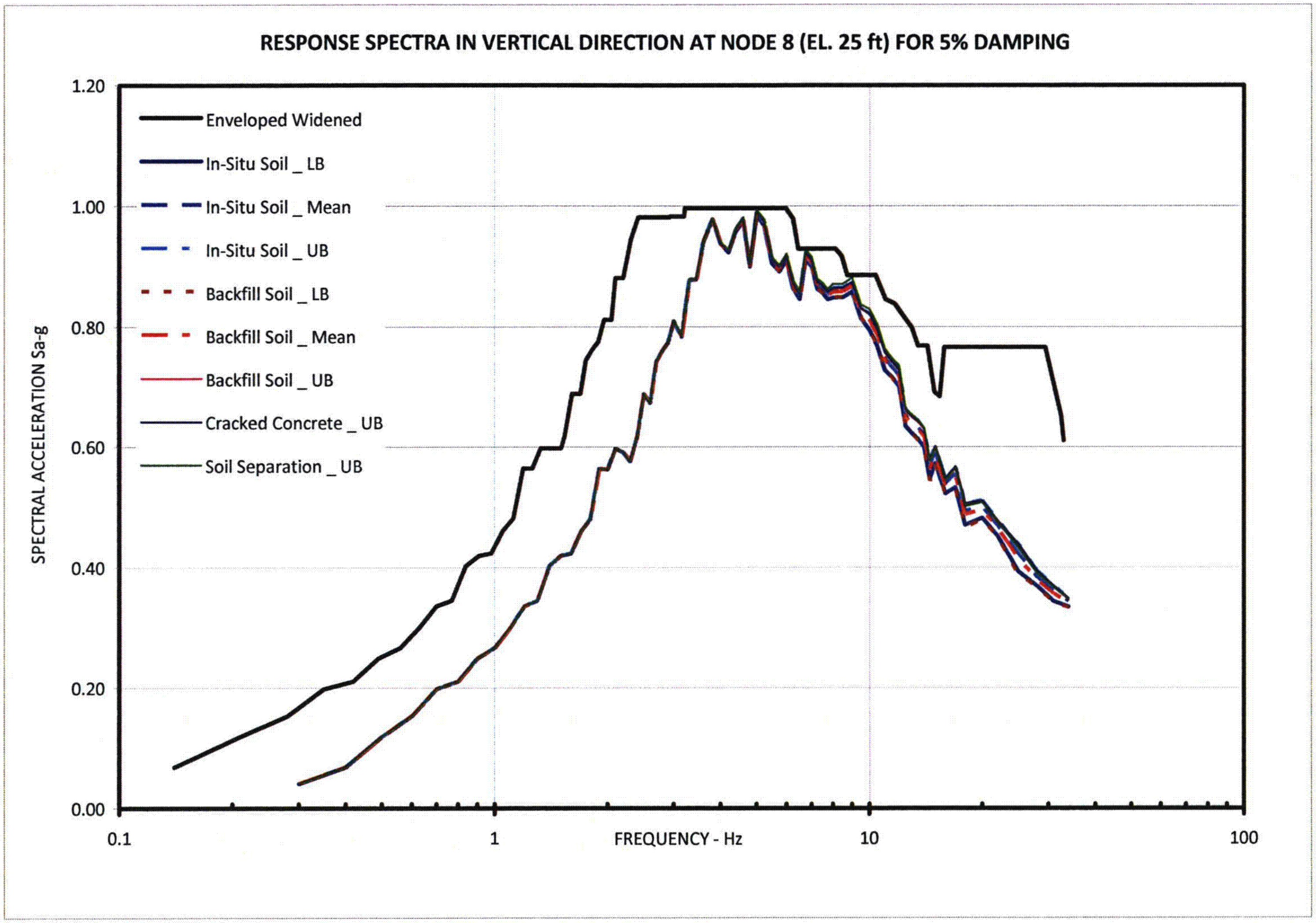


Figure 03.07.01-27 S3.F44: Vertical Response Spectra Comparison for DGFOT, Top of Basemat

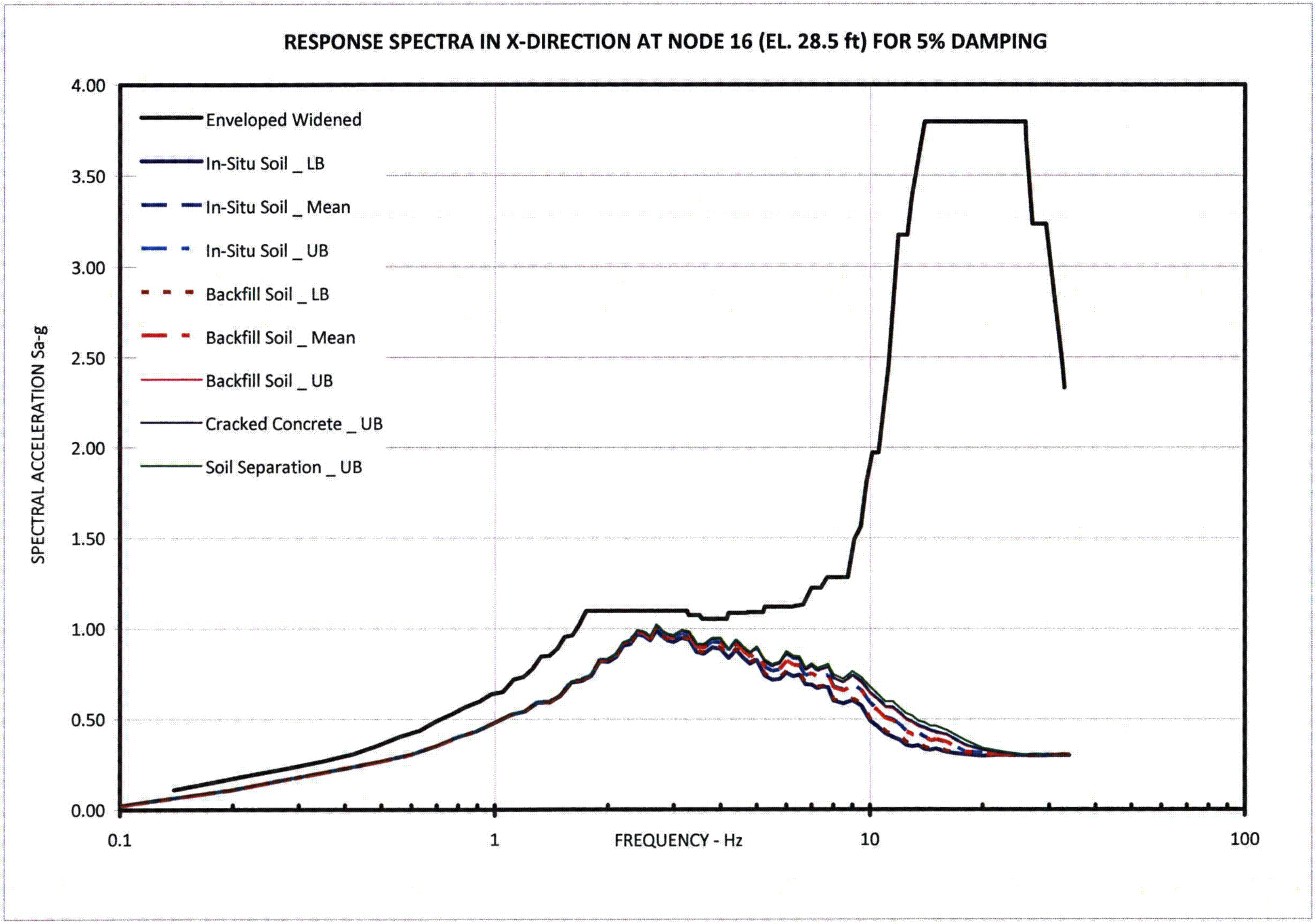


Figure 03.07.01-27 S3.F45: N-S Response Spectra Comparison for DGFOT, at El. 28.5 ft of Walls along E-W

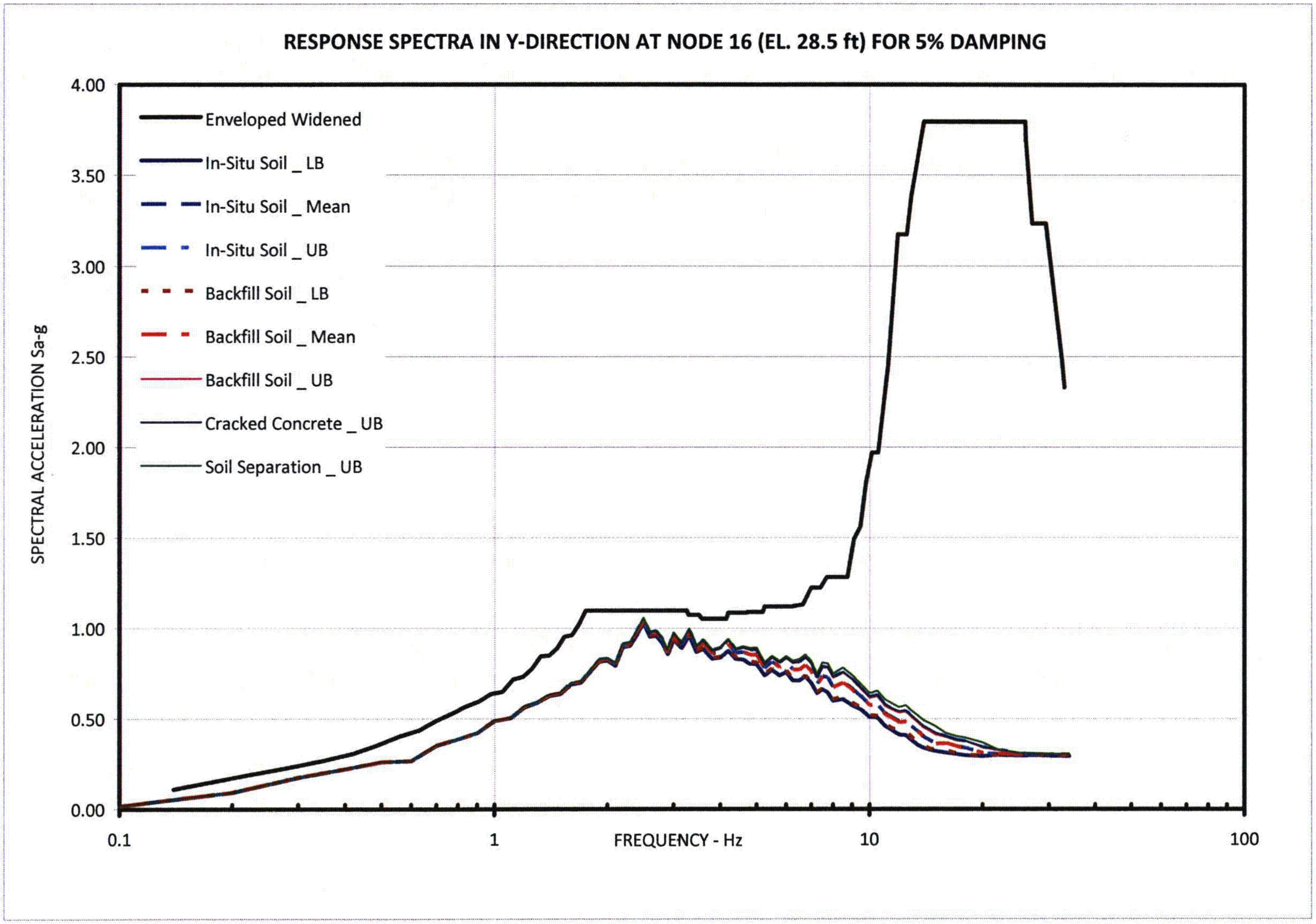


Figure 03.07.01-27 S3.F46: E-W Response Spectra Comparison for DGFOT, at El. 28.5 ft of Walls along N-S

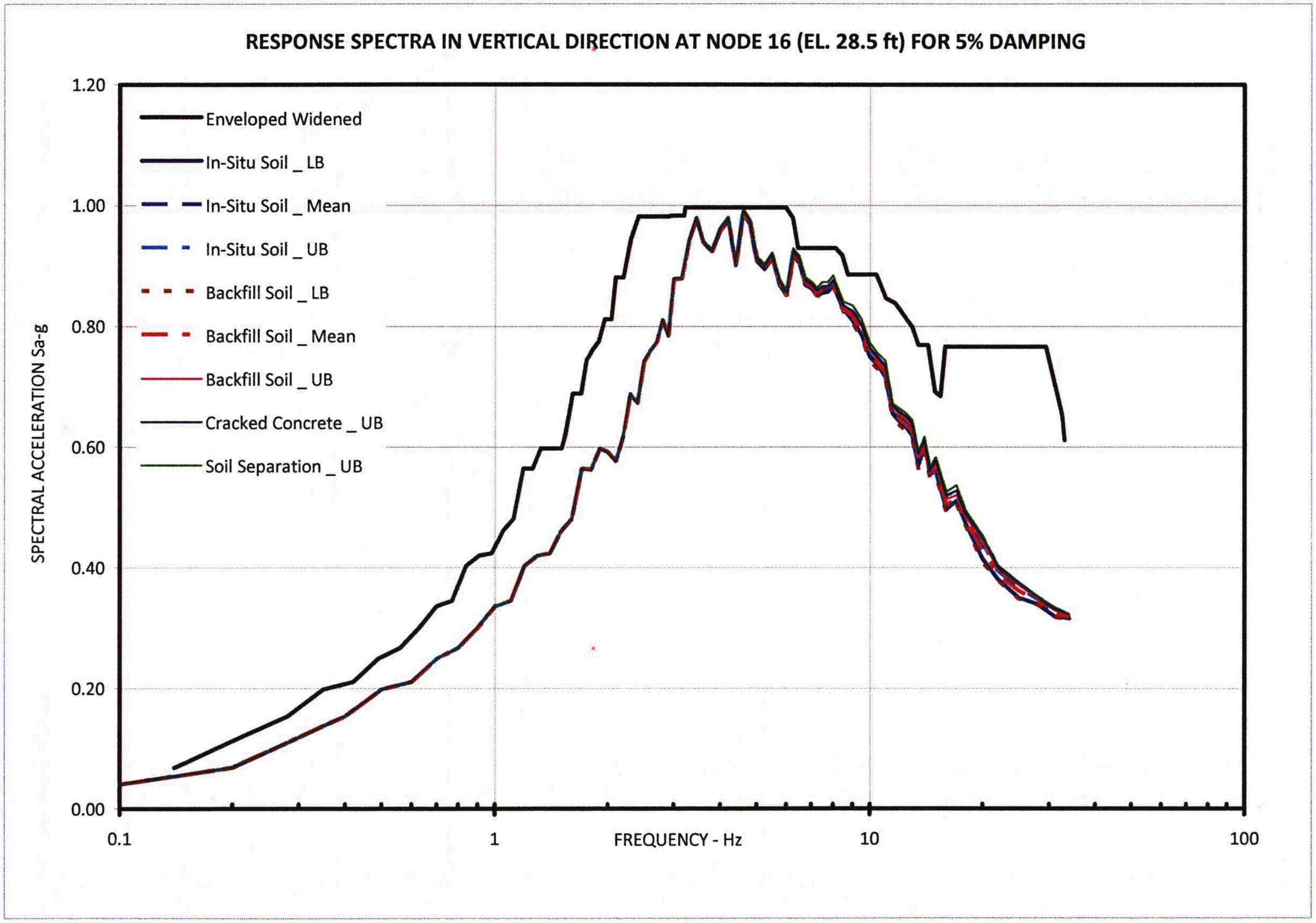


Figure 03.07.01-27 S3.F47: Vertical Response Spectra Comparison for DGFOT, at El. 28.5 ft of Walls

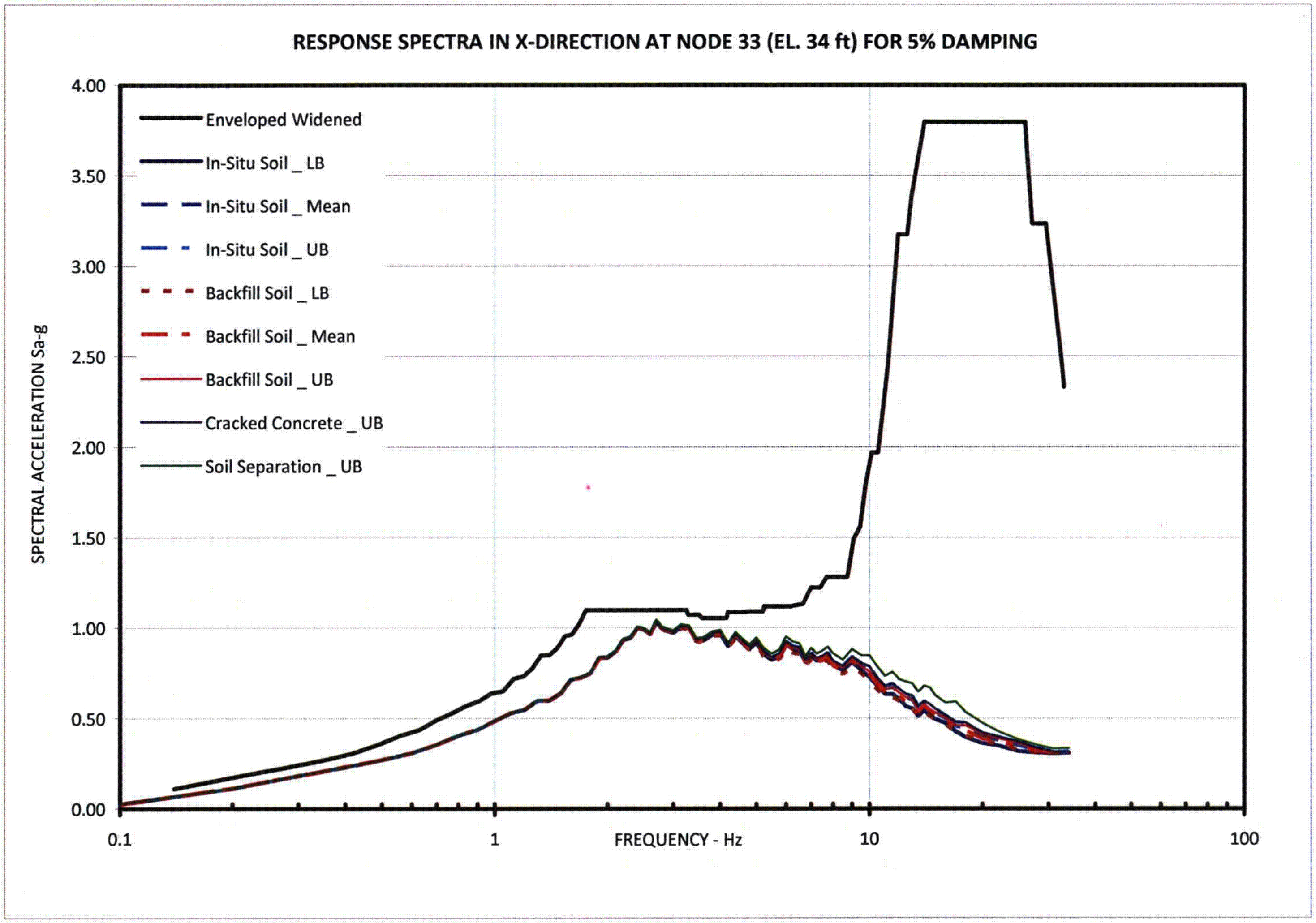


Figure 03.07.01-27 S3.F48: N-S Response Spectra Comparison for DGFOT, Top of Roof

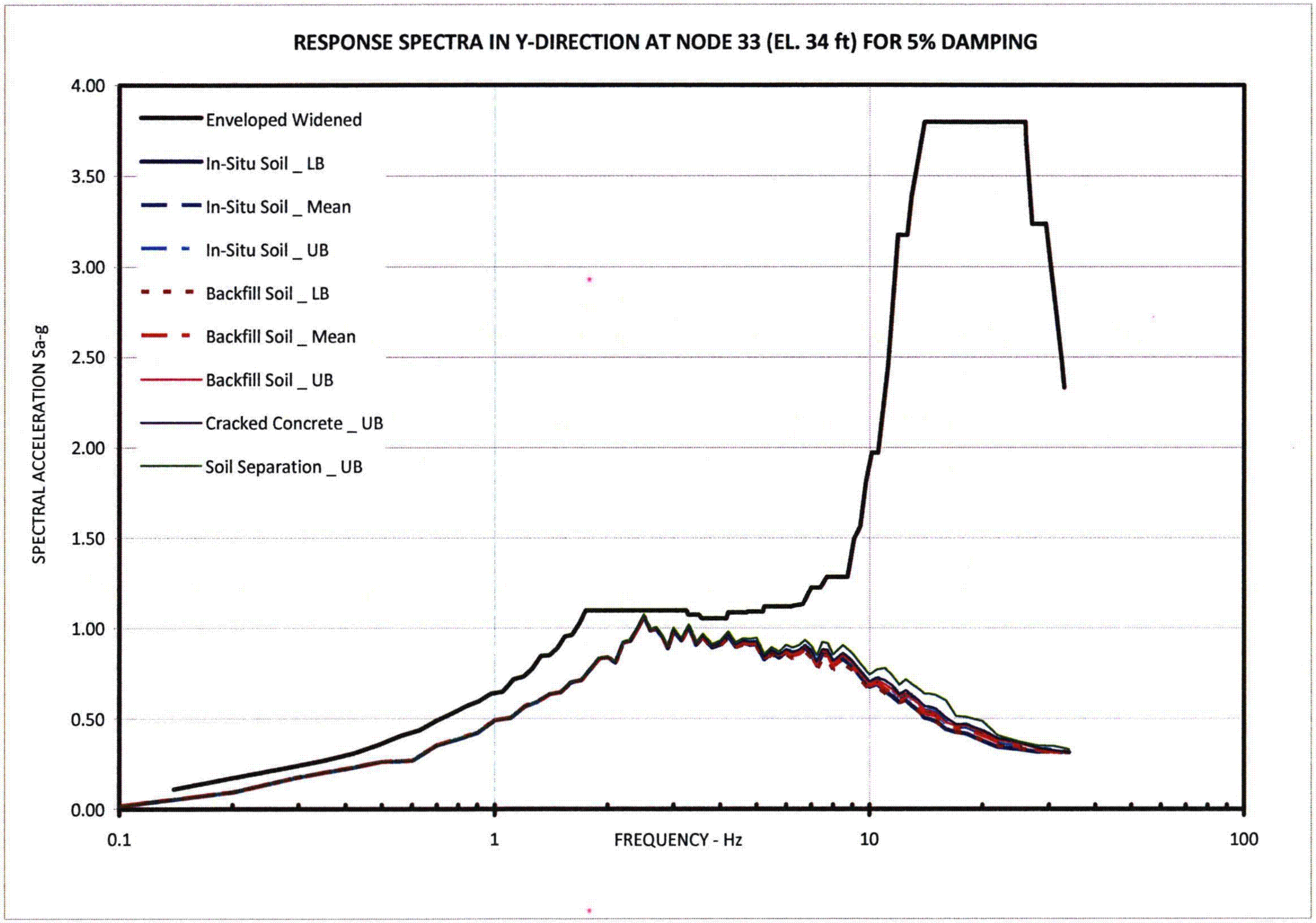


Figure 03.07.01-27 S3.F49: E-W Response Spectra Comparison for DGFOT, Top of Roof

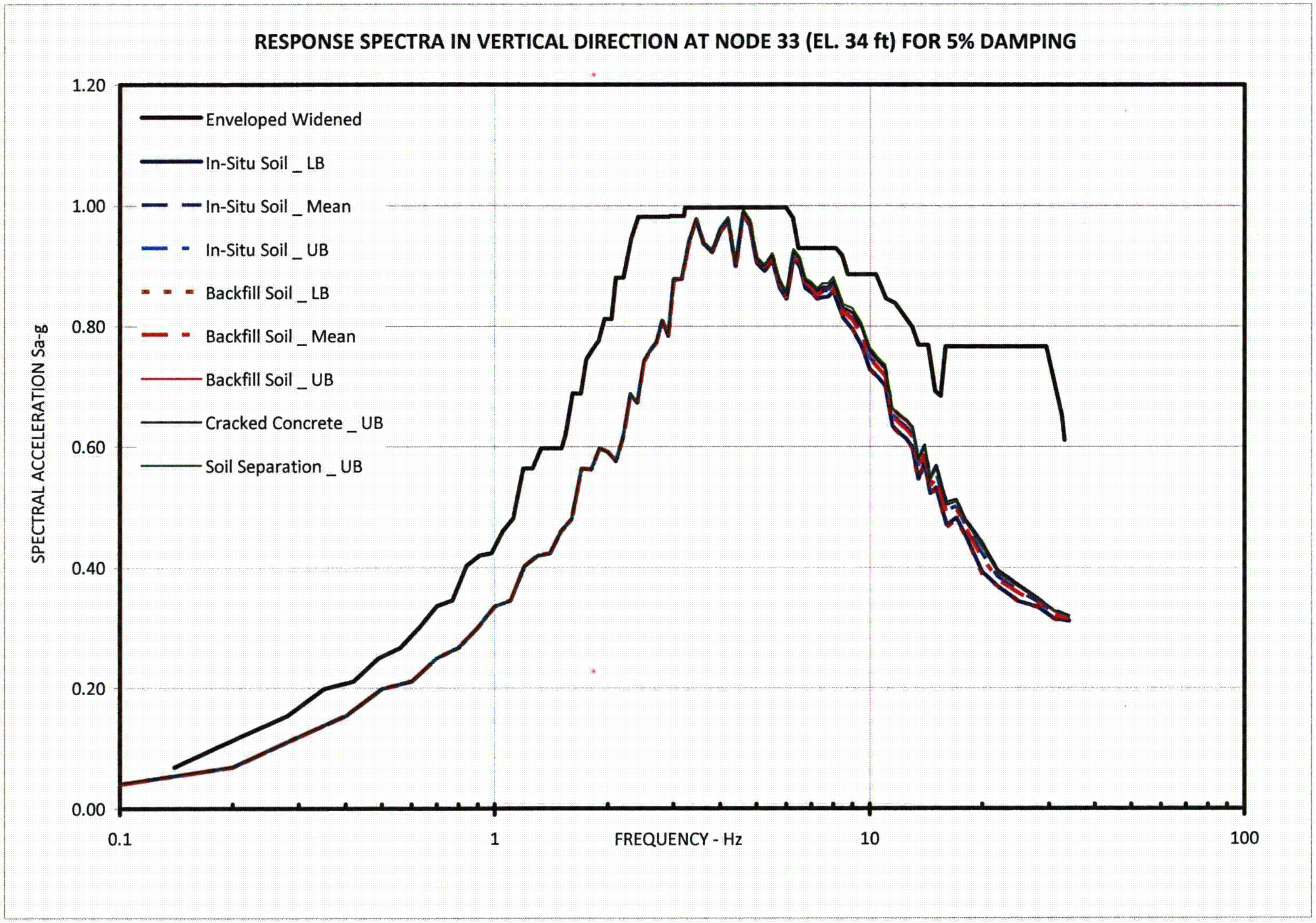


Figure 03.07.01-27 S3.F50: Vertical Response Spectra Comparison for DGFOT, Top of Roof

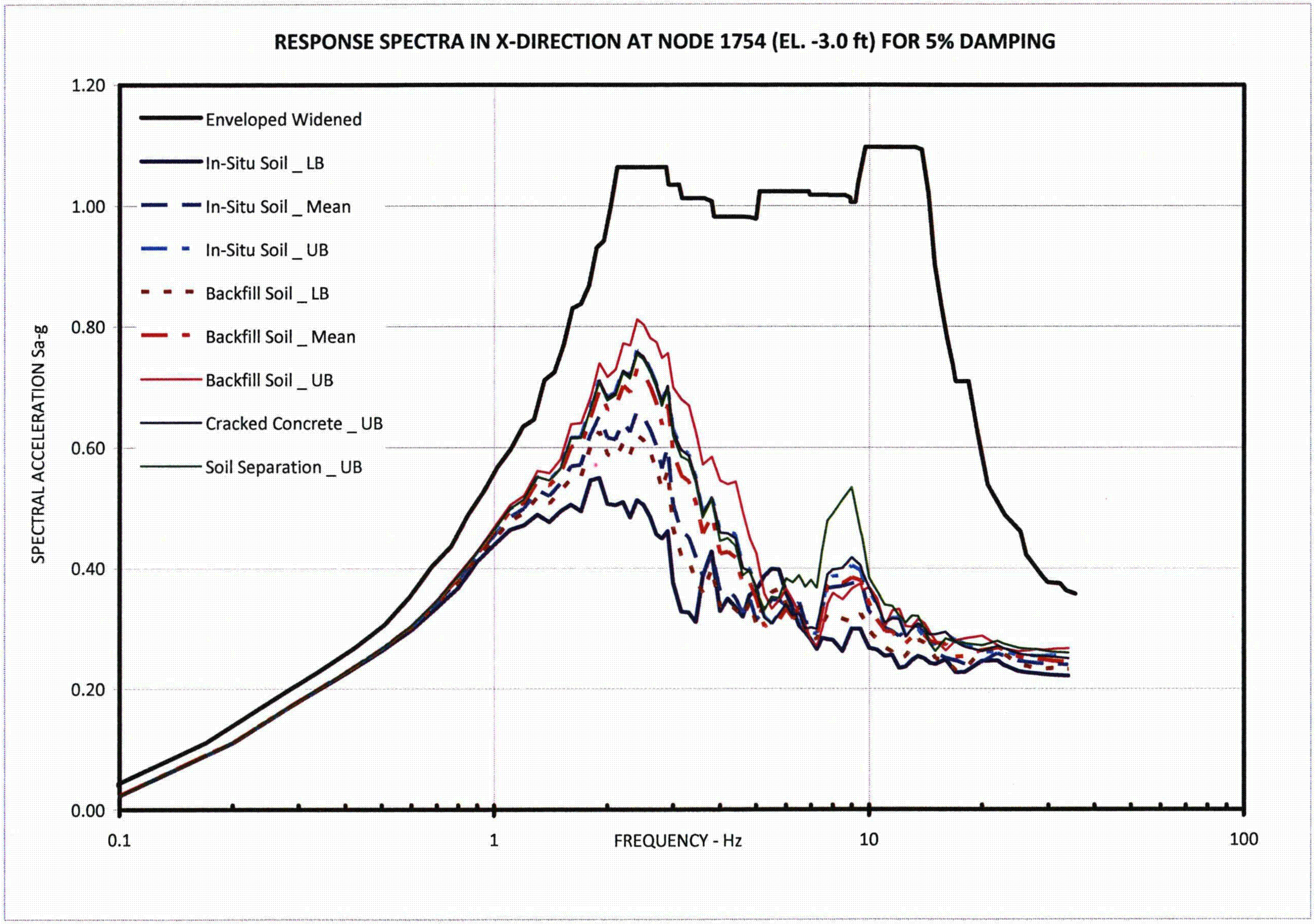


Figure 03.07.01-27 S3.F51: N-S Response Spectra Comparison for DGFOSV, Top of Basemat

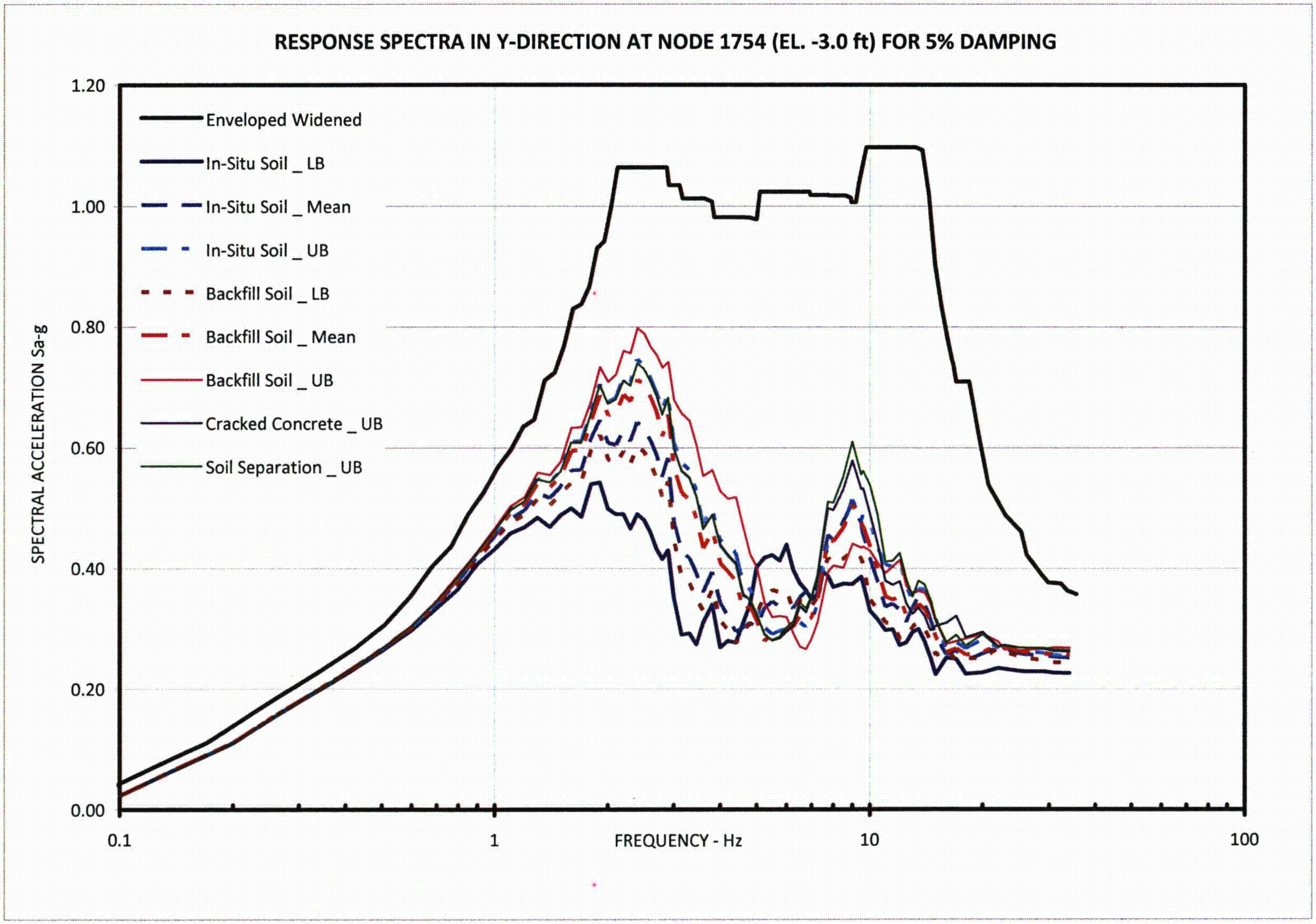


Figure 03.07.01-27 S3.F52: E-W Response Spectra Comparison for DGFOSV, Top of Basemat

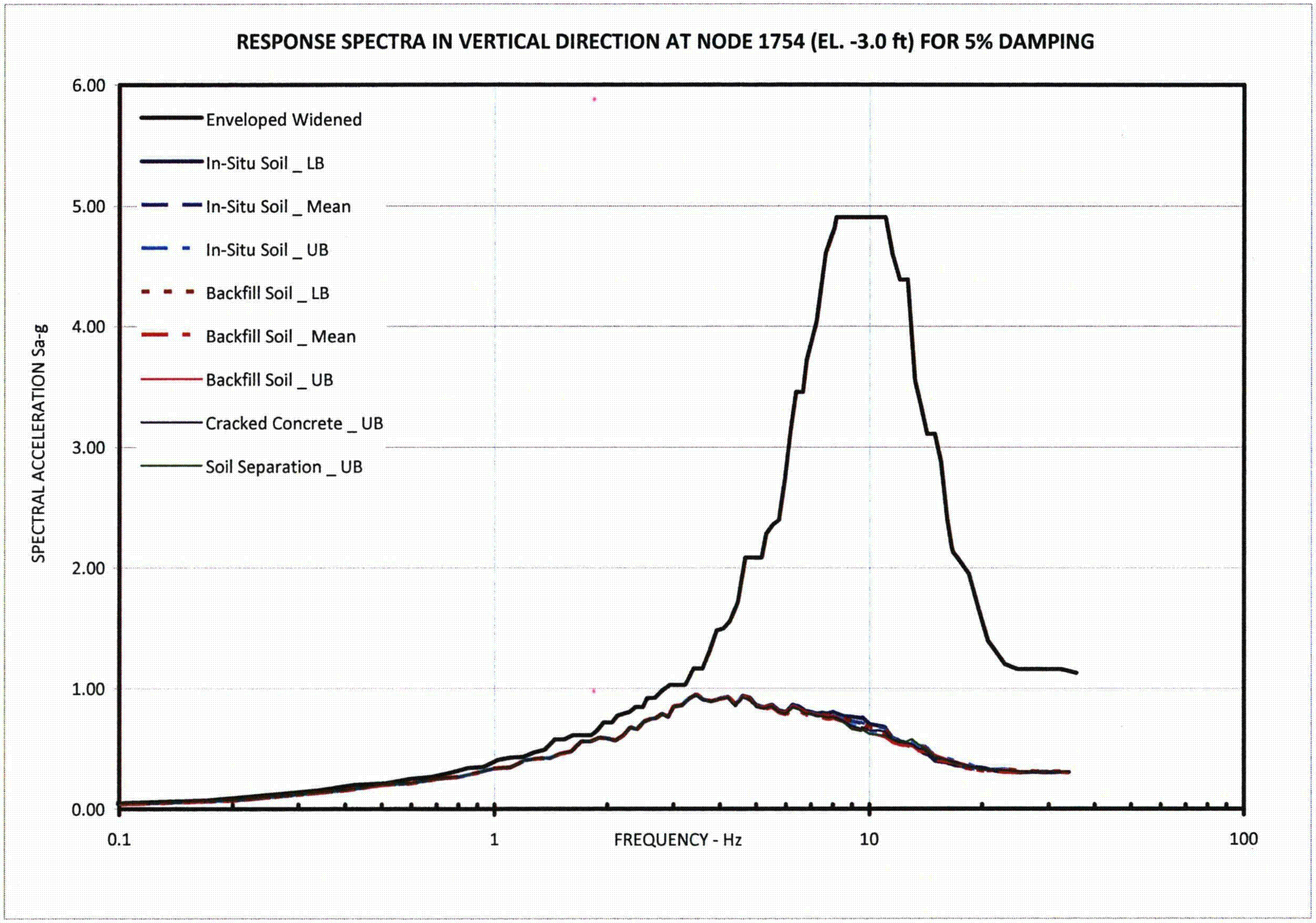


Figure 03.07.01-27 S3.F53: Vertical Response Spectra Comparison for DGFOSV, Top of Basemat

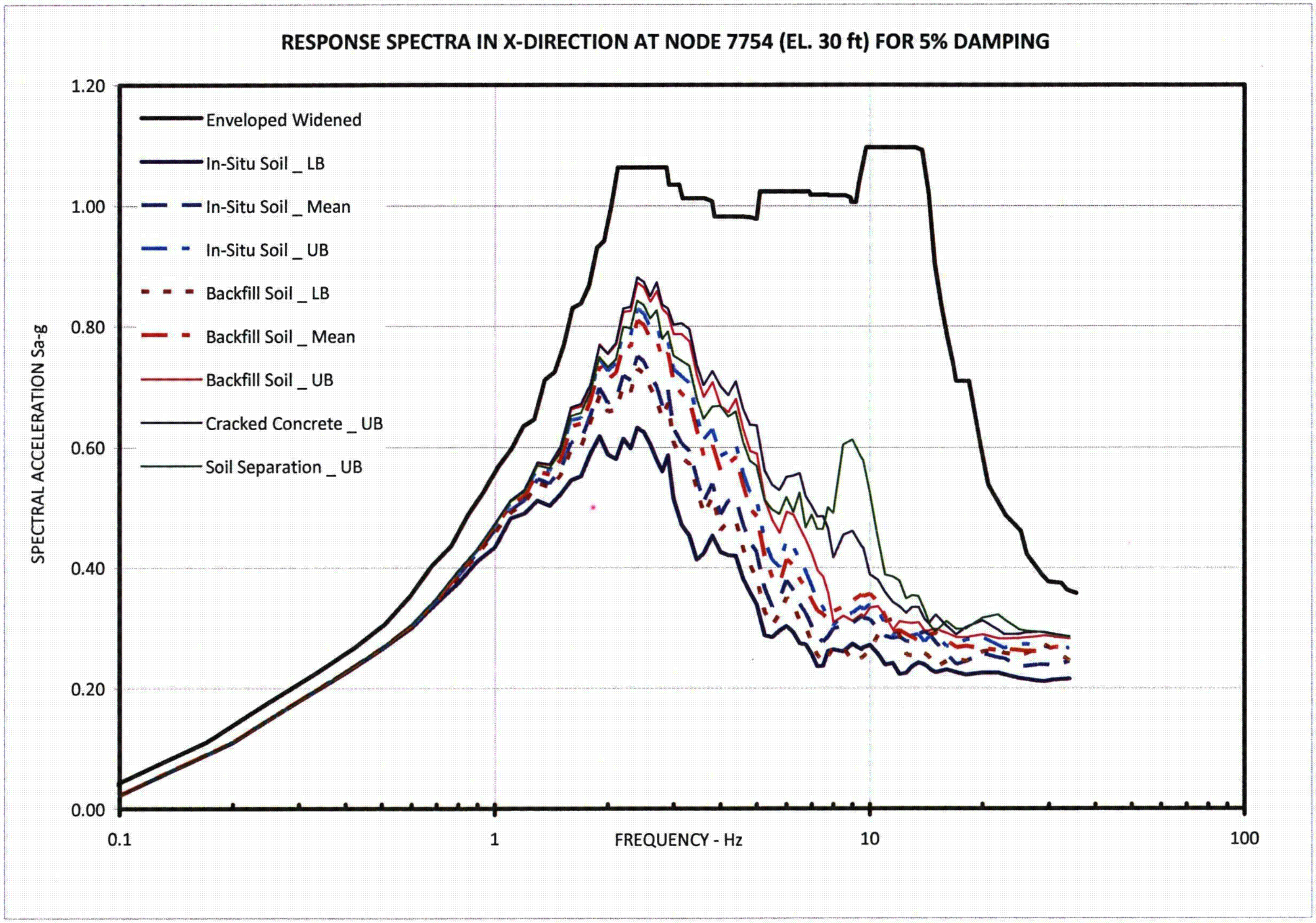


Figure 03.07.01-27 S3.F54: N-S Response Spectra Comparison for DGFOSV, Top of Vault Roof

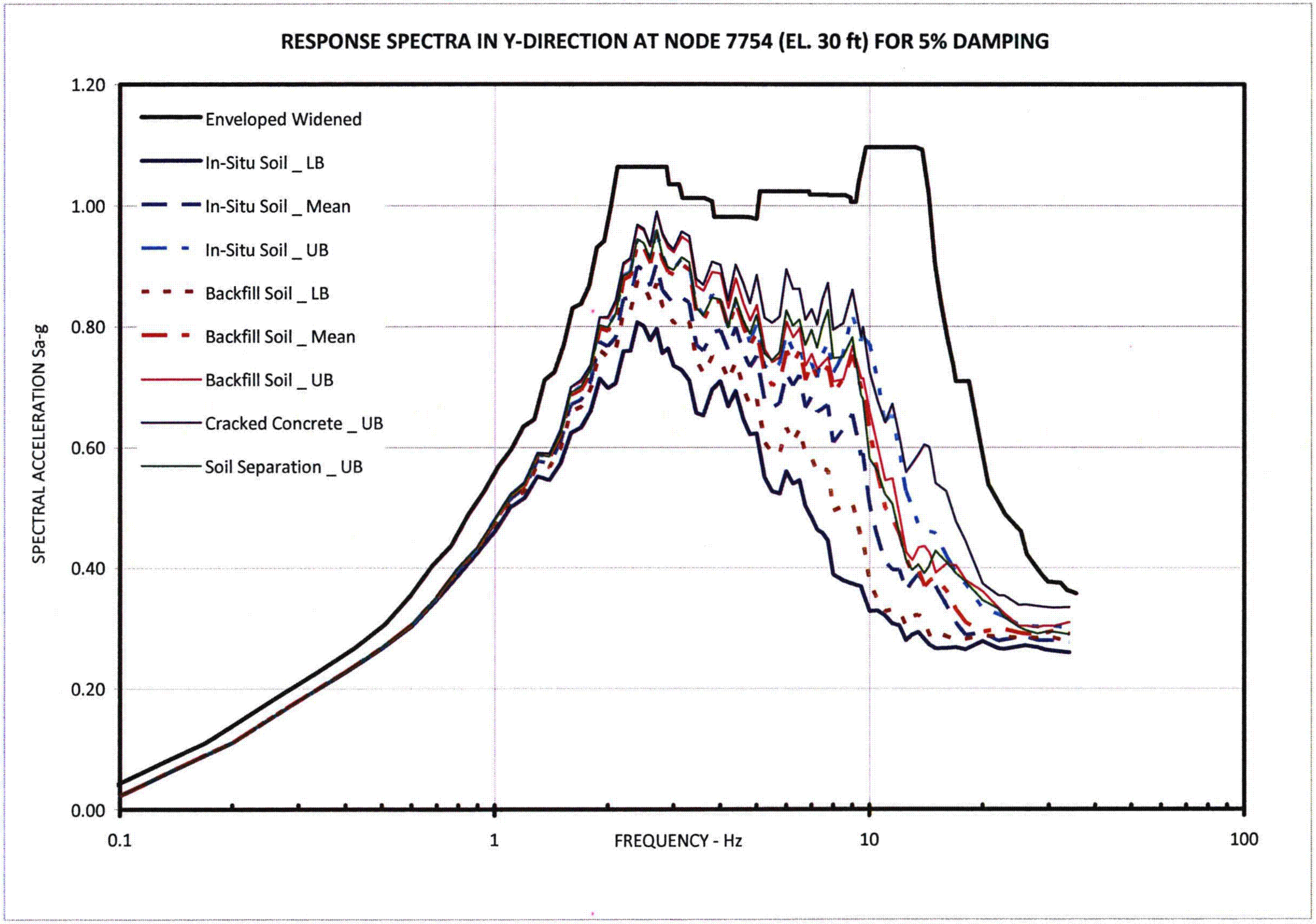


Figure 03.07.01-27 S3.F55: E-W Response Spectra Comparison for DGFOSV, Top of Vault Roof

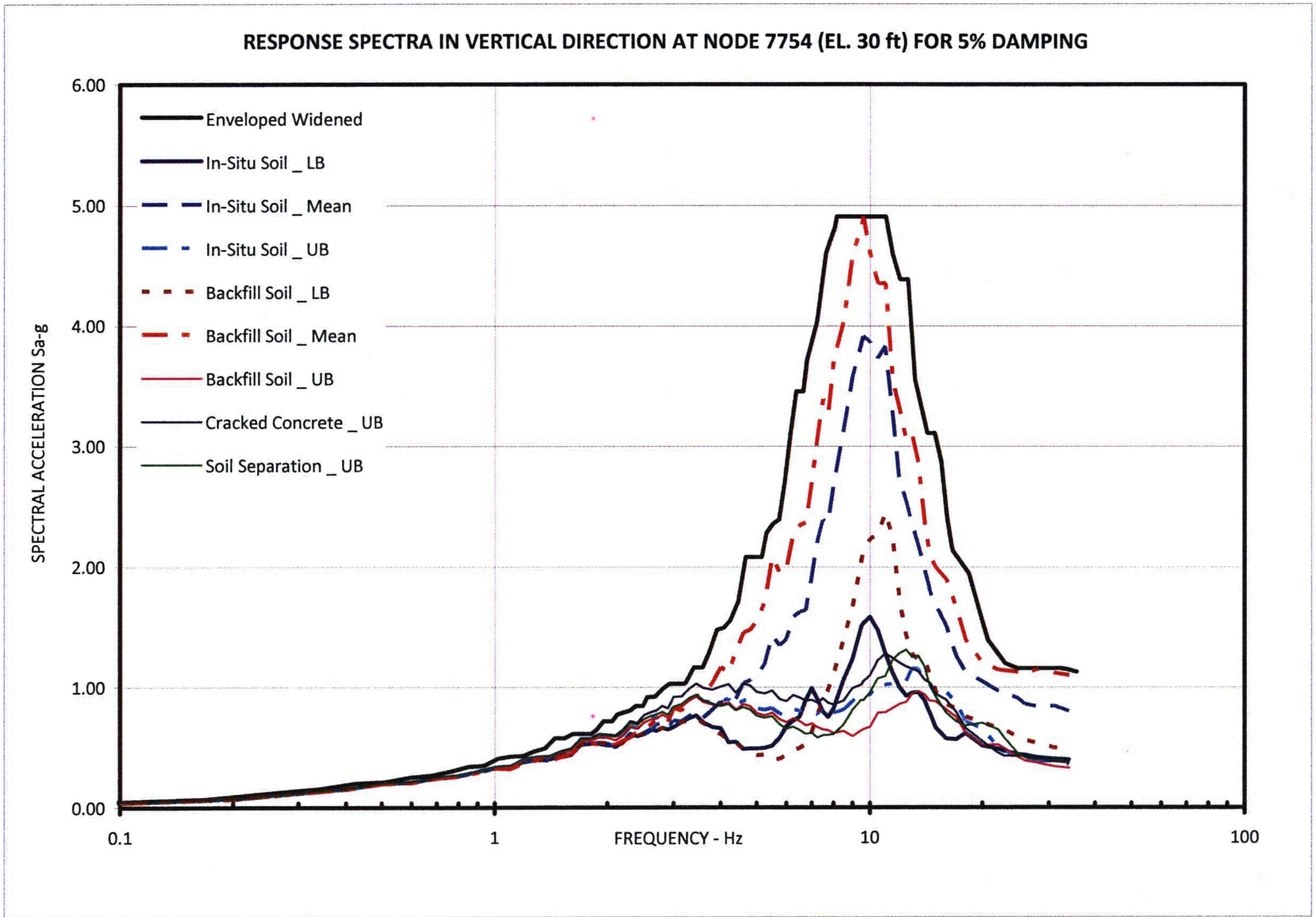


Figure 03.07.01-27 S3.F56: Vertical Response Spectra Comparison for DGFOSV, Top of Vault Roof

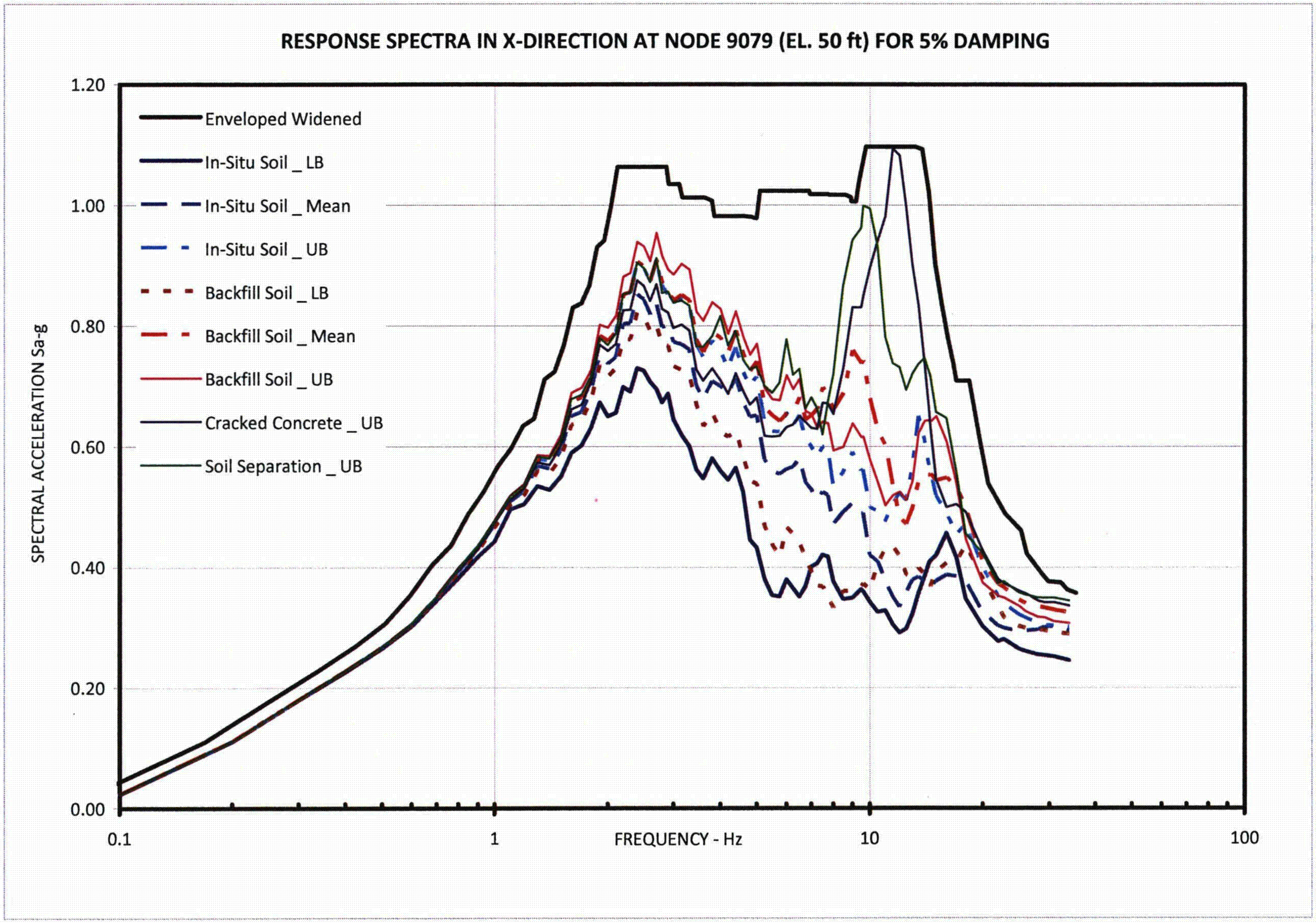


Figure 03.07.01-27 S3.F57: N-S Response Spectra Comparison for DGFOSV, Roof of Vault Entrance

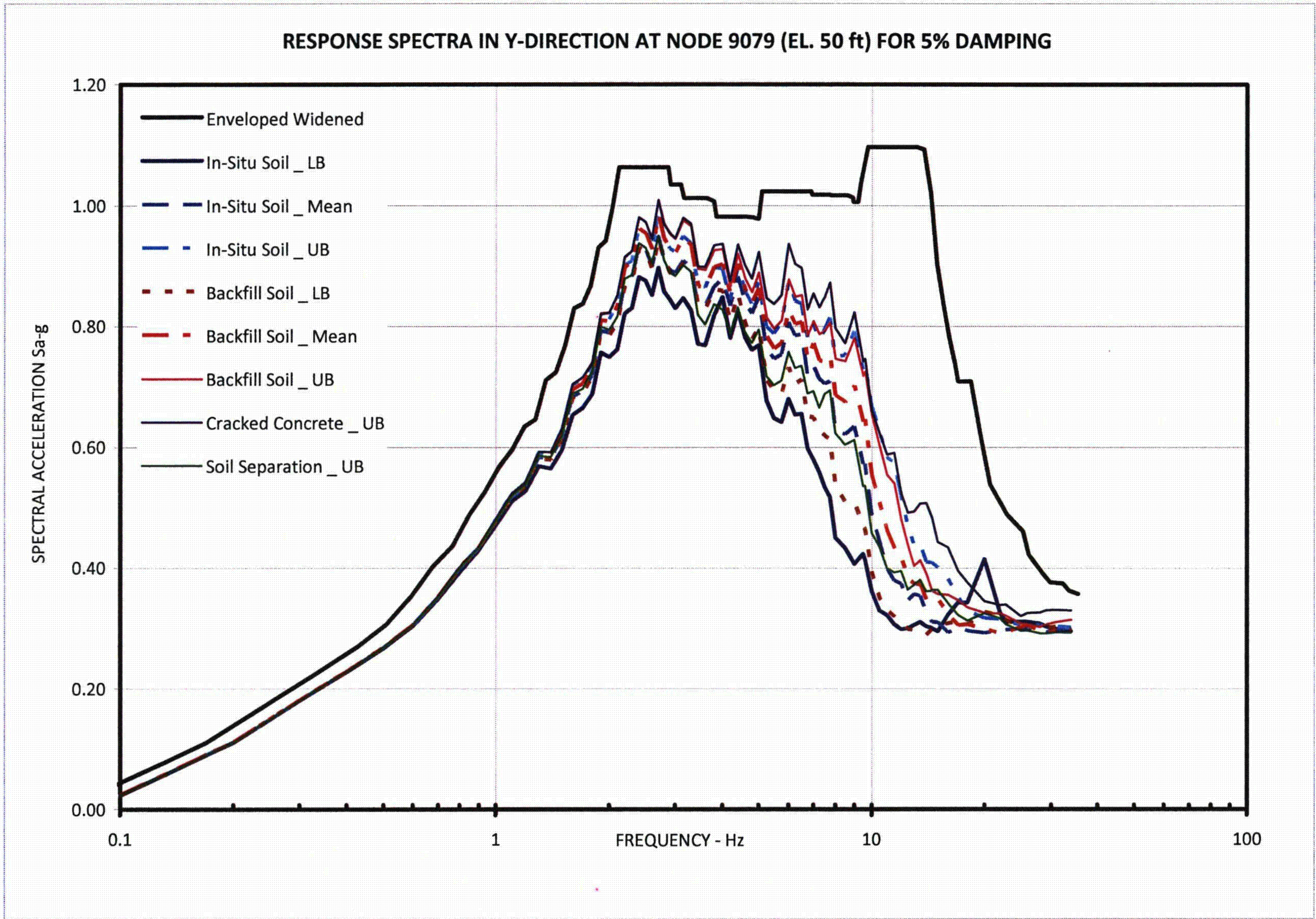


Figure 03.07.01-27 S3.F58: E-W Response Spectra Comparison for DGFOSV, Roof of Vault Entrance

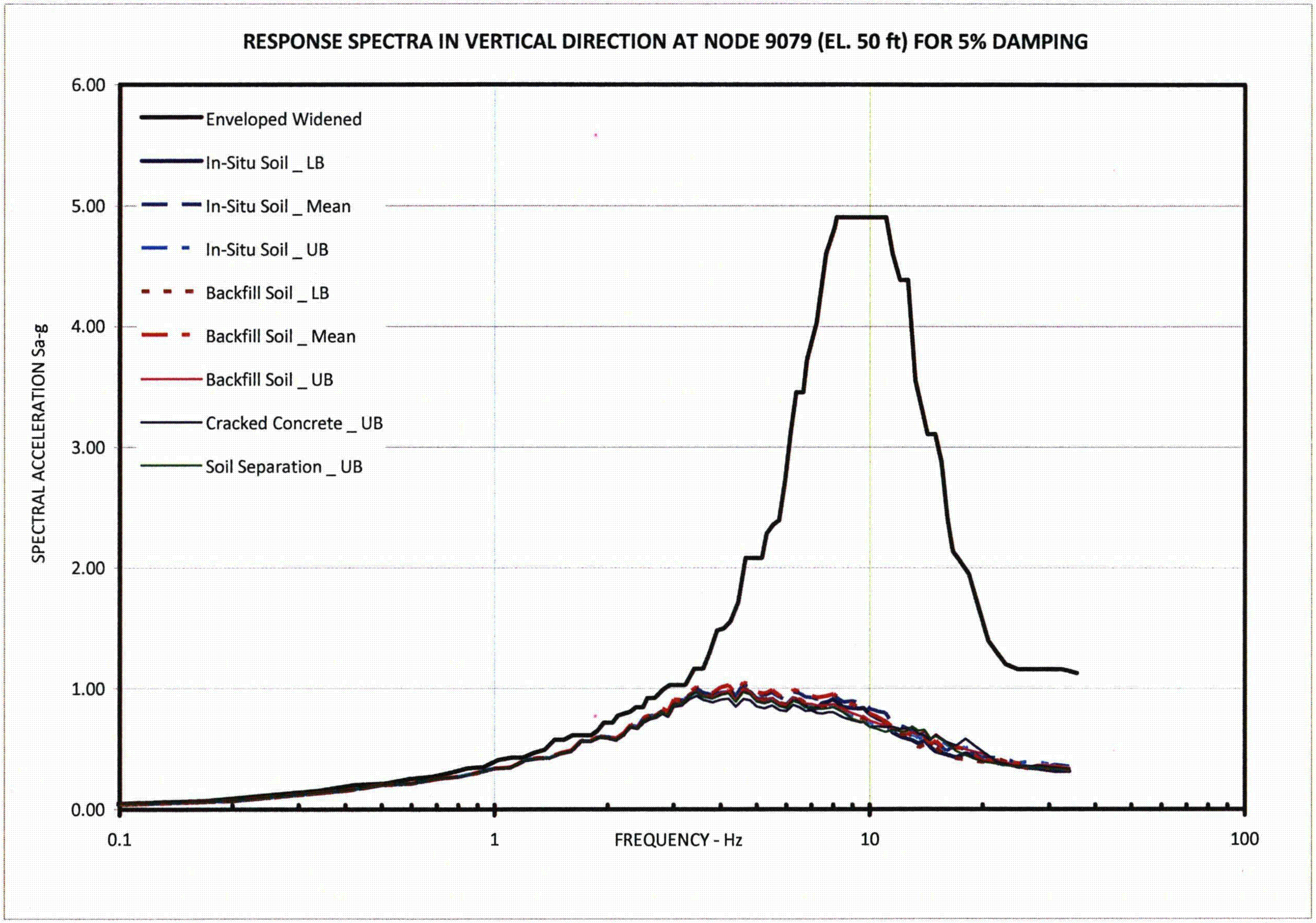


Figure 03.07.01-27 S3.F59: Vertical Response Spectra Comparison for DGFOSV, Roof of Vault Entrance

Enclosure

COLA MARK-UPS

These COLA Part 2, Tier 2 mark-ups are based on COLA Revision 5 and subsequent mark-ups provided in RAI responses submitted through March 25, 2011.

3A.15 Site Conditions

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 upperbound in-situ soil properties (or the DCD soil properties in case of upper bound shear modulus).

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, which showed no significant effect on the analysis results.

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

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 FSAR Subsection 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.

3H.6.5.3 Seismic Analysis of RSW Piping Tunnels

SSI Analysis of the Typical 2D Section of RSW Tunnel

- Groundwater ~~is~~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, 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.

- Input motion is the amplified site specific SSE motion 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.

  - In the three dimensional SSI analysis of the RB for site-specific SSE, one interaction node at the ground surface and one interaction node at the depth corresponding to the bottom elevation of the RSW Piping Tunnel were located at six locations along the centerline of the RSW Piping Tunnel.
  - In the three dimensional SSI analysis of the UHS/RSW Pump House for site-specific SSE, one interaction node at the ground surface and one interaction node at the depth corresponding to the bottom elevation of the RSW Piping Tunnel were located at one location at centerline of the Tunnel.
  - The resulting amplified response spectra at the interaction nodes, representing the response of the RSW Piping Tunnel, from the above SSI analyses of RB and UHS/RSW Pump House were obtained. In order to find a reasonable envelop of these response spectra, to be used in the SSI analysis of the RSW Piping Tunnels, these spectra were compared to 1.15 x site-specific SSE to identify those exceeding 1.15 x site-specific SSE. Figures 3H.6-209a through 3H.6-209d include the response spectra which exceed 1.15 x site-specific SSE.
  - Based on the comparison of the response spectra shown in Figures 3H.6-209a through 3H.6-209d, six motions were selected as envelop amplified motions for SSI analysis. These six motions correspond to 1.15 x site-specific SSE and amplified motion time histories for Nodes 29378, 29379, 29390, 29392, and 15129.
  - SSI analyses of the RSW Piping Tunnel were performed, for each soil case, using 1.15 x site-specific SSE input and acceleration time histories for the five nodes, noted above, obtained from the RB and UHS/RSW Pump House SSI analyses for the corresponding soil cases.

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

- Lower bound in-situ, ~~U~~upper bound in-situ, and upper bound in-situ with upper bound backfill strain-dependent soil properties were used in the SSSI analysis.

- Groundwater ~~is~~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, 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.

SSSI Analysis of the North-South 2D section of the RSW piping tunnel between the DGFOSV and UHS/RSW PH

- Lower bound in-situ and Uupper bound in-situ strain-dependent soil properties were used in the SSSI analysis
- Groundwater iswas 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, 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.

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

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~~three 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. For each of these ~~two~~three DGFOSV, first an average of the spectra at five nodes at the surface and foundation each is calculated and then envelope of the two average spectra is calculated. Similarly, in the SSI analysis for the RSW Pump House, interaction nodes are added in the model and amplified motion for the DGFOSV close to the RSW Pump House is obtained. ~~A similar SSI analysis is performed for the third DGFOSV close to the RSW Pump House.~~ Since the diesel oil tank is a standard plant equipment, the input motion for the SSI analysis ~~should~~ also considers the 0.3g Regulatory Guide 1.60 response spectra. Therefore, the envelope of the envelope average spectra for the three DGFOSV and the 0.3g Regulatory Guide 1.60 response spectra are used as the input response spectra for the SSI analysis of the DGFOSV. As shown in Figures 3H.6-222a through 3H.6-222 c, ~~T~~the 0.3g Regulatory Guide 1.60 response spectra were found to be the bounding spectra. The DGFOSV and the equipment and components inside the vault are designed using the results of the SSI analysis.

2D 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).

To evaluate the effects of the soil variation, ~~five~~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.

3H.7.5.2.1 Seismic Analysis

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

- Groundwater ~~is~~was considered at 8 ft depth (26 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 ~~and~~ 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~~ instead of 0.48~~. 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.

- Since the tunnels run along both East-West and North-South directions, the horizontal input motions from both East-West and North-South time histories are considered. East-West input motion is applied to the tunnel sections running North-South and North-South input motion is applied to the tunnel sections running East-West. To account for the impact of nearby heavy RB, in the three dimensional SSI analysis of the RB for site-specific SSE, one interaction node at the ground surface and one interaction node at the depth corresponding to the bottom elevation of the DGFOT are located at several locations along each of the three DGFOTs. The envelope of the amplified motions at these interaction nodes and 0.3g Regulatory Guide 1.60 response spectra are used for SSI analysis of the DGFOT. As shown in Figures 3H.7-30a through 3H.7-30c, the 0.3g Regulatory Guide 1.60 response spectra are found to be the bounding spectra. ~~The input motions consistent with RG 1.60 response spectra anchored at 0.3g peak ground acceleration envelop both the site-specific input motions and the amplified site-specific motions considering the impact of nearby heavy RB and Ultimate Heat Sink (UHS)/Reactor Service Water (RSW) Pump House.~~

Figure 3A-301: Comparison of DCD SSE and Site-Specific SSE Seismic Soil Pressures for Reactor Building North Wall

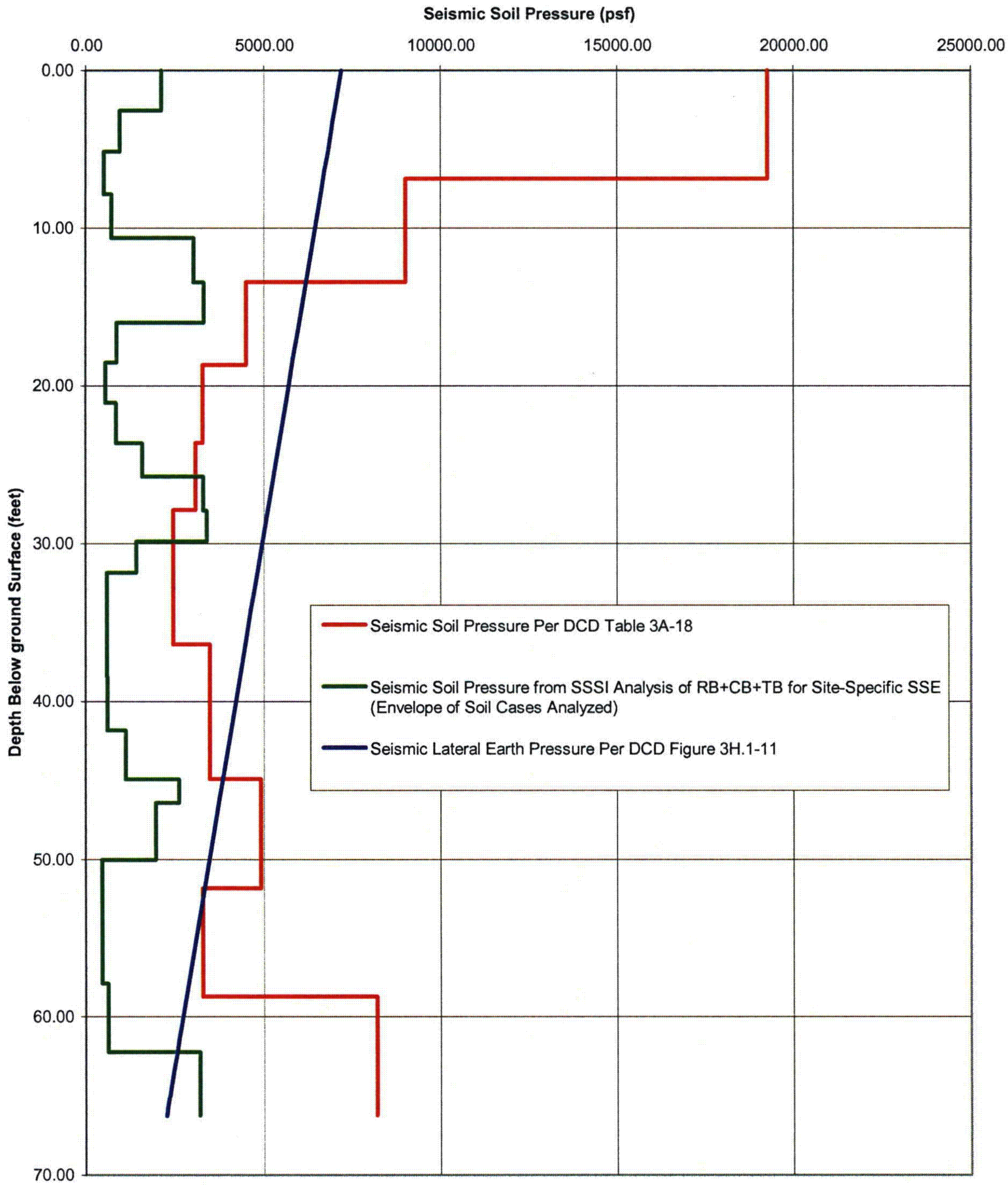
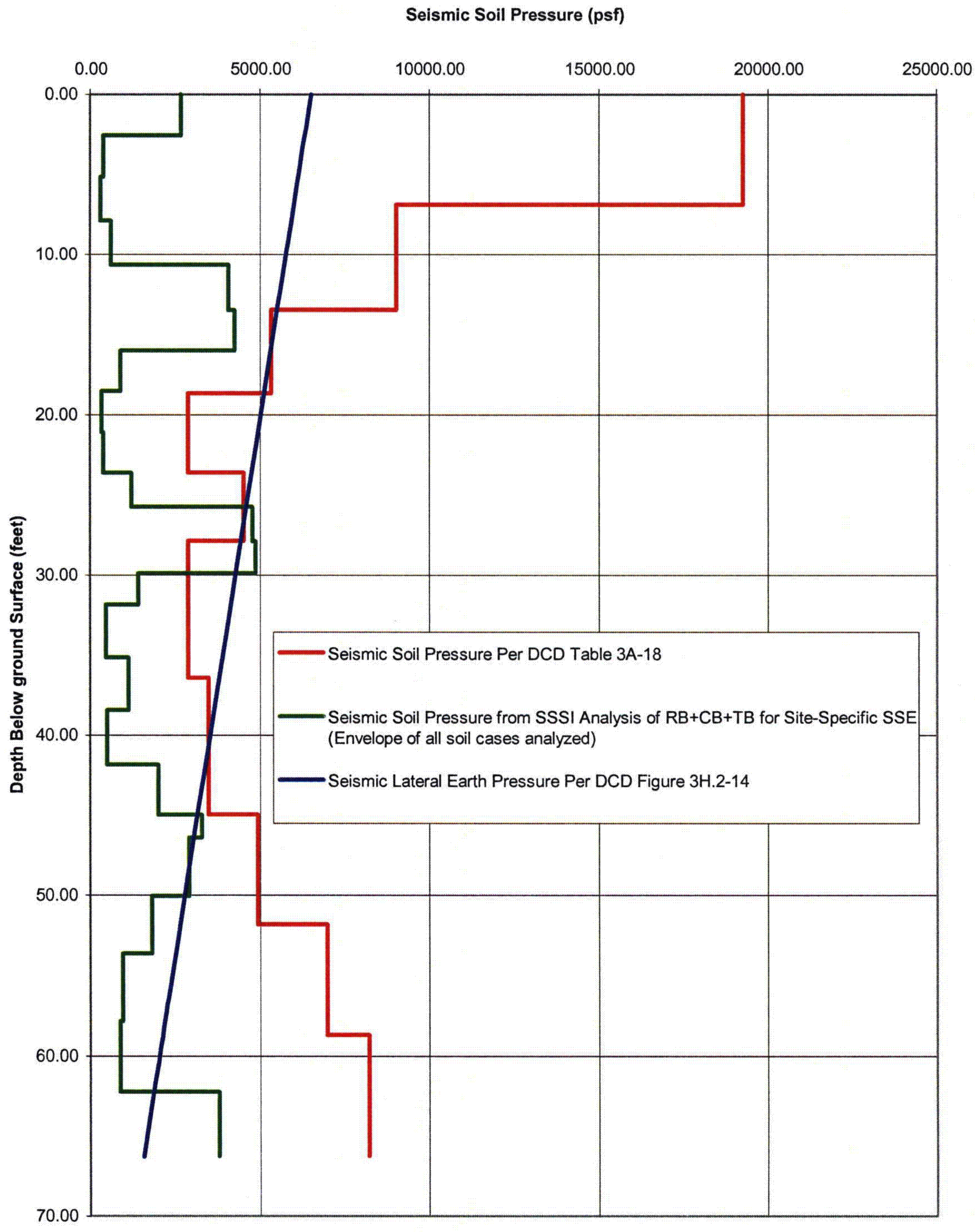


Figure 3A-302: Comparison of DCD SSE and Site-Specific SSE Seismic Soil Pressures for Control Building South Wall



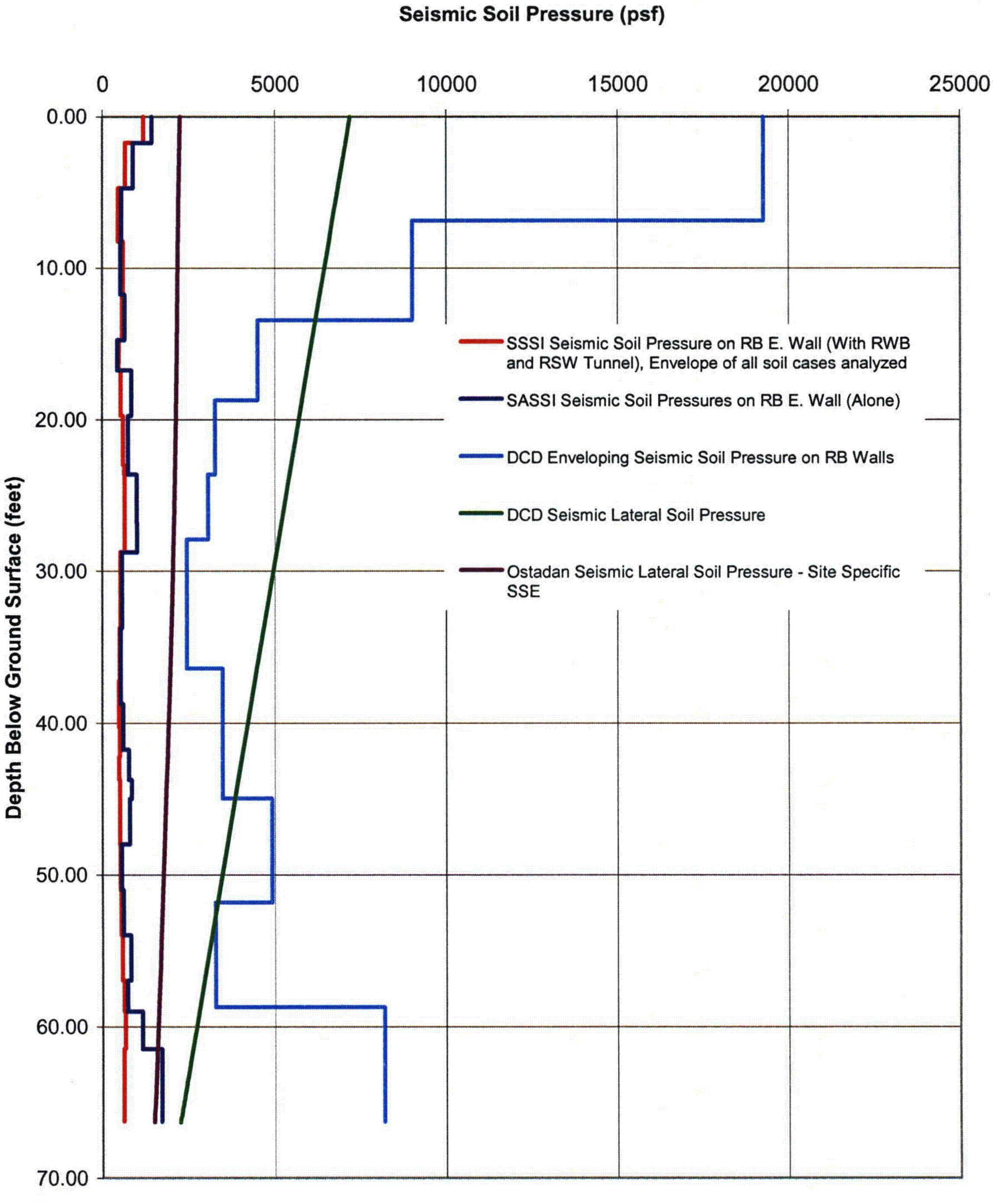


Figure 3H.1-1: Lateral Seismic Soil Pressure Comparison for RB East Wall (Considering RSW Tunnel & Radwaste Building)

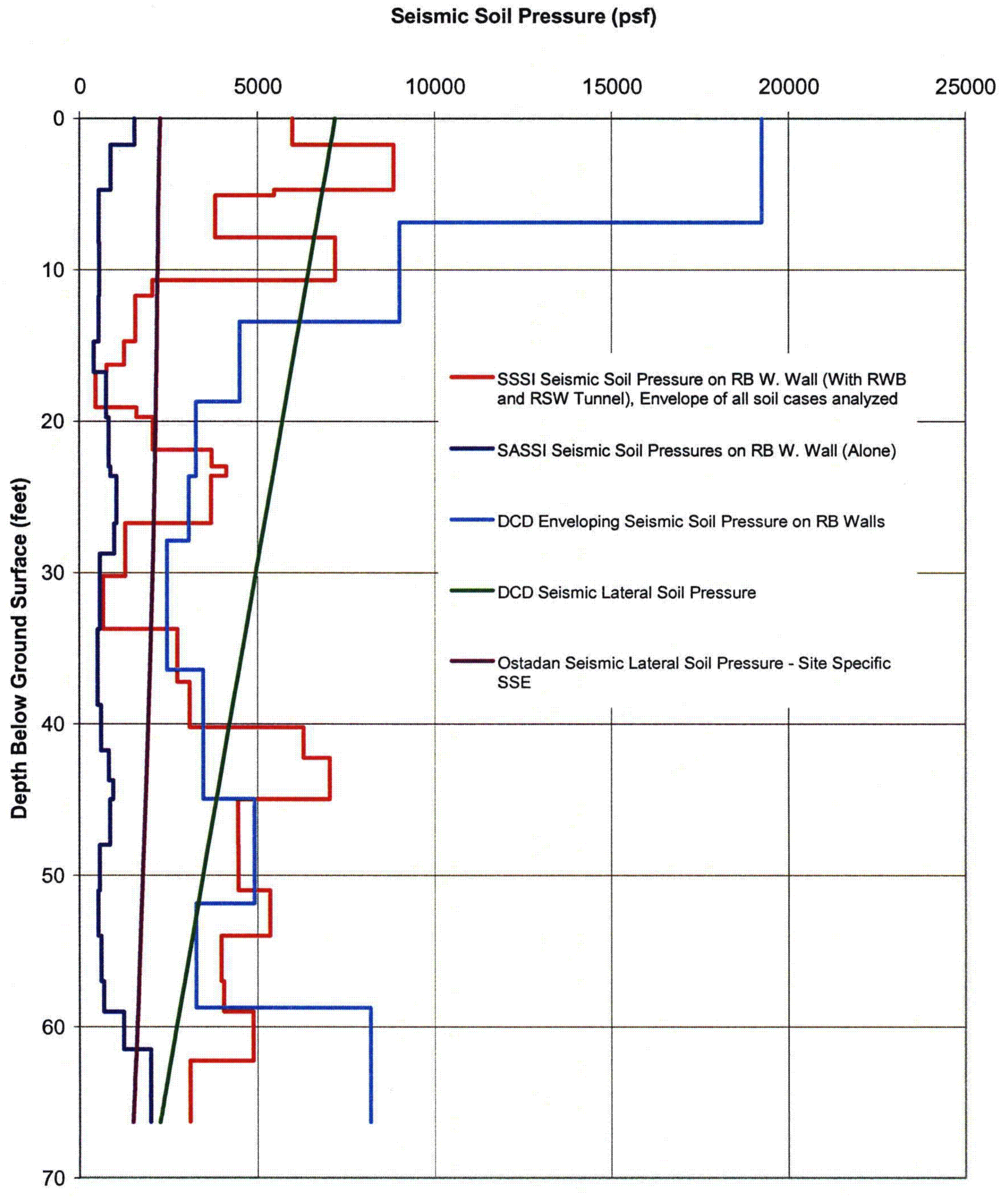


Figure 3H.1-2: Lateral Seismic Soil Pressure Comparison for RB West Wall (Considering RSW Tunnel & Radwaste Building)

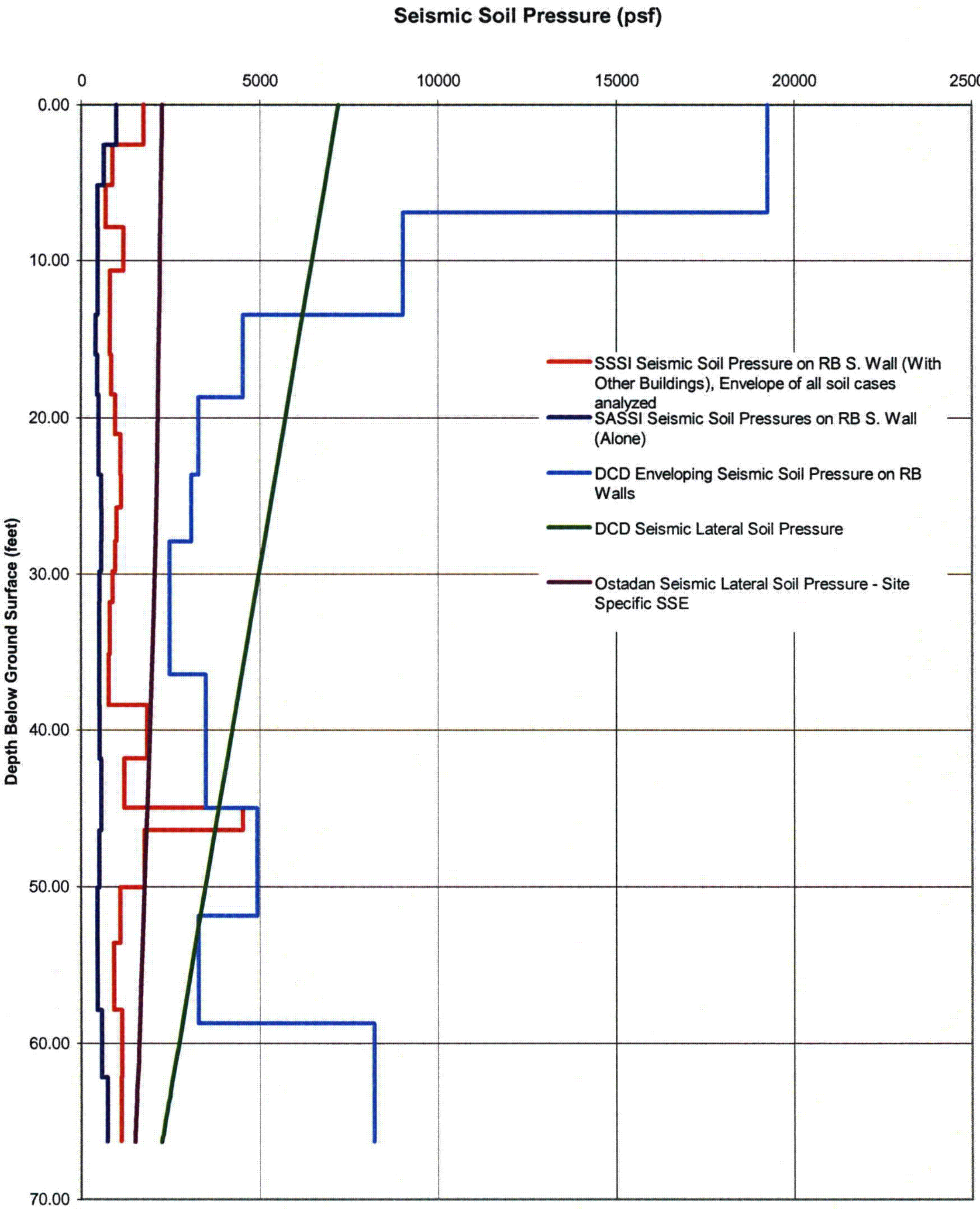


Figure 3H.1-3: Lateral Seismic Soil Pressure Comparison for RB South Wall (Considering DGFOSVs, RSW Tunnel & UHS/RSW Pump House Building)

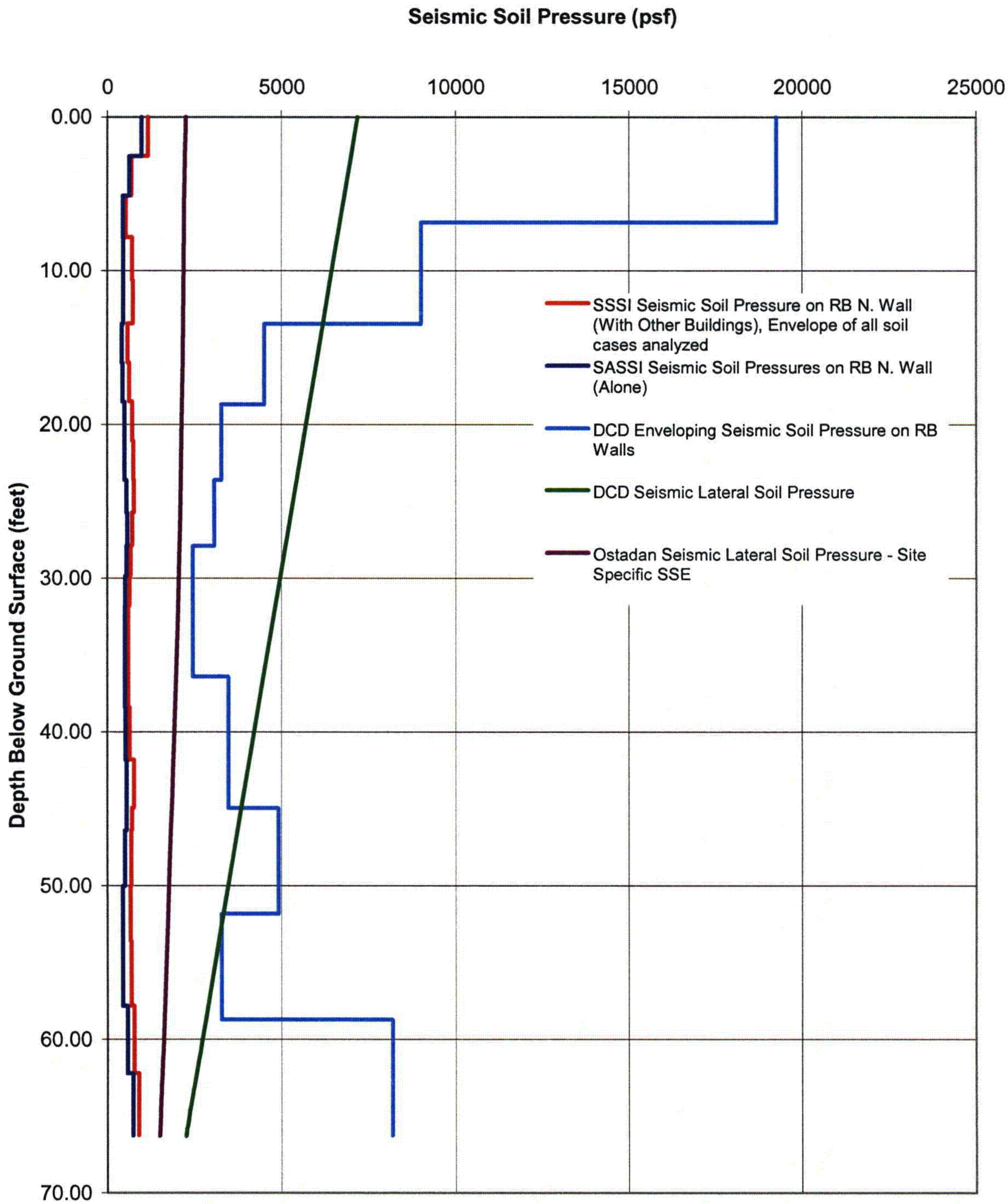


Figure 3H.1-4: Lateral Seismic Soil Pressure Comparison for RB North Wall (Considering DGFOSVs, RSW Tunnel & UHS/RSW Pump House Building)

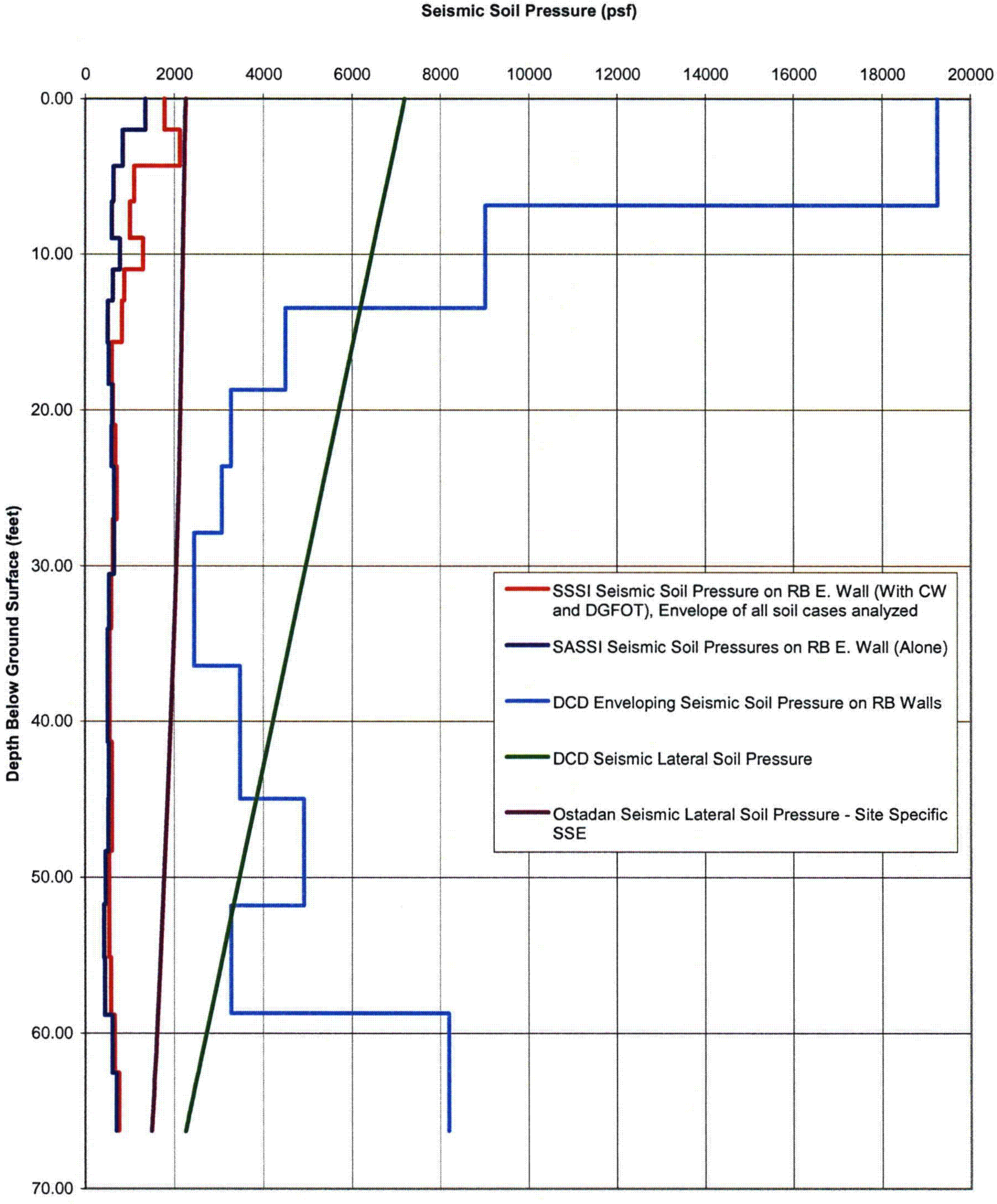


Figure 3H.1-5: Lateral Seismic Soil Pressure Comparison for RB East Wall (Considering DGFOT & Crane Wall)

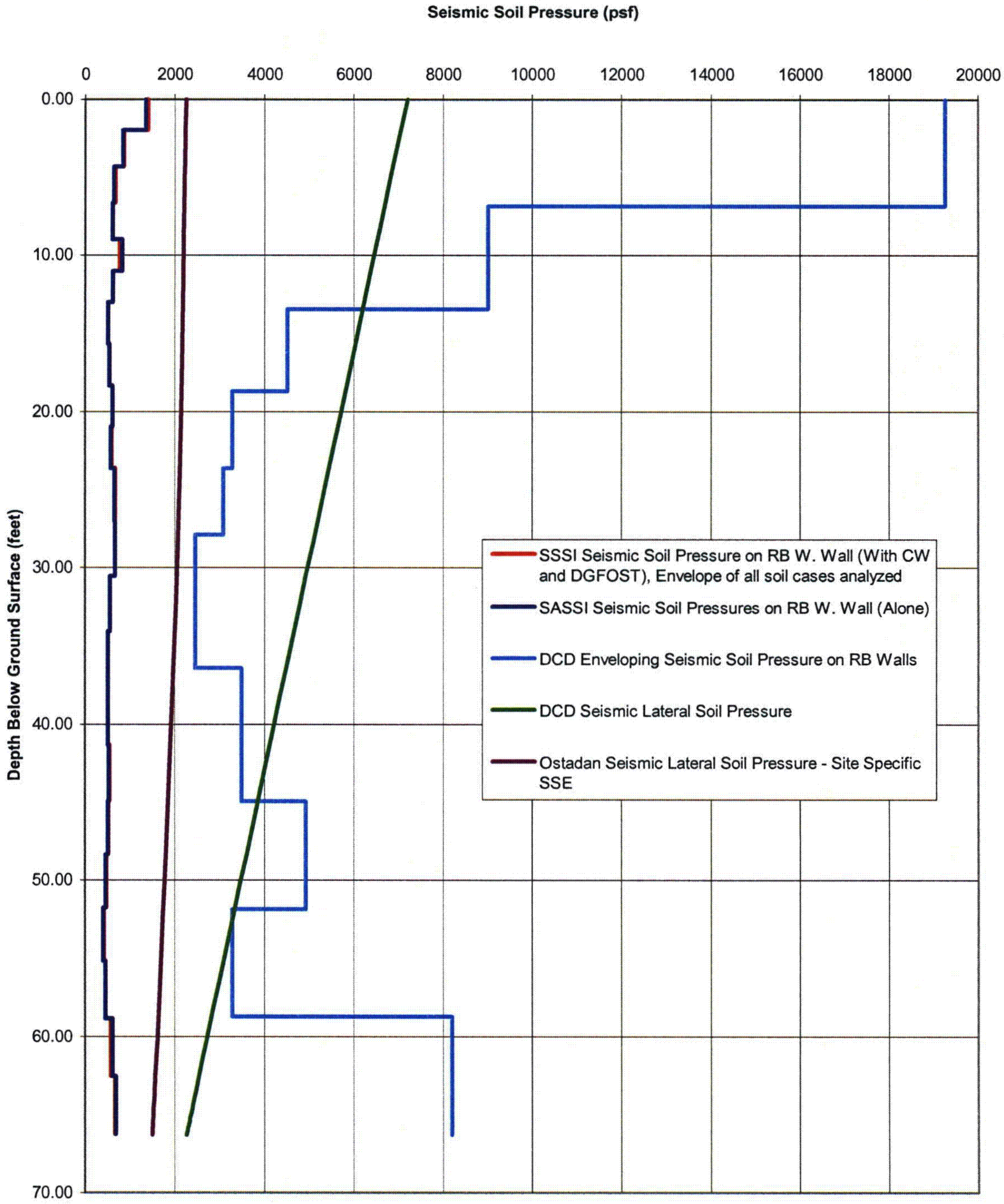


Figure 3H.1-6: Lateral Seismic Soil Pressure Comparison for RB West Wall (Considering DGFOT & Crane Wall)

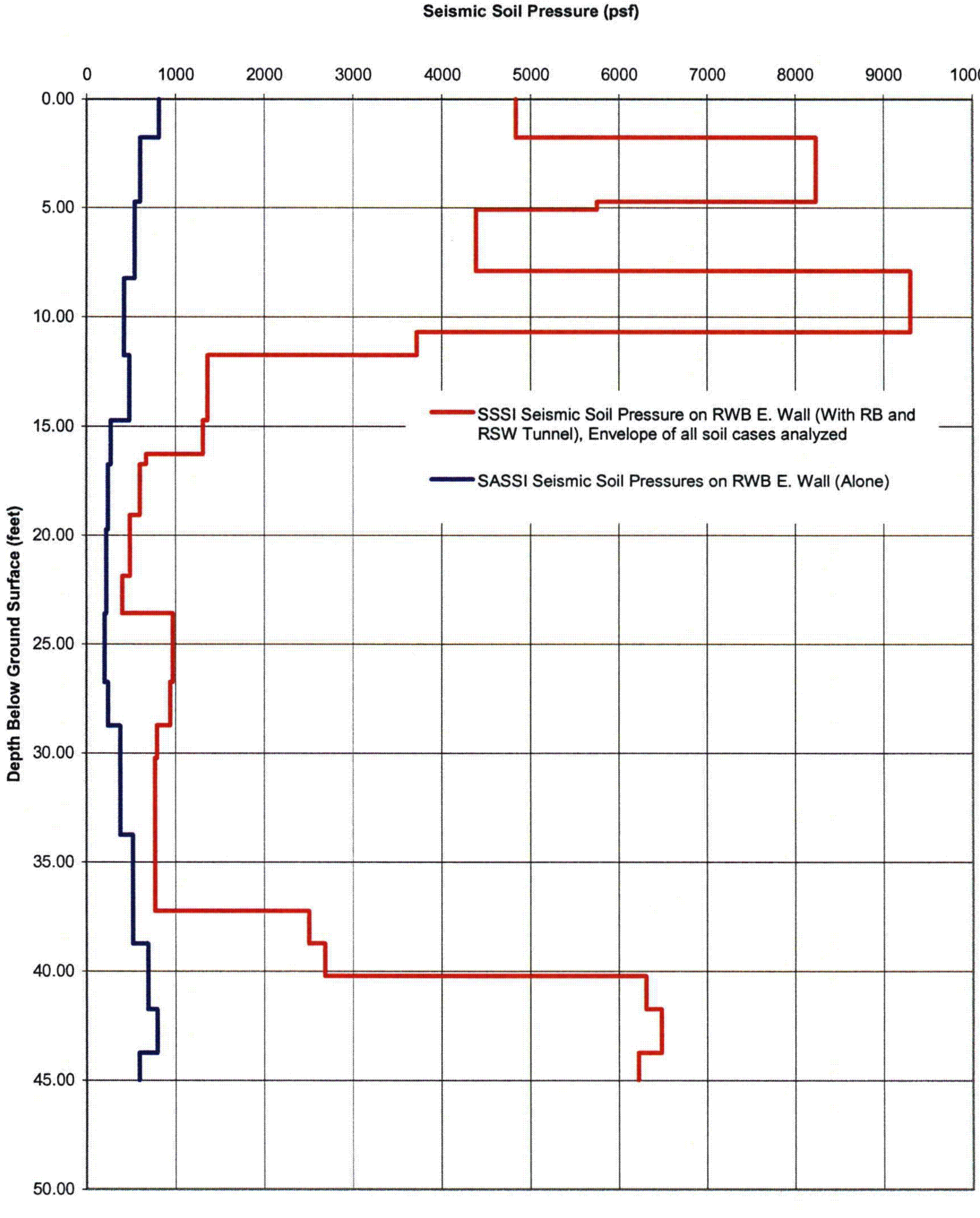


Figure 3H.3-50: SSI and SSSI Lateral Seismic Soil Pressure (psf) on Radwaste Building East Wall

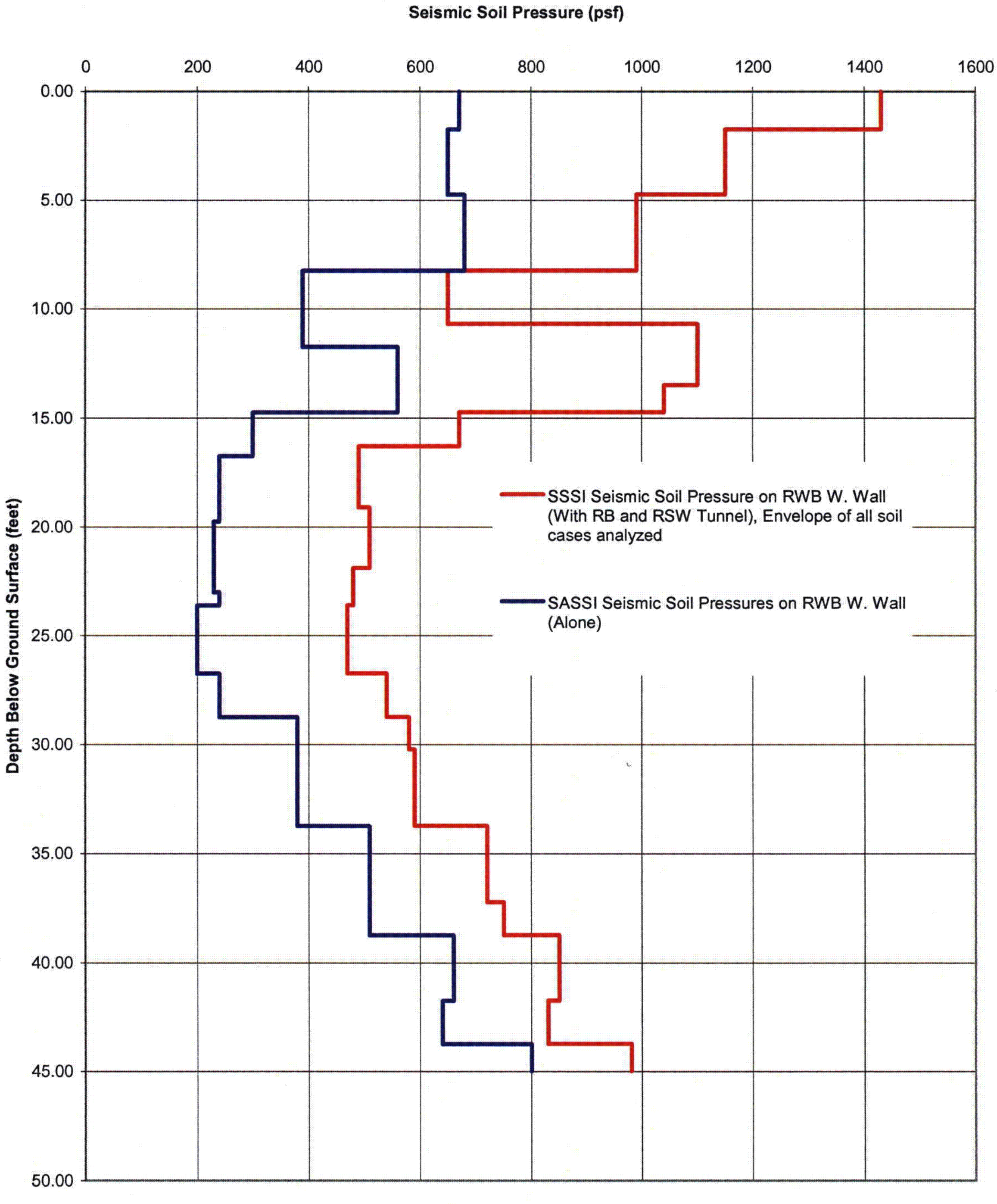


Figure 3H.3-51: SSI and SSSI Lateral Seismic Soil Pressure (psf) on Radwaste Building West Wall

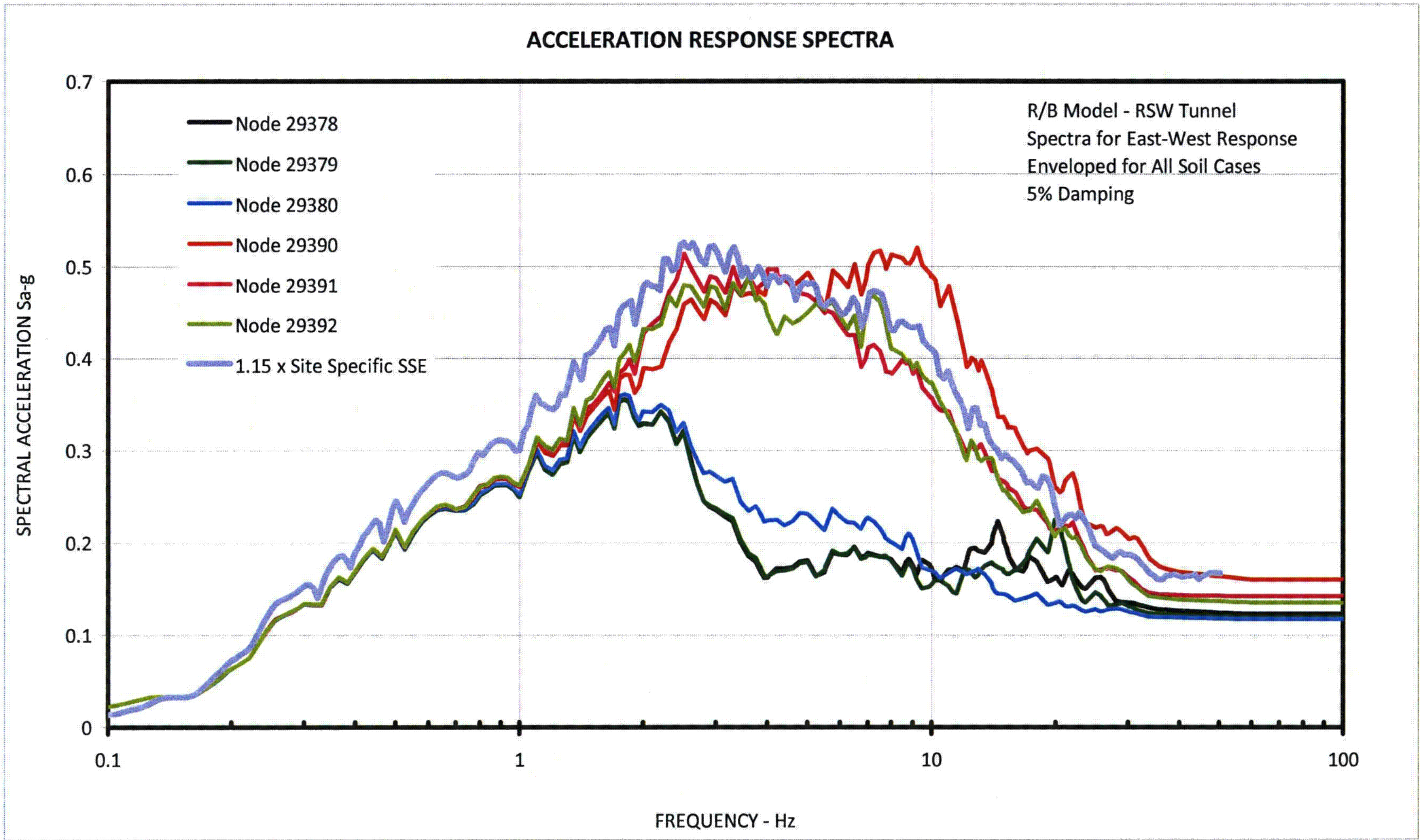


Figure 3H.6-209a: Amplified E-W Site-Specific Response Spectra for Reactor Service Water (RSW) Piping Tunnel (Based on SSI Analysis of Reactor Building)

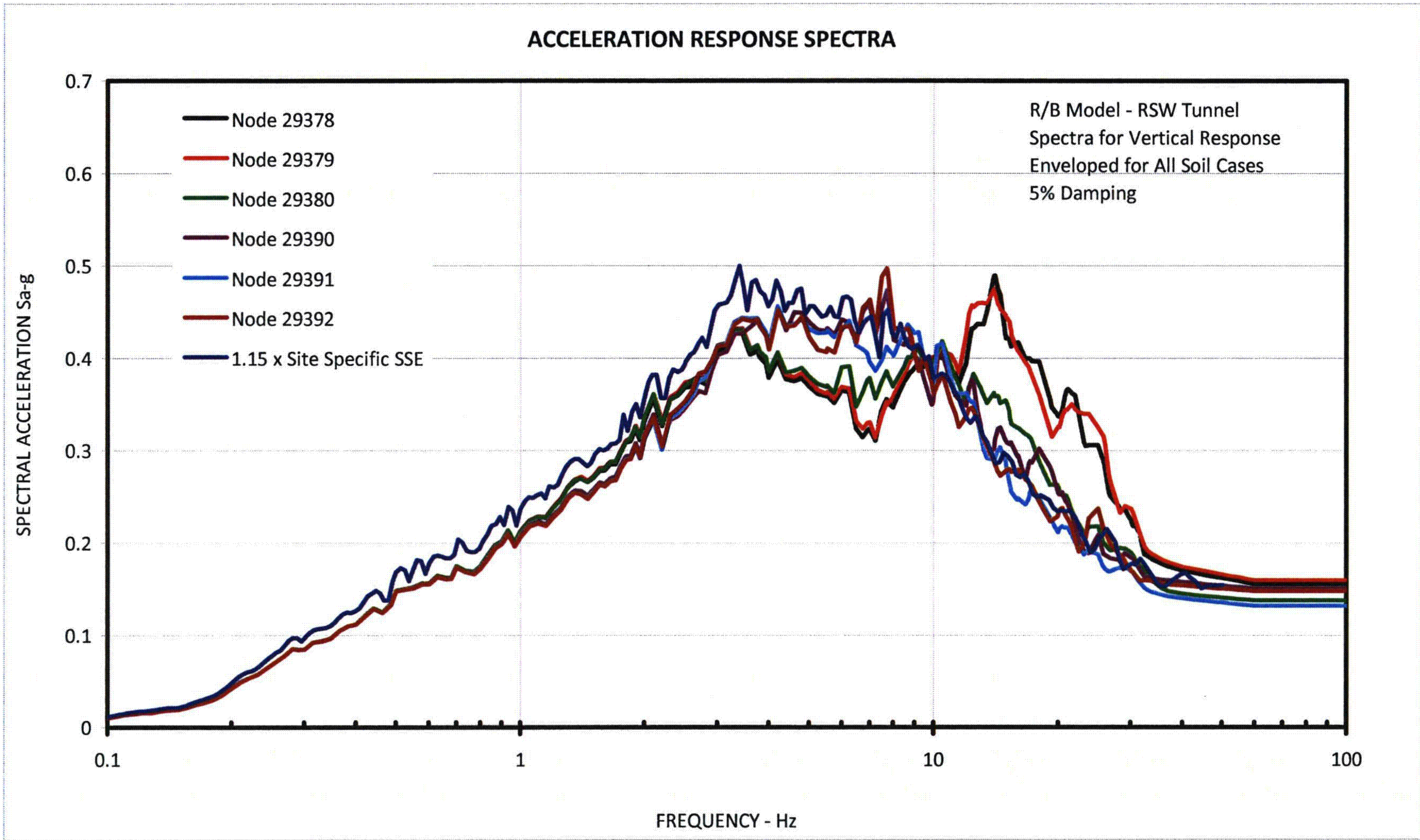


Figure 3H.6-209b: Amplified Vertical Site-Specific Response Spectra for Reactor Service Water (RSW) Piping Tunnel (Based on SSI Analysis of Reactor Building)

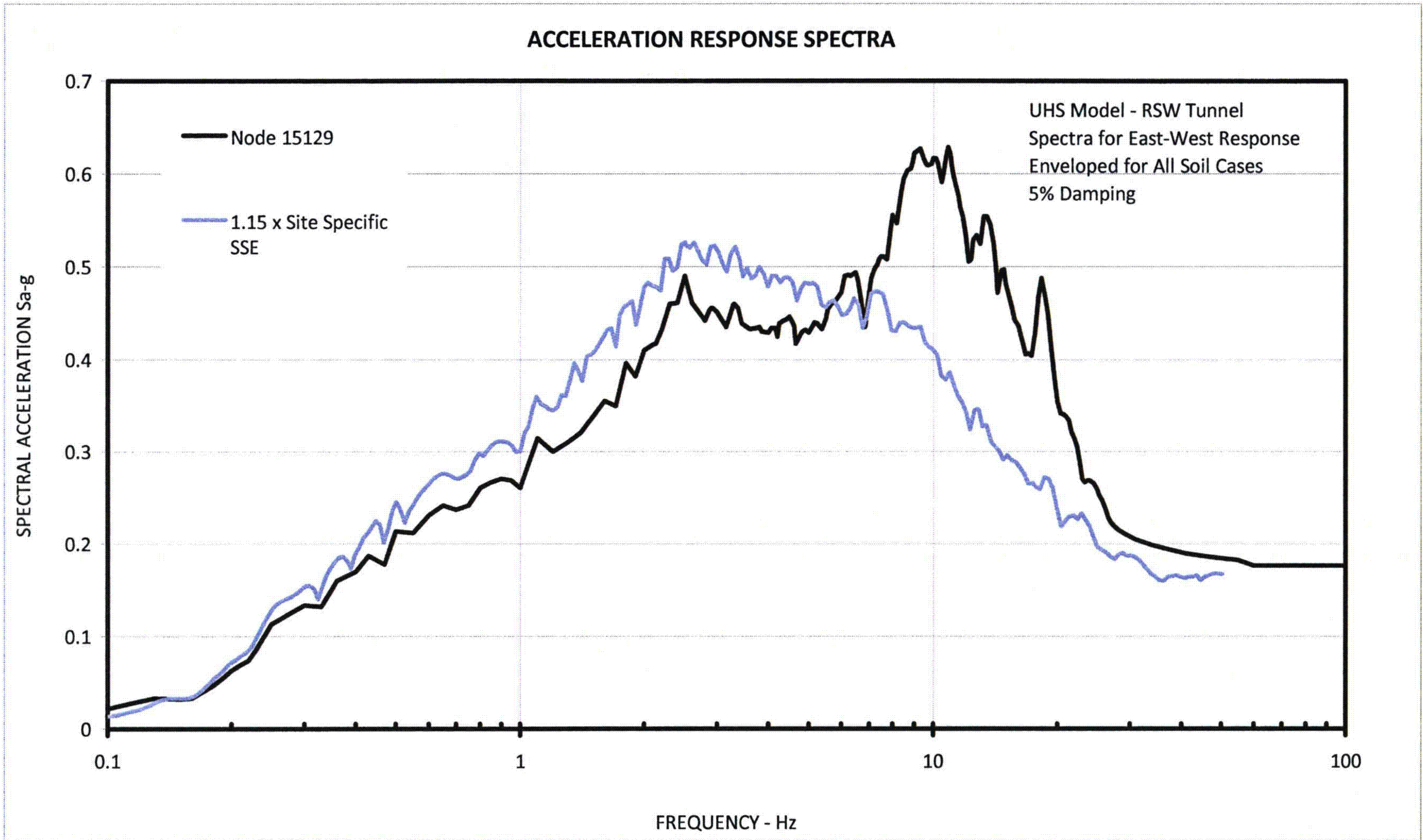


Figure 3H.6-209c: Amplified E-W Site-Specific Response Spectra for Reactor Service Water (RSW) Piping Tunnel (Based on SSI Analysis of UHS/RSW Pump House)

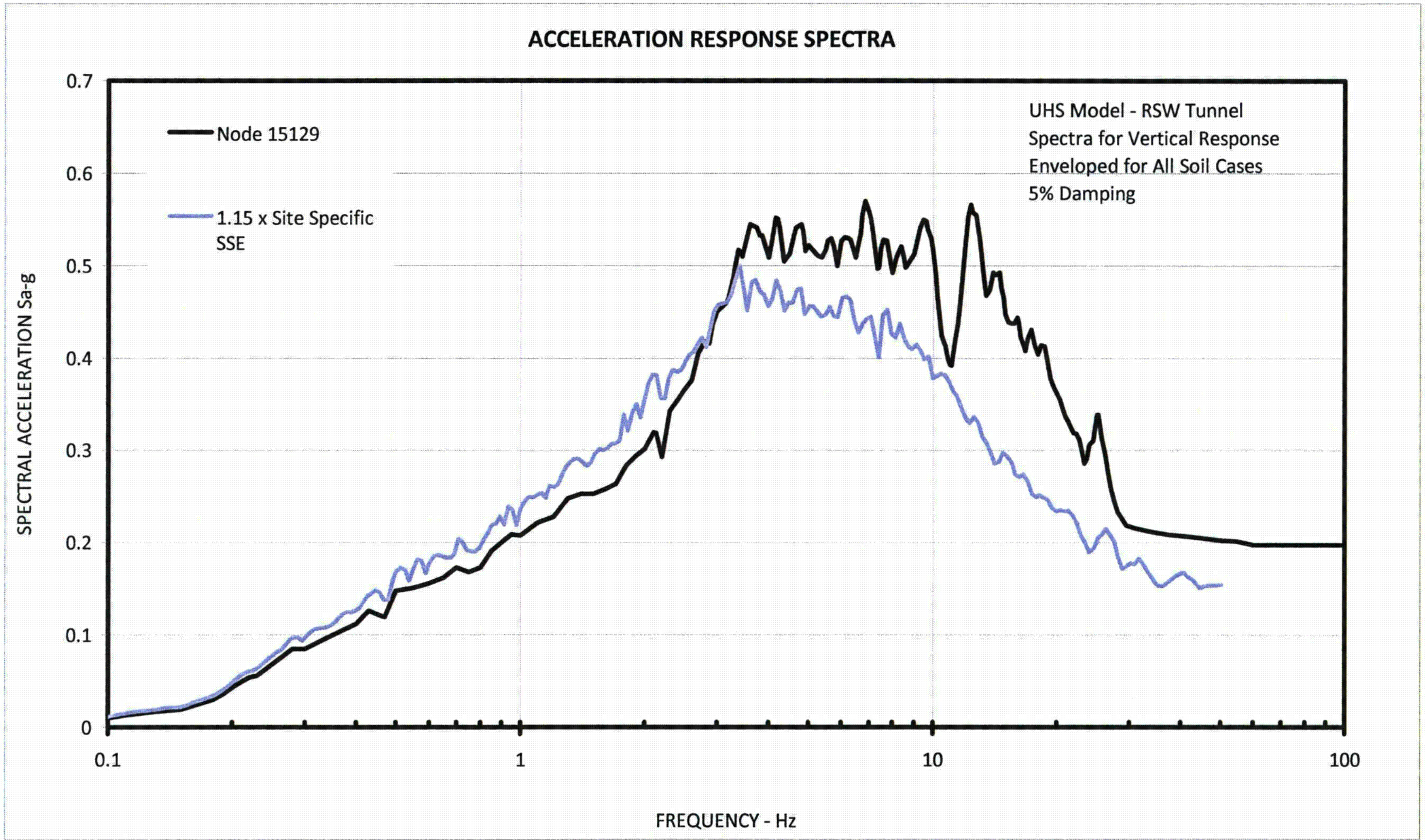


Figure 3H.6-209d: Amplified Vertical Site-Specific Response Spectra for Reactor Service Water (RSW) Piping Tunnel (Based on SSI Analysis of UHS/RSW Pump House)

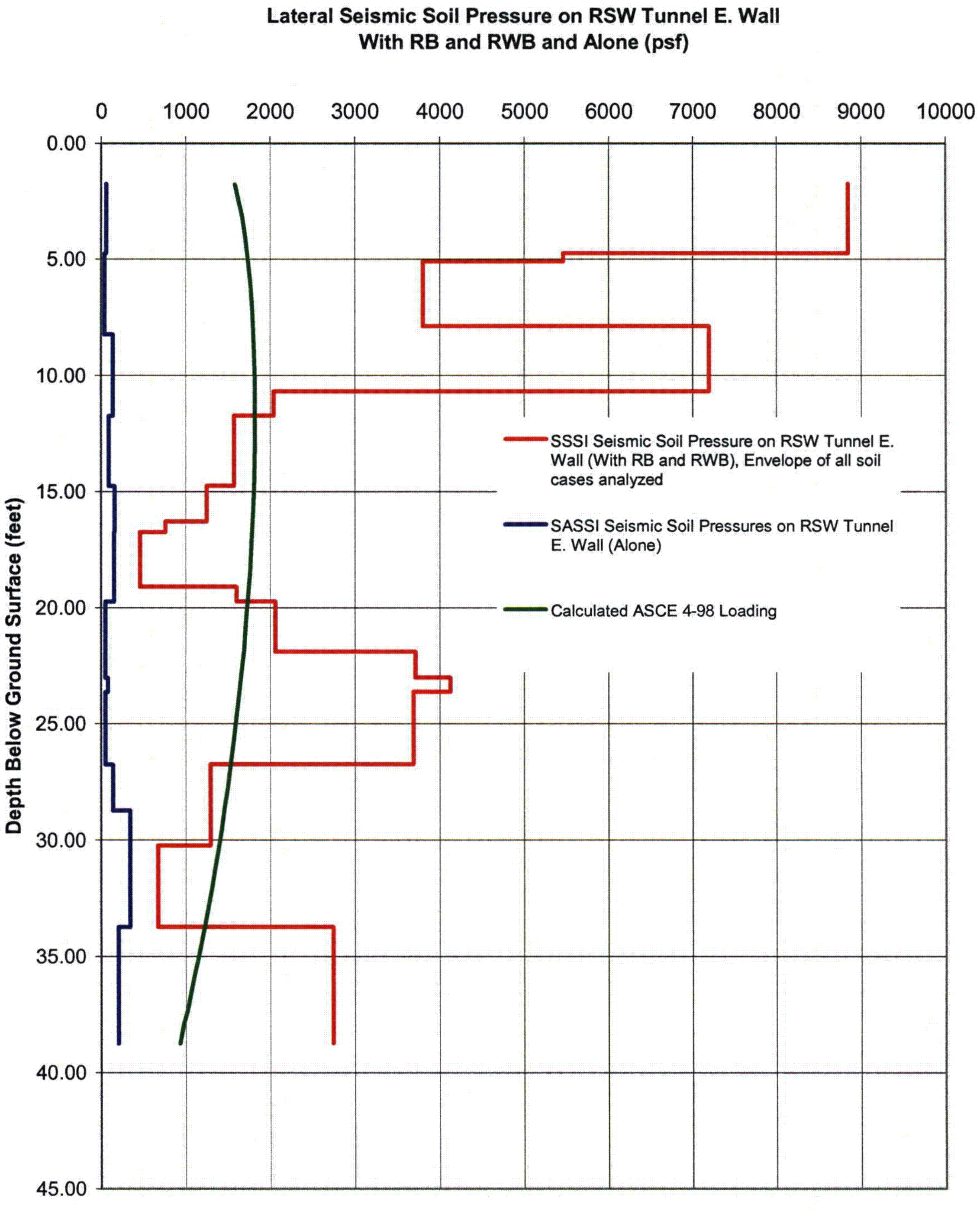


Figure 3H.6-212: Lateral Seismic Soil Pressure (psf) on RSW Piping Tunnel East Wall (Main Cross Section of RSW Piping Tunnel)

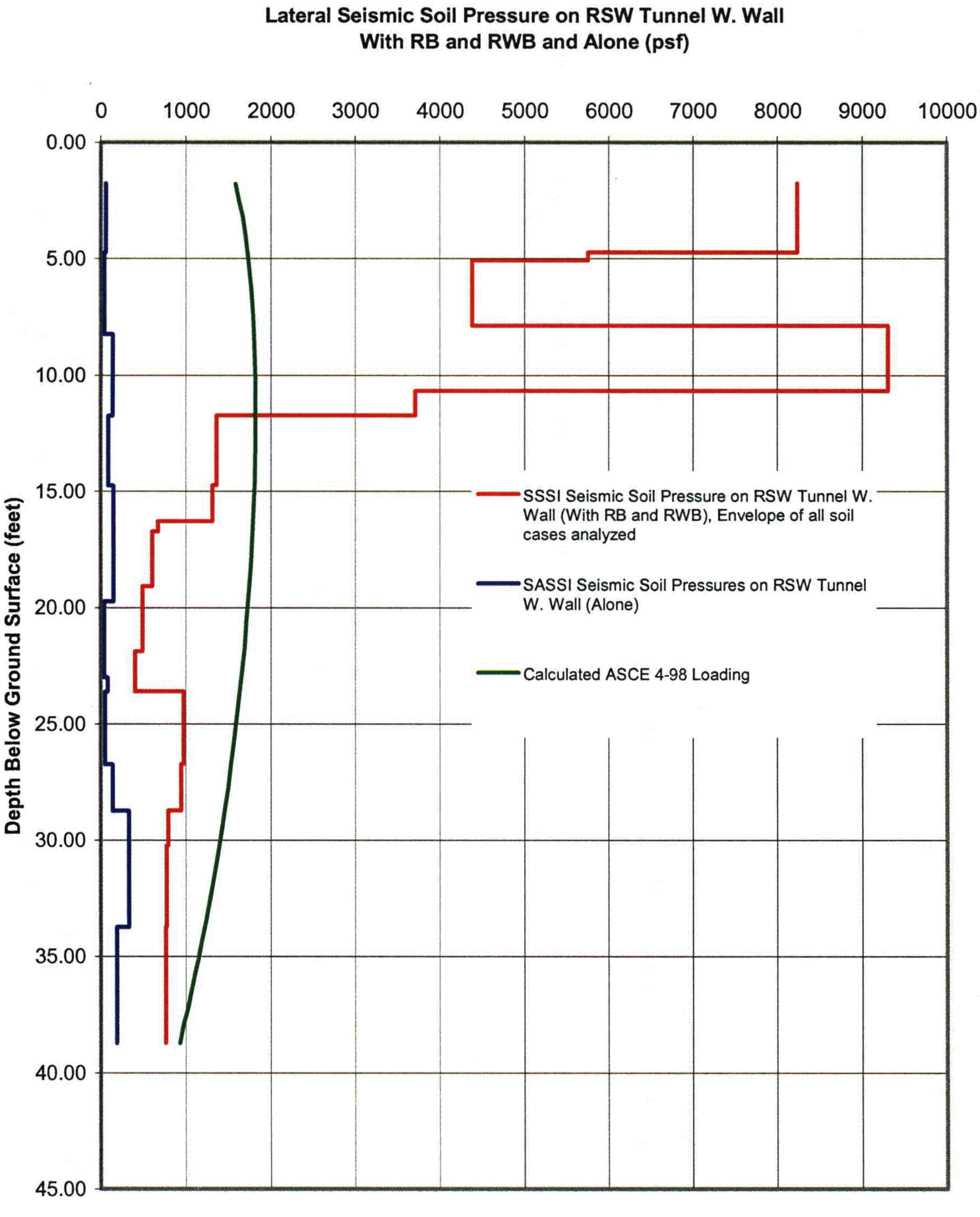


Figure 3H.6-213: Lateral Seismic Soil Pressure (psf) on RSW Piping Tunnel West Wall (Main Cross Section of RSW Piping Tunnel)

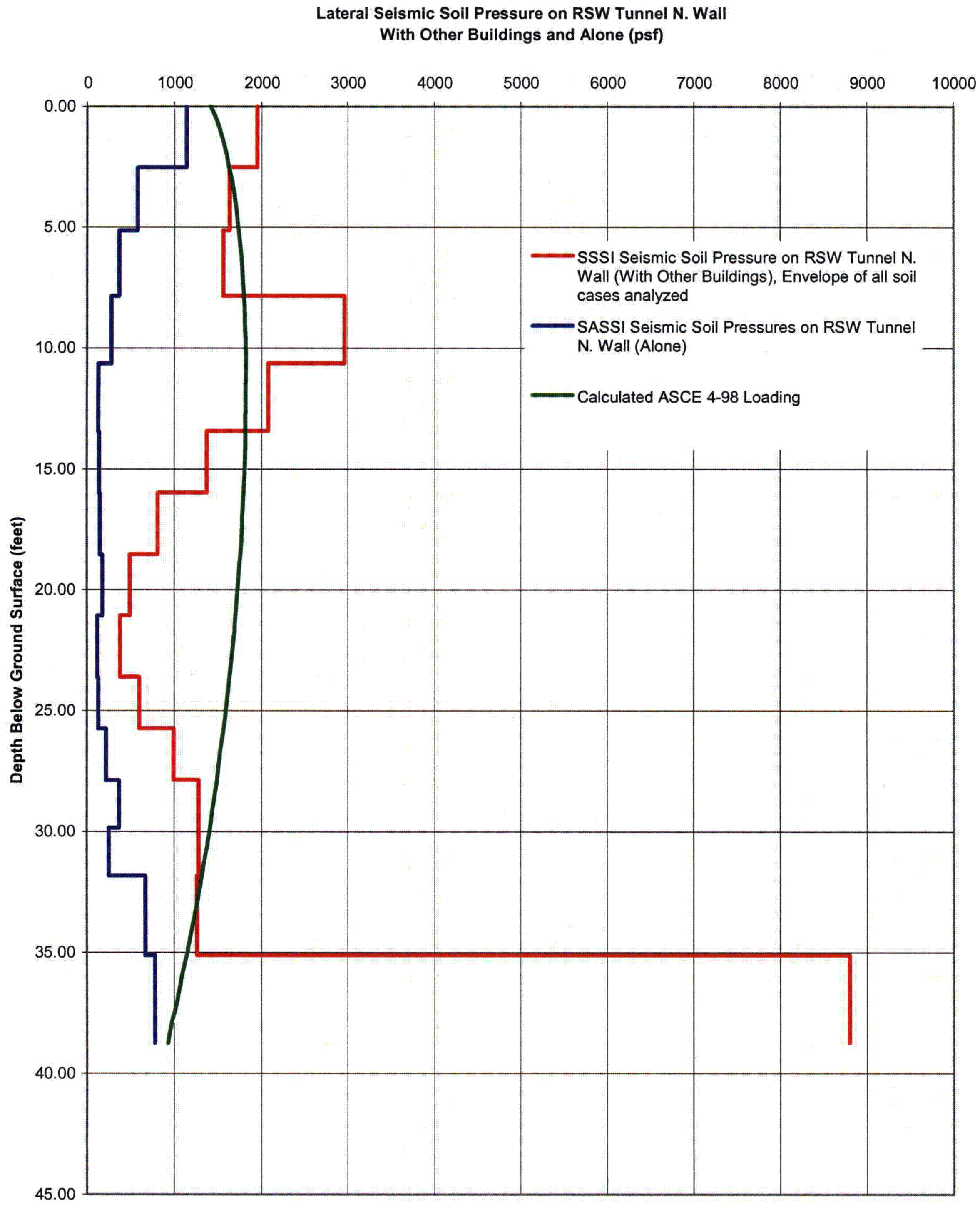


Figure 3H.6-214: Lateral Seismic Soil Pressure (psf) on RSW Piping Tunnel North Wall (RSW Piping Tunnel near UHS/RSW Pump House)

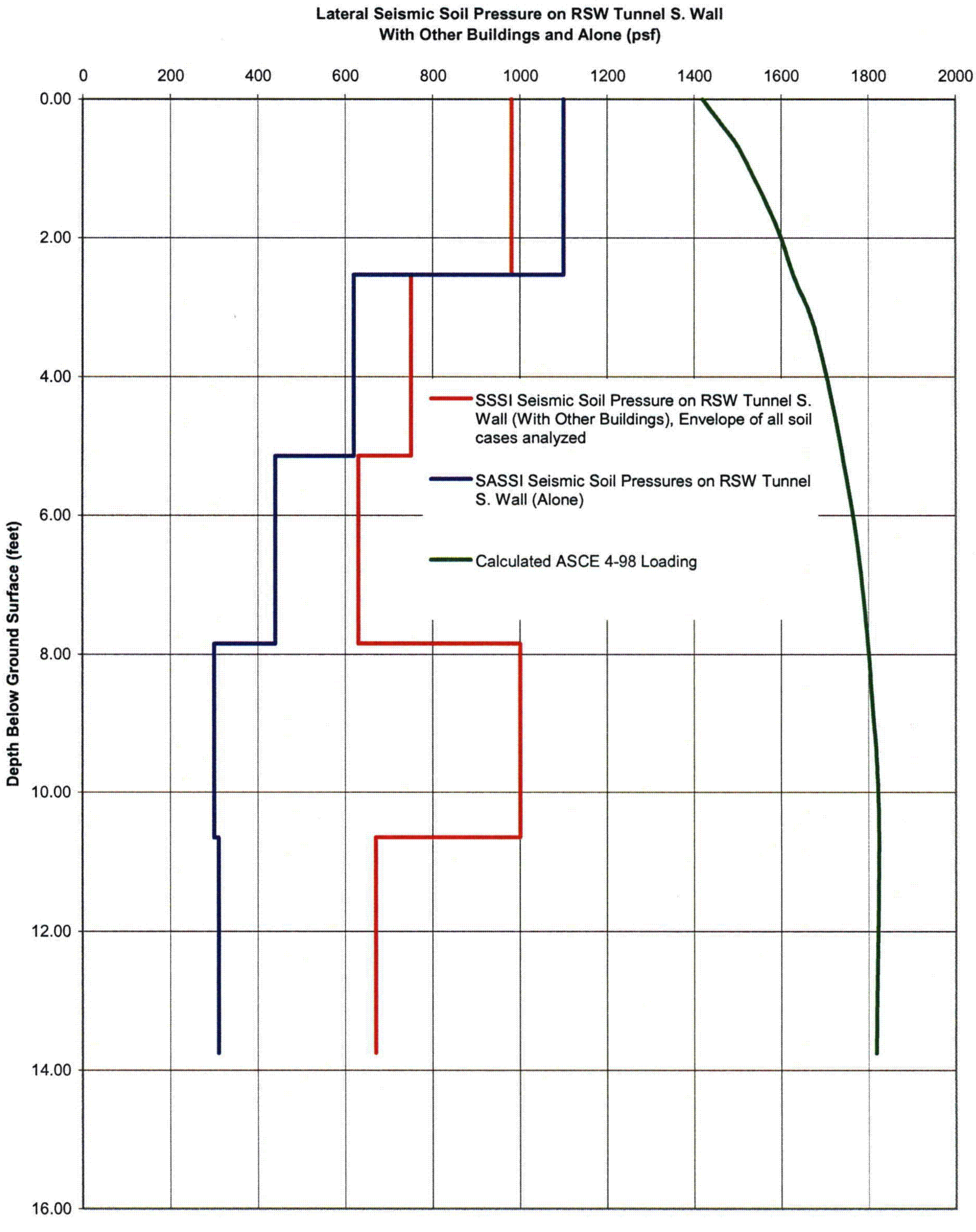


Figure 3H.6-215: Lateral Seismic Soil Pressure (psf) on RSW Piping Tunnel South Wall (RSW Piping Tunnel near UHS/RSW Pump House)

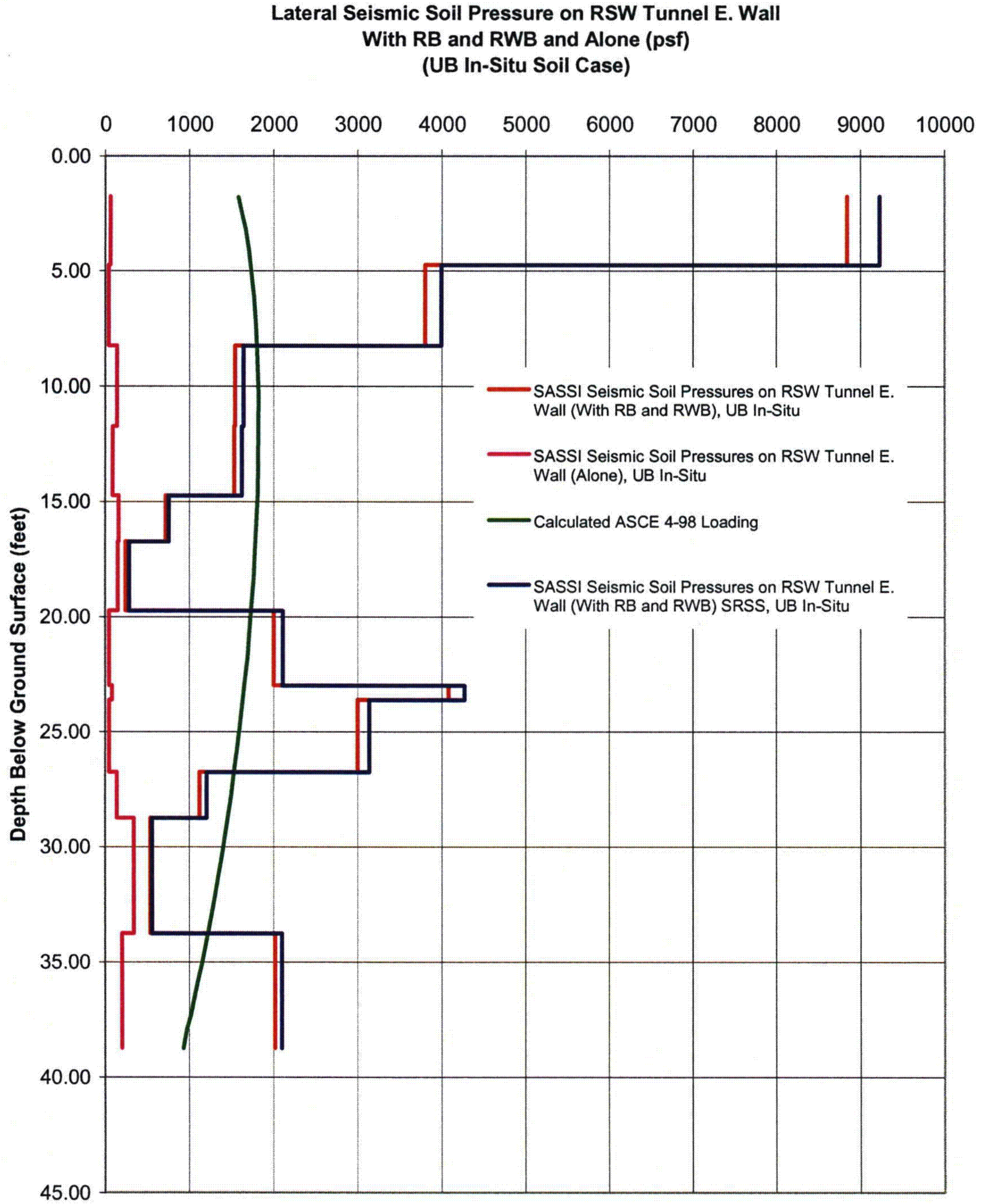


Figure 3H.6-216: Lateral Seismic Soil Pressure (psf) on RSW Piping Tunnel East Wall For UB In-Situ Soil Case (Main Cross Section of RSW Piping Tunnel, Including Effect of Vertical Excitation)

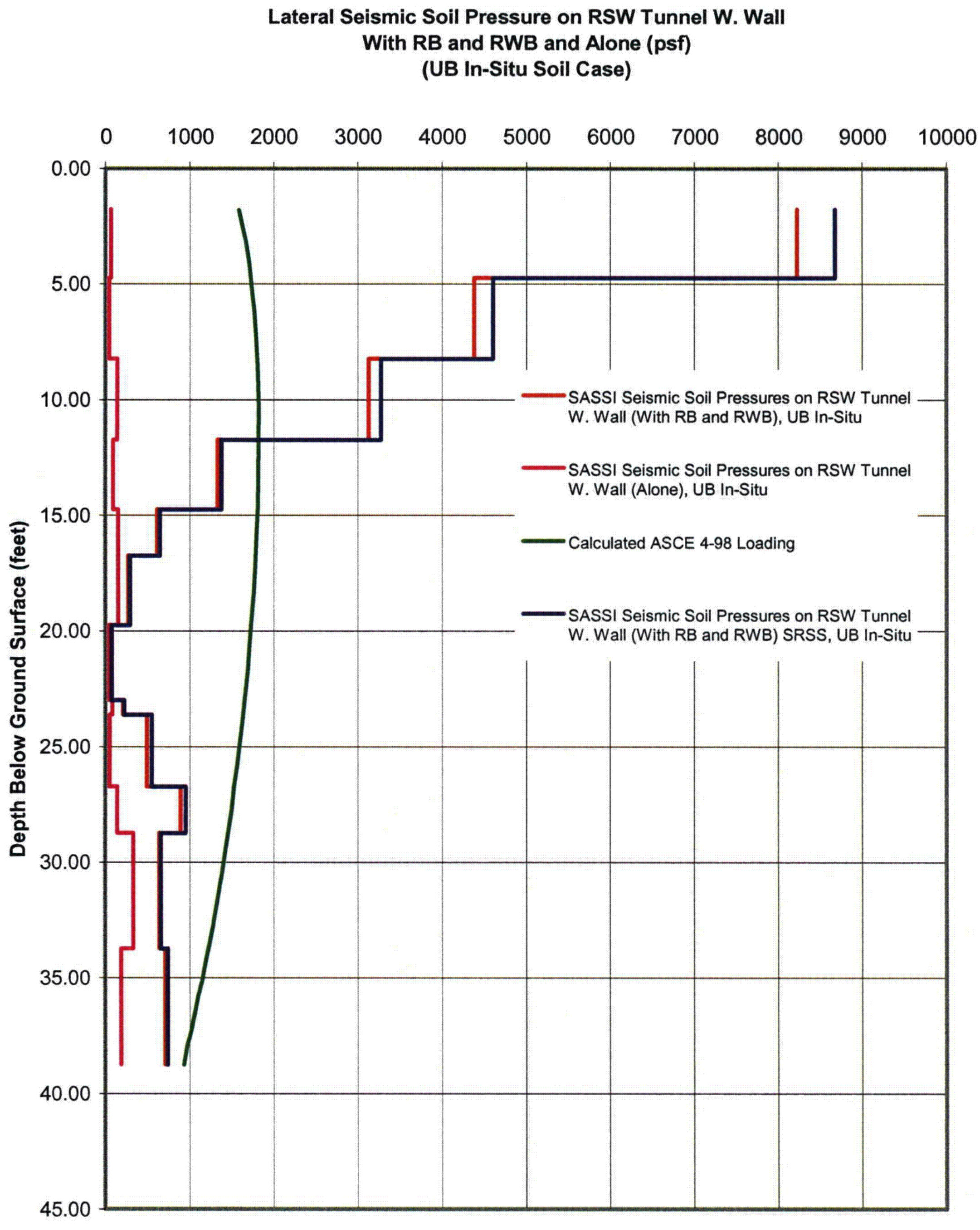


Figure 3H.6-217: Lateral Seismic Soil Pressure (psf) on RSW Piping Tunnel West Wall For UB In-Situ Soil Case (Main Cross Section of RSW Piping Tunnel, Including Effect of Vertical Excitation)

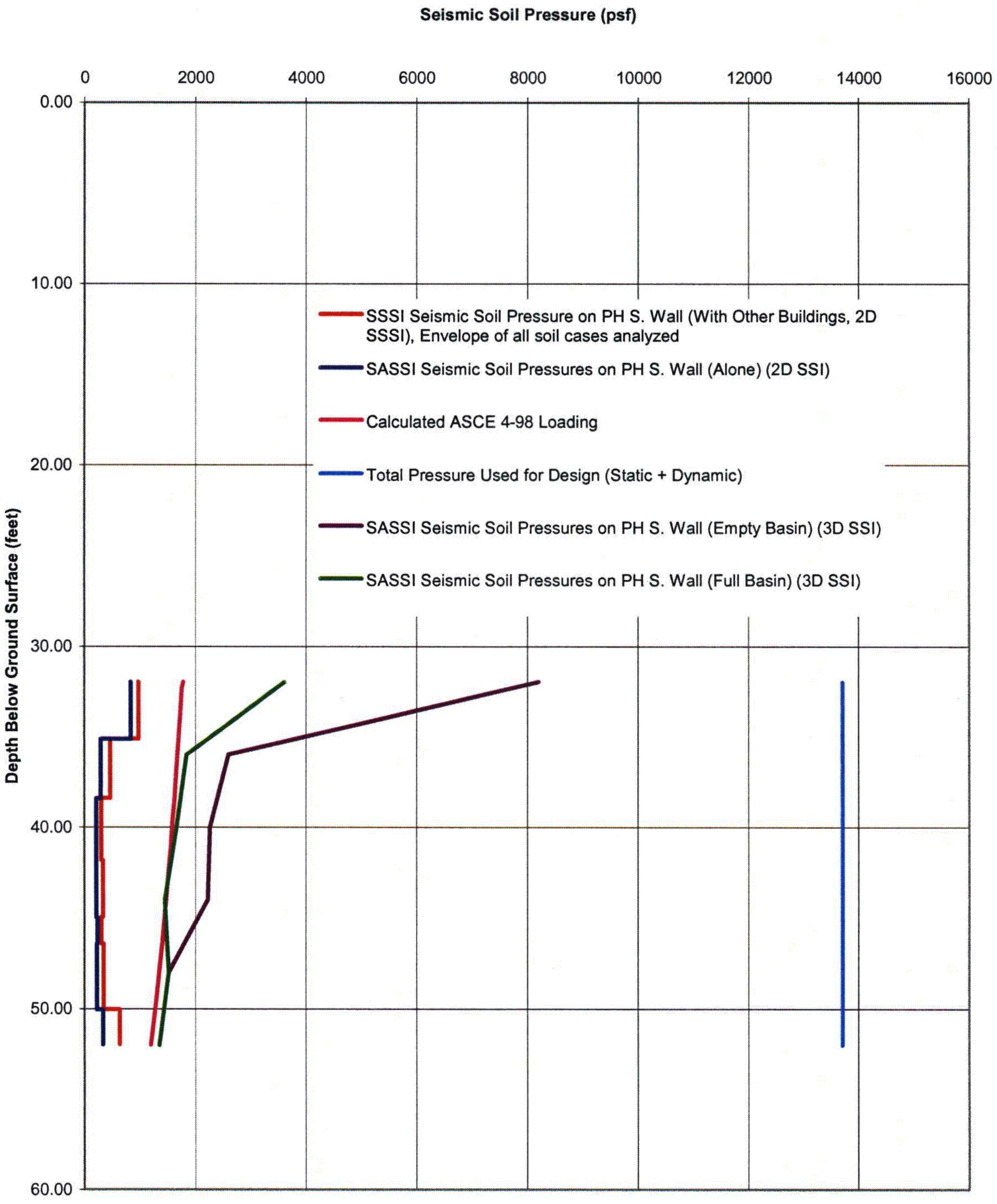


Figure 3H.6-218: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on RSW Pump House South Wall

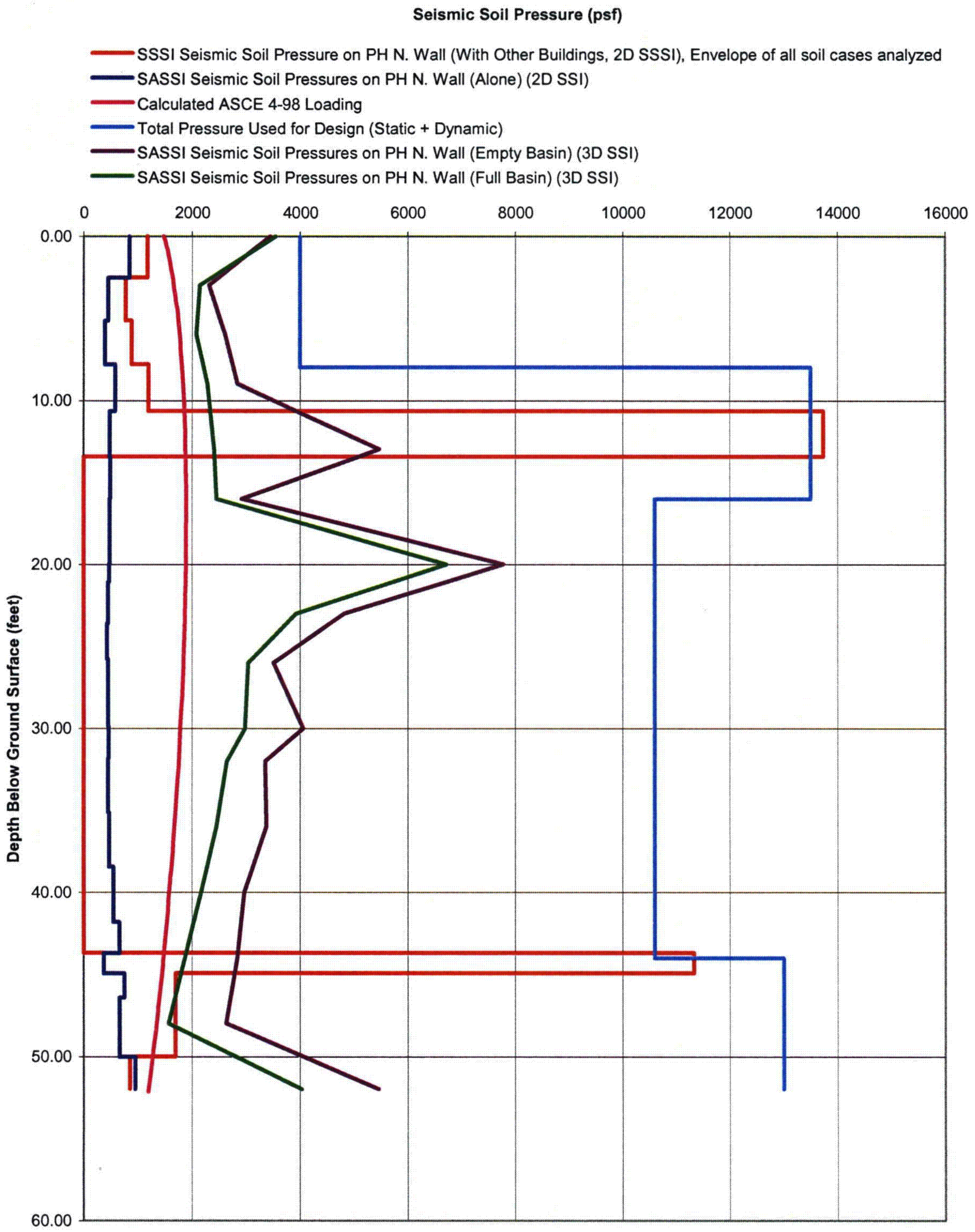


Figure 3H.6-219: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on RSW Pump House North Wall

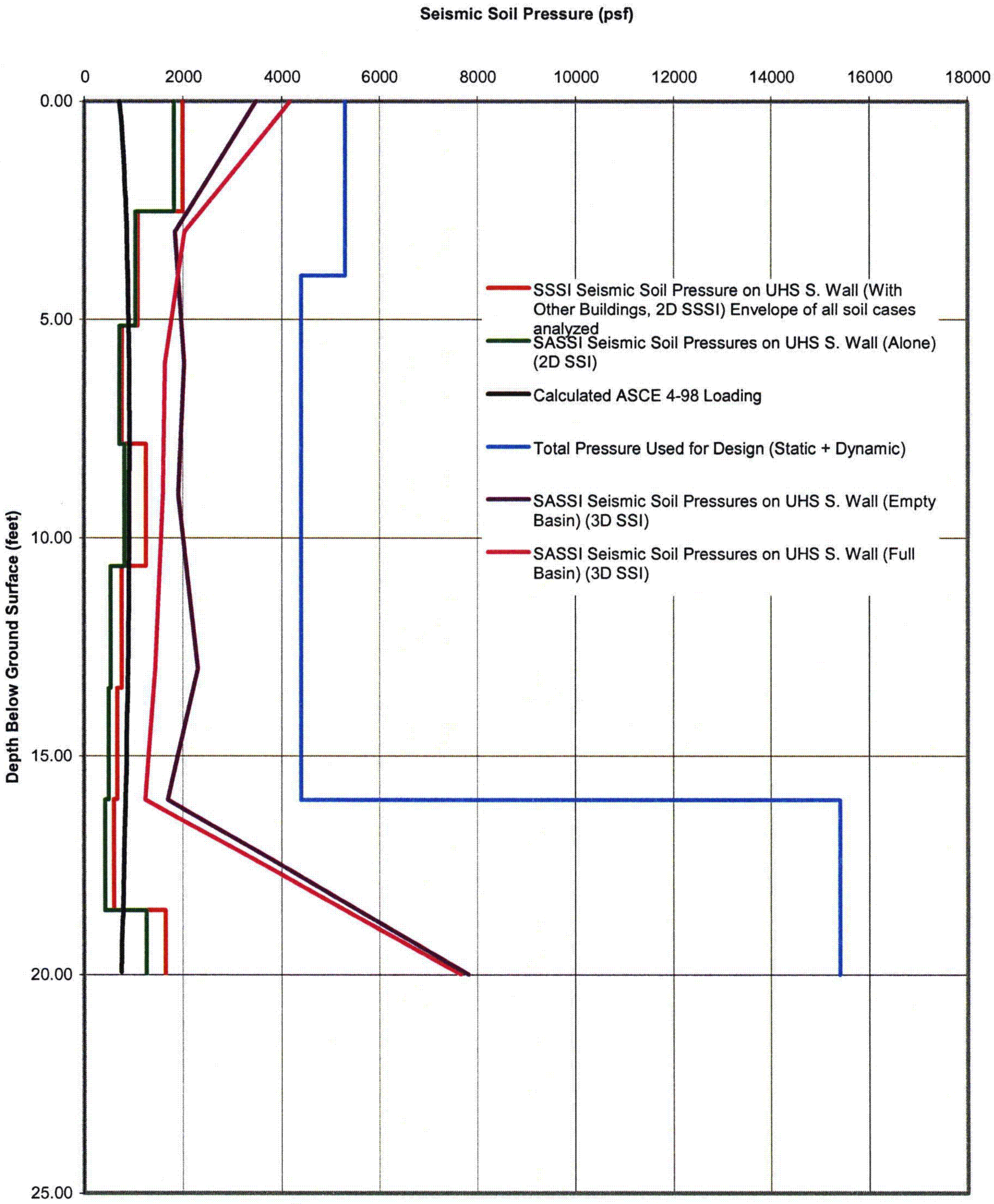


Figure 3H.6-220: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Ultimate Heat Sink Basin South Wall

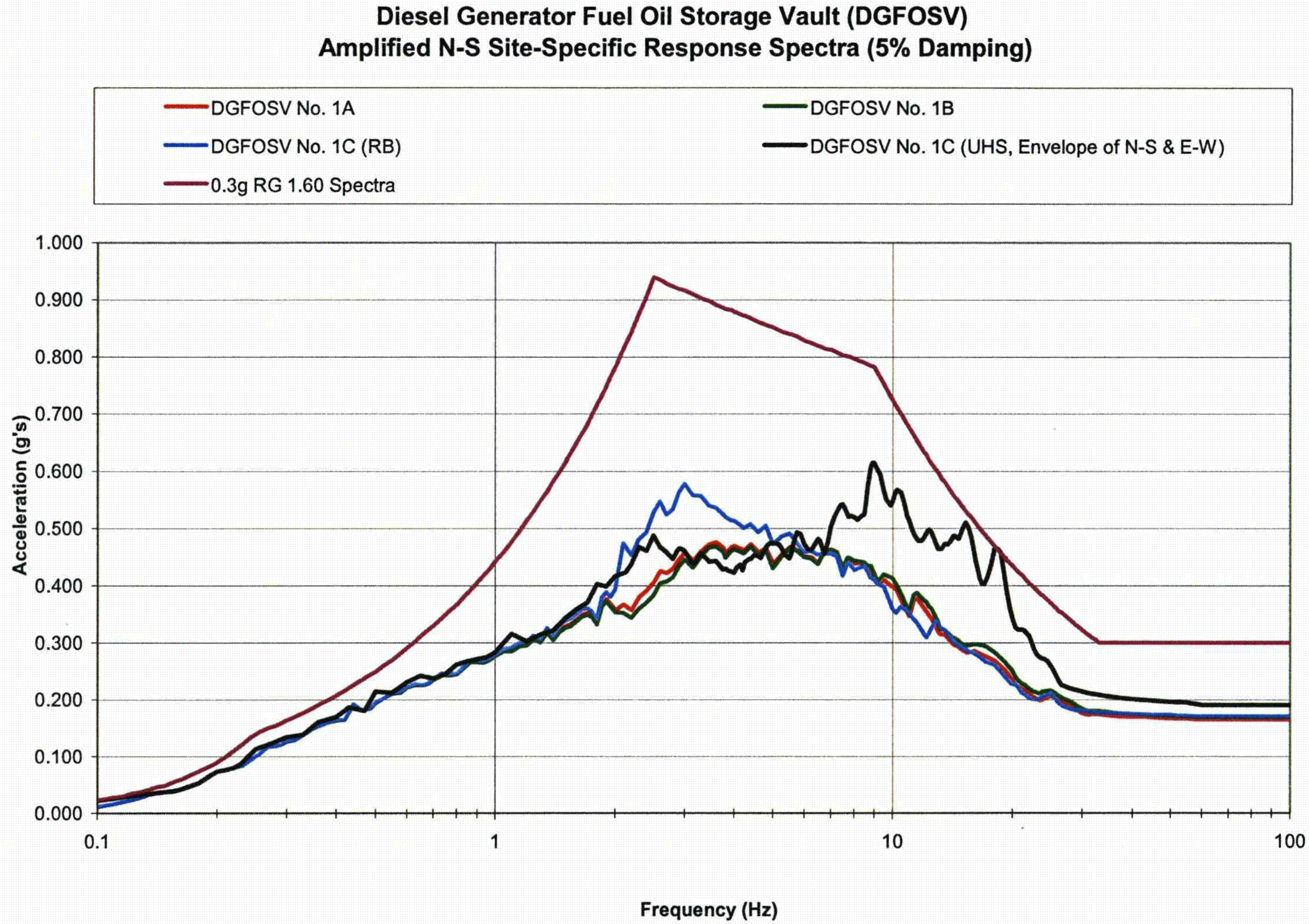


Figure 3H.6-222a: Amplified N-S Site-Specific Response Spectra
Diesel Generator Fuel Oil Storage Vault (DGFOSV)

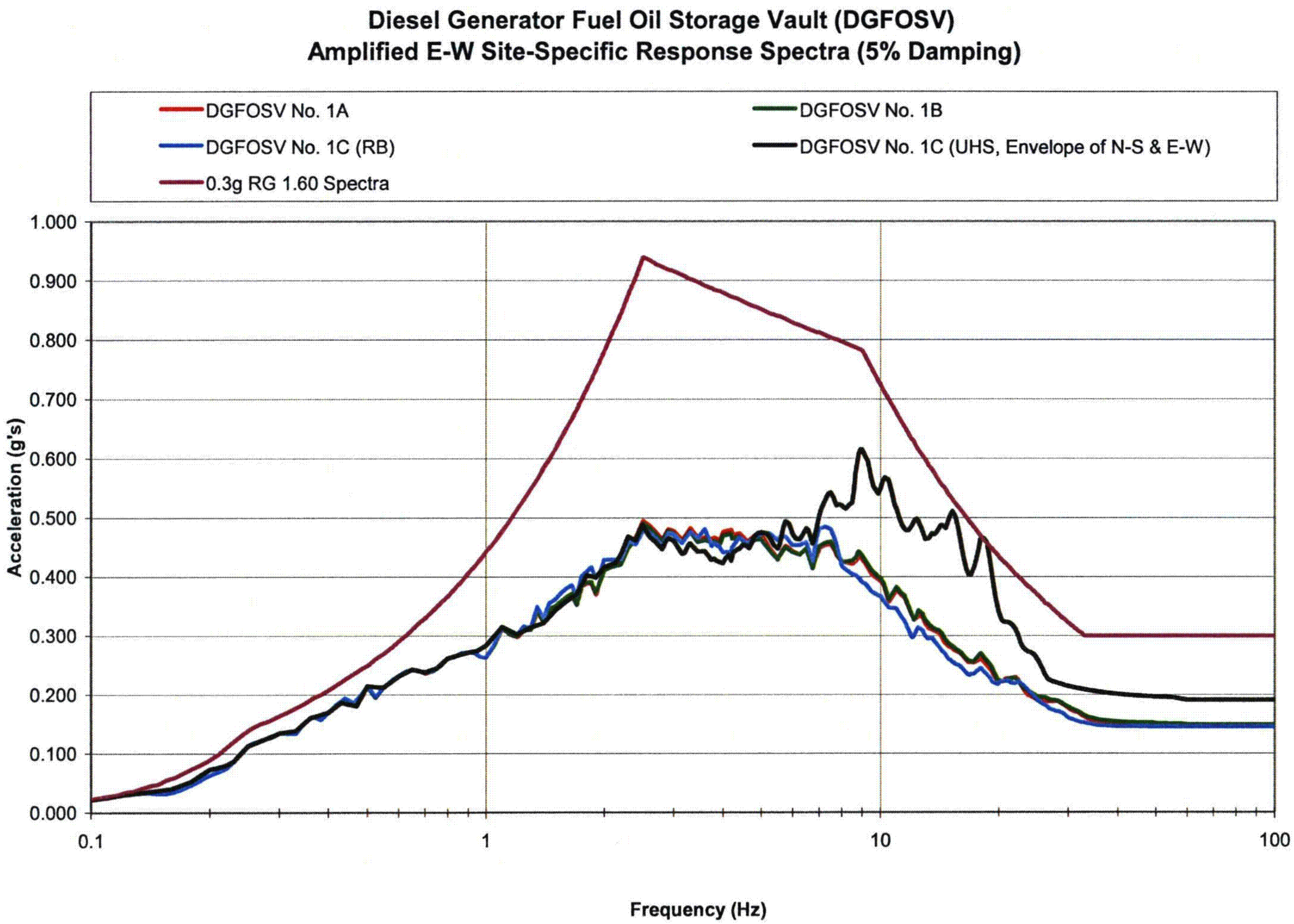


Figure 3H.6-222b: Amplified E-W Site-Specific Response Spectra Diesel Generator Fuel Oil Storage Vault (DGFOSV)

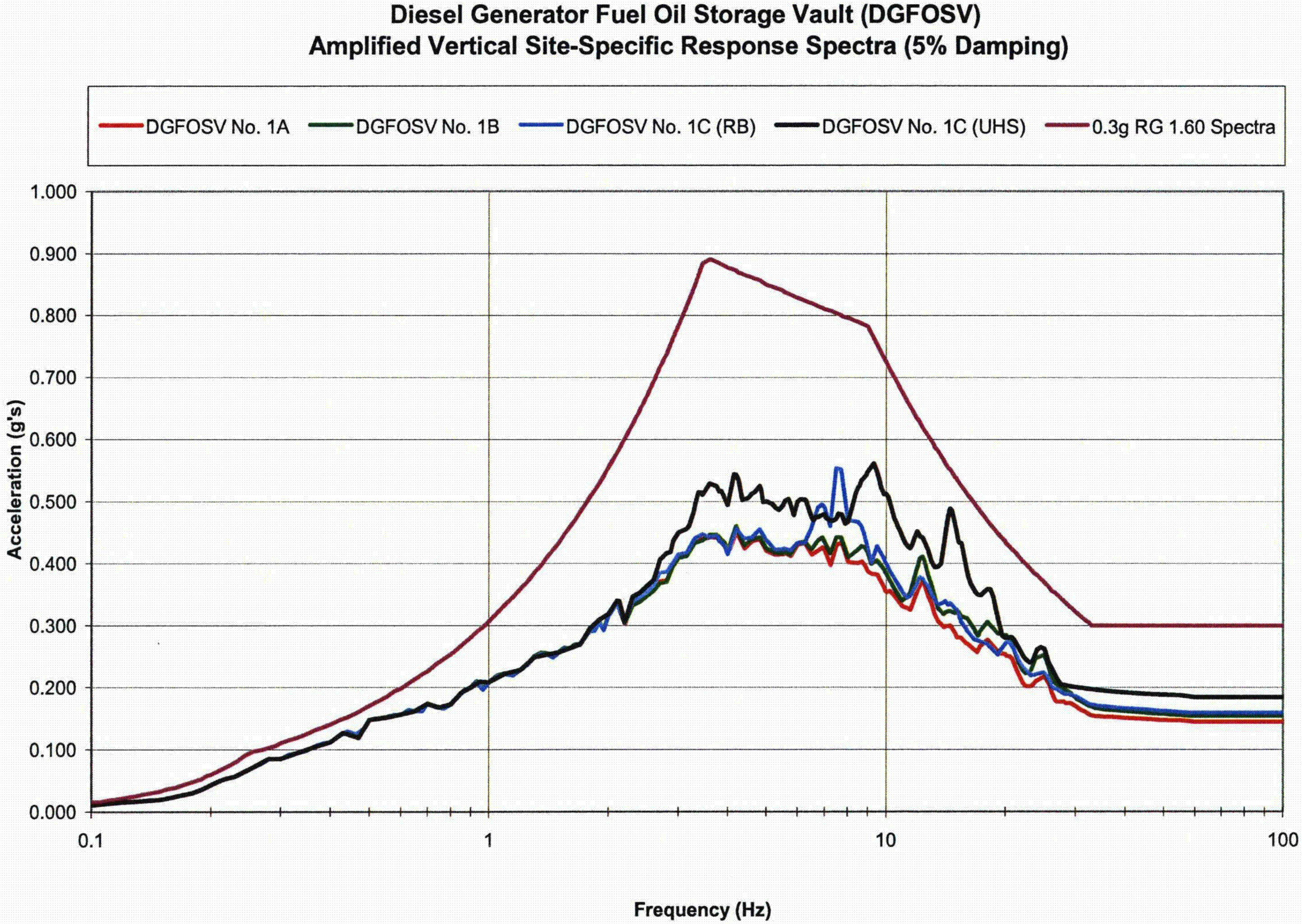


Figure 3H.6-222c: Amplified Vertical Site-Specific Response Spectra Diesel Generator Fuel Oil Storage Vault (DGFOSV)

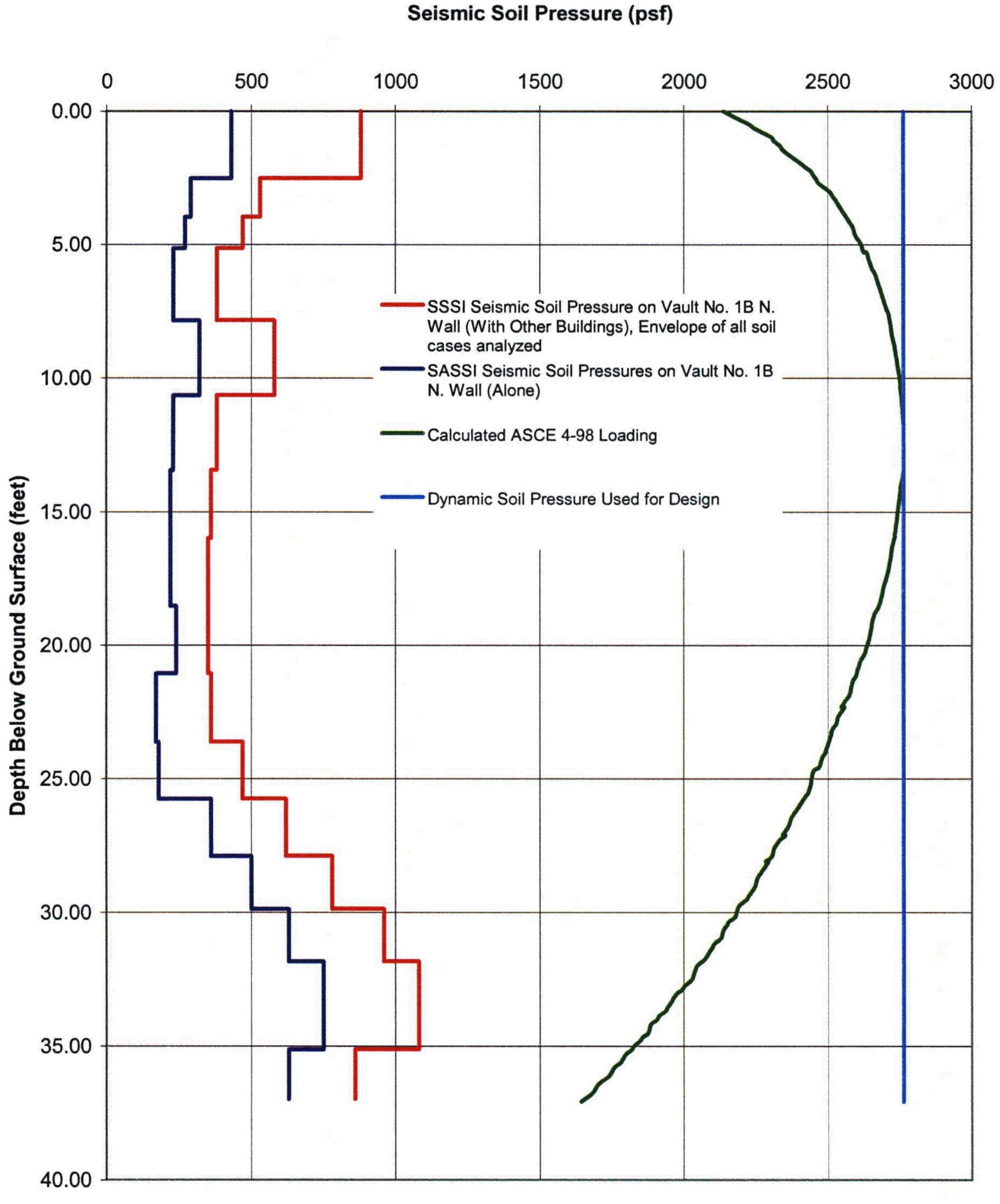


Figure 3H.6-226: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1B North Wall

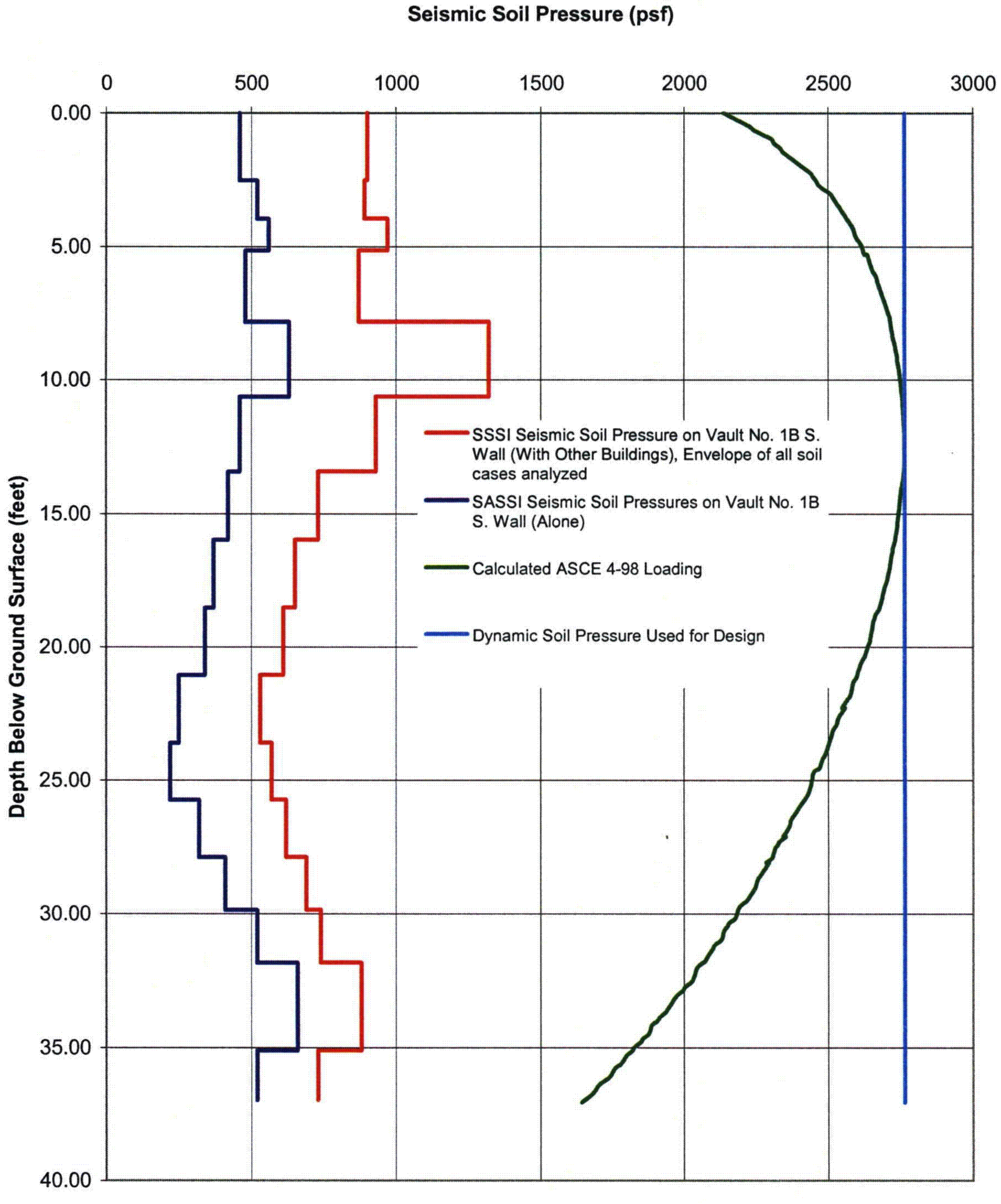


Figure 3H.6-227: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1B South Wall

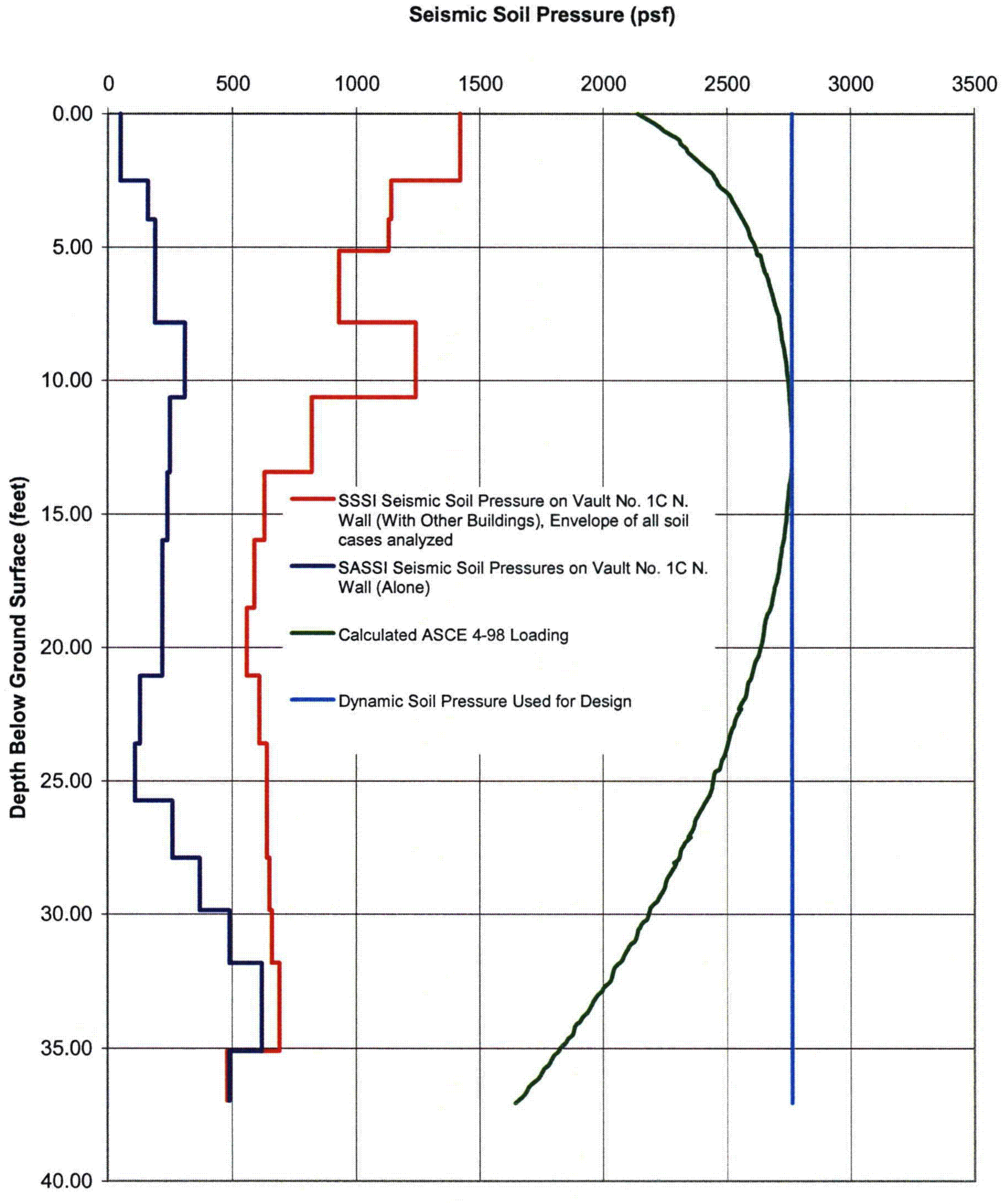


Figure 3H.6-228: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1C North Wall

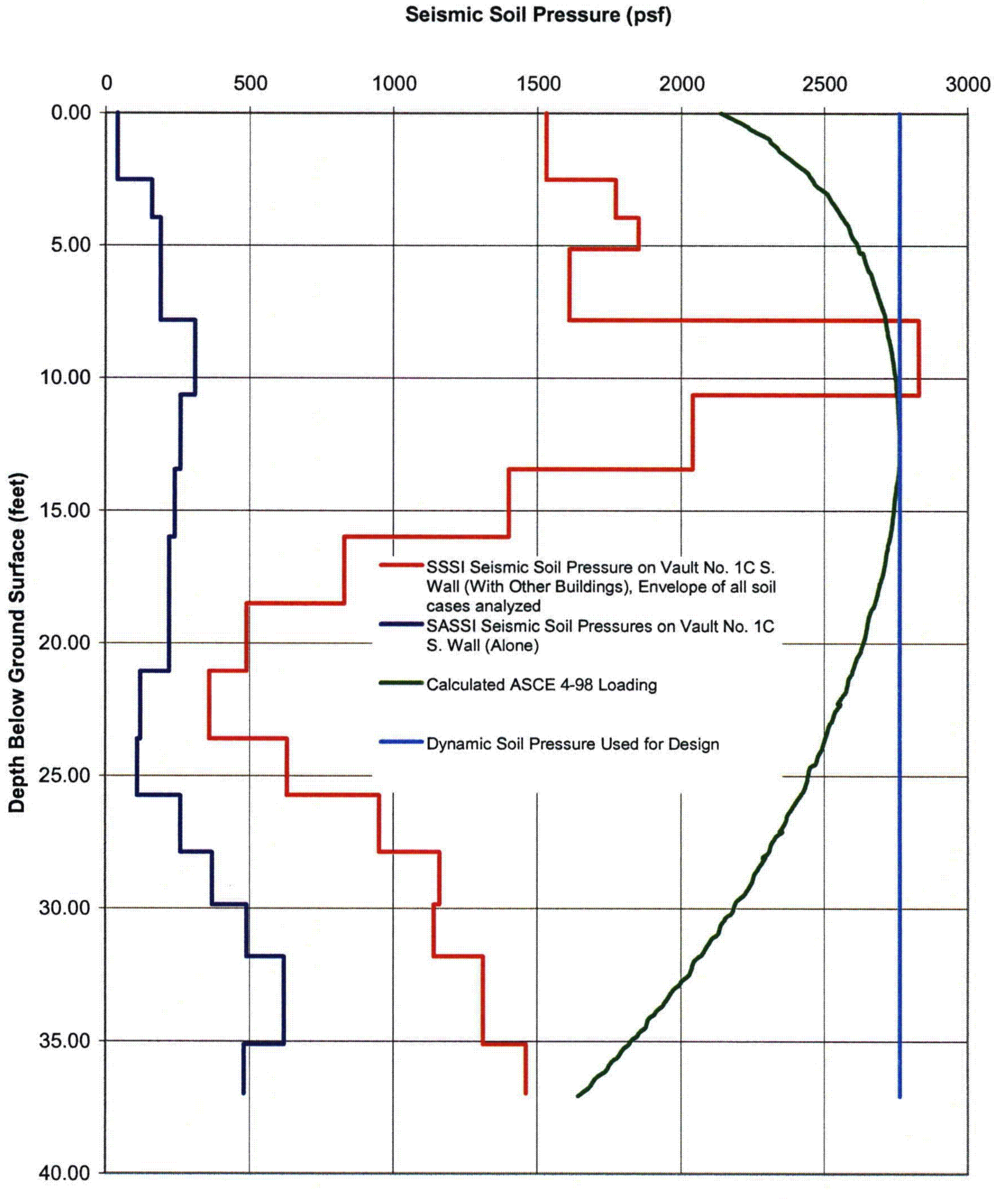


Figure 3H.6-229: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1C South Wall

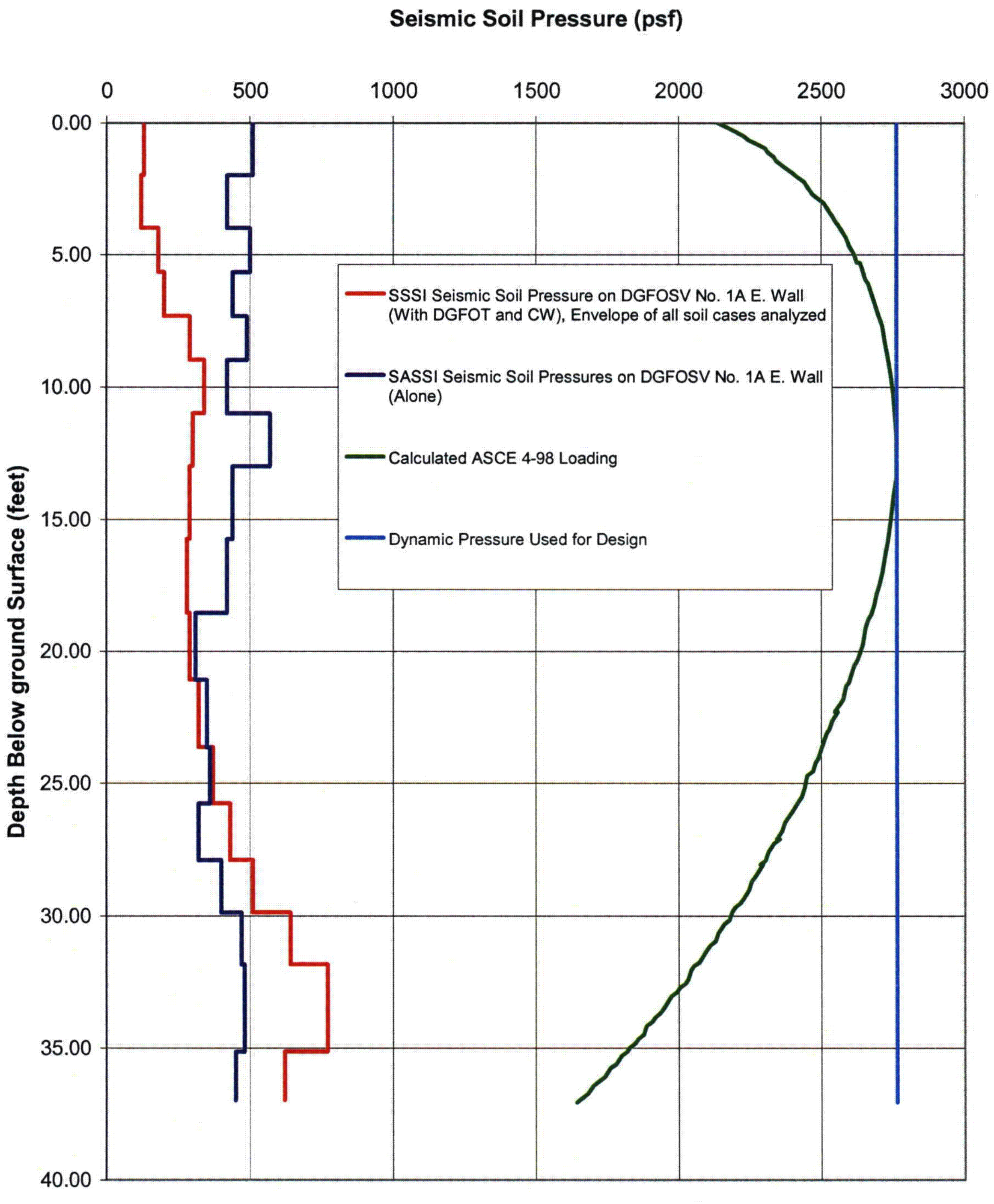


Figure 3H.6-230: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1A East Wall

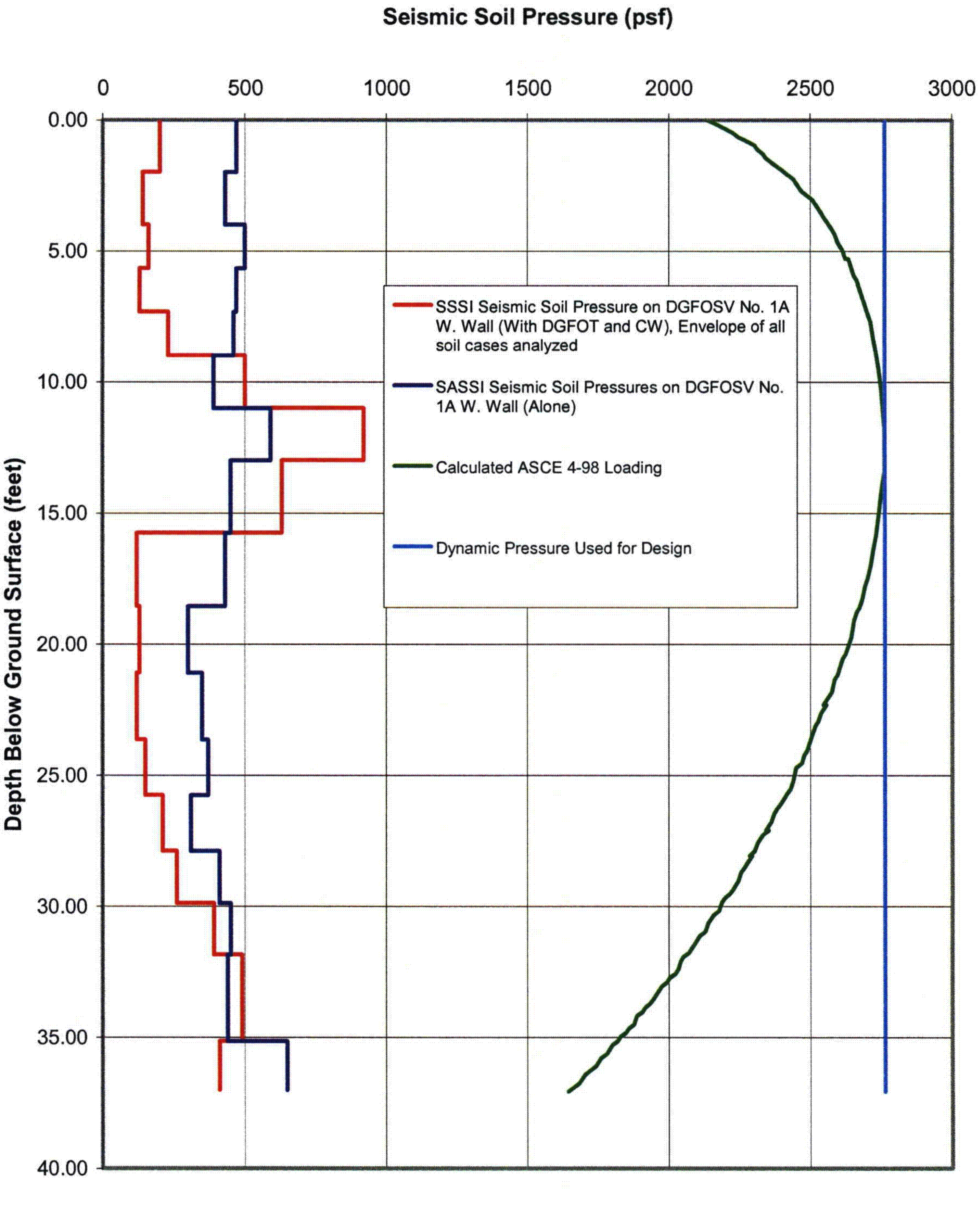


Figure 3H.6-231: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures on Diesel Generator Fuel Oil Storage Vault No. 1A West Wall

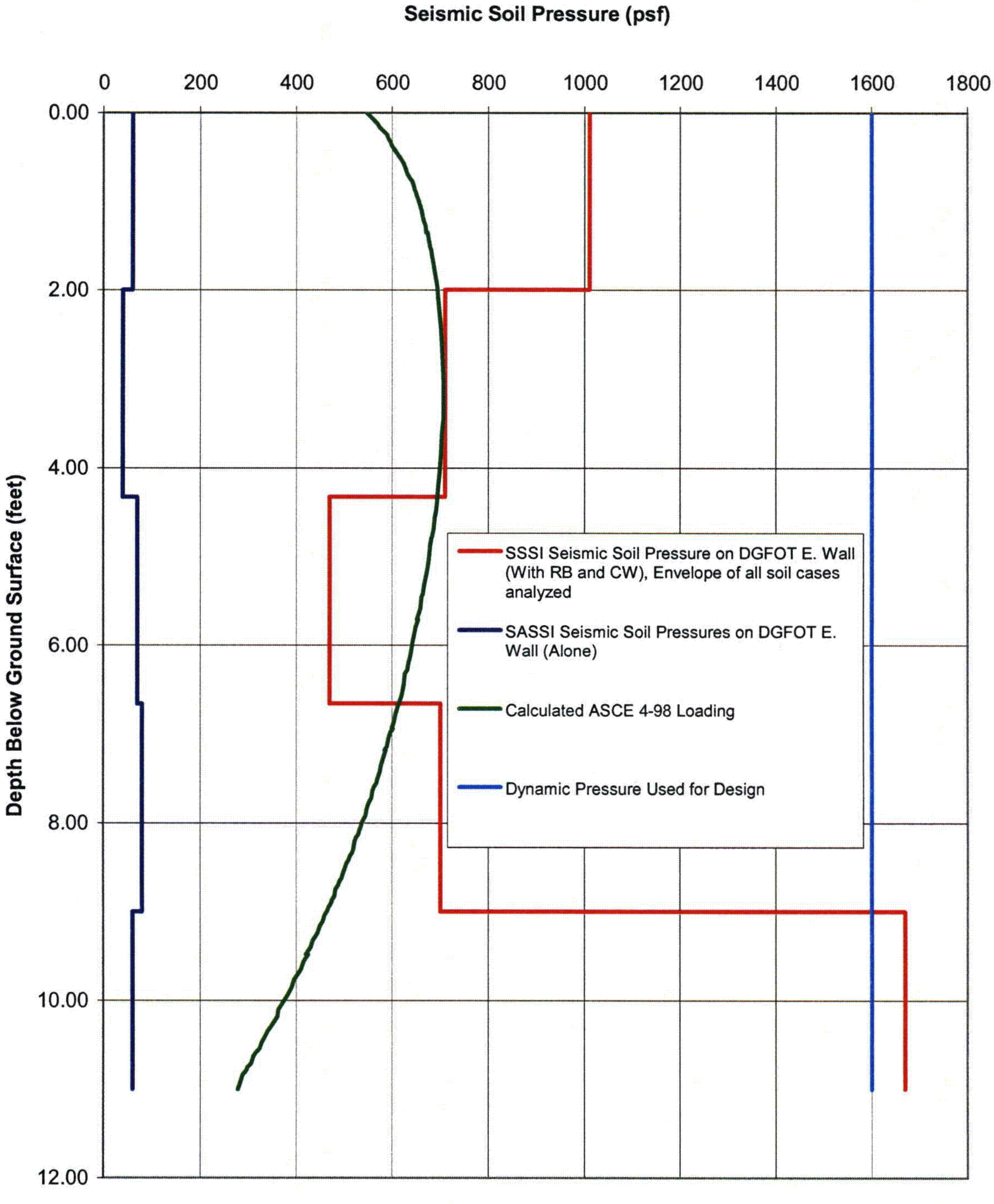


Figure 3H.7-5: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures (psf) on Fuel Oil Tunnel East Wall with Reactor Building and Crane Wall

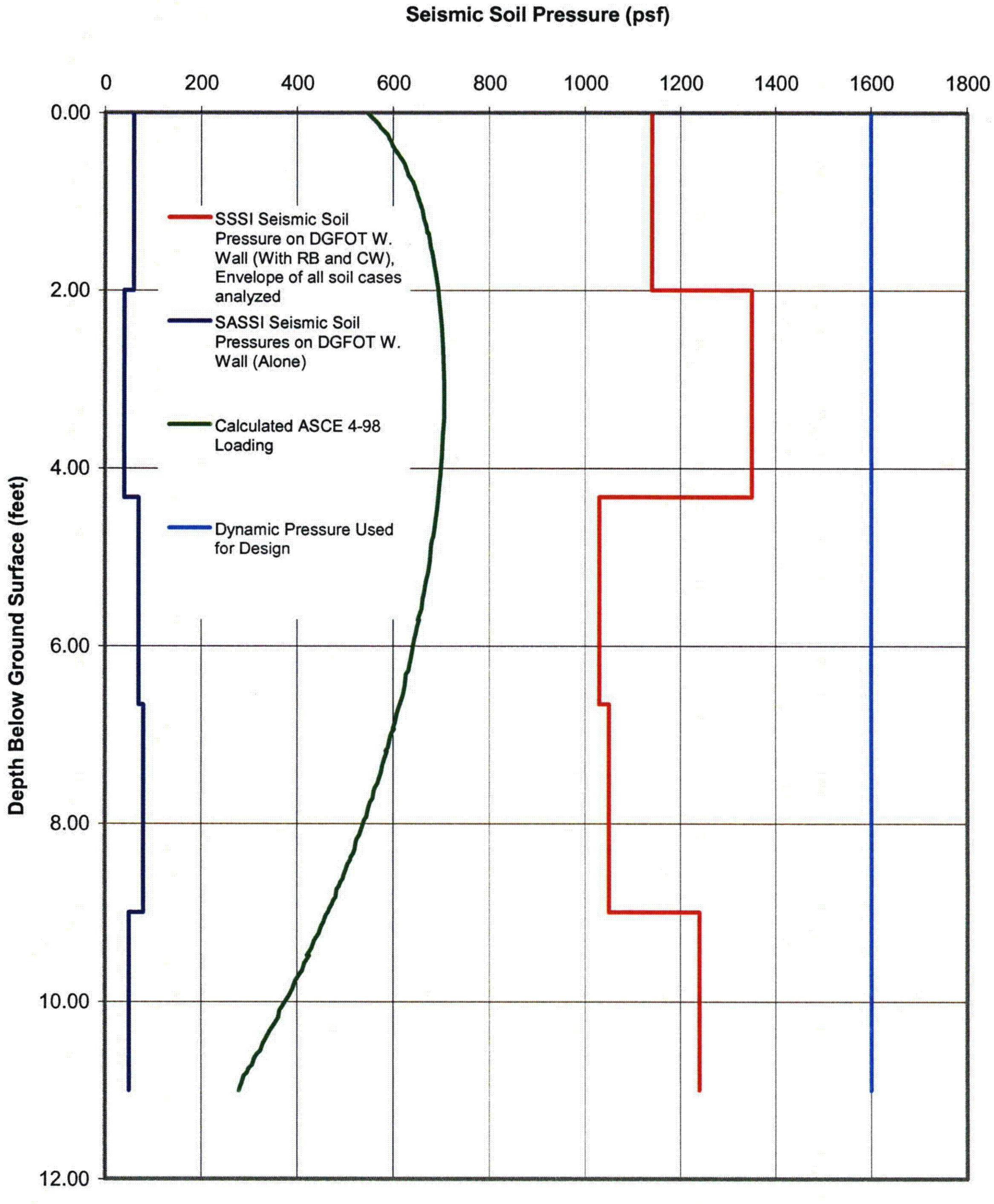


Figure 3H.7-6: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures (psf) on Fuel Oil Tunnel West Wall with Reactor Building and Crane Wall

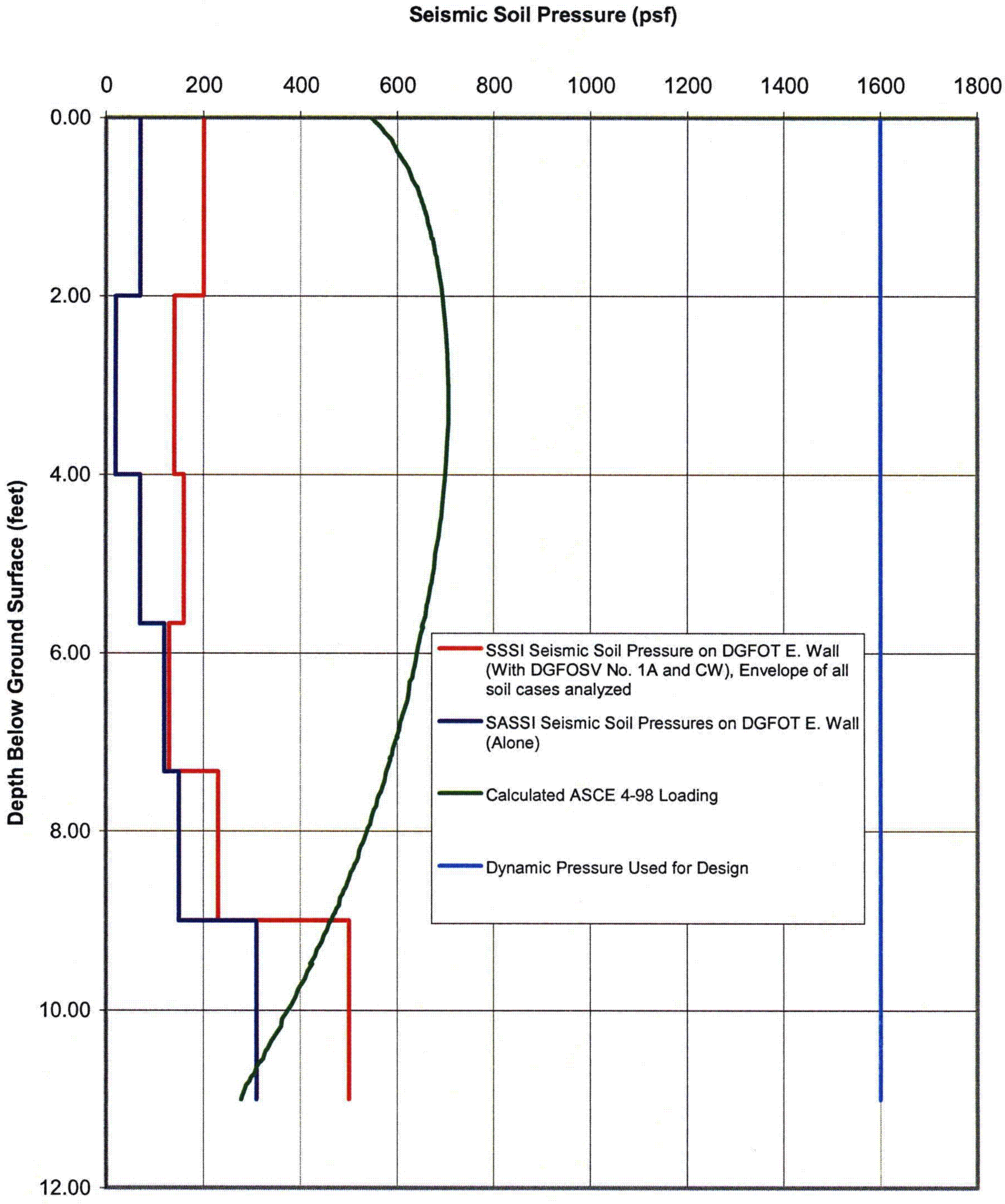


Figure 3H.7-7: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures (psf) on Fuel Oil Tunnel East Wall with Diesel Generator Fuel Oil Storage Vault and Crane Wall

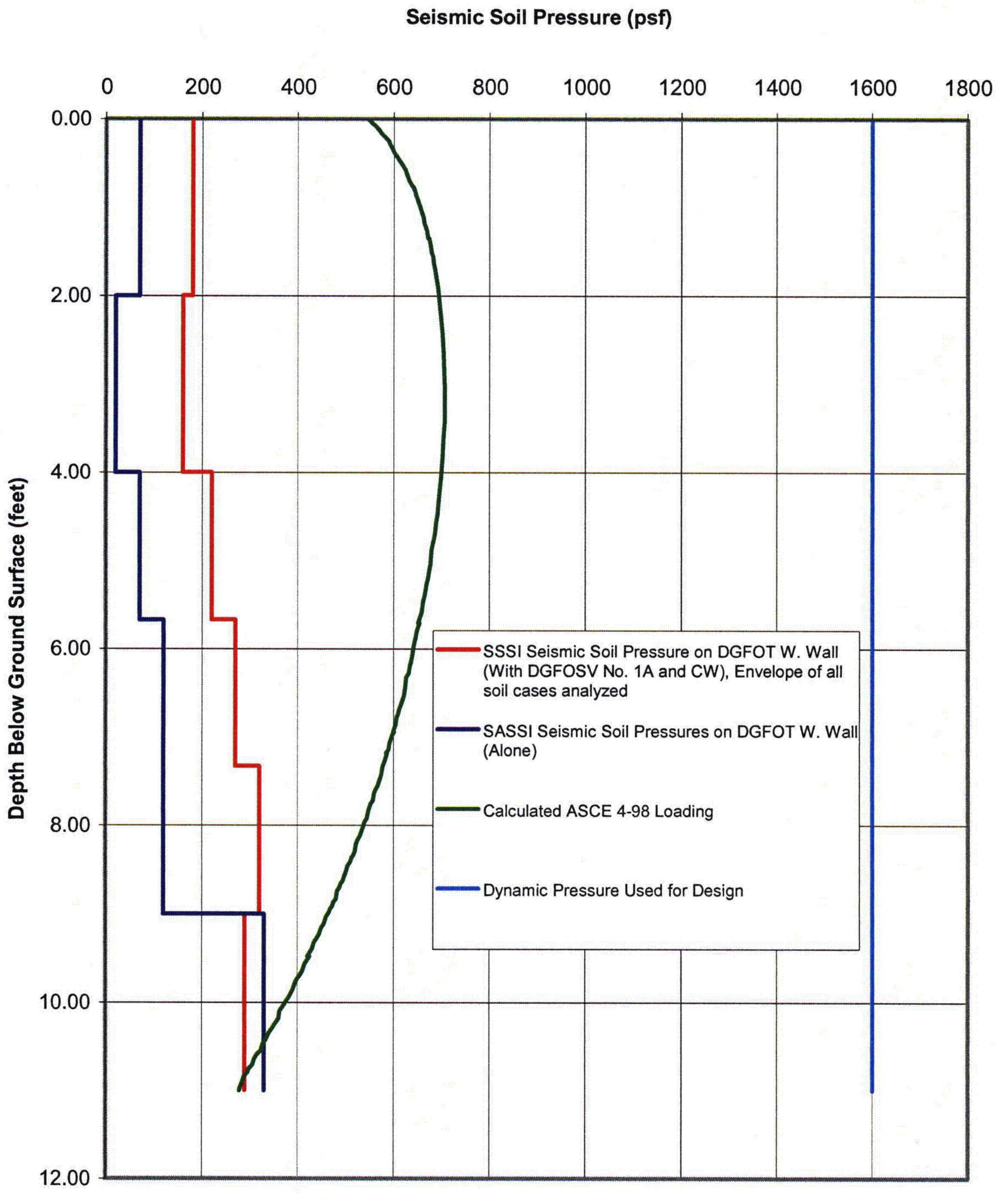


Figure 3H.7-8: SSI, SSSI, ASCE 4-98 and Design Lateral Seismic Soil Pressures (psf) on Fuel Oil Tunnel West Wall with Diesel Generator Fuel Oil Storage Vault and Crane Wall

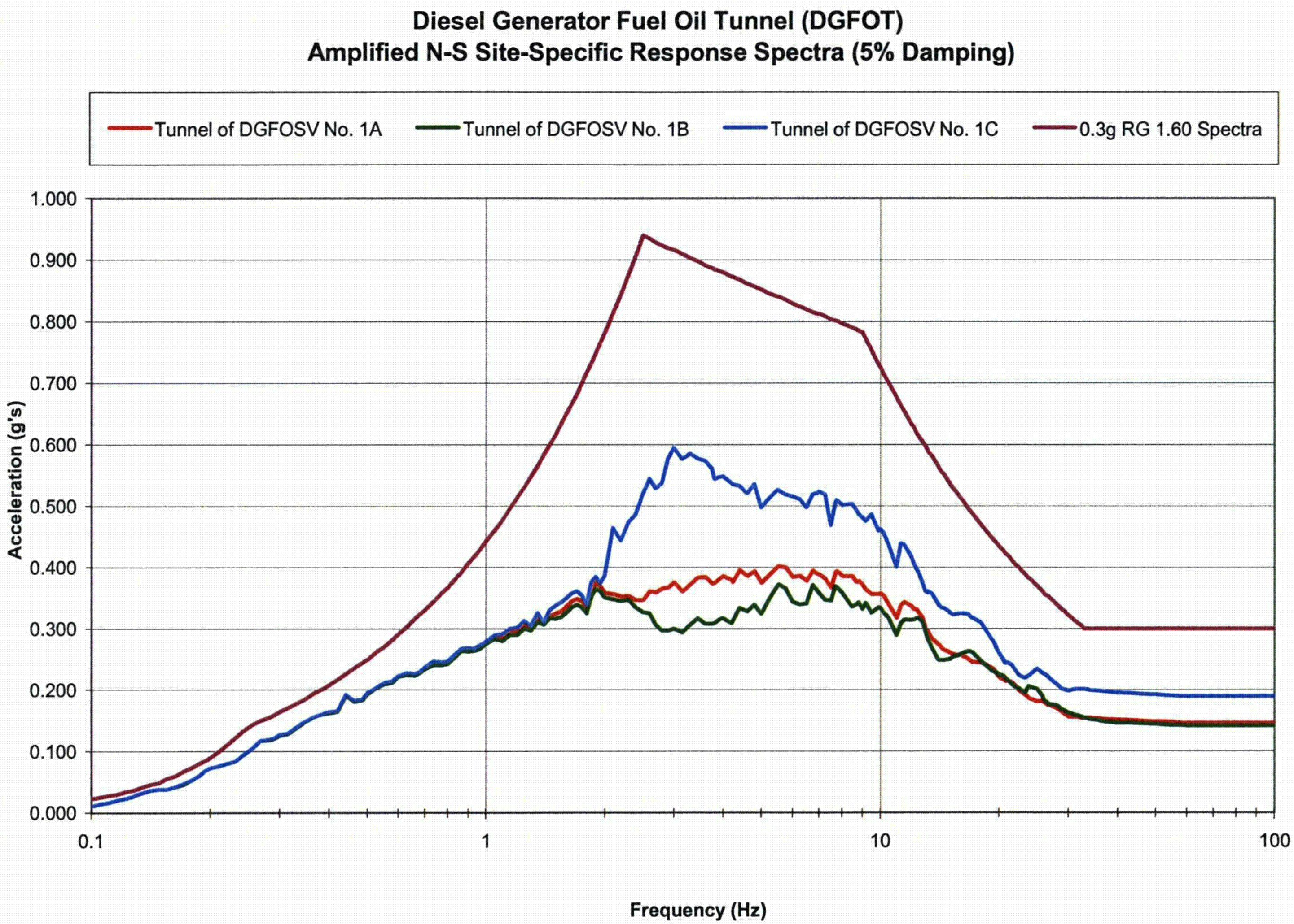


Figure 3H.7-30a: Amplified N-S Site-Specific Response Spectra Diesel Generator Fuel Oil Tunnel (DGFOT)

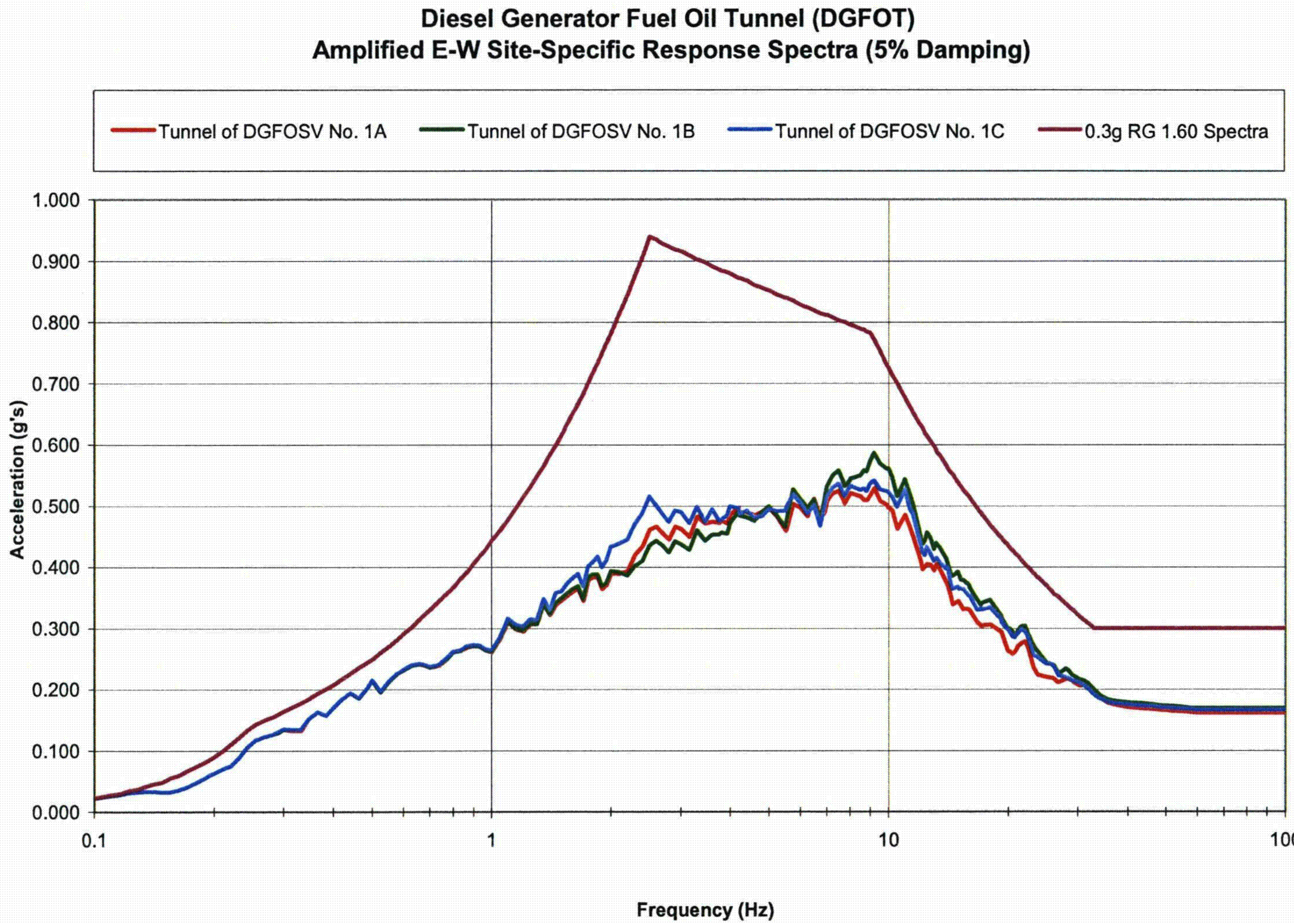


Figure 3H.7-30b: Amplified E-W Site-Specific Response Spectra Diesel Generator Fuel Oil Tunnel (DGFOT)

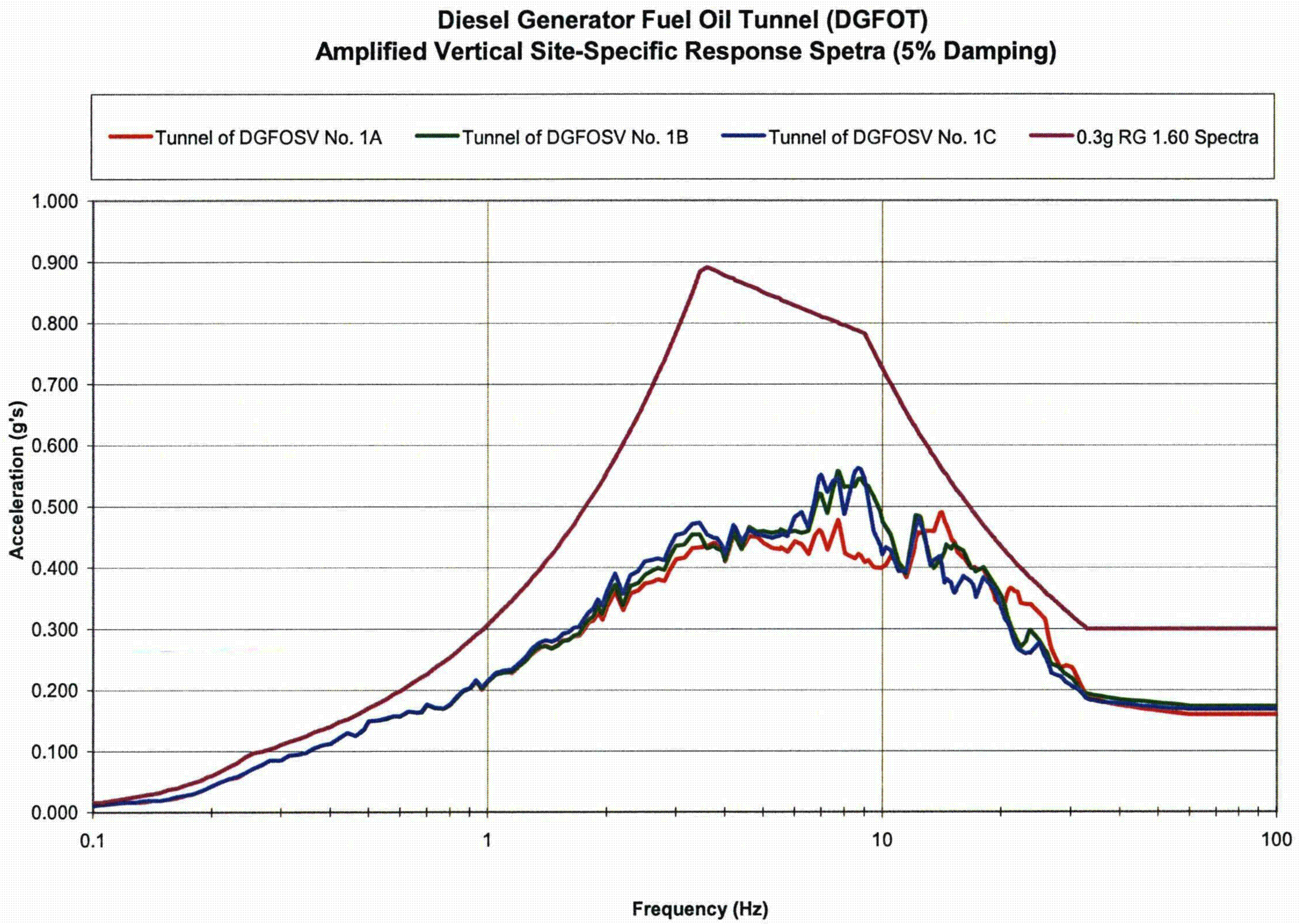


Figure 3H.7-30c: Amplified Vertical Site-Specific Response Spectra Diesel Generator Fuel Oil Tunnel (DGFOT)

RAI 03.08.04-30 Supplement 2

QUESTION:

Follow-up to Question 03.08.04-23

In response to staff question requesting additional information (Letter U7-C-STP-NRC-100036, dated February 10, 2010) about how various steel and concrete elements of site-specific structures are designed, and the design results, the applicant provided some analysis and design information. The applicant also referred to the Supplement 2 response to Question 03.07.01-13 (Letter U7-C-STP-NRC-090230, dated 12/30/09) for pertinent design summary information. In order for the staff to conclude that the design of site-specific structures meet the requirements of GDC 2 by meeting the guidance provided in SRP 3.8.4 and 3.8.5, or otherwise, the applicant is requested to provide the following additional information:

1. The applicant states in the response that a three dimensional finite element analysis (FEA) is used for structural analysis and design of the UHS/RSW Pump House. FSAR Section 3H.6.6.1 states that analysis for the seismic loads was performed using equivalent static loads and the induced forces due to X, Y, and Z seismic excitations were combined using the SRSS method of combination. However, the applicant did not describe how the equivalent static loads due to seismic excitation were determined and applied to the static FEA model from the results of soil structure interaction (SSI) analysis used for determination of seismic response. Therefore, the applicant is requested to provide details of how seismic response analysis results from dynamic SSI analysis were transferred to the static FEA model, including how the effects of accidental torsion were included in the analysis and design of UHS/RSW Pump house. Please also update FSAR with the information, as appropriate.

2. The applicant stated in its response that the modulus of subgrade reaction for static loading was calculated as the average of the local values at nine locations under the foundation. The applicant is requested to provide these nine values, and explain why it is considered appropriate to use the average value. Please also explain how the foundation subgrade modulus was used for calculating nodal springs for the FEA model, and how the effect due to coupling of soil springs was considered in the analysis.

3. For seismic loading, the applicant has outlined a hand-calculated procedure that utilizes published formulas and charts to estimate the foundation spring constants. According to this procedure, the equivalent modulus and Poisson's ratio of a layered soil system are first estimated using the cumulative strain energy method. The resulting values are then used in the equations for computation of the spring constants for a rigid foundation of an arbitrary shape embedded in a uniform half-space. The shear moduli used for individual layers are strain compatible values, and include the mean, upper bound, and lower bound soil cases. The approximate procedure outlined above for developing the foundation spring constants does not take into account the pressure distribution under the base slab. Furthermore, this procedure does not account for the frequency dependence of these springs. As such, the applicant is requested to provide a justification for not considering the effects of pressure distribution and system frequency

in developing the foundation dynamic springs including describing the impact on the calculated results.

4. The applicant's response does not provide details as to how the soil springs calculated under static and seismic loadings are inputted to the 3-D static FEA model to calculate the design stresses. Therefore, the applicant is requested to describe in detail how the static and seismic soil springs are inputted into the FEA model, and how the results are obtained for stress evaluations. Specifically, the applicant is requested to explain if the two sets of springs were used in a single model, and how the two sets were combined to a single set of springs. Otherwise, if the two sets of springs were applied to separate FEA models, describe how the load combinations were performed. The applicant is also requested to provide sufficient detail to assist staff in understanding how static and seismic soil springs are used in the FEA model and results combined for stress evaluations.

5. In the FSAR mark-up of Sections 3H.6.6.3.1 and 3H.6.6.3.2 provided with the response, the applicant identifies the method used by the applicant for combining forces and moments. In this method, for each reinforcing zone, the maximum force or moment is coupled with the corresponding moment or force for design for the same load combination. It is not clear if this method of combining forces and moments for design will envelop the worst combination of forces and moments for all elements in a reinforcing zone. Therefore, the applicant is requested to describe the method of combining forces and moments used by the applicant with a typical example of a reinforcing zone, and demonstrate that this method of combination will yield the worst combination of forces and moments that should be considered for design.

6. The staff notes that in the FSAR mark-up of Section 3H.6.6.3.1 provided with the response, the reported values of soil springs for the RSW Pump House are significantly larger than those for the UHS basin. The applicant is requested to confirm these values, and explain the reason for the large difference.

7. The response did not include any information about the maximum static and dynamic bearing pressures under the foundations of UHS/RSW Pump House. The applicant is requested to provide the maximum static and dynamic bearing pressure under the foundations of UHS/RSW Pump House, compare these values with the maximum allowable static and dynamic bearing pressures, and include this information in the FSAR.

8. In its response to Question 03.07.01-19 (letter U7-C-STP-NRC-100129, dated June 7, 2010), the applicant provided analysis and design information for the seismic category I Diesel Generator Fuel Oil Storage Vault (DGFOSV) a which was not previously included in the FSAR. The information included in the response does not describe how structural analysis and design of the structure was performed. Also, reference is made to FSAR Section 3H.6.4 for design loads. FSAR Section 3H.6.4 has been updated several times in various responses, and it is not clear where this information can be found. Therefore, the applicant is requested to provide complete structural analysis and design information for the DGFOSV to ensure it meets acceptance criteria 1 through 7 of SRP 3.8.4 and 3.8.5.

The staff needs this information to conclude that the DGFOSV is designed to withstand seismic loads and meet GDC 2. Include in the response an updated version of Appendix 3H where structural analysis and design information for all seismic category I structures can be found.

9. While reviewing this response, and other responses referenced in this response, the staff noted that the applicant has used different values of coefficient of friction for sliding stability evaluation; e.g., the value 0.3 was used for the RSW Pump House, 0.4 was used for UHS basin, 0.58 was used DGFOSV, and for the Reactor Building (RB) and the Control Building (CB), it was stated to be more than 0.47. It is not clear if these values are the required coefficient of friction, or the minimum coefficient of friction available. The applicant is requested to clearly specify the minimum coefficient of friction at various locations of the site, if they are different, and explain how these values were determined. Please also clarify this information in the FSAR.

10. The staff noted references to Diesel Generator Fuel Oil Tunnel (DGFOT) in several RAI responses. Please confirm that DGFOT is not a seismic category I structure, and if it is seismic category I, include the analysis and design information to show how the design of the DGFOT meets the acceptance criteria 1 through 7 in the SRP 3.8.4 and 3.8.5 in the FSAR.

SUPPLEMENTAL RESPONSE:

The supplement 1 response to this RAI was submitted with Nuclear Innovation North America (NINA) letter U7-C-NINA-NRC-110043, dated March 15, 2011. This supplement provides the response to the Clarification Issue 10, described below, as provided by the NRC staff subsequent to the March 14-18, 2011 audit.

Issue 10: ***Calc Report, U7-YARD-S-CALC-DESN-6001, Rev. E: "Basic Structural Design of Diesel Generator Fuel Oil Storage Vaults"*** *The seismic design of the DGFOSV is performed with equivalent static forces, whereby the inertial forces are computed as products of masses and accelerations. The accelerations are taken from the corresponding SSI analyses as to envelope all soil conditions, design parameters, and seismic input motions. The masses are determined from the building drawings and specific weights for concrete, oil, steel and soil. The SAP structural model is divided into regions, and constant average acceleration values are applied to each region, simulating the absolute acceleration distribution of the SSI model. These inertial forces are applied in global X, Y and Z direction as external static loading to the nodes and elements of the SAP model. The response quantities, i.e. internal forces, displacements, etc., resulting from each earthquake component are combined by the SRSS rule. As a verification of the equivalent static procedure, the resultant base shear, total vertical base force and overturning moments obtained from the SAP model are compared to the corresponding values of the SSI (SASSI) model. If required, adjustment factors are applied to the input acceleration components in SAP as to provide base forces and moments which envelope the corresponding SSI base values. The maximum resultant SSI absolute acceleration values are approximately: X=0.31g; Y=0.31g and Z=0.33g. The equivalent horizontal acceleration values obtained* *from the SAP analysis are: X=0.33g and Y=0.32g and therefore match closely the SSI accelerations. The equivalent vertical acceleration in the SAP analysis however, had to be amplified by a factor of about 1.27 to yield Z=0.42g, in order to meet the total base forces and moments from the SSI analysis. As both, the SASSI and the SAP models, should be based on the same geometry and total weight and are subject to the same absolute accelerations, it is not apparent why an additional, relatively large amplification would be needed in vertical direction to obtain comparable total base seismic loads. Therefore, the applicant is requested to provide a justification regarding the different behavior of both structural models.*

Response:

Even though the structural models in SASSI2000 and SAP are based on the same geometry and weight properties, the SASSI2000 analysis accounts for the effect of how the soil around and below the structure interacts with the structure in calculating the structural responses. On the other hand, in the equivalent static analysis (SAP model), since the soil is not modeled, the soil-structure interaction (SSI) effect is not accounted for. Therefore, the seismic design loads obtained from the SSI analysis are more accurate. For the structural design, equivalent static method is used to facilitate the design for all applicable loads and load combinations. The equivalent horizontal and vertical accelerations to be used in the equivalent static model are calculated using the accelerations from the SSI analysis, and amplifying these accelerations to obtain loads that are greater than the corresponding loads from the SSI analysis. Depending on the structural dynamic characteristics and structure's interaction with soil, the behavior of the horizontal and vertical models may be different. Therefore, amplification factors for accelerations for horizontal and vertical load calculations to be used in the equivalent static model may not necessarily be the same. Since the design has ensured that the equivalent static loads bound the loads from the SSI analysis, there is no impact on the design.

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