CHAPTER 3

DESIGN OF STRUCTURES, SYSTEMS, COMPONENTS, AND EQUIPMENT

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ACRONYMS AND ABBREVIATIONS

A/B	auxiliary building
AC/B	access building
ACI	American Concrete Institute
ARS	acceleration response spectra
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
BE	best estimate
CAV	cumulative absolute velocity
CCWS	component cooling water system
CFR	Code of Federal Regulations
COL	Combined License
COLA	Combined License Application
CPNPP	Comanche Peak Nuclear Power Plant
CSDRS	certified seismic design response spectra
DBFL	design-basis flooding level
DCD	Design Control Document
EQ	environmental qualification
EQSDS	equipment qualification summary data sheet
ESF	engineered safety features
ESW	essential service water
ESWPT	essential service water pipe tunnel
ESWS	essential service water system
FE	finite element
FIRS	foundation input response spectra
FW	feedwater
GMRS	ground motion response spectra
IEEE	Institute of Electrical and Electronic Engineers
ILRT	integrated leak rate test
ISI	inservice inspection
ISRS	in-structure response spectra
IST	inservice testing
LB	lower bound
LBB	leak before break
MCR	main control room
MOV	motor operated valve
MS	main steam
N/A	not applicable
NRC	U.S. Nuclear Regulatory Commission

ACRONYMS AND ABBREVIATIONS (Continued)

NS	non-seismic
O/B	outside building
OBE	operating-basis earthquake
PAM	post accident monitoring
PCCV	prestressed concrete containment vessel
PGA	peak ground acceleration
PMP	probable maximum precipitation
PS/B	power source building
PSFSV	power source fuel storage vault
PSI	preservice inspection
QAP	quality assurance program
R/B	reactor building
RCL	reactor coolant loop
RG	Regulatory Guide
RV	reactor vessel
RWSP	refueling water storage pit
SEI	Structural Engineering Institute
SG	steam generator
SRP	Standard Review Plan
SRSS	square root sum of the squares
SSC	structure, system, and component
SSE	safe-shutdown earthquake
SSI	soil-structure interaction
T/B	turbine building
T/G	turbine generator
UB	upper bound
UHS	ultimate heat sink
UHSRS	ultimate heat sink related structures

3.0 DESIGN OF STRUCTURES, SYSTEMS, COMPONENTS, AND EQUIPMENT

3.1 CONFORMANCE WITH NRC GENERAL DESIGN CRITERIA

This section of the referenced Design Control Document (DCD) is incorporated by reference with the following departures and/or supplements.

3.1.4.16.1 Discussion

STD COL 3.1(1) Replace the fourth and fifth sentences of the first paragraph in DCD Subsection 3.1.4.16.1 with the following.

These components have suitable inspection capability enhanced with appropriate layout features, as discussed in Section 9.2. The essential service water system (ESWS) and component cooling water system (CCWS) piping is arranged to permit access for inspection. Manholes, handholes, or inspection ports are provided for periodic inspection of system components. The integrity of underground piping is demonstrated by pressure and functional tests.

3.1.7 Combined License Information

Replace the content of DCD Subsection 3.1.7 with the following.

STD COL 3.1(1) ***3.1(1)*** *Design provisions for inspections*

This Combined License (COL) item is addressed in Subsection 3.1.4.16.1.

3.2 CLASSIFICATION OF STRUCTURES, SYSTEMS, AND COMPONENTS

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

3.2.1.2 Classifications

STD COL 3.2(4) Replace last sentence of first paragraph in DCD Subsection 3.2.1.2 with the following.

The site-specific, safety-related systems and components that are designed to withstand the effects of earthquakes without loss of capability to perform their safety function; and those site-specific, safety-related fluid systems or portions thereof; as well as the applicable industry codes and standards for pressure-retaining components are identified in Table 3.2-201.

3.2.2 System Quality Group Classification

STD COL 3.2(5) Replace the last sentence of the eleventh paragraph in DCD Subsection 3.2.2 with the following.

The equipment class and seismic category of the site-specific safety-related and non-safety related fluid systems, components (including pressure retaining), and equipment as well as the applicable industry codes and standards are provided in Table 3.2-201.

3.2.3 Combined License Information

Replace the content of DCD Subsection 3.2.3 with the following.

3.2(1) *Deleted from the DCD.*

3.2(2) *Deleted from the DCD.*

3.2(3) *Deleted from the DCD.*

STD COL 3.2(4) ***3.2(4)*** *Site-specific safety-related systems and components designed to withstand earthquakes*

This COL item is addressed in Subsection 3.2.1.2 and Table 3.2-201.

STD COL 3.2(5) ***3.2(5)*** *Equipment class and seismic category*

This COL item is addressed in Subsection 3.2.2 and Table 3.2-201.

CP COL 3.2(4)
CP COL 3.2(5)

Table 3.2-201 (Sheet 1 of 3)
Classification of Site-Specific Mechanical and Fluid Systems, Components, and Equipment

System and Components	Equipment Class	Location	Quality Group	10 CFR 50 Appendix B (Reference 3.2-8)	Code and Standards[(3)]	Seismic Category	Notes
1. ESWS							
Basin blowdown line piping and valves from and excluding essential service water supply header piping up to the following valves: Ultimate heat sink (UHS) basin blowdown control valves ESW-HVC-2000, 2001, 2002, 2003 UHS basin blowdown control bypass valves ESW-VLV-544A, B, C, D	3	ultimate heat sink related structures (UHSRS)	C	YES	3	I	
Essential service water (ESW) supply line piping connected to the fire protection system in the UHSRS, and valves from and excluding ESW supply header piping up to the following isolation valves: ESW-VLV-551A, B, C, D	3	UHSRS	C	YES	3	I	
ESW supply line piping connected to the fire protection system in the reactor building (R/B), and valves from and excluding ESW supply header piping up to the following isolation valves: ESW-VLV-552A, B, C, D	3	R/B	C	YES	3	I	

CP COL 3.2(4)
CP COL 3.2(5)

Table 3.2-201 (Sheet 2 of 3)
Classification of Site-Specific Mechanical and Fluid Systems, Components, and Equipment

System and Components	Equipment Class	Location	Quality Group	10 CFR 50 Appendix B (Reference 3.2-8)	Code and Standards(3)	Seismic Category	Notes
2. UHS							
UHS transfer pumps	3	UHSRS	C	YES	3	I	
UHS cooling tower fans	3	UHSRS	C	YES	5	I	
UHS basins	3	UHSRS	C	YES	3	I	
Transfer line piping and valves from UHS sink transfer pumps to basins	3	UHSRS essential service water pipe tunnel (ESWPT)	C	YES	3	I	
ESW return line piping	3	UHSRS	C	YES	3	I	
3. UHS ESW pump house ventilation system							
ESW pump room exhaust fans	3	UHSRS	C	YES	5	I	
UHS transfer pump room exhaust fans	3	UHSRS	C	YES	5	I	
UHS ESW pump house supply and exhaust backdraft dampers	3	UHSRS	C	YES	5	I	
ESW pump room unit heaters	3	UHSRS	C	YES	5	I	
UHS transfer pump room unit heaters	3	UHSRS	C	YES	5	I	

CP COL 3.2(4)
CP COL 3.2(5)

Table 3.2-201 (Sheet 3 of 3)
Classification of Site-Specific Mechanical and Fluid Systems, Components, and Equipment

System and Components	Equipment Class	Location	Quality Group	10 CFR 50 Appendix B (Reference 3.2-8)	Code and Standards(3)	Seismic Category	Notes
4. Startup steam generator (SG) blowdown system							
System components, piping and valves	4	turbine building (T/B), auxiliary building (A/B), outside building (O/B)	D	not applicable (N/A)	4	non-seismic (NS)	

Notes:
1. Not used.
2. Not used.
3. Identification number for “Code and Standards”
(1) American Society of Mechanical Engineers (ASME) Code, Section III, Class 1 (Reference 3.2-14)
(2) ASME Code, Section III, Class 2 (Reference 3.2-14)
(3) ASME Code, Section III, Class 3 (Reference 3.2-14)
(4) RG 1.26 (Reference 3.2-13), Table 1, Quality Standards
(5) Codes and standards as defined in design bases
(6) RG 1.143 (Reference 3.2-10), Table 1, Code and Standards for Design of SSC in Radwaste Facilities

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 and Recurrence Interval

CP COL 3.3(1) Replace the last sentence of the second paragraph in DCD Subsection 3.3.1.1 with the following.

The site-specific basic wind speed of 90 mph corresponds to a 3-second gust at 33 ft. above ground for exposure category C, with the same recurrence interval as described above, and is therefore enveloped by the basic wind speed used for the design of the standard plant. Site-specific structures, systems, and components (SSCs) are designed using the site-specific basic wind speed of 90 mph, or higher.

3.3.1.2 Determination of Applied Forces

CP COL 3.3(4) Replace the last paragraph in DCD Subsection 3.3.1.2 with the following.

Specific descriptions of wind load design method and importance factor for US-APWR site-specific plant structures are as follows:

- The UHSRS (seismic category I) are analyzed using method 2 of American Society of Civil Engineers (ASCE)/Structural Engineering Institute (SEI) 7-05 (Reference 3.3-1) and an importance factor of 1.15.
- The exposed portions of the ESWPT (seismic category I) and power source fuel storage vaults (PSFSVs) (seismic category I) are analyzed using method 1 of ASCE/SEI 7-05 (Reference 3.3-1) and an importance factor of 1.15.

3.3.2.2.2 Tornado Atmospheric Forces

CP COL 3.3(5) Replace the last paragraph in DCD Subsection 3.3.2.2.2 with the following.

Site-specific seismic category I structures include the UHSRS, ESWPT, and the PSFSVs. The UHSRS, including the pump houses and transfer pump rooms, are configured with large openings and/or vents and are therefore designed as vented with respect to tornado atmospheric differential pressure loading. Where applicable, interior walls are designed considering tornado differential atmospheric pressure loading. The ESWPT and PSFSV structures are designed as unvented because they do not have openings that permit depressurization during a tornado.

3.3.2.2.4 Combined Tornado Effects

CP COL 3.3(2) Replace the first and second sentences of the last paragraph in DCD Subsection 3.3.2.2.4 with the following.

Site-specific seismic category I structures, i.e., the UHSRS and exposed portions of the ESWPT and PSFSVs, are designed for the same tornado loadings and combined tornado effects using the same methods for qualification described for standard plant SSCs.

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

CP COL 3.3(3) Replace the last paragraph of DCD Subsection 3.3.2.3 with the following.

Other miscellaneous NS buildings and structures in the plant yard are located and/or anchored such that their failure will neither jeopardize safety-related SSCs nor generate missiles not bounded by those discussed in Subsection 3.5.1.4. Further, any site-specific or field routed safety-related SSCs in the plant yard are evaluated prior to their installation to determine if structural reinforcement and/or missile barriers are required to ensure their function and integrity.

3.3.3 Combined License Information

Replace the content of DCD Subsection 3.3.3 with the following.

CP COL 3.3(1) ***3.3(1)*** W*ind speed requirements*

This COL item is addressed in Subsection 3.3.1.1.

CP COL 3.3(2) ***3.3(2)*** *Tornado loadings and combined tornado effects*

This COL item is addressed in Subsection 3.3.2.2.4.

CP COL 3.3(3) ***3.3(3)*** *Structures not designed for tornado loads*

This COL item is addressed in Subsection 3.3.2.3.

CP COL 3.3(4) ***3.3(4)*** *Wind load design methods and importance factors*

This COL item is addressed in Subsection 3.3.1.2.

CP COL 3.3(5) ***3.3(5)*** *Vented and unvented requirements for site-specific buildings and structures*

This COL item is addressed in Subsection 3.3.2.2.2.

3.4 WATER LEVEL (FLOOD) DESIGN

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

3.4.1.2 Flood Protection from External Sources

CP COL 3.4(1) Replace the first sentence of the third paragraph in DCD Subsection 3.4.1.2 with the following.

Entrances to all Comanche Peak Nuclear Power Plant (CPNPP) Units 3 and 4 safety-related structures on site are above the design-basis flooding level (DBFL) listed in Section 2.4, and adequate sloped site grading and drainage prevents flooding caused by probable maximum precipitation (PMP) or postulated failure of non safety-related, non seismic storage tanks located on site.

CP COL 3.4(5) Replace the fourth paragraph in DCD Subsection 3.4.1.2 with the following.

No site-specific flood protection measures such as levees, seawalls, floodwalls, site bulkheads, revetments, or breakwaters are applicable at CPNPP Units 3 and 4, since the plant is built above the DBFL and has adequate site grading. The lowest point of the structure foundation is above the groundwater elevation identified in Section 2.4, and therefore no permanent dewatering system is required.

CP COL 3.4(4) Replace the seventh paragraph in DCD Subsection 3.4.1.2 with the following.

The lowest point of the structure foundation is above the groundwater elevation identified in Section 2.4. In addition, no intermittent head of water occurs from surface precipitation or groundwater due to the placement of course aggregate wrapped in geotextile filter fabric with perforated drainage pipe sloped to daylight to Squaw Creek Reservoir. Construction joints in the exterior walls and base mats are provided with water stops to prevent seepage of ground water. A dampproofing barrier treatment that resists the passage of ground water in the absence of hydrostatic pressure is therefore applied to all subgrade outer foundation walls in accordance with American Concrete Institute (ACI) 515.1R-79 (Reference 3.4-201). A cementitious membrane waterproofing is provided on the inside face of the UHS basin walls and foundation slab, including the UHS sump pit, to prevent water migration from the UHS basin into the subgrade.

CP COL 3.4(3) Replace the last sentence in the ninth paragraph in DCD Subsection 3.4.1.2 with the following.

Site-specific potential sources of external flooding such as the cooling tower, service water piping, or circulating water piping are not located near structures containing safety-related SSCs, with the exception of piping entering plant structures. The CWS enters only within the T/B, and any postulated pipe break is prevented from back-flowing into the safety-related R/B by watertight separation. Postulated pipe breaks near structures are prevented from entering the structures by adequate sloped site grading and drainage.

3.4.1.4 Evaluation of External Flooding

CP COL 3.4(2) Replace the last sentence in the last paragraph of DCD Subsection 3.4.1.4 with the following.

As discussed in Chapter 2, the site-specific DBFL does not exceed the maximum flood level for the standard plant design. Therefore, there are no static and/or dynamic flooding forces beyond those considered in the standard plant design.

3.4.2 Analysis Procedures

CP COL 3.4(6) Replace the last paragraph of DCD Subsection 3.4.2 with the following.

No site-specific physical models are used to predict prototype performance of hydraulic structures and systems, since there are no unusual design or configuration or design or operating bases involving thermal and erosion problems.

3.4.3 Combined License Information

Replace the content of DCD Subsection 3.4.3 with the following.

CP COL 3.4(1) ***3.4(1)*** *Site-specific design of plant grading and drainage*

This COL item is addressed in Subsection 3.4.1.2.

CP COL 3.4(2) ***3.4(2)*** *DBFL applicability to site*

This COL item is addressed in Subsection 3.4.1.4.

CP COL 3.4(3) ***3.4(3)*** *Site-specific flooding hazards from engineered features*

This COL item is addressed in Subsection 3.4.1.2.

CP COL 3.4(4) ***3.4(4)*** *Additional ground water protection*

This COL item is addressed in Subsection 3.4.1.2.

CP COL 3.4(5) ***3.4(5)*** *DBFL and site-specific conditions*

This COL item is addressed in Subsection 3.4.1.2.

CP COL 3.4(6) ***3.4(6)*** *Physical models for performance of hydraulic structures and systems*

This COL item is addressed in Subsection 3.4.2.

3.4.4 References

Add the following reference after the last reference in DCD Subsection 3.4.4.

3.4-201 *A Guide to the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete,* ACI 515.1R-79, American Concrete Institute, Revised 1985.

3.5 MISSILE PROTECTION

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

3.5.1.1.2.1 Missiles Not Considered Credible

CP COL 3.5(1) Replace the last paragraph of DCD Subsection 3.5.1.1.2.1 with the following.

CPNPP Unit 3 and 4 procedures will be issued prior to fuel load in accordance with Subsection 13.5.2.2 to require equipment for maintenance or undergoing maintenance to be removed from containment prior to operation, moved to a location where it is not a potential hazard to SSCs important to safety, or seismically restrained to prevent it from becoming a missile.

3.5.1.3.1 Geometry

CP COL 3.5(6) Replace the third paragraph of DCD Subsection 3.5.1.3.1.

The CPNPP site plan (Figure 1.2-1R) reflects the placement of CPNPP Units 3 and 4 in relation to existing Units 1 and 2. The location of CPNPP Units 3 and 4 is such that CPNPP Units 1 and 2 are outside the low-trajectory turbine missile strike zone inclined at 25 degrees to the turbine, and therefore no postulated low-trajectory turbine missiles affect CPNPP Units 1 and 2. Similarly, no postulated low trajectory turbine missiles from CPNPP Units 1 and 2 will affect CPNPP Units 3 and 4. The placement of CPNPP Units 3 and 4, however, does generate an unfavorable orientation, as defined in NUREG-0800, Section 3.5.1, of the turbine generator (T/G) in relationship with safety-related SSCs of the adjacent US-APWR Unit. (See Subsection 3.5.1.3.2 for impact to P_4).

3.5.1.3.2 Evaluation

CP COL 3.5(2) Replace the third paragraph of DCD Subsection 3.5.1.3.2 with the following.

Mathematically, $P_4 = P_1 \times P_2 \times P_3$, where RG 1.115 (Reference 3.5-6) considers an acceptable risk rate for P_4 as less than 10^{-7} per year. For unfavorably oriented T/Gs determined in Subsection 3.5.1.3, the product of P_2 and P_3 is estimated as 10^{-2} per year, which is a more conservative estimate than for a favorably oriented single unit. CPNPP Unit 3 and 4 procedures will be implemented 6 months prior to delivery of the T/G to require inspection intervals established in Technical Report, MUAP-07028-NP, Probability of Missile Generation From Low Pressure Turbines (Reference 3.5-17) and other actions to maintain P_1 within acceptable limits as outlined in NUREG-0800, Standard Review Plan (SRP) 3.5.1.3, Table 3.5.1.3-1 (Reference 3.5-7). These inspection intervals maintain the probability of turbine failure resulting in the ejection of turbine rotor (or internal structure) fragments through the turbine casing, P_1, as less than 10^{-5} per year. The acceptable risk rate $P_4 = P_1 \times P_2 \times P_3$ is therefore maintained as less than 10^{-7} per year.

3.5.1.5 Site Proximity Missiles (Except Aircraft)

CP COL 3.5(3) Replace the paragraph of DCD Subsection 3.5.1.5 with the following.

As described in Section 2.2, no potential site-proximity missile hazards are identified except aircraft, which are evaluated in Subsection 3.5.1.6.

3.5.1.6 Aircraft Hazards

CP COL 3.5(4) Replace the paragraph of DCD Subsection 3.5.1.6 with the following.

The probability of aircraft-related accidents for CPNPP Units 3 and 4 is less than an order of magnitude of 10^{-7} per year for aircraft, airway, and airport information reflected in Subsection 2.2.2.7 and expanded as follows.

- Allowing for an 8 nautical mile wide airway, the plant is at least 2 statute miles beyond the edge of the nearest federal airways.
- The reported average operations of 73 per day (26,645 per year) at Granbury Municipal airport are well below the conservative threshold of 500 D^2 operations per year, where D is the plant-to-airport distance of 10 statute miles.
- Allowing for a 10 nautical mile wide airway, the plant is 2 statute miles beyond the edge of the nearest military flight path.

Since the plant is within 5 statute miles from the nearest edge of military training route VR-158, the probability of an aircraft crashing into the plant (P_{FA}) is estimated in the following manner:

$$P_{FA} = C \times N \times A/w$$

where

C = In-flight crash rate per mile for aircraft using the airway

w = Width of airway, plus twice the distance from the airway edge to the site, conservatively provided in statute miles, equals 10 statute miles + (2 x 2 statute miles)

N = Estimated annual number of aircraft operations

A = Effective area of plant in square miles

In order to maintain P_{FA} less than the order of 10^{-7} for both Units 3 and 4, the above equation is rearranged to solve for N using values of C, A and w determined below:

$$N = P_{FA} /(C \times A/w) = 19{,}300 \text{ operations per year}$$

NUREG-0800, SRP 3.5.1.6 provides a value of $C = 4 \times 10^{-10}$ for commercial aircraft. A table within SRP 3.5.1.6 also provides values for C for various distances up to 10 statute miles from the end of the runway, and notes data are not available for military aircraft greater than 5 statute miles from the end of runway. Since the probability of military crashes is otherwise similar or less than the probability of commercial air carriers within 5 statute miles of the end of runway, the value of $C = 4 \times 10^{-10}$ provides a conservative approach for determining the probability of in-route crashes on military airways. This methodology is also consistent with the determination for the probability of in-flight military aircraft crash in “The Annual Probability of an Aircraft Crash on the U.S. Department of Energy Reservation in Oak Ridge, Tennessee” (Reference 3.5-201), Subsection 3.3.1.

The effective area of each unit is conservatively determined as 0.0907 square miles from the sum of the aircraft shadow area (A_S), skid area (A_K), and footprint area (A_B), calculated using a bounding power block volume by enveloping the outer boundaries of the R/B, access building (AC/B), A/B, power source buildings (PS/Bs), and T/B of 490 ft wide by 650 ft long by 230 ft high.

A_S = 230 ft x 650 ft = 149,500 ft^2, where the shadow length is conservatively determined using a 45 degree angle from the tallest point of the power block, and the shadow width is equal to the widest dimension of the power block.

A_K = 0.6 miles (skid length) x 650 ft = 2,059,200 ft^2, where the skid length for military aircraft is determined from Reference 3.5-201, and the width of skid is equal to the widest dimension of the power block.

A_B = 490 ft x 650 ft = 318,500 ft^2 as the total land occupied by the power block.

The annual number of aircraft operations on military training route VR-158 noted in Subsection 2.2.2.7.2 confirms operations are less than 19,300 operations per year. Therefore, neither an air crash nor an air transportation accident is required to be considered as part of the design basis.

3.5.2 Structures, Systems, and Components to be Protected from Externally Generated Missiles

CP COL 3.5(5) Replace the second sentence in the second paragraph of DCD Subsection 3.5.2 with the following.

No site-specific hazards for external events are shown to produce missiles more energetic than tornado missiles identified for the US-APWR standard plant design. The design basis for externally generated missiles is therefore bounded by the standard plant design criteria for tornado-generated missiles.

3.5.4 Combined License Information

Replace the content of DCD Subsection 3.5.4 with the following.

CP COL 3.5(1) ***3.5(1)*** *Equipment removed from containment prior to operation*

This COL item is addressed in Subsection 3.5.1.1.2.1.

CP COL 3.5(2) ***3.5(2)*** *Maintain P_1 within acceptable limit*

This COL item is addressed in Subsection 3.5.1.3.2.

CP COL 3.5(3) ***3.5(3)*** *Presence of potential hazards and effects in vicinity of site, except aircraft*

This COL item is addressed in Subsection 3.5.1.5.

CP COL 3.5(4) ***3.5(4)*** *Site interface parameters for aircraft crashes and air transportation accidents*

This COL item is addressed in Subsection 3.5.1.6.

CP COL 3.5(5) ***3.5(5)*** *Other potential site-specific missiles*

This COL item is addressed in Subsection 3.5.2.

CP COL 3.5(6) ***3.5(6)*** *Orientation of T/G of other unit(s)*

This COL item is addressed in Subsection 3.5.1.3.1.

3.5.5 References

Add the following reference after the last reference in DCD Subsection 3.5.5.

3.5-201 *The Annual Probability of an Aircraft Crash on the U.S. Department of Energy Reservation in Oak Ridge, Tennessee*, ORNL/ENG/TM-36, Oak Ridge National Laboratory, Oak Ridge, TN, November 1992.

3.6 PROTECTION AGAINST DYNAMIC EFFECTS ASSOCIATED WITH POSTULATED RUPTURE OF PIPING

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

3.6.1.3 Postulated Failures Associated with Site-Specific Piping

STD COL 3.6(1) Replace the paragraph in DCD Subsection 3.6.1.3 with the following.

There is no site-specific high-energy piping. A site-specific pipe break evaluation report will be completed prior to the installation and fabrication of site-specific piping systems or installation of connected components and equipment. The evaluation report identifies the site-specific systems or components, such as the essential service water piping system, that are safety-related or required for safe shutdown that are located near high-energy or moderate-energy piping systems, and are susceptible to the consequences of these piping failures. The evaluation report also provides a list of site-specific moderate-energy piping systems, which includes a description of the layout of all piping systems where physical arrangement of the piping systems provides the required protection, the design basis of structures and compartments used to protect nearby essential systems or components, or the arrangements to assure the operability of safety-related features where neither separation nor protective enclosures are practical. Additionally, the evaluation report provides the failure modes and effect analyses that verifies the consequences of failures in site-specific moderate-energy piping does not affect the ability to safely shut down the plant.

3.6.2.1 Criteria used to Define Break and Crack Location and Configuration

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STD COL 3.6(4) Replace the second paragraph in DCD Subsection 3.6.2.1 with the following.

There is no site-specific high-energy piping. The criteria also apply for defining pipe break and crack locations and configurations, and the locations and configurations of design basis pipe breaks and cracks, for site-specific moderate-energy piping systems. The postulated rupture orientation of each postulated break location is identified for the site-specific moderate-energy piping systems. The as-built configuration of site-specific moderate-energy lines will also be evaluated to this criterion. As-built inspections will be completed, prior to system turnover for testing and operation, to verify that the installed piping, support locations, types, component locations are consistent with the design intent, and as-built drawings are produced showing component locations and support locations and types that confirm this consistency.

3.6.2.5 Implementation of Criteria Dealing with Special Features

STD COL 3.6(6) Replace the sentence in DCD Subsection 3.6.2.5 with the following.

The criteria dealing with special features will be implemented prior to fabrication and installation of piping and components. Special features include an augmented inservice inspection (ISI) program or use of special protective devices such as pipe whip restraints, including diagrams showing their final configurations, locations, and orientations in relation to break locations.

3.6.4 Combined License Information

Replace the content of DCD Subsection 3.6.4 with the following.

STD COL 3.6(1) ***3.6(1)*** *Postulated failures associated with site-specific piping*

This COL item is addressed in Subsection 3.6.1.3.

3.6(2) *Deleted from the DCD.*

3.6(3) *Deleted from the DCD.*

STD COL 3.6(4) ***3.6(4)*** *Criteria used to define break and crack location and configuration for site-specific piping.*

This COL item is addressed in Subsection 3.6.2.1.

3.6(5) *Deleted from the DCD.*

STD COL 3.6(6) ***3.6(6)*** *Criteria for special features*

This COL item is addressed in Subsection 3.6.2.5.

3.6(7) *Deleted from the DCD.*

3.6(8) *Deleted from the DCD.*

3.6(9) *Deleted from the DCD.*

3.7 SEISMIC DESIGN

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

CP COL 3.7(20) Replace the third paragraph in DCD Section 3.7 with the following.

The validity of the site-independent seismic design of the standard plant for the site-specific seismic conditions is addressed in this Section 3.7, and in Appendix 3NN. The site-specific ground motion response spectra (GMRS), which are developed as free-field outcrop motions on the uppermost in-situ competent material, are discussed in Subsection 3.7.1.1.

CP COL 3.7(21) Replace the fourth paragraph in DCD Section 3.7 with the following.

For the site-specific seismic design of those seismic category I and seismic category II SSCs that are not part of the US-APWR standard plant, spectra appropriately derived from the site-specific GMRS are used to define the site-specific safe-shutdown earthquake (SSE) design ground motion. The response spectra of the site-specific SSE are developed following the requirements of RG 1.208 (Reference 3.7-3), and represent the envelope of the foundation input response spectra (FIRS) and a minimum response spectra as discussed in Subsection 3.7.1.1.

CP COL 3.7(6) Replace the fifth paragraph in DCD Section 3.7 with the following.

Site-specific GMRS and FIRS are developed by analysis methodology described in Subsection 3.7.1.1 and account for the upward propagation of the GMRS. The site-specific horizontal GMRS are shown in Figure 3.7-201 as FIRS1. The FIRS are compared to the minimum design earthquake which is defined as the certified seismic design response spectra (CSDRS) scaled to a 0.1 g peak ground acceleration (PGA). This confirms that the minimum design earthquake envelopes the FIRS at all locations for all frequencies by a large margin.

3.7.1.1 Design Ground Motion

CP COL 3.7(1) Replace the second sentence of the first paragraph in DCD Subsection 3.7.1.1 with the following.

The applicable site-specific PGA is 0.1 g for the two horizontal directions and the vertical direction.

CP COL 3.7(22) Replace the last sentence of the ninth paragraph in DCD Subsection 3.7.1.1 with the following.

The CPNPP is not in a high seismic area, is not founded on hard rock, and the site-specific seismic GMRS and FIRS demonstrate that there are no high frequency exceedances of the CSDRS that could create damaging effects.

CP COL 3.7(5) Replace the last two sentences of the sixteenth paragraph in DCD Subsection 3.7.1.1 with the following.

The site-specific horizontal response spectra are obtained from site-specific response analyses performed in accordance with RG 1.208 (Reference 3.7-3) and account for upward propagation of the GMRS. The nominal GMRS and horizontal response spectra for 5 percent damping resulting from these site-specific response analyses are shown in Figure 3.7-201. The spectra shown in Figure 3.7-201 represent nominal spectra for the following site-specific conditions:

FIRS1 = the nominal GMRS, at the top of the stiff limestone (nominal elevation 782’) described in Chapter 2. The R/B-prestressed concrete containment vessel (PCCV)-containment internal structure, PS/Bs, UHSRS, PSFSVs, ESWPT, and A/B are founded directly on this limestone layer, have a thin layer of fill concrete placed between the top of limestone and bottom of mat foundation, and/or the fill concrete is analyzed in SASSI (Reference 3.7-17) as part of the seismic structural model.

FIRS2 = the nominal response spectrum for structures located on a layer of fill concrete placed between the top of the limestone at nominal elevation 782’ and bottom of the structure’s foundation. Note that a comparison of FIRS1 and FIRS2 shows that the presence of several feet of fill concrete does not result in amplification of the ground motion seismic response, and is well below the minimum design earthquake.

FIRS3 = nominal response spectrum corresponding to typical plant grade elevation 822’ for shallow-embedment structures founded on native, in-situ, undisturbed materials occurring below plant grade as described in Chapter 2. FIRS3 does not apply currently to any plant structures. FIRS3 represents the free-field ground motion.

FIRS4 = nominal response spectrum corresponding to typical plant grade elevation 822’ for shallow-embedment structures founded on engineered and compacted structural backfill that extends down to top of limestone at nominal elevation 782’. FIRS4 is computed using both a 30 percent and a 50 percent coefficient of variation for the engineered fill properties to account for a wide range of potential backfill materials. FIRS4 applies to seismic category I duct banks and chases used for routing yard piping and conduits.

The 5 percent damping site-specific horizontal response spectra accelerations for all frequencies, at all FIRS locations, are less than those of the 5 percent damping minimum response spectra tied to the shape of the CSDRS and anchored at 0.1 g, as demonstrated in Figure 3.7-201. Similarly, the 5 percent damping site-specific vertical response spectra, which are developed from the horizontal response spectra using vertical/horizontal response spectral ratios appropriate for the site, are less than the 5 percent damping minimum vertical response spectra tied to the shape of the CSDRS and anchored at 0.1g. The nominal site-specific response spectra described above are less than the minimum required response spectra, and are therefore not used for site-specific design. Instead, the site-specific FIRS are defined as the shape of the CSDRS anchored at 0.1g, in order to comply with the intent of Appendix S (IV)(a)(1)(i) of 10 CFR 50 (Reference 3.7-7). By definition, the site-specific FIRS are automatically enveloped by the CSDRS given in Figures 3.7.1-1 and 3.7.1-2 for standard plant seismic category I structures. The site-specific FIRS (CSDRS anchored at 0.1g) are used for the design of seismic category I and II SSCs that are not part of the US-APWR standard plant.

The site-specific FIRS are presented in Figures 3.7-202 and 3.7-203 for the horizontal and vertical FIRS, respectively. Tabulated values of the corresponding spectral accelerations for each of the spectral control points are presented in Tables 3.7-201 and 3.7-202 for the horizontal and vertical FIRS, respectively.

CP COL 3.7(2) Replace the seventeenth paragraph in DCD Subsection 3.7.1.1 with the following.

The site-specific verification analysis of US-APWR standard plant seismic category I structures is performed considering SSI effects and using the site-specific FIRS as described in Subsection 3.7.2.4.1.

CP COL 3.7(13) Replace the first and second sentences of the nineteenth paragraph in DCD Subsection 3.7.1.1 with the following.

For CPNPP Units 3 and 4, the value of the operating-basis earthquake (OBE) ground motion that serves as the basis for defining the criteria for shutdown of the plant is 1/3 of the site-specific FIRS shown in Figures 3.7-202 and 3.7-203. Option A is maintained for site-specific seismic category I structures; therefore, OBE is not a site-specific seismic design case.

CP COL 3.7(24) Replace the first sentence of the next-to-last paragraph in DCD Subsection 3.7.1.1 with the following.

In development of the site-specific GMRS, as provided in Subsection 2.5.2, the site-specific ratios V/A and AD/V^2 (A, V, D, are PGA, ground velocity, and ground displacement, respectively) are verified to be consistent with values characteristic for the magnitude and distance of the appropriate controlling events defining the site-specific uniform hazard response spectra.

CP COL 3.7(30) Replace the last paragraph in DCD Subsection 3.7.1.1.with the following

Site-Specific Design Ground Motion Time Histories and Durations of Motion

For the site-specific design of the UHSRS, ESWPT, and PSFSVs, one set of three statistically independent time histories of seismic motion is synthesized artificially for use as the input outcrop motion in the earthquake response analyses. The time histories are compatible with the minimum required design spectra discussed above. The three time histories are developed to represent the ground motion for the three orthogonal earthquake components, two horizontal ("H1" and "H2") and vertical ("V") following the requirements and conditions set in Section II of SRP 3.7.1 (Reference 3.7-10) for the development of a single set of time histories Option 1, Approach 2. Figures 3.7-204, 3.7-205, and 3.7-206 provide H1, H2, and V time histories, respectively, used for the design of UHSRS, ESWPT, and PSFSVs and site-specific verification analysis of US-APWR standard plant. Approach 2 is utilized with the objective to generate artificial acceleration time histories with response spectra which achieve approximately mean based fits to the site-specific FIRS target spectra, as shown in Figures 3.7-207, 3.7-208, and 3.7-209. The average ratio of the acceleration response spectra (ARS) calculated from the artificial time histories to the corresponding target spectra is kept only slightly greater than one. The spectral acceleration ratio is calculated frequency by frequency.

The time histories meet the requirements of Approach 2 steps (a) through (d) as follows:

a) Total duration is 40 seconds and the time step is 0.005 seconds (Nyquist frequency is 100 Hz). Note that the total duration of the artificial time histories is increased by zero packing.

b) Spectral accelerations at 5 percent damping are computed at a minimum of 100 points per frequency decade, uniformly spaced over the log frequency scale from 0.1 Hz to 100 Hz. A comparison of the response spectra obtained from the time histories to the FIRS spectra is made at each of the frequencies in this range.

c) The computed 5 percent damped spectra do not fall more than 8 percent below target spectra at any one frequency, which meets the 10 percent nonexceedance requirement. Also, any nonexceedance windows are less than +/- 10 percent of the particular frequency upon which they are centered.

d) The computed 5 percent damped response spectra of the artificial time histories do not exceed the target spectra by more than 6 percent (factor of 1.06) in the frequency range of interest.

The cross-correlation coefficients between the three components of the design time histories are as follows:

$\rho_{12} = 0.116$, $\rho_{23} = 0.154$, and $\rho_{31} = 0.071$

where 1, 2, and 3 have been adopted as the same three global directions used for the standard plant. Because the cross-correlation coefficients do not exceed 0.16, they are statistically independent of each other and acceptable.

The strong durations of motion of the site-specific time histories are each at least 8.1 seconds and the total durations are each at least 40 seconds, which exceeds SRP 3.7.1 (Reference 3.7-10) criteria. The durations of motion have been determined using random phase characteristics, and it has been demonstrated that they are long enough such that adequate representation of the Fourier components at low frequency are included in the time histories. The corresponding stationary phase strong-motion duration is consistent with the longest duration of strong motion from the earthquakes defined in SRP 2.5.2 (Reference 3.7-8) at low and high frequency and as presented in NUREG/CR-6728 (Reference 3.7-14). The uniformity of the growth of this Arias Intensity has been examined and is acceptable.

3.7.1.2 Percentage of Critical Damping Values

CP COL 3.7(4) Replace the last three sentences of the second paragraph in DCD Subsection 3.7.1.2 with the following.

Since the design of the UHSRS, ESWPT, and PSFSVs considers site-specific subgrade conditions, the lower damping values in Table 3.7.3-1(b) are used, both for analysis of the structures and for computation of their in-structure response spectra (ISRS). This is in accordance with Section 1.2 of RG 1.61 (Reference 3.7-15), and prevents non-conservative results in the site-specific design. Further, the lower OBE damping values of Table 3.7.3-1(b) are also used for the site-specific SASSI (Reference 3.7-17) analysis of the R/B-PCCV-containment internal structure described in Subsection 3.7.2.4.1, in order to confirm that the ISRS and site-specific effects are enveloped by the standard plant design.

3.7.1.3 Supporting Media for Seismic Category I Structures

CP COL 3.7(28) Replace the second sentence of the first paragraph in DCD Subsection 3.7.1.3 with the following.

The overall basemat dimensions, basemat embedment depths, and maximum height of major seismic category I buildings and structures are given in Table 3.7.1-3R.

CP COL 3.7(7) Replace the last two sentences of the second paragraph in DCD Subsection 3.7.1.3 with the following.

For CPNPP Units 3 and 4, all major seismic category I and II buildings and structures, including the R/B-PCCV-containment internal structure on a common mat, the PS/Bs, UHSRS, ESWPT, PSFSVs, A/B, and T/B, are founded directly on solid limestone or on fill concrete which extends from the foundation bottom to the top of solid limestone at nominal elevation 782’. The material properties of the limestone are presented in Table 3.7-203. The underlying stratigraphy is discussed further in Chapter 2.

The fill concrete has a design compressive strength of 3,000 psi that corresponds to a shear wave velocity of 6,400 ft/sec. To further assure that the site-specific effects of the fill concrete are captured, where applicable, the fill concrete is considered as part of the structure in the site-specific SASSI (Reference 3.7-17) models used to perform the site-specific SSI analyses of the R/B-PCCV-containment internal structure, UHSRS, ESWPT, and PSFSVs.

The maximum bearing loads and available factors of safety for all major category I and II buildings and structures are presented in Table 3.8-202. Table 3.8-202 demonstrates that the minimum factor of safety for ultimate bearing capacity versus maximum bearing load (static + dynamic/seismic) is at least 2 for the R/B-PCCV-containment internal structure, PS/Bs, UHSRS, ESWPT, PSFSVs, A/B, and T/B, based on site-specific subgrade conditions and the site-specific FIRS ground input motion with a PGA of 0.1 g.

3.7.2.1 Seismic Analysis Methods

CP COL 3.7(29) Replace the second sentence of the first paragraph in DCD Subsection 3.7.2.1 with the following.

Table 3.7.2-1R presents a summary of dynamic analysis and combination techniques including types of models and computer programs used, seismic analysis methods, and method of combination for the three directional components for the seismic analysis of the US-APWR standard and site-specific seismic category I buildings and structures.

3.7.2.3.1 General Discussion of Analytical Models

CP COL 3.7(3) Replace the sixth paragraph (including bullets) in DCD Subsection 3.7.2.3.1 with the following.

Analytical models used for the seismic analyses of buildings and structures are developed on a site-specific basis as follows:

- PSFSVs (seismic category I). A three-dimensional site-specific SASSI (Reference 3.7-17) finite element (FE) model is used for seismic analysis. The PSFSV analytical model is discussed in Appendix 3MM.
- ESWPT (seismic category I). Three-dimensional site-specific SASSI (Reference 3.7-17) FE models are used for seismic analysis. The ESWPT analytical models are discussed in Appendix 3LL.
- UHSRS (seismic category I). Three-dimensional site-specific SASSI (Reference 3.7-17) FE models are used for seismic analysis. The UHSRS analytical model is discussed in Appendix 3KK.
- To account for seismic response of site-specific seismic category I yard piping and conduits routed within reinforced concrete duct banks (solid) or reinforced concrete chases (hollow), a nominal FIRS (FIRS4) was developed considering a wide range of potential variation of the site-specific backfill properties. The FIRS4 was compared to and found to be enveloped by the minimum required design response spectrum. The artificial time histories corresponding to the minimum response spectra are developed in compliance with SRP 3.7.1 (Reference 3.7-10), Option 1, Approach 2, and independently from (not scaled from) the CSDRS time histories. This forms a basis for seismic design of these items which therefore accounts for the site-specific soil media (backfill) characteristics and the site-specific earthquake.

3.7.2.3.4 Subsystem Coupling Requirements

CP COL 3.7(11) Replace the last two sentences of the third paragraph in DCD Subsection 3.7.2.3.4 with the following.

The polar crane and fuel handling crane manufacturers are selected and a site-specific design of these cranes will be performed prior to construction. The site-specific seismic analysis and design of the cranes consider their masses and frequencies, and are coupled with the building analyses as required by ASME NOG-1 (Reference 3.7-22) or SRP 3.7.2 (Reference 3.7-16).

3.7.2.4.1 Requirements for Site-Specific SSI Analysis of US-APWR Standard Plant

CP COL 3.7(25) Replace the first and second paragraph in DCD Subsection 3.7.2.4.1 with the following.

The site-specific SSI analysis for the R/B-PCCV-containment internal structure is performed utilizing the program ACS-SASSI Version 2.2 (Reference 3.7-17). The analysis confirms that site-specific effects are enveloped by the standard design. The site-specific SSI analysis of the R/B-PCCV-containment internal structure is addressed in Appendix 3NN.

CP COL 3.7(26) Replace the third paragraph in DCD Subsection 3.7.2.4.1 with the following.

The site-specific SSI analyses of the UHSRS, ESWPT, and PSFSVs are performed using the computer program ACS-SASSI (Reference 3.7-17). The SASSI analyses for these structures are performed using the same methodology as the site-specific SASSI analysis of the R/B-PCCV-containment internal structure. The SASSI analyses and results for the UHSRS, ESWPT, and PSFSVs are addressed in further detail in Appendices 3KK, 3LL, and 3MM, respectively.

The SSI analyses of the A/B and T/B are performed based on lumped parameter SSI analyses which consider a range of subgrade conditions that envelope the site-specific subgrade conditions, including site-specific effects due to soil layering and location of the water table. The SSI damping values used do not exceed the values specified by ASCE 4-98 (Reference 3.7-9).

CP COL 3.7(8) Replace the sixth, seventh, and eighth paragraphs with the following.

The SSI analysis uses stiffness and damping properties of the subgrade materials that are compatible with the strains generated by the site-specific design earthquake.

All standard plant and site-specific seismic category I and II buildings and major structures are founded directly on a limestone stratum approximately 65 ft. thick, with a layer of fill concrete (not backfill) installed underneath the entire basemat where required to fill the volume between the basemat bottom and the top of limestone. The dynamic properties of the rock subgrade at CPNPP Units 3 and 4 are considered to be strain-independent. The mean shear wave velocity of the top 400 ft. of subgrade below seismic category I and II buildings and structures is 3,830 ft/s. This is above the limit of 3,500 ft/s (corresponding to subgrade material defined as rock with strain-independent dynamic properties) typically used as the cut-off point, below which dynamic testing of the subgrade material would be implemented. At depths below the 400 ft. range discussed above, the shear wave velocity of the rock is higher than 5,500 ft/s. Due to the low site seismicity, the anticipated strains in the rock subgrade due to the site-specific earthquake are very low, less than 0.01 percent. As previously mentioned in Subsection 3.7.2.4, the seismic design of the R/B-PCCV-containment internal structure does not rely on the backfill present on the sides of the building to derive lateral or structural support. Furthermore, the seismic designs of all other seismic category I and II buildings and structures, including the PS/Bs, A/B, T/B, UHSRS, ESWPT, and PSFSVs, also do not rely on backfill for lateral or structural support. The designs of the exterior walls of the building basements consider the earth pressures generated by the design earthquake.

Seismic category I shallow-embedded duct banks and chases are installed in and rest on compacted engineered structural backfill at the site. These structures consist of ruggedly designed reinforced concrete and are equipped with expansion joints that accommodate potentially large strains in the surrounding backfill.

Based on these site conditions, in which the basemats of all seismic category I and II buildings rest directly on limestone or fill concrete, dynamic testing is not required to evaluate the strain-dependent properties of the rock subgrade and compacted backfill at CPNPP Units 3 and 4.

The water table at the site is located below the basemat bottom elevations and is taken as no higher than elevation 780 ft. for purposes of seismic analysis. The P-wave velocities of the saturated rock layers exceed the P-wave velocity of the water (5,000 ft/s). Therefore, the water table elevation does not affect the P-wave velocities of the submerged subgrade materials. Significant variations in the water table elevation and significant variations of the subgrade properties in the horizontal direction are addressed by using additional sets of site profiles.

In order to accurately capture effects of basemat embedment and flexibility, a 3-D finite element model is used to represent the stiffness and mass inertia of the basement in the SASSI model developed for the site-specific SSI verification analysis. To assure proper comparability with the US-APWR standard plant design, the above-ground portion of the R/B-PCCV-containment internal structure is modeled using lumped mass stick models with properties identical to those of the verified and validated lumped mass stick models of the building superstructure used in the US-APWR standard design.

The properties of the SASSI (Reference 3.7-17) seismic model are verified by an SSI analysis of the building resting on the surface of a hard rock subgrade that simulates fixed base conditions. The results of the SASSI analysis are demonstrated to match the results from the time history analyses of fixed base lump mass stick models.

CP COL 3.7(23) Replace the third sentence of the ninth paragraph in DCD Subsection 3.7.2.4.1 with the following.

The results of the site-specific SSI analysis documented in Appendix 3NN demonstrate that the standard plant broadened ISRS contained in Appendix 3I for the R/B-PCCV-containment internal structure are enveloped by a high margin. Considering the low site-specific seismic response (based on FIRS tied to 0.1 g versus standard plant CSDRS tied to 0.3 g), it is concluded from the review of the Appendix 3NN results that the R/B basemat seismic pressures and basement walls lateral soil pressures are also enveloped by the US-APWR standard design.

The range of subgrade properties considered in the A/B and T/B SSI lumped parameter models envelope site-specific variations related to subgrade stratigraphy and foundation flexibility. Since the basemat embedment effects are neglected, this also yields conservative results which envelope the site-specific responses.

3.7.2.8 Interaction of Non-Category I Structures with Seismic Category I Structures

CP COL 3.7(10) Replace the last sentence of the fifth paragraph in DCD Subsection 3.7.2.8 with the following.

Structure-to-structure interactions, which could potentially influence the measured seismic response levels, will not occur because the R/B and PS/B are both founded on the same very stiff limestone layer and are separated by expansion joints which prevent seismic interaction.

Site-specific conditions at CPNPP Units 3 and 4 do not result in exceedance of the assumed pressure distributions used for the US-APWR standard plant design.

CP COL 3.7(9) Replace the seventh paragraph in DCD Subsection 3.7.2.8 with the following.

There are no installations of site-specific seismic category I SSCs (e.g., buried yard piping or duct banks) that could be impacted by a potential collapse or failure of the non-seismic category I structures. Final locations of safety-related SSCs in the plant yard adjacent to the AC/B, including those which may be field routed, will be reviewed prior to first fuel load to assure that distances away from the AC/B and/or burial depths are sufficient to prevent potential failure effects that could jeopardize their function and integrity.

3.7.2.13 Methods of Seismic Analysis of Dams

CP COL 3.7(27) Replace the paragraph in DCD Subsection 3.7.2.13 with the following.

Neither the US-APWR standard plant design nor the CPNPP Units 3 and 4 plant design include the use of dams.

3.7.3.8 Methods for Seismic Analysis of Category I Concrete Dams

CP COL 3.7(27) Replace the paragraph in DCD Subsection 3.7.3.8 with the following.

Neither the US-APWR standard plant design nor the CPNPP Units 3 and 4 plant design include the use of dams.

3.7.3.9 Methods for Seismic Analysis of Aboveground Tanks

CP COL 3.7(12) Replace the first paragraph in DCD Subsection 3.7.3.9 with the following.

The seismic category I fuel oil storage tanks are metal tanks which are enclosed by tornado missile protecting concrete vaults (that is, the seismic category I PSFSVs). Since the PSFSVs are below-grade structures, the fuel oil storage tanks are not above-ground tanks. However, the tanks and their mountings are seismically analyzed consistent with the discussion of hydrodynamic loads for above-ground tanks given further below. The tanks' seismic analysis is based on the ISRS which are derived from site-specific SSI analysis of the PSFSVs as documented in Appendix 3MM, using the corresponding site-specific FIRS. Flexibility of the tank shell and tank shell damping effects are considered in estimating the fundamental frequency and spectral accelerations of the tank including its impulsive fluid weight.

3.7.4.1 Comparison with Regulatory Guide 1.12

CP COL 3.7(16) Replace the third paragraph, except the first sentence, in DCD Subsection 3.7.4.1 with the following.

Using these site-specific values of OBE ground input motion, in-structure acceleration and velocity response spectra are developed for the two Unit 3 seismic instrumentation foundation basemat locations in the R/B and east PS/B for 5 percent critical damping. The other three instrument locations described in Subsection 3.7.4.2 serve as back-up data sources in the unlikely event that the foundation instruments are inoperable during an earthquake, and the upper-level instrument locations are also not required by RG 1.12 (Reference 3.7-40) to be used for shutdown determination.

For CPNPP Units 3 and 4, it is considered acceptable to utilize the foundation-level seismic instrumentation to perform the cumulative absolute velocity (CAV) exceedance check for the following reasons:

- The minimum required site-specific ground motion input response spectra (which are the CSDRS anchored at 0.1 g) are greater than the calculated site-specific free-field ground motion, and are also greater than the nominal site-specific ground motion input response spectra calculated for the R/B and PS/B foundations. This is shown in Figure 3.7-201, where FIRS3 represents the free-field ground motion, and FIRS1 represents the nominal site-specific ground motion input spectra for the R/B and PS/B foundations. In this case, it is acceptable to perform a CAV check of seismic responses measured at the R/B and PS/B foundation locations.

- Structure-to-structure interactions, which could potentially influence the measured seismic response levels, will not occur because the R/B and PS/B are both founded on the same very stiff limestone layer and are separated by expansion joints which prevent seismic interaction.

3.7.4.2 Location and Description of Instrumentation

CP COL 3.7(15) Replace the first sentence of the fourth paragraph in DCD Subsection 3.7.4.2 with the following.

A time-history analyzer/recorder which has the capability to provide pre-event recording time of 3 seconds minimum and post-event recording time of 5 seconds minimum, and to record at least 25 minutes of sensed motion, will be selected and installed in Unit 3 at least 12 months prior to first fuel load.

3.7.4.3 Control Room Operator Notification

CP COL 3.7(14) Replace the third sentence of the paragraph in DCD Subsection 3.7.4.3 with the following.

For CPNPP Units 3 and 4, the anticipated seismic response is essentially the same since both units are founded at the same elevation and on the same subgrade with the same stratigraphies, and have the same backfill conditions (including fill concrete) as previously described in Subsection 3.7.1.3 and Chapter 2. Only Unit 3 will be equipped with seismic monitoring instrumentation; however, the main control room (MCR) for both units will be provided with annunciation upon triggering of the instrumentation.

3.7.4.5 Instrument Surveillance (Including Calibration and Testing)

STD COL 3.7(18) Replace the fourth paragraph in DCD Subsection 3.7.4.5 with the following.

A site-specific seismic instrumentation program that includes an instrument surveillance program as well as calibration and testing procedures, and site-specific maintenance and repair procedures that maximize the number of instruments in service during plant operation and shutdown, will be established at least 12 months prior to first fuel load.

3.7.4.6 Program Implementation

CP COL 3.7(19) Replace the paragraph in DCD Subsection 3.7.4.6 with the following.

The seismic instrumentation implementation plan for CPNPP Units 3 and 4 will be established at least 12 months prior to first fuel load.

3.7.5 Combined License Information

Replace the content of DCD Subsection 3.7.5 with the following.

CP COL 3.7(1) ***3.7(1)*** *Site-specific PGA*

This COL item is addressed in Subsection 3.7.1.1.

CP COL 3.7(2) ***3.7(2)*** *Analysis of Site-specific FIRS and Site-independent CSDRS*

This COL item is addressed in Subsection 3.7.1.1.

CP COL 3.7(3) ***3.7(3)*** *Analytical models for site-specific buildings and structures*

This COL item is addressed in Subsection 3.7.2.3.1, and Appendices 3KK, 3LL, and 3MM

CP COL 3.7(4) ***3.7(4)*** *Damping values for site-specific ISRS*

This COL item is addressed in Subsection 3.7.1.2.

CP COL 3.7(5) ***3.7(5)*** *Horizontal FIRS, Vertical FIS, and Minimum Response Spectra*

This COL item is addressed in Subsection 3.7.1.1 , Tables 3.7-201, 3.7-202, and Figures 3.7-201, 3.7-202, and 3.7-203.

CP COL 3.7(6) ***3.7(6)*** *Site-specific GMRS and FIRS*

This COL item is addressed in Section 3.7 and Figure 3.7-201.

CP COL 3.7(7) ***3.7(7)*** *Allowable dynamic bearing capacity*

This COL item is addressed in Subsection 3.7.1.3, Table 3.7-203, and Table 3.8-202.

CP COL 3.7(8) ***3.7(8)*** *Strain-dependent variation of material dynamic properties*

This COL item is addressed in Subsection 3.7.2.4.1.

CP COL 3.7(9) ***3.7(9)*** *Failure or collapse of non-seismic category I structures*

This COL item is addressed in Subsection 3.7.2.8.

CP COL 3.7(10) ***3.7(10)*** *Structure-to-structure interaction*

This COL item is addressed in Subsection 3.7.2.8.

CP COL 3.7(11) ***3.7(11)*** *Mass and frequencies of cranes*

This COL item is addressed in Subsection 3.7.2.3.4.

CP COL 3.7(12) ***3.7(12)*** *Liquid-retaining metal tanks*

This COL item is addressed in Subsection 3.7.3.9 and Appendix 3MM.

CP COL 3.7(13) ***3.7(13)*** *Value of OBE to define criteria for shutdown*

This COL item is addressed in Subsection 3.7.1.1.

CP COL 3.7(14) ***3.7(14)*** *Seismic instrumentation at multiple-unit site*

This COL item is addressed in Subsection 3.7.4.3.

CP COL 3.7(15) ***3.7(15)*** *Time-history analyzer/recorder capabilities*

This COL item is addressed in Subsection 3.7.4.2.

CP COL 3.7(16) ***3.7(16)*** *Seismic monitors and need for free-field motion sensors*

The COL item is addressed in Subsection 3.7.4.1.

3.7(17) *Deleted from the DCD.*

STD COL 3.7(18) ***3.7(18)*** *Site-specific instrument surveillance program*

This COL item is addressed in Subsection 3.7.4.5.

CP COL 3.7(19) ***3.7(19)*** *Site-specific details of seismic instrumentation implementation plan*

This COL item is addressed in Subsection 3.7.4.6.

CP COL 3.7(20) ***3.7(20)*** *Standard plant for site-specific conditions*

This COL item is addressed in Subsection 3.7 and Appendix 3NN.

CP COL 3.7(21) ***3.7(21)*** *Seismic design of non-standard plant SSCs*

This COL item is addressed in Subsection 3.7.

CP COL 3.7(22) ***3.7(22)*** *High seismic areas*

This COL item is addressed in Subsection 3.7.1.1

CP COL 3.7(23) ***3.7(23)*** *Broadened ISRS and lateral soil pressure*

This COL item is addressed in Subsection 3.7.2.4.1 and Appendix 3NN

CP COL 3.7(24) ***3.7(24)*** *Site-specific uniform hazard response spectra*

This COL item is addressed in Subsection 3.7.1.1.

CP COL 3.7(25) ***3.7(25)*** *SSI analysis of R/B-PCCV-containment internal structure*

This COL item is addressed in Subsection 3.7.2.4.1, and Appendix 3NN.

CP COL 3.7(26) ***3.7(26)*** *SSI effects for non-standard plant structures*

This COL item is addressed in Subsection 3.7.2.4.1, and Appendices 3KK, 3LL, and 3MM.

CP COL 3.7(27) ***3.7(27)*** *Seismic analysis of dams*

This COL item is addressed in Subsections 3.7.2.13 and 3.7.3.8.

CP COL 3.7(28) ***3.7(28)*** *Overall site-specific building dimensions*

This COL item is addressed in Subsection 3.7.1.3, and Table 3.7.1-3R.

CP COL 3.7(29) ***3.7(29)*** *Summary of dynamic analysis and combination techniques*

This COL item is addressed in Subsections 3.7.2.1, and Table 3.7.2-1R.

CP COL 3.7(30) ***3.7(30)*** *Site-specific design ground motion time histories and duration*

This COL item is addressed in Subsections 3.7.1.1, and Figures 3.7-204 through 3.7-209.

Table 3.7.1-3R
Major Dimensions of Seismic Category I Structures[1]

	Structure	Basemat Embedment Depth Below Grade (ft)	Basemat Width and Length (ft)	Max. Structure Height
	R/B	26’-8”/38’-10”	210’ x 309’[3]	190’ - 9”
	PCCV	See note 2.	See note 2.	268’ - 3”
	Containment Internal Structure	See note 2.	See note 2.	139’ - 6” (top of pressurizer compartment)
	PS/B	37’-3”	71’ x 117’	51’-11”
CP COL 3.7(28)	PSFSV	40’-0” (nominal)	88’-6” x 78’-6”	42’-7” (+/-) [4],[6]
CP COL 3.7(28)	UHSRS	47’-0”/35’-0”	131’-6” x 131’-6” [5]	112’-0” [4]
CP COL 3.7(28)	ESWPT	30’-11” (typical) 31’-5” (maximum) [7]	26’ (typical) / 35’ (maximum) [7] x length connecting R/B to UHSRS	18’-8” (typical) [4] 51’-5” (maximum) [7]

Notes:

1) The dimensions shown are approximate and are based on the general arrangement drawings in Section 1.2.
2) The R/B, PCCV, and containment internal structure rest on a common basemat as shown on the general arrangement drawings in Section 1.2.
3) Width and height are the distances between column lines of exterior walls.
4) The maximum structure height indicated for these structures is from bottom of mat to top of structure. The shear key dimensions of the ESWPT and PSFSVs are not included.

CP COL 3.7(28)

5) Each mat foundation supports one UHS basin with two pools.
6) This includes height of curb at the high point on the roof slab.
7) The maximum dimensions occur at the UHS air intake missile shields mounted on the ESWPT adjacent to the UHSRS.

CP COL 3.7(29)

Table 3.7.2-1R
Summary of Dynamic Analysis and Combination Techniques
(Sheet 1 of 2)

Model	Analysis Method	Program	Three Components Combination (for Purposes of Dynamic Analysis)	Modal Combination
Three-dimensional R/B-PCCV-containment internal structure Lumped Mass Stick Model (4)	Direct Integration Time History Analysis	ANSYS	square root sum of the squares (SRSS)	N/A
Three-dimensional R/B-PCCV-containment internal structure FE Model (1)	Time History Analysis in Frequency Domain	NASTRAN	N/A (1)	N/A
Three-dimensional R/B-PCCV-containment internal structure SSI Model	Time History Analysis in Frequency Domain using sub-structuring technique	SASSI	N/A (5)	N/A
Three-dimensional reactor coolant loop (RCL) Piping FE Model (2)	Direct Integration Time History Analysis	ANSYS	SRSS	N/A
Three-dimensional PS/Bs Lumped Mass Stick Models (3)	Direct Integration Time History Analysis	ANSYS	SRSS	N/A
Three-dimensional RCL-R/B-PCCV-containment internal structure Lumped Mass Stick Model	Direct Integration Time History Analysis	ANSYS	SRSS	N/A
Three-dimensional UHSRS FE model (6)	Response Spectra Analysis	ANSYS	Newmark 100-40-40	Lindley-Yow method
Three-dimensional UHSRS SSI model	Time History Analysis in Frequency Domain using sub-structuring technique	SASSI	SRSS	N/A
Three-dimensional ESWPT FE models	Modal Analysis	ANSYS	N/A(7)	N/A
Three-dimensional ESWPT SSI models	Time History Analysis in Frequency Domain using sub-structuring technique	SASSI	SRSS	N/A
Three-dimensional PSFSV FE model	Modal Analysis	ANSYS	N/A(7)	N/A
Three-dimensional PSFSV SSI model	Time History Analysis in Frequency Domain using sub-structuring technique	SASSI	SRSS	N/A

CP COL 3.7(29)

Table 3.7.2-1R
Summary of Dynamic Analysis and Combination Techniques
(Sheet 2 of 2)

Notes:

1) The FE model for the R/B-PCCV-containment internal structure on their common basemat is used only for validation of the dynamic lumped mass stick models and for static analysis for design of structural members and components as addressed in Section 3.8.
2) The FE model for the RCL is addressed in a Technical Report (Reference 3.7-18).
3) The lumped mass stick models for the PS/Bs are addressed in a Technical Report (Reference 3.7-33).
4) Three-dimensional RCL-R/B-PCCV-containment internal structure lumped mass stick models are addressed in a Technical Report (Reference 3.7-18).
5) SASSI analysis of the R/B-PCCV-containment internal structure on their common basemat is used only for validation of the dynamic lumped mass stick modeling approach with respect to capturing site-specific effects.
6) Response spectra analysis is performed to obtain response under seismic design loads for UHSRS and is described further in Appendix KK. The seismic response obtained from the response spectra analysis envelopes the results of SASSI analysis of UHSRS.
7) The modal analysis performed on ANSYS FE models of ESWPTs and PSFSVs are used only for the validation of SASSI models.

CP COL 3.7(5)

Table 3.7-201
Site-Specific Horizontal FIRS Acceleration Values and Control Points(1), (2), (3)

Control Point (Hz)		Acceleration (g)
0.5 percent Damping		
A	(50)	0.1
B	(12)	0.50
C	(2.5)	0.60
D	(0.25)	0.073
2 percent Damping		
A	(50)	0.1
B	(12)	0.353
C	(2.5)	0.43
D	(0.25)	0.057
5 percent Damping		
A	(50)	0.1
B	(12)	0.26
C	(2.5)	0.313
D	(0.25)	0.047
7 percent Damping		
A	(50)	0.1
B	(12)	0.23
C	(2.5)	0.273
D	(0.25)	0.043
10 percent Damping		
A	(50)	0.1
B	(12)	0.19
C	(2.5)	0.23
D	(0.25)	0.04

Notes:

1) 0.1 g PGA
2) Amplification factors are based on RG 1.60, Rev. 1 (Reference 3.7-6).
3) For Control Point D, acceleration is computed as follows:
   Acceleration $= (\varpi^2 D / 386.4 \text{ in/sec}^2) \times F_A \times 0.1$

   ϖ = 2π x frequency (rad/sec)
   D = Displacement (in)
   F_A = Amplification Factor from RG 1.60

CP COL 3.7(5)

Table 3.7-202
Site-Specific Vertical FIRS Acceleration Values and Control Points[(1), (2), (3)]

Control Point (Hz)	Acceleration (g)
0.5 percent Damping	
A (50)	0.1
B (12)	0.50
C (3.5)	0.57
D (0.25)	0.05
2 percent Damping	
A (50)	0.1
B (12)	0.353
C (3.5)	0.407
D (0.25)	0.04
5 percent Damping	
A (50)	0.1
B (12)	0.26
C (3.5)	0.30
D (0.25)	0.031
7 percent Damping	
A (50)	0.1
B (12)	0.23
C (3.5)	0.26
D (0.25)	0.029
10 percent Damping	
A (50)	0.1
B (12)	0.19
C (3.5)	0.217
D (0.25)	0.027

Notes:

1) 0.1 g PGA
2) Amplification factors are based on RG 1.60, Rev. 1 (Reference 3.7-6).
3) For Control Point D, acceleration is computed as follows:

$$\text{Acceleration} = (\varpi^2 D \,/\, 386.4 \text{ in/sec}^2) \times F_A \times 0.1$$

ϖ = 2π x frequency (rad/sec)
D = Displacement (in)
F_A = Amplification Factor from RG 1.60

CP COL 3.7(7)

Table 3.7-203
Material Properties of Limestone Layer Supporting Major Category I and II Buildings and Structures

Description	Value
Ultimate bearing capacity	146 ksf
Mean shear wave velocity (V_s)	5,685 ft/s[(1)]
Poisson's ratio	0.33
Mean shear modulus (G_s)	1,080.4 ksi
Density	155 pcf (wet), 148.0 pcf (dry)
Low shear strain damping value (D_s)	1.8 percent
Low unconstrained compression damping value (D_c)	0.9 percent

Notes:

1) The mean shear wave velocity shown is for the top limestone layer, approximately 65 ft. thick, located directly underneath the major seismic category I and II structures on site. The average value of V_s for the top 400 ft. of subgrade beneath the structures is 3,830 ft/s, computed based on the equivalent arrival time method.

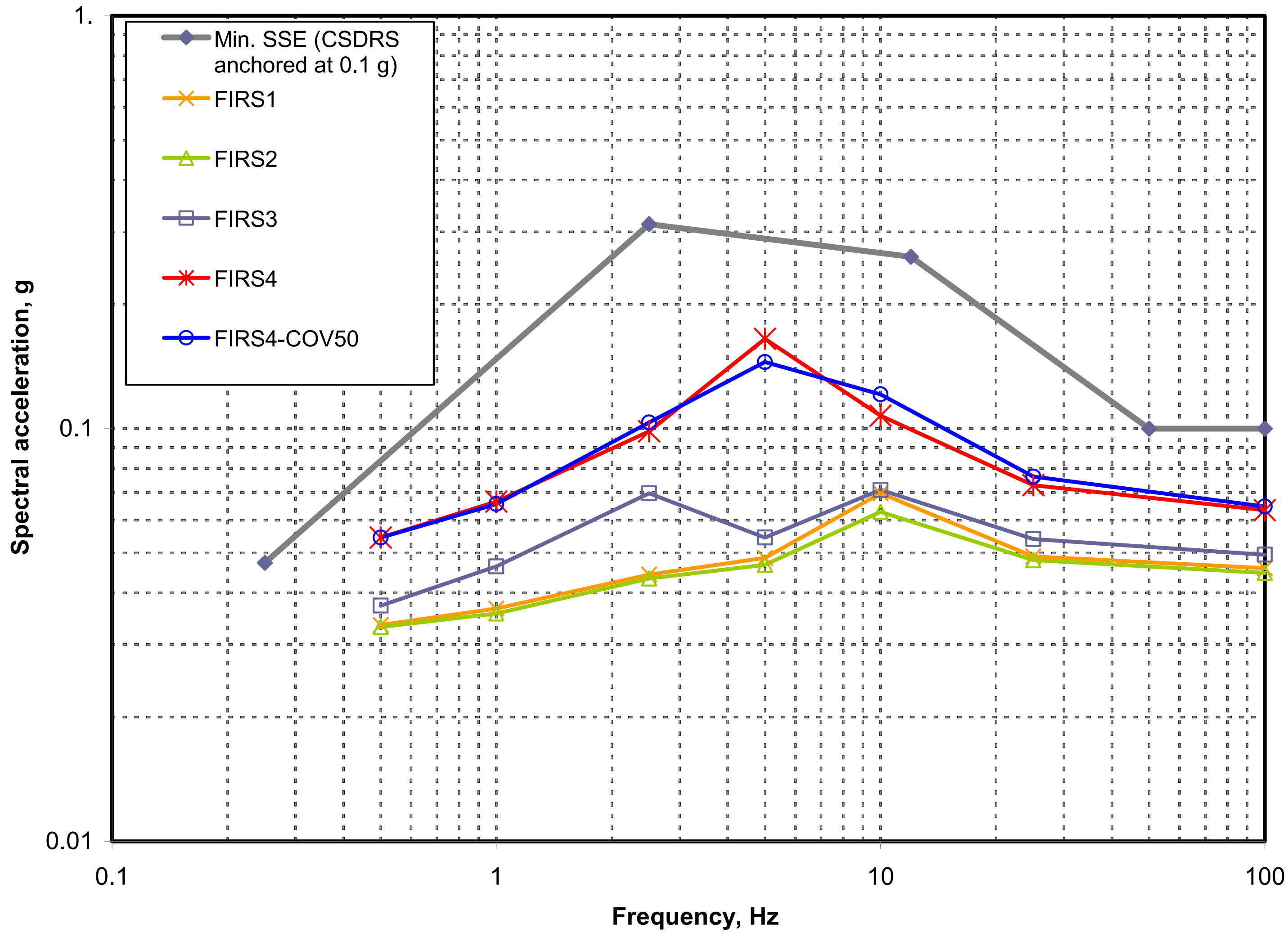


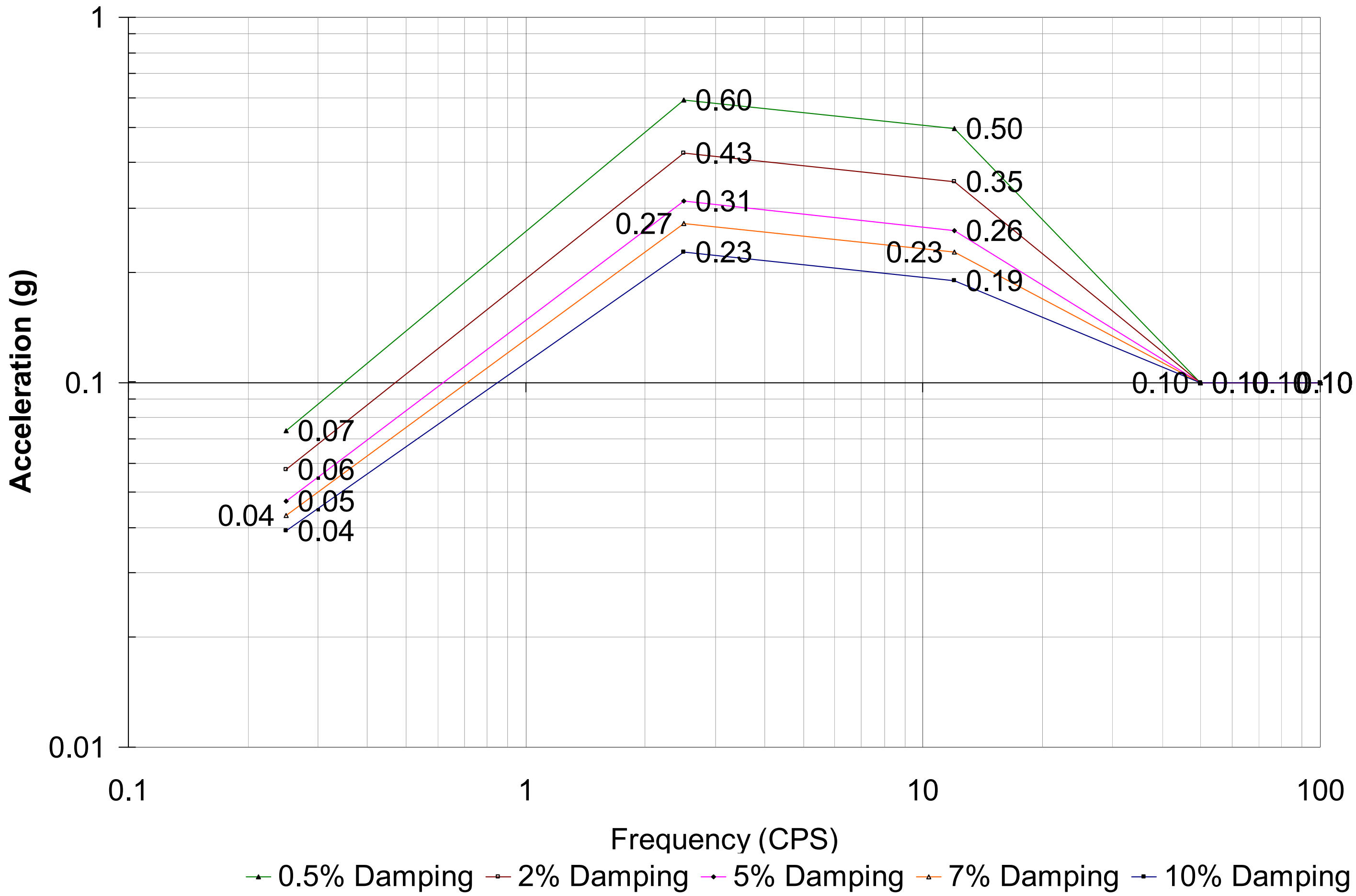
Figure 3.7-201 Nominal Horizontal GMRS and FIRS(1),(2) (Sheet 1 of 2)

CP COL 3.7(5)
CP COL 3.7(6)

Notes:

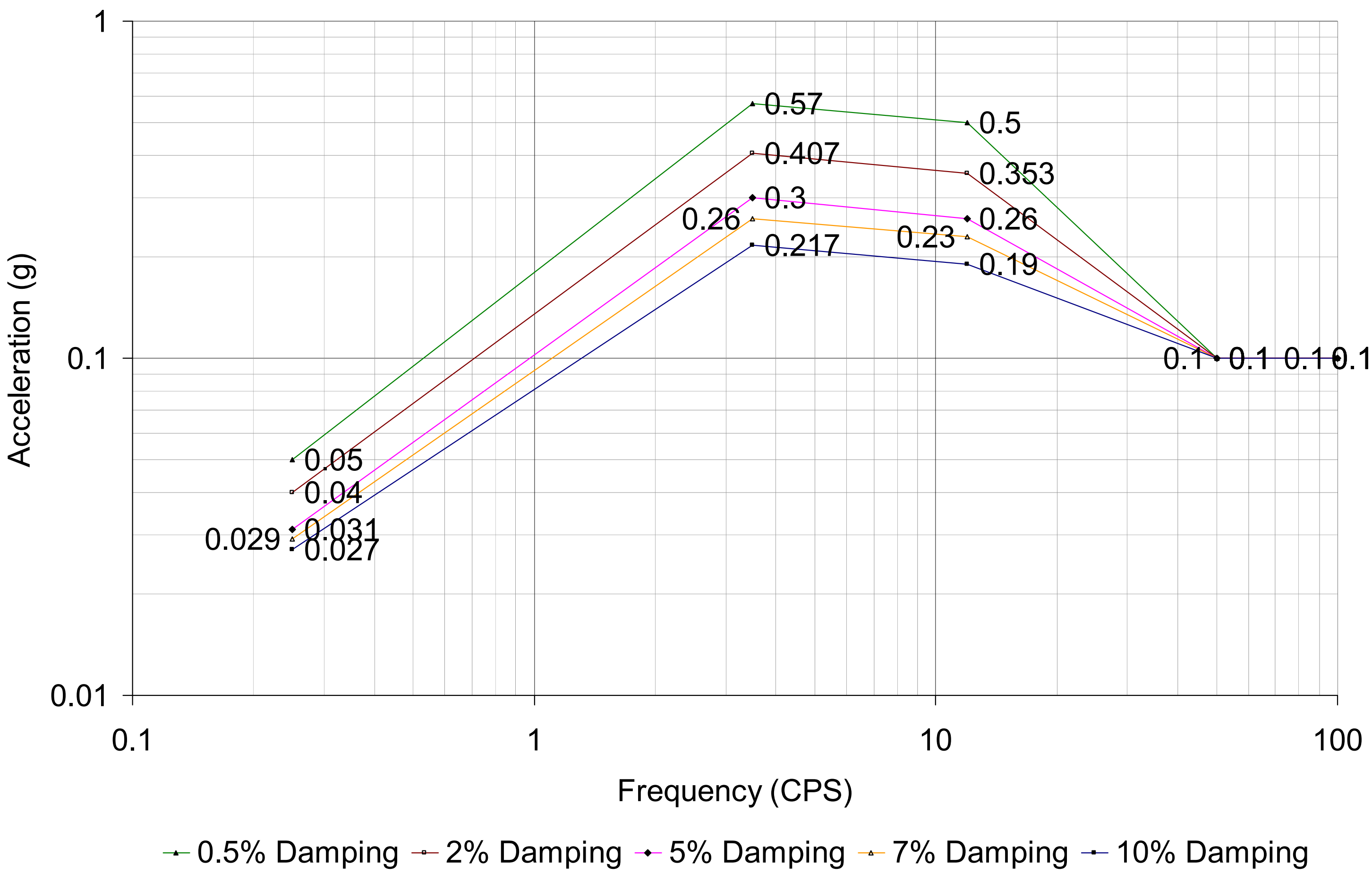
1) The site-specific horizontal ground motion response spectrum is shown as "FIRS1" in the figure above and represents the GMRS corresponding to top of limestone at nominal elevation 782'. The site-specific FIRS and GMRS shown above are discussed in Subsection 3.7.1.1.
2) The nominal site-specific GMRS and FIRS for CPNPP Units 3 and 4 are shown above. However, the nominal GMRS and FIRS are less than the minimum required design response spectra, which are the standard plant CSDRS anchored at 0.1 g as discussed in Subsection 3.7.1.1. Therefore, for site-specific design, the nominal GMRS and FIRS are *not* used. Instead, the minimum applicable design response spectra for site-specific design are the CSDRS anchored at 0.1 g, which are shown separately in Figures 3.7-202 and 3.7-203 for the horizontal and vertical directions, respectively.

Figure 3.7-201 Nominal Horizontal GMRS and FIRS[(1),(2)] (Sheet 2 of 2)



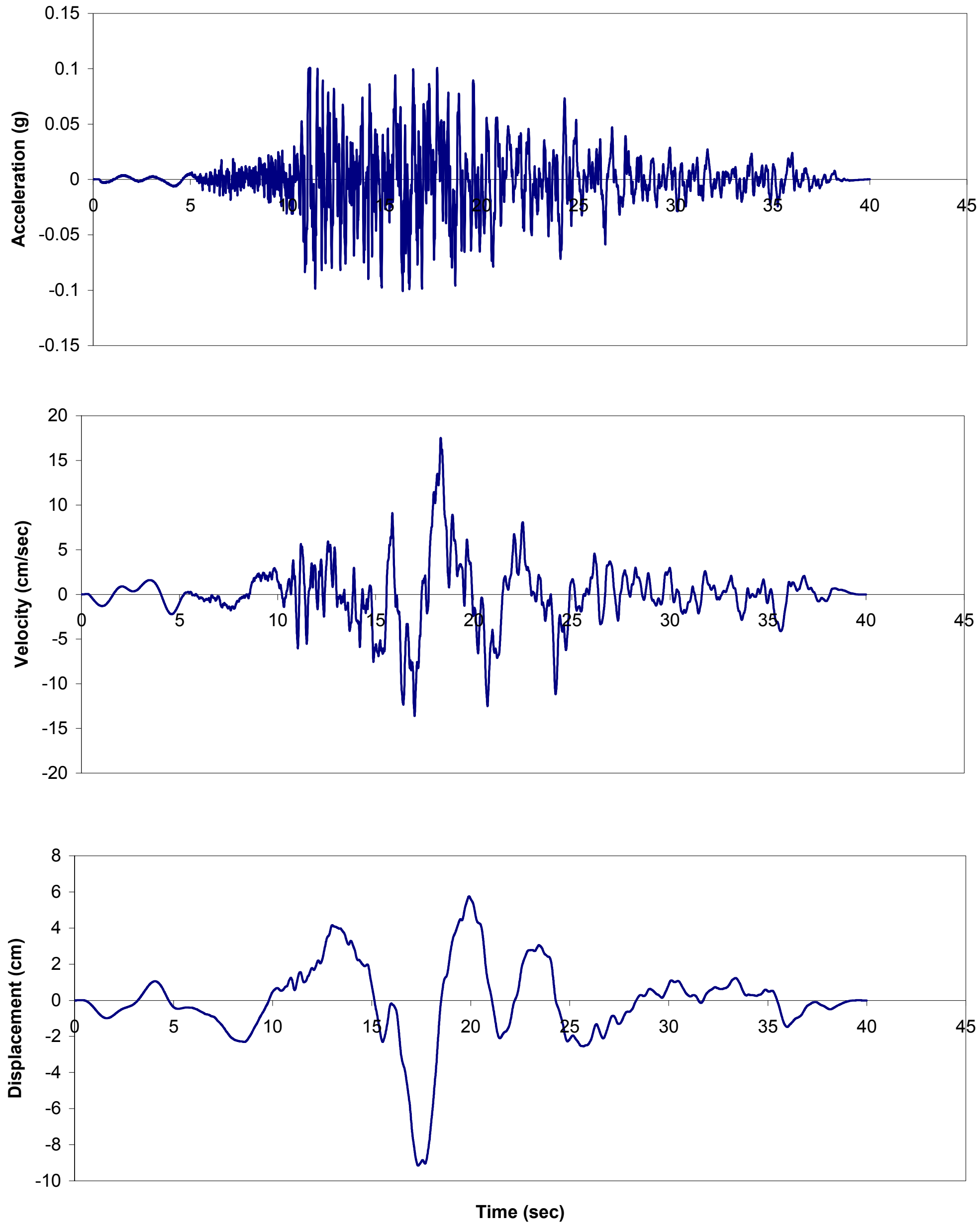
CP COL 3.7(5)

Figure 3.7-202 Comanche Peak Site-Specific Horizontal FIRS

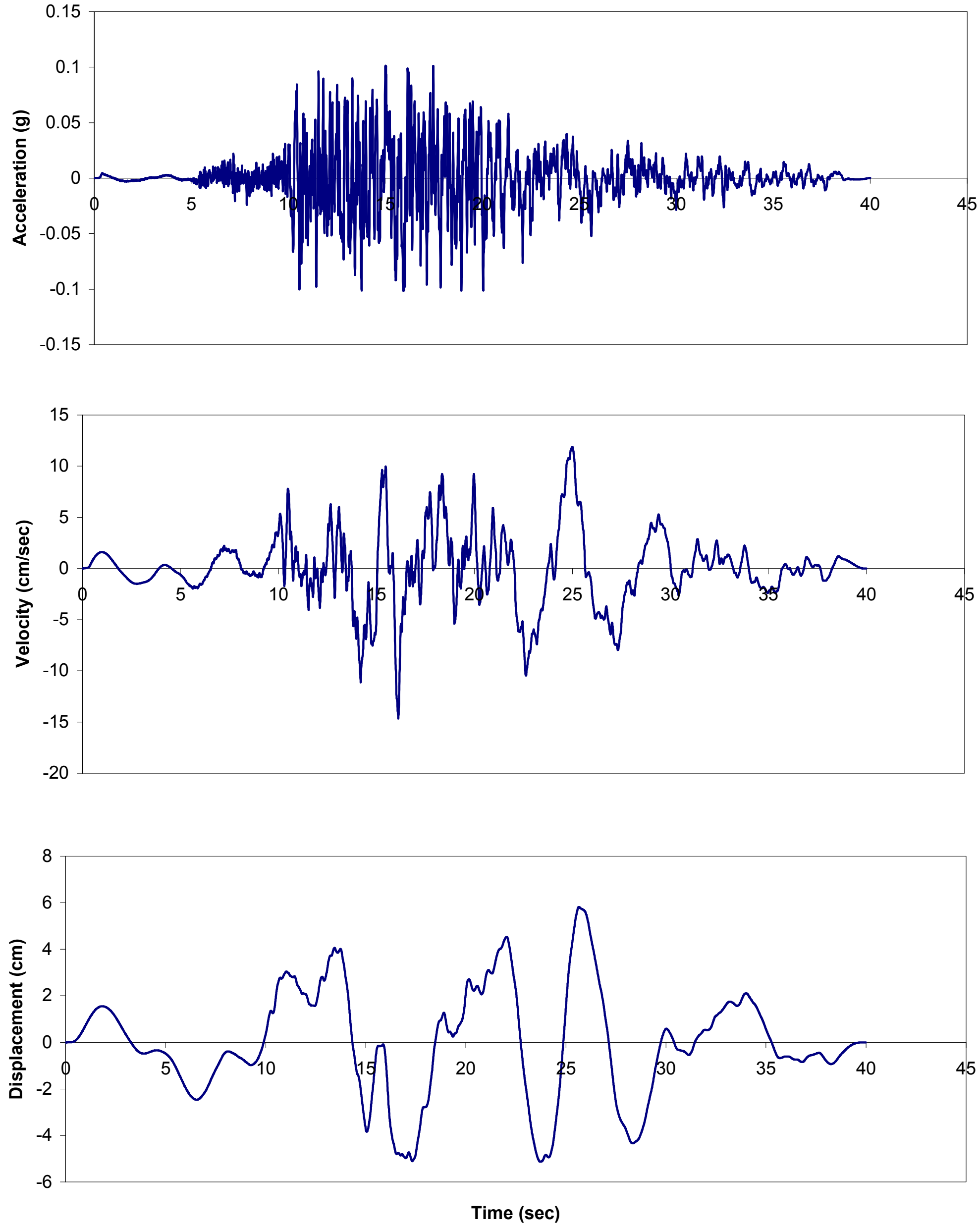


CP COL 3.7(5)

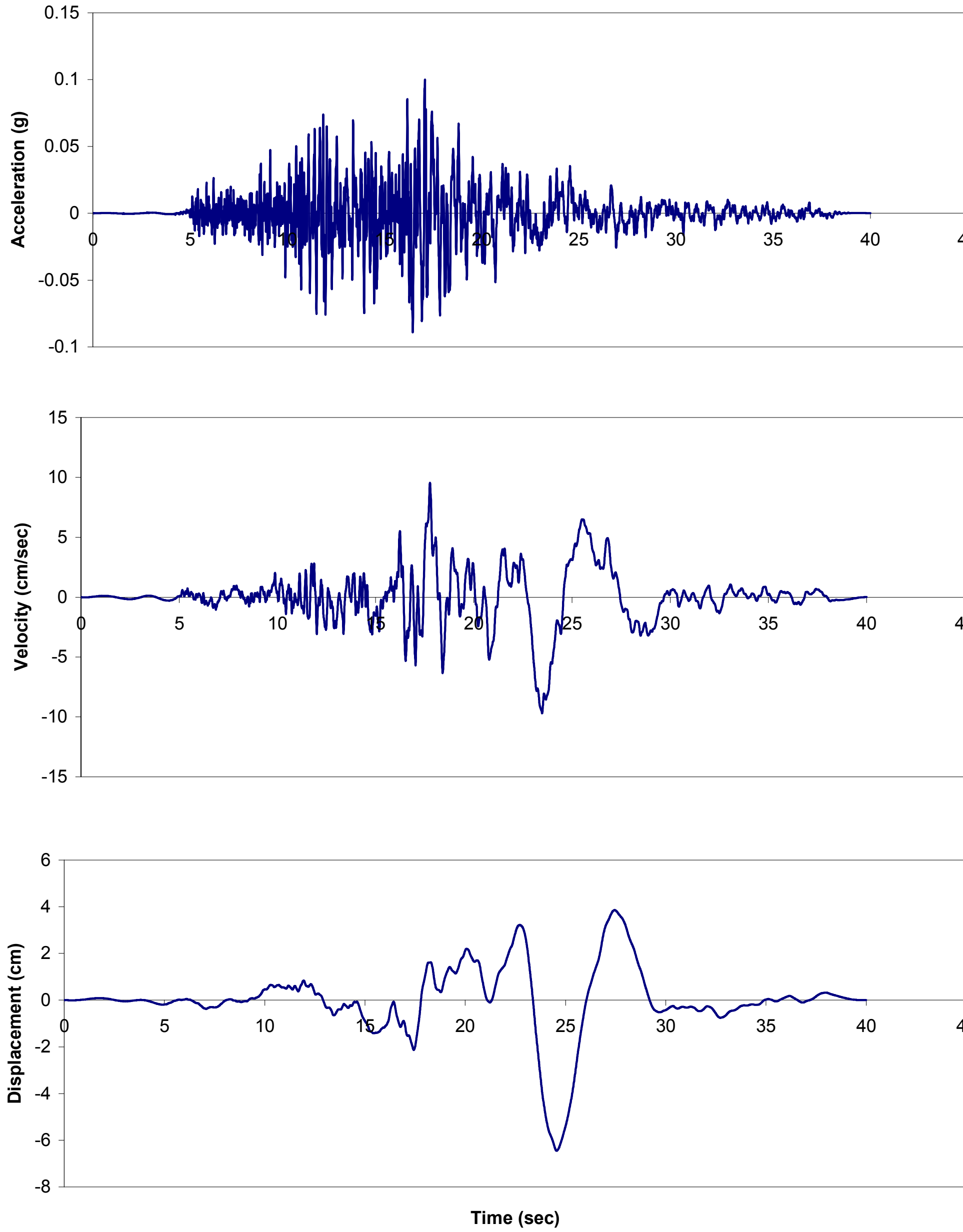
Figure 3.7-203 Comanche Peak Site-Specific Vertical FIRS



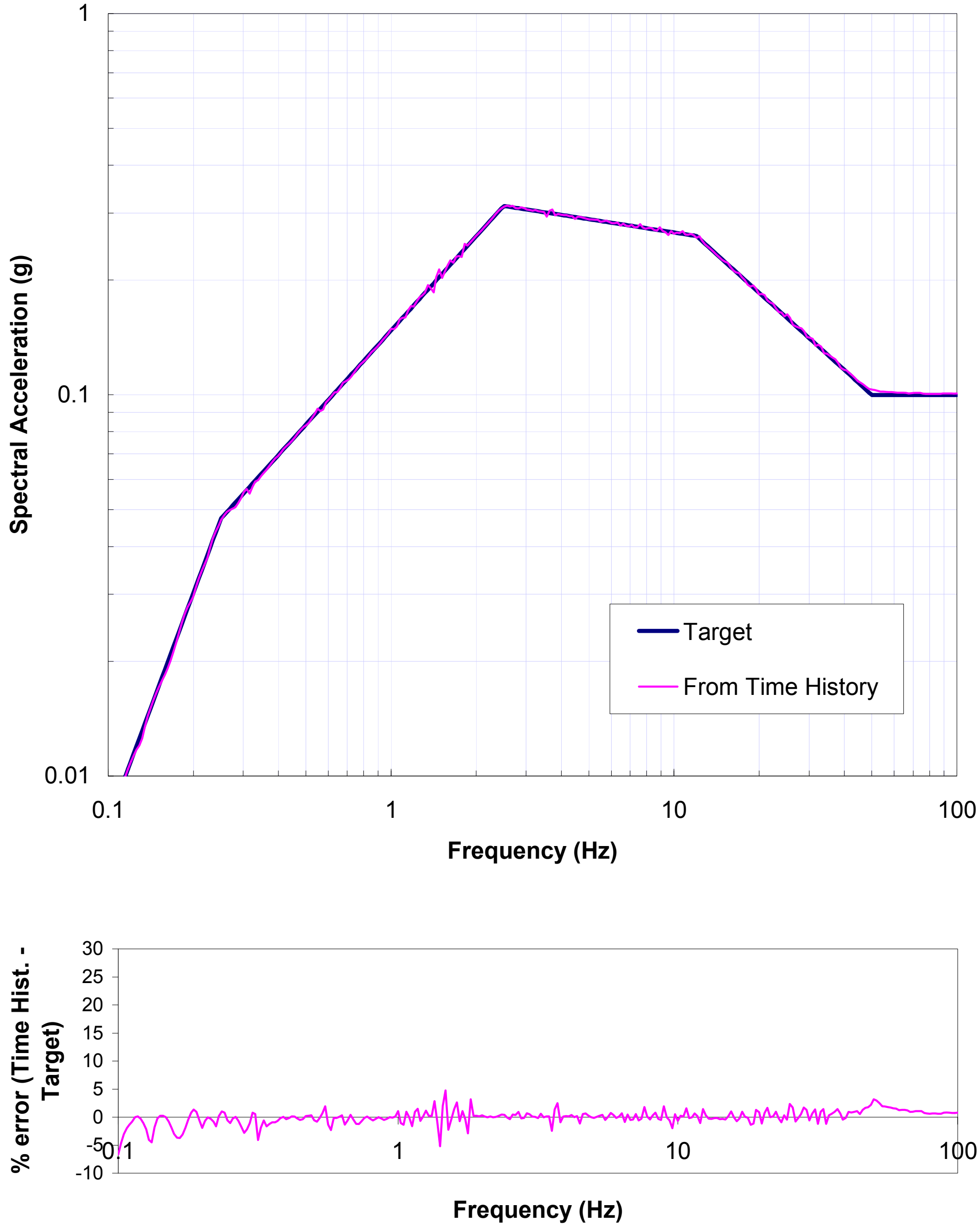
CP COL 3.7(30) **Figure 3.7-204 Time Histories of Acceleration, Velocity, and Displacement – First Horizontal Component (H1) - Compatible to Site-specific SSE Design Spectra**



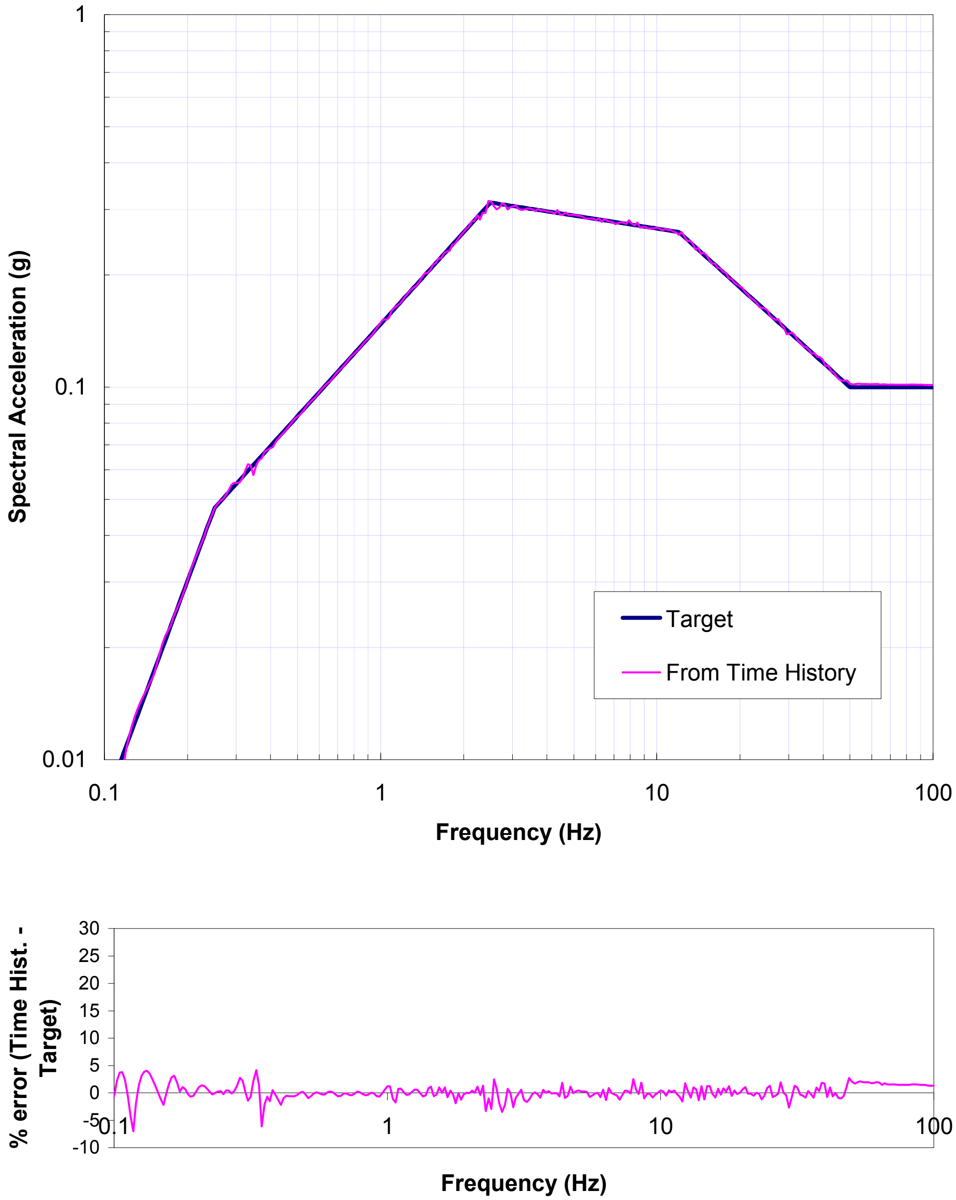
CP COL 3.7(30) **Figure 3.7-205 Time Histories of Acceleration, Velocity, and Displacement – Second Horizontal Component (H2) – Compatible to Site-specific SSE Design Spectra**



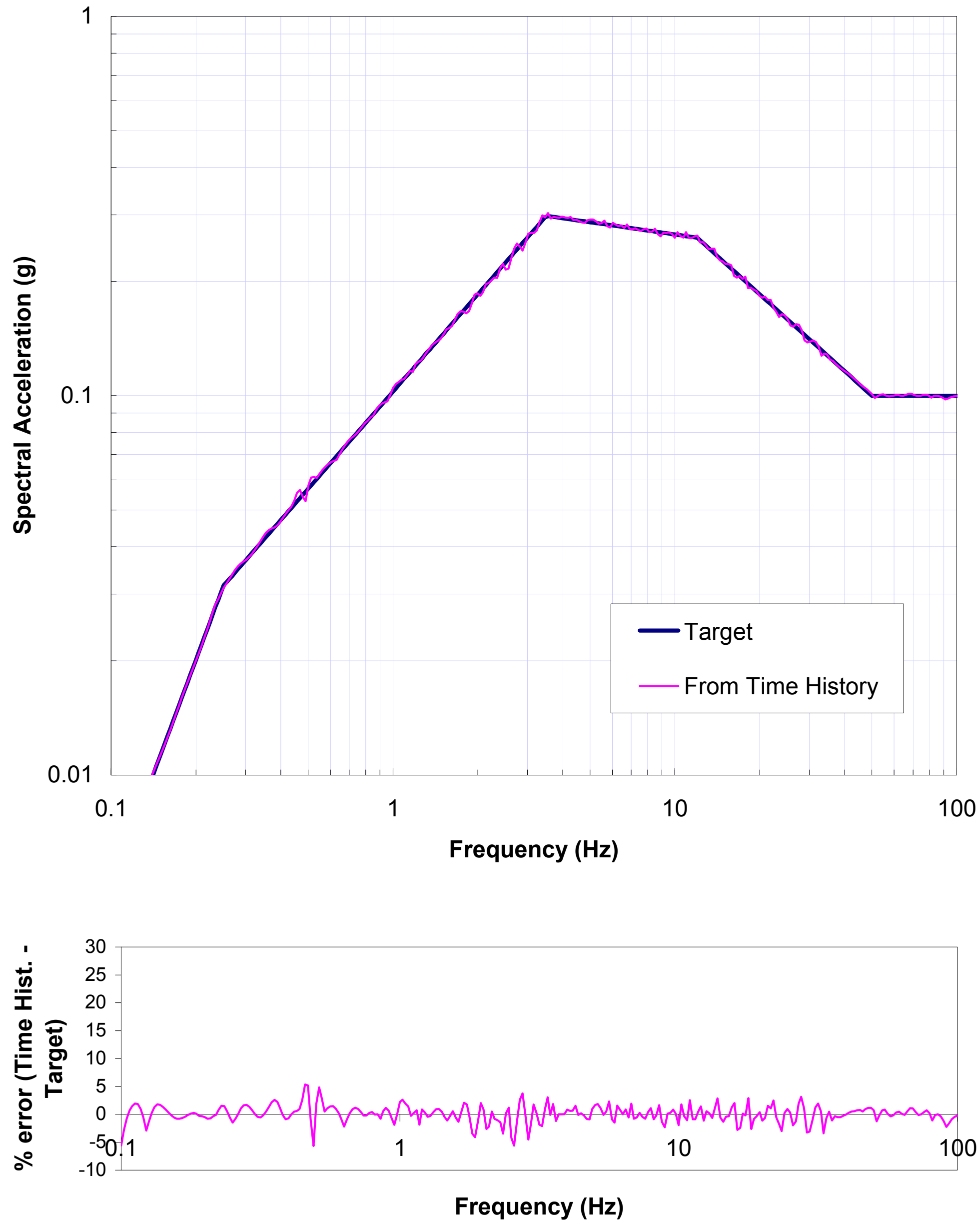
CP COL 3.7(30) **Figure 3.7-206 Time Histories of Acceleration, Velocity, and Displacement – Vertical Component (V) – Compatible to Site-specific SSE Design Spectra**



CP COL 3.7(30) **Figure 3.7-207 Calculated Response Spectra Versus Site-specific SSE Design Target Spectra – First Horizontal Component (H1)**



CP COL 3.7(30) **Figure 3.7-208 Calculated Response Spectra Versus Site-specific SSE Design Target Spectra – Second Horizontal Component (H2)**



CP COL 3.7(30) **Figure 3.7-209 Calculated Response Spectra Versus Site-specific SSE Design Target Spectra – Vertical Component (V)**

3.8 DESIGN OF CATEGORY I STRUCTURES

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

3.8.1.4.1.3 Variation of Physical Material Properties

STD COL 3.8(1) Replace the last sentence in DCD Subsection 3.8.1.4.1.3 with the following.

Reconciliation evaluations of the as-built materials properties with the design physical properties of materials will be completed 12 months prior to the containment system turnover for testing.

3.8.1.5.1.2 Prestressing System

STD COL 3.8(2) Replace the last sentence of the last paragraph in DCD Subsection 3.8.1.5.1.2 with the following.

Prestress friction losses of the tendons due to wobble and curvature coefficients used in the analysis will be reconciled with the site-specific tendon system corrosion protection coatings present at the time of prestressing.

3.8.1.5.2.2 Prestressing System

STD COL 3.8(2) Replace the last sentence of the last paragraph in DCD Subsection 3.8.1.5.2.2 with the following.

Prestress friction losses of the tendons due to wobble and curvature coefficients used in the analysis will be reconciled with the site-specific tendon system corrosion protection coatings present at the time of prestressing.

3.8.1.6 Material, Quality Control, and Special Construction Techniques

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STD COL 3.8(3) Replace the second sentence of the first paragraph in DCD Subsection 3.8.1.6 with the following.

Any material changes to the site-specific materials for construction of the PCCV will meet the requirements specified in ASME Code, Section III (Reference 3.8-2), Article CC-2000, and supplementary requirements of RG 1.136 (Reference 3.8-3), as well as SRP 3.8.1 (Reference 3.8-7).

STD COL 3.8(4) Replace the fourth paragraph in DCD Subsection 3.8.1.6 with the following.

Site-specific concrete ingredients will be selected, and concrete mix design will be developed prior to construction to produce the concrete design strengths specified for the US-APWR PCCV. All the concrete mix ingredients conform to applicable codes and standards.

STD COL 3.8(5) Replace the fourth sentence of the seventh paragraph in DCD Subsection 3.8.1.6 with the following.

Site-specific concrete design mix is tested for creep and shrinkage parameters and compared with the creep and shrinkage parameters used in the design analysis of the PCCV. The PCCV design analysis will be revised, prior to start of the PCCV superstructure construction, if the final test results affect the conclusions of the PCCV calculations.

STD COL 3.8(6) Replace the fifth sentence of the seventh paragraph in DCD Subsection 3.8.1.6 with the following.

A site-specific specification that includes the concrete production and batch plant requirements, placement requirements, and all relevant quality requirements, will be prepared prior to start of construction.

CP COL 3.8(7) Replace the first sentence of the eighth paragraph in DCD Subsection 3.8.1.6 with the following.

Site-specific aggressivity of the ground water/soil at the CPNPP site is not applicable, as discussed in Chapter 2.

STD COL 3.8(8) Replace the first sentence of the twelfth paragraph in DCD Subsection 3.8.1.6 with the following.

A site-specific specification will be developed to define the material, welding, testing, and quality requirements for the liner plate prior to start of fabrication.

STD COL 3.8(9) Replace the first sentence of the thirteenth paragraph in DCD Subsection 3.8.1.6 with the following.

A site-specific specification will be prepared for the PCCV personnel airlocks and equipment hatch prior to start of procurement.

CP COL 3.8(10) Replace the second and third sentences of the eighteenth paragraph in DCD Subsection 3.8.1.6 with the following.

The prestressing system is designed as a strand system.

STD COL 3.8(12) Replace the bullet of the twenty-fourth paragraph in DCD Subsection 3.8.1.6 with the following.

A site-specific specification will be developed per RG-1.136 (Reference 3.8-3) for the material requirements of the prestressing system, which also includes the material and special material testing requirements, and references Article CC-2400 of the ASME Code, Section III (Reference 3.8-2) for items, where applicable, prior to start of procurement.

STD COL 3.8(13) Replace the first sentence of the thirty-first paragraph in DCD Subsection 3.8.1.6 with the following.

A site-specific specification that covers the material and special material testing requirements for the reinforcing steel system, including bars and splices and all material conforming to Article CC-2300 of ASME Code, Section III (Reference 3.8-2), will be developed prior to start of procurement.

3.8.1.7 Testing and Inservice Inspection Requirements

STD COL 3.8(14) Replace the third paragraph in DCD Subsection 3.8.1.7 with the following.

A site-specific preservice inspection (PSI) program for the PCCV will be completed at least 12 months prior to initial fuel load. ISI are performed during the initial and subsequent 10 year intervals as identified in Subsections IWE and IWL Article 2000, Examination Program B. The PCCV PSI and ISI programs include preservice examination, testing and ISI requirements, and also address personnel qualification requirements and responsibilities. The PCCV ISI program also provides detailed inspection plans and surveillance schedules consistent with those of the integrated leak rate test (ILRT) program, which is discussed further below and in Subsection 6.2.6. ASME Code Section XI requirements incorporated by reference in 10 CFR 50.55a on the date 12 months prior to issuance of the operating license, and optional ASME code cases endorsed by the NRC via RG 1.147, establish the requirements for the initial 120-month ISI program interval. ISI conducted during successive 120 month intervals complies with the requirements incorporated by reference (in 10 CFR 50.55a) 12 months before the start of the 120-month inspection interval, subject to the modifications and limitations listed in paragraph (b) of that section, or the optional ASME Code cases endorsed by the NRC via RG 1.147.

The PCCV ISI program surveillance requirements for periodic surveillance and inspection of the overall structure, as well as the liner and prestressing tendon systems, are in accordance with ASME Code Section XI (Reference 3.8-4) Subsections IWA, IWE, and IWL. Further, inservice inspection requirements for the tendons also follow the applicable guidelines of RG 1.35 (Reference 3.8-5) and 1.35.1 (Reference 3.8-6). The ISI of the PCCV includes the pertinent items in all examination categories identified in Tables IWE-2500-1 and IWL-2500-1 of ASME (Reference 3.8-4), summarized as follows:

- PCCV pressure retaining boundary, including all accessible interior and exterior surfaces of the liner, penetration liners, and class MC components, parts, and appurtenances.
- Containment structural and pressure retaining boundary welds and pressure-retaining bolted connections.
- Integral structural attachments and welds connecting the attachments to the liner.
- Wetted surfaces of submerged areas [such as the refueling water storage pit (RWSP)].
- Moisture barriers (where applicable).
- Areas at tendon end anchors, wherever accessible, to inspect for concrete cracking, corrosion protection material leakage, and/or tendon cap deformation.
- Examination of, sampling, and testing corrosion protection material.
- Examination of wires or strand and anchorage hardware for cracks, wear, and corrosion.
- Determination of tendon forces by measuring lift-off forces.
- Detensioning tendons and the removal of a wire or strand for inspection for corrosion and testing to measure strength and elongation.
- Establish acceptability and compare measured lift-off values with predictions and minimum requirements.
- General visual inspection of all accessible concrete surface areas to assess the general structural condition of the containment.

3.8.4 Other Seismic Category I Structures

CP COL 3.8(15) Replace the fourth paragraph in DCD Subsection 3.8.4 with the following.

The ESWPT, UHSRS, and PSFSVs are site-specific seismic category I structures and are designed to the site-specific SSE. These structures are discussed in detail in Subsection 3.8.4.1.3. No site-specific seismic category II structures are applicable at CPNPP.

3.8.4.1.3 ESWPT, UHSRS, PSFSVs, and Other Site-Specific Structures

CP COL 3.8(19) Replace the second paragraph in DCD Subsection 3.8.4.1.3 with the following.

The ESWPT, UHSRS, and PSFSVs are designed to the site-specific SSE, and are described in detail in Subsections 3.8.4.1.3.1, 3.8.4.1.3.2, and 3.8.4.1.3.3, respectively. Figure 3.8-201 provides the general arrangement of ESWPT, UHSRS, and PSFSVs.

3.8.4.1.3.1 ESWPT

The ESWPT is an underground reinforced concrete structure. Figure 3.8-203 shows the typical section of the ESWPT. The tunnel layout is a rectangular configuration forming a closed looped structure starting at the UHS Basins and terminating at the T/B. The outside dimensions of the tunnel are shown in Figure 3.8-203. The tunnel is divided into two sections by an interior concrete wall to provide separation of piping trains. Each section contains both ESWS supply and return lines. End walls are also provided where required to maintain train separation. The top of the tunnel is approximately 12.25 ft. below grade. Access to the tunnel is provided by reinforced concrete manholes.

The following structures are supported by the ESWPT as an integral part of the tunnel:

- Fuel/Pipe access tunnels, providing access from the PS/B to the PSFSVs are shown in Figures 3.8-204 and 3.8-212.
- Reinforced concrete air intake enclosures projecting above the ground for ESWS piping from the ESWS pump houses.

For details see Figures 3.8-202 through 3.8-205.

3.8.4.1.3.2 UHSRS

The UHSRS consists of a cooling tower enclosure; the ESWS pump houses, and the UHS basin. All of them are reinforced concrete structures, described below.

UHS Basin - There are four basins for each unit and each reinforced concrete basin has one cooling tower with two cells. Each basin rests on a separate foundation, is square in shape, constructed of reinforced concrete, and separated from the adjacent basin by a minimum 4 inch expansion joint. Each basin serves as a reservoir for the ESWS. An ESWS pump house is located at the south-west corner of each basin. Adjacent to the pump house on the east side of the basin are cooling tower enclosures supported by UHS basin walls. The ESWPT runs east-west along the south exterior wall of the UHS basin, and is separated by a minimum 4 inch expansion joint.

Each basin is divided into two parts, as shown on Figure 3.8-206. The larger section of the basin shares the pump house and one cooling tower cell enclosure. The other cooling tower cell enclosure is in the smaller segment of the basin. A reinforced concrete wall, running east-west, separates the cooling tower enclosure basin area from rest of the basin. This wall is provided with slots to maintain the continuity of the reservoir.

See Figure 3.8-206 for general arrangement, layout, and dimensions of the UHSRS.

ESWS pump house - The pump house is an integral part of the UHS basin supported by UHS basin exterior and interior walls. Each pump house contains one ESW pump and one transfer pump with associated auxiliaries. The pump bay (lowest portion of the pump house required for the pump suction) is deeper than the rest of the UHS basin. A reinforced concrete wall, running east-west, divides the pump house basin from rest of the UHS basin. This wall is provided with slots for flow of water. Two baffle walls (running east-west) are provided inside the pump house basin, before the pump bay. These baffle walls are provided with slots to maintain the flow of water and are staggered to prevent trajectory of postulated direct or deflected design basis tornado missiles.

The operating floor of the pump house is a reinforced concrete slab spanning east-west and supported by UHS basin exterior and interior walls. The operating floor supports the ESWS pump, transfer pump, and motors. The roof of the pump house is a reinforced concrete slab spanning north-south and supported by reinforced concrete beams. To allow access to the ESWS pump/motor, a removable reinforced concrete cover is provided in an opening in the roof of the pump house.

UHS cooling tower enclosures - Each UHS basin has one cooling tower with two cells. Each cell is enclosed by reinforced concrete structures that house the equipment required to cool the water for ESWS. The reinforced concrete wall running north-south separates the two cell enclosures. The enclosures are an integral part of the UHS basin supported by the basin interior and exterior walls on the basemat foundation. A reinforced concrete wall, running east-west, separates the cell enclosure portion of the basin from the rest of the UHS basin. An east-west wall is provided with openings at the basemat to maintain the continuity of the UHS basin. Air intakes are located at the north and south faces of the enclosure and configured to protect the safety-related substructures and components from tornado missiles. The north side air intake is an integral part of the cooling tower enclosure, whereas the south side air intake is an integral part of the ESWPT, and is supported by reinforced concrete piers which are supported by the ESWPT walls and basemat.

Each cooling tower cell enclosure is equipped with a fan and associated equipment to cool the water. Equipment includes header pipe, spray nozzles, and drift eliminators with associated reinforced concrete beams supported by the exterior walls of the enclosure. The fan and motor are supported by reinforced concrete deck above the drift eliminators. A circular opening is provided in the deck for the fan, and the deck is supported by enclosure walls and a deep upside circular concrete beam around the fan opening. The fan is supported by a north-south concrete beam at the center of enclosure. For air circulation and to protect the fan and motor from tornado missiles, a circular opening is provided at the roof of the enclosure (centered on the fan) with a reinforced concrete slab and heavy steel grating between the roof and the deck.

For details see Figures 3.8-207 through 3.8-211 for the UHS basin, ESWS pump house and cooling tower enclosures.

3.8.4.1.3.3 PSFSVs

The PSFSVs are underground reinforced concrete structures required to house the safety-related and non safety-related fuel oil tanks. There is one vault for each PS/B. The vault contains two safety-related and one non safety-related oil tanks. Each tank is contained in a separate compartment. Compartments are separated by reinforced concrete walls. A common mat supports the tanks and the rest of the vault. The PSFSV roof slab is sloped to facilitate drainage. The highest point of the roof slab is slightly above grade. Bollards and a concrete curb are provided to prevent vehicular traffic on the roof.

Access to each vault is provided by a reinforced concrete tunnel from the applicable PS/B. Each tank compartment has a separate pipe/access tunnel, which is an integral part of the ESWPT.

For vault details see Figures 3.8-212 through 3.8-214.

3.8.4.1.3.4 Other Site-Specific Structures

Site-specific seismic category I yard piping and conduits are routed within reinforced concrete duct banks (solid) or reinforced concrete chases (hollow). The duct banks and chases have shallow embedments and are buried partially or wholly below grade within structurally engineered and compacted backfill that extends down to top of limestone at nominal elevation 782 ft. The duct banks and pipe chases are constructed in segments, which are separated from each other and other structures by expansion joints. The expansion joints accommodate all anticipated differential settlement and movement (due to seismic and other loading) at support points, penetrations, and entry points into other structures.

3.8.4.3 Loads and Load Combinations

CP COL 3.8(20) Replace the second paragraph in DCD Subsection 3.8.4.3 with the following.

Externally generated loads from the following postulated site-specific sources are evaluated in the following subsections:

- Subsection 2.4.2.3 concludes no loads induced by floods are applicable.
- Subsection 3.5.1.6 concludes no loads from non-terrorism related aircraft crashes are applicable.
- Subsection 2.2.3.1.1 concludes no explosive hazards in proximity to the site are applicable, and
- Subsection 3.5.1.6 concludes no projectiles and missiles generated from activities of nearby military installations are applicable.

3.8.4.3.7.1 Operating Thermal Loads (T_o)

CP COL 3.8(27) Replace the second paragraph in DCD Subsection 3.8.4.3.7.1 with the following.

The UHSRS, PSFSVs, and ESWPT structures experience only small ranges of operating temperatures and loads which do not require explicit analysis. The designs of the UHSRS, PSFSVs and ESWPT accommodate normal operating thermal loads and environmental thermal gradients such as those identified in Table 3.8-201.

3.8.4.4.3 Other Seismic Category I Structures

CP COL 3.8(29) Replace the last paragraph in DCD Subsection 3.8.4.4.3 with the following.

3.8.4.4.3.1 ESWPT

The ESWPT is designed to withstand the loads specified in Subsection 3.8.4.3. The structural design of the ESWPT is performed using the computer program ANSYS (Reference 3.8-14). The seismic analysis and the computer programs used for the seismic analysis are addressed in Appendix 3LL.

The static analyses are performed on the ANSYS model placed on soil springs at the top of the concrete fill representing the stiffness of the support provided by the concrete fill and limestone. The stiffness of the subgrade springs under different sections of the ESWPT is calculated using the methodology in ASCE-4 Section 3.3.4.2 (Reference 3.8-34), for vibration of a rectangular foundation resting on an elastic half space. Since the support below the structure (fill concrete and rock) will not exhibit long-term settlement effects, the subgrade stiffness calculated from ASCE-4 Section 3.3.4.2 is used for analysis of both static and seismic loads.

Gravity loads on the tunnel roof are resisted by one-way slab action of the roof. These loads are distributed to the outer and interior walls, transferred through the walls down to the mat slab where they are distributed, and from the bottom of the mat slab to the concrete fill over limestone bedrock.

Lateral soil pressures on outer tunnel walls are typically resisted by one-way action of the outer walls. Forces from these pressures are transferred to the roof and mat slabs. Where axial force in the roof and mat slabs are not balanced by an equal and opposite force from the other side of the tunnel, the roof and mat slabs work with the walls as a moment frame to resist the unbalanced lateral forces. Some tunnel segments resist unbalanced lateral loads in part by moment frame action and in part by return walls located at an end of the segment (such as where the ESWPT changes direction).

Lateral forces that are not balanced by an equal and opposite force on the other side of the tunnel are transferred to the concrete fill below the tunnel by friction, and where a shear key is present, by friction and lateral bearing of the shear key on the fill concrete. Lateral forces in the fill are then transferred to bedrock by friction, and where required, by lateral bearing of another shear key that extends into bedrock.

For dynamic forces oriented parallel to the length of the tunnel segment, the roof slab acts as a diaphragm that transfers loads to the outer and interior walls. The walls act as shear walls that transfer the forces to the mat slab. The exterior walls are also designed for static and dynamic soil pressure in accordance with ASCE 4-98 (Reference 3.8-34).

3.8.4.4.3.2 UHSRS

The UHSRS are designed to withstand the loads specified in Subsection 3.8.4.3. The structural design of the UHSRS is performed using the computer program ANSYS (Reference 3.8-14). The seismic analysis and the computer programs used for the seismic analysis are addressed in Appendix 3KK.

ANSYS analyses are performed on the model placed on soil springs at the bottom of the base slab, with the springs representing the stiffness of the rock subgrade. To address the sensitivity of the structural response on the subgrade stiffness, an additional set of analyses simulating a fixed base condition is performed on the model. The stiffness of the subgrade springs is calculated using the methodology in ASCE-4 Section 3.3.4.2 (Reference 3.8-34) for vibration of a rectangular foundation resting on an elastic half space. The evaluation of subgrade stiffness considers the best estimate properties of the layers above elevation 393 ft. Since the support below the structure will not exhibit long-term settlement effects, the subgrade stiffness calculated from ASCE-4 Section 3.3.4.2 is used for analysis of both static and seismic loads.

Each UHS cooling tower, air intake enclosures, and ESWS pump house are designed for tornado wind and tornado generated missiles and in-plane and out-of-plane seismic forces. The walls are shear/bearing walls carrying the loads from the superstructure and transferring to the basemat. The UHS basin exterior walls are also designed for static and dynamic soil pressure, and hydrostatic and hydrodynamic pressures in accordance with ASCE 4-98 (Reference 3.8-34). Below-grade walls loaded laterally by soil pressure on the outside, or hydrostatic pressure on the inside, act as two-way slabs, spanning horizontally to perpendicular shear walls, and cantilevering vertically from the mat slab (at the pump room, the walls span vertically between the mat slab and the pump room floor). For seismic loads, the shear walls are designed to resist 100% of the applied lateral load through in-plane shear. The shear walls transmit load to the mat slab. The shear in the mat slab is transferred to the fill concrete via friction, and direct bearing at the pump house sump. The shear in the fill concrete is transferred to the bedrock via friction and bearing at the pump hose sump.

Above grade walls loaded laterally by seismic forces, or by wind or tornado wind, atmospheric and missile loads, act as two-way slabs, spanning horizontally to perpendicular shear walls and vertically to floor and roof slabs. These slabs act as horizontal diaphragms, and span horizontally to the perpendicular shear walls. The shear in the shear walls is transferred to bedrock as described above.

Vertical loads in the floor and roof slabs are due to dead load, live load, and wind or tornado missile loads. The floor and roof slabs act as two-way slabs, spanning to the walls or beams below in both directions. The vertical loads are transmitted to the mat slab, then into the fill concrete, and then into bedrock.

3.8.4.4.3.3 PSFSVs

The PSFSVs are designed to withstand the loads specified in Subsection 3.8.4.3. The structural design of the PSFSV is performed using the computer program ANSYS (Reference 3.8-14). The seismic analysis and the computer programs used for the seismic analysis are addressed in Appendix 3MM.

The ANSYS analyses are performed on the model placed on soil springs at the bottom of the concrete fill / top of limestone level representing the stiffness provided by the rock subgrade. The stiffness of the subgrade springs is calculated using the methodology in ASCE-4 Section 3.3.4.2 (Reference 3.8-34) for vibration of a rectangular foundation resting on an elastic half space. The evaluation of subgrade stiffness considers the best estimate properties of the layers above elevation 215 ft. Since the support below the structure will not exhibit long-term settlement effects, the subgrade stiffness calculated from ASCE-4 Section 3.3.4.2 is used for analysis of both static and seismic loads.

Vertical loads present on the roof of the PSFSVs are carried by the perimeter and interior walls. The roof acts as a two-way slab with a single span in the north-south direction and a 3-span continuous slab with two-way action in the east-west direction. The vertical wall loads are transmitted to the mat slab and into the bedrock. The exterior walls are also designed for static and dynamic soil pressure in accordance with ASCE 4-98 (Reference 3.8-34). Walls loaded laterally by earth pressure act as two-way plate members, spreading load to the mat slab and perpendicular shear walls. For seismic load cases, the shear walls are designed to resist 100% of the applied lateral load. The shear walls transmit load to the foundation mat along their length. The load in the foundation mat is then transferred to the bedrock via friction and shear keys.

3.8.4.6.1.1 Concrete

CP COL 3.8(28) Replace the second sentence of the first paragraph in DCD Subsection 3.8.4.6.1.1 with the following.

For ESWPT, UHSRS, and PSFSVs concrete compressive strength, f'_c = 5,000 psi is utilized.

3.8.4.7 Testing and Inservice Inspection Requirements

CP COL 3.8(22) Replace the content of Subsection 3.8.4.7 with the following.

Monitoring of seismic category I structures is required to be performed in accordance with the requirements of NUMARC 93-01 (Reference 3.8-28) and 10 CFR 50.65 (Reference 3.8-29) as detailed in RG 1.160 (Reference 3.8-30).

Prior to completion of construction, site-specific programs are developed in accordance with RG 1.127 (Reference 3.8-47) for ISI of seismic category I water control structures, including the UHSRS and any associated safety and performance instrumentation.

The site-specific programs address in particular ISI of critical areas to assure plant safety through appropriate levels of monitoring and maintenance. Any special design provisions (such as providing sufficient physical access or providing alternative means for identification of conditions in inaccessible areas that can lead to degradation) to accommodate ISI are also required to be addressed in the ISI program.

Because the CPNPP site exhibits nonaggressive ground water/soil (i.e., pH greater than 5.5, chlorides less than 500 ppm, and sulfates less than 1,500 ppm), the program for ISI of inaccessible, below-grade concrete walls and foundations of the UHSRS is less stringent than would be applied for sites with aggressive ground water/soil. The program is required to include requirements for (1) examination of the exposed portions of the below-grade concrete, when excavated for any reason, for signs of degradation; and (2) conducting periodic site monitoring of ground water chemistry, to confirm that the ground water remains nonaggressive.

3.8.5.1 Description of the Foundations

CP COL 3.8(23) Replace the second sentence of the second paragraph in DCD Subsection 3.8.5.1 with the following.

The 4 ft. depth exceeds the maximum depth of frost penetration at CPNPP.

3.8.5.1.3 Site-Specific Structures

CP COL 3.8(24) Replace the paragraph in DCD Subsection 3.8.5.1.3 with the following new subsections.

3.8.5.1.3.1 ESWPT

The ESPWT is an underground structure supported by a monolithic reinforced concrete basemat. The basemat is a 2 ft. thick concrete slab with top and bottom reinforcement in each direction arranged in a rectangular grid.

The bottom of the basemat is at elevation 791.08 ft., and is founded on structural concrete fill placed directly on limestone. The basemat has a shear key which extends into the fill concrete in the portion of ESWPT adjacent to the UHSRS as shown in Figure 3.8-202. The fill concrete at this portion also has a shear key which extends into the limestone as shown in Figure 3.8-202.

3.8.5.1.3.2 UHSRS

The UHS basins, ESWS pump house, and the cooling towers are free-standing structures supported on a reinforced concrete basemat. Each basin, including its pump house and cooling towers, rests on a 4 ft. thick mat with top and bottom reinforcement in each direction arranged in a rectangular grid.

The bottom of the UHS basemat is at elevation 787 ft., except the pump house sump mat is at elevation 775 ft. The pump house basemat is founded directly on limestone, whereas the rest of the UHS mat is founded on structural concrete fill placed directly on limestone.

3.8.5.1.3.3 PSFSVs

PSFSVs are underground structures supported by a monolithic reinforced concrete basemat. The basemat is a 6'-6" thick concrete slab with top and bottom reinforcement in each direction arranged in a rectangular grid.

The bottom of the basemat is at elevation 782 ft., and is founded directly on limestone. Shear keys are provided which extend into the limestone as shown in Figures 3.8-213 and 3.8-214.

3.8.5.4.4 Analyses of Settlement

CP COL 3.8(26) Replace the last sentence of the first paragraph in DCD Subsection 3.8.5.4.4 with the following.

As discussed in Section 2.5.4.10.2, maximum and differential CPNPP settlements of all the major seismic category I buildings and structures at the CPNPP Units 3 and 4 site, including R/B, PS/Bs, ESWPT, UHSRS, and PSFSVs are less than ½ inch, including long-term settlements.

3.8.5.5 Structural Acceptance Criteria

CP COL 3.8(25) Replace the second sentence of the first paragraph in DCD Subsection 3.8.5.5 with the following.

All major seismic category I buildings and structures at the CPNPP Units 3 and 4 site, including R/B, PS/Bs, ESWPT, UHSRS, and PSFSVs, are founded either directly on a limestone layer or structural concrete fill which is placed directly on the limestone. The ultimate bearing capacity of the limestone is 146,000 psf. Table 3.8-202 shows the actual bearing pressure during static and seismic load cases with minimum factor of safety.

3.8.6 Combined License Information

Replace the content of DCD Subsection 3.8.6 with the following.

STD COL 3.8(1) ***3.8(1)*** *Reconciliation evaluations using as-built properties*

This COL item is addressed in Subsection 3.8.1.4.1.3.

STD COL 3.8(2) ***3.8(2)*** *Consistency of wobble and curvature coefficients*

This COL item is addressed in Subsections 3.8.1.5.1.2, and 3.8.1.5.2.2.

STD COL 3.8(3) ***3.8(3)*** *Material changes for PCCV*

This COL item is addressed in Subsection 3.8.1.6.

STD COL 3.8(4) ***3.8(4)*** *Concrete ingredients*

This COL item is addressed in Subsection 3.8.1.6.

STD COL 3.8(5) ***3.8(5)*** *Concrete creep and shrinkage parameters*

This COL item is addressed in Subsection 3.8.1.6.

STD COL 3.8(6) ***3.8(6)*** *Specification of concrete production*

This COL item is addressed in Subsection 3.8.1.6.

CP COL 3.8(7) ***3.8(7)*** *Aggressivity of ground water/soil*

This COL item is addressed in Subsection 3.8.1.6.

STD COL 3.8(8) ***3.8(8)*** *Liner plate specification*

This COL item is addressed in Subsection 3.8.1.6.

STD COL 3.8(9) ***3.8(9)*** *PCCV airlocks and equipment hatch specification*

This COL item is addressed in Subsection 3.8.1.6.

CP COL 3.8(10) ***3.8(10)*** *Alternate wire prestressing system*

This COL item is addressed in Subsection 3.8.1.6.

3.8(11) *Deleted from the DCD.*

STD COL 3.8(12) ***3.8(12)*** *Prestressing system specification*

This COL item is addressed in Subsection 3.8.1.6.

STD COL 3.8(13) ***3.8(13)*** *Reinforcing steel specification*

This COL item is addressed in Subsection 3.8.1.6.

STD COL 3.8(14) ***3.8(14)*** *PCCV testing and ISI*

This COL item is addressed in Subsection 3.8.1.7.

CP COL 3.8(15) ***3.8(15)*** *Seismic design of SSCs not part of standard plant*

This COL item is addressed in Subsection 3.8.4.

3.8(16) *Deleted from the DCD.*

3.8(17) *Deleted from the DCD.*

3.8(18) *Deleted from the DCD.*

CP COL 3.8(19) ***3.8(19)*** *Design and analysis of ESWPT, UHSRS, PSFSVs, and other site-specific structures*

This COL item is addressed in Subsection 3.8.4.1.3, and Figures 3.8-201 through 3.8-214.

CP COL 3.8(20) ***3.8(20)*** *Externally generated loads*

This COL item is addressed in Subsection 3.8.4.3.

3.8(21) *Deleted from the DCD.*

CP COL 3.8(22) ***3.8(22)*** *Monitoring of seismic category I structures*

This COL item is addressed in Subsection 3.8.4.7.

CP COL 3.8(23) ***3.8(23)*** *Maximum frost penetration level*

This COL item is addressed in Subsection 3.8.5.1.

CP COL 3.8(24) ***3.8(24)*** *Design of other non-standard seismic category I buildings and structures*

This COL item is addressed in Subsection 3.8.5.1.3, and Figures 3.8-202, 3.8-213, and 3.8-214.

CP COL 3.8(25) ***3.8(25)*** *Design soil conditions*

This COL item is addressed in Subsection 3.8.5.5 and Table 3.8-202.

CP COL 3.8(26) ***3.8(26)*** *Subsidence and differential displacement*

This COL item is addressed in Subsection 3.8.5.4.4.

CP COL 3.8(27) ***3.8(27)*** *Normal operating thermal loads*

This COL item is addressed in Subsection 3.8.4.3.7.1, and Table 3.8-201.

CP COL 3.8(28) ***3.8(28)*** *Concrete strength in non-standard plant seismic category I structures*

This COL item is addressed in Subsection 3.8.4.6.1.1.

CP COL 3.8(29) ***3.8(29)*** *Design and analysis procedures for ESWPT, UHSRS, and PSFSVs*

This COL item is addressed in Subsection 3.8.4.4.3, and Appendices 3KK, 3LL, and 3NN

CP COL 3.8(27)

Table 3.8-201
Environmental Temperature Gradients for the Exterior Walls and Roofs of UHSRS, PSFSV, and ESWPT

Normal air temperatures range from a maximum of 115° F to a minimum -10° F. The seasonal soil temperature gradient follows:

	Winter (minimum °F)	Summer (maximum °F)
Plant Grade	42	92
-10 ft.	57	77
-20 ft.	62	72
-30 ft.	65	69

Note: Based on 2°F increase in range from Reference NOAA NCDC data.

CP COL 3.7(7)
CP COL 3.8(25)

Table 3.8-202
Summary of Bearing Pressures and Factor of Safety

Building	Bearing Pressures (ksf)		Ultimate Bearing Capacity (ksf)	Available Factor of Safety	
	Static Case	Seismic Case(1),(2)		Static Case	Seismic Case
R/B	11.3	18.9	146.00	12.9	7.7
T/B	5.9	7.4	146.00	24.7	19.7
A/B	6.6	10.8	146.00	22.1	13.5
PS/Bs	4.3	7.4	146.00	34	19.7
PSFSVs	2.9(3)	5.1(3)	146.00	50.3	28.6
UHSRS	4.5(4)	16.2(4)	146.00	32.4	9.0
ESWPT	3.6(5)	12.4(5)	146.00	40.6	11.8

Notes:

1) All seismic case bearing pressures are based on the site-specific FIRS with 0.1 g PGA as described in Subsection 3.7.1.
2) Seismic case bearing pressures shown above include static bearing pressures.
3) The pressure shown includes bearing pressure due to full fuel oil tanks.
4) The pressure shown includes bearing pressure due to full reservoirs.
5) The maximum bearing pressures occur underneath the portion of the ESWPT supporting the air intake missile shields adjacent to the UHSRS.

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-201 General Arrangement of ESWPT, UHSRS, and PSFSV

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)
CP COL 3.8(24)

Figure 3.8-202 Typical ESWPT Sections Adjacent to UHS Basin with Cooling Water Air Intake Missile Shield Enclosure Supported by the Tunnel

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-203 Typical Section for ESWPT

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-204 Section of ESWPT at PS/B and PSFSVs Showing Fuel Pipe/Access Tunnel

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-205 Section of ESWPT at R/B and T/B Interface

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-206 General Arrangement of UHS Basin

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-207 Plan of Fan-Supporting Structure and Concrete, and Slab/Grating Plan Above the Fan

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-208 Typical Section of UHS Looking North at Pump House, UHS Basin and Cooling Tower Fans

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-209 Typical Section Looking West at UHS Basin and Pump House Interface with ESWPT

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-210 Typical Section Looking West at UHS Basin and Cooling Tower Interface with ESWPT

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-211 Typical Section Looking North at UHS Basin, Elevated Cooling Tower and Pump House Slabs

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)

Figure 3.8-212 Plan of East and West PSFSVs

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)
CP COL 3.8(24)

Figure 3.8-213 Typical Section Looking West at PSFSV

Security-Related Information – Withheld Under 10 CFR 2.390

CP COL 3.8(19)
CP COL 3.8(24)

Figure 3.8-214 Typical Section Looking North at PSFSV

3.9 MECHANICAL SYSTEMS AND COMPONENTS

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

3.9.2.4.1 Background

CP COL 3.9(2) Replace the first, second and third paragraphs in DCD Subsection 3.9.2.4.1 with the following.

The CPNPP Unit 3 reactor internals are classified as a prototype in accordance with RG 1.20 (Reference 3.9-21). Upon qualification of the CPNPP Unit 3 as a valid prototype, the CPNPP Unit 4 reactor internals will be classified as non-prototype category I based on the designation of RG 1.20 (Reference 3.9-21).

Following the recommendation of RG 1.20 (Reference 3.9-21), a pre-operational vibration measurement program is developed for the CPNPP Unit 3 as the first operational US-APWR reactor internals. Data will be acquired only during the hot functional test, before core loading. This is in accordance with RG 1.20. Analysis (Subsection 3.9.2.3) shows that the responses under normal operating conditions with fuel assemblies in the core are almost the same or slightly smaller than those under hot functional test conditions without the core. The final report of the results of the vibration assessment program is submitted to the NRC within 180 days following completion of vibration testing.

Subsequent to the completion of the vibration assessment program for the CPNPP Unit 3 reactor internals, the vibration analysis program will be used to qualify the CPNPP Unit 4 under the criteria for non-prototype category I.

3.9.3.3.1 Pump Operability

CP COL 3.9(10) Replace the last sentence of the first paragraph in DCD Subsection 3.9.3.3.1 with the following.

The site-specific list of active pumps is provided in Table 3.9-201.

3.9.3.4.2.5 Design Specifications

STD COL 3.9(1) Replace the second paragraph of DCD Subsection 3.9.3.4.2.5 with the following.

The design specification for snubbers installed in harsh service conditions (e.g., high humidity, temperature, radiation levels) assures that snubber functionality including snubber materials (e.g., lubricants, hydraulic fluids, seals), are evaluated for the projected life of the snubber.

3.9.6 Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints

STD COL 3.9(8) Replace the second sentence of the third paragraph in DCD Subsection 3.9.6 with the following.

The edition and addenda used for the inservice testing (IST) program for pumps, valves, and dynamic restraints is administratively controlled as part of the operational program procedures. The preservice test program is implemented as described in Section 13.4. The requirements of functional testing for pumps, valves, and dynamic restraints will be in accordance with the IST program plan outlined 12 months prior to fuel load.

3.9.6.2 IST Program for Pumps

CP COL 3.9(11) Replace the third paragraph in DCD Subsection 3.9.6.2 with the following.

The site-specific safety-related pump IST parameters and frequency is provided in Table 3.9-202.

3.9.6.3 IST Program for Valves

STD COL 3.9(12) Replace the fifth paragraph in DCD Subsection 3.9.6.3 with the following.

The type of testing and frequency of site-specific valves subject to IST in accordance with the ASME Code is provided in Table 3.9-203.

STD COL 3.9(7) Replace the last sentence of the eleventh paragraph in DCD Subsection 3.9.6.3 with the following.

Any alternate method for verification of valve position indicator operation, and its justification, is described in the IST program plan outlined 12 months prior to fuel load.

3.9.6.3.1 IST Program for MOVs

STD COL 3.9(9) Replace the second sentence of the third paragraph in DCD Subsection 3.9.6.3.1 with the following.

The IST program plan identifies those motor operated valves (MOVs) that require non-intrusive testing technique.

3.9.6.4 IST Program for Dynamic Restraints

STD COL 3.9(6) Replace the second paragraph in DCD Subsection 3.9.6.4 with the following.

The IST program plan for dynamic restraints (snubbers) complies with the requirements in the latest edition and addenda of ASME OM Code incorporated by reference in 10 CFR 50.55a (Reference 3.9-29). The IST program for dynamic restraints will be described based on the IST program plan outlined 12 months prior to fuel load.

3.9.9 Combined License Information

Replace the content of DCD Subsection 3.9.9 with the following.

STD COL 3.9(1) ***3.9(1)*** *Snubber functionality*

This COL item is addressed in Subsection 3.9.3.4.2.5

CP COL 3.9(2) ***3.9(2)*** *Classification of CPNPP Unit 3 reactor internals as prototype*

This COL item is addressed in Subsection 3.9.2.4.1.

3.9(3) *Deleted from the DCD.*

3.9(4) *Deleted from the DCD.*

3.9(5) *Deleted from the DCD.*

STD COL 3.9(6) ***3.9(6)*** *Program plan for IST of dynamic restraints*

This COL item is addressed in Subsection 3.9.6.4.

STD COL 3.9(7) ***3.9(7)*** *Alternate method of valve position indicator operation*

This COL item is addressed in Subsection 3.9.6.3.

STD COL 3.9(8) ***3.9(8)*** *Administrative control of the edition and addenda used for the IST program plan*

This COL item is addressed in Subsection 3.9.6.

STD COL 3.9(9) ***3.9(9)*** *Non-intrusive diagnostic testing of MOVs*

This COL item is addressed in Subsection 3.9.6.3.1.

CP COL 3.9(10) ***3.9(10)*** *Site-specific active pumps*

This COL item is addressed in Subsection 3.9.3.3.1, and Table 3.9-201.

CP COL 3.9(11) ***3.9(11)*** *Site-specific, safety-related pump IST parameters and frequency*

This COL item is addressed in Subsection 3.9.6.2, and Table 3.9-202.

CP COL 3.9(12) ***3.9(12)*** *Testing and frequency of site-specific valves subject to IST*

This COL item is addressed in Subsection 3.9.6.3, and Table 3.9-203.

CP COL 3.9(12)

Table 3.9-201
List of Site-Specific Active Pumps

Pump	System	ASME Class	Normal Operation Mode	Post LOCA Mode	Basis
A-UHS Transfer Pump	UHS	3	ON/OFF	ON/OFF	Required For Transferring Water Between Basins
B-UHS Transfer Pump	UHS	3	ON/OFF	ON/OFF	Required For Transferring Water Between Basins
C-UHS Transfer Pump	UHS	3	ON/OFF	ON/OFF	Required For Transferring Water Between Basins
D-UHS Transfer Pump	UHS	3	ON/OFF	ON/OFF	Required For Transferring Water Between Basins

CP COL 3.9(13)

Table 3.9-202
Site-Specific Pump IST Requirements

Tag No.	Description	Pump Type	ASME IST Category	Required Test				Test Frequency	Acceptance Criteria
				Outlet Flow	Differential Pressure	Vibration	Speed		
UHS-OPP-001A	A-UHS Water Transfer Pump	Vertical Line Shaft Centrifugal	B	O	-	O	N/A (constant speed induction motor)	(1)Quarterly, Required Test is conducted (2)Biennially, Comprehensive Test is conducted	Table ISTB-5221-1 in ASME OM Code-2004 is applied.
UHS-OPP-001B	B-UHS Water Transfer Pump	Vertical Line Shaft Centrifugal	B	O	-	O	N/A (constant speed induction motor)	(1)Quarterly, Required Test is conducted (2)Biennially, Comprehensive Test is conducted	Table ISTB-5221-1 in ASME OM Code-2004 is applied.
UHS-OPP-001C	C-UHS Water Transfer Pump	Vertical Line Shaft Centrifugal	B	O	-	O	N/A (constant speed induction motor)	(1)Quarterly, Required Test is conducted (2)Biennially, Comprehensive Test is conducted	Table ISTB-5221-1 in ASME OM Code-2004 is applied.
UHS-OPP-001D	D-UHS Water Transfer Pump	Vertical Line Shaft Centrifugal	B	O	-	O	N/A (constant speed induction motor)	(1)Quarterly, Required Test is conducted (2)Biennially, Comprehensive Test is conducted	Table ISTB-5221-1 in ASME OM Code-2004 is applied.

CP COL 3.9(14)

Table 3.9-203 (Sheet 1 of 6)
Site-Specific Valve IST Requirements

Valve Tag Number	Description	Valve Type	Safety-Related Missions	Safety Functions	ASME IST Category	Inservice Testing Type and Frequency	IST Notes
UHS-VLV-502A	A-UHS Transfer Pump Discharge Check Valve	Check	Transfer Close Transfer Open	Active	BC	Check Exercise / Refueling Outage	3
UHS-VLV-502B	B-UHS Transfer Pump Discharge Check Valve	Check	Transfer Close Transfer Open	Active	BC	Check Exercise / Refueling Outage	3
UHS-VLV-502C	C-UHS Transfer Pump Discharge Check Valve	Check	Transfer Close Transfer Open	Active	BC	Check Exercise / Refueling Outage	3

CP COL 3.9(14)

Table 3.9-203 (Sheet 2 of 6) Site-Specific Valve IST Requirements

Valve Tag Number	Description	Valve Type	Safety-Related Missions	Safety Functions	ASME IST Category	Inservice Testing Type and Frequency	IST Notes
UHS-VLV-502D	D-UHS Transfer Pump Discharge Check Valve	Check	Transfer Close Transfer Open	Active	BC	Check Exercise / Refueling Outage	3
UHS-MOV-503A	A-UHS Transfer Pump Discharge Valve	Remote	Maintain Close Transfer Close Transfer Open	Active Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6
UHS-MOV-503B	B-UHS Transfer Pump Discharge Valve	Remote	Maintain Close Transfer Close Transfer Open	Active Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6

CP COL 3.9(14)

Table 3.9-203 (Sheet 3 of 6)
Site-Specific Valve IST Requirements

Valve Tag Number	Description	Valve Type	Safety-Related Missions	Safety Functions	ASME IST Category	Inservice Testing Type and Frequency	IST Notes
UHS-MOV-503C	C-UHS Transfer Pump Discharge Valve	Remote	Maintain Close Transfer Close Transfer Open	Active Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6
UHS-MOV-503D	D-UHS Transfer Pump Discharge Valve	Remote	Maintain Close Transfer Close Transfer Open	Active Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6
UHS-MOV-506A	A-UHS Transfer Line Basin Inlet Valve	Remote	Maintain Close Transfer Close Transfer Open	Active Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6

CP COL 3.9(14)

Table 3.9-203 (Sheet 4 of 6)
Site-Specific Valve IST Requirements

Valve Tag Number	Description	Valve Type	Safety-Related Missions	Safety Functions	ASME IST Category	Inservice Testing Type and Frequency	IST Notes
UHS-MOV-506B	B-UHS Transfer Line Basin Inlet Valve	Remote	Maintain Close Transfer Close Transfer Open	Active Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6
UHS-MOV-506C	C-UHS Transfer Line Basin Inlet Valve	Remote	Maintain Close Transfer Close Transfer Open	Active Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6
UHS-MOV-506D	D-UHS Transfer Line Basin Inlet Valve	Remote	Maintain Close Transfer Close Transfer Open	Active Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6

CP COL 3.9(14)

Table 3.9-203 (Sheet 5 of 6)
Site-Specific Valve IST Requirements

Valve Tag Number	Description	Valve Type	Safety-Related Missions	Safety Functions	ASME IST Category	Inservice Testing Type and Frequency	IST Notes
ESW-HVC-2000	A-UHS Basin Blowdown Control Valve	Remote	Maintain Close Transfer Close	Active-to-Fail Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6
ESW-HVC-2001	B-UHS Basin Blowdown Control Valve	Remote	Maintain Close Transfer Close	Active-to-Fail Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6
ESW-HVC-2002	C-UHS Basin Blowdown Control Valve	Remote	Maintain Close Transfer Close	Active-to-Fail Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6

CP COL 3.9(14)

Table 3.9-203 (Sheet 6 of 6)
Site-Specific Valve IST Requirements

Valve Tag Number	Description	Valve Type	Safety-Related Missions	Safety Functions	ASME IST Category	Inservice Testing Type and Frequency	IST Notes
ESW-HVC-2003	D-UHS Basin Blowdown Control Valve	Remote	Maintain Close Transfer Close	Active-to-Fail Remote Position	B	Remote Position Indication, Exercise/2 Years Exercise Full Stroke/Cold Shutdown Operability Test	6

Notes:

1) Not used.
2) Not used.
3) The check valve exercise test is performed during refueling outage. Valves in the inaccessible primary containment can not be tested during power operation. Test of valves in operating systems may cause impact of power operation. Simultaneous testing of valves in the same system group will be considered.
4) Not used.
5) Not used.
6) Exercising these valves would stop necessary line for operation such as utilities etc. Therefore, exercise testing will be performed at cold shutdown to avoid impact on power operation.
7) Not used.
8) Not used.
9) Not used.
10) Not used.
11) Not used.
12) Not used.

3.10 SEISMIC AND DYNAMIC QUALIFICATION OF MECHANICAL AND ELECTRICAL EQUIPMENT

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

STD COL 3.10(3) Replace the second sentence of the fifth paragraph in DCD Section 3.10 with the following.

As part of the equipment seismic qualification program, an equipment qualification file will be developed six months prior to procurement of equipment that contains a list of systems, equipment, and equipment supports, as defined above, and equipment qualification summary data sheets (EQSDSs) for the seismic qualification of each piece of safety-related seismic category I equipment. The data sheets will be populated during the procurement/start up testing phase.

CP COL 3.10(10) Replace the sixth paragraph in DCD Section 3.10 with the following.

An equipment seismic qualification program which addresses all requisite aspects of seismic and dynamic qualification of mechanical and electrical equipment is established, as discussed in Subsection 3.10.4.1. The equipment seismic qualification program addresses analysis and testing for qualification of site-specific equipment and components. The site-specific equipment seismic qualification program is also applied for qualification of select standard plant equipment and components, when detailed supplier characteristics cannot be verified prior to procurement. The equipment seismic qualification program incorporates all applicable requirements and guidance, including but not limited to the requirements and guidance of the reference DCD, Institute of Electrical and Electronic Engineers (IEEE) Std 344-1987 (Reference 3.10-6), IEEE Std 344-2004 (for Figure D.1 in Annex D only) (Reference 3.10-8), RG 1.100 (Reference 3.10-7), and SRP 3.10 (Reference 3.10-9).

The equipment seismic qualification program describes, in detail, the practices followed in seismic and dynamic qualification, including site-specific aspects such as site-specific seismic response spectra, and criteria, methods, and procedures used in conducting testing and analysis. The program includes establishment of an equipment qualification database which is shared with the environmental qualification (EQ) program discussed in Section 3.11.

3.10.1 Seismic Qualification Criteria

CP COL 3.10(8) Replace the last sentence of third paragraph in DCD Subsection 3.10.1 with the following.

For design of seismic category I and seismic category II SSCs that are site-specific (not part of the standard plant), the OBE is set at 1/3 of the site-specific SSE, as discussed in Subsection 3.7.1.1, and is therefore eliminated from explicit design analysis, except for fatigue effects as explained below.

3.10.2 Methods and Procedures for Qualifying Mechanical and Electrical Equipment and Instrumentation

CP COL 3.10(9) Replace the last two sentences of the fourth paragraph in DCD Subsection 3.10.2 with the following.

However, the site-specific GMRS and FIRS as reported in Section 3.7 do not exceed the CSDRS. Therefore, high frequency exceedances of in-structure response spectra and subsequent potential effects on the functional performance of vibration-sensitive components, such as relays and other instrument and control devices, whose output could be affected by high frequency excitation, are not applicable.

CP COL 3.10(5) Replace the twenty-sixth paragraph (starts with “Components that have been previously tested …”) in DCD Subsection 3.10.2 with the following.

Components that have been previously tested to IEEE Std 344-1971 prior to submittal of the DCD will be reevaluated six months prior to procurement of equipment to justify the appropriateness of the input motion and requalify the equipment using biaxial test input motion, except when a single-axis test input motion is justified.

3.10.4.1 Implementation Program and Milestones

CP COL 3.10(1) Replace the second sentence of the first paragraph in DCD Subsection 3.10.4.1 with the following.

The plan for the documentation and implementation of the CPNPP Units 3 and 4 equipment seismic qualification program, including milestones and completion dates with appropriate information for review and approval prior to installation of equipment, will be established by December 2008.

3.10.5 Combined License Information

Replace the content of DCD Subsection 3.10.5 with the following.

CP COL 3.10(1) ***3.10(1)*** *Equipment seismic qualification program plan*

This COL item is addressed in Subsection 3.10.4.1.

3.10(2) *Deleted from the DCD.*

STD COL 3.10(3) ***3.10(3)*** *Maintenance of equipment qualification files, including EQSDSs*

This COL item is addressed in Section 3.10.

3.10(4) *Deleted from the DCD.*

CP COL 3.10(5) ***3.10(5)*** *Previously tested components*

This COL item is addressed in Subsection 3.10.2.

3.10(6) *Deleted from the DCD.*

3.10(7) *Deleted from the DCD.*

CP COL 3.10(8) ***3.10(8)*** *Site-specific OBE*

This COL item is addressed in Subsection 3.10.1.

CP COL 3.10(9) ***3.10(9)*** *Applicability of high frequency*

This COL item is addressed in Subsection 3.10.2.

CP COL 3.10(10) ***3.10(10)*** *Equipment seismic qualification program*

This COL item is addressed in Subsection 3.10.

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.

CP COL 3.11(3) Replace the last sentence of the fifth paragraph in DCD Section 3.11 with the following.

The CPNPP Units 3 and 4 EQ Program implementation schedule is as follows*:

Activity	Date
Formulate Units 3 and 4 EQ Program	2008-2009
Designate Applicant EQ Program Coordinator	2009
Assist Reactor Vendor/Architect-Engineer/Constructor EQ Program	2009-2012
Assign Applicant EQ Staff to project site	2013
Assist with Reactor Vendor/Architect-Engineer/Constructor EQ Program	2013-2016
Assume EQ Responsibilities for Unit 3	2017
Assume EQ Responsibilities for Unit 4	2019

* Dependent on actual project schedule

CP COL 3.11(1) Replace the first sentence of the sixth paragraph in DCD Section 3.11 with the following.

CPNPP Units 3 and 4, at time of license issuance, assumes full responsibility for the EQ program, assembles, and maintains the EQ records for the life of the plant to fulfill the records retention requirements delineated in 10 CFR 50.49 (Reference 3.11-2) and in compliance with the quality assurance program (QAP) described in Chapter 17.

CP COL 3.11(4) Replace the eighth paragraph in DCD Section 3.11 with the following.

This subsection addresses EQ implementation in conjunction with the initial design, procurement, construction, startup and testing up to the point of turnover and initial license issuance. Implementation of the operational EQ program is included in Table 13.4-201. Periodic tests, calibrations, and inspections which verify that the identified equipment remains capable of fulfilling its intended function are described in Reference 3.11-3.

3.11.1.1 Equipment Identification

CP COL 3.11(5) Replace the last sentence of the first paragraph in DCD Subsection 3.11.1.1 with the following.

Table 3D-201 identifies CPNPP Units 3 and 4 site-specific electrical and mechanical equipment locations and environmental conditions (both normal and accident) to be addressed in the EQ program. This table lists information on site-specific safety-related or important to safety equipment.

3.11.1.2 Definition of Environmental Conditions

CP COL 3.11(9) Replace the fourth sentence of the first paragraph in DCD Subsection 3.11.1.2 with the following.

Any parameters based on site-specific considerations are identified in the environmental qualification documentation described in Section 3.11.

3.11.3 Qualification Test Results

CP COL 3.11(2) Replace the fifth paragraph in DCD Subsection 3.11.3 with the following.

Test results for site-specific electrical and mechanical equipment are maintained with the project records as auditable files. Such records are maintained from the time of initial receipt through the entire period during which the subject equipment remains installed in the plant, is stored for future use, or is held for permit verification. The license holder for CPNPP Units 3 and 4 assumes full responsibility for the EQ program at time of license issuance. The EQ records are maintained for the life of plant to fulfill the records retention requirements delineated in 10 CFR 50.49 (Reference 3.11-2) and in compliance with the QAP described in Chapter 17.

3.11.4 Loss of Ventilation

CP COL 3.11(6) Replace the second paragraph in DCD Subsection 3.11.4 with the following.

Site-specific electrical and mechanical equipment (including instrumentation and control and certain accident monitoring equipment), subject to environmental stress associated with loss of ventilation or other environmental control systems including heat tracing, heating, and air conditioning, is qualified using an equivalent qualification process to that delineated for the US-APWR standard plant.

3.11.5 Estimated Chemical and Radiation Environment

CP COL 3.11(7) Replace paragraph in DCD, Subsection 3.11.5 with the following.

Chemical and radiation environmental requirements for site-specific electrical and mechanical equipment (including instrumentation and control and certain accident monitoring equipment) are to be included in Table 3D-201 by completion of [Later]. This equipment is qualified using an equivalent qualification process to that delineated for the US-APWR standard plant.

3.11.6 Qualification of Mechanical Equipment

CP COL 3.11(8) Replace the second paragraph in DCD, Subsection 3.11.6 with the following.

Site-specific mechanical equipment requirements are to be included in Table 3D-201 by completion of detailed design. This equipment is qualified using an equivalent qualification process to that delineated for the US-APWR standard plant.

3.11.7 Combined License Information

Replace the content of DCD Subsection 3.11.7 with the following.

CP COL 3.11(1) ***3.11(1)*** *Environmental qualification document assembly and maintenance*

This COL item is addressed in Section 3.11.

CP COL 3.11(2) ***3.11(2)*** *Qualification tests results recorded*

This COL item is addressed in Subsection 3.11.3.

CP COL 3.11(3) ***3.11(3)*** *Schedule for EQ program implementation milestones*

This COL item is addressed in Section 3.11.

CP COL 3.11(4) ***3.11(4)*** *Periodic tests, calibrations, and inspections*

This COL item is addressed in Section 3.11.

CP COL 3.11(5) ***3.11(5)*** *Site-specific equipment addressed in EQ program*

This COL item is addressed in Subsection 3.11.1.1 and Table 3D-201.

CP COL 3.11(6) ***3.11(6)*** *Site-specific equipment, equivalent qualification process*

This COL item is addressed in Subsection 3.11.4.

CP COL 3.11(7) ***3.11(7)*** *Site-specific chemical and radiation environmental requirements*

This COL item is addressed in Subsection 3.11.5 and Table 3D-201.

CP COL 3.11(8) ***3.11(8)*** *Site-specific mechanical equipment requirements*

This COL item is addressed in Subsection 3.11.6 and Table 3D-201.

CP COL 3.11(9) ***3.11(9)*** *Parameters based on site-specific considerations*

This COL item is addressed in Subsection 3.11.1.2.

3.12 PIPING DESIGN REVIEW

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

3.12.5.1 Seismic Input Envelope vs. Site-Specific Spectra

STD COL 3.12(2) Replace the second paragraph in DCD Subsection 3.12.5.1 with the following.

For piping located in the yard that is not part of the US-APWR standard design, site specific response spectra described in Subsection 3.7.1 are used for piping analysis.

3.12.5.3.6 Wind/Tornado Loads

CP COL 3.12(3) Replace the paragraph in DCD Subsection 3.12.5.3.6 with the following.

There is no ASME Code, Section III (Reference 3.12-2) Class 2 or 3 piping exposed to wind or tornado loading. Non-ASME piping, such as B31.1 (Reference 3.12-1) exposed to wind or tornado loading, is evaluated to the wind and tornado loading identified in Section 3.3, in conjunction with the applicable piping code load combinations.

3.12.5.6 High-Frequency Modes

CP COL 3.12(4) Replace the second paragraph in DCD Subsection 3.12.5.6 with the following.

For the site-specific ground motion response spectra, there are no high frequency exceedances of the CSDRS. Therefore, high frequency screening of the piping system for high frequency sensitivity is not required.

3.12.7 Combined License Information

Replace the content of DCD Subsection 3.12.7 with the following.

3.12(1) *Deleted from the DCD.*

STD COL 3.12(2) ***3.12(2)*** *Site-specific seismic response spectra for design of piping*

This COL item is addressed in Subsection 3.12.5.1.

CP COL 3.12(3) ***3.12(3)*** *Site-specific ASME Code, Section III, Class 2 or 3 piping, exposed to wind or tornado loads*

This COL item is addressed in Subsection 3.12.5.3.6.

CP COL 3.12(4) ***3.12(4)*** *Piping systems evaluation for sensitivity to high frequency modes*

This COL item is addressed in Subsection 3.12.5.6.

3.13 THREADED FASTENERS (ASME CODE CLASS 1, 2, AND 3)

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

3.13.1.2.3 Reactor Vessel Closure Stud Bolting

STD COL 3.13(1) Replace the last sentence of the third paragraph in DCD Subsection 3.13.1.2.3 with the following.

Procedures will be prepared in accordance with Subsection 13.5.2.2, prior to initial installation of stud bolting to the RV head, to control the use of seal plugs, to maintain stud bolting following head removal in an area free from corrosion and contamination, to provide adequate protection for the stud bolting, and to permit ISI on the bolting while removed from the RV.

3.13.1.2.5 Fastener Thread Lubricants and Sealants

STD COL 3.13(2) Replace the last sentence of the second paragraph in DCD Subsection 3.13.1.2.5 with the following.

Procedures will be prepared in accordance with Subsection 13.5.2.2, prior to safety-related use, to control the use of fastener thread lubricants, sealants, and cleaning fluids that comply with the recommendations provided, including References 3.13-6 through 3.13-10.

3.13.1.5 Certified Material Test Reports

STD COL 3.13(3) Replace the first sentence in the first paragraph in DCD Subsection 3.13.1.5 with the following.

Quality records, including certified material test reports for all property test and analytical work performed on nuclear threaded fasteners, are maintained for the life of plant as part of the QAP described in Chapter 17.

3.13.2 Inservice Inspection Requirements

STD COL 3.13(4) Replace the last sentence of the first paragraph in DCD Subsection 3.13.2 with the following.

Compliance with the requirements of the ISI program relating to threaded fasteners, including any applicable PSI and IST, is implemented as part of the operational programs. The ISI program is baselined using PSI. A PSI program relating to threaded fasteners will be implemented after the start of construction and prior to initial plant startup to comply with the requirements of ASME Section XI (Reference 3.13-14). Additionally, in accordance with ASME Section XI, IWA-1200, the PSI code requirements may be performed irrespective of location (such as at manufacturer) once the construction Code requirements have been met.

STD COL 3.13(5) Replace the first sentence of the fifth paragraph in DCD Subsection 3.13.2 with the following.

An ISI program for the pressure testing of mechanical joints utilizing threaded fasteners is implemented in accordance with the requirements of ASME Code, Section XI, IWA-5000 (Reference 3.13-14), and the requirements of 10 CFR 50.55a(b)(2)(xxvi) (Reference 3.13-11), Pressure Testing Class 1, 2, and 3 Mechanical Joints, and Removal of Insulation, paragraph (xxvii).

3.13.3 Combined License Information

Replace the content of DCD Subsection 3.13.3 with the following.

STD COL 3.13(1) ***3.13(1)*** *Procedures for effective corrosion protection for stud bolting to allow ISI*

This COL Item is addressed in Subsection 3.13.1.2.3.

STD COL 3.13(2) ***3.13(2)*** *Procedures for final selection of lubricants, sealants, and cleaning fluids*

This COL Item is addressed in Subsection 3.13.1.2.5.

STD COL 3.13(3) ***3.13(3)*** *Quality records including certified material test reports for property test and analytical work on threaded fasteners*

This action is resolved in Subsection 3.13.1.5.

STD COL 3.13(4) ***3.13(4)*** *Compliance with ISI requirements*

This COL Item is addressed in Subsection 3.13.2.

STD COL 3.13(5) ***3.13(5)*** *Complying with requirements of ASME Code, Section XI, and 10 CFR 50.55a*

This COL Item is addressed in Subsection 3.13.2.

APPENDIX 3A

HEATING, VENTILATION, AND AIR CONDITIONING DUCTS AND DUCT SUPPORTS

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3A HEATING, VENTILATION, AND AIR CONDITIONING DUCTS AND DUCT SUPPORTS

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

APPENDIX 3B

BOUNDING ANALYSIS CURVE DEVELOPMENT FOR LEAK BEFORE BREAK EVALUATION OF HIGH-ENERGY PIPING FOR UNITED STATES – ADVANCED PRESSURIZED WATER REACTOR

TABLE OF CONTENTS

3B BOUNDING ANALYSIS CURVE DEVELOPMENT FOR LEAK BEFORE BREAK EVALUATION OF HIGH-ENERGY PIPING FOR UNITED STATES – ADVANCED PRESSURIZED WATER REACTOR

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

APPENDIX 3C

REACTOR COOLANT LOOP ANALYSIS METHODS

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3C REACTOR COOLANT LOOP ANALYSIS METHODS

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

APPENDIX 3D

US-APWR EQUIPMENT QUALIFICATION LIST SAFETY AND IMPORTANT TO SAFETY ELECTRICAL AND MECHANICAL EQUIPMENT

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3D US-APWR EQUIPMENT QUALIFICATION LIST SAFETY AND IMPORTANT TO SAFETY ELECTRICAL AND MECHANICAL EQUIPMENT

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

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Add the following new table in DCD Appendix 3D.

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Table 3D-201 (Sheet 1 of 10)
Site-Specific Environmental Qualification Equipment List

Item Num	Equipment Tag	Description	Location	Purpose	Operational Duration	Environmental Conditions	Qualification Process	Seismic Category	Comments
			PCCV, R/B, A/B, O/B, T/B, UHSRS, ESWPT	Engineered Safety Feature (ESF), Post Accident Monitoring (PAM), Other		Harsh or Mild	E=Electrical M=Mechanical	I, II, Non	
1	UHS-LT-2070A	A - UHS Basin Water Level	UHSRS	PAM, Other	2 wks	Mild	E	I	
2	UHS-LT-2070B	A – UHS Basin Water Level	UHSRS	PAM, Other	2 wks	Mild	E	I	
3	UHS-LT-2071A	B – UHS Basin Water Level	UHSRS	PAM, Other	2 wks	Mild	E	I	
4	UHS-LT-2071B	B - UHS Basin Water Level	UHSRS	PAM, Other	2 wks	Mild	E	I	
5	UHS-LT-2072A	C - UHS Basin Water Level	UHSRS	PAM, Other	2 wks	Mild	E	I	
6	UHS-LT-2072B	C - UHS Basin Water Level	UHSRS	PAM, Other	2 wks	Mild	E	I	
7	UHS-LT-2073A	D - UHS Basin Water Level	UHSRS	PAM, Other	2 wks	Mild	E	I	
8	UHS-LT-2073B	D – UHS Basin Water Level	UHSRS	PAM, Other	2 wks	Mild	E	I	
9	UHS-TE-2070	A - UHS Basin Temperature	UHSRS	PAM, Other	2 wks	Mild	E	I	

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Table 3D-201 (Sheet 2 of 10)
Site-Specific Environmental Qualification Equipment List

Item Num	Equipment Tag	Description	Location	Purpose	Operational Duration	Environmental Conditions	Qualification Process	Seismic Category	Comments
			PCCV, R/B, A/B, O/B, T/B, UHSRS, ESWPT	ESF, PAM, Other		Harsh or Mild	E=Electrical M=Mechanical	I, II, Non	
10	UHS-TE-2071	B - UHS Basin Temperature	UHSRS	PAM, Other	2 wks	Mild	E	I	
11	UHS-TE-2072	C - UHS Basin Temperature	UHSRS	PAM, Other	2 wks	Mild	E	I	
12	UHS-TE-2073	D - UHS Basin Temperature	UHSRS	PAM, Other	2 wks	Mild	E	I	
13	VRS-OFN-601A	A - ESW Pump Room Exhaust Fan	UHSRS	ESF	1 yr	Mild	M	I	
14	VRS-OFN-601B	B - ESW Pump Room Exhaust Fan	UHSRS	ESF	1 yr	Mild	M	I	
15	VRS-OFN-601C	C - ESW Pump Room Exhaust Fan	UHSRS	ESF	1 yr	Mild	M	I	
16	VRS-OFN-601D	D - ESW Pump Room Exhaust Fan	UHSRS	ESF	1 yr	Mild	M	I	
17	VRS-OFN-602A	A - UHS Transfer Pump Room Exhaust Fan	UHSRS	ESF	1 yr	Mild	M	I	
18	VRS-OFN-602B	B - UHS Transfer Pump Room Exhaust Fan	UHSRS	ESF	1 yr	Mild	M	I	

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Table 3D-201 (Sheet 3 of 10)
Site-Specific Environmental Qualification Equipment List

Item Num	Equipment Tag	Description	Location	Purpose	Operational Duration	Environmental Conditions	Qualification Process	Seismic Category	Comments
			PCCV, R/B, A/B, O/B, T/B, UHSRS, ESWPT	ESF, PAM, Other		Harsh or Mild	E=Electrical M=Mechanical	I, II, Non	
19	VRS-OFN-602C	C - UHS Transfer Pump Room Exhaust Fan	UHSRS	ESF	1 yr	Mild	M	I	
20	VRS-OFN-602D	D - UHS Transfer Pump Room Exhaust Fan	UHSRS	ESF	1 yr	Mild	M	I	
21	VRS-OEQ-601A	A - ESW Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
22	VRS-OEQ-601B	B - ESW Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
23	VRS-OEQ-601C	C - ESW Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
24	VRS-OEQ-601D	D - ESW Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
25	VRS-OEQ-602A	A - ESW Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
26	VRS-OEQ-602B	B - ESW Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
27	VRS-OEQ-602C	C - ESW Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
28	VRS-OEQ-602D	D - ESW Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
29	VRS-OEQ-603A	A - UHS Transfer Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Table 3D-201 (Sheet 4 of 10)
Site-Specific Environmental Qualification Equipment List

Item Num	Equipment Tag	Description	Location	Purpose	Operational Duration	Environmental Conditions	Qualification Process	Seismic Category	Comments
			PCCV, R/B, A/B, O/B, T/B, UHSRS, ESWPT	ESF, PAM, Other		Harsh or Mild	E=Electrical M=Mechanical	I, II, Non	
30	VRS-OEQ-603B	B - UHS Transfer Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
31	VRS-OEQ-603C	C - UHS Transfer Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
32	VRS-OEQ-603D	D - UHS Transfer Pump Room Unit Heater	UHSRS	ESF	1 yr	Mild	M	I	
33	VRS-TS-2610C	A - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
34	VRS-TS-2610D	A - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
35	VRS-TS-2610E	A - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
36	VRS-TS-2610F	A - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
37	VRS-TS-2615C	A - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
38	VRS-TS-2615D	A - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Table 3D-201 (Sheet 5 of 10)
Site-Specific Environmental Qualification Equipment List

Item Num	Equipment Tag	Description	Location	Purpose	Operational Duration	Environmental Conditions	Qualification Process	Seismic Category	Comments
			PCCV, R/B, A/B, O/B, T/B, UHSRS, ESWPT	ESF, PAM, Other		Harsh or Mild	E=Electrical M=Mechanical	I, II, Non	
39	VRS-TS-2615E	A - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
40	VRS-TS-2615F	A - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
41	VRS-TS-2620C	B - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
42	VRS-TS-2620D	B - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
43	VRS-TS-2620E	B - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
44	VRS-TS-2620F	B - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
45	VRS-TS-2625C	B - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
46	VRS-TS-2625D	B - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Table 3D-201 (Sheet 6 of 10)
Site-Specific Environmental Qualification Equipment List

Item Num	Equipment Tag	Description	Location	Purpose	Operational Duration	Environmental Conditions	Qualification Process	Seismic Category	Comments
			PCCV, R/B, A/B, O/B, T/B, UHSRS, ESWPT	ESF, PAM, Other		Harsh or Mild	E=Electrical M=Mechanical	I, II, Non	
47	VRS-TS-2625E	B - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
48	VRS-TS-2625F	B - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
49	VRS-TS-2630C	C - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
50	VRS-TS-2630D	C - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
51	VRS-TS-2630E	C - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
52	VRS-TS-2630F	C - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
53	VRS-TS-2635C	C -UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
54	VRS-TS-2635D	C - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Table 3D-201 (Sheet 7 of 10)
Site-Specific Environmental Qualification Equipment List

Item Num	Equipment Tag	Description	Location	Purpose	Operational Duration	Environmental Conditions	Qualification Process	Seismic Category	Comments
			PCCV, R/B, A/B, O/B, T/B, UHSRS, ESWPT	ESF, PAM, Other		Harsh or Mild	E=Electrical M=Mechanical	I, II, Non	
55	VRS-TS-2635E	C - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
56	VRS-TS-2635F	C - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
57	VRS-TS-2640C	D - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
58	VRS-TS-2640D	D - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
59	VRS-TS-2640E	D - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
60	VRS-TS-2640F	D - ESW Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
61	VRS-TS-2645C	D - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
62	VRS-TS-2645D	D - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Table 3D-201 (Sheet 8 of 10)
Site-Specific Environmental Qualification Equipment List

Item Num	Equipment Tag	Description	Location	Purpose	Operational Duration	Environmental Conditions	Qualification Process	Seismic Category	Comments
			PCCV, R/B, A/B, O/B, T/B, UHSRS, ESWPT	ESF, PAM, Other		Harsh or Mild	E=Electrical M=Mechanical	I, II, Non	
63	VRS-TS-2645E	D - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
64	VRS-TS-2645F	D - UHS Transfer Pump Room Temperature	UHSRS	Other	2 wks	Mild	E	I	
65	UHS-OPP-001A	A - UHS Transfer Pump	UHSRS	ESF	1 yr	Mild	M	I	
66	UHS-OPP-001B	B - UHS Transfer Pump	UHSRS	ESF	1 yr	Mild	M	I	
67	UHS-OPP-001C	C - UHS Transfer Pump	UHSRS	ESF	1 yr	Mild	M	I	
68	UHS-OPP-001D	D - UHS Transfer Pump	UHSRS	ESF	1 yr	Mild	M	I	
69	UHS-OEQ-001A	A – UHS Cooling Tower Fan No.1	UHSRS	ESF	1 yr	Mild	M	I	
70	UHS-OEQ-001B	B – UHS Cooling Tower Fan NO.1	UHSRS	ESF	1 yr	Mild	M	I	

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Table 3D-201 (Sheet 9 of 10)
Site-Specific Environmental Qualification Equipment List

Item Num	Equipment Tag	Description	Location	Purpose	Operational Duration	Environmental Conditions	Qualification Process	Seismic Category	Comments
			PCCV, R/B, A/B, O/B, T/B, UHSRS, ESWPT	ESF, PAM, Other		Harsh or Mild	E=Electrical M=Mechanical	I, II, Non	
71	UHS-OEQ-001C	C - UHS Cooling Tower Fan NO.1	UHSRS	ESF	1 yr	Mild	M	I	
72	UHS-OEQ-001D	D - UHS Cooling Tower Fan No.1	UHSRS	ESF	1 yr	Mild	M	I	
73	UHS-OEQ-002A	A – UHS Cooling Tower Fan No.2	UHSRS	ESF	1 yr	Mild	M	I	
74	UHS-OEQ-002B	B – UHS Cooling Tower Fan NO.2	UHSRS	ESF	1 yr	Mild	M	I	
75	UHS-OEQ-002C	C - UHS Cooling Tower Fan NO.2	UHSRS	ESF	1 yr	Mild	M	I	
76	UHS-OEQ-002D	D - UHS Cooling Tower Fan No.2	UHSRS	ESF	1 yr	Mild	M	I	
77	UHS-MOV-503A	A - UHS Transfer Pump Discharge Valve	UHSRS	ESF	1 yr	Mild	M	I	
78	UHS-MOV-503B	B – UHS Transfer Pump Discharge Valve	UHSRS	ESF	1 yr	Mild	M	I	
79	UHS-MOV-503C	C – UHS Transfer Pump Discharge Valve	UHSRS	ESF	1 yr	Mild	M	I	
80	UHS-MOV-503D	D – UHS Transfer Pump Discharge Valve	UHSRS	ESF	1 yr	Mild	M	I	

CP COL 3.11(5)
CP COL 3.11(7)
CP COL 3.11(8)

Table 3D-201 (Sheet 10 of 10)
Site-Specific Environmental Qualification Equipment List

Item Num	Equipment Tag	Description	Location	Purpose	Operational Duration	Environmental Conditions	Qualification Process	Seismic Category	Comments
			PCCV, R/B, A/B, O/B, T/B, UHSRS, ESWPT	ESF, PAM, Other		Harsh or Mild	E=Electrical M=Mechanical	I, II, Non	
81	UHS-MOV-506A	A - UHS Transfer Line Basin Inlet Valve	UHSRS	ESF	1 yr	Mild	M	I	
82	UHS-MOV-506B	B - UHS Transfer Line Basin Inlet Valve	UHSRS	ESF	1 yr	Mild	M	I	
83	UHS-MOV-506C	C - UHS Transfer Line Basin Inlet Valve	UHSRS	ESF	1 yr	Mild	M	I	
84	UHS-MOV-506D	D - UHS Transfer Line Basin Inlet Valve	UHSRS	ESF	1 yr	Mild	M	I	
85	UHS-HCV-2000	A - UHS Basin Blowdown Control Valve	UHSRS	ESF	1 yr	Mild	M	I	
86	UHS-HCV-2001	B - UHS Basin Blowdown Control Valve	UHSRS	ESF	1 yr	Mild	M	I	
87	UHS-HCV-2002	C - UHS Basin Blowdown Control Valve	UHSRS	ESF	1 yr	Mild	M	I	
88	UHS-HCV-2003	D - UHS Basin Blowdown Control Valve	UHSRS	ESF	1 yr	Mild	M	I	

APPENDIX 3E

HIGH ENERGY AND MODERATE ENERGY PIPING IN THE PRESTRESSED CONCRETE CONTAINMENT VESSEL AND REACTOR BUILDING

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3E HIGH ENERGY AND MODERATE ENERGY PIPING IN THE PRESTRESSED CONCRETE CONTAINMENT VESSEL AND REACTOR BUILDING

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

APPENDIX 3F

DESIGN OF CONDUIT AND CONDUIT SUPPORTS

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3F DESIGN OF CONDUIT AND CONDUIT SUPPORTS

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

APPENDIX 3G

SEISMIC QUALIFICATION OF CABLE TRAYS AND SUPPORTS

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3G SEISMIC QUALIFICATION OF CABLE TRAYS AND SUPPORTS

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

APPENDIX 3H

MODEL PROPERTIES AND SEISMIC ANALYSIS RESULTS FOR LUMPED MASS STICK MODELS OF R/B-PCCV-CONTAINMENT INTERIOR STRUCTURES ON A COMMON BASEMAT, AND PS/BS ON INDIVIDUAL BASEMATS

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3H MODEL PROPERTIES AND SEISMIC ANALYSIS RESULTS FOR LUMPED MASS STICK MODELS OF R/B-PCCV-CONTAINMENT INTERIOR STRUCTURES ON A COMMON BASEMAT, AND PS/BS ON INDIVIDUAL BASEMATS

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

APPENDIX 3I

IN-STRUCTURE RESPONSE SPECTRA

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3I IN-STRUCTURE RESPONSE SPECTRA

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

APPENDIX 3J

REACTOR, POWER SOURCE AND CONTAINMENT INTERNAL STRUCTURAL DESIGN

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3J REACTOR, POWER SOURCE AND CONTAINMENT INTERNAL STRUCTURAL DESIGN

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

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APPENDIX 3KK

MODEL PROPERTIES AND SEISMIC ANALYSIS RESULTS FOR UHSRS

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ACRONYMS AND ABBREVIATIONS

Acronyms	Definitions
3D	three-dimensional
BE	best estimate
ESW	essential service water
ESWPT	essential service water pipe tunnel
FE	finite element
FIRS	foundation input response spectra
ISRS	in-structure response spectra
LB	lower bound
OBE	operating-basis earthquake
PCCV	prestressed concrete containment vessel
R/B	reactor building
SRSS	square root sum of the squares
SSI	soil-structure interaction
UB	upper bound
UHS	ultimate heat sink
UHSRS	ultimate heat sink related structure
ZPA	zero period acceleration

3KK MODEL PROPERTIES AND SEISMIC ANALYSIS RESULTS FOR UHSRS

3KK.1 Introduction

This Appendix discusses the seismic analysis of the ultimate heat sink related structures (UHSRSs), including the ultimate heat sink (UHS) Basin and its pump house. The computer program SASSI (Reference 3KK-1) serves as the platform for the soil-structure interaction (SSI) analyses. The three-dimensional (3D) finite element (FE) models of the UHSRS used in the SASSI analysis are generated from FE models with finer mesh patterns initially developed using the ANSYS computer program (Reference 3KK-2). The SASSI model is confirmed by comparing the structural frequencies between the SASSI model mesh and the fine mesh design model. The structural frequencies are calculated from modal analysis performed in ANSYS, and the similar results ensure compatibility between the two models and indicate that the SASSI model is acceptable.

Dynamic analysis is performed in SASSI to obtain seismic response of the structure that includes SSI effects. Response spectra analyses are performed in ANSYS to obtain seismic design demands. The SASSI analyses results for maximum accelerations and seismic soil pressures are used to verify the load demands assigned to the ANSYS structural design analysis that are included in the load combinations in accordance with the requirements of Section 3.8. The SASSI analysis and results presented in this Appendix include site-specific features such as the layering of the subgrade, embedment of the UHSRS, flexibility of the basemat and seismic motion scattering. Due to the low seismic response at the Comanche Peak Nuclear Power Plant site and lack of high-frequency exceedances, the SASSI capability to consider incoherence of the input control motion is not implemented in the design of the UHSRS.

3KK.2 Model Description and Analysis Approach

The SASSI FE structural model for the UHSRS is shown in Figures 3KK-1. Table 3KK-1 presents the structural element material properties for the SASSI FE model. Detailed descriptions of the UHSRS are contained in Subsection 3.8.4. Figures 3.8-206 through 3.8-211 show detailed dimensions and layout of the UHSRS.

The UHSRS model is developed and analyzed using methods and approaches consistent with ASCE 4 (Reference 3KK-3), and accounting for the site-specific stratigraphy and subgrade conditions described in Chapter 2, as well as the backfill conditions around the embedded UHSRS. The four UHSRS (per unit) are nearly symmetric with minor variations on layout for the east and west walls. The essential service water pipe tunnel (ESWPT) is present along the full length on the south side of the UHSRS. Backfill is present on the north and west sides of UHSRS B and D, and on the north and east sides of UHSRS A and C. Due to symmetry, soil-structure interaction (SSI) analysis is performed only on UHSRS B/D, and the responses are deemed applicable to the other UHSRS.

The input within-layer motion and strain-compatible backfill properties for the SASSI analysis are developed from site response analyses described in Section 3NN.2 of Appendix 3NN by using the site-specific foundation input response spectra (FIRS) discussed in Subsection 3.7.1.1. The properties of the supporting media (rock) as well as the site-specific strain-compatible backfill properties used for the SASSI analysis of the UHSRS are the same as those presented in Appendix 3NN for the reactor building (R/B)-prestressed concrete containment vessel (PCCV)-containment internal structure SASSI analyses. To account for uncertainty in the site-specific properties, three profiles of subgrade properties are considered, including best estimate (BE), lower bound (LB), and upper bound (UB). For backfill, an additional high bound (HB) profile is also used together with the UB subgrade profile to account for expected uncertainty in the backfill properties.

The following SSI analyses and site profiles are used for calculating seismic responses of UHSRS:

- a surface foundation condition (without the presence of backfill) for the lower bound case
- an embedded foundation without separation of the backfill from the UHSRS exterior walls for the best estimate case
- an embedded foundation with separation of the backfill from the UHSRS exterior walls for all four soil cases, namely; LB, BE, UB, and HB

The backfill separation is modeled by reducing the shear wave velocity by a factor of 10 for the soil elements adjacent to the structure that are determined to be separated. The potential for separation of backfill is determined using an iterative approach that compares the peak envelope soil pressure results for the best estimate (BE) case to the at-rest soil pressure. Consideration of all these conditions assures that the enveloped results presented herein capture all potential seismic effects of a wide range of backfill properties and conditions in combination with the site-specific supporting media conditions.

Operating-basis earthquake (OBE) structural damping values of Chapter 3 Table 3.7.1-3(b), such as 4 percent damping for reinforced concrete, are used in the site-specific SASSI analysis. This is consistent with the requirements of Section 1.2 of RG 1.61 (Reference 3KK-4) for structures on sites with low seismic responses where the analyses consider a relatively narrow range of site-specific subgrade conditions.

Shell elements are used to model the basemat and brick elements are used for the concrete fill that is present beneath basemat. Beam elements are used for the concrete beams, that support slabs and equipment in the structure, and for the concrete columns in the cooling towers. Beam elements are also used to model the steel members in the UHSRS. Shell elements are used for the reinforced concrete walls and elevated slabs. Walls are modeled using gross section properties at the centerline. All roof slabs and elevated slabs (pump room, fan slab, missile shield protection) are considered as cracked with an out-of-plane bending stiffness of ½ of the gross section stiffness. The properties assigned to the slab elements are modified to account for cracked out-of plane flexural stiffness and non-cracked in-plane axial and shear stiffness of the slabs as follows:

$$E_{cracked} = [1/(C_F)^{0.5}] \cdot E_{concrete}$$

$$t_{cracked} = (C_F)^{0.5} \cdot t$$

$$\gamma_{cracked} = [1/(C_F)^{0.5}] \cdot \gamma_{concrete}$$

where:

C_F = the factor for the reduction of flexural stiffness, taken as 1/2,

$t_{cracked}$ = the effective slab thickness to account for cracking

t = the gross section thickness

$\gamma_{cracked}$ = the effective unit weight to offset the reduced stiffness and provide the same total mass

$\gamma_{concrete}$ = unit weight of concrete

$E_{cracked}$ = effective modulus to account for the reduction in thickness that keeps the same axial stiffness while reducing the flexural stiffness by C_F.

$E_{concrete}$ = modulus of elasticity of concrete.

Density of the structural walls and slabs is modified to include the dynamic masses of self-weight plus equivalent dead load and 25 percent of live load. Equivalent dead load is 50 psf on all interior surfaces above water (except inside the air-intake or the cooling tower walls at locations beneath the fan slab). Live load on the elevated floor slabs is 200 psf, and live load on roof slabs is taken as 100 psf. Weights are applied in the model at appropriate locations to represent the following equipment and component masses: transfer pump, essential service water (ESW) pump, tile fill located below the cooling tower fans, distribution nozzles and system, fan, fan motor, gear-reducer, driveshaft, steel grating.

The hydrodynamic effects of the water contained in the basins, cooling towers, and pump room of the UHS are considered in the model. The water is separated into rectangular regions in which water sloshing can develop under horizontal seismic excitation. Using the methodology specified in ACI 350.3-06 (Reference 3KK-5), the water within each region is separated into impulsive (fixed) and convective (sloshing) masses. The impulsive mass of the water is lumped uniformly along the height of the walls at each end of the rectangular region in the direction perpendicular to the wall. For the response spectra analyses performed to obtain seismic design demands, the sloshing mass is not required to be modeled since its fundamental frequency is much lower than the structural or soil frequencies. The vertical mass of the water is distributed uniformly across the basemat.

3KK.3 Seismic Analysis Results

Table 3KK-2 presents the natural frequencies of the UHSRS FE structural model used for the SASSI analysis. Table 3KK-3 presents a summary of SSI effects on the seismic response of the UHSRS. The maximum absolute nodal accelerations obtained from the SASSI analyses are presented in Table 3KK-4 for key UHSRS locations. The results envelope all site conditions considered. The maximum accelerations have been obtained by combining cross-directional contributions in accordance with RG 1.92 (Reference 3KK-6) using the square root sum of the squares (SRSS) method.

The dynamic horizontal soil pressure of the backfill on the basin walls varied depending on the soil case considered as the soil frequency approached that of the wall. The peak soil pressures varied along the height of the wall from values of approximately 0.5 ksf to almost 2ksf. The dynamic horizontal soil pressure used for design varied linearly from a value of 0.50ksf at the base slab to 1.5ksf at soil grade. The base shear and moment demands on walls, calculated in SASSI calculated lateral dynamic soil pressures and equivalent pressure used for design analysis, were compared and the design pressure profile shown to be conservative. The peak design vertical soil pressure calculated under the base slab is 11.7 ksf, which reduces away from edges. This value excludes the peak corner pressure of 23.0 ksf calculated on a single element, representing less than 0.2 percent of the total base slab area. The average peak vertical seismic pressure calculated under the base slab is 1.6 ksf.

For design of the UHSRS per the loads and load combinations given in Section 3.8, response spectra analysis is performed to obtain seismic demands. The response spectra analysis includes sloshing effects on the basins considering 0.5 percent damping, and follows the Lindley-Yow method (Reference 3KK-8) and 10 percent modal combination method. Note that the rigid response coefficient is set to zero for frequencies below the spectral peak acceleration (2.5 Hz for horizontal directions, 3.5 Hz for vertical direction) in accordance with RG 1.92 (Reference 3KK-6). Since the sloshing modes are well separated from all structural modes, the decreased level of damping is accounted for by increasing the spectrum for frequencies below 1.0Hz (all sloshing mode frequencies are below this value and all structural mode frequencies are above this value). The spectrum is increased by a factor of 1.57, which is equal to the ratio of 0.5% damped spectral values to 5 percent damped values for the frequency range in which the sloshing modes act. An equivalent static acceleration equal to the ZPA (0.10g) which accounts for “missing mass” is also applied to the UHSRS, and the results are combined with the Lindley-Yow spectral response using SRSS. The spectra used for this approach were confirmed to be higher than the enveloped base spectra calculated from the SASSI analysis.

For structural design of members and components, the design seismic forces due to three different components of the earthquake are combined using the

Newmark 100 percent - 40 percent – 40 percent combination method. The walls' shear forces were increased to account for 5 percent accidental torsion, and total base shear to be resisted by in-plane shear of the walls. Figure 3KK-2 presents the total adjusted wall seismic shear forces used for design.

The model used for response spectra seismic design analysis considered two bounding base slab behaviors; (a) flexible base slab – modeled with slab supported by using soil springs calculated using ASCE 4 (Reference 3KK-3) methodology, and (b) rigid base slab – modeled by fixing the nodes across the base of the structure. The design analysis enveloped the demands from these two cases.

The seismic design forces and moments resulting from the design analysis are presented in Table 3KK-5 at key UHSRS locations. The force and moment values represent the enveloped results for the seismic demands for all soil cases considered in the SASSI analyses.

Table 3KK-6 summarizes the resulting maximum displacements for enveloped seismic loading conditions at key UHSRS locations obtained from the seismic analysis.

3KK.4 In-Structure Response Spectra (ISRS)

The enveloped broadened in-structure response spectra (ISRS) are presented in Figure 3KK-3 for the UHSRS base slab, pump room elevated slab, pump room roof slab, and cooling tower fan support slab for each of the three orthogonal directions (east-west, north-south, vertical) for 0.5 percent, 2 percent, 3 percent, 4 percent, 5 percent, 7 percent, 10 percent and 20 percent damping. The ISRS for each orthogonal direction are resultant spectra, which have been combined using SRSS to account for cross-directional coupling effects in accordance with RG 1.122 (Reference 3KK-7). The ISRS include the envelope of the 6 site conditions (BE, LB, UB, and HB with and BE without backfill separation from the structure, and the no-fill surface foundation condition with LB subgrade conditions). All results have been broadened by 15 percent and all valleys removed. It is permitted to perform 15 percent peak clipping of the spectra presented herein in accordance with ASCE-4 (Reference 3KK-3) for spectra with less than 10 percent damping. For the design of seismic category I and II subsystems and components mounted to the UHSRS walls, it is required to account for the effects of out-of-plane wall flexibility.

3KK.5 References

3KK-1 *An Advanced Computational Software for 3D Dynamic Analysis Including Soil Structure Interaction,* ACS SASSI Version 2.2, Ghiocel Predictive Technologies, Inc., July 23, 2007.

3KK-2 ANSYS Release 11.0, SAS IP, Inc. 2007.

3KK-3 *Seismic Analysis of Safety-Related Nuclear Structures,* American Society of Civil Engineers, ASCE 4-98, Reston, Virginia, 2000.

3KK-4 *Damping Values for Seismic Design of Nuclear Power Plants*, Regulatory Guide 1.61, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, March 2007.

3KK-5 *Seismic Design of Liquid-Containing Concrete Structures and Commentary*, ACI 350.3, American Concrete Institute, Farmington Hills, Michigan, 2006.

3KK-6 *Combining Responses and Spatial Components in Seismic Response Analysis*, Regulatory Guide 1.92, Rev. 2, U.S. Nuclear Regulatory Commission, Washington, DC, July 2006.

3KK-7 *Development of Floor Design Response Spectra for Seismic Design of Floor-supported Equipment or Components*, Regulatory Guide 1.122, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, February 1978.

3KK-8 Morante, R. and Wang, Y. *Reevaluation of Regulatory Guidance on Modal Response Combination Methods for Seismic Response Spectrum Analysis*, NUREG/CR-6645, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC, December 1999.

Table 3KK-1
FE Model Material Properties (1), (2)

Component	E (ksi)	Poisson's Ratio	Unit Weight (kcf)	Damping Ratio	Element type
Concrete slabs, walls, beams, and columns	4,031	0.17	0.150	0.04	Shell
Concrete base mats	4,031	0.17	0.150	0.04	Shell
Steel beams, columns, and other structural steel elements	30,000	0.30	0.49	0.04	Beam
Concrete fill	3,125	0.17	0.150	0.04	Brick

Notes:

1) The concrete material properties are adjusted where appropriate to account for cracking as discussed in Appendix Section 3KK.2.

2) Dynamic analysis unit weights are increased where appropriate from those shown above to account for equivalent dead loads and live loads as discussed in Appendix Section 3KK.2.

Table 3KK-2
Natural Frequencies of Dynamic FE Models

Frequency (Hz)	Percentage of Effective Mass	Comments
7.1	26%	East-West Response
7.6	19%	North-South response
20.7	0.7%	Fan Slabs out of plane response
11.5	7.0%	Pump room elevated slab out of plane response

Notes:

1) Natural frequencies and effective masses were calculated in ANSYS using the same mesh as used for SASSI analyses.

2) Effective mass is that portion of mass of the overall structure which can participate in the seismic response in the frequency range of interest (< 50 Hz). This is considered to be the mass associated with the total dynamic weight of the UHS. The weight corresponding to the effective mass is 73,400 kips.

Table 3KK-3
SASSI Results for UHSRS Seismic Response

SSI Effect	Observed Response
Rock Subgrade	The rock subgrade has insignificant SSI effect on the UHSRS seismic response. The structural natural frequencies characterize the response because of the high stiffness of the rock and the small weight of the foundation.
Backfill Embedment	The properties of the backfill embedment affect the overall response of UHSRS structure. Backfill soil frequencies, in the range of 4 Hz for lower bound to 8 Hz for high bound, characterize the UHSRS horizontal response. The basin wall responses increase as the backfill frequency approaches the wall frequency and is largest for the high bound soil case. Frequencies of 7 Hz for lower bound, 11 Hz for best estimate, 14 Hz for upper bound, and 17 Hz for high bound, characterize the vertical response of the backfill. The resonance effects affect the out of plane response of the pump room elevated slab where the backfill frequency for upper bound case is nearly in tune with the natural frequency of the slab.
Backfill soil separation	The effects of backfill soil separation on the UHSRS response are small.
Motion Scattering Effects	Motion scattering effects are inherent in the SASSI analysis results. The dynamic properties mismatch between the backfill and the rock results in reflection of the seismic waves within the backfill stratum. Consequentially, multiple modes characterize the backfill soil column and affect the UHSRS response when their frequencies are close to the structural frequencies.
Hydrodynamic Effects	The low frequencies characterize the sloshing effects of the top of the water retained in UHSRS. The lower part of the water retained in each region of the UHSRS acts rigidly with the structure. In all regions except between the baffle walls in the pump room the sloshing frequencies range between 0.16 to 0.30 Hz and the frequency of sloshing in between the baffle walls is 0.65 Hz. In general, the sloshing portion of the water mass ranges from 5-50% of the total water mass in any particular region of the UHSRS. The maximum sloshing wave height, obtained from analysis of hydrodynamic effects using the response spectrum analysis, is less than 2 ft, which is less than the available freeboard.

Table 3KK-4
SASSI FE Model Peak Accelerations at Key UHSRS Locations (1), (2)

Component	N-S Acceleration (g) (+/- Y Direction)	E-W Acceleration (g) (+/- X Direction)	Vertical (g) (+/- Z Direction)
Basemat	0.11	0.11	0.12
Basin Exterior Walls	1.72	0.82	0.13
Basin Separation Wall	0.13	0.99	0.12
Pump Room Elevated Slab	0.16	0.23	0.81
Pump Room Roof Slab	0.20	0.34	0.54
Cooling Tower Fan Support Slab	0.38	0.42	1.33
Cooling Tower Roof Slab	0.56	0.46	0.25

Notes:

1) The peak accelerations presented above envelope all of the considered site conditions, i.e. UHSRS embedded in BE, LB, UB, and HB backfill with soil separation, UHSRS embedded in BE backfill without soil separation, as well as the UHSRS supported by a surface foundation.

2) The peak accelerations include amplification effects due to out-of-plane flexibility of walls and slabs.

Table 3KK-5
Maximum Component Seismic Forces and Moments at Key UHSRS Locations[(1),(2),(3)]

Component		Maximum component forces and moments							
		N_V (k/ft)	N_L (k/ft)	Q_V (k/ft)	Q_L (k/ft)	S_W (k/ft)	M_V (k-ft/ft)	M_L (k-ft/ft)	M_{VL} (k-ft/ft)
Basemat	+/-	159	70.1	54.5	72.6	93.3	265	332	52.4
Basin Exterior Walls	+/-	215	99.1	127	113	71.6	530	508	144
Basin Separation Wall	+/-	236	128	114	110	96.4	366	291	68.9
Cooling Tower Below Grade Exterior Walls	+/-	367	91.2	67.0	51.9	101	187	161	46.4
Pump Room Walls[(4)]	+/-	218	214	50.8	71.3	132	222	135	69.7
Upper Cooling Tower Walls[(5)]	+/-	243	152	62.8	84.3	60.2	105	147	55.5
Cooling Tower Fan Support Slabs	+/-	38.2	25.5	5.60	4.33	26.3	11.1	9.38	5.31
Pump Room Elevated Slab	+/-	91.5	25.8	16.0	12.8	30.3	30.6	16.9	8.80

Notes:

1) The forces and moments are obtained by combination of the three orthogonal directions using the Newmark 100%-40%-40% method.

2) In the table above the vertical and longitudinal directions define the plane of the walls. N stands for axial force, Q for out-of-plane shear, S_W for in-plane shear and M for moment. The M_V results in normal stresses in the vertical direction of the wall and similarly, M_L results in normal stresses in the longitudinal (horizontal) direction of the wall, and M_{VL} is the torsional moment on the wall. The Q_V is out-of-plane shear force acting on horizontal cross section of the wall, and Q_L is out-of-plane shear force acting on a vertical cross section of the wall. For slabs, the referenced “vertical” axis is oriented along the east-west direction and the longitudinal in the north-south direction

3) The force and moment values are the maximum/minimum element forces for walls and slabs and may be a result of force concentrations due to openings or corners.

4) Includes element forces for both lower (4’ thick) and upper (2’ thick) walls in the pump room

5) Includes element forces for all walls above the air-intakes

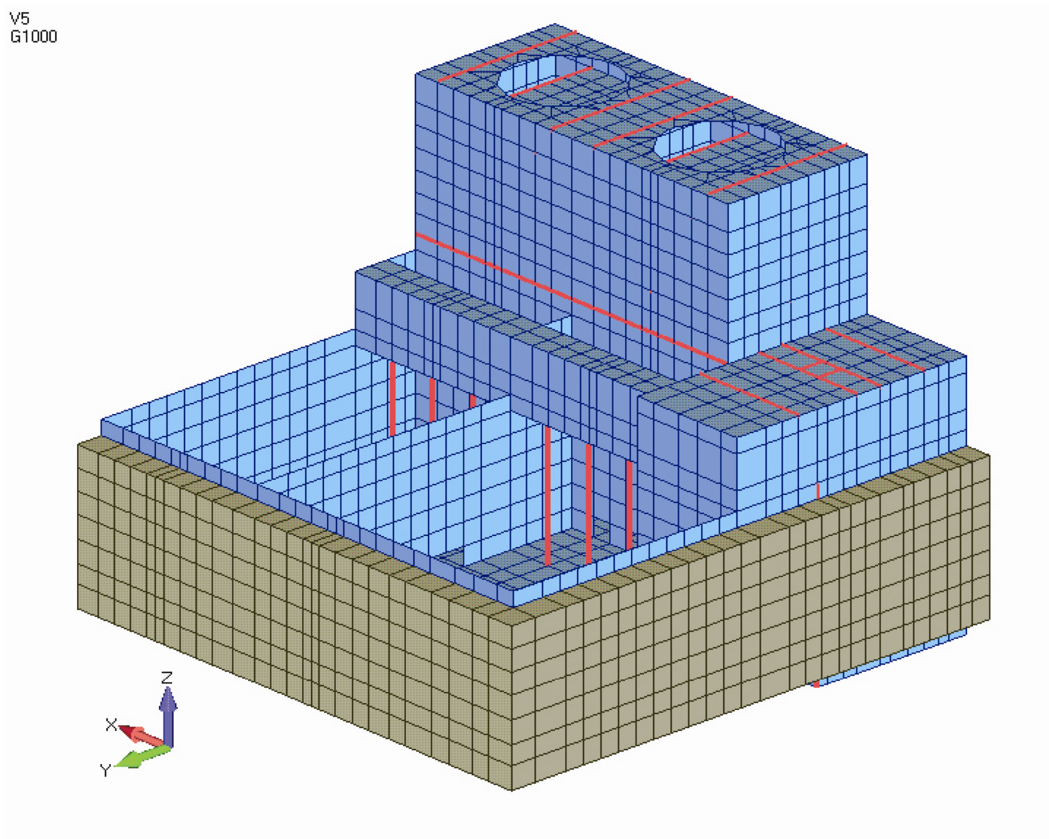
Table 3KK-6
Maximum Displacements for All Enveloped Conditions at Key UHSRS Locations[1]

Component	Maximum Displacement (inches)	Description
UHSRS South Wall	0.09	Maximum north-south displacement adjacent to ESWPT
Cooling Tower Roof Slab	0.24	Maximum horizontal displacement
Pump Room Elevated Slab	0.08	Maximum vertical (out-of-plane) displacement
Pump Room Roof Slab	0.11	Maximum horizontal displacement
Air Intake Missile Shield Top Slab	0.13	Maximum horizontal displacement
Basin Exterior Wall	0.61	Maximum out-of-plane displacement[2]
Basin Exterior Wall Top Corner	0.06	Maximum horizontal displacement at northeast and northwest corners

Notes:

1) Displacements include base flexibility, average horizontal displacements at the base slab is 0.013 inches

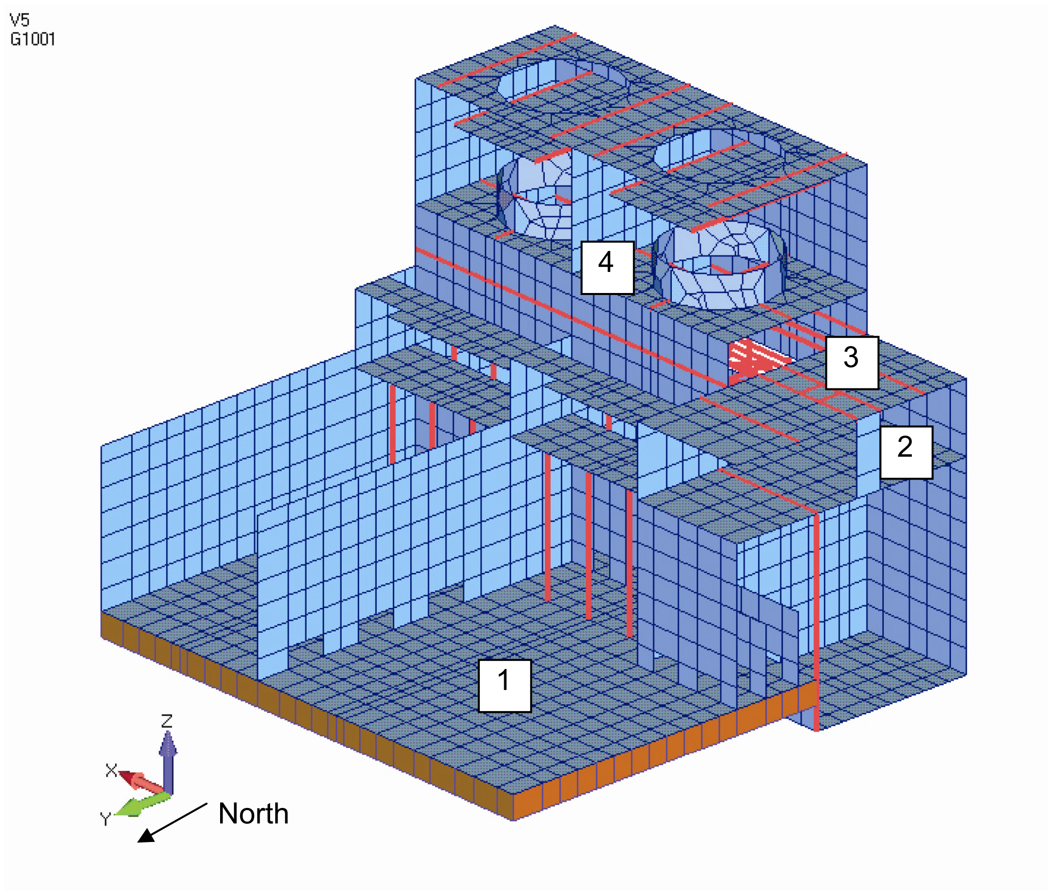
2) Occurs at approximately mid-span of the west basin north wall



Notes:

1) The soil (backfill) elements are on the north and west faces of the structure as shown above.

Figure 3KK-1 Overall SASSI Model of UHSRS (sheet 1 of 2)



Legend:
1 = Base Slab
2 = Pump Room Elevated Slab
3 = Pump Room Roof Slab
4 = Cooling Tower Fan Support Slab

Note: ISRS are presented in Figure 3KK-3 for the locations identified in the legend above.

Figure 3KK-1 Overall SASSI Model of UHSRS (Sheet 2 of 2, Cutaway View of SASSI Model of UHSRS)

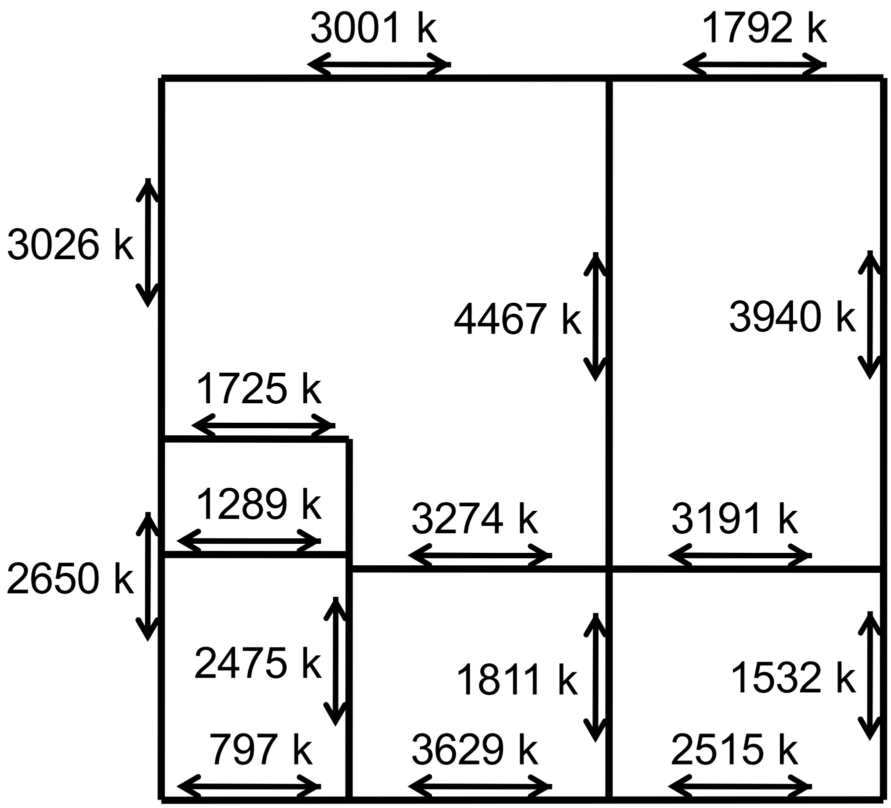


Figure 3KK-2 Wall Maximum Seismic Base Shear Forces (Sheet 1 of 2, Lower Buried UHS Basin Walls)

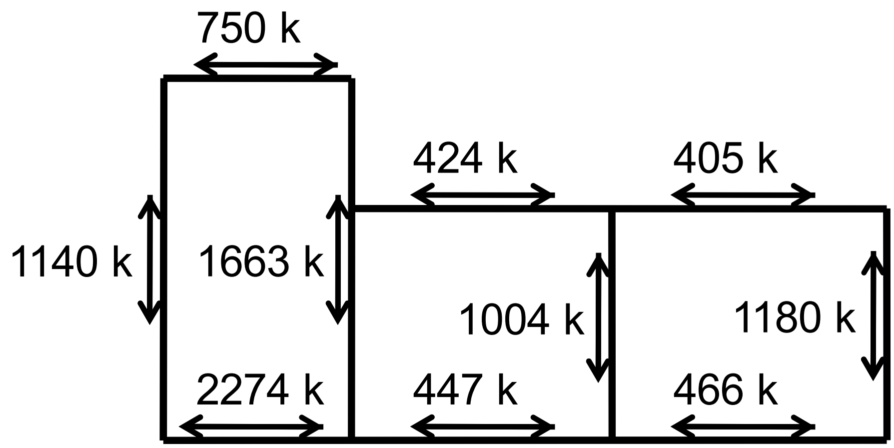


Figure 3KK-2 Wall Maximum Seismic Base Shear Forces (Sheet 2 of 2, Elevated Walls, EL. 828’)

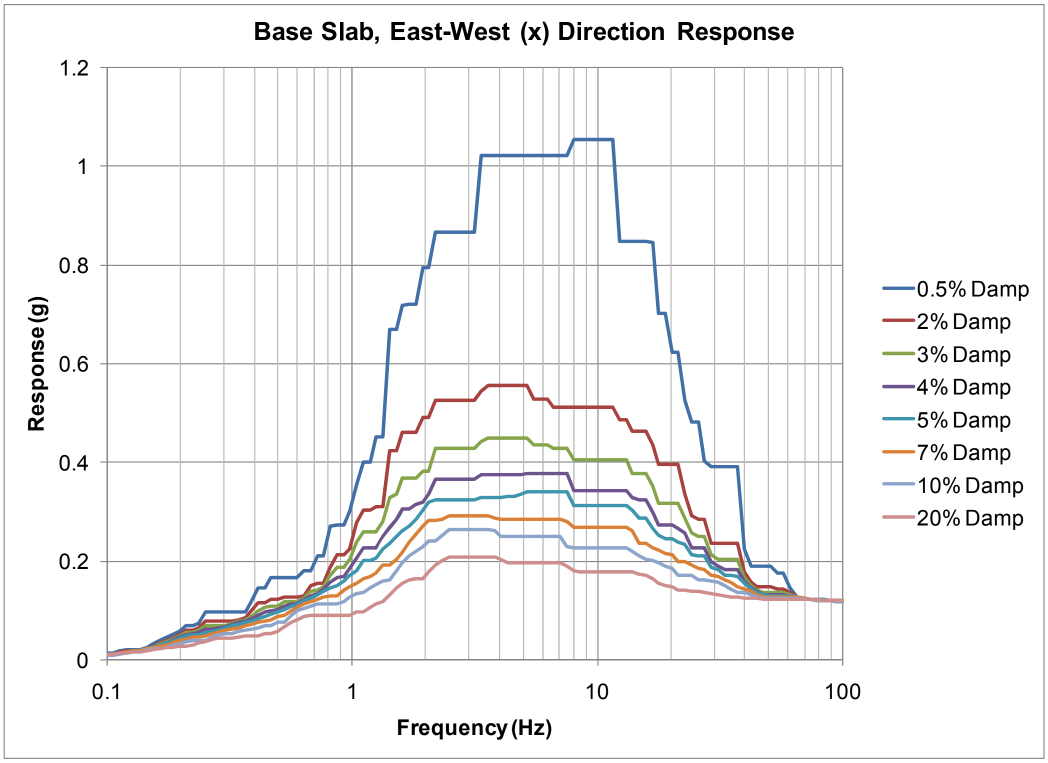


Figure 3KK-3 ISRS for UHSRS (Sheet 1 of 12)

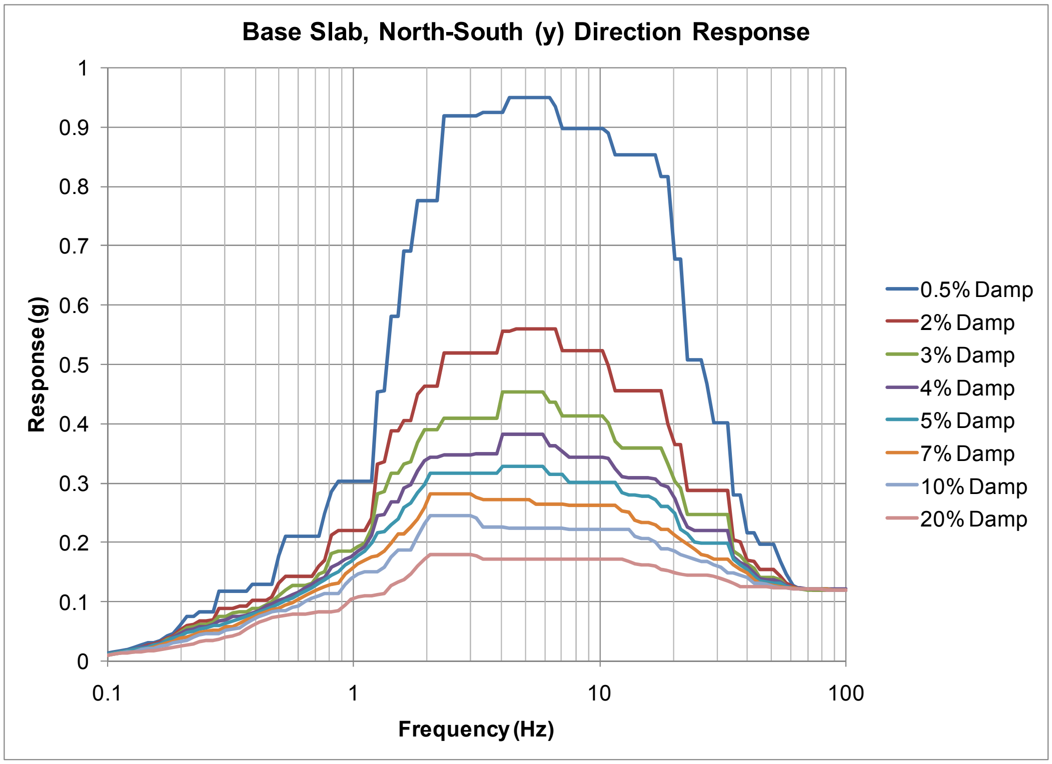


Figure 3KK-3 ISRS for UHSRS (Sheet 2 of 12)

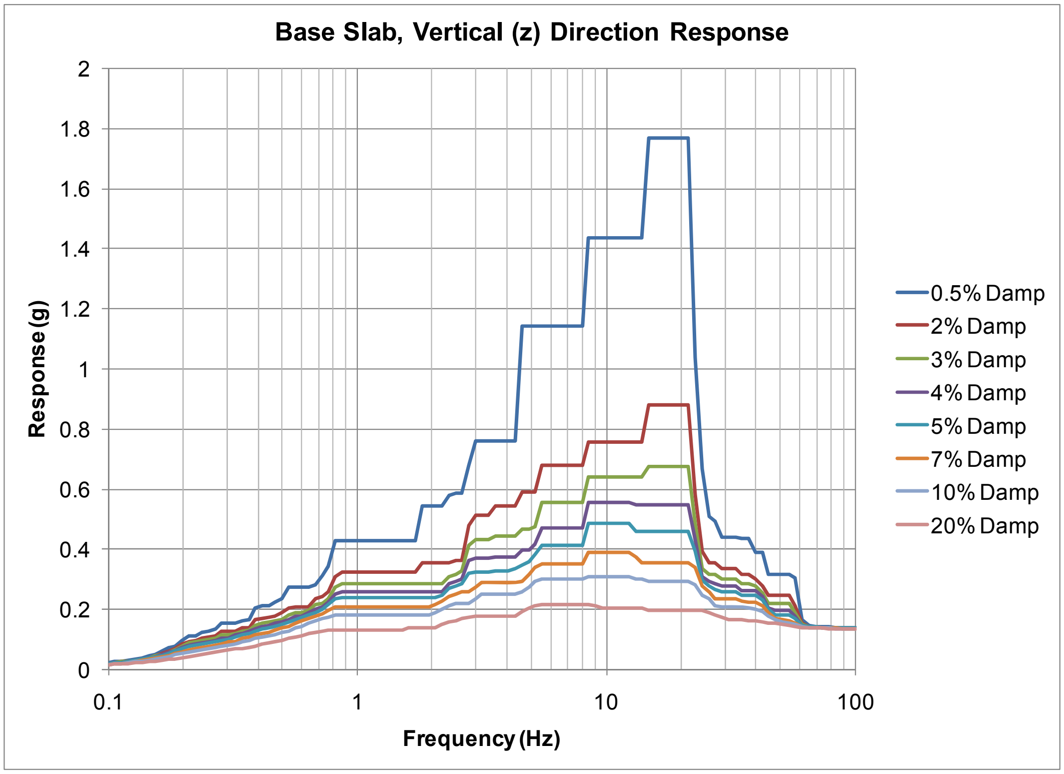


Figure 3KK-3 ISRS for UHSRS (Sheet 3 of 12)

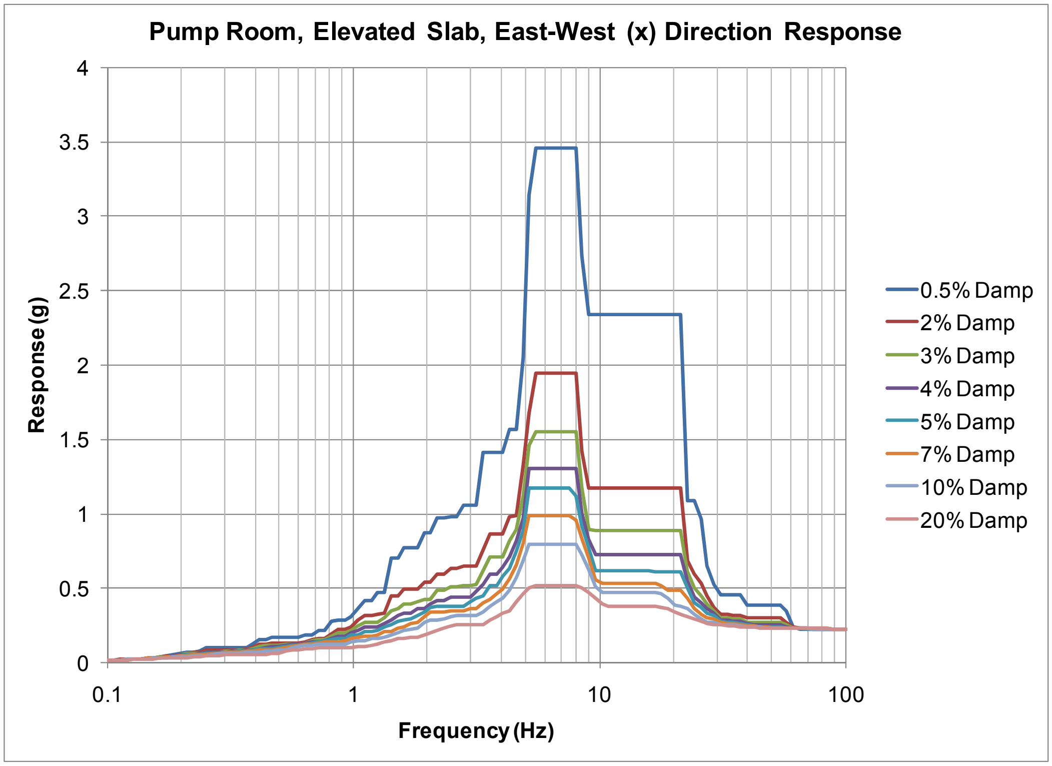


Figure 3KK-3 ISRS for UHSRS (Sheet 4 of 12)

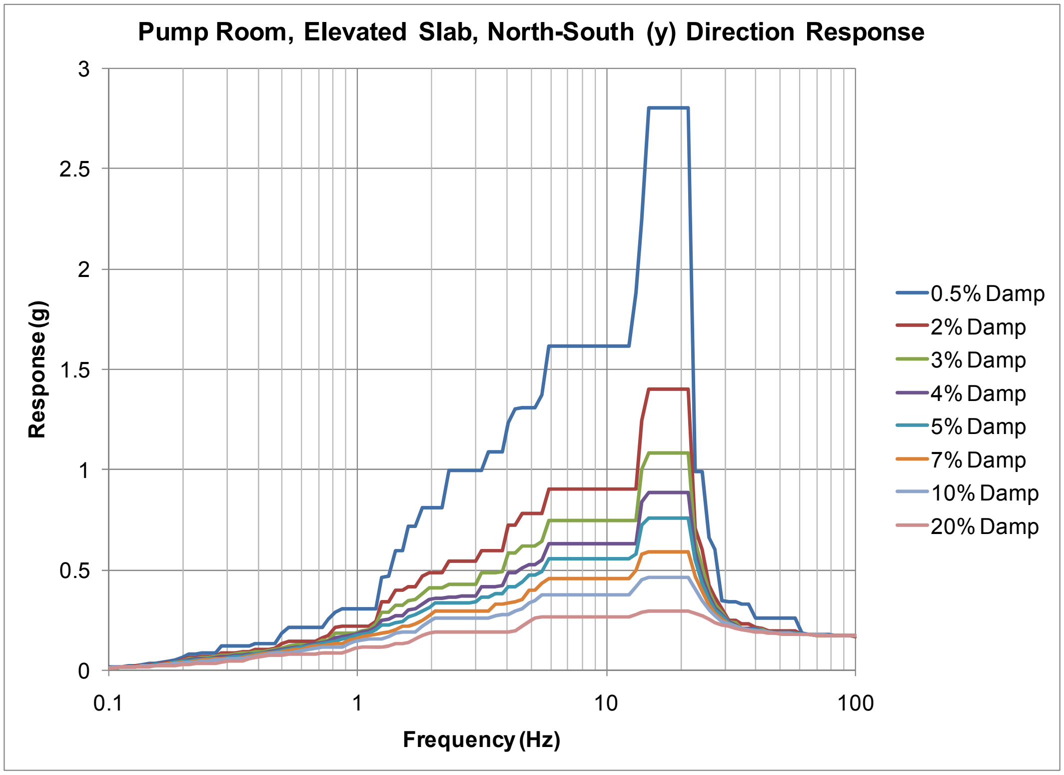


Figure 3KK-3 ISRS for UHSRS (Sheet 5 of 12)

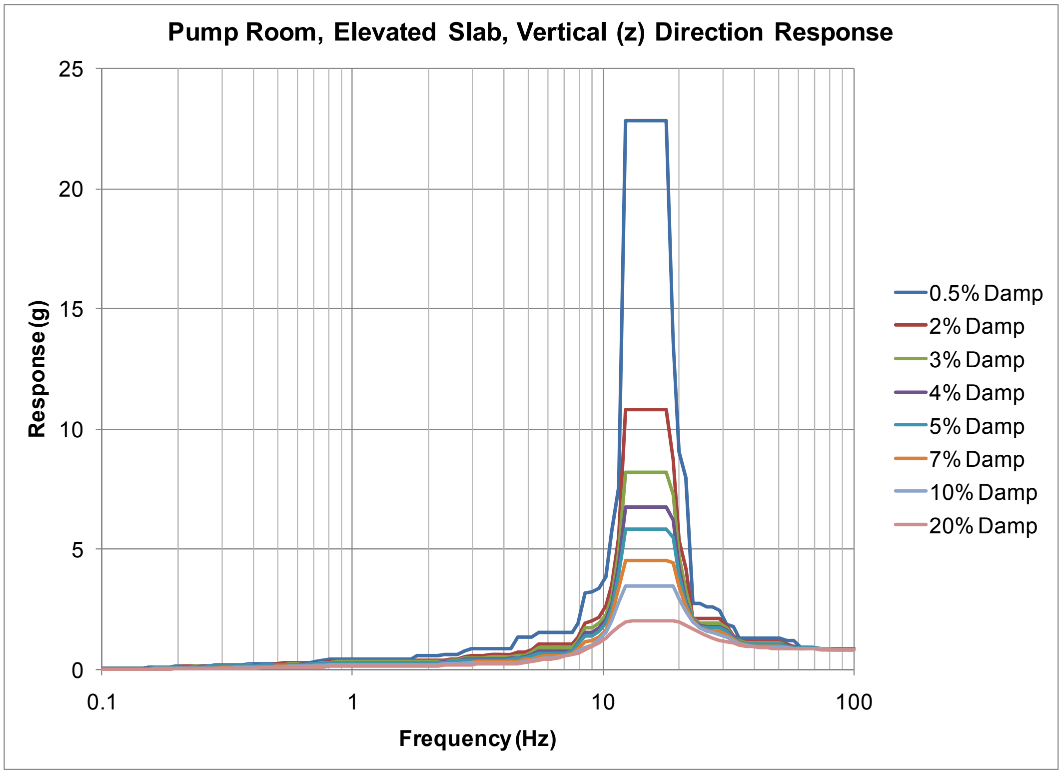


Figure 3KK-3 ISRS for UHSRS (Sheet 6 of 12)

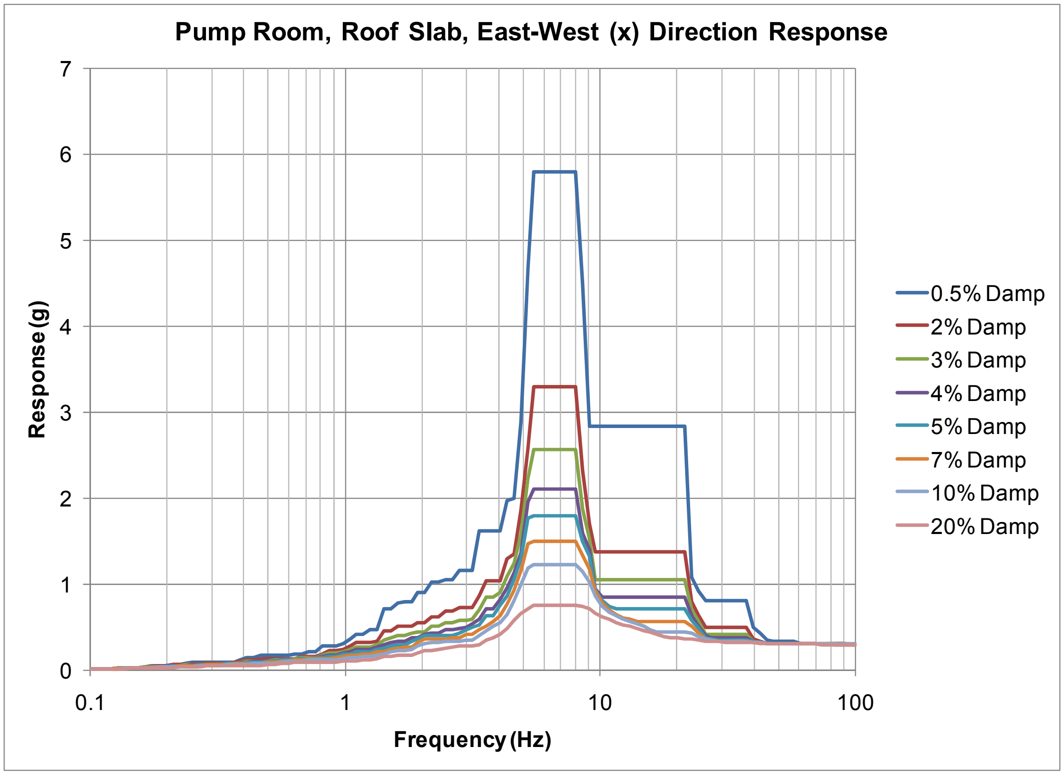


Figure 3KK-3 ISRS for UHSRS (Sheet 7 of 12)

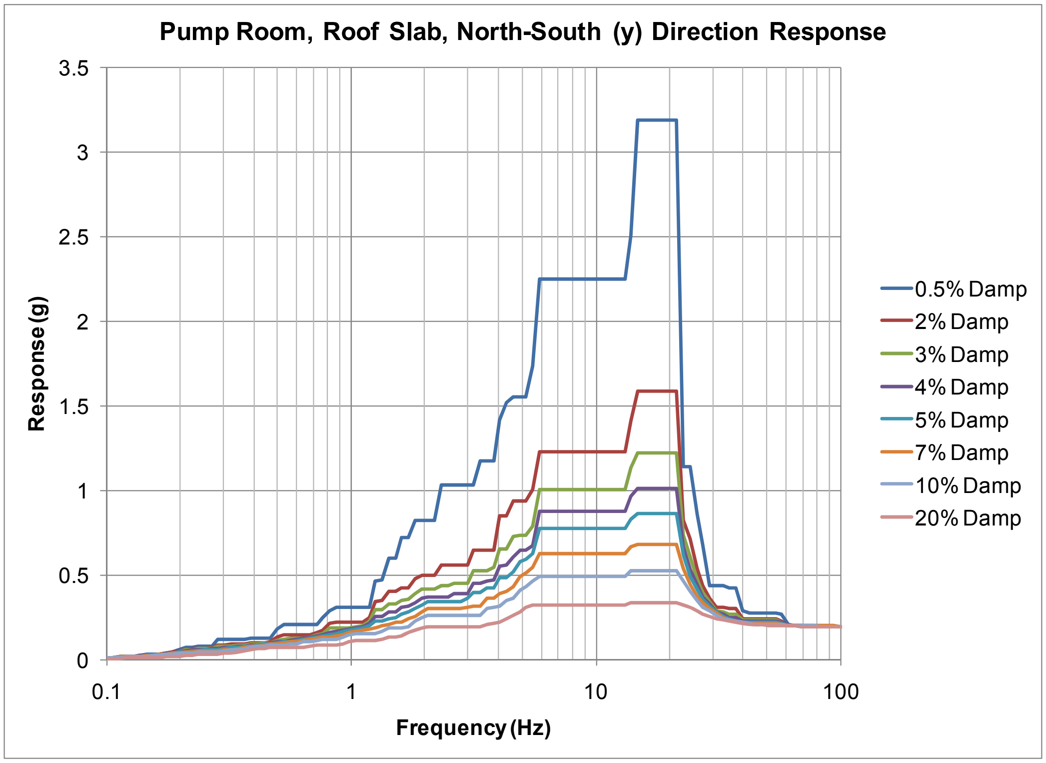


Figure 3KK-3 ISRS for UHSRS (Sheet 8 of 12)

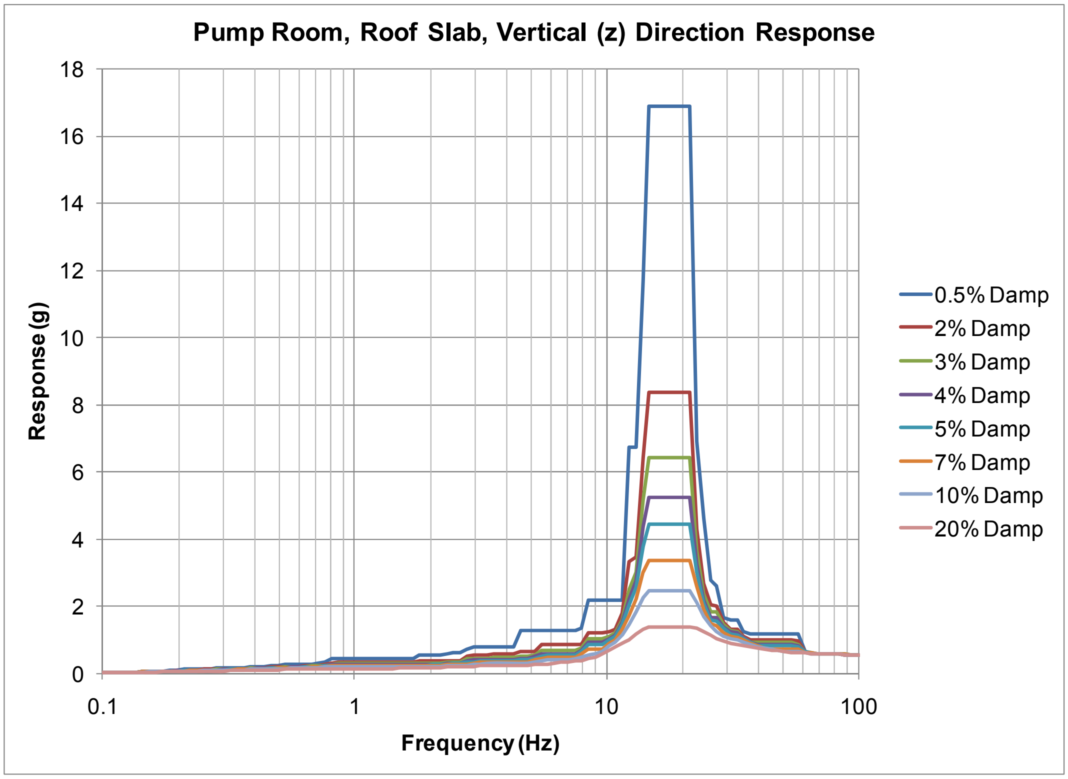


Figure 3KK-3 ISRS for UHSRS (Sheet 9 of 12)

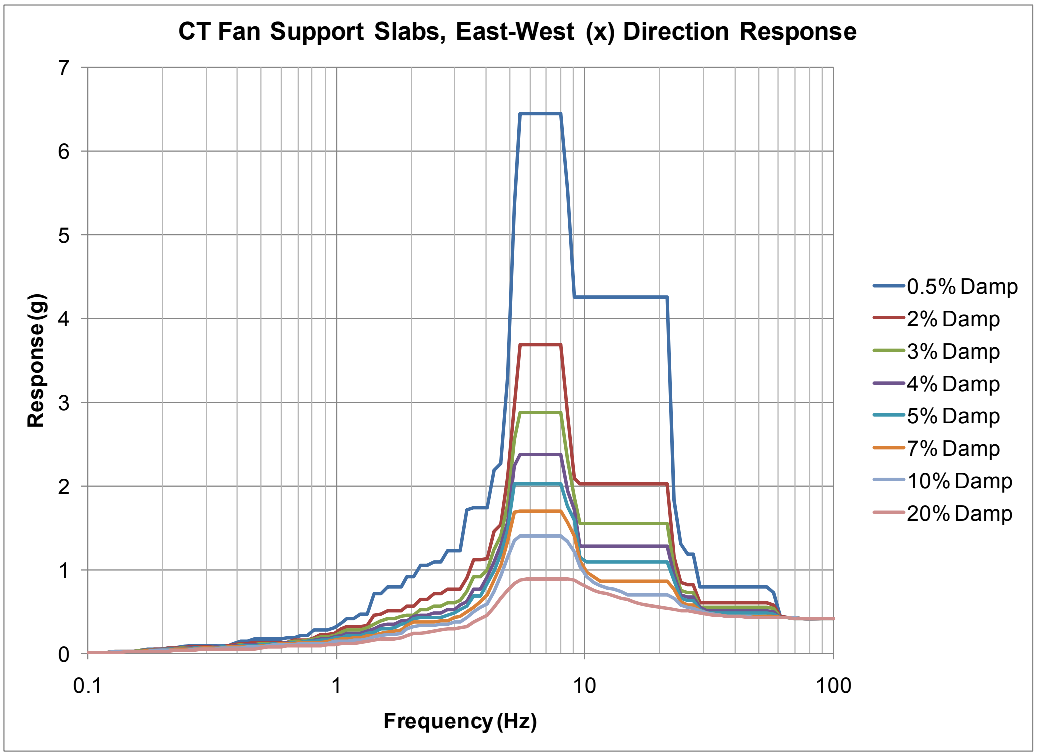


Figure 3KK-3 ISRS for UHSRS (Sheet 10 of 12)

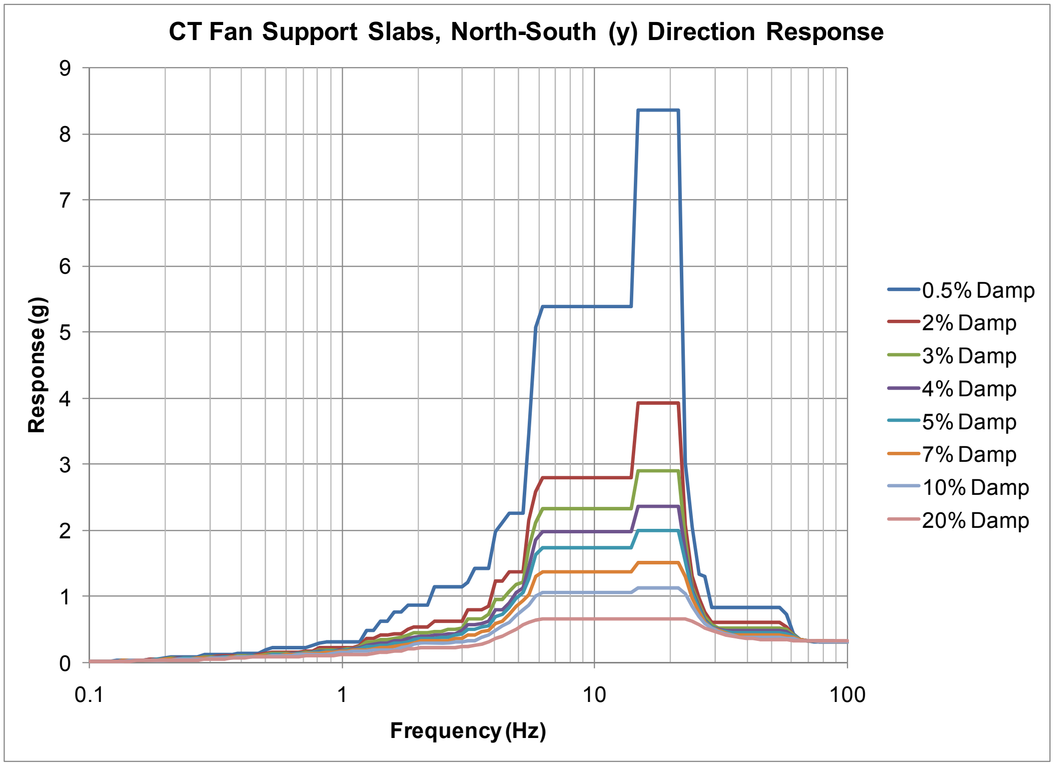


Figure 3KK-3 ISRS for UHSRS (Sheet 11 of 12)

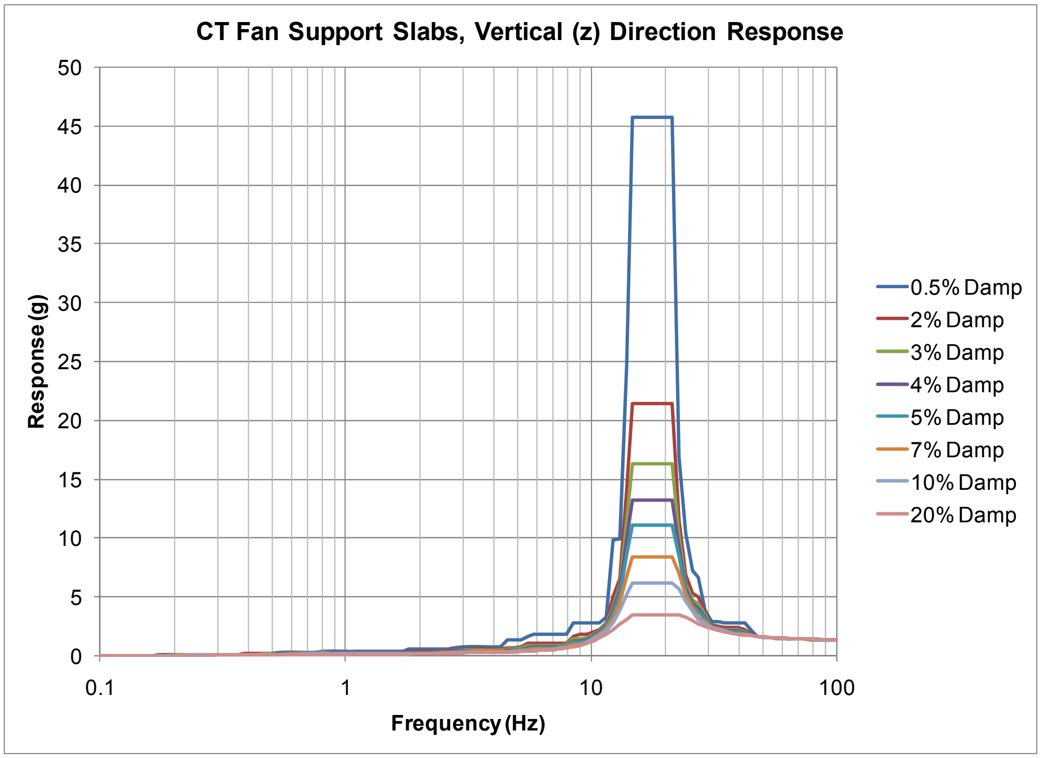


Figure 3KK-3 ISRS for UHSRS (Sheet 12 of 12)

CP COL 3.7(3)
CP COL 3.7(26)
CP COL 3.8(29)

APPENDIX 3LL

MODEL PROPERTIES AND SEISMIC ANALYSIS RESULTS FOR ESWPT

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ACRONYMS AND ABBREVIATIONS

Acronyms	Definitions
3D	three-dimensional
BE	best estimate
ESW	essential service water
ESWPT	essential service water pipe tunnel
FE	finite element
FIRS	foundation input response spectra
HB	high bound
ISRS	in-structure response spectra
LB	lower bound
OBE	operating-basis earthquake
PCCV	prestressed concrete containment vessel
PSFSV	power source fuel storage vault
R/B	reactor building
SRSS	square root sum of the squares
SSI	soil-structure interaction
UB	upper bound
UHS	ultimate heat sink
UHSRS	ultimate heat sink related structure

3LL MODEL PROPERTIES AND SEISMIC ANALYSIS RESULTS FOR ESWPT

3LL.1 Introduction

This Appendix discusses the seismic analysis of the essential service water pipe tunnel (ESWPT). The computer program SASSI (Reference 3LL-1) serves as the platform for the soil-structure interaction (SSI) analyses. The three-dimensional (3D) finite element (FE) models used in SASSI are condensed from FE models with finer mesh patterns initially developed using the ANSYS computer program (Reference 3LL-2). The dynamic analysis of the SASSI 3D FE model in the frequency domain provides results for the ESWPT seismic response that include SSI effects. The SASSI model results for maximum accelerations and seismic soil pressures are used as input to the ANSYS models for performing the detailed structural design, including loads and load combinations in accordance with the requirements of Section 3.8. The SASSI analysis and results presented in this Appendix include site-specific SSI effects such as the layering of the subgrade, flexibility, and embedment of the ESWPT structure, and scattering of the input control design motion. Due to the low seismic response at the Comanche Peak Nuclear Power Plant site and the lack of high-frequency exceedances, the SASSI capability to consider incoherence of the input control motion is not implemented in the design of the ESWPT.

3LL.2 Model Description and Analysis Approach

The ESWPT is modeled with three separate models, each model representing a physical portion of the ESWPT. Tunnel Segment 1 represents a typical straight north-south tunnel segment buried in backfill soil. Tunnel Segment 2 represents east-west segments adjacent to the ultimate heat sink related structures (UHSRS). Two tornado missile shields extend from the top of this segment to protect the essential service water (ESW) piping and openings into the ultimate heat sink (UHS). The FE model for Segment 3 represents east-west segments adjacent to the power source fuel storage vault (PSFSV) and includes elements representing the fuel pipe access tunnels that extend across the top of the ESWPT. The FE models for each of the three ESWPT segments are shown in Figures 3LL-1 through 3LL-6 as overall and cutaway views. Tables 3LL-1, 3LL-2, and 3LL-3 present the properties assigned to the structural components of the SASSI FE models for Segments 1, 2, and 3, respectively. Detailed descriptions and figures of the ESWPT including actual dimensions are contained in Section 3.8. Shell elements model the roof, interior, and exterior walls, and basemat. Brick elements model the backfill and fill concrete below the ESWPT basemat.

The input motion for the SASSI model analysis is developed using the site-specific foundation input response spectra (FIRS) discussed in Subsection 3.7.1.1. The earthquake input motion for SASSI is developed by converting the outcrop motion of the FIRS to within-layer motion. Site-specific strain-compatible backfill and rock properties are used in determining the within-layer motion. This process is described further in Appendix 3NN.

The ESWPT model is developed and analyzed using methods and approaches consistent with ASCE 4 (Reference 3LL-3) and accounting for the site-specific stratigraphy and subgrade conditions described in Chapter 2, as well as the backfill conditions around the embedded portions of the ESWPT.

The input within-layer motion and strain-compatible backfill properties for the SASSI analysis are developed from site response analyses described in Section 3NN.2 of Appendix 3NN by using the site-specific foundation input response spectra (FIRS) discussed in Subsection 3.7.1.1. The properties of the supporting media (rock) as well as the site-specific strain-compatible backfill properties used for the SASSI analysis of the ESWPT are the same as those presented in Appendix 3NN for the reactor building (R/B)-prestressed concrete containment vessel (PCCV)-containment internal structure SASSI analyses. The typical properties for a granular engineered backfill are adopted as the best estimate (BE) values for the dynamic properties of the backfill. Four profiles, lower bound (LB), BE, upper bound (UB), and high bound (HB) of input backfill properties are developed for the SASSI analyses considering the different coefficient of variation. The LB and BE backfill profiles are combined with corresponding LB and BE rock subgrade profiles, and the UB and HB backfill profiles are combined with the UB rock subgrade profile. Four sets of SASSI analyses are performed on each segment of the ESWPT embedded in backfill with BE, LB, UB, and HB properties.

ESWPT Segment 2 is additionally analyzed considering partial separation of the backfill from the exterior shielding walls above the roof slab. Separation is modeled by reducing the shear wave velocity by a factor of 10 for those layers of backfill that are determined to be separated. The potential for separation of the backfill along Segment 2 is determined using an iterative approach that compares peak soil pressure results for the BE condition to the at-rest soil pressure. The analyses also consider unbalanced fill conditions where applicable, such as for Segment 2 of the ESWPT along the interface with the UHSRS. Consideration of these conditions assures that the enveloped results presented herein capture all potential seismic effects of a wide range of backfill properties and conditions in combination with the site-specific supporting media conditions.

Operating-basis earthquake (OBE) structural damping values of Chapter 3 Table 3.7.1-3(b), such as 4 percent damping for reinforced concrete, are used in the site-specific SASSI analysis. This is consistent with the requirements of Section 1.2 of RG 1.61 (Reference 3LL-4) for structures on sites with low seismic responses where the analyses consider a relatively narrow range of site-specific subgrade conditions.

3LL.3 Seismic Analysis Results

Table 3LL-4 presents the natural frequencies and descriptions of the associated modal responses obtained from the fixed-base ANSYS analysis of the straight portion of the ESWPT (Segment 1 Model). These frequencies were compared to the frequencies calculated from the transfer functions for the SASSI model to confirm adequacy of the coarser mesh SASSI model to represent dynamic behavior of the tunnels. Table 3LL-5 presents a summary of SSI effects on the seismic response of the ESWPT segments.

The maximum absolute nodal accelerations obtained from the time history analyses of the ESWPT models are presented in Tables 3LL-6 to 3LL-8. The results are presented for each of the major ESWPT components and envelope all backfill conditions described above. The maximum accelerations have been obtained by combining cross-directional contributions in accordance with RG 1.92 (Reference 3LL-5) using the square root sum of the squares (SRSS) method.

Tables 3LL-9, 3LL-10, and 3LL-11 present the maximum seismic design forces and moments that represent the envelope of the results for all considered site conditions. The forces and moments are obtained by combination of the three orthogonal directions used in the model by the Newmark 100%-40%-40% method. The seismic design forces are applied to the ANSYS model for structural design of members and components. For structural design, the accidental torsion load case results in increased shear in the outer walls, which is included in the values reported in Tables 3LL-9, 3LL-10, and 3LL-11. Note that addition of the torsion by scaling the seismic demands results in shear demand in the outer walls that meets or exceeds the accidental torsion requirements for design.

Table 3LL-12 summarizes the resulting maximum displacements for enveloped seismic loading conditions for each of the three segments of the ESWPT.

Table 3LL-13 presents the maximum pressures below the basemat of the ESWPT.

3LL.4 In-Structure Response Spectra (ISRS)

The enveloped broadened ISRS are presented in Figures 3LL-7, 3LL-8, and 3LL-9 for ESWPT Segments 1, 2, and 3, respectively. The spectra are presented for the horizontal and vertical directions for the ESWPT base slab and roof for 0.5 percent, 2 percent, 3 percent, 4 percent, 5 percent, 7 percent, 10 percent, and 20 percent damping. The ISRS for the roof of the PSFSV access tunnels are also presented in Figure 3LL-9. The ISRS are resultant spectra, which have been combined using SRSS to account for cross-directional coupling effects in accordance with RG 1.122 (Reference 3LL-6). The ISRS include the envelope of the four site conditions (BE, LB, UB, and HB) with and without backfill separation from the structure. All results have been broadened by 15 percent and all valleys removed. The shape of the spectra presented herein can be simplified by further enveloping of peaks for the design of seismic category I and II subsystems and components housed within or mounted to the ESWPT and PSFSV access tunnels. It is permitted to perform 15 percent peak clipping of the spectra presented herein in accordance with ASCE-4 (Reference 3LL-3) during the design process for spectra with damping values less than 10 percent. For the design of seismic category I and II subsystems and components mounted to the ESWPT walls, it is required to account for the effects of out-of-plane wall flexibility.

3LL.5 References

3LL-1 *An Advanced Computational Software for 3D Dynamic Analysis Including Soil Structure Interaction,* ACS SASSI Version 2.2, Ghiocel Predictive Technologies, Inc., July 23, 2007.

3LL-2 ANSYS Release 11.0, SAS IP, Inc. 2007.

3LL-3 *Seismic Analysis of Safety-Related Nuclear Structures,* American Society of Civil Engineers, ASCE 4-98, Reston, Virginia, 2000.

3LL-4 *Damping Values for Seismic Design of Nuclear Power Plants*, Regulatory Guide 1.61, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, March 2007.

3LL-5 *Combining Responses and Spatial Components in Seismic Response Analysis*, Regulatory Guide 1.92, Rev. 2, U.S. Nuclear Regulatory Commission, Washington, DC, July 2006.

3LL-6 *Development of Floor Design Response Spectra for Seismic Design of Floor-supported Equipment or Components*, Regulatory Guide 1.122, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, February 1978.

Table 3LL-1
ESWPT Segment 1 FE Model Component Properties

Components	Material	E (ksi)	Poisson's Ratio	Unit Weight (kcf)	Damping Ratio	Width or Height x Thickness (ft)	Element type
Roof	5,000 psi concrete	4,030	0.17	0.225[(1)]	0.04	23 x 2	Shell
Base slab	5,000 psi concrete	4,030	0.17	0.200[(1)]	0.04	23 x 2	Shell
Exterior Walls	5,000 psi concrete	4,030	0.17	0.175[(1)]	0.04	16.67 x 2	Shell
Interior Walls	5,000 psi concrete	4,030	0.17	0.250[(1)]	0.04	16.67 x 1	Shell
Fill Concrete	3,000 psi concrete	3,125	0.17	0.15	0.04	23 x 10.08	Brick

Notes:

1) The unit weight includes equivalent dead loads due to piping and other supported components, and 25% of applicable live load for dynamic analysis purposes. A pipe load of 150 psf is considered on the roof slab and 50 psf is considered on all other interior surfaces. The applicable floor live load is 200 psf.

2) The width or height of the component is adjusted from actual dimensions to suit the mesh pattern used for the FE model. The adjustments are minor and do not affect the accuracy of the analysis results. Actual component dimensions are shown in Section 3.8 Figure 3.8-203 and 3.8-205.

Table 3LL-2
ESWPT Segment 2 FE Model Component Properties

Components	Material	E (ksi)	Poisson's Ratio	Unit Weight (kcf)	Damping Ratio	Width or Height x Thickness (ft) (2)	Element type
Roof	5,000 psi concrete	4,030	0.17	0.21(1)	0.04	23 x 2.5	Shell
Base slab	5,000 psi concrete	4,030	0.17	0.19(1)	0.04	34 x 2.5	Shell
Exterior Walls	5,000 psi concrete	4,030	0.17	0.175(1)	0.04	17.17 x 2	Shell
Interior Walls	5,000 psi concrete	4,030	0.17	0.250(1)	0.04	17.17 x 1	Shell
Basin Missile Shield Walls	5,000 psi concrete	4,030	0.17	0.15	0.4	32 x 2	Shell
Basin Missile Shield Roof Slab	5,000 psi concrete	4,030	0.17	0.15	0.4	11.5 x 2 x 95	Shell
Pump House Missile Shield Walls	5,000 psi concrete	4,030	0.17	0.1875(1)	0.04	26 x 2	Brick
Pump House Missile Shield Roof Slab	5,000 psi concrete	4,030	0.17	0.1875(1)	0.04	10 x 2 x 23	Brick
Fill Concrete	3,000 psi concrete	3,125	0.17	0.15	0.04	34 x 9.83	Brick

Notes:

1) The unit weight includes equivalent dead loads due to piping and other supported components, and 25% of applicable live load for dynamic analysis purposes. A pipe load of 150 psf is considered on the tunnel roof slab, 75 psf on the pump house missile shield surfaces, and 50 psf is considered on all other interior surfaces. The applicable floor live load is 200 psf.

2) The width or height of the component is adjusted from actual dimensions to suit the mesh pattern used for the FE model. The adjustments are minor and do not affect the accuracy of the analysis results. Actual component dimensions are shown in Section 3.8 Figure 3.8-202.

Table 3LL-3
ESWPT Segment 3 FE Model Component Properties

Components	Material	E (ksi)	Poisson's Ratio	Unit Weight (kcf)	Damping Ratio	Width or Height x Thickness (ft) (2)	Element type
Roof	5,000 psi concrete	4,030	0.17	0.225(1)	0.04	23 x 2	Shell
Base slab	5,000 psi concrete	4,030	0.17	0.200(1)	0.04	23 x 2	Shell
Exterior Walls	5,000 psi concrete	4,030	0.17	0.175(1)	0.04	16.67 x 2	Shell
Interior Walls	5,000 psi concrete	4,030	0.17	0.250(1)	0.04	16.67 x 1	Shell
Service Tunnel Roof	5,000 psi concrete	4,030	0.17	0.344(1)	0.4	Width varies x 2	Shell
Service Tunnel Outer Walls	5,000 psi concrete	4,030	0.17	0.175(1)	0.04	13.25 x 2	Shell
Service Tunnel Inner Walls	5,000 psi concrete	4,030	0.17	0.217(1)	0.4	13.25 x 1.5	Shell
Fill Concrete	3,000 psi concrete	3,125	0.17	0.15	0.04	23 x 10.08	Brick

Notes:

1) The unit weight includes equivalent dead loads due to piping and other supported components, and 25% of applicable live load for dynamic analysis purposes. A pipe load of 150 psf is considered on the roof slab and service tunnel roof, and 50 psf is considered on all other interior surfaces. The applicable floor live load is 200 psf for the base slab and service tunnel roof. Also, additional backfill dead load of 187.5 psf due to fill above elevation 822 is considered on the service tunnel roof.

2) The width of the component is adjusted from actual dimensions to suit the mesh pattern used for the FE model. The adjustments are minor and do not affect the accuracy of the analysis results. Actual component dimensions are shown in Section 3.8 Figures 3.8-203 and 3.8-204.

Table 3LL-4
ESWPT Structural Frequencies

Frequency (Hz)	Comments
7.3	Tunnel racking (due to shear deformation) in transverse direction
31.3	Local out of plane response of interior wall

Notes:

1) Natural frequencies and effective masses were calculated in ANSYS using the same mesh as used for SASSI analyses.

Table 3LL-5
SASSI Results for ESWPT Seismic Response

SSI Effect	Observed Response
Rock Subgrade	The rock subgrade has insignificant SSI effect on the ESWPT seismic response.
Backfill	The properties of the backfill determine the overall response of the buried ESWPT structure. The analyses of ESWPT Segment 1 show that the aboveground part of the structure has small effect on the response of the underground tunnel. The backfill soil frequencies that are in the range from 3 Hz for lower bound to 9 Hz for high bound, characterize the ESWPT horizontal response for all three segments. Frequencies of 7 Hz for lower bound, to 17 Hz for high bound characterize the vertical response of the ESWPT.
Backfill soil separation	The potential for backfill separation of ESWPT Segment 2 results in a small increase in the structural peak amplification.
Motion Scattering Effects	Motion scattering effects are inherent in the SASSI analysis results. The dynamic properties mismatch between the backfill and the rock results in reflection of the seismic waves within the backfill stratum. Consequentially, multiple modes characterize the backfill soil column and affect the ESWPT response when their frequencies are close to the structural frequencies.

Table 3LL-6
ESWPT Segment 1 SASSI FE Model Component Peak Accelerations(1) (g)

Component	Transverse Direction	Longitudinal Direction	Vertical Direction
Base Slab	0.12	0.12	0.15
Roof Slab	0.24	0.14	0.19
Interior Walls	0.26	0.13	0.17
Exterior Walls	0.24	0.14	0.16

Notes:

1) For structural design using the loads and load combinations in Section 3.8, the seismic loads are obtained by applying to the ESWPT segment a statically equivalent uniform acceleration that envelopes the above accelerations and a dynamic soil pressure.

Table 3LL-7
ESWPT Segment 2 SASSI FE Model Component Peak Accelerations[3] (g)

Component	Transverse Direction	Longitudinal Direction	Vertical Direction
Base Slab	0.13	0.12	0.13
Roof Slab	0.36	0.16	0.21
Interior Walls	0.35	0.14	0.16
Exterior Walls	0.35	0.14	0.15
Pump House Pipe Missile Shield	0.95[1]	0.46[1]	0.19
Air Intake Missile Shield	0.83[2]	0.21[2]	1.09

Notes:

1) The transverse direction for the pipe missile shield is the east-west direction; the longitudinal direction is the north-south direction.

2) The transverse direction for the duct missile shield is the north-south direction; the longitudinal direction is the vertical direction.

3) For structural design using the loads and load combinations in Section 3.8, design accelerations are determined separately using a response spectra analysis of the Segment 2 ANSYS FE model using as input the enveloped accelerations shown above, and a dynamic soil pressure.

Table 3LL-8
ESWPT Segment 3 SASSI FE Model Component Peak Accelerations[4] (g)

Component	Transverse Direction	Longitudinal Direction	Vertical Direction
Base Slab	0.12[1]	0.12[1]	0.13[1]
Roof Slab	0.50[1]	0.16[1]	0.21[1]
Interior Walls	0.50[3]	0.19	0.20
Exterior Walls	0.50[3]	0.16	0.15
PSFSV Service Tunnel Walls	0.32[2]	0.38[2]	0.15
PSFSV Service Tunnel Roof	0.32[2]	0.38[2]	0.16

Notes:

1) The transverse direction for the base slab and roof is the north-south direction; the longitudinal direction is the east-west direction.

2) The transverse direction for the PSFSV service tunnel walls and roof is the east-west direction; the longitudinal direction is the north south direction.

3) For interior and exterior walls, the transverse direction is the out-of-plane direction.

4) For structural design using the loads and load combinations in Section 3.8, the seismic loads are obtained by applying to the ESWPT segment a statically equivalent uniform acceleration that envelopes the above accelerations, and a dynamic soil pressure.

Table 3LL-9
ESWPT Segment 1 FE Model Maximum Component Seismic Forces and Moments

Component		Maximum component forces and moments							
		N_V (k/ft)	N_L (k/ft)	Q_V (k/ft)	Q_L (k/ft)	In-plane Shear (k/ft)	M_V (k-ft/ft)	M_L (k-ft/ft)	M_{VL} (k-ft/ft)
Base Slab	+	4.75	2.38	8.83	1.77	1.07	32.60	5.56	1.00
	-	7.86	2.87	8.83	1.77	1.07	39.40	6.70	1.00
Roof Slab	+	0.33	1.06	4.22	2.15	0.83	22.60	0.72	0.72
	-	4.19	1.42	4.22	2.15	0.83	29.00	4.90	0.72
Interior Walls	+	5.57	0.79	1.91	1.08	0.58	9.55	1.62	0.29
	-	4.89	0.66	1.91	1.08	0.63	9.55	1.62	0.29
Exterior Walls	+	7.91	1.28	7.68	2.09	2.14	36.61	6.19	1.01
	-	8.57	1.17	7.68	2.09	2.14	36.61	6.19	1.01

Notes:

1) The forces and moments shown above envelope all four subgrade shear wave velocity conditions (LB, BE, UB, and HB). The forces and moments are used for structural design as described in Section 3.8.
2) The forces and moments are obtained by combination of the three orthogonal directions used in the model by the Newmark 100%-40%-40% method.
3) In the table above the vertical and longitudinal directions define the plane of the walls. N stands for axial force, Q for out-of-plane shear and M for moment. The M_V results in normal stresses in the vertical direction of the wall and similarly, M_L results in normal stresses in the longitudinal (horizontal) direction of the wall, and M_{VL} is the torsional moment on the wall. The Q_V is out-of-plane shear force acting on horizontal cross section of the wall, and Q_L is out-of-plane shear force acting on a vertical cross section of the wall. For the roof slab and base slab the vertical axis is oriented along the east-west direction and the longitudinal along the north-south direction.

Table 3LL-10
ESWPT Segment 2 FE Model Maximum Component Seismic Forces and Moments

Component		Maximum component forces and moments							
		N_V (k/ft)	N_L (k/ft)	Q_V (k/ft)	Q_L (k/ft)	In-plane Shear (k/ft)	M_V (k-ft/ft)	M_L (k-ft/ft)	M_{VL} (k-ft/ft)
Base Slab	+/-	44.99	29.32	93.44	25.14	31.03	128.74	31.82	21.56
Roof Slab	+/-	85.48	31.38	39.62	22.41	62.82	88.21	51.33	14.78
Interior Walls	+/-	58.08	141.34	12.03	4.23	62.54	22.46	7.20	2.00
Exterior Walls	+/-	76.65	216.05	47.54	24.29	76.22	142.71	30.27	17.35
Pump House Pipe Missile Shield Walls	+/-	69.99	34.46	22.68	9.29	42.20	40.75	10.93	4.64
Pump House Pipe Missile Shield Roof	+/-	1.77	24.75	1.93	3.82	7.56	7.63	10.63	4.35
Air Intake Missile Shield	+/-	46.51	18.70	18.10	9.81	23.18	31.91	14.45	6.49

Notes:

1) The forces and moments shown above envelope all four subgrade shear wave velocity conditions (LB, BE, UB, and HB) and any effects due to soil separation. The forces and moments are used for structural design as described in Section 3.8.
2) The forces and moments are obtained by combination of the three orthogonal directions used in the model by the Newmark 100%-40%-40% method. For Segment 2 a response spectra analysis was performed and combined with the absolute value of dynamic soil pressure. The demands obtained from this combination were found to envelope the SASSI demands.
3) In the table above the vertical and longitudinal directions define the plane of the walls. N stands for axial force, Q for out-of-plane shear and M for moment. The M_V results in normal stresses in the vertical direction of the wall and similarly, M_L results in normal stresses in the longitudinal (horizontal) direction of the wall, and M_{VL} is the torsional moment on the wall. The Q_V is out-of-plane shear force acting on horizontal cross section of the wall, and Q_L is out-of-plane shear force acting on a vertical cross section of the wall. For the roof slab and base slab the vertical axis is oriented along the north-south direction and the longitudinal in the east-west direction.

Table 3LL-11
ESWPT Segment 3 FE Model Maximum Component Seismic Forces and Moments

Component		Maximum component forces and moments							
		N_V (k/ft)	N_L (k/ft)	Q_V (k/ft)	Q_L (k/ft)	In-plane Shear (k/ft)	M_V (k-ft/ft)	M_L (k-ft/ft)	M_{VL} (k-ft/ft)
Base Slab	+	29.25	26.53	58.48	21.90	25.42	54.31	23.73	15.30
	-	31.50	29.59	56.36	24.43	25.52	53.70	21.08	15.78
Roof Slab	+	32.24	59.80	22.30	19.00	35.79	46.43	25.12	7.47
	-	37.42	61.68	22.42	19.00	36.54	46.57	28.26	7.19
Interior Walls	+	59.24	93.26	12.02	4.27	36.67	18.08	5.62	1.94
	-	53.12	98.64	11.12	3.92	38.67	18.21	5.76	1.88
Exterior Walls	+	30.48	95.00	20.16	15.99	45.89	66.74	69.98	11.48
	-	31.06	98.80	19.29	16.49	46.23	65.90	67.39	11.48
PSFSV Service Tunnel Walls	+	32.95	10.05	12.16	5.94	19.81	40.35	8.50	3.64
	-	32.62	10.21	13.76	5.70	19.47	39.74	7.82	3.78
PSFSV Service Tunnel Roof	+	10.79	6.21	8.69	20.78	4.28	12.17	21.25	2.21
	-	11.80	6.56	8.63	20.69	4.44	16.00	20.98	2.17

Notes:

1) The forces and moments shown above envelope all four subgrade shear wave velocity conditions (LB, BE, UB, and HB). The forces and moments are used for structural design as described in Section 3.8.
2) The forces and moments are obtained by combination of the three orthogonal directions used in the model by the Newmark 100%-40%-40% method.
3) In the table above the vertical and longitudinal directions define the plane of the walls. N stands for axial force, Q for out-of-plane shear and M for moment. The M_V results in normal stresses in the vertical direction of the wall and similarly, M_L results in normal stresses in the longitudinal (horizontal) direction of the wall, and M_{VL} is the torsional moment on the wall. The Q_V is out-of-plane shear force acting on horizontal cross section of the wall, and Q_L is out-of-plane shear force acting on a vertical cross section of the wall. For the roof slab and base slab the vertical axis is oriented along the north-south direction and the longitudinal in the east-west direction.

Table 3LL-12
ESWPT Maximum Seismic Displacements for All Enveloped Conditions

ESWPT Segment	Longitudinal Direction (in)	Transverse (in)	Vertical (in)
1	0.002	0.11	0.003
2	0.09(1)	0.18	0.05(2)
3	0.10(1)	0.19	0.01

Notes:

1) The reported displacement are the north-south displacement at edge of separation joints that is about 10 ft south or north of north or south tunnels respectively. The maximum longitudinal (east-west) displacement of the east-west part of Segment 2 or 3 tunnel is less than 0.002 inches.
2) The maximum vertical occurs at the edge of separation joint edge 10 ft south of the east-west part of the tunnel, which is due to rocking behavior of the tunnel with tall shielding walls.

Table 3LL-13
Bearing Pressures Below ESWPT (ksf)

	Peak Single Element(1)	Peak Design(2)	Average Dynamic(3)
Segment 1	4.4	4.4	2.1
Segment 2	16.6	8.8	2.2
Segment 3	17.5	5.7	2.5

Notes:

1) Peak single element pressure represents corner pressures on elements representing less than 1% of the slab area.
2) Peak design pressure is the edge envelope pressure excluding the corner peaks, to be used for design.
3) Average dynamic pressure is the average of peak values for every element below the base slab.

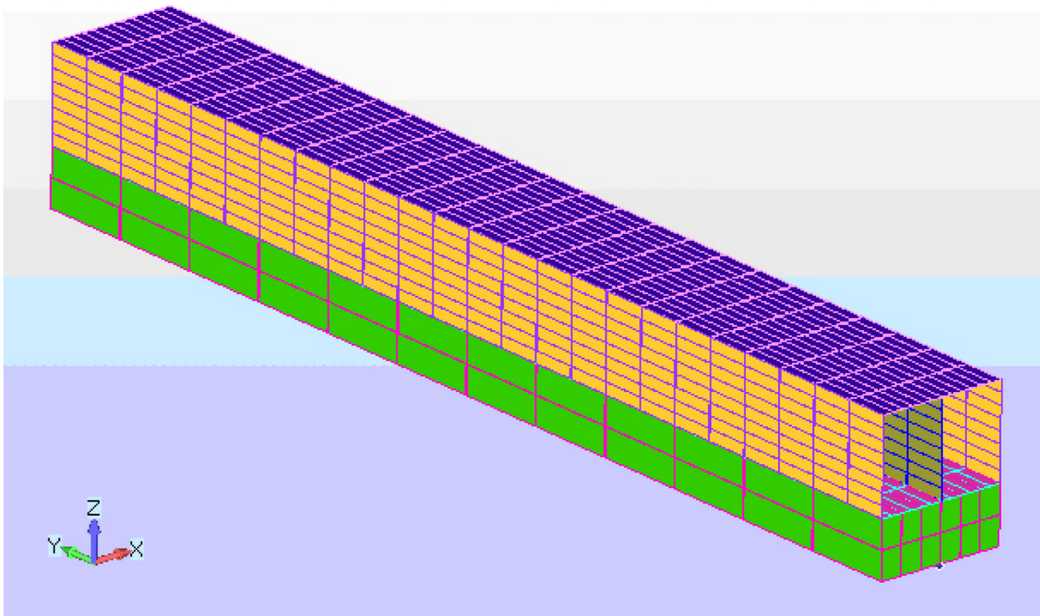

Figure 3LL-1 Overall SASSI Model of ESWPT Segment 1 (Excluding elements representing backfill)

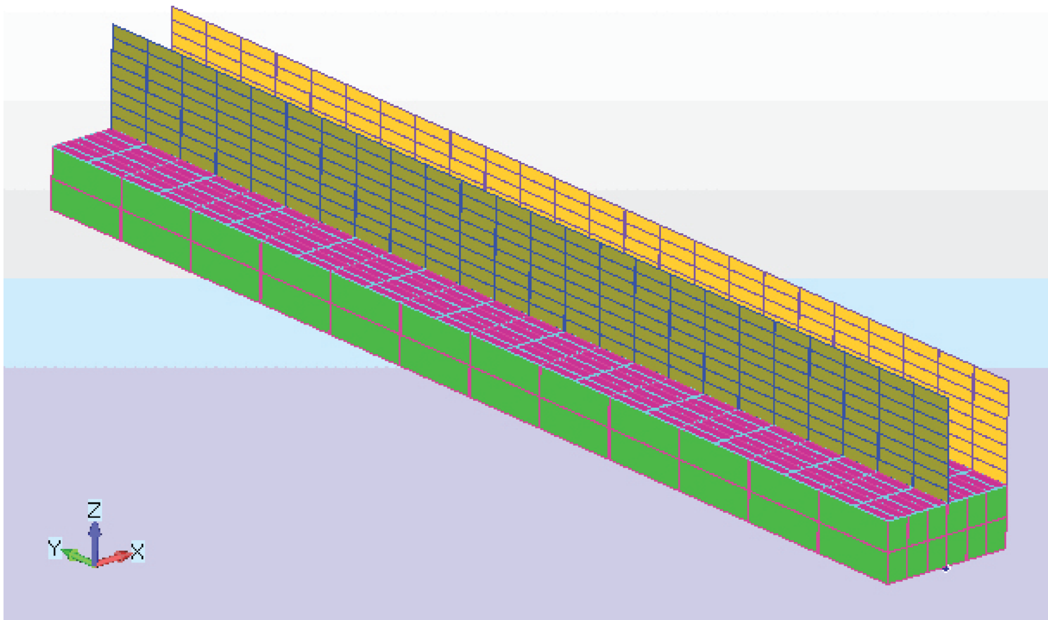

Figure 3LL-2 Cutaway View of SASSI Model of ESWPT Segment 1
(Excluding backfill, roof, and one side wall elements)

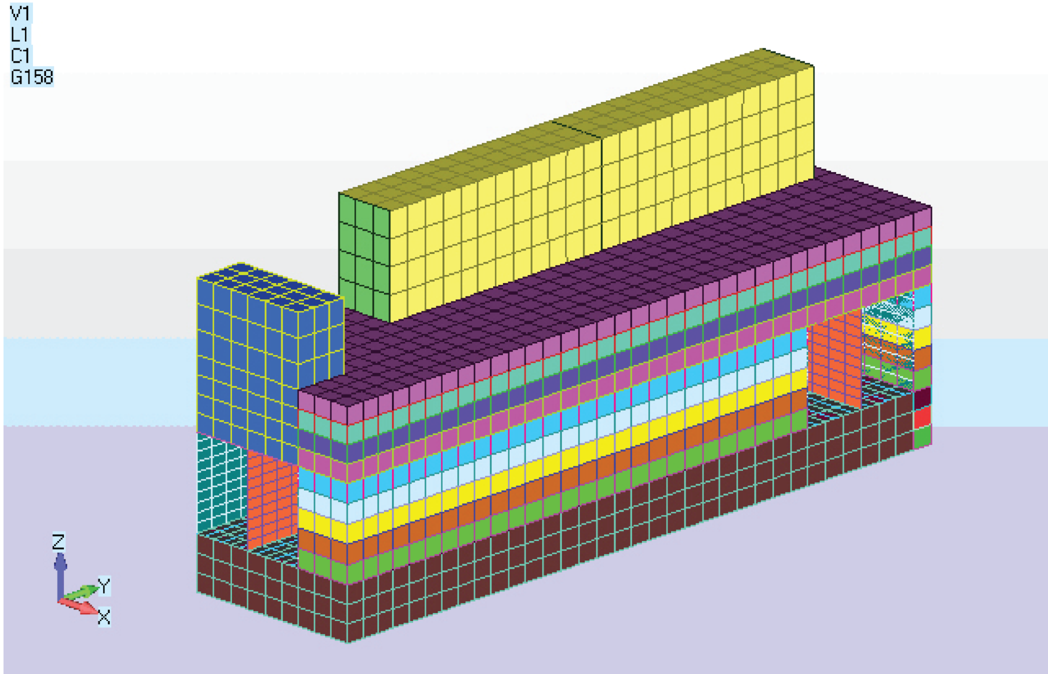

Figure 3LL-3 Overall View of SASSI Model of ESWPT Segment 2 (Including backfill elements)

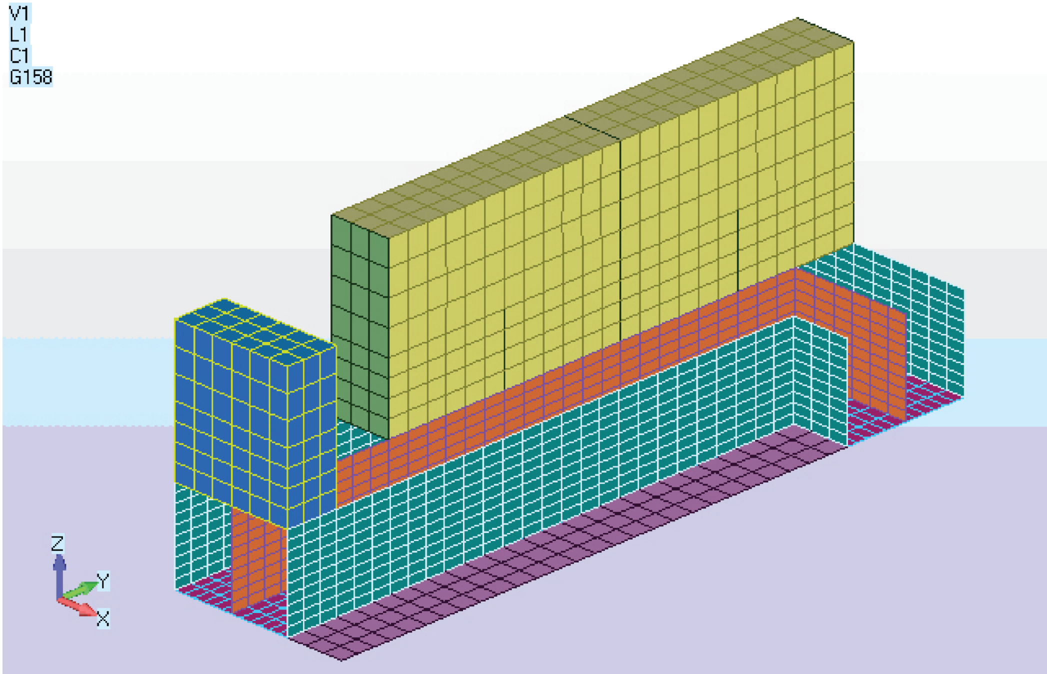

Figure 3LL-4 Cutaway View of SASSI Model of ESWPT Segment 2 (Excluding backfill, concrete fill, and roof slab)

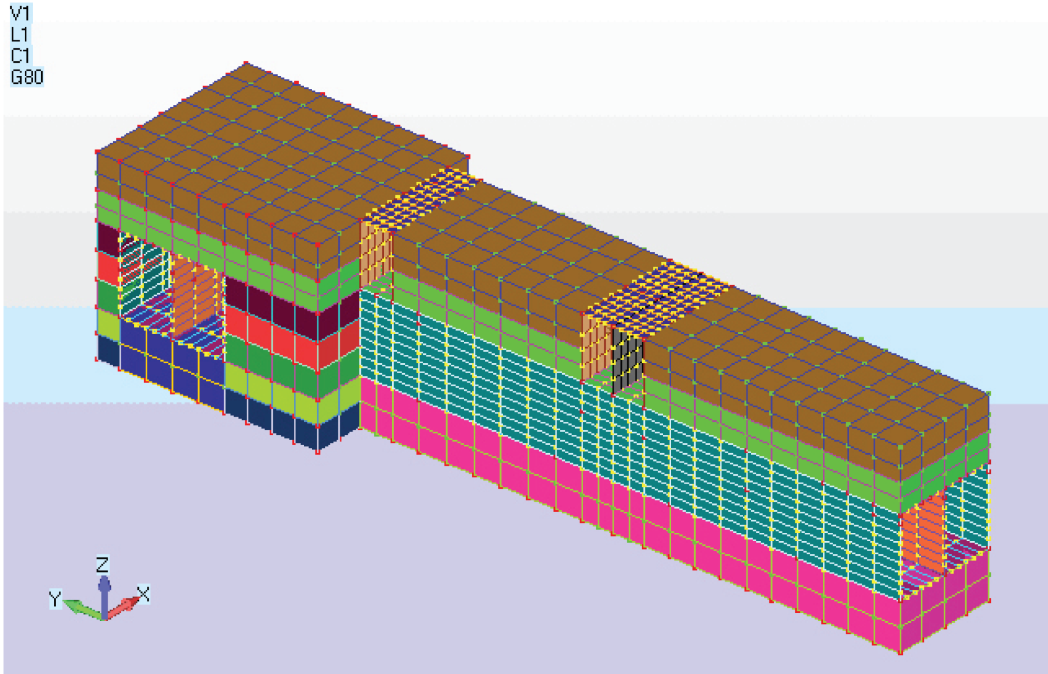

Figure 3LL-5 Overall View of SASSI Model of ESWPT Segment 3 (Including PSFSV tunnel elements)

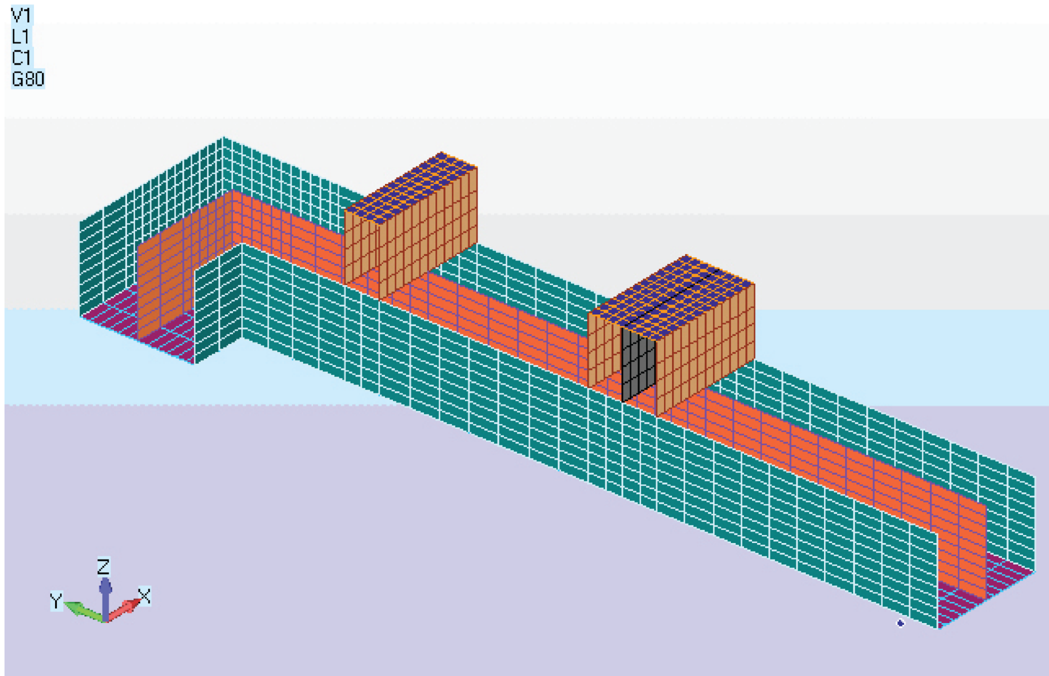

Figure 3LL-6 Cutaway View of SASSI Model of ESWPT Segment 3
(Excluding backfill, concrete fill, and roof elements)

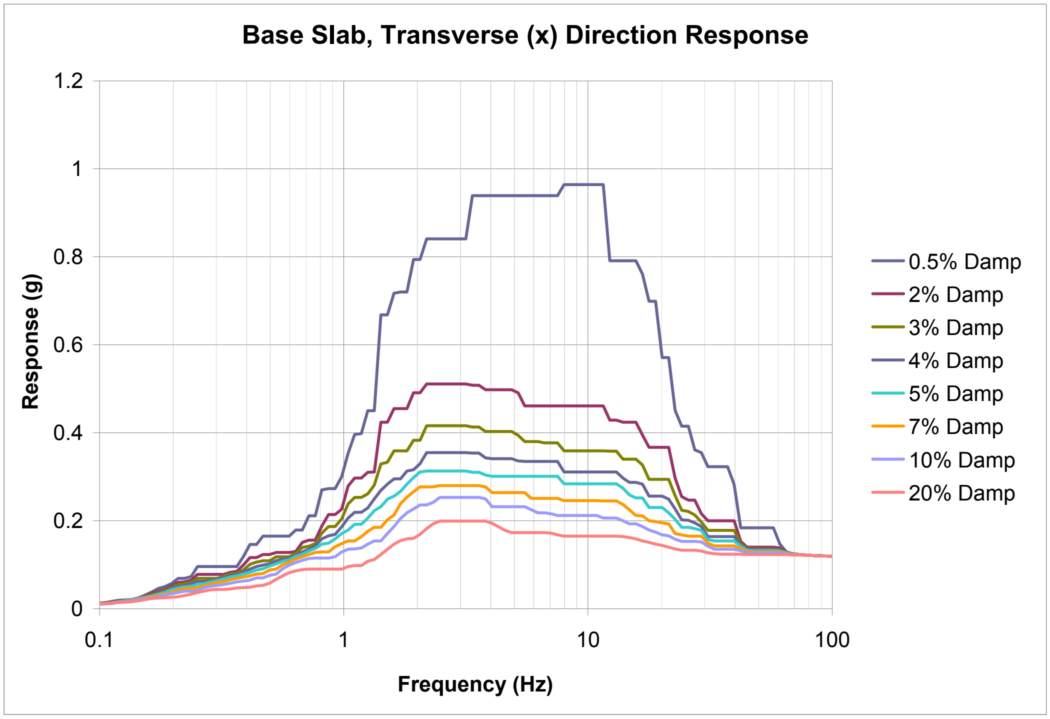

Figure 3LL-7 ISRS for ESWPT Segment 1 (Sheet 1 of 6)

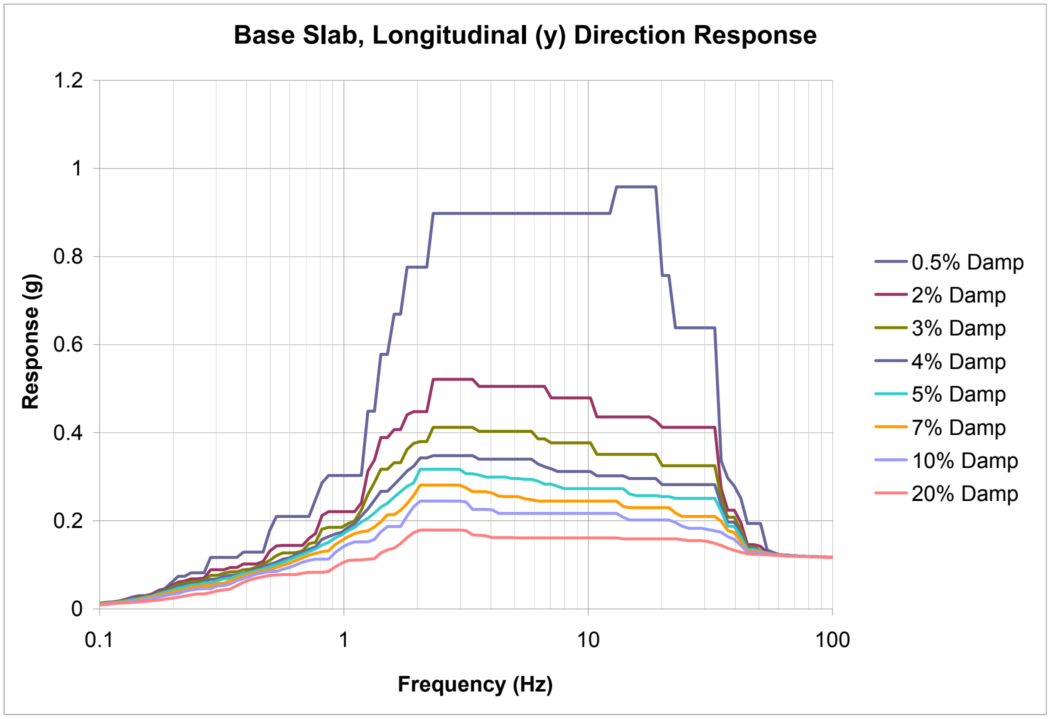

Figure 3LL-7 ISRS for ESWPT Segment 1 (Sheet 2 of 6)

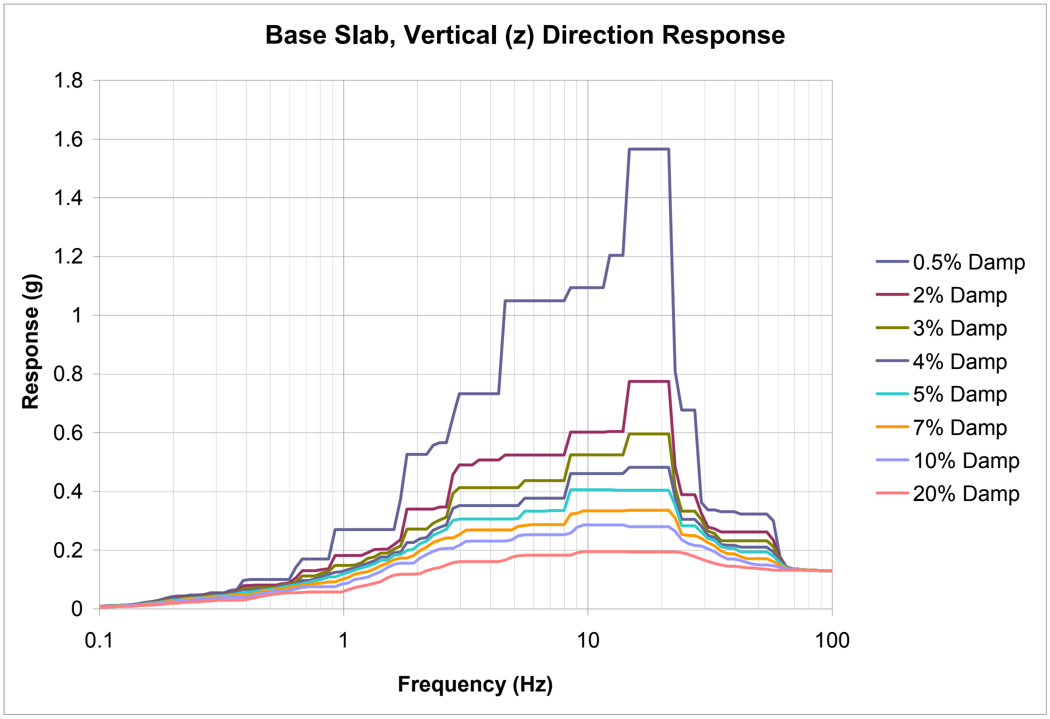

Figure 3LL-7 ISRS for ESWPT Segment 1 (Sheet 3 of 6)

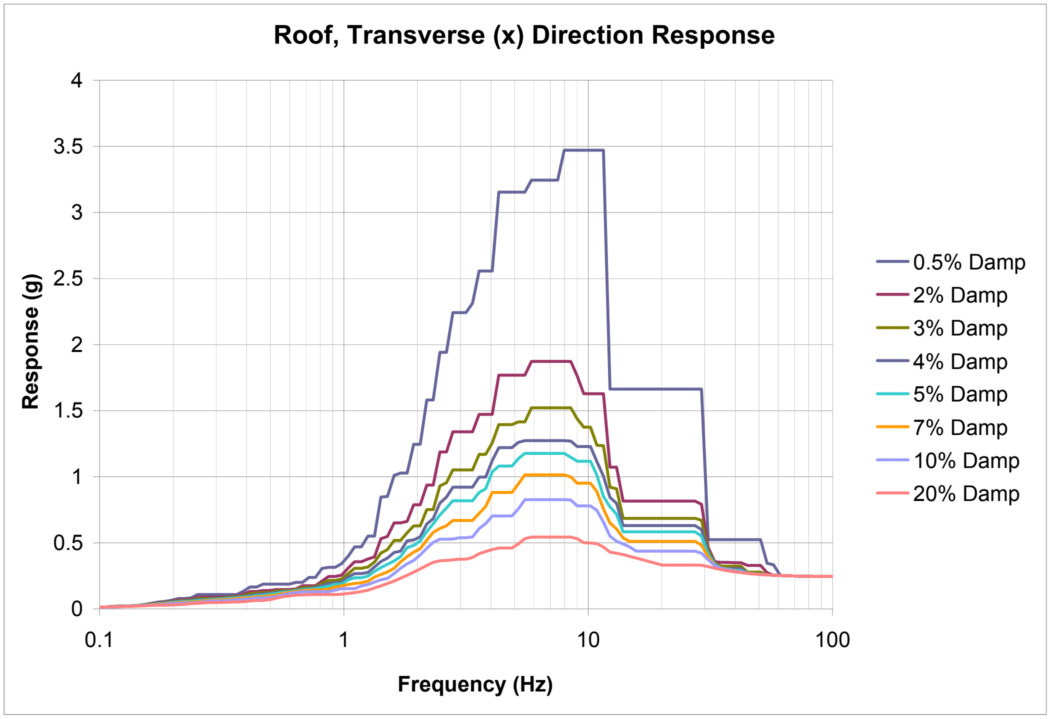

Figure 3LL-7 ISRS for ESWPT Segment 1 (Sheet 4 of 6)

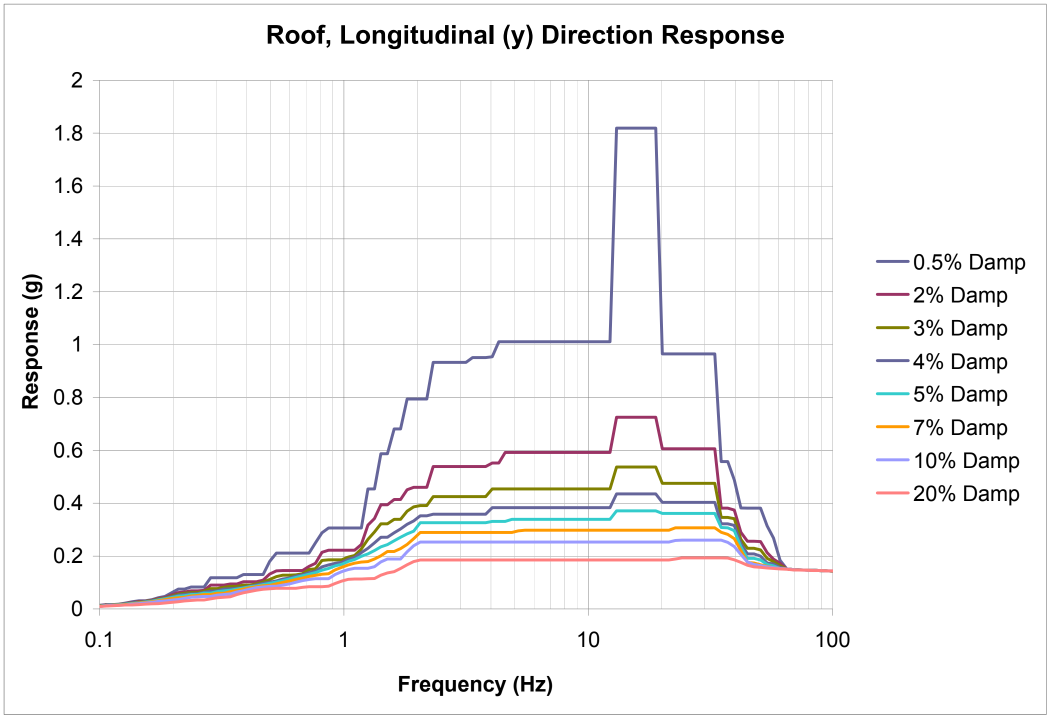

Figure 3LL-7 ISRS for ESWPT Segment 1 (Sheet 5 of 6)

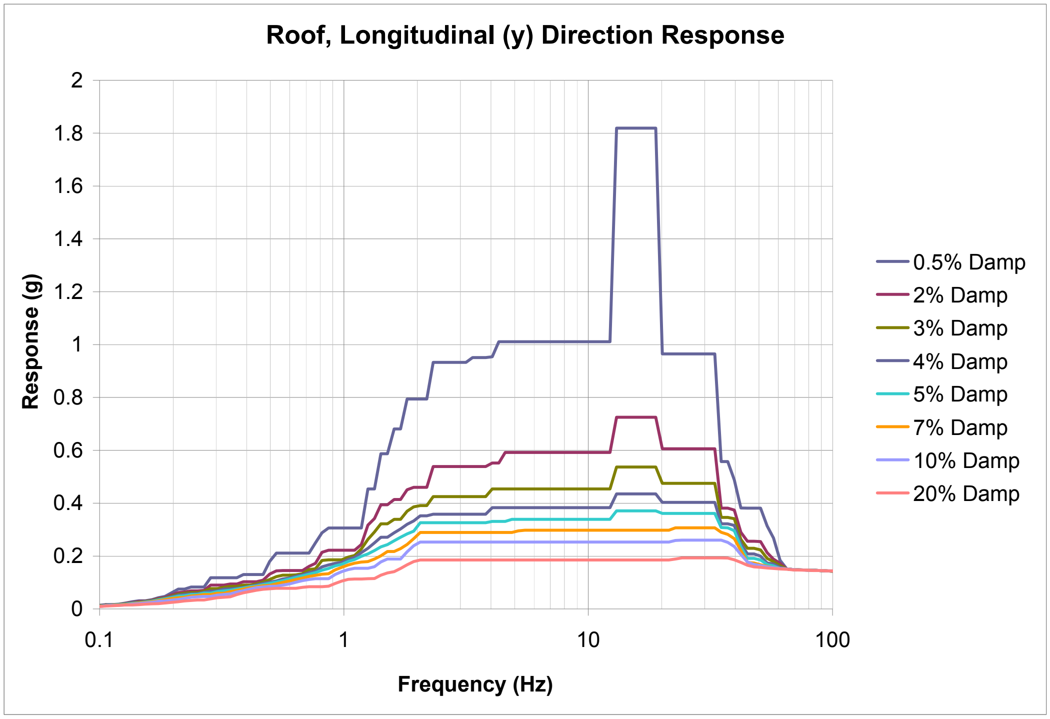

Figure 3LL-7 ISRS for ESWPT Segment 1 (Sheet 6 of 6)

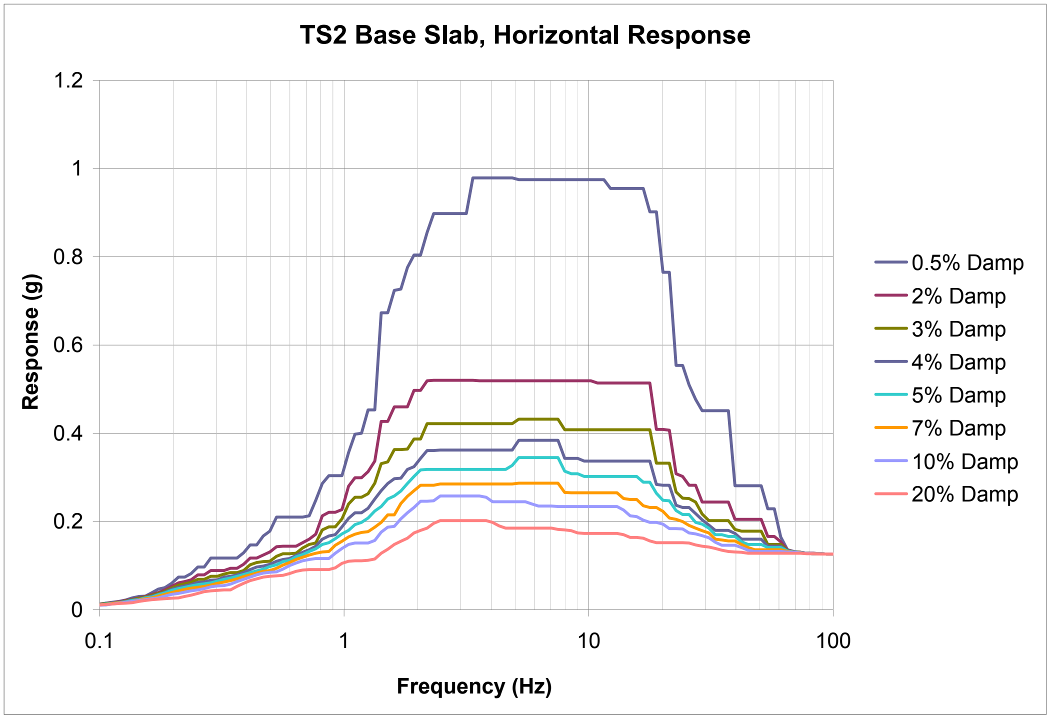

Figure 3LL-8 ISRS for ESWPT Segment 2 (Sheet 1 of 4) (enveloped response for east-west and north-south directions)

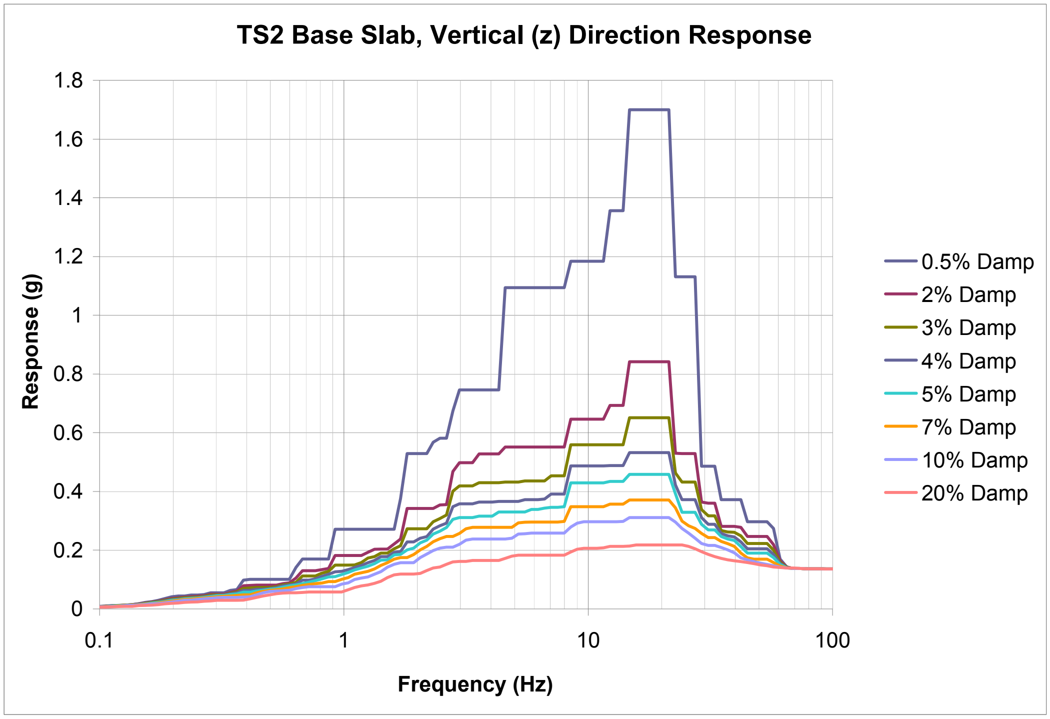

Figure 3LL-8 ISRS for ESWPT Segment 2 (Sheet 2 of 4)

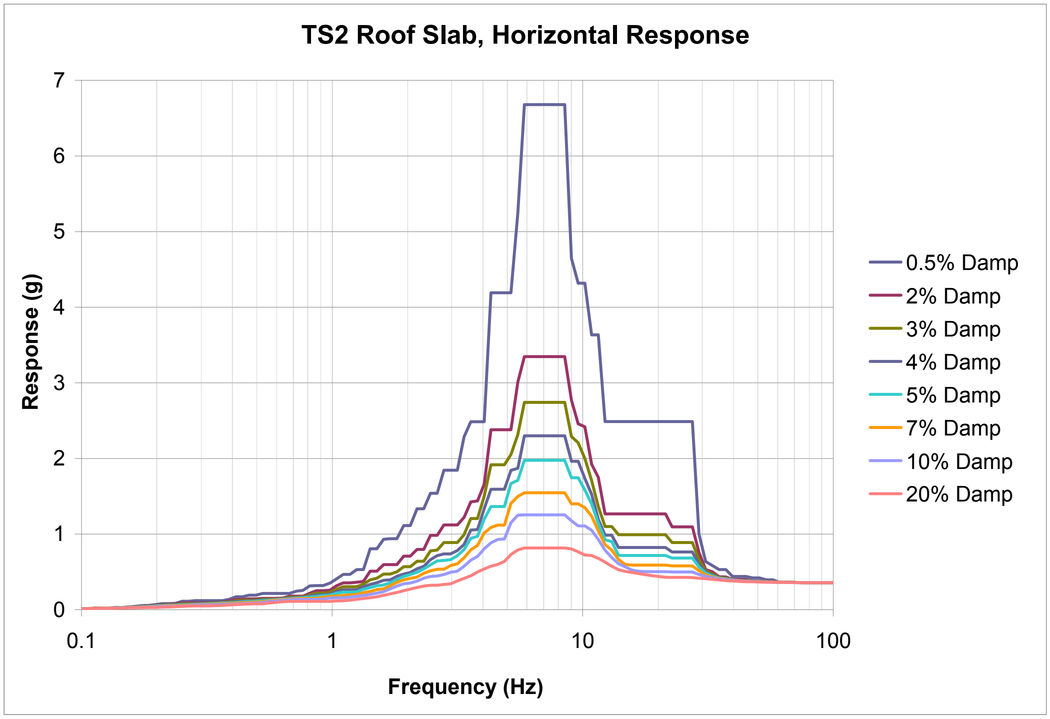

Figure 3LL-8 ISRS for ESWPT Segment 2 (Sheet 3 of 4) (enveloped response for the east-west and north-south directions)

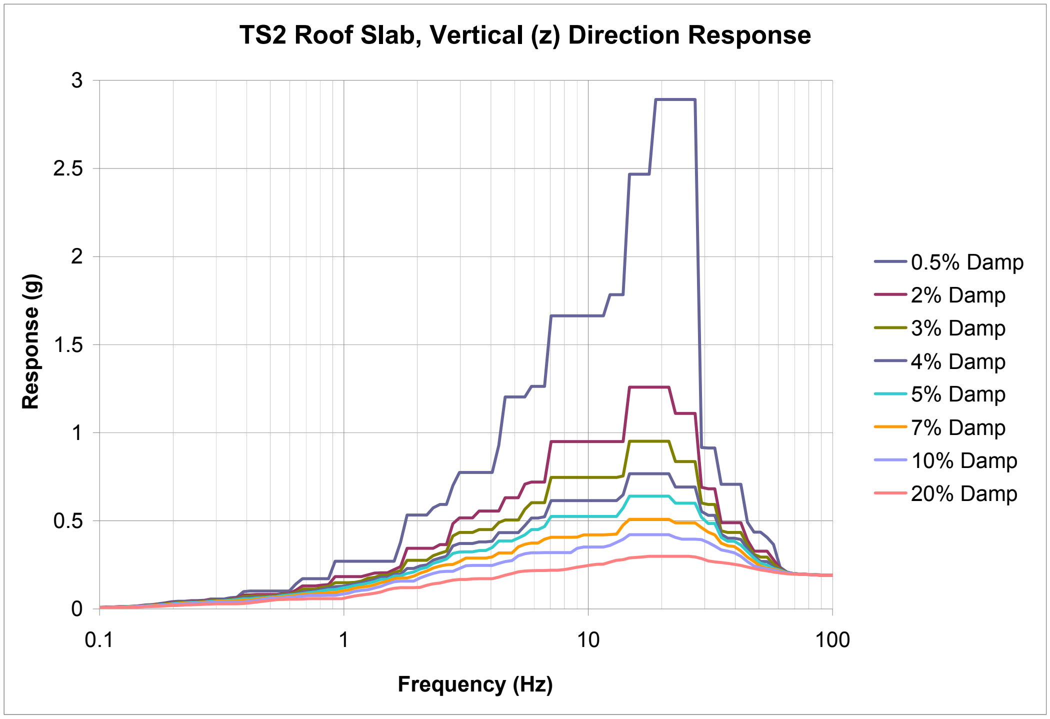

Figure 3LL-8 ISRS for ESWPT Segment 2 (Sheet 4 of 4)

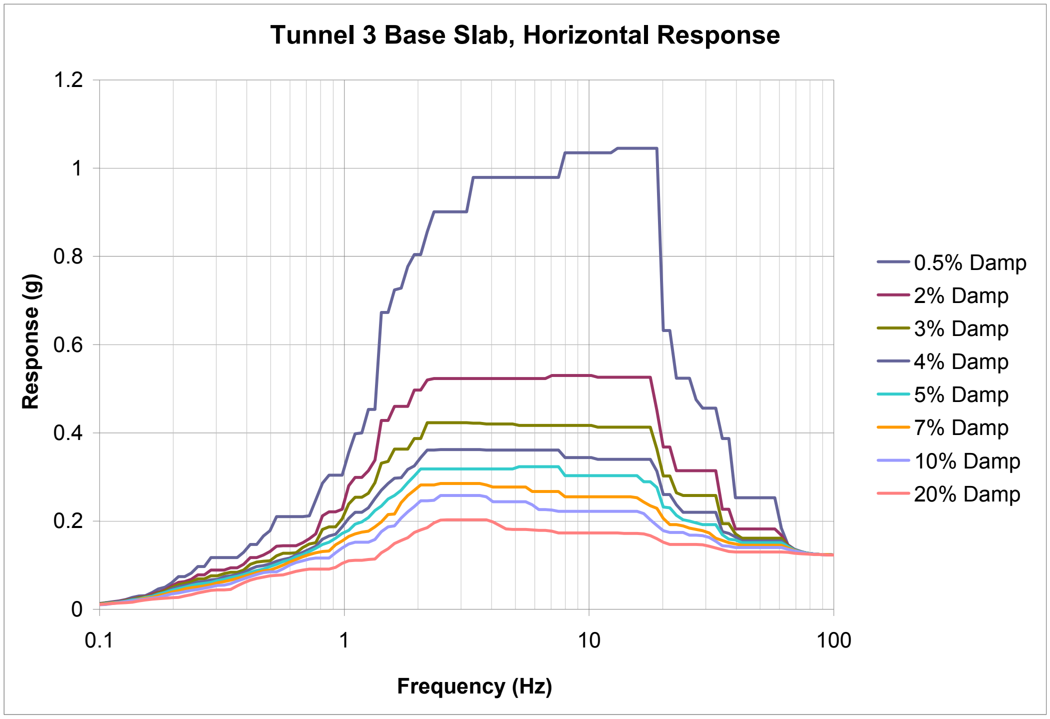

Figure 3LL-9 ISRS for ESWPT Segment 3 (Sheet 1 of 6) (enveloped north-south and east-west response)

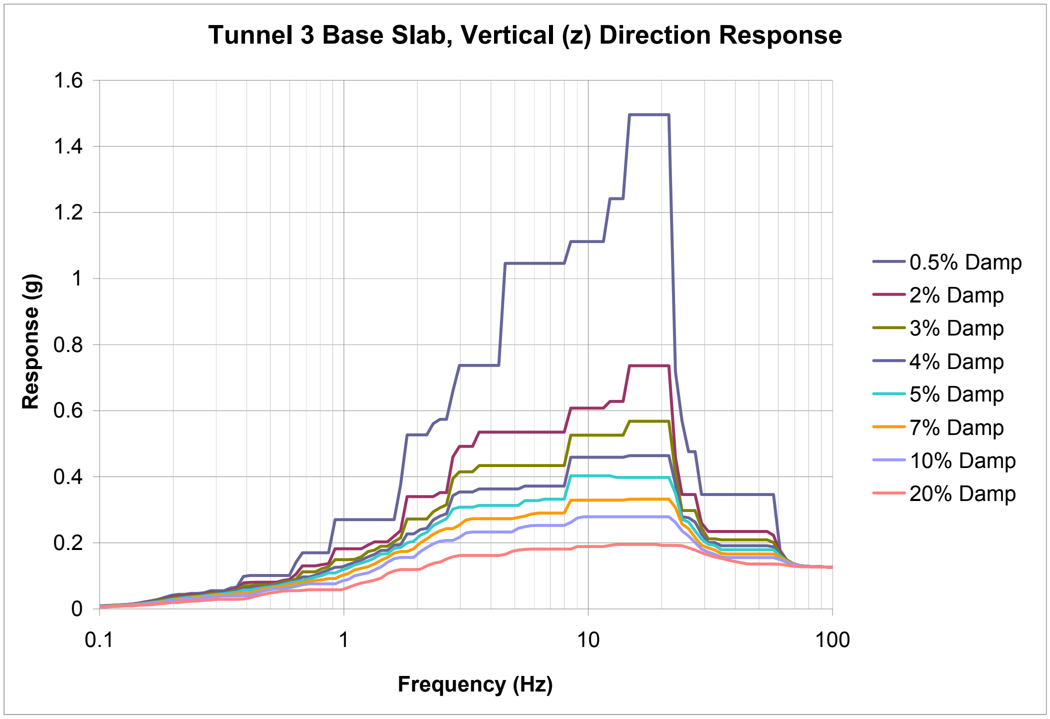

Figure 3LL-9 ISRS for ESWPT Segment 3 (Sheet 2 of 6)

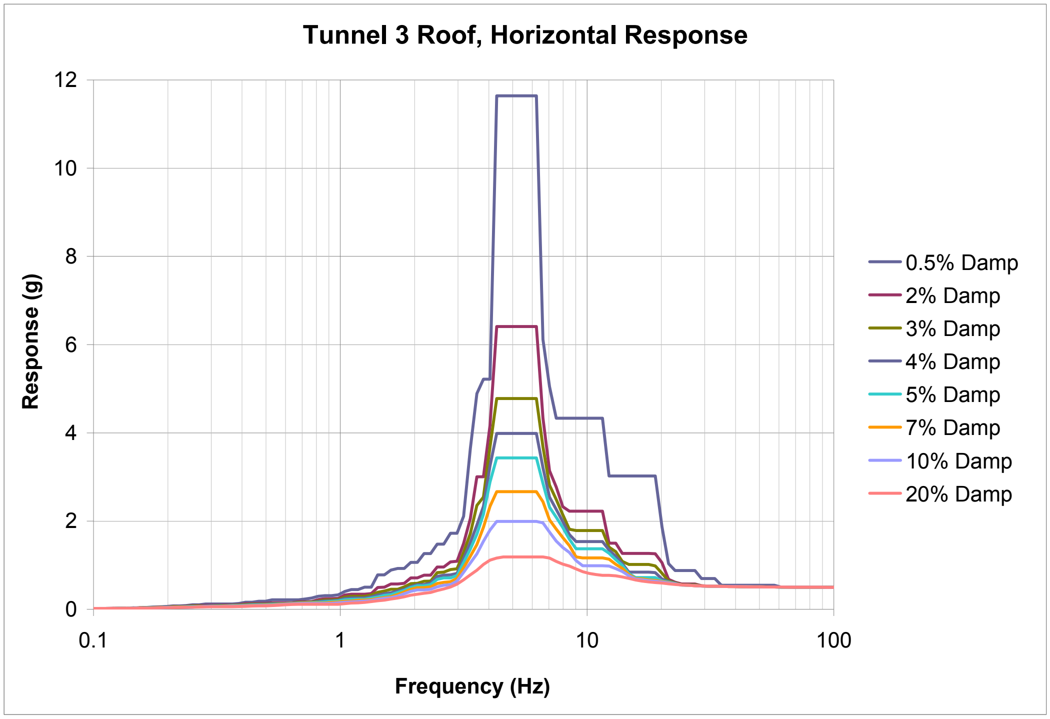

Figure 3LL-9 ISRS for ESWPT Segment 3 (Sheet 3 of 6) (enveloped north-south and east-west response)

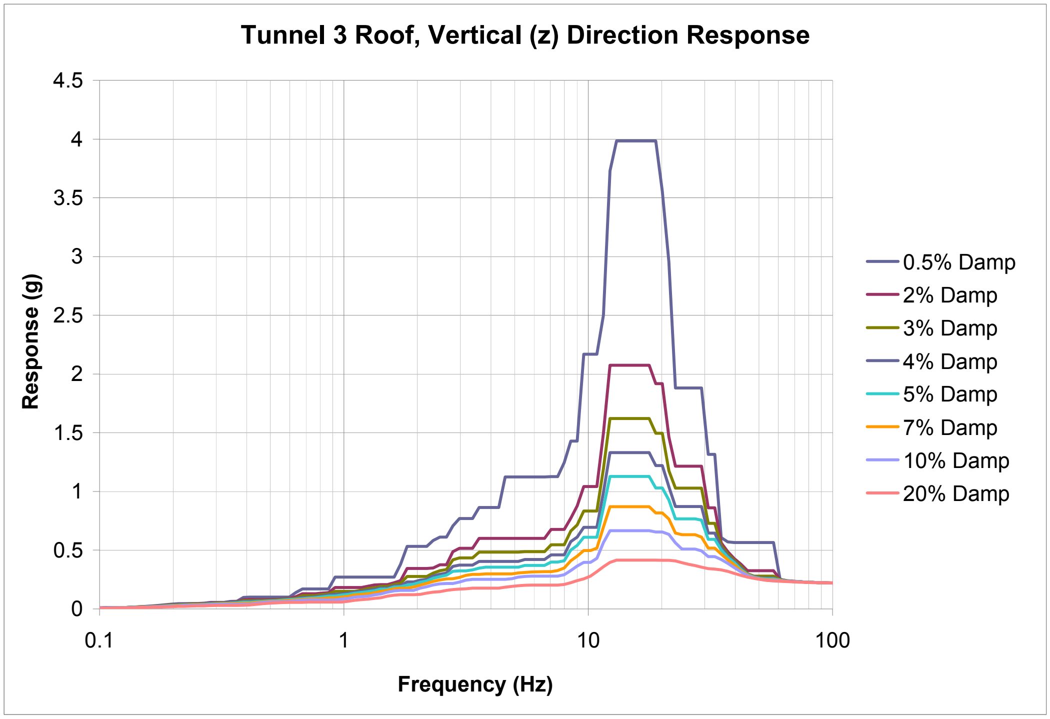

Figure 3LL-9 ISRS for ESWPT Segment 3 (Sheet 4 of 6)

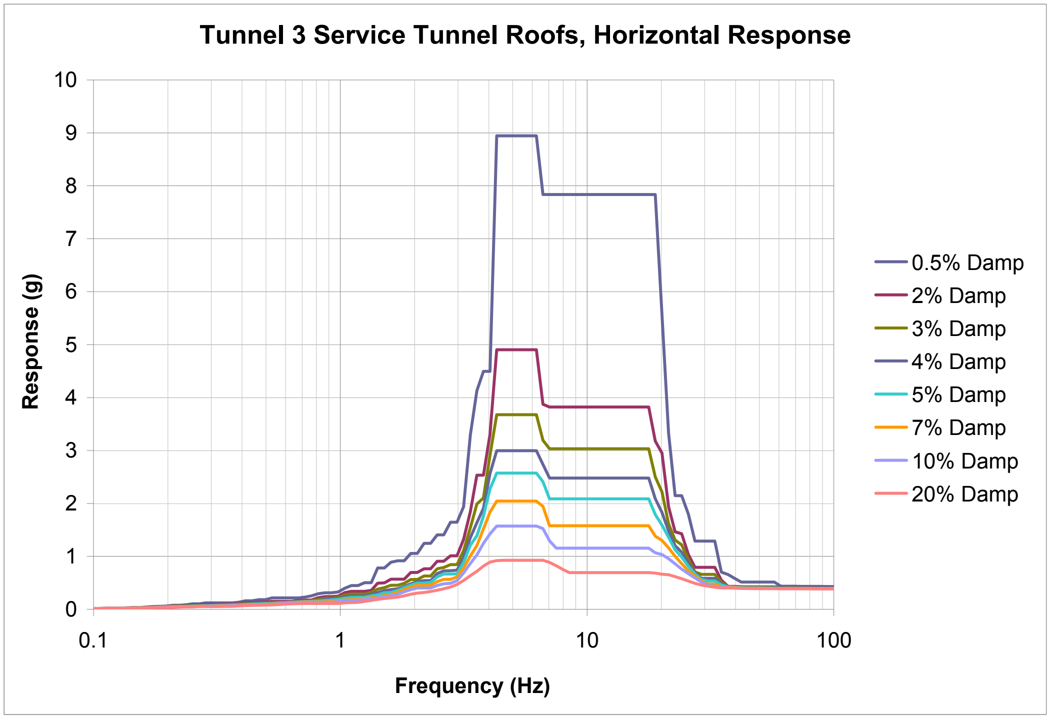

Figure 3LL-9 ISRS for Roofs of Service Tunnels Crossing ESWPT Segment 3 (Sheet 5 of 6) (enveloped response for north-south and east-west directions)

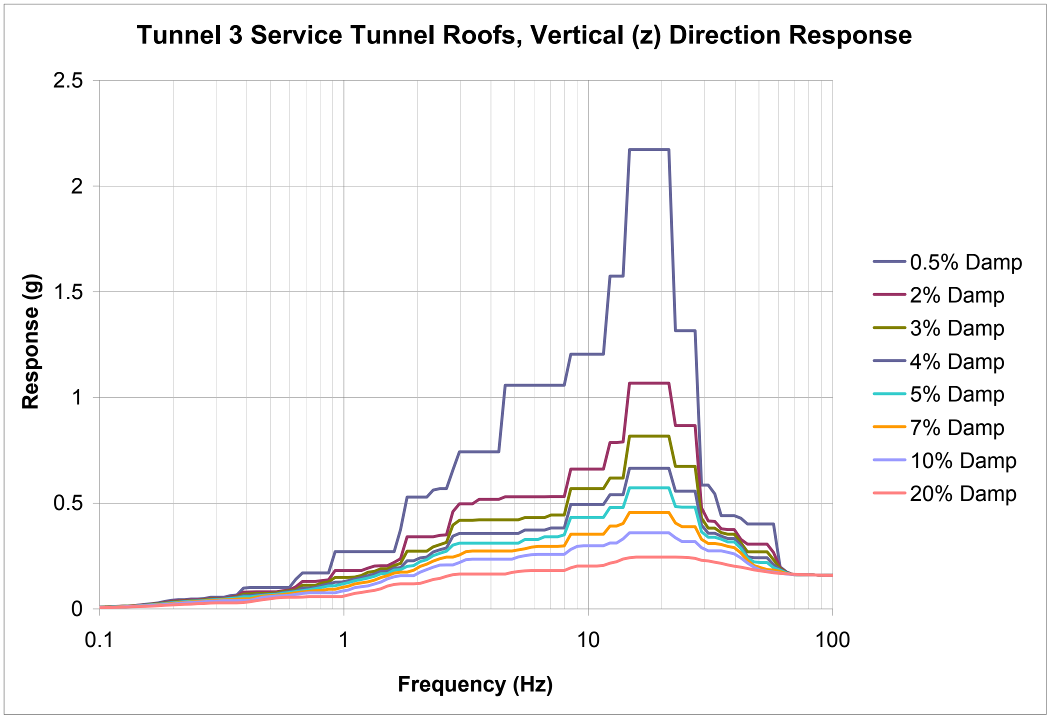

Figure 3LL-9 ISRS for Roofs of Service Tunnels Crossing ESWPT Segment 3 (Sheet 6 of 6)

CP COL 3.7(3)
CP COL 3.7(26)
CP COL 3.8(29)

APPENDIX 3MM

MODEL PROPERTIES AND SEISMIC ANALYSIS RESULTS FOR PSFSVs

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ACRONYMS AND ABBREVIATIONS

Acronyms	Definitions
3D	three-dimensional
BE	best estimate
FE	finite element
FIRS	foundation input response spectra
HB	high bound
ISRS	in-structure response spectra
LB	lower bound
OBE	operating-basis earthquake
PSFSV	power source fuel storage vault
SRSS	square root sum of the squares
SSI	soil-structure interaction
UB	upper bound

3MM MODEL PROPERTIES AND SEISMIC ANALYSIS RESULTS FOR PSFSVS

3MM.1 Introduction

This Appendix discusses the seismic analysis of the power source fuel storage vaults (PSFSVs). The computer program SASSI (Reference 3MM-1) serves as the platform for the soil-structure interaction (SSI) analyses. The three-dimensional (3D) finite element (FE) models used in the SASSI are condensed from FE models with finer mesh patterns initially developed using the ANSYS computer program (Reference 3MM-2). Further, the translation of the model from ANSYS to SASSI is confirmed by comparing the results from the modal analysis of the fixed base structure in ANSYS and the SASSI analysis of the model resting on a half-space with high stiffness. The close correlation between the SASSI transfer function results with the ANSYS eigenvalues results ensures the accuracy of the translation.

The SASSI 3D FE model is dynamically analyzed to obtain seismic results including SSI effects. The SASSI model results including seismic soil pressures are used as input to the ANSYS models for performing the detailed structural design including loads and load combinations in accordance with the requirements of Section 3.8. The SASSI analysis and results presented in this Appendix include site-specific effects such as the layering of the subgrade, embedment of the PSFSVs, flexibility of the basemat and subgrade, and scattering of the input control design motion. Due to the low seismic response at the Comanche Peak Nuclear Power Plant site and lack of high-frequency exceedances, the SASSI capability to consider incoherence of the input control motion is not implemented in the design of the PSFSVs.

3MM.2 Model Description and Analysis Approach

The FE model for the PSFSV is shown in Figure 3MM-1. Table 3MM-1 presents the properties assigned to the structural components of the SASSI FE model. Table 3MM-2 summarizes the SASSI FE model structural component dimensions and weights. Detailed descriptions and figures of the PSFSV are contained in Section 3.8.

Shell elements are used for the roof, interior and exterior walls, brick elements are used for the base mat, and beam elements are used to represent the emergency power fuel oil tanks and their supports, which are connected to the basemat. Walls are modeled using gross section properties at the centerline. The tapered east wall of the vault is modeled at the centerline of the top portion of the wall. The change in thickness is modeled using the average thickness of the wall at each element layer. The materials and properties of the roof slab are changed to reflect the cracked concrete properties for out of plane bending. The cracked concrete properties are modeled for one-half of the uncracked flexural stiffness of the roof. Un-cracked properties are considered for the in-plane stiffness and the mass of the roof (Reference 3MM-3). Therefore, to achieve 1/2 flexural out-of-plane stiffness of the slab without reducing its in-plane stiffness, the following element properties are assigned:

$t_{cracked} = (C_F)^{0.5} \cdot t$

$E_{cracked} = [1/(C_F)^{0.5}] \cdot E_{concrete}$

$\gamma_{cracked} = [1/(C_F)^{0.5}] \cdot \gamma_{concrete}$

where:

C_F = the factor for the reduction of flexural stiffness, taken as 1/2,

$t_{cracked}$ = the effective slab thickness to account for cracking

t = the gross section thickness

$\gamma_{cracked}$ = the effective unit weight to offset the reduced stiffness and provide the same total mass

$\gamma_{concrete}$ = unit weight of concrete

$E_{cracked}$ = effective modulus to account for the reduction in thickness that keeps the same axial stiffness while reducing the flexural stiffness by C_F

$E_{concrete}$ = modulus of elasticity of concrete.

The natural frequencies and descriptions of the associated modal responses of the fixed-base model are presented in Table 3MM-3 for the PSFSV and these frequencies are compared to structural frequencies calculated from the transfer functions of the SASSI model.

The PSFSV model is developed and analyzed using methods and approaches consistent with ASCE 4 (Reference 3MM-3) and accounting for the site-specific stratigraphy and subgrade conditions described in Chapter 2, as well as the backfill conditions around the embedded PSFSVs. The PSFSV structure is modeled using three orthogonal axes: a y-axis pointing south, an x-axis pointing west, and a z-axis pointing up. The east and west PSFSVs are nearly symmetric; backfill is present on the south and east sides of the east vault and on the south and west sides of the west vault. Due to symmetry, SSI analysis is performed only on the east vault, and the responses are deemed applicable to the west vault.

The input within-layer motion and strain-compatible backfill properties for the SASSI analysis are developed from site response analyses described in Section 3NN.2 of Appendix 3NN by using the site-specific foundation input response spectra (FIRS) discussed in Subsection 3.7.1.1. The properties of the supporting media (rock) as well as the site-specific strain-compatible backfill properties used for the SASSI analysis of the PSFSVs are the same as those presented in Appendix 3NN for the R/B-PCCV-containment internal structure SASSI analyses. To account for uncertainty in the site-specific properties, several sets of dynamic properties of the rock and the backfill are considered, including best estimate (BE), lower bound (LB), and upper bound (UB) properties. For backfill, an additional high bound (HB) set of properties is also used to account for expected uncertainty in the backfill properties.

The above four sets of soil dynamic properties are applied for analysis of the PSFSV structure considering full embedment within the backfill, partial separation of the backfill, and a surface foundation condition without the presence of any backfill. The backfill separation is modeled by reducing the shear wave velocity by a factor of 10 for those layers of backfill that are determined to be separated. The potential for separation of backfill is determined using an iterative approach that compares the peak envelope soil pressure results to the at-rest soil pressure. Consideration of all these conditions assures that the enveloped results presented herein capture all potential seismic effects of a wide range of backfill properties and conditions in combination with the site-specific supporting media conditions.

Operating-basis earthquake (OBE) structural damping values of Chapter 3 Table 3.7.1-3(b), such as 4 percent damping for reinforced concrete, are used in the site-specific SASSI analysis. This is consistent with the requirements of Section 1.2 of RG 1.61 (Reference 3MM-4) for structures on sites with low seismic responses where the analyses consider a relatively narrow range of site-specific subgrade conditions.

3MM.3 Seismic Analysis Results

Table 3MM-4 presents a summary of SSI effects on the seismic response of the PSFSV. The maximum absolute nodal accelerations obtained from the time history analyses of the PSFSV models are presented in Table 3MM-5. The results are presented for each of the major PSFSV components and envelope all site conditions described above. The maximum accelerations have been obtained by combining cross-directional contributions in accordance with RG 1.92 (Reference 3MM-5) using the square root sum of the squares (SRSS) method.

The seismic design forces and moments are presented in Table 3MM-6. The force and moment values represent the enveloped seismic results for all site conditions considered in the analysis. These results are calculated from ANSYS design model subjected to the enveloped of accelerations and dynamic lateral soil pressure from all calculated SASSI analyses. Accidental torsion is accounted by increasing the wall shears given in Table 3MM-6. The walls seismic base shear was increased to account for accidental torsion and total seismic base shear to be resisted by in plane shear of walls. The total adjusted wall shear forces used for design are presented in Figure 3MM-2. For structural design of members and components, the design seismic forces due to three different components of the earthquake are combined using the Newmark 100% - 40% – 40% method.

The PSFSV displacements due to seismic loading are less than 0.07 inch. Table 3MM-7 summarizes the resulting maximum displacements for enveloped seismic loading conditions.

3MM.4 In-Structure Response Spectra (ISRS)

The enveloped broadened ISRS are presented in Figure 3MM-3 for the PSFSV base slab and roof for each of the three orthogonal directions (east-west, north-south, vertical) for 0.5 percent, 2 percent, 3 percent, 4 percent, 5 percent, 7 percent, 10 percent and 20 percent damping. The ISRS for each orthogonal direction are resultant spectra which have been combined using SRSS to account for cross-directional coupling effects in accordance with RG 1.122 (Reference 3MM-6). The ISRS include the envelope of the 11 site conditions (BE, LB, UB, and HB with and without backfill separation from the structure, and the no-fill surface foundation condition with BE, LB, and UB subgrade conditions). All results have been broadened by 15 percent and all valleys removed. The spectra can be used for the design of seismic category I and II subsystems and components housed within or mounted to the PSFSV. It is permitted to perform 15 percent peak clipping of the spectra for damping values below 10 percent in accordance with ASCE-4 (Reference 3MM-3). For the design of seismic category I and II subsystems and components mounted to the PSFSV walls, it is required to account for the effects of out-of-plane wall flexibility.

3MM.5 References

3MM-1 *An Advanced Computational Software for 3D Dynamic Analysis Including Soil Structure Interaction,* ACS SASSI Version 2.2, Ghiocel Predictive Technologies, Inc., July 23, 2007.

3MM-2 ANSYS Release 11.0, SAS IP, Inc. 2007.

3MM-3 *Seismic Analysis of Safety-Related Nuclear Structures*. American Society of Civil Engineers, ASCE 4-98, Reston, Virginia, 2000.

3MM-4 *Damping Values for Seismic Design of Nuclear Power Plants*, Regulatory Guide 1.61, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, March 2007.

3MM-5 *Combining Responses and Spatial Components in Seismic Response Analysis,* Regulatory Guide 1.92, Rev. 2, U.S. Nuclear Regulatory Commission, Washington, DC, July 2006.

3MM-6 *Development of Floor Design Response Spectra for Seismic Design of Floor-supported Equipment or Components*, Regulatory Guide 1.122, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, February 1978.

Table 3MM-1
FE Model Component Properties

Components	Material	E (ksi)	Poisson's Ratio	Unit Weight (kcf)	Damping Ratio	FE Thickness (ft)	Element type
Exterior Walls	5,000 psi concrete	4,030	0.17	0.170(1)	0.04	2.5	Shell
Exterior Tapered Wall	5,000 psi concrete	4,030	0.17	0.170(1)	0.04	3.14 to 4.38	Shell
Interior Walls	5,000 psi concrete	4,030	0.17	0.2167(1)	0.04	1.5	Shell
Roof (2)	5,000 psi concrete	5,696	0.17	0.2475(2)	0.04	1.414	Shell
Base slab	5,000 psi concrete	4,030	0.17	0.1577(1)	0.04	6.5	Brick
Emergency Fuel Oil Tanks	Steel	29,000	0.3	5.28(3)	0.04	N/A	Beam

Notes:

1) The unit weight includes uniform equivalent dead loads of 50 psf on all interior surfaces.

2) The values of E, thickness and unit weight are adjusted to consider cracked concrete properties of the roof slab for out-of-plane bending as discussed in Appendix Subsection 3MM.2. Roof unit weight includes 50 psf (for either 50 psf pipe load or 25 percent of a 200 psf live load on the roof slab).

3) The unit weight includes the weight of the emergency fuel oil tanks and the oil stored within. Tank supports are modeled as massless beams.

Table 3MM-2
SASSI FE Model Component Dimensions and Weights[1]

FE Component	Slab Width or Wall Height (ft)	Slab or Wall Length (ft)	Slab or Wall Thickness (ft)	Weight (kips)
North Exterior Wall	40	83.5	2.5	1,330
South Exterior Wall	40	83.5	2.5	1,420
West Exterior Wall	40	75.5	2.5	1,284
East Exterior Wall	40	75.5	Varies from 4.5 at bottom to 2.5 at top	1,926
West Interior Wall	40	75.5	1.5	982
East Interior Wall	40	75.5	1.5	982
Roof Slab	83.5 (east-west)	75.5 (north-south)	2[2]	2,206
Base mat	83.5 (east-west)	75.5 (north – south)	6.5	6,462
Tanks including full fuel oil content	N/A	N/A	N/A	1,162 x 3 = 3,486
Total Weight	40	83.5	2.5	20,078
Equivalent Weight (ksf) on Slab Area (78'x88')				2.9
Peak Dynamic Pressure[3] (ksf)				2.2

Notes:

1) The width and length dimensions in the table have been adjusted from actual dimensions to suit the mesh pattern used for the FE model. The adjustments are minor and do not affect the accuracy of the analysis results. Actual component dimensions are shown in Section 3.8 Figures 3.8-212, 3.8-213, and 3.8-214.

2) The actual roof slab thickness of 2 ft is adjusted to 1.414 ft in the FE model to account for its cracked properties, as discussed in Appendix Subsection 3MM.2.

3) Peak dynamic pressure at corner elements, each representing less than 1 percent of the slab area, are as high as 4.1 ksf. Average peak pressure over total slab area is 0.7 ksf.

Table 3MM-3
SASSI FE Model Natural Frequencies(1)

Frequency (Hz)	Comments
12.7	East-west response, interior walls out-of plane
15.5	East-west response, exterior walls out-of plane
18.3	East-west response, walls in plane
18.9	Vertical response, roof slab
23.7	North-south response, overall structure

Notes:

1) Natural frequencies and effective masses were calculated in ANSYS using the same mesh as used for SASSI analyses.

Table 3MM-4
SASSI Results for PSFSV Seismic Response

SSI Effect	Observed Response
Rock Subgrade	The rock subgrade has insignificant SSI effect on the PSFSV seismic response. Instead, the structural natural frequencies obtained from SASSI analyses of the surface foundation characterize the response, due to the high stiffness of the rock and the small weight of the foundation.
Backfill Embedment	The properties of the backfill embedment affect the overall response of PSFSV structure. Backfill soil frequencies, in the range of 4 Hz for lower bound to 8 Hz for high bound, characterize the PSFSV horizontal response. Frequencies of 7 Hz for lower bound, 11 Hz for best estimate, 14 Hz for upper bound, and 17 Hz for high bound, characterize the vertical response of the backfill. The peaks increase in magnitude as the frequency of the backfill approaches that of the PSFSV structure.
Backfill soil separation	The effects of backfill soil separation on the PSFSV response are small.
Scattering Effects	The dynamic properties mismatch between the backfill and the rock results in reflection of the seismic waves within the backfill stratum. Multiple modes characterize the backfill soil column that can have some effect on the PSFSV response when their frequencies are close to the structural frequencies.

Table 3MM-5
SASSI FE Model Component Peak Accelerations

Component	N-S Acceleration (g) (+/- Y Direction)	E-W Acceleration (g) (+/- X Direction)	Vertical (g) (+/- Z Direction)
North Exterior Wall	0.18	0.18	0.13
South Exterior Wall	0.21	0.17	0.13
West Exterior Wall	0.16	0.42	0.13
East Exterior Wall	0.15	0.26	0.13
West Interior Wall	0.17	0.67	0.13
East Interior Wall	0.17	0.67	0.13
Roof Slab	0.17	0.21	0.63
Basemat	0.11	0.12	0.12

Notes:

1) The peak accelerations presented above envelope all of the considered site conditions, i.e. PSFSV embedded in BE, LB, UB, and HB backfill with and without soil separation, as well as the PSFSV supported by a surface foundation.

2) For structural design using the loads and load combinations in Section 3.8, the seismic loads are obtained by applying uniform accelerations to the PSFSV structure. This approach captured effects due to localized peak accelerations presented above. The uniform accelerations are applied as follows: For the horizontal direction a uniform acceleration of 0.25g was applied. For the vertical direction a uniform acceleration of 0.15g was applied. These accelerations were applied to all elements in the vault (including tanks). An additional distributed load corresponding to 0.40g was applied to the two interior walls and the east wall to account for increased local out-of-plane accelerations obtained from the SASSI analysis. An additional distributed load corresponding to 0.50g was applied to all the roof slabs to account for increased local accelerations obtained from the SASSI analysis. Seismic load also includes seismic backfill pressures on the sides of the PSFSV walls.

Table 3MM-6
Maximum Component Seismic Forces and Moments

Component		Maximum component forces and moments							
		N_V (k/ft)	N_L (k/ft)	Q_V (k/ft)	Q_L (k/ft)	S_W (k/ft)	M_V (k-ft/ft)	M_L (k-ft/ft)	M_{VL} (k-ft/ft)
South Exterior Wall	+	65.07	54.87	14.32	23.61	41.24	25.70	28.28	13.42
	-	87.05	63.09	10.58	24.39	24.18	39.11	68.79	14.45
North Exterior Wall	+	22.62	6.88	4.06	2.02	29.98	9.37	27.50	3.60
	-	19.94	15.12	19.53	3.54	19.54	12.38	15.04	4.68
West Exterior Wall	+	20.07	17.25	19.82	5.27	19.90	76.89	26.73	29.56
	-	15.06	27.82	14.26	13.00	14.06	119.32	48.10	30.14
East Exterior Wall	+	13.82	24.29	6.40	4.71	16.40	34.89	32.23	7.53
	-	16.42	17.29	6.28	5.52	14.10	37.00	14.21	8.06
West Interior Wall	+	25.13	4.29	9.18	5.27	18.51	18.97	11.95	3.38
	-	17.33	31.42	5.31	4.95	13.27	19.53	12.14	3.28
East Interior Wall	+	12.04	4.14	5.20	9.63	17.96	18.75	14.01	3.92
	-	12.87	32.65	6.50	7.75	8.89	19.75	16.26	3.56
Roof Slab	+	25.64	20.19	9.78	6.72	21.22	19.77	8.82	6.74
	-	43.10	20.47	10.99	7.73	17.65	21.19	20.59	7.06
Basemat	+	13.71	19.23	18.68	25.70	21.67	176.90	154.34	58.57
	-	21.55	19.61	18.42	26.43	21.07	84.34	157.24	59.04

Notes:

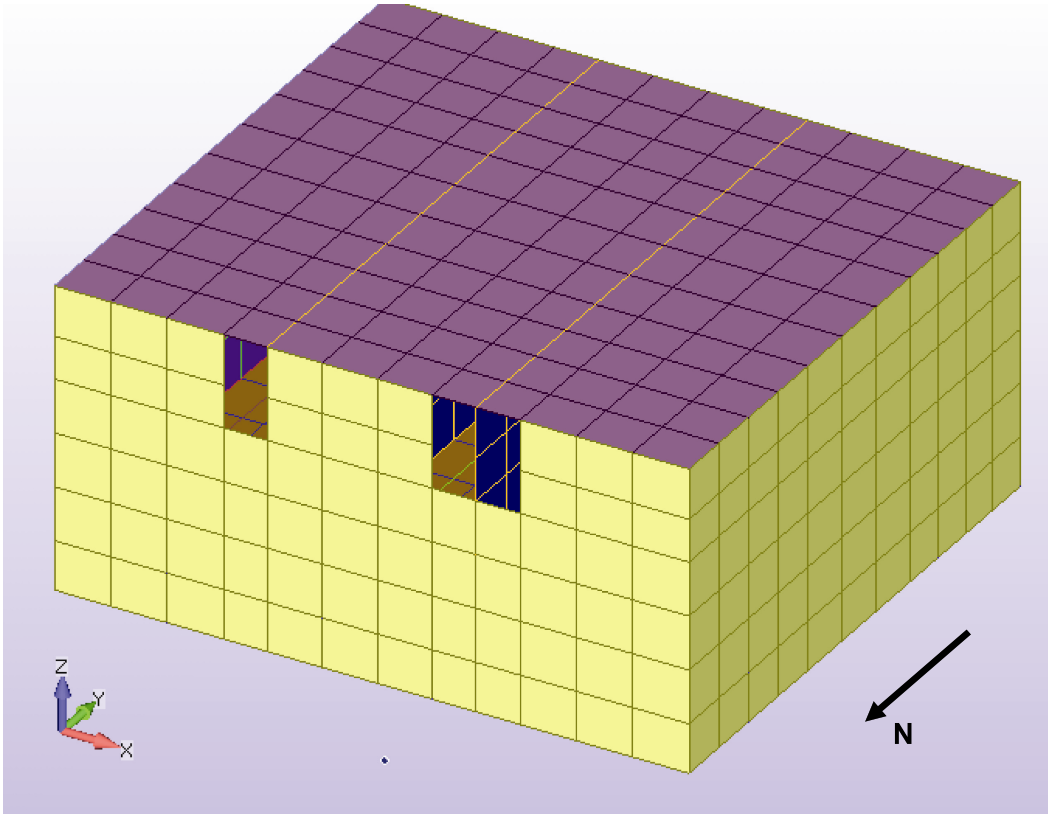
1) The forces and moments shown above envelope the all four subgrade site conditions (LB, BE, UB, and HB) and any effects due to soil separation.

2) The forces and moments are obtained by combination of the three orthogonal directions used in the model by the Newmark 100%-40%-40% method.

3) In the table above the vertical and longitudinal directions define the plane of the walls. N stands for axial force, Q for out-of-plane shear, S_W for in-plane shear and M for moment. The M_V results in normal stresses in the vertical direction of the wall and similarly, M_L results in normal stresses in the longitudinal (horizontal) direction of the wall, and M_{VL} is the torsional moment on the wall. The Q_V is out-of-plane shear force acting on horizontal cross section of the wall, and Q_L is out-of-plane shear force acting on a vertical cross section of the wall. For the roof slab and base slab the vertical axis is oriented along the east-west direction and the longitudinal in the north-south direction

Table 3MM-7
PSFSV Maximum Displacements for All Enveloped Conditions

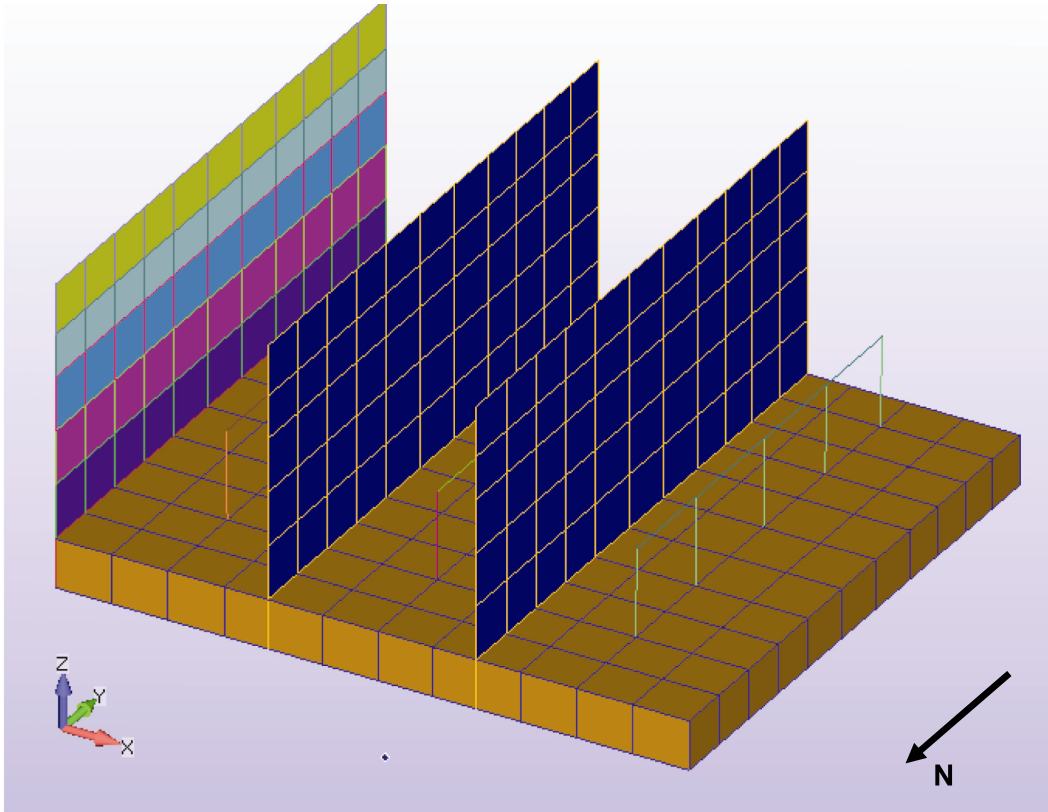
Component	Maximum Displacement (inches)	Description
Roof slab	0.05	Horizontal displacement equivalent to story drift; occurs at edge of slab near center of wall
East exterior wall	0.07	Horizontal (out-of-plane) displacement near center of wall
West exterior wall	0.05	Horizontal (out-of-plane) displacement near center of wall



Notes:

1) The vault pipe/access tunnel openings are on the north exterior wall as shown in the model above.

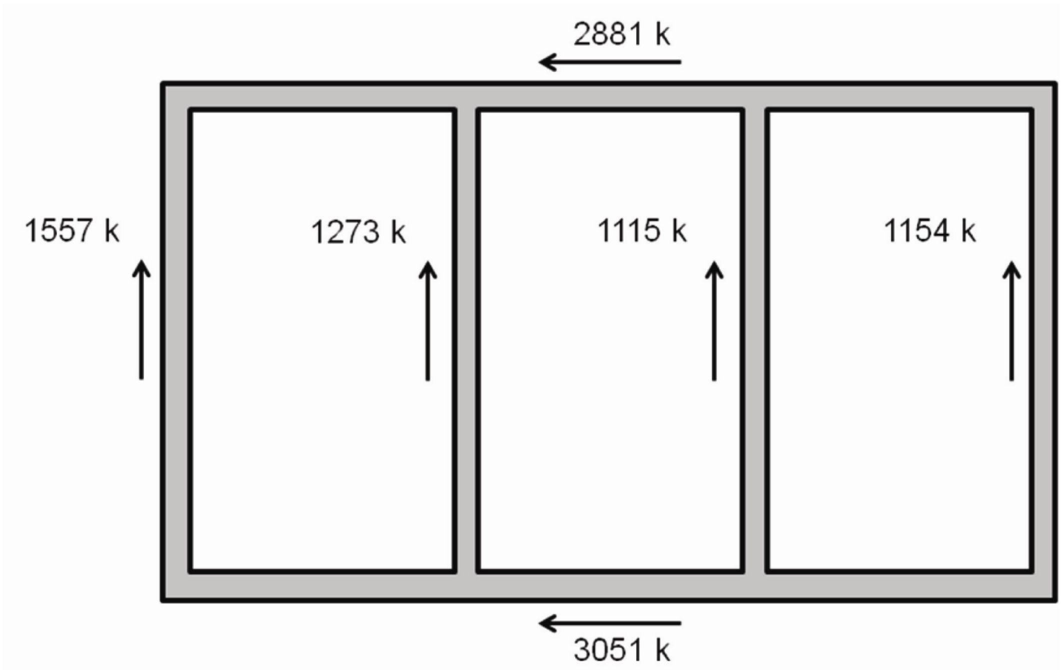
Figure 3MM-1 Overall SASSI Model of PSFSV (Sheet 1 of 2)



Notes:

1) The steel elements representing the tank are shown above as column and beams. The tank supports are modeled as beam elements oriented in the east-west direction and located at the base of each tank column element.

Figure 3MM-1 Overall SASSI Model of PSFSV (Sheet 2 of 2, Cutaway View of SASSI Model of PSFSV)



Notes:

1) The seismic shear forces shown above are computed at the bottom of each wall at the interface with the foundation mat and account for accidental eccentricity and total seismic base shear to be resisted by in plane shear of walls.

Figure 3MM-2 Maximum Seismic Base Shear Forces in Wall

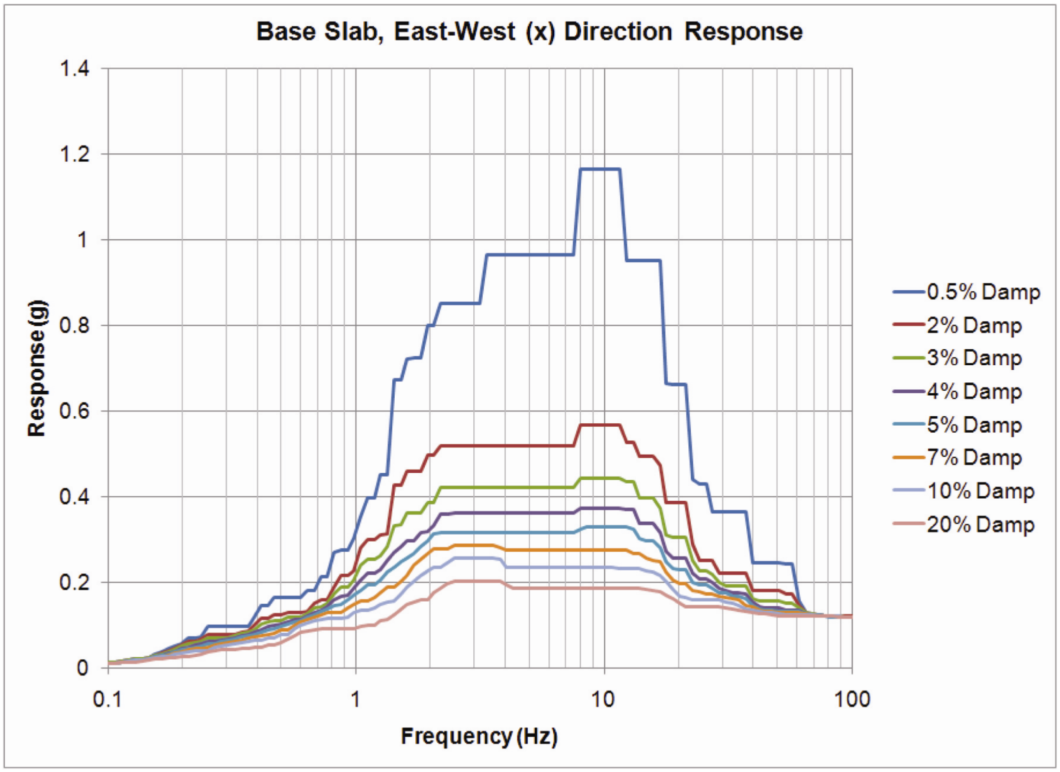


Figure 3MM-3 ISRS for PSFSV (Sheet 1 of 6)

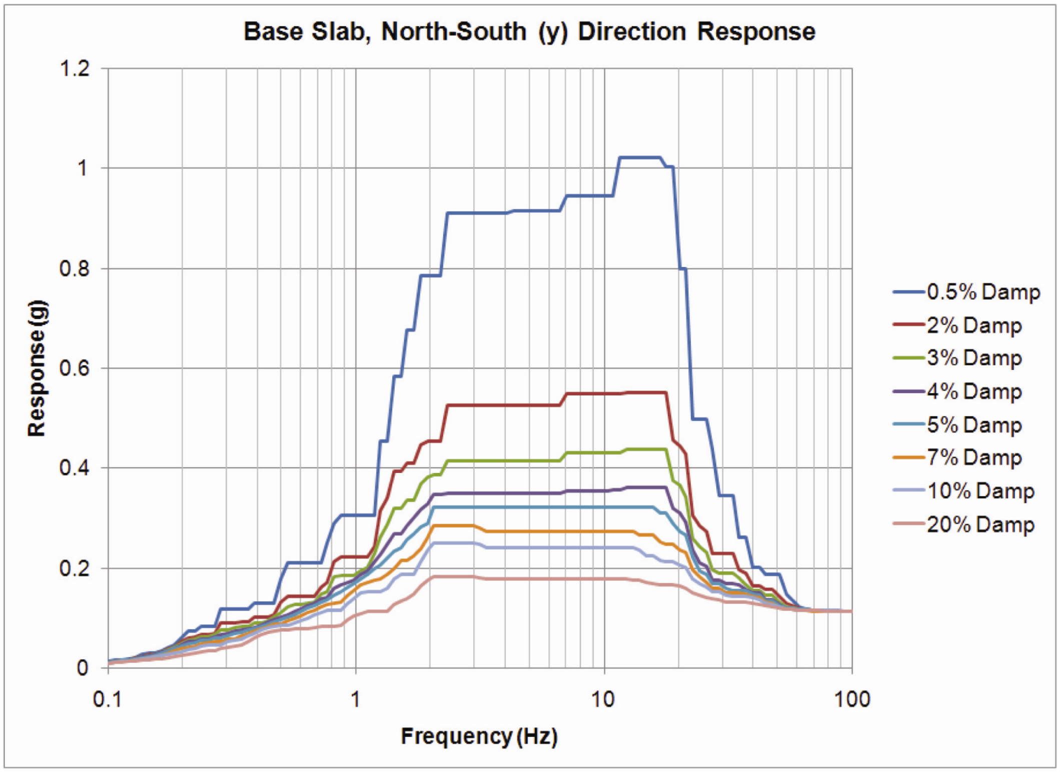


Figure 3MM-3 ISRS for PSFSV (Sheet 2 of 6)

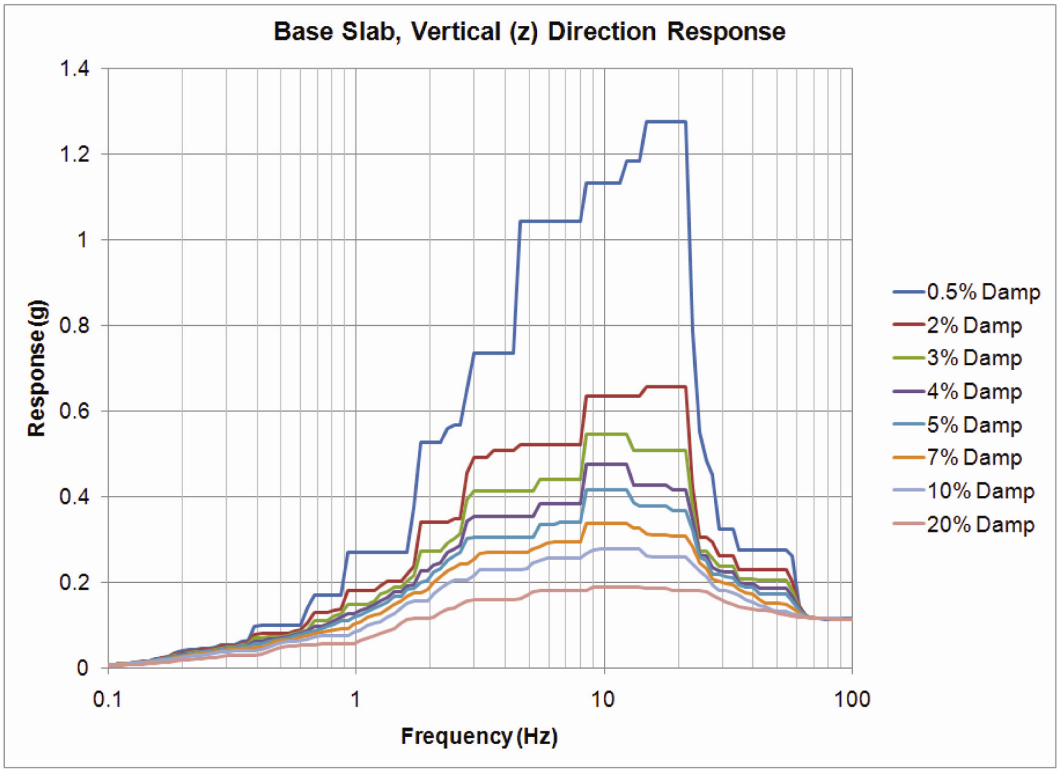


Figure 3MM-3 ISRS for PSFSV (Sheet 3 of 6)

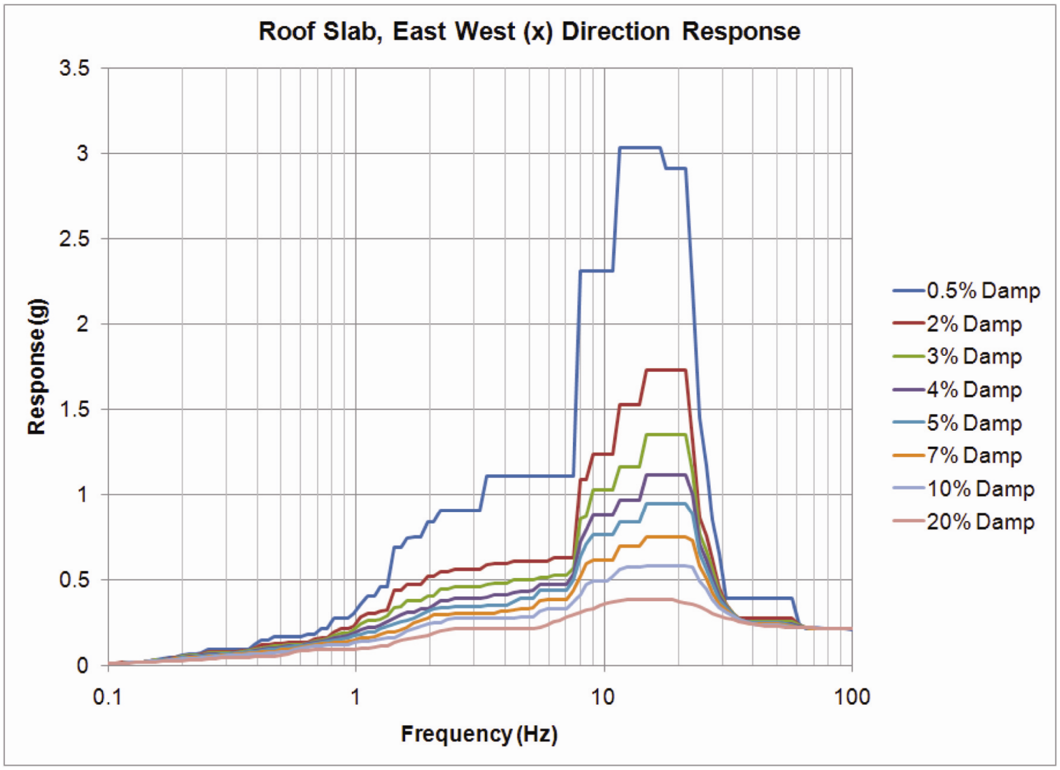


Figure 3MM-3 ISRS for PSFSV (Sheet 4 of 6)

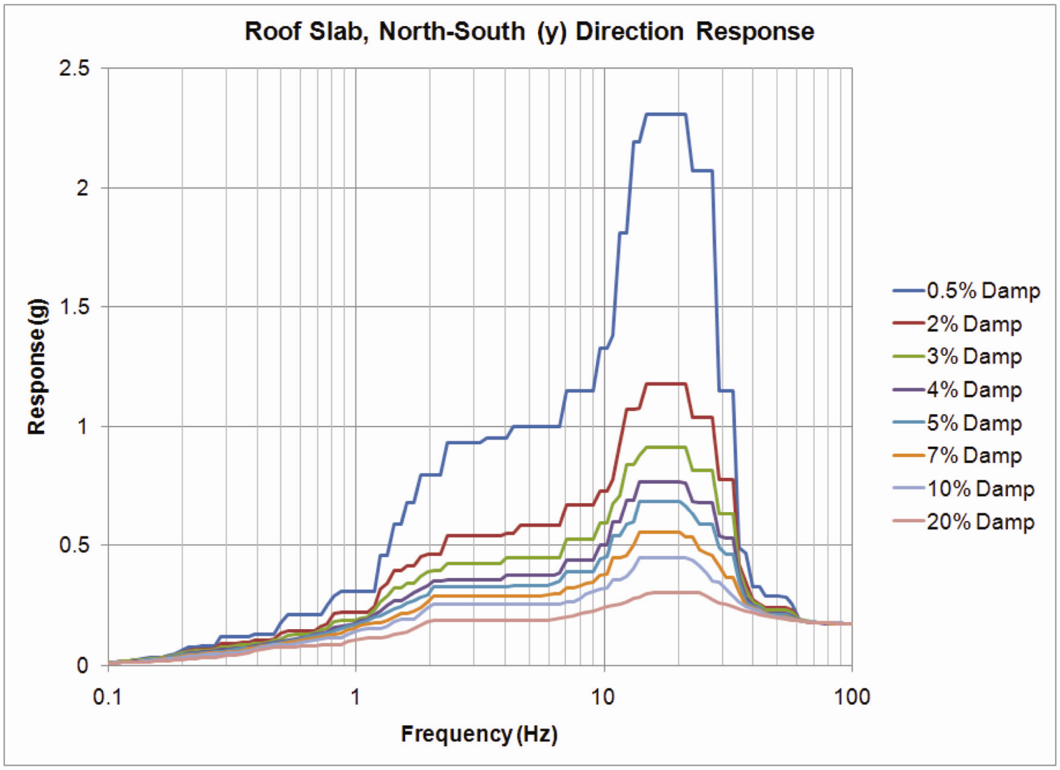


Figure 3MM-3 ISRS for PSFSV (Sheet 5 of 6)

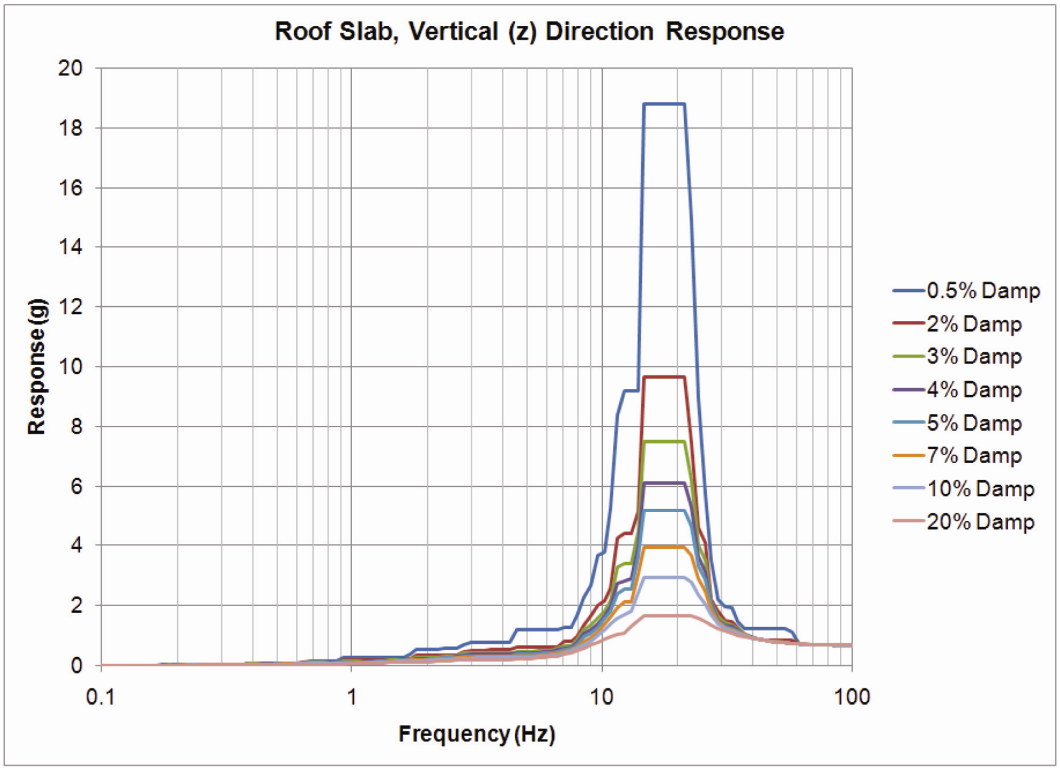


Figure 3MM-3 ISRS for PSFSV (Sheet 6 of 6)

CP COL 3.7(3)
CP COL 3.7(26)
CP COL 3.8(29)

APPENDIX 3NN

MODEL PROPERTIES AND SEISMIC ANALYSIS RESULTS R/B-PCCV-CONTAINMENT INTERNAL STRUCTURE

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ACRONYMS AND ABBREVIATIONS

Acronyms	Definitions
3D	three-dimensional
ARS	acceleration response spectra
BE	best estimate
COV	coefficient of variation
CSDRS	certified seismic design response spectra
DCD	Design Control Document
FE	finite element
EBE	embedded best estimate
ELB	embedded lower bound
EHB	embedded high bound
EUB	embedded upper bound
FH/A	fuel handling area
GMRS	ground motion response spectra
HB	high bound
ISRS	in-structure response spectra
LB	lower bound
OBE	operating-basis earthquake
PCCV	prestressed concrete containment vessel
R/B	reactor building
SBE	surface best estimate
SLB	surface lower bound
SUB	surface upper bound
SRSS	square root sum of the squares
SSE	safe-shutdown earthquake
SSI	soil-structure interaction
UB	upper bound

3NN SASSI MODEL PROPERTIES AND SEISMIC ANALYSIS RESULTS FOR R/B-PCCV-CONTAINMENT INTERNAL STRUCTURE

3NN.1 Introduction

This Appendix documents the SASSI site-specific analysis of the US-APWR prestressed concrete containment vessel (PCCV), containment internal structure, and reactor building (R/B) including the fuel handling area (FH/A) of Comanche Peak Nuclear Power Plant Units 3 and 4.

As stated in Subsection 3.7.2.4.1, site-specific soil-structure interaction (SSI) analyses are performed to validate the US-APWR standard plant seismic design, and to confirm that site-specific SSI effects are enveloped by the lumped parameter SSI analysis described in Subsection 3.7.2.4. The SASSI computer program (Reference 3NN-1) serves as a computational platform for the site-specific SSI analysis. SASSI is used to model the overall stiffness and mass inertia properties of the R/B-PCCV-containment internal structure and the following SSI site-specific effects:

- Layering of the rock subgrade.
- Foundation flexibility.
- Embedment of the foundation and layering of backfill material.
- Scattering of the input control design motion.

The SASSI program provides a frequency domain solution of the SSI model response based on the complex response method and finite element (FE) modeling technique. The SASSI analyses of the US-APWR standard plant employ the subtraction method of sub-structuring to capture the above-listed SSI effects. Due to the low seismic response at the Comanche Peak site and lack of high-frequency exceedances, the SASSI analyses do not consider incoherence of the input control motion.

The SASSI site-specific analyses are conducted using methods and approaches consistent with ASCE 4 (Reference 3NN-2). This Appendix documents the SASSI analysis of the R/B-PCCV-containment internal structure and demonstrates that the in-structure response spectra (ISRS) developed from the SASSI analysis results are enveloped by the standard plant seismic design.

3NN.2 Seismological and Geotechnical Considerations

The R/B-PCCV-containment internal structure of Units 3 and 4 will be constructed on a rock subgrade by removing the native soil above the top of the limestone layer with shear wave velocity exceeding 5000 fps that is located at nominal elevation of 782 ft. A thin layer of fill concrete will be placed on the top of the limestone to level the surface below the building basemat established at nominal elevation of 783 ft.-2 in. Fill concrete will be also placed below the surface mat located at the north-east corner of the FH/A under the central portion of the mat underneath the PCCV. The foundation will be backfilled with a 40 ft.

thick layer of engineered fill material to establish the nominal elevation of the plant ground surface at 822 ft.

Besides the best estimate (BE) values, the site-specific analyses address the variation of the subgrade properties by considering lower bound (LB) and upper bound (UB) properties. The LB and UB properties represent a coefficient of variation (COV) on the subgrade shear modulus of 0.65, the value of variation that was also used in Chapter 2 for development of ground motion response spectra (GMRS). The typical properties for a granular engineered backfill are adopted as the BE values for the dynamic properties of the backfill. Four profiles, LB, BE, UB, and high bound (HB) of input backfill properties are developed for the SASSI analyses considering the different coefficient of variation. The LB and BE backfill profiles are combined with corresponding LB and BE rock subgrade profiles, and the UB and HB backfill profiles are combined with the UB rock subgrade profile. The profiles address the possibility of stiffer backfill, and the project specifications limit the minimum shear wave velocity of the backfill material to 600 ft/s for 0 to 3 ft. depth, 720 ft/s for 3 to 20 ft. depth, and 900 ft/s for 20 to 40 ft. depth. Table 3NN-1 presents the COV on shear modulus used for development of different soil profiles.

Due to the small intensity of the seismic motion and the high stiffness of the rock, the SSI analyses use rock subgrade input properties derived directly from the measured low-strain values, i.e., the dynamic properties of the rock subgrade are considered strain-independent (Refer to FSAR Chapter 2 for further discussion). The SSI analyses use input stiffness and damping properties of the backfill that are compatible to the strains generated by the design input motion. The strain-compatible backfill properties are obtained from site response analyses of the four backfill profiles using two horizontal acceleration time histories compatible to the GMRS that are applied as outcrop motion on the surface of the rock subgrade at nominal elevation of 782 ft.

The compression or P-wave velocity is developed for the rock and the backfill from the strain-compatible shear or S-wave velocity (Vs) and the measured value of the Poisson’s ratio. The SSI analyses use identical values for the shear S-wave and compression P-wave velocity damping. Figure 3NN-1, Figure 3NN-2 and Figure 3NN-3 present, respectively, the rock subgrade LB, BE and UB profiles for shear (S) wave velocity (Vs), compression (P) wave velocity (Vp) and material damping. Figure 3NN-4, Figure 3NN-5 and Figure 3NN-6 present in solid lines the results of the site response analyses for the profiles of strain-compatible backfill properties. The plots also show with dashed lines the backfill profiles that were modified to match the geometry of the mesh of the SASSI basement model. The presented input S and P wave profiles are modified using the equal arrival time averaging method.

The minimum design spectra, tied to the shapes of the certified seismic design response spectra (CSDRS) and anchored at 0.1g, define the safe-shutdown earthquake (SSE) design motion for the seismic design of category I structures that is specified as outcrop motion at the top of the limestone at nominal elevation of 782 ft. Two statistically independent time histories H1 and H2 are developed compatible to the horizontal design spectrum, and a vertical acceleration time history V is developed compatible to the vertical design spectrum. The SASSI analysis requires the object motion to be defined as within-layer motion. The site response analyses convert the design motion that is defined as outcrop motion (or motion at the free surface) to within-layer (or base motion) that depends on the properties of the backfill above the rock surface. The site response analyses provide for each considered backfill profile, two horizontal acceleration time histories of the design motion within the top limestone rock layer that are used as input in the SASSI analyses of embedded foundation. The outcrop horizontal time histories are used as input for the SASSI analyses of surface foundations. The time history of the vertical outcrop accelerations serves as input for both surface and embedded foundations. The time step of the acceleration time histories used as input for the SASSI analysis is 0.005 sec.

3NN.3 SASSI Model Description and Analysis Approach

Figure 3NN-7 shows the three-dimensional SASSI FE model used for site-specific seismic analysis of the US-APWR R/B-PCCV-containment internal structure of Units 3 and 4. The SASSI structural model uses lumped-mass-stick models of the PCCV, containment internal structure, and R/B to represent the stiffness and mass inertia properties of the building above the ground elevation. A three-dimensional (3D) FE model, presented in Figure 3NN-8, represents the building basement and the floor slabs at ground elevation.

The model is established with reference to the Cartesian coordinate system with origin established 2 ft.-7 in. below the ground surface elevation at the center of the PCCV foundation. The origin location corresponds to the location of the coordinate system used as reference for the seismic analysis of the standard plant presented in Section 3.7. The orientation of the Z-axis is upward. The orientation of the standard plant model is modified such that the positive X-axis is oriented northward and the Y-axis is oriented westward.

The geometry and the properties of the lumped-mass-stick models representing the above ground portion of the building are identical to those of the lumped mass stick model used for the R/B-PCCV-containment internal structure seismic analysis, as addressed in Appendix 3H. SASSI 3D beam and spring elements with cross sectional properties identical to those of the standard plant models represent stiffness properties. All of the modeling characteristics present in the standard plant lumped mass stick models for the R/B-PCCV-containment internal structure are the same as for the SASSI model, with the exception of minor adjustments for compatibility with SASSI, described as follows. The rigid links in the lumped mass stick models that connect different nodal points at the same floor elevation are replaced with SASSI 3D beam elements with high stiffness properties.

The major coordinates that define the geometry of the FE basement model are listed in Table 3NN-2 to Table 3NN-5. Table 3NN-6 presents the types of SASSI finite elements used to model the different structural members in the basement model. The table also presents the stiffness and mass inertia properties assigned to each group of finite elements. The stiffness and damping properties assigned to each material of the SASSI model are listed in Table 3NN-7. The site-specific

SASSI analysis uses the operating-basis earthquake (OBE) damping values of Chapter 3, Table 3.7.1-3(b), which is consistent with the requirements of Section 1.2 of RG 1.61 (Reference 3NN-4) for structures on sites with low seismic responses where the analyses consider a relatively narrow range of site-specific subgrade conditions.

SASSI solid FE elements, shown in Figure 3NN-9, model the stiffness and mass inertia properties of the building basemat. The modeling of the thick central part of the basemat supporting the PCCV and containment internal structure is simplified to minimize the size of the SASSI model as shown in Figure 3NN-10. Rigid shell elements connect the thick portion of the basemat with the floor slabs at the ground elevation. Rigid 3D beam elements connect the PCCV and containment internal structure lumped-mass stick models to the rigid shell elements as shown in Figure 3NN-13 and Figure 3NN-14. Massless shell elements are added at the top of the basemat solid element to accurately model the bending stiffness of the central part of the mat. Figure 3NN-11 shows the solid FE elements representing the stiffness and mass inertia of the fill concrete placed under the central elevated part of the basemat and under the surface mat at the northeast corner of the building.

SASSI 3D shell elements model the basement shear walls, the surface mat under the northeast corner of the R/B, and the R/B slabs at ground floor elevation. The elastic modulus and unit weight assigned to the material of the shell elements modeling the R/B basement shear walls shown in Figure 3NN-12 are adjusted to account for the different height of walls and reductions of stiffness due to the openings. Table 3NN-8 lists the adjusted material properties assigned to the shell elements of the walls with openings.

Rigid 3D beam elements connect the top of the basement shear walls with lumped-mass stick model representing the above ground portion of the R/B and FH/A. This modeling approach enables the R/B-FH/A to be connected to the flexible part of the building basement and decoupled from the thick central part that serves as foundation to the PCCV and containment internal structure part of the building.

In addition to the weights assigned to the lumped-mass-stick models of the US-APWR standard plant summarized in Table 3H.2-10 of Appendix 3H, the SASSI model used for site specific analyses includes the weight of 47,085 kips pertaining to the fill concrete placed beneath the building basemat. The combined total weight of the R/B, containment internal structure, and PCCV including the basemat and the fill concrete is 781,685 kips. The equivalent uniform pressure under the building foundation is 11.86 ksf. In the SASSI model of the basement, unit mass weight is assigned only to the 3D shell elements modeling the shear walls of R/B and to the portion of the basemat represented by 3D brick elements. Table 3NN-9 presents the weights assigned to the elements of the basement structural members. The remaining weight of the basement is lumped at a single node that, as shown in Figure 3NN-10, is connected to the central portion of the foundation by rigid beams. As shown in Table 3NN-10, the magnitude and the location of the lumped mass are calculated such that, when combined with the mass inertia properties of the mat and walls, the FE model duplicates the overall lumped mass inertia properties assigned to the standard plant lumped mass stick model at basement node BS01.

Four layers of SASSI solid elements, shown Figure 3NN-15, are used to represent the stiffness and the mass inertia of the excavated backfill soil. Figure 3NN-4, Figure 3NN-5, and Figure 3NN-6 show in dashed lines the input strain-compatible properties assigned to the different layers of excavated soil elements.

The results of a SASSI analysis in which fixed-base conditions are simulated by attaching the lumped-mass-stick models to a rigid foundation resting on a rigid rock subgrade, verify the accuracy of the conversion of the standard plant lumped-mass-stick models into SASSI. An additional verification analysis is performed on the combined SASSI model resting on the surface of rigid half-space to identify the dynamic properties of the SASSI model. Table 3NN-11 presents the frequencies that characterize the different modes of response of the structural models. In the table, the results of the two verification SASSI analyses are compared with the results of the fixed base modal analysis of the model presented in Appendix 3H.

3NN.4 Seismic Analysis Results

The buildings surrounding the R/B (including FH/A), PCCV, and containment internal structures are separated by expansion joints to prevent their interaction during an earthquake. A part of the building foundation is embedded in backfill of engineered granular material. The site-specific SSI analyses address the effects of these site-specific conditions by considering both surface foundation and foundation basement embedded in backfill that is modeled as infinite in the horizontal direction. Seven sets of SASSI analyses are performed that consider the following site conditions:

1. SLB - Foundation without backfill resting on the surface of the rock subgrade profile with LB properties.
2. SBE - Foundation without backfill resting on the surface of the rock subgrade profile with BE properties.
3. SUB - Foundation without backfill resting on the surface the rock subgrade profile with UB properties.
4. ELB - Foundation embedded in backfill with LB properties resting on the surface of the rock subgrade profile with LB properties.
5. EBE - Foundation embedded in backfill with BE properties resting on the surface of the rock subgrade profile with BE properties.
6. EUB - Foundation embedded in backfill with UB properties resting on the surface of the rock subgrade profile with UB properties.

7. EHB - Foundation embedded in backfill with high bound HB properties resting on the surface of the rock subgrade profile with UB properties.

Each set of SASSI runs includes three runs where the input motion is applied to the models at top of the rock subgrade in North-South (NS), East-West (EW) and vertical direction. The responses obtained for the earthquake components in the three global orthogonal directions are combined in accordance with RG 1.92 (Reference 3NN-3) using the square root sum of the squares (SRSS) method.

Table 3NN-12, Table 3NN-13, and Table 3NN-14 present maximum absolute accelerations (zero period acceleration values) at lumped-mass locations of the R/B-PCCV-containment internal structure in NS, EW, and vertical direction, respectively. The results obtained from each set of SASSI analysis are listed together with the enveloped value from all of the considered site conditions.

Table 3NN-15 presents the influence of different SSI effects on the response of the PCCV, R/B, and containment internal structures.

3NN.5 In-Structure Response Spectra (ISRS)

The site-specific SASSI analysis provides results for the 5 percent damping acceleration response spectra (ARS) at all lumped mass locations for the three orthogonal directions. The ARS results for the three components of the input earthquake are combined using the SRSS method and compared with the US-APWR standard plant ISRS. Figure 3NN-16, Figure 3NN-20 and Figure 3NN-24 compare of the ARS results for seismic response in three directions at ground elevation at the nominal center of the basement (mass location CV00) with the corresponding CSDRS. The comparison of the ARS results for the response at the top of PCCV (mass node CV11) with the corresponding ISRS are shown in Figure 3NN-17, Figure 3NN-21, and Figure 3NN-25. Figure 3NN-18, Figure 3NN-22, and Figure 3NN-26 present the comparison of ISRS and ARS results for the containment internal structure response at lumped mass location IC18. The ARS results for the response of R/B structure at lumped mass location RE05 are presented in Figure 3NN-19, Figure 3NN-23 and Figure 3NN-27. The ISRS envelope by a high margin all of the ARS results at all lumped mass locations, which confirms the validity of the US-APWR R/B-PCCV-containment internal structure standard plant seismic design for the Comanche Peak Units 3 and 4 site.

3NN.6 References

3NN-1 *An Advanced Computational Software for 3D Dynamic Analysis Including Soil Structure Interaction,* ACS SASSI Version 2.2, Ghiocel Predictive Technologies, Inc., July 23, 2007.

3NN-2 *Seismic Analysis of Safety-Related Nuclear Structures,* American Society of Civil Engineers, ASCE 4-98, Reston, Virginia, 2000.

3NN-3 *Combining Responses and Spatial Components in Seismic Response Analysis*, Regulatory Guide 1.92, Rev. 2, U.S. Nuclear Regulatory Commission, Washington, DC, July 2006.

3NN-4 *Damping Values for Seismic Design of Nuclear Power Plants*, Regulatory Guide 1.61, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, March 2007.

Table 3NN-1
Variation in Input Soil Properties

Stratum	Coefficient Of Variation on Shear Modulus		
	Lower Bound (LB)	Upper Bound (LB)	High Bound (HB)
Backfill	0.69	0.69	1.25
Rock Subgrade	0.65	0.65	0.65

Table 3NN-2
Basement Model Z Coordinates (Bottom to Top)

Z (ft)	Elevation (ft)	Description
-37.420	782.00	Basemat Bottom
-24.083	795.34	Bottom of Basemat under Reactor
2.583	822.00	Ground Elevation

Table 3NN-3
Basement Model X-Coordinates (South to North)

X (ft)	Column Line	Description
-161.67	LR	South Exterior Wall
-139.33	K1R	R/B South Basement Wall
-127.00	KR	R/B South Basement Wall
-106.00	J1R	E-W Interior Wall R/B South Basement
-94.00	JR	Reactor Basemat South End
-39.08	D1R & ER	Reactor Basement South Edge
0.00	FR	Reactor E-W Centerline
39.08	GR & G2R	Reactor Basement North Edge
94.00	CR	North Interior Wall
102.25	BR	Reactor Basemat North End
124.42	A1R	Basement Exterior Wall under Fuel Handling Area Surface Mat
147.25	AR	Basement North Exterior Wall

Table 3NN-4
Basement Model Y-Coordinates (East to West)

Y (ft)	Column Line	Description
-106.67	11R	Basement East External Wall
-92.167	10R	Reactor Basemat East End
-85.667	9bR	R/B Basement N-S Interior Wall
-70.00	9R	R/B Basement N-S Interior Wall
-48.75	8aR & 8R	Reactor Basement East Edge
-43.917	8R	N-S External Wall under Fuel Handling Area Surface Mat
-38.833	7R	R/B Basement N-S Interior Wall
0.00	6R	Reactor N-S Centerline
17.833	5aR	Tendon Gallery Access Exterior Wall
39.333	4bR	Tendon Gallery Access West Wall
39.333	5R	R/B Basement N-S Interior Wall
48.75	5R & 4aR	Reactor Basement West Edge
63.71	4R	Fuel Handling Area N-S Interior Wall
70.000	3R	R/B Basement N-S Interior Wall
86.583	2aR	Fuel Handling Area and R/B N-S Interior Wall
92.167	2R	Reactor Basemat West End
106.67	1R	Basement West External Wall

Table 3NN-5
Basement Model Radial Coordinates

R (ft)	Description
0.00	Reactor Center
9.86	Reactor Pit Radius
59.00	Radius of Elevated Part of Reactor Foundation
71.83	Tendon Gallery Inner Radius
80.42	Tendon Gallery Outer Radius
93.50	Reactor Foundation Radius

Table 3NN-6
Finite Elements Assigned to Basement Model

Structural Member	Element	Mass	Stiffness
Upper Portion of Reactor Mat	Shell	Weightless	Concrete f_c=4000psi
Fuel Handling Area Surface Basemat	Shell	Weightless	Concrete f_c =4000psi
NS Exterior Walls	Shell	Concrete (adjusted)	Concrete f_c =4000psi (adjusted)
EW Exterior Walls	Shell	Concrete (adjusted)	Concrete f_c =4000psi (adjusted)
NS Basement Inner Shear Walls	Shell	Concrete (adjusted)	Concrete f_c =4000psi (adjusted)
EW Basement Inner Shear Walls	Shell	Concrete (adjusted)	Concrete f_c =4000psi (adjusted)
Connecting Shells	Shell	Weightless	Rigid
Ground Floor Slabs	Shell	Weightless	Concrete f_c =4000psi
Basemat	Solid	Concrete (adjusted)	Concrete f_c =4000psi (adjusted)
Fill Concrete	Solid	Concrete	Concrete f_c =3000psi
Rigid Rim at top of Reactor Mat	Beam	Weightless	Rigid
PCCV stick Rigid Connection	Beam	Weightless	Rigid
Containment Internal Structure Stick Rigid Connection	Beam	Weightless	Rigid
R/B-Fuel Handling Area Stick Rigid Connection	Beam	Weightless	Rigid
BS01 Lumped Mass Rigid Connection	Beam	Weightless	Rigid

Table 3NN-7
Input Material Properties

Structural Component	Concrete Compressive Strength (psi)	Young's Modulus ($x10^5$ ksf)	Poisson's Ratio	Damping OBE
PCCV	7,000	6.86	0.17	3%
R/B including FH/A, and Basement	4,000	5.191	0.17	4%
Containment Internal Structure	4,000	5.191	0.17	4%
Fill Concrete	3,000	4.496	0.17	4%

Table 3NN-8
Adjusted Material Properties of Basement Shear Walls with Openings

Wall Location	Wall Dimensions (ft)			Openings Dimensions (ft)		Stiffness Ratios		Adjusted	
	Thick.	Width	Height	Width	Height	Outplane	Inplane	E (x10^5 ksf)	w (kcf)
CL-1R segment AR-CR	3.33	53.25	27.25	8.33	8.33	0.812	0.800	4.153	0.146
CL-1R segment CR-JR CL-11R segment CR-JR	3.33	188.0	27.25	8.33	8.33	0.902	0.940	4.880	0.146
CL-1R segment JR-KR CL-11R segment JR-KR	3.33	45.33	27.25	6.66	8.33	0.823	0.807	4.189	0.146
CL-1R segment KR-LR CL-11R segment KR-LR	3.33	33.0	27.25	6.66	8.33	0.779	0.738	3.833	0.146
CL-2R segment CR-ER CL-10R segment CR-ER	2.67	55.92	26.58	3,6.6,9	6.6,10,14.41	0.750	0.672	3.490	0.149
CL-2R segment GR-JR CL-10R segment GR-JR	2.67	55.92	26.58	7.5,6.6,3	14.41,10,6.6	0.727	0.610	3.167	0.149
CL-CR segments 1R-2R & 10R-11R	3.33	12.83	26.58	6.66	8.33	0.551	0.676	2.902	0.150
CL-J1R segments 2aR-3R & 9bR-9R	2.67	16.58	25.92	3.33	6.66	0.927	0.814	4.223	0.146
CL-J1R segments 3R-5R & 7R-9R	1.67	31.17	25.92	6.66	8.33	0.950	0.866	4.494	0.146
CL-J1R segments 5R-6R & 6R-7R	1.67	38.83	25.92	6.66	8.33	0.931	0.838	4.353	0.146
CL-K1R segments 1R-2aR & 11R-9bR	2.00	18.32	25.92	3.33	6.66	0.944	0.873	4.530	0.146

Table 3NN-9
Weights Assigned to Basement Structural Members in SASSI FE Model

FE Component	Weight (kips)
EW Exterior Walls	8370
NS Exterior Walls	5871
NS Interior Walls	7337
EW Interior Walls	5167
Basemat	75855
Fill Concrete	47085
Weight assigned to basement	102600
Total Weight including fill concrete	149685

Table 3NN-10
Basement Mass Inertia

Component	Mass ($k\text{-}s^2/ft$)	I_{mx} ($k\text{-}s^2\text{-}ft$)	I_{my} ($k\text{-}s^2\text{-}ft$)	I_{mz} ($k\text{-}s^2\text{-}ft$)	Center of Mass (ft)		
					X	Y	Z
FE Mass	3186.3	16,649,068	30,226,708	46,335,404	-21.71	2.27	-25.10
Lumped Mass	1720.5	1,552,795	6,425,121	7,960,663	25.94	-1.69	-24.92
DCD BS01	4906.8	18,245,342	39,251,208	56,935,818	-5.00	0.88	-25.04

Table 3NN-11
Dynamic Properties of SASSI Model

Response		Characteristic Frequency (Hz)		
Model	**Direction**	**DCD Lumped Mass Stick Model**	**SASSI Above Ground Stick Models**	**SASSI Combined FE Model**
PCCV	NS	4.57	4.59	4.54
		12.93	13.01	12.94
	EW	4.57	4.59	4.52
		12.93	13.04	12.96
	Vertical	12.54	12.62	12.45
		22.96	23.12	23.05
R/B-FH/A	NS	5.29	5.30	5.20
		10.48	10.05	10.15
	EW	6.34	6.17	5.69
		13.13	12.20	11.55
	Vertical	16.94	16.60	15.58
Containment Internal Structure	NS	5.73	5.74	5.71
		9.42	9.35	9.23
	EW	6.25	6.20	6.20
		9.12	9.10	8.99
	Vertical	20.76	20.68	20.12
		25.12	25.95	24.85

Table 3NN-12
Maximum Accelerations in NS Direction

Structure	Lumped Mass	El. (ft)	Site Profile							Env.
			SLB	SBE	SUB	ELB	EBE	EUB	EHB	
PCCV	CV11	230.2	0.496	0.595	0.722	0.495	0.493	0.661	0.653	0.722
	CV10	225.0	0.481	0.586	0.707	0.481	0.485	0.648	0.639	0.707
	CV09	201.7	0.434	0.540	0.629	0.409	0.446	0.582	0.569	0.629
	CV08	173.1	0.384	0.476	0.559	0.346	0.395	0.508	0.505	0.559
	CV07	145.6	0.374	0.407	0.494	0.335	0.341	0.448	0.446	0.494
	CV06	115.5	0.356	0.375	0.417	0.321	0.305	0.374	0.380	0.417
	CV05	92.2	0.324	0.342	0.346	0.295	0.284	0.311	0.321	0.346
	CV04	76.4	0.292	0.306	0.313	0.268	0.260	0.281	0.293	0.313
	CV03	68.3	0.272	0.286	0.293	0.251	0.244	0.264	0.275	0.293
	CV02	50.2	0.223	0.235	0.239	0.207	0.204	0.217	0.227	0.239
	CV01	25.3	0.163	0.159	0.164	0.154	0.147	0.139	0.158	0.164
	CV00	1.9	0.129	0.124	0.128	0.114	0.126	0.123	0.118	0.129
Containment Internal Structure	IC09	139.5	0.913	1.054	1.156	0.819	0.869	0.976	0.911	1.156
	IC08	112.3	0.507	0.574	0.627	0.497	0.494	0.520	0.523	0.627
	IC18	110.8	0.482	0.546	0.595	0.477	0.470	0.493	0.499	0.595
	IC61	96.6	0.266	0.305	0.349	0.233	0.301	0.287	0.266	0.349
	IC62	96.6	0.272	0.301	0.347	0.238	0.300	0.294	0.267	0.347
	IC05	76.4	0.224	0.252	0.278	0.189	0.237	0.219	0.209	0.278
	IC07	76.4	0.224	0.252	0.278	0.189	0.237	0.219	0.209	0.278
	IC15	59.2	0.199	0.207	0.221	0.164	0.195	0.193	0.187	0.221
	IC04	50.2	0.186	0.189	0.201	0.155	0.178	0.177	0.176	0.201
	IC14	45.7	0.177	0.179	0.189	0.148	0.169	0.169	0.162	0.189
	IC03	35.6	0.156	0.159	0.163	0.135	0.151	0.151	0.150	0.163
	IC02	25.3	0.139	0.139	0.142	0.127	0.135	0.133	0.132	0.142
	IC01	16.0	0.132	0.132	0.132	0.120	0.131	0.128	0.124	0.132
	IC00	1.9	0.129	0.124	0.128	0.114	0.127	0.124	0.119	0.129
R/B-FH/A	FH08	154.5	0.606	0.701	0.780	0.586	0.892	0.742	0.723	0.892
	FH07	125.7	0.384	0.444	0.506	0.396	0.557	0.450	0.472	0.557
	RE05	115.5	0.218	0.250	0.277	0.210	0.252	0.325	0.260	0.325
	RE04	101.0	0.192	0.213	0.254	0.175	0.209	0.307	0.228	0.307
	RE41	101.0	0.205	0.229	0.263	0.189	0.217	0.303	0.238	0.303
	RE42	101.0	0.209	0.232	0.283	0.190	0.225	0.298	0.236	0.298
	FH06	101.0	0.247	0.289	0.322	0.239	0.331	0.284	0.295	0.331
	RE03	76.4	0.178	0.191	0.222	0.162	0.189	0.233	0.195	0.233
	RE02	50.2	0.163	0.173	0.183	0.144	0.174	0.190	0.163	0.190
	RE01	25.3	0.144	0.154	0.159	0.136	0.155	0.157	0.136	0.159
	RE00	3.6	0.127	0.125	0.127	0.115	0.118	0.126	0.121	0.127

Table 3NN-13
Maximum Accelerations in EW Direction

Structure	Lumped Mass	El. (ft)	Site Profile							Env.
			SLB	SBE	SUB	ELB	EBE	EUB	EHB	
PCCV	CV11	230.2	0.565	0.713	0.854	0.538	0.552	0.704	0.691	0.854
	CV10	225.0	0.555	0.699	0.837	0.532	0.541	0.689	0.678	0.837
	CV09	201.7	0.510	0.635	0.757	0.506	0.491	0.620	0.616	0.757
	CV08	173.1	0.445	0.544	0.644	0.427	0.420	0.526	0.528	0.644
	CV07	145.6	0.389	0.448	0.526	0.366	0.349	0.427	0.439	0.526
	CV06	115.5	0.321	0.347	0.405	0.298	0.276	0.327	0.341	0.405
	CV05	92.2	0.283	0.306	0.319	0.253	0.237	0.269	0.280	0.319
	CV04	76.4	0.249	0.276	0.280	0.220	0.212	0.237	0.243	0.280
	CV03	68.3	0.230	0.259	0.261	0.202	0.199	0.221	0.223	0.261
	CV02	50.2	0.185	0.214	0.213	0.163	0.169	0.188	0.181	0.214
	CV01	25.3	0.133	0.151	0.153	0.120	0.136	0.139	0.128	0.153
	CV00	1.9	0.119	0.118	0.117	0.102	0.111	0.120	0.111	0.120
Containment Internal Structure	IC09	139.5	0.920	1.034	1.108	0.790	0.965	1.054	0.937	1.108
	IC08	112.3	0.511	0.561	0.622	0.480	0.540	0.569	0.552	0.622
	IC18	110.8	0.484	0.532	0.593	0.461	0.514	0.541	0.527	0.593
	IC61	96.6	0.333	0.353	0.373	0.241	0.279	0.294	0.287	0.373
	IC62	96.6	0.333	0.353	0.373	0.241	0.279	0.294	0.287	0.373
	IC05	76.4	0.254	0.260	0.262	0.189	0.218	0.223	0.232	0.262
	IC07	76.4	0.256	0.264	0.266	0.198	0.212	0.216	0.226	0.266
	IC15	59.2	0.192	0.197	0.204	0.167	0.182	0.184	0.200	0.204
	IC04	50.2	0.175	0.180	0.182	0.159	0.173	0.170	0.183	0.183
	IC14	45.7	0.164	0.168	0.168	0.150	0.164	0.159	0.171	0.171
	IC03	35.6	0.144	0.146	0.146	0.130	0.146	0.134	0.143	0.146
	IC02	25.3	0.126	0.131	0.128	0.112	0.129	0.127	0.124	0.131
	IC01	16.0	0.123	0.124	0.123	0.107	0.119	0.123	0.118	0.124
	IC00	1.9	0.119	0.118	0.117	0.102	0.111	0.120	0.112	0.120
R/B-FH/A	FH08	154.5	0.350	0.413	0.455	0.320	0.425	0.482	0.462	0.482
	FH07	125.7	0.292	0.304	0.343	0.264	0.327	0.442	0.350	0.442
	RE05	115.5	0.271	0.317	0.383	0.247	0.308	0.337	0.333	0.383
	RE04	101.0	0.230	0.267	0.337	0.234	0.267	0.285	0.284	0.337
	RE41	101.0	0.246	0.306	0.382	0.247	0.285	0.326	0.319	0.382
	RE42	101.0	0.241	0.288	0.364	0.242	0.272	0.310	0.306	0.364
	FH06	101.0	0.245	0.247	0.282	0.223	0.267	0.287	0.266	0.287
	RE03	76.4	0.198	0.206	0.229	0.194	0.217	0.221	0.207	0.229
	RE02	50.2	0.174	0.179	0.185	0.161	0.180	0.195	0.168	0.195
	RE01	25.3	0.149	0.151	0.146	0.137	0.144	0.167	0.139	0.167
	RE00	3.6	0.126	0.125	0.125	0.114	0.115	0.136	0.113	0.136

Table 3NN-14
Maximum Accelerations in Vertical Direction

Structure	Lumped Mass	El. (ft)	Site Profile							Env.
			SLB	SBE	SUB	ELB	EBE	EUB	EHB	
PCCV	CV11	230.2	0.437	0.482	0.515	0.362	0.394	0.626	0.430	0.626
	CV10	225.0	0.388	0.420	0.448	0.323	0.341	0.543	0.334	0.543
	CV09	201.7	0.313	0.327	0.349	0.230	0.240	0.398	0.249	0.398
	CV08	173.1	0.271	0.283	0.302	0.185	0.220	0.327	0.212	0.327
	CV07	145.6	0.255	0.266	0.284	0.174	0.212	0.303	0.203	0.303
	CV06	115.5	0.227	0.237	0.253	0.163	0.196	0.263	0.187	0.263
	CV05	92.2	0.201	0.209	0.223	0.152	0.179	0.232	0.170	0.232
	CV04	76.4	0.180	0.188	0.201	0.144	0.166	0.209	0.158	0.209
	CV03	68.3	0.169	0.177	0.188	0.138	0.159	0.196	0.149	0.196
	CV02	50.2	0.148	0.154	0.159	0.127	0.141	0.166	0.132	0.166
	CV01	25.3	0.128	0.132	0.133	0.117	0.122	0.130	0.120	0.133
	CV00	1.9	0.110	0.112	0.113	0.111	0.110	0.108	0.122	0.122
Containment Internal Structure	IC09	139.5	0.199	0.220	0.264	0.242	0.232	0.275	0.249	0.275
	IC08	112.3	0.192	0.214	0.253	0.231	0.222	0.263	0.235	0.263
	IC18	110.8	0.190	0.213	0.252	0.229	0.220	0.261	0.233	0.261
	IC61	96.6	0.160	0.181	0.205	0.176	0.180	0.203	0.198	0.205
	IC62	96.6	0.160	0.182	0.209	0.173	0.178	0.208	0.195	0.209
	IC05	76.4	0.121	0.133	0.146	0.144	0.143	0.163	0.134	0.163
	IC07	76.4	0.157	0.178	0.208	0.181	0.184	0.204	0.178	0.208
	IC15	59.2	0.112	0.122	0.132	0.131	0.129	0.146	0.123	0.146
	IC04	50.2	0.108	0.117	0.126	0.123	0.122	0.136	0.117	0.136
	IC14	45.7	0.106	0.113	0.122	0.119	0.117	0.131	0.117	0.131
	IC03	35.6	0.106	0.107	0.112	0.116	0.112	0.118	0.119	0.119
	IC02	25.3	0.107	0.109	0.109	0.114	0.108	0.107	0.119	0.119
	IC01	16.0	0.109	0.111	0.111	0.112	0.108	0.105	0.121	0.121
	IC00	1.9	0.110	0.112	0.113	0.111	0.110	0.107	0.122	0.122
R/B-FH/A	FH08	154.5	0.318	0.361	0.392	0.363	0.401	0.501	0.408	0.501
	FH07	125.7	0.290	0.330	0.358	0.331	0.373	0.473	0.374	0.473
	RE05	115.5	0.264	0.294	0.312	0.262	0.306	0.325	0.322	0.325
	RE04	101.0	0.245	0.273	0.286	0.241	0.291	0.308	0.309	0.309
	RE41	101.0	0.314	0.354	0.371	0.348	0.420	0.512	0.400	0.512
	RE42	101.0	0.259	0.292	0.325	0.274	0.309	0.354	0.305	0.354
	FH06	101.0	0.265	0.300	0.332	0.302	0.342	0.438	0.345	0.438
	RE03	76.4	0.131	0.140	0.148	0.164	0.182	0.228	0.174	0.228
	RE02	50.2	0.124	0.127	0.127	0.153	0.164	0.205	0.154	0.205
	RE01	25.3	0.117	0.119	0.119	0.143	0.147	0.172	0.141	0.172
	RE00	3.6	0.111	0.114	0.115	0.135	0.134	0.139	0.126	0.139

Table 3NN-15
SASSI Results for R/B-PCCV-Containment Internal Structure Seismic Response

SSI Effect	Observed Response
Rock Subgrade	The rock subgrade, due to its high stiffness, has insignificant SSI effect on the seismic response of PCCV, R/B, and containment internal structures. The structural natural frequencies characterize the response obtained from SASSI analyses of the surface foundation.
Backfill Embedment	The embedment affects the overall response of the PCCV, R/B, and containment internal structure. In general, the horizontal response of the structures is reduced due to the dissipation of energy in the backfill. The reduction is more pronounced for cases of soft backfill, which has higher values of strain-compatible material damping.
Motion Scattering Effects	Motion scattering effects are inherent in the SASSI analysis results. The dynamic properties mismatch between the backfill and the rock results in reflection of the seismic waves within the backfill stratum. The response of the backfill is characterized by multiple modes that magnify the response of the structure as their frequencies approach the structural frequencies. These resonance effects are most pronounced in the vertical direction is for stiffer backfill with low material damping.
Basement Flexibility	The flexibility of the basement shear walls has some effect on the structural response. Due to the flexibility of the shear walls under the R/B, and FH/A, their response at ground elevation is decoupled from the response of PCCV and containment internal structures that are supported directly on the central thick portion of the basemat.

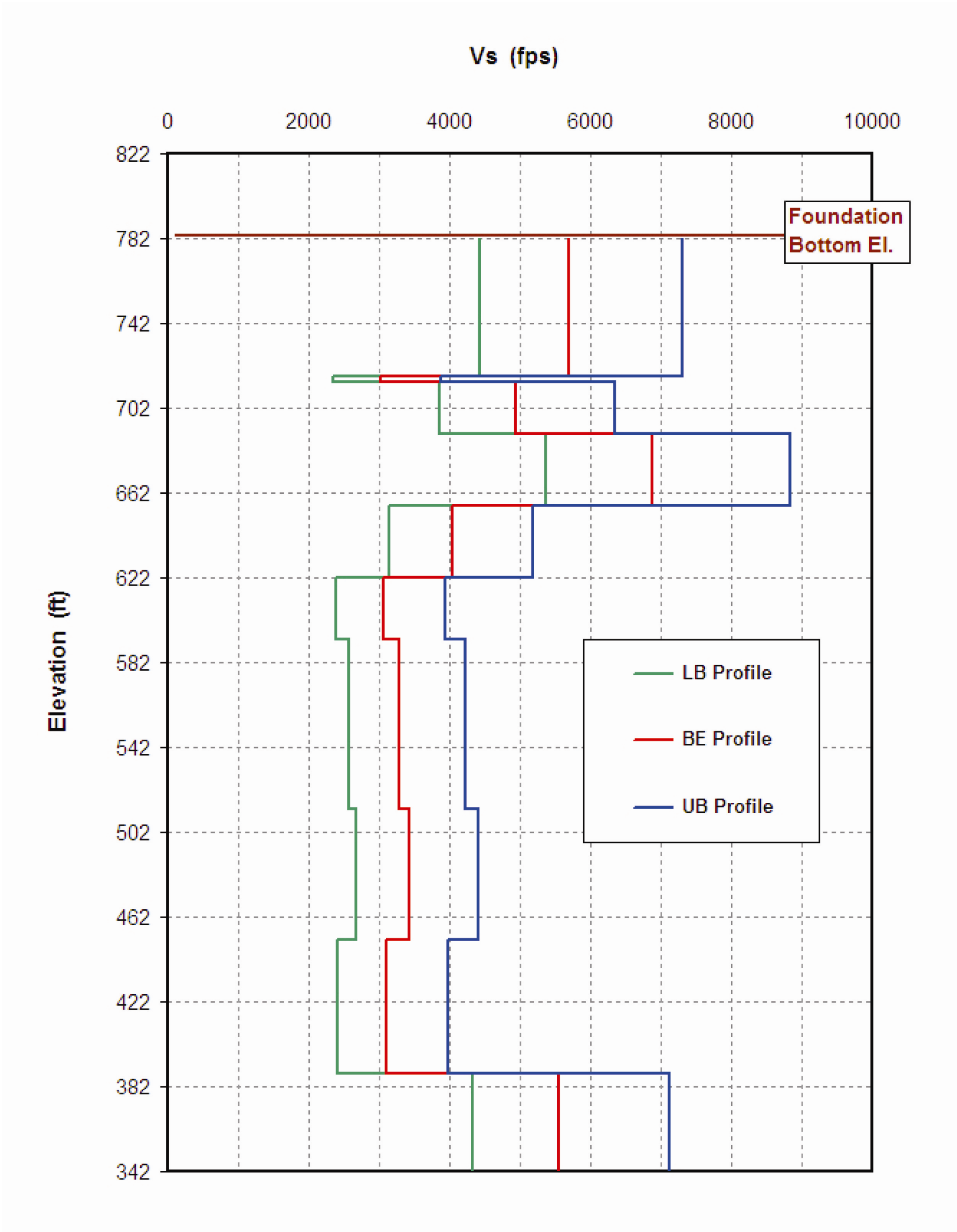

Figure 3NN-1 Rock Subgrade S-Wave Velocity Profiles

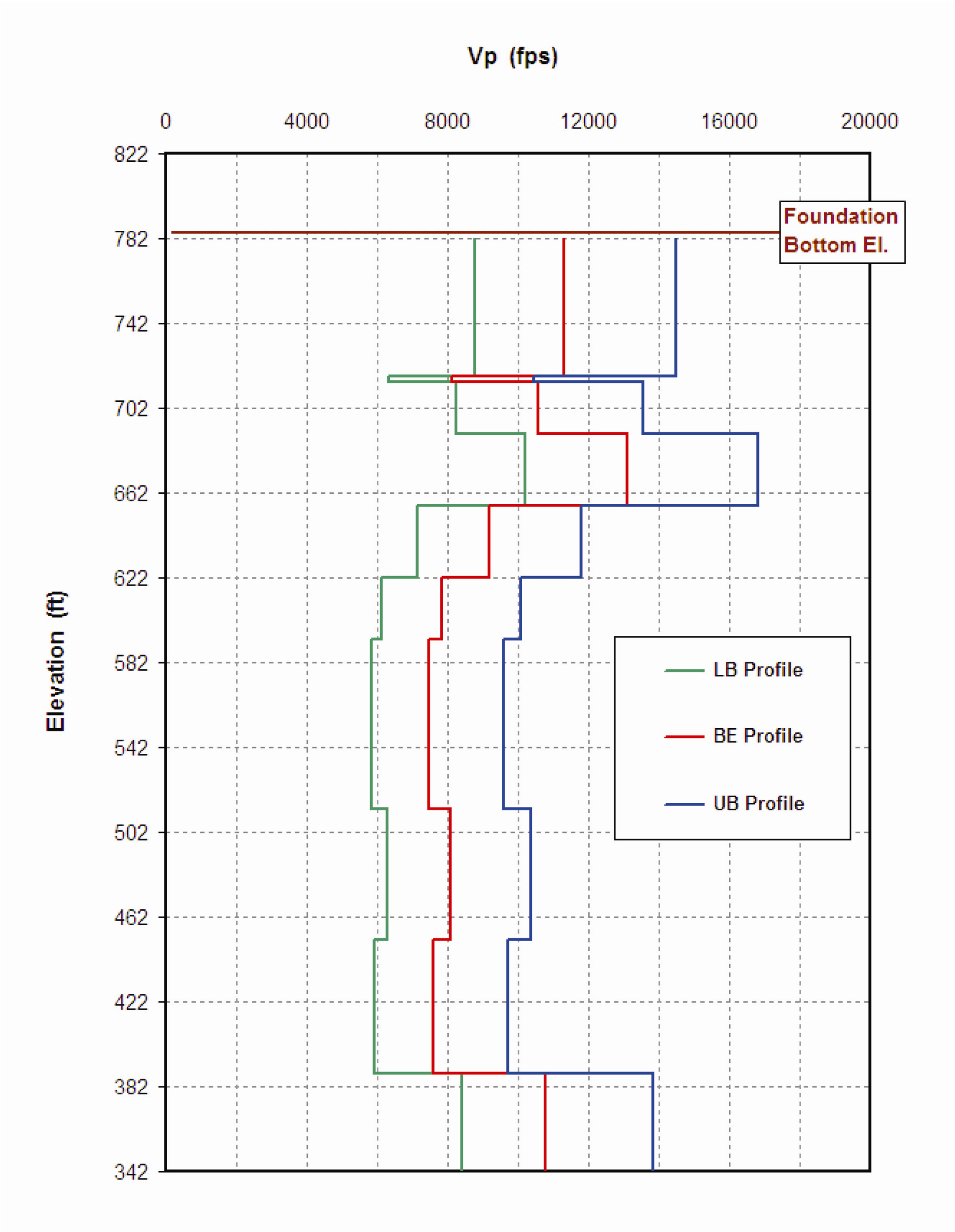

Figure 3NN-2 Rock Subgrade P-Wave Velocity Profiles

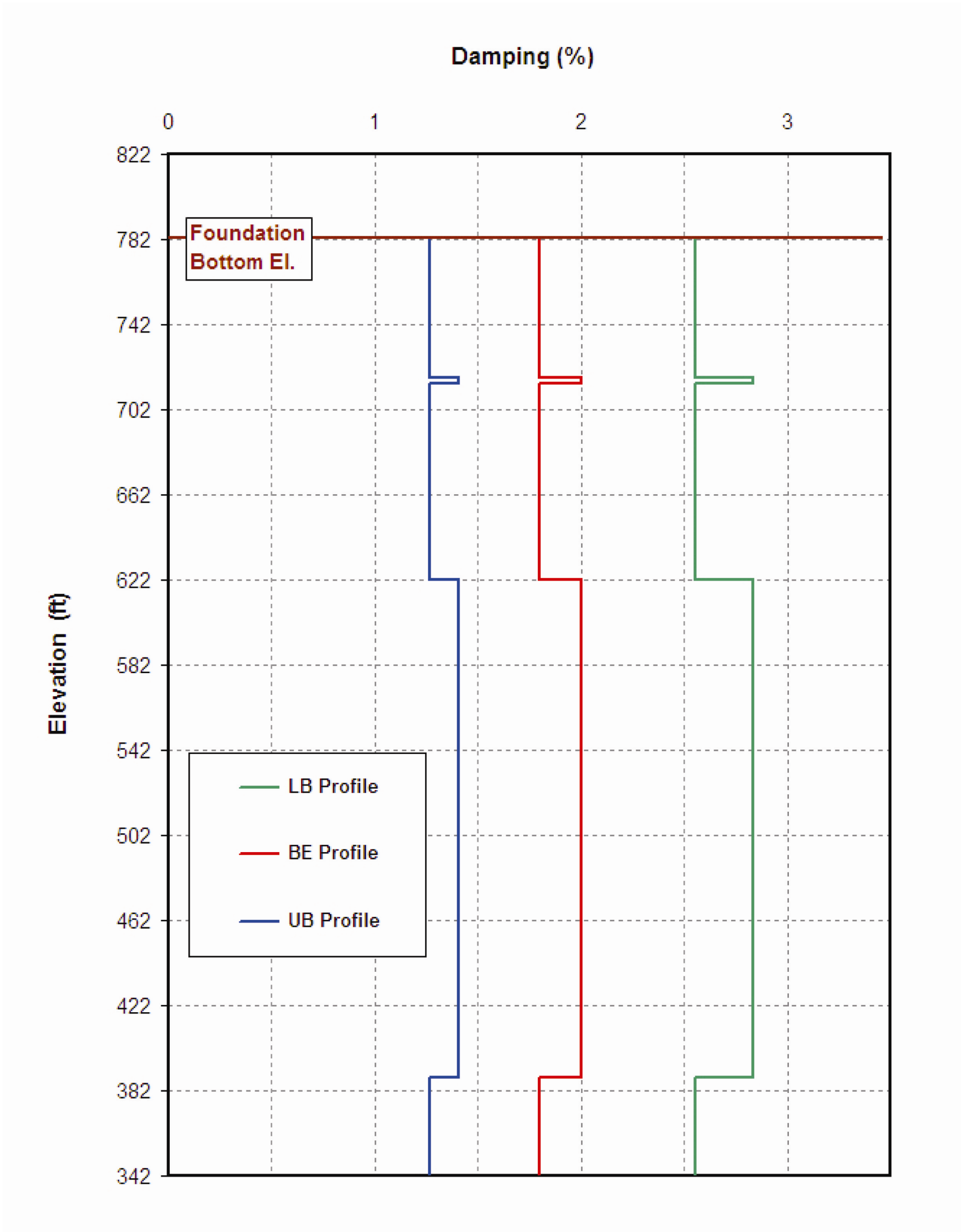

Figure 3NN-3 Rock Subgrade Damping Profiles

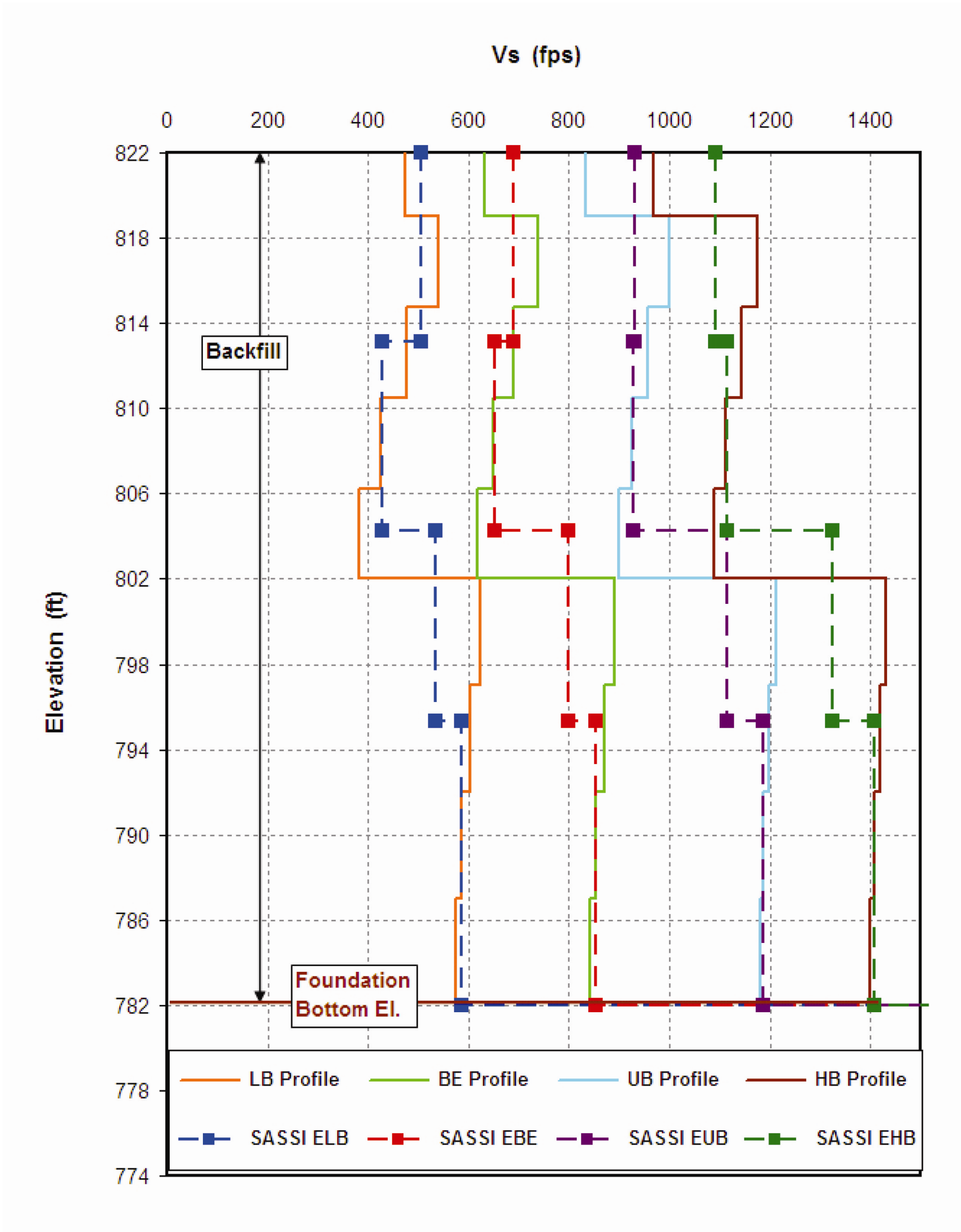

Figure 3NN-4 Backfill Strain-Compatible S-Wave Velocity Profiles

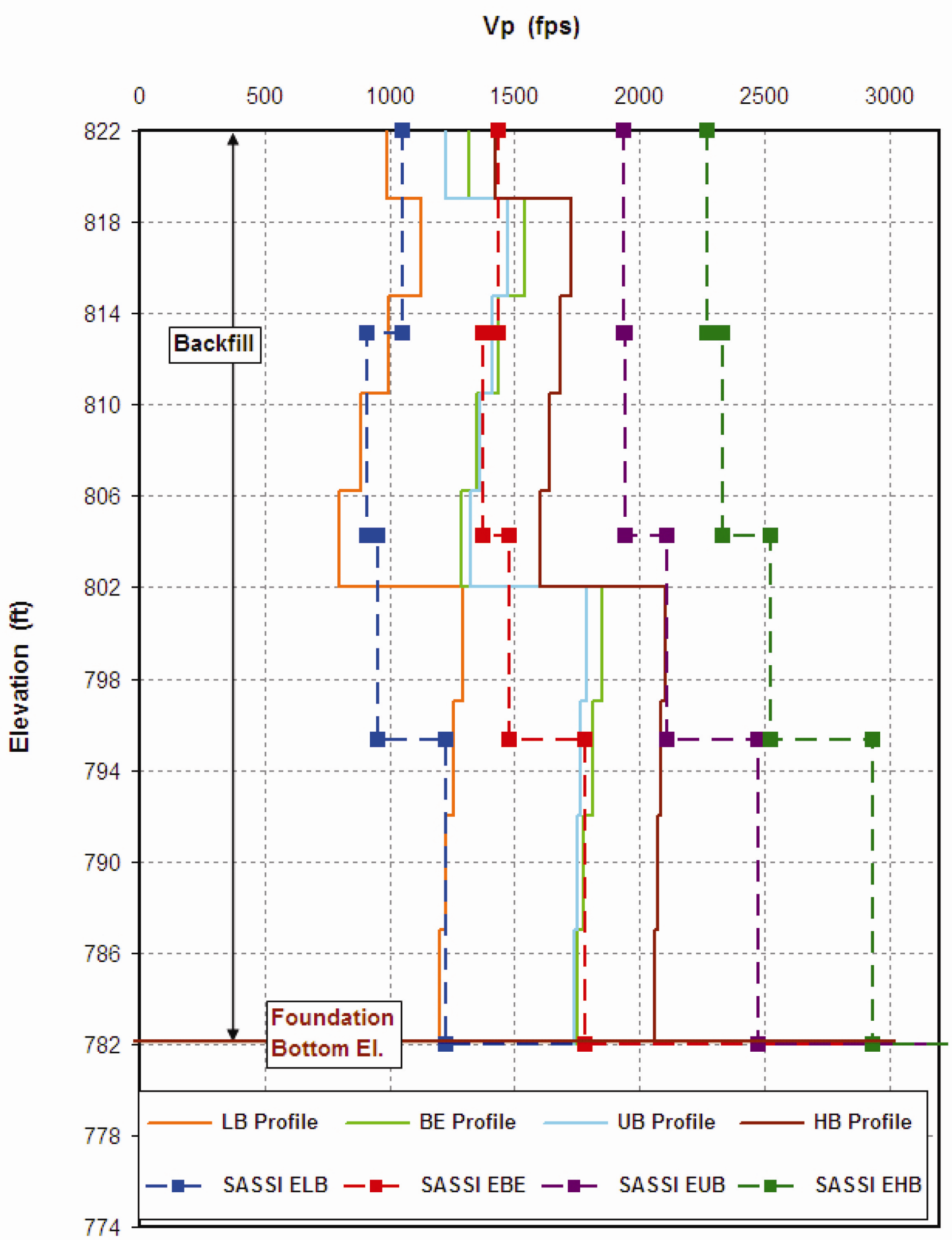

Figure 3NN-5 Backfill Strain-Compatible P-Wave Velocity Profiles

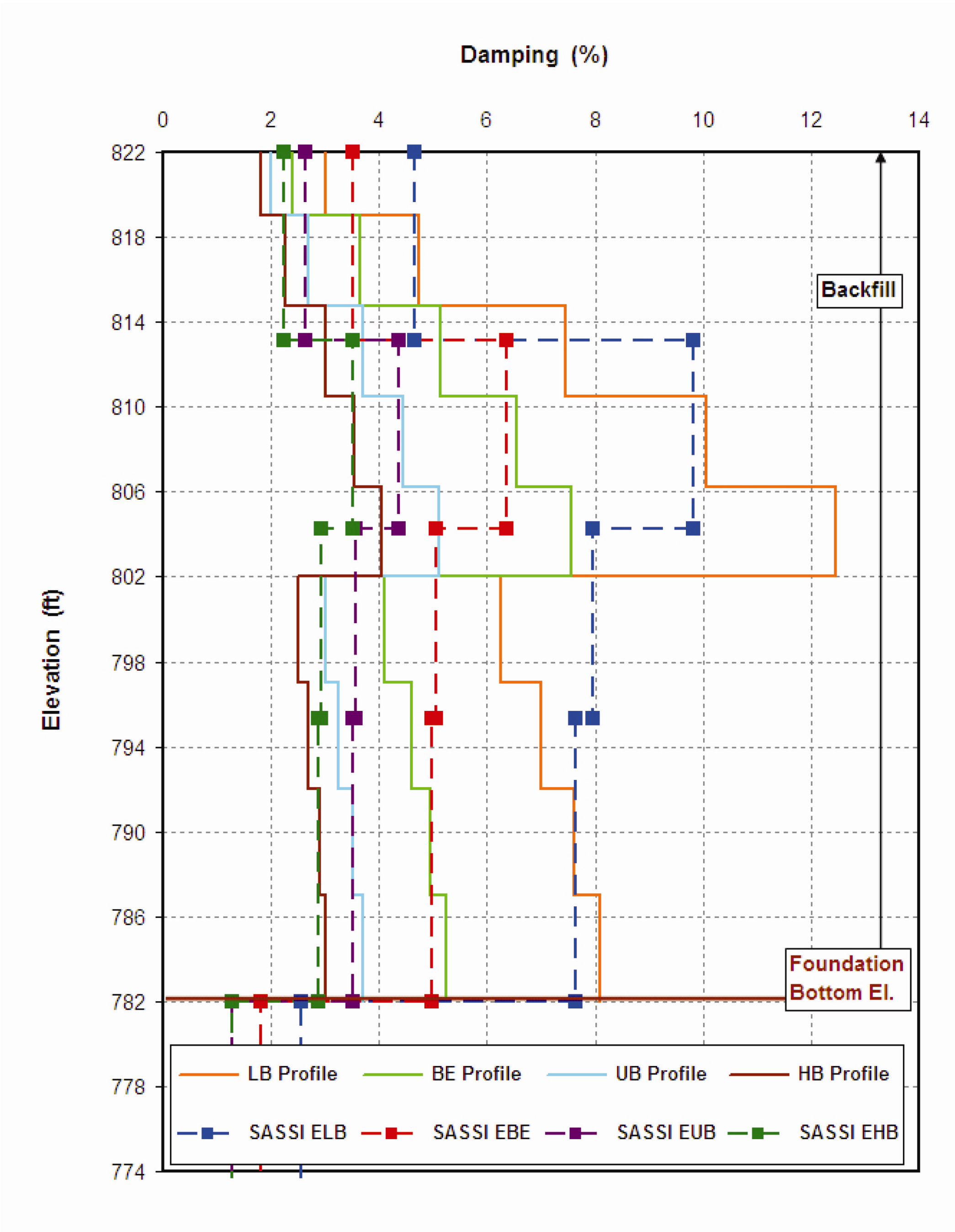

Figure 3NN-6 Backfill Strain-Compatible Damping Profiles