CHAPTER 3:
DESIGN OF STRUCTURES, COMPONENTS, EQUIPMENT AND SYSTEMS
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CHAPTER 3 DESIGN OF STRUCTURES, COMPONENTS, EQUIPMENT AND SYSTEMS

3.1 CONFORMANCE WITH NUCLEAR REGULATORY COMMISSION GENERAL DESIGN CRITERIA

This section of the referenced DCD is incorporated by reference with no departures or supplements.

3.2 CLASSIFICATION OF STRUCTURES, COMPONENTS, AND SYSTEMS

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

3.2.1 SEISMIC CLASSIFICATION

Add the following text to the end of DCD Subsection 3.2.1.

STD SUP 3.2-1 There are no safety-related structures, systems, or components outside the scope of the DCD.

The nonsafety-related structures, systems, and components outside the scope of the DCD are classified as non-seismic (NS).

3.2.2 AP1000 CLASSIFICATION SYSTEM

Add the following text to the end of DCD Subsection 3.2.2.

STD SUP 3.2-1 There are no safety-related structures, systems, or components outside the scope of the DCD.

3.3 WIND AND TORNADO LOADINGS

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

3.3.1.1 Design Wind Velocity

Add the following text to the end of DCD Subsection 3.3.1.1.

PTN DEP 2.0-1
PTN COL 3.3-1
PTN COL 3.5-1

The wind velocity characteristics for Turkey Point Units 6 & 7 are given in Subsection 2.3.1.3.1. These values exceed the design wind velocity values given in DCD Subsection 3.3.1.1 for the AP1000 plant. The higher wind velocity does not have an adverse impact on safety-related structures and components.

3.3.2.1 Applicable Design Parameters

Add the following text to the end of DCD Subsection 3.3.2.1.

PTN COL 3.3-1
PTN COL 3.5-1

The tornado characteristics for Units 6 & 7 are given in Subsection 2.3.1.3.2. These values are bounded by the tornado design parameters given in DCD Subsection 3.3.2.1 for the AP1000 plant.

3.3.2.3 Effect of Failure of Structures or Components Not Designed for Tornado Loads

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Add the following text to the end of DCD Subsection 3.3.2.3.

STD COL 3.3-1
PTN COL 3.5-1

Consideration of the effects of wind and tornado due to failures in an adjacent AP1000 plant is bounded by the evaluation of the buildings and structures in a single unit.

3.3.3 COMBINED LICENSE INFORMATION

Add the following text to the end of DCD Subsection 3.3.3.

PTN COL 3.3-1
PTN DEP 2.0-1

The Units 6 & 7 site satisfies the site interface criteria for wind and tornado (see Subsections 3.3.2.1 and 3.3.2.3) and will not have a tornado-initiated failure of structures and components within the applicant's scope that compromises the safety of safety-related structures and components (see also Subsection 3.5.4).

The site wind velocity characteristics exceed the design wind velocity values given in DCD Subsection 3.3.1.1 for the AP1000 plant (see Subsection 3.3.1.1). The higher wind velocity will not have an adverse impact on safety-related structures and components.

Subsection 1.2.2 discusses differences between the plant specific site plan (see Figure 1.1-201) and the AP1000 typical site plan shown in DCD Figure 1.2-2.

There are no other structures adjacent to the nuclear island other than as described and evaluated in the DCD.

Missiles caused by external events separate from the tornado are addressed in Subsections 2.2 through 2.2.3, 3.5.1.5, and 3.5.1.6.

3.4 WATER LEVEL (FLOOD) DESIGN

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

3.4.1.3 Permanent Dewatering System

Add the following text to the end of DCD Subsection 3.4.1.3.

PTN COL 3.4-1 No permanent dewatering system is required because site groundwater levels are 2 feet or more below site grade level as described in Subsection 2.4.12.5.

3.4.3 COMBINED LICENSE INFORMATION

Replace the first paragraph of DCD Subsection 3.4.3 with the following text.

PTN COL 3.4-1 The site-specific water levels given in Section 2.4 satisfy the interface requirements identified in DCD Section 2.4.

3.5 MISSILE PROTECTION

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

3.5.1.3 Turbine Missiles

Add the following text to the end of the DCD Subsection 3.5.1.3.

STD SUP 3.5-1 The potential for a turbine missile from another AP1000 plant in close proximity has been considered. As noted in DCD Subsection 10.2.2, the probability of generation of a turbine missile (or P1 as identified in SRP 3.5.1.3) is less than 1 x 10^{-5} per year. This missile generation probability (P1) combined with an unfavorable orientation P2xP3 conservative product value of 10^{-2} (from SRP 3.5.1.3) results in a probability of unacceptable damage from turbine missiles (or P4 value) of less than 10^{-7} per year per plant which meets the SRP 3.5.1.3 acceptance criterion and the guidance of Regulatory Guide 1.115. Thus, neither the orientation of the side-by-side AP1000 turbines nor the separation distance is pertinent to meeting the turbine missile generation acceptance criterion. In addition, the reinforced concrete shield building and auxiliary building walls, roofs, and floors, provide further conservative, inherent protection of the safety-related SSCs from a turbine missile.

PTN SUP 3.5-1 The five steam turbine generators associated with Units 1 through 5 are oriented along a N/S axis and are located far enough north of Units 6 & 7 that there is no turbine missile hazard from Units 1 through 5.

STD SUP 3.5-2 The turbine system maintenance and inspection program is discussed in Subsection 10.2.3.6.

3.5.1.5 Missiles Generated by Events Near the Site

Add the following text to the end of DCD Subsection 3.5.1.5.

PTN COL 3.5-1
PTN COL 3.3-1

The gatehouse, administrative building, security control building, warehouse and shops, structures related to water services, diesel-driven fire pump/enclosure, and miscellaneous structures are common structures at a nuclear power plant. They are of similar design and construction to those that are typical at nuclear power plants. Therefore, any missiles resulting from a tornado-initiated failure are not more energetic than the tornado missiles postulated for design of the AP1000.

The missiles generated by events near the site are described and evaluated in Subsection 2.2.3. With the exception of a potential barge explosion, the effects of external events on the safety-related components of the plant are insignificant. The probability of a missile generating barge explosion is determined to be less than 1E-07 events per year. Based on RG 1.91, this does not represent a design basis event. This also meets the criteria of 1E-06 occurrences per year in the DCD Section 2.2 for not requiring changes to the AP1000 design for an external accident leading to severe consequences.

3.5.1.6 Aircraft Hazards

Add the following text to the end of DCD Subsection 3.5.1.6.

PTN COL 3.5-1
PTN COL 3.3-1

RG 1.206 and NUREG-0800 state that the risks as a result of aircraft hazards should be sufficiently low. Further, aircraft accidents that could lead to radiological consequences in excess of the exposure guidelines of 10 CFR 50.34 (a)(1) with a probability of occurrence greater than an order of magnitude of 1E-07 per year should be considered in the design of the plant. In accordance with NUREG-0800, there are three acceptance criteria for the probability of aircraft accidents resulting in radiological consequences greater than the 10 CFR Part 100 exposure guidelines to be less than an order of magnitude of 1E-07 per year:

- Meeting plant-to-airport distance and projected annual operations criteria
- Plant is at least 5 statute miles from the nearest edge of military training routes

- Plant is at least 2 statute miles beyond the nearest edge of a federal airway, holding pattern, or approach pattern

The aircraft facilities and airways are described in Subsection 2.2.2.7. There exists one airport, Homestead Air Reserve Base, located approximately 4.76 miles from the Units 6 & 7 site with projected annual operations that do not meet the plant-to-airport acceptance criteria. RG 1.206 requires that the Homestead Air Reserve Base be considered regardless of the projected annual operations because the plant-to-airport distance is less than 5 miles. The Homestead Air Reserve Base has approximately 36,429 annual operations and this projection is not expected to change over the period of the license duration.

Additionally, the Units 6 & 7 site is located closer than 2 miles to the nearest edge of a federal airway, V3. The site is approximately 5.98 nautical miles from the centerline of airway V3. The width of a federal airway is typically 8 nautical miles, 4 nautical miles on each side of the centerline, placing the airway approximately 1.4 miles to the nearest edge.

Therefore, an analysis was performed in order to determine whether the accident probability rate is less than an order of magnitude of 1E-07. Details of the analysis are provided in Subsection 2.2.2.7.

The analysis results show that the rate of aircraft accidents that could lead to radiological consequences in excess of the exposure guidelines of 10 CFR 50.34(a)(1) is 4.86E-07 crashes per year. This includes the following inherent conservatisms:

- Shielding by adjacent structures, topographical features, and barriers were not credited. The skid distance would virtually be eliminated, reducing the effective area if this were credited, because the nuclear island is shielded on three sides and partially on the fourth side by other structures.

- A conservative value of the conditional core damage probability was used. General aviation aircraft were not screened out, that is, a core damage probability of zero was not applied to the general aviation class, even though studies have shown they are not considered a significant hazard to nuclear power stations because of their low weight and low penetration hazard.

- DOE methodology has conservatisms built in. One such example is in determining the effective area of the bounding building where the heading of the crashing aircraft with respect to the facility is assumed to be the worst-case perpendicular to the diagonal of the bounding rectangle regardless of direction of actual flights.

Therefore, a value of 4.86E-07 aircraft crashes per year that may lead to radiological consequences meets the guidance in NUREG-0800, Section 3.5.1.6, which states that 10 CFR 100.1, 10 CFR 100.20, 10 CFR 100.21, 10 CFR 52.17, and 10 CFR 52.79 requirements are met if the probability of aircraft accidents resulting in radiological consequences greater than the 10 CFR Part 100 exposure criteria is less than an order of magnitude of 1E-07 per year. The value of 4.86E-07 aircraft crashes per year also meets RG 1.206 guidance that states that design basis events internal and external to the nuclear plant are defined as those accidents that have a probability of occurrence on the order of magnitude of 1E-07 per year or greater, and potential consequences serious enough to affect the safety of the plant to the extent that the criteria in 10 CFR Part 100 are exceeded.

3.5.4 COMBINED LICENSE INFORMATION

Add the following text to the end of DCD Subsection 3.5.4.

PTN COL 3.5-1

The PTN site satisfies the site interface criteria for wind and tornado as discussed in Subsections 3.3.1.1, 3.3.2.1 and 3.3.2.3 and will not have a tornado-initiated failure of structures and components within the applicant's scope that compromises the safety of Units 6 & 7 safety-related structures and components (see also Subsection 3.3.3).

Subsection 1.2.2 discusses differences between the plant specific site plan (see Figure 1.1-201) and the AP1000 typical site plan shown in DCD Figure 1.2-2.

There are no other structures adjacent to the nuclear island other than as described and evaluated in the DCD.

Missiles caused by external events separate from the tornado are addressed in Subsections 2.2 through 2.2.3, 3.5.1.5, and 3.5.1.6.

3.6 PROTECTION AGAINST THE DYNAMIC EFFECTS ASSOCIATED WITH THE POSTULATED RUPTURE OF PIPING

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

3.6.4.1 Pipe Break Hazard Analysis

Replace the last paragraph in DCD Subsection 3.6.4.1 with the following text.

STD COL 3.6-1 The as-designed pipe rupture hazards evaluation is made available for NRC review. The completed as-designed pipe rupture hazards evaluation will be in accordance with the criteria outlined in DCD Subsections 3.6.1.3.2 and 3.6.2.5. Systems, structures, and components identified to be essential targets protected by associated mitigation features (Reference is DCD Table 3.6-3) will be confirmed as part of the evaluation, and updated information will be provided as appropriate.

A pipe rupture hazard analysis is part of the piping design. The evaluation will be performed for high and moderate energy piping to confirm the protection of systems, structures, and components which are required to be functional during and following a design basis event. The locations of the postulated ruptures and essential targets will be established and required pipe whip restraints and jet shield designs will be included. The report will address environmental and flooding effects of cracks in high and moderate energy piping. The as-designed pipe rupture hazards evaluation is prepared on a generic basis to address COL applications referencing the AP1000 design.

The pipe whip restraint and jet shield design includes the properties and characteristics of procured components connected to the piping, components, and walls at identified break and target locations. The design will be completed prior to installation of the piping and connected components.

The as-built reconciliation of the pipe rupture hazards evaluation whip restraint and jet shield design in accordance with the criteria outlined in DCD Subsections 3.6.1.3.2 and 3.6.2.5 will be completed prior to fuel load (in accordance with DCD Tier 1 Table 3.3-6, item 8).

This COL item is also addressed in Subsection 14.3.3.

3.6.4.4 Primary System Inspection Program for Leak-before-Break Piping

Replace the first paragraph of DCD Subsection 3.6.4.4 with the following text.

STD COL 3.6-4

Alloy 690 is not used in leak-before-break piping. No additional or augmented inspections are required beyond the inservice inspection program for leak-before-break piping. An as-built verification of the leak-before-break piping is required to verify that no change was introduced that would invalidate the conclusion reached in this subsection.

3.7 SEISMIC DESIGN

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

3.7.1.1 Design Response Spectra

Add the following sections after DCD Subsection 3.7.1.1 as follows:

PTN SUP 3.7-1

3.7.1.1.1 Soil Profiles and Input Motions for Soil-Structure Interaction Analysis

The site-specific Ground Motion Response Spectra (GMRS) are described in Section 2.5.2. The development of the Foundation Input Response Spectra (FIRS) is described in Subsection 3.7.1.1.1.1. Strain-compatible soil properties are presented in Subsection 3.7.1.1.1.2. The development of acceleration time histories for soil-structure interaction (SSI) analysis is summarized in Subsection 3.7.1.1.1.3. A detailed discussion of each of these steps is provided in Appendix 3JJ.

The developed input is used for SSI analysis, which is provided in Appendix 3KK.

3.7.1.1.1.1 Development of FIRS

The Uniform Hazard Response Spectra (UHRS), described in Section 2.5.2.4, are defined for hard rock characterized with a shear wave velocity of Vs = 9200 feet/second (2.8 kilometers/second), which is located at about 10,000 feet (3000 meters) below the ground surface. Section 2.5.2.5 describes the development of the site amplification factors at the GMRS horizon. Section 2.5.2.6 discusses the development of the horizontal and vertical GMRS. The same procedures are followed in this section to develop FIRS at the bottom of the nuclear island foundation horizon.

The full soil columns used for computation of soil amplification factors represent the two soil conditions found at the location of Units 6 & 7. The soil column far from the nuclear island consists of in situ soil layers except for the upper 30.5 feet (9.3 meters) of structural fill. This is the fill required for the general plant area to raise the site grade elevation from the existing grade to the finished grade, and is designated as "FAR" in this Section. A second soil column, representing the site conditions near the nuclear island, where, in addition to the general fill, lean concrete, and structural fill replace the in situ soils down to a depth of 60.5 feet (18.4 meters) below finished grade. This is designated "NI" in the following discussion.

The site response analysis is conducted on a set of 60 randomized profiles, for each of the two soil profiles, to account for the variability in the dynamic soil properties. The randomization procedure is described in detail in Section 2.5.2.5.2. Using the randomized soil profiles, the soil column analyses are performed with the de-aggregated low frequency (LF) and high frequency (HF) spectra of the hard rock motion at 10^{-4} and 10^{-5} annual-frequency-of-exceedance, presented in Section 2.5.2.4, following the same methodology described in Section 2.5.2.5. Log-mean amplification functions and soil response spectra are developed for "outcrop" motions for both FAR and NI soil conditions at the FIRS horizon, located at the bottom of the nuclear island foundation at elevation –16 feet (–4.9 meters) corresponding to a depth of 41.5 feet (12.7 meters) below finished ground surface.

FIRS are computed at the elevation of –16 feet from the envelope of NI and FAR soil columns representing near and far field soil columns. The input for SSI analysis in terms of acceleration time histories were computed as in-column motion as described in Section 3JJ.5 in Appendix 3JJ. In application of the SSI input acceleration time histories, the control point was defined at elevation of –14 feet at the bottom of the NI basemat.

The change of 2 feet accounts for the thickness of the mud mat(s) and the water proofing membrane. This is considered acceptable since, in computation of the FIRS for NI soil column, 19 feet of lean concrete is already included in the soil column analysis and an additional 2 feet of concrete has negligible effects on the FIRS and associated SSI input motion.

Following the same procedure as used in Section 2.5.2.6 to obtain the GMRS, the procedure presented in RG 1.208 is implemented to develop the horizontal design response spectrum (DRS) for each of the FAR and NI soil columns. The horizontal FIRS is defined as the envelope of the FAR and NI DRS. The vertical FIRS is obtained by scaling the horizontal FIRS by the same V/H as presented in Section 2.5.2.6. The details of the site response analysis and development of FIRS are documented in Appendix 3JJ.

In addition to the FIRS, from the same set of soil amplification analyses, design spectra at the ground surface for both NI and FAR soil profiles are developed and enveloped. The surface DRS are used to check the adequacy of the SSI input motion as described in Subsection 3.7.1.1.1.3 and Appendix 3JJ.

The resulting horizontal and vertical FIRS are plotted in Figure 3.7-201 and reported in Table 3.7-201. As developed and described in Appendix 3KK, comparisons of the FIRS developed indicate they are enveloped completely by the AP1000 Certified Seismic Design Response Spectra (CSDRS) for all frequencies, as shown in Figure 3.7-202. The analysis results show that the Nuclear Island Floor Response Spectra (FRS) of AP1000 at the Turkey Point site at six key locations are enveloped by the AP1000 Certified Design Response Spectra (CSDRS).

3.7.1.1.1.2 Strain-Compatible Soil Property Profiles

From the results of soil amplification analysis of FAR and NI soil profiles, two sets of strain-compatible soil profiles are developed. Each set consists of the best estimate (BE), the lower bound (LB) and the upper bound (UB) strain-compatible shear-wave velocity, P-wave velocity and damping profiles. The development of strain-compatible soil profiles, consistent with the developed FIRS, is discussed in detail in Appendix 3JJ.

3.7.1.1.1.3 Acceleration Time Histories for SSI Input

Acceleration time histories for use in SSI analysis of the nuclear island (which includes modeling of the embedment of the nuclear island) are presented in this section. The seed acceleration time histories were selected from the database of candidate time histories given in NUREG/CR-6728 based on the low frequency de-aggregation results (i.e., magnitudes > 7 and distances > 500 km). For the analysis, the three component (i.e., two horizontal and one vertical component) strong ground motion recordings from the 1999 Chi-Chi earthquake (magnitude=7.6) recorded at the TAP024 station (closest distance=100.2 km) were selected and matched to the 5 percent damping FIRS developed earlier (see Subsection 3.7.1.1.1.1 for FIRS). These time histories were modified to be spectrum-compatible to the FIRS target spectra following the spectral matching criteria given in NUREG/CR-6728. The acceleration response spectra of the generated time histories matching FIRS are shown in Appendix 3JJ.

For SSI input motion of nuclear island with embedment, these acceleration time histories are propagated through the strain-compatible soil profiles, presented in Subsection 3.7.1.1.1.2, where they are used as input “outcrop” motions in the soil column at the FIRS horizon and the “within” acceleration time histories at the same horizon are computed. No further iterations on soil properties are performed. This analysis results in a set of 3 “within” motions for each soil profile in the two horizontal directions (H1 and H2) and vertical direction (UP), respectively. Six (6) sets are developed corresponding to the LB, BE and UB profiles for NI and FAR soil conditions. The analysis also incorporates the requirement for checking the adequacy of the SSI input motion (References 201 and 202). Checks are made with respect to the corresponding surface design response spectra (DRS) and modifications are made where necessary. The analysis steps are discussed in detail in Appendix 3JJ.

The “within” acceleration time histories are recommended for use in the SSI analysis of the nuclear island SSI model that includes embedment. The time histories are to be applied at the FIRS horizon as “within” motion and shall be used in combination with the respective SSI soil profiles discussed in Subsection 3.7.1.1.1.2.

3.7.2.12 Methods for Seismic Analysis of Dams

Add the following text to the end of DCD Subsection 3.7.2.12.

PTN COL 3.7-1 There are no existing or new dams whose failure could affect the site interface flood level specified in DCD Section 2.4.1.2, as discussed in Subsection 2.4.4.

3.7.4.1 Comparison with Regulatory Guide 1.12

STD SUP 3.7-1 Add the following text to the end of DCD Subsection 3.7.4.1.

Administrative procedures define the maintenance and repair of the seismic instrumentation to keep the maximum number of instruments in-service during plant operation and shutdown in accordance with Regulatory Guide 1.12.

3.7.4.2.1 Triaxial Acceleration Sensors

Add the following text to the end of DCD Subsection 3.7.4.2.1.

STD COL 3.7-5

A free-field sensor will be located and installed to record the ground surface motion representative of the site. It will be located such that the effects associated with surface features, buildings, and components on the recorded ground motion will be insignificant. The trigger value is initially set at 0.01 g.

3.7.4.4 Comparison of Measured and Predicted Responses

Add the following text to the end of DCD Subsection 3.7.4.4.

STD COL 3.7-2

Post-earthquake operating procedures utilize the guidance of EPRI Reports NP-5930, TR-100082, and NP-6695, as modified and endorsed by the NRC in Regulatory Guides 1.166 and 1.167. A response spectrum check up to 10 Hz will be based on the foundation instrument. The cumulative absolute velocity will be calculated based on the recorded motions at the free field instrument. If the operating basis earthquake ground motion is exceeded or significant plant damage occurs, the plant must be shutdown in an orderly manner.

3.7.4.5 Tests and Inspections

Add the following text to the end of DCD Subsection 3.7.4.5.

STD SUP 3.7-2

Installation and acceptance testing of the triaxial acceleration sensors described in DCD Subsection 3.7.4.2.1 is completed prior to initial startup. Installation and acceptance testing of the time-history analyzer described in DCD Subsection 3.7.4.2.2 is completed prior to initial startup

3.7.5 COMBINED LICENSE INFORMATION

3.7.5.1 Seismic Analysis of Dams

PTN COL 3.7-1 This COL Item is addressed in Subsection 3.7.2.12.

3.7.5.2 Post-Earthquake Procedures

STD COL 3.7-2 This COL Item is addressed in Subsection 3.7.4.4.

3.7.5.3 Seismic Interaction Review

Replace DCD Subsection 3.7.5.3 with the following text.

STD COL 3.7-3 The seismic interaction review will be updated for as-built information. This review is performed in parallel with the seismic margin evaluation. The review is based on as-procured data, as well as the as-constructed condition. The as-built seismic interaction review is completed prior to fuel load.

3.7.5.4 Reconciliation of Seismic Analyses of Nuclear Island Structures

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Replace DCD Subsection 3.7.5.4 with the following text.

STD COL 3.7-4 The seismic analyses described in DCD Subsection 3.7.2 will be reconciled for detailed design changes, such as those due to as-procured or as-built changes in component mass, center of gravity, and support configuration based on as-procured equipment information. Deviations are acceptable based on an evaluation consistent with the methods and procedure of DCD Section 3.7 provided the amplitude of the seismic floor response spectra, including the effect due to these deviations, does not exceed the design basis floor response spectra by more than 10 percent. This reconciliation will be completed prior to fuel load.

3.7.5.5 Free Field Acceleration Sensor

STD COL 3.7-5 This COL Item is addressed in Subsection 3.7.4.2.1.

3.7.6 REFERENCES

Add the following text to the end of DCD Subsection 3.7.6:

201. NRC Letter, Nilesh C Chokshi, deputy division director, office of new reactors, NRC to Adrian P Hymer, senior director, NEI, dated January 9, 2009, Subject NEI Draft White Paper *Consistent Site-Response/Soil-Structure Interaction Analysis and Evaluation* (USNRC ADAMS Accession Number ML083580072).

202. NEI letter, Adrian P Hymer, senior director of NEI to Nilesh C Chokshi, deputy division director, office of new reactors, NRC, dated October 10, 2008, Subject *White paper in support of New Plant Applications*, (USNRC ADAMS Accession Number ML083020171).

PTN SUP 3.7-1

Table 3.7-201 (Sheet 1 of 2) Recommended Horizontal and Vertical FIRS (Elevation –16 foot Horizon at Bottom of Nuclear Island Foundation)

FIRS Frequency (Hz)	Horizontal Sa(g)	Vertical Sa(g)
100	5.38E-02	5.38E-02
90	5.39E-02	5.39E-02
80	5.42E-02	5.42E-02
70	5.47E-02	5.47E-02
60	5.59E-02	5.59E-02
50	5.82E-02	5.82E-02
45	6.01E-02	6.01E-02
40	6.25E-02	6.25E-02
35	6.76E-02	6.76E-02
30	7.78E-02	7.78E-02
25	9.41E-02	9.41E-02
20	9.83E-02	9.83E-02
15	8.59E-02	8.59E-02
12.5	8.07E-02	8.07E-02
10	8.17E-02	8.17E-02
9	8.34E-02	8.34E-02
8	8.47E-02	8.47E-02
7	8.34E-02	8.34E-02
6	8.04E-02	8.04E-02
5	8.71E-02	8.70E-02
4	7.97E-02	7.96E-02
3	8.77E-02	7.51E-02
2.5	9.45E-02	6.76E-02
2	7.94E-02	5.64E-02
1.5	6.92E-02	4.87E-02
1.25	7.43E-02	5.20E-02
1	8.59E-02	5.98E-02
0.9	9.94E-02	6.89E-02
0.8	1.07E-01	7.42E-02
0.7	1.01E-01	6.97E-02
0.6	9.46E-02	6.49E-02
0.5	8.04E-02	5.48E-02
0.4	5.02E-02	3.40E-02
0.3	3.21E-02	2.16E-02

PTN SUP 3.7-1

Table 3.7-201 (Sheet 2 of 2) Recommended Horizontal and Vertical FIRS (Elevation –16 foot Horizon at Bottom of Nuclear Island Foundation)

FIRS Frequency (Hz)	Horizontal Sa(g)	Vertical Sa(g)
0.2	2.09E-02	1.40E-02
0.15	1.34E-02	8.93E-03
0.125	9.69E-03	6.48E-03
0.1	5.83E-03	3.90E-03

PTN SUP 3.7-1

Figure 3.7-201 Recommended Horizontal and Vertical FIRS (Elevation –16 foot Horizon at Bottom of Nuclear Island Foundation)

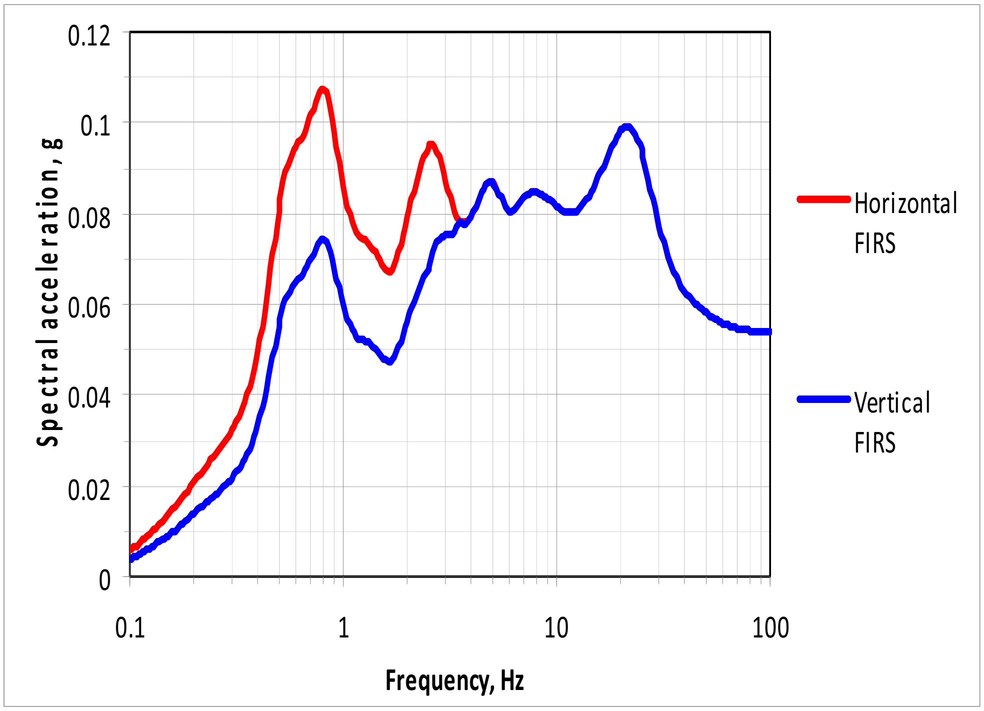
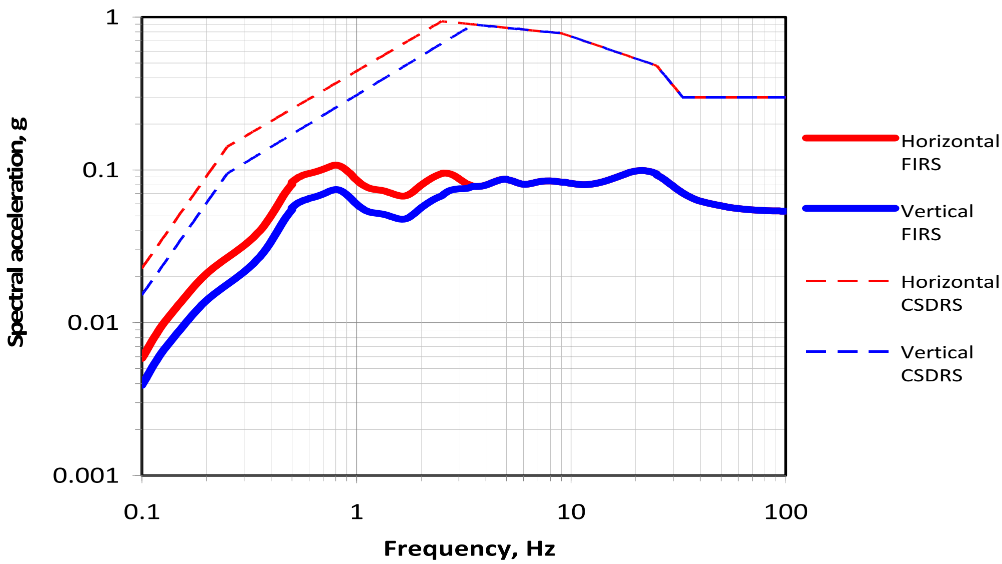
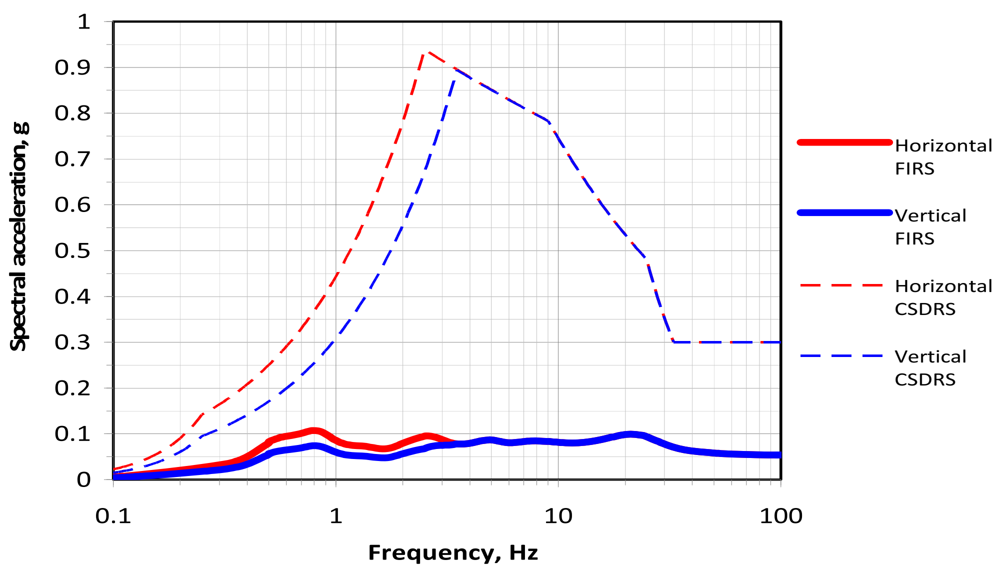


Figure 3.7-202 Comparison of Turkey Point Horizontal and Vertical FIRS with AP1000 Horizontal and Vertical CSDRS

PTN SUP 3.7-1



(Log-Log Format)



(Log-Linear Format)

3.8 DESIGN OF CATEGORY I STRUCTURES

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

3.8.5.1 Description of the Foundations

Add the following text after paragraph one of DCD Subsection 3.8.5.1.

STD SUP 3.8-1 The depth of overburden and depth of embedment are given in Subsection 2.5.4.

3.9 MECHANICAL SYSTEMS AND COMPONENTS

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

3.9.3.1.2 Loads for Class 1 Components, Core Support, and Component Supports

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STD COL 3.9-5

Add the following after the last paragraph under DCD subheading Request 3) and prior to DCD subheading Other Applications:

PRESSURIZER SURGE LINE MONITORING

General

The pressurizer surge line is monitored at the first AP1000 plant to record temperature distributions and thermal displacements of the surge line piping, as well as pertinent plant parameters. This monitoring occurs during the hot functional testing and first fuel cycle. The resulting monitoring data is evaluated to verify that the pressurizer surge line is within the bounds of the analytical temperature distributions and displacements.

Subsequent AP1000 plants (after the first AP1000 plant) confirm that the heatup and cooldown procedures are consistent with the pertinent attributes of the first AP1000 plant surge line monitoring. In addition, changes to the heatup and cooldown procedures consider the potential impact on stress and fatigue analyses consistent with the concerns of NRC Bulletin 88-11.

The pressurizer surge line monitoring activities include the following methodology and requirements:

Monitoring Method

The pressurizer surge line pipe wall is instrumented with outside mounted temperature and displacement sensors. The data from this instrumentation is supplemented by plant computer data from related process and control parameters.

Locations to be Monitored

In addition to the existing permanent plant temperature instrumentation, temperature and displacement monitoring will be included at critical locations on the surge line.

Data Evaluation

Data evaluation is performed at the completion of the monitoring period (one fuel cycle). The evaluation includes a comparison of the data evaluation results with the thermal profiles and transient loadings defined for the pressurizer surge line, accounting for expected pipe outside wall temperatures. Interim evaluations of the data are performed during the hot functional testing period, up to the start of normal power operation, and again once three months worth of normal operating data has been collected, to identify any unexpected conditions in the pressurizer surge line.

3.9.3.4.4 Inspection, Testing, Repair, and/or Replacement of Snubbers

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Add the following text after the last paragraph of DCD Subsection 3.9.3.4.4:

STD SUP 3.9-3

a. Snubber Design and Testing

1. A list of snubbers on systems which experience sufficient thermal movement to measure cold to hot position is included in Table 3.9-201.

2. The snubbers are tested to verify they can perform as required during the seismic events, and under anticipated operational transient loads or other mechanical loads associated with the design requirements for the plant. Production and qualification test programs for both hydraulic and mechanical snubbers are carried out by the snubber vendors in accordance with the snubber installation instruction manual required to be furnished by the snubber supplier. Acceptance criteria for compliance with ASME Section III Subsection NF, and other applicable codes, standards, and requirements, are as follows:

- Snubber production and qualification test programs are carried out by strict adherence to the manufacturer's snubber installation and instruction manual. This manual is prepared by the snubber manufacturer and subjected to review for compliance with the applicable provisions of the ASME Pressure Vessel and Piping Code of record. The test program is periodically audited during implementation for compliance.

- Snubbers are inspected and tested for compliance with the design drawings and functional requirements of the procurement specifications.

- Snubbers are inspected and qualification tested. No sampling methods are used in the qualification tests.

- Snubbers are load rated by testing in accordance with the snubber manufacturer's testing program and in compliance with the applicable sections of ASME QME-1-2007, Subsection QDR and the ASME Code for Operation and Maintenance of Nuclear Power Plants (OM Code), Subsection ISTD.

- Design compliance of the snubbers per ASME Section III Paragraph NF-3128, and Subparagraphs NF-3411.3 and NF-3412.4.

- The snubbers are tested for various abnormal environmental conditions. Upon completion of the abnormal environmental transient test, the snubber is tested dynamically at a frequency within a specified frequency range. The snubber must operate normally during the dynamic test. The functional parameters cited in Subparagraph NF-3412.4 are included in the snubber qualification and testing program. Other parameters in accordance with applicable ASME QME-1-2007 and the ASME OM Code will be incorporated.

- The codes and standards used for snubber qualification and production testing are as follows:

  — ASME B&PV Code Section III (Code of Record date) and Subsection NF.

— ASME QME-1-2007, Subsection QDR and ASME OM Code, Subsection ISTD.

- Large bore hydraulic snubbers are full Service Level D load tested, including verifying bleed rates, control valve closure within the specified velocity ranges and drag forces/ breakaway forces are acceptable in accordance with ASME, QME-1-2007 and ASME OM Codes.

3. Safety-related snubbers are identified in Table 3.9-201, including the snubber identification and the associated system or component, e.g., line number. The snubbers on the list are hydraulic and constructed to ASME Section III, Subsection NF. The snubbers are used for shock loading only. None of the snubbers are dual purpose or vibration arrestor type snubbers.

b. Snubber Installation Requirements

Installation instructions contain instructions for storage, handling, erection, and adjustments (if necessary) of snubbers. Each snubber has an installation location drawing that contains the installation location of the snubber on the pipe and structure, the hot and cold settings, and additional information needed to install the particular snubber.

STD COL 3.9-3

The description of the snubber preservice and inservice testing programs in this section is based on the ASME OM Code 2001 Edition through 2003 Addenda. The initial inservice testing program incorporates the latest edition and addenda of the ASME OM Code approved in 10 CFR 50.55a(f) on the date 12 months before initial fuel load. Limitations and modifications set forth in 10 CFR 50.55a are incorporated.

c. Snubber Preservice and Inservice Examination and Testing

The preservice examination plan for applicable snubbers is prepared in accordance with the requirements of the ASME Code for Operation and Maintenance of Nuclear Power Plants (OM Code), Subsection ISTD, and the additional requirements of this Section. This examination is made after snubber installation but not more than 6 months prior to initial system preoperational testing. The preservice examination verifies the following:

1. There are no visible signs of damage or impaired operational readiness as a result of storage, handling, or installation.

2. The snubber load rating, location, orientation, position setting, and configuration (attachments, extensions, etc.) are according to design drawings and specifications.

3. Snubbers are not seized, frozen, or jammed.

4. Adequate swing clearance is provided to allow snubber movements.

5. If applicable, fluid is to the recommended level and is not to be leaking from the snubber system.

6. Structural connections such as pins, fasteners, and other connecting hardware such as lock nuts, tabs, wire, cotter pins are installed correctly.

If the period between the initial preservice examination and initial system preoperational tests exceeds 6 months, reexamination of Items 1, 4, and 5 is performed. Snubbers, which are installed incorrectly or otherwise fail to meet the above requirements, are repaired or replaced and re-examined in accordance with the above criteria.

A preservice thermal movement examination is also performed, during initial system heatup and cooldown. For systems whose design operating temperature exceeds 250°F (121°C), snubber thermal movement is verified.

Additionally, preservice operational readiness testing is performed on snubbers. The operational readiness test is performed to verify the parameters of ISTD 5120. Snubbers that fail the preservice operational readiness test are evaluated to determine the cause of failure, and are retested following completion of corrective action(s).

Snubbers that are installed incorrectly or otherwise fail preservice testing requirements are re-installed correctly, adjusted, modified, repaired or replaced, as required. Preservice examination and testing is re-performed on installation-corrected, adjusted, modified, repaired or replaced snubbers as required.

d. Snubber Inservice Examination and Testing

Inservice examination and testing of safety-related snubbers is conducted in accordance with the requirements of the ASME OM Code, Subsection ISTD. Inservice examination is initially performed not less than two months after attaining 5 percent reactor power operation and is completed within 12 calendar months after attaining 5 percent reactor power. Subsequent examinations are performed at intervals defined by ISTD-4252 and Table ISTD-4252-1. Examination intervals, subsequent to the third interval, are adjusted based on the number of unacceptable snubbers identified in the current interval.

An inservice visual examination is performed on the snubbers to identify physical damage, leakage, corrosion, degradation, indication of binding, misalignment or deformation and potential defects generic to a particular design. Snubbers that do not meet visual examination requirements are evaluated to determine the root cause of the unacceptability, and appropriate corrective actions (e.g., snubber is adjusted, repaired, modified, or replaced) are taken. Snubbers evaluated as unacceptable during visual examination may be accepted for continued service by successful completion of an operational readiness test.

Snubbers are tested inservice to determine operational readiness during each fuel cycle, beginning no sooner than 60 days before the start of the refueling outage. Snubber operational readiness tests are conducted with the snubber in the as-found condition, to the extent practical, either in-place or on a test bench, to verify the test parameters of ISTD-5210. When an in-place test or bench test cannot be performed, snubber subcomponents that control the parameters to be verified are examined and tested. Preservice examinations are performed on snubbers after reinstallation when bench testing is used (ISTD-5224), or on snubbers where individual subcomponents are reinstalled after examination (ISTD-5225).

Defined test plan groups (DTPG) are established and the snubbers of each DTPG are tested according to an established sampling plan each fuel cycle. Sample plan size and composition is determined as required for the selected sample plan, with additional sampling as may be required for that sample plan based on test failures and failure modes identified. Snubbers that do not meet test requirements are evaluated to determine root cause of the failure, and are assigned to failure mode groups (FMG) based on the evaluation, unless the failure is considered unexplained or isolated. The number of unexplained snubber failures, not assigned to a FMG, determines the additional testing sample. Isolated failures do not require additional testing. For unacceptable snubbers, additional testing is conducted for the DTPG or FMG until the appropriate sample plan completion criteria are satisfied.

Unacceptable snubbers are adjusted, repaired, modified, or replaced. Replacement snubbers meet the requirements of ISTD-1600. Post-maintenance examination and testing, and examination and testing of repaired snubbers, is done to verify as acceptable the test parameters that may have been affected by the repair or maintenance activity.

Service life for snubbers is established, monitored and adjusted as required by ISTD-6000 and the guidance of ASME OM Code Nonmandatory Appendix F.

3.9.6 INSERVICE TESTING OF PUMPS AND VALVES

Revise the third sentence of the third paragraph of DCD Subsection 3.9.6, and add information between the third and fourth sentences as follows:

STD COL 3.9-4 The edition and addenda to be used for the inservice testing program are administratively controlled; the description of the inservice testing program in this section is based on the ASME OM Code 2001 Edition through 2003 Addenda. The initial inservice testing program incorporates the latest edition and addenda of the ASME OM Code approved in 10 CFR 50.55a(f) on the date 12 months before initial fuel load. Limitations and modifications set forth in 10 CFR 50.55a are incorporated.

Revise the fifth sentence of the sixth paragraph of DCD Subsection 3.9.6 as follows:

STD COL 3.9-4 Alternate means of performing these tests and inspections that provide equivalent demonstration may be developed in the inservice test program ~~as described in subsection 3.9.8~~.

Revise the first two sentences of the final paragraph of DCD Subsection 3.9.6 to read as follows:

STD COL 3.9-4 A preservice test program, which identifies the required functional testing, is to be submitted to the NRC prior to performing the tests and following the start of construction. The inservice test program, which identifies requirements for functional testing, is to be submitted to the NRC prior to the anticipated date of commercial operation as described above.

Add the following text after the last paragraph of DCD Subsection 3.9.6:

Table 13.4-201 provides milestones for preservice and inservice test program implementation.

3.9.6.2.2 Valve Testing

Add the following prior the initial paragraph of DCD Subsection 3.9.6.2.2:

STD COL 3.9-4 Valve testing uses reference values determined from the results of preservice testing or inservice testing. These tests that establish reference and IST values are performed under conditions as near as practicable to those expected during the IST. Reference values are established only when a valve is known to be operating acceptably.

Pre-conditioning of valves or their associated actuators or controls prior to IST testing undermines the purpose of IST testing and is not allowed. Pre-conditioning includes manipulation, pre-testing, maintenance, lubrication, cleaning, exercising, stroking, operating, or disturbing the valve to be tested in any way, except as may occur in an unscheduled, unplanned, and unanticipated manner during normal operation.

Add the following sentence to the end of the fourth paragraph under the heading “Manual/Power-Operated Valve Tests”:

STD COL 3.9-4 Stroke time is measured and compared to the reference value, except for valves classified as fast-acting (e.g., solenoid-operated valves with stroke time less than 2 seconds), for which a stroke time limit of 2 seconds is assigned.

Add the following paragraph after the fifth paragraph under the heading “Manual/ Power-Operated Valve Tests”:

STD COL 3.9-4 During valve exercise tests, the necessary valve obturator movement is verified while observing an appropriate direct indicator, such as indicating lights that signal the required changes of obturator position, or by observing other evidence or positive means, such as changes in system pressure, flow, level, or temperature that reflects change of obturator position.

Insert new second sentence of the paragraph containing the subheading “Power-Operated Valve Operability Tests” in DCD Subsection 3.9.6.2.2 (immediately following the first sentence of the DCD paragraph) to read:

STD COL 3.9-4 Power-Operated Valve Operability Tests - The safety-related, power-operated valves (POVs) are required by the procurement specifications to have the capabilities to perform diagnostic testing to verify the capability of the valves to perform their design basis safety functions. The POVs include the motor-operated valves.

Add the following sentence as the last sentence of the paragraph containing the subheading “Power-Operated Valve Operability Tests” in DCD Subsection 3.9.6.2.2:

STD COL 3.9-4 Table 13.4-201 provides milestones for the MOV program implementation.

Insert the following as the last sentence in the paragraph under the bulleted item titled "Risk Ranking" in DCD Subsection 3.9.6.2.2:

STD COL 3.9-4 Guidance for this process is outlined in the JOG MOV PV Study, MPR-2524-A.

Insert the following text after the last paragraph under the sub-heading of "Power-Operated Valve Operability Tests" and before the sub-heading "Check Valve Tests" in DCD Subsection 3.9.6.2.2:

STD COL 3.9-4 **Active MOV Test Frequency Determination** — The ability of a valve to meet its design basis functional requirements (i.e. required capability) is verified during valve qualification testing as required by procurement specifications. Valve qualification testing measures valve actuator actual output capability. The actuator output capability is compared to the valve's required capability defined in procurement specifications, establishing functional margin; that is, that increment by which the MOV's actual output capability exceeds the capability required to operate the MOV under design basis conditions. DCD Subsection 5.4.8 discusses valve functional design and qualification requirements. The initial inservice test frequency is determined as required by ASME OM Code Code Case OMN-1, Revision 1 (Reference 202). The design basis capability testing of MOVs utilizes guidance from Generic Letter 96-05 and the JOG MOV Periodic Verification PV Program. Valve functional margin is evaluated following subsequent periodic testing to address potential time-related performance degradation, accounting for applicable uncertainties in the analysis. If the evaluation shows that the functional margin will be reduced to less than established acceptance criteria within the established test interval, the test interval is decreased to less than the time for the functional margin to decrease below acceptance criteria. If there is not sufficient data to determine test frequency as described above, the test frequency is limited to not exceed two (2) refueling cycles or three (3) years, whichever is longer, until sufficient data exist to extend the test frequency. Appropriate justification is provided for any increased test interval, and the maximum test interval shall not exceed 10 years. This is to ensure that each MOV in the IST program will have adequate margin (including consideration for aging-related degradation, degraded voltage, control switch repeatability, and load-sensitive MOV behavior) to remain operable until the next scheduled test, regardless of its risk categorization or safety significance. Uncertainties associated with performance of these periodic verification tests and use of the test results (including those associated with measurement equipment and potential degradation mechanisms) are addressed appropriately. Uncertainties may be considered in the specification of acceptable valve setup parameters or in the interpretation of the test results (or a combination of both). Uncertainties affecting both valve function and structural limits are addressed.

Maximum torque and/or thrust (as applicable) achieved by the MOV (allowing sufficient margin for diagnostic equipment inaccuracies and control switch repeatability) are established so as not to exceed the allowable structural and undervoltage motor capability limits for the individual parts of the MOV.

Solenoid-operated valves (SOVs) are tested to confirm the valve moves to its energized position and is maintained in that position, and to confirm that the valve moves to the appropriate failure mode position when de-energized.

Other Power-Operated Valve Operability Tests — Power-Operated valves other than active MOVs are exercised quarterly in accordance with ASME OM ISTC, unless justification is provided in the inservice testing program for testing these valves at other than Code mandated frequencies.

Although the design basis capability of power-operated valves is verified as part of the design and qualification process, power-operated valves that perform an active safety function are tested again after installation in the plant, as required, to ensure valve setup is acceptable to perform their required functions, consistent with valve qualification. These tests, which are typically performed under static (no flow or pressure) conditions, also document the "baseline" performance of the valves to support maintenance and trending programs. During the testing, critical parameters needed to ensure proper valve setup are measured. Depending on the valve and actuator type, these parameters may include seat load, running torque or thrust, valve travel, actuator spring rate, bench set and regulator supply pressure. Uncertainties associated with performance of these tests and use of the test results (including those associated with measurement equipment and potential degradation mechanisms) are addressed appropriately. Uncertainties may be considered in the specification of acceptable valve setup parameters or in the interpretation of the test results (or a combination of both). Uncertainties affecting both valve function and structural limits are addressed.

Additional testing is performed as part of the air-operated valve (AOV) program, which includes the key elements for an AOV Program as identified in the JOG AOV program document, Joint Owners Group Air Operated Valve Program Document, Revision 1, December 13, 2000 (Reference 203 and Reference 204). The AOV program incorporates the attributes for a successful power-operated valve long-term periodic verification program, as discussed in Regulatory Issue Summary 2000-03, Resolution of Generic Safety Issue 158: Performance of Safety-Related Power-Operated Valves Under Design Basis Conditions, by incorporating lessons learned from previous nuclear power plant operations and research programs as they apply to the periodic testing of air- and other power-operated valves included in the IST program. For example, key lessons learned addressed in the AOV program include:

- Valves are categorized according to their safety significance and risk ranking.
- Setpoints for AOVs are defined based on current vendor information or valve qualification diagnostic testing, such that the valve is capable of performing its design-basis function(s).
- Periodic static testing is performed, at a minimum on high risk (high safety significance) valves, to identify potential degradation, unless those valves are periodically cycled during normal plant operation, under conditions that meet or exceed the worst case operating conditions within the licensing basis of the plant for the valve, which would provide adequate periodic demonstration of AOV capability. If required based on valve qualification or operating experience, periodic dynamic testing is performed to re-verify the capability of the valve to perform its required functions.
- Sufficient diagnostics are used to collect relevant data (e.g., valve stem thrust and torque, fluid pressure and temperature, stroke time, operating and/or control air pressure, etc.) to verify the valve meets the functional requirements of the qualification specification.
- Test frequency is specified, and is evaluated each refueling outage based on data trends as a result of testing. Frequency for periodic testing is in accordance with Reference 203 and Reference 204, with a minimum of 5 years (or 3 refueling cycles) of data collected and evaluated before extending test intervals.
- Post-maintenance procedures include appropriate instructions and criteria to ensure baseline testing is re-performed as necessary when maintenance on the valve, repair or replacement, have the potential to affect valve functional performance.
- Guidance is included to address lessons learned from other valve programs specific to the AOV program.
- Documentation from AOV testing, including maintenance records and records from the corrective action program are retained and periodically evaluated as a part of the AOV program.

Insert the following paragraph as the last paragraph under the sub-heading of "Power-Operated Valve Operability Tests" (following the previously added paragraph) and just before the sub-heading "Check Valve Tests" in DCD Subsection 3.9.6.2.2:

STD COL 3.9-4 Successful completion of the preservice and IST of MOVs, in addition to MOV testing as required by 10 CFR 50.55a, demonstrates that the following criteria are met for each valve tested: (i) valve fully opens and/or closes as required by its safety function; (ii) adequate margin exists and includes consideration of diagnostic equipment inaccuracies, degraded voltage, control switch repeatability, load-sensitive MOV behavior, and a margin for degradation; and (iii) maximum torque and/or thrust (as applicable) achieved by the MOV (allowing sufficient margin for diagnostic equipment inaccuracies and control switch repeatability) does not exceed the allowable structural and undervoltage motor capability limits for the individual parts of the MOV.

Add the paragraph below as the last paragraph of FSAR Subsection 3.9.6.2.2 prior to the subheading "Check Valve Tests":

STD COL 3.9-4 The attributes of the AOV testing program described above, to the extent that they apply to and can be implemented on other safety-related power-operated valves, such as electro-hydraulic valves, are applied to those other power-operated valves.

Add the following new paragraph under the heading "Check Valves Tests" in DCD Subsection 3.9.6.2.2:

STD COL 3.9-4 Preoperational testing is performed during the initial test program (refer to DCD Subsection 14.2) to verify that valves are installed in a configuration that allows correct operation, testing, and maintenance. Preoperational testing verifies that piping design features accommodate check valve testing requirements. Tests also verify disk movement to and from the seat and determine, without disassembly, that the valve disk positions correctly, fully opens or fully closes as expected, and remains stable in the open position under the full spectrum of system design-basis fluid flow conditions.

Add the following new last paragraphs under the subheading "Check Valve Exercise Tests" in DCD Subsection 3.9.6.2.2:

STD COL 3.9-4

Acceptance criteria for this testing consider the specific system design and valve application. For example, a valve's safety function may require obturator movement in both open and closed directions. A mechanical exerciser may be used to operate a check valve for testing. Where a mechanical exerciser is used, acceptance criteria are provided for the force or torque required to move the check valve's obturator. Exercise tests also detect missing, sticking, or binding obturators.

When operating conditions, valve design, valve location, or other considerations prevent direct observation or measurements by use of conventional methods to determine adequate check valve function, diagnostic equipment and nonintrusive techniques are used to monitor internal conditions. Nonintrusive tests used are dependent on system and valve configuration, valve design and materials, and include methods such as ultrasonic (acoustic), magnetic, radiography, and use of accelerometers to measure system and valve operating parameters (e.g., fluid flow, disk position, disk movement, disk impact, and the presence or absence of cavitation and back-tapping). Nonintrusive techniques also detect valve degradation. Diagnostic equipment and techniques used for valve operability determinations are verified as effective and accurate under the PST program.

Testing is performed, to the extent practicable, under normal operation, cold shutdown, or refueling conditions applicable to each check valve. Testing includes effects created by sudden starting and stopping of pumps, if applicable, or other conditions, such as flow reversal. When maintenance that could affect valve performance is performed on a valve in the IST program, post-maintenance testing is conducted prior to returning the valve to service.

Add the following new paragraph under the heading “Other Valve Inservice Tests” following the Explosively Actuated Valves paragraph in DCD Subsection 3.9.6.2.2:

STD COL 3.9-4

Industry and regulatory guidance is considered in development of IST program for squib valves. In addition, the IST program for squib valves incorporates lessons learned from the design and qualification process for these valves such that surveillance activities provide reasonable assurance of the operational readiness of squib valves to perform their safety functions.

3.9.6.2.3 Valve Disassembly and Inspection

Add the following paragraph as the new second paragraph of DCD Subsection 3.9.6.2.3:

STD COL 3.9-4

During the disassembly process, the full-stroke motion of the obturator is verified. Nondestructive examination is performed on the hinge pin to assess wear, and seat contact surfaces are examined to verify adequate contact. Full-stroke motion of the obturator is re-verified immediately prior to completing reassembly. At least one valve from each group is disassembled and examined at each refueling outage, and all the valves in each group are disassembled and examined at least once every eight years. Before being returned to service, valves disassembled for examination or valves that received maintenance that could affect their performance are exercised with a full- or part-stroke. Details and bases of the sampling program are documented and recorded in the test plan.

Add Subsections 3.9.6.2.4 and 3.9.6.2.5 following the last paragraph of DCD Subsection 3.9.6.2.3:

3.9.6.2.4 Valve Preservice Tests

STD COL 3.9-4

Each valve subject to inservice testing is also tested during the preservice test period. Preservice tests are conducted under conditions as near as practicable to those expected during subsequent inservice testing. Valves (or the control system) that have undergone maintenance that could affect performance, and valves that have been repaired or replaced, are re-tested to verify performance parameters that could have been affected are within acceptable limits. Safety and relief valves and nonreclosing pressure relief devices are preservice tested in accordance with the requirements of the ASME OM Code, Mandatory Appendix I.

Preservice tests for valves are performed in accordance with ASME OM, ISTC-3100.

3.9.6.2.5 Valve Replacement, Repair, and Maintenance

Testing in accordance with ASME OM, ISTC-3310 is performed after a valve is replaced, repaired, or undergoes maintenance. When a valve or its control system has been replaced, repaired, or has undergone maintenance that could affect valve performance, a new reference value is determined, or the previous value is reconfirmed by an inservice test. This test is performed before the valve is returned to service, or immediately if the valve is not removed from service. Deviations between the previous and new reference values are identified and analyzed. Verification that the new values represent acceptable operation is documented.

3.9.6.3 Relief Requests

Insert the following text after the first paragraph in DCD Subsection 3.9.6.3:

STD COL 3.9-4

The IST Program described herein utilizes Code Case OMN-1, Revision 1, “Alternative Rules for the Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in Light Water Reactor Power Plants” (Reference 202). Code Case OMN-1 establishes alternate rules and requirements for preservice and inservice testing to assess the operational readiness of certain motor operated valves, in lieu of the requirements set forth in ASME OM Code Subsection ISTC.

OMN-1, Alternative Rules for the Preservice and Inservice Testing of Certain MOVs

Code Case OMN-1, Revision 1, "Alternative Rules for the Preservice and Inservice Testing of Certain Electric Motor Operated Valve Assemblies in Light Water Reactor Power Plants," establishes alternate rules and requirements for preservice and inservice testing to assess the operational readiness of certain motor-operated valves in lieu of the requirements set forth in OM Code Subsection ISTC. However, Regulatory Guide 1.192, "Operation and Maintenance Code Case Acceptability, ASME OM Code," June 2003, has not yet endorsed OMN-1, Revision 1.

Code Case OMN-1, Revision 0, has been determined by the NRC to provide an acceptable level of quality and safety when implemented in conjunction with the conditions imposed in Regulatory Guide 1.192. NUREG-1482, Revision 1, "Guidelines for Inservice Testing at Nuclear Power Plants," recommends the implementation of OMN-I by all licensees. Revision 1 to OMN-1 represents an improvement over Revision 0, as published in the ASME OM-2004 Code. OMN-1 Revision 1 incorporates the guidance on risk-informed testing of MOVs from OMN-11, "Risk-Informed Testing of Motor-Operated Valves," and provides additional guidance on design basis verification testing and functional margin, which eliminates the need for the figures on functional margin and test intervals in Code Case OMN-1.

The IST Program implements Code Case OMN-1, Revision 1, in lieu of the stroke-time provisions specified in ISTC-5120 for MOVs, consistent with the guidelines provided in NUREG-1482, Revision 1, Section 4.2.5.

Regulatory Guide 1.192 states that licensees may use Code Case OMN-1, Revision 0, in lieu of the provisions for stroke-time testing in Subsection ISTC of the 1995 Edition up to and including the 2000 Addenda of the ASME OM Code when applied in conjunction with the provisions for leakage rate testing in ISTC-3600 (1998 Edition with the 1999 and 2000 Addenda). Licensees who choose to apply OMN-1 are required to apply all of its provisions. The IST program incorporates the following provisions from Regulatory Guide 1.192:

(1) The adequacy of the diagnostic test interval for each motor-operated valve (MOV) is evaluated and adjusted as necessary, but not later than 5 years or three refueling outages (whichever is longer) from initial implementation of OMN-1.

(2) The potential increase in CDF and risk associated with extending high risk MOV test intervals beyond quarterly is determined to be small and consistent with the intent of the Commission's Safety Goal Policy Statement.

(3) Risk insights are applied using MOV risk ranking methodologies accepted by the NRC on a plant-specific or industry-wide basis, consistent with the conditions in the applicable safety evaluations.

(4) Consistent with the provisions specified for Code Case OMN-11 the potential increase in CDF and risk associated with extending high risk MOV test intervals beyond quarterly is determined to be small and consistent with the intent of the Commission's Safety Goal Policy Statement.

Compliance with the above items is addressed in Section 3.9.6.2.2. Code Case OMN-1, Revision 1, is considered acceptable for use with OM Code-2001 Edition with 2003 Addenda. Finally, consistent with Regulatory Guide 1.192, the benefits of performing any particular test are balanced against the potential adverse effects placed on the valves or systems caused by this testing.

3.9.8 COMBINED LICENSE INFORMATION

3.9.8.2 Design Specifications and Reports

Add the following text after the second paragraph in DCD Subsection 3.9.8.2:

STD COL 3.9-2 Design specifications and design reports for ASME Section III piping are made available for NRC review. Reconciliation of the as-built piping (verification of the thermal cycling and stratification loading considered in the stress analysis discussed in DCD Subsection 3.9.3.1.2) is completed by the COL holder after the construction of the piping systems and prior to fuel load (in accordance with DCD Tier 1 Section 2 ITAAC line item for the applicable systems).

3.9.8.3 Snubber Operability Testing

STD COL 3.9-3 This COL Item is addressed in Subsection 3.9.3.4.4.

3.9.8.4 Valve Inservice Testing

STD COL 3.9-4 This COL Item is addressed in Subsections 3.9.6, 3.9.6.2.2, 3.9.6.2.4, 3.9.6.2.5, and 3.9.6.3.

3.9.8.5 Surge Line Thermal Monitoring

STD COL 3.9-5 This COL item is addressed in Subsection 3.9.3.1.2, and Subsection 14.2.9.2.22.

3.9.8.7 As-Designed Piping Analysis

Add the following text to the end of DCD Subsection 3.9.8.7.

STD COL 3.9-7 The as-designed piping analysis is provided for the piping lines chosen to demonstrate all aspects of the piping design. A design report referencing the as-designed piping calculation packages, including ASME Section III piping analysis, support evaluations and piping component fatigue analysis for Class 1 piping using the methods and criteria outlined in DCD Table 3.9-19 is made available for NRC review.

This COL item is also addressed in Subsection 14.3.3.

3.9.9 REFERENCES

201. Not used.

202. ASME Code Case OMN-1, Revision 1, “Alternative Rules for the Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in Light Water Reactor Power Plants.”

203. Joint Owners Group Air Operated Valve Program Document, Revision 1, December 13, 2000.

204. USNRC, Eugene V. Imbro, letter to Mr. David J. Modeen, Nuclear Energy Institute, Comments On Joint Owners' Group Air Operated Valve Program Document, dated October 8, 1999.

STD SUP 3.9-3

Table 3.9-201
Safety Related Snubbers

System	Snubber (Hanger) No.	Line #	System	Snubber (Hanger) No.	Line #
CVS	APP-CVS-PH-11Y0164	L001	RNS	APP-RNS-PH-12Y2060	L006
PXS	APP-PXS-PH-11Y0020	L021A	SGS	APP-SGS-PH-11Y0001	L003B
RCS	APP-RCS-PH-11Y0039	L215	SGS	APP-SGS-PH-11Y0002	L003B
RCS	APP-RCS-PH-11Y0067	L005B	SGS	APP-SGS-PH-11Y0004	L003B
RCS	APP-RCS-PH-11Y0080	L112	SGS	APP-SGS-PH-11Y0057	L003A
RCS	APP-RCS-PH-11Y0081	L215	SGS	APP-SGS-PH-11Y0058	L004B
RCS	APP-RCS-PH-11Y0082	L112	SGS	APP-SGS-PH-11Y0063	L003A
RCS	APP-RCS-PH-11Y0090	L118A	SGS	APP-SGS-PH-11Y0065	L005B
RCS	APP-RCS-PH-11Y0099	L022B	SGS	APP-SGS-PH-12Y0136	L015C
RCS	APP-RCS-PH-11Y0103	L003	SGS	APP-SGS-PH-12Y0137	L015C
RCS	APP-RCS-PH-11Y0105	L003	SGS	APP-SGS-PH-11Y0470	L006B
RCS	APP-RCS-PH-11Y0112	L032A	SGS	APP-SGS-PH-11Y2002	L006A
RCS	APP-RCS-PH-11Y0429	L225B	SGS	APP-SGS-PH-11Y2021	L006A
RCS	APP-RCS-PH-11Y0528	L005A	SGS	APP-SGS-PH-11Y3101	L006B
RCS	APP-RCS-PH-11Y0539	L225C	SGS	APP-SGS-PH-11Y3102	L006B
RCS	APP-RCS-PH-11Y0550	L011B	SGS	APP-SGS-PH-11Y3121	L006B
RCS	APP-RCS-PH-11Y0551	L011A	SGS	APP-SGS-PH-11Y0463	L006A
RCS	APP-RCS-PH-11Y0553	L153B	SGS	APP-SGS-PH-11Y0464	L006A
RCS	APP-RCS-PH-11Y0555	L153A	SGS	SG 1 Snubber A (1A)	(a)
RCS	APP-RCS-PH-11Y2005	L022A	SGS	SG 1 Snubber B (1B)	(a)
RCS	APP-RCS-PH-11Y2101	L032B	SGS	SG 2 Snubber A (2A)	(a)
RCS	APP-RCS-PH-11Y2117	L225A	SGS	SG 2 Snubber B (2B)	(a)

(a) These snubbers are on the upper lateral support assembly of the steam generators.

3.10 SEISMIC AND DYNAMIC QUALIFICATION OF SEISMIC CATEGORY I MECHANICAL AND ELECTRICAL EQUIPMENT

This section of the referenced DCD is incorporated by reference with no departures or supplements.

3.11 ENVIRONMENTAL QUALIFICATION OF MECHANICAL AND ELECTRICAL EQUIPMENT

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

3.11.5 COMBINED LICENSE INFORMATION ITEM FOR EQUIPMENT QUALIFICATION FILE

Add the following text to the end of DCD Subsection 3.11.5:

STD COL 3.11-1

The COL holder is responsible for the maintenance of the equipment qualification file upon receipt from the reactor vendor. The documentation necessary to support the continued qualification of the equipment installed in the plant that is within the Environmental Qualification (EQ) Program scope is available in accordance with 10 CFR Part 50 Appendix A, General Design Criterion 1.

EQ files developed by the reactor vendor are maintained as applicable for equipment and certain post-accident monitoring devices that are subject to a harsh environment. The contents of the qualification files are discussed in DCD Section 3D.7. The files are maintained for the operational life of the plant.

For equipment not located in a harsh environment, design specifications received from the reactor vendor are retained. Any plant modifications that impact the equipment use the original specifications for modification or procurement. This process is governed by applicable plant design control or configuration control procedures.

Central to the EQ Program is the EQ Master Equipment List (EQMEL). This EQMEL identifies the electrical and mechanical equipment or components that must be environmentally qualified for use in a harsh environment. The EQMEL consists of equipment that is essential to emergency reactor shutdown, containment isolation, reactor core cooling, or containment and reactor heat removal, or that is otherwise essential in preventing significant release of radioactive material to the environment. This list is developed from the equipment list provided in AP1000 DCD Table 3.11-1. The EQMEL and a summary of equipment qualification results are maintained as part of the equipment qualification file for the operational life of the plant.

Administrative programs are in place to control revision to the EQ files and the EQMEL. When adding or modifying components in the EQ Program, EQ files are generated or revised to support qualification. The EQMEL is revised to reflect these new components. To delete a component from the EQ Program, a deletion justification is prepared that demonstrates why the component can be deleted.

This justification consists of an analysis of the component, an associated circuit review if appropriate, and a safety evaluation. The justification is released and/or referenced on an appropriate change document. For changes to the EQMEL, supporting documentation is completed and approved prior to issuing the changes. This documentation includes safety reviews and new or revised EQ files. Plant modifications and design basis changes are subject to change process reviews, e.g. reviews in accordance with 10 CFR 50.59 or Section VIII of Appendix D to 10 CFR Part 52, in accordance with appropriate plant procedures. These reviews address EQ issues associated with the activity. Any changes to the EQMEL that are not the result of a modification or design basis change are subject to a separate review that is accomplished and documented in accordance with plant procedures.

Engineering change documents or maintenance documents generated to document work performed on an EQ component, which may not have an impact on the EQ file, are reviewed against the current revision of the EQ files for potential impact. Changes to EQ documentation may be due to, but not limited to, plant modifications, calculations, corrective maintenance, or other EQ concerns.

Table 13.4-201 provides milestones for EQ implementation.

APPENDIX 3A HVAC DUCTS AND DUCT SUPPORTS

This section of the referenced DCD is incorporated by reference with no departures or supplements.

APPENDIX 3B LEAK-BEFORE-BREAK EVALUATION OF THE AP1000 PIPING

This section of the referenced DCD is incorporated by reference with no departures or supplements.

APPENDIX 3C REACTOR COOLANT LOOP ANALYSIS METHODS

This section of the referenced DCD is incorporated by reference with no departures or supplements.

APPENDIX 3D METHODOLOGY FOR QUALIFYING AP1000 SAFETY-RELATED ELECTRICAL AND MECHANICAL EQUIPMENT

This section of the referenced DCD is incorporated by reference with no departures or supplements.

APPENDIX 3E HIGH-ENERGY PIPING IN THE NUCLEAR ISLAND

This section of the referenced DCD is incorporated by reference with no departures or supplements.

APPENDIX 3F CABLE TRAYS AND CABLE TRAY SUPPORTS

This section of the referenced DCD is incorporated by reference with no departures or supplements.

APPENDIX 3G NUCLEAR ISLAND SEISMIC ANALYSES

This section of the referenced DCD is incorporated by reference with no departures or supplements.

APPENDIX 3H AUXILIARY AND SHIELD BUILDING CRITICAL SECTIONS

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

3H3.3 LOADS

Replace the first paragraph under Wind Load with the following:

PTN DEP 2.0-1 *[The wind loads are as follows:*

- *Design wind (W)*

  For the design of the exterior walls, wind loads are applied in accordance with ASCE 7-98 with a basic wind speed of 150 mph. The importance factor is 1.15, and the exposure category is C. Wind loads are not combined with seismic loads.

APPENDIX 3I EVALUATION FOR HIGH FREQUENCY SEISMIC INPUT

This section of the referenced DCD is incorporated by reference with no departures or supplements.

PTN SUP 3 JJ-1

APPENDIX 3JJ SOIL STRUCTURE INTERACTION SOIL PROFILES AND INPUT MOTIONS

3JJ.0 INTRODUCTION

Subsection 3.7.1.1.1 summarizes the development of the Foundation Input Response Spectra (FIRS), the strain-compatible soil profiles, and the development of acceleration time histories for use as input motions in soil-structure interaction (SSI) analysis. Appendix 3JJ discusses these steps in detail.

In Subsection 3JJ.1, the site response analysis leading to the development of amplification factors at the FIRS horizon is discussed. Subsection 3JJ.2 presents the developed FIRS while Subsection 3JJ.3 presents the calculated strain-compatible soil profiles. The matching of acceleration time histories to the FIRS is discussed in Subsection 3JJ.4 and the final acceleration time histories suitable for use in SSI analysis are presented in Subsection 3JJ.5.

3JJ.1 DEVELOPMENT OF AMPLIFICATION FACTORS AT FIRS HORIZON

The Uniform Hazard Response Spectra (UHRS), described in Subsection 2.5.2.4, are defined on hard rock characterized with a shear wave velocity of V_s = 9200 feet/second (2.8 kilometers/second), which is located at about 10,000 feet (3000 meters) below the ground surface. Subsection 2.5.2.5 describes the development of the site amplification factors at the GMRS horizon that results from the transmission of the seismic waves through the thick soil column. The effect is modeled by randomized soil columns, extending from the finished ground surface (including structural fill) to randomized hard rock depths varying between 7400 feet (2256 meters) and 11,400 feet (3476 meters), and an adjustment to the soil damping within the soil column to represent the anelastic attenuation of ground motion by the entire soil column (the “kappa” value). The same procedures are followed in this section to develop amplification factors at the FIRS horizon at the bottom of the nuclear island foundation.

The full soil columns used for computation of soil amplification factors represent two site conditions. The site condition far from the nuclear island consists of in situ soil layers except for the upper 30.5 feet (9.3 meters) of structural fill. This is the fill required for the general site to raise the site grade elevation from the existing grade to the final grade, and is designated as “FAR” in this section. In addition, a second soil column represents the site conditions near the nuclear island where, in addition to the general fill, lean concrete and structural fill replace the in situ soils down to a depth of 60.5 feet (18.4 meters). This second column is designated “NI” in the following discussion.

The site response analysis is conducted on a set of 60 randomized profiles, for each of the two base soil profiles, to account for the variability in the dynamic soil properties. The randomization procedure is described in detail in Subsection 2.5.2.5.2. Figures 3JJ-201 and 3JJ-202 present the low-strain randomized shear-wave velocity profiles for NI and FAR site conditions respectively. The “input median” used as input for randomization and the median of the 60 randomized profiles (“Randomized Median”) are compared in these figures. The apparent mismatch at depths greater than 7400 feet (2256 meters) is due to the termination of certain randomized profiles at that depth. Therefore the “Randomized Median” is calculated for the remaining profiles only and shows lower values than the “Input Median”, as expected.

Using the randomized profiles, the soil column analysis is performed with the de-aggregated low frequency (LF) and high frequency (HF) spectra of hard rock motion at 10^{-4} and 10^{-5} annual-frequency-of-exceedance, presented in Subsection 2.5.2.4, following the same methodology described in Subsection 2.5.2.5. The 5 percent damping acceleration response spectra (ARS) are calculated as “outcrop” motion at the selected horizons at 301 frequencies between 0.1 and 100 Hz. Amplification factors are calculated as the ratio of the calculated ARS at the selected horizon to the input UHRS at the bottom of the soil column.

Log-mean (median) amplification factors are developed for both FAR and NI site conditions at the ground surface at elevation +25.5 feet (7.8 meters) as well as at the FIRS horizon, located at the bottom of the NI foundation at elevation –16 feet (–4.9 meters) corresponding to a depth of 41.5 feet (12.7 meters) below the finished ground surface.

Figures 3JJ-203 and 3JJ-204 present the amplification factors at the FIRS horizon from analyses of the 60 randomized profiles, for NI and FAR site conditions respectively, for different rock input motions. Figures 3JJ-205 and 3JJ-206 present the amplification factors at the ground surface. Note that LF amplification factors for the low frequency range are larger than the corresponding HF ones, and that amplification greater than 1.0 of the ARS is observed in the low frequency range, while at higher frequencies, de-amplification occurs. The amplification due to the 10^{-5} level of input motion is smaller than for the 10^{-4} level of input motion, at frequencies larger than 0.8 Hz, due to the higher strain levels and nonlinearity in the soil column.

The median of maximum strains versus depth from analyses of the 60 randomized profiles for LF and HF, 10^{-4} and 10^{-5} input motions, are presented in Figures 3JJ-207 and 3JJ-208 for NI and FAR site conditions, respectively. Note that strains are generally low and do not exceed 0.045 percent for both NI and FAR site conditions. Comparison of the profiles of median maximum strains clearly confirms that the strains due to LF motions are larger than under HF motions.

3JJ.2 DEVELOPMENT OF FIRS

The recommended horizontal and vertical FIRS are calculated for elevation –16 feet horizon. This horizon corresponds to the bottom of the nuclear island foundation horizon, refer to Subsection 3JJ.1. The same RG 1.208 methodology used for the development of the GMRS design response spectra in FSAR Subsection 2.5.2.6 is used for the recommended FIRS design response spectra. For the development of the FIRS, however, the methodology is performed twice: once to develop a design response spectrum (DRS) for the FAR soil column, and once to develop a DRS for the NI soil column. The horizontal FIRS is defined as the envelope of the FAR and NI DRS. The vertical FIRS is obtained by scaling the horizontal FIRS by the same V:H ratios as presented in Subsection 2.5.2.6. Similar to the GMRS, the recommended FIRS design response spectra are for 5 percent spectral damping.

With the site-specific amplification calculations described in the previous subsection, the site horizontal design response spectrum (DRS) for both FAR and NI soil columns were determined as follows. Figures 3JJ-209 and 3JJ-210 show the 10^{-4} and 10^{-5} horizontal HF and LF acceleration response spectra (ARS) resulting from the site response analysis, plotted on a linear spectral acceleration scale for the FAR and NI soil columns, respectively. The “LF SA(g)” and “HF SA(g)” columns in Tables 3JJ-201 and 3JJ-202 list these ARS at a 38-frequency subset of the 301 frequencies analyzed for the annual frequencies of exceedance of 10^{-4} and 10^{-5}, respectively. For each soil column the HF and LF 10^{-4} and 10^{-5} horizontal site spectra are enveloped to give a “raw” soil uniform hazard response spectrum (UHRS) and smoothed to remove small frequency-to-frequency variations, using a smoothing function that averages over spectral accelerations at adjacent frequencies. Figures 3JJ-211 and 3JJ-212 show the smoothed, UHRS calculated in this way, plotted on a linear spectral acceleration scale for the FAR and NI soil columns, respectively. Tables 3JJ-201 and 3JJ-202 tabulate the “raw” and smoothed UHRS for both FAR and NI soil columns for the annual frequencies of exceedance of 10^{-4} and 10^{-5}, respectively.

The horizontal DRS for both soil columns are calculated at each frequency using the following equations:

$A_R = SA(10^{-5})/SA(10^{-4})$ Equation 3JJ-1

$DF = 0.6 \times A_R^{0.8}$ Equation 3JJ-2

$DRS = \mathit{max}[SA(10^{-4}) \times \mathit{max}(1.0, DF), 0.45 \times SA(10^{-5})]$ Equation 3JJ-3

where $SA(10^{-4})$ is the smoothed UHRS as spectral acceleration for the 10^{-4} hazard level at each spectral frequency (and similarly for 10^{-5}), and DRS is the design response spectrum at that spectral frequency. These equations follow the procedure in RG 1.208 to determine the DRS from the 10^{-4} and 10^{-5} response spectra.

Figures 3JJ-211 and 3JJ-212 show the FAR and NI horizontal DRS, respectively, calculated with the above equations at each spectral frequency from the smoothed 10^{-4} and 10^{-5} horizontal spectra. Tables 3JJ-203 and 3JJ-204 document the smoothed 10^{-4} and 10^{-5} horizontal spectral amplitudes, the calculation of A_R and DF from Equations 3JJ-1 and 3JJ-2, and the horizontal DRS calculated according to Equation 3JJ-3 for the FAR and NI soil columns, respectively. At low spectral frequencies (about 2 Hz and below), the hazard curves are steep, so A_R in Equation 3JJ-2 above is low, and the DRS from Equation 3JJ-3 is nearly equal to the 10^{-4} UHRS.

To calculate vertical spectra, V:H ratios from RG 1.60 are adopted, as in Subsection 2.5.2.6 in development of the GMRS. The V:H ratios are applied to the smoothed 10^{-4} and 10^{-5} horizontal spectra to calculate 10^{-4} and 10^{-5} vertical UHRS, and Equations 3JJ-1 through 3JJ-3 are applied to the 10^{-4} and 10^{-5} vertical spectral accelerations to calculate a vertical DRS for both FAR and NI soil columns. The resulting vertical 10^{-4} and 10^{-5} spectra and vertical DRS are plotted in Figures 3JJ-213 and 3JJ-214 for the FAR and NI soil columns, respectively. Tables 3JJ-205 and 3JJ-206 document the V:H ratios, the 10^{-4} and 10^{-5} vertical spectral amplitudes, the calculation of A_R and DF from Equations 3JJ-1 and 3JJ-2, and the vertical DRS calculated according to Equation 3JJ-3 for the FAR and NI soil columns, respectively.

Finally, the FIRS is defined as the envelope of the DRS for FAR and NI soil columns. Figure 3JJ-215 plots the horizontal and vertical FIRS, and Table 3JJ-207 provides a tabulation of the horizontal and vertical FIRS spectra.

In addition to the FIRS, from the same set of soil amplification analysis, DRS at the ground surface for both NI and FAR soil profiles are developed and enveloped. The surface DRS are calculated using the ground surface amplification factors presented in Subsection 3JJ.1 following the same procedure for development of FIRS. Surface DRS are used to check the adequacy of the SSI input motion as described in Subsection 3JJ.5.

3JJ.3 STRAIN-COMPATIBLE SOIL PROPERTY PROFILES

Two sets of strain-compatible profiles are developed for the NI and FAR site conditions, respectively. Each set consists of best estimate (BE), lower bound (LB) and upper bound (UB) strain-compatible shear-wave velocity, P-wave velocity and damping profiles. The soil properties are developed consistent with the developed FIRS. The upper bound and the lower bound shear wave velocity profiles maintain the minimum coefficient of variation of 0.50 in terms of the best estimate soil shear modulus.

P-wave velocities are calculated using Equation 3JJ-4 where ν is the Poisson's ratio corresponding to each soil layer. In addition, below the ground water level at elevation +1 feet (0.3 meters), a minimum P-wave velocity of 5000 feet/sec (1524 meter/sec) is maintained, on the condition that ν does not exceed 0.48 to avoid numerical problems in SSI analysis.

$$V_P = V_S \sqrt{\frac{2-2\nu}{1-2\nu}} \qquad \text{Equation 3JJ-4}$$

The resulting profiles are plotted in Figures 3JJ-216, 3JJ-217, and 3JJ-218 for NI site conditions and in Figures 3JJ-219, 3JJ-220, and 3JJ-221 for FAR site conditions. Note that the lower bound SSI soil profile is composed of the lower bound shear-wave velocity profile, the lower bound P-wave velocity profile and the upper bound (larger) damping profile. Similarly, the soil property profiles are combined for the upper bound SSI soil profiles. The presented profiles are recommended for use in the SSI analysis of the nuclear island.

3JJ.4 SPECTRAL MATCHING OF ACCELERATION TIME HISTORIES

Spectrum-compatible acceleration time histories are presented in this section. The first step in the development of spectrum-compatible time histories was the selection of appropriate seed acceleration time histories. These selected input seed time histories were taken from the database of candidate time histories given in NUREG/CR-6728 based on the low frequency de-aggregation results (i.e., magnitudes > 7 and distances > 500 km). For the analysis, the three component (i.e., two horizontal and one vertical component) strong ground motion recordings from the 1999 Chi-Chi earthquake (magnitude=7.6) recorded at the TAP024 station (closest distance=100.2 km) were selected and matched to the 5 percent damping FIRS developed earlier (see Subsection 3JJ.2).

The spectral matching procedure is a time domain procedure and emphasis was placed on maintaining the phase characteristics of the initial time history in the final modified spectrum-compatible time history. In addition, emphasis was placed on maintaining the characteristic of the normalized Arias intensities (the integral of the square of the acceleration-time history, a ground motion parameter that captures the potential destructiveness of an earthquake) of the initial and final modified spectrum-compatible time histories. These time histories were modified to be spectrum-compatible to the FIRS target spectra following the spectral matching criteria given in NUREG/CR-6728. In most cases, as additional constant scale factor was applied after the spectral matching procedure to comply with the spectral matching criteria given in NUREG/CR-6728. Scale factors of 1.02, 1.022, and 1.01 were applied for the two horizontal directions (H1, H2), and vertical direction (UP) components, respectively.

The modified spectrum-compatible acceleration, velocity, and displacement time histories prior to the application of the noted constant scale factors are plotted in Figure 3JJ-222a for the H1 component. Figure 3JJ-222c shows target horizontal FIRS spectrum, 1.3*FIRS target spectrum, 0.9*FIRS target spectrum and the modified time history response spectrum including the 1.02 constant scale factor. The normalized Arias intensities for the first horizontal (H1) component initial and modified spectrum-compatible time histories are plotted in Figure 3JJ-222b. The results for the second horizontal (H2) component and the UP component are shown in Figures 3JJ-223a, 3JJ-223b, and 3JJ-223c and Figures 3JJ-224a, 3JJ-224b, and 3JJ-224c, respectively. The zero-lag cross correlation was computed for combinations between the three spectrum-compatible acceleration time histories and they all fall below the required value of 0.30.

3JJ.5 SSI ACCELERATION TIME HISTORIES

Acceleration time histories, suitable for use in SSI analysis of the nuclear island, are presented in this section. Section 3JJ.4 provides a set of two horizontal motions and one vertical motion, spectrally matched to FIRS. The acceleration time histories are propagated through the developed strain-compatible profiles, presented in Subsection 3JJ.3, where they are used as input “outcrop” motions in the soil column at the FIRS horizon and the “within” acceleration time histories at the same horizon are computed. No further iterations on soil properties are performed.

These analyses result in a set of 3 “within” motions for each soil profile in the H1 and H2 directions and the UP direction, respectively. Note that while for horizontal motions, strain-compatible shear-wave velocity profiles are used to describe the shear modulus of the soil column, in the case of vertical motions, P-wave velocity profiles are used instead. Six (6) sets of 3 orthogonal motions are developed corresponding to the LB, BE and UB profiles for NI and FAR site conditions.

From the same set of soil amplification analyses, the 5 percent damping ARS at the ground surface level are calculated. Checks are made with respect to the corresponding surface design response spectra (DRS), per applicable requirements (References 201and 202) to ensure that the envelope of LB, BE and UB surface ARS, in each direction and site condition, envelops the corresponding surface DRS. Figures 3JJ-225, 3JJ-226, and 3JJ-227 present this comparison for NI site condition in the 3 orthogonal directions. Figures 3JJ-228, 3JJ-229, and 3JJ-230 present the same plots for FAR site condition. In these figures, the surface-DRS-to-envelope-ARS ratios (DRS/ENV) are also plotted.

Note that for horizontal motions, the DRS/ENV exceed unity in most cases, but by not greater than 19 percent in all horizontal motions. Therefore, the horizontal motions can be amplified by a factor not greater than 19 percent to ensure the surface ARS envelop the surface DRS in the horizontal directions for both NI and FAR site conditions.

In the case of vertical motions, the DRS/ENV exceed unity and reach a maximum of about 1.5 but in a narrow range of frequencies, between 1 and 8 Hz, for both NI and FAR site conditions. To avoid the amplification of the “within” motions by a large constant factor, close to 1.5, it was decided to re-generate an “outcrop” vertical acceleration time history matched to an adjusted target. The adjusted target spectrum is obtained by multiplying a smoothed version of the vertical DRS/ENV by the original target vertical FIRS. Figure 3JJ-231 presents the original and adjusted targets, as well as the amplification factor applied to the original vertical FIRS. The amplification factor is shown to envelop the DRS/ENV for both NI and FAR site conditions. A new vertical acceleration time history is matched to the adjusted vertical motion target ARS following the same procedure described in Subsection 3JJ.4. The new vertical motion is used as input and the site response analysis is repeated to obtain the corresponding “within” motions at FIRS horizon.

The resulting adjusted acceleration time histories are presented in Figures 3JJ-232, 3JJ-233, and 3JJ-234 for NI site condition and in Figures 3JJ-235, 3JJ-236, and 3JJ-237 for FAR site condition. The “within” acceleration time histories are recommended for use in the SSI analysis of the nuclear island SSI model that includes embedment. The time histories are to be applied at the FIRS horizon as “within” motion and shall be used in combination with the respective SSI soil profiles discussed in Subsection 3JJ.3.

3JJ.6 REFERENCES

201. NRC Letter, Nilesh C Chokshi, deputy division director, office of new reactors, NRC to Adrian P Hymer, senior director, NEI, dated January 9, 2009, Subject NEI Draft White Paper *Consistent Site-Response/Soil-Structure Interaction Analysis and Evaluation* (USNRC ADAMS Accession Number ML083580072).

202. NEI letter, Adrian P Hymer, senior director of NEI to Nilesh C Chokshi, deputy division director, office of new reactors, NRC, dated October 10, 2008, *Subject White paper in support of New Plant Applications*, (USNRC ADAMS Accession Number ML083020171).

Table 3JJ-201 (Sheet 1 of 2)
HF and LF Horizontal 10^{-4} Site Spectra, and Raw and Smoothed Envelope UHRS Spectra for the FAR and NI Soil Columns at FIRS Horizon

Horizontal 10^{-4} Site Spectra UHRS (g)								
Freq.	FAR Soil Column FIRS Horizon UHRS		Raw Envelope	Smooth Envelope	NI Soil Column FIRS Horizon UHRS		Raw Envelope	Smooth Envelope
Hz	LF SA(g)	HF SA(g)	SA(g)	SA(g)	LF SA(g)	HF SA(g)	SA(g)	SA(g)
100	4.84E-02	3.04E-02	4.84E-02	4.84E-02	4.73E-02	2.90E-02	4.73E-02	4.73E-02
90	4.85E-02	3.06E-02	4.85E-02	4.85E-02	4.74E-02	2.92E-02	4.74E-02	4.74E-02
80	4.88E-02	3.09E-02	4.88E-02	4.88E-02	4.76E-02	2.95E-02	4.76E-02	4.76E-02
70	4.93E-02	3.17E-02	4.93E-02	4.93E-02	4.81E-02	3.01E-02	4.81E-02	4.81E-02
60	5.03E-02	3.32E-02	5.03E-02	5.03E-02	4.91E-02	3.15E-02	4.91E-02	4.91E-02
50	5.23E-02	3.64E-02	5.23E-02	5.23E-02	5.06E-02	3.39E-02	5.06E-02	5.06E-02
45	5.36E-02	3.85E-02	5.36E-02	5.35E-02	5.14E-02	3.52E-02	5.14E-02	5.15E-02
40	5.48E-02	4.05E-02	5.48E-02	5.48E-02	5.28E-02	3.73E-02	5.28E-02	5.28E-02
35	5.64E-02	4.32E-02	5.64E-02	5.65E-02	5.50E-02	4.10E-02	5.50E-02	5.51E-02
30	6.01E-02	4.91E-02	6.01E-02	6.03E-02	5.90E-02	4.73E-02	5.90E-02	5.90E-02
25	6.67E-02	5.86E-02	6.67E-02	6.66E-02	6.35E-02	5.40E-02	6.35E-02	6.35E-02
20	6.90E-02	6.19E-02	6.90E-02	6.86E-02	6.47E-02	5.59E-02	6.47E-02	6.44E-02
15	6.47E-02	5.61E-02	6.47E-02	6.45E-02	6.24E-02	5.27E-02	6.24E-02	6.24E-02
12.5	6.35E-02	5.45E-02	6.35E-02	6.34E-02	6.15E-02	5.20E-02	6.15E-02	6.17E-02
10	6.57E-02	5.62E-02	6.57E-02	6.55E-02	6.32E-02	5.35E-02	6.32E-02	6.32E-02
9	6.73E-02	5.84E-02	6.73E-02	6.71E-02	6.41E-02	5.43E-02	6.41E-02	6.41E-02
8	6.83E-02	5.94E-02	6.83E-02	6.82E-02	6.44E-02	5.49E-02	6.44E-02	6.48E-02
7	6.77E-02	5.85E-02	6.77E-02	6.76E-02	6.64E-02	5.70E-02	6.64E-02	6.58E-02
6	6.63E-02	5.63E-02	6.63E-02	6.68E-02	6.72E-02	5.79E-02	6.72E-02	6.77E-02
5	6.97E-02	6.03E-02	6.97E-02	6.94E-02	7.21E-02	6.23E-02	7.21E-02	7.15E-02
4	6.57E-02	5.09E-02	6.57E-02	6.63E-02	6.55E-02	5.05E-02	6.55E-02	6.64E-02
3	8.08E-02	6.12E-02	8.08E-02	8.06E-02	7.97E-02	5.94E-02	7.97E-02	7.92E-02
2.5	8.98E-02	6.00E-02	8.98E-02	8.82E-02	8.34E-02	5.49E-02	8.34E-02	8.23E-02
2	7.41E-02	4.11E-02	7.41E-02	7.34E-02	6.92E-02	3.78E-02	6.92E-02	6.89E-02
1.5	6.72E-02	2.87E-02	6.72E-02	6.72E-02	6.42E-02	2.69E-02	6.42E-02	6.43E-02
1.25	7.35E-02	2.71E-02	7.35E-02	7.35E-02	7.15E-02	2.62E-02	7.15E-02	7.18E-02
1	8.45E-02	2.48E-02	8.45E-02	8.59E-02	8.34E-02	2.43E-02	8.34E-02	8.49E-02
0.9	1.00E-01	2.60E-02	1.00E-01	9.94E-02	9.86E-02	2.54E-02	9.86E-02	9.79E-02
0.8	1.10E-01	2.47E-02	1.10E-01	1.07E-01	1.09E-01	2.43E-02	1.09E-01	1.06E-01
0.7	9.93E-02	1.89E-02	9.93E-02	9.99E-02	9.97E-02	1.88E-02	9.97E-02	1.00E-01
0.6	9.19E-02	1.49E-02	9.19E-02	9.18E-02	9.31E-02	1.50E-02	9.31E-02	9.28E-02
0.5	7.97E-02	1.09E-02	7.97E-02	7.76E-02	8.02E-02	1.09E-02	8.02E-02	7.82E-02
0.4	4.72E-02	6.38E-03	4.72E-02	4.80E-02	4.80E-02	6.45E-03	4.80E-02	4.88E-02
0.3	3.09E-02	4.19E-03	3.09E-02	3.10E-02	3.12E-02	4.21E-03	3.12E-02	3.14E-02

Table 3JJ-201 (Sheet 2 of 2)
HF and LF Horizontal 10^{-4} Site Spectra, and Raw and Smoothed Envelope UHRS Spectra for the FAR and NI Soil Columns at FIRS Horizon

Horizontal 10^{-4} Site Spectra UHRS (g)								
Freq. Hz	FAR Soil Column FIRS Horizon UHRS		Raw Envelope	Smooth Envelope	NI Soil Column FIRS Horizon UHRS		Raw Envelope	Smooth Envelope
	LF SA(g)	HF SA(g)	SA(g)	SA(g)	LF SA(g)	HF SA(g)	SA(g)	SA(g)
0.2	2.05E-02	2.80E-03	2.05E-02	2.05E-02	2.03E-02	2.76E-03	2.03E-02	2.02E-02
0.15	1.30E-02	1.81E-03	1.30E-02	1.31E-02	1.28E-02	1.78E-03	1.28E-02	1.29E-02
0.125	9.55E-03	1.36E-03	9.55E-03	9.48E-03	9.45E-03	1.34E-03	9.45E-03	9.38E-03
0.1	5.71E-03	8.02E-04	5.71E-03	5.71E-03	5.67E-03	7.95E-04	5.67E-03	5.67E-03

Notes:
FIRS= Foundation input response spectrum
UHRS=Uniform hazard response spectra
LF = Low frequencies
HF = High frequencies
SA = Spectral acceleration
Amp = Amplitude

Table 3JJ-202 (Sheet 1 of 2)
HF and LF Horizontal 10^{-5} Site Spectra, and Raw and Smoothed Envelope UHRS Spectra for the FAR and NI Soil Columns at FIRS Horizon

Horizontal 10^{-5} Site Spectra UHRS (g)								
Freq. Hz	FAR Soil Column FIRS Horizon UHRS		Raw Envelope	Smooth Envelope	NI Soil Column FIRS Horizon UHRS		Raw Envelope	Smooth Envelope
	LF SA(g)	HF SA(g)	SA(g)	SA(g)	LF SA(g)	HF SA(g)	SA(g)	SA(g)
100	1.05E-01	8.62E-02	1.05E-01	1.05E-01	1.02E-01	8.24E-02	1.02E-01	1.02E-01
90	1.05E-01	8.68E-02	1.05E-01	1.05E-01	1.02E-01	8.30E-02	1.02E-01	1.02E-01
80	1.05E-01	8.79E-02	1.05E-01	1.05E-01	1.03E-01	8.40E-02	1.03E-01	1.03E-01
70	1.06E-01	9.02E-02	1.06E-01	1.06E-01	1.04E-01	8.62E-02	1.04E-01	1.04E-01
60	1.09E-01	9.51E-02	1.09E-01	1.09E-01	1.06E-01	9.06E-02	1.06E-01	1.06E-01
50	1.13E-01	1.06E-01	1.13E-01	1.13E-01	1.10E-01	9.88E-02	1.10E-01	1.10E-01
45	1.17E-01	1.14E-01	1.17E-01	1.17E-01	1.12E-01	1.04E-01	1.12E-01	1.12E-01
40	1.21E-01	1.21E-01	1.21E-01	1.22E-01	1.17E-01	1.12E-01	1.17E-01	1.17E-01
35	1.28E-01	1.33E-01	1.33E-01	1.34E-01	1.25E-01	1.26E-01	1.26E-01	1.28E-01
30	1.42E-01	1.56E-01	1.56E-01	1.57E-01	1.40E-01	1.52E-01	1.52E-01	1.52E-01
25	1.68E-01	1.95E-01	1.95E-01	1.94E-01	1.58E-01	1.80E-01	1.80E-01	1.79E-01
20	1.78E-01	2.06E-01	2.06E-01	2.04E-01	1.65E-01	1.87E-01	1.87E-01	1.85E-01
15	1.62E-01	1.76E-01	1.76E-01	1.75E-01	1.56E-01	1.67E-01	1.67E-01	1.67E-01
12.5	1.54E-01	1.63E-01	1.63E-01	1.62E-01	1.50E-01	1.58E-01	1.58E-01	1.58E-01
10	1.60E-01	1.65E-01	1.65E-01	1.64E-01	1.55E-01	1.59E-01	1.59E-01	1.59E-01
9	1.63E-01	1.66E-01	1.66E-01	1.67E-01	1.58E-01	1.60E-01	1.60E-01	1.59E-01
8	1.68E-01	1.70E-01	1.70E-01	1.69E-01	1.58E-01	1.59E-01	1.59E-01	1.59E-01
7	1.67E-01	1.65E-01	1.67E-01	1.67E-01	1.61E-01	1.59E-01	1.61E-01	1.60E-01
6	1.58E-01	1.50E-01	1.58E-01	1.59E-01	1.57E-01	1.50E-01	1.57E-01	1.59E-01
5	1.63E-01	1.58E-01	1.63E-01	1.62E-01	1.75E-01	1.72E-01	1.75E-01	1.73E-01
4	1.54E-01	1.33E-01	1.54E-01	1.55E-01	1.56E-01	1.34E-01	1.56E-01	1.58E-01
3	1.70E-01	1.46E-01	1.70E-01	1.70E-01	1.70E-01	1.44E-01	1.70E-01	1.68E-01
2.5	1.84E-01	1.46E-01	1.84E-01	1.82E-01	1.73E-01	1.34E-01	1.73E-01	1.72E-01
2	1.55E-01	9.90E-02	1.55E-01	1.53E-01	1.43E-01	9.06E-02	1.43E-01	1.43E-01
1.5	1.32E-01	6.54E-02	1.32E-01	1.32E-01	1.25E-01	6.12E-02	1.25E-01	1.26E-01
1.25	1.41E-01	6.07E-02	1.41E-01	1.41E-01	1.37E-01	5.85E-02	1.37E-01	1.37E-01
1	1.53E-01	5.41E-02	1.53E-01	1.56E-01	1.51E-01	5.32E-02	1.51E-01	1.54E-01
0.9	1.81E-01	5.65E-02	1.81E-01	1.80E-01	1.78E-01	5.52E-02	1.78E-01	1.77E-01
0.8	2.05E-01	5.40E-02	2.05E-01	1.99E-01	2.03E-01	5.31E-02	2.03E-01	1.98E-01
0.7	1.91E-01	4.13E-02	1.91E-01	1.91E-01	1.92E-01	4.11E-02	1.92E-01	1.92E-01
0.6	1.78E-01	3.19E-02	1.78E-01	1.78E-01	1.80E-01	3.21E-02	1.80E-01	1.80E-01
0.5	1.56E-01	2.29E-02	1.56E-01	1.52E-01	1.57E-01	2.29E-02	1.57E-01	1.53E-01
0.4	9.26E-02	1.33E-02	9.26E-02	9.42E-02	9.43E-02	1.34E-02	9.43E-02	9.57E-02
0.3	6.01E-02	8.64E-03	6.01E-02	6.04E-02	6.08E-02	8.70E-03	6.08E-02	6.11E-02

Table 3JJ-202 (Sheet 2 of 2)
HF and LF Horizontal 10^{-5} Site Spectra, and Raw and Smoothed Envelope UHRS Spectra for the FAR and NI Soil Columns at FIRS Horizon

Horizontal 10^{-5} Site Spectra UHRS (g)								
Freq. Hz	FAR Soil Column FIRS Horizon UHRS		Raw Envelope	Smooth Envelope	NI Soil Column FIRS Horizon UHRS		Raw Envelope	Smooth Envelope
	LF SA(g)	HF SA(g)	SA(g)	SA(g)	LF SA(g)	HF SA(g)	SA(g)	SA(g)
0.2	3.98E-02	5.78E-03	3.98E-02	3.98E-02	3.93E-02	5.69E-03	3.93E-02	3.93E-02
0.15	2.53E-02	3.82E-03	2.53E-02	2.54E-02	2.50E-02	3.76E-03	2.50E-02	2.51E-02
0.125	1.86E-02	2.86E-03	1.86E-02	1.85E-02	1.84E-02	2.82E-03	1.84E-02	1.83E-02
0.1	1.11E-02	1.69E-03	1.11E-02	1.11E-02	1.10E-02	1.67E-03	1.10E-02	1.10E-02

Notes:
FIRS= Foundation input response spectrum
UHRS=Uniform hazard response spectra
LF = Low frequencies
HF = High frequencies
SA = Spectral acceleration
Amp = Amplitude

Table 3JJ-203 (Sheet 1 of 2)
Horizontal 10^{-4} and 10^{-5} Smoothed Site Spectra, Values of AR and DF, and DRS for the FAR Soil Column at FIRS Horizon

Freq. Hz	Horizontal 10^{-4}	Horizontal 10^{-5}	A_R	DF	Horizontal DRS
100	4.84E-02	1.05E-01	2.16	1.11	5.38E-02
90	4.85E-02	1.05E-01	2.16	1.11	5.39E-02
80	4.88E-02	1.05E-01	2.16	1.11	5.42E-02
70	4.93E-02	1.06E-01	2.16	1.11	5.47E-02
60	5.03E-02	1.09E-01	2.16	1.11	5.59E-02
50	5.23E-02	1.13E-01	2.17	1.11	5.82E-02
45	5.35E-02	1.17E-01	2.19	1.12	6.01E-02
40	5.48E-02	1.22E-01	2.23	1.14	6.25E-02
35	5.65E-02	1.34E-01	2.37	1.20	6.76E-02
30	6.03E-02	1.57E-01	2.61	1.29	7.78E-02
25	6.66E-02	1.94E-01	2.91	1.41	9.41E-02
20	6.86E-02	2.04E-01	2.97	1.43	9.83E-02
15	6.45E-02	1.75E-01	2.71	1.33	8.59E-02
12.5	6.34E-02	1.62E-01	2.56	1.27	8.07E-02
10	6.55E-02	1.64E-01	2.50	1.25	8.17E-02
9	6.71E-02	1.67E-01	2.48	1.24	8.34E-02
8	6.82E-02	1.69E-01	2.48	1.24	8.47E-02
7	6.76E-02	1.67E-01	2.46	1.23	8.34E-02
6	6.68E-02	1.59E-01	2.38	1.20	8.03E-02
5	6.94E-02	1.62E-01	2.34	1.18	8.22E-02
4	6.63E-02	1.55E-01	2.33	1.18	7.84E-02
3	8.06E-02	1.70E-01	2.10	1.09	8.77E-02
2.5	8.82E-02	1.82E-01	2.06	1.07	9.45E-02
2	7.34E-02	1.53E-01	2.09	1.08	7.94E-02
1.5	6.72E-02	1.32E-01	1.96	1.03	6.92E-02
1.25	7.35E-02	1.41E-01	1.92	1.01	7.43E-02
1	8.59E-02	1.56E-01	1.82	1.00	8.59E-02
0.9	9.94E-02	1.80E-01	1.82	1.00	9.94E-02
0.8	1.07E-01	1.99E-01	1.86	1.00	1.07E-01
0.7	9.99E-02	1.91E-01	1.92	1.01	1.01E-01
0.6	9.18E-02	1.78E-01	1.94	1.02	9.36E-02
0.5	7.76E-02	1.52E-01	1.96	1.03	7.98E-02
0.4	4.80E-02	9.42E-02	1.96	1.03	4.94E-02
0.3	3.10E-02	6.04E-02	1.95	1.02	3.17E-02
0.2	2.05E-02	3.98E-02	1.94	1.02	2.09E-02
0.15	1.31E-02	2.54E-02	1.95	1.02	1.34E-02

Table 3JJ-203 (Sheet 2 of 2)
Horizontal 10^{-4} and 10^{-5} Smoothed Site Spectra, Values of AR and DF, and DRS for the FAR Soil Column at FIRS Horizon

Freq. Hz	Horizontal 10^{-4}	Horizontal 10^{-5}	A_R	DF	Horizontal DRS
0.125	9.48E-03	1.85E-02	1.95	1.02	9.69E-03
0.1	5.71E-03	1.11E-02	1.94	1.02	5.83E-03

Notes:
FIRS= Foundation input response spectrum
AR and DF are defined in Equations 3JJ-1 and 3JJ-2, respectively.
DRS = Design response spectrum, defined in Equation 3JJ-3

Table 3JJ-204 (Sheet 1 of 2)
Horizontal 10^{-4} and 10^{-5} Smoothed Site Spectra, Values of AR and DF, and DRS for the NI Soil Column at FIRS Horizon

Freq. Hz	Horizontal 10^{-4}	Horizontal 10^{-5}	A_R	DF	Horizontal DRS
100	4.73E-02	1.02E-01	2.16	1.11	5.25E-02
90	4.74E-02	1.02E-01	2.16	1.11	5.27E-02
80	4.76E-02	1.03E-01	2.16	1.11	5.29E-02
70	4.81E-02	1.04E-01	2.16	1.11	5.34E-02
60	4.91E-02	1.06E-01	2.16	1.11	5.45E-02
50	5.06E-02	1.10E-01	2.17	1.11	5.64E-02
45	5.15E-02	1.12E-01	2.18	1.12	5.77E-02
40	5.28E-02	1.17E-01	2.22	1.13	5.99E-02
35	5.51E-02	1.28E-01	2.32	1.18	6.49E-02
30	5.90E-02	1.52E-01	2.58	1.28	7.54E-02
25	6.35E-02	1.79E-01	2.82	1.37	8.73E-02
20	6.44E-02	1.85E-01	2.87	1.40	8.99E-02
15	6.24E-02	1.67E-01	2.67	1.32	8.22E-02
12.5	6.17E-02	1.58E-01	2.57	1.28	7.87E-02
10	6.32E-02	1.59E-01	2.51	1.25	7.92E-02
9	6.41E-02	1.59E-01	2.49	1.24	7.97E-02
8	6.48E-02	1.59E-01	2.46	1.23	7.99E-02
7	6.58E-02	1.60E-01	2.43	1.22	8.03E-02
6	6.77E-02	1.59E-01	2.35	1.19	8.04E-02
5	7.15E-02	1.73E-01	2.42	1.22	8.71E-02
4	6.64E-02	1.58E-01	2.38	1.20	7.97E-02
3	7.92E-02	1.68E-01	2.13	1.10	8.69E-02
2.5	8.23E-02	1.72E-01	2.08	1.08	8.89E-02
2	6.89E-02	1.43E-01	2.07	1.08	7.41E-02
1.5	6.43E-02	1.26E-01	1.95	1.03	6.59E-02
1.25	7.18E-02	1.37E-01	1.91	1.01	7.22E-02
1	8.49E-02	1.54E-01	1.82	1.00	8.49E-02
0.9	9.79E-02	1.77E-01	1.81	1.00	9.79E-02
0.8	1.06E-01	1.98E-01	1.86	1.00	1.06E-01
0.7	1.00E-01	1.92E-01	1.92	1.01	1.01E-01
0.6	9.28E-02	1.80E-01	1.94	1.02	9.46E-02
0.5	7.82E-02	1.53E-01	1.96	1.03	8.04E-02
0.4	4.88E-02	9.57E-02	1.96	1.03	5.02E-02
0.3	3.14E-02	6.11E-02	1.95	1.02	3.21E-02
0.2	2.02E-02	3.93E-02	1.94	1.02	2.06E-02
0.15	1.29E-02	2.51E-02	1.95	1.02	1.32E-02

Table 3JJ-204 (Sheet 2 of 2)
Horizontal 10^{-4} and 10^{-5} Smoothed Site Spectra, Values of AR and DF, and DRS for the NI Soil Column at FIRS Horizon

Freq. Hz	Horizontal 10^{-4}	Horizontal 10^{-5}	A_R	DF	Horizontal DRS
0.125	9.38E-03	1.83E-02	1.95	1.02	9.59E-03
0.1	5.67E-03	1.10E-02	1.94	1.02	5.79E-03

Notes:
FIRS= Foundation input response spectrum
AR and DF are defined in Equations 3JJ-1 and 3JJ-2, respectively.
DRS = Design response spectrum, defined in Equation 3JJ-3

Table 3JJ-205 (Sheet 1 of 2)
V/H Ratios, Vertical 10^{-4} and 10^{-5} Smoothed Site Spectra, Values of AR and DF, and DRS for the FAR Soil Column at FIRS Horizon

Freq. Hz	V/H	Vertical 10^{-4}	Vertical 10^{-5}	A_R	DF	Vertical DRS
100	1.000	4.84E-02	1.05E-01	2.16	1.11	5.38E-02
90	1.000	4.85E-02	1.05E-01	2.16	1.11	5.39E-02
80	1.000	4.88E-02	1.05E-01	2.16	1.11	5.42E-02
70	1.000	4.93E-02	1.06E-01	2.16	1.11	5.47E-02
60	1.000	5.03E-02	1.09E-01	2.16	1.11	5.59E-02
50	1.000	5.23E-02	1.13E-01	2.17	1.11	5.82E-02
45	1.000	5.35E-02	1.17E-01	2.19	1.12	6.01E-02
40	1.000	5.48E-02	1.22E-01	2.23	1.14	6.25E-02
35	1.000	5.65E-02	1.34E-01	2.37	1.20	6.76E-02
30	1.000	6.03E-02	1.57E-01	2.61	1.29	7.78E-02
25	1.000	6.66E-02	1.94E-01	2.91	1.41	9.41E-02
20	1.000	6.86E-02	2.04E-01	2.97	1.43	9.83E-02
15	1.000	6.45E-02	1.75E-01	2.71	1.33	8.59E-02
12.5	1.000	6.34E-02	1.62E-01	2.56	1.27	8.07E-02
10	1.000	6.55E-02	1.64E-01	2.50	1.25	8.17E-02
9	1.000	6.71E-02	1.67E-01	2.48	1.24	8.34E-02
8	1.000	6.82E-02	1.69E-01	2.48	1.24	8.47E-02
7	1.000	6.76E-02	1.66E-01	2.46	1.23	8.34E-02
6	0.999	6.68E-02	1.59E-01	2.38	1.20	8.03E-02
5	0.999	6.93E-02	1.62E-01	2.34	1.18	8.21E-02
4	0.999	6.63E-02	1.55E-01	2.33	1.18	7.83E-02
3	0.857	6.90E-02	1.45E-01	2.10	1.09	7.51E-02
2.5	0.715	6.31E-02	1.30E-01	2.06	1.07	6.76E-02
2	0.710	5.21E-02	1.09E-01	2.09	1.08	5.64E-02
1.5	0.704	4.73E-02	9.29E-02	1.96	1.03	4.87E-02
1.25	0.701	5.15E-02	9.88E-02	1.92	1.01	5.20E-02
1	0.696	5.98E-02	1.09E-01	1.82	1.00	5.98E-02
0.9	0.694	6.89E-02	1.25E-01	1.82	1.00	6.89E-02
0.8	0.691	7.42E-02	1.38E-01	1.86	1.00	7.42E-02
0.7	0.689	6.88E-02	1.32E-01	1.92	1.01	6.95E-02
0.6	0.686	6.30E-02	1.22E-01	1.94	1.02	6.42E-02
0.5	0.682	5.29E-02	1.04E-01	1.96	1.03	5.44E-02
0.4	0.678	3.25E-02	6.38E-02	1.96	1.03	3.35E-02
0.3	0.672	2.08E-02	4.06E-02	1.95	1.02	2.13E-02
0.2	0.668	1.37E-02	2.66E-02	1.94	1.02	1.40E-02
0.15	0.668	8.73E-03	1.70E-02	1.95	1.02	8.93E-03

Table 3JJ-205 (Sheet 2 of 2)
V/H Ratios, Vertical 10^{-4} and 10^{-5} Smoothed Site Spectra, Values of AR and DF, and DRS for the FAR Soil Column at FIRS Horizon

Freq. Hz	V/H	Vertical 10^{-4}	Vertical 10^{-5}	A_R	DF	Vertical DRS
0.125	0.668	6.34E-03	1.23E-02	1.95	1.02	6.48E-03
0.1	0.668	3.82E-03	7.42E-03	1.94	1.02	3.90E-03

Notes:
FIRS= Foundation input response spectrum
AR and DF are defined in Equations 3JJ-1 and 3JJ-2, respectively.
DRS = Design response spectrum, defined in Equation 3JJ-3

Table 3JJ-206 (Sheet 1 of 2)
V/H Ratios, Vertical 10^{-4} and 10^{-5} Smoothed Site Spectra, Values of AR and DF, and DRS for the NI Soil Column at FIRS Horizon

Freq. Hz	V/H	Vertical 10^{-4}	Vertical 10^{-5}	A_R	DF	Vertical DRS
100	1.000	4.73E-02	1.02E-01	2.16	1.11	5.25E-02
90	1.000	4.74E-02	1.02E-01	2.16	1.11	5.27E-02
80	1.000	4.76E-02	1.03E-01	2.16	1.11	5.29E-02
70	1.000	4.81E-02	1.04E-01	2.16	1.11	5.34E-02
60	1.000	4.91E-02	1.06E-01	2.16	1.11	5.45E-02
50	1.000	5.06E-02	1.10E-01	2.17	1.11	5.64E-02
45	1.000	5.15E-02	1.12E-01	2.18	1.12	5.77E-02
40	1.000	5.28E-02	1.17E-01	2.22	1.13	5.99E-02
35	1.000	5.51E-02	1.28E-01	2.32	1.18	6.49E-02
30	1.000	5.90E-02	1.52E-01	2.58	1.28	7.54E-02
25	1.000	6.35E-02	1.79E-01	2.82	1.37	8.73E-02
20	1.000	6.44E-02	1.85E-01	2.87	1.40	8.99E-02
15	1.000	6.24E-02	1.67E-01	2.67	1.32	8.22E-02
12.5	1.000	6.17E-02	1.58E-01	2.57	1.28	7.87E-02
10	1.000	6.32E-02	1.59E-01	2.51	1.25	7.92E-02
9	1.000	6.41E-02	1.59E-01	2.49	1.24	7.97E-02
8	1.000	6.48E-02	1.59E-01	2.46	1.23	7.99E-02
7	1.000	6.58E-02	1.60E-01	2.43	1.22	8.03E-02
6	0.999	6.76E-02	1.59E-01	2.35	1.19	8.04E-02
5	0.999	7.14E-02	1.73E-01	2.42	1.22	8.70E-02
4	0.999	6.63E-02	1.58E-01	2.38	1.20	7.96E-02
3	0.857	6.78E-02	1.44E-01	2.13	1.10	7.45E-02
2.5	0.715	5.89E-02	1.23E-01	2.08	1.08	6.36E-02
2	0.710	4.89E-02	1.01E-01	2.07	1.08	5.26E-02
1.5	0.704	4.53E-02	8.85E-02	1.95	1.03	4.64E-02
1.25	0.701	5.03E-02	9.59E-02	1.91	1.01	5.06E-02
1	0.696	5.91E-02	1.07E-01	1.82	1.00	5.91E-02
0.9	0.694	6.79E-02	1.23E-01	1.81	1.00	6.79E-02
0.8	0.691	7.36E-02	1.37E-01	1.86	1.00	7.36E-02
0.7	0.689	6.90E-02	1.32E-01	1.92	1.01	6.97E-02
0.6	0.686	6.37E-02	1.23E-01	1.94	1.02	6.49E-02
0.5	0.682	5.33E-02	1.05E-01	1.96	1.03	5.48E-02
0.4	0.678	3.31E-02	6.49E-02	1.96	1.03	3.40E-02
0.3	0.672	2.11E-02	4.11E-02	1.95	1.02	2.16E-02
0.2	0.668	1.35E-02	2.63E-02	1.94	1.02	1.38E-02
0.15	0.668	8.61E-03	1.68E-02	1.95	1.02	8.81E-03

Table 3JJ-206 (Sheet 2 of 2)
V/H Ratios, Vertical 10^{-4} and 10^{-5} Smoothed Site Spectra, Values of AR and DF, and DRS for the NI Soil Column at FIRS Horizon

Freq. Hz	V/H	Vertical 10^{-4}	Vertical 10^{-5}	A_R	DF	Vertical DRS
0.125	0.668	6.27E-03	1.22E-02	1.95	1.02	6.41E-03
0.1	0.668	3.79E-03	7.37E-03	1.94	1.02	3.87E-03

Notes:
FIRS= Foundation input response spectrum
AR and DF are defined in Equations 3JJ-1 and 3JJ-2, respectively.
DRS = Design response spectrum, defined in Equation 3JJ-3

Table 3JJ-207
Recommended Horizontal and Vertical FIRS

FIRS Frequency (Hz)	Horizontal Sa(g)	Vertical Sa(g)
100	5.38E-02	5.38E-02
90	5.39E-02	5.39E-02
80	5.42E-02	5.42E-02
70	5.47E-02	5.47E-02
60	5.59E-02	5.59E-02
50	5.82E-02	5.82E-02
45	6.01E-02	6.01E-02
40	6.25E-02	6.25E-02
35	6.76E-02	6.76E-02
30.0	7.78E-02	7.78E-02
25	9.41E-02	9.41E-02
20	9.83E-02	9.83E-02
15	8.59E-02	8.59E-02
12.5	8.07E-02	8.07E-02
10	8.17E-02	8.17E-02
9	8.34E-02	8.34E-02
8	8.47E-02	8.47E-02
7	8.34E-02	8.34E-02
6	8.04E-02	8.04E-02
5	8.71E-02	8.70E-02
4	7.97E-02	7.96E-02
3	8.77E-02	7.51E-02
2.5	9.45E-02	6.76E-02
2	7.94E-02	5.64E-02
1.5	6.92E-02	4.87E-02
1.25	7.43E-02	5.20E-02
1	8.59E-02	5.98E-02
0.9	9.94E-02	6.89E-02
0.8	1.07E-01	7.42E-02
0.7	1.01E-01	6.97E-02
0.6	9.46E-02	6.49E-02
0.5	8.04E-02	5.48E-02
0.4	5.02E-02	3.40E-02
0.3	3.21E-02	2.16E-02
0.2	2.09E-02	1.40E-02
0.15	1.34E-02	8.93E-03
0.125	9.69E-03	6.48E-03
0.1	5.83E-03	3.90E-03

Figure 3JJ-201 Randomized Shear Wave Velocity Profiles, Median Shear Wave Velocity Profile and the Input Median Profile Used for Randomization — NI Site Conditions

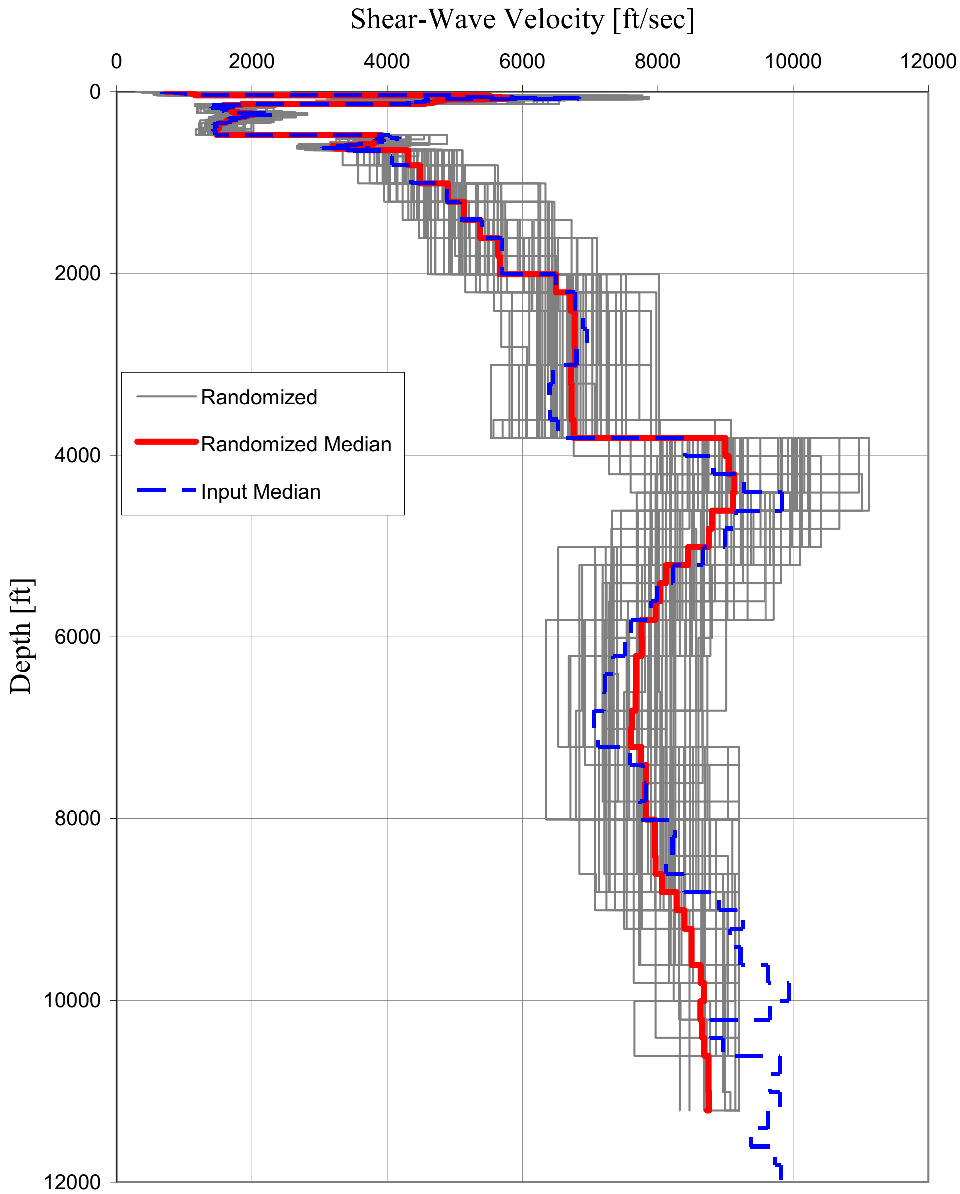


Figure 3JJ-202 Randomized Shear Wave Velocity Profiles, Median Shear Wave Velocity Profile and the Input Median Profile Used for Randomization — FAR Site Conditions

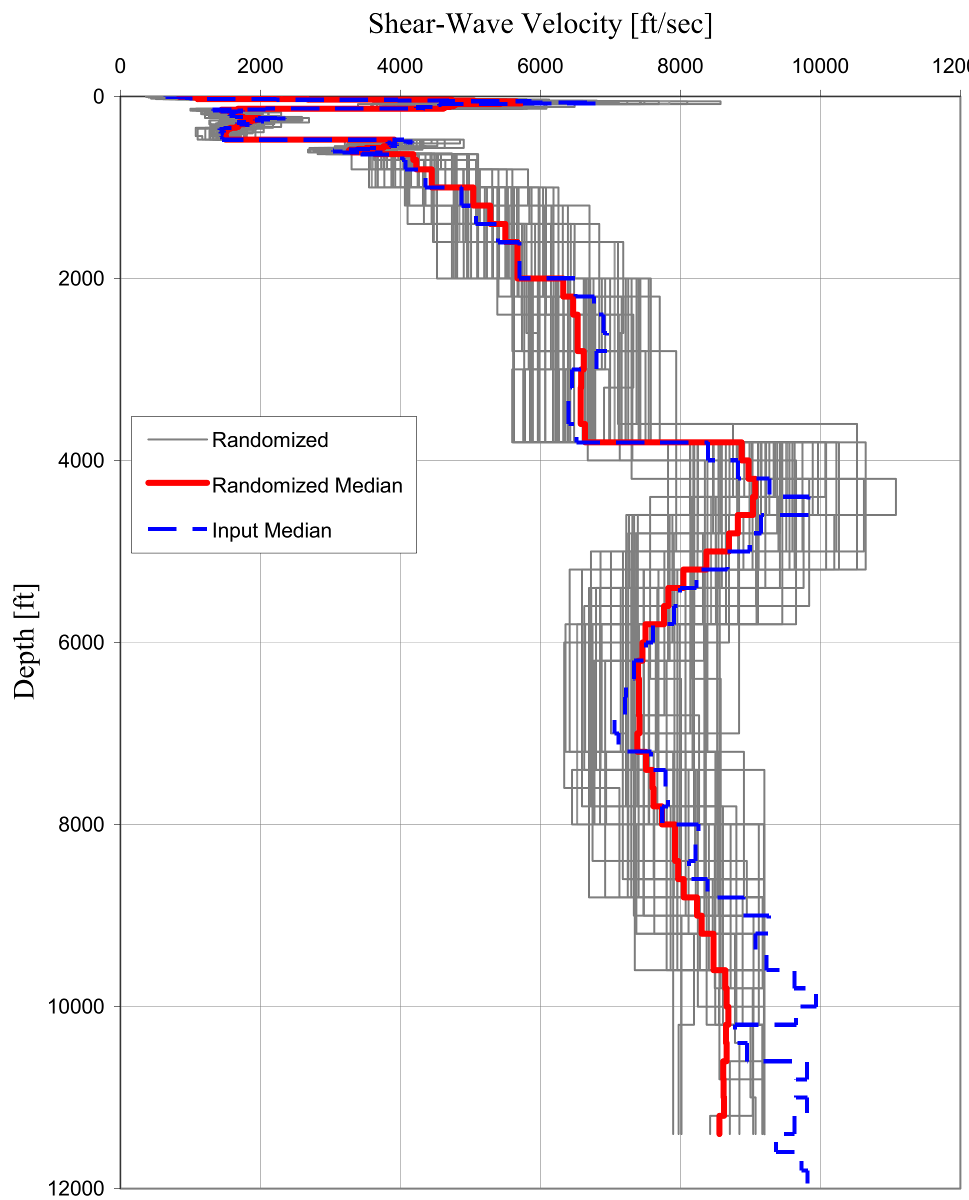


Figure 3JJ-203 ARS Amplification Factors at FIRS Horizon — NI Site Conditions

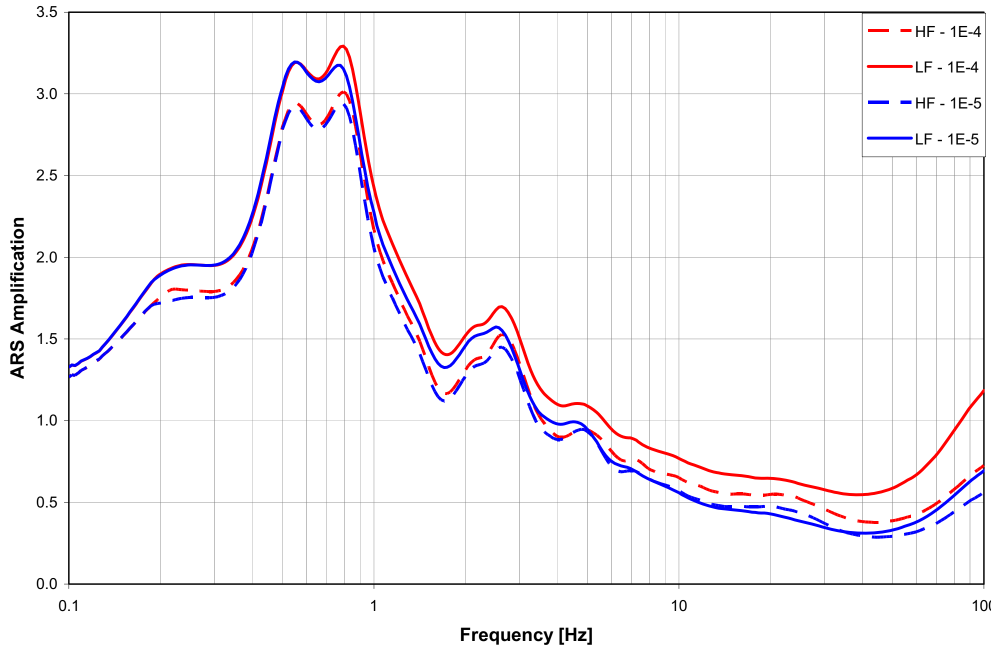


Figure 3JJ-204 ARS Amplification Factors at FIRS Horizon — FAR Site Conditions

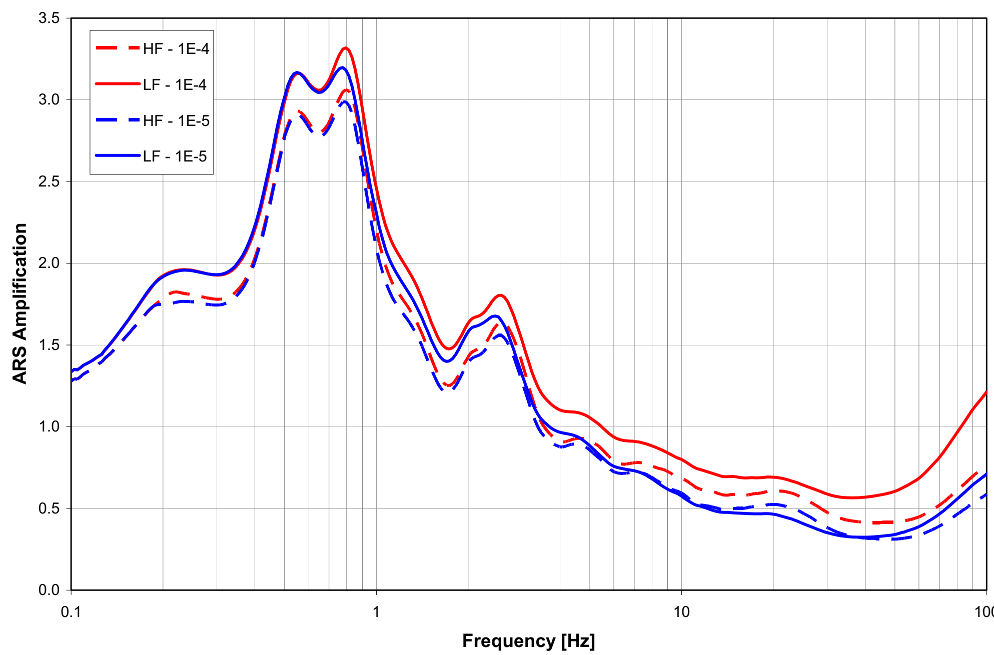


Figure 3JJ-205 ARS Amplification Factors at Ground Surface — NI Site Conditions

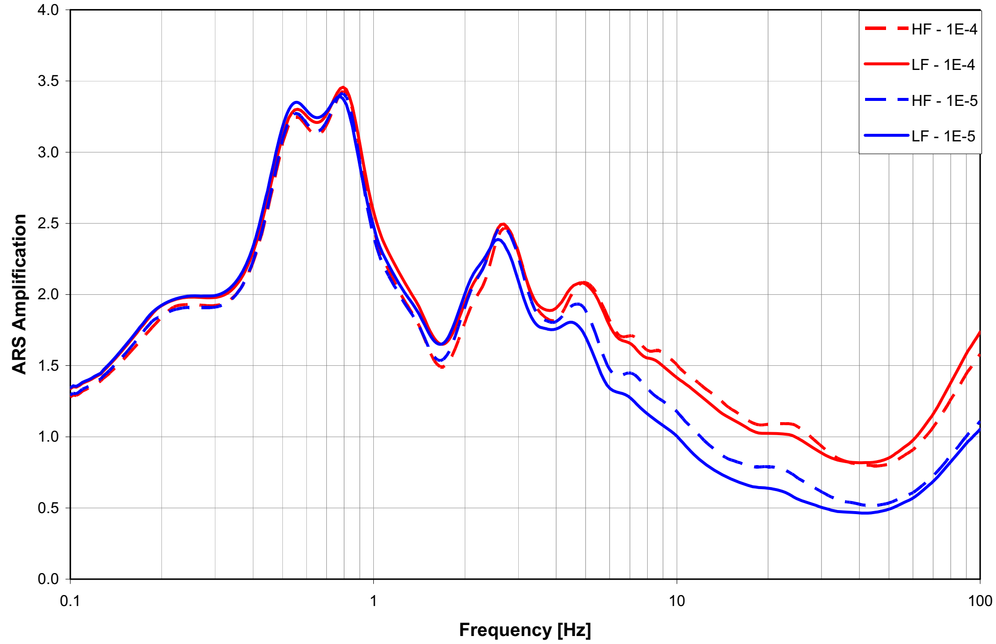


Figure 3JJ-206 ARS Amplification Factors at Ground Surface — FAR Site Conditions

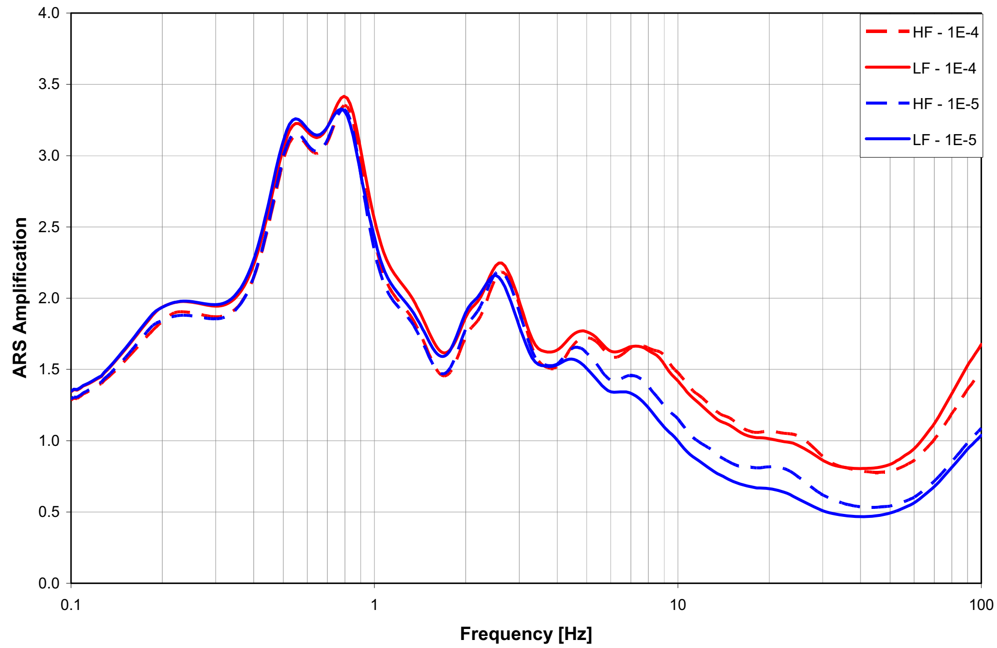


Figure 3JJ-207 Strain Profiles — NI Site Conditions

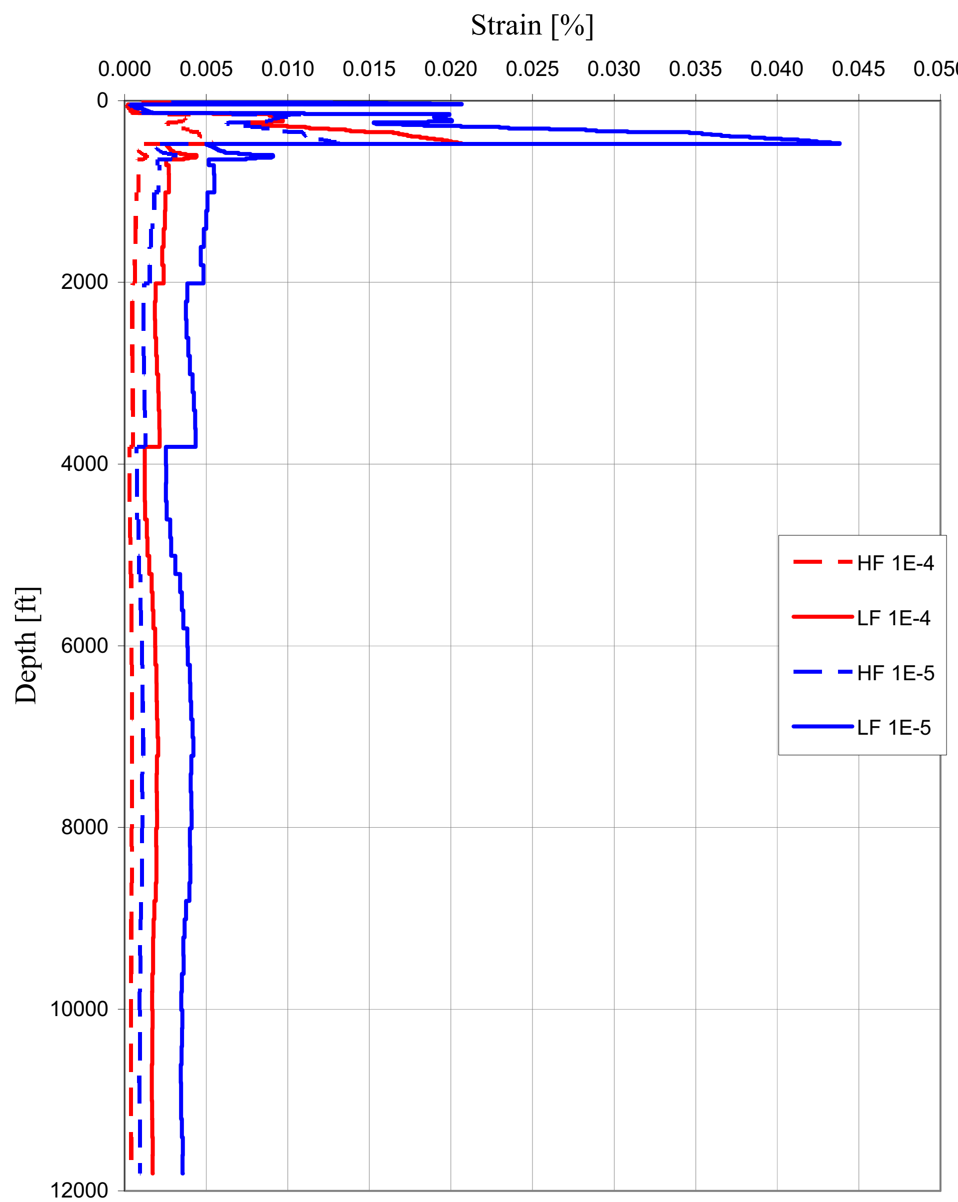


Figure 3JJ-208 Strain Profiles — FAR Site Conditions

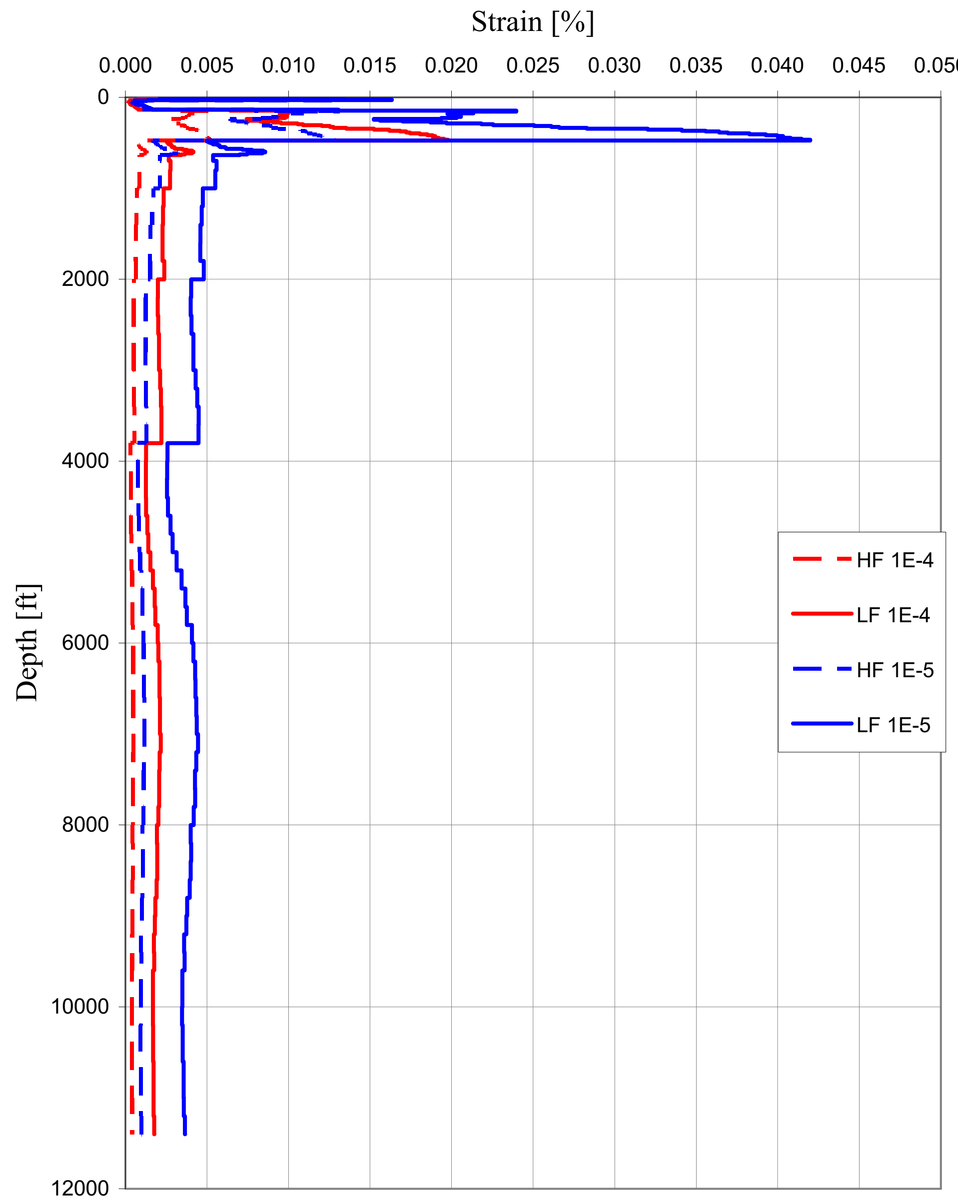


Figure 3JJ-209 HF and LF Horizontal 10^{-4} and 10^{-5} Site Spectra — FAR Soil Column

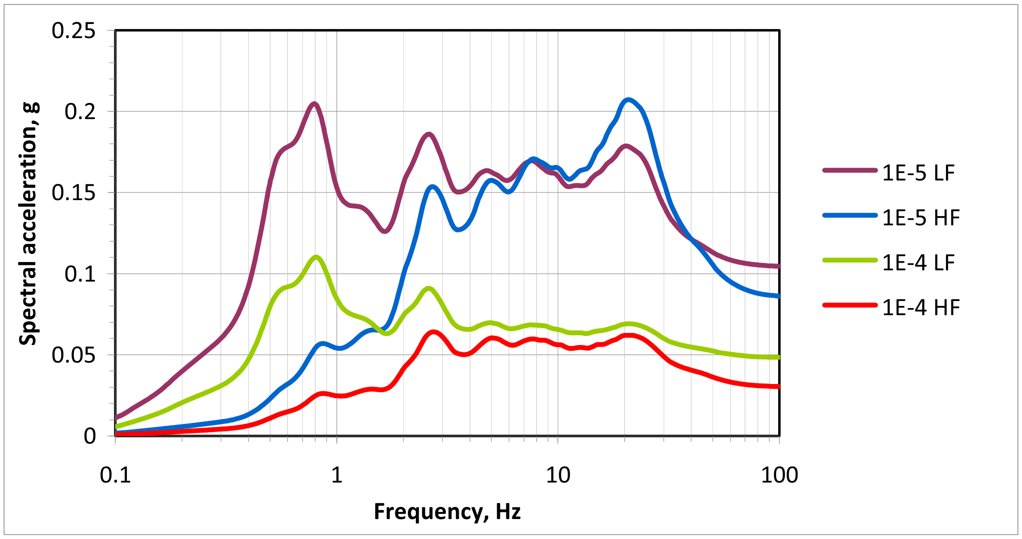


Figure 3JJ-210 HF and LF Horizontal 10^{-4} and 10^{-5} Site Spectra — NI Soil Column

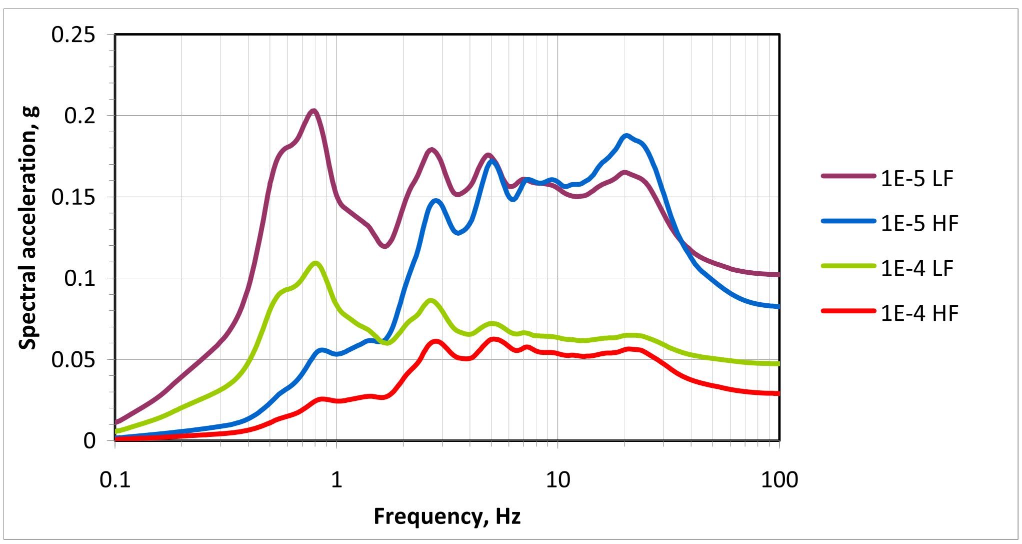


Figure 3JJ-211 Smoothed Horizontal 10^{-4} and 10^{-5} Site Spectra and DRS — FAR Soil Column

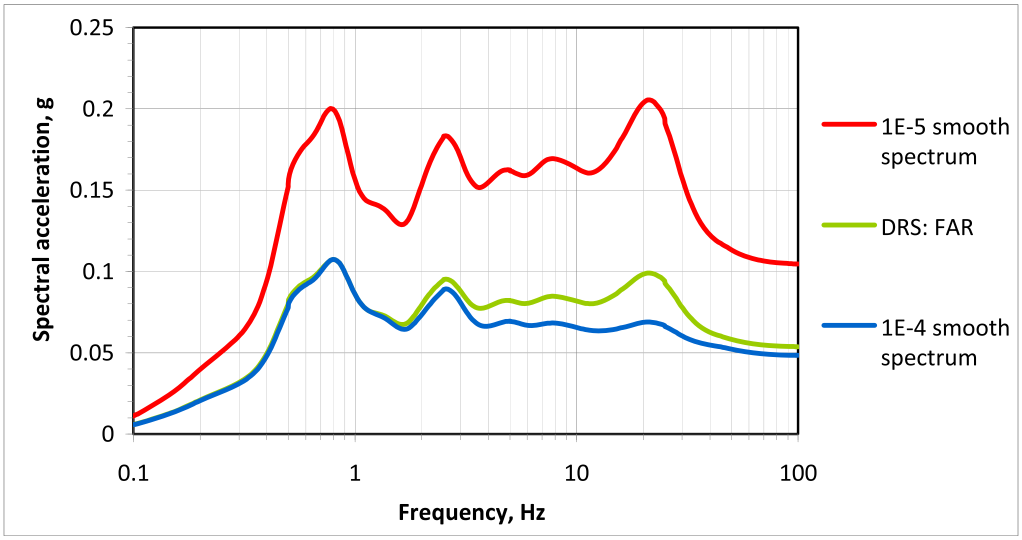


Figure 3JJ-212 Smoothed Horizontal 10^{-4} and 10^{-5} Site Spectra and DRS — NI Soil Column

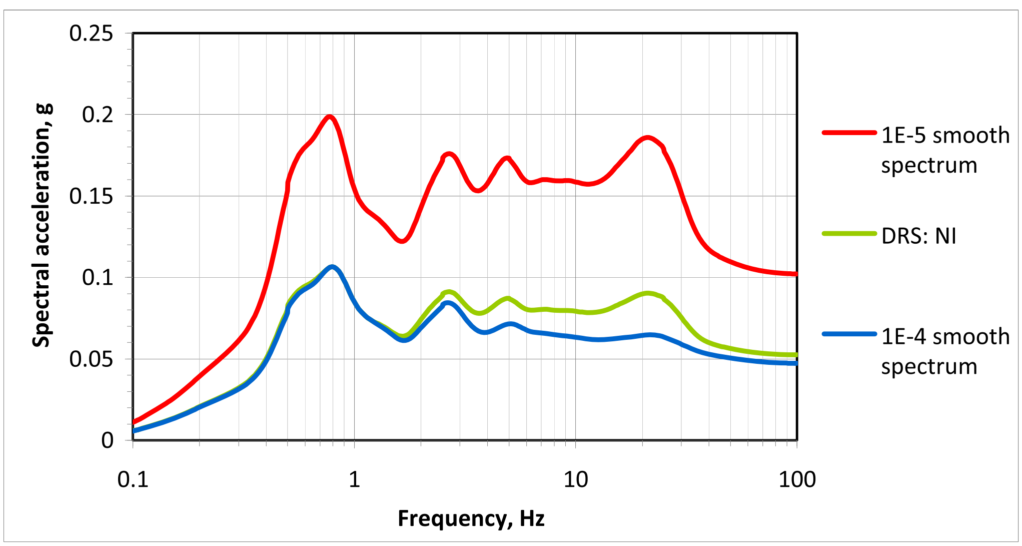


Figure 3JJ-213 Smoothed Vertical 10^{-4} and 10^{-5} Site Spectra and DRS — FAR Soil Column

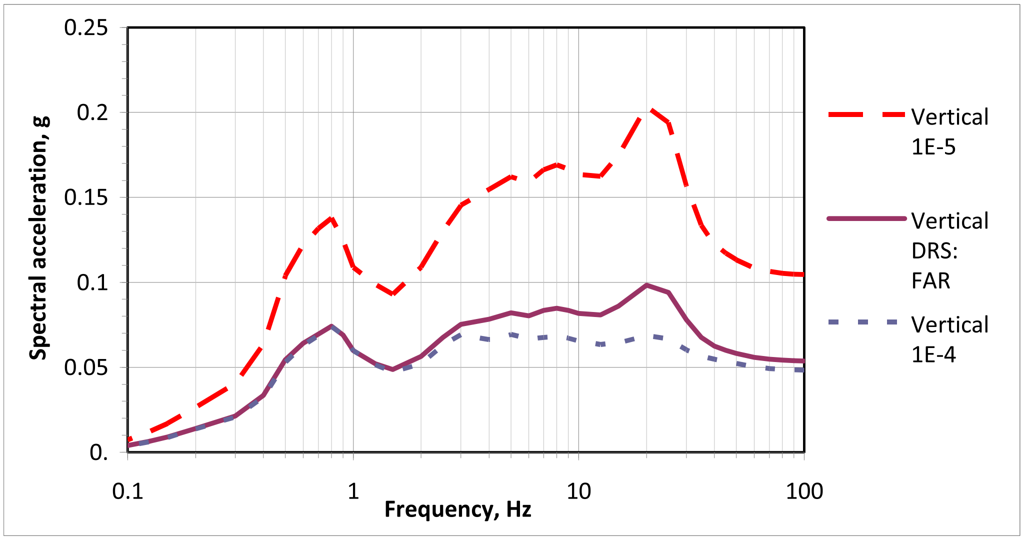


Figure 3JJ-214 Smoothed Vertical 10^{-4} and 10^{-5} Site Spectra and DRS — NI Soil Column

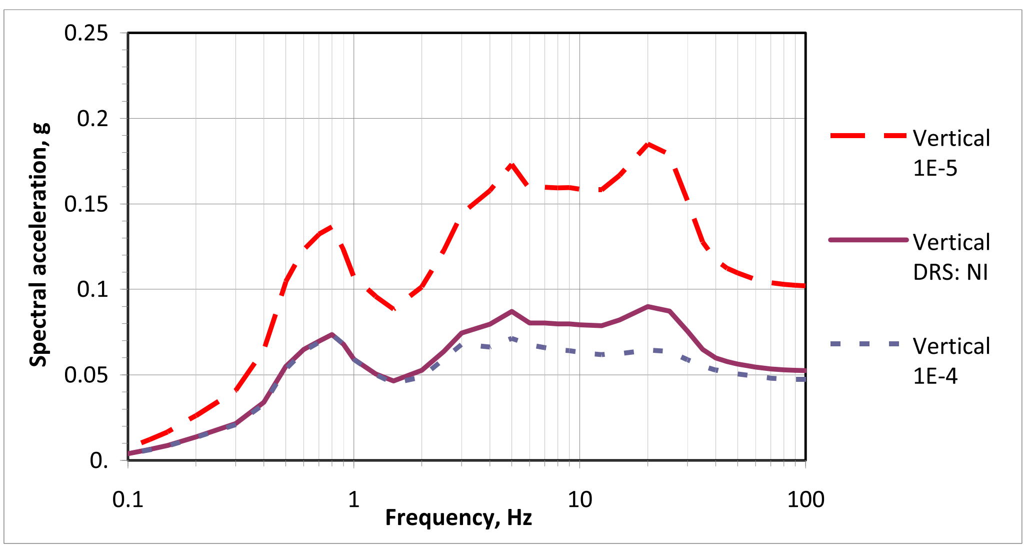


Figure 3JJ-215 Recommended Horizontal and Vertical FIRS (Elevation –16 foot Horizon at Bottom of Nuclear Island Foundation)

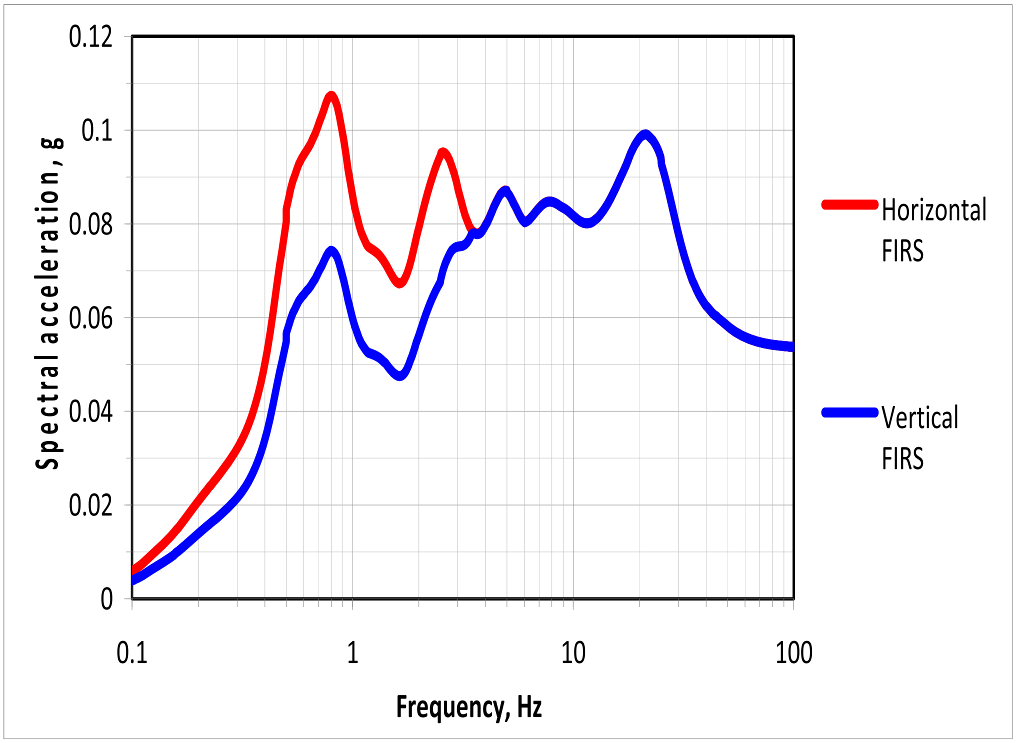


Figure 3JJ-216 Recommended SSI Shear-Wave Velocity Profiles — NI Site Conditions (Upper 1000 feet — below 1000 feet depth is not shown)

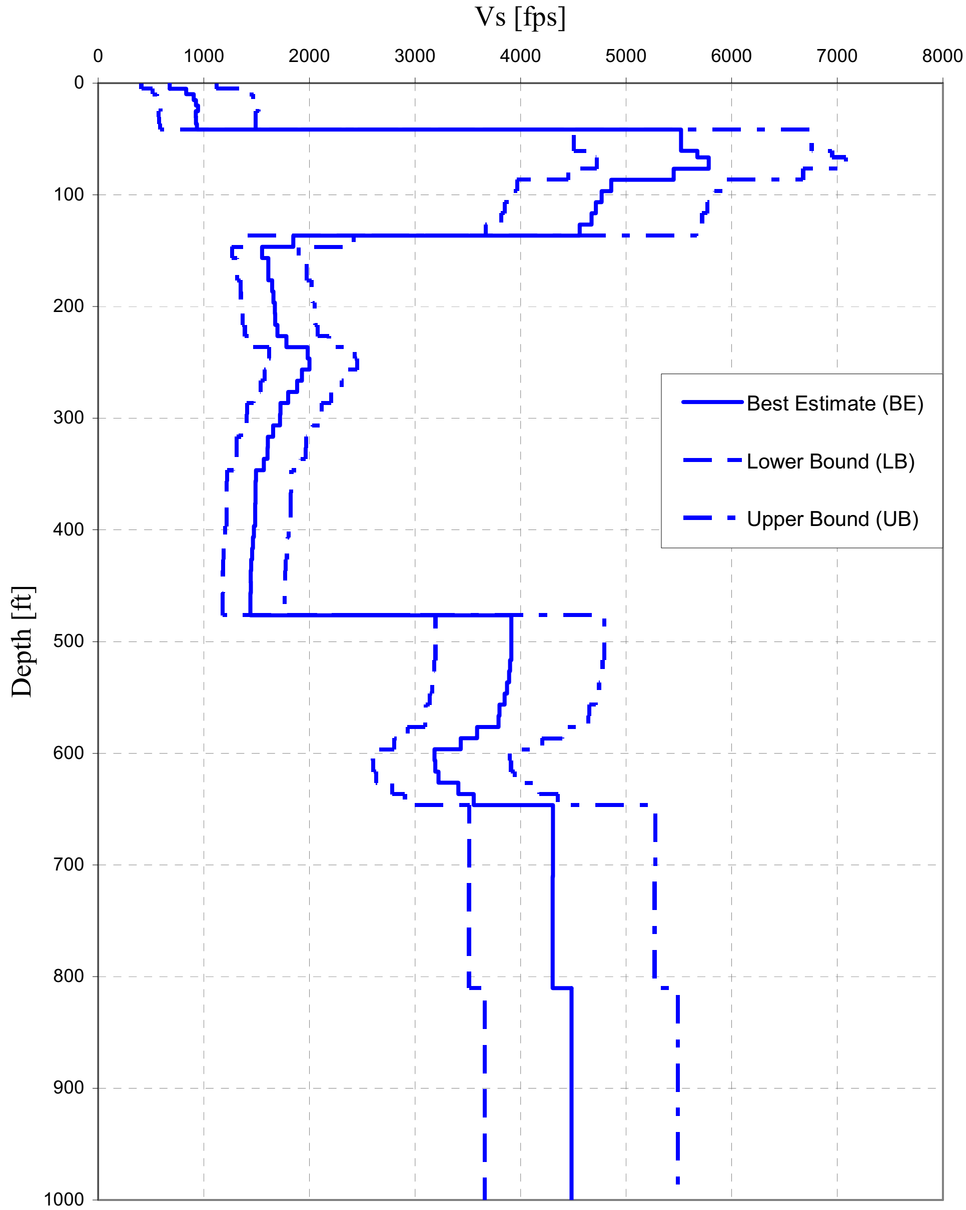


Figure 3JJ-217 Recommended SSI Damping Profiles — NI Site Conditions (Upper 1000 feet — below 1000 feet depth is not shown)

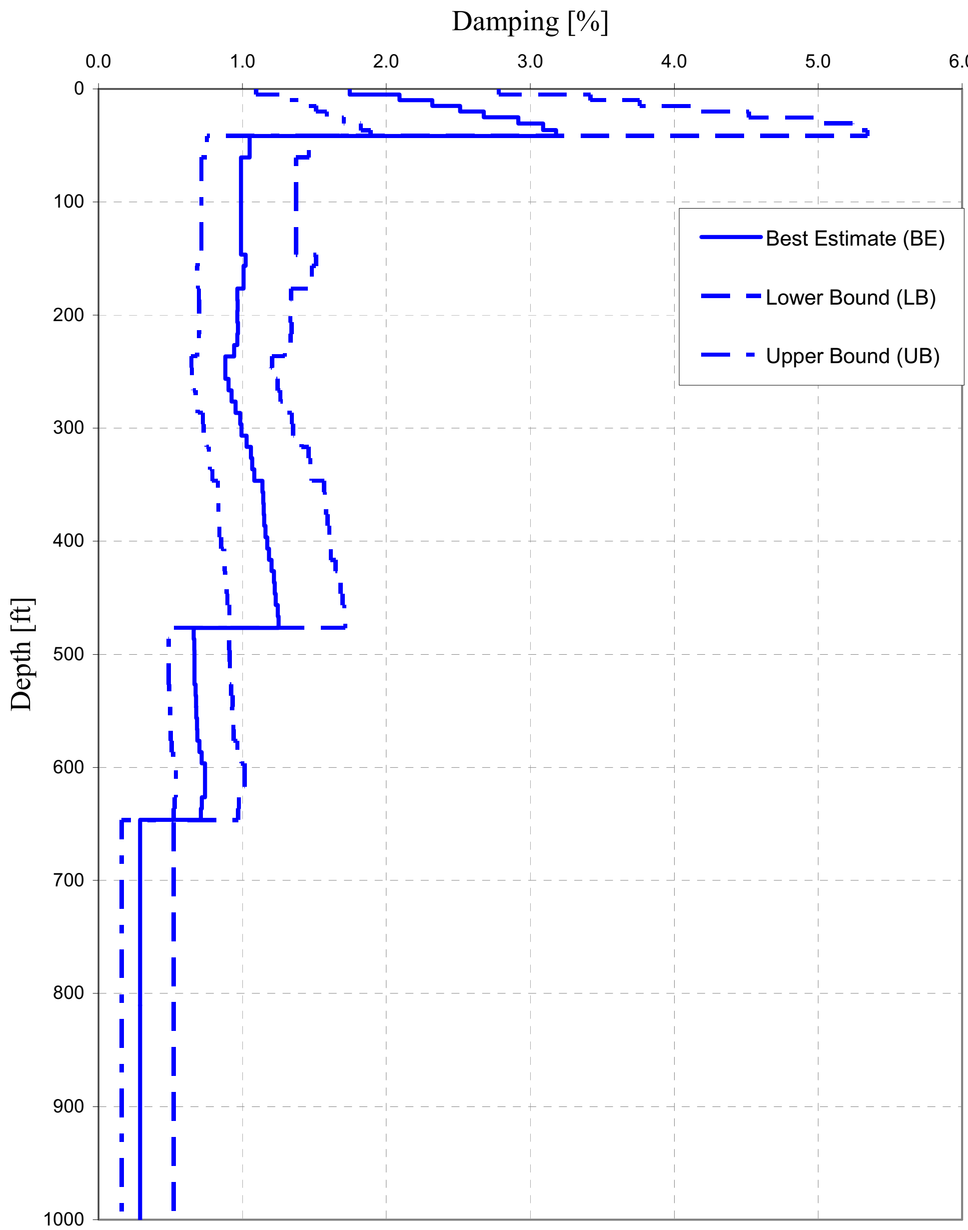


Figure 3JJ-218 Recommended P-Wave Velocity Profiles — NI Site Conditions (Upper 1000 feet — below 1000 feet depth is not shown)

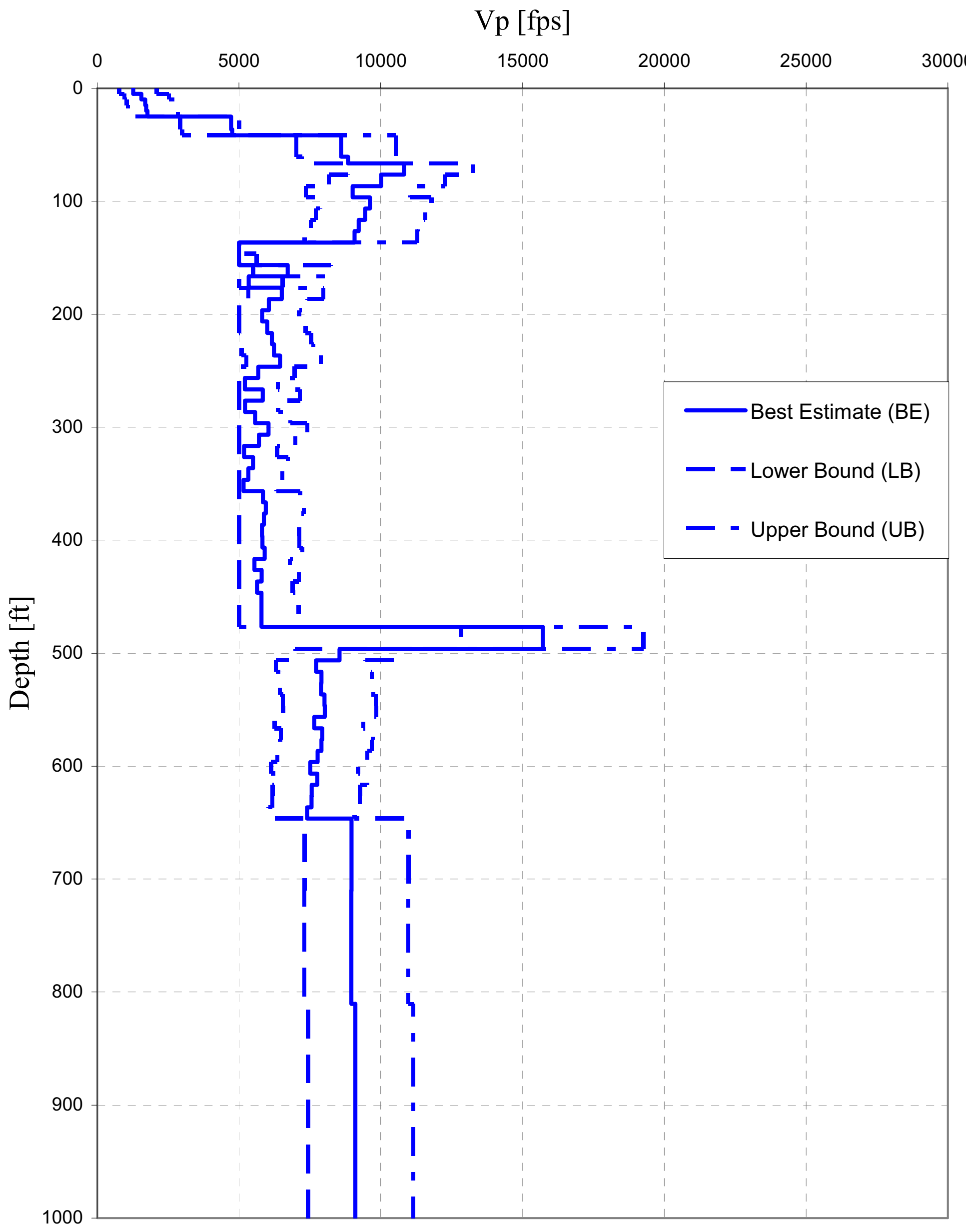


Figure 3JJ-219 Recommended SSI Shear-Wave Velocity Profiles — FAR Site Conditions (Upper 1000 feet — below 1000 feet depth is not shown)

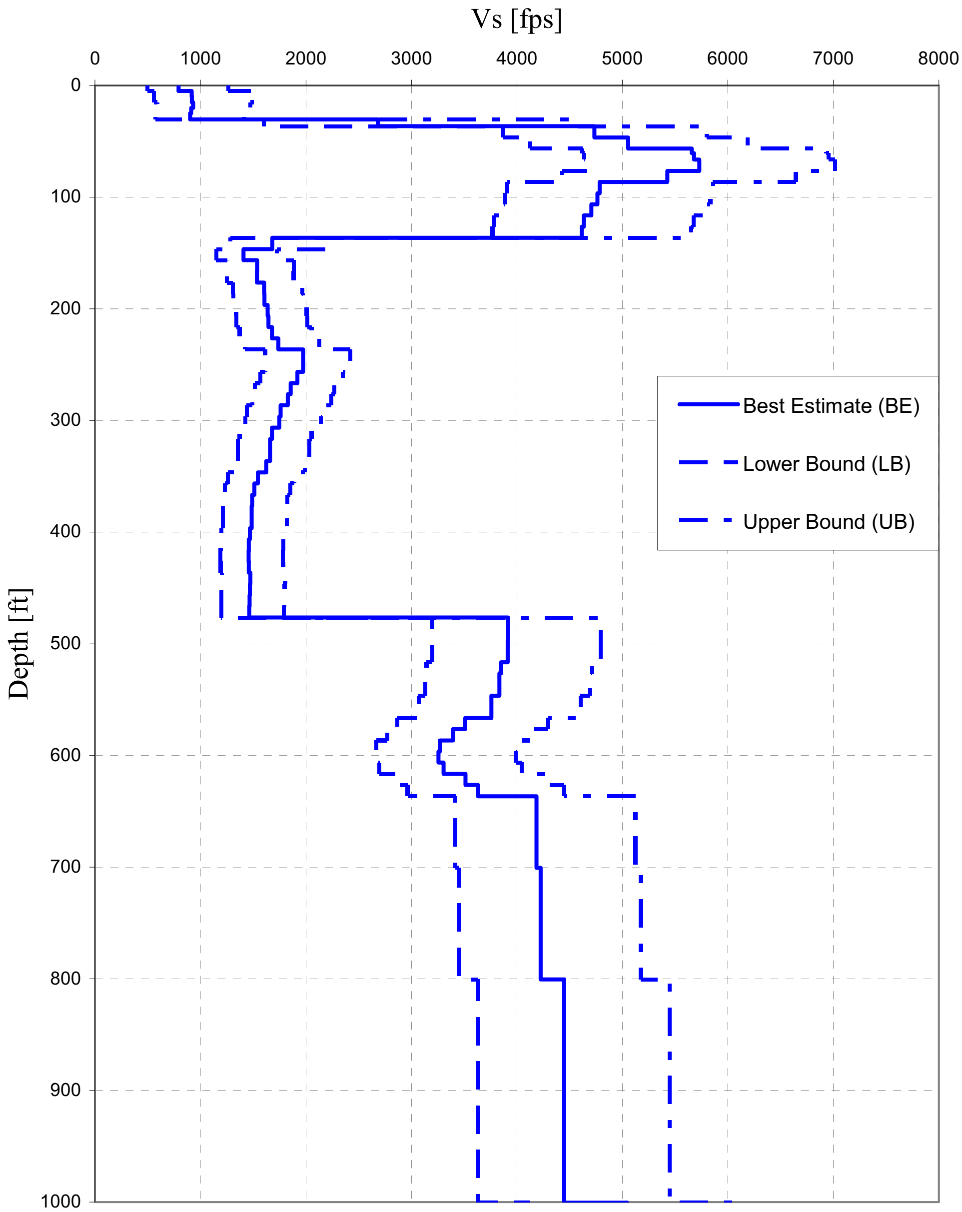


Figure 3JJ-220 Recommended SSI Damping Profiles — FAR Site Conditions (Upper 1000 feet — below 1000 feet depth is not shown)

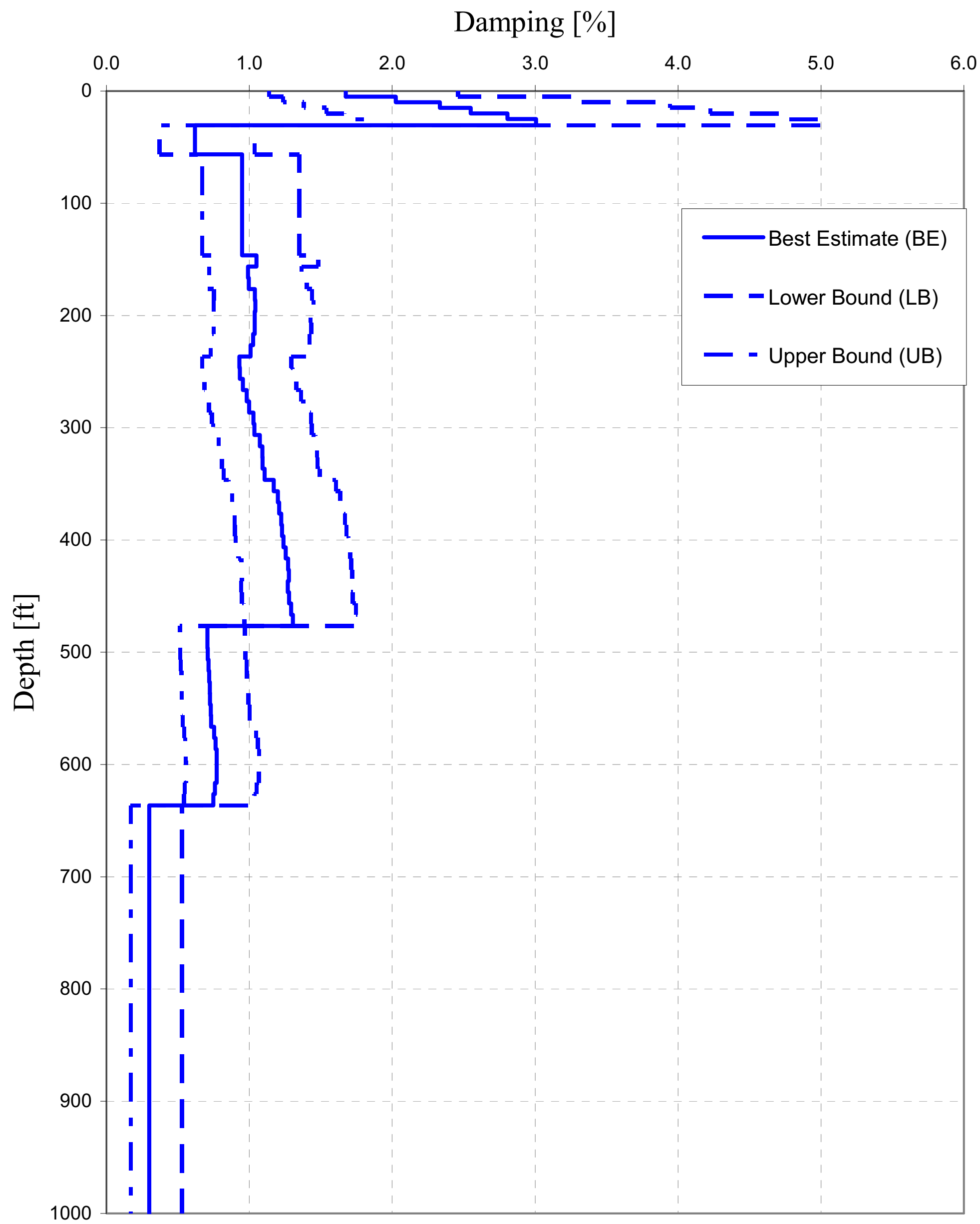


Figure 3JJ-221 Recommended P-Wave Velocity Profiles — FAR Site Conditions (Upper 1000 feet — below 1000 feet depth is not shown)

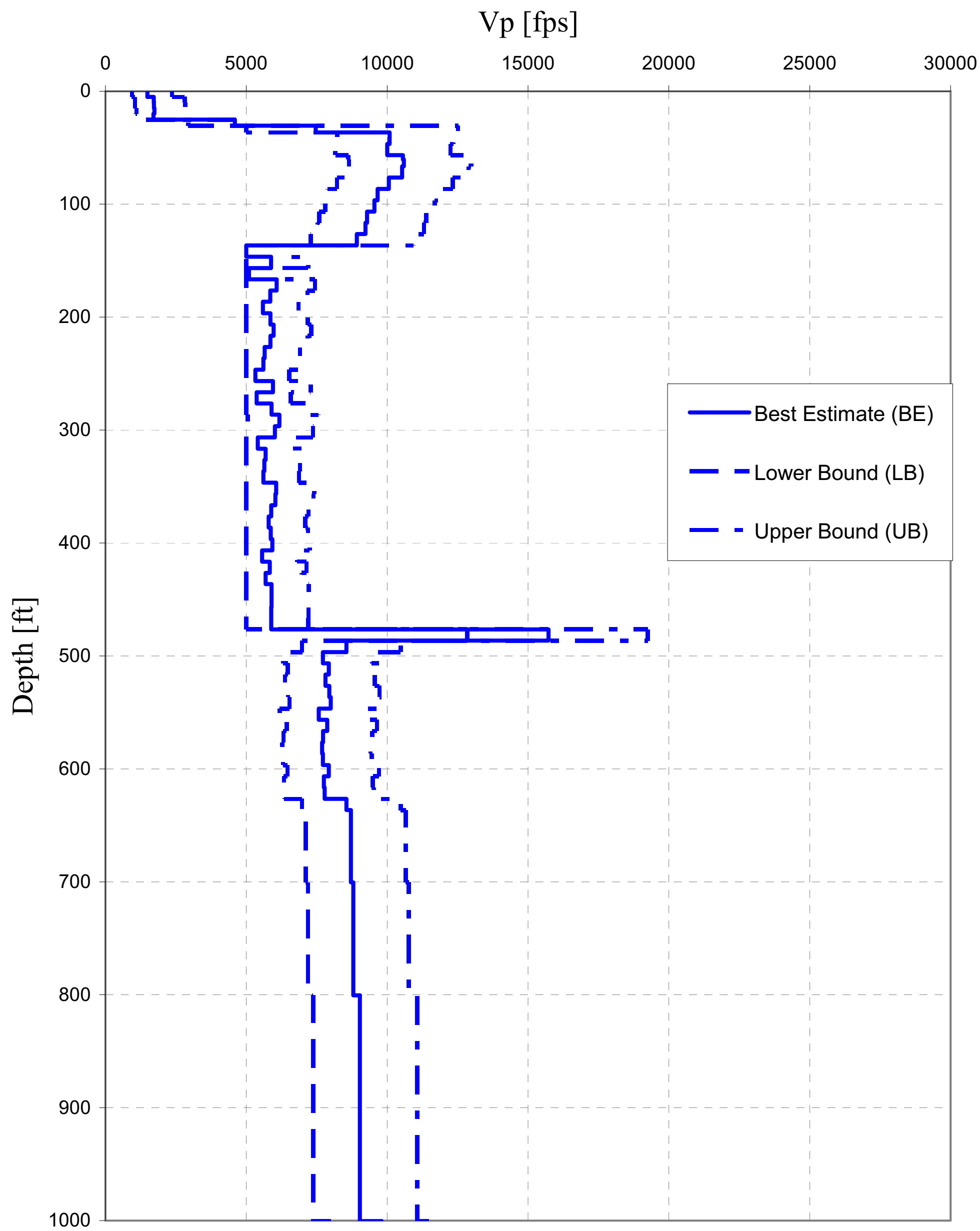


Figure 3JJ-222a Final Spectrum-Compatible Acceleration, Velocity, and Displacement Time Histories for Horizontal 1 Case Before Constant Scale Factor of 1.02 Is Applied

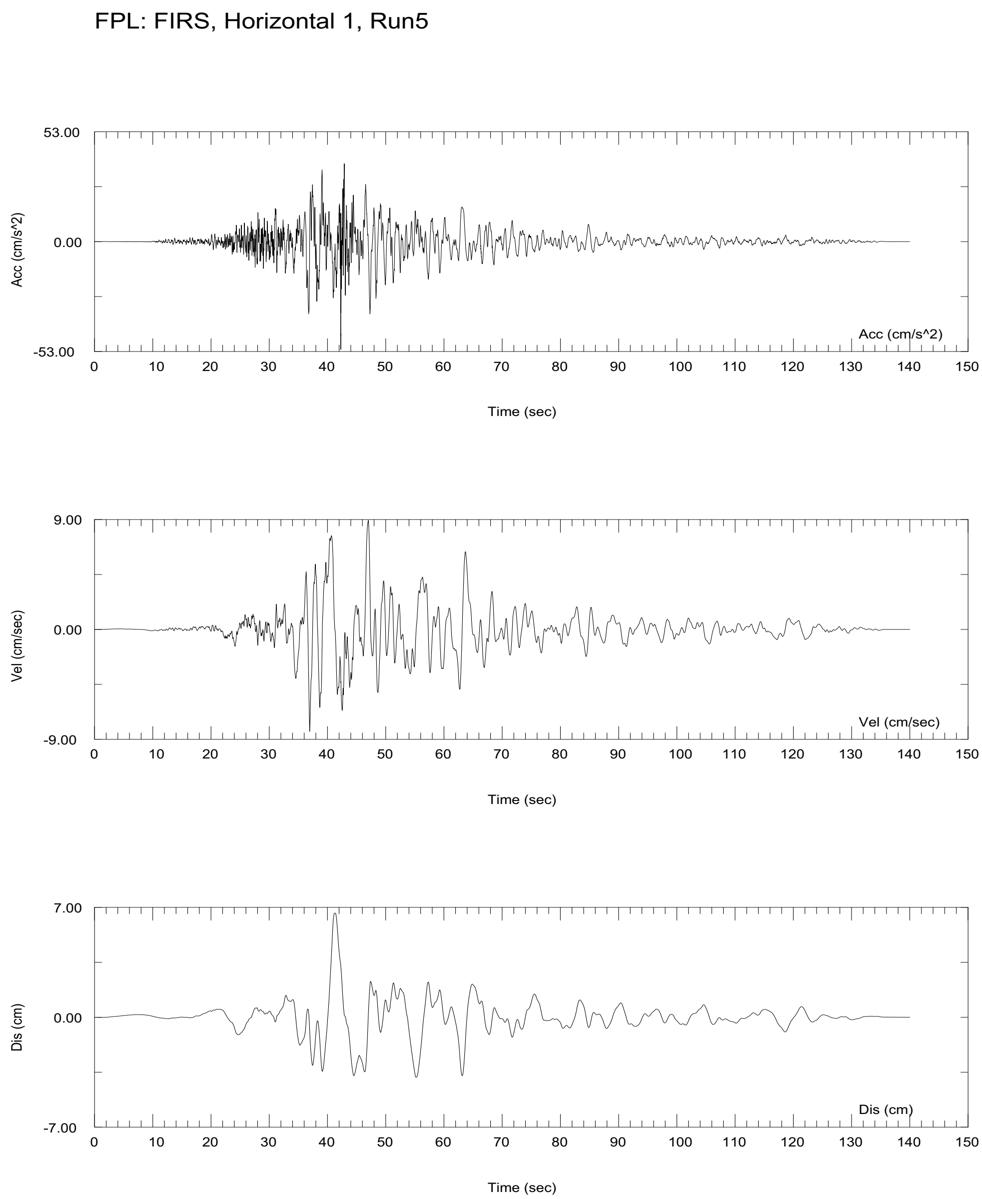


Figure 3JJ-222b Comparison of Initial Seed Acceleration Normalized Arias Intensities Plot and Final Spectrum-Compatible Acceleration Normalized Arias Intensities Plot for Horizontal 1 Cases Before Constant Scale Factor of 1.02 is Applied

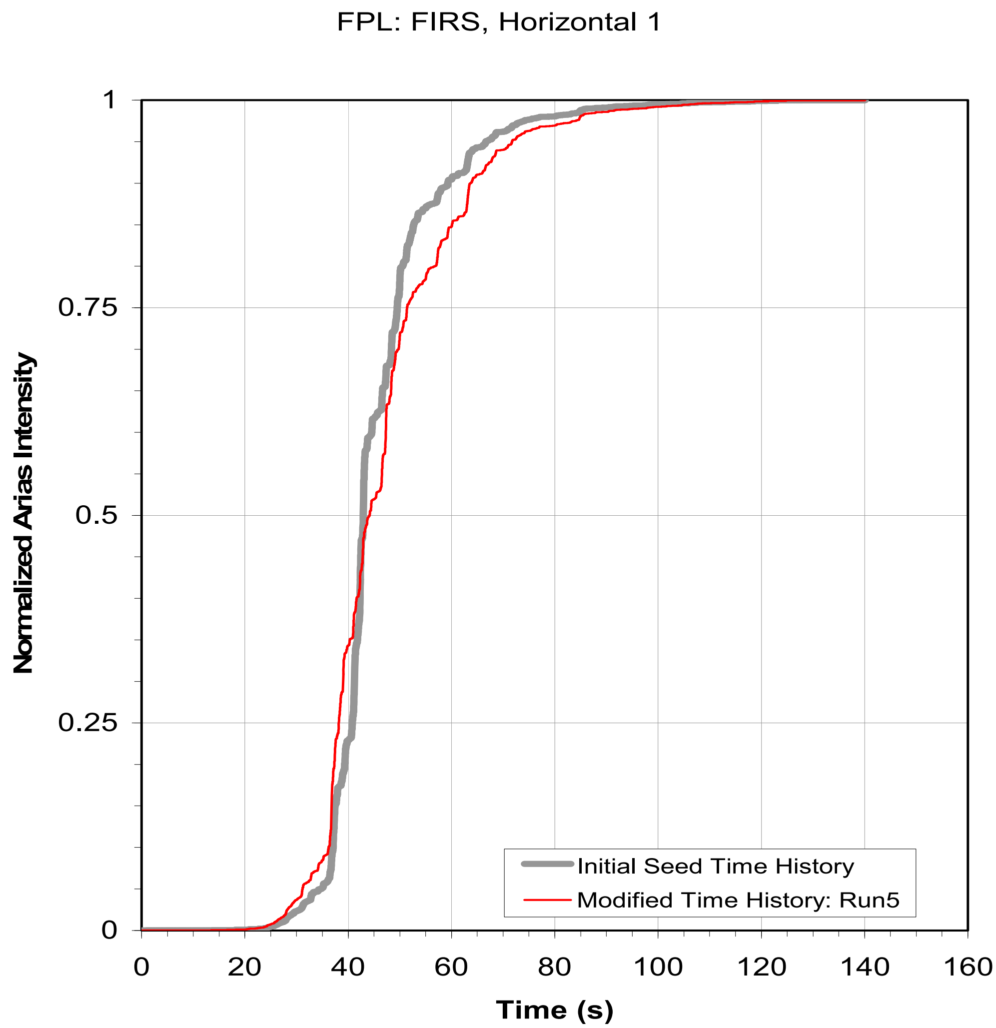


Figure 3JJ-222c Comparison Between the Final Scaled Spectrum-Compatible Response Spectrum, FIRS Horizontal Target Spectrum, and Upper and Lower Target Spectrum Bounds for Horizontal 1 Case With the Constant Scale Factor of 1.02 Applied

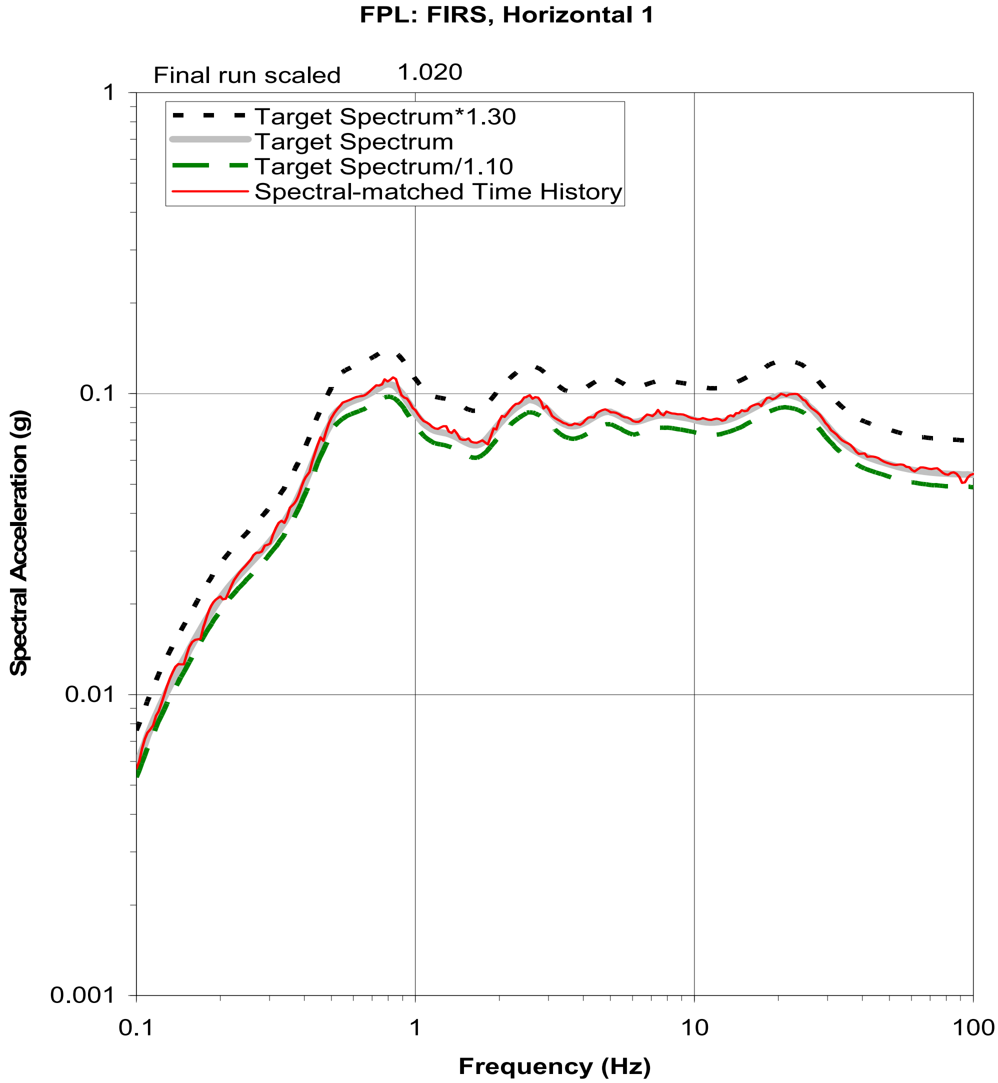


Figure 3JJ-223a Final Spectrum-Compatible Acceleration, Velocity, and Displacement Time Histories for Horizontal 2 Case Before Constant Scale Factor of 1.022 is Applied

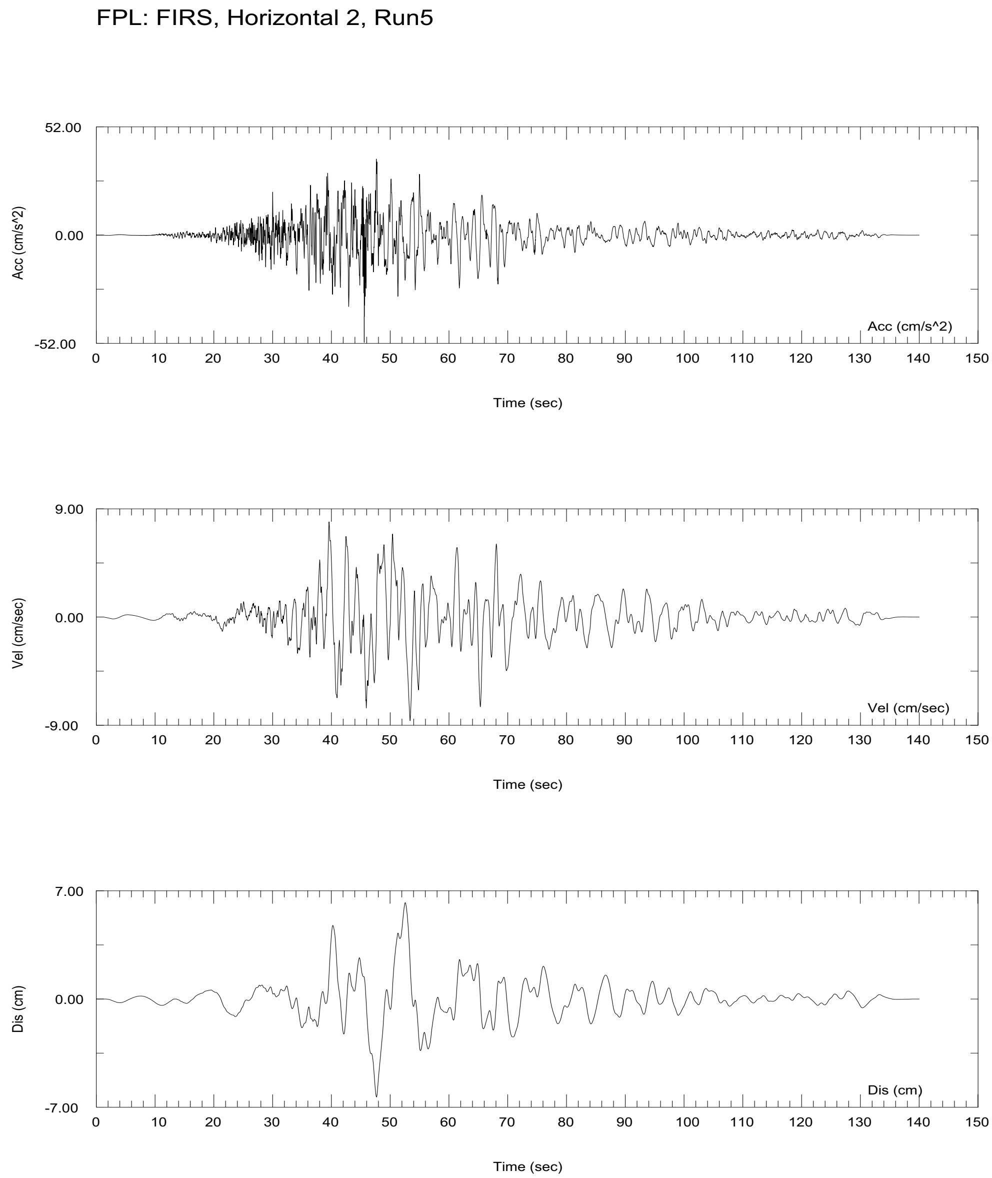


Figure 3JJ-223b Comparison of Initial Seed Acceleration Normalized Arias Intensities Plot and Final Spectrum-Compatible Acceleration Normalized Arias Intensities Plot for Horizontal 2 Cases Before Constant Scale Factor of 1.022 is Applied

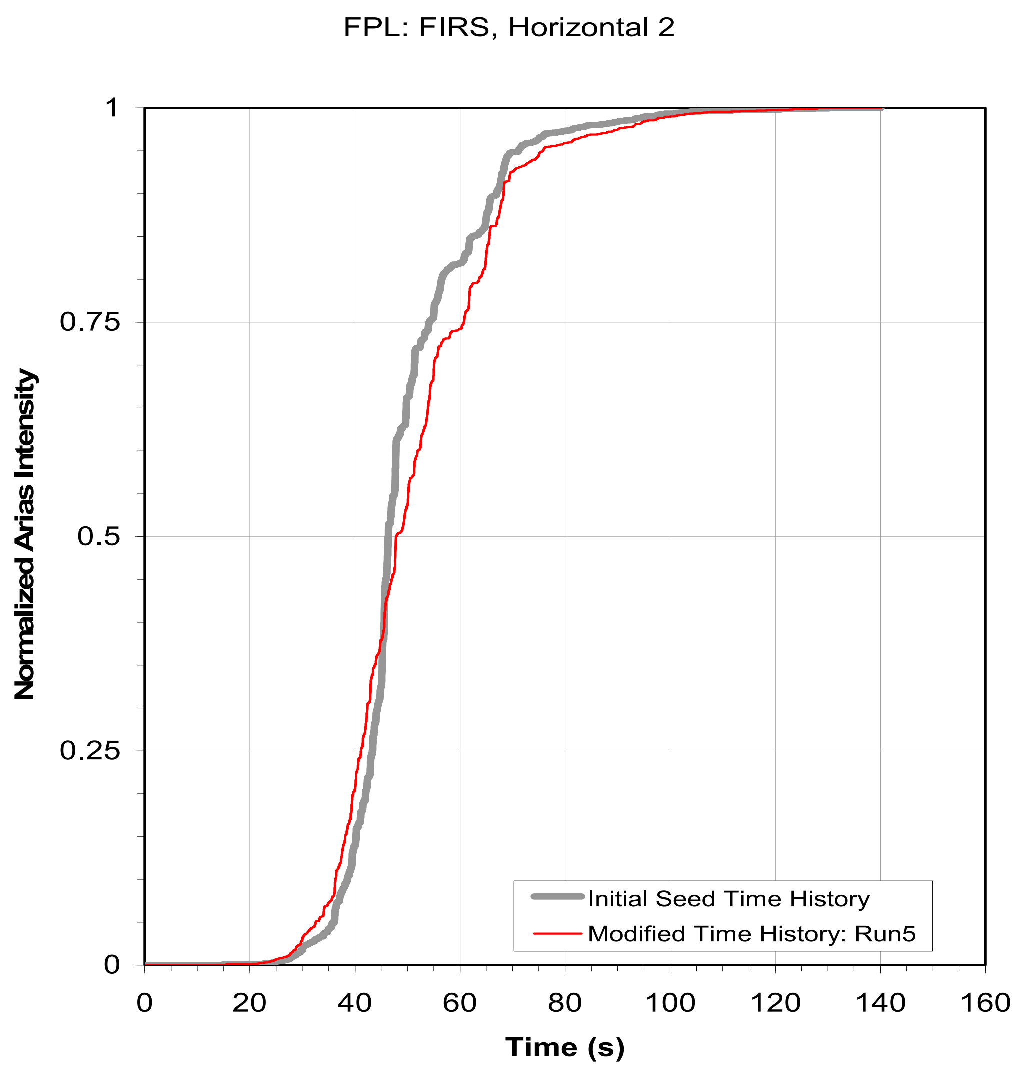


Figure 3JJ-223c Comparison Between the Final Scaled Spectrum-Compatible Response Spectrum, FIRS Horizontal Target Spectrum, and Upper and Lower Target Spectrum Bounds for Horizontal 2 Case With the Constant Scale Factor of 1.022 Applied

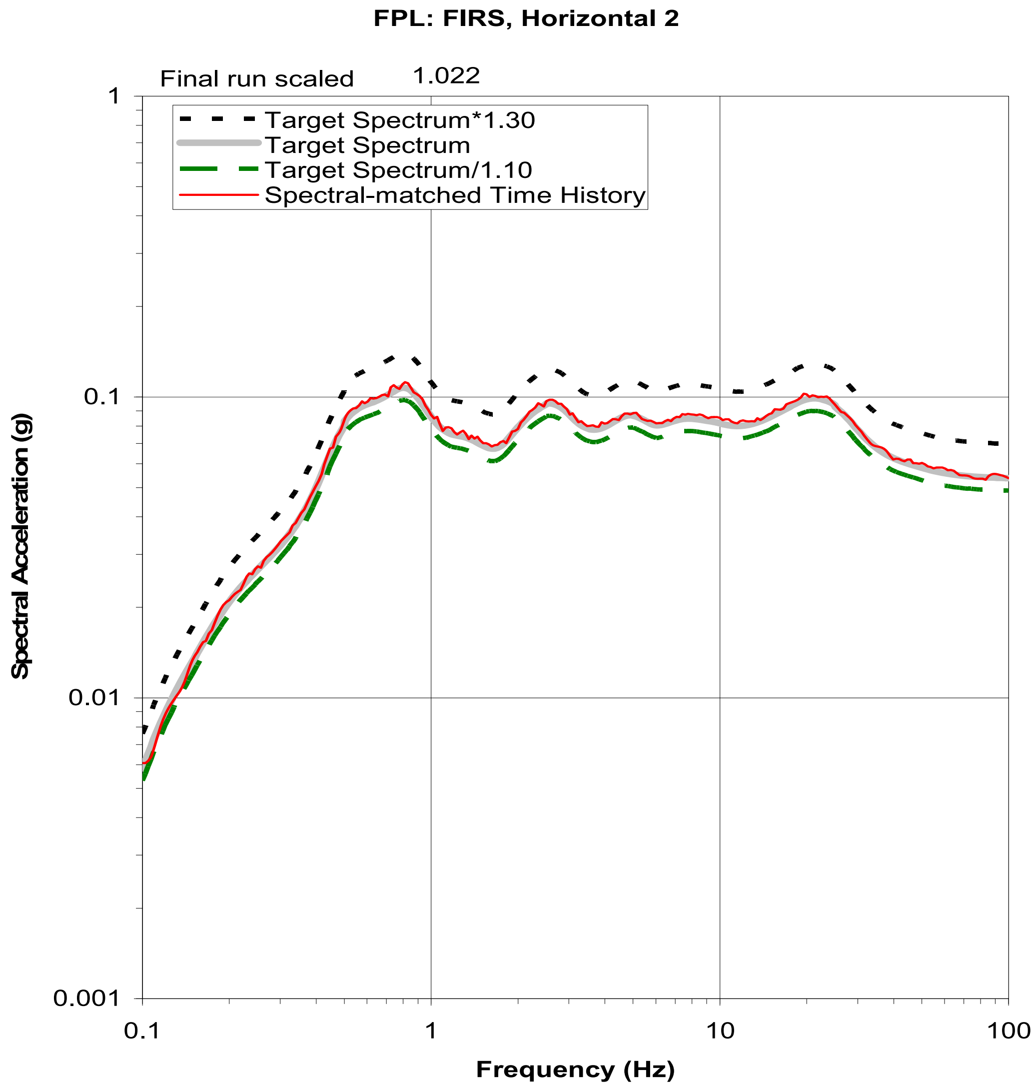


Figure 3JJ-224a Final Spectrum-Compatible Acceleration, Velocity, and Displacement Time Histories for Vertical Case Before Constant Scale Factor of 1.01 is Applied

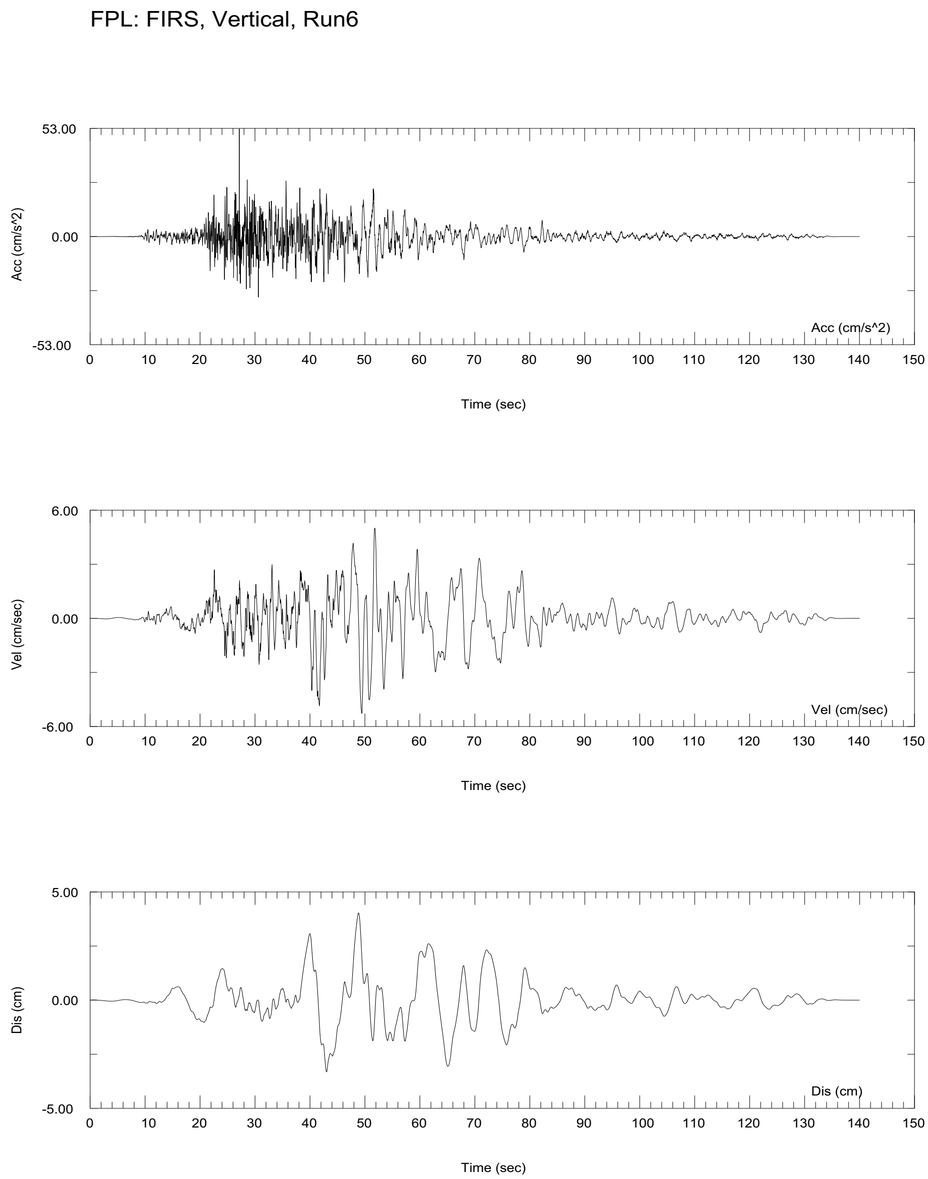


Figure 3JJ-224b Comparison of Initial Seed Acceleration Normalized Arias Intensities Plot and Final Spectrum-Compatible Acceleration Normalized Arias Intensities Plot for Vertical Cases Before Constant Scale Factor of 1.01 is Applied

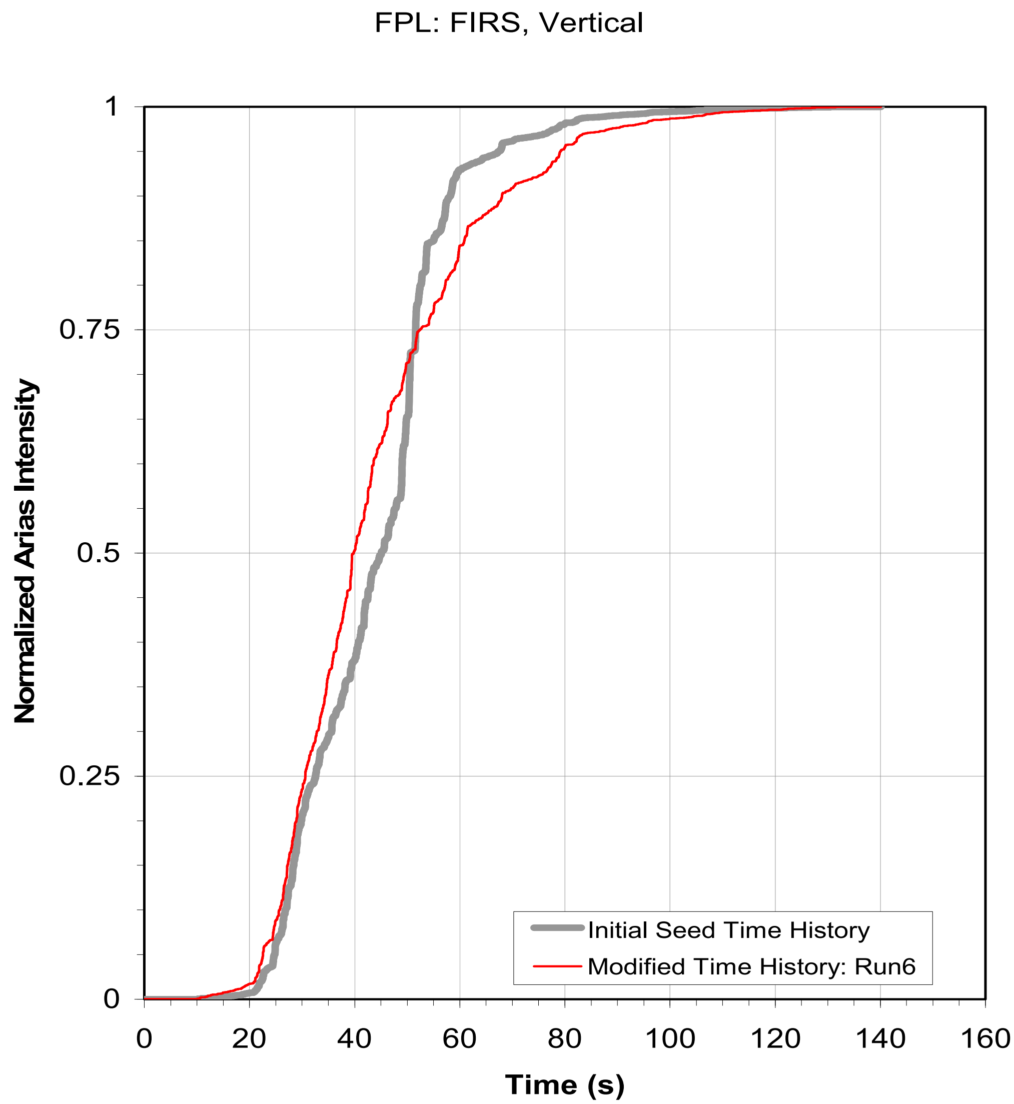


Figure 3JJ-224c Comparison Between the Final Scaled Spectrum-Compatible Response Spectrum, FIRS Vertical Target Spectrum, and Upper and Lower Target Spectrum Bounds for Vertical Case With the Constant Scale Factor of 1.01 Applied

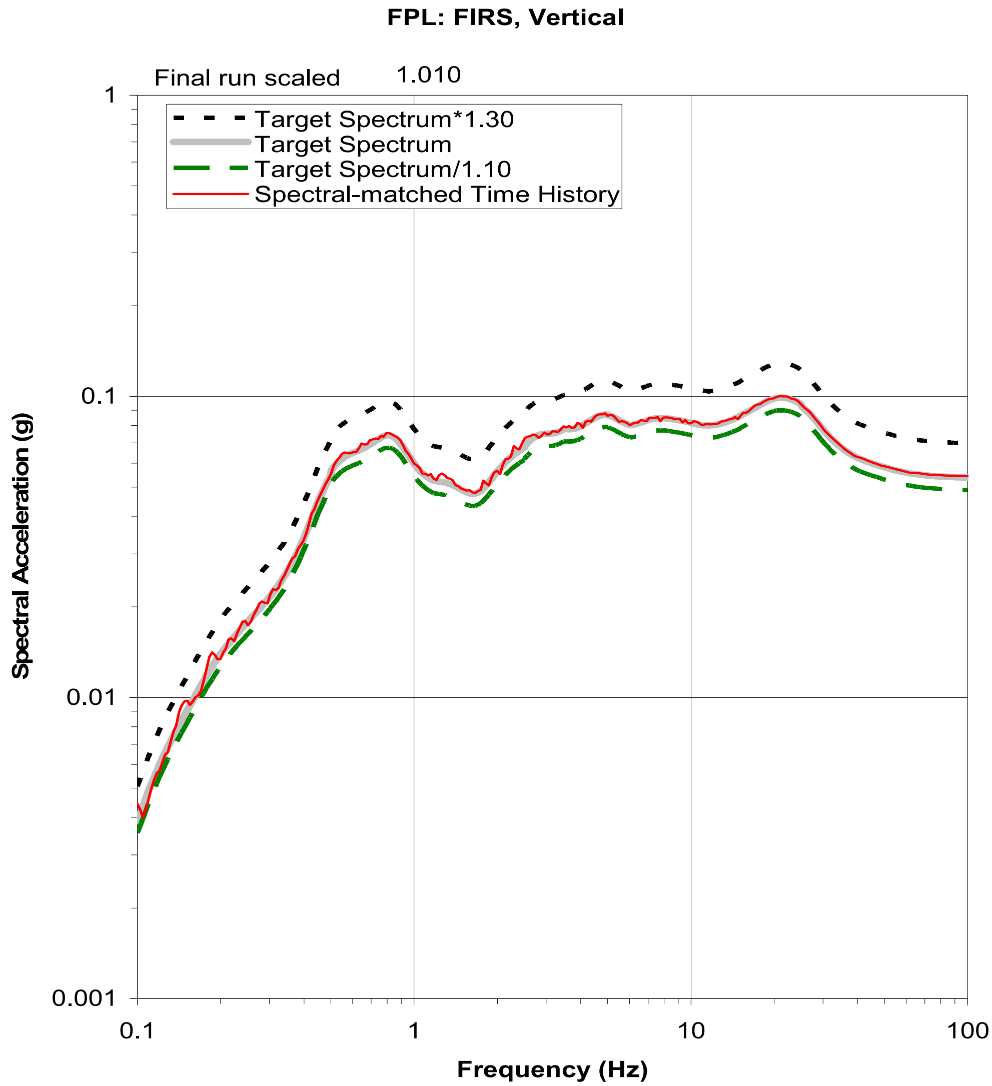


Figure 3JJ-225 5% Damping ARS at Ground Surface — Direction H1 — NI Site Condition

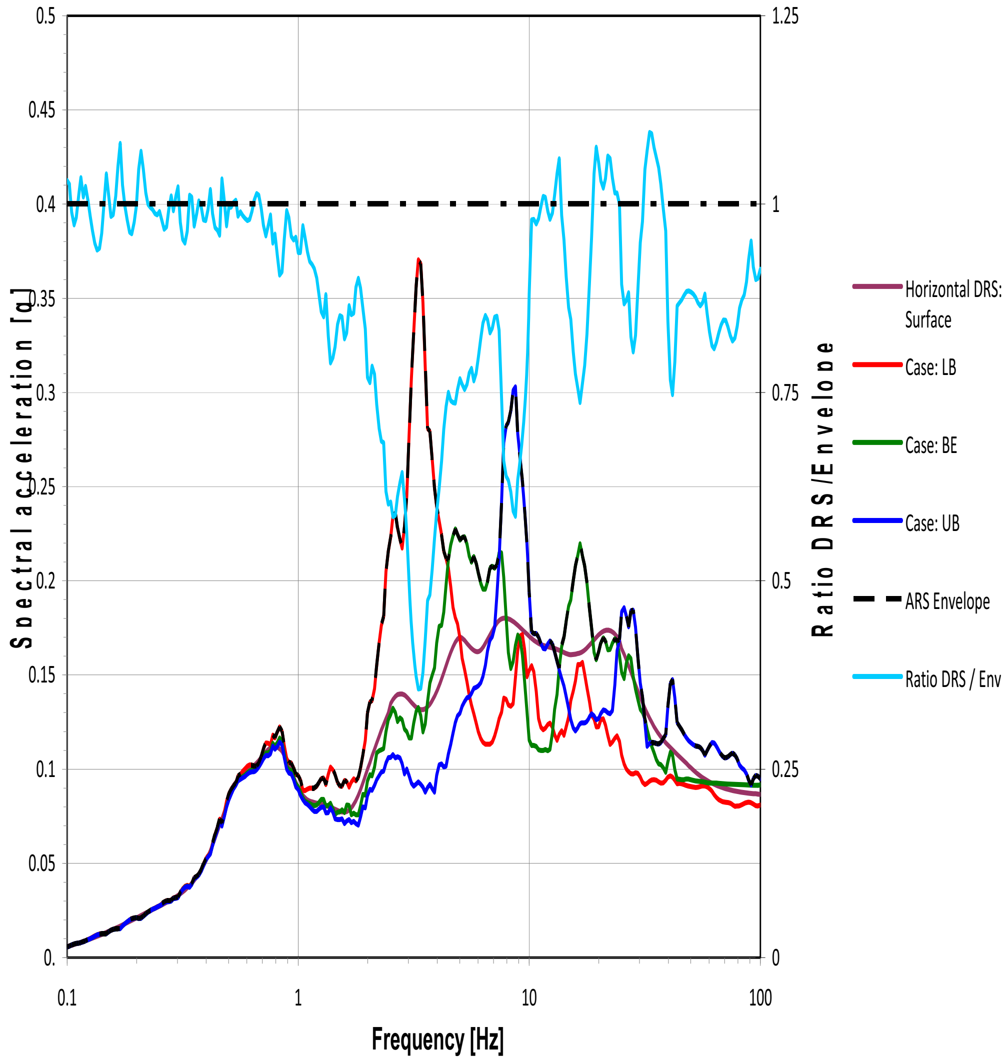


Figure 3JJ-226 5% Damping ARS at Ground Surface — Direction H2 — NI Site Condition

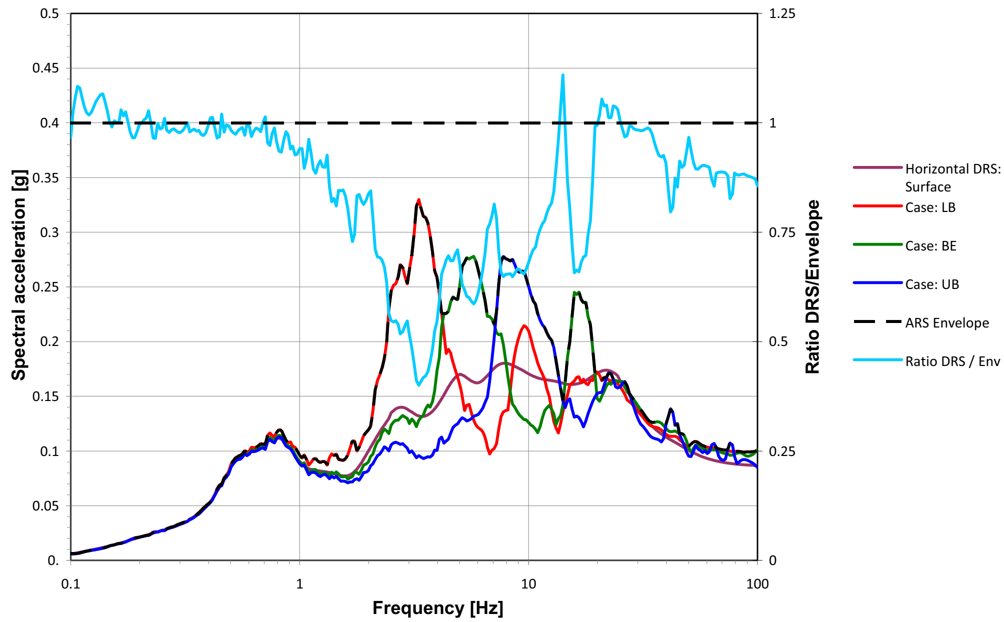


Figure 3JJ-227 5% Damping ARS at Ground Surface — Direction UP — NI Site Condition

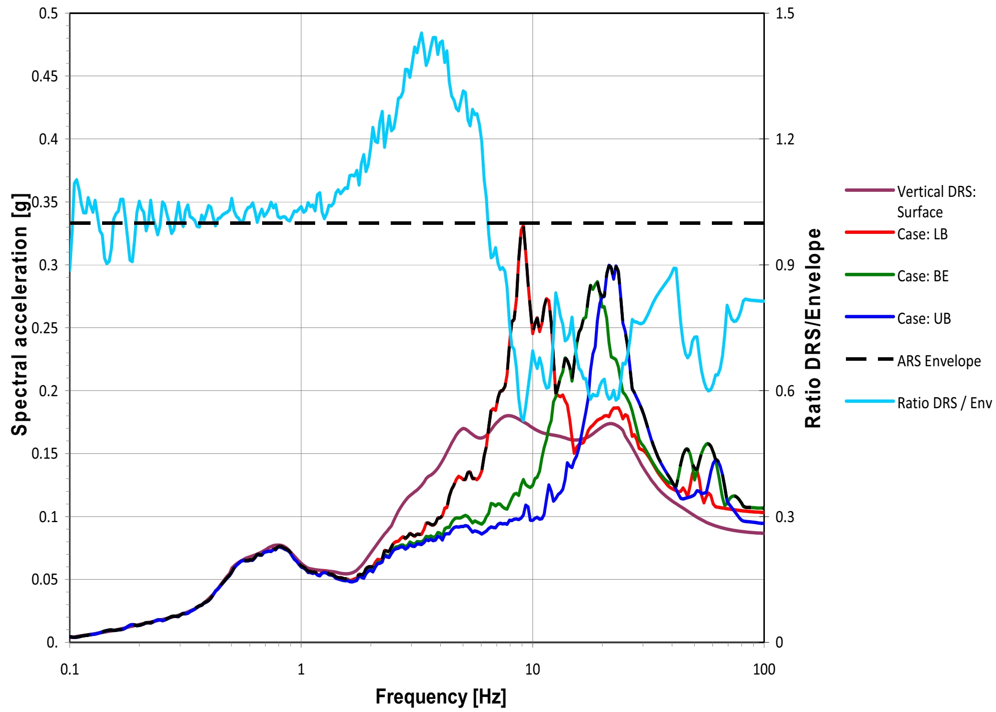


Figure 3JJ-228 5% Damping ARS at Ground Surface — Direction H1 — FAR Site Condition

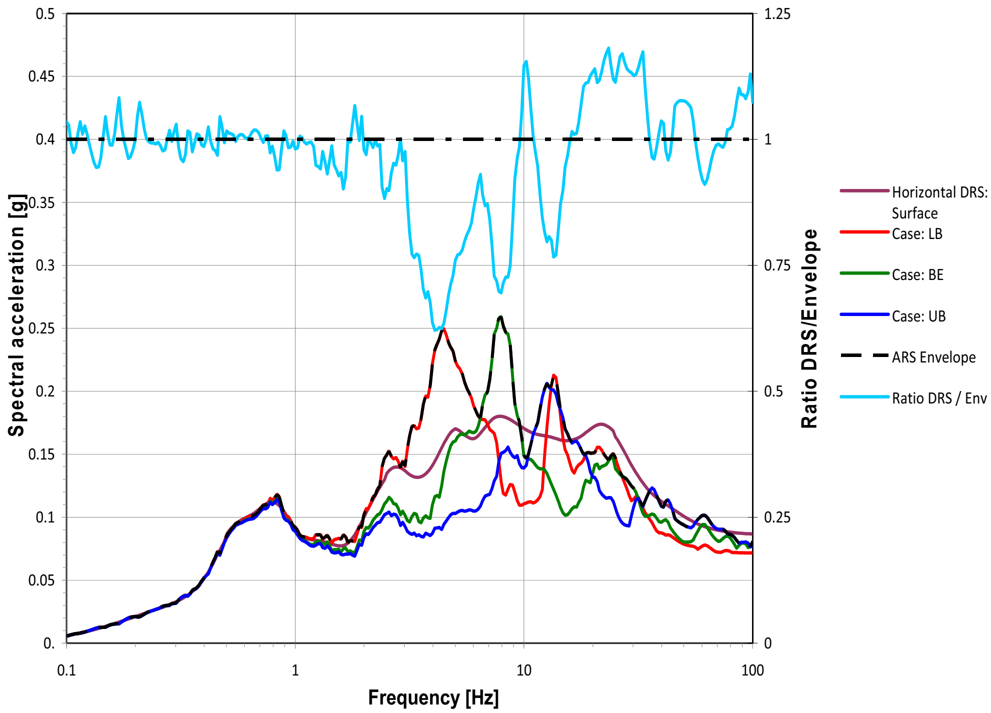


Figure 3JJ-229 5% Damping ARS at Ground Surface — Direction H2 — FAR Site Condition

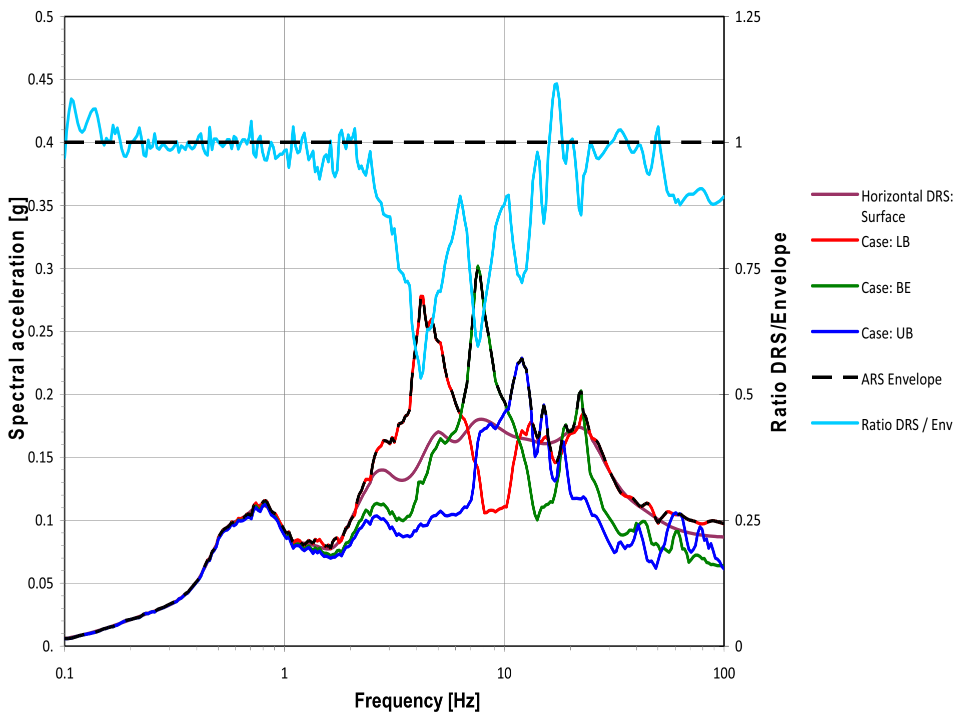


Figure 3JJ-230 5% Damping ARS at Ground Surface — Direction UP — FAR Site Condition

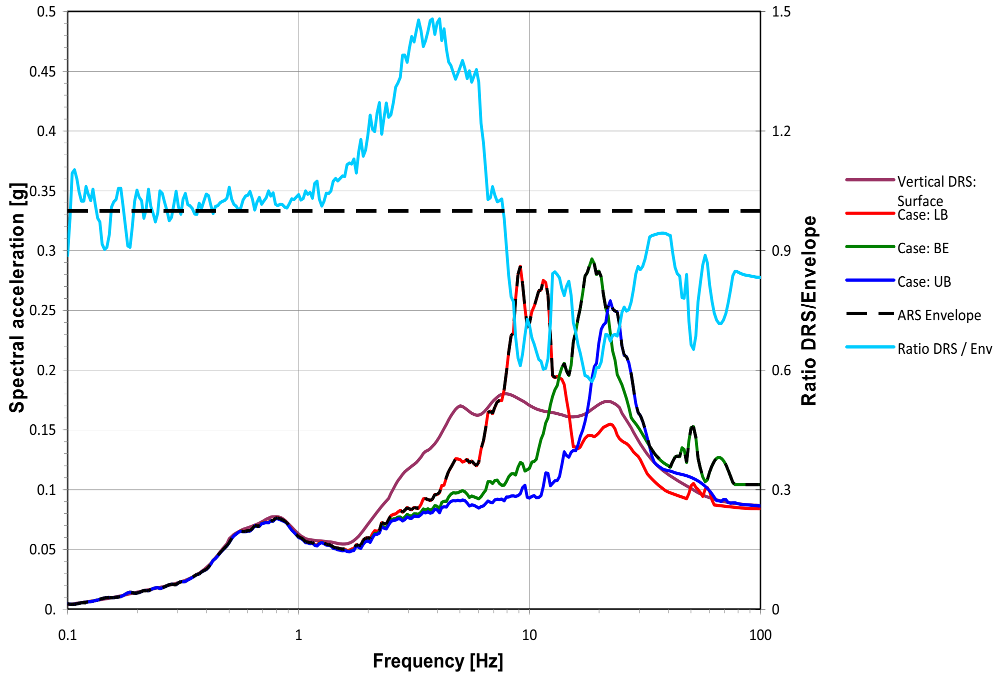


Figure 3JJ-231 Adjusted Vertical Target ARS at FIRS Horizon (5% Damping) Time [sec]

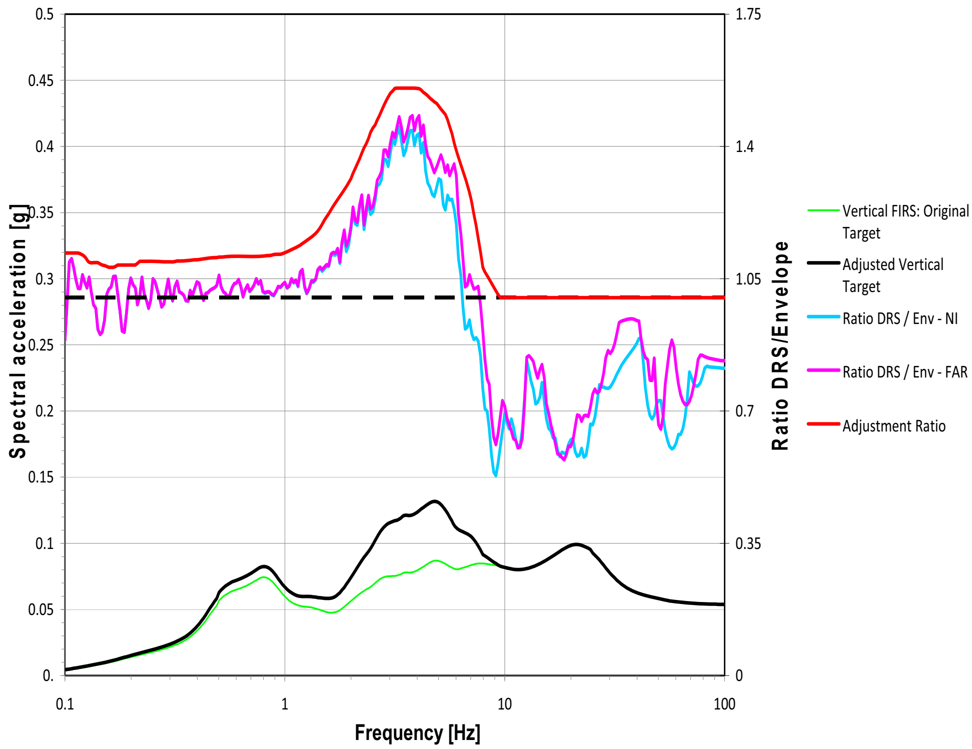


Figure 3JJ-232 SSI Input "Within" Acceleration Time History — Direction H1 — NI Site Condition Time [sec]

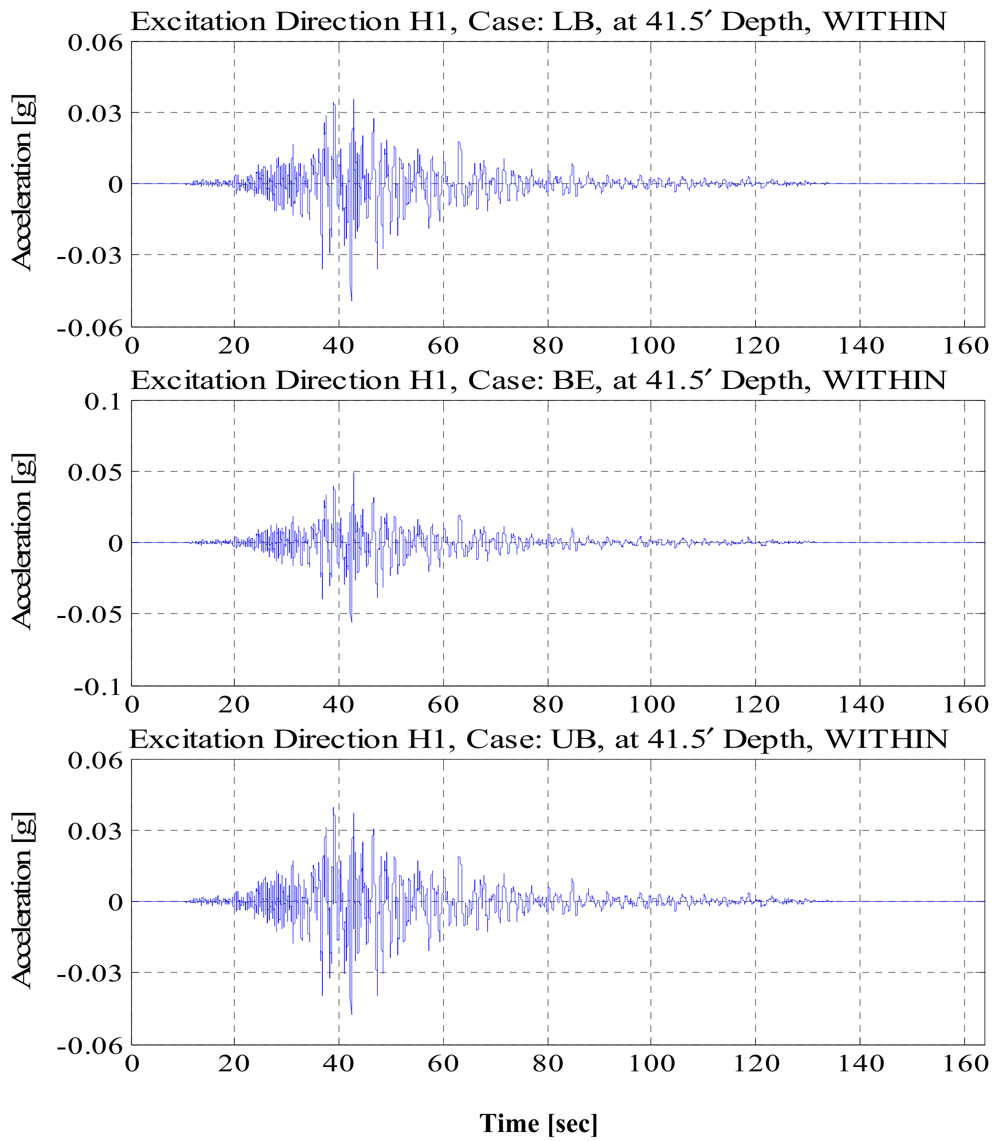


Figure 3JJ-233 SSI Input "Within" Acceleration Time History — Direction H2 — NI Site Condition Time [sec]

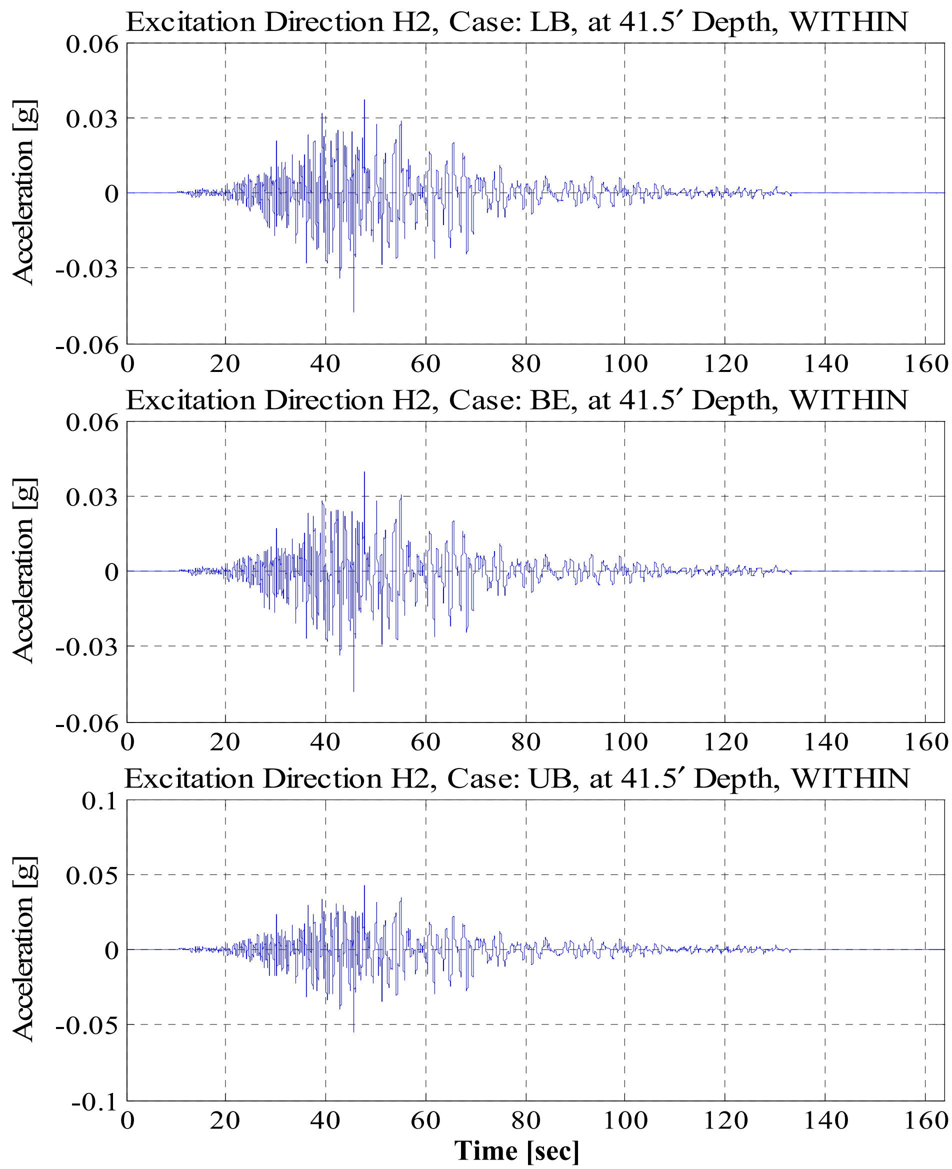


Figure 3JJ-234 SSI Input "Within" Acceleration Time History — Direction UP — NI Site Condition Time [sec]

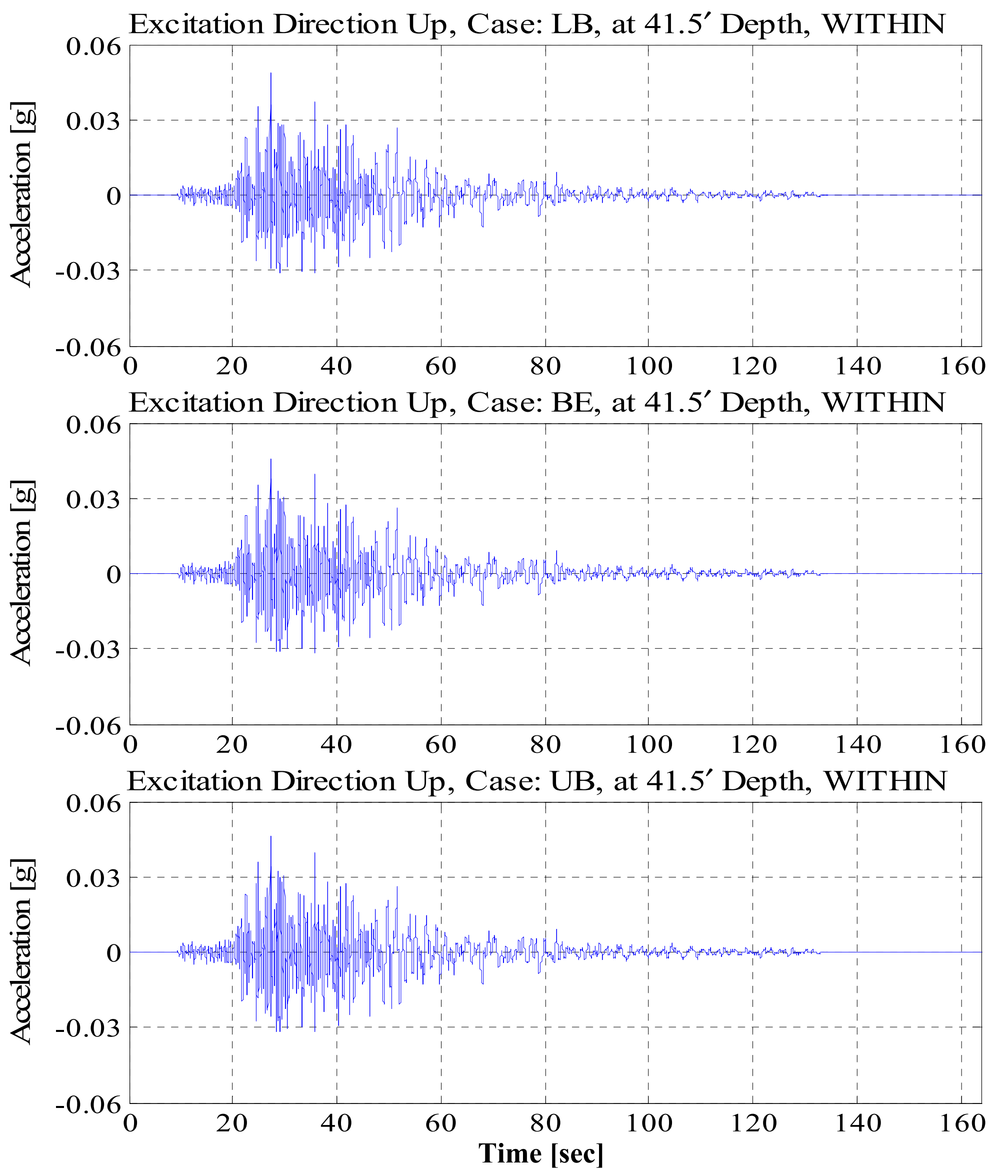


Figure 3JJ-235 SSI Input "Within" Acceleration Time History — Direction H1 — FAR Site Condition Time [sec]

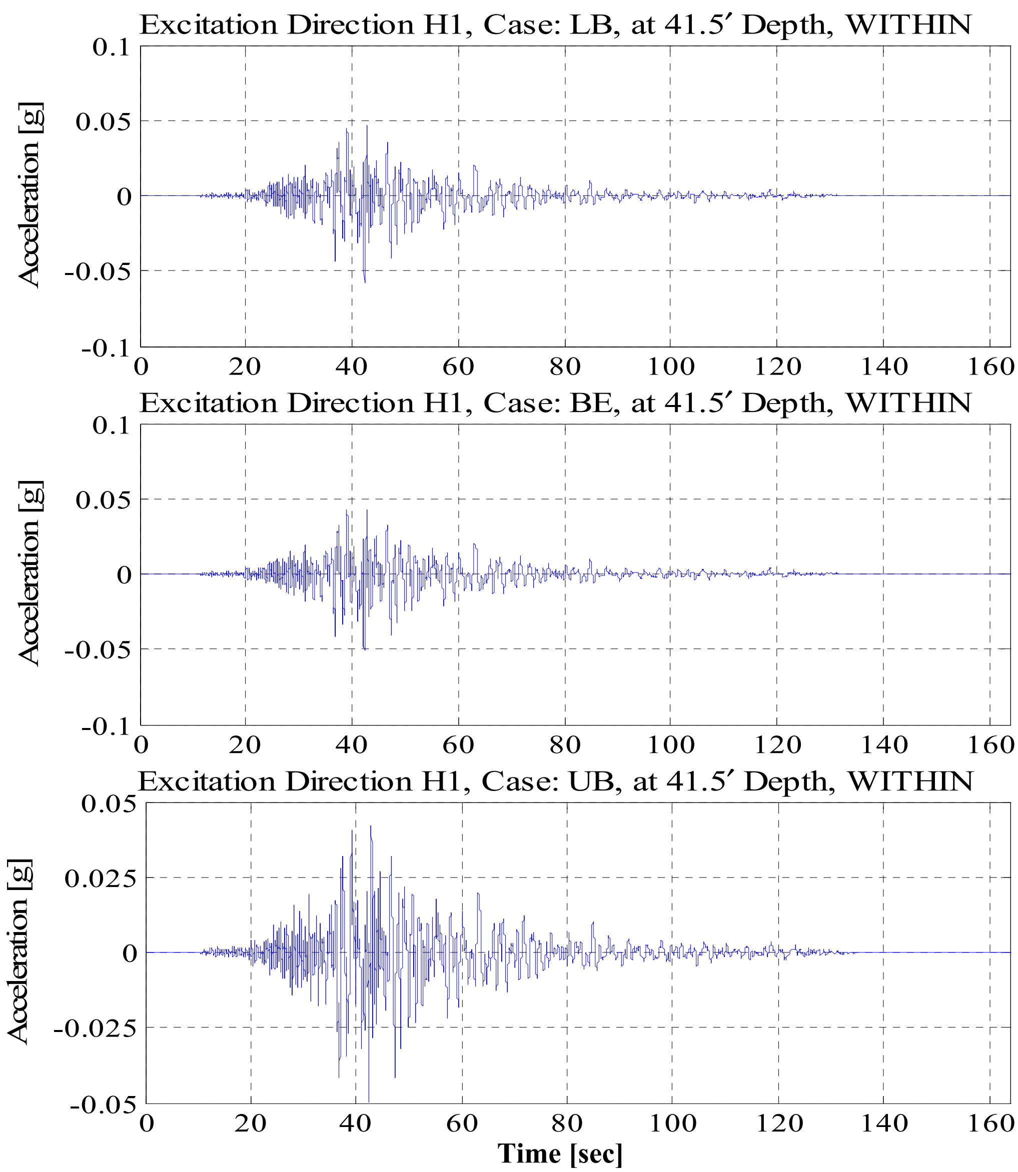


Figure 3JJ-236 SSI Input "Within" Acceleration Time History — Direction H2 — FAR Site Condition Time [sec]

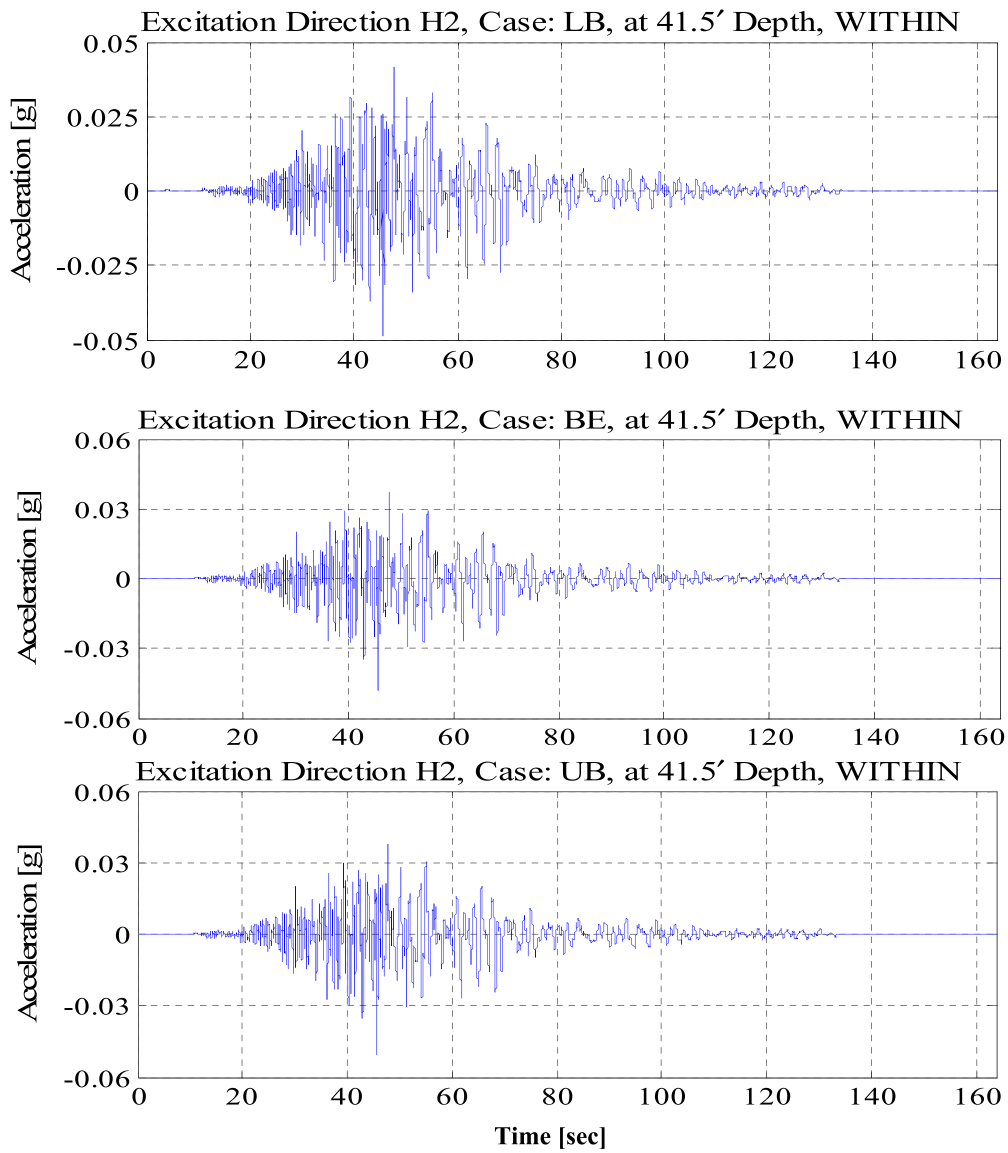
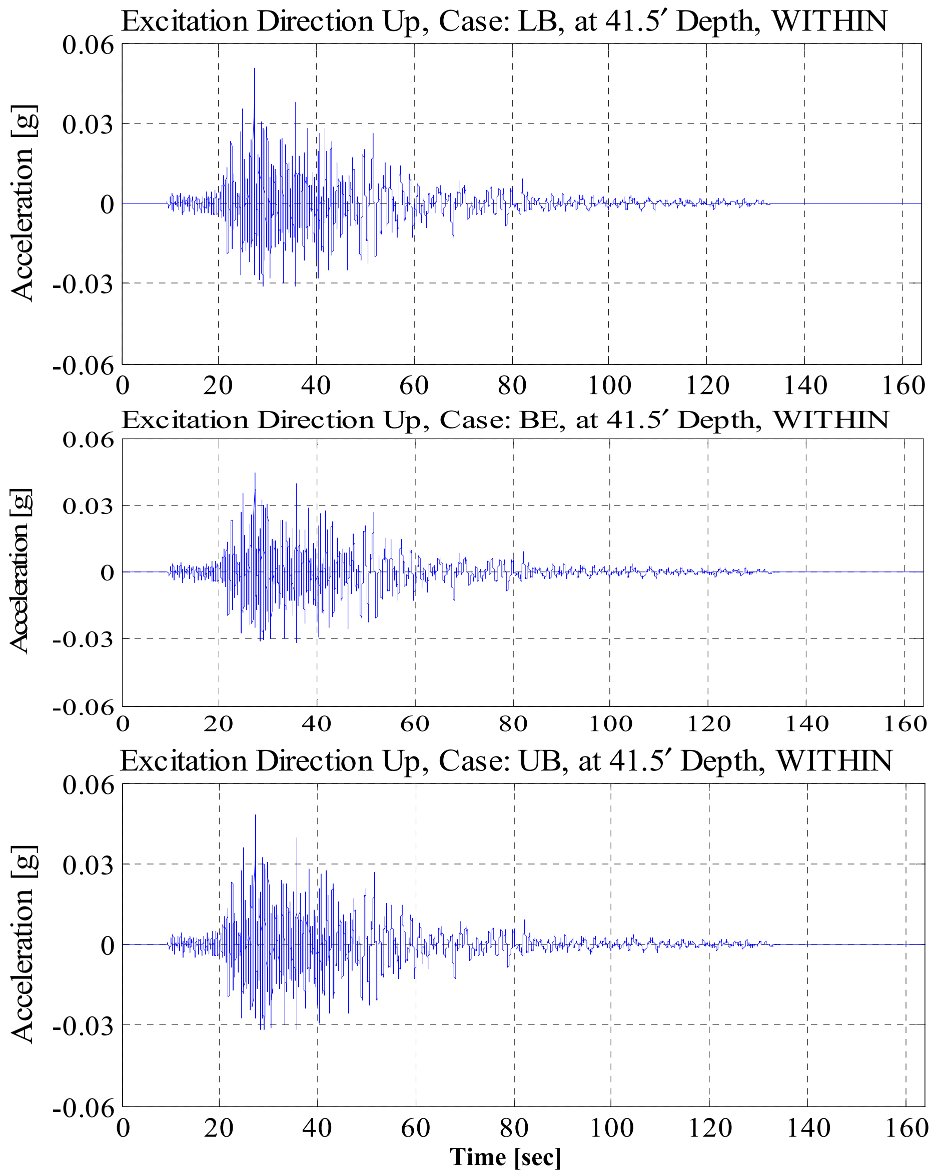


Figure 3JJ-237 SSI Input "Within" Acceleration Time History — Direction UP — FAR Site Condition



PTN SUP 3KK-1

APPENDIX 3KK SITE SPECIFIC SEISMIC EVALUATION REPORT

This Appendix 3KK is comprised, in its entirety, of the attached AP1000 Turkey Point Site Specific Seismic Evaluation Report, Westinghouse Document Number TPG-1000-S2R-802, Revision 1.

TPG-1000-S2R-802
Revision 1

June 2009
Westinghouse Non-Proprietary Class 3

AP1000
Turkey Point Site Specific Seismic Evaluation Report

Westinghouse Electric Company LLC
Nuclear Power Plants
Post Office Box 355
Pittsburgh, PA 15230-0355

Record of Revisions

Rev	Date	Revision Description[1]
0	See EDMS	Original Issue
1	6/2009	The first twelve rows data in Table 3-1 were replaced with the Far Field soil profile data to match the description of the model above Table 3-1.

Note (1) Significant changes are briefly described in this table. In the rest of the report, each row that has changed is marked using a revision bar in the margin of the page. This approach satisfies the change identification requirements in WP 4.5 Section 7.4.

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1.0 Introduction

Two AP1000 units are to be constructed at the Florida Power & Light (FPL) Turkey Point site. Since the soil shear wave velocity profiles at the Turkey Point Units 6 & 7 site are different from the generic soil shear wave velocity profiles used for the AP1000 design, a site specific Soil-Structure Interaction (SSI) analysis was performed.

This report describes the results of the site-specific SSI analyses that have been performed to demonstrate the acceptability of the AP1000 plant at the Turkey Point site. The site specific SSI seismic evaluations performed address the following:

- 2-D SASSI parametric studies to establish: (1) the extent of subsurface characterization; site response characteristics and surface motions; (2) the effects of the fill concrete underlying the Nuclear Island footprint.
- 3-D SASSI analyses using the parameters established from the 2-D SASSI studies to develop Floor Response Spectra (FRS) of the AP1000 at Turkey Point site for comparison to the AP1000 Certified Seismic Design Response Spectra (CSDRS).

3D SASSI analysis results show the Floor Response Spectra (FRS) of an AP1000 at the Turkey Point Units 6 & 7 site is enveloped by the AP1000 Certified Seismic Design Floor Response Spectra at the Nuclear Island key locations.

1.1 Acronyms

ASB	Auxiliary and Shield Building
CIS	Containment Internal Structures
CSDRS	Certified Seismic Design Response Spectra
DCD	Design Control Document
DRS	Design Response Spectra
EL (El.)	Elevation (unless otherwise noted all EL are generic AP1000 EL grade is 100’)
EW	East West
FIRS	Foundation Input Response Spectra
FRS	Floor Response Spectra
GMRS	Ground Motion Response Spectra
MSL	Mean Sea Level
NS	North South
SASSI	A System for Analysis of Soil-Structure Interaction Finite Element Program
SSI	Soil Structure Interaction
SCV	Steel Containment Vessel
ZPA	Zero Period Acceleration

2.0 Turkey Point Site Characteristics

Turkey Point Units 6 & 7 is part of the larger Turkey Point plant site located in unincorporated Miami-Dade County, Florida. The approximately 11,000-acre Turkey Point plant site includes two natural gas/oil steam electric generating units, (Units1, 2), two pressurized water reactor units (Units 3, 4), and one combined cycle steam electric generating unit (Unit 5).

The site is at or near sea level with a natural relief of approximately 3 feet from it's northern to southern boundary and approximately 0.5 feet of relief from its western to eastern boundary. The site is flat and uniform throughout with the exception of the vegetated depressions.

The site is located within the Gulf Coastal Plains physiographic province. Elevation of the ground surface in the site region varies from 3 feet below sea level to 400 feet above sea level. The geologic and tectonic setting of the region is the product of a complex history of continental collisions and rifting followed by deposition of sediments upon the newly formed Florida platform. Site regional stratigraphy consists of Paleozoic and Mesozoic igneous, metamorphic and sedimentary basement rock overlain by up to 14,000 feet of additional Mesozoic carbonate and evaporate sedimentary rock units, which are in turn overlain by 5000 to 6000 feet of Cenozoic carbonate and siliciclastic sediments.

Surficial deposits at the site consist of organic muck and the Miami Limestone. The organic muck is the dominant sediment type, whereas the Miami Limestone is located surficially in the northwestern portion of the site area. The Miami Limestone is a marine carbonate consisting predominately of oolitic facies of white to gray limestone with fossils (mollusks, bryozoans, and corals.) The overlying organic muck in the site area can be described as either a light gray-dark gray to pale brown muck with trace amounts of shell fragments, with little to no reaction to hydrochloric acid and/or black to brown muck with organic fibers and strong reaction to hydrochloric acid. The thickness of the muck varies from 2 to 6 feet across the site area.

The subsurface soils underlying the 5 feet of mud/muck in the vicinity of the power blocks consist of formational material capable of substantial groundwater yield.

2.1 Soil Profile

Due to the differences between the soil column close to Nuclear Island (i.e. near field – NI) and the soil column outside of the slurry wall (i.e., far field -FAR), two columns will be constructed. The far field soil profile will consist of approximately 30 feet of compacted Class 2 limestone fill (i.e., approximately 25 feet to raise the ground surface to 25.5 feet plus approximately 5 feet to replace the muck layer that will be removed during the construction). This fill will be placed over in-situ limestone (Miami limestone and Key Largo formation.)

Figures 2-1 to 2-6 show the shear wave velocity, damping value and P wave velocity for NI and FAR.

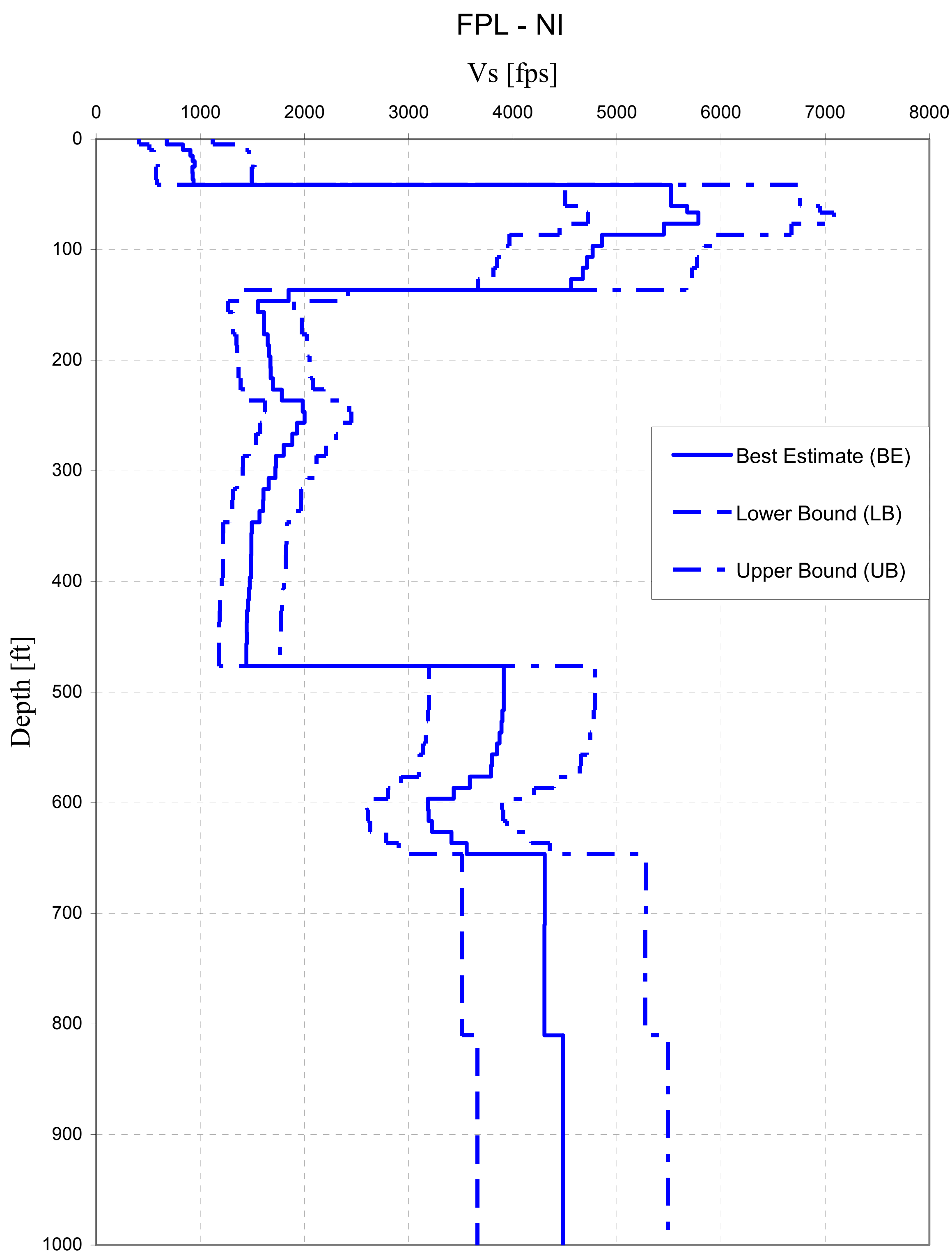


Figure 2-1: Turkey Point Site (FPL) - NI V_S

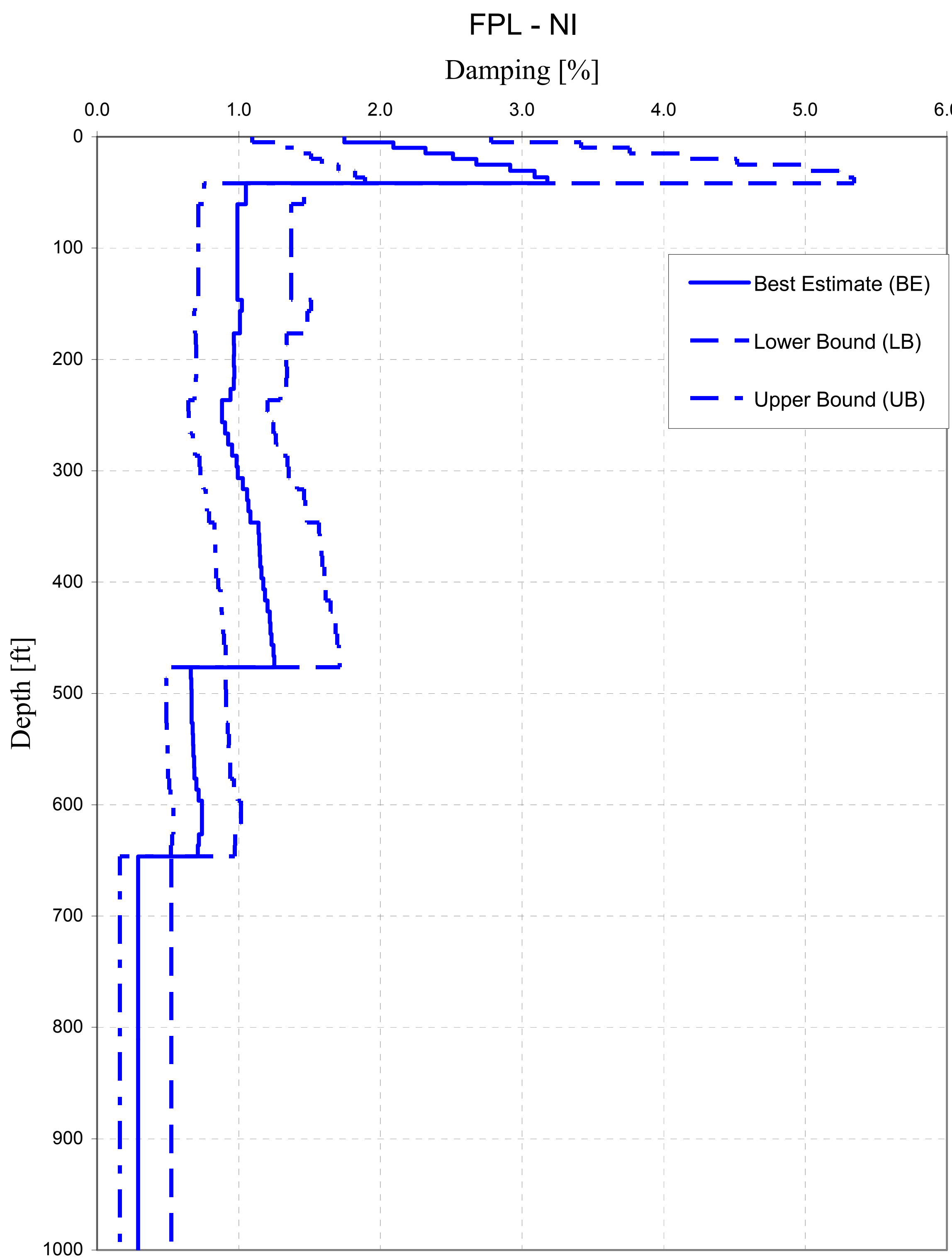


Figure 2-2: Turkey Point Site (FPL) - NI Damping

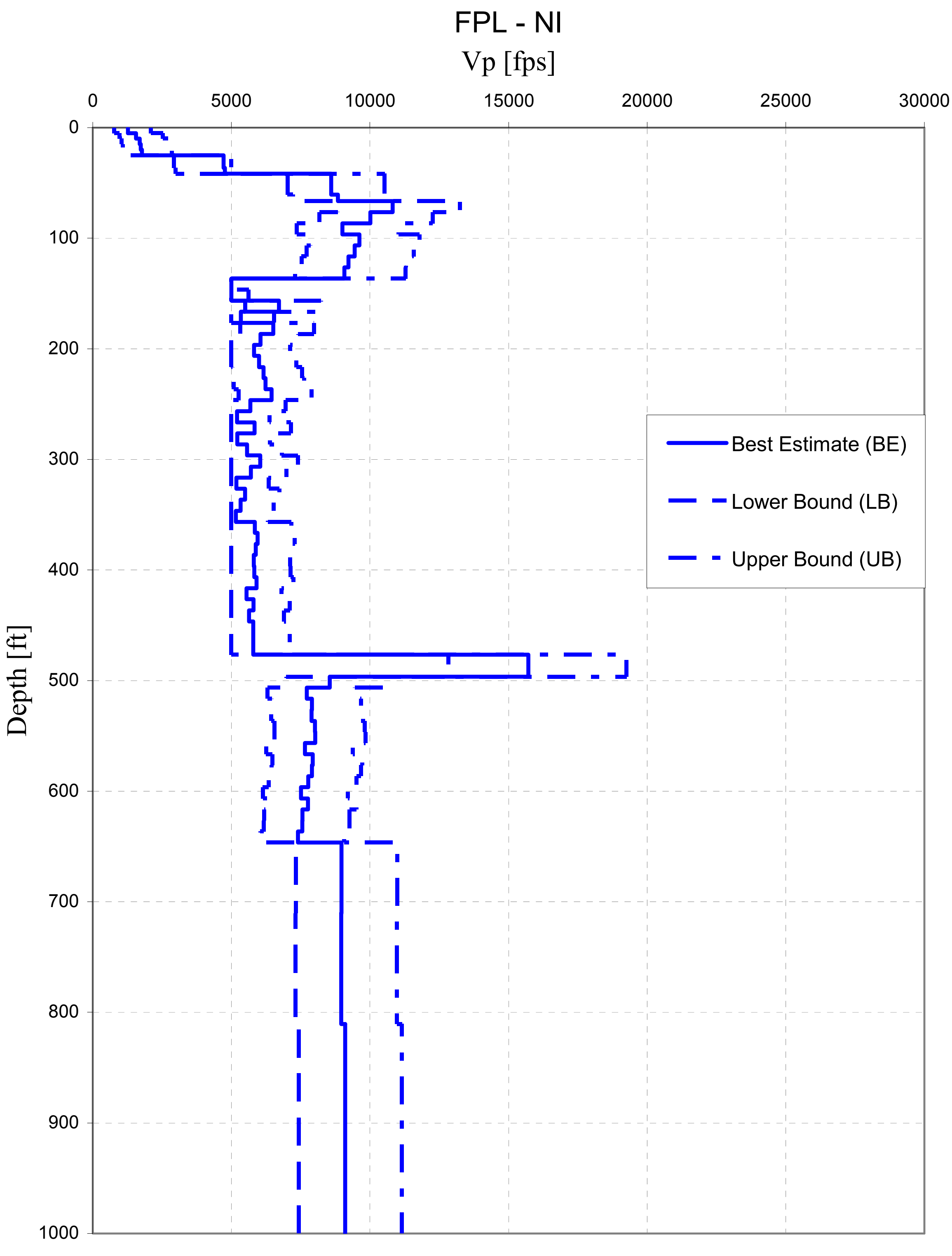


Figure 2-3: Turkey Point Site (FPL) - NI V_P

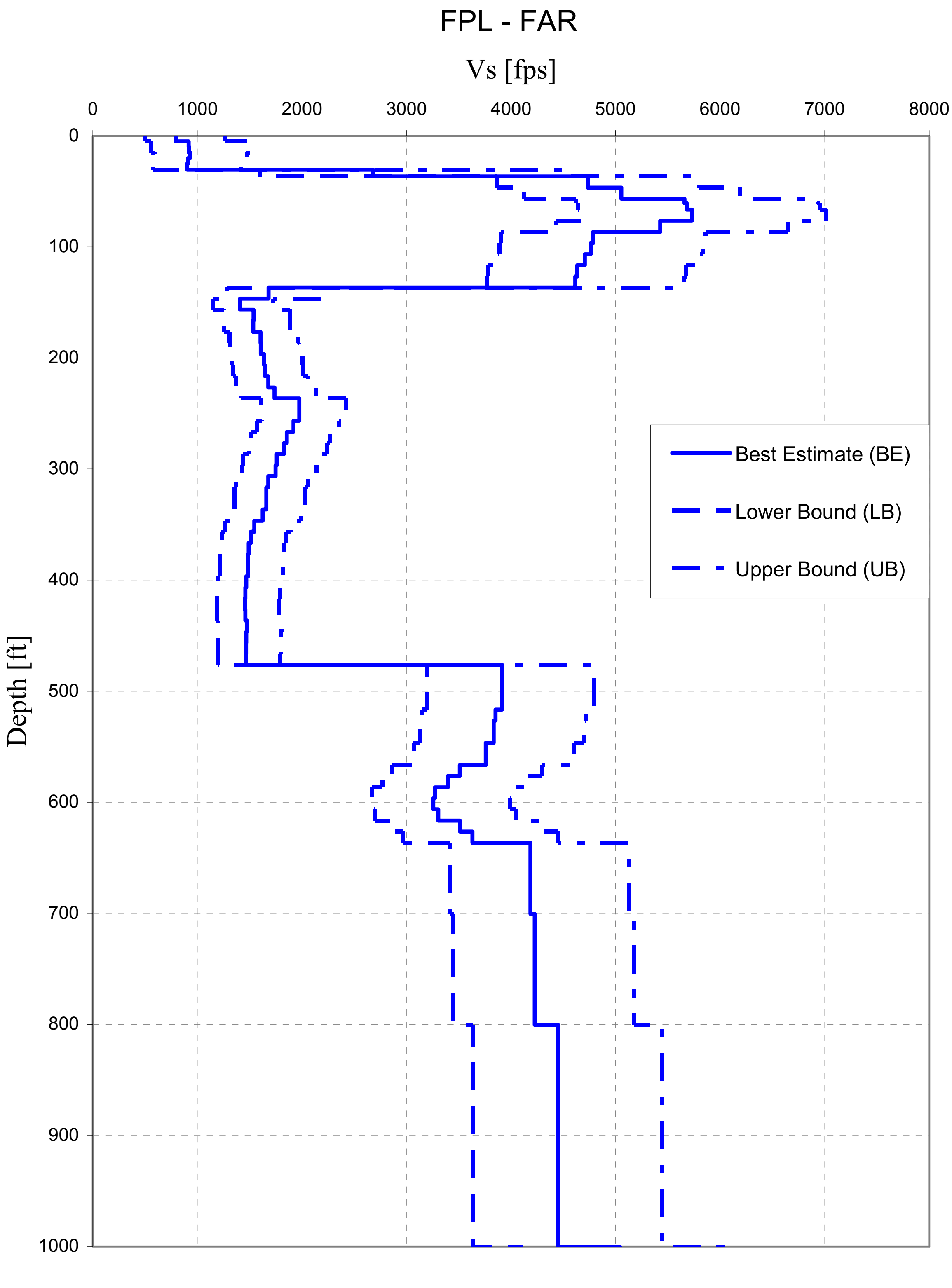


Figure 2-4: Turkey Point Site (FPL) - FAR V_S

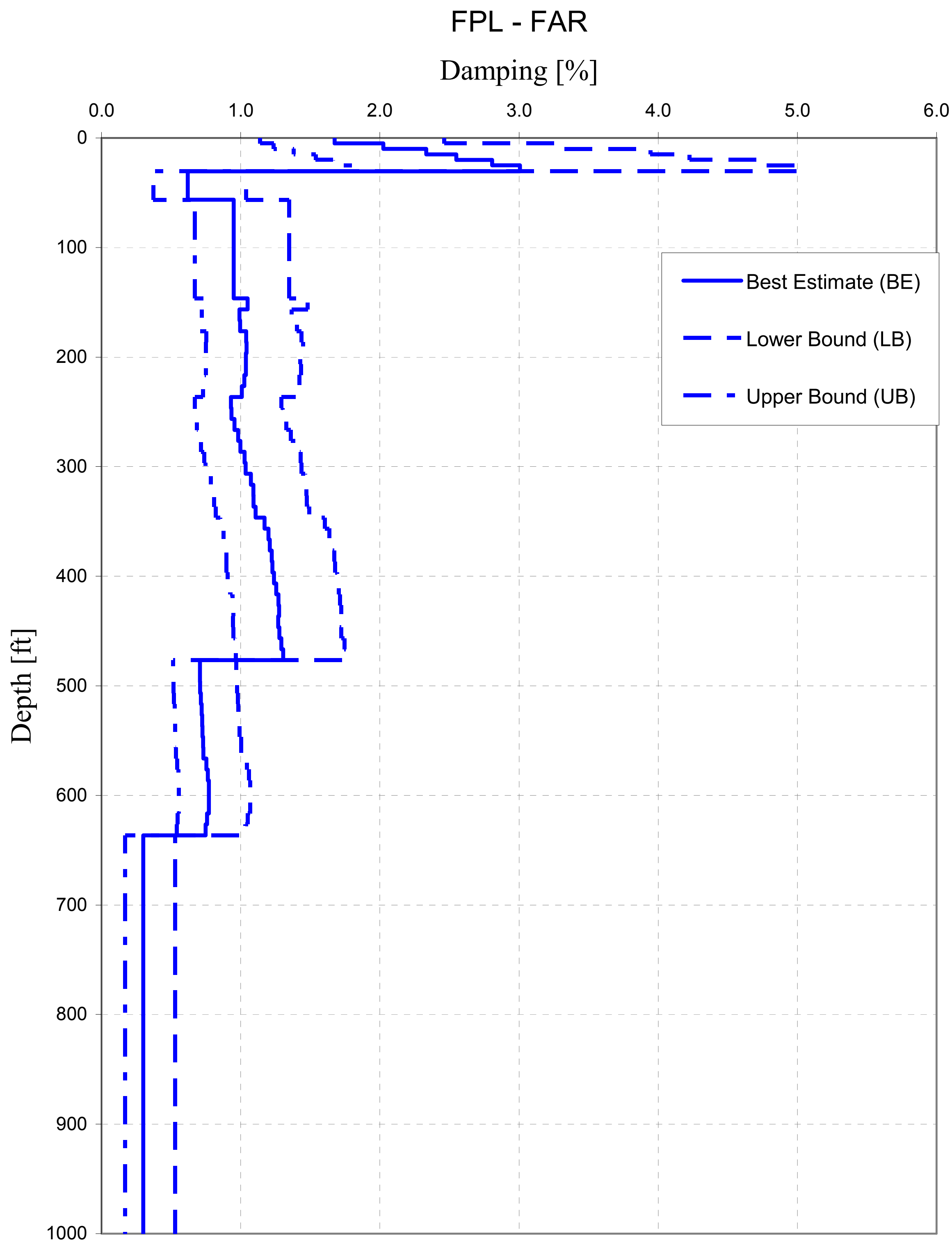


Figure 2-5: Turkey Point Site (FPL) - FAR Damping

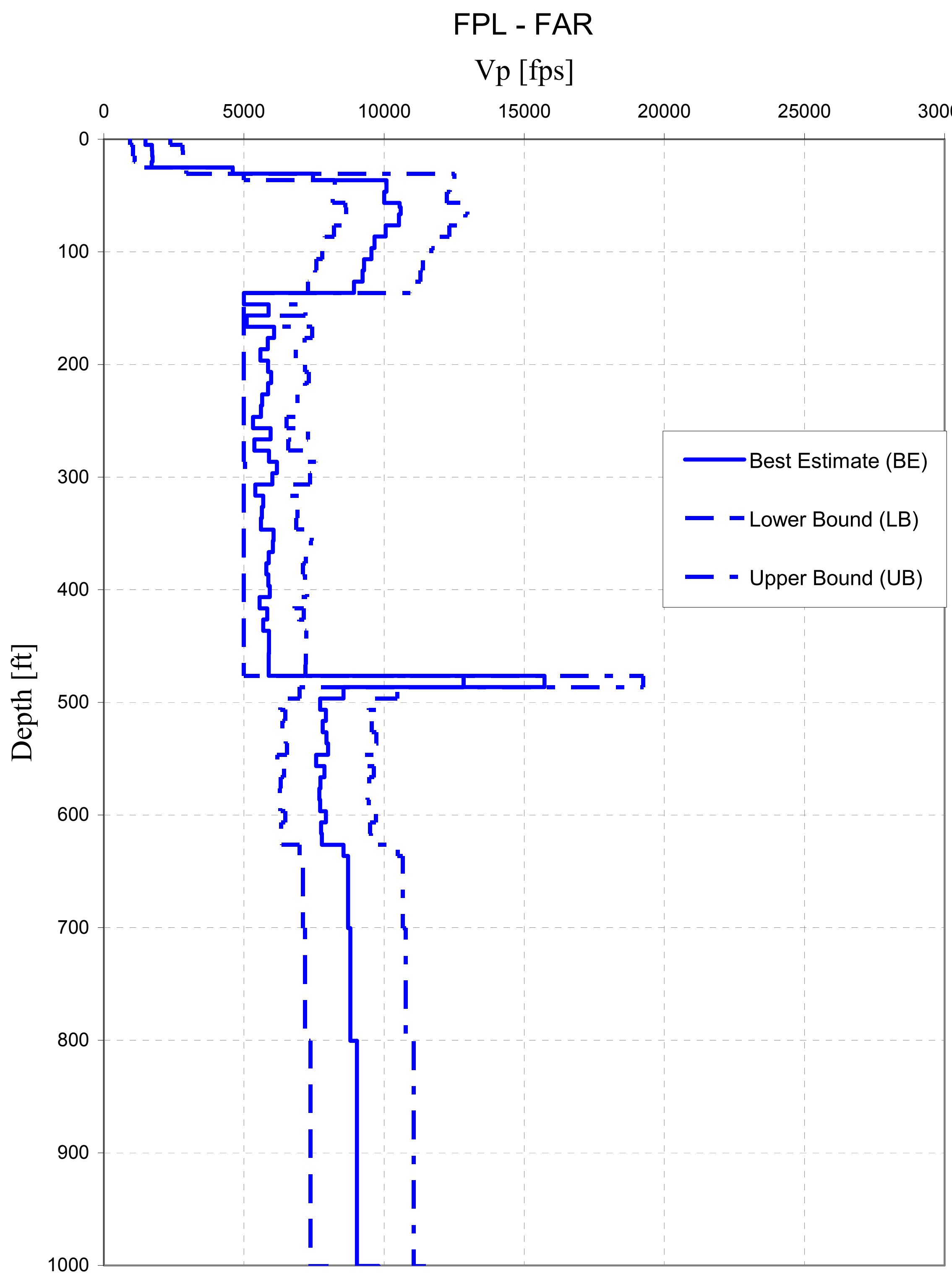


Figure 2-6: Turkey Point Site (FPL) - FAR V_P

2.2 2D Model for Turkey Point

An East-West (EW) cross sectional view of the AP1000 at the Turkey Point Units 6 & 7 Site is shown in Figure 2.1. The overall site elevation will be raised by approximately 25.5 feet with compacted crushed limestone. Adjacent to the Nuclear Island, a circular slurry wall will be constructed to facilitate dewatering of the Nuclear Island excavation. Inside the slurry wall area, the Miami Limestone will be excavated to competent rock, a surface elevation estimated to be approximately 35 feet below Mean Seal Level (MSL) (i.e., - 35 feet). On this surface, approximately 19 feet of mass concrete will be placed to bring the surface to -16 feet for the foundation of the Nuclear Island. Adjacent to the Nuclear Island, backfill (Class 1 compacted limestone) will be placed to bring the ground surface to +25.5 feet MSL.

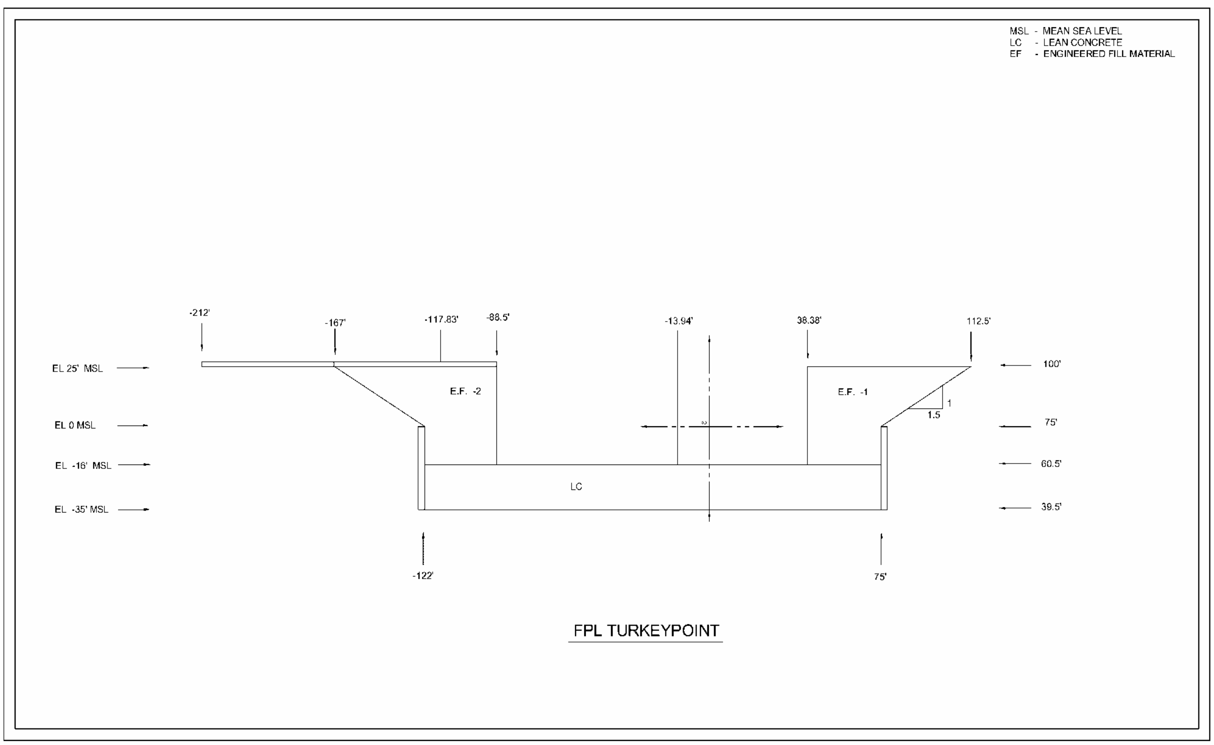


Figure 2-7: EW Cross Section of the AP1000 Plant at the Turkey Point Site

3.0 Turkey Point Analysis Dynamic Soil Properties

The Turkey Point site specific characteristics are analyzed with the SASSI 2D analysis from Bechtel letter: 25409-000-TCM-GEG-00338 (Reference 3). AP1000 plant AP 2D model use the NI soil profile. The soil property used in 2D bathtub model is as follows:

1. Layers 1 to 12 are from FAR soil profiles.
2. Layers 13 to 69 are from NI soil profiles.
3. Half space data equal to Layer 126 NI soil profiles, namely the Unit Weight of 0.17 kcf, the shear wave velocity of 9200 ft/sec, the p wave velocity of 17211.6 ft/sec and the 1% damping.
4. Backfill soil properties (Layers 1 to 8) are from Layers 1 to 8 NI soil profiles.
5. Fill concrete properties (Layers 9 to 12) are from Layers 9 to 12 NI soil profiles.

Tables 3-1 and 3-2 list the Best Estimate (BE) dynamic soil profiles used in the 2D SASSI analysis.

SASSI 3D model uses 64 soil layers from the NI soil profile with the top three layers of 17.5 feet, 22 feet, and 5.5 feet. Tables 3-3 to 3-5 show three dynamic soil profiles analyzed in this report - Medium (Best Estimate), Lower Bound and Upper Bound.

Table 3-1: Turkey Point 2D Soil Profile – Medium (BE)

Layer No.	Thickness [ft]	Unit Weight [kcf]	S-Wave Vel. [ft/sec]	P-Wave Vel. [ft/sec]	Damping
1	5	0.130	792.6	1482.8	0.02
2	5	0.130	916.8	1715.2	0.02
3	5	0.130	920.3	1721.6	0.02
4	5	0.130	931.4	1742.5	0.03
5	5	0.130	912.0	1706.2	0.03
6	5	0.130	902.6	4602.3	0.03
7	3.5	0.125	2681.2	7460.1	0.01
8	6	0.125	4735.1	10085.5	0.01
9	5.5	0.125	4735.1	10085.5	0.01
10	5	0.125	5053.1	9998.6	0.01
11	5	0.125	5053.1	9998.6	0.01
12	5.5	0.136	5658.6	10552.7	0.01
13	5	0.136	5781.3	10815.9	0.01
14	5	0.136	5781.3	10815.9	0.01
15	5	0.136	5449.9	10015.8	0.01
16	5	0.136	5449.9	10015.8	0.01
17	5	0.136	4858.1	9006.7	0.01
18	5	0.136	4858.1	9006.7	0.01
19	5	0.136	4768.7	9622.9	0.01
20	5	0.136	4768.7	9622.9	0.01
21	5	0.136	4712.1	9446.3	0.01
22	5	0.136	4712.1	9446.3	0.01
23	5	0.136	4670.9	9223.8	0.01
24	5	0.136	4670.9	9223.8	0.01
25	5	0.136	4559.3	9080	0.01
26	5	0.136	4559.3	9080	0.01
27	5	0.136	1847	5000	0.01
28	5	0.136	1847	5000	0.01
29	5	0.12	1552.6	5000	0.01
30	5	0.12	1552.6	5000	0.01
31	5	0.12	1612	6723.2	0.01
32	5	0.12	1612	6723.2	0.01
33	5	0.12	1611.4	5341.1	0.01
34	5	0.12	1611.4	5341.1	0.01
35	5	0.12	1648.1	6514.9	0.01
36	5	0.12	1648.1	6514.9	0.01
37	5	0.12	1658.5	6049.1	0.01
38	5	0.12	1658.5	6049.1	0.01
39	5	0.12	1673	5817.4	0.01

Table 3-1: Turkey Point 2D Soil Profile – BE (Cont'd)

Layer No.	Thickness [ft]	Unit Weight [kcf]	S-Wave Vel. [ft/sec]	P-Wave Vel. [ft/sec]	Damping
40	5	0.12	1673	5817.4	0.01
41	5	0.12	1676.8	6001.6	0.01
42	5	0.12	1676.8	6001.6	0.01
43	5	0.12	1697.5	6164.6	0.01
44	5	0.12	1697.5	6164.6	0.01
45	5	0.12	1783.4	6229.6	0.009
46	5	0.12	1783.4	6229.6	0.009
47	5	0.12	1984.7	6444.8	0.009
48	5	0.12	1984.7	6444.8	0.009
49	5	0.12	2001.3	5685	0.009
50	5	0.12	2001.3	5685	0.009
51	5	0.12	1929.8	5203.4	0.009
52	5	0.12	1929.8	5203.4	0.009
53	5	0.12	1883.5	5836.6	0.009
54	5	0.12	1883.5	5836.6	0.009
55	5	0.12	1800.3	5215.9	0.01
56	5	0.12	1800.3	5215.9	0.01
57	5	0.12	1726.5	5563.4	0.01
58	5	0.12	1726.5	5563.4	0.01
59	5	0.12	1722.1	6045.7	0.01
60	5	0.12	1722.1	6045.7	0.01
61	5	0.12	1657.3	5699.9	0.01
62	5	0.12	1657.3	5699.9	0.01
63	5	0.12	1607.8	5179.7	0.011
64	5	0.12	1607.8	5179.7	0.011
65	5	0.12	1603.5	5494.8	0.011
66	5	0.12	1603.5	5494.8	0.011
67	5	0.12	1567.8	5332.1	0.011
68	5	0.12	1567.8	5332.1	0.011
69	5	0.12	1495.6	5161.7	0.011
70		0.17	9200.0	17211.6	0.01

Table 3-2: Turkey Point 2D Backfill Soil and Fill Concrete Profile – BE

Layer No.	Unit Weight [kcf]	S-Wave Vel. [ft/sec]	P-Wave Vel. [ft/sec]	Damping
1	0.130	679.1	1270.5	0.017
2	0.130	832.9	1558.3	0.021
3	0.130	904.4	1691.9	0.023
4	0.130	925.9	1732.2	0.025
5	0.130	946.3	1770.3	0.027
6	0.130	924.8	4715.4	0.029
7	0.130	926.2	4722.9	0.031
8	0.130	935.2	4768.7	0.032
9	0.150	5518.5	8600.0	0.011
10	0.150	5518.5	8600.0	0.011
11	0.150	5518.5	8600.0	0.011
12	0.136	5674.2	8842.7	0.010

Table 3-3: Turkey Point 3D Soil Profile – Best Estimate

Layer No.	Thickness [ft]	Unit Weight [kcf]	S-Wave Vel. [ft/sec]	P-Wave Vel. [ft/sec]	Damping
1	17.5	0.13	835.6	1563.2	0.022
2	22	0.13	931.7	3541.9	0.029
3	5.5	0.15	5518.5	8600	0.011
4	7	0.15	5518.5	8600	0.011
5	6.33	0.15	5518.5	8600	0.011
6	6	0.136	5674.2	8842.7	0.01
7	10	0.136	5781.3	10815.9	0.01
8	10	0.136	5449.9	10015.8	0.01
9	10	0.136	4858.1	9006.7	0.01
10	10	0.136	4768.7	9622.9	0.01
11	10	0.136	4712.1	9446.3	0.01
12	10	0.136	4670.9	9223.8	0.01
13	10	0.136	4559.3	9080	0.01
14	10	0.136	1847	5000	0.01
15	10	0.12	1552.6	5000	0.01
16	10	0.12	1612	6723.2	0.01
17	10	0.12	1611.4	5341.1	0.01
18	10	0.12	1648.1	6514.9	0.01
19	10	0.12	1658.5	6049.1	0.01
20	10	0.12	1673	5817.4	0.01
21	10	0.12	1676.8	6001.6	0.01
22	10	0.12	1697.5	6164.6	0.01
23	10	0.12	1783.4	6229.6	0.009
24	10	0.12	1984.7	6444.8	0.009
25	10	0.12	2001.3	5685	0.009
26	10	0.12	1929.8	5203.4	0.009
27	10	0.12	1883.5	5836.6	0.009
28	10	0.12	1800.3	5215.9	0.01
29	10	0.12	1726.5	5563.4	0.01
30	10	0.12	1722.1	6045.7	0.01
31	10	0.12	1657.3	5699.9	0.01
32	10	0.12	1607.8	5179.7	0.011
33	10	0.12	1603.5	5494.8	0.011
34	10	0.12	1567.8	5332.1	0.011
35	10	0.12	1495.6	5161.7	0.011
36	10	0.12	1490.7	5848.2	0.011
37	10	0.12	1489.8	5945.5	0.011
38	10	0.12	1488.1	5879.4	0.012
39	10	0.12	1487.6	5810.1	0.012
40	10	0.12	1474.5	5827.1	0.012
41	10	0.12	1466.2	5908.8	0.012
42	10	0.12	1457.6	5551	0.012

Table 3-3: Turkey Point 3D Soil Profile – Best Estimate (Cont'd)

Layer No.	Thickness [ft]	Unit Weight [kcf]	S-Wave Vel. [ft/sec]	P-Wave Vel. [ft/sec]	Damping
43	10	0.12	1448.9	5800	0.012
44	10	0.12	1445.4	5635.2	0.012
45	10	0.12	1446.1	5790.2	0.012
46	10	0.12	1441.6	5793.2	0.012
47	10	0.12	1441	5788.1	0.013
48	10	0.13	3913.6	15720.1	0.007
49	10	0.13	3913.4	15719.5	0.007
50	10	0.13	3913.3	8549.2	0.007
51	10	0.13	3913.2	7719.9	0.007
52	10	0.13	3901.3	7903.4	0.007
53	10	0.13	3891	7891.1	0.007
54	10	0.13	3873	8018.8	0.007
55	10	0.13	3847.3	8027.7	0.007
56	10	0.13	3800.1	7658.9	0.007
57	10	0.13	3790.9	7938.7	0.007
58	10	0.13	3588	7903.1	0.007
59	10	0.13	3432.3	7776	0.007
60	10	0.13	3184	7513.6	0.007
61	10	0.13	3191.8	7763.7	0.007
62	10	0.13	3222.5	7564.4	0.007
63	10	0.13	3410.8	7557.8	0.007
64	10	0.13	3556.1	7402.6	0.007
65		0.17	9200	17211.6	0.01

Table 3-4: Turkey Point 3D Soil Profile – Lower Bound

Layer No.	Thickness [ft]	Unit Weight [kcf]	S-Wave Vel. [ft/sec]	P-Wave Vel. [ft/sec]	Damping
1	17.5	0.13	514.4	962.3	0.035
2	22	0.13	579.9	2204.7	0.049
3	5.5	0.15	4505.9	7021.9	0.015
4	7	0.15	4505.9	7021.9	0.015
5	6.33	0.15	4505.9	7021.9	0.015
6	6	0.136	4633	7220	0.014
7	10	0.136	4720.4	8831.1	0.014
8	10	0.136	4449.8	8177.8	0.014
9	10	0.136	3966.7	7353.9	0.014
10	10	0.136	3893.6	7857.1	0.014
11	10	0.136	3847.4	7712.9	0.014
12	10	0.136	3813.8	7531.2	0.014
13	10	0.136	3669.2	7307.4	0.014
14	10	0.136	1409.7	5000	0.014
15	10	0.12	1267.7	5000	0.015
16	10	0.12	1316.2	5489.4	0.015
17	10	0.12	1315.7	5000	0.015
18	10	0.12	1345.7	5319.4	0.013
19	10	0.12	1354.2	5000	0.013
20	10	0.12	1366	5000	0.013
21	10	0.12	1369.1	5000	0.013
22	10	0.12	1386	5033.3	0.013
23	10	0.12	1456.1	5086.4	0.013
24	10	0.12	1620.5	5262.2	0.012
25	10	0.12	1634	5000	0.012
26	10	0.12	1575.7	5000	0.012
27	10	0.12	1537.9	5000	0.013
28	10	0.12	1469.9	5000	0.013
29	10	0.12	1409.7	5000	0.013
30	10	0.12	1406.1	5000	0.014
31	10	0.12	1353.2	5000	0.014
32	10	0.12	1312.8	5000	0.015
33	10	0.12	1309.2	5000	0.015
34	10	0.12	1280.1	5000	0.015
35	10	0.12	1221.1	5000	0.016
36	10	0.12	1217.2	5000	0.016
37	10	0.12	1216.4	5000	0.016
38	10	0.12	1215	5000	0.016
39	10	0.12	1214.7	5000	0.016
40	10	0.12	1203.9	5000	0.016
41	10	0.12	1197.2	5000	0.016
42	10	0.12	1190.1	5000	0.016
43	10	0.12	1183.1	5000	0.017

Table 3-4: Turkey Point 3D Soil Profile – Lower Bound (Cont'd)

Layer No.	Thickness [ft]	Unit Weight [kcf]	S-Wave Vel. [ft/sec]	P-Wave Vel. [ft/sec]	Damping
44	10	0.12	1180.2	5000	0.017
45	10	0.12	1180.8	5000	0.017
46	10	0.12	1177.1	5000	0.017
47	10	0.12	1176.6	5000	0.017
48	10	0.13	3195.4	12835.4	0.009
49	10	0.13	3195.3	12834.9	0.009
50	10	0.13	3195.2	6980.4	0.009
51	10	0.13	3195.1	6303.3	0.009
52	10	0.13	3185.4	6453.1	0.009
53	10	0.13	3177	6443.1	0.009
54	10	0.13	3162.3	6547.3	0.009
55	10	0.13	3141.3	6554.6	0.009
56	10	0.13	3102.7	6253.5	0.009
57	10	0.13	3095.3	6482	0.009
58	10	0.13	2929.6	6452.9	0.01
59	10	0.13	2802.5	6349.1	0.01
60	10	0.13	2599.8	6134.8	0.01
61	10	0.13	2606.1	6339	0.01
62	10	0.13	2631.2	6176.3	0.01
63	10	0.13	2784.9	6170.9	0.01
64	10	0.13	2903.6	6044.2	0.01
65		0.17	9200	17211.6	0.01

Table 3-5: Turkey Point 3D Soil Profile – Upper Bound

Layer No.	Thickness [ft]	Unit Weight [kcf]	S-Wave Vel. [ft/sec]	P-Wave Vel. [ft/sec]	Damping
1	17.5	0.13	1357.5	2539.6	0.013
2	22	0.13	1497	4126	0.017
3	5.5	0.15	6758.8	10532.8	0.008
4	7	0.15	6758.8	10532.8	0.008
5	6.33	0.15	6758.8	10532.8	0.008
6	6	0.136	6949.5	10830	0.007
7	10	0.136	7080.6	13246.7	0.007
8	10	0.136	6674.7	12266.8	0.007
9	10	0.136	5950	11030.9	0.007
10	10	0.136	5840.4	11785.6	0.007
11	10	0.136	5771.1	11569.3	0.007
12	10	0.136	5720.7	11296.8	0.007
13	10	0.136	5665.2	11282.6	0.007
14	10	0.136	2419.9	5000	0.007
15	10	0.12	1901.5	5621.6	0.007
16	10	0.12	1974.3	8234.1	0.007
17	10	0.12	1973.6	6541.5	0.007
18	10	0.12	2018.5	7979.1	0.007
19	10	0.12	2031.3	7408.6	0.007
20	10	0.12	2049	7124.8	0.007
21	10	0.12	2053.7	7350.5	0.007
22	10	0.12	2079	7550	0.007
23	10	0.12	2184.2	7629.7	0.007
24	10	0.12	2430.7	7893.2	0.006
25	10	0.12	2451	6962.7	0.006
26	10	0.12	2363.6	6372.9	0.007
27	10	0.12	2306.8	7148.4	0.007
28	10	0.12	2204.9	6388.1	0.007
29	10	0.12	2114.5	6813.7	0.007
30	10	0.12	2109.1	7404.5	0.007
31	10	0.12	2029.7	6980.9	0.008
32	10	0.12	1969.2	6343.8	0.008
33	10	0.12	1963.9	6729.7	0.008
34	10	0.12	1920.2	6530.4	0.008
35	10	0.12	1831.7	6321.8	0.008
36	10	0.12	1825.8	7162.6	0.008
37	10	0.12	1824.6	7281.7	0.008
38	10	0.12	1822.5	7200.7	0.008
39	10	0.12	1822	7115.9	0.008
40	10	0.12	1805.8	7136.8	0.009
41	10	0.12	1795.7	7236.7	0.009

Table 3-5: Turkey Point 3D Soil Profile – Upper Bound (Cont'd)

Layer No.	Thickness [ft]	Unit Weight [kcf]	S-Wave Vel. [ft/sec]	P-Wave Vel. [ft/sec]	Damping
42	10	0.12	1785.1	6798.5	0.009
43	10	0.12	1774.6	7103.5	0.009
44	10	0.12	1770.2	6901.7	0.009
45	10	0.12	1771.1	7091.6	0.009
46	10	0.12	1765.6	7095.2	0.009
47	10	0.12	1764.8	7089	0.009
48	10	0.13	4793.1	19253.1	0.005
49	10	0.13	4792.9	19252.4	0.005
50	10	0.13	4792.8	10470.6	0.005
51	10	0.13	4792.6	9455	0.005
52	10	0.13	4778.1	9679.7	0.005
53	10	0.13	4765.5	9664.6	0.005
54	10	0.13	4743.4	9821	0.005
55	10	0.13	4712	9831.9	0.005
56	10	0.13	4654.1	9380.2	0.005
57	10	0.13	4642.9	9722.9	0.005
58	10	0.13	4394.3	9679.3	0.005
59	10	0.13	4203.7	9523.6	0.005
60	10	0.13	3899.6	9202.3	0.005
61	10	0.13	3909.1	9508.5	0.005
62	10	0.13	3946.7	9264.5	0.005
63	10	0.13	4177.4	9256.4	0.005
64	10	0.13	4355.3	9066.3	0.005
65		0.17	9200	17211.6	0.01

4.0 Turkey Point Site Seismic Input

The Turkey Point Foundation Input Response Spectra (FIRS) at the Nuclear Island has the peak ground accelerations for the Safe Shutdown Earthquake equal to 0.056g for horizontal and 0.048g for vertical. These seismic response spectra are shown in Figures 4-1 to 4-3. The corresponding time histories used in the site-specific SSI analysis are ratioed up to 0.1g Zero Period Accelerate (ZPA). Table 4-1 provides the list of excel files which document the corresponding time history data. Figures 4-4 to 4-6 show the Best Estimate time histories in the Horizontal direction 1 (H1), 2 (H2), and the Vertical Direction (Vp), respectively.

Table 4-1: Turkey Point Time History Files

Soil Case	File Name	ZPA	Ratio
Median	FPL-NI-BE-H1	0.056	1.79
	FPL-NI-BE-H2	0.048	2.08
	FPL-NI-BE-Up	0.045	2.22
Lower Bound	FPL-NI-LB-H1	0.049	2.04
	FPL-NI-LB-H2	0.047	2.13
	FPL-NI-LB-Up	0.049	2.04
Upper Bound	FPL-NI-UB-H1	0.047	2.13
	FPL-NI-UB-H2	0.055	1.82
	FPL-NI-UB-Up	0.046	2.17
Minimum Ratio to 0.1g ZPA			1.79

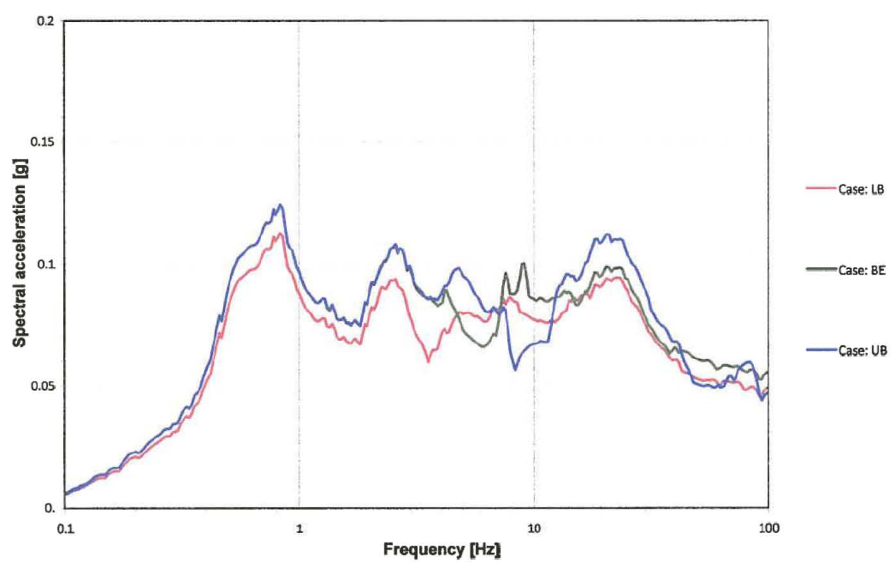


Figure 4-1: Turkey Point Foundation Input Response Spectra in Horizontal Direction 1 (H1)

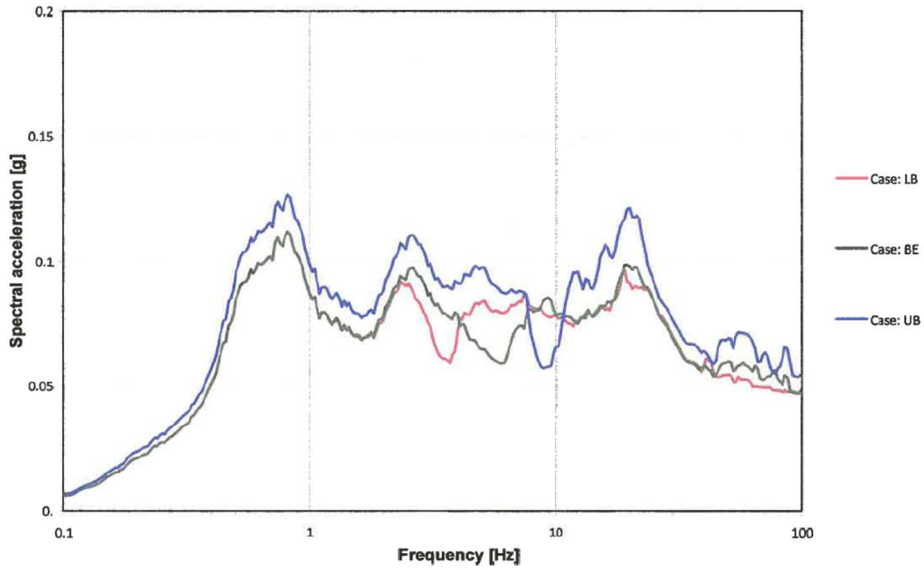


Figure 4-2: Turkey Point Foundation Input Response Spectra in Horizontal Direction 2 (H2)

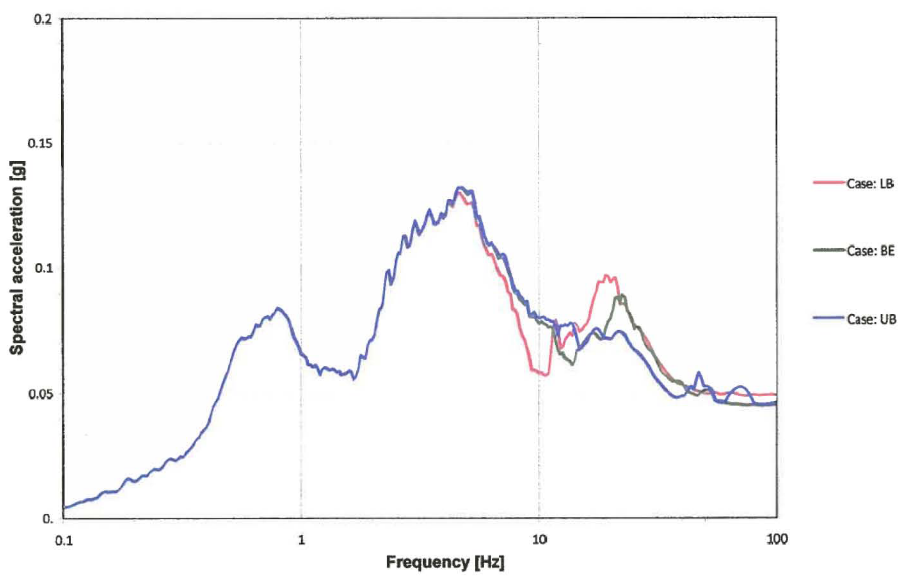


Figure 4-3: Turkey Point Vertical Foundation Input Response Spectra (UP)

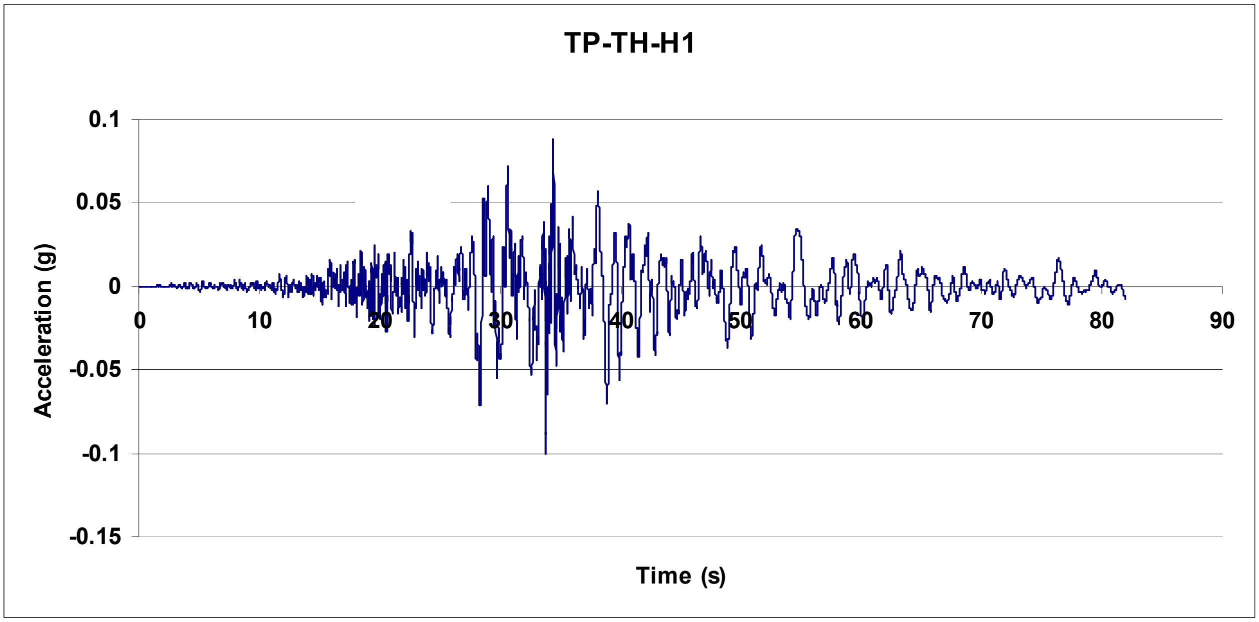


Figure 4-4: Turkey Point Acceleration Time History in Horizontal Direction 1 (H1)

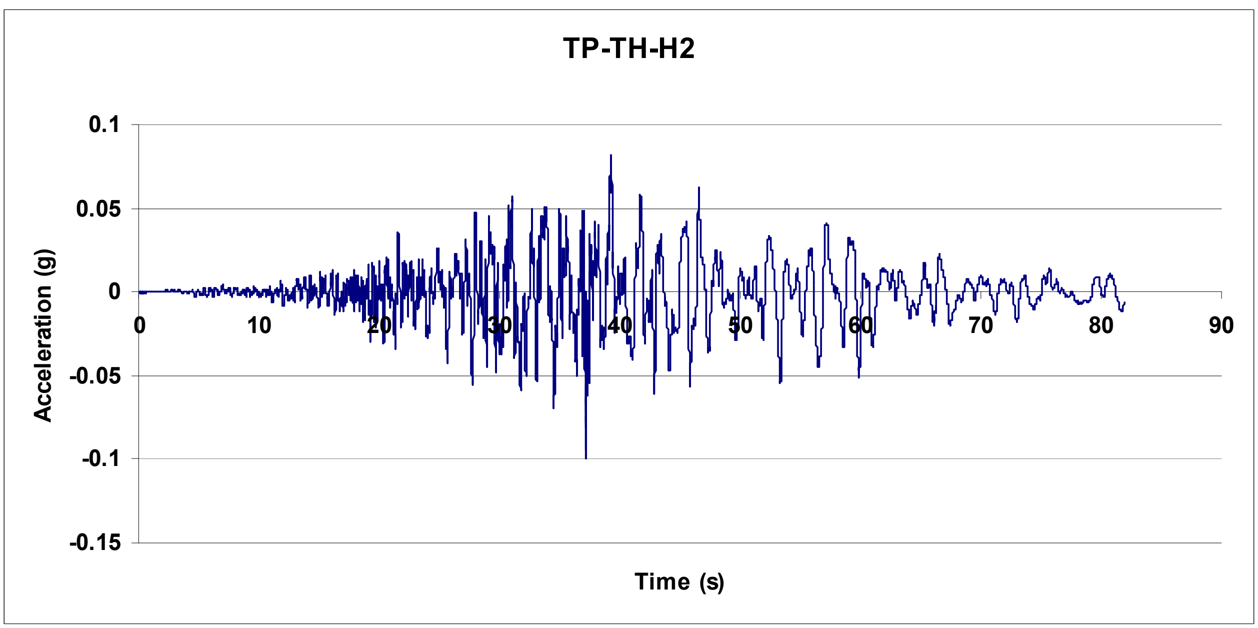


Figure 4-5: Turkey Point Acceleration Time History in Horizontal Direction 2 (H2)

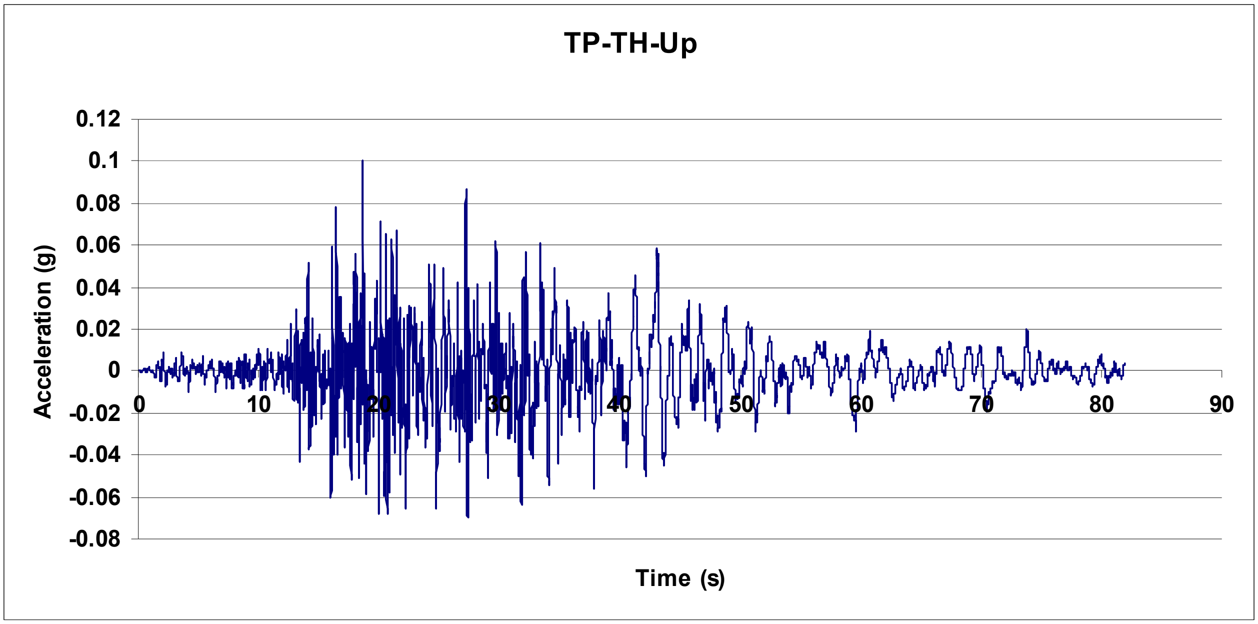


Figure 4-6: Turkey Point Vertical Accerleration Time History (UP)

5.0 SASSI Parametric Studies

Parametric studies were performed to address and define the following;

- Extent of subsurface characterization;
- Site response characteristics and surface motions
- Effects of the fill concrete underlying the Nuclear Island footprint;

Two models will be used for the parametric study: a SASSI stick model and a SASSI bathtub model.

5.1 SASSI Stick Model

The 2D model of the AP1000 Nuclear Island is the stick model representing the Auxiliary Shield Building (ASB), the Steel Containment Vessel (SCV), and the Containment Internal Structure (CIS). In the 2D model, the Nuclear Island sticks are considered in conjunction with their foundation and supporting media to form a soil-structure interaction model. This model is shown in Figure 5-1. From the analysis using the 2D models, the important modes of the structure and the seismic interaction between the nuclear island structures and supporting media are obtained. It is noted that the stick models for the ASB, SCV, and CIS are collocated, and therefore, appear as one stick even if there are three sticks present as shown in Figure 5-1.

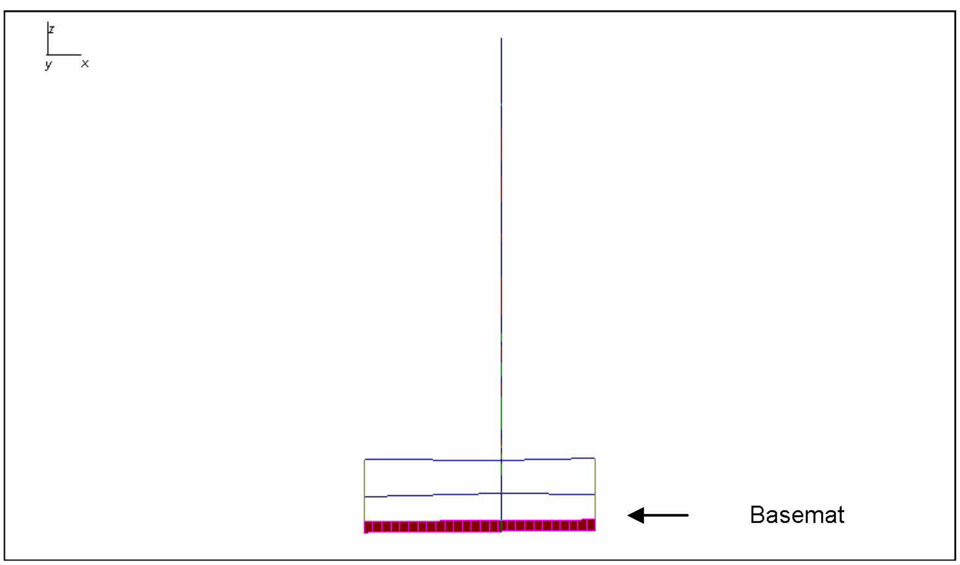


Figure 5-1: 2D Soil Structure Interaction Stick Model

5.2 SASSI Bathtub Model

The 2D SASSI Bathtub Model was developed to represent the East-West (EW) cross section of the AP1000 plant at the Turkey Point site. The 2D SASSI East-West (EW) Bathtub Model for Turkey Point is shown in Figure 5-2.

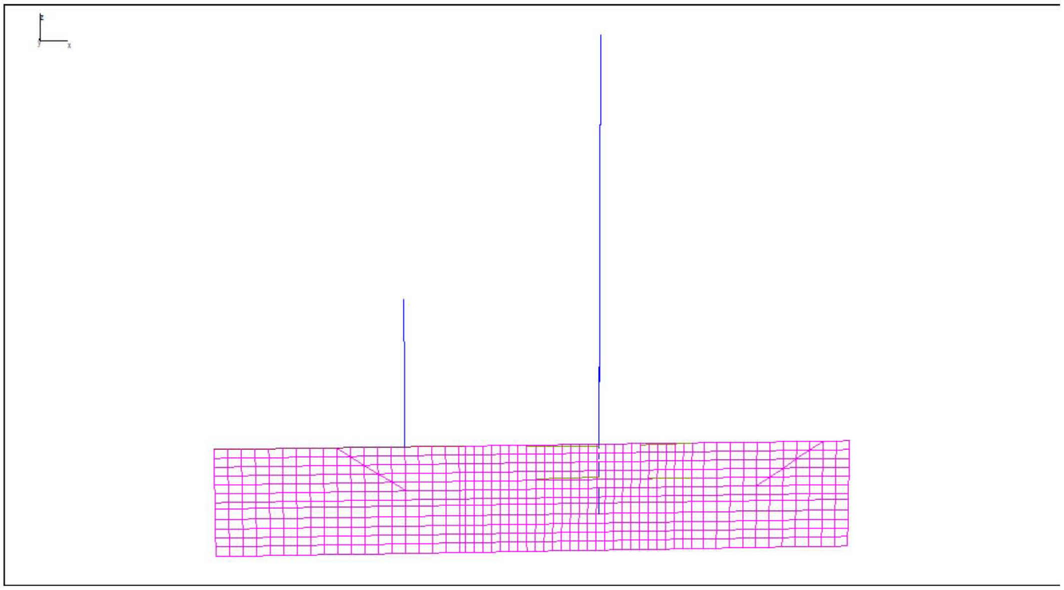


Figure 5-2: 2D SASSI Bathtub Model for Turkey Point AP1000

6.0 2D SASSI Analysis Results

The 2D SASSI analyses performed consist of the following two cases:

- The 2D SASSI AP1000 Stick Model with the Turkey Point Best Estimate NI soil profile subjected to the Turkey Point Best Estimate acceleration time history, referred to as AP-BE;
- The 2D SASSI Bathtub Model with the Turkey Point Best Estimate bathtub soil profile subjected to the Turkey Point Best Estimate acceleration time history, referred to as TP-2D-BE;

The response spectra at 5% damping and the transfer functions at six key locations of the Nuclear Island were generated by the 2D SASSI analyses. These six key locations are defined in Table 6-1. The response spectra are calculated in the EW (Y) direction. Figures 6-1 through 6-6 compare the 5% damping response spectra calculated by the above mentioned 2D SASSI analysis cases and generic soil cases envelope (ssienv_ap2d) at these six locations, respectively. The ZPA of the calculated response spectra are summarized in Table 6-2.

The response spectra of 2D SASSI stick model AP-BE and the bathtub TP-2D-BE are in good agreement for most of the frequency ranges. Based on the comparison results, it can be concluded that the 3D SASSI analysis using the Turkey Point NI soil profile is justified.

The subsequent 3D analysis shall be performed using the Turkey Point NI soil profile and compared with the AP1000 CSDRS. The 3D SASSI analysis is documented in Section 7.0.

Table 6-1: Six Key Locations of Nuclear Island

Location	2D Elevations (ft)	NI20 SASSI 2D Node	NI20 SASSI 3D Node	General Area
CIS at Reactor Vessel Support Elevation	99.00	4041	1761	RPV Center
CIS at Operating Deck	134.25	4535	2199	SG West Compartment, NE
ASB NE Corner at Control Room Floor	116.50	4061	2078	NE Corner
ASB Corner of Fuel Building Roof at Shield Building	179.19	4120	2675	NW Corner of Fuel Bldg
ASB Shield Building Roof Area	327.41	4310	3329	South Side of Shield Bldg
SCV Near Polar Crane	224.00	4412	2788	SCV Stick Model

Table 6-2: 2D SSI ZPA Comparison in EW (Y) Direction

Nodes	Elevation (ft)	AP	BE	Ratio
4041	99.0	0.085	0.083	0.98
4061	116.5	0.086	0.092	1.07
4120	179.56	0.123	0.116	0.94
4310	327.4	0.277	0.281	1.01
4412	224.0	0.181	0.199	1.10
4535	134.25	0.136	0.105	0.77
Maximum BE ZPA / AP ZPA				1.07

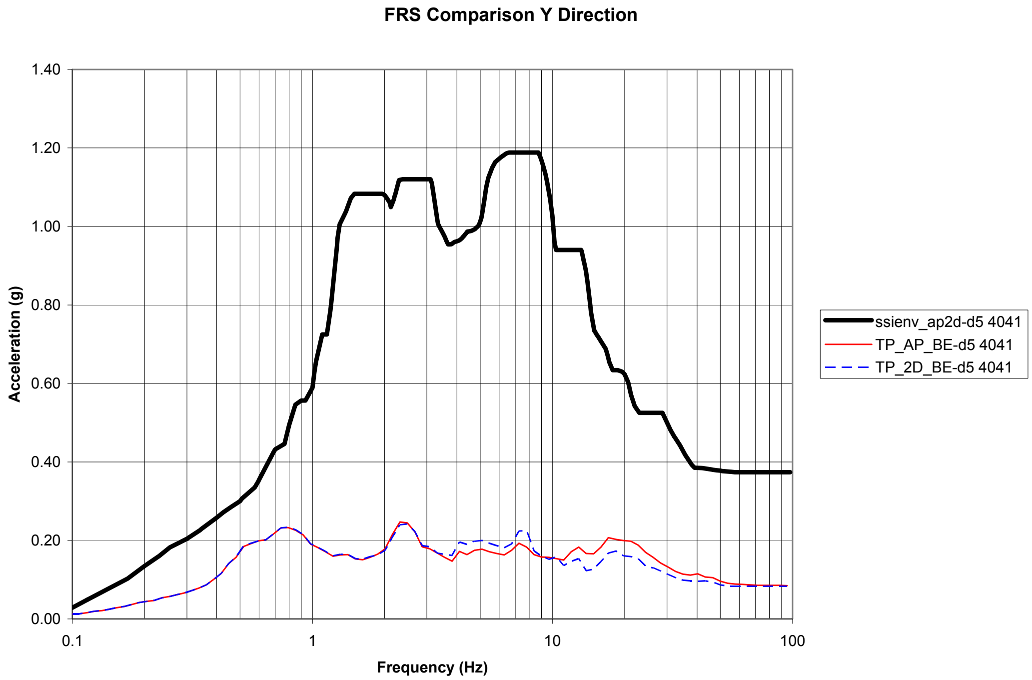


Figure 6-1: Response Spectra Comparison of Node 4041 in EW (Y) Direction

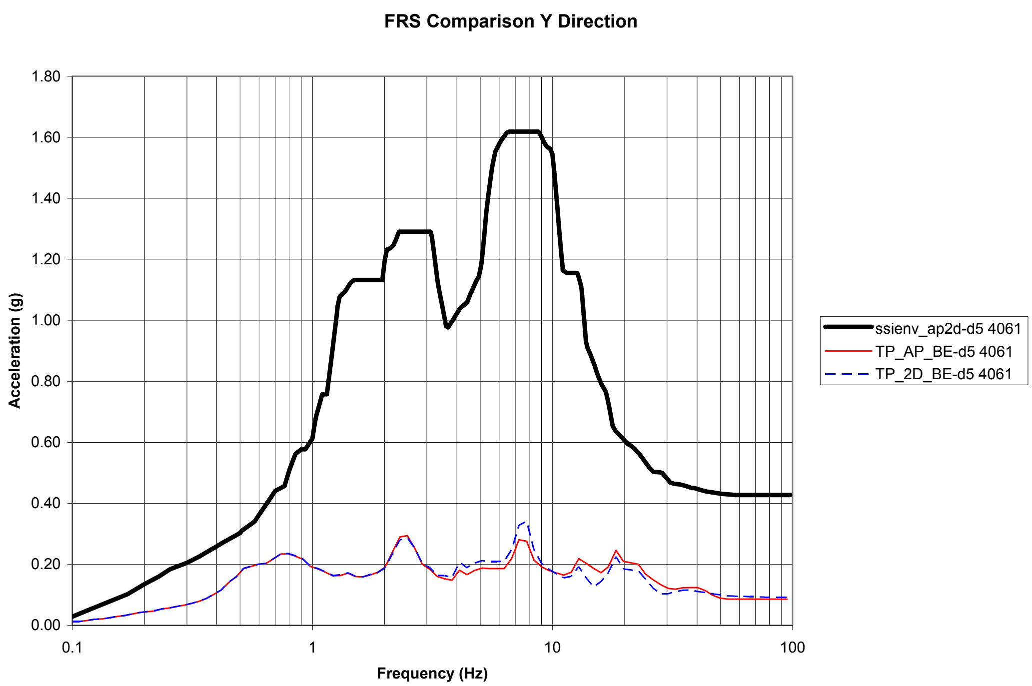


Figure 6-2: Response Spectra Comparison of Node 4061 in EW (Y) Direction

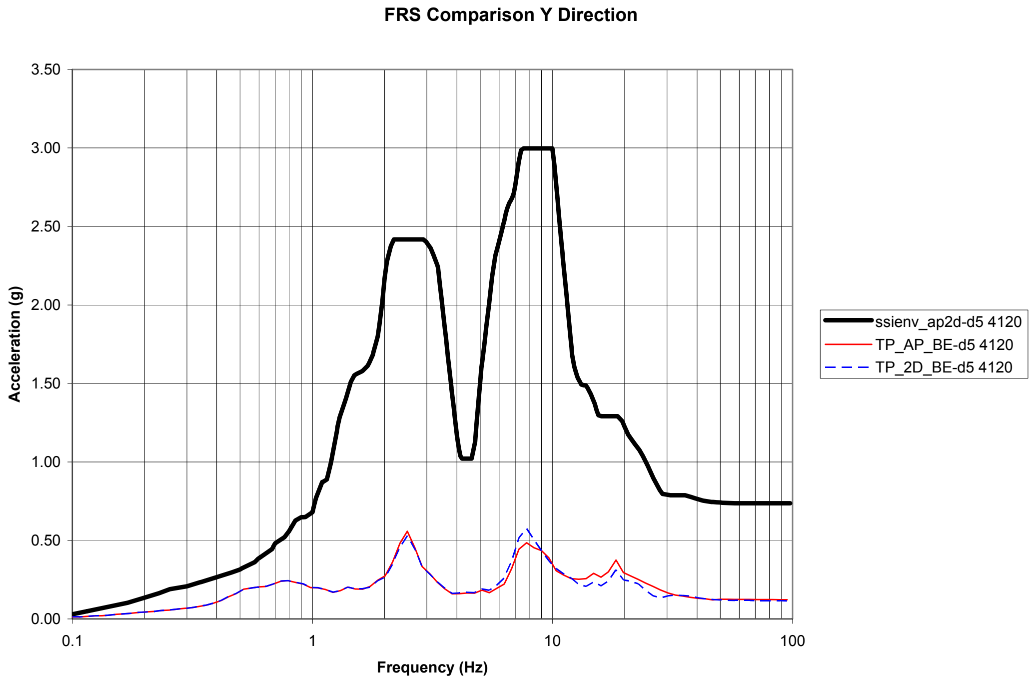


Figure 6-3: Response Spectra Comparison of Node 4120 in EW (Y) Direction

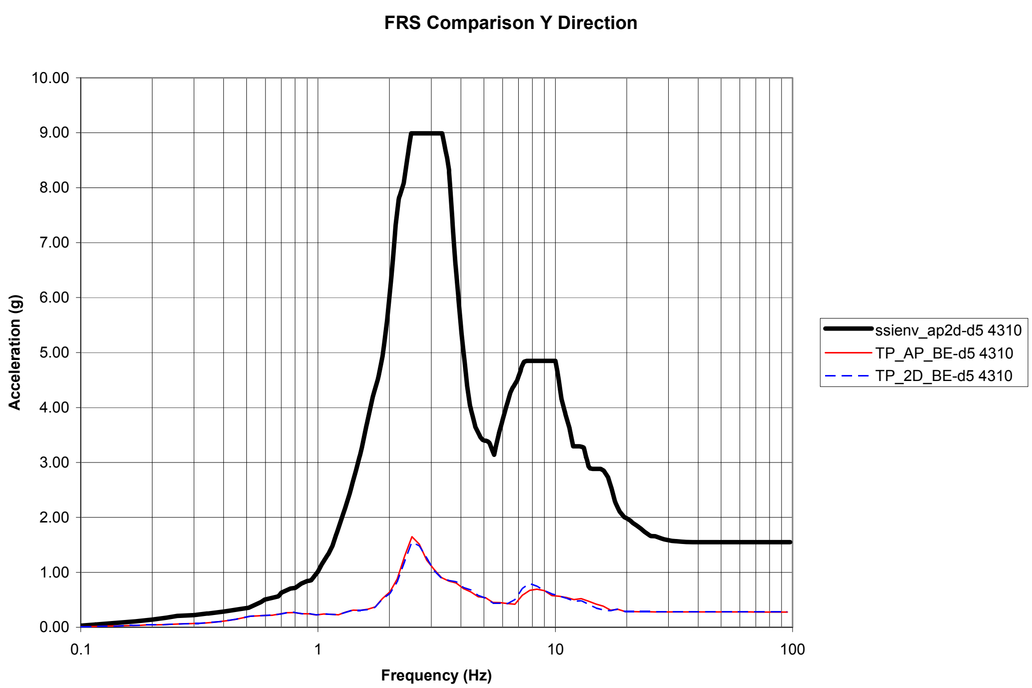


Figure 6-4: Response Spectra Comparison of Node 4310 in EW (Y) Direction

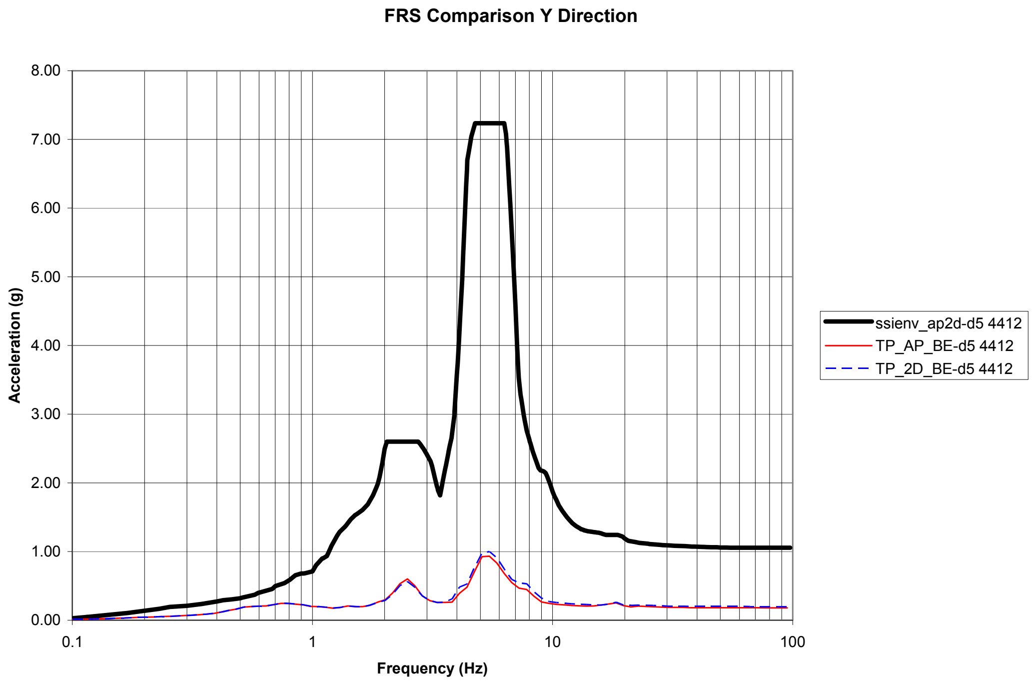


Figure 6-5: Response Spectra Comparison of Node 4412 in EW (Y) Direction

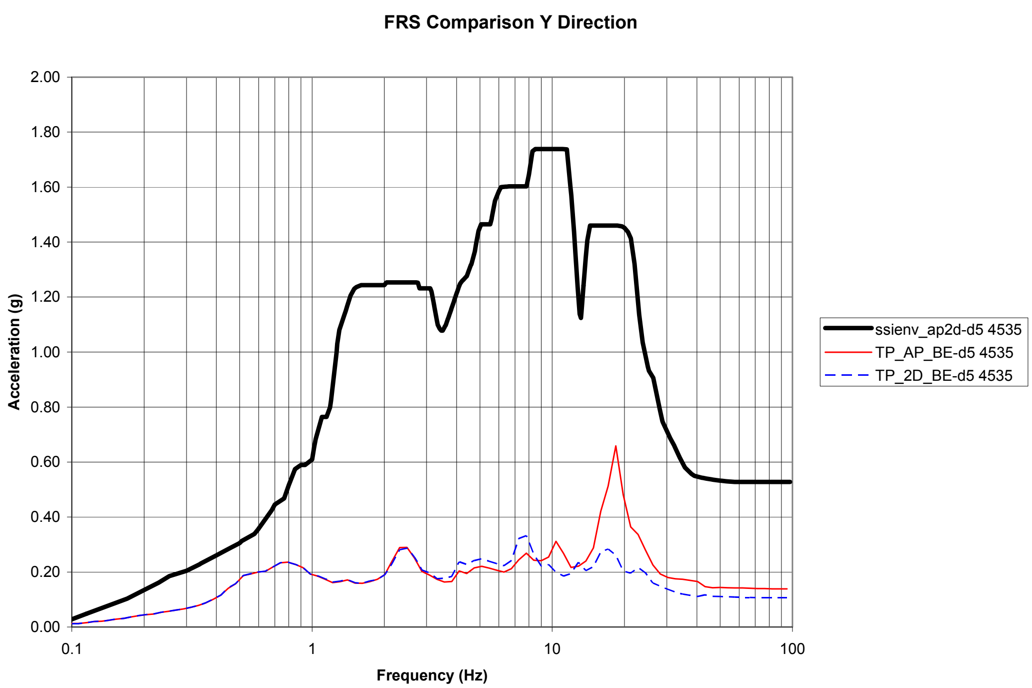


Figure 6-6: Response Spectra Comparison of Node 4535 in EW (Y) Direction

7.0 3D SASSI Analysis

The 3D SASSI finite element model of the AP1000 Nuclear Island course model (NI20) is used for the soil structure interaction analysis. The three building structures that make up the nuclear island are the coupled auxiliary and shield building (ASB), the steel containment vessel (SCV), and the containment internal structures (CIS).

The Nuclear Island structures, including the SCV, the CIS, and the ASB are founded on a common basemat. The nuclear island is embedded approximately forty feet below an assumed plant grade (for modeling purposes) located at Plant Grade Elevation 100’-0”. Thus, the bottom of the basemat is located at Plant Elevation 60’-6”. Figure 7-1 shows the 3D NI20 Finite Element Model as described in the Westinghouse Technical Report TR03 (APP-GW-S2R-010, “Extension of Nuclear Island Seismic Analysis to Soil Site”, Reference 4.)
.

The steel containment vessel is a freestanding cylindrical steel structure with elliptical upper and lower heads. It is surrounded by the reinforced concrete shield building. The inside diameter and height are equal to 130’ and 215’4”, respectively. The top of the containment is at Elevation 281’10”.

The containment internal structures are designed using reinforced concrete and structural steel. At the lower elevations conventional concrete and reinforcing steel are used, except that permanent steel forms are used in some areas in lieu of removable forms based on constructability considerations. These modules are structural elements built up with welded structural shapes and plates. Concrete is used where required for shielding, but reinforcing steel in the form of bars is not normally used.

The shield building is an enhanced cylindrical reinforced concrete structure which includes the open annulus area surrounding the containment vessel. It has a conical roof structure which supports the containment air cooling diffuser and the Passive Containment Cooling System (PCCS) water storage tank.

The auxiliary building is a reinforced concrete structure. Structural modules, similar to those used in the containment internal structures, are used in the southern portion of the auxiliary building. It essentially wraps approximately 50 percent of the circumference of the shield building. The floor slabs and the structural walls of the auxiliary building are structurally connected to the cylindrical section of the shield building. The auxiliary building includes the fuel handling area located south of the shield building.

The 3D SASSI analysis was performed on the Turkey Point site using Best Estimate, Lower Bound and Upper Bound NI soil profiles and the corresponding acceleration time histories in the Horizontal Directions 1 (H1), 2 (H2) and the Vertical Direction (Up) as shown in Section 4.0

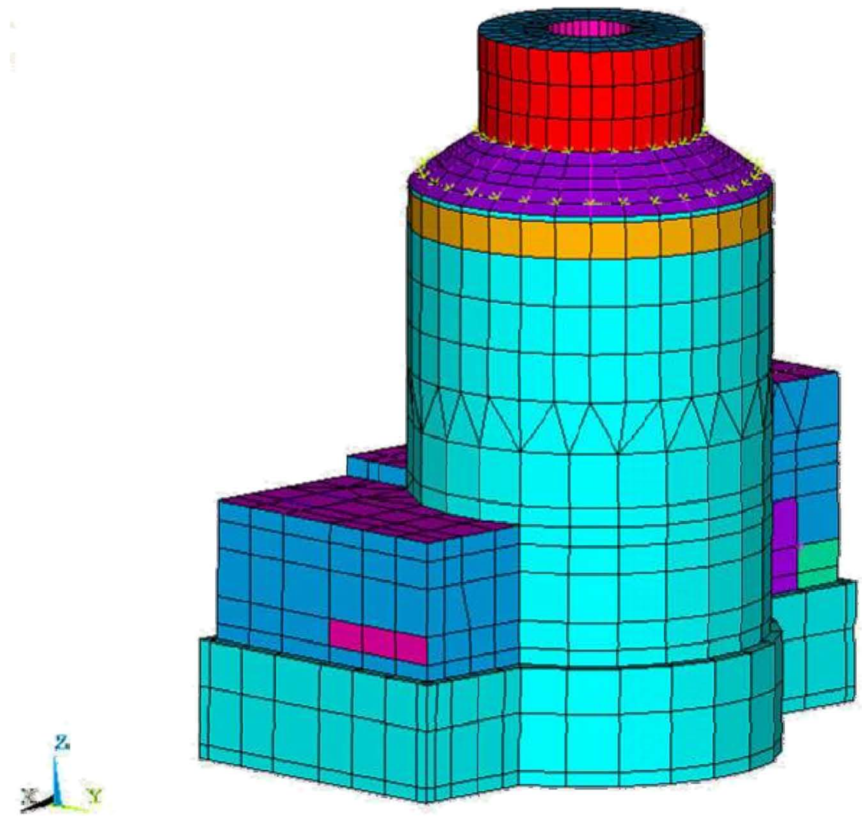


Figure 7-1: 3D SASSI Model for AP1000 Plant at Turkey Point Site

8.0 3D SASSI Analysis Results

The transfer functions at the six locations calculated in the 3D SASSI analysis with the Best Estimate Turkey Point NI soil profile are documented in Appendix B.

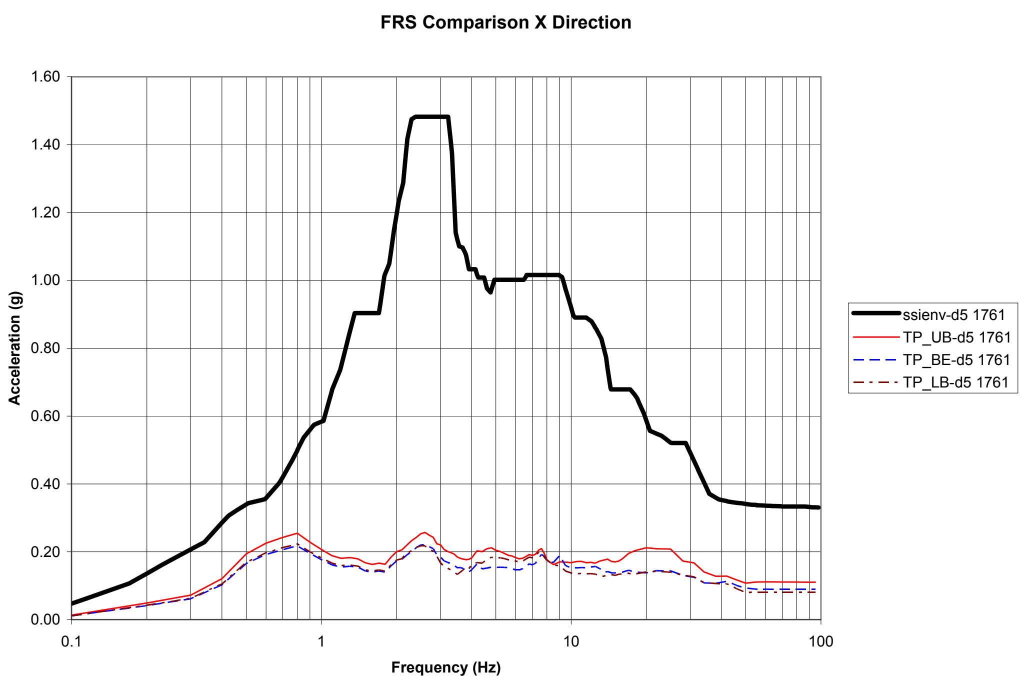
The response spectra at 5% damping at six key locations of the Nuclear Island are calculated by the 3D SASSI analysis and shown in Appendix C. The analysis results show that the Nuclear Island Floor Response Spectra (FRS) of AP1000 at the Turkey Point site at six key locations are enveloped by the AP1000 Certified Seismic Design Response Spectra (CSDRS).

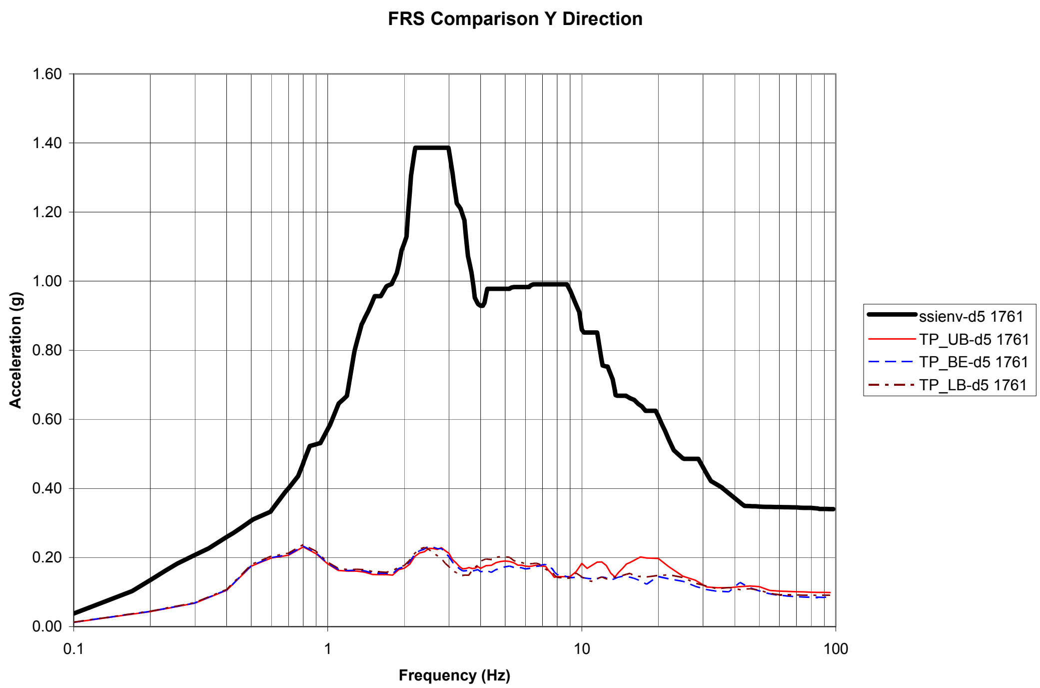
9.0 References

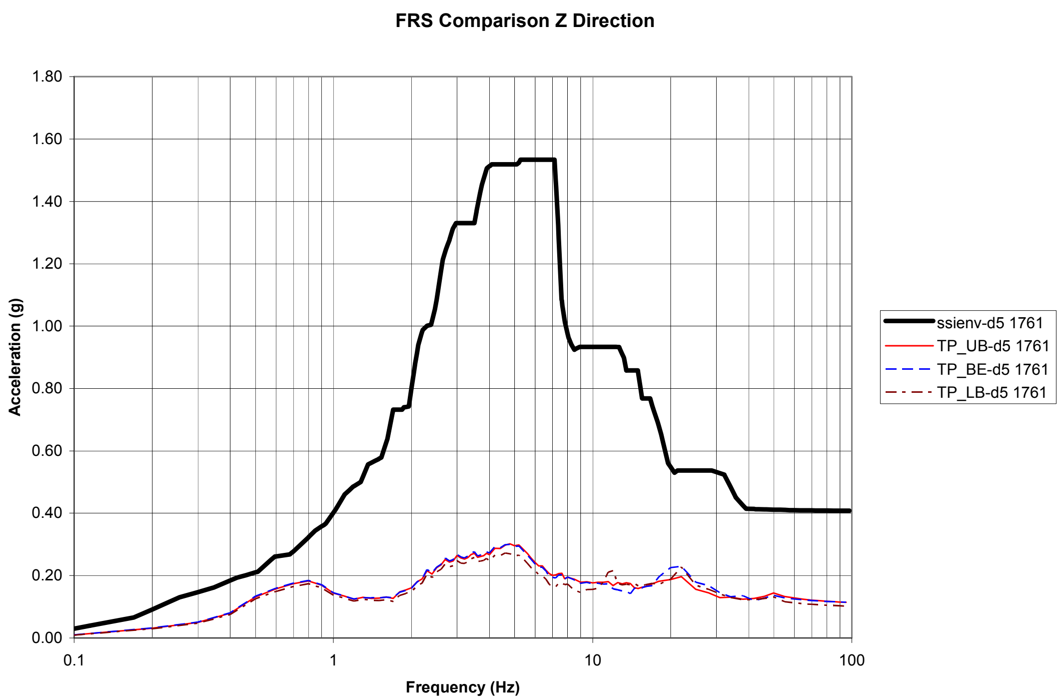
1. Turkey Point Units 6 & 7 COL Application, Part 2 FSAR (Draft)
2. Turkey Point Units 6 & 7 COL Application, Part 3 Environment Report, Revision A
3. Bechtel Letter: 25409-000-TCM-GEG-00338 – Release of Calculation 25409-000-K0C-0000-00032 Rev. 0 for Turkey Point Units 6&7 COLA
4. APP-GW-S2R-010, Rev 2, "Extension of Nuclear Island Seismic Analyses to Soil Sites"

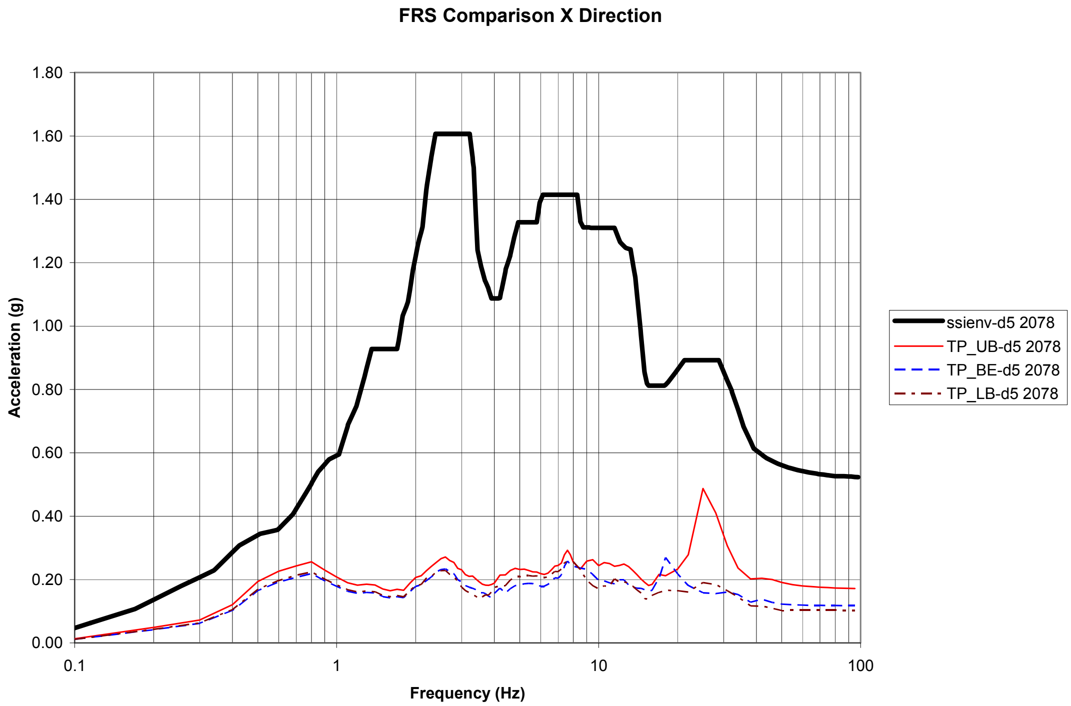
Appendix A: 3D Response Spectra

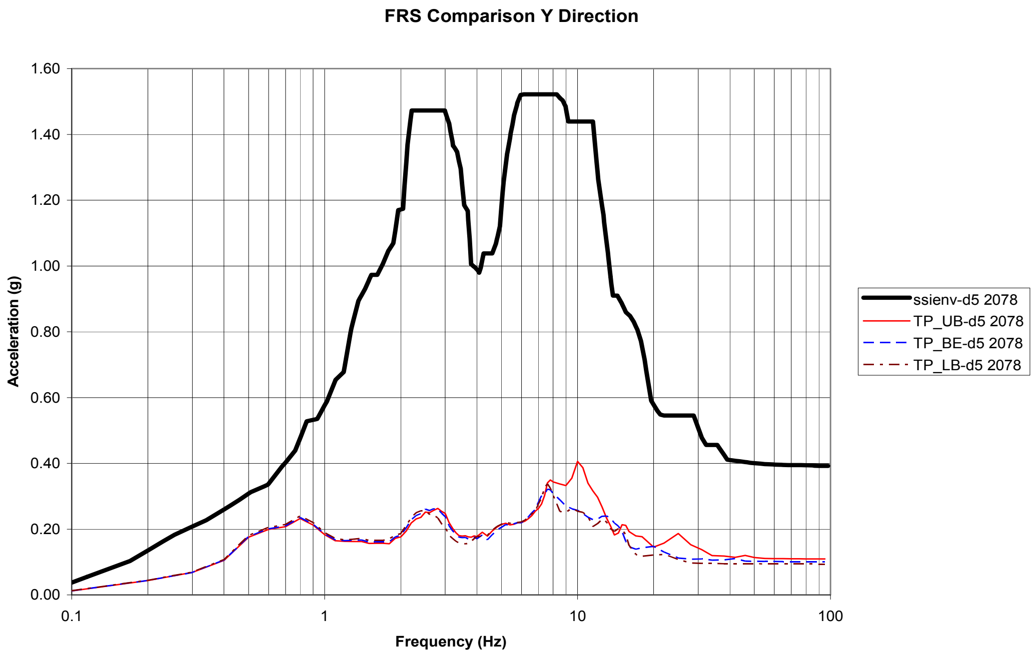
The Floor Response Spectra at 5% damping at six key locations as defined in Table 6-1 are shown in the following figures. In these figures, TP_UB, TP_BE, and TP_LB represent the response spectra calculated by the 3D SASSI with the Turkey Point Upper Bound, Best Estimate and Lower Bound soil profile. SSIENV denotes the AP1000 CSDRS envelope.

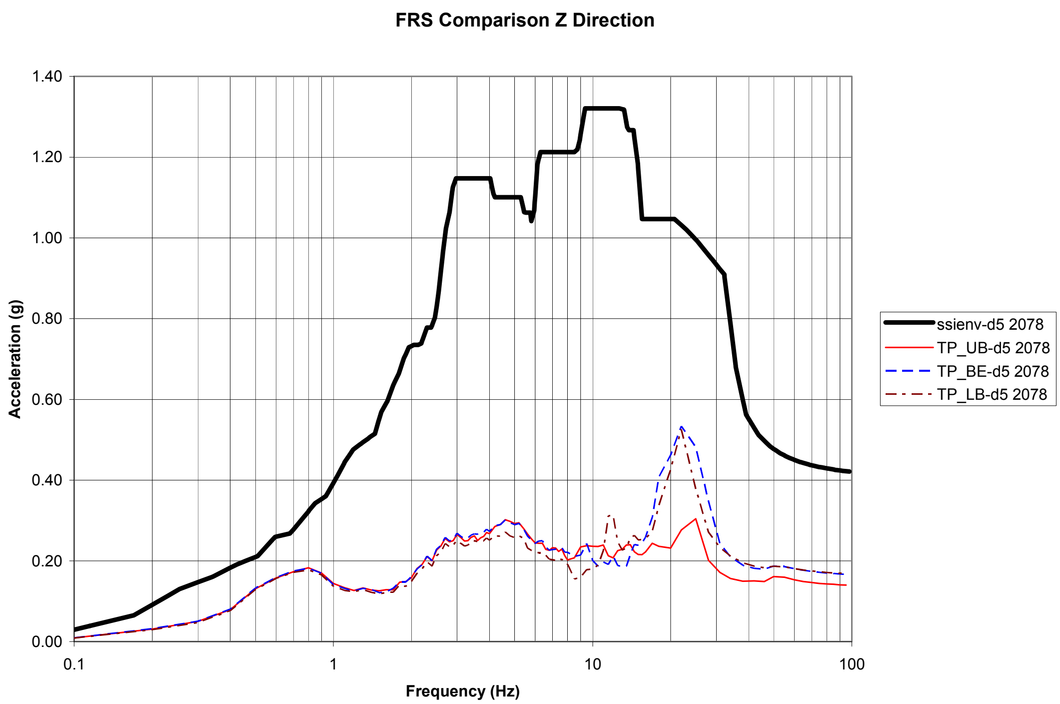


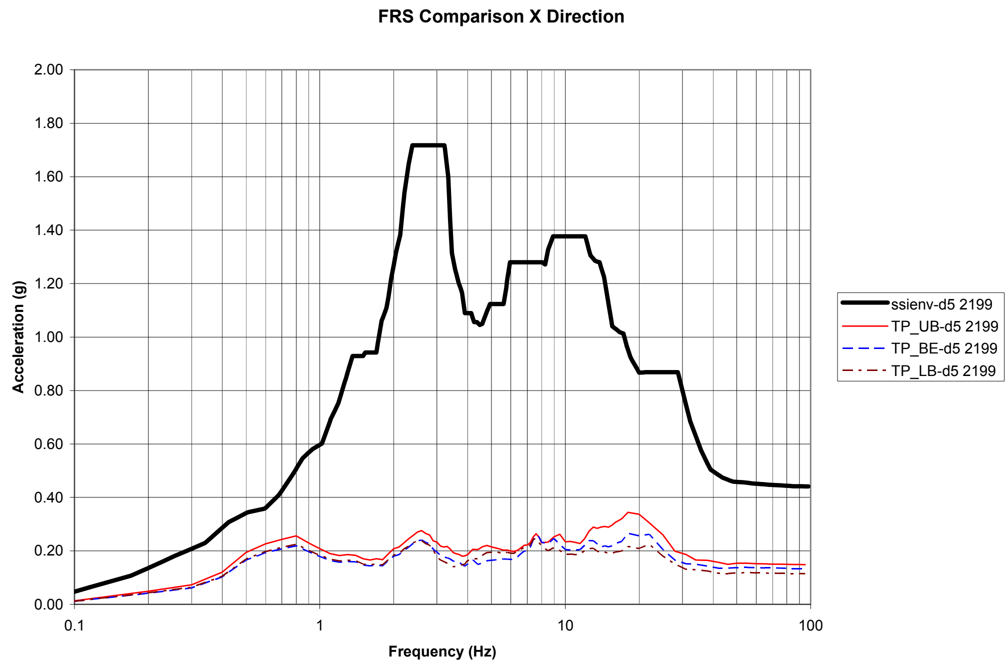

FRS Comparison Y Direction
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.1
1
10
100
Acceleration (g)
Frequency (Hz)
ssienv-d5 1761
TP_UB-d5 1761
TP_BE-d5 1761
TP_LB-d5 1761

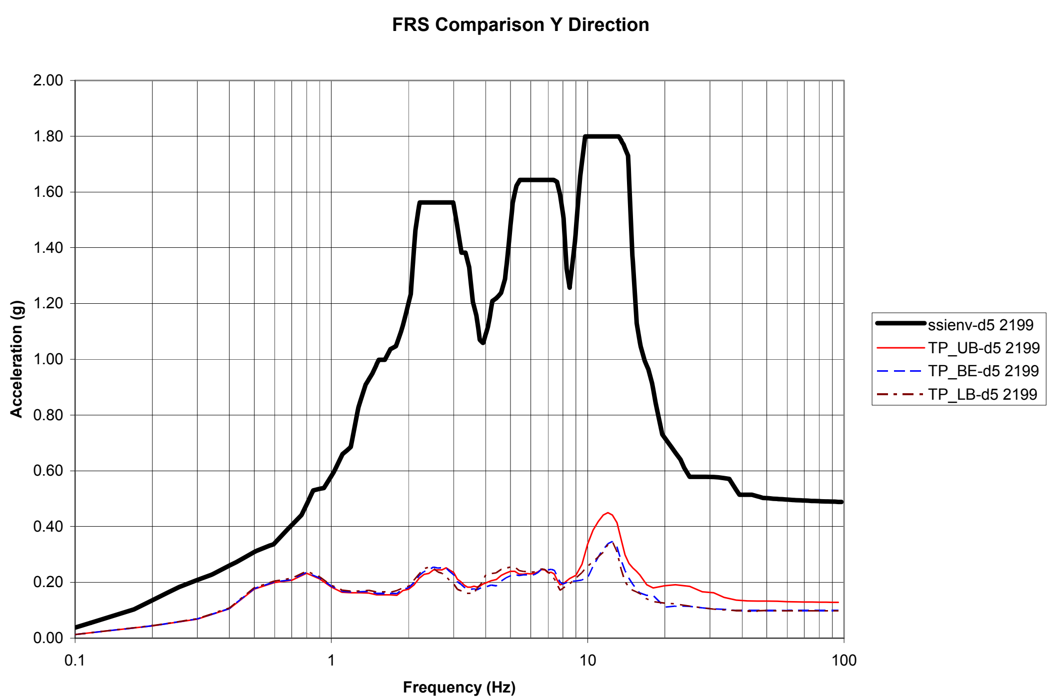

FRS Comparison Z Direction
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.1
1
10
100
Acceleration (g)
Frequency (Hz)
ssienv-d5 1761
TP_UB-d5 1761
TP_BE-d5 1761
TP_LB-d5 1761

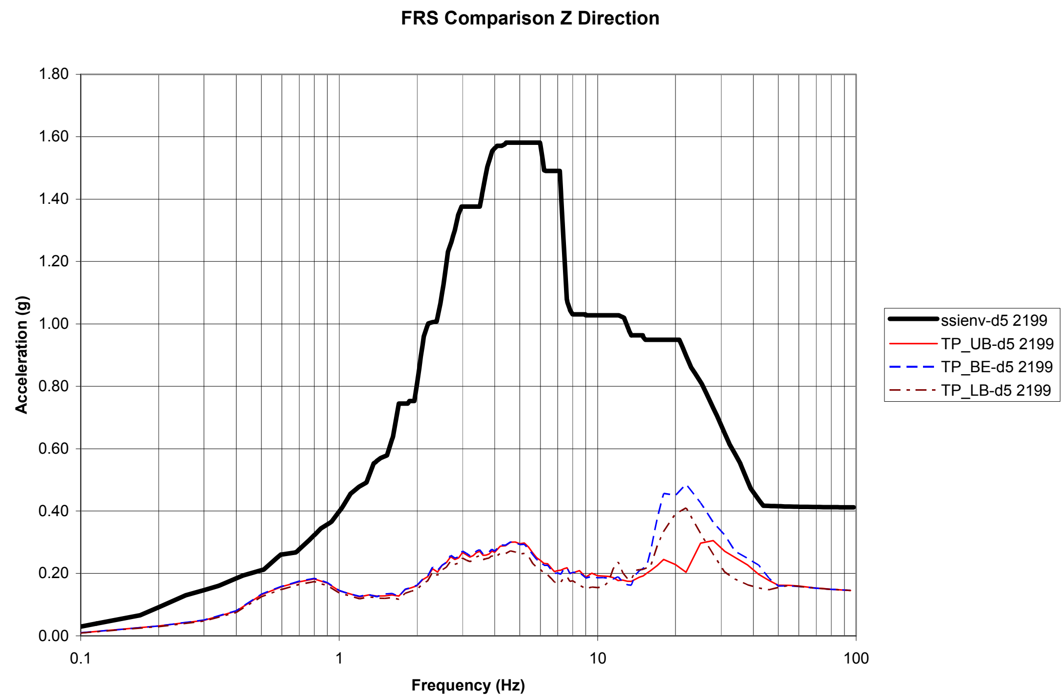

FRS Comparison X Direction
Acceleration (g)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.1
1
10
100
Frequency (Hz)
ssienv-d5 2078
TP_UB-d5 2078
TP_BE-d5 2078
TP_LB-d5 2078

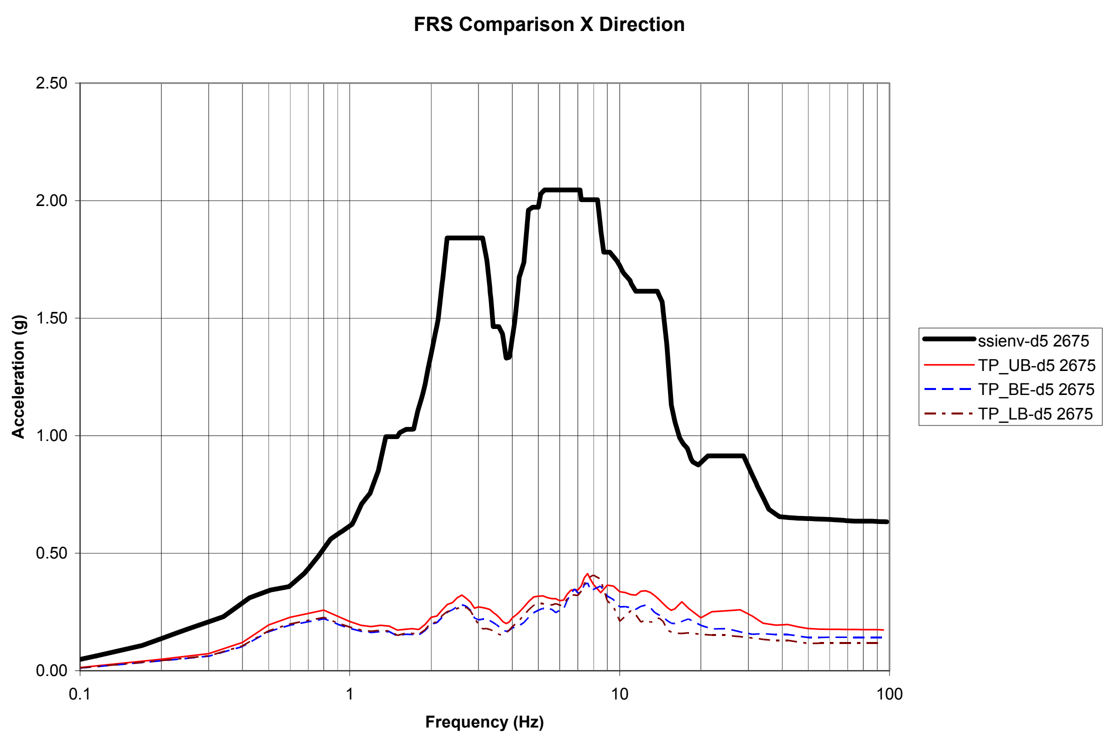

FRS Comparison Y Direction
Acceleration (g)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.1
1
10
100
Frequency (Hz)
ssienv-d5 2078
TP_UB-d5 2078
TP_BE-d5 2078
TP_LB-d5 2078

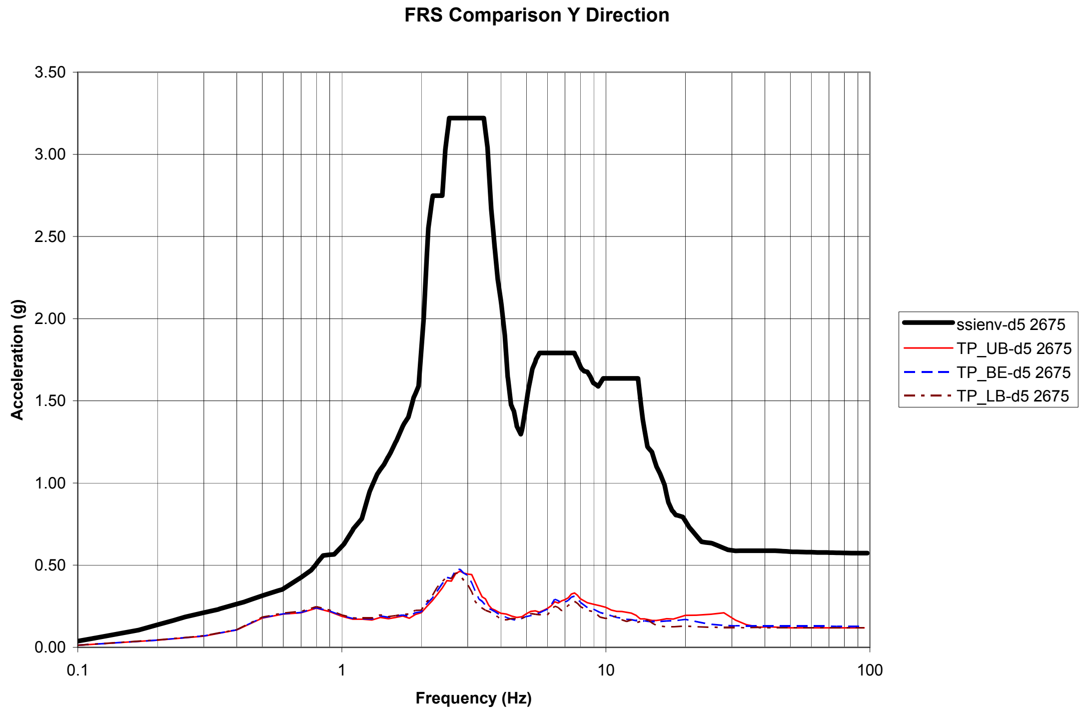

FRS Comparison Z Direction
Acceleration (g)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.1
1
10
100
Frequency (Hz)
ssienv-d5 2078
TP_UB-d5 2078
TP_BE-d5 2078
TP_LB-d5 2078

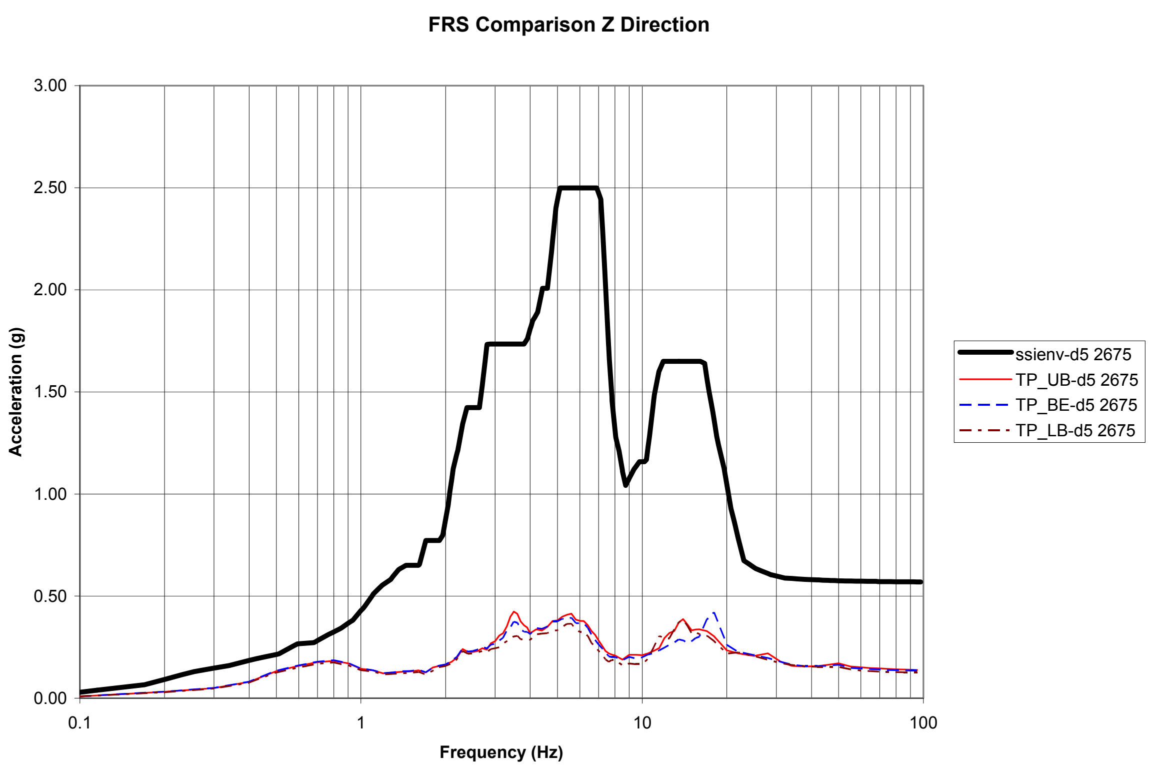

FRS Comparison X Direction
Acceleration (g)
Frequency (Hz)
ssienv-d5 2199
TP_UB-d5 2199
TP_BE-d5 2199
TP_LB-d5 2199

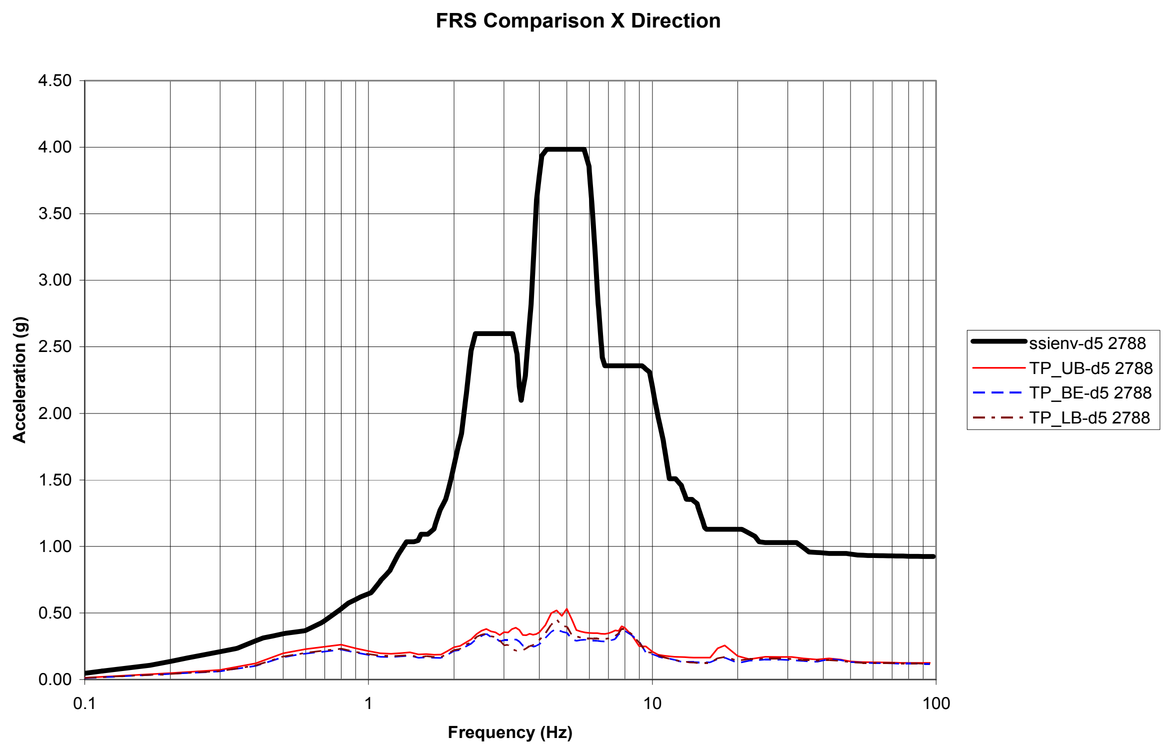

FRS Comparison Y Direction
Acceleration (g)
Frequency (Hz)
ssienv-d5 2199
TP_UB-d5 2199
TP_BE-d5 2199
TP_LB-d5 2199

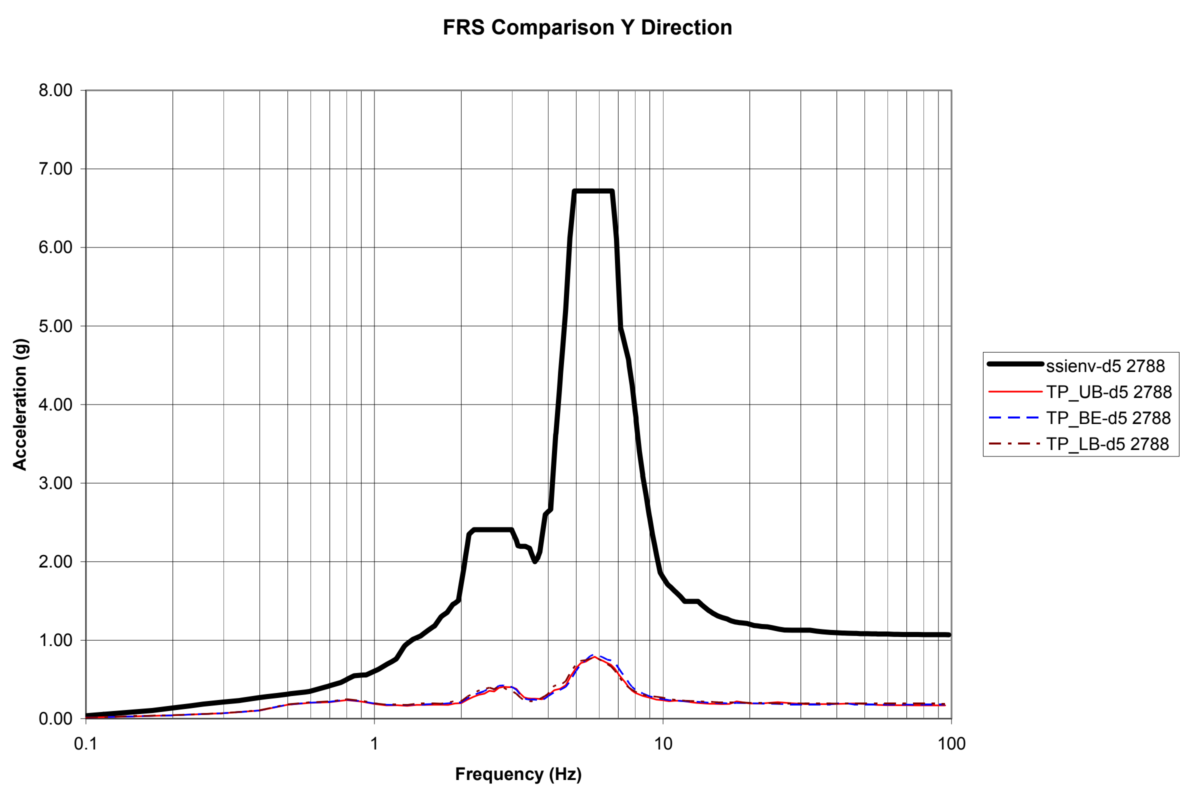

FRS Comparison Z Direction
Acceleration (g)
Frequency (Hz)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
0.1
1
10
100
ssienv-d5 2199
TP_UB-d5 2199
TP_BE-d5 2199
TP_LB-d5 2199

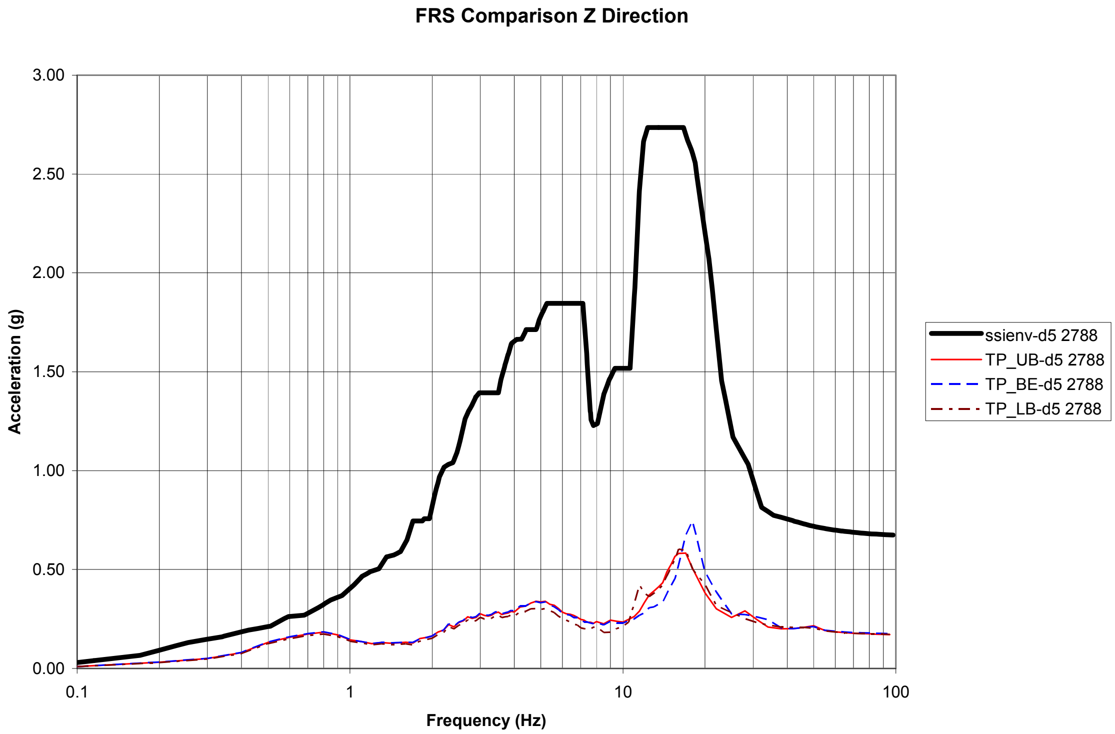

FRS Comparison X Direction
Acceleration (g)
Frequency (Hz)
0.00
0.50
1.00
1.50
2.00
2.50
0.1
1
10
100
ssienv-d5 2675
TP_UB-d5 2675
TP_BE-d5 2675
TP_LB-d5 2675

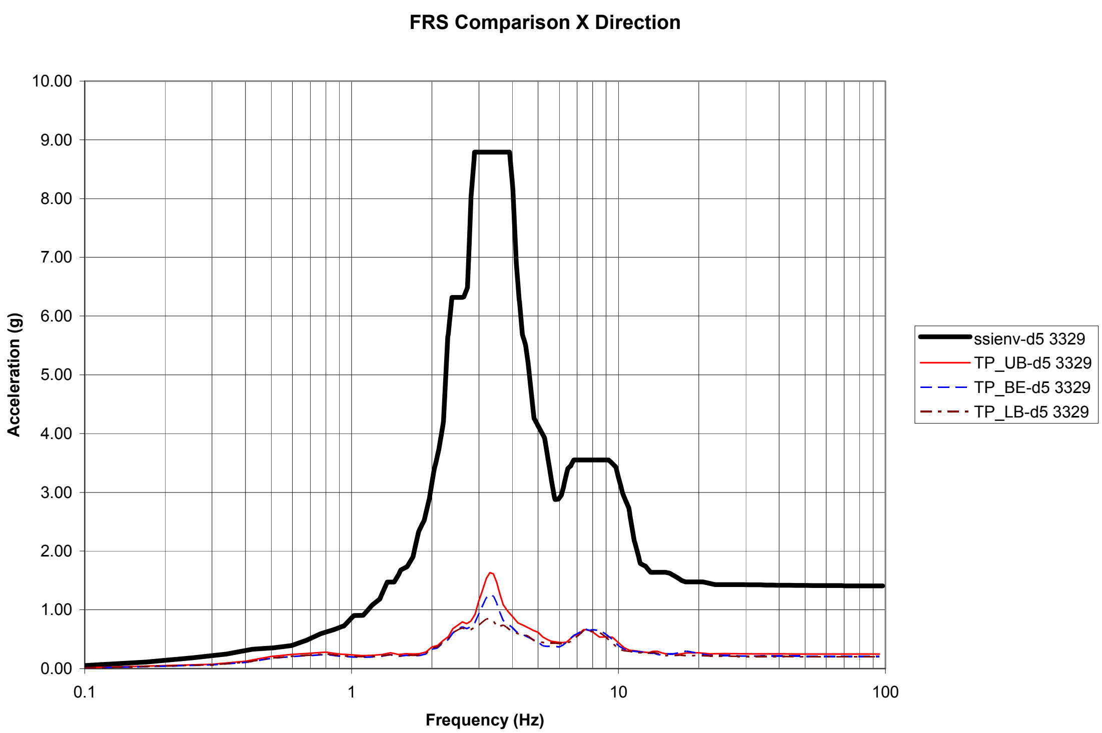

FRS Comparison Y Direction
Acceleration (g)
Frequency (Hz)
ssienv-d5 2675
TP_UB-d5 2675
TP_BE-d5 2675
TP_LB-d5 2675

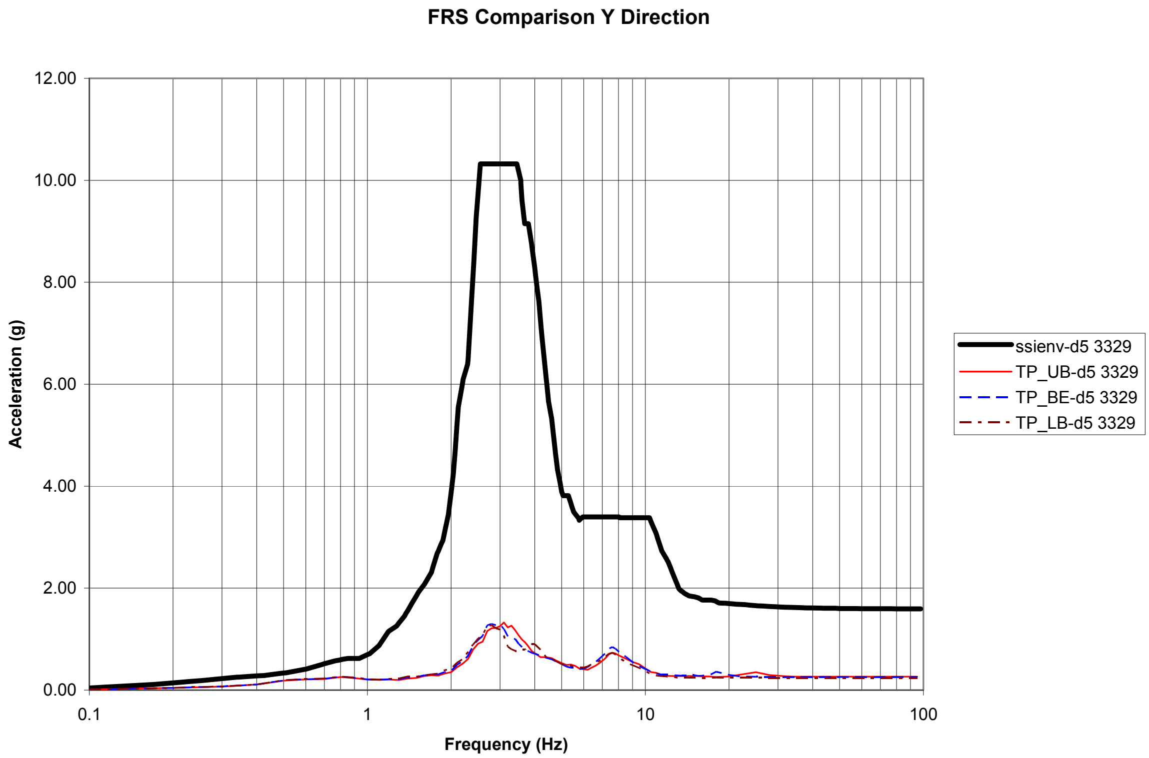

FRS Comparison Z Direction
Acceleration (g)
Frequency (Hz)
ssienv-d5 2675
TP_UB-d5 2675
TP_BE-d5 2675
TP_LB-d5 2675

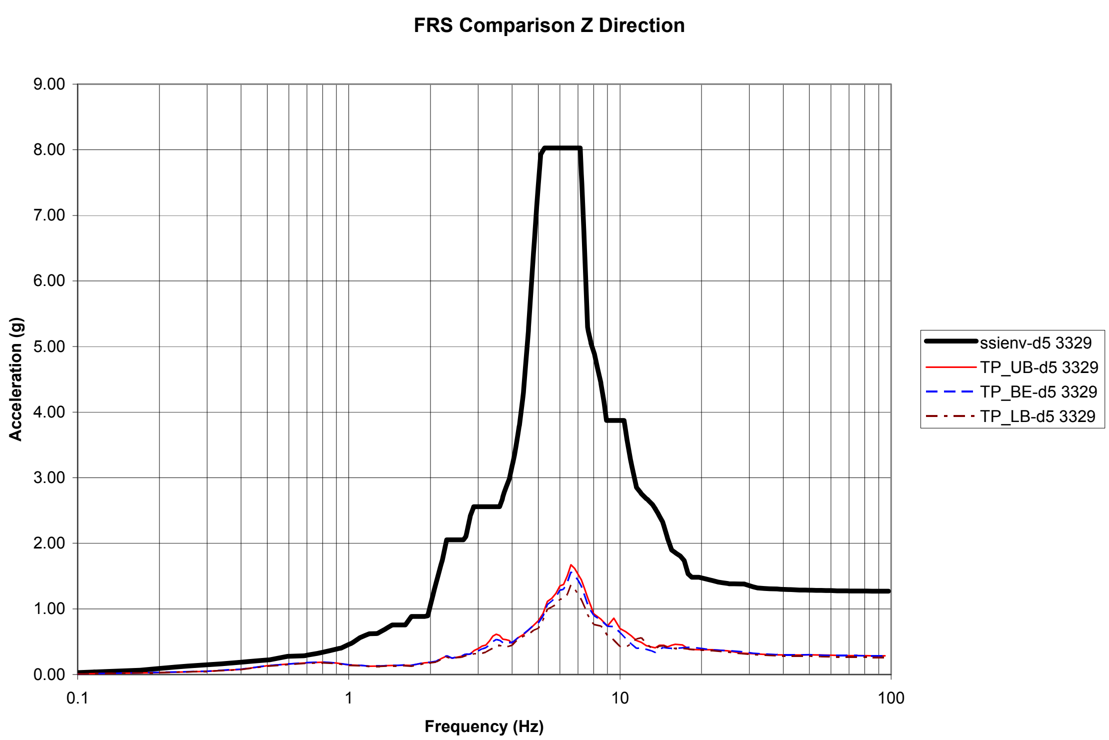

FRS Comparison X Direction
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Acceleration (g)
0.1
1
10
100
Frequency (Hz)
ssienv-d5 2788
TP_UB-d5 2788
TP_BE-d5 2788
TP_LB-d5 2788


FRS Comparison Y Direction
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Acceleration (g)
0.1
1
10
100
Frequency (Hz)
ssienv-d5 2788
TP_UB-d5 2788
TP_BE-d5 2788
TP_LB-d5 2788


FRS Comparison Z Direction
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Acceleration (g)
0.1
1
10
100
Frequency (Hz)
ssienv-d5 2788
TP_UB-d5 2788
TP_BE-d5 2788
TP_LB-d5 2788


FRS Comparison X Direction
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Acceleration (g)
0.1
1
10
100
Frequency (Hz)
ssienv-d5 3329
TP_UB-d5 3329
TP_BE-d5 3329
TP_LB-d5 3329


FRS Comparison Y Direction
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Acceleration (g)
0.1
1
10
100
Frequency (Hz)
ssienv-d5 3329
TP_UB-d5 3329
TP_BE-d5 3329
TP_LB-d5 3329


FRS Comparison Z Direction
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Acceleration (g)
0.1
1
10
100
Frequency (Hz)
ssienv-d5 3329
TP_UB-d5 3329
TP_BE-d5 3329
TP_LB-d5 3329