

Updated Seismic Shake Table Test Plan

Spent Fuel and Waste Disposition

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EXECUTIVE SUMMARY

This report documents the updated seismic shake table test plan. The report describes the shake table inputs (ground motions), test hardware, shake table facility, friction experiment, and proposed instrumentation.

Ground Motions

The ground motions are the most important inputs into the shake table test. Development of ground motion inputs was a challenging task because they must be representative of the range of seismotectonic and other conditions that any site in the Western U.S. (WUS) or Central and Eastern U.S. (CEUS) might entail. A new methodology was developed by SC Solutions (Dr. Norm Abrahamson) and SC Solutions consultants in collaboration with Sandia National Laboratories (SNL) and Pacific Northwest National Laboratory (PNNL) to define the representative free-field ground motions.

The free-field horizontal spectral shapes were developed for hard rock, soft rock, and soil conditions for CEUS and soft rock and soil conditions for WUS for different seismic scenarios (Magnitude-Distance pairs). The selection of the scenario events was based on the observed controlling earthquakes for sites located in the CEUS and WUS, separately. The free-field hard rock ground motions were used to define 55 shake table inputs for the CEUS hard rock conditions.

At the soft rock and soil sites, the top of the pad motions differ from the free-field ground motions due to the amplification in the soft rock/soil and to the soil-structure interaction (SSI). The SSI analysis was performed by SC Solutions in collaboration with SNL and PNNL to define the time histories on the pad that incorporate the effects of SSI and pad flexibility. The SSI analysis was conducted for the representative soil and soft rock conditions in CEUS and WUS and for the representative pad configurations. A total of 70-time histories representative of the top of the pad motions at the soft rock and soil sites in CEUS and WUS was proposed for the test.

Test Hardware

The main part of the test unit is the NUHOMS 32 PTH2 dry storage canister. For the shake table test the canister will be loaded with four surrogate assemblies and 28 dummy assemblies. The estimated loaded weight of the NUHOMS 32 PTH2 canister is 101,252 lbs.

Two surrogate assemblies used for the test will be a 16x16 CE PLUS7 and a 17x17 Westinghouse. An additional 16x16 surrogate assembly will be manufactured for the test. One 17x17 Westinghouse surrogate assembly will be the SNL surrogate assembly that was slightly damaged in the 30 cm drop test.

The dummy assembly designs were finalized and are being manufactured. Twenty-six dummy assemblies will have a cross-section of 207 mm. One dummy assembly will have a cross-section of 210 mm while the other will have a cross-section of 214 mm.

The steel skeleton of the vertical cask mockup was manufactured, delivered to University of California in San Diego (UCSD), and filled with concrete in June 2022. The



vertical cask mockup is located on the concrete pad next to the shake table and is ready for use.

For the horizontal test configuration, either an Advanced Horizontal Storage Module (AHSM) base unit from San Onofre Nuclear Generating Station (SONGS) will be used or a horizontal storage module (HSM) mockup will be manufactured.

The total weight of the loaded vertical cask will be 324,645 lbs. The total weight of the loaded HSM will be approximately 271,252 lbs (AHSM) or 226,252 lbs (HSM mockup).

Shake Table Facility

A preliminary agreement to conduct the seismic test was made with the world's largest outdoor earthquake simulator, the large capacity high-performance outdoor shake table (LHPOST6), operated by structural engineers at UCSD. The LHPOST6 is the only facility in the U.S. that can accommodate the large size and weight of the test units. The test is scheduled for the spring of 2023.

Friction Experiment

Concrete will be poured on the shake table surface before the test to provide friction between the cask and the concrete representative of the independent spent fuel storage installation (ISFSI) pads. A friction experiment is being conducted at the University of New Mexico (UNM) to determine steel to concrete static and dynamic friction coefficients of concrete samples with different surface roughness. Two concrete surface finishes will be selected for the shake table test based on the results of the experiment.

Instrumentation

The proposed instrumentation was guided by the results of the previous experiments and the pre-test modeling study.

The test unit will be instrumented with a large number of sensors (accelerometers, strain gauges, and dynamic inclinometers) to capture all the important differences in the responses to the seismic excitations. The total number of channels will be 296.

The extreme low and ultra-low pressure paper sheets (pressure range from 7.2 to 85 psi) will be installed between the rods of the surrogate assemblies in two long spans to register rod to rod contact if such contact occurs during the test.

High-speed cameras will be installed to record the test unit behaviour from different viewpoints.

High-speed optical imaging and digital image correlation (DIC) will be used to obtain representative snapshots of the test unit velocity during the test.

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CONTENTS

EXECUTIVE SUMMARY	iii
ACKNOWLEDGEMENTS.....	v
LIST OF FIGURES	ix
LIST OF TABLES.....	xiv
REVISION HISTORY.....	xv
ACRONYMS.....	xvii
1. INTRODUCTION.....	19
2. SHAKE TABLE INPUTS	23
2.1 Conceptual Description of the Problem	23
2.2 Development of Free-Field Ground Motions.....	28
2.2.1 Methodology.....	28
2.2.2 Results.....	31
2.3 Development of Ground Motions for Soil and Soft Rock Sites.....	50
2.3.1 Vertical Cask Modeling Results	57
2.3.2 Horizontal Storage Modules	74
2.4 Shake Table Input Summary.....	76
3. TEST HARDWARE	78
3.1 NUHOM 32 PTH2 Dry Storage Canister	78
3.2 Surrogate and Dummy Assemblies.....	80
3.2.1 Surrogate Fuel assemblies.....	80
3.2.2 Dummy Fuel Assemblies.....	83
3.3 Dry Storage Overpacks	85
3.3.1 Horizontal Storage Overpack.....	85
3.3.2 Vertical Storage Overpack.....	87
4. SHAKE TABLE FACILITY.....	94
5. FRICTION EXPERIMENT	97
6. INSTRUMENTATION.....	105
6.1 Results of the Previous Experiments.....	105
6.2 Results of the Pre-Test Modeling.....	107
6.3 Proposed Instrumentation	111
6.3.1 Data Acquisition System.....	111
6.3.2 Accelerometers.....	113
6.3.3 Strain Gauges	115
6.3.4 Dynamic Inclinometers	115
6.3.5 Pressure Paper.....	115
6.3.6 Load Cells	117

6.3.7	High-Speed Cameras.....	117
6.3.8	High-Speed Optical Imaging	117
6.3.9	Proposed Instrumentation Summary	117
7.	SUMMARY	118
8.	REFERENCES	122
Appendix A.	ISFSI Satellite Images.....	126
A.1.	CEUS Soil.....	127
A.2.	CEUS Soft Rock	140
A.3.	WUS Soil and Soft Rock	147
Appendix B.	Soil-structure interaction SC Solutions Report.....	151

LIST OF FIGURES

Figure 1-1.	Dry Storage Systems Loaded in U.S. as of June 2022 [1].....	19
Figure 1-2.	Locations of the Independent Spent-Fuel Storage Installations in the U.S. [2].....	21
Figure 1-3.	Seismic Shake Table Test Roadmap.	22
Figure 2-1.	Conceptual Representation of a Dry Storage System Located on Hard Rock and Soft Rock/Soil for the Shake Table Test.	24
Figure 2-2.	Site Conditions and Screening Reports PGAs at the CEUS NPP Sites.....	25
Figure 2-3.	Depth to Basement at the Soft Rock and Soil Sites in CEUS.	26
Figure 2-4.	Depth to Bedrock in Central and Eastern U.S.	27
Figure 2-5.	Depth to Bedrock in WUS.....	28
Figure 2-6.	Seismotectonic Regions in CEUS and Earthquakes in the CEUS Seismic Source Characterization Project Catalog [14].	29
Figure 2-7.	PGA Rock Seismic Hazard Curves for the Seven Test Sites.	30
Figure 2-8.	Median Ground Motion Spectra for CEUS Sites for Hard Rock Site Conditions.....	32
Figure 2-9.	Median Ground Motion Spectra for CEUS Sites for Soft Rock Site Conditions.	32
Figure 2-10.	Median Ground Motion Spectra for CEUS Sites for Soil Site Conditions.....	33
Figure 2-11.	Median Ground Motion Spectra for WUS Sites with Soft Rock Conditions.....	34
Figure 2-12.	Median Ground Motion Spectra for WUS Sites with Soil Conditions.....	34
Figure 2-13.	Vertical to Horizontal (V/H) Ratio for CEUS Sites for Hard Rock Site Conditions.....	35
Figure 2-14.	Vertical to Horizontal (V/H) Ratio for CEUS Sites for Soft Rock Site Conditions.....	35
Figure 2-15.	Vertical to Horizontal (V/H) Ratio for CEUS Sites for Soil Site Conditions.	36
Figure 2-16.	Vertical to Horizontal (V/H) Ratio for WUS Sites for Soft Rock Site Conditions.	36
Figure 2-17.	Vertical to Horizontal (V/H) Ratio for WUS Sites for Soil Site Conditions.....	37
Figure 2-18.	Cumulative Weights of the PGA Scaling Factors for CEUS Hard Rock Site Conditions.	38
Figure 2-19.	Cumulative Weights of the PGA Scaling Factors for CEUS Soft Rock Site Conditions.	38
Figure 2-20.	Cumulative Weights of the PGA Scaling Factors for CEUS Soil Site Conditions.	39
Figure 2-21.	PGAs from New GMRS Compared to 84th Percentile of 5E-04 and 5E-05 PGAs Calculated for Hard Rock Site Conditions.	40
Figure 2-22.	PGAs from New GMRS Compared to 84th Percentile of 5E-04 and 5E-05 PGAs Calculated for Soft Rock Site Conditions.....	41
Figure 2-23.	PGAs from New GMRS Compared to 84th Percentile of 5E-04 and 5E-05 PGAs Calculated for Soil Site Conditions.	41
Figure 2-24.	PGA Percentiles from New GMRS Corresponding to 84th Percentiles of 5E-05 PGAs Calculated for Soft Rock Site Conditions.	42

Figure 2-25.	PGAs Corresponding to 5E-04 and 5E-05 Seismic Hazard Level for Soft Rock and Soil Site Conditions in WUS.	43
Figure 2-26.	Horizontal Time Histories for CEUS Hard Rock Conditions for 5.5 Magnitude Earthquake at 15 km (Seed: L'Aquila (aftershock 1) Italy, 2009).....	46
Figure 2-27.	Vertical Time Histories for CEUS Hard Rock Conditions for 5.5 Magnitude Earthquake at 15 km (Seed: L'Aquila (aftershock 1) Italy, 2009).....	46
Figure 2-28.	Hard Rock Horizontal Spectra for 3 Earthquake Scenarios and Scenario Considered in NUREG/CR-6865 [18].....	47
Figure 2-30.	PGAs Specified in Hard Rock Shake Table Test Case (Table 2-10).....	50
Figure 2-31.	Soil-Structure Interaction Analysis Diagram.	51
Figure 2-32.	CEUS Representative Pad Configurations.	52
Figure 2-33.	WUS Representative Pad Configurations.....	53
Figure 2-34.	Clinton Power Station ISFSI (left) and Nine Mile Point Nuclear Generating Station ISFSI (right) (Satellite Image from Google Maps).	53
Figure 2-35.	CEUS Base Shear Velocity Profiles for Soil and Soft Rock Sites.	55
Figure 2-36.	WUS Base Shear Velocity Profiles for Soil and Soft Rock Sites.....	56
Figure 2-37.	Examples of Strain Compatible Shear Velocity Profiles for CEUS (left) and WUS (right).....	56
Figure 2-38.	Dimensions of the Vertical Cask.	57
Figure 2-39.	Detailed View of the Pad Corner Cask Model Showing Pad and Cask Mesh.	58
Figure 2-40.	An Example of the Mesh of a Fully-Loaded Pad with Vertical Casks.....	58
Figure 2-41.	Cask Monitoring Points.	59
Figure 2-42.	Scenario 1 Pad Response Spectra in X Direction for the Fully Loaded Pad.	59
Figure 2-43.	Scenario 1 Pad Response Spectra in Y Direction for the Fully Loaded Pad.	60
Figure 2-44.	Scenario 1 Pad Response Spectra in Z Direction for the Fully Loaded Pad (Time History 1).....	60
Figure 2-45.	Scenario 1 Maximum Accelerations on the Pad in Different Time Histories in X, Y, and Z Directions.	61
Figure 2-46.	Scenario 1 Maximum Spectral Accelerations and PGAs in Z Direction on the Fully Loaded Pad (Time History 1).....	61
Figure 2-47.	Locations on the Pad with the Maximum Z Acceleration in CEUS Scenarios.	62
Figure 2-48.	Locations on the Pad with the Maximum Z Acceleration in WUS Scenarios.....	63
Figure 2-49.	Maximum Z Accelerations on the Pad in CEUS Soft Rock Scenario 6 (PGA 0.29g), Time History 2.	63
Figure 2-50.	Maximum Z Accelerations on the Pad in WUS Diablo Canyon Scenario 13 (PGA 0.92g), Time History 1.	64
Figure 2-51.	Spectral Shapes in Five Time Histories at the Locations with max Z Accelerations on Fully Loaded (Configuration 1) and Partially Loaded (Configuration 4) Pad, CEUS Soil Scenario 1.	65

Figure 2-52.	Amplification in X, Y, and Z Directions in CEUS Soil and Soft Rock Scenarios.	68
Figure 2-53.	Amplification in X, Y, and Z Directions in WUS Soil and Soft Rock Scenarios.	69
Figure 2-54.	Peak Frequencies in CEUS and WUS Soil and Soft Rock Scenarios.	70
Figure 2-55.	Maximum Amplification in CEUS and WUS Soil and Soft Rock Scenarios.	70
Figure 2-56.	Scenario 1, TH5 (CEUS Soil, M 5.5, D 15 km, PGA 0.56 g) Acceleration and Displacement Time Histories.	71
Figure 2-57.	Scenario 12, TH1 (WUS Soft Rock, M 7.5, D 5 km, PGA 0.52 g) Acceleration and Displacement Time Histories.	72
Figure 2-58.	X, Y, and Z Displacements in CEUS Soil and Soft Rock Scenarios.	73
Figure 2-59.	X, Y, and Z Displacements in CEUS Soil and Soft Rock Scenarios.	73
Figure 2-60.	Temporal Displacement Traces in X-Y Plane in CEUS Soft Rock Scenario 7.	74
Figure 2-61.	Temporal Displacement Traces in X-Y Plane in WUS Soft Rock Scenario 12.	74
Figure 2-62.	Representative HSM Configuration.	75
Figure 2-63.	Single HSM Schematics.	75
Figure 2-64.	Fragment of the Seismic Shake Table Test Roadmap Related to the Shake Table Input Development.	76
Figure 2-65.	Mineral (VA) Earthquake Time Histories, Containment Basemat [18].	77
Figure 3-1.	NUHOMS 32 PTH2 Dry Storage Canisters at SNL Facility.	78
Figure 3-2.	NUHOMS 32 PTH2 Schematics.	79
Figure 3-3.	NUHOMS 32 PTH2 Basket. Square openings are known as “basket tubes”.	80
Figure 3-4.	NUHOM 32 PTH2 Basket Tube Measurement.	80
Figure 3-5.	CE PLUS7 16x16 and Westinghouse 17x17 Fuel Assembly Cross-Sectional View.	81
Figure 3-6.	Photos of PLUS7 CE16x16 (left) and WEC 17x17 (right).	82
Figure 3-7.	SNL 17x17 Surrogate Assembly (left) and the Spacer Grid with Largest Deformation (right).	83
Figure 3-8.	Dummy Assembly Overall View.	84
Figure 3-9.	Dummy Assembly Main Parts.	85
Figure 3-10.	Photo of AHSMs at SONGs.	86
Figure 3-11.	AHSM Tied to the Shake Table.	87
Figure 3-12.	Preliminary Design of a Simplified Horizontal Storage Overpack.	87
Figure 3-13.	Vertical Cask Over All View and Cross-Sectional View.	89
Figure 3-14.	Inner Shell of the Cask at the Manufacturing Facility in Colorado Springs.	90
Figure 3-15.	Partially Assembled Cask (left) and Fully Assembled Cask (right) Loaded on the Truck for Transport to UCSD (CA).	90
Figure 3-16.	Cask Arrival to the Shake Table Facility at the UCSD.	91
Figure 3-17.	Cask Unloading al to the Shake Table Facility at the UCSD.	91

Figure 3-18.	Pouring Concrete into the Cask (top and bottom left) and Filled with Concrete Cask (bottom right).....	92
Figure 3-19.	Completed Vertical Cask Covered with the Tarp (left) and Concrete Samples (right).....	93
Figure 3-20.	Vertical Test Unit Components.	93
Figure 3-21.	Vertical Cask Mockup (left) and HI_STAR 100 Vertical Overpack (right).	94
Figure 4-1.	Vertical Cask Mockup at the LHPOST6 (UCSD).....	95
Figure 4-2.	Comparison of Target and Achieved Tri-Axial 1994 Northridge Earthquake Accelerations (A) and Response Spectra (B).	97
Figure 4-3.	PGA Proposed for CEUS and WUS Compared to PGA from Table 4-2.	97
Figure 5-1.	Closeup View of the Shake Table Surface.	98
Figure 5-2.	International Concrete Repair Institute's Concrete4 Surface Profiles.....	99
Figure 5-3.	Specifications of the Roughness Levels Used in the Experiment.	99
Figure 5-4.	Friction Experiment Setup.....	100
Figure 5-5.	3D Model and Physical Implementation of the Friction Experiment Setup.....	101
Figure 5-6.	3 mm/s Light Sandblast Force versus Displacement Data.	103
Figure 5-7.	3 mm/s Light-Medium Sandblast Force versus Displacement Data.	103
Figure 5-8.	3 mm/s Medium Bush Hammer Force versus Displacement Data.....	104
Figure 5-9.	3 mm/s Heavy Sandblast Force versus Displacement Data.....	104
Figure 6-1.	Maximum Accelerations on the Dummy Assemblies (Front End of 1/3 Scale Cask) in the 30 cm Drop.....	105
Figure 6-2.	Peak Surrogate Assembly Accelerations During the First Impact in the 30 cm Drop of Full-Scale Surrogate Assembly.....	106
Figure 6-3.	Peak Axial Strain Values (top) and Color Maps of the Peak Strain Values (bottom) in the 30 cm Drop Test of Full-Scale Surrogate Assembly.	106
Figure 6-4.	Distribution of Maximum and Minimum Strains on the Rods in Hard Rock Scenarios from [7].	107
Figure 6-5.	Distribution of Maximum and Minimum Strains on the Rods in Soil Scenarios from [7].	108
Figure 6-6.	3D Distribution of Peak Strains on the Rods in Hard Rock (left) and Soil Scenario (right), Seismic Hazard 5×10^{-5} from [7].	109
Figure 6-7.	Proposed Locations of the Surrogate Assemblies within the Canister and Canister Orientation During the Test.	110
Figure 6-8.	Pre-Test Modeling Prediction Regarding the Strain on the Fuel Rods.	110
Figure 6-9.	Endevco Corporation Accelerometers (images not at same scale).....	112
Figure 6-10.	Strain Gauge CEA-03-062UW-350 (left) and its Installation (right).	112
Figure 6-11.	TILT-57A Dynamic Inclinometer.	112
Figure 6-12.	Block of 3 Uniaxial Accelerometers and Its Location on the Dummy Assembly.....	113

Figure 6-13.	Surrogate Assembly Instrumentation Diagram.	114
Figure 6-14.	Accelerometers on the Cask, Canister, and Basket.	115
Figure 6-15.	Pressure Paper Locations and Specifications.	116
Figure A-1	Callawya.....	127
Figure A-2	Calvert Cliffs	128
Figure A-3.	Clinton.....	129
Figure A-4.	Farley.....	129
Figure A-5.	Fort Calhoun.....	130
Figure A-6.	Hatch	131
Figure A-7.	LaSalle.....	132
Figure A-8.	Monticello	133
Figure A-9.	Oyster Creek.....	133
Figure A-10.	Palisades	134
Figure A-11.	Point Beach.....	135
Figure A-12.	River bend	135
Figure A-13.	Robinson.....	136
Figure A-14.	South Texas	137
Figure A-15.	St. Lucie.....	138
Figure A-16.	Vogtle.....	138
Figure A-17.	Waterford.....	139
Figure A-18.	Beaver Valley	140
Figure A- 19.	Braidwood	140
Figure A-20.	Brunswick.....	141
Figure A-21.	Byron.....	141
Figure A-22.	Grand Gulf.....	142
Figure A-23.	Hope Creek.....	143
Figure A-24.	Prairie Island.....	143
Figure A-25.	Salem	144
Figure A-26.	Surry	145
Figure A-27.	Turkey Point	146
Figure A-28.	Diablo Canyon – Soft Rock.....	147
Figure A-29.	Hanford – Soil	147
Figure A-30.	Palo Verde – Soil.....	148
Figure A-31.	Columbia – Soil.....	149

LIST OF TABLES

Table 1-1.	Type of Dry Storage at the Different NPPs.....	20
Table 2-1.	Classification of the CEUS Sites.....	24
Table 2-2.	Test Sites from NUREG-2115 [14].....	29
Table 2-3.	Scaling Factors for WUS Sites.....	39
Table 2-4.	Average Scaling Factors for 1E-3/1E-4 and 1E-5/1E-4 Hazard Level ratios.	39
Table 2-5.	Scaling Factors for 84th Percentile, 5E-05 and 5E-04 Seismic Hazards for CEUS.....	42
Table 2-6.	Scaling Factors for 50th Percentile, 5E-05 and 5E-04 Seismic Hazards for WUS.....	43
Table 2-7.	Selected Seed Candidate Time Histories for CEUS.....	44
Table 2-8.	Selected Seed Candidate Time Histories for WUS.....	45
Table 2-9.	Test Cases for Hard Rock Conditions in CEUS.....	48
Table 2-10.	SSI Analysis Scenarios.	52
Table 2-11.	Concrete Pad Material Properties.....	53
Table 2-12.	Site Conditions, Base Profiles and Reference Profiles.	54
Table 2-13.	Locations on the Pad Recommended for the Seismic Shake Table Test.	66
Table 2-14.	PGAs in Mineral (VA) earthquake Compared to the Design Based PGA [24].	77
Table 3-1.	NUHOMS 32 PTH2 Specifications.	79
Table 3-2.	Surrogate Assembly Specifications.....	81
Table 3-3.	Dummy Assembly Specifications.....	84
Table 3-4.	Dummy Assembly Parts.....	84
Table 3-5.	Estimated Weights of the Loaded NUHOM 32 PTH2 Canister	85
Table 3-6.	Estimated Weight of the Cask Different Parts.	89
Table 3-7.	Specifications of the Vertical Cask Mockup and HI-STAR Vertical Overpack.....	94
Table 4-1.	LHPOST Outdoor Earthquake Simulator Specifications.....	96
Table 4-2.	Strong Ground Motion Considered for the Design of the Six Degrees of Freedom LHPOST6 (from [30]).....	96
Table 5-1.	Specifications of the Concrete Blocks and Steel Plate Used in the Experiment.....	100
Table 5-2.	Experimental Results from 3 mm/s Friction Tests.....	102
Table 6-1.	Fujifilm Pressure Paper Specifications.	116
Table 6-2.	Instrumentation Summary.....	117
Table A-1.	Site Region and Type.....	126

REVISION HISTORY

Revision No.	Date:	Description of Revision
0	9/13/2021	Initial Issue
1	07/29/22	Update

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ACRONYMS

3D	3-dimensional
AHSM	Advanced Horizontal Storage Module
CEUS	Central and Eastern U.S.
CISF	consolidated interim storage facilities
CSP	Concrete Surface Profiles
DAQ	Data Acquisition System
DIC	digital image correlation
ENSA	Equipos Nucleares S.A.
EPRI	Electric Power Research Institute
FSAR	Final Safety Analysis Report
FY	Fiscal Year
GMRS	Ground Motion Response Spectrum
HCGS	Hope Creek Generating Station
HD	High Definition
HSM	Horizontal Storage Module
ISFSI	Independent Spent Fuel Storage Installation
KNF	Korean Nuclear Fuel
LHPOST6	large capacity high-performance outdoor shake table
MMTT	Multi Modal Transportation Test
MTU	Metric Tons of Uranium
NEI	Nuclear Energy Institute
NEUP	Nuclear Energy University Program
NGA	Next Generation Attenuation
NPPs	nuclear power plants
NRC	Nuclear Regulatory Commission
PGA	peak ground acceleration
PNNL	Pacific Northwest National Laboratory
PSHA	Probabilistic Seismic Hazard Assessment
PWR	pressurized water reactor
SASSI	System for Analysis of Soil-Structure Interaction
SFWD	Spent Fuel Waste Disposition
SNF	Spent nuclear fuel
SNL	Sandia National Laboratories
SONGS	San Onofre Nuclear Generating Station
SSE	Safe Shutdown Earthquake
SSI	soil-structure interaction

TH	time-history
UCSD	University of California in San Diego
UHRS	Uniform Hazard Response Spectra
UNM	University of New Mexico
USGS	United States Geological Survey
V/H	Vertical to Horizontal
Vs30	Average shear velocity within the top 30 m
WCS	Waste Control Specialists
WUS	Western U.S.

SPENT FUEL AND WASTE DISPOSITION SEISMIC SHAKE TABLE TEST PLAN

1. INTRODUCTION

Currently, spent nuclear fuel (SNF) is stored in onsite independent spent-fuel storage installations (ISFSIs) at seventy-three (73) nuclear power plant (NPP) sites. Only three NPP sites do not have on-site dry storage. However, two of them are considering building on-site ISFSIs in the near future. As of June 2022, 3,751 dry storage systems [1] were loaded in the U.S. and were placed for long-term storage on the ISFSI pads. Figure 1-1 shows the number of dry storage systems by vendor. The Holtec systems, 44% of the current total, are vertical concrete casks. The Orano systems, 39% of the current total, are horizontal storage modules (HSMs).

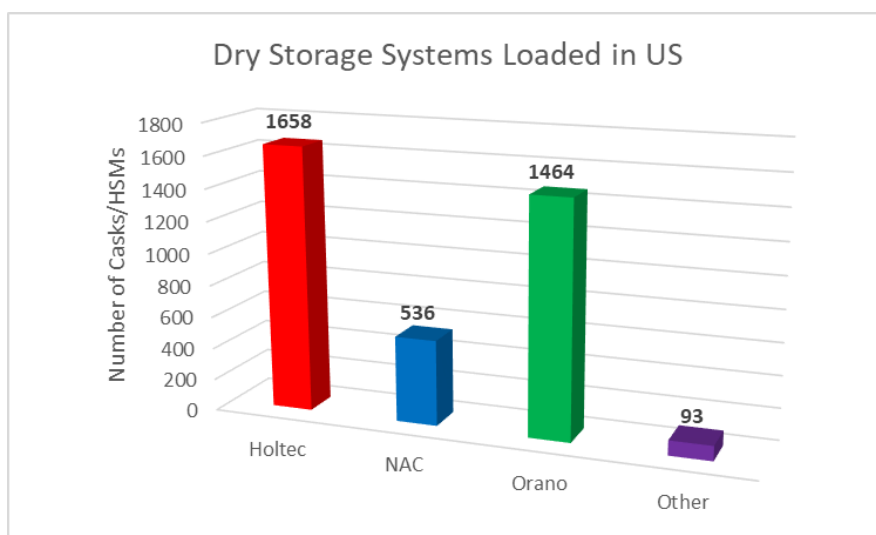


Figure 1-1. Dry Storage Systems Loaded in U.S. as of June 2022 [1].

Table 1-1 provides the data on the types of dry storage systems at the different NPP sites. Note that a few NPP sites have both vertical and horizontal systems. Not included in the table are the two sites that have in-ground vertical storage systems.

Table 1-1. Type of Dry Storage at the Different NPPs.

NPPs with Horizontal Dry Storage Systems		NPPs with Vertical Dry Storage Systems	
Horizontal System Type	NPP Name	Vertical System Type	NPP Name
Advanced NUHOMS	SONGS 1	HI-STORM	ANO
	SONGS 2		Braidwood
NUHOMS 708	Robinson		Browns Ferry
NUHOMS HD	North Anna		Byron
	Seabrook		Columbia
	St. Lucie		Comanche Peak
	Surry		D.C. Cook
	Turkey Point		Diablo Canyon
NUHOMS Standardized	Brunswick		Dresden
	Calvert Cliffs		Farley
	Cooper		Fitzpatrick
	Davis-Bessel		GE Trojan
	Duane Arnold		Grand Gulf
	Fort Calhoun		Hatch
	Ginna		Hope Creek
	Kewaunee		Indian Point 1
	Limerick		Indian Point 2 &
	Millstone		LaSalle
	Monticello		Perry
	Nine Mile Point		Quad Cities
	Oconee		River Bend
	Oyster Creek		Salem
	Palisades		Sequoyah
	Point Beach		Vermont Yankee
	Rancho Seco		Vogtle
	Robinson		Waterford
	Susquehanna	NAC-MAGNASTOR	Catawba
			McGuire
			Zion
		NAC-MPC	Connecticut
			Lacrosse
			Yankee Rowe
		NAC-UMS	Catawba
			Maine Yankee
			McGuire
			Palo Verde
		VSC 24	ANO
			Palisades
			Point Beach

Two private companies submitted license applications to the U.S. Nuclear Regulatory Commission (NRC) to build and operate consolidated interim storage facilities (CISF) of SNF. Holtec is seeking a license for a site in south-eastern New Mexico for an initial 40-year period of operations, with up to two 40-year license renewals. If approved, the SNF could be stored at this facility for up to 120 years.

Waste Control Specialists (WCS) submitted a license application for CISF on the site of the company's existing low-level waste disposal facility in west Texas. A site-specific license is for 40 years, with renewals of up to 20 years each as needed. Later in the process, WCS and Orano CIS LLC formed a joint venture, Interim Storage Partners (ISP), to complete the licensing of the WCS CISF, and then to build and operate it.

Figure 1-2 reproduced from the NRC site [2] shows the locations of the existing on-site ISFSIs and the locations of two sites pursuing private CISFs.

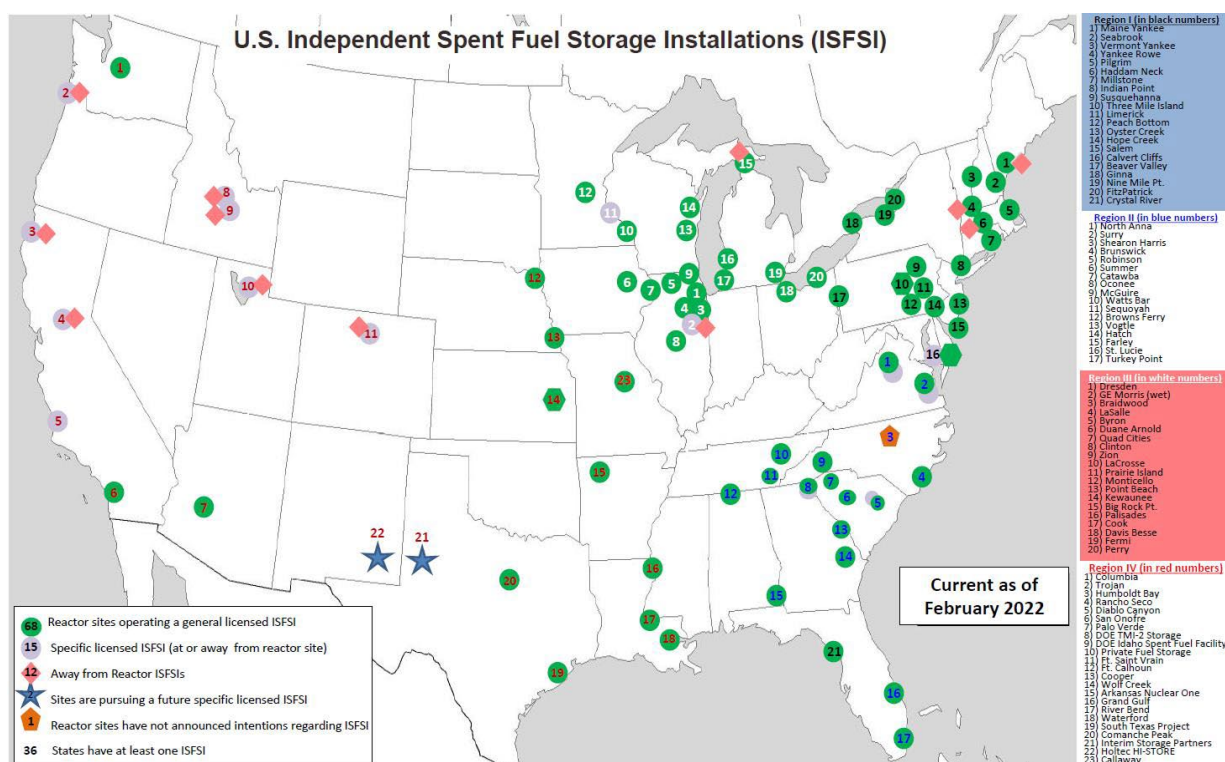


Figure 1-2. Locations of the Independent Spent-Fuel Storage Installations in the U.S. [2]

Because a site for geologic repository for permanent disposal of SNF has not been constructed, the SNF will remain in dry storage at many locations in the U.S., ISFSIs and possibly at the private and federal CISFs, for a long time, potentially for 100 years or longer. During this time, the ISFSIs and CISFs may experience earthquakes of different magnitudes from local and distant sources. The dry storage systems are designed and licensed to withstand large seismic loads. However, there are little experimental data on the response of the SNF assemblies stored inside the dry storage systems to the seismic loads posed by the earthquakes.

The only full-scale experiment that considered all the components of the dry storage system, including surrogate fuel rods, was performed in Japan in 2007 [3]. The test unit consisted of a full-scale simplified concrete cask mockup, dry storage canister, 20 dummy and one surrogate pressurized water reactor (PWR) fuel assemblies, and a concrete pad. The test was conducted using a three-dimensional (3-D)

shake table in E-Defence, a 3-D full-scale earthquake testing facility. The scaled ground motions recorded during two actual earthquakes and one artificial ground motion were used as inputs to the shake table. The actual earthquakes were 6.9 magnitude El Centro Imperial Valley Earthquake (1940) and 7.2 JMA Kobe Hyogo-ken Nanbu Earthquake (1995).

A series of shake table experiments with scale-model representations of the free standing vertical dry storage systems (a scaled dry storage cask with a scaled canister) were conducted under the Nuclear Energy University Program (NEUP), 2016 final NEUP report “Seismic Performance of Dry Casks Storage for Long-Term Exposure” [4]. The scaled canister in these tests did not contain surrogate fuel assemblies. Instead, additional mass was added to the test units using 16 lead panels.

The Spent Fuel Waste Disposition (SFWD) program is planning to conduct a full-scale seismic shake table test with the goal of closing the gap related to the seismic loads on the fuel assemblies in dry storage systems. This test will allow for quantifying the strains and accelerations on surrogate fuel assembly hardware and cladding during representative earthquake scenarios. The full-scale test is needed because a dry storage system is a complex and highly nonlinear system making it hard to predict (model) the responses to the seismic excitations. The non-linearity arises from the multiple gaps in the system – between the fuel rods and the basket, between the basket and dry storage canister, between the dry storage canister and the storage cask (overpack), and ventilation gaps. The non-linearities pose significant limitations on the value of tests with scaled systems.

This report describes the updated seismic shake table test plan and supersedes the preliminary test plan released in 2021 [5]. The shake table test roadmap is presented in Figure 1-3. A short description of the roadmap elements is provided below. The details regarding each element are provided in the following sections.

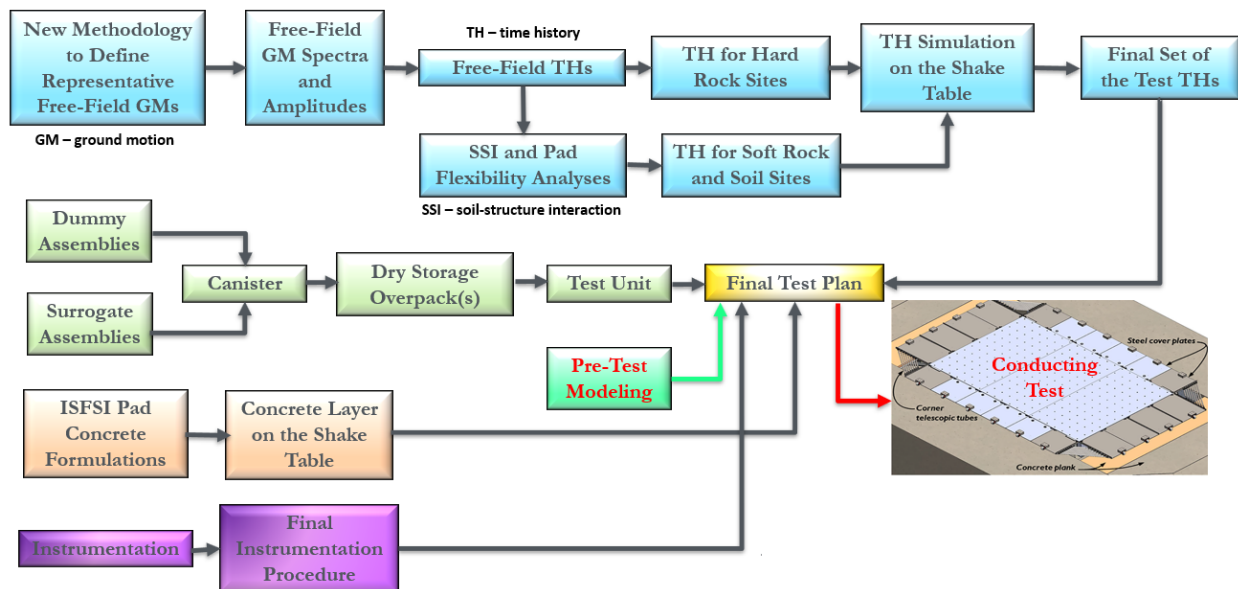


Figure 1-3. Seismic Shake Table Test Roadmap.

One of the most important tasks is defining the acceleration time histories (THs) to be used as inputs to the shake table. The elements that are part of this task are shown in the blue boxes in Figure 1-3. This task starts with developing a new methodology for defining free-field time histories. The free-field time histories are used in soil-structure interaction (SSI) and pad flexibility analyses. Finally, the proposed time histories are analysed to confirm that they can be implemented on the shake table.

The test unit consists of a dry storage canister loaded with surrogate and dummy assemblies and placed in a dry storage overpack. The corresponding elements are shown in green boxes in Figure 1-3.

A concrete layer will be installed on the shake table. The concrete formulation should be representative of an ISFSI pad. The elements in the orange boxes in Figure 1-3 are related to defining the appropriate concrete properties.

All the components of the test unit will be instrumented. The elements in the purple box in Figure 1-3 are related to the instrumentation task.

The pre-test modeling (bright green box in Figure 1-3) provides support to all the tasks. The preliminary pre-test modeling results are documented in *Modeling and Analysis for Spent Nuclear Fuel Seismic Testing* [6]. The most recent pre-test modeling is documented in *Spent Nuclear Fuel Modeling Methods for Seismic Loads* [7].

2. SHAKE TABLE INPUTS

2.1 Conceptual Description of the Problem

Development of shake table inputs is a challenging task. These inputs must be representative of the range of seismotectonic and other conditions that any site in the Western U.S. (WUS) or Central and Eastern U.S. (CEUS) might encounter. This required development of a special approach. The details regarding the approach and supporting data are provided in *Ground Motions for Shake-Table Testing of Dry Casks* [8]. The major results reported in [8] are the representative free-field ground motions that are defined as the movements of the surface without any engineering structure on the top of it in response to an earthquake. The free-field ground motions were developed for three general site categories: hard rock, soft rock, and soil. At the CEUS sites, all three categories are present. At the WUS sites, two categories are present - soft rock and soil.

Figure 2-1 shows the conceptual differences between the sites located on hard rock and the sites located on soft rock and soil. At the hard rock sites, the pad motions can be assumed the same as the free-field ground motions as demonstrated in the initial SSI analysis [9]. At the soft rock and soil sites, the pad motions differ from the free-field ground motions due to the amplification in the soft rock/soil and to the SSI. Note, that due to non-linearity of soil properties, the amplifications are functions of the applied seismic load.

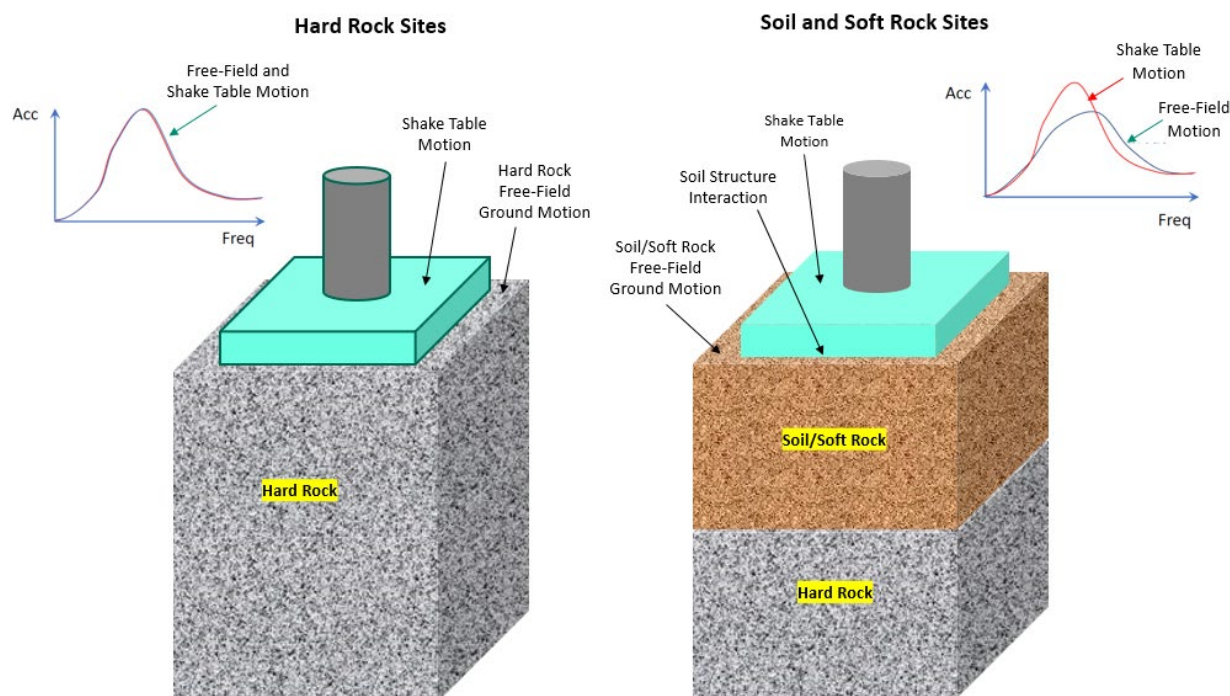


Figure 2-1. Conceptual Representation of a Dry Storage System Located on Hard Rock and Soft Rock/Soil for the Shake Table Test.

Five NPP (ISFSIs) in the WUS are located on soft rock and one NPP (ISFSI) is located on soil. The Humboldt Bay NPP was shut down in 1976. It is a decommissioned site with 6 vertical casks on the ISFSI pad. Little information is available on the site-specific subsurface properties. The FSAR assumed that the site was located on hard rock. All the other NPPs (ISFSIs) are located in the CEUS. The site classification of the NPPs in CEUS was based on the most up to date data from the screening reports. Each NPP site in the U.S. was required to submit a Seismic Hazard Evaluation and Screening Report per NRC letter, “*Request for Information related to the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident*” [10] issued on March 12, 2012. In preparing the screening report, each NPP was asked to re-evaluate seismic hazards against present-day NRC requirements (e.g., RG 1.208) [11]. The NPPs submitted the screening reports in the 2014-to-2017 time frame.

The grouping of the CEUS NPP sites was performed based on the average shear velocity within the top 30 m (98.42 ft) (V_{s30}) values calculated from the data in the screening reports. Table 2-1 provides the summary of this analysis. 24 sites were classified as hard rock sites; 11 sites were classified as soft rock sites; and 16 sites were classified as soil sites.

Table 2-1. Classification of the CEUS Sites.

Site Classification	Average V_{s30} (m/sec)	Average V_{s30} (ft/sec)	Number of Sites
Soil	320.7	1052.2	16
Soft Rock	698.7	2292.3	11
Hard Rock	1868.3	6129.2	24

Figure 2-2 shows the CEUS sites and their type as defined in Table 2-1. Also shown on this figure are the peak ground acceleration (PGA) values from the new ground motion response spectra (GMRS) defined in the screening reports. The NPP sites used the guidance in the Electric Power Research Institute (EPRI) Report 102528 [12] and the updated EPRI ground motion attenuation model to calculate new GMRS. The new GMRS are based on modern techniques and updated models compared to the ones used for plant licensing. The new GMRS were used to characterize the amplitude of the new seismic hazard at each of the NPP sites. The new GMRS were compared to the previously defined Safe Shutdown Earthquake (SSE). If the new GMRS exceeded the SSE, the NPP site was required to conduct an additional evaluation per the Expedited Seismic Evaluation Process. The PGA values for these 36 sites (64% of all sites) are shown in purple font. If the new GMRS was equal to or smaller than the SSE, no further action was required. The PGA values for these 20 sites are shown in black font.

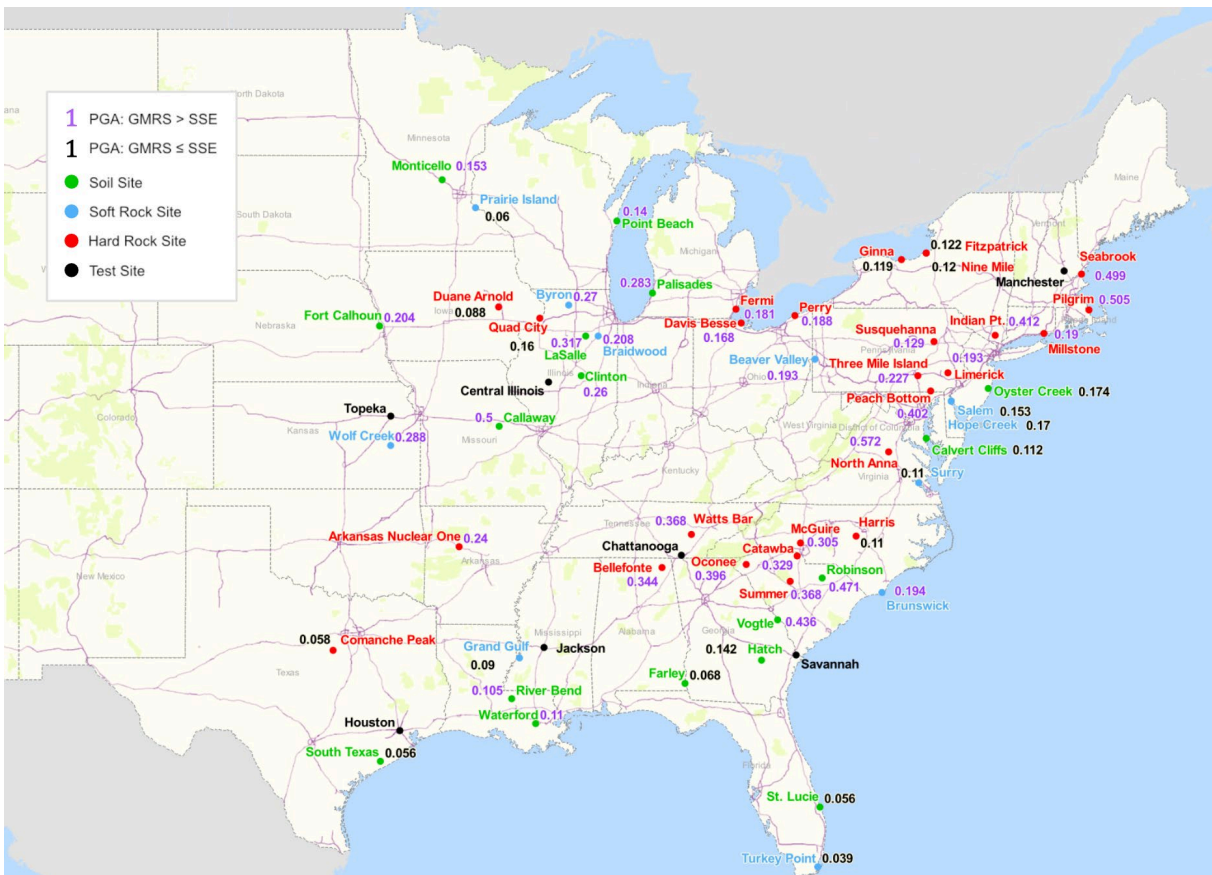


Figure 2-2. Site Conditions and Screening Reports PGAs at the CEUS NPP Sites.

Figure 2-3 shows the depth to basement rock (rock with shear wave velocity equal to or greater than 3,000 m/s) for the soft rock and soil sites from the screening reports using a box-and-whiskers plot. This plot allows for displaying the data based on the minimum, maximum, median, and the first and third quartile values. The 25th to 75th percentile depths to basement rock are from 1,700 m (5,577.4 ft) to 4,100 m (13,451.4 ft) for the soft rock sites and from 499 m (1,637.1 ft) to 4,000 m (13,123.4 ft) for the soil sites. Consequently, the conceptual models of the soft rock and soil sites should consider deep soft rock and soil conditions.

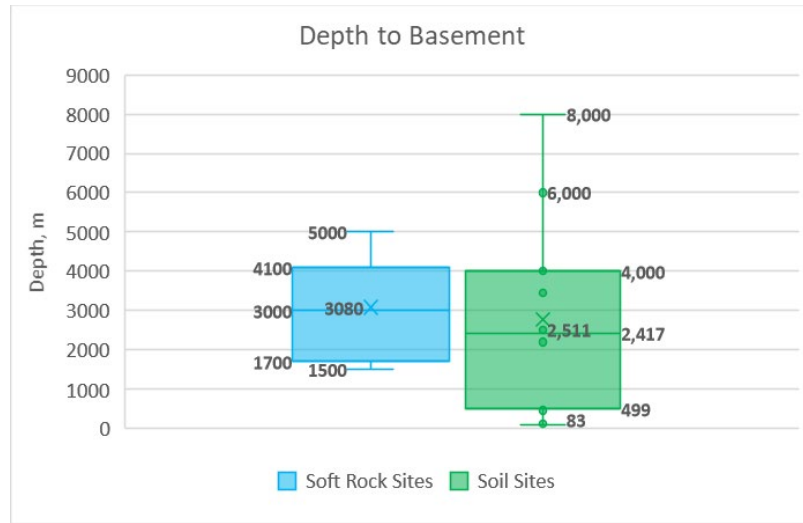


Figure 2-3. Depth to Basement at the Soft Rock and Soil Sites in CEUS.

Figure 2-4 and Figure 2-5 are the maps that show the depth to hard rock in the CEUS and WUS respectively. The hard rock shear velocity is assumed to be 3,000 m/s, which is a common assumption. The data is from the United States Geological Survey (USGS) National Crustal Model [13]. The depth to bedrock is greater than 1,000 m along the east coast where 10 soil sites and soft rock sites are located. The depth to bedrock is greater than 1,000 m along the west coast where all, except one, WUS site are located. The Humboldt Bay site is shown as a hard rock site because this was an assumption in the FSAR. As was discussed earlier, the site-specific information is very limited. Based on the depth to basement map, this site is located on deep soil (greater than 1,000 m).

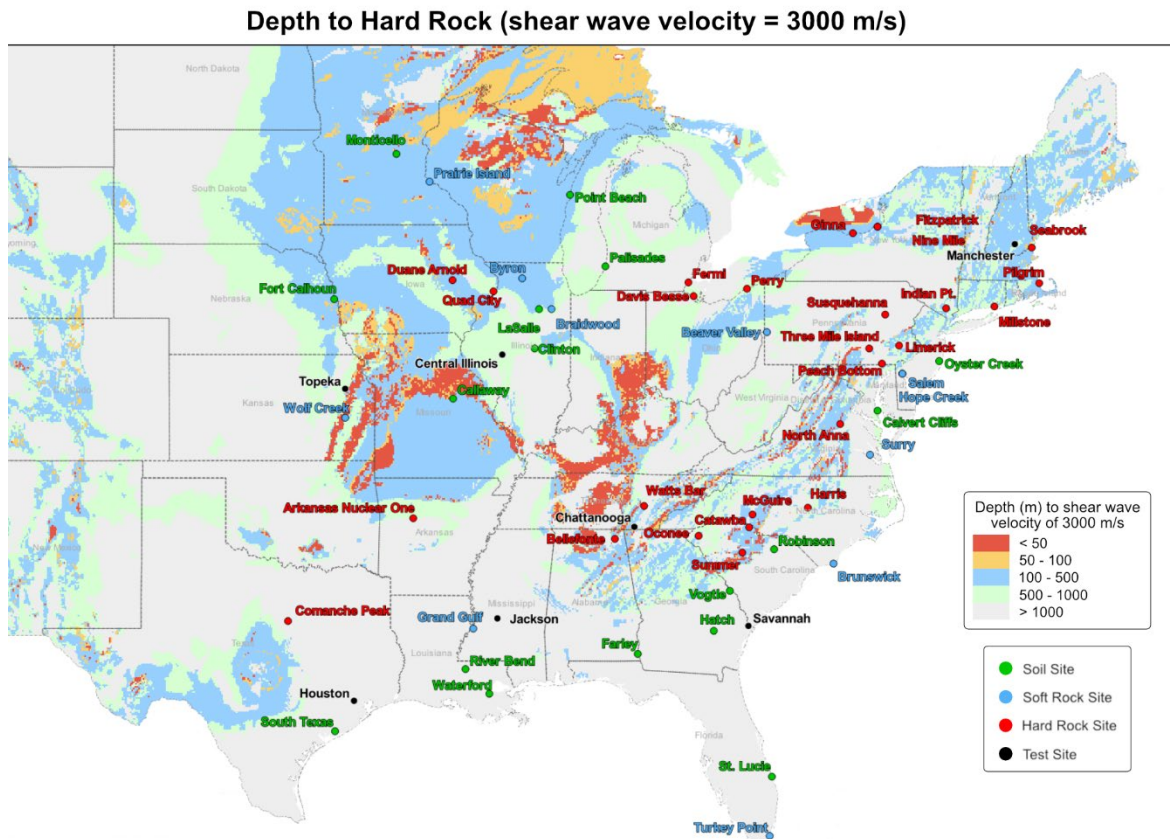


Figure 2-4. Depth to Bedrock in Central and Eastern U.S.

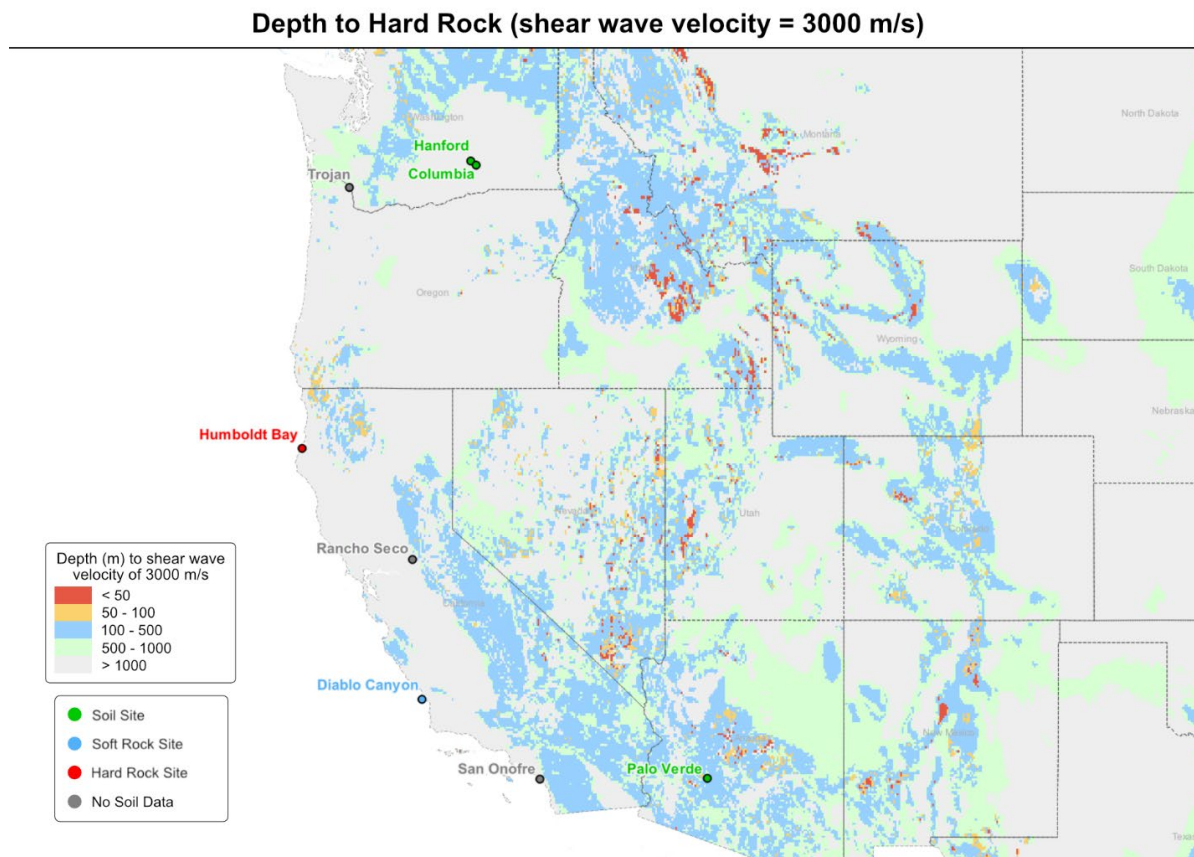


Figure 2-5. Depth to Bedrock in WUS.

Section 2.2 describes the development of the free-field ground motions. The free-field ground motions are used for defining:

- Representative time histories for the hard rock sites in CEUS
- Boundary conditions in the SSI analysis

Section 2.3 describes the SSI analysis conducted for the soil and soft rock sites and representative time histories derived from this analysis.

2.2 Development of Free-Field Ground Motions

2.2.1 Methodology

An approach taken for the CEUS sites was to leverage a recent extensive study of the CEUS “*Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*” documented in NUREG-2115 [14]. In NUREG 2115, seven test sites were selected to illustrate the effects that the seismic sources have on calculated seismic hazard. The test sites were selected to be representative of the range of seismotectonic conditions that any site in the CEUS might entail. The site information and reasons for selection are listed in Table 2-2 reproduced from NUREG 2115 (Table 8.1-1). Figure 2-6 reproduced from NUREG 2115 (Figure 5.4.4-1) shows the seismotectonic zones in the CEUS and spatial distribution of earthquakes in the CEUS from the Seismic Source Characterization Project catalogue. This provides an illustration of how different the seismotectonic conditions are in the different parts of CEUS. The test sites are shown as black circles in Figure 2-2.

Table 2-2. Test Sites from NUREG-2115 [14].

Test Site Name	N. Latitude	W. Longitude	Reason for Selection
Central Illinois	40.000	-90.000	Hazard from New Madrid seismic zones and paleoearthquake zones in central Illinois
Chattanooga	35.064	-85.255	Hazard from Eastern Tennessee seismic zone
Houston	29.760	-95.363	Hazard in Gulf Coast region
Jackson	32.312	-90.178	Hazard from New Madrid seismic zone
Manchester	42.991	-71.463	Hazard in New England
Savannah	32.082	-81.097	Hazard from Charleston source
Topeka	39.047	-95.682	Hazard in central plains region

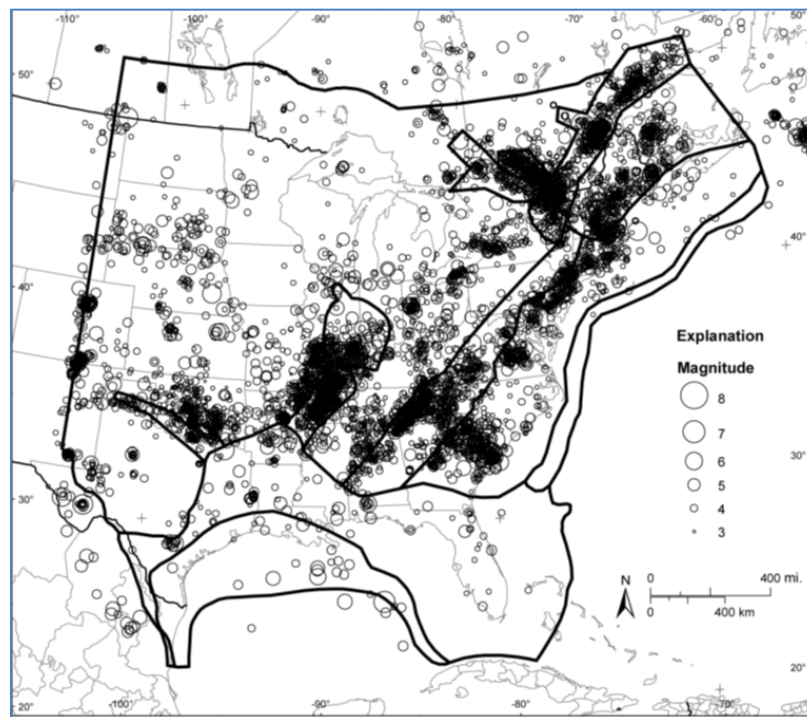


Figure 2-6. Seismotectonic Regions in CEUS and Earthquakes in the CEUS Seismic Source Characterization Project Catalog [14].

Figure 2-7 shows the rock seismic hazard curves for the seven test sites for PGA plotted using the tabulated data in NUREG 2115. It illustrates the differences in hazards between the test sites which are apparent at all levels of the annual frequency of exceedance.

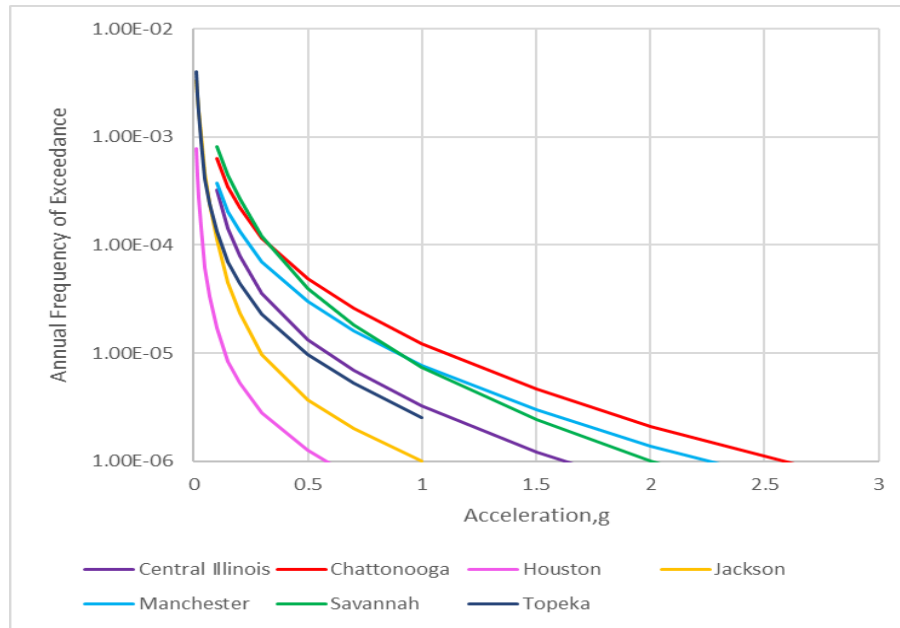


Figure 2-7. PGA Rock Seismic Hazard Curves for the Seven Test Sites.

The approach for the WUS site was to select four representative sites out of seven NPP sites located in WUS.

The following summarizes the methodology developed by Nicholas Gregor and Linda Al Atik (consultants to the SC Solutions) under the leadership of Norman Abrahamson (SC Solutions). The details are documented in the SC Solutions report [8].

The methodology consists of the following steps:

- Compile uniform hazard response spectra (UHRS) for 1E-03, 1E-04, and 1E-05 annual exceedance levels.
- For the CEUS seven demonstration sites (i.e., representative sites not specifically located at a NPP site), the modal de-aggregation results for the 1E-04 annual exceedance level are compiled from the USGS Probabilistic Seismic Hazard Assessment (PSHA) results.
- Three representative earthquakes scenario are selected based on the compiled de-aggregation information and the de-aggregation information provided in the PSHA reports from the NPP sites. These three scenario events are selected to generally represent the controlling events for any site in the CEUS region and are not specifically meant to represent the results for a given NPP site.
- Given the selected scenario events, median ground motion spectra are computed given the input ground motion models applicable for the two different regions (i.e., CEUS and WUS).
- For the 1E-04 annual exceedance level, an optimized scaling factor is developed for each of the three scenario events to minimize the difference between the scaled scenario spectra and the UHS over the frequency range of 0.5 – 40 Hz.

- Compute the cumulative distribution of the scale factors at the 1E-04 annual exceedance level for the different site classifications to allow for the scaling of the time histories to cover the observed ground motions at the suite of NPP sites.
- Compute the spectral ratio scaling factors for the UHRS: 1E-03/1E-04 and 1E-05/1E-04 annual exceedance levels.
- Given the scenario events for both the CEUS and WUS regions, apply the empirical vertical to horizontal (V/H) spectral ratio model to estimate the vertical spectra.
- Select candidate seed time histories that are consistent with the scenario events (e.g., magnitude and distance values) and spectra.
- Modify the selected seed time histories (5 for each seed) to be spectrum compatible to the 1E-04 annual exceedance target scenario spectra while maintaining the variability about the target spectra.

2.2.2 Results

The horizontal spectral shapes were developed for hard rock, soft rock, and soil conditions for CEUS and soft rock and soil conditions for WUS for the different scenarios (Magnitude-Distance pairs). The selection of the scenario events was based on the observed controlling earthquakes for sites located in the CEUS and WUS, separately.

In the CEUS, representative controlling events were selected based on the de-aggregation of the PSHA results for seven test sites in the CEUS. The USGS web tool was queried to extract the modal de-aggregation values from the USGS 2014 PSHA results for hard rock site conditions at 1E-04 annual frequency of exceedance. Based on these de-aggregation results, three scenarios were selected as being representative for sites in the CEUS:

- Local event with magnitude 5.5 at 15 km (9.32 mi)
- Moderate event with magnitude 6.5 at 40 km (24.85 mi)
- Large magnitude distant event with magnitude 7.8 at 200 km (124.27 mi)

The median horizontal ground motion spectra from these events (Figure 2-8) were computed based on the Next Generation Attenuation (NGA) for Central and Eastern North America ground motion model.

The median horizontal ground motion spectra for the soft rock and soil conditions were calculated from the hard rock ground motion spectra using the site amplification factor model. In this model, the selected shear velocity in the top 30 m (98.42 ft) (V_{s30}) values for the soft rock and soil were those given in Table 2-1. The median hard rock PGA was used in the application of the site amplification model. The horizontal ground motion spectra for the soft rock and soil conditions are shown in Figure 2-9 and Figure 2-10.

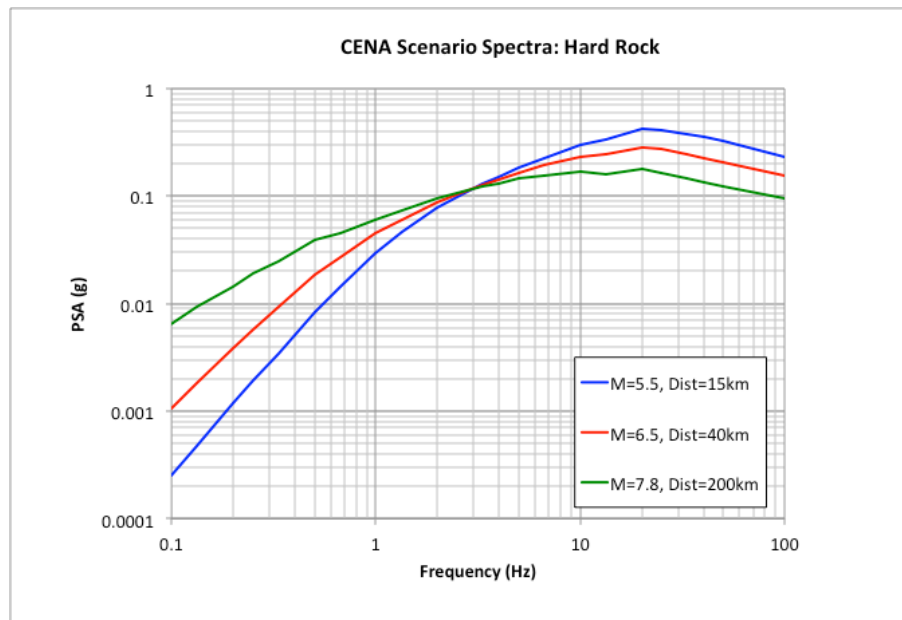


Figure 2-8. Median Ground Motion Spectra for CEUS Sites for Hard Rock Site Conditions.

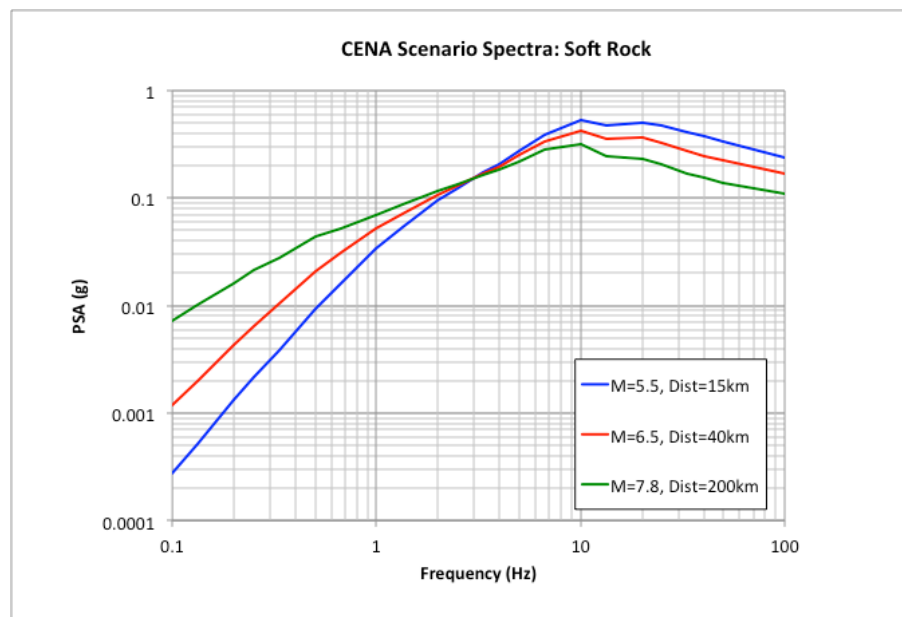


Figure 2-9. Median Ground Motion Spectra for CEUS Sites for Soft Rock Site Conditions.

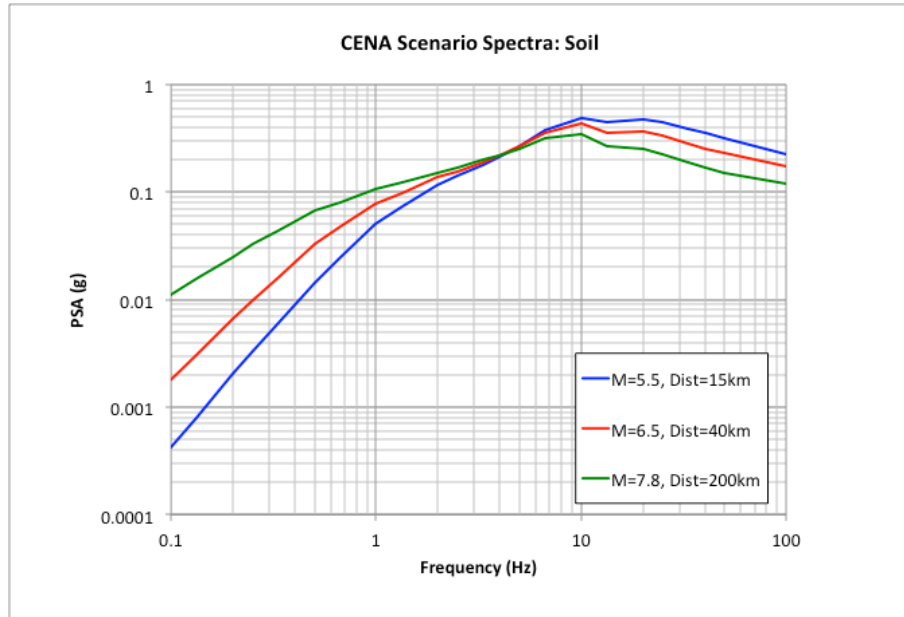


Figure 2-10. Median Ground Motion Spectra for CEUS Sites for Soil Site Conditions.

For the WUS case, the PSHA results from Diablo Canyon, Hanford, and Palo Verde NPPs were used. Based on the de-aggregation from the recently conducted PSHAs, three controlling scenario events were selected:

- Local event with magnitude 6.25 at 10 km (6.21 mi)
- Large magnitude local event with magnitude 7.5 at 5 km (3.11 mi)
- Large magnitude distant event with magnitude 7.5 at 200 km (124.27 mi)

The first two scenarios are applicable to the Diablo Canyon and Hanford NPP sites. Both sites have V_{s30} equal to 760 m/sec (2,493.44 ft/sec) which is representative of soft rock conditions. The first and third scenarios are applicable to Palo Verde site. This site has V_{s30} equal to 344 m/sec (1,128.61 ft/sec) which is representative of soil conditions.

The median horizontal ground motion spectra for these scenarios represent the weighted mean calculated from four NGA-West2 ground motion models [15]. Figure 2-11 shows the median ground motion spectra for WUS sites with soft rock conditions. Figure 2-12 shows the median ground motion spectra for WUS sites with soil conditions.

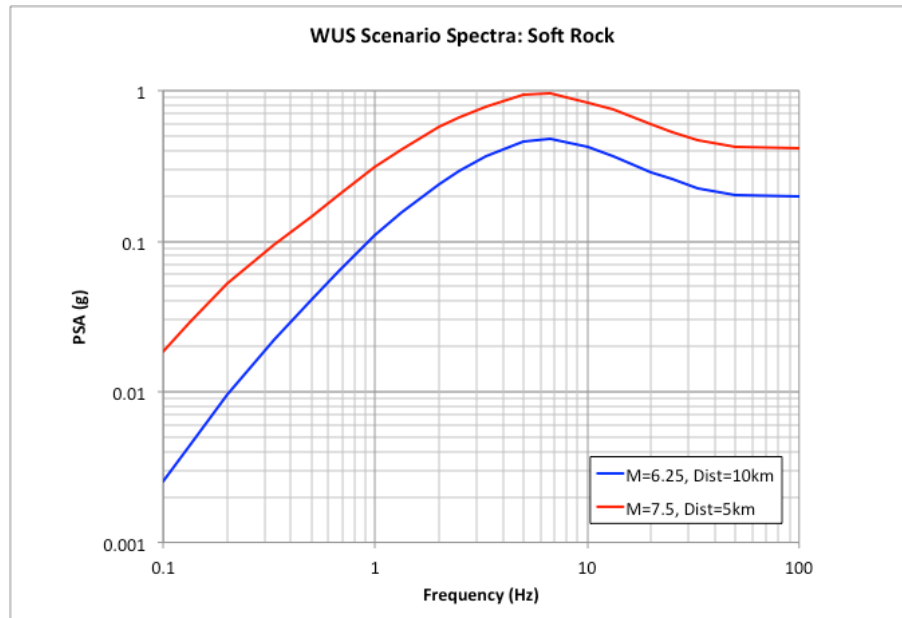


Figure 2-11. Median Ground Motion Spectra for WUS Sites with Soft Rock Conditions.

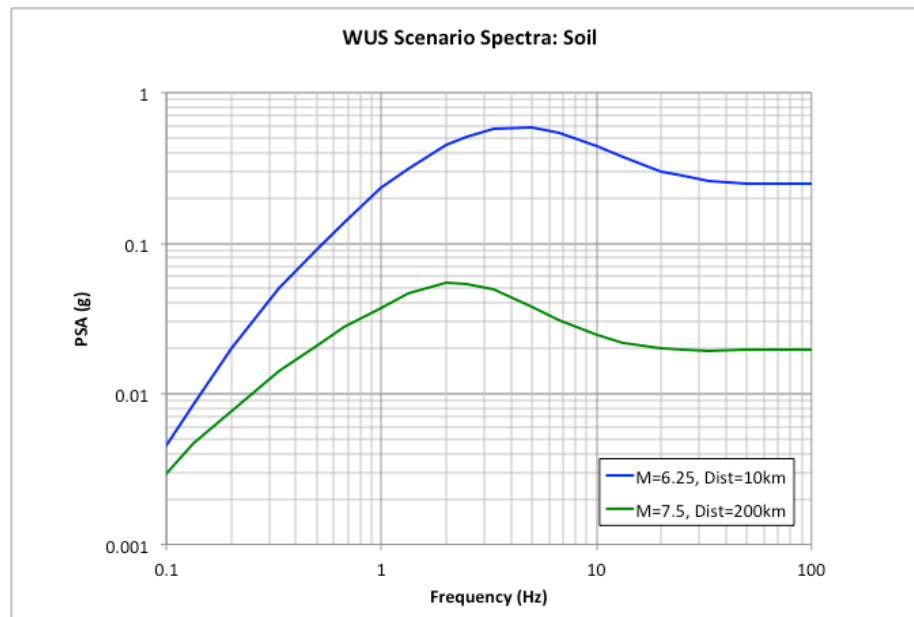
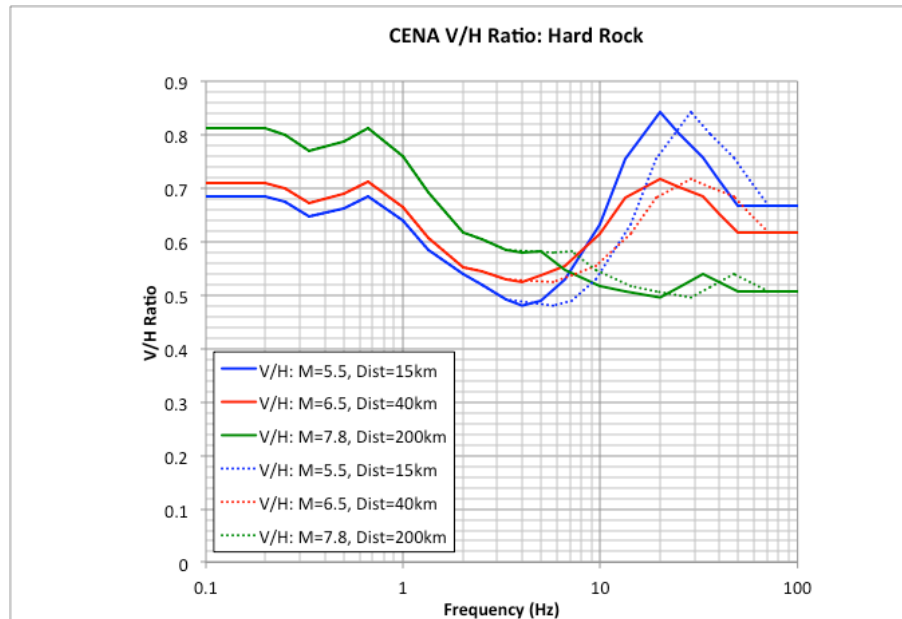


Figure 2-12. Median Ground Motion Spectra for WUS Sites with Soil Conditions.

The vertical spectral shapes are based on an empirical vertical to horizontal (V/H) spectral ratio model described in [16]. The model was developed from empirical data recorded on sites in active tectonic regions and in general with V_{s30} values less than about 1,000 m/sec (3,280.84 ft/sec) and is applicable to soft-rock and soil sites. An adjustment of the model was developed to address the effects of hard-rock sites on the V/H ratio.

The calculated V/H ratios for the different scenarios and site conditions in CEUS and WUS are shown in Figure 2-13 to Figure 2-17. Both non-adjusted and adjusted ratios for CEUS hard rock are shown in Figure 2-13.



Note: solid lines show non-adjusted V/H ratios and dotted lines show adjusted V/Ratios.

Figure 2-13. Vertical to Horizontal (V/H) Ratio for CEUS Sites for Hard Rock Site Conditions.

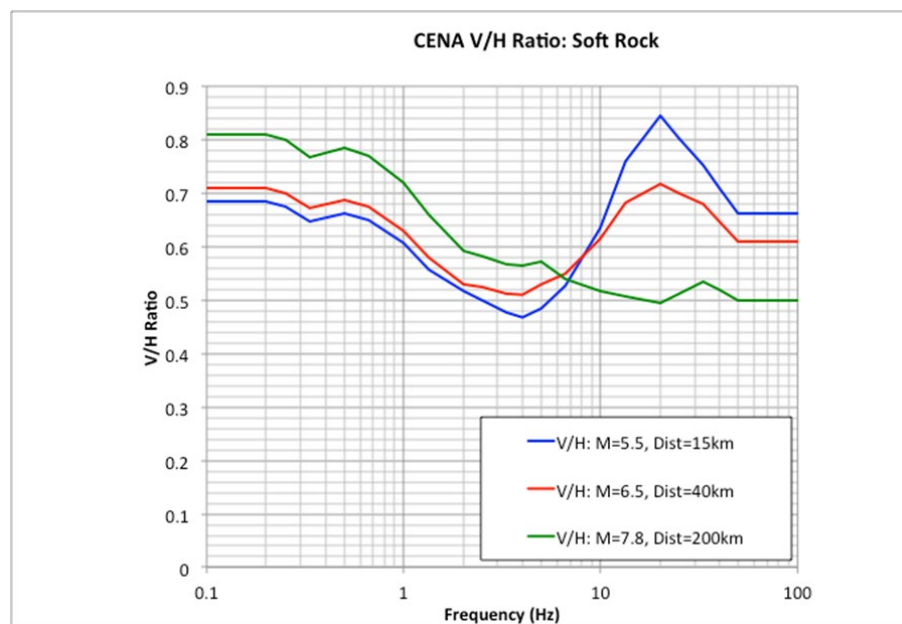


Figure 2-14. Vertical to Horizontal (V/H) Ratio for CEUS Sites for Soft Rock Site Conditions.

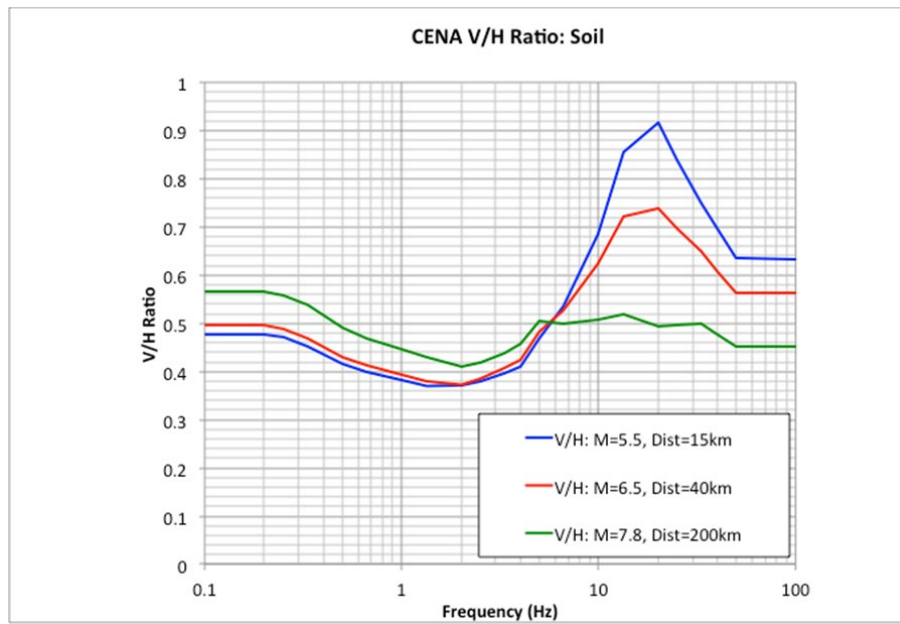


Figure 2-15. Vertical to Horizontal (V/H) Ratio for CEUS Sites for Soil Site Conditions.

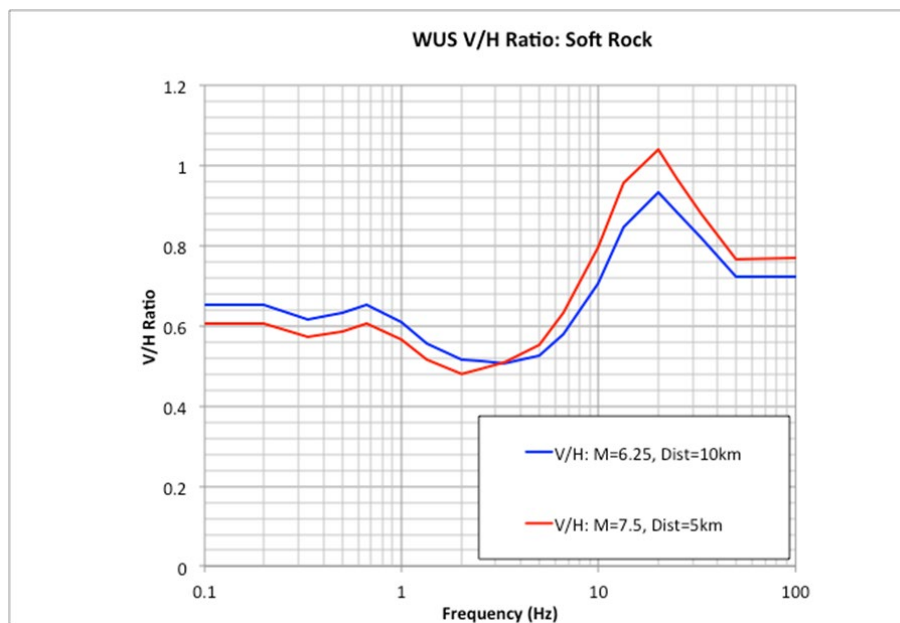


Figure 2-16. Vertical to Horizontal (V/H) Ratio for WUS Sites for Soft Rock Site Conditions.

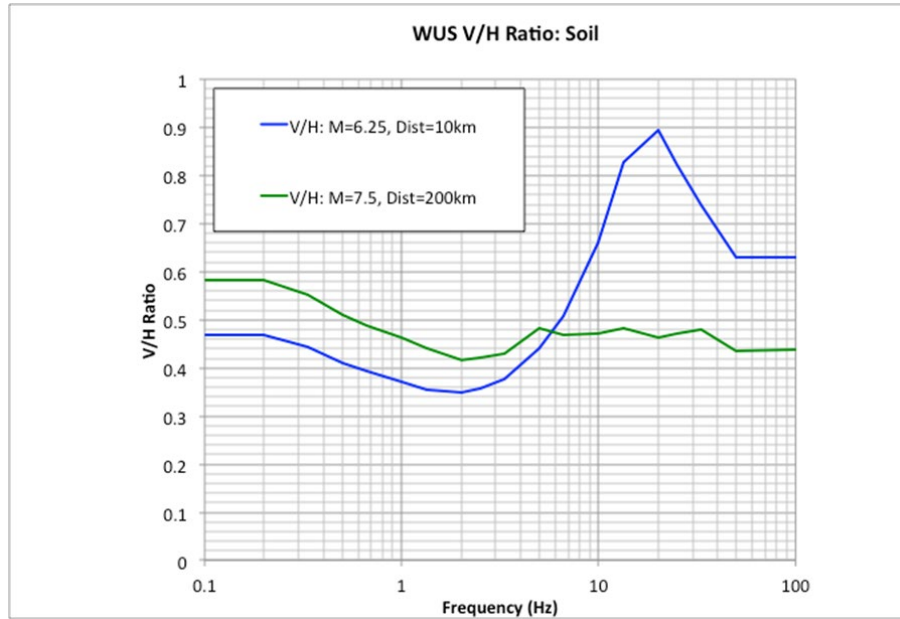


Figure 2-17. Vertical to Horizontal (V/H) Ratio for WUS Sites for Soil Site Conditions.

To define the amplitudes, the spectral shapes must be scaled to cover the seismic hazard from 1E-03 to 1E-05 annual frequency of exceedance at any of the ISFSI sites. The following procedure was developed to calculate the scaling factors.

In the first step, the 1E-04 UHRS were extracted for the three sites in WUS, the seven test sites in CEUS, and for the 51 NPP sites in the CEUS. The latter were extracted from the NPP screening reports.

For the CEUS NPP sites, either hard rock or soft rock, or soil horizontal spectra for each Magnitude-Distance scenario were anchored to the corresponding site-specific (hard rock, soft rock, or soil) PGA. For the WUS sites, either soft rock or soil horizontal spectra for each Magnitude-Distance scenario were anchored to the corresponding site-specific (soft rock or soil) PGA.

At each site, the 1E-04 UHRS was compared to the applicable (hard rock, soft rock, or soil) scaled Magnitude-Distance scenario spectra. The curve enveloping these scenarios was calculated next. Additional scaling was performed to reduce the difference between the enveloping curve and the UHRS over the frequency range of 0.5 – 40 Hz. The scaling factors were calculated next using the adjusted scenario spectra for each Magnitude-Distance scenario. For the CEUS sites, the scaling factors were calculated for hard rock sites, soft rock sites, and soil sites. The cumulative distributions of scaling factors for these three site conditions are shown in Figure 2-18 through Figure 2-20. The scaling factors for the three WUS sites are provided in Table 2-3. These factors represent the seismic hazards at 1E-4 annual frequency of exceedance.

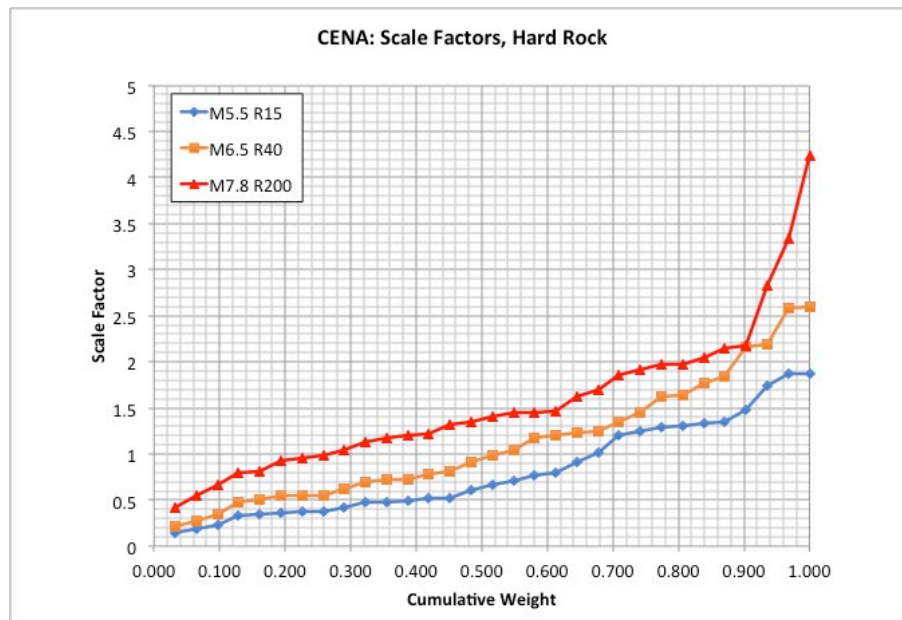


Figure 2-18. Cumulative Weights of the PGA Scaling Factors for CEUS Hard Rock Site Conditions.

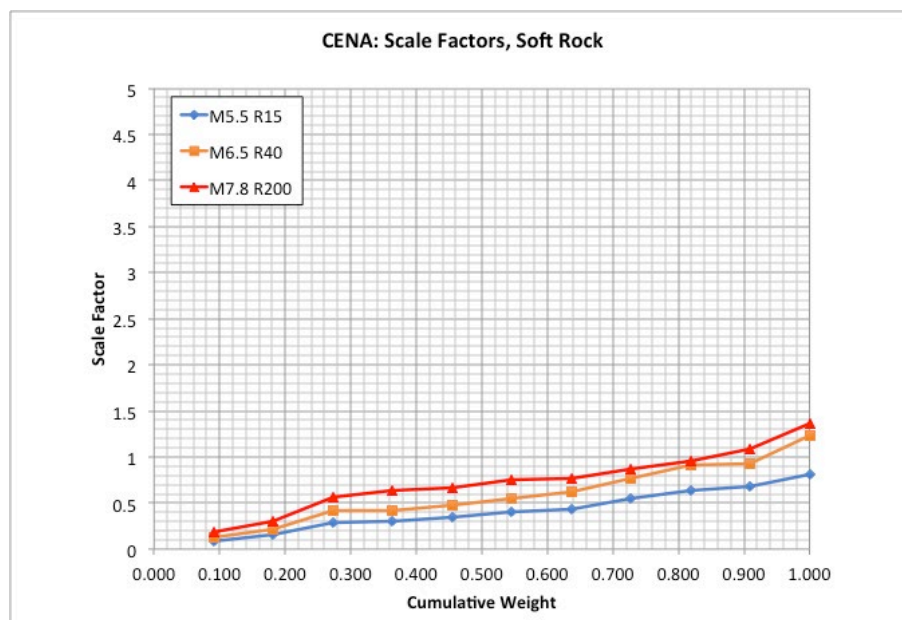


Figure 2-19. Cumulative Weights of the PGA Scaling Factors for CEUS Soft Rock Site Conditions.

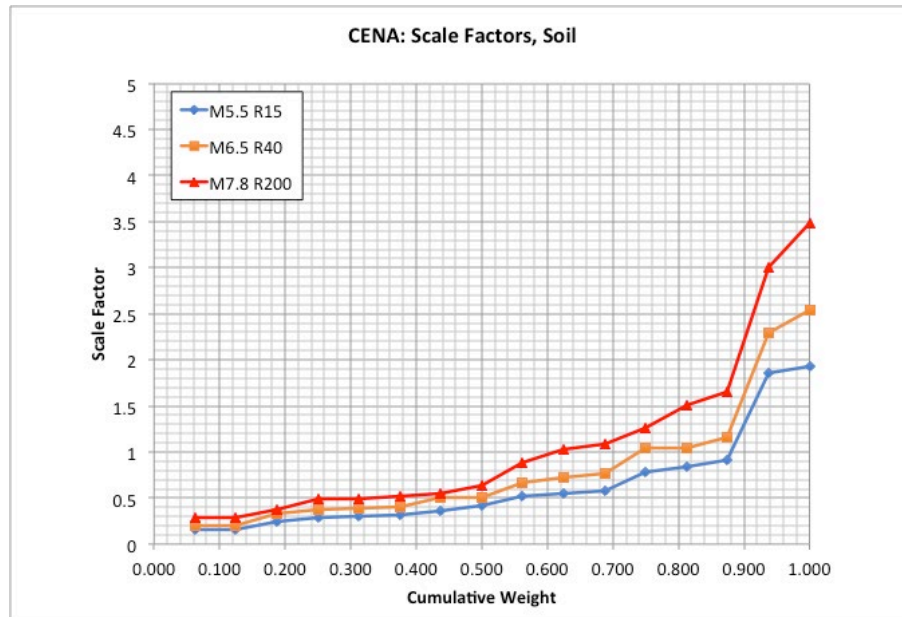


Figure 2-20. Cumulative Weights of the PGA Scaling Factors for CEUS Soil Site Conditions.

Table 2-3. Scaling Factors for WUS Sites.

Case	6.25 Magnitude at 10 km (6.21 mi)	7.5 Magnitude at 5 km (3.11 mi)	7.5 Magnitude at 200 km (124.27 mi)
Soft Rock	1.887	0.969	---
Soft Rock	4.022	2.206	---
Soil	0.670	---	5.151

To develop the scaling factors representing the seismic hazards at 1E-03 and 1E-05 annual frequency of exceedance the spectral ratios of 1E-03/1E-04 UHRS and 1E-05/1E-04 UHRS were calculated for the CEUS (hard rock, soft rock, and soil) and WUS (soft rock and soil) site conditions. The average PGA ratios were very similar for the different site conditions. It was recommended that the values estimated from the average across all of the data are applicable to scale the spectra and time histories for the two additional hazard levels of 1E-03 and 1E-05. Scale factors for other hazard levels can be estimated based on a linear interpolation of the log of the hazard level and log of the scale factors given the values provided in Table 2-4 and the desired interpolation hazard level.

Table 2-4. Average Scaling Factors for 1E-03/1E-4 and 1E-05/1E-04 Hazard Level Ratios.

Case	Average, All Site Conditions	Hard Rock	Soft Rock	Soil
CEUS Sites				
1E-3/1E-4	0.32	0.29	0.33	0.37
1E-5/1E-4	3.04	3.21	3.03	2.74
WUS Sites				
1E-3/1E-4	0.37	-	0.36	0.40
1E-5/1E-4	2.38	-	2.32	2.52

In accordance with RG1.208 [11], the site-specific GMRS must be defined based on 1E-04 UHRS adjusted using 1E-05 UHRS. The resulting GMRS, with few exceptions, approximately correspond to the 5E-5 seismic hazard level. Seismic hazard of 5E-04 represents smaller, but more frequently occurring earthquakes. Figure 2-21 – Figure 2-23 show the new GMRS from the screening reports for the hard rock, soft rock, and soil sites in CEUS. Also shown in these figures are the PGAs for three seismic scenarios calculated using the 84th percentile (~1 standard deviation above the mean) scaling factors for hard rock, soft rock, and soil sites and 5E-05 and 5E-04 seismic hazard scaling ratios based on Table 2-5 values.

Figure 2-24 shows the PGA percentiles from new GMRS corresponding to 84th Percentiles of 5E-05 PGAs calculated for hard rock, soft rock, and soil site conditions. The PGA values from the seismic scenarios corresponding to the 84th percentile of 5E-05 seismic hazard level are representative of the new GMRS PGA values within the range from 53-78 to 81-92 percentile. Consequently, the 84th percentile scaling factor values and 5E-5 seismic hazard level will be used to scale the time histories for the test cases entailing the design basis seismic conditions of the sites in CEUS. The scaling factors are provided in Table 2-5.

Only a few CEUS sites have the new GMRS PGAs higher than 84th percentile of 5E-05 seismic hazard level. Those sites are North Anna NPP (hard rock), Wolf Creek NPP (soft rock), and Vogtle, Robinson, and St. Lucia (soil).

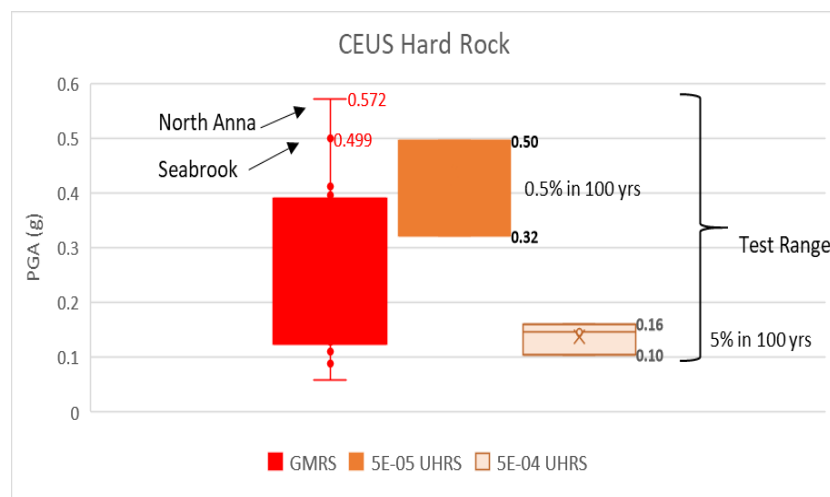


Figure 2-21. PGAs from New GMRS Compared to 84th Percentile of 5E-04 and 5E-05 PGAs Calculated for Hard Rock Site Conditions.

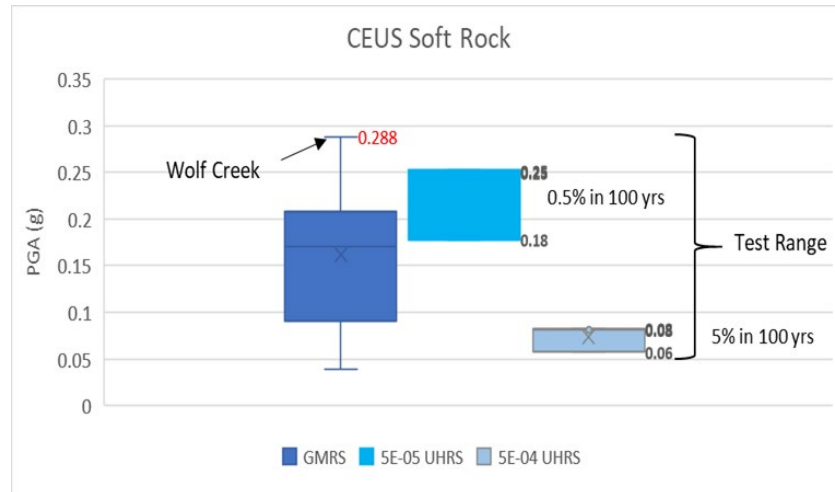


Figure 2-22. PGAs from New GMRS Compared to 84th Percentile of 5E-04 and 5E-05 PGAs Calculated for Soft Rock Site Conditions.

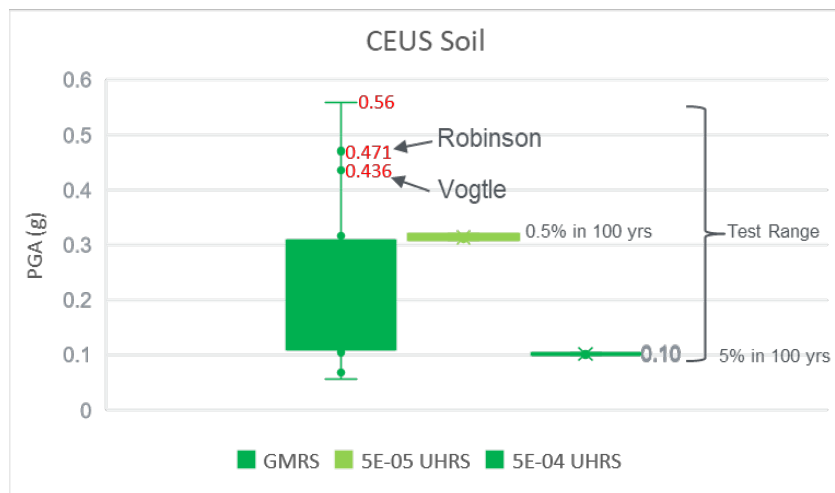


Figure 2-23. PGAs from New GMRS Compared to 84th Percentile of 5E-04 and 5E-05 PGAs Calculated for Soil Site Conditions.

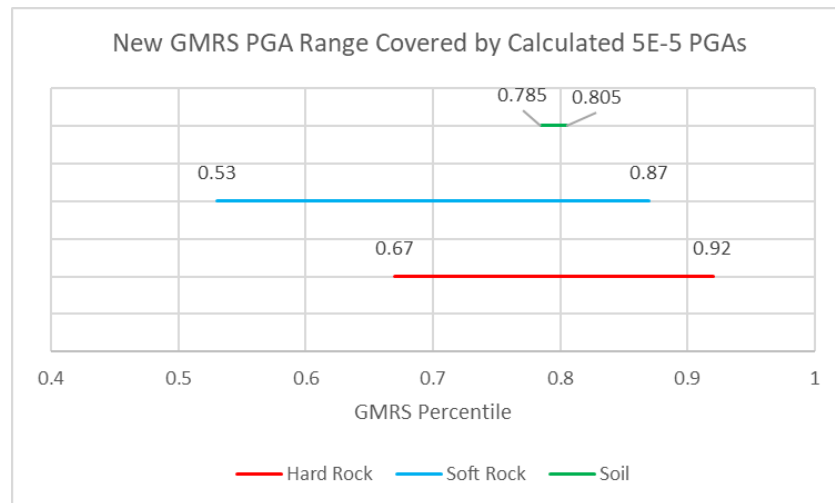


Figure 2-24. PGA Percentiles from New GMRS Corresponding to 84th Percentiles of 5E-05 PGAs Calculated for Soft Rock Site Conditions.

Table 2-5. Scaling Factors for 84th Percentile, 5E-05 and 5E-04 Seismic Hazards for CEUS.

Site Conditions	Seismic Scenario		
	M 5.5 at 15 km (9.32 mi)	M 6.5 at 40 km (24.85 mi)	M 7.8 200 km (124.27 mi)
5E-05 Hazard Level			
Hard Rock	2.158	2.886	3.336
Soft Rock	1.057	1.479	1.627
Soil	1.418	1.805	2.570
5E-04 Hazard Level			
Hard Rock	0.702	0.938	1.084
Soft Rock	0.343	0.481	0.529
Soil	0.461	0.587	0.836

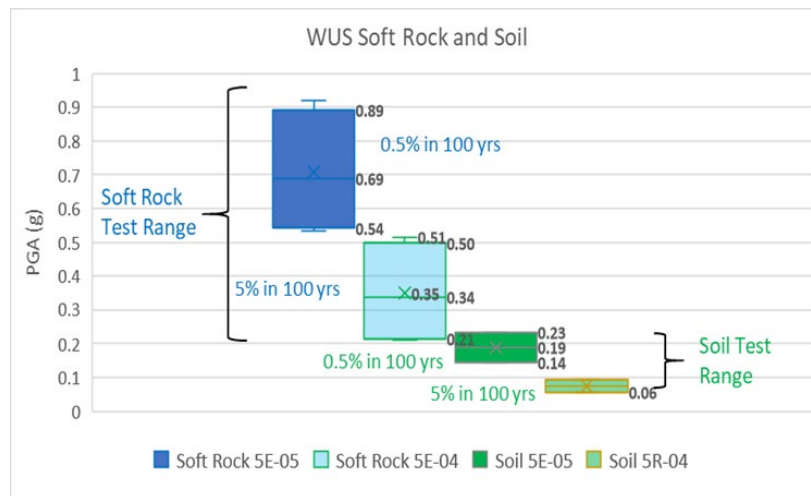
For the WUS sites, 5E-05/1E-04 seismic hazard scaling ratio is 1.415 based on Table 2-4 values. The resulting 5E-05 seismic hazard level scaling factors (median UHRS scaling factors x1.415) are provided in Table 2-6. Also provided in this table are 5E-04 seismic hazard level scaling factors. Note that the values shown in red font in Table 2-6 are for 1E-04 seismic hazard. This was needed to be consistent with the maximum PGA from the re-evaluated GMRS.

Table 2-6. Scaling Factors for 50th Percentile, 5E-05 and 5E-04 Seismic Hazards for WUS.

Site Conditions	Seismic Scenario		
	M 6.25 at 10 km (6.21 mi)	M 7.5 at 5 km (3.11 mi)	M 7.5 at 200 km (124.27 mi)
5E-05 Hazard Level			
Soft Rock	2.670	1.371	
Soft Rock	4.022	2.206	
Soil	0.948		7.289
5E-04 Hazard Level			
Soft Rock	1.132	0.581	
Soft Rock	2.412	1.323	
Soil	0.402		3.089

Note: the values shown in red font are for 1E-04 seismic hazard.

Figure 2-25 shows the 5E-04 and 5E-05 seismic hazard PGA ranges for the soft rock and soil site conditions in WUS. Note that two soft rock PGAs in this figure correspond to 1E-04 seismic hazard to be consistent with the maximum PGA from the re-evaluated GMRS as described above.



Note: Two soft rock PGAs correspond to 1E-04 seismic hazard to be consistent with the maximum PGA from the re-evaluated GMRS.

Figure 2-25. PGAs Corresponding to 5E-04 and 5E-05 Seismic Hazard Level for Soft Rock and Soil Site Conditions in WUS.

Five sets of three component (two horizontal and one vertical) time histories were developed for each of the 13 horizontal spectral shapes shown in Figure 2-8 through Figure 2-12. The vertical spectral shapes were defined using the V/H ratios shown in Figure 2-13 – Figure 2-17. The scaling factors defined in Table 2-5 and Table 2-6 can be used to scale these time histories to 5E-05 and 5E-04 seismic hazard levels.

The time histories were developed using candidate seed time histories. The candidate seed-time histories were selected given the time history database from the NGA-West2 program [15]. The spectral modification was performed in the time domain using the program RSPMatch [17] while maintaining the non-stationary characteristics of the empirical candidate seed-time history. For the CEUS cases, the same selected candidate seed time histories were used for hard rock, soft rock, and soil for a given earthquake scenario. For WUS cases, different seed candidate time histories were used for soft rock and soil for a given earthquake scenario. The seed time histories are summarized in Table 2-7 and Table 2-8.

Seed time histories were matched to the component-specific target spectra frequencies from 100Hz (0.01 sec) to 0.2 Hz (5 sec). The comparisons were performed to ensure that the non-stationary characteristics of the seed input time histories and modified time histories of acceleration, velocity, and displacement and the associated peak ground motion parameters and durations are reasonable and acceptable. The details regarding the selection of the seed time histories and spectral matching are provided in [8].

The initial and modified time histories (acceleration, velocity, and displacement), as well as the response spectra, Fourier amplitude spectra, and normalized Arias intensity are provided in [8] for each of the 13 spectral shapes. Examples of horizontal and vertical components time histories are provided in Figure 2-29 and Figure 2-30 for the hard rock conditions for the 5.5 magnitude earthquake at 15 km (9.32 mi) scenario. The seed time history for this example was from 2009 L'Aquila (aftershock 1) earthquake in Italy. Both, original and modified time histories are shown.

Table 2-7. Selected Seed Candidate Time Histories for CEUS.

Set	Earthquake	Year	Station Name	Vs30 (m/sec)	Vs30 (ft/sec)
5.5 at 15 km					
1	L'Aquila (aftershock 1) Italy	2009	L'Aquila - V. Aterno - Ferriera	561.04	1840.8
2	Coalinga-02	1983	SGT (temp)	481.07	1578.4
3	Chalfant Valley-03	1986	Bishop - Paradise Lodge	585.12	1919.8
4	Whittier Narrows-01	1987	Pomona - 4th & Locust FF	384.44	1261.4
5	Umbria Marche (aftershock 1) Italy	1997	Nocera Umbra-Salmata	394	1292.7
6.5 at 40 km					
6	Imperial Valley-06	1979	Victoria	242.05	794.2
7	San Fernando	1971	Pearlblossom Pump	529.09	1735.9
8	Chi-Chi, Taiwan-05	1999	TCU140	223.6	733.6
9	Chuetsu-oki, Japan	2007	NIGH12	564.25	1851.3
10	Tottori, Japan	2000	OKY002	592.05	1942.5
7.8 at 200 km					
11	Tabas, Iran	1978	Sedeh	354.37	1162.7
12	Denali, Alaska	2002	TAPS Pump Station #08	424.9	1394.1
13	Kocaeli, Turkey	1999	Tekirdag	521.76	1711.9
14	Chi-Chi, Taiwan	1999	TAP046	816.9	2680.3
15	Landers	1992	Tarzana - Cedar Hill	257.21	843.9

Table 2-8. Selected Seed Candidate Time Histories for WUS.

Set	Earthquake	Year	Station Name	Vs30 (m/sec)	Vs30 (ft/sec)
6.25 at 10 km, Soft Rock					
16	Parkfield	1966	Cholame - Shandon Array #8	256.82	842.6
17	L'Aquila, Italy	2009	GRAN SASSO (Assergi)	488	1601.1
18	Coalinga-01	1983	Pleasant Valley P.P. - bldg.	257.38	844.5
19	Chi-Chi Taiwan-06	1999	TCU076	614.98	2017.8
20	Mammoth Lakes-01	1980	Long Valley Dam (Upr L Abut)	537.16	1762.4
6.25 at 10 km, Soil					
21	Chalfant Valley-02	1986	Bishop - LADWP South St	303.47	995.7
22	L'Aquila, Italy	2009	GRAN SASSO (Assergi)	488	1601.1
23	Coalinga-01	1983	Pleasant Valley P.P. - bldg.	257.38	844.5
24	Chi-Chi Taiwan-06	1999	TCU076	614.98	2017.8
25	Mammoth Lakes-01	1980	Long Valley Dam (Upr L Abut)	537.16	1762.4
7.5 at 5 km, Soft Rock					
26	Tabas, Iran	1978	Tabas	766.77	2515.8
27	Kocaeli, Turkey	1999	Duzce	281.86	924.8
28	El Mayor-Cucapah, Mexico	2010	El Centro - Imperial & Ross	229.25	752.2
29	Landers	1992	Desert Hot Springs	359	1177.9
30	Chi-Chi, Taiwan	1999	TCU076	614.98	2017.8
7.5 at 200 km, Soil					
31	Tabas, Iran	1978	Sedeh	354.37	1162.7
32	Hector Mine	1999	Castaic - Hasley Canyon	421.05	1381.5
33	Kocaeli, Turkey	1999	Balikesir	468.44	1537.0
34	Landers	1992	Chatsworth - Devonshire	409.4	1343.2
35	El Mayor-Cucapah, Mexico	2010	Santa Ana - Grand & Santa Clara	301.93	990.6

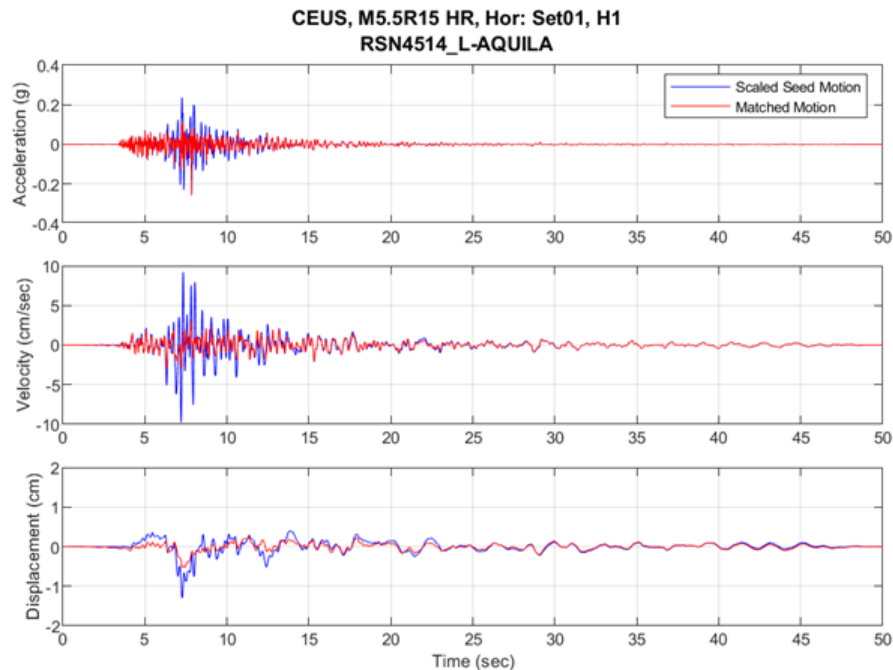


Figure 2-26. Horizontal Time Histories for CEUS Hard Rock Conditions for 5.5 Magnitude Earthquake at 15 km (Seed: L'Aquila (aftershock 1) Italy, 2009).

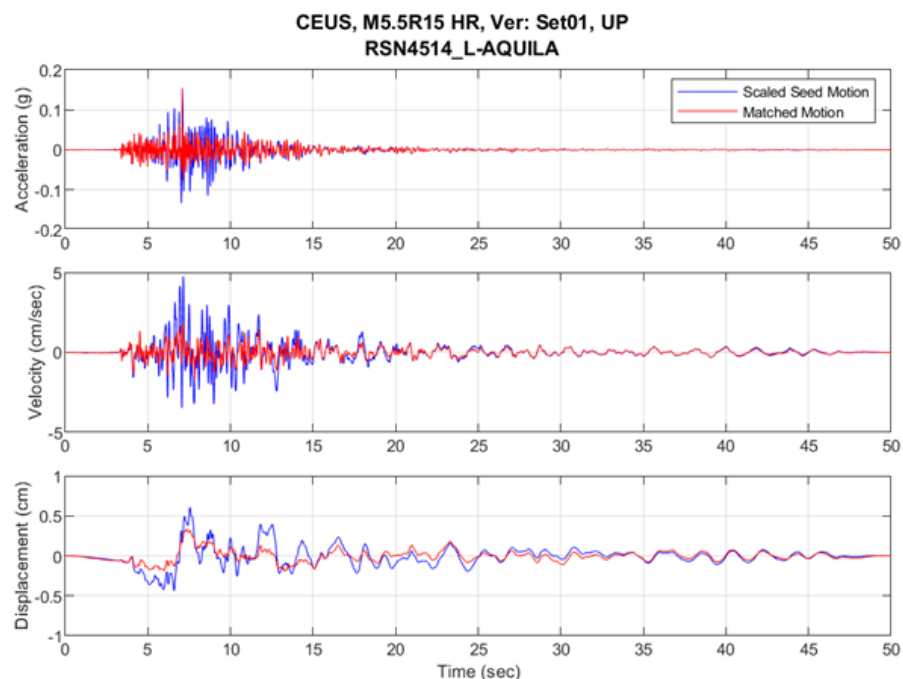


Figure 2-27. Vertical Time Histories for CEUS Hard Rock Conditions for 5.5 Magnitude Earthquake at 15 km (Seed: L'Aquila (aftershock 1) Italy, 2009).

As was previously discussed, the movement of the top of the ISFSI pad (shake table) is the same as the free-field ground motions at the hard rock sites. Table 2-9 defines the shake table inputs for the hard rock

sites. In addition to the 5E-05 and 5E-04 seismic hazard cases, a case with the PGA of 0.572 g will be considered. This is the maximum PGA from the new GMRS in CEUS from the screening reports.

One more case was added to provide a comparison with a similar case in NUREG/CR-6865 [18]. The horizontal and vertical spectral shapes considered in NUREG/CR-6865 for the CEUS rock conditions are compared to the corresponding spectral shapes of the rock site earthquake scenarios in Figure 2-28 and Figure 2-29. The spectral shapes were normalized by PGA of 1 g. The NUREG/CR-6865 spectral shapes are very similar to the spectral shapes of the or 6.5 magnitude earthquake at 40 km scenario.

NUREG/CR-6865 provides modeling results for a concrete cask system similar to the test unit on the ISFSI pad in earthquake defined by these spectral shapes scaled to PGA 0.25, 0.6, 1, and 1.25 g. The test cases will consider the 6.5 magnitude earthquake at 40 km (24.85 mi) scenario scaled to PGA of 0.25 and 0.6. The test data will be compared to the NUREG/CR-6865 results.

The hard rock PGAs specified in Table 2-9 are plotted in Figure 2-30 to show the ranges considered in the test cases.

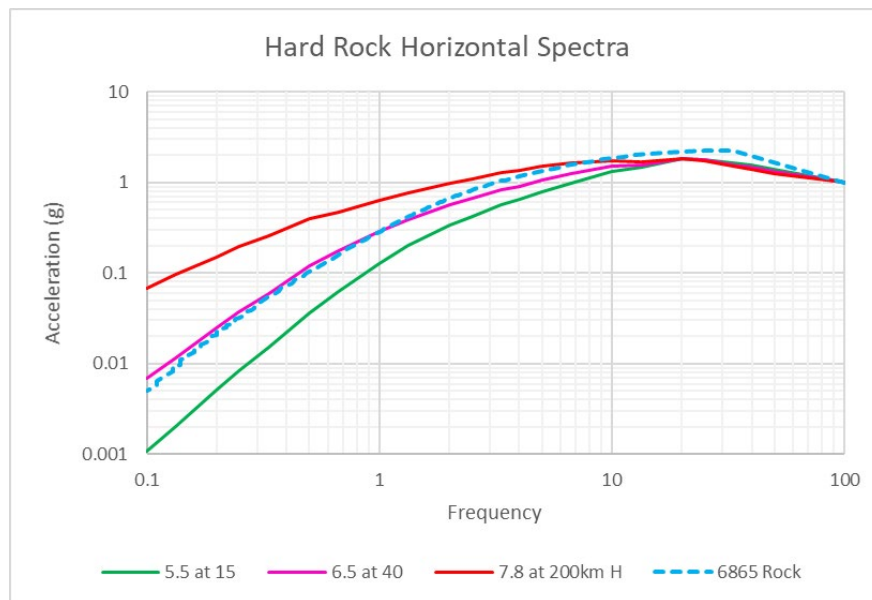


Figure 2-28. Hard Rock Horizontal Spectra for 3 Earthquake Scenarios and Scenario Considered in NUREG/CR-6865 [18].

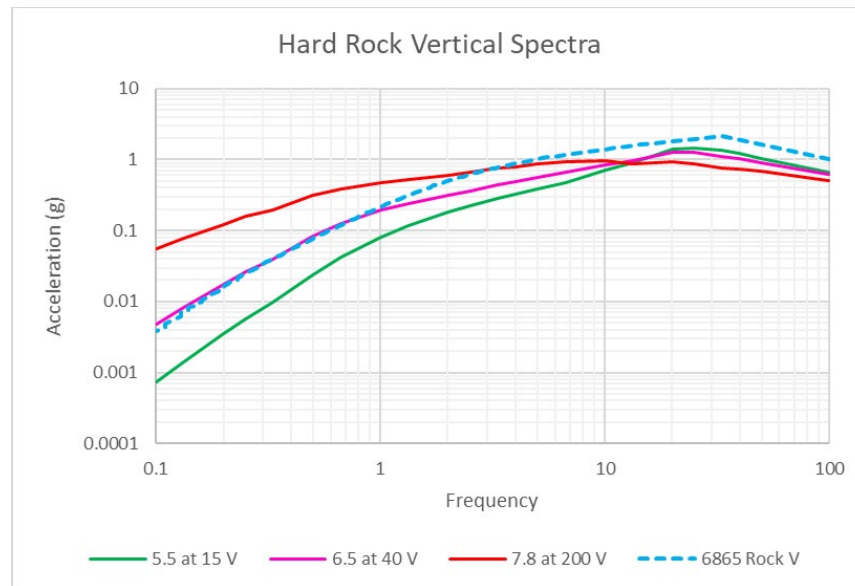


Figure 2-29. Hard Rock Vertical Spectra for 3 Earthquake Scenarios and Scenario Considered in NUREG/CR-6865.

Table 2-9. Test Cases for Hard Rock Conditions in CEUS.

Test Case NN	Seismic Hazard	Earthquake Scenario	Time History ID	Scaling Factor	PGA, X (g)
1	5.00E-05	5.5 at 15 km (9.32 mi)	1	2.158	0.495
2			2	2.158	0.495
3			3	2.158	0.495
4			4	2.158	0.495
5			5	2.158	0.495
6		6.5 at 40 km (24.85 mi)	6	2.886	0.448
7			7	2.886	0.448
8			8	2.886	0.448
9			9	2.886	0.448
10			10	2.886	0.448
11		7.8 at 200 km (124.27 mi)	11	3.336	0.322
12			12	3.336	0.322
13			13	3.336	0.322
14			14	3.336	0.322
15			15	3.336	0.322
16	5.00E-04	5.5 at 15 km (9.32 mi)	1	0.702	0.161
17			2	0.702	0.161
18			3	0.702	0.161
19			4	0.702	0.161
20			5	0.702	0.161

Test Case NN	Seismic Hazard	Earthquake Scenario	Time History ID	Scaling Factor	PGA, X (g)
21		6.5 at 40 km (24.85 mi)	6	0.938	0.146
22			7	0.938	0.146
23			8	0.938	0.146
24			9	0.938	0.146
25			10	0.938	0.146
26		7.8 at 200 km (124.27 mi)	11	1.084	0.105
27			12	1.084	0.105
28			13	1.084	0.105
29			14	1.084	0.105
30			15	1.084	0.105
31	Max PGA in CEUS	5.5 at 15 km (9.32 mi)	1	2.296	0.527
32			2	2.296	0.527
33			3	2.296	0.527
34			4	2.296	0.527
35			5	2.296	0.527
36		6.5 at 40 km (24.85 mi)	6	3.395	0.527
37			7	3.395	0.527
38			8	3.395	0.527
39			9	3.395	0.527
40			10	3.395	0.527
41		7.8 at 200 km (124.27 mi)	11	5.458	0.527
42			12	5.458	0.527
43			13	5.458	0.527
44			14	5.458	0.527
45			15	5.458	0.527
46	NUREG/CR-6865	6.5 at 40 km (24.85 mi)	6	1.611	0.250
47			7	1.611	0.250
48			8	1.611	0.250
49			9	1.611	0.250
50			10	1.611	0.250
51		6.5 at 40 km (24.85 mi)	6	3.866	0.600
52			7	3.866	0.600
53			8	3.866	0.600
54			9	3.866	0.600
55			10	3.866	0.600
56	North Ana	5.8 at 17.7 km (11 mi)	N/A	N/A	0.264

Note: Time history description including IDs is provided in Table 2-7.

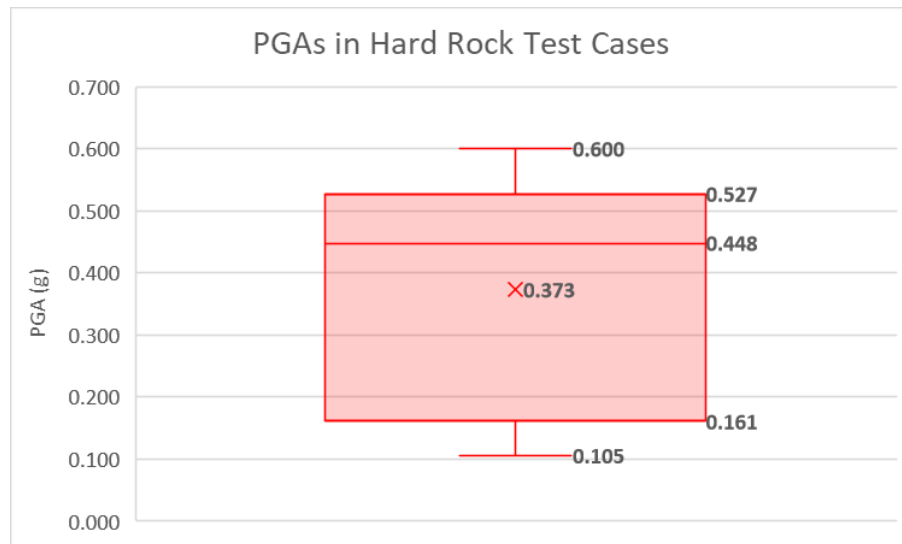


Figure 2-30. PGAs Specified in Hard Rock Shake Table Test Case (Table 2-9).

2.3 Development of Ground Motions for Soil and Soft Rock Sites

The ground motion on the top of the pad at the soil and soft rock sites will be affected by the soil (soft-rock) structure interaction and pad flexibility resulting in amplification/attenuation of the corresponding free-field ground motions and related time histories. SSI analysis has to be conducted to develop the time histories representative of the soil and soft rock sites in the CEUS and WUS.

The major inputs into the SSI analysis are:

- Soil and soft rock free-field ground motions in CEUS and WUS for the representative earthquake scenarios
- The representative soil and soft rock properties
- The concrete pad properties, configuration and loading conditions
- The dry storage overpack parameters

The analysis consists of two parts. The first part is the site response analysis. The purpose of this analysis is to calculate soil/soft rock properties strain compatible with the representative ground motions and PGAs reflecting different levels of seismic hazard. The analysis is performed with software code SHAKE91. SHAKE91 computes the response of a semi-infinite horizontally layered soil deposit overlying a uniform half-space subjected to vertically propagating shear waves (horizontal motions). An equivalent-linear site response analysis is used to account for the nonlinear behaviour of the soils/soft rock via an iterative procedure.

The results of the site response analysis are used as input in a linear analysis program System for Analysis of Soil-Structure Interaction (SASSI). The version of SASSI used was the SC Solutions version of the code that incorporates a number of modifications to allow for easier pre and post processing. SASSI was executed for each representative free-field ground motion-peak ground acceleration scenario to calculate response spectra at the different locations on the pad. The SASSI results were then postprocessed to obtain the time histories using five sets of time histories for each case. The diagram in Figure 2-31 (developed by William Johnson, SRNL) shows the flowchart of the analysis and the inputs into the different analysis modules.

The SSI analysis was performed by SC Solutions in collaboration with SRNL and SNL. The details of this analysis are documented in [19] which is provided as Appendix B to this report. This section provides a summary of the SSI analysis and recommendations regarding the locations on the pad to be considered in the shake table test.

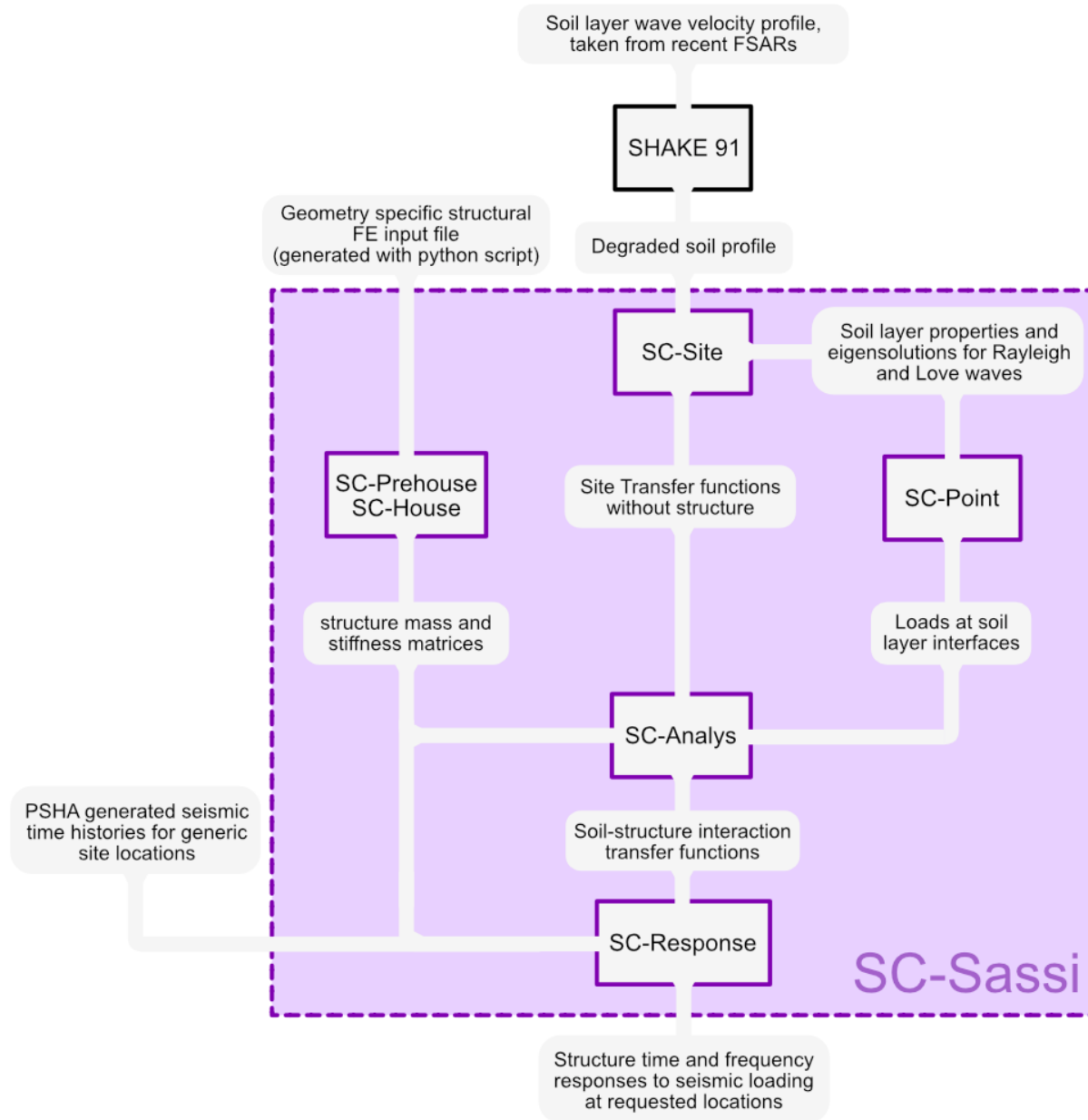


Figure 2-31. Soil-Structure Interaction Analysis Diagram.

Fourteen scenarios considered in the SSI analysis are described in Table 2-10. Three soil and four soft rock scenarios were considered in CEUS. Three soil and four soft rock scenarios were considered in WUS. The pad configuration representative of soil and rock sites in CEUS and WUS was derived based on Google Earth images of the corresponding ISFSIs. The images are provided in Appendix A. The resulting vertical systems (casks) pad capacity (number of casks in X and Y direction) is provided in

Table 2-10. The representative horizontal storage modules (HSMs) configuration is 2x16 side to side and back-to-back connected HSMs. The HSMs are applicable to all CEUS scenarios and to scenario 11 and 12 in WUS.

Table 2-10. SSI Analysis Scenarios.

Scenario Number	Site Conditions	PGA (g)	Representative Earthquake magnitude (M) and Distance (D) in km	Seismic Hazard	Vertical System Pad Capacity
1	CEUS Soil	0.56	M 5.5, D 15	GMRS	2 x 6
2	CEUS Soil	0.31	M 6.5, D 40	5.E-05	2 x 6
3	CEUS Soil	0.1	M 7.8, D 200	5.E-04	2 x 6
4	CEUS Soft Rock	0.25	M 5.5, D 15	5.E-05	6 x 12
5	CEUS Soft Rock	0.08	M 6.5, D 40	5.E-04	6 x 12
6	CEUS Soft Rock	0.29	M 5.5, D 15	GMRS	6 x 12
7	CEUS Soft Rock	0.18	M 7.8, D 200	5.E-05	6 x 12
8	WUS Soil	0.23	M 6.25, D 10	5.E-05	2 x 15
9	WUS Soil	0.14	M 7.5, D 200	5.E-05	2 x 15
10	WUS Soil	0.09	M 6.25, D 10	5.E-04	2 x 15
11	WUS Soft Rock	0.22	M 6.25, D 10	5.E-04	2 x 15
12	WUS Soft Rock	0.52	M 7.5, D 5	5.E-04	2 x 15
13	Diablo Canyon	0.92	M 7.5, D 5	GMRS	5 x 28
14	Diablo Canyon	1.3	M 7.5, D 5	5.E-05	5 x 28

The vertical system pad configurations are shown in Figure 2-32 and Figure 2-33 for CEUS and WUS sites respectively. The red circles in these figures show the cask locations in partially loaded configurations. Both fully loaded and partially loaded configurations were considered.

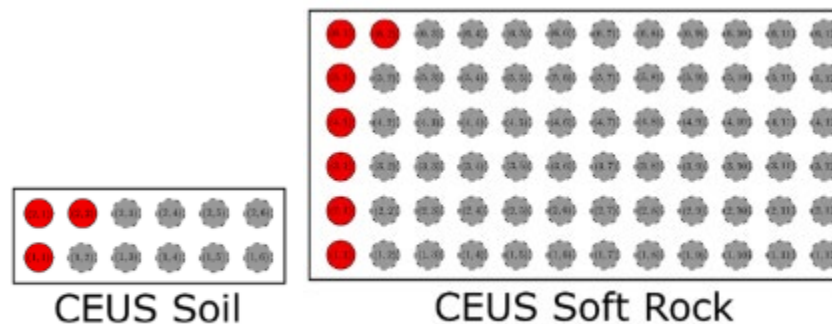


Figure 2-32. CEUS Representative Pad Configurations.

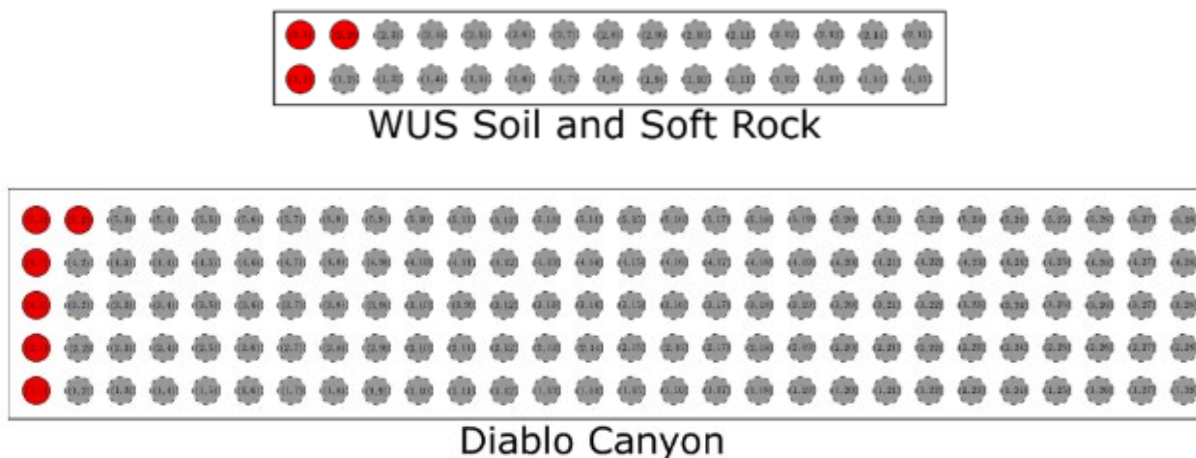


Figure 2-33. WUS Representative Pad Configurations.

The examples of the actual ISFSI pads with the vertical casks (Clinton) and HSMs (Nine Mile Point) are shown in Figure 2-34.

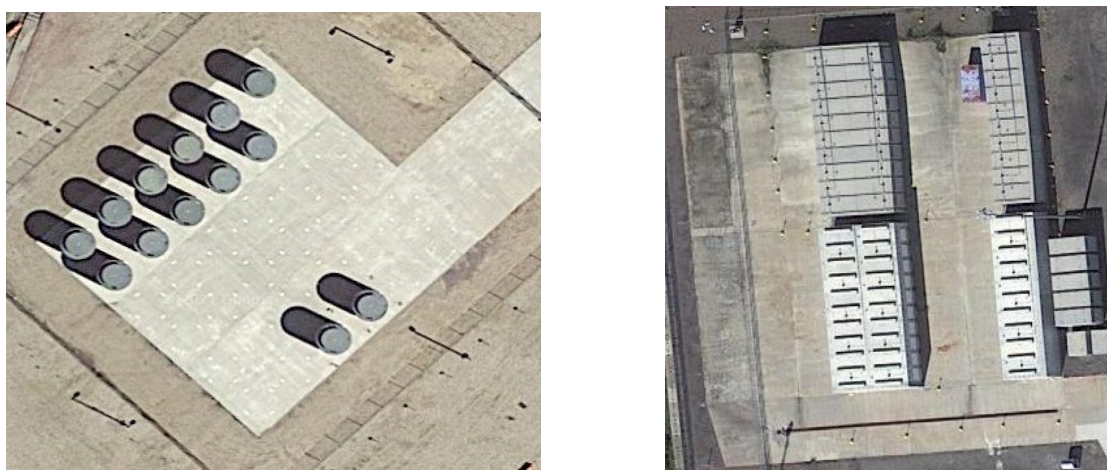


Figure 2-34. Clinton Power Station ISFSI (left) and Nine Mile Point Nuclear Generating Station ISFSI (right) (Satellite Image from Google Maps).

The partially loaded configurations are based on the sensitivity studies [19]. The pad configurations with fewer cask located on the edge of the pad resulted in higher accelerations on the pad.

The pad reinforced concrete material properties are provided in Table 2-11.

Table 2-11. Concrete Pad Material Properties.

Young's Modulus	Poisson's Ratio	Density	Damping Ratio
3605 ksi	0.25	150 pcf (2,403 kg/m ³)	0.07

Representative soil and soft rock profiles were generated for CEUS and WUS. A site-specific profile was used for the Diablo Canyon site. These profiles were meant to create generic site conditions while keeping realistic site characteristics. The representative profiles are generated by creating a hybrid profile between two actual site profiles: one base site and one bedrock reference site. The soil/soft rock properties are taken from the base site. The shear wave velocity (V_s) is then linearly scaled to match the bedrock V_s value with the V_s value of the bedrock in the reference profile. The base site and reference site used to generate site properties are listed in Table 2-12. The selection of the base profile sites was driven by the availability of the actual soil and soft rock data for the deep soil and soft rock conditions typical for the soil and soft rock sites in both, CEUS and WUS.

Table 2-12. Site Conditions, Base Profiles and Reference Profiles.

Site conditions	Base Profile	Reference Profile
CEUS Soil	Vogle	Farley
CEUS Soft Rock	Hope Creek	Surry
WUS Soil	Hanford	Average Bedrock of Hanford and Palo Verde
WUS Soft Rock	Palo Verde	Average Bedrock of Hanford and Palo Verde

The CEUS soil and soft rock base shear velocity profiles are shown in Figure 2-35.

The soil strata at Vogtle can be subdivided into three major units:

- Compacted backfill mostly consisting of sands mixtures with occasional clay seams
- Blue Bluff Marl consisting of very hard calcareous over-consolidated clay marl
- Lower Sand Stratum consisting of a dense sand with minor interbedded clay and silt

The base rock is encountered at a depth of approximately 1,056 ft and consists of Paleozoic crystalline rock, as well as Triassic-Jurassic sedimentary rock of the Dunbarton Basin.

The Hope Creek Generating Station (HCGS) site stratigraphy includes the following major strata: hydraulic fill, alluvium, Tertiary sands, Cretaceous dense sand, and Potomac Formation. The Cretaceous Potomac Formation, Middle Zone at depth 1248 ft is selected as base rock for site response analysis.

The soft rock properties were taken from the nearby PSEG ESPA site (about 1 km away) [20] and reflect direct shear-wave measurements to a depth of the top of the Potomac Formation.

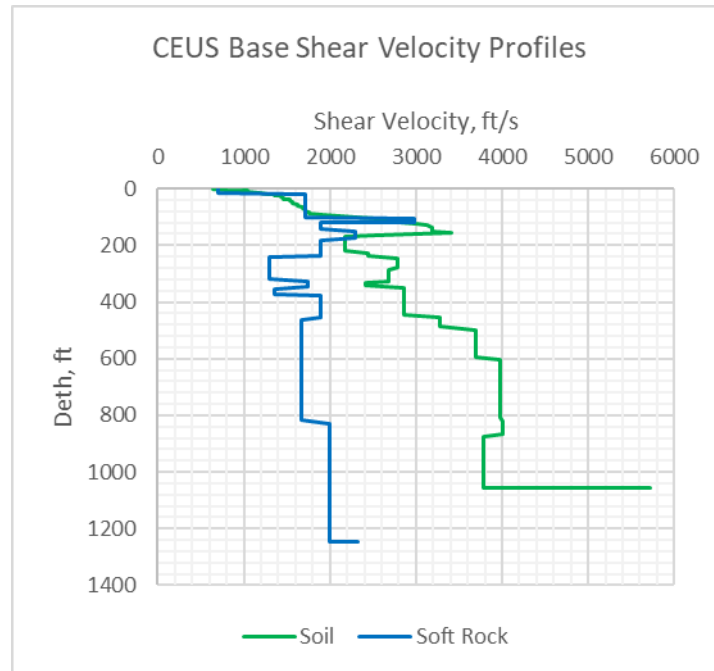


Figure 2-35. CEUS Base Shear Velocity Profiles for Soil and Soft Rock Sites.

The WUS soil and soft rock base shear velocity profiles are shown in Figure 2-36

For the Hanford site, the soil profile from Columbia Generating Station [21], about 10 miles away from Hanford was used for site response sensitivity study. The subsoil profile includes the following units:

- Pasco Gravel, a Quaternary deposit consisting of loose to medium dense sand with scattered gravel
- Pliocene-age Ringold Formation (Middle Member) consisting of a very dense sandy gravel with interbedded sandy and silty layers
- Ringold Formation (Lower Member) consisting of very dense interbedded layers of sandy gravel, silt, and soft sandstone with some conglomerate present at the base of the layer.

The base rock below 525 ft consists of the Saddle Mountains Basalt with shear wave velocity V_s of 7,575 ft/sec.

For Palo Verde site, the best estimate shallow soil profile was used [22]. The subsurface strata at Palo Verde site consist of alternate layers of sand and clay underlain by the Andesite/basalt/flow breccia/tuff bedrock located at depth of 427 feet with $V_s = 4,485$ ft/sec.

For the Diablo Canyon site, the Central Profile [23] was used. The profile was truncated at depth 916 ft where the V_s reaches 5,907 ft/sec.

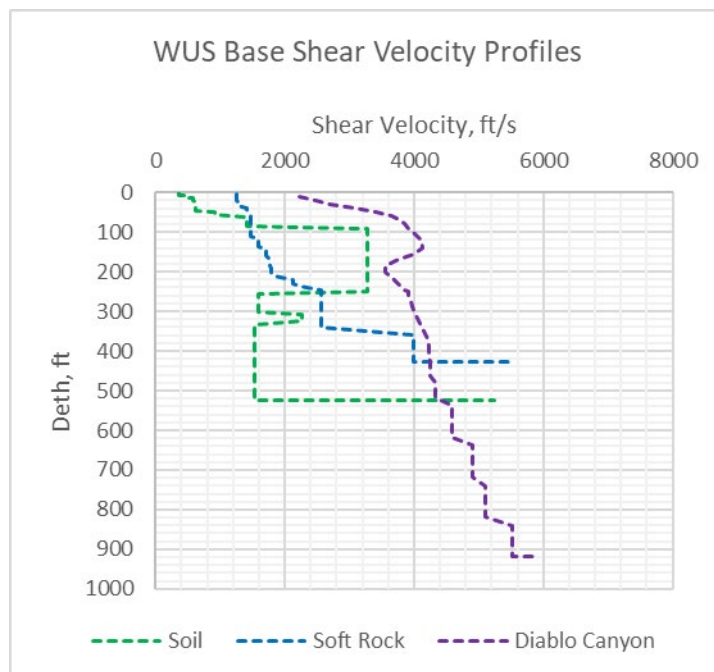


Figure 2-36. WUS Base Shear Velocity Profiles for Soil and Soft Rock Sites.

The soil and soft rock properties for the four representative profiles in Table 2-12 and Diablo Canyon including layer thickness, unit weight, low-strain shear wave velocity (V_s), and damping can be found in Appendix B. These properties were inputs into the site response analysis.

Figure 2-37 shows examples in which the strain compatible shear velocity profile was slightly different from the initial for CEUS (left) and somewhat different from the initial for WUS (right). The strain compatible shear velocity profiles for all scenarios are provided in Appendix B.

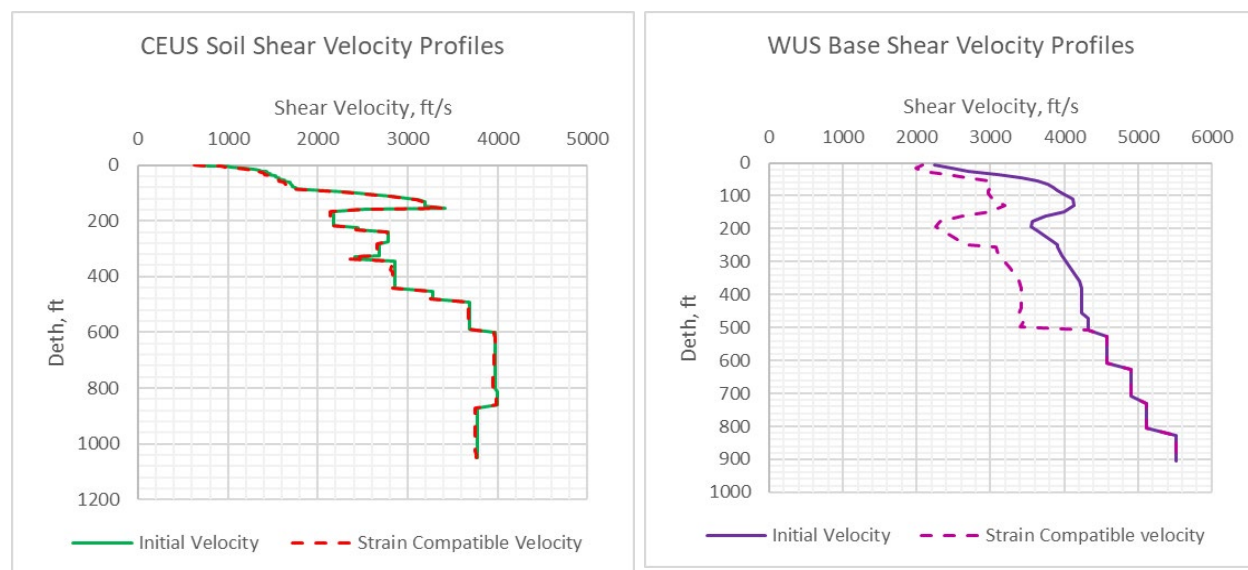


Figure 2-37. Examples of Strain Compatible Shear Velocity Profiles for CEUS (left) and WUS (right).

2.3.1 Vertical Cask Modeling Results

The parameters of the vertical dry storage overpack (cask) that are needed for SASSI simulations are the center-of-gravity height, outer diameter, and the total weight of the cask, canister, and assemblies. The dimensions of the vertical cask are shown in Figure 2-38. The total weight of the dry storage cask system is 335,952 lbs. The cask is a mockup of an actual dry storage cask with the dimensions and weight similar to the HI STORM 100 cask (Holtec). The details about the cask mockup are provided in Section 3.3.

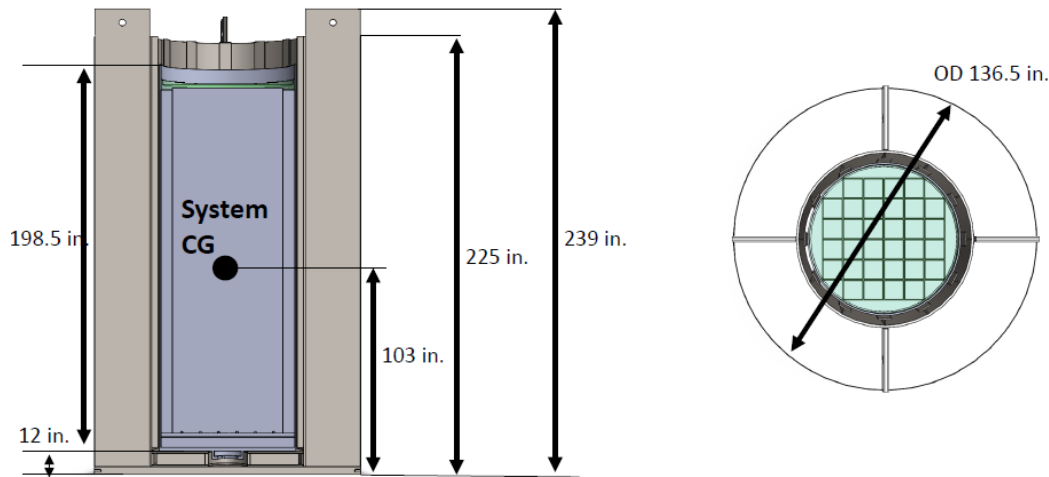


Figure 2-38. Dimensions of the Vertical Cask.

The cask finite element model is shown in Figure 2-39. The cask internals are not modeled. The cask is represented with a single vertical rigid beam element with the cask mass lumped at its center-of-gravity and eight horizontal rigid beam elements representing the contact area with the concrete pad, causing the cask to behave as a rigid body. The horizontal rigid beam elements representing the cask base are connected to the pad with 8 vertical stiff springs having a length of half the pad thickness to locate the casks at the pad surface. The horizontal rigid beam ends connected to the vertical springs have rotational end releases. This configuration minimizes the effect of stiffening of the concrete pad due to the connection of the rigid beam members to the concrete pad. Horizontal forces and bending/torsional moments are transferred between the cask and the pad via the short element at the center of the cask, connecting the cask single vertical rigid beam element with the concrete pad.

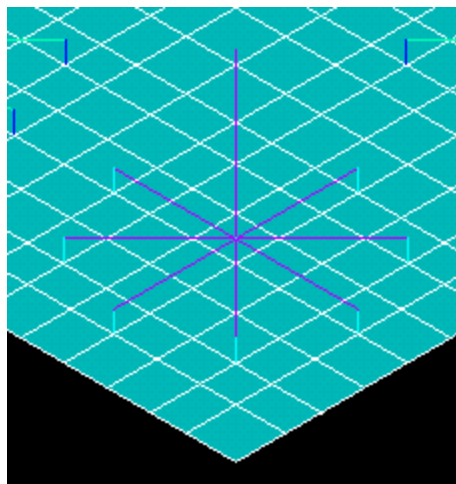


Figure 2-39. Detailed View of the Pad Corner Cask Model Showing Pad and Cask Mesh.

An example of the mesh of a fully loaded pad with multiple casks is shown in Figure 2-40. The model assumes that the pad-cask interface response is linear - the casks neither shift nor tip on the pad.

A survey of HI-STORM 100 casks deployed on ISFSIs around the country showed that the typical center-to-center distance between the casks is 15 to 16 ft, leaving approximately 4 ft of clearance. The center-to-center distance of 16 ft was assumed between casks in all considered pad configurations.

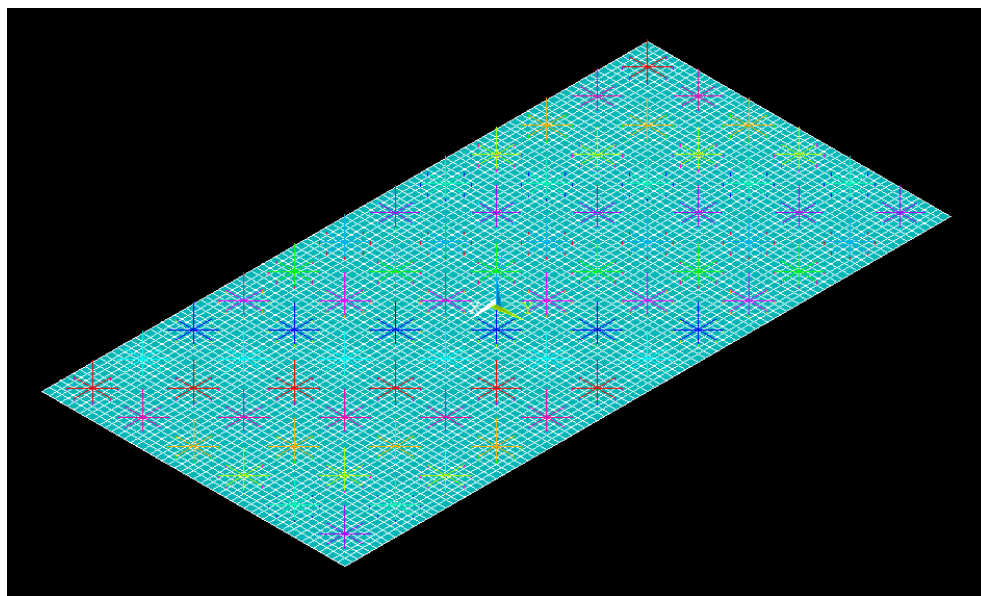


Figure 2-40. An Example of the Mesh of a Fully-Loaded Pad with Vertical Casks.

The SSI analyses were performed for 14 scenarios (Table 2-10). Each scenario considered a fully loaded pad and a partially loaded pad configurations. The frequency domain responses were calculated using the module SC-ANALYS. Time history postprocessing was performed using 5 sets of time histories for each scenario case. Acceleration time histories and response spectra, as well as displacement time histories were extracted using the module SC-RESPONSE. The results were provided for each cask node for two locations, the center of gravity and the center of the base of the cask (which is the same as the top of the pad), shown in Figure 2-41.

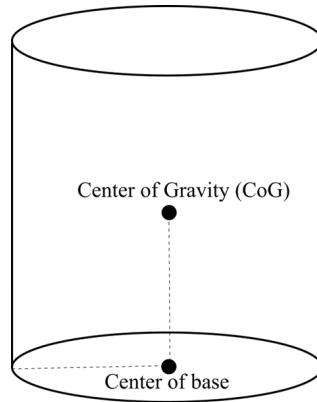
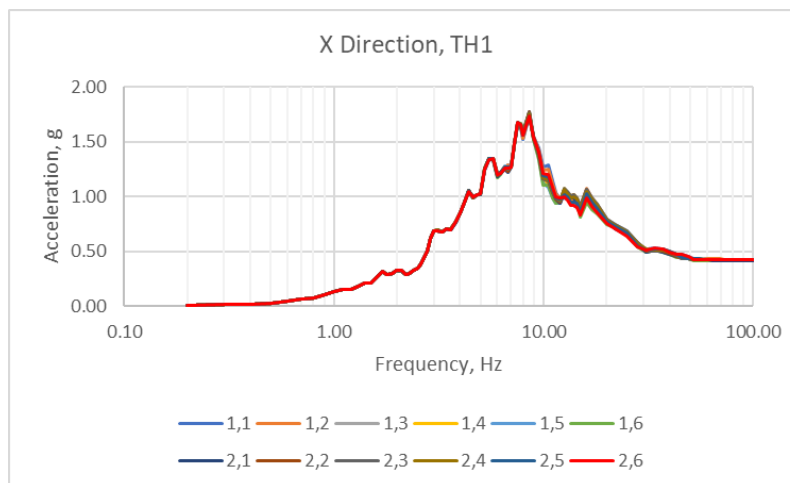


Figure 2-41. Cask Monitoring Points.

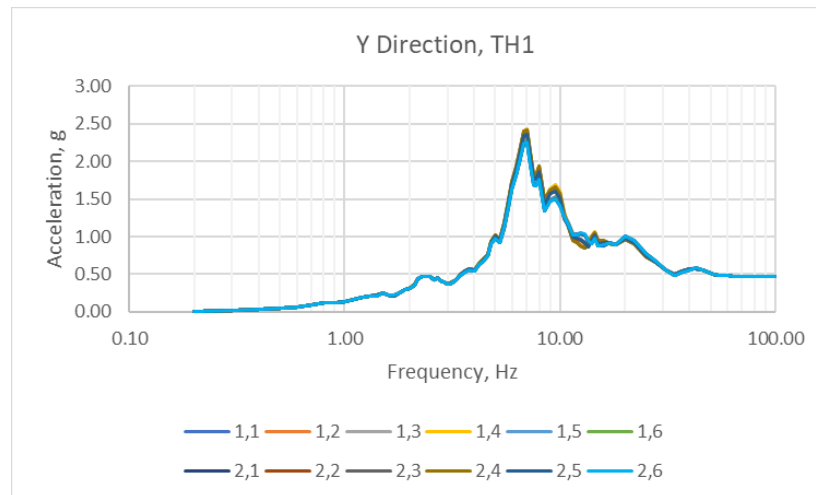
The results were analyzed to select the locations on the pad and corresponding time histories to be used in the shake table test. The summary of the analysis is presented below using as an example one of the scenarios (Scenario 1 in Table 2-10). The other scenarios have the same trends as Scenario 1.

Scenario 1 is the CEUS soil scenario with 12 casks (2 x 6) on the fully loaded pad and three casks on the partially loaded pad (Figure 2-32). The spectral accelerations in the X and Y directions are very similar in all locations on the pad as shown on Figure 2-42 and Figure 2-43 for the time history 1 (TH1). The spectral accelerations in Z direction change with location as shown in Figure 2-44 for time history 1 (TH1). Same is true for the other four time histories as demonstrated in Figure 2-45.



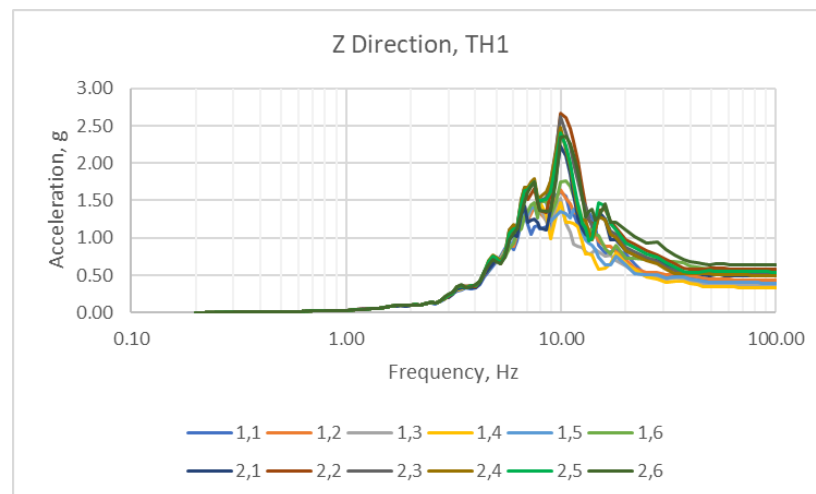
Note: (1,1) is the node ID. The IDs are shown in Figure 2-32 for the CEUS soil scenario.

Figure 2-42. Scenario 1 Pad Response Spectra in X Direction for the Fully Loaded Pad.



Note: (1,1) is the node ID. The IDs are shown in Figure 2-32 for the CEUS soil scenario.

Figure 2-43. Scenario 1 Pad Response Spectra in Y Direction for the Fully Loaded Pad.



Note: (1,1) is the node ID. The IDs are shown in Figure 2-32 for the CEUS soil scenario.

Figure 2-44. Scenario 1 Pad Response Spectra in Z Direction for the Fully Loaded Pad (Time History 1).

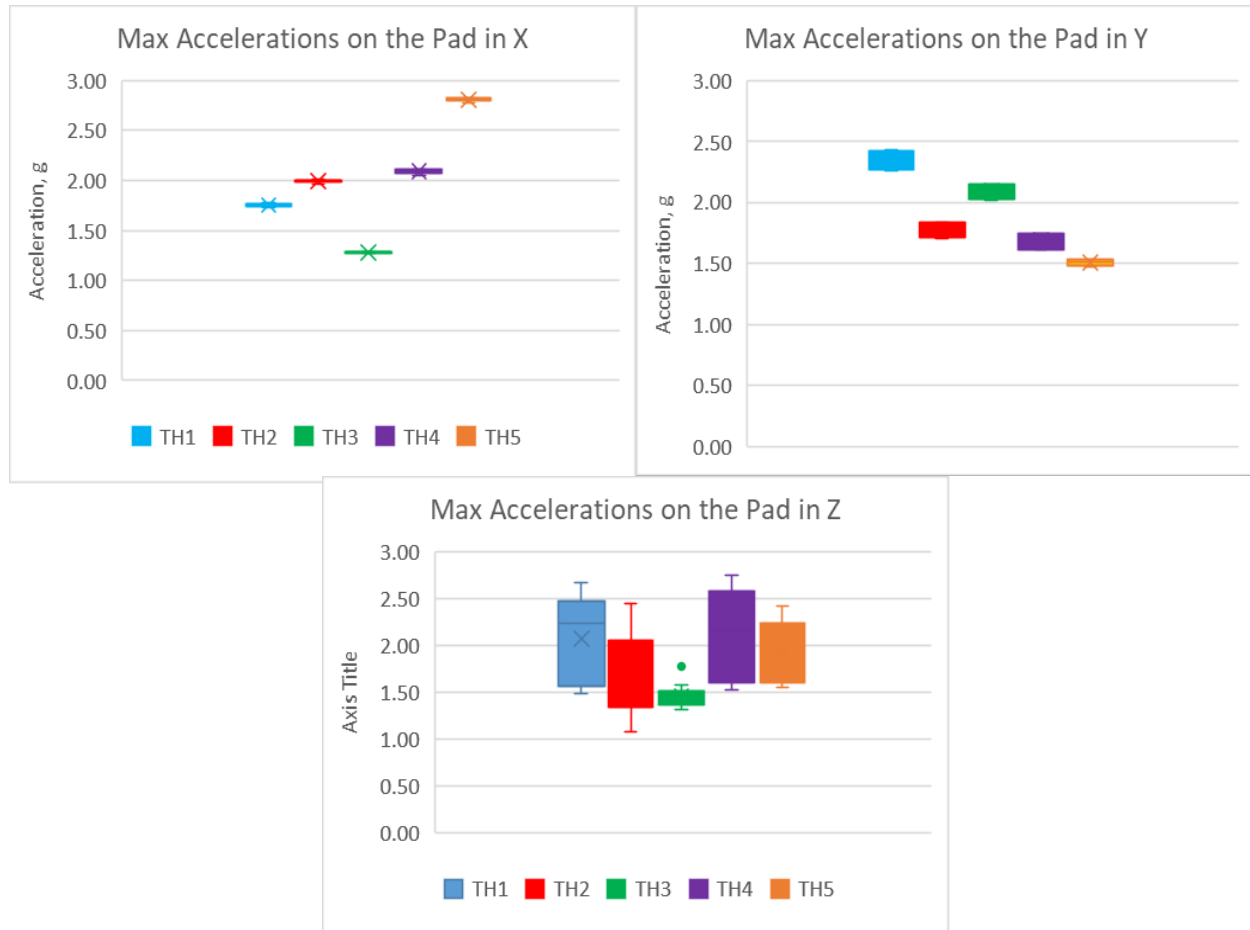


Figure 2-45. Scenario 1 Maximum Accelerations on the Pad in Different Time Histories in X, Y, and Z Directions.

The variability in maximum spectral acceleration on the pad is significantly larger than the variability in PGAs as demonstrated in Figure 2-46 for the Z direction (time history 1).

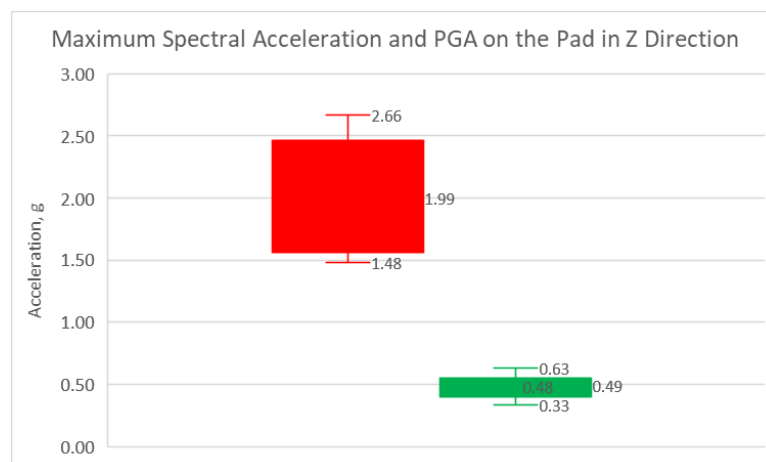


Figure 2-46. Scenario 1 Maximum Spectral Accelerations and PGAs in Z Direction on the Fully Loaded Pad (Time History 1).

Because the accelerations in X and Y directions vary very little at the different locations on the pad, the points of interest are the ones with the max Z accelerations. Figure 2-47 shows the locations on the pad with maximum Z accelerations in three CEUS soil scenarios and four CEUS soft rock scenarios. Figure 2-48 shows the locations on the pad with maximum Z accelerations in three WUS soil scenarios, four WUS soft rock scenarios, and 2 Diablo Canyon scenarios. Green circles show the locations where maximum occurred once, and the blue circles show the locations in which the maximum occurred more than once. A red circle with no green or blue circle on it means the maximum was never experienced in that location. In 11 of the scenarios, the maximum Z accelerations mostly occur at the edge and corner locations on the pad.

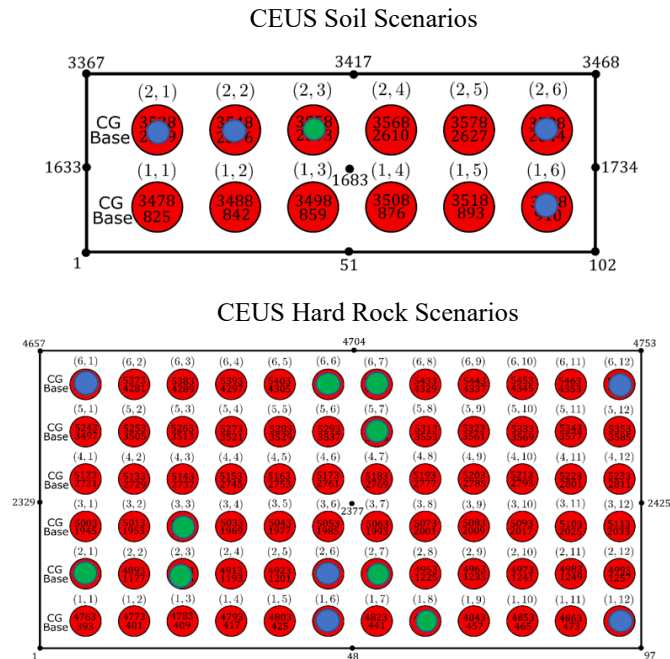


Figure 2-47. Locations on the Pad with the Maximum Z Acceleration in CEUS Scenarios.

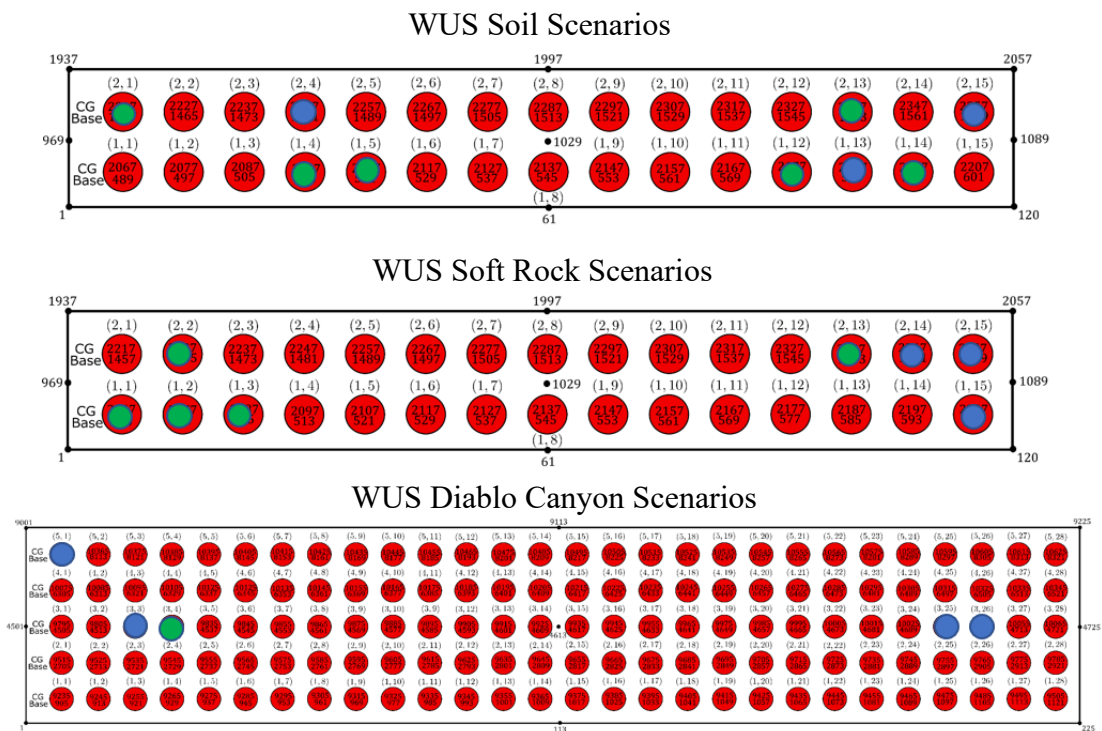


Figure 2-48. Locations on the Pad with the Maximum Z Acceleration in WUS Scenarios.

The examples of the maximum spectral acceleration distributions on the pad are shown in Figure 2-49 for the CEUS soft rock scenario 6 (PGA 0.29 g) and in Figure 2-50 for the WUS Diablo Canyon scenario 13 (PGA 0.92 g) to demonstrate where the locations with the highest maximum accelerations are.

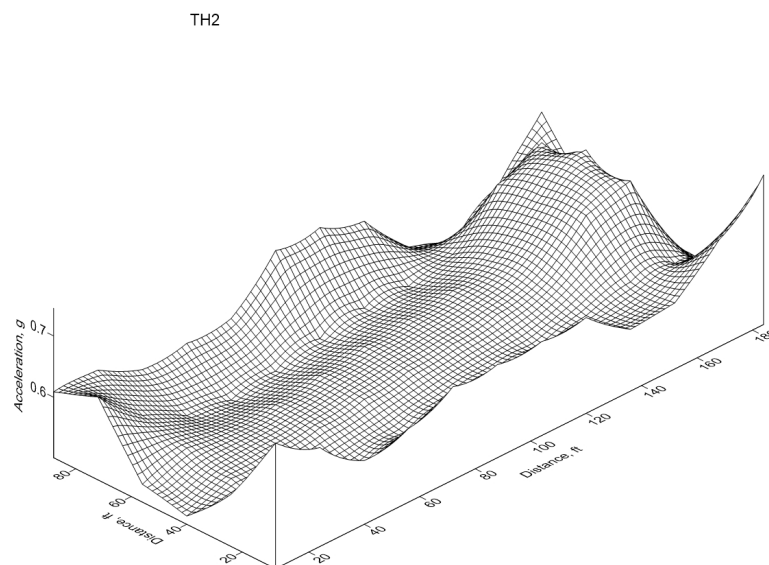


Figure 2-49. Maximum Z Accelerations on the Pad in CEUS Soft Rock Scenario 6 (PGA 0.29g), Time History 2.

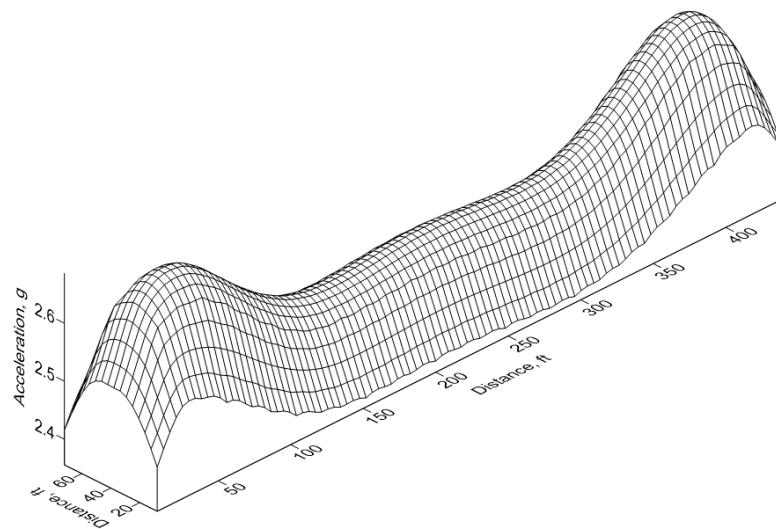


Figure 2-50. Maximum Z Accelerations on the Pad in WUS Diablo Canyon Scenario 13 (PGA 0.92g), Time History 1.

Figure 2-51 compares response spectra for five time histories of the fully loaded (Configuration 1) and partially loaded (Configuration 4) pad at the locations with maximum Z accelerations for the CEUS soil scenario 1 (PGA 0.56 g). The locations in which maximum Z accelerations were observed are mostly different in Configuration 1 and Configuration 4. However, the accelerations spectra are very similar. Same trend was observed in the other scenarios. Consequently, the locations with the maximum Z accelerations on the fully loaded pad were recommended for the seismic shake table test.

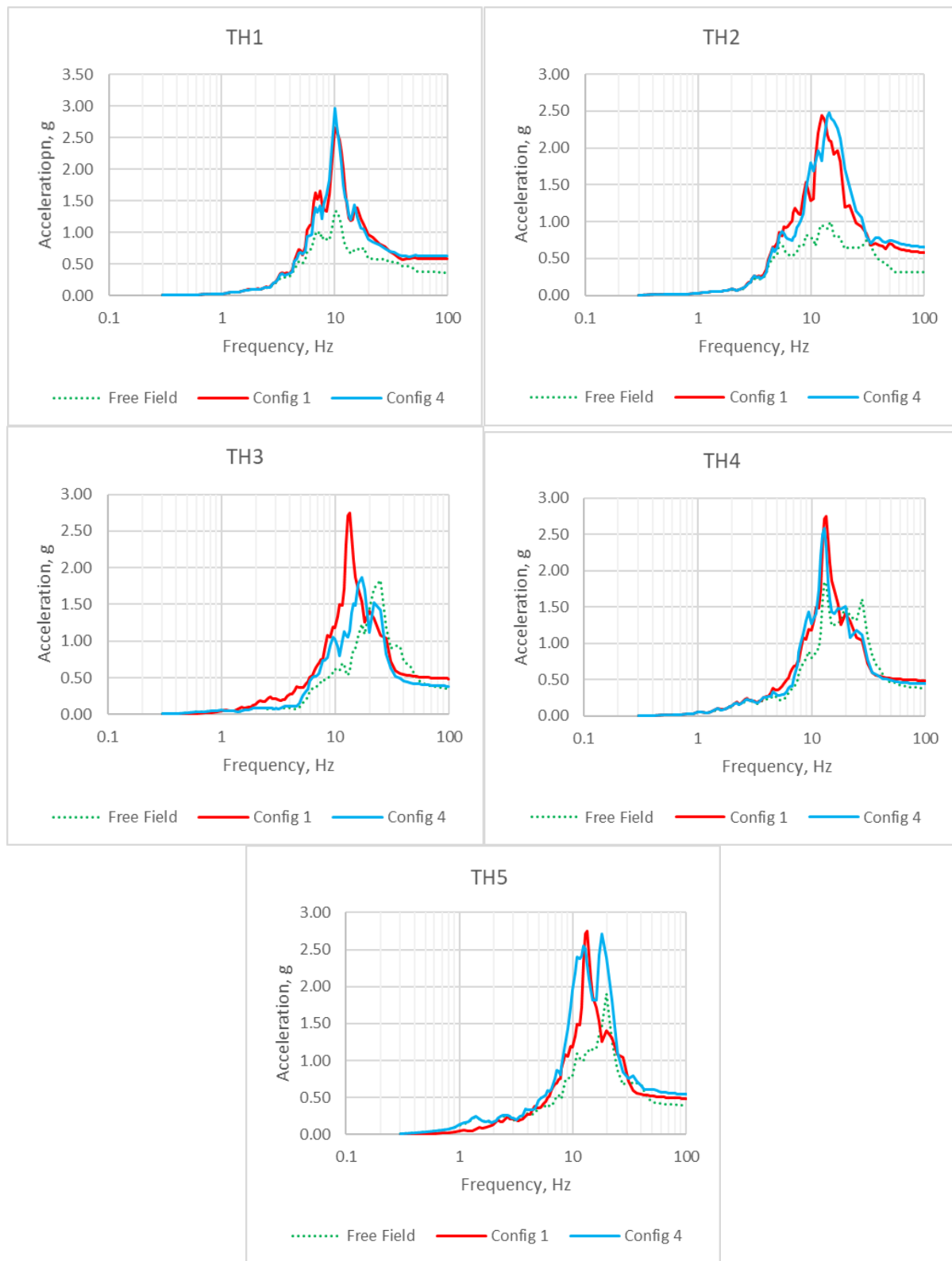


Figure 2-51. Spectral Shapes in Five Time Histories at the Locations with max Z Accelerations on Fully Loaded (Configuration 1) and Partially Loaded (Configuration 4) Pad, CEUS Soil Scenario 1.

Figure 2-52 and Figure 2-53 show amplification in CEUS and WUS soil and soft rock scenarios. In CEUS scenarios, the amplification is in the low frequency band up to 12.5 Hz. The PGA is not amplified, except in Z direction in CEUS soil scenarios. In WUS soft rock scenarios, the amplification is in the low frequency band up to 11.4 Hz. The PGA is only slightly amplified, In WUS soil scenarios, the amplification is in the low frequency band up to 33.7 Hz. The PGA is only slightly amplified, except Scenario 9 (magnitude 7.5, distance 200 km, PGA 0.14 g).

Table 2-13. Locations on the Pad Recommended for the Seismic Shake Table Test.

NN	Region	Site Conditions	Magnitude	Distance, km	PGA, g	Annual Exceedance	Scenario	TH	Node
1	CEUS	Soil	5.5	15	0.56	GMRS	1	1	(2,2)
2								2	(1,6)
3								3	(2,6)
4								4	(1,6)
5								5	(2,6)
6			6.5	40	0.31	5.00E-05	2	1	(2,2)
7								2	(1,6)
8								3	(2,6)
9								4	(1,6)
10								5	(2,1)
11			7.8	200	0.1	5.00E-04	3	1	(2,3)
12								2	(1,6)
13								3	(2,6)
14								4	(1,6)
15								5	(2,1)
16		Soft Rock	5.5	15	0.25	5.00E-05	4	1	(6,1)
17								2	(1,12)
18								3	(2,7)
19								4	(1,12)
20								5	(6,12)
21			6.5	40	0.08	5.00E-04	5	1	(1,8)
22								2	(6,7)
23								3	(6,6)
24								4	(3,3)
25								5	(5,7)
26			5.5	15	0.29	GMRS	6	1	(6,1)
27								2	(1,12)
28								3	(2,6)
29								4	(1,12)
30								5	(6,12)

NN	Region	Site Conditions	Magnitude	Distance, km	PGA, g	Annual Exceedance	Scenario	TH	Node
31			7.8	200	0.18	5.00E-05	7	1	(2,3)
32								2	(1,6)
33								3	(2,6)
34								4	(1,6)
35								5	(2,1)
36	WUS	Soil	6.25	10	0.09	5.00E-04	8	1	(2,15)
37								2	(1,4)
38								3	(1,14)
39								4	(2,13)
40								5	(2,4)
41			7.5	200	0.14	5.00E-05	9	1	(1,5)
42								2	(1,13)
43								3	(2,4)
44								4	(1,12)
45								5	(2,15)
46		6.25	10	0.23	5.00E-05	10	1	(2,15)	
47							2	(1,13)	
48							3	(2,4)	
49							4	(2,15)	
50							5	(2,1)	
51		Soft Rock	6.25	10	0.22	5.00E-04	11	1	(2,15)
52								2	(2,14)
53								3	(2,2)
54								4	(1,1)
55								5	(2,13)
56	7.5			5	0.52	5.00E-05	12	1	(2,15)
57								2	(1,2)
58								3	(2,14)
59								4	(1,3)
60								5	(1,15)
61	7.5		5	0.95	GMRS	13	1	(3,3)	
62							2	(3,25)	
63							3	(5,1)	
64							4	(3,26)	
65							5	(3,26)	
66	7.5		5	1.3	5.00E-05	14	1	(3,3)	
67							2	(3,25)	
68							3	(5,1)	
69							4	(3,4)	
70							5	(3,26)	

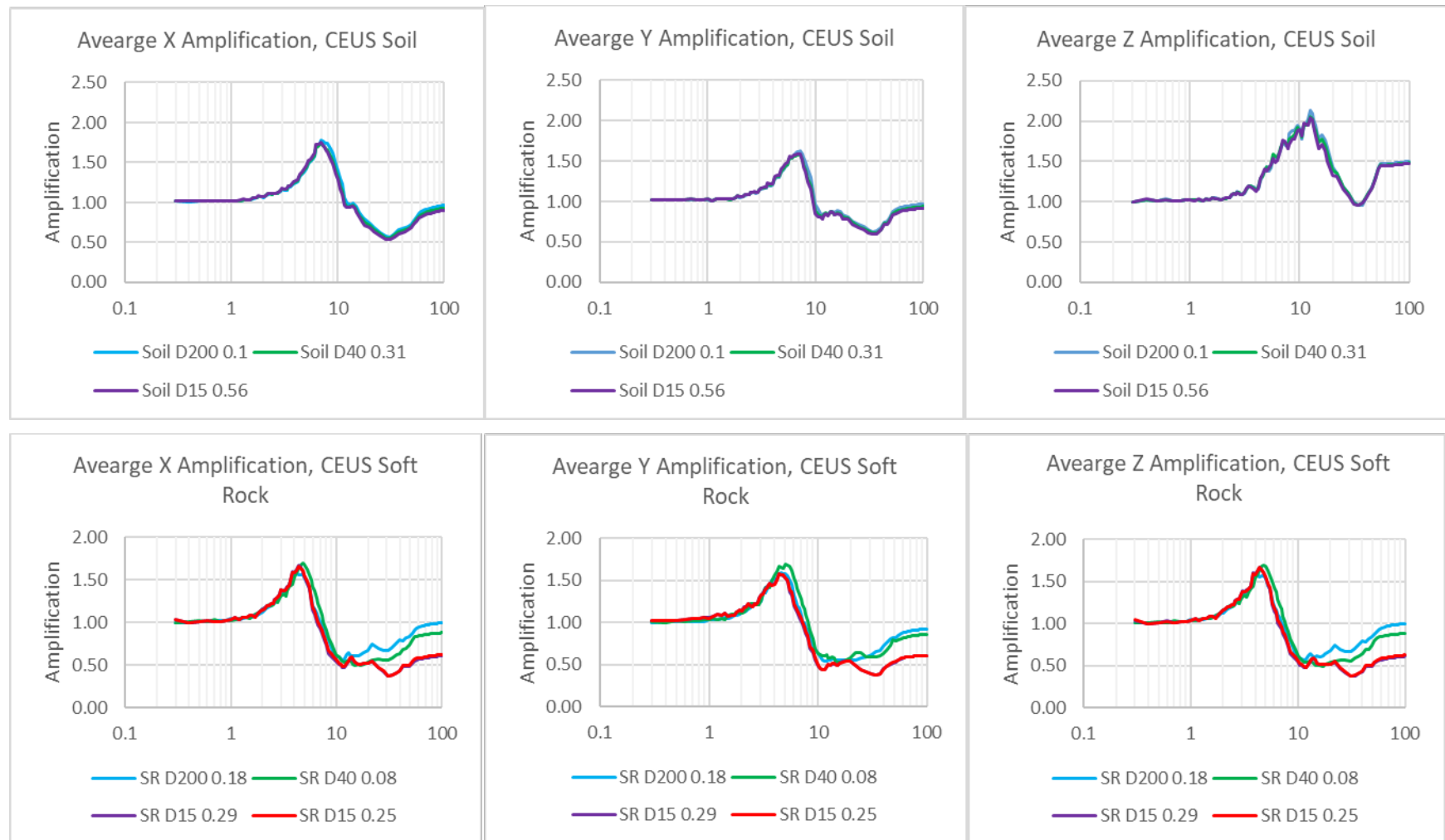


Figure 2-52. Amplification in X, Y, and Z Directions in CEUS Soil and Soft Rock Scenarios.



Figure 2-53. Amplification in X, Y, and Z Directions in WUS Soil and Soft Rock Scenarios.

Figure 2-54 compares average peak frequencies in X, Y, and Z directions in CEUS and WUS soil and soft rock scenarios. All scenarios have higher peak frequency in Z direction compared to X and Y directions and similar peak frequency in X and Y directions, except the WUS soft rock scenarios have slightly higher frequency in Y direction than in X direction. The WUS soil scenarios have the lowest peak frequencies – 2.1 to 3.7 Hz. The WUS soft rock scenarios have the highest X and Y peak frequencies – 8.4 and 9.7 Hz. The CEUS soil scenarios have the highest Z peak frequency – 12.5 Hz.

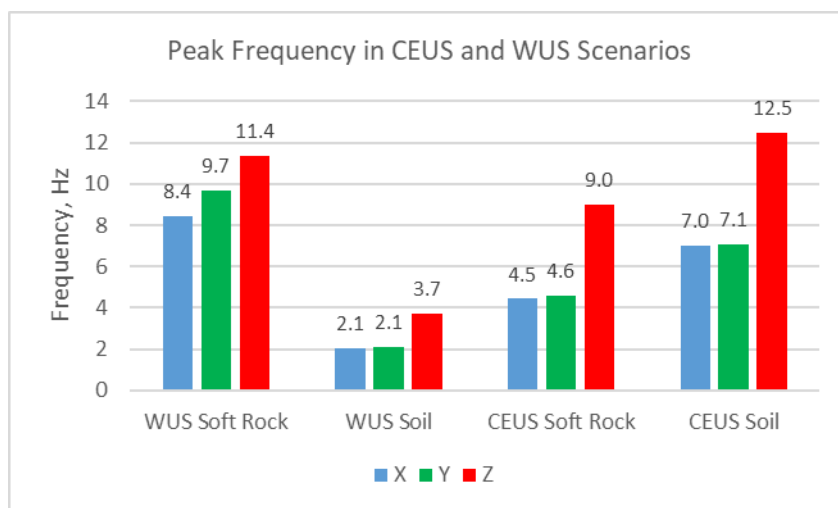


Figure 2-54. Peak Frequencies in CEUS and WUS Soil and Soft Rock Scenarios.

Figure 2-55 compare average amplifications in X, Y, and Z directions in CEUS and WUS soil and soft rock scenarios. The WUS soil and CEUS soft rock and soil scenarios have similar X, Y, and Z amplifications – 1.7 to 1.8. The WUS soft rock scenarios have the smallest amplifications – 1.2. The highest amplification is Z amplification in WUS soil scenarios – 2.9.

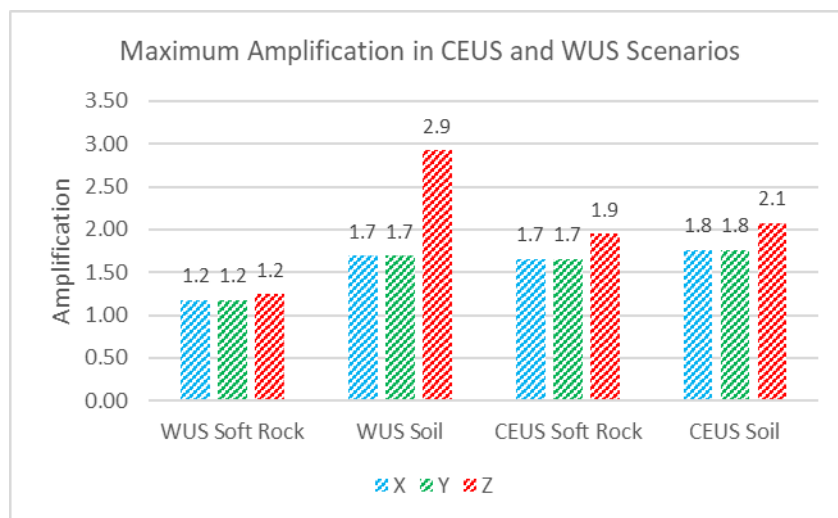


Figure 2-55. Maximum Amplification in CEUS and WUS Soil and Soft Rock Scenarios.

Figure 2-56 and Figure 2-57 show the examples of X, Y, Z accelerations and displacements for CEUS Scenario 1 (soil, magnitude 5.5, distance 15 km, PGA 0.56 g) and WUS Scenario 12 (soft rock, magnitude 7.5, distance 5 km, PGA 0.52 g) respectively. Scenario 1 has very small displacements up to 17 mm (Y direction). The displacements in Scenario 12 are up to 302 mm (Y direction).

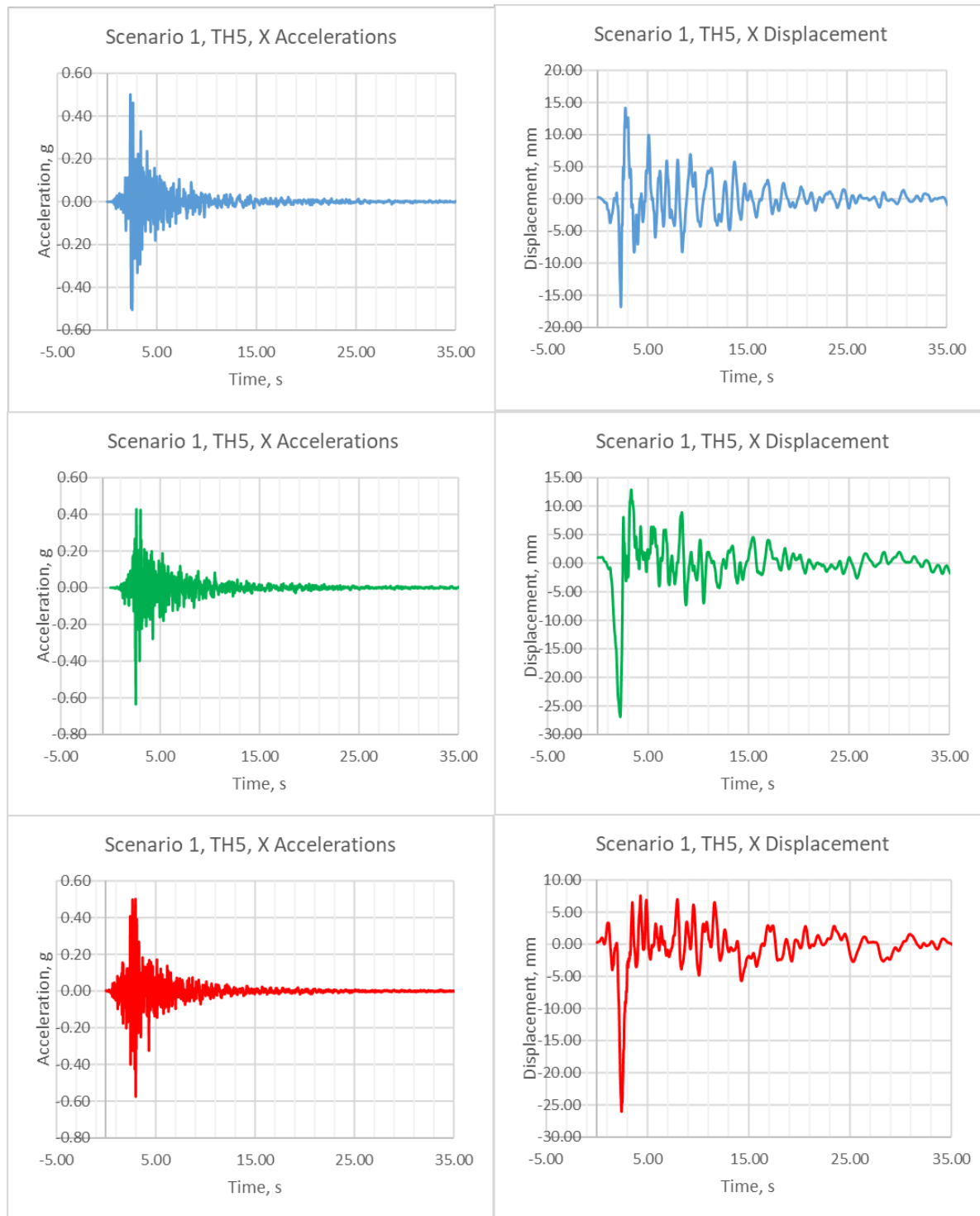


Figure 2-56. Scenario 1, TH5 (CEUS Soil, M 5.5, D 15 km, PGA 0.56 g) Acceleration and Displacement Time Histories.

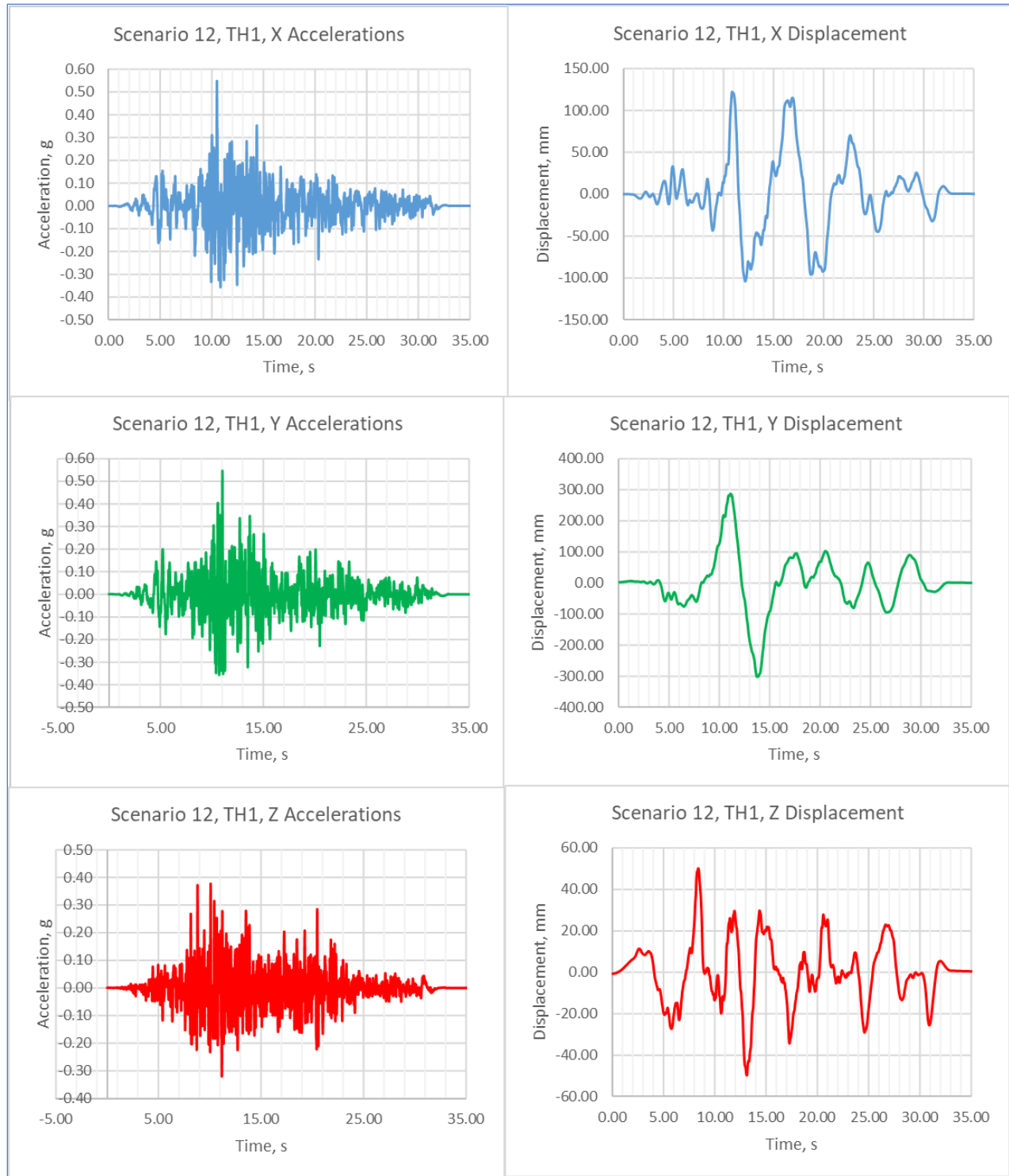


Figure 2-57. Scenario 12, TH1 (WUS Soft Rock, M 7.5, D 5 km, PGA 0.52 g) Acceleration and Displacement Time Histories.

Largest displacements occurred in Scenario 14 (Diablo Canyon, PGA 1.3g) with horizontal displacements of 1,168 mm and 881 mm in X and Y directions and vertical displacement of 533 mm. Note that the cask will be anchored to the shake table in the Diablo Canyon scenarios. Consequently, the cask displacement will be restricted.

The X, Y, and Z displacements in CEUS soil and soft rock scenarios are shown in Figure 2-58. The X, Y, and Z displacements in WUS soil and soft rock scenarios are shown in Figure 2-59. The displacements in the CEUS scenarios are about an order of magnitude smaller than in WUS scenarios. The displacements in the soft rock scenarios are larger than the displacements in soil scenarios in both, CEUS and WUS. The horizontal displacements are larger than vertical displacements in both, CEUS and WUS.

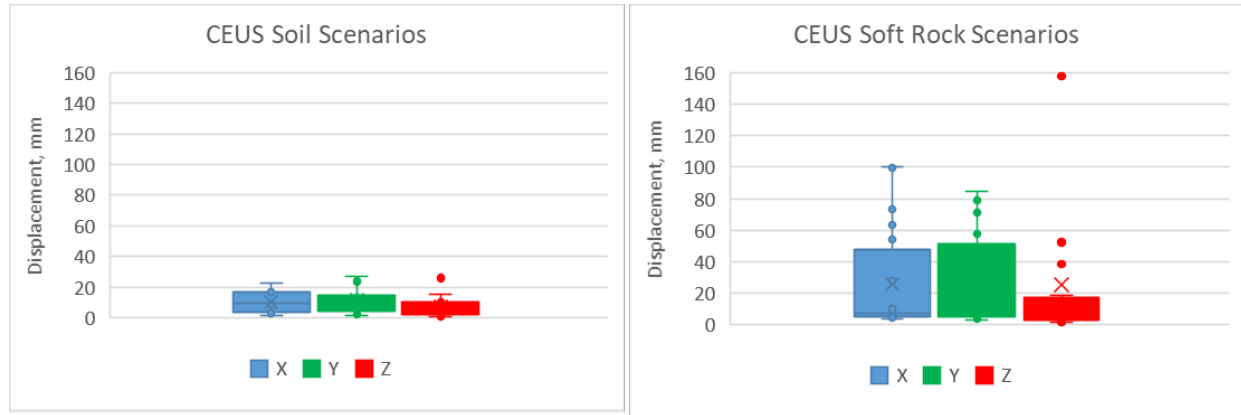


Figure 2-58. X, Y, and Z Displacements in CEUS Soil and Soft Rock Scenarios.

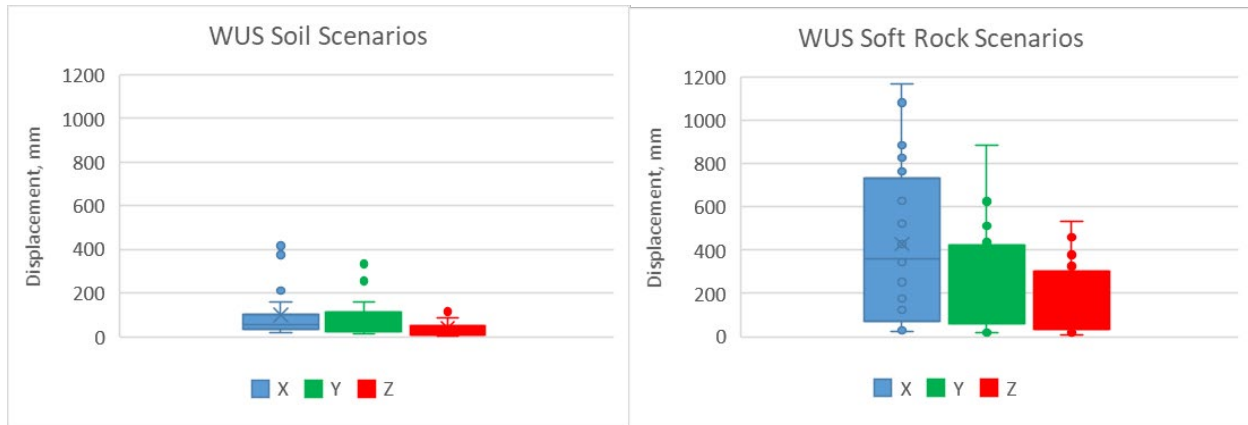


Figure 2-59. X, Y, and Z Displacements in CEUS Soil and Soft Rock Scenarios.

Figure 2-60 shows the temporal displacement traces in X-Y plane in CEUS soft rock Scenario 7 (magnitude 7.8, distance 200 km, PGA 0.18 g) with largest X displacement in the CEUS soft rock scenarios. Figure 2-61 shows the temporal displacement traces in X-Y plane in WUS soft rock Scenario 12 (magnitude 7.5, distance 5 km, PGA 0.52 g) with largest X displacement in the WUS soft rock scenarios, except the Diablo Canyon scenarios (Scenarios 13 and 14). In both examples, the movement in X direction is greater than the movement in Y direction.

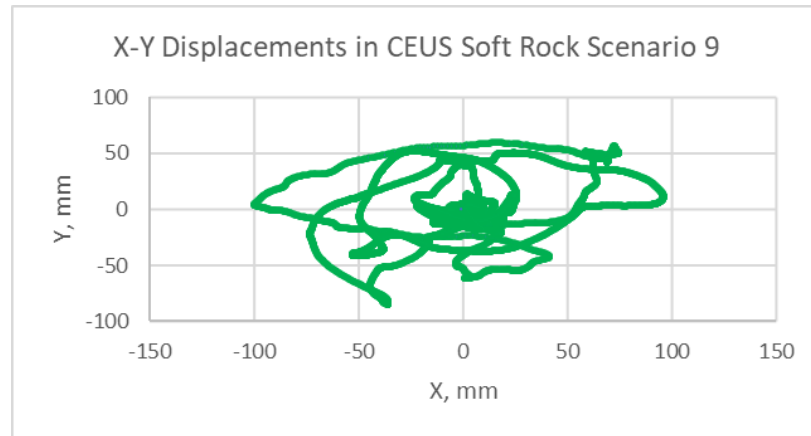


Figure 2-60. Temporal Displacement Traces in X-Y Plane in CEUS Soft Rock Scenario 7.

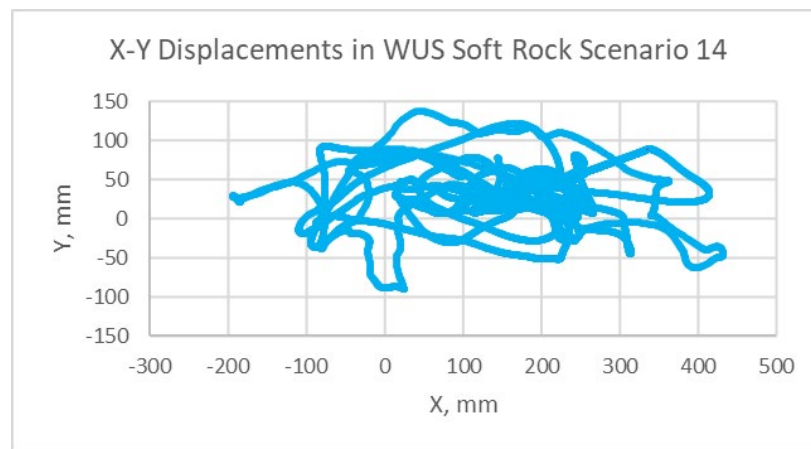


Figure 2-61. Temporal Displacement Traces in X-Y Plane in WUS Soft Rock Scenario 12.

The angular accelerations were relatively small in all scenarios, on the order of 0.01 rad/s^2 or smaller. The angular displacements (rotations) were also relatively small with the highest rotation on the order of 0.004 degrees. This shows that the ISFSI pads behave as rigid. The angular accelerations and displacements occur only due to the flexibility of the pad. The input free-field ground motions did not have any rotational ground motion, particularly those typically attributed to seismic surface waves. Because the expected rotations are very small, most of the shake table inputs will be translational – acceleration time histories in X, Y, and Z directions.

The data also showed that accelerations and displacements are similar but slightly higher at the CG's of the casks compared to the base of the casks. The CG and base center angular accelerations are almost identical, which is consistent with the relatively high stiffness of the cask.

2.3.2 Horizontal Storage Modules

There are eight sites with HSMs in soil and three in soft rocks in CEUS. They all are arranged on the pad mostly in two side by side rows with 6 to 25 HSMs in each row. The images of the ISFSIs with HSMs are provided in Appendix A. The most common configuration is 16 HSMs in two rows. A diagram in Figure 2-62 shows this configuration based on proposed pad at SONGS. This pad configuration will be considered in all SSI analysis. The scenarios applicable to the HSMs are Scenarios 1, 2-7, 13, 14 in Table 2-10.

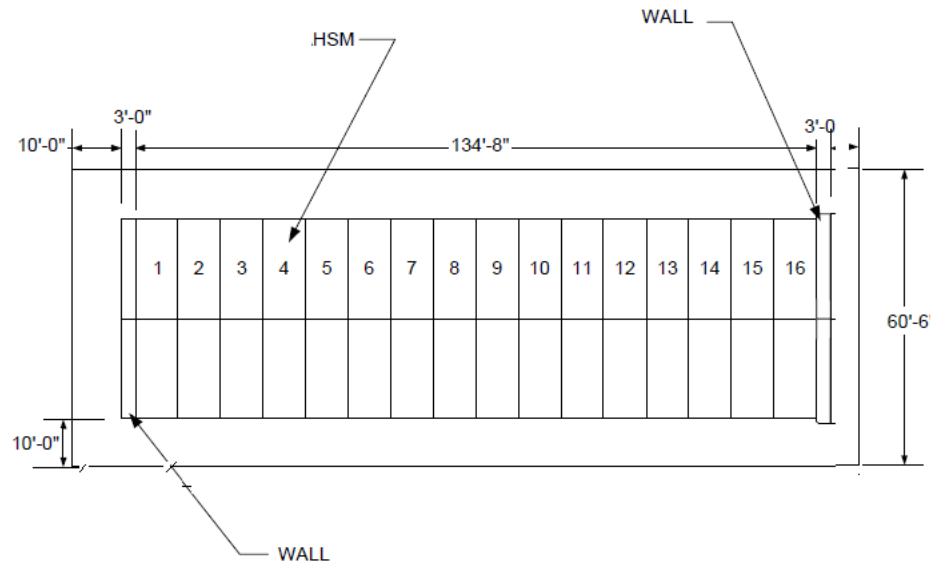


Figure 2-62. Representative HSM Configuration.

Figure 2-63 shows a single HSM schematics. The center of mass is (0", 125.16", 115.72") with reference to the origin at the location shown in the figure. The HSM width is 101". The length not including the front concrete cover (door) is 248" and including the cover it is 258.25". The total weight is 348,954.56 lbs (HSM and fully loaded canister).

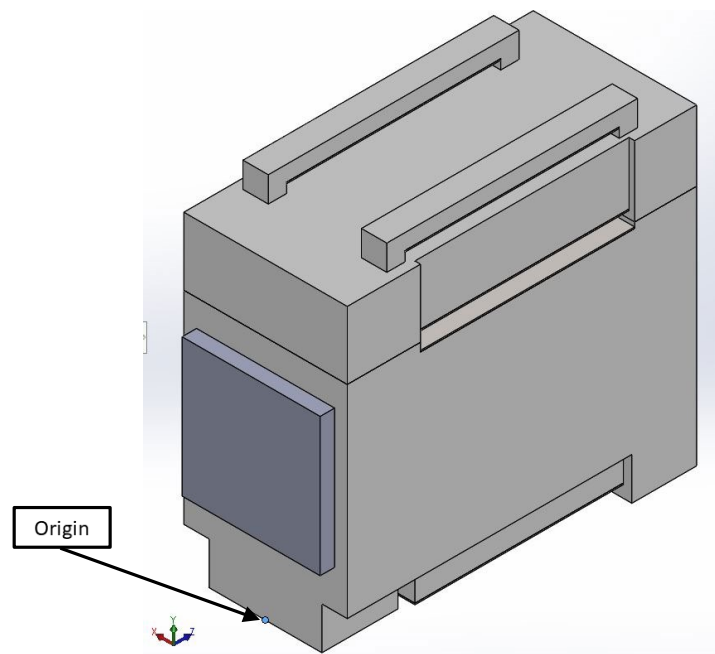


Figure 2-63. Single HSM Schematics.

A separate analysis will be conducted to determine whether the SSI effects, soil/soft rock amplification and pad flexibility, apply to the HSMs. If these effects are negligible, the free-field ground motions will be recommended for the shake table test and the corresponding time histories will be used. The results of this analysis will be documented in a separate report.

2.4 Shake Table Input Summary

Figure 2-64 shows the fragment of the seismic shake table test roadmap related to the development of the shake table inputs. This section describes the methods and results associated with each box on this roadmap, except 1 box inside the area delineated with a red dashed line. The major results are 55 acceleration time histories developed for the CEUS hard rock conditions (Table 2-9) and 70 time histories developed for CEUS and WUS soil and soft rock conditions (Table 2-13). The PGA accelerations of these time histories correspond to the seismic hazard level of $5E-05$ and $5E-04$. The PGAs representing the maximum GMRS in CEUS and WUS are also included. The remaining step (box inside the area delineated with the red dashed line) consists of simulating the developed time histories using the large capacity high-performance outdoor shake table (LHPOST6) software to determine whether the time histories can be adequately implemented on the shake table. The analysis will be performed by the LHPOST6 staff. The results of this analysis will provide the final set of time histories for the shake table test.

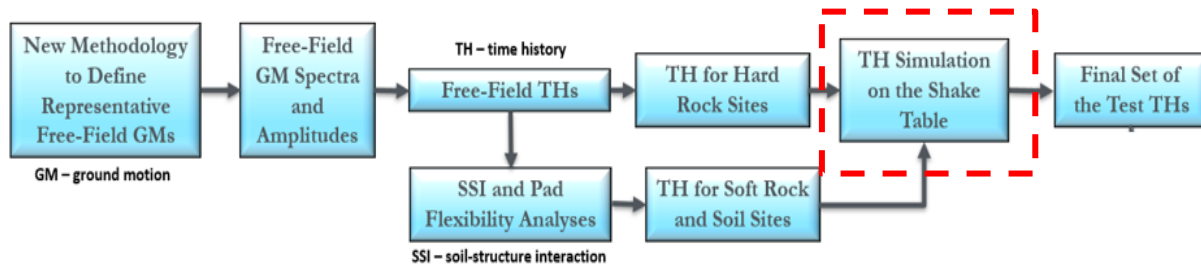


Figure 2-64. Fragment of the Seismic Shake Table Test Roadmap Related to the Shake Table Input Development.

One more case will be added to the CEUS hard rock scenarios – an actual 5.8 magnitude earthquake that occurred at 1:51 pm on August 23, 2011 in the vicinity of the North Anna Nuclear Plant. The earthquake's epicenter was 11 miles southwest of the station in Mineral, VA. As a result of this earthquake, the vertical casks at the North Anna ISFSI moved from 1 to 4 inches on the pad. It was determined [24] that the recorder data at the containment base-mat of Unit 1 provided the most reliable data of the earthquake characteristics. The corrected acceleration time-histories reproduced from [24] are shown in Figure 2-65 for the East-West, North-South and the vertical orientations. The earthquake duration was about 18 seconds.

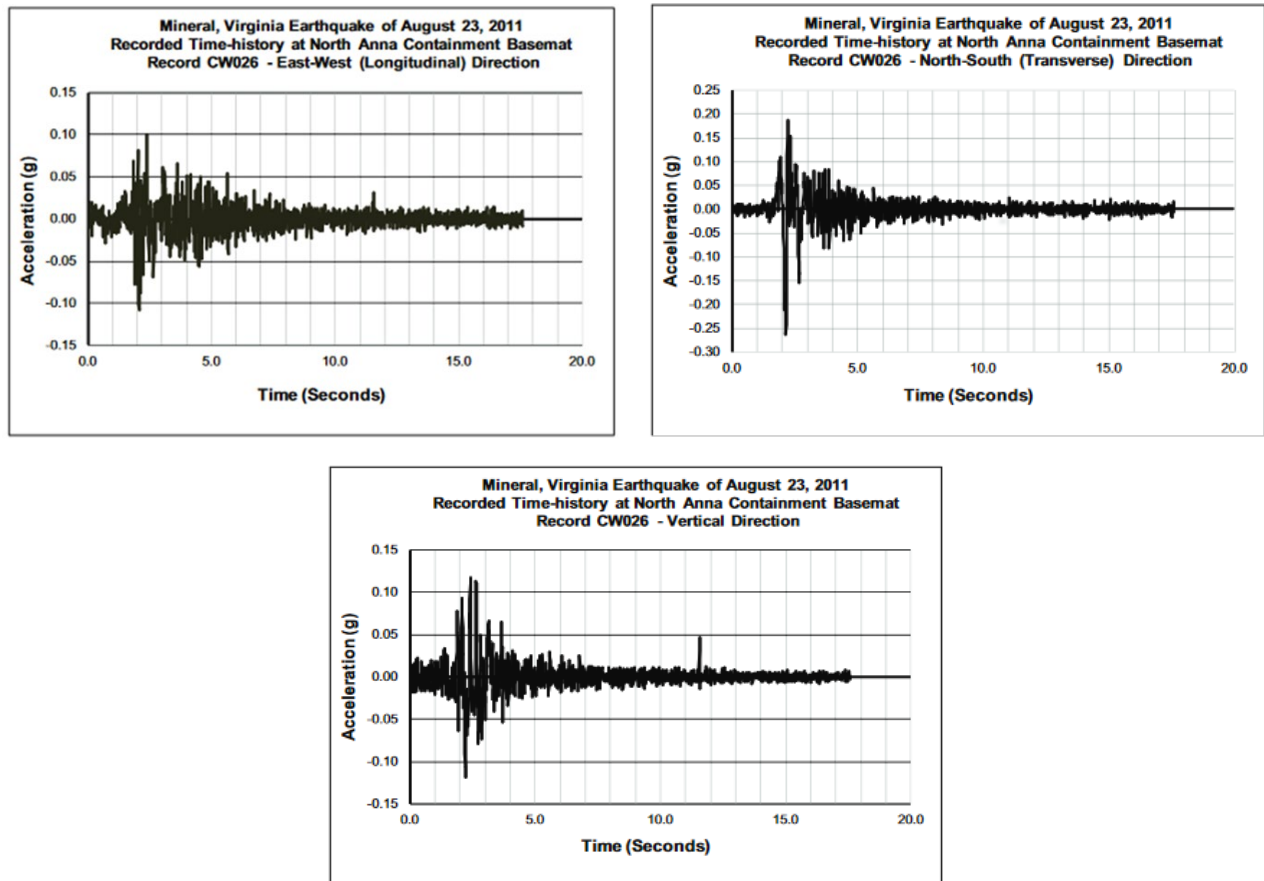


Figure 2-65. Mineral (VA) Earthquake Time Histories, Containment Basemat [24].

The PGAs observed at the containment basemat during the Mineral (VA) earthquake and the design-based PGAs are shown in Table 2-14 reproduced from [24]. The design based horizontal N-S PGA and vertical PGA exceeded the design-based values.

Table 2-14. PGAs in Mineral (VA) earthquake Compared to the Design Based PGA [24].

Component	Design Based PGAs (g)	Observed PGAs (g)
Horizontal N-S	0.12	0.264
Horizontal E-W	0.12	0.109
Vertical	0.08	0.118

In total, 126 time history sets were recommended for the shake table test. The additional input time histories will be added if:

- the SSI analysis with HSMs identifies noticeable amplification in soil and soft rock conditions
- during the review process some new cases of interest are identified
- during the test, the conditions that require considering new cases are discovered

3. TEST HARDWARE

3.1 NUHOM 32 PTH2 Dry Storage Canister

The seismic shake table test will be a full-scale dry storage system test. This only became possible because the SFWD received at no cost to the program the actual NUHOMS 32 PTH2 dry storage canisters. The canisters were transferred to DOE from SONGS and will be used in different projects, including the seismic shake table tests. Figure 3-1 shows two NUHOMS 32 PTH2 dry storage canisters at the SNL test facility in Albuquerque, NM.

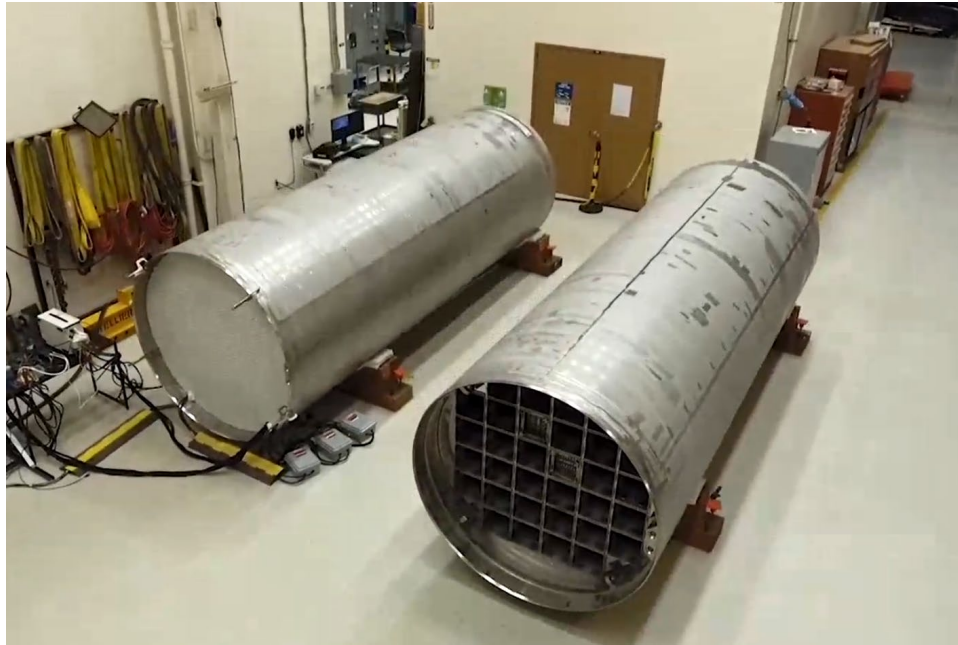
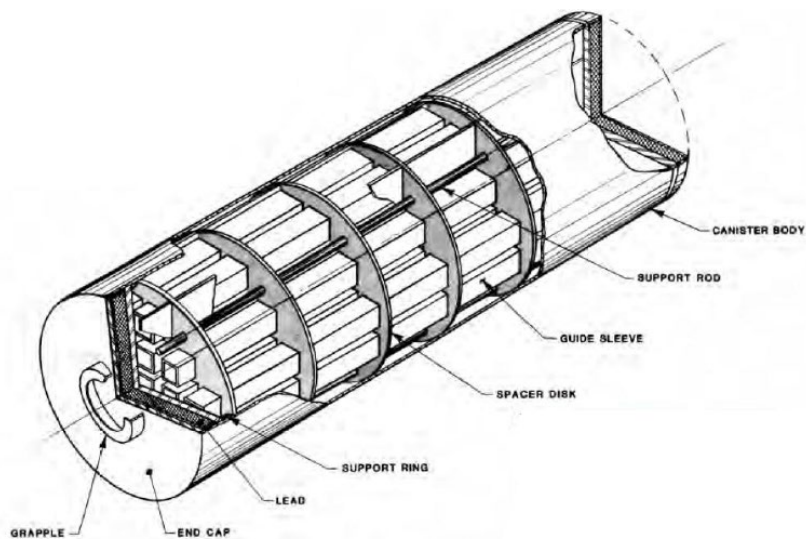


Figure 3-1. NUHOMS 32 PTH2 Dry Storage Canisters at SNL Facility.

The NUHOMS 32 PTH2 canister specifications are provided in Table 3-1. Figure 3-2 shows the canister schematics. Figure 3-3 shows the canister internals. Figure 3-4 shows the measurement of the basket tube cross-section. The average was 8.653" (219.79 mm). The NUHOMS 32 PTH2 and related canisters have been used by NPPs to store spent fuel assemblies, such as 16x16 CE or Framatome ones. These assemblies are ~207 mm (8.15 in) in cross-section. Consequently, the radial gap between the assembly and basket tube is ~6.4 mm (0.25 in). The 17x17 assembly, such as a Westinghouse one, has cross-section of ~214 mm (8.42 in). It can fit into the canister, but the radial gap will be significantly smaller – 2.9 mm (0.11 in).

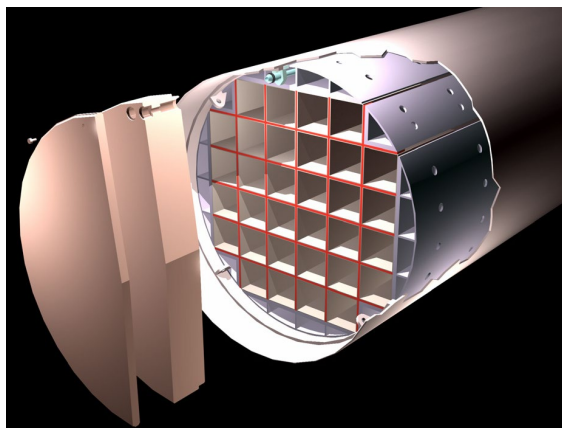
Table 3-1. NUHOMS 32 PTH2 Specifications.

Attribute	NUHOMS-32PTH, NUHOMS-32PTH Type 1	
a. Capacity (intact assemblies)	32 PWR	
b. Weight	lbs	kg
Empty	58.000	26,310
Loaded	108.850	49,370
c. Thermal		
Design Heat Rejection (kW)	34.8	
Maximum Per Assy Heat Load (kW)	1.2	
Maximum Burnup (GWD/MTU)	60	
d. Shape	Cylindrical	
e. Dimensions	in	mm
Overall Length	193.0	4802.2
Cross Section	69.75	1771.65
Cavity Length	171.63	4359.4
Wall Thickness	0.5	12.7
f. Materials of Construction		
Canister Body	SS	
Basket	SS/B-Al/Boral/MMC	
Shield Plugs	Steel	
g. Cavity Atmosphere	He	
h. Maximum Leak Rate (atm-cm ³ /sec)	1 x 10 ⁻⁷	
i. Transport Cask	NUHOMS-MP197HB	



Note: this figure is from Rod McCullum's Nuclear Energy Institute (NEI) Presentation, October 19, 2012.

Figure 3-2. NUHOMS 32 PTH2 Schematics.



Note: Square Openings are known as “basket tubes”.

Figure 3-3. NUHOMS 32 PTH2 Basket.

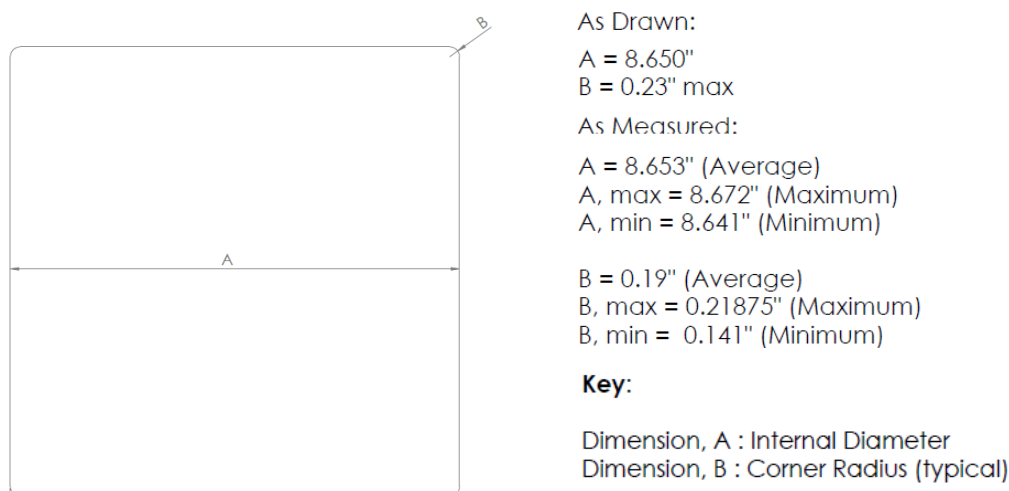


Figure 3-4. NUHOM 32 PTH2 Basket Tube Measurement.

3.2 Surrogate and Dummy Assemblies

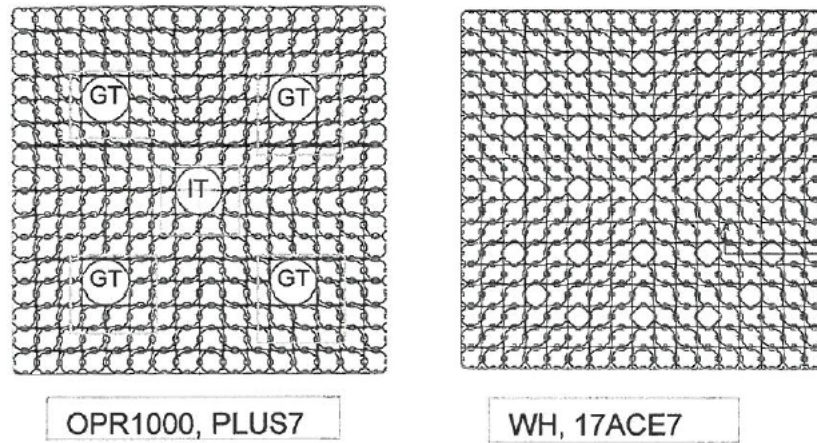
The NUHOMS 32 PTH2 dry storage canister is designed for 32 fuel assemblies. For the shake table test the canister will be loaded with four surrogate assemblies and 28 dummy assemblies.

3.2.1 Surrogate Fuel assemblies

Four surrogate assemblies will be used in the test to assess the differences related to the assembly type, radial gap, and condition (intact versus slightly damaged spacer grid) and its location in the basket. Note that in the Japanese test [3] only one surrogate assembly placed in the center of the cask was used.

Two surrogate assemblies will be 16x16 CE PLUS7 and 17x17 Westinghouse. These assemblies will be provided for the test by the Korean Nuclear Fuel (KNF) company. SNL, PNNL, and KNF signed an NDA to collaborate on the shake test. The assemblies will be delivered to the SNL test facility in Albuquerque

(NM) in November 2022 where they will be instrumented. Figure 3-5 shows the cross-sectional view of these two assemblies.



Note: GT is a guide tube

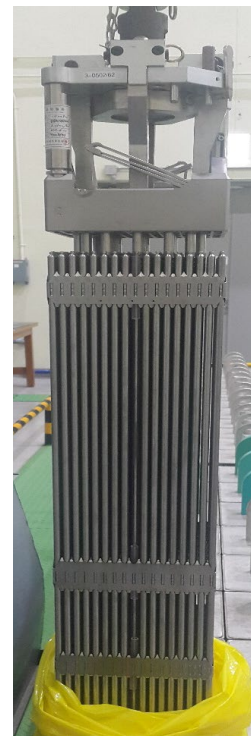
Figure 3-5. CE PLUS7 16x16 and Westinghouse 17x17 Fuel Assembly Cross-Sectional View.

The assembly specifications are provided in Table 3-2. The outer and inner diameters of the rods in these 16x16 and 17x17 surrogate assemblies are the same. The guide tube outer and inner diameter are about 2 times larger in the 16x16 assembly compared to the 17x17 assembly.

Table 3-2. Surrogate Assembly Specifications.

Assembly Type	16x16 CE PLUS7		17x17 Westinghouse	
Length (mm in)	4,528	178.27	4,063	159.96
Cross-section (mm in)	207.264	8.16	213.97	8.42
Weight (kg lbs)	639	1408.75	673	1483.71
Number of Rods	236		264	
Number of guide tubes	4		24	
Pitch (mm in)	12.85	0.51	12.6	0.50

The photos of the KNF surrogate assemblies are shown in Figure 3-6. The photos were provided by KNF.



Note: the photos were provided by KNF.

Figure 3-6. Photos of PLUS7 CE16x16 (left) and WEC 17x17 (right).

One 16x16 surrogate assembly will be manufactured specifically for the test. The RFQ for manufacturing this surrogate assembly was developed and issued by PNNL in June 2022. It is expected that the manufacturer will be selected and the manufacturing contract will be placed in July 2022. The surrogate assembly will be delivered to the SNL facility in Albuquerque, NM for instrumentation at the end of 2022.

The RFQ requires the following:

- The surrogate assembly will be complete and similar in all respects to a 16×16 PWR fuel assembly typically sold to a nuclear utility with the exception that no UO₂ fuel pellets or other radioactive material will be included. Instead, pellets of the same dimension as UO₂ pellets will be included in each rod to approximate the mass of a typical assembly. The preferred material for the surrogate pellets is either molybdenum or lead.
- The springs in the grid spacers, and any flow mixers, will be relaxed to closely approximate those in a spent fuel assembly. This will be accomplished by inserting a larger diameter rod into each rod location prior to inserting the surrogate fuel rod.
- The manufacturer will supply as-fabricated drawings together with pellet and total assembly mass, as well as rod pressure (if the rods are pressurized), under Non-disclosure Agreement (NDA). This data will be used in developing the models and instrumentation.

One 17x17 Westinghouse surrogate assembly will be the SNL surrogate assembly used in the 30 cm (11.81 in) drop test in 2020 [25]. The spacer grids were deformed up to 6.1 mm (0.24 in) in this test, but

the rods and other hardware were not damaged. The assembly and the spacer grid with the largest deformation are shown in Figure 3-7.

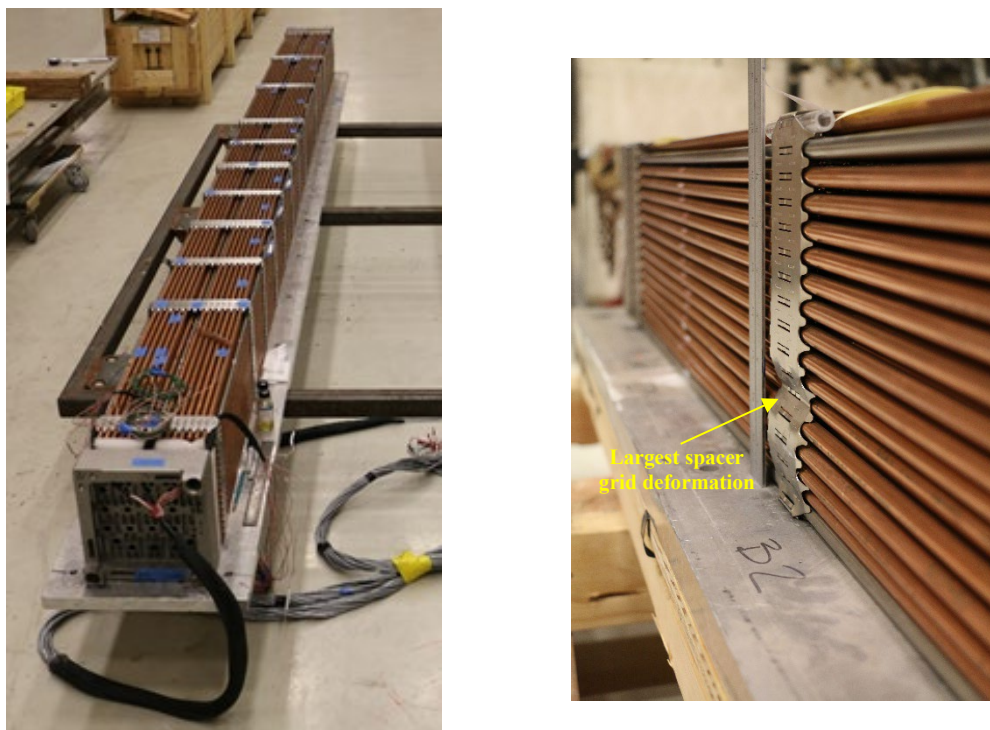


Figure 3-7. SNL 17x17 Surrogate Assembly (left) and the Spacer Grid with Largest Deformation (right).

3.2.2 Dummy Fuel Assemblies

The contract was placed in March 2022 with the Equipos Nucleares S.A., S.M.E., (ENSA) for manufacturing 30 dummy assemblies for the shake table test. ENSA supported SNL with the multi-modal transportation test (MMTT) [26] and 30 cm drop test [27]. As a part of this support, ENSA manufactured 17x17 dummy assemblies for the MMTT in 2017 and a dummy assembly for the 30 cm drop test in 2019. The dummy assemblies will be delivered to the SNL test facility in Albuquerque, NM at the end of 2022.

In the test configuration with four surrogate assemblies, 28 dummy assemblies will be used. However, if less than four surrogate assemblies are available, the additional dummy assemblies will be used to achieve the total number of assemblies equal to 32.

The dummy assembly drawings were developed by PNNL [28] and then revised by ENSA to incorporate European standards for the steel tube sizes. Twenty-eight dummy assemblies will have a cross-section of 207 mm (8.14 in), the same as the 16x16 surrogate assemblies. One dummy assembly will have a cross-section of 210 mm (8.27 in) and another one will have a cross-section of 21 mm (8.42 in), the same as the 17x17 surrogate assemblies. Using different cross-sections will allow for evaluating the effects related to the radial gap. Table 3-3 provides the weight of the dummy assemblies with the different cross-sections. Table 3-4 provides the description of the dummy assembly parts. The overall dummy assembly view is shown in Figure 3-8.

Figure 3-9 shows the dummy assembly parts. The main part is the 4,482 mm (1,76.457 in) long steel square tube with 180 mm (7.09 in) cross-section and 12.5 mm (0.49 in) wall thickness. Twenty aluminum plates installed on four sides of the steel tube will provide the desirable cross-section of the dummy assembly – either 207, 210, or 214 mm (8.14, 8.27, or 8.42 in) depending on the aluminum plate thickness. Because of this design, the dummy assemblies with different cross-sections will have similar weight (Table 3-3).

A 70 mm (2.76 in) in diameter steel support rod with four rebars welded to it in five locations along its length will be placed inside the square steel tube to provide reinforcement. The steel tube will be filled with concrete. The concrete density will be 146.7 lbs/ft³ (2,350 kg/m³). The bottom plate will be placed on the bottom end and two angle irons will be placed on the top end of the square tube. The length of the tube with the concrete will be 4,177.60 mm (164.47 in). The remaining 312.4 mm (12.30 in) of the empty steel tube (instrumentation niche) will be used for instrumentation.

Table 3-3. Dummy Assembly Specifications.

Assembly Width (mm in)		Weight (kg lbs)	
207	8.15	639.4	1409.63
210	8.27	641.2	1413.60
214	8.42	643.4	1418.45

Table 3-4. Dummy Assembly Parts.

Item No.	Part Number	Quantity
1	Fuel Support Rod	1
2	Angle Iron	2
3	175 mm Square Tube	1
4	Bottom Plate	1
5	Aluminum Plate	20
6	Rebars	20
7	Concrete Filling	1

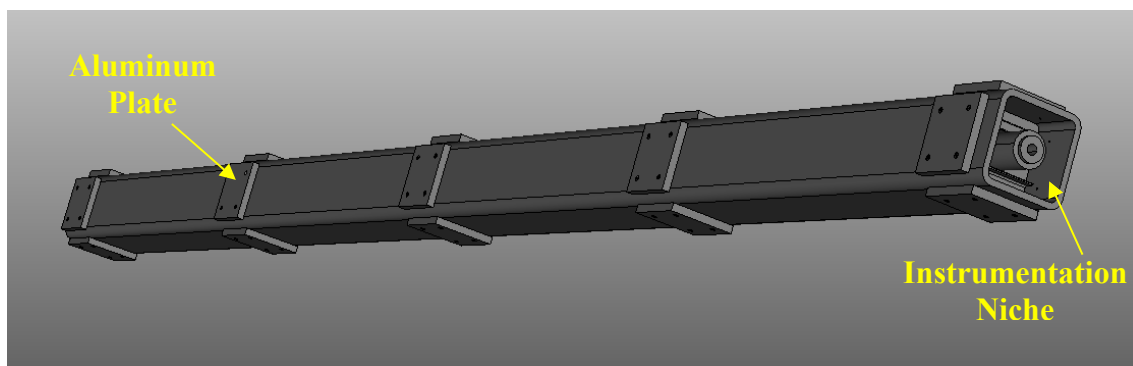


Figure 3-8. Dummy Assembly Overall View.

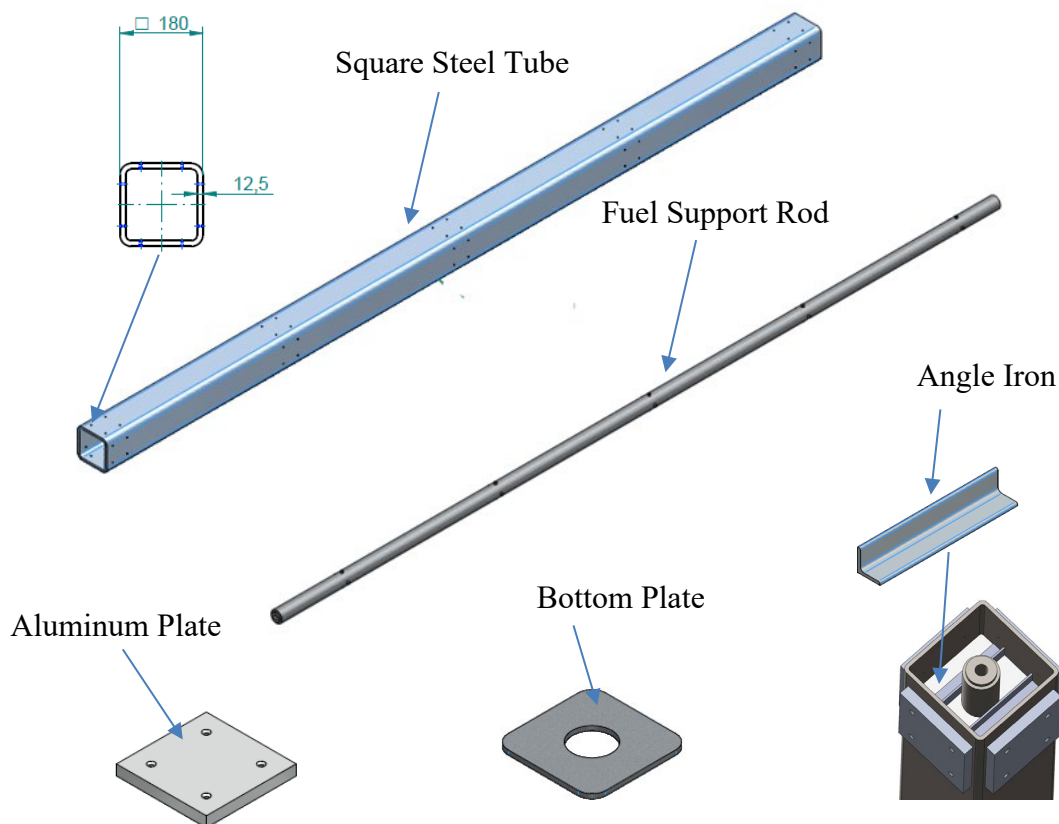


Figure 3-9. Dummy Assembly Main Parts.

3.3 Dry Storage Overpacks

The shake table test will be conducted in horizontal and vertical overpacks. Both overpacks will be representative of full-scale dry storage systems of SNF. The NUHOM 32 PTH2 dry storage canister loaded with surrogate and dummy assemblies will be placed in vertical and horizontal overpacks for the test. The estimated weights of the canister, dummy assemblies, and surrogate assemblies are provided in Table 3-5. The total weight of the loaded canister is 101,252 lbs (45,927 kg).

Table 3-5. Estimated Weights of the Loaded NUHOM 32 PTH2 Canister

Component	Weight (lbs)	Weight (kg)
Canister and basket	56,170	25,478
28 dummy assemblies	39,307	17,829
4 surrogate assemblies	5,775	2,619
Loaded canister	101,252	45,927

3.3.1 Horizontal Storage Overpack

The original plan was to use a NUHOMS Advanced Horizontal Storage Module (AHSM) as a dry storage overpack for the horizontal test configuration. The NUHOMS 32PTH canister is designed for storage in a

NUHOMS HSM. An AHSM module can be transferred to the projects by SONGS. Figure 3-10 shows the AHSM at SONGS. The proposed cost of transporting and assembling an AHSM (it consists of a base unit, roof, and door) at the UCSD shake table facility LHPOST6 was prohibitive. The project is evaluating two alternatives.



Figure 3-10. Photo of AHSMs at SONGs.

The first alternative is to use the base unit of an AHSM in the test. The base unit is ~170,000lbs and can be transported to UCSD. The base unit will be tied to the shake table in all the tests because single HSM configuration is not used. As discussed in Section 2.3, the HSMs are connected to each other side wall to side wall in single rows and back wall to back wall in double rows. The representative HSM configuration is 16×2 (i.e., 2 connected rows, each row has 16 HSMs). The diagram in Figure 3-11 shows how the base unit of AHSM can be tied to the shake table using four holes in the side walls. The holes are the part of the AHSM design and are used to connect the units. The total weight of the test unit would be 271,252 lbs (123,038 kg).

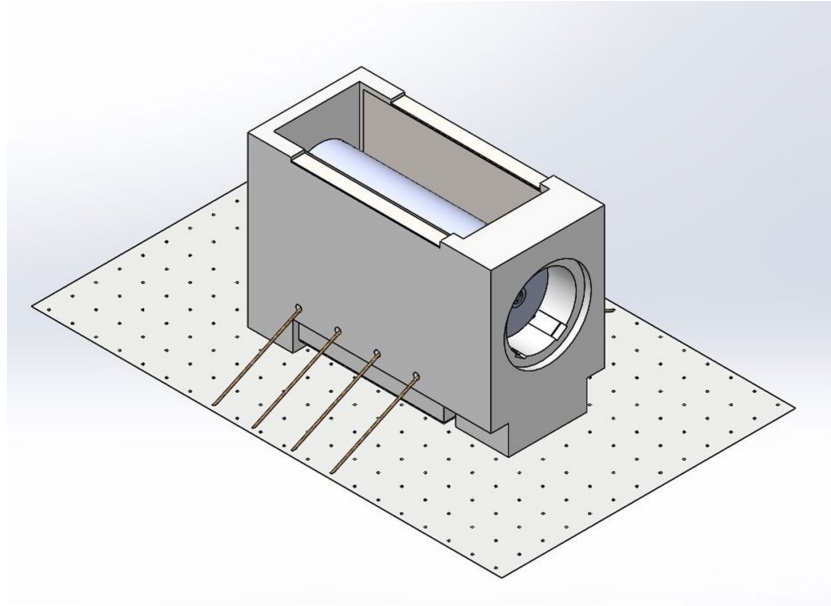


Figure 3-11. AHSM Tied to the Shake Table.

The second alternative is to manufacture a simplified representation of an HSM. The preliminary design was developed by PNNL (Taylor Mason) and is shown in Figure 3-12. The main parts are the steel frame with the skids that holds the canister and the concrete trough. The weight of this mockup is ~ 125,000 lbs. The brackets at the bottom are for anchoring the trough to the shake table. The cost and time involved in manufacturing the mockup of the horizontal overpack are being evaluated. The total weight of the test unit would 226,252 lbs (102,626 kg).

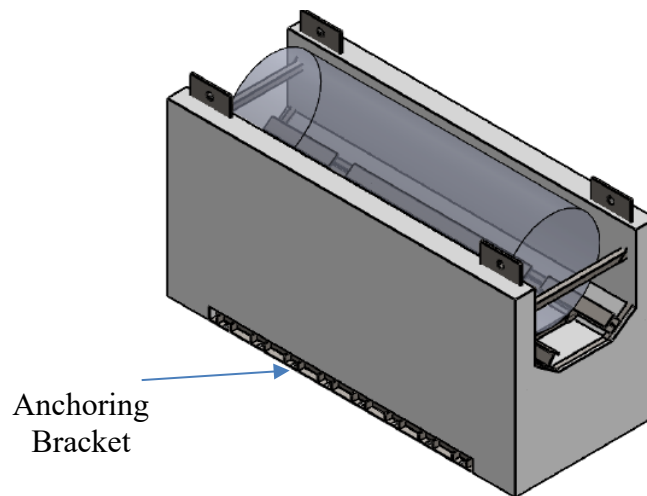


Figure 3-12. Preliminary Design of a Simplified Horizontal Storage Overpack.

3.3.2 Vertical Storage Overpack

For the vertical test configuration, the original plan was to use either a MAGNASTOR or HI-STORM 100 cask as a dry storage overpack. Both casks can accommodate the NUHOMS 32 PTH2 canister even though they are designed for other types of dry storage canisters. The cost of acquiring these casks is

significantly higher than the project can afford. A decision was made to manufacture a simplified model of a vertical concrete cask.

The drawings of the cask were developed by PNNL [29]. The cask consists of a steel carcass filled with concrete. It is 5.6 m (18.37 ft) in height and 3.56 m (11.68 ft) in diameter. The cask is composed of the following main parts with the quantity shown in parentheses:

- Part #1 – Outer Shell (1)
- Part #2 - Baseplate (1)
- Part #3 - Pedestal (1)
- Part #4 – Inner Shell (1)
- Part #5 – Concrete (4)

The overall view and cross-sectional view of the cask and the dimensions of main components are shown in Figure 3-13. The numbers in Figure 3-13 correspond to the part numbers in Table 3-6. The circular opening in the middle of the pedestal is for accommodating the NUHOM 32 PTH2 grapple shown in Figure 3-2. The cask is lifted with four lugs/pins inserted into the lifting holes located on the top of the cask. The tapped holes in the base plate are for mounting the anchor brackets. Most of the shake table tests will be performed with the cask free-standing. However, a few tests with the cask anchored to the shake table are planned to address the conditions that currently exist at two NPPs and might be the conditions at the other NPPs in the future.

The inner shell, outer shell, baseplate, and pedestal are made of carbon steel and are assembled into the cask carcass. The estimated weight of each part is provided in Table 3-6. The outer shell wall thickness is 0.25 in. The inner shell is 79.75 in in diameter with the wall thickness of 1 in. The total weight of the steel carcass is 54,564 lbs (24,342 kg).

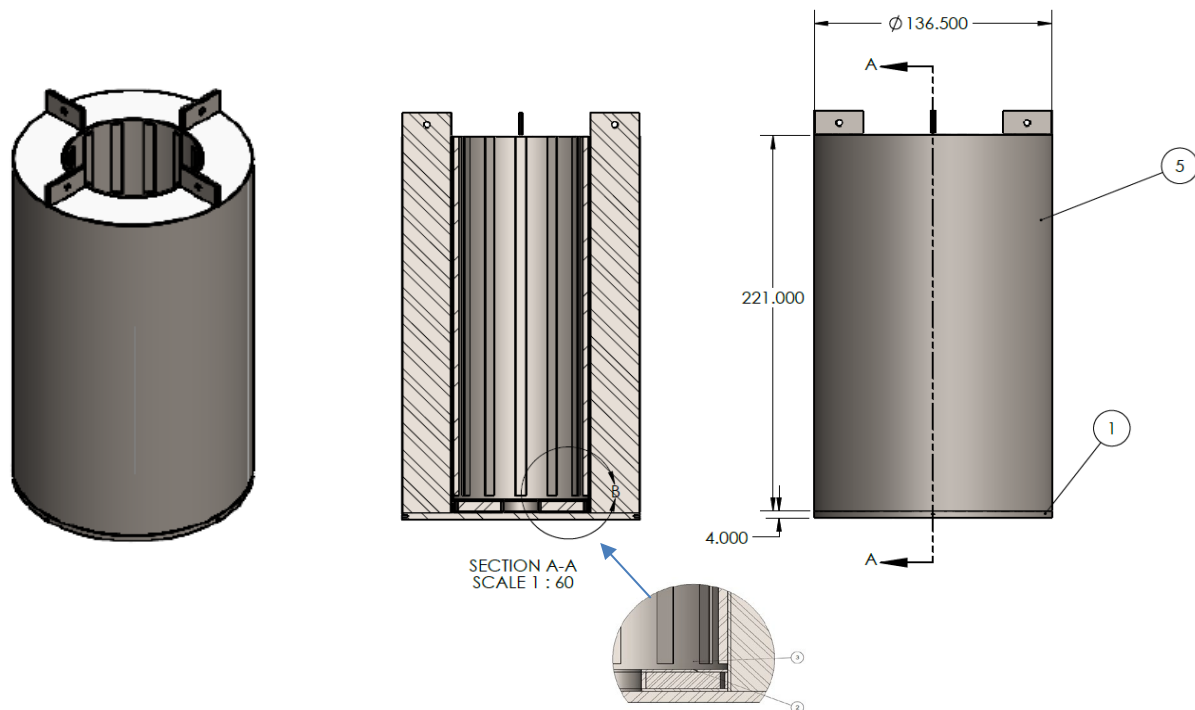


Figure 3-13. Vertical Cask Over All View and Cross-Sectional View.

The concrete will be poured into four sections formed by the inner shell and outer shell. The total volume of the concrete is 1,204 ft³ (34 m³). The estimated concrete weight in Table 3-6 is based on the concrete density of 150 pcf (2,403 kg/m³).

The following were the requirements on the vertical cask materials:

- Steel minimum yield strength should be 46 ksi (3130.11 atm).
- Concrete minimum compressive strength should be 4 ksi (272.18 atm) and concrete minimum density should be 150 pcf (2403 kg/m³).

Table 3-6. Estimated Weight of the Cask Different Parts.

Part NN	Unit Name	Weight (lbs kg)		Comments
1	Baseplate	6,716	3,046	To be manufactured
2	Pedestal	16,473	7,472	To be manufactured
3	Inner Shell	3,351	1,520	To be manufactured
4	Concrete	28,024	12,711	To be provided by a concrete contractor.
5	Outer Shell	180,156	81,717	To be manufactured r.
	Cask Total Weight	234,720	97,974	
	Steel Carcass Total Weight	54,564	24,342	

The contract for manufacturing the vertical cask was placed in December 2022 with Springs Fabrication, LLC located in Colorado Springs, CO. Figure 3-14 shows the inner shell at the manufacturing facility. Figure 3-15 shows the partially assembled cask on the left and the fully assembled cask on the right loaded on the truck for transport to the shake table facility at UCSD (San Diego, CA).



Figure 3-14. Inner Shell of the Cask at the Manufacturing Facility in Colorado Springs.



Figure 3-15. Partially Assembled Cask (left) and Fully Assembled Cask (right) Loaded on the Truck for Transport to UCSD (CA).

The cask arrived at UCSD on June 10, 2022. The concrete pad was built at the beginning of May next to the shake table facility to house the cask until the time of the test. Figure 3-16 shows the arrival of the cask to the shake table facility. Figure 3-17 shows the unloading of the cask using two cranes.



Figure 3-16. Cask Arrival to the Shake Table Facility at the UCSD.



Figure 3-17. Cask Unloading at the Shake Table Facility at the UCSD.

The cask was filled with concrete on June 14, 2022. The local suppliers were limited to the concrete mix with the final concrete density of 143-144 pcf. Figure 3-18 shows the process of concrete pouring (top and bottom left) and the cask filled with concrete (bottom right). The concrete samples are shown in Figure 3-19 (right).



Figure 3-18. Pouring Concrete into the Cask (top and bottom left) and Filled with Concrete Cask (bottom right).

The cask was covered with the tarp as shown in Figure 3-19.



Figure 3-19. Completed Vertical Cask Covered with the Tarp (left) and Concrete Samples (right).

Figure 3-20 shows the components of the vertical test unit – dummy assembly, canister, and cask.



Figure 3-20. Vertical Test Unit Components.

The total weight of the test unit is 335,952 lbs (152,385 kg). The vertical cask mockup is very similar to the HI-STAR 100 overpack with regard to the dimensions and empty and loaded weights. The mockup is built as steel-concrete-steel, similar to HI-STAR 100. Figure 3-21 shows the schematics of the vertical

cask mockup and the HI-STAR 100 vertical overpack. Table 3-7 compares the vertical cask mockup and HI-STAR 100 (Holtec) specifications.

Table 3-7. Specifications of the Vertical Cask Mockup and HI-STAR Vertical Overpack.

Specification	Vertical Cask Model		Hi-STAR 100 Vertical Overpack	
Length (m in)	225.00	5.72	231.25	5.87
Outer diameter (in m)	136.50	3.47	132.50	3.37
Wall thickness (in m)	28.43	0.72	29.50	0.75
Empty weight (lbs kg)	234,720	106,458	270,000	122,470
Loaded weight (lbs kg)	335,952	152,385	360,000	163,293

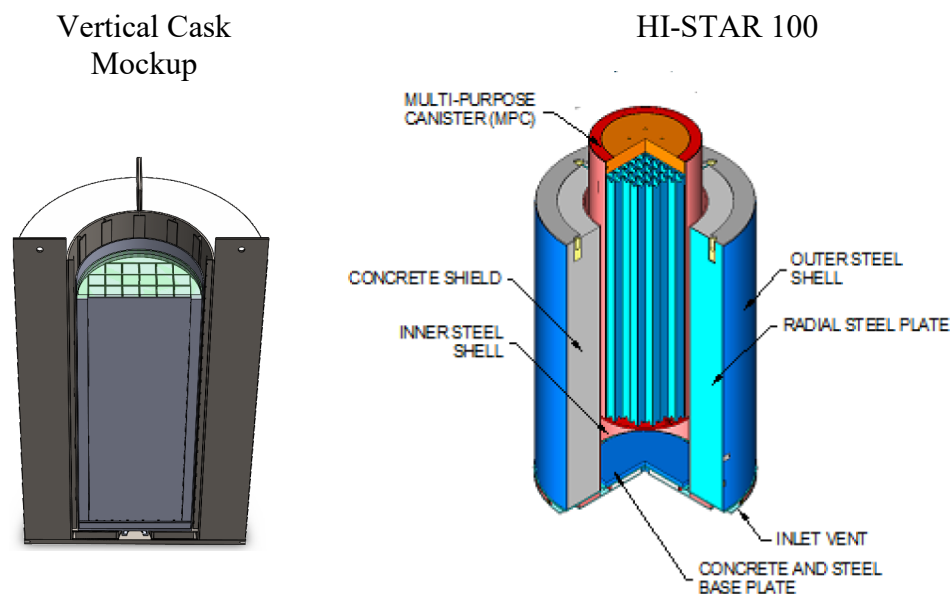


Figure 3-21. Vertical Cask Mockup (left) and HI_STAR 100 Vertical Overpack (right).

4. SHAKE TABLE FACILITY

A preliminary agreement to conduct the seismic test was made with the world's largest outdoor earthquake simulator, the LHPOST6, operated by structural engineering department at the UCSD. LHPOST6 and the E-Defense facility in Japan are the only two large-capacity six degrees of freedom shake tables in the world. LHPOST6 has the largest payload capacity in the world 2,040 tonnes. Existing moderate scale six degrees of freedom shake tables in the U.S. are at:

- University of California at Berkeley (71 tons)
- State University of New York at Buffalo (46 tons)
- University of Nevada Reno (46 tons)

The LHPOST6 is the only facility in the U.S. that can accommodate the large size and weight of the test units with the weight of vertical dry storage system around 152 tonnes and the weight of the horizontal dry storage system around 103 tonnes (if horizontal storage mockup is used) or 123 tonnes (if AHSM base is used).

The LHPOST6 facility is a part of the Natural Hazards Engineering Research Infrastructure program. The facility was recently renovated to implement the capability to conduct six degrees of freedom testing and was reopened in April 2022. The seismic test is tentatively scheduled for the spring of 2023. As discussed in Section 3.3.2, the vertical cask mockup was placed on the concrete pad next to the shake table (Figure 4-1). The horizontal storage mockup or AHSM will be transported to LHPOST closer to the time of the test.



Figure 4-1. Vertical Cask Mockup at the LHPOST6 (UCSD).

Table 4-1 provides the shaker table specifications. The shake table parameters allow for far-source and near-source earthquake ground motions to be reproduced. A maximum horizontal peak ground and peak table acceleration (with 363 tonnes payload) of just over 1 g was selected based on the upper bound for the majority of recorded ground motion records. Higher accelerations can be achieved with the smaller payloads, such as the test unit payloads of 103 and 152 tonnes.

Table 4-1. LHPOST Outdoor Earthquake Simulator Specifications.

Attribute	Specification	
Size	7.6 m x 12.2 m	24.93 ft x 40.03 ft
Peak acceleration: bare table, 400 ton payload	4.2 g, 1.2 g	
Peak velocity	1.8 m/s	5.91 ft/s
Stroke	± 0.75 m	± 2.46 ft
Maximum gravity (vertical) load	20 MN	4.50E+6 lbf
Force capacity of actuators	6.8 MN	1.53E+6 lbf
Maximum overturning moment: bare table, 400 ton specimen	35 MN-m, 50 MN-m	12915 ton-ft, 18450 ton-ft
Frequency bandwidth	0 - 33 Hz	

The LHPOST6 facility will allow measurements of the test unit displacement during the shake table test. Displacement is possible during strong ground motions and obtaining the test data is important for bounding the canister responses and for model validation. The pre-test modeling is being conducted to determine which ground motions defined in Section 2 may result in sliding or rocking of the test units.

The target performance of the LHPOST6 was defined through its ability to reproduce the six tri-axial strong ground motions. These ground motions are described in Table 4-2 reproduced from [30]. Comparison of target and achieved tri-axial 1994 Northridge earthquake accelerations and response Spectra is shown in Figure 4-2 reproduced from [30]. The shake table is capable of reproducing the strong ground motion with high accuracy. Note that the 1977 Tabas (Iran) and 1999 Chi-Chi (Taiwan) earthquakes are on the lists of the earthquakes in Table 2-8 and Table 2-9.

Table 4-2. Strong Ground Motion Considered for the Design of the Six Degrees of Freedom LHPOST6 (from [30]).

Event name	Station name	M	PGA (g)			PGV (m/s)			PGD (m)		
			EW	NS	UP	EW	NS	UP	EW	NS	UP
Tabas, 1978	Tabas, Iran	7.4	0.97	0.88	0.72	1.0	0.87	0.33	0.62	0.33	0.11
Chi-Chi, Taiwan, 1999	TCU065	7.6	0.72	0.49	0.23	0.82	0.73	0.38	0.36	0.24	0.10
Kobe, 1995	Takatori, Japan	6.9	0.62	0.67	0.28	1.21	1.23	0.16	0.40	0.30	0.04
Northridge, 1994	Rinaldi Receiving Station	6.7	0.87	0.47	0.96	1.48	0.75	0.42	0.42	0.23	0.04
Nepal, 2015	Kathmandu, Nepal	7.8	0.16	0.17	0.15	0.43	0.40	0.26	0.30	0.20	0.10
AC-156 compatible earthquake		–	1.01	0.96	0.71	1.04	1.13	0.77	0.22	0.21	0.12

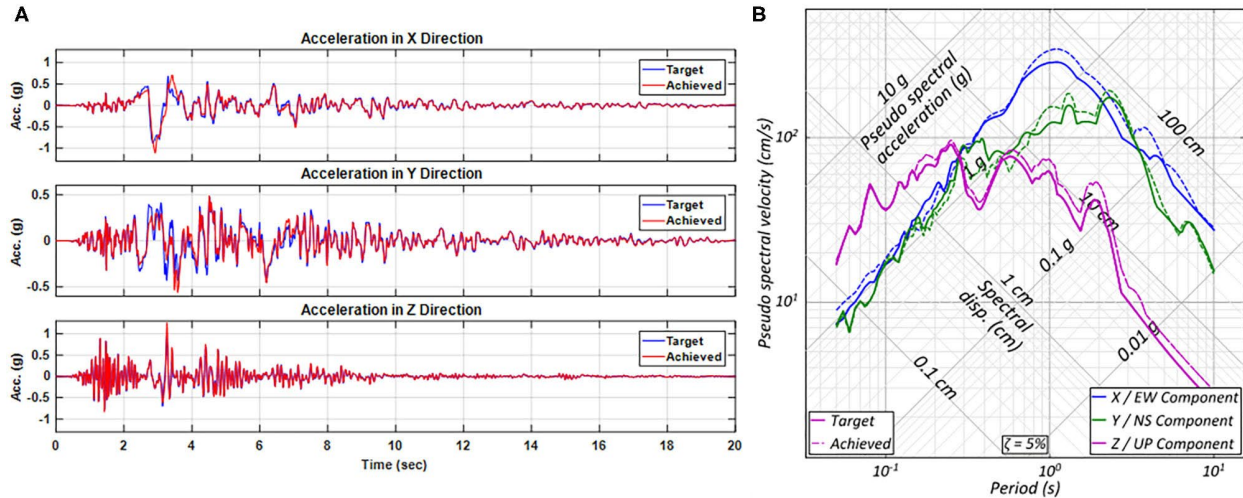


Figure 4-2. Comparison of Target and Achieved Tri-Axial 1994 Northridge Earthquake Accelerations (A) and Response Spectra (B).

Figure 4-3 compares the proposed CEUS and WUS PGAs to the PGAs in Table 4-2. The range of PGAs considered for the design of LHPOST6 covers the range proposed for CEUS and WUS. Consequently, there is high confidence that the test time histories can be accurately reproduced with LHPOST6.

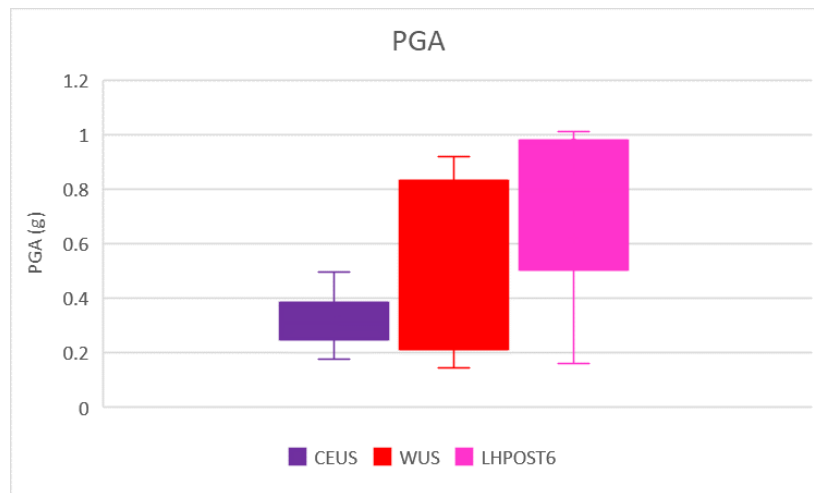


Figure 4-3. PGA Proposed for CEUS and WUS Compared to PGA from Table 4-2.

5. FRICTION EXPERIMENT

The concrete will be poured on the shake table surface before the test. The concrete surface will have different finish on the left and right side of the table to provide friction coefficients representative of the ISFSI pads. This is shown in Figure 5-1 reproduced from [30].

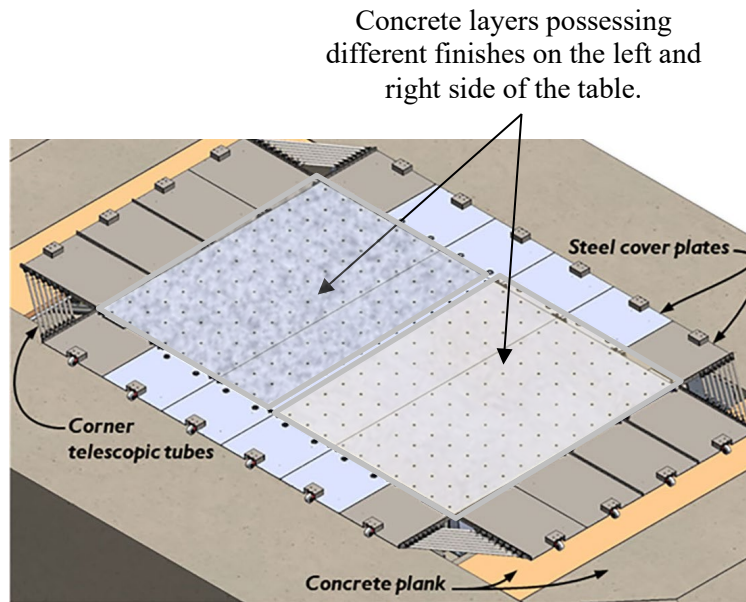


Figure 5-1. Closeup View of the Shake Table Surface.

In the shake table tests with the vertical cask, the cask will be free-standing because this is representative of all ISFSIs in the U.S. except two. The cask will be anchored to the shake table in a few cases with high PGAs. The static and dynamic friction coefficients between the steel bottom of the cask and the concrete layer on the shake table and friction decay constant are important parameters that will affect cask behavior during the test. This parameter must be known for the pre and post-test modeling, data analysis, and model validation.

The ISFSI pad friction coefficient range assumed in NUREG/CR-6865 [18] was from 0.2 to 0.8 with average of 0.53. The friction coefficient value used in HI-STORM 100 FSAR [31] was 0.53. A construction report for the Grand Gulf ISFSI, performed experiments to verify friction coefficient and determined that it was 0.54 [32]. The desirable range of the friction coefficient for the test is from 0.4 to 0.6.

The friction experiment was initiated to determine the friction coefficients between the steel plate with the same finish as the bottom of the vertical cask and the different concrete surfaces. The experiment is being conducted at the UNM Civil Engineering Department and is led by Dr. Mahmoud Taha. The results will be documented in a separate report that will be issued in August 2022.

The International Concrete Repair Institute's defines ten standard Concrete Surface Profiles (CSP) shown in Figure 5-2. Each profile has specific roughness characteristics. The concrete contractors can treat the concrete surface to assure it meets the specified CSP requirements.

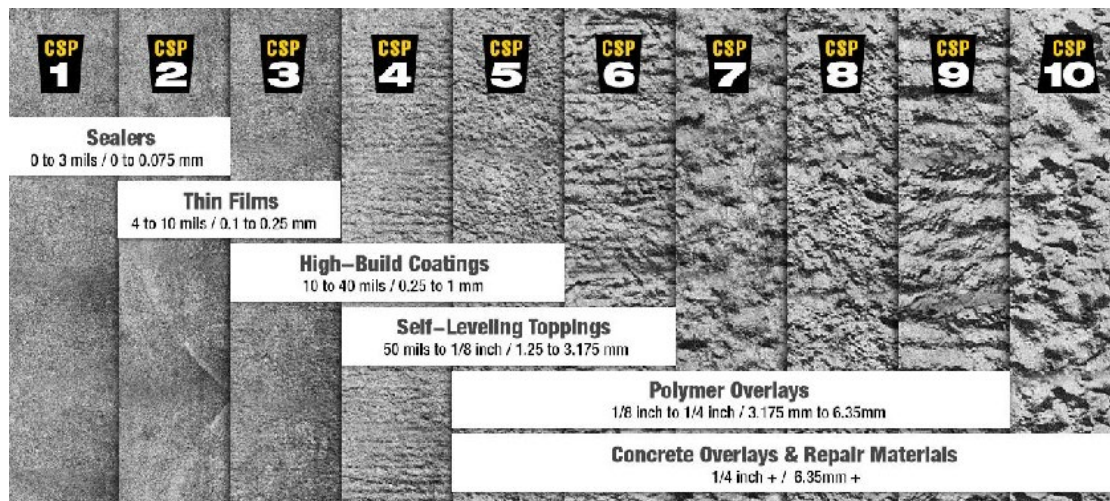


Figure 5-2. International Concrete Repair Institute's Concrete4 Surface Profiles.

Based on the literature data, the friction coefficients between steel and concrete with CSP 5, 6, 7, and 8 should cover the desired friction range. Four concrete blocks will be used in the experiment, each with a different CSP. The roughness levels of these four blocks can be described as: light sandblast, light-medium sandblast, medium bush hammer, and heavy sandblast. Examples are shown in Figure 5-3. These surface roughness standards can be achieved in many ways, in this experiment the surfaces will be imprinted with plastic sheets whose topography is representative of the desired surfaces.

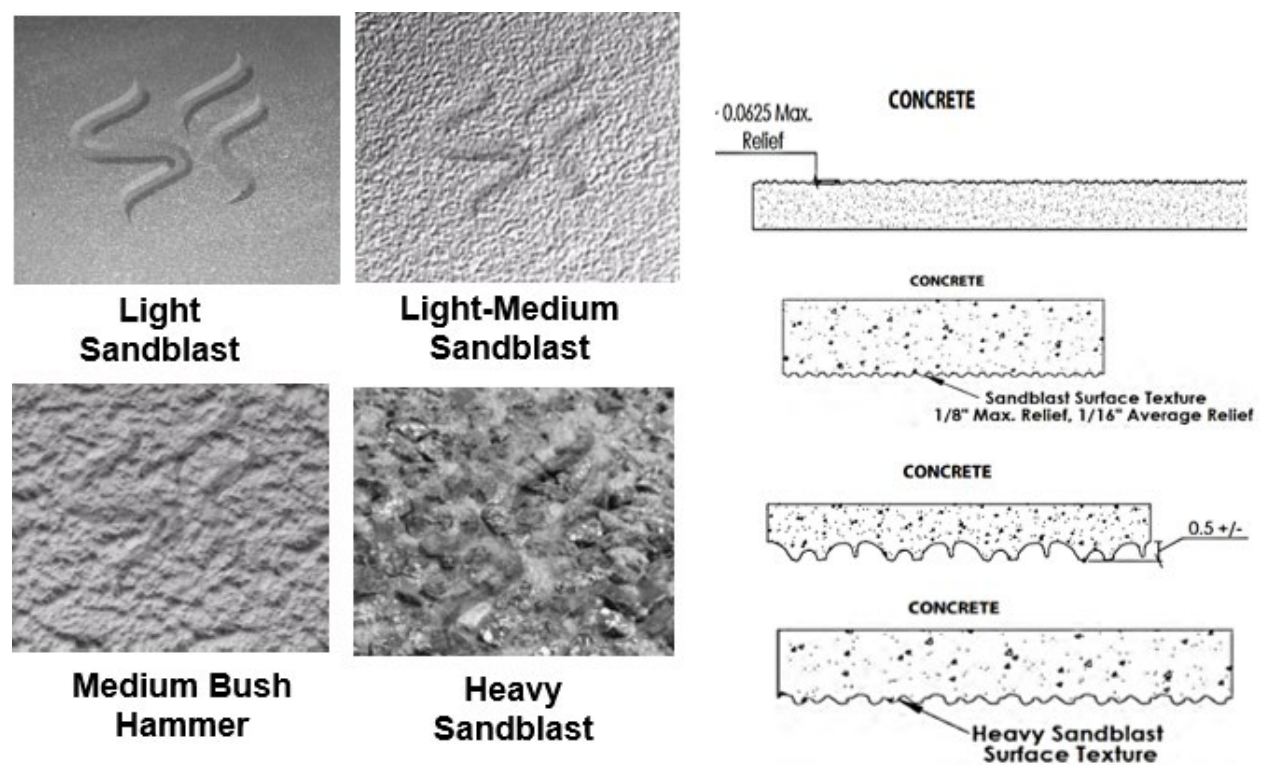


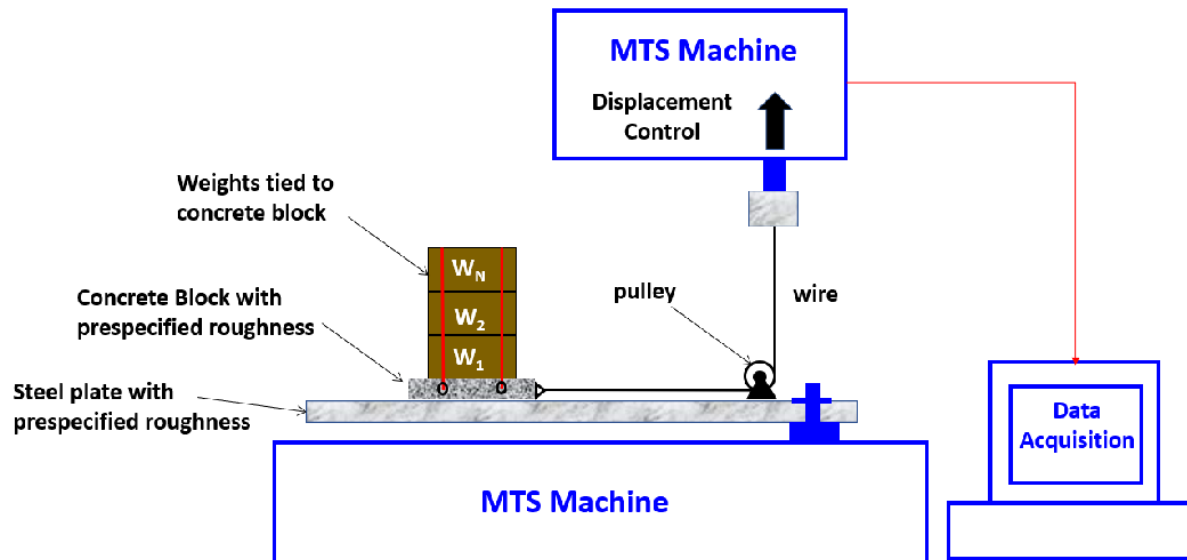
Figure 5-3. Specifications of the Roughness Levels Used in the Experiment.

The specifications of the concrete blocks and steel plate are provided in Table 5-1.

Table 5-1. Specifications of the Concrete Blocks and Steel Plate Used in the Experiment.

Specimen	Dimensions	Strength
4 Concrete blocks with different CSP	4" x 4" x 3"	5000 psi
Steel plate, SP6	24" x 12" x 1/2"	60,000 psi (ASTM A108)

The experiment setup is shown in Figure 5-4. A horizontal force will be applied and measured by the MTS machine. The MTS machine traditionally applies a vertical force, to achieve a horizontal force acting on the block, the setup will utilize a pulley and wire as pictured. The MTS machine will also measure the displacement and velocity of the concrete block. The motion of the concrete block will also be monitored with a DIC camera system.

**Figure 5-4. Friction Experiment Setup.**

The three-dimensional (3D) model of the experimental setup and the physical implementation are shown in Figure 5-5.

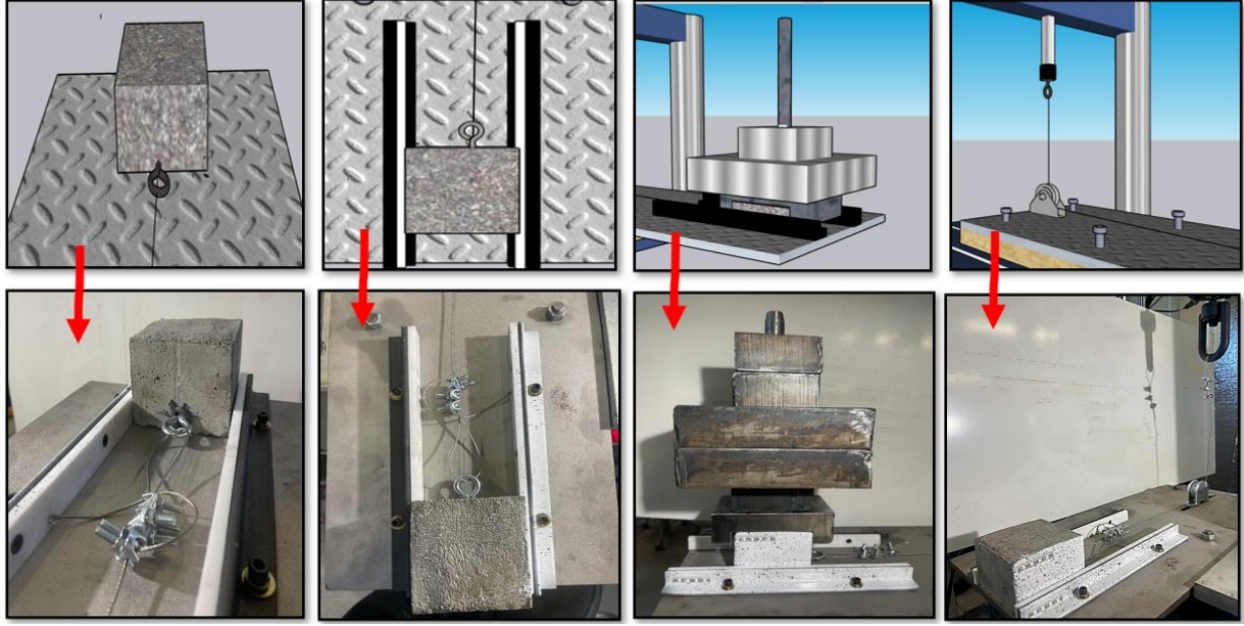


Figure 5-5. 3D Model and Physical Implementation of the Friction Experiment Setup.

The output from the experiment are measurements of displacement of the concrete block and the horizontal force applied by the MTS machine. For each of four concrete blocks, tests will be done with three different applied weight loads, each at three different speeds. Consequently, 36 tests will be completed, and nine sets of the friction coefficients will be obtained for each concrete surface. The concrete surfaces to be used in the seismic shake table test will be determined based on these data.

The static friction coefficient μ_s will be calculated as:

$$\mu_s = \frac{F_s}{N} \quad \text{Eq. (5-1)}$$

where F_s is the measured horizontal force at the moment of the first displacement of the concrete block and N is the applied load.

The dynamic friction coefficient μ_D will be calculated as:

$$\mu_D = \frac{F_k}{N} \quad \text{Eq. (5-2)}$$

where F_k is the measured horizontal force required to move the concrete block at a constant velocity.

The varying coefficient of friction is defined as:

$$\mu = \mu_s - \mu_D e^{-D_c v} \quad \text{Eq. (5-3)}$$

Where D_c is the decay constant and v is the relative velocity between the surfaces. The decay constant can be estimated from Eq. (5-3).

Table 5-2 summarizes the preliminary experimental results from the friction tests with 3 mm/s velocity. Figure 5-6 through Figure 5-9 show the preliminary experimental data. The additional tests will be conducted to obtain the data for samples 1 and 4 with load 342 N (80 lbs). The tests will be repeated with the different speeds. The static and dynamic friction coefficients will be derived after all the tests are completed.

Table 5-2. Experimental Results from 3 mm/s Friction Tests.

Surface Roughness	Displacement rate (mm/s)	Applied load N (lb)	Applied Stress kPa (psi)	Static Coefficient of Friction	Mean Static Coefficient of Friction	Dynamic Coefficient of Friction	Mean Dynamic Coefficient of Friction
1: Light Sandblast	3	180 (40)	21 (3)	0.73	0.77	0.49	0.54
		342 (80)	33 (5)	0.8		0.59	
2: Light-Medium Sandblast	3	180 (40)	21 (3)	0.74	0.70	0.57	0.58
		342 (80)	33 (5)	0.7		0.58	
		538 (121)	55 (8)	0.67		0.59	
3: Medium Bush Hammer	3	180 (40)	21 (3)	0.67	0.68	0.51	0.54
		342 (180)	33 (5)	0.68		0.57	
		538 (121)	55 (8)	0.69		0.55	
4: Heavy Sandblast	3	180 (40)	21 (3)	0.67	0.70	0.54	0.52
		342 (80)	33 (5)	0.73		0.49	

Experimental Results

1. Light Sandblast

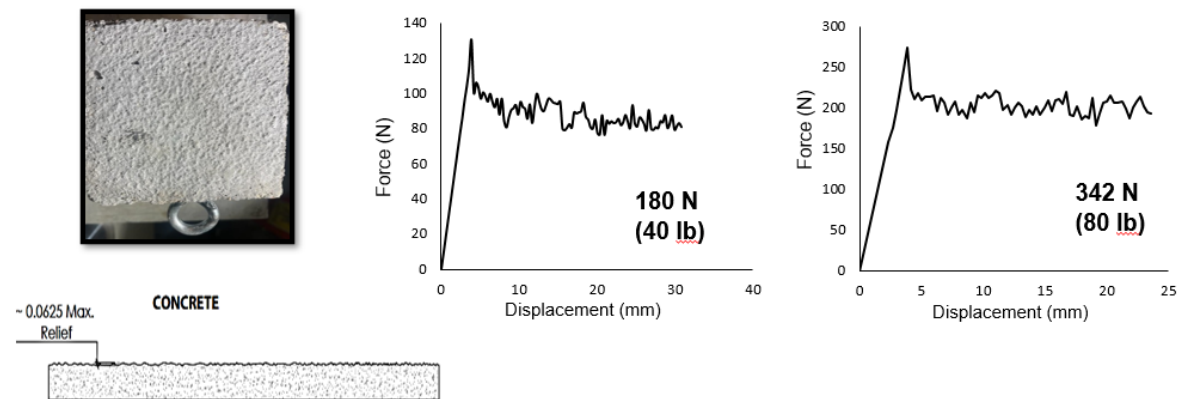


Figure 5-6. 3 mm/s Light Sandblast Force versus Displacement Data.

Experimental Results

2. Light - Medium Sandblast

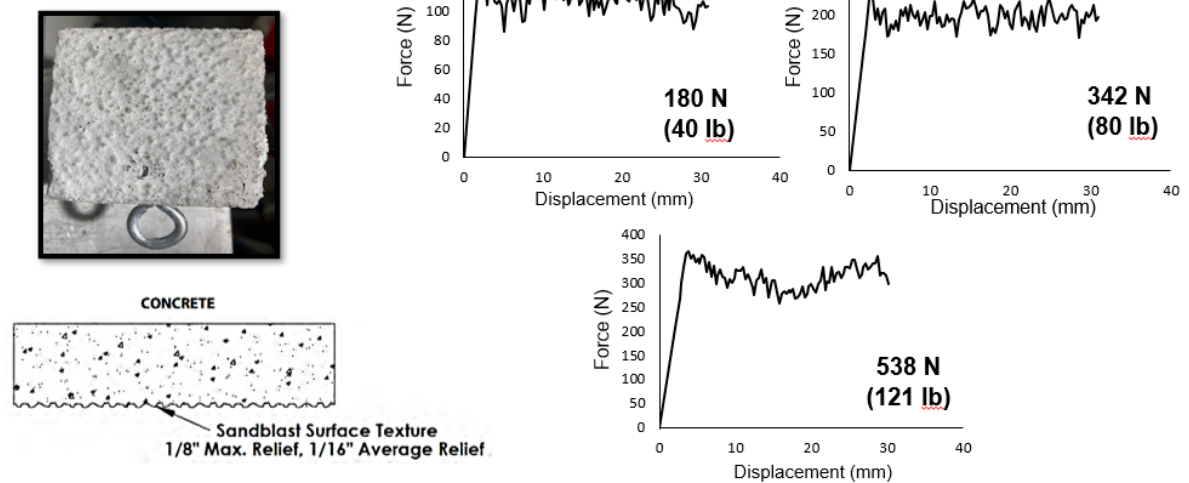


Figure 5-7. 3 mm/s Light-Medium Sandblast Force versus Displacement Data.

Experimental Results

3. Medium Bush Hammer

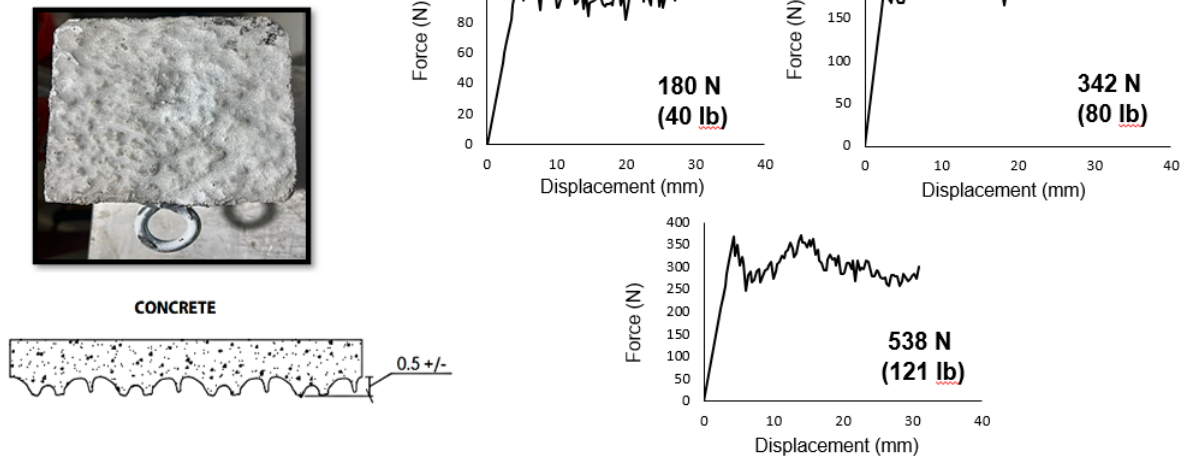


Figure 5-8. 3 mm/s Medium Bush Hammer Force versus Displacement Data.

Experimental Results

4. Heavy Surface Friction

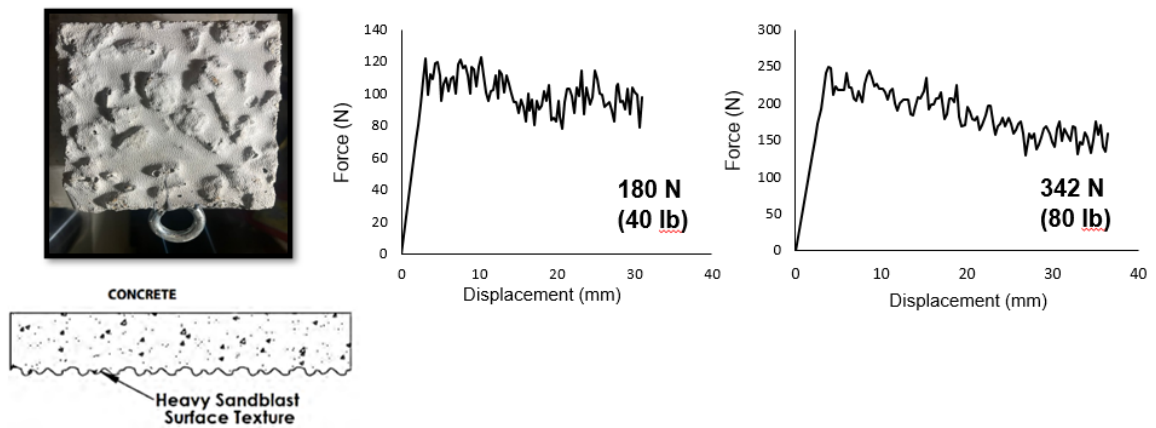


Figure 5-9. 3 mm/s Heavy Sandblast Force versus Displacement Data.

One concern regarding concrete to steel friction in the shake table test is whether the friction levels will remain the same over multiple tests with heavy vertical cask, especially if the cask slides in some tests. According to [33], after repeating many cycles of a steel on mortar shake table seismic experiment, the friction coefficient value was maintained and unaffected by loading frequencies and acceleration magnitudes. During sliding, the friction coefficient also remained unchanged. Additionally, in this study the friction coefficient remained unchanged even during cycles including vertical accelerations.

After the shake table tests, samples of the concrete layer that was directly beneath the test unit will be cut out. These samples will be used to conduct friction experiments similar to the ones described above. These experiments will provide further evidence as to whether the concrete friction coefficients remained the same during the shake table tests.

6. INSTRUMENTATION

The instrumentation is guided by the results of the previous experiments and the pre-test modeling. The summary of the important results is provided in Sections 6.1 and 6.2, Section 6.3 described the proposed instrumentation.

6.1 Results of the Previous Experiments

The accelerations and strains were measured on the three surrogate assemblies in the MMTT [26] and on the dummy (accelerations) and surrogate (accelerations and strains) assembly in a series of 30 cm drop tests [27], [25]. Both experiments demonstrated that the accelerations and strains are different at the different locations. The examples described in this section are based on the 30 cm drop test [27].

Figure 6-1 reproduced from [27] shows maximum accelerations on the 1/3 scale dummy assemblies (front end of 1/3 scale cask) in the 30 cm (11.81 in) drop. The numbers in this figure represent accelerometer ID's and color represents maximum recorded acceleration filtered to 300 Hz. Also shown are the time history of the maximum acceleration seen in A10AZ (peak acceleration ~100g), and the minimum acceleration seen in A2AZ (peak acceleration ~40g). The difference between the maximum and minimum is 2.5.

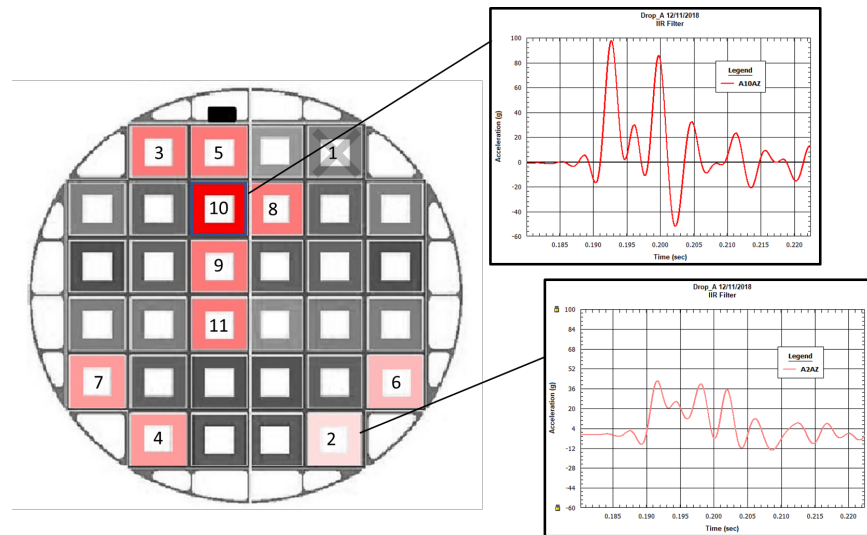


Figure 6-1. Maximum Accelerations on the Dummy Assemblies (Front End of 1/3 Scale Cask) in the 30 cm Drop.

The accelerations are also different at different locations on the surrogate assembly. Figure 6-2 reproduced from [25] shows maximum accelerations at the different locations on the full-scale 17x17 Westinghouse surrogate assembly in the 30 cm (11.81 in) drop. The minimum acceleration was 38 g on the top nozzle end of the assembly and the maximum acceleration was 67 g on the bottom nozzle end, a 1.8 times difference.

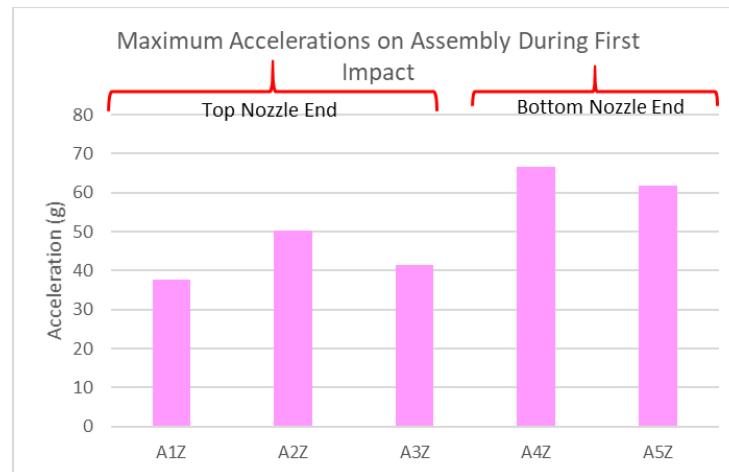


Figure 6-2. Peak Surrogate Assembly Accelerations During the First Impact in the 30 cm Drop of Full-Scale Surrogate Assembly.

The different accelerations result in different strains on the surrogate assembly rods. Figure 6-3 shows peak axial strain values (top) and color maps of the peak strain values (bottom) in the 30 cm drop test of full-scale surrogate assembly. The strain values are from 180 microstrain to 1,724 microstrain, a 9.6 times difference.

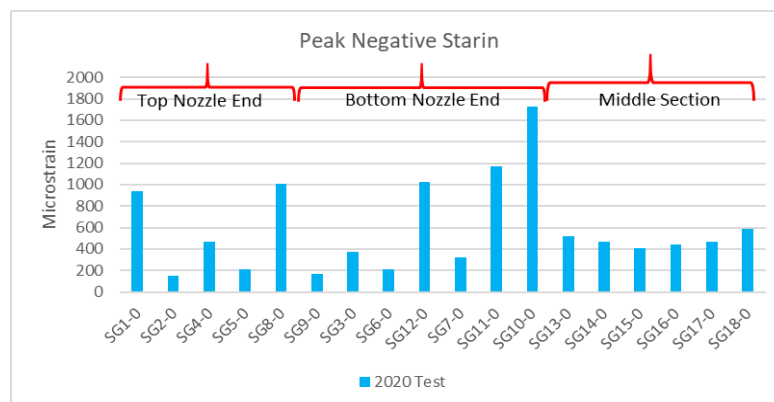


Figure 6-3. Peak Axial Strain Values (top) and Color Maps of the Peak Strain Values (bottom) in the 30 cm Drop Test of Full-Scale Surrogate Assembly.

6.2 Results of the Pre-Test Modeling

The preliminary pre-test modeling results are documented in [6]. The latest pre-test modeling results are documented in [7]. The pre-test modeling provided guidance for:

- Selecting surrogate assembly rods and locations on the rods for instrumentation with accelerometers and strain gauges.
- Placing surrogate assemblies in the NUHOM 32 PTH2 canister.

In [7], the strain distribution on the rods of 17x17 fuel assembly were obtained for two CEUS hard rock scenarios (magnitude 5.5, distance 15 km, seismic hazard 5×10^{-4} and 5×10^{-5}) and two soil scenarios (magnitude 6.5, distance 40 km, seismic hazard 5×10^{-4} and magnitude 5.5, distance 15 km, seismic hazard $\sim 5 \times 10^{-5}$). Different combinations of the burnup and temperature were considered. For soil conditions, the different gaps between the assembly and basket wall were considered as well.

Figure 6-4 reproduced from two figures in [7] shows the distribution of maximum and minimum strains on the rods in hard rock scenarios with 10 GWd/MTU burnup and 22°C temperature. The distribution is asymmetrical because the fuel assembly is swaying during seismic excitation and in some cases resides towards one side of the basket longer than the others causing larger strain on that side. This figure suggests that the peak strain values can be captured if the strain gauges are located in the middle rod on each side of the assembly in the first or second row from the external surface.

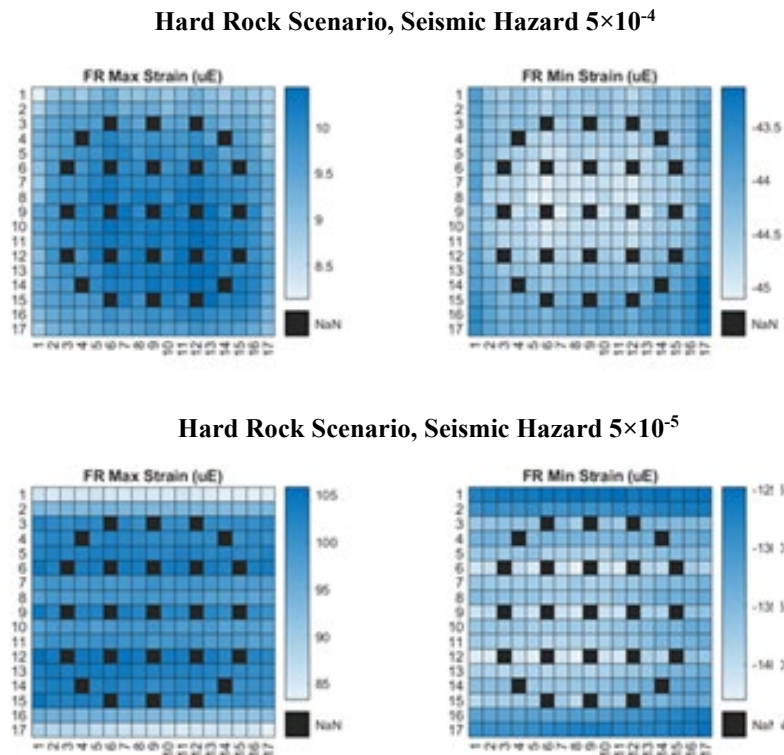


Figure 6-4. Distribution of Maximum and Minimum Strains on the Rods in Hard Rock Scenarios from [7].

Figure 6-5 reproduced from three figures in [7] shows the distribution of maximum and minimum strains on the rods in soil scenarios with 10 GWd/MTU burnup and 22°C temperature (top and middle plots) and with 10 GWd/MTU, 300°C temperature, and 2 mm basket-to-assembly gap (bottom plot). The strain distribution is asymmetrical in all three cases and in the bottom plot, the strain in the central part is smaller than on the edges. This figure suggests the same locations for the strain gauges as Figure 6-4.

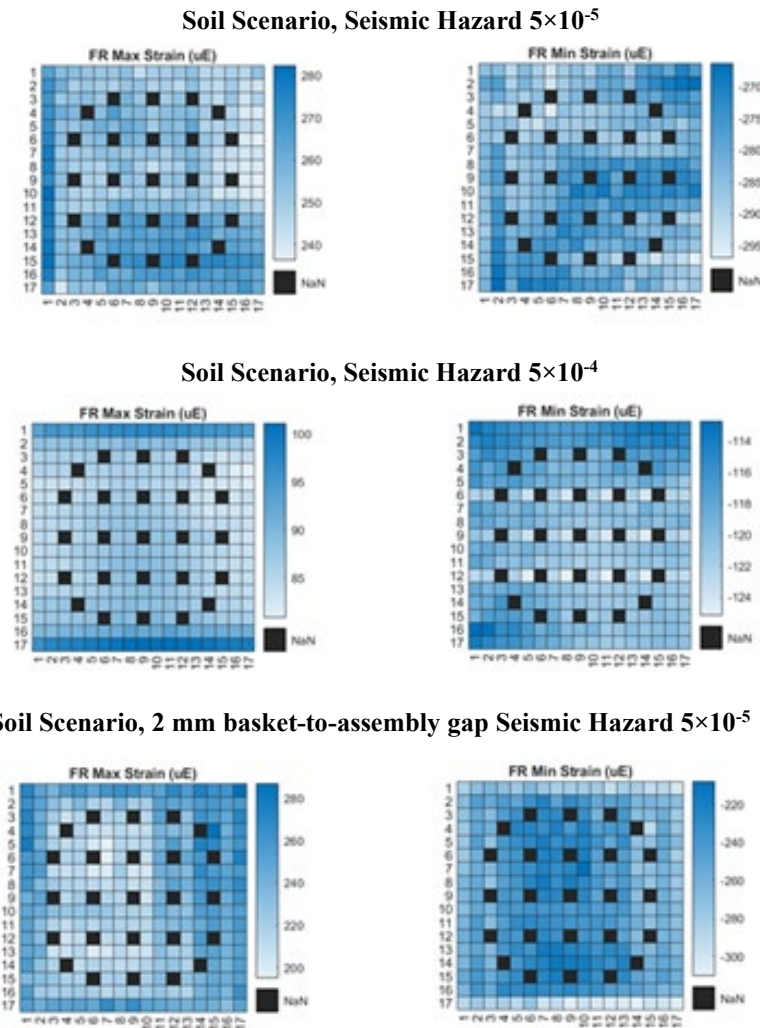


Figure 6-5. Distribution of Maximum and Minimum Strains on the Rods in Soil Scenarios from [7].

Figure 6-6 shows 3D distribution of peak strains on the fuel assembly rods in hard rock scenario (left) and soil scenario (right) corresponding to seismic hazard 5×10^{-5} reproduced from [7]. The peak fuel rod strains occur at the top and bottom of the fuel assembly in vicinity of the spacer grids. As explained in [7], the spacer grids add lateral stiffness to the fuel assembly and act as stress concentrations. The strains are larger at the bottom of the fuel assembly because the bending moments induced by the seismic excitation are highest toward the bottom. The high strains at the top of the fuel assembly are due to impact between the top nozzle and the basket. These results suggest that one strain gauge placed at the top and three strain gauges placed at the bottom part of the assembly should capture the largest strains on the rods.

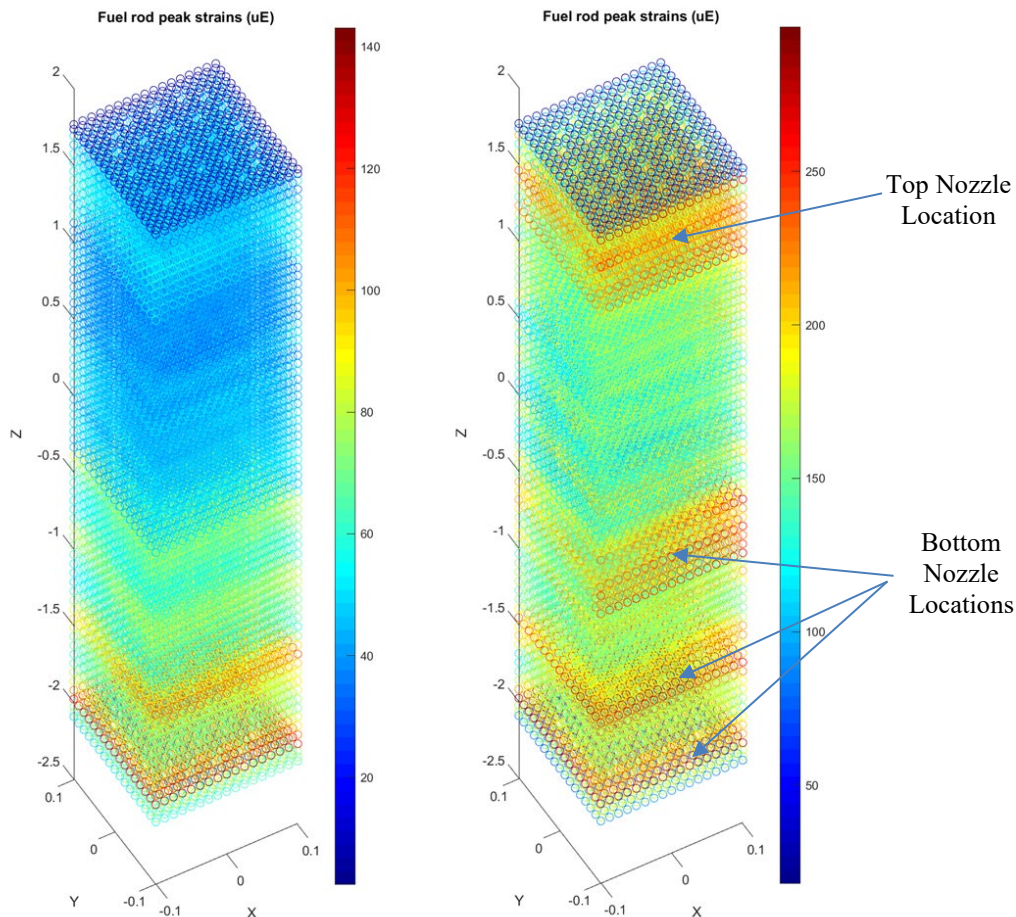


Figure 6-6. 3D Distribution of Peak Strains on the Rods in Hard Rock (left) and Soil Scenario (right), Seismic Hazard 5×10^{-5} from [7].

To capture the differences in responses related to the location within the canister, the surrogate assemblies should be placed in the different regions (Klymyshyn, personal communication) shown in different colors in Figure 6-7:

- 1) Center Cells
- 2) Outer Cells
- 3) Mid/Corner Cell
- 4) Outer Cell in Corner

Figure 6-7 shows the proposed four locations for the surrogate assemblies inside the canister. Rotating the coordinate system by 90 degrees will be equivalent to having the surrogate assemblies in the locations shown with the red crosses. Rotating the coordinate system by 45 degrees will allow for evaluating responses in the case when the canister basket is not aligned with the excitation axes.

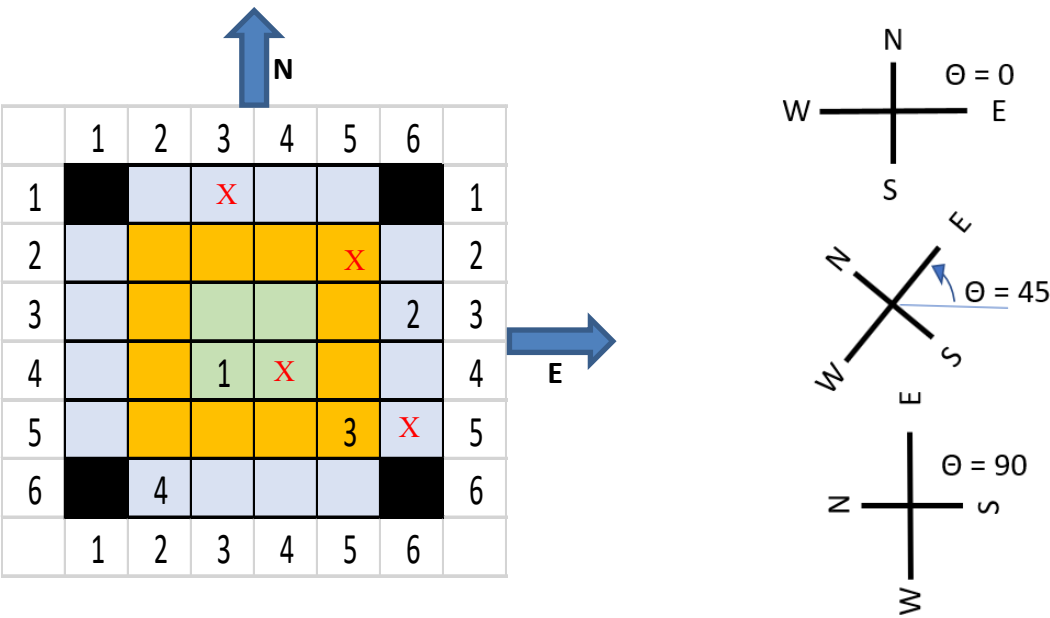


Figure 6-7. Proposed Locations of the Surrogate Assemblies within the Canister and Canister Orientation During the Test.

The pre-test modeling results suggest that the fuel rods will not contact each other, and the spacer grids will not buckle as it was observed in the 30 cm drop test. The peak strain values in nine different cases (calculated in [7]) are shown in Figure 6-8. The peak strain ranges from 45 to 364 microstrain.

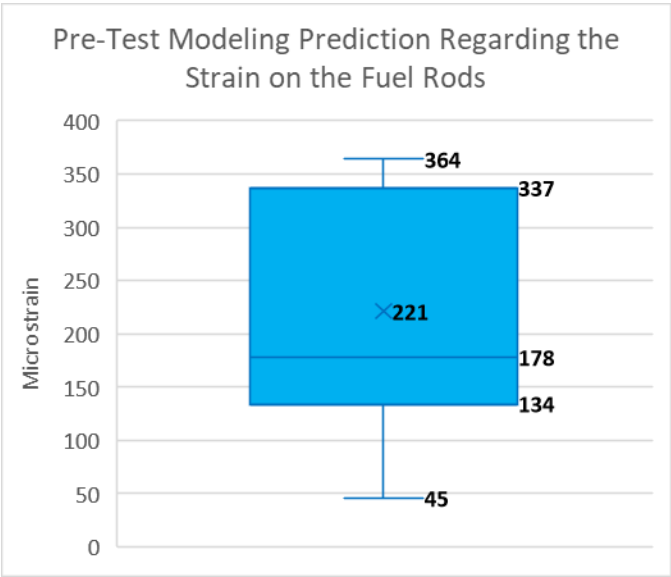


Figure 6-8. Pre-Test Modeling Prediction Regarding the Strain on the Fuel Rods.

The observed strain on the rods within the short middle spans of the surrogate assembly in the 30 cm drop test was 400-600 microstrain. The pressure paper inserted between the rods in these spans did not register rod to rod contact. The rod-to-rod contact was registered in the bottom and top long spans at the locations with the observed strain from 400 microstrain to 1,724 microstrain. The low end is only slightly higher

than the maximum predicted strain. Placing pressure paper in the long span will allow for registering the rod-to-rod contact if such contact occurs under any of seismic excitations.

6.3 Proposed Instrumentation

The following describes the preliminary instrumentation plan for the seismic shake table test.

6.3.1 Data Acquisition System

The UCSD data acquisition system (DAQ) will be used to collect the data during the seismic shake table tests. The new UCSD DAQ system consists of 12 nodes with 64 channels each for a total of 768 measurement channels.

The UCSD sensors includes:

- MEMS-based accelerometers – 205
- Linear displacement transducers – 142
- String potentiometer displacement transducers – 119
- Load jacks – 4
- Load cells – 31
- GPS with RTD_NET Software (Geodetics) with three 50 Hz receivers to measure translational motions in 3D with a precision of 1.5 mm.
- Array of 1080 and 4K high definition (HD) video cameras (30 frames per second) fully synchronized with the sensors: GoPros 4K (15), Axis 240Q/241Q video servers streaming (4), IQeye streaming/timelapse video (3).

The decision on which UCSD sensors to use will be made while preparing the contract to conduct this work.

SNL has two different models of Endevco Corporation accelerometers (Figure 6-9) with a total of 38 accelerometers:

- 7270A-20K (acceleration up to 20,000 g) – 20 accelerometers are available
- 727-2K (acceleration up to 2,000 g) – 18 accelerometers are available



Figure 6-9. Endeveco Corporation Accelerometers (images not at same scale).

SNL is planning on purchasing strain gauges CEA-03-062UW-350, the same as the ones used in the 30 cm drop tests. The strain gauge is shown in Figure 6-10 (left). Its installation on the surrogate assembly rod for the 30 cm (11.81 in) drop test is shown in Figure 6-10 (right) [25].

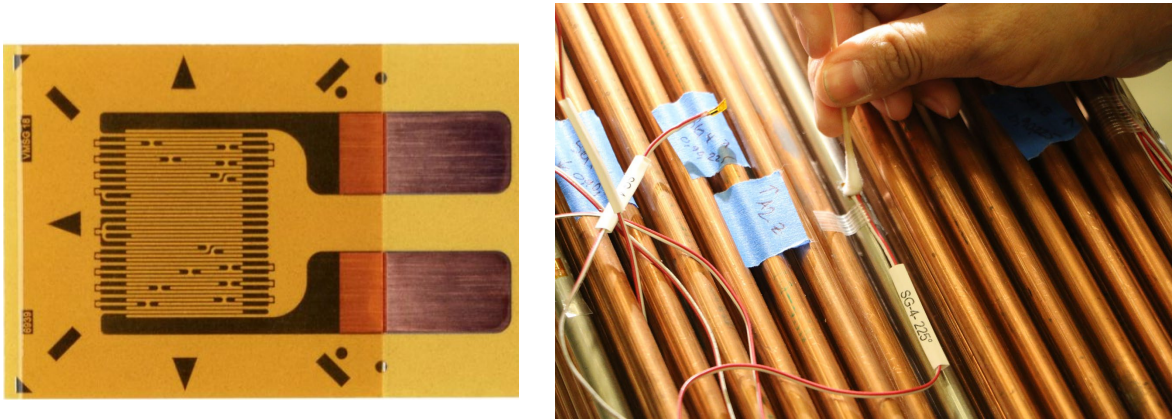


Figure 6-10. Strain Gauge CEA-03-062UW-350 (left) and its Installation (right).

SNL is planning on purchasing TILT-57A dynamic inclinometers. The TILT-57A dynamic inclinometer is a high performance, high resolution three axis digital dynamic compensated inclinometer that uses the latest miniature technology in the form of accelerometer and gyroscope MEMS sensors. It is contained within a robust aluminium housing (Figure 6-11).



Figure 6-11. TILT-57A Dynamic Inclinometer.

6.3.2 Accelerometers

One triaxial accelerometer will be installed on the top of each dummy assembly. This can be a block of three uniaxial accelerometers located in X, Y, and Z direction as shown in Figure 6-12. The tri-axial accelerometer, or a block, will be located at the top of the concrete inside the dummy assembly steel tube. The total number of accelerometers will be 28 (triaxial) or 84 uniaxial.

One triaxial accelerometer (or a block of three uniaxial accelerometers) will be installed on each surrogate assembly on the top tie plate. The top of the assembly banging against the basket is predicted to be a major loading indicator [6]. The purpose of these accelerometers is to track the motion of the surrogate assemblies and the timing of impacts. The total number of accelerometers will be 4 (triaxial) or 12 uniaxial.

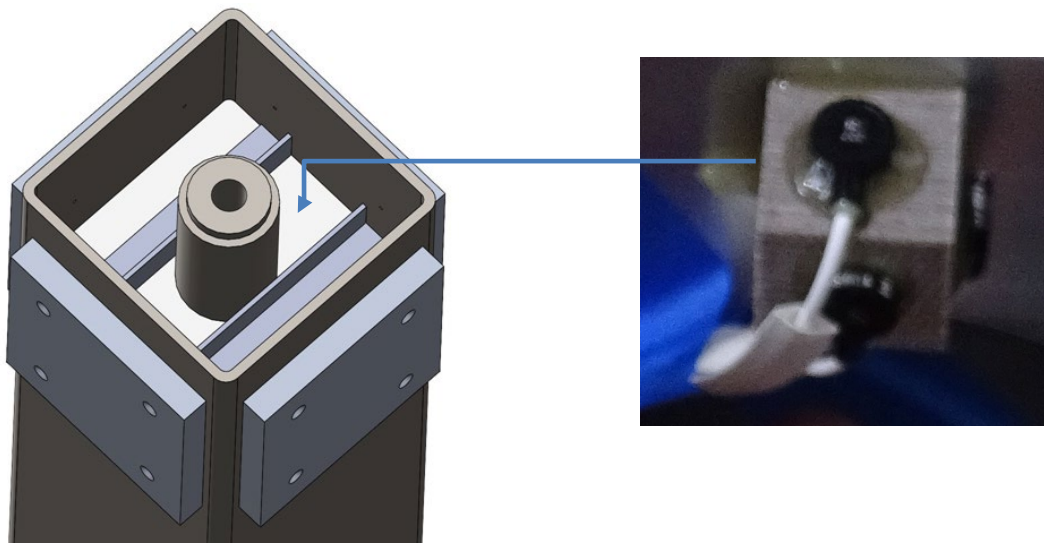


Figure 6-12. Block of 3 Uniaxial Accelerometers and Its Location on the Dummy Assembly.

The uniaxial accelerometers will be installed on the surrogate assembly rods. Four rods of each surrogate assembly will be instrumented. The proposed locations are within the long spacer grid span near the top nozzle and bottom nozzle ends (Figure 6-13). At two locations (sides 1 and 3), uniaxial accelerometers will be placed at 0° and the other two locations (sides 2 and 4) they will be placed at 90° to allow for adequate sampling of the 0° and 90° components. The total number of uniaxial accelerometers will be 32 (2 accelerometers x 2 locations x 2 rods x 4 surrogate assemblies). In addition, one triaxial accelerometer (or uniaxial accelerometer block) will be installed on the top of surrogate assembly on the tie plate.

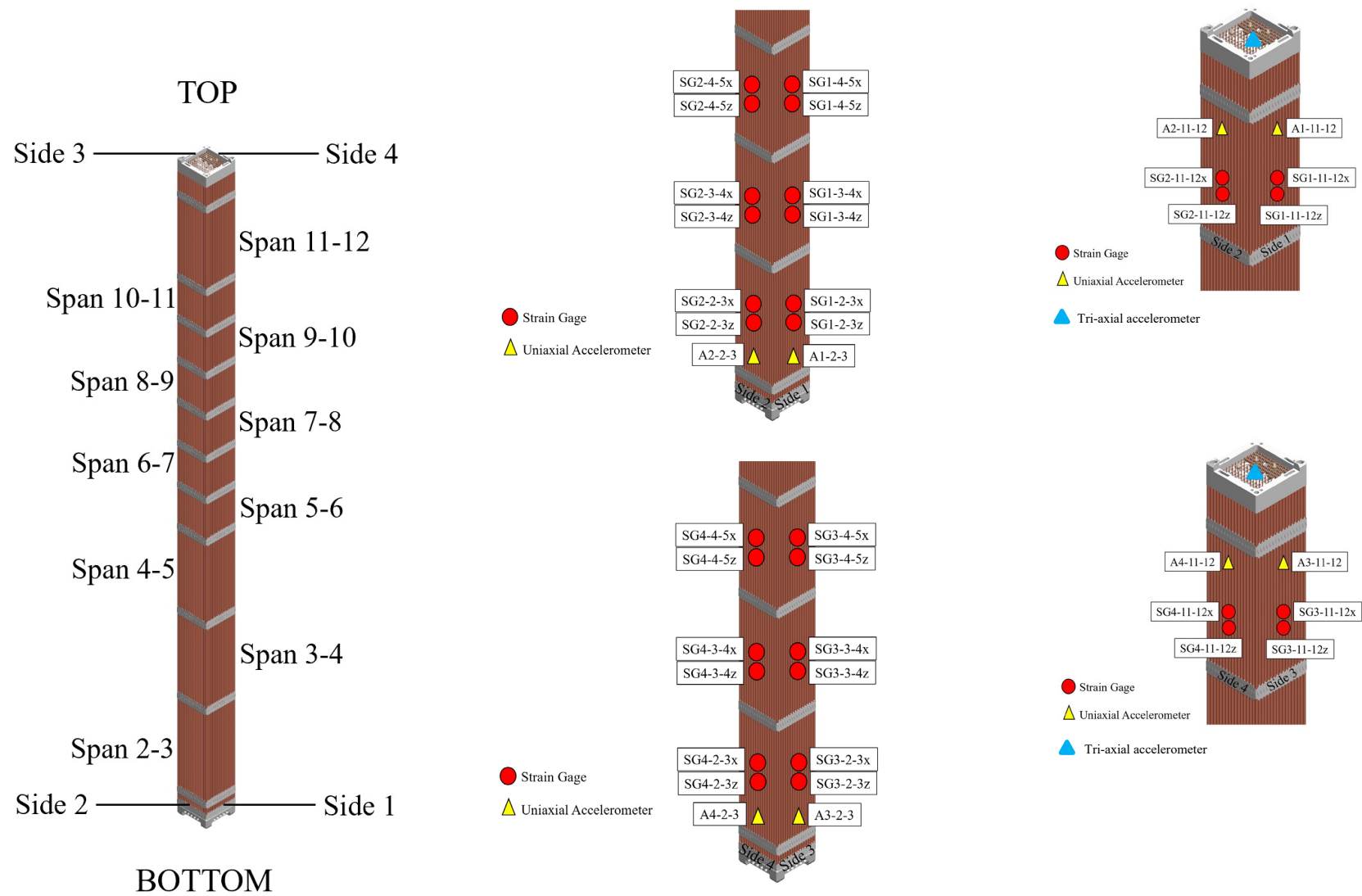


Figure 6-13. Surrogate Assembly Instrumentation Diagram.

Two triaxial accelerometers (or blocks of uniaxial accelerometers) will be installed on the canister top and bottom separated by 90 degrees. Two triaxial accelerometers (or blocks of uniaxial accelerometers) will be installed on the overpack (vertical cask and HSM) top and bottom separated by 180 degrees. Two uniaxial accelerometers will be installed at the top of the basket close to the triaxial accelerometers on the top of the canister. The total number of triaxial accelerometers will be eight (or 24 uniaxial accelerometers (Figure 6-14). The total number of uniaxial accelerometers will be two.

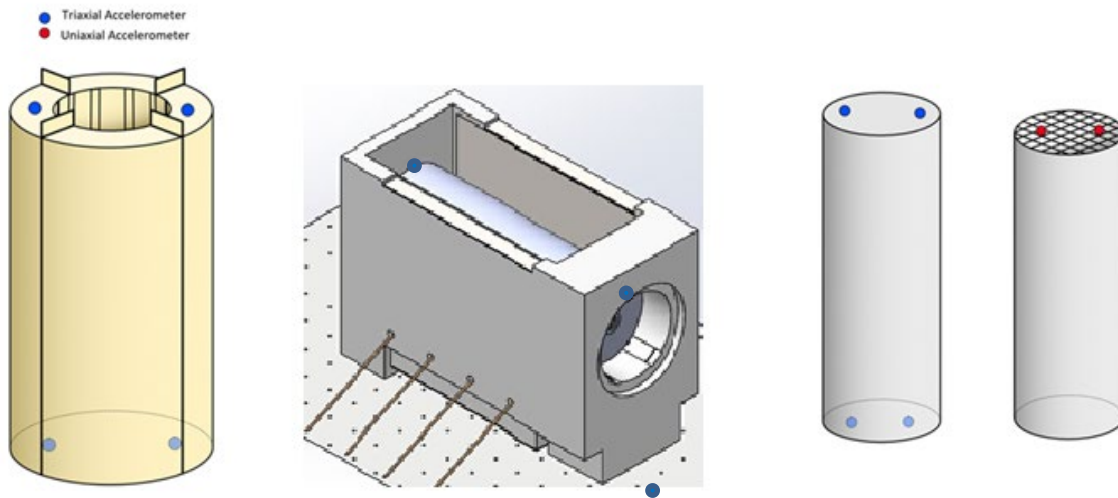


Figure 6-14. Accelerometers on the Cask, Canister, and Basket.

6.3.3 Strain Gauges

A number of strain gauges will be installed on the surrogate assembly rods to register the variations of responses as the fuel assembly impacts different faces of the basket wall as discussed in Section 6.2. Four rods on each surrogate assembly will be instrumented with strain gauges as shown in the instrumentation diagram (Figure 6-13).

At each location, the strain gauges will be placed at 0 degrees and 90 degrees to pick up 3-dimensional vibrations. Four locations are proposed on each rod – three long spans at the bottom nozzle end and one long span at the top nozzle end as discussed in Section 6.2. The strain gauges will be located on the same rods as the accelerometers. This will allow for filtering high frequency acceleration spikes that do not result in strain spikes. The total number of strain gauges will be 128 (2 strain gauges per location x 4 locations x 4 rods x 4 surrogate assemblies).

6.3.4 Dynamic Inclinometers

Two inclinometers will be placed on the top of the cask at 0 and 90 degrees and two on the top of the canister at 0 and 90 degrees to measure tip angle. Two inclinometers will be placed on the top of the shake table at 0 and 90 degrees. The total number of inclinometers will be six.

6.3.5 Pressure Paper

Pressure paper (Fujifilm) was used in 30 cm drop tests to record any contact between the rods and associated pressures. Table 6-1 shows the available types of the pressure paper. The types acquired for the

30 cm drop test were: Extreme Low, Super Low, Low, and Medium. Because rod to rod contact is not predicted by modeling (Section 6.2), the pressure paper that will be used in the seismic shake table test will be Extreme Low (A) and Ultra Low (B). This will cover the contact pressure range of 7.2 to 85 psi.

The pressure paper sheets will be installed between the rods of the surrogate assemblies in two long spans. The sequence will be A, B as shown in Figure 6-15.

Table 6-1. Fujifilm Pressure Paper Specifications.

Table 1: Fujifilm Prescale® Specifications		
Film Type	Roll Dimensions	Pressure Range
Extreme Low (LLLLW/4LW)	9.8 ft × 12.2in (3 m × 310mm)	7.2–28 psi (0.5–1.97 kg/cm ²)
Ultra Low (LLLW)	16.4 ft × 10.6in (5 m × 270mm)	28–85 psi (2–6 kg/cm ²)
Super Low (LLW)	19.7 ft × 10.6in (6 m × 270mm)	70–350 psi (5–25 kg/cm ²)
Low (LW)	39.4 ft × 10.6in (12 m × 270mm)	350–1,400 psi (25–100 kg/cm ²)
Medium (MS)	39.4 ft × 10.6in (12 m × 270mm)	1,400–7,100 psi (100–500 kg/cm ²)
High (HS)	39.4 ft × 10.6in (12 m × 270mm)	7,100–18,500 psi (500–1,300 kg/cm ²)
Super High (HHS)	39.4 ft × 10.6in (12 m × 270mm)	18,500–43,200 psi (1,300–3,000 kg/cm ²)

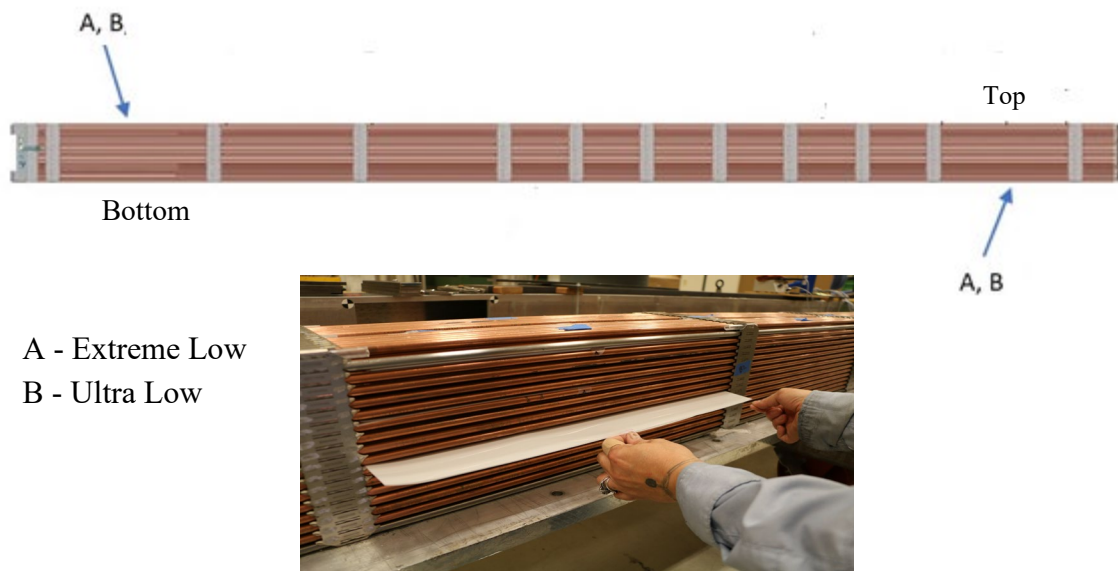


Figure 6-15. Pressure Paper Locations and Specifications.

6.3.6 Load Cells

To determine if the degree of rocking of the canister within the vertical concrete overpack eight load cells will be installed. Four of these load cells will be at the base of the canister and will be installed axially 90-degrees apart near the outer radius of the canister. Four additional load cells will be installed radially 90-degrees apart near the top of the canister. These load cells will be positioned such that the canister will contact the load cells just before it contacts the structural T stiffeners on the inside of the concrete overpack.

6.3.7 High-Speed Cameras

One fast speed camera will be looking at the canister top. Two high-speed cameras will be looking at the overpack at 0 and 90 degrees.

6.3.8 High-Speed Optical Imaging

The highspeed optical imaging of the overpack surface will be performed during the tests. The DIC will be used to obtain representative snapshots of the magnitude of the particle velocities on the overpack surface. The speckles will be placed along the vertical line at a few locations – near the top, middle part, and the bottom of the overpack.

6.3.9 Proposed Instrumentation Summary

Table 6-2 provides the summary of the proposed instrumentation. The total number of channels required for strain gauge alternatives one and two is 96 and 128 respectively.

Table 6-2. Instrumentation Summary.

Accelerometers			
Instrumented Element	Location	NN of Triaxial	NN of Uniaxial
Dummy Assemblies (28)	top	28	(84)
Surrogate Assemblies (4)	tie plate	4	(12)
Surrogate Assemblies (4)	rods		32
Canister	top	2	(6)
Canister	bottom	2	(6)
Cask	top	2	(6)
Cask	bottom	2	(6)
Basket	top		2
Total		40	34 (120)
Strain Gauges			
Instrumented Element	Location	NN, Alternative 1	NN, Alternative 2
Surrogate Assembly (4)	rods	96	128
Dynamic Inclinometers			
Instrumented Element	Location	NN	

Canister	Top	2	
Cask	Top	2	
Shake table	Top	2	
Total		6	
Load Cells			
Canister	Top	4	
Canister	Bottom	4	
Total		8	

7. SUMMARY

This report documents the updated seismic shake table test plan and replaces the preliminary test plan [5]. The report describes the shake table inputs (ground motions), test hardware, shake table facility, friction experiment, and instrumentation.

Ground Motions

Ground motions are the most important inputs into the shake table test. Development of ground motions is a challenging task because they must be representative of the range of seismotectonic and other conditions that any site in the WUS or CEUS might entail. A new methodology was developed by SC Solutions (Dr. Norm Abrahamson) and SC Solutions consultants in collaboration with SNL and PNNL to define the representative free-field ground motions.

The free-field horizontal spectral shapes were developed for hard rock, soft rock, and soil conditions for CEUS and soft rock and soil conditions for WUS for different seismic scenarios (Magnitude-Distance pairs). The selection of the scenario events was based on the observed controlling earthquakes for sites located in the CEUS and WUS, separately.

The vertical spectral shapes were calculated from an empirical vertical to horizontal (V/H) spectral ratio model developed by Gulerce and Abrahamson [16]. An adjustment of this model was developed to address the effects of hard-rock sites on the V/H ratio.

Five sets of three component (two horizontal and one vertical) free-field time histories were developed using the candidate seed time histories for each of 13 spectral shapes defined for CEUS and WUS. Seed time histories were matched to the component-specific target spectra frequencies from 100Hz (0.01 sec) to 0.2 Hz (5 sec). The scaling factors for CEUS and WUS were developed to scale the time histories to the desired seismic hazard levels.

The free-field hard rock ground motions were used to define 55 shake table inputs (Table 2-9) for the CEUS hard rock conditions. These inputs included 5E-05 and 5E-04 seismic hazard cases and a case with the PGA of 0.572 g, highest design-based PGA in CEUS. One more case was added to provide a comparison with a similar case modeled in NUREG/CR-6865. The acceleration time histories on the containment basemat at the North Anna NPP observed in the 2011 Mineral (VA) will be also used in the test.

At the soft rock and soil sites, the top of the pad motions differ from the free-field ground motions due to the amplification/attenuation in the soft rock/soil and to the SSI. The SSI analysis was performed by SC Solutions in collaboration with SNL and PNNL to define the time histories on the pad that incorporate the effects of SSI and pad flexibility. The free-field ground motions developed for the CEUS and WUS soil and soft rock conditions were used as an input into this analysis.

The SSI analysis was conducted for the representative soil and soft rock conditions in CEUS and WUS and for the representative pad configurations. Both fully loaded and partially loaded pads were considered. The SSI analysis was performed for 140 cases - 14 earthquake-PGA scenarios and five time histories and two pad loading schemes per scenario. The locations on the pad with maximum amplifications were identified and the corresponding time histories were recommended for the shake table test. The amplifications were different for the different conditions, but the peak amplifications were within the low frequency band in all the cases.

A total of 70 time histories representative of the top of the pad motions at the soft rock and soil sites in CEUS and WUS was proposed for the test with the vertical cask (Table 2-13). The SSI analysis for the HSM is being conducted and will be documented in a separate report.

Test Hardware

The main part of the test unit is the NUHOMS 32 PTH2 dry storage canister. The canister was transferred to SNL by DOE and is stored at SNL. For the shake table test, the canister will be loaded with four surrogate assemblies and 28 dummy assemblies. The estimated weight of the NUHOMS 32 PTH2 canister loaded with 28 dummy assemblies and four surrogate assemblies will be 101,252 lbs.

Four surrogate assemblies will be used in the test to assess the differences related to the assembly type, radial gap and condition (intact versus slightly damaged spacer grids), and its location in the basket. Two surrogate assemblies will be a 16x16 CE PLUS7 and a 17x17 Westinghouse OFA. They will be provided by KNF company as a part of an international collaboration. One 16x16 surrogate assembly will be manufactured for the test. The RFQ was issued, and the manufacturer will be selected by August 2022. One 17x17 Westinghouse surrogate assembly was the SNL surrogate assembly used in the 30 cm drop test in 2020. The spacer grids were deformed in this test, but the rods and other hardware were not damaged. This will allow for evaluating cumulative effects.

Thirty dummy assemblies will be manufactured for the shake table test with two being spare dummy assemblies. Twenty-eight dummy assemblies will have a cross-section of 207 mm (8.15 in), the same as the 16x16 surrogate assemblies. One dummy assembly will have a cross-section of 210 mm (8.27 in) and another one will have a cross-section of 214 mm (8.42 in), the same as the 17x17 surrogate assemblies. Using different cross-section will allow for evaluating the effects related to the radial gap between the fuel assemblies and the basket cell walls. The dummy assemblies were designed to have a very similar weight despite the different cross-sections. The contract for manufacturing the dummy assemblies was placed with ENSA. ENSA has provided support to SNL with the MMTT and 30 cm drop tests.

For the vertical test configuration, the original plan was to use either a MAGNASTOR or a HI-STORM 100 cask. Because the cost of these casks was prohibitive, the mockup of the vertical cask was designed specifically for the test. The mockup is similar in its dimensions and weight to a HI-STORM 100 but is structurally simplistic. The steel skeleton of the vertical cask mockup was manufactured and transported to the UCSD in June 2022 where it was filled with concrete. The vertical cask mockup is located on the concrete pad next to the shake table and is ready for use.

For the horizontal test configuration, two alternatives are being considered. In the first alternative, an AHSM base unit from SONGS will be transported to UCSD and used in the test. In the second alternative, a HSM mockup will be manufactured instead.

The total weight of the loaded vertical cask will be 324,645 lbs (147.3 tonnes). The total weight of the loaded HSM will be 271,252 lbs (123.0 tonnes) in alternative 1 and 226,252 lbs (in alternative 2).

Shake Table Facility

A preliminary agreement to conduct the seismic test was made with the world's largest outdoor earthquake simulator, the LHPOST6, operated by structural engineers at the UCSD. The LHPOST6 is the only facility in the U.S. that can accommodate the large size and weight of the test units - 147 tonnes (loaded vertical cask) and 123 or 103 tonnes (loaded AHSM). The test is scheduled for the spring of 2023.

The range of PGAs considered for the design of LHPOST6 covers the range proposed for CEUS and WUS. Consequently, there is high confidence that the test time histories can be accurately reproduced with LHPOST6.

Friction Experiment

Concrete will be poured on the shake table surface before the test to provide friction between the cask and the concrete typical for the ISFSI pads. A friction experiment is being conducted at UNM to determine steel to concrete static and dynamic friction coefficients of four concrete samples with different surface roughnesses. The steel plate used in the experiment has the same surface roughness as the steel at the bottom of the vertical cask. Two concrete surface finishes will be selected for the shake table test based on the results of the experiment. The details of the experiment will be documented in a separate report that will be issued in August 2022.

Instrumentation

The proposed instrumentation was guided by the results of the previous experiments and the pre-test modeling study.

The previous experiments demonstrated that the accelerations on the assembly are very different in different locations in the cask. The accelerations are also different at different locations on the surrogate assembly. The different accelerations result in different strains on the surrogate assembly rods.

The pre-test modeling provided guidance for:

- Selecting surrogate assembly rods and locations on the rods for instrumentation with accelerometers and strain gauges, and
- Placing surrogate assemblies in the NUHOM 32 PTH2 canister.

The test unit will be instrumented with a large number of sensors (accelerometers, strain gauges, and dynamic inclinometers) to capture all the important differences in the responses to the seismic excitations. Table 6-2 provides the instrumentation summary. The total number of channels is 296. Collection of the data from these gages can be implemented with the new UCSD DAQ system (12 nodes with 64 channels each) designed for a total of 768 measurement channels.

The Extreme Low and Ultra Low pressure paper sheets will be installed between the rods of the surrogate assemblies in two long spans to register rod to rod contact if such contact occurs during the test. The

Extreme Low and Ultra Low pressure paper cover the contact pressure range from 7.2 to 85 psi. This range is appropriate because the modeling results suggest that the rods will not contact each other.

High-speed cameras will be installed to record the test unit behavior from different viewpoints.

High-speed optical imaging and DIC will be used to obtain representative snapshots of the test unit velocity during the test.

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APPENDIX A. ISFSI SATELLITE IMAGES

This appendix provides the images of the ISFSIs located on soil and soft rock in CEUS and WUS. Table A-1 provides the information on the site region and type. This information was used to develop the representative ISFSIs configurations used in SSI analysis (Section 2.3).

Table A-1. Site Region and Type.

CEUS NPP	Site Type	Appendix
Callaway	CEUS Soil	A1
Calvert Cliffs	CEUS Soil	A1
Clinton	CEUS Soil	A1
Farley	CEUS Soil	A1
Fort Calhoun	CEUS Soil	A1
Hatch	CEUS Soil	A1
LaSalle	CEUS Soil	A1
Monticello	CEUS Soil	A1
Oyster Creek	CEUS Soil	A1
Palisades	CEUS Soil	A1
Point Beach	CEUS Soil	A1
River Bend	CEUS Soil	A1
Robinson	CEUS Soil	A1
South Texas	CEUS Soil	A1
St. Lucie	CEUS Soil	A1
Vogtle	CEUS Soil	A1
Waterford	CEUS Soil	A1
Beaver Valley	CEUS Soft Rock	A2
Braidwood	CEUS Soft Rock	A2
Brunswick	CEUS Soft Rock	A2
Byron	CEUS Soft Rock	A2
Grand Gulf	CEUS Soft Rock	A2
Hope Creek	CEUS Soft Rock	A2
Prairie Island	CEUS Soft Rock	A2
Salem	CEUS Soft Rock	A2
Surry	CEUS Soft Rock	A2
Turkey Point	CEUS Soft Rock	A2
Diablo Canyon	WUS Soft Rock	A3
Columbia	WUS Soil	A3
Hanford	WUS Soil	A3
Palo Verde	WUS Soil	A3

A.1. CEUS Soil



Note: these are HISTORM-100U in ground systems.

Figure A-1 Callaway



Figure A-2 Calvert Cliffs

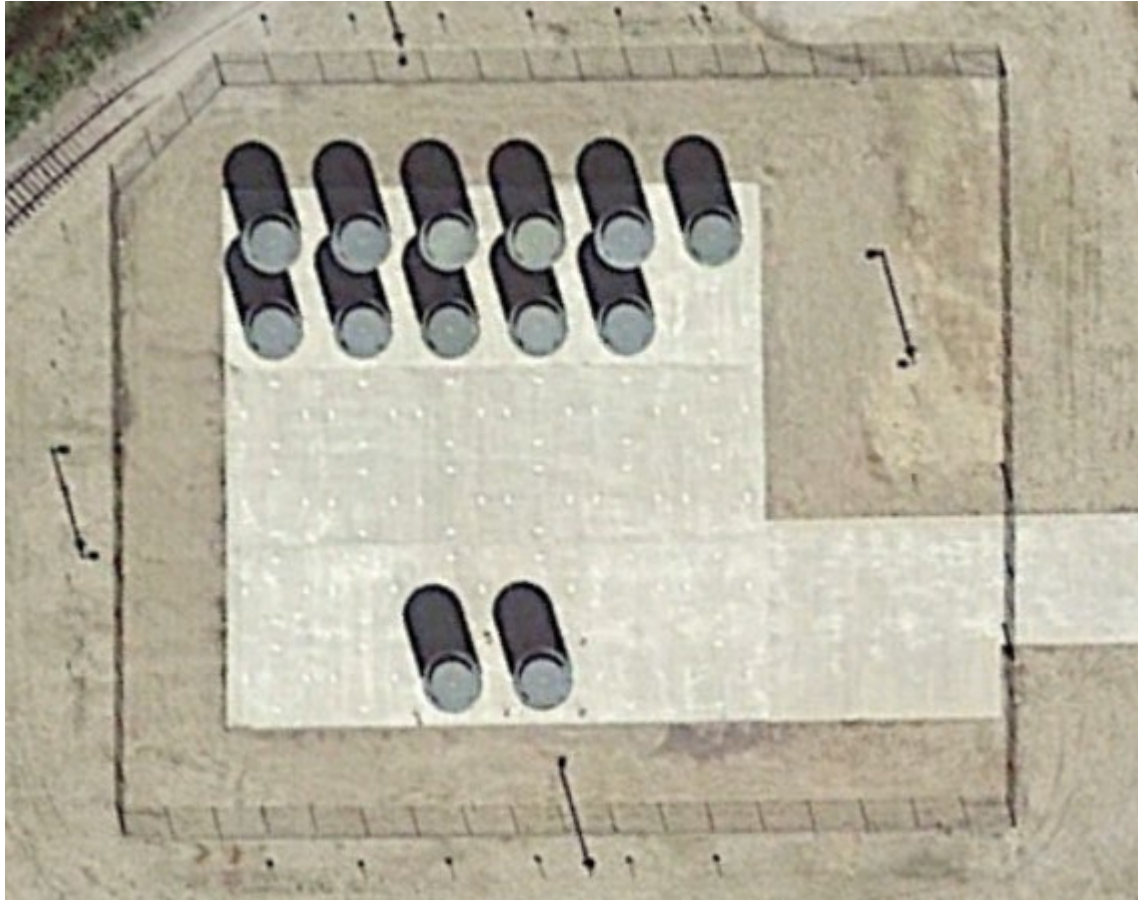


Figure A-3. Clinton



Figure A-4. Farley



Figure A-5. Fort Calhoun



Figure A-6. Hatch



Figure A-7. LaSalle



Figure A-8. Monticello

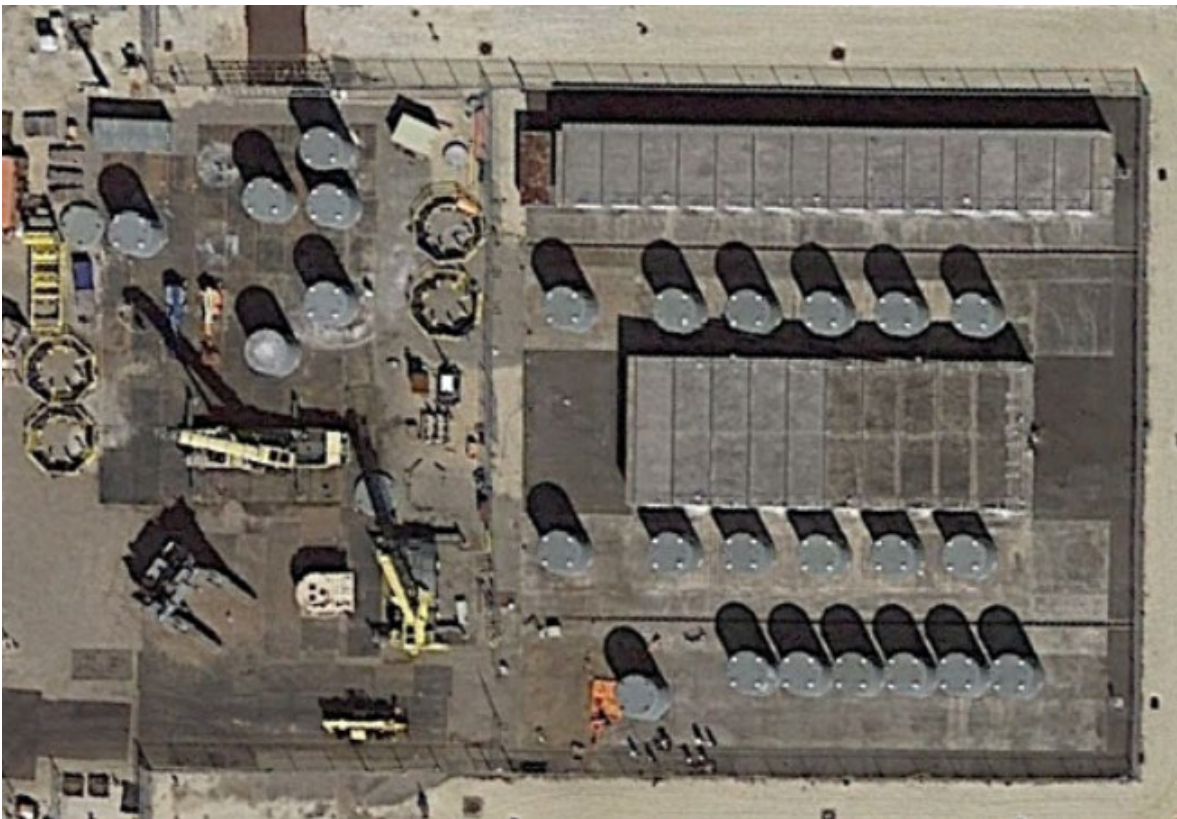


Figure A-9. Oyster Creek



Figure A-10. Palisades

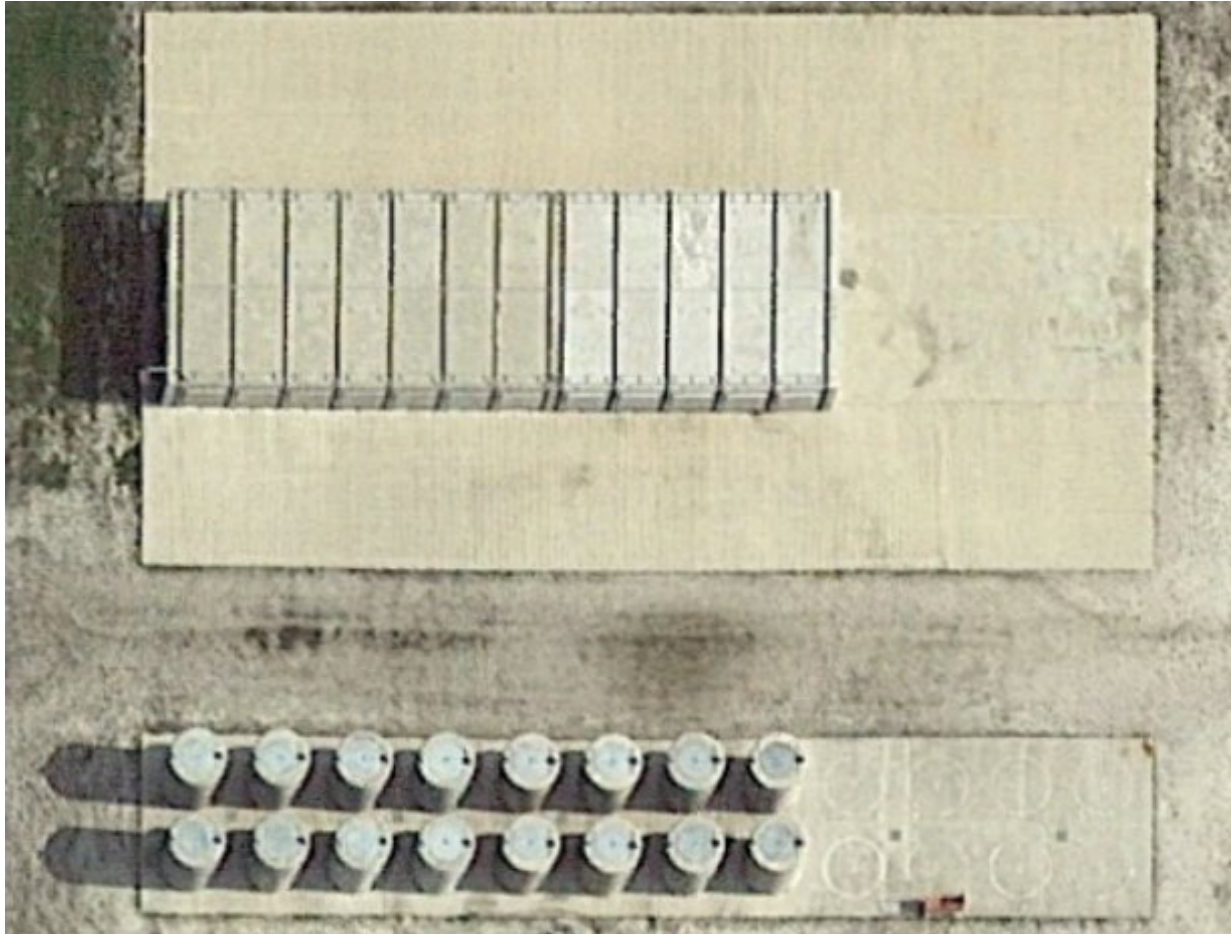


Figure A-11. Point Beach

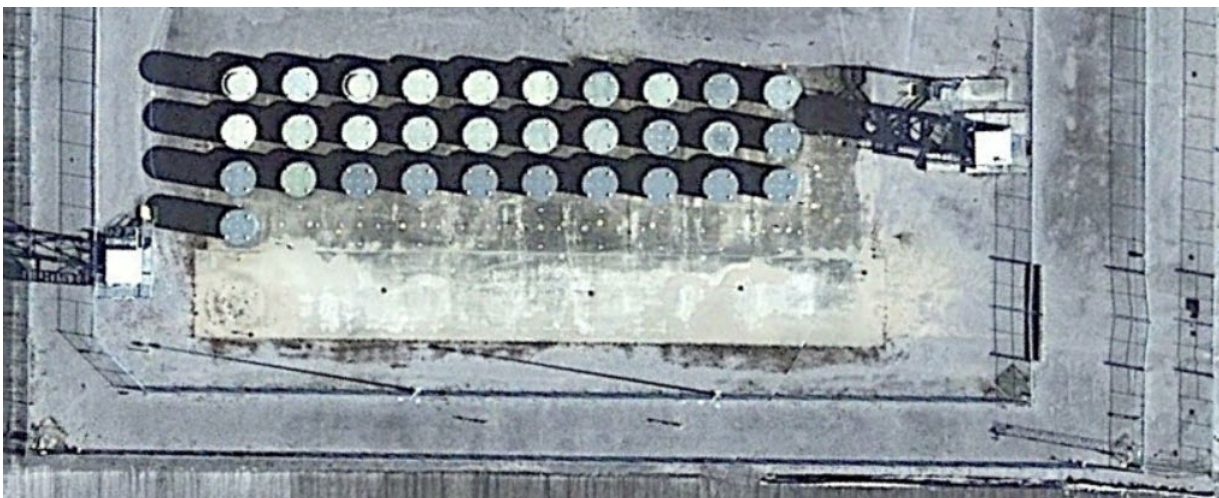


Figure A-12. River bend



Figure A-13. Robinson



Figure A-14. South Texas



Figure A-15. St. Lucie

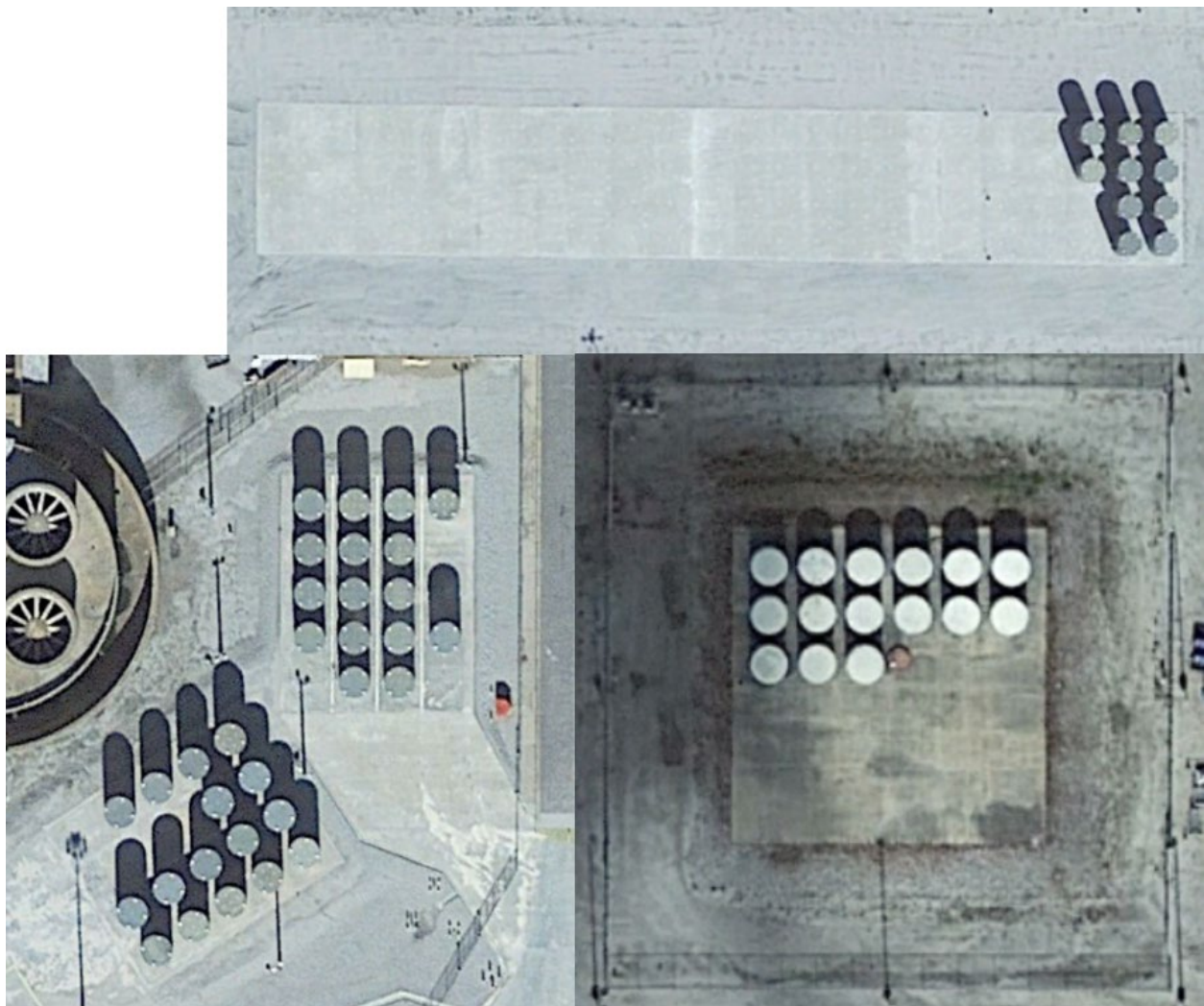


Figure A-16. Vogtle

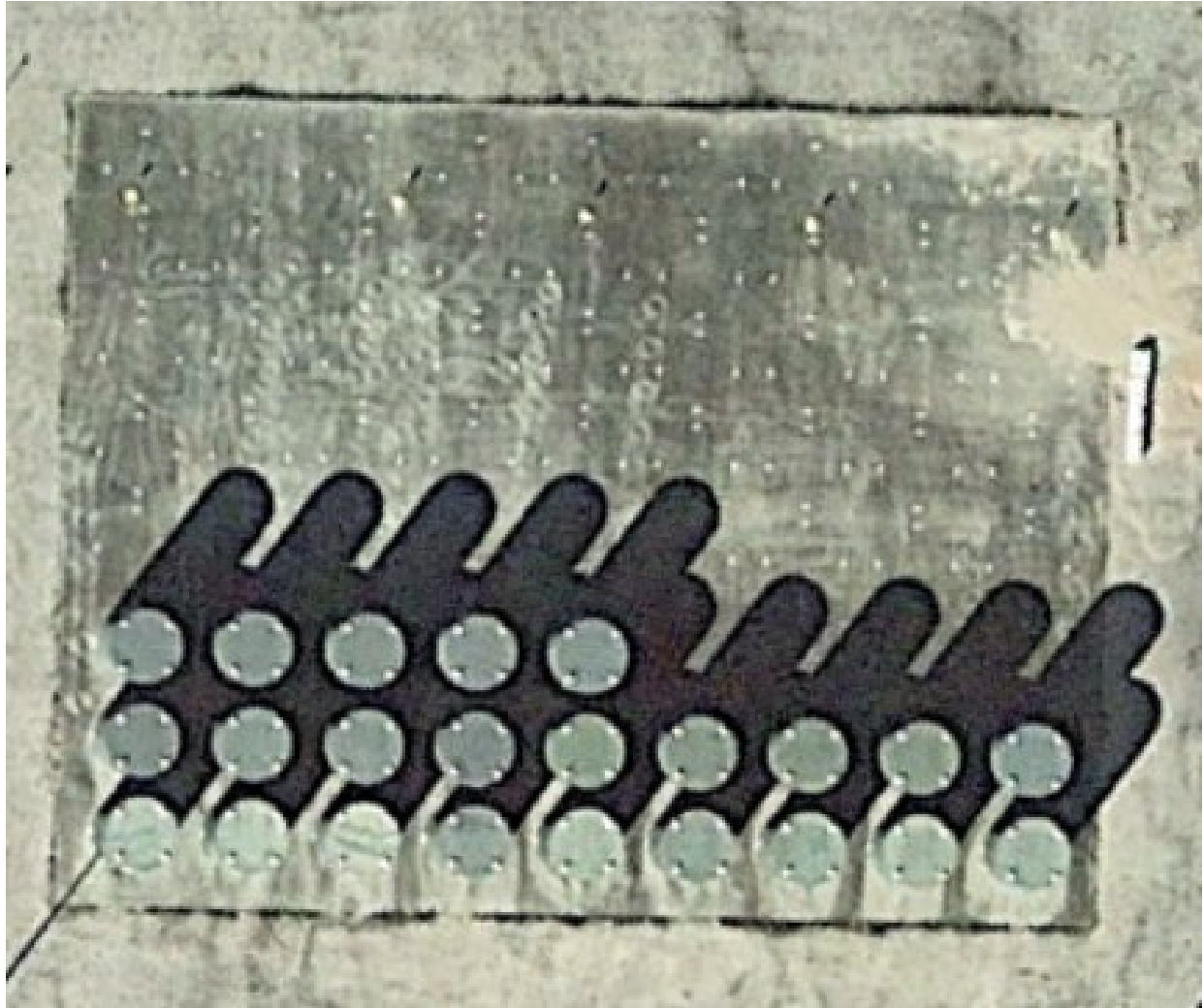


Figure A-17. Waterford

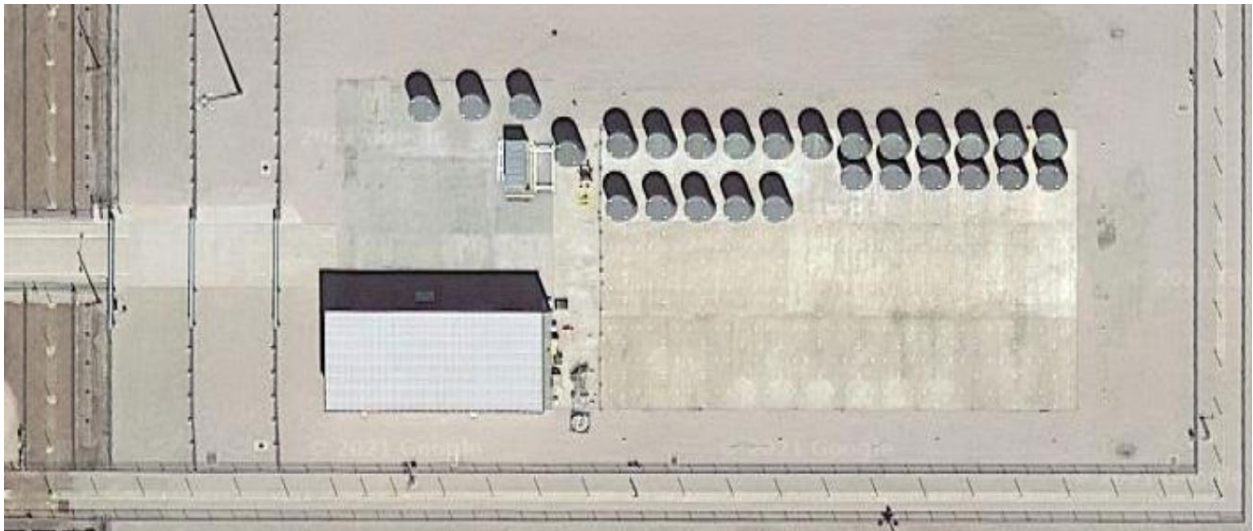
A.2. CEUS Soft Rock**Figure A-18. Beaver Valley****Figure A- 19. Braidwood**



Figure A-20. Brunswick



Figure A-21. Byron



Figure A-22. Grand Gulf



Figure A-23. Hope Creek



Figure A-24. Prairie Island

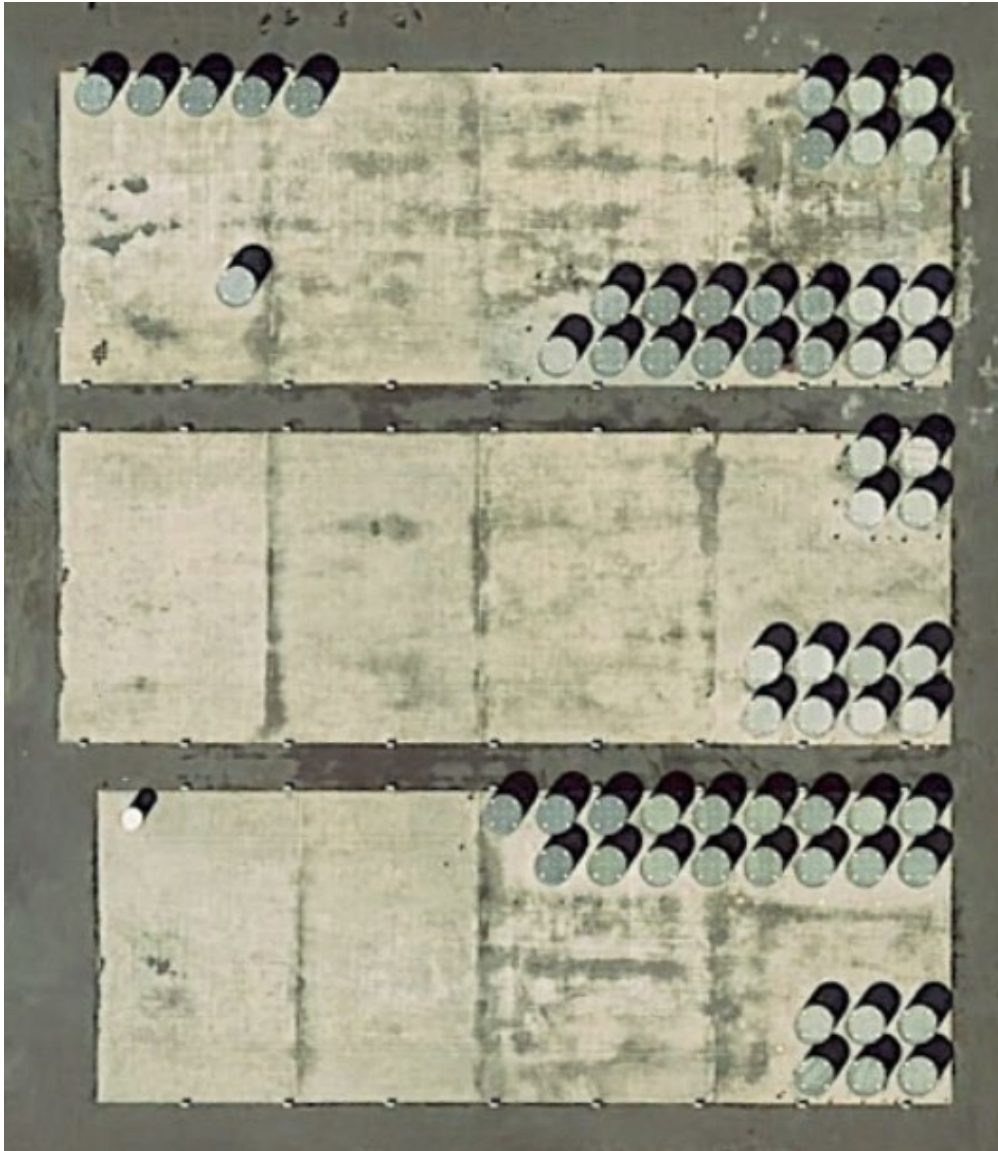


Figure A-25. Salem

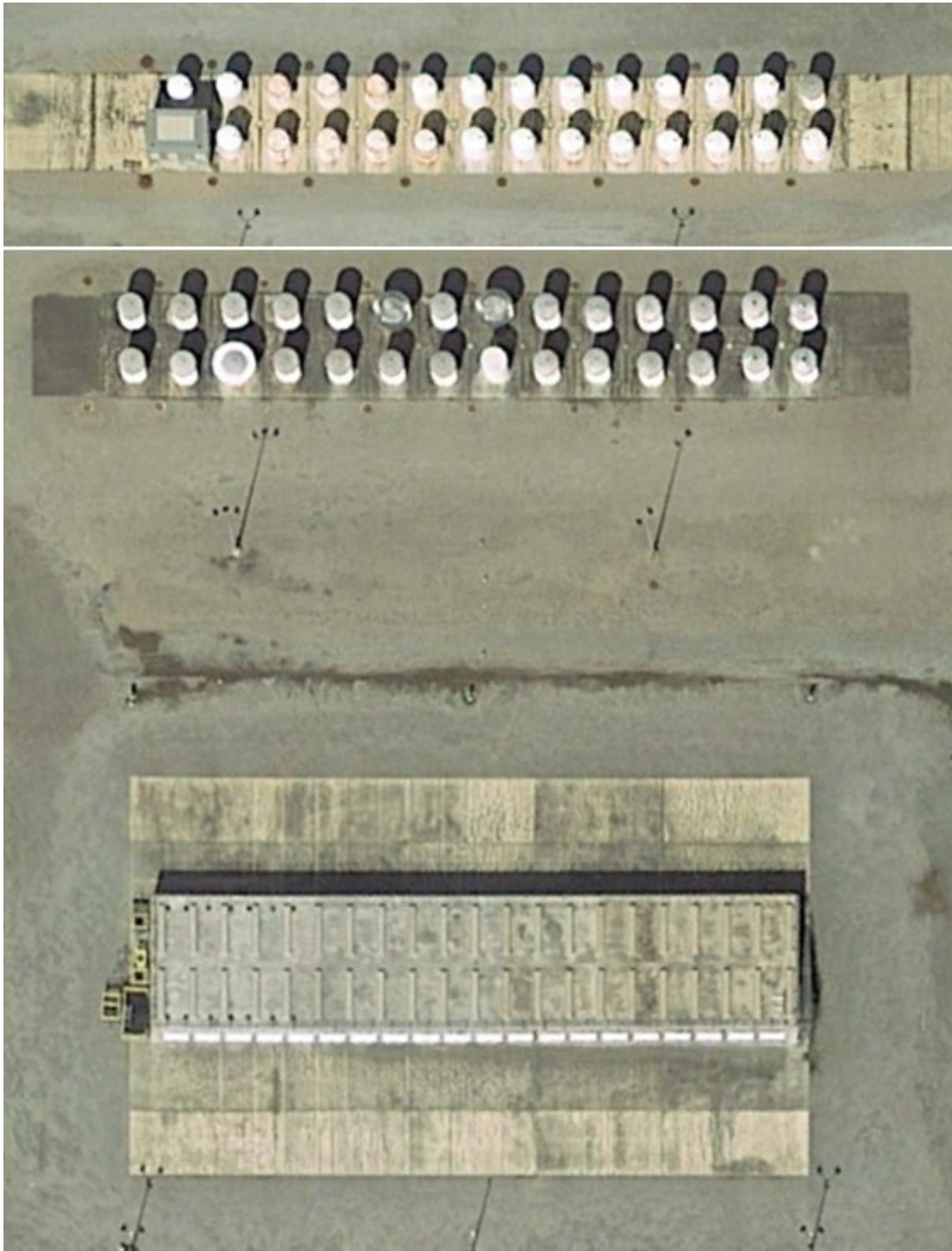


Figure A-26. Surry



Figure A-27. Turkey Point

A.3. WUS Soil and Soft Rock

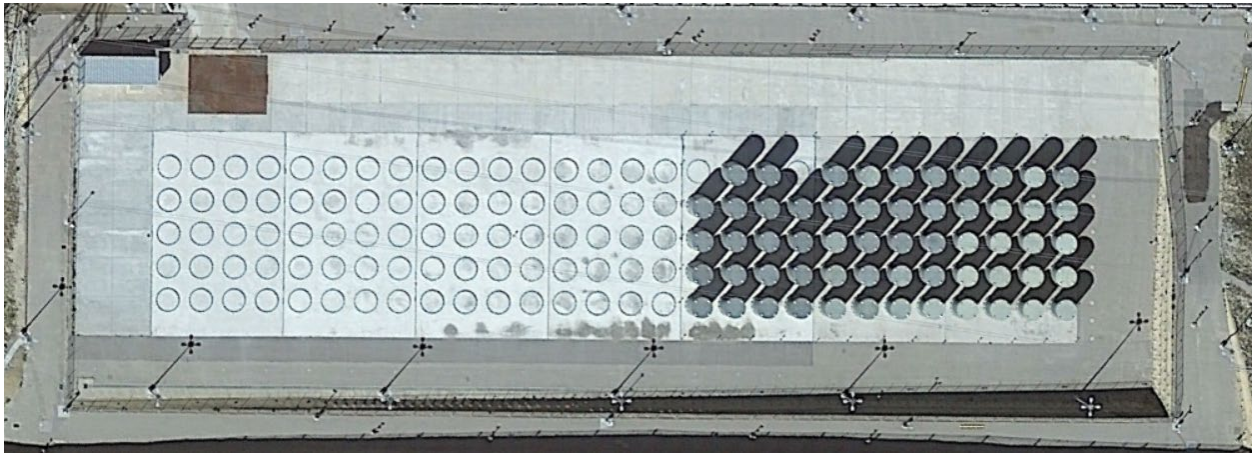


Figure A-28. Diablo Canyon – Soft Rock

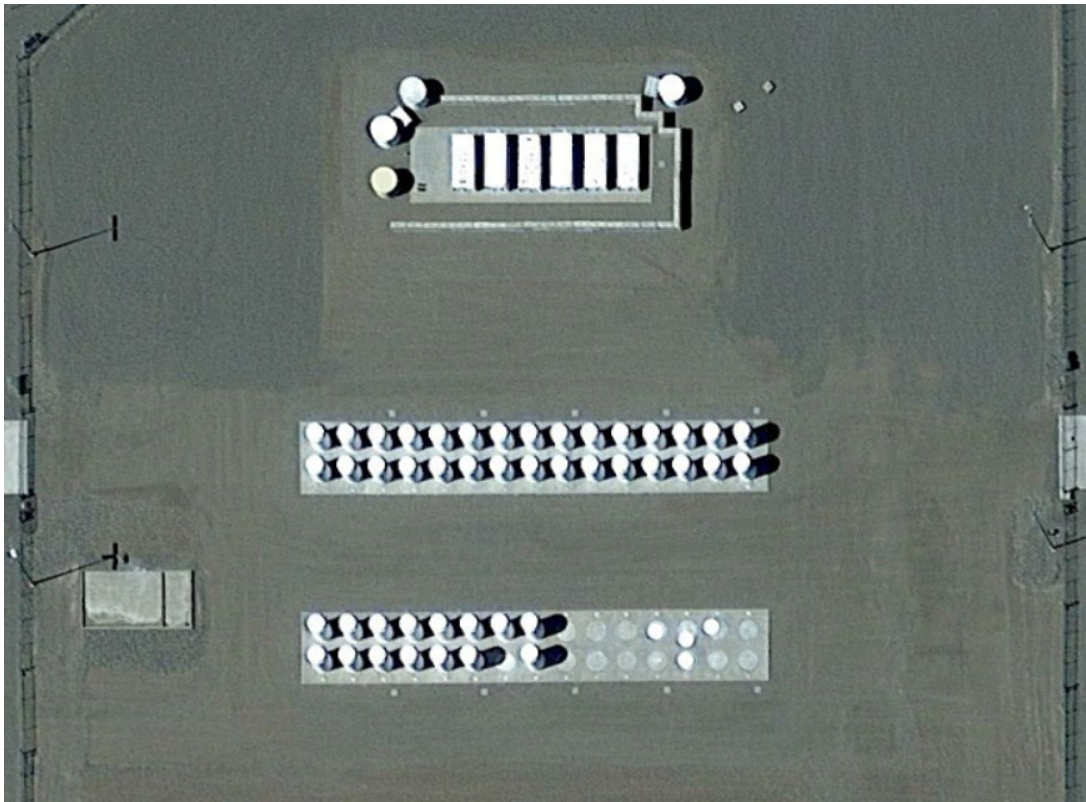


Figure A-29. Hanford – Soil

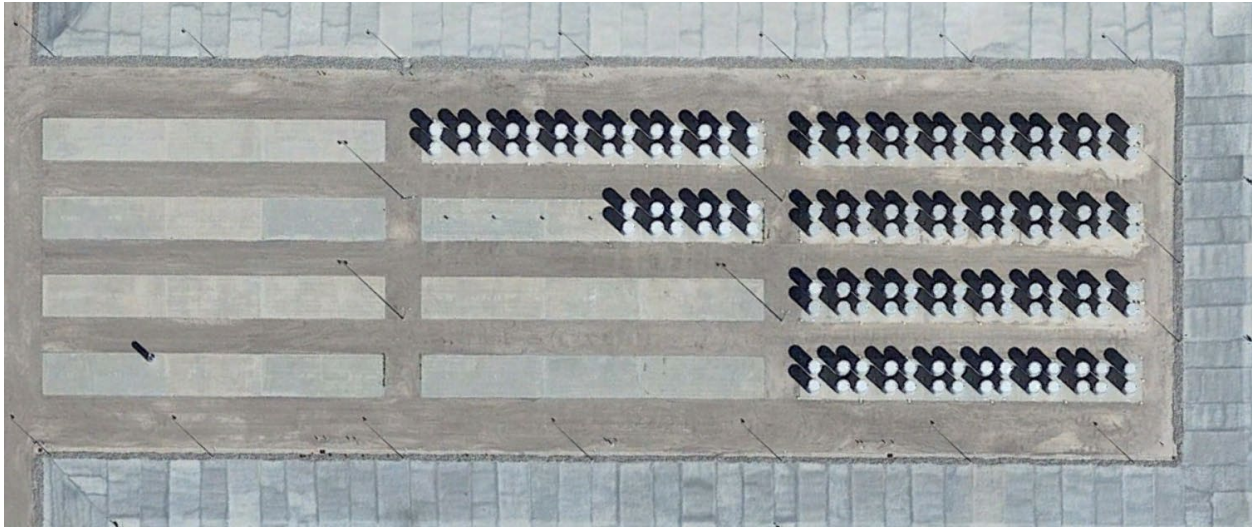


Figure A-30. Palo Verde – Soil

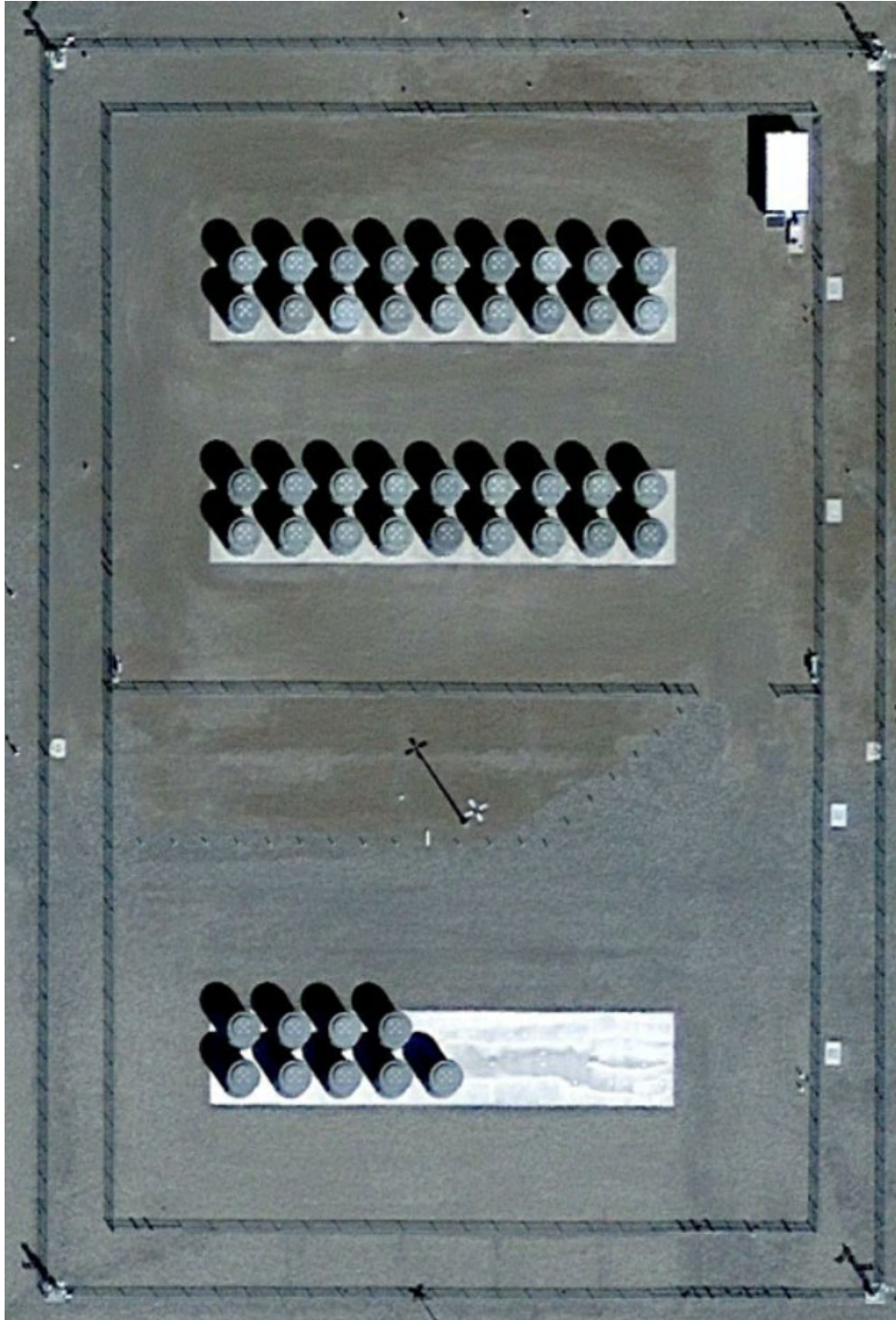


Figure A-31. Columbia – Soil

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APPENDIX B. SOIL-STRUCTURE INTERACTION SC SOLUTIONS REPORT

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

Final Report, Phase 2

Prepared by

SC SOLUTIONS



For

Sandia National Laboratories



**Sandia
National
Laboratories**

May 4, 2022

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

Final Report, Phase 2

Revision 0

May 4, 2022

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Revision History

Revision	Date	Description
0	5/04/2022	Initial DRAFT Issue Document

Table of Contents

Executive Summary.....1

Glossary.....3

1 Introduction and Objectives.....4

2 Methodology and Analysis Overview5

3 Inputs7

 3.1 Input Motions7

 3.2 Site Properties 11

 3.3 Pad and Cask Configurations 22

4 Site Response Analysis – Model and Results 24

5 Soil Structure Interaction – Models..... 25

6 Soil Structure Interaction –Results 27

7 Conclusions 30

8 Recommendations for Future Consideration..... 32

9 References 33

Appendix A Low-Strain Soil Properties A-1

Appendix B Strain-Compatible Soil Profiles B-1

Appendix C ISFSI Pad Maximum Cask Responses C-1

Appendix D List of Electronic Files D-1

Table of Figures

Figure 1 Response Spectra for Five Spectrally Matched Time Histories: Case 1, M=5.5, D=15km, GMRS hazard level, PGA=0.56g	9
Figure 2 Stiffness degradation curves for CEUS Soil Site	14
Figure 3 Damping Curves for CEUS Soil Site	14
Figure 4 Stiffness degradation curves based on EPRI Cohesionless Soil Model used for CEUS Soft Rock Site.....	16
Figure 5 Damping curves based on EPRI Cohesionless Soil Model used for CEUS Soft Rock Site	16
Figure 6 Stiffness degradation curves for clay layers in WUS Soft Rock Site based on Vucetic and Dobry (1991) PI=30 model	19
Figure 7 Damping curves for clay layers in WUS Soft Rock Site based on Vucetic and Dobry (1991) PI=30 model.....	19
Figure 8 Stiffness degradation curves for rocks between depth 0 and 500 ft used for Diablo Canyon Site based on EPRI Rock Model [7]	21
Figure 9 Damping curves for rocks between depth 0 and 500 ft used for Diablo Canyon Site based on EPRI Rock Model [7]	21
Figure 10 Cask Configuration B for Each ISFSI Soil/Site Analyzed.....	23
Figure 11 Detailed View of the Pad Corner Cask Model Showing Pad and Cask Mesh.	25
Figure 12 Pad and Cask Model	26
Figure 13 Cask Monitoring Points	27
Figure 14 Example of Averaging Response Spectra for Individual Time Histories Using the Case 1: CEUS Soil Site, PGA=0.56g, Configuration B Cask (1, 1)	29
Figure 15 Example Comparison of Response Spectra at Cask Base for Configurations A and B, for Case 1: CEUS Soil Site, PGA=0.56g, Cask (1, 1)	29
Appendix Figure B-1 Shear Wave Velocity for Case 1 - CEUS Soil, PGA=0.56g.	B-15
Appendix Figure B-2 Shear Wave Velocity for Case 6 - CEUS Soft Rock, PGA=0.29g.....	B-34
Appendix Figure B-3 Shear Wave Velocity for Case 8 - WUS Soil, PGA=0.23g.	B-44
Appendix Figure B-4 Shear Wave Velocity for Case 12 - WUS Soft Rock, PGA=0.52g.	B-56
Appendix Figure B-5 Shear Wave Velocity for Case 14 - Diablo Canyon, PGA=1.3g.	B-62
Appendix Figure C-1 Cask Maximum Responses for the CEUS Soil 15km 0.56g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.	C-2
Appendix Figure C-2 Cask Maximum Responses for the CEUS Soil 40km 0.31g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.	C-3

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: iv

Appendix Figure C-3 Cask Maximum Responses for the CEUS Soil 200km 0.1g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.	C-4
Appendix Figure C-4 Cask Maximum Responses for the CEUS Soft Rock 15km 0.29g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.....	C-5
Appendix Figure C-5 Cask Maximum Responses for the CEUS Soft Rock 15km 0.25g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.....	C-6
Appendix Figure C-6 Cask Maximum Responses for the CEUS Soft Rock 200km 0.18g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.	C-7
Appendix Figure C-7 Cask Maximum Responses for the CEUS Soft Rock 40km 0.08g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.....	C-8
Appendix Figure C-8 Cask Maximum Responses for the WUS Soil 10km 0.23g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.	C-9
Appendix Figure C-9 Cask Maximum Responses for the WUS Soil 200km 0.14g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.....	C-10
Appendix Figure C-10 Cask Maximum Responses for the WUS Soil 10km 0.19g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.....	C-11
Appendix Figure C-11 Cask Maximum Responses for the WUS Soft Rock 5km 0.52g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.....	C-12
Appendix Figure C-12 Cask Maximum Responses for the WUS Soft Rock 10km 0.22g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.	C-13
Appendix Figure C-13 Cask Maximum Responses for the WUS Diablo 5km 1.3g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.....	C-14
Appendix Figure C-14 Cask Maximum Responses for the WUS Diablo 5km 0.92g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.....	C-15

Table of Tables

Table 1 Overview of Analysis Cases	6
Table 2 Earthquake Scenarios used in SSI for CEUS Soil	7
Table 3 Earthquake Scenarios used in SSI for CEUS Soft Rock	7
Table 4 Earthquake Scenarios used in SSI for WUS Soil	8
Table 5 Earthquake Scenarios used in SSI for WUS Soft Rock	8
Table 6 Earthquake Scenarios used in SSI for Diablo Canyon	8
Table 7 Earthquake Scenarios used in Site Response for CEUS Soil.....	10
Table 8 Earthquake Scenarios used in Site Response for CEUS Soft Rock	10
Table 9 Earthquake Scenarios used in Site Response for WUS Soil.....	10
Table 10 Earthquake Scenarios used in Site Response for WUS Soft Rock.....	11
Table 11 Earthquake Scenarios used in Site Response for Diablo Canyon	11
Table 12 Site Conditions, Base Profiles and Reference Profiles.....	12
Table 13 Stiffness degradation and damping versus shear strain relationships used for CEUS Soil Site	13
Table 14 Stiffness degradation and damping versus shear strain relationships based on EPRI Cohesionless Soil Model used for CEUS Soft Rock Site.....	15
Table 15 Stiffness degradation and damping curves used for clay layers at WUS Soft Rock site based on Vucetic and Dobry (1991)-PI=30 model	18
Table 16 Stiffness degradation and damping curves used for Diablo canyon for rocks between depth 0 to 500 ft based on EPRI Rock model.....	20
Table 17 Test Cask Key Dimensions and Weight.....	22
Table 18 ISFSI Pad Dimensions and Number of Casks.....	22
Table 19 ISFSI Reinforced Concrete Pad Material Properties	23
Appendix Table A-1 Dynamic Soil Profile for CEUS Soil Site used in Site Response Analysis ..	A-1
Appendix Table A-2 Dynamic Soil Profile for CEUS Soft Rock Site used in Site Response Analysis based on [4]	A-4
Appendix Table A-3 Dynamic Soil Profile for WUS Soil Site used in Site Response Analysis ...	A-8
Appendix Table A-4 Dynamic Soil Profile for WUS Soft Rock Site used in Site Response Analysis	A-10
Appendix Table A-5 Dynamic Soil Profile for Diablo Canyon Site used in Site Response Analysis	A-11

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: vi

Appendix Table B-1 Strain-Compatible Soil Properties for Case 2, CEUS Soil PGA =0.31g	B-1
Appendix Table B-2 Strain-Compatible Soil Properties for Case 3 - CEUS Soil, PGA =0.1g	B-5
Appendix Table B-3 Strain-Compatible Soil Properties for Case 1 - CEUS Soil, PGA =0.56g...	B-10
Appendix Table B-4 Strain-Compatible Soil Properties for Case 4 - CEUS Soft Rock, PGA =0.25 g	B-16
Appendix Table B-5 Strain-Compatible Soil Properties for Case 5 - CEUS Soft Rock, PGA =0.08 g	B-22
Appendix Table B-6 Strain-Compatible Soil Properties for Case 6 - CEUS Soft Rock, PGA =0.29 g	B-28
Appendix Table B-7 Strain-Compatible Soil Properties for Case 7 - CEUS Soft Rock, PGA =0.18 g	B-35
Appendix Table B-8 Strain-Compatible Soil Properties for Case 8 - WUS Soil, PGA =0.23 g...	B-41
Appendix Table B-9 Strain-Compatible Soil Properties for Case 9 - WUS Soil, PGA =0.14 g...	B-45
Appendix Table B-10 Strain-Compatible Soil Properties for Case 10 - WUS Soil, PGA =0.19 g	B-48
Appendix Table B-11 Strain-Compatible Soil Properties for Case 11 - WUS Soft Rock, PGA =0.22 g	B-51
Appendix Table B-12 Strain-Compatible Soil Properties for Case 12 - WUS Soft Rock, PGA =0.52 g	B-53
Appendix Table B-13 Strain-Compatible Soil Properties for Case 13 - Diablo Canyon, PGA =0.92 g	B-57
Appendix Table B-14 Strain-Compatible Soil Properties for Case 14 - Diablo Canyon, PGA =1.3 g	B-59
Appendix Table C-1 Cask X Direction Maximum PGA Base Responses.	C-16
Appendix Table C-2 Cask Y Direction Maximum PGA Base Responses.....	C-17
Appendix Table C-3 Cask Z Direction Maximum PGA Base Responses	C-18
Appendix Table C-4 Cask X Rotation Maximum PGA Base Responses	C-20
Appendix Table C-5 Cask Y Rotation Maximum PGA Base Responses	C-21
Appendix Table C-6 Cask Z Rotation Maximum PGA Base Responses	C-23
Appendix Table C-7 Cask X Direction Maximum PGA CG Responses	C-25
Appendix Table C-8 Cask Y Direction Maximum PGA CG Responses	C-26
Appendix Table C-9 Cask Z Direction Maximum PGA CG Responses	C-27

Appendix Table C-10 Cask X Rotation Maximum PGA CG ResponsesC-29

Appendix Table C-11 Cask Y Rotation Maximum PGA CG ResponsesC-30

Appendix Table C-12 Cask Z Rotation Maximum PGA CG ResponsesC-32

Executive Summary

This report documents numerical simulations for Soil-Structure Interaction (SSI) analysis of Independent Spent Fuel Storage Installations (ISFSIs) to support future shake table experiments of full-scale dry storage casks. A phased implementation is used for seismic SSI simulations. Equivalent linear SSI analysis is performed in phase 1, as documented in this report. Nonlinear structural analysis using the input motions obtained from phase 1 SSI analyses will be performed in a future phase 2.

The analysis cases use input ground motions, site profiles, pad sizes and configurations representative of the geographic distribution of ISFSIs in the United States and for typical design conditions. The input ground motions cover a range of annual exceedance frequencies from 1E-3 to 1E-5, including Ground Motion Response Spectrum (GMRS). The site conditions are distributed geographically in two regions: Central and Eastern United States (CEUS) as well as Western United States (WUS), and by site conditions characterized as soil sites, soft rock sites and hard rock sites. The hard rock sites are assumed not to have significant soil-structure interaction effects and therefore are excluded from the SSI analysis cases. Representative pad sizes and cask configurations are selected from the geographic regions and site conditions analyzed.

Results provided include structural responses on the concrete pad in terms of acceleration time histories, including SSI effects, to be used as input for the Shake Table testing campaign; maximum displacement amplitudes (translations and rotations) to be compared with displacement limits of the Shake Table; and structural responses on the center of gravity of the cask: maximum amplitudes for acceleration and displacement time histories, to be used for benchmarking and comparison with nonlinear analysis (performed by others), and eventually with measurements from experimental results.

The zero period accelerations (ZPA) on the concrete pad at the location of the casks with the maximum ZPA for each scenario are reported as responses of interest. The zero period displacements (ZPD), i.e. maximum displacements for these casks, are also reported. The ratio ZPA/PGA, which is used as evaluation parameter, is calculated as index of how much acceleration amplification (or de-amplification) occurs on the response of the key cask and direction of interest, respective to the input motion.

With few exceptions of some of the CEUS soft rock cases, all other cases demonstrated amplification in the structural acceleration response compared to the input motion. The highest amplification in horizontal direction occurs for WUS soil, while in vertical direction occurs for CEUS soil. However, displacements show almost no amplification for all 14 analysis cases and in all three directions. Angular acceleration and angular displacements reported relatively small values, indicating a mainly rigid behavior of the ISFSI pad. The worst-case scenarios occurred for Diablo Canyon, which experienced a ZPA more than double that of any other scenario and peak displacement of between 2 and 3 feet in each direction, an order of magnitude larger than most other displacements.

Based on the findings of this study and the overall project plan, recommendations are provided for future studies, which include: alignment of the equivalent linear SSI model with the nonlinear model; verification of the equivalent linear behavior assumptions in SSI

models; and, re-evaluation of ground motions and structural systems for low frequency energy content in input ground motions.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 3 of 33

Glossary

Independent Spent Fuel Storage Installation (ISFSI): A complex designed and constructed for the interim storage of spent nuclear fuel; solid, reactor-related, greater than Class C waste; and other associated radioactive materials.

Ground Motion Response Spectrum (GMRS): Performance-based site-specific ground motion spectrum, generated with the surface 1 E-04 and 1 E-05 Uniform Hazard Response Spectrum

Peak Ground Acceleration (PGA): Maximum amplitude of ground motion acceleration time history.

Zero Period Acceleration (ZPA): Maximum amplitude of structural response acceleration time history.

Zero Period Displacement (ZPD): Maximum amplitude of structural response displacement time history.

1 Introduction and Objectives

Currently, the spent nuclear fuel (SNF) is stored in onsite independent spent fuel storage installations (ISFSIs), which are dry storage facilities, at 55 nuclear power plant sites. Because the SNF will be stored at ISFSIs for an extended period of time, there is growing concern with regards to the behavior of the SNF within these dry storage systems during earthquakes. To address these concerns, SNL/NTESS, under the Spent Fuel Waste Disposition (SFWD) Program is planning to conduct a series of earthquake shake table tests. The goal of this test program is to determine the strains and accelerations on fuel assembly hardware and cladding during earthquakes of different magnitudes to better quantify the potential damage an earthquake could inflict on spent nuclear fuel rods.

The shake table experiments are designed to consist of one dry cask sitting on a concrete pad poured over the platen of the shake table. The effects of the underlying soil as well as of the neighboring casks, as in an actual ISFSI, will be numerically simulated through Soil-Structure Interaction (SSI) analyses and applied as input motion to the shake table.

A phased implementation is used for seismic SSI simulations. Equivalent linear SSI analysis is performed in phase 1, as documented in this report. The response output SSI motions are used as input motion for a future phase 2 model. Nonlinear structural analysis using the input motions obtained from phase 1 SSI analyses need to be performed in a future phase 2.

This report documents the numerical simulations for phase 1 SSI analysis, with the following objectives: (1) Perform a series of (equivalent) linear Soil-Structure Interaction (SSI) analysis on a pre-defined matrix of analysis cases; (2) generate acceleration time histories on the concrete pad, including SSI effects, to be used as input for the Shake Table testing campaign; (3) identify maximum displacement amplitudes (translations and rotations) on the concrete pad to be compared with displacement limits of the Shake Table; and (4) generate acceleration time histories on the cask center of gravity, which are to be used for benchmarking and comparison with nonlinear analysis (performed by others at PNNL), and eventually with measurements from experimental results (from the testing campaign).

This report is organized as follows: Section 2 describes the methodology used; Section 3 presents the inputs used for analysis; Section 4 documents site response analyses to obtain strain-compatible soil properties, which are used as site inputs for SSI analyses; Section 5 details the SSI simulations models; Section 6 documents the main observations of the SSI results; conclusions are presented in Section 7; recommendations are provided in Section 8; and references are listed in Section 9. Appendix A provides low-strain soil properties; Appendix B documents strain-compatible soil profiles; Structural responses for cask base and cask center of gravity are summarized in Appendix C; and Appendix D includes a list of the electronic files that accompany this report.

2 Methodology and Analysis Overview

Analysis and results evaluation are developed as follows:

- Site Response Analysis: To calculate soil properties strain compatible with the ground motions, which are used as input for the site models.
- SSI Model Development: Assembly of structural model with site model
- SSI Analysis: (a) solution computed in frequency domain, performed for each analysis case; (b) time history (TH) postprocessing, using 5 sets of THs for each analysis case
- Responses are evaluated at two locations per cask: (1) Center of cask base (Pad Base Cask); (2) Center of Gravity of casks.
- Results extracted consist of acceleration TH, displacement TH (translational and rotational), and acceleration response spectra (translational).
- For each analysis case, 15 zero period accelerations (ZPAs) are identified (one in each direction (x, y, z), for each of the 5 TH sets), and three mean ZPAs (one in each direction (x, y, z), from 5 ZPAs) are calculated.
- The critical location is identified for the cask with the highest mean ZPA: one critical location for each direction, for a total of three critical locations per case of analysis.
- For each critical location and direction, the TH that provides the maximum ZPA (max ZPA) is identified, and the corresponding zero period displacement (ZPD) is extracted.

Results provided consist, for each critical location for each direction:

- Center of cask base: mean ZPA, max ZPA, ZPD (translational and rotational) are tabulated (and compared with input motion PGA and PGD). Plots of acceleration response spectra are provided. Acceleration (and displacement) THs for max ZPA and associated ZPD are provided as input motion for Shake Table experiment (in electronic format).
- Center of Gravity of Casks: mean ZPA, max ZPA, ZPD, provided for benchmarking: comparison with NL analysis, and with experiments. Acceleration THs for max ZPA, and Displacement THs for corresponding max ZPA are provided (in electronic format).

Analyses are performed for a total of 14 analysis cases as agreed with the project stakeholders and identified in Table 1.

Table 1 Overview of Analysis Cases

No.	Cases	PGA (g)	Scenario	Hazard	Pad Capacity	Cask Loadings
1	CEUS Soil	0.56	M 5.5, D 15	GMRS	2 x 6	2
2	CEUS Soil	0.31	M 6.5, D 40	5.E-05	2 x 6	2
3	CEUS Soil	0.1	M 7.8, D 200	5.E-04	2 x 6	2
4	CEUS Soft Rock	0.25	M 5.5, D 15	5.E-05	6 x 12	2
5	CEUS Soft Rock	0.08	M 6.5, D 40	5.E-04	6 x 12	2
6	CEUS Soft Rock	0.29	M 5.5, D 15	GMRS	6 x 12	2
7	CEUS Soft Rock	0.18	M 7.8, D 200	5.E-05	6 x 12	2
8	WUS Soil	0.23	M 6.25, D 10	5.E-05	2 x 15	2
9	WUS Soil	0.14	M 7.5, D 200	5.E-05	2 x 15	2
10	WUS Soil	0.19	M 6.25, D 10	5.E-04	2 x 15	2
11	WUS Soft Rock	0.22	M 6.25, D 10	5.E-04	2 x 15	2
12	WUS Soft Rock	0.52	M 7.5, D 5	5.E-04	2 x 15	2
13	Diablo Canyon	0.92	M 7.5, D 5	GMRS	5 x 28	2
14	Diablo Canyon	1.3	M 7.5, D 5	5.E-05	5 x 28	2

3 Inputs

The analysis cases use input ground motions, site profiles, as well as pad sizes and loading configurations representative of the geographic distribution of ISFSIs in the United States and for typical design conditions. The input ground motions cover a range of annual exceedance frequencies from 1E-3 to 1E-5, including GMRS. The site conditions are distributed geographically in two regions: Central and Eastern United States (CEUS) as well as Western United States (WUS), and site conditions characterized as soil sites, soft rock sites, and hard rock sites. Note that the hard rock sites are assumed to have insignificant soil-structure interaction effects and therefore are excluded from the analysis cases. Representative pad sizes and cask configurations are selected from the geographic regions and site conditions analyzed. The input motions, site properties as well as pad and cask configurations are described in detail in the following subsections, respectively.

3.1 Input Motions

Acceleration ground motion time histories used are documented in the Project's Ground Motions Report [2]. An overview of earthquake scenario (Magnitude M and distance D), as well as peak ground acceleration (PGA) used in this study is listed in Table 2 through Table 6. For each earthquake scenario a total of 5 sets of acceleration time histories are used for input ground motions for the soil structure interaction (Section 5).

Table 2 Earthquake Scenarios used in SSI for CEUS Soil

Case No.	1	2	3
PGA (g)	0.56	0.31	0.1
M	5.5	6.5	7.8
D (km)	15	40	200
Hazard Level	GMRS	5.00E-05	5.00E-04

Table 3 Earthquake Scenarios used in SSI for CEUS Soft Rock

Case No.	4	5	6	7
PGA (g)	0.25	0.08	0.29	0.18
M	5.5	6.5	5.5	7.8
D (km)	15	40	15	200
Hazard Level	5.00E-05	5.00E-04	GMRS	5.00E-05

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 8 of 33

Table 4 Earthquake Scenarios used in SSI for WUS Soil

Case No.	8	9	10
PGA (g)	0.23	0.14	0.19
M	6.25	7.5	6.25
D (km)	10	200	10
Hazard Level	5.00E-05	5.00E-05	5.00E-04

Table 5 Earthquake Scenarios used in SSI for WUS Soft Rock

Case No.	11	12
PGA (g)	0.22	0.52
M	6.25	7.5
D (km)	10	5
Hazard Level	5.00E-04	5.00E-04

Table 6 Earthquake Scenarios used in SSI for Diablo Canyon

Case No.	13	14
PGA (g)	0.92	1.3
M	7.5	7.5
D (km)	5	5
Hazard Level	GMRS	5.00E-05

As indicated in the Project's Ground Motions Report [2], the spectral matching procedure uses a methodology that generates one horizontal component spectrum greater than the other horizontal component spectrum. When combined, however, the geometric mean of the two horizontal components would approximately equal the target horizontal spectrum, while maintaining the horizontal-to-horizontal component variability. For the generation of vertical components, together on average, the five vertical spectra match the vertical target

spectra, with each individual component having spectral period dependent variability about this vertical target spectra. As an illustrative example, the response spectra for one analysis case (five sets of spectrally matched time histories): Case 1, $M=5.5$, $D=15\text{km}$, GMRS hazard level, $\text{PGA}=0.56\text{g}$, are displayed in Figure 1. It is apparent that the procedure used provides a “loose” match on each individual component, but the geomean of the 5 components in the same direction provide a closer match to the target spectrum.

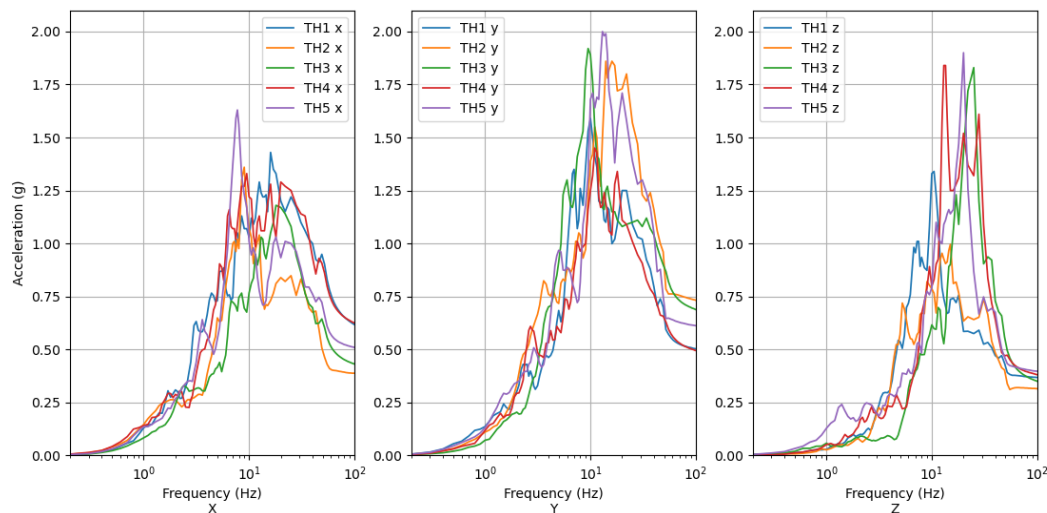


Figure 1 Response Spectra for Five Spectrally Matched Time Histories: Case 1, $M=5.5$, $D=15\text{km}$, GMRS hazard level, $\text{PGA}=0.56\text{g}$

For the purpose of site response analysis to calculate the strain compatible soil properties (Section 4), one set of time history per case study, comprised of two horizontal components (H1 and H2) are used. Acceleration values in each time history are linearly scaled to match the target PGA values using scaling factors. Ground motions consisting of time histories, PGA values and scaling factors used as inputs for site response analyses are listed in Table 7 through Table 11.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 10 of 33

Table 7 Earthquake Scenarios used in Site Response for CEUS Soil

Case No.	1	2	3
PGA (g)	0.31	0.1	0.56
Selected Time History	Set01-RSN191	Set01-RSN142	Set01-RSN4514
Scale Factor applied to H1	2.113	0.84	2.26
Scale Factor applied to H2	1.572	0.797	2.71

Table 8 Earthquake Scenarios used in Site Response for CEUS Soft Rock

Case No.	4	5	6	7
PGA (g)	0.25	0.08	0.29	0.18
Selected Time History	Set01-RSN4514	Set01-RSN191	Set01-RSN4514	Set01-RSN142
Scale Factor applied to H1	0.967	0.556	1.122	1.667
Scale Factor applied to H2	1.136	0.413 Set01-RSN142	1.318	1.632

Table 9 Earthquake Scenarios used in Site Response for WUS Soil

Case No.	8	9	10
PGA (g)	0.23	0.14	0.19
Selected Time History	Set01-RSN549-H1	Set01-RSN142	Set01-RSN549
Scale Factor applied to H1	0.776	7.421	0.641
Scale Factor applied to H2	1.177	7.033	0.973

Table 10 Earthquake Scenarios used in Site Response for WUS Soft Rock

Case No.	11	12
PGA (g)	0.22	0.52
Selected Time History	Set01-RSN31	Set01-RSN143
Scale Factor applied to H1	1.209	1.280
Scale Factor applied to H2	1.049	1.257

Table 11 Earthquake Scenarios used in Site Response for Diablo Canyon

Case No.	13	14
PGA (g)	0.92	1.3
Selected Time History	Set01-RSN143	Set01-RSN143
Scale Factor applied to H1	2.265	3.200
Scale Factor applied to H2	2.225	3.144

3.2 Site Properties

The studies use representative CEUS and WUS geographic regions, each with two site conditions: soft rock and soil. Representative profiles are generated to create generic site conditions for a relatively large geographic area and to keep realistic site characteristics; these representative profiles are generated by creating a hybrid profile between two actual site profiles: one base site and one bedrock reference site. In detail, the hybrid profile properties are generated by taking the soil properties from the base site and linearly scaling the shear wave velocity (V_s) for the profile to cause the bedrock to have a V_s value corresponding to the V_s for bedrock as in the reference profile. In addition to the CEUS and WUS sites, the site Diablo Canyon is also considered as site-specific, i.e., without any

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 12 of 33

modifications. The base site and reference site used to generate site properties are listed in Table 12. Details about the generation for site conditions are provided in the next sections; tables and figures describing the site conditions are provided in 9Appendix A.

Table 12 Site Conditions, Base Profiles and Reference Profiles

Site conditions	Base Profile	Reference Profile
CEUS Soil	Vogle	Farley
CEUS Soft Rock	Hope Creek	Surry
WUS Soil	Hanford	Average Bedrock of Hanford and Palo Verde
WUS Soft Rock	Palo Verde	Average Bedrock of Hanford and Palo Verde
Diablo Canyon	N/A	N/A

CEUS Soil

The Vogle site profile was used to represent the CEUS soil conditions as base profile. The soil properties were then scaled to match the properties of lower sand units at Farley site (reference profile). The subsurface soils at Vogle can be subdivided into three major soil strata including:

- Compacted backfill mostly consisting of sands mixtures with occasional clay seams
- Blue Bluff Marl (BBM) consisting of very hard calcareous over-consolidated clay marl
- Lower Sand Stratum (LSS) consisting of a dense sand with minor interbedded clay and silt

The base rock is encountered at a depth of approximately 1,056 ft and consists of Paleozoic crystalline rock, as well as Triassic-Jurassic sedimentary rock of the Dunbarton Basin.

The shear wave velocity (V_s) profile at Vogle site was linearly scaled to match the V_s of the Cape Fear sand unit (a sub-unit of LSS just above the base rock) at the Farley site. This unit is encountered at depth 865 ft to 1,056 ft and is characterized with $V_s = 3,777$ ft/sec at the Farley site and $V_s = 2,710$ ft/sec at the Vogle site. To match the V_s values a scaling factor of $3777/2710 = 1.39$ was used.

The input soil properties including layer thickness, unit weight, as well as low-strain shear wave velocity (V_s), and Damping are taken from [3] and are listed in Appendix Table A-1.

The stiffness degradation curves (G/G_{Max} vs shear strain) and Damping curves (damping vs shear strain) are taken from [3] based on site specific data for the backfill, the BBM, and

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 13 of 33

the LSS using combined RCTS test methods [3]. Within the backfill, these relationships are designated by depth. Within the BBM, relationships are provided for both Low PI and High PI soils, where PI is plasticity index. These low and high plasticity soils were encountered throughout the BBM, thus, for the purpose of this sensitivity study the low PI and high PI curves were averaged (designated as MID PI) and applied to the entire BBM layer. Within the LSS, these relationships are designated by material type (sand and clay). Table 13 provides a summary of G/G_{Max} and damping values and Figure 2 and Figure 3 provides a plot of G/G_{Max} and damping versus shear strain.

Table 13 Stiffness degradation and damping versus shear strain relationships used for CEUS Soil Site

Stratum	Backfill						Lower Sands			
Substrata	<25ft		>25ft		Mid-PI		Sands		Clay (Congaree/Snapp)	
Shear Strain (%)	G/G_{Max}	Damping Ratio	G/G_{Max}	Damping Ratio	G/G_{Max}	Damping Ratio	G/G_{Max}	Damping Ratio	G/G_{Max}	Damping Ratio
0.00010	1	0.97	1	0.62	1.00000	1.2200	1	0.62	1	0.86
0.00032	1	1.05	1	0.62	1.00000	1.3050	1	0.62	1	0.87
0.00100	0.998	1.05	1	0.7	1.00000	1.4950	1	0.7	1	0.93
0.00359	0.942	1.44	0.975	0.89	0.97825	2.0250	0.997	0.89	0.99	1.21
0.01019	0.826	2.26	0.902	1.3	0.91850	2.7650	0.954	1.32	0.928	1.8
0.03170	0.603	4.55	0.748	2.6	0.77650	4.8600	0.858	2.6	0.8	3.62
0.10000	0.355	8.97	0.495	5.64	0.53700	8.6725	0.649	5.59	0.56	7.54
0.30690	0.172	14.94	0.269	10.65	0.31000	13.7525	0.411	10.65	0.327	13
0.65313	0.089	19.38	0.158	14.73	0.18925	16.8125	0.263	14.68	0.198	17.42
1.00000	0.072	22.12	0.117	17.11	0.14250	17.4450	0.209	17.11	0.154	19.87

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 14 of 33

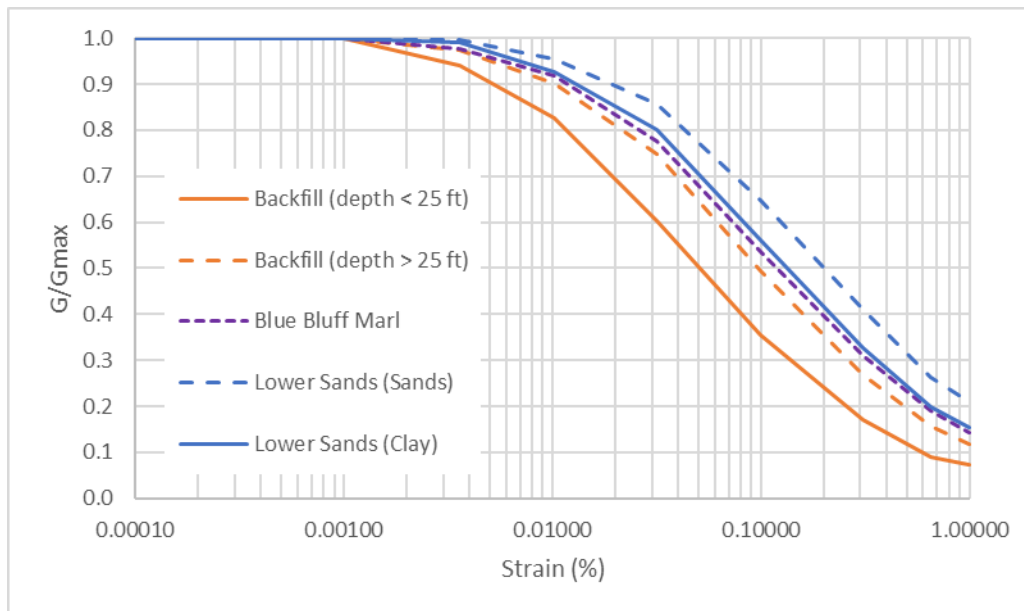


Figure 2 Stiffness degradation curves for CEUS Soil Site

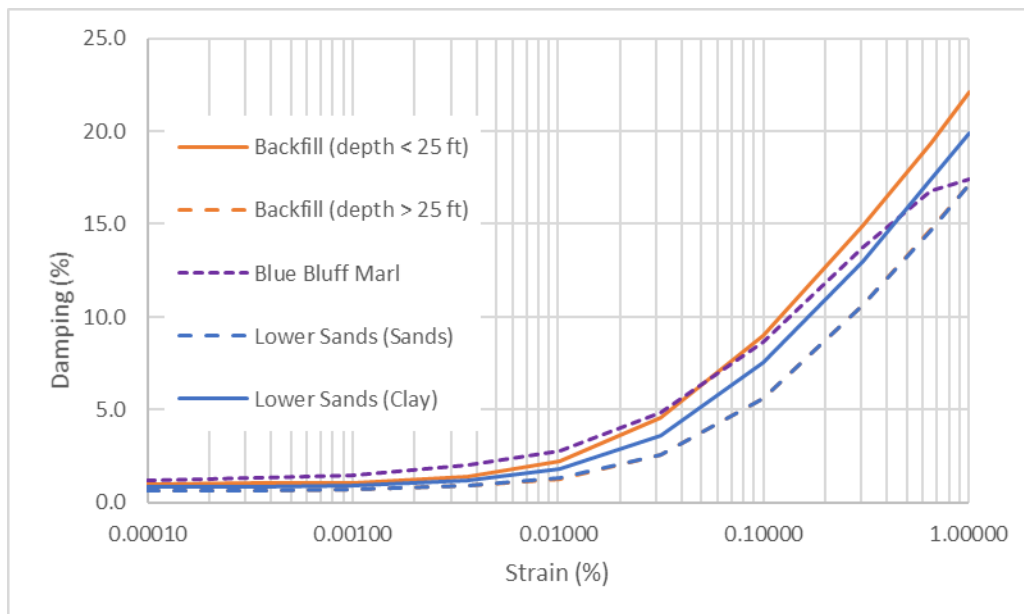


Figure 3 Damping Curves for CEUS Soil Site

CEUS Soft Rock The Hope Creek Generating Station (HCGS) site was used to represent the CEUS Soft Rock conditions as base profile. For site response sensitivity study, the base profile No.1 from [4] was selected. The soil properties for Profile No.1 are taken from the

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 15 of 33

nearby PSEG ESPA site (about 1 km away) and reflect direct shear-wave measurements to a depth of the top of the Potomac Formation [4]. Below that depth, Potomac Formation and below, the shear-wave velocities were based on compressional-wave refraction surveys and assumed Poisson ratios, all at the ESPA site.

The site stratigraphy includes the following major strata: hydraulic fill, alluvium, Tertiary sands, Cretaceous dense sand and Potomac Formation. The Cretaceous Potomac Formation, Middle Zone at depth 1248 ft is selected as base rock for site response analysis.

The V_s values for base Profile No.1 were linearly scaled to match the V_s of Potomac formation unit to 2,000 ft/sec, the V_s for bedrock at the Surry site (reference profile). This unit is encountered just above the base rock between depths 818 ft to 1248 ft below ground surface and is characterized with $V_s=2,630$ ft/sec in Profile No.1 [4]. As a result, the scaling factor will be $2000/2630 = 0.76$. Accordingly, the bedrock V_s is adjusted to $V_s=3060*0.76=2327$ ft/sec.

The input soil properties including layer thickness, unit weight, as well as low-strain shear wave velocity (V_s), and Damping are taken from [4] and are listed in Appendix Table A-2.

For degradation curves, EPRI cohesionless soil curves designated by depth were used to represent the more nonlinear response following recommendations provided in [4]. Table 14 provides a summary of G/G_{Max} and damping values and Figure 4 and Figure 5 provide a plot of G/G_{Max} and damping versus shear strain.

Table 14 Stiffness degradation and damping versus shear strain relationships based on EPRI Cohesionless Soil Model used for CEUS Soft Rock Site

Shear Strain (%)	EPRI Cohesionless 0-20 ft		EPRI Cohesionless 20-50 ft		EPRI Cohesionless 50-120 ft		EPRI Cohesionless 120-250 ft		EPRI Cohesionless 250-500 ft		EPRI Cohesionless > 500 ft	
	G/G_{Max}	Damping Ratio	G/G_{Max}	Damping Ratio	G/G_{Max}	Damping Ratio	G/G_{Max}	Damping Ratio	G/G_{Max}	Damping Ratio	G/G_{Max}	Damping Ratio
0.00010	1	1.49	1	1.26	1.00000	1.0200	1	0.80	1	0.76	1	0.56
0.00030	1	1.57	1	1.26	0.99800	1.0400	1	0.85	1	0.85	1	0.56
0.00100	0.971	1.84	1	1.5	0.99100	1.2600	1	1.0	1	0.85	1	0.56
0.00320	0.906	2.77	0.938	2.12	0.96800	1.7300	0.976	1.39	0.99	1.18	0.991	0.75
0.01000	0.754	5.02	0.822	3.6	0.86800	2.8300	0.897	2.21	0.928	1.9	0.948	1.1
0.03120	0.516	9.38	0.611	7.1	0.68200	5.5300	0.742	4.4	0.8	3.54	0.854	2.44
0.10030	0.269	15.20	0.376	12.26	0.44500	10.1700	0.505	8.58	0.58	7.05	0.648	5.28
0.31490	0.112	21.78	0.163	18.99	0.21800	16.2900	0.269	14.53	0.326	13	0.419	10
1.00960	0.038	26.62	0.058	24.71	0.09000	22.6800	0.118	20.90	0.142	19.12	0.200	16.20
3.00000	0.020	30.00	0.025	27.80	0.05200	26.8000	0.070	24.90	0.090	22.90	-	-

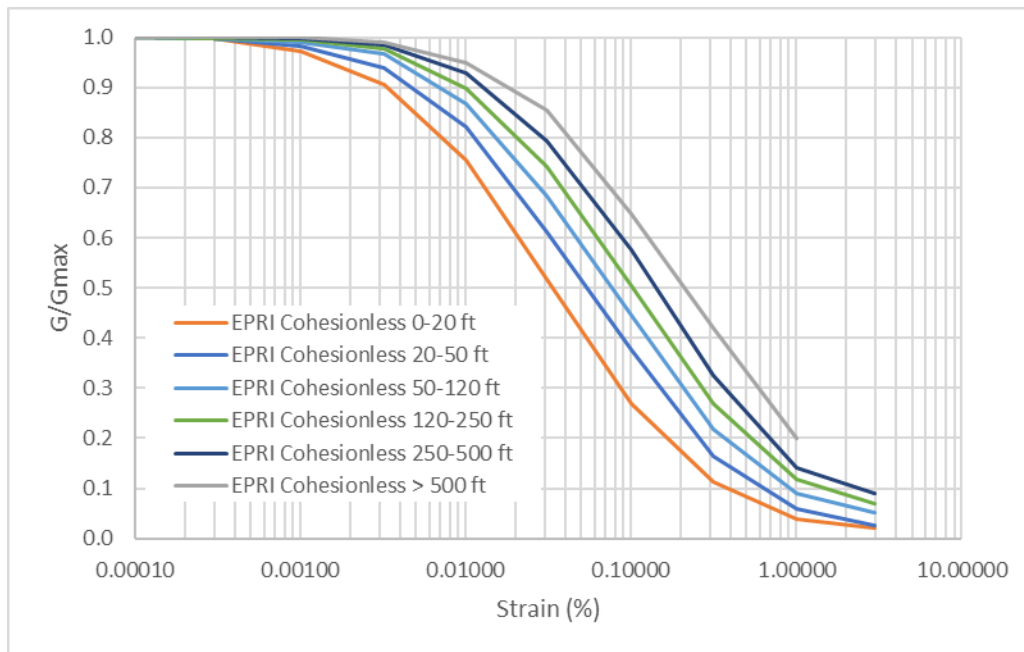


Figure 4 Stiffness degradation curves based on EPRI Cohesionless Soil Model used for CEUS Soft Rock Site

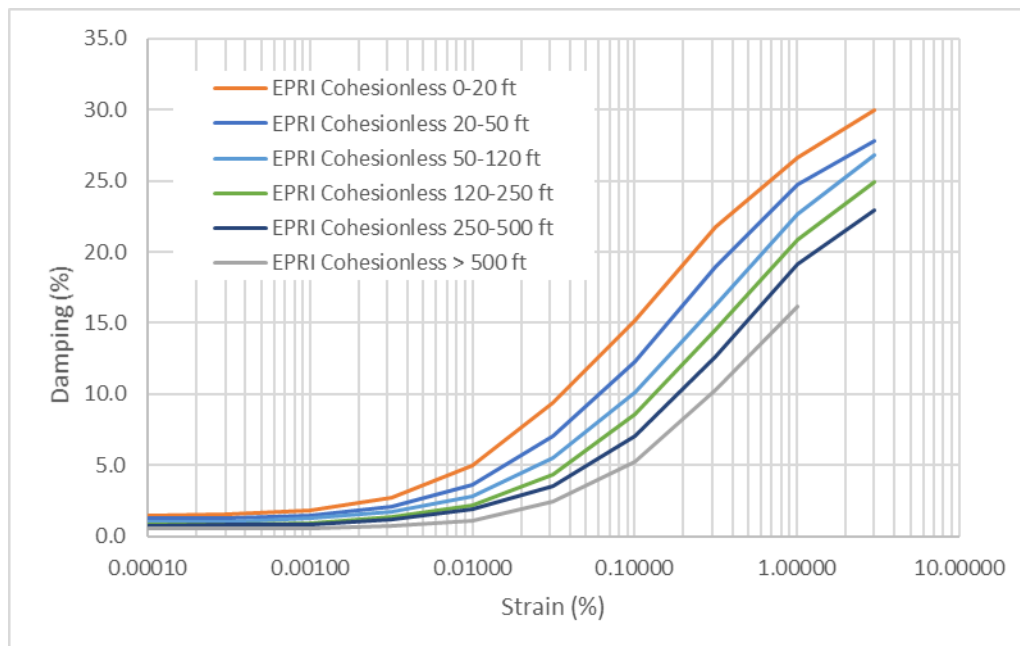


Figure 5 Damping curves based on EPRI Cohesionless Soil Model used for CEUS Soft Rock Site

WUS Soil

Hanford site was selected as base profile to represent the WUS Soil conditions for site response analysis. For this purpose, the soil profile from Columbia Generating Station, about 10 miles away from Hanford was used for site response sensitivity study [5]. The subsoil profile includes the following units:

- Pasco Gravel, a Quaternary deposit consisting of loose to medium dense sand with scattered gravel
- Pliocene-age Ringold Formation (Middle Member) consisting of a very dense sandy gravel with interbedded sandy and silty layers
- Ringold Formation (Lower Member) consisting of very dense interbedded layers of sandy gravel, silt, and soft sandstone with some conglomerate present at the base of the layer.

The base rock below 525 ft consists of the Saddle Mountains Basalt (SMB) with shear wave velocity V_s of 7,575 ft/sec. The V_s profile was scaled by setting the SMB base rock V_s value equal to 5,250 ft/s, the average rock V_s between Hanford and Palo Verde site (reference profiles). This results in a scaling factor = $5,250 / 7,575 = 0.69$.

The input soil properties including layer thickness, unit weight, as well as low-strain shear wave velocity (V_s), and damping used for site response analysis are based on base case profile presented in [5] after linear scaling as described above. The soil profile used for WUS soil site response analysis is presented in Appendix Table A-3.

Following recommendations in [5], the stiffness degradation and damping curves based on EPRI model for cohesionless soils were used for site response analysis. These curves are provided in Table 14 in tabular format and plotted in Figure 4 and Figure 5 presented above for CEUS soft rock site.

WUS Soft Rock

Palo Verde site was selected as base profile to represent the WUS soft rock conditions for site response analysis. For Palo Verde site the best estimate shallow soil profile presented in [6] was used. The subsurface strata at Palo Verde site consist of alternate layers of sand and clay underlain by the Andesite/basalt/flow breccia/tuff bedrock located at depth of 427 feet with $V_s = 4,485$ ft/sec. The V_s profile was linearly scaled by setting the V_s for bedrock at 5,500 ft/sec (average V_s for bedrock at the Palo Verde and Hanford sites: reference profiles) resulting in scaling factor equal to $5500/4485 = 1.226$.

The input soil properties including layer thickness, unit weight, as well as low-strain shear wave velocity (V_s), and damping used for site response analysis are based on base estimate profile presented in [6] after linear scaling as described above. The soil profile used for WUS soft rock site response analysis is presented in Appendix Table A-4.

For the purpose of site response analysis, the stiffness degradation and damping curves based on the EPRI model for cohesionless soil were used for sand layers. The clay layers

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 18 of 33

were modeled using Vucetic and Dobry (1991) for cohesive soil with plasticity index (PI) of 30. The EPRI curves are presented in Table 14 and plotted in Figure 4 and Figure 5.

The stiffness degradation and damping curves based on the Vucetic and Dobry (1991) model used for clay layers are presented in Table 15 and Figure 6 and Figure 7 below.

Table 15 Stiffness degradation and damping curves used for clay layers at WUS Soft Rock site based on Vucetic and Dobry (1991)-PI=30 model

Vucetic and Dobry (1991)-PI=30			
Shear Strain (%)	G/G _{Max}	Shear Strain (%)	Damping Ratio
0.00100	1.000	0.00200	1.700
0.00200	0.995	0.00300	2.100
0.00300	0.985	0.00400	2.500
0.00400	0.970	0.00500	2.600
0.00500	0.960	0.00600	2.900
0.00600	0.950	0.00800	3.300
0.00800	0.925	0.01000	3.700
0.00900	0.910	0.02000	5.050
0.01000	0.900	0.03000	5.700
0.02000	0.820	0.04000	6.400
0.03000	0.745	0.05000	6.900
0.04000	0.700	0.06000	7.300
0.07000	0.600	0.08000	8.100
0.10000	0.530	0.10000	8.700
0.20000	0.420	0.20000	10.800
0.30000	0.350	0.30000	12.300
0.40000	0.305	0.40000	13.300
0.60000	0.240	0.50000	14.100
0.80000	0.205	0.70000	15.600
1.00000	0.165	1.00000	16.900

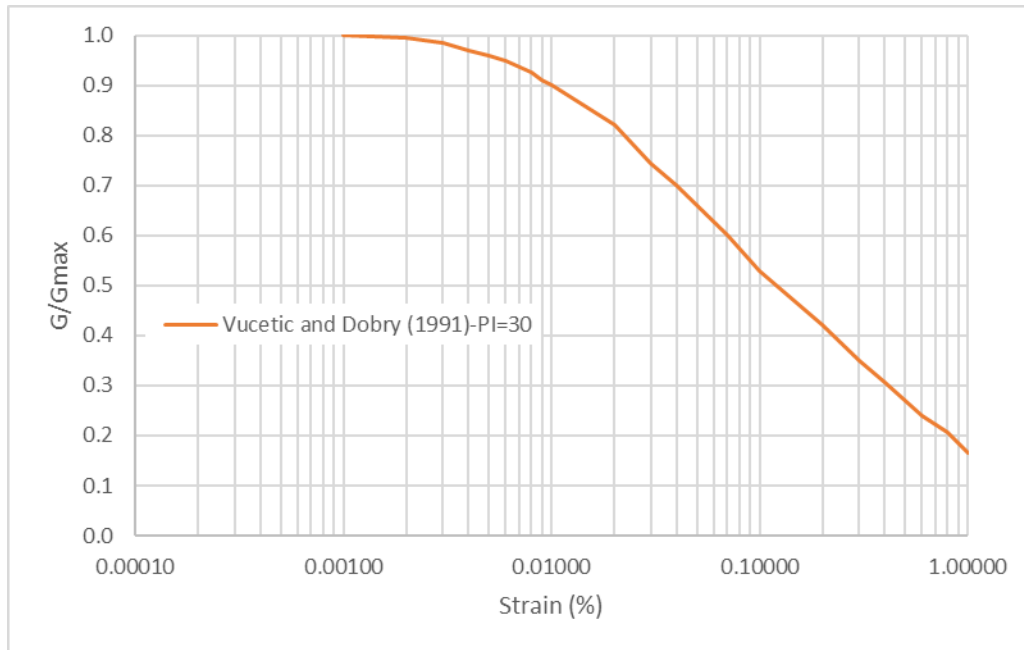


Figure 6 Stiffness degradation curves for clay layers in WUS Soft Rock Site based on Vucetic and Dobry (1991) PI=30 model

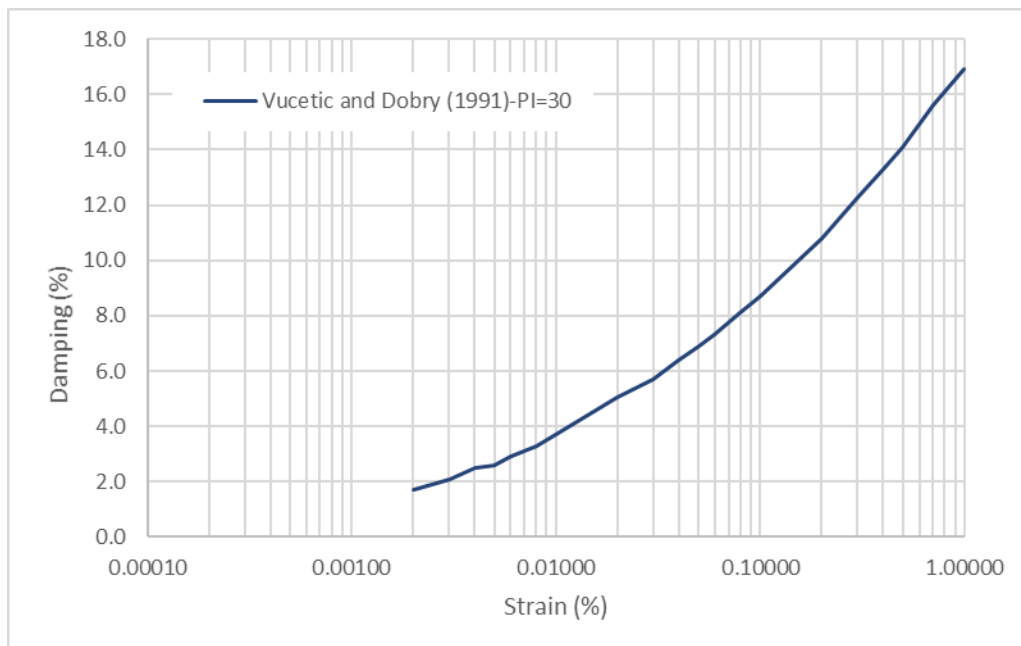


Figure 7 Damping curves for clay layers in WUS Soft Rock Site based on Vucetic and Dobry (1991) PI=30 model

Diablo Canyon

In addition to the four sites described above (combinations of geographic regions and site conditions), Diablo Canyon is included as a specific site. The relatively high seismicity (associated with high amplitudes of PGA), as well as the fact that the casks are actually bolted to the concrete pad, are unique for this site and deserves specific analyses.

For purpose of site response analysis the Central Profile presented in [7] was used with no scaling of shear wave velocity. The profile was truncated at depth 916 ft where the V_s reaches 5,907 ft/sec. The variation of V_s with the depth is provided in Appendix B Figure B-5.

For site response analysis, the stiffness degradation curves provided by EPRI for generic rock [7] were used for rocks between depth 0 to 500 ft below the ground surface. These curves are provided in Table 16 and plotted in Figure 8 and Figure 9.

Table 16 Stiffness degradation and damping curves used for Diablo canyon for rocks between depth 0 to 500 ft based on EPRI Rock model

	EPRI Rock 0-20 ft		EPRI Rock 20-50 ft		EPRI Rock 50-120 ft		EPRI Rock 120-250 ft		EPRI Rock 250-500 ft	
Shear Strain (%)	G/G _{Max}	Damping Ratio	G/G _{Max}	Damping Ratio	G/G _{Max}	Damping Ratio	G/G _{Max}	Damping Ratio	G/G _{Max}	Damping Ratio
0.00000	1	3.26	1	3.24	1.00000	3.2200	1	3.21	1	3.19
0.00000	1	3.39	1	3.34	1.00000	3.2800	1	3.23	1	3.17
0.00001	0.972	4.02	1	3.9	0.99000	3.7000	1	3.5	1	3.35
0.00003	0.861	5.58	0.884	5.25	0.91200	4.8600	0.942	4.46	0.97	3.99
0.00010	0.629	9.19	0.665	8.6	0.71200	7.7700	0.767	6.93	0.832	5.9
0.00032	0.383	14.40	0.418	13.5	0.46500	12.4300	0.526	11.1	0.6	9.40
0.00100	0.175	15.00	0.197	15.00	0.22900	15.0000	0.273	15.00	0.35	15.00
0.00316	0.071	15.00	0.082	15.00	0.09800	15.0000	0.122	15.00	0.165	15
0.01000	0.024	15.00	0.028	15.00	0.03400	15.0000	0.043	15.00	0.061	15.00
0.03160	0.008	15.00	0.010	15.00	0.01200	15.0000	0.015	15.00	0.022	15.00

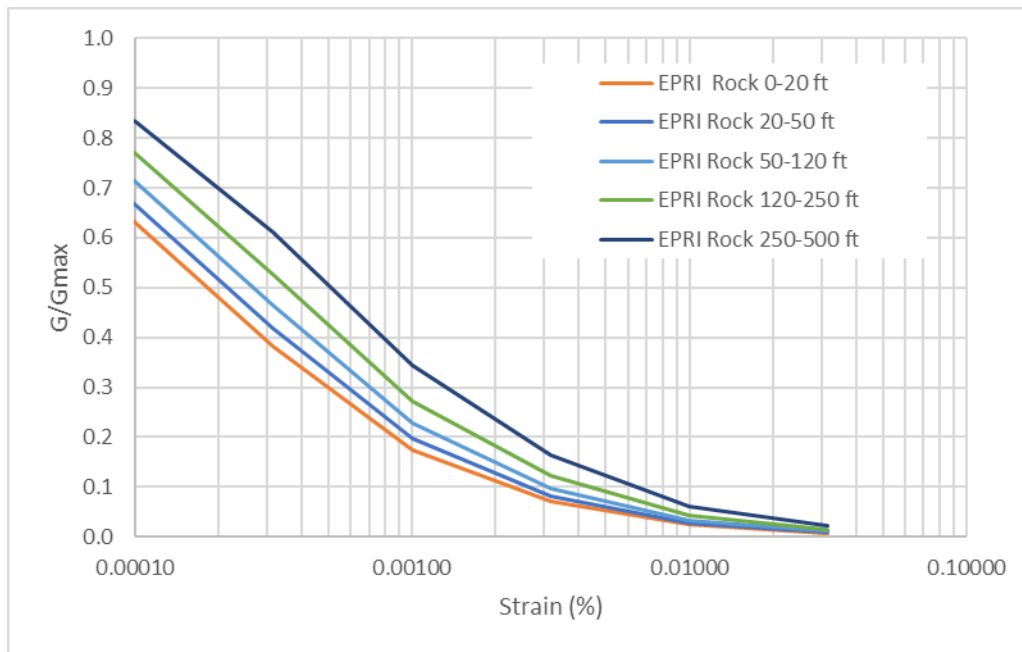


Figure 8 Stiffness degradation curves for rocks between depth 0 and 500 ft used for Diablo Canyon Site based on EPRI Rock Model [7]

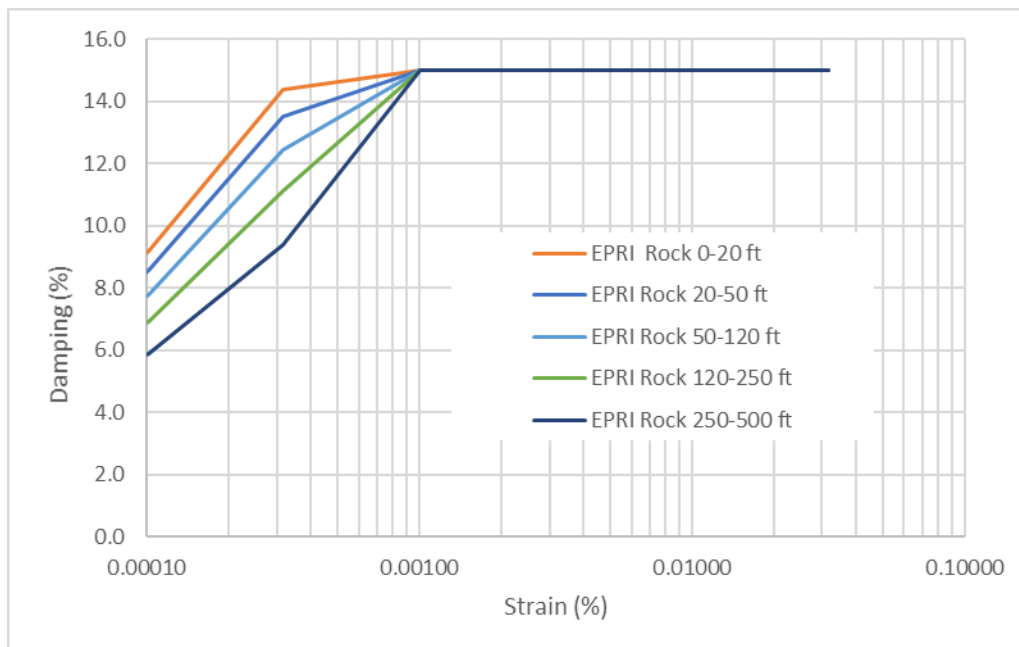


Figure 9 Damping curves for rocks between depth 0 and 500 ft used for Diablo Canyon Site based on EPRI Rock Model [7]

For rocks below 500 ft, linear material model with no stiffness degradation and constant damping of 3.2% was used.

3.3 Pad and Cask Configurations

This study uses the project's test cask properties, which are given in Table 17. These properties are consistent with those of the cask which will be tested and is similar in size and weight to the HI-STORM 100. A survey of HI-STORM 100 casks deployed on ISFSIs around the country showed that the typical center-to-center distance is 15 to 16 ft, leaving approximately 4 ft of clearance. For the cask configurations analyzed here, 16 ft center to center is assumed between casks.

Different sized ISFSI pads, typical to the 4 different regions and additional site were analyzed. The ISFSI pad sizes and the total number of casks they could hold are provided in Table 18. The ISFSI pads are constructed of reinforced concrete. Cracked reinforced concrete section properties are considered consistent with the ground motion amplitudes and stress level expected. Material properties are provided in

Table 19. Sensitivity studies were previously performed [9] to determine the most important cask loading configurations on the pads. The study showed that two configurations, a full pad, and a pad with casks wrapping around one edge, hereafter designated configuration A and configuration B respectively, were the most important configurations for analysis. Configuration A, a fully loaded ISFSI pad, was chosen because it is expected to be the most common configuration in practice. Configuration B was chosen because it was found to have the highest amplitude cask accelerations during seismic excitation. Configuration B for each region and site, along with the numbering system used for the casks, are shown in Figure 10.

Table 17 Test Cask Key Dimensions and Weight

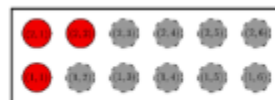
Cask Outer Diameter	Cask Base Height	CG Height	Cask Weight
11.375 ft	1 ft	8.583 ft	335,952 lbs

Table 18 ISFSI Pad Dimensions and Number of Casks

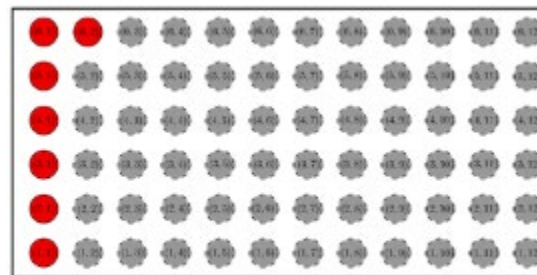
Site Conditions	Pad Dimensions			Number of Casks		
	x (ft)	y (ft)	z (ft)	x	y	Total Casks
CEUS Soil	96	32	3	6	2	12
CEUS Soft Rock	192	96	3	12	6	72
WUS Soil	240	32	3	15	2	30
WUS Soft Rock	240	32	3	15	2	30
Diablo Canyon	448	80	3	28	5	140

Table 19 ISFSI Reinforced Concrete Pad Material Properties

Young's Modulus	Poisson's Ratio	Density	Damping Ratio
3605 ksi	0.25	150 pcf	0.07



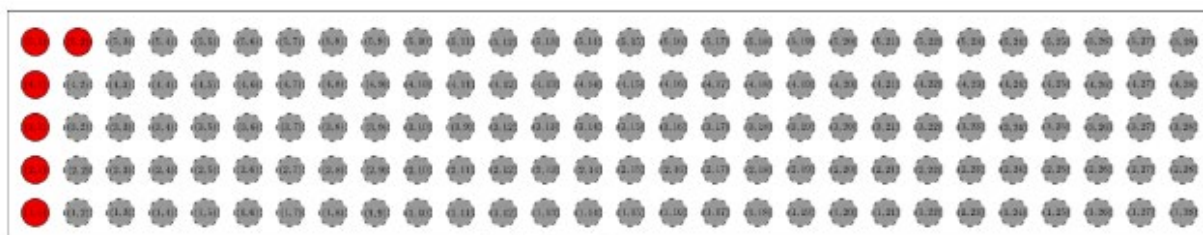
CEUS Soil



CEUS Soft Rock



WUS Soil and Soft Rock



Diablo Canyon

Figure 10 Cask Configuration B for Each ISFSI Soil/Site Analyzed.

4 Site Response Analysis – Model and Results

Site response analyses are performed to calculate the equivalent soil properties (V_s and damping) strain-compatible with ground motion amplitudes. A soil column consisting of the low-strain soil properties is subjected to ground motions prescribed at the ground surface (top of the soil column), consistent with the ground motion generation conditions [2]. The nonlinear soil behavior, characterized by the degradation curves [3], is simulated in frequency domain using the software SHAKE2000 [8]. Output quantities are strain-compatible V_s and damping. The analysis is performed for the two components H1 and H2 of Set 1 of time histories, and the average values of the response quantities are provided per soil layer. Strain-compatible properties are used as site inputs for the soil-structure interaction analysis (Section 5) and are listed in Appendix Table B-1 through Appendix Table B-14.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 25 of 33

5 Soil Structure Interaction – Models

Seismic soil-structure interaction (SSI) analyses are performed in the frequency domain using the software SC-SASSI [1]. The calculations are performed in the frequency range of 0 to 50 Hz and output transfer functions at selected locations are inspected to ensure they are free of numerical anomalies and to identify characteristic resonance frequencies of the SSI system. The response acceleration time histories are output at selected locations and response spectra are calculated in the range of 0 to 100 Hz.

The mesh for the pad and multiple cask structural models for different ISFSI's is generated using a parametrized python script. The cask finite element (FE) model is shown in Figure 11. The storage casks are represented with a single vertical rigid beam element with the cask mass lumped at its center of gravity (CoG) and 8 horizontal rigid beam elements representing the contact area with the concrete pad, causing the cask to behave as a rigid body. The horizontal rigid beam elements representing the cask base are connected to the pad with 8 vertical stiff springs having a length of half the pad thickness to locate the casks at the pad surface. The horizontal rigid beam ends connected to the vertical springs have rotational end releases. This configuration minimizes the effect of stiffening of the concrete pad due to the connection of the rigid beam members to the concrete pad. Horizontal forces and bending/torsional moments are transferred between the cask and the pad via the short element at the center of the cask, connecting the cask single vertical rigid beam element with the concrete pad.

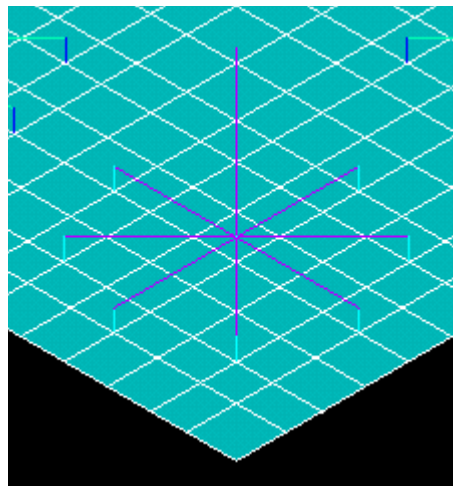


Figure 11 Detailed View of the Pad Corner Cask Model Showing Pad and Cask Mesh.

The pad is modeled using quadrilateral plane-strain elements (shell elements) with an average characteristic length h of 2 ft. This value is chosen to facilitate the alignment of the cask geometry while also providing adequate mesh refinement to capture the pad flexibility. Figure 11 shows a close-up view of the typical pad mesh in the corner of a representative ISFSI.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 26 of 33

A fully loaded pad is shown in Figure 12. The model assumes that the pad-cask interface response is linear, meaning that the casks neither shift nor tip on the pad. The soil properties for the respective sites are described in Section 3.2 and the excitation is described in Section 3.1.

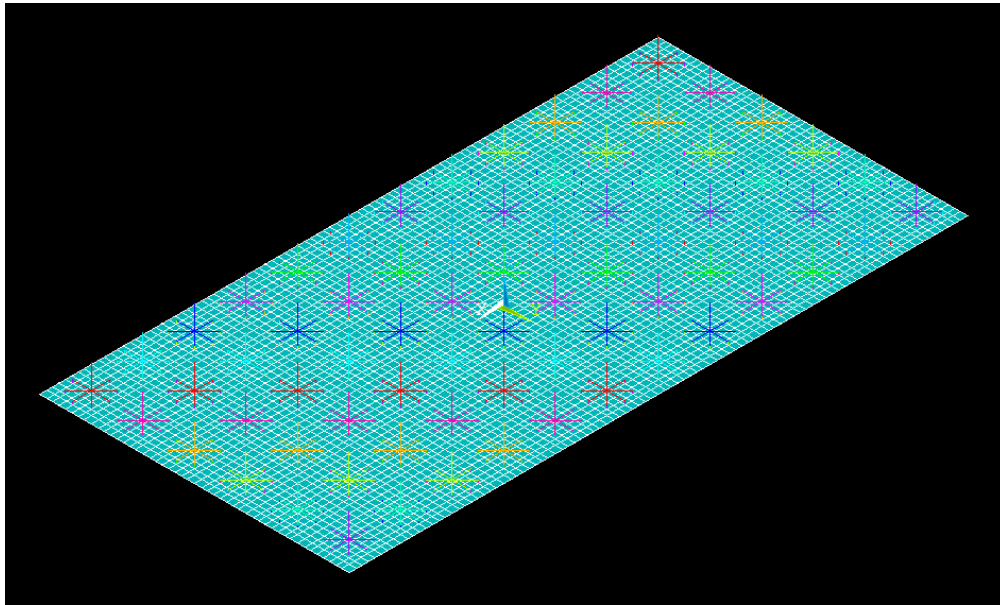


Figure 12 Pad and Cask Model

6 Soil Structure Interaction –Results

SSI analyses are performed in the frequency domain using the software SC-SASSI [1], and frequency domain responses (transfer functions) are calculated for every analysis case using the module SC-ANALYS [1], and then inspected for accuracy.

Time history postprocessing is performed using 5 sets of time histories for each analysis case. Acceleration time histories and response spectra, as well as displacement time histories are extracted using the module SC-RESPONSE [1].

The scope of this study (5 site conditions, 14 analysis cases, 5 sets of time histories per analysis case) makes it prohibitive to present all of the results in this report. Instead, only representative responses for selected casks are provided in this report. To reduce the presented data to a meaningful level, for each of the 14 analysis cases, the 5 response spectra corresponding to the 5 sets of time histories were averaged for each cask on the pad at two locations of interest, the CoG and the center base of the cask, as shown in Figure 13. These averages were then compared for all of the casks on a pad for a given site seismic scenario to determine the cask for the x, y, z translation, and x, y, z rotation degrees of freedom with the highest zero period acceleration (ZPA). This quantity was determined to be of most importance for the casks because a detailed nonlinear model of the cask (excluding the fuel rod bundles) showed that the cask had no local resonances below approximately 80 Hz [10].

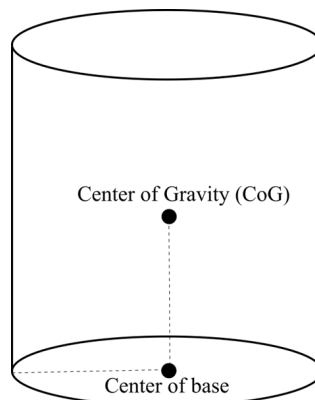


Figure 13 Cask Monitoring Points

As an example, in the case 1: CEUS soil $PGA = 0.56g$ configuration B analysis cask (1, 1) was found to have the highest average ZPA at the base in the y direction. The response spectra for each of the 5 sets of time history components along with their average in y direction, are shown in Figure 14. The average response spectra for the 5 sets of time histories associated with the cask location that has the highest average ZPA at the base, both for configuration A and configuration B, are plotted in Figure 15. Besides, the response spectra for the time history that provides the maximum ZPA for the same cask location are also plotted in Figure 15. Similar response spectra plots for each direction, for each analysis case, for the both the base center and CoG, are provided in 9Appendix C. A summary of the

maximum ZPA at the base for each cask, in the X translation direction, is given in Appendix Table C-1. This table provides the mean ZPA, max ZPA, zero period displacement (ZPD), and amplification factor (max ZPA/PGA). The ratio "max ZPA/PGA" indicates how much amplification (or de-amplification) occurs on the response of the key cask and direction of interest, with respect to the input motion. Similar tables for the Y, Z translation, and X, Y, Z rotation degrees of freedom for both the base and CoG are also provided in Appendix C.

Several overall trends in the data are apparent:

The cases for CEUS soil indicate that configuration B has higher amplification than configuration A. On the other hand, the cases for WUS soil, WUS soft rock and Diablo Canyon, they show a mixed behavior that configuration A has amplification factors similar than configuration B.

For CEUS soft rock, three of the four cases show de-amplification in the response in the horizontal directions (x and y). For CEUS soft rock in vertical direction, configurations A and B report amplifications around and higher than 50% and 70%, respectively.

The highest amplification in horizontal direction reaching 47% occurs for WUS soil. The highest amplification in vertical direction reaching 84% occurs for CEUS soil.

For CEUS soil in horizontal direction (x and y), configurations A and B report about 10% and 25% of amplification, respectively; in vertical direction, configurations A and B report about 70% and 80% of amplification, respectively.

For WUS soil in the horizontal directions (x and y), configurations A and B report about 25% and 15% of amplification, respectively; in the vertical direction, configurations A and B report around and higher than 35% and 40% of amplification, respectively.

For WUS soft rock in the horizontal directions (x and y), both configurations A and B report about 15% of amplification; in the vertical direction, both configurations A and B report around and higher than 10% of amplification.

For Diablo Canyon in the horizontal directions (x and y), both configurations A and B report around and higher than 10% of amplification; in the vertical direction, both configurations A and B report around and higher than 10% of amplification.

In general, it is observed that overall the soil sites have higher amplifications than harder sites.

Displacement results show that the ratios of ZPD/PGD are very close to 1, meaning almost no amplification for all 14 analysis cases and in all three directions. Largest displacements occur for case 13: Diablo Canyon with $PGA=1.3g$, with horizontal displacement (y-direction) of 34.7 in and vertical displacement of 21 in.

The data also showed that accelerations and displacements are similar but slightly higher at the CG's than at the base.

The angular accelerations identified are relatively small, on the order of 0.01 rad/s^2 or smaller. The angular displacements (rotations) are also relatively small, with the highest rotation on the order of 0.004 degrees. This shows that the ISFSI pads behave as rigid.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: 29 of 33

Note that angular accelerations and displacements in the pad reported occur only due to the flexibility of the pad, as the input ground motions used do not consider account for any rotational ground motion, particularly those typically attributed to seismic surface waves.

Another result is that the CG and base center angular accelerations are almost identical, which is consistent with the relatively high stiffness of the cask.

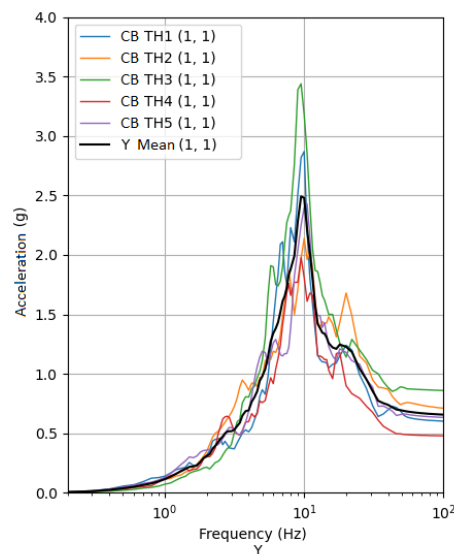


Figure 14 Example of Averaging Response Spectra for Individual Time Histories Using the Case 1: CEUS Soil Site, PGA=0.56g, Configuration B Cask (1, 1)

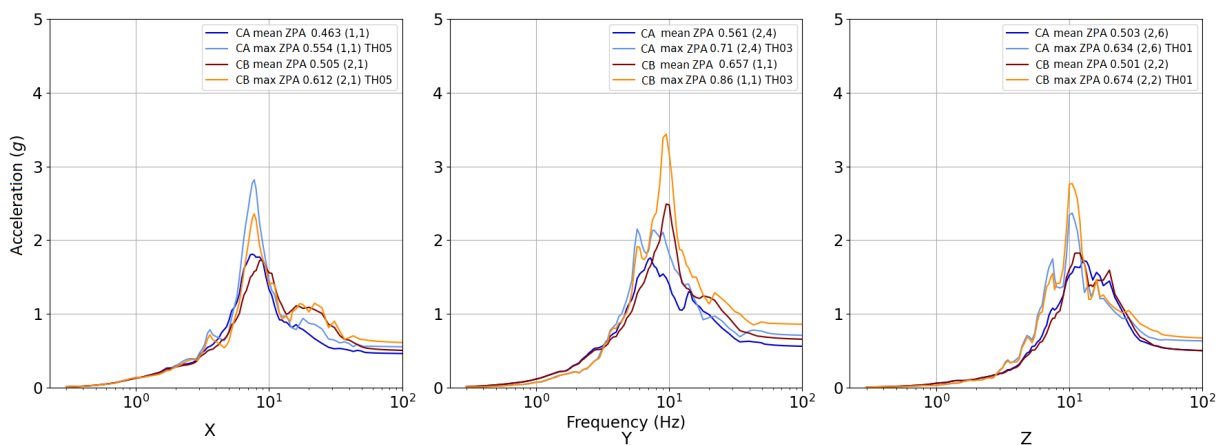


Figure 15 Example Comparison of Response Spectra at Cask Base for Configurations A and B, for Case 1: CEUS Soil Site, PGA=0.56g, Cask (1, 1)

7 Conclusions

Dry spent fuel casks on their accompanying ISFSI's are modeled using SC-SASSI as part of the Spent Fuel Waste Disposition program. These models are developed to provide inputs to a series of earthquake shake table tests as well as high fidelity nonlinear finite element models. The goal of this program is to determine the strains and accelerations on fuel assembly hardware and cladding during earthquakes of different magnitudes to better quantify the potential damage an earthquake could inflict on spent nuclear fuel rods.

Two representative configurations of casks on an ISFSI, a fully loaded ISFSI, and a single row wrapping around the corner of the ISFSI are analyzed for 5 different soil conditions, CEUS soil, CEUS soft rock, WUS soil, WUS soft rock, and Diablo Canyon. Diablo Canyon is considered as a separate case, due to the relatively high seismicity, as well as the fact that the casks are actually bolted into the concrete pad.

The soil properties for each of these cases are created as composites of different ISFSI's in their corresponding region, from locations where up-to-date information is available. For example, for the CEUS soil, the Vogtle shear wave profile is used as a base case, scaled to match the shear wave velocity of the deep Cape Fear sand unit at Farley site. The input motions for different soil scenarios are chosen to cover and explore the responses of casks to a range of seismic excitations that an ISFSI could reasonably experience within a geographic region.

The results are described in Section 6 and shown comprehensively in 9Appendix C. They provide typical maximum responses for casks under each of these loading scenarios. These results, along with their accompanying time history and response spectra (provided in separate data files) should provide sufficient input data for both nonlinear models as well as shake table tests of casks.

In particular, the ZPA for the casks with the maximum ZPA for each scenario are reported as responses of interest. The maximum displacements for these casks are also reported. The ZPA is tracked as the quantity of greatest interest because preliminary nonlinear models showed that no local modes occurred in the casks below approximately 80 Hz, well beyond the peak amplitudes of the input motion.

With few exceptions of some of the CEUS soft rock cases, all other cases depicted amplification in the structural acceleration response compared to the input motion. The highest amplification in horizontal direction occurs for WUS soil, while in vertical direction occurs for CEUS soil. Displacements show almost no amplification for all 14 analysis cases and in all three directions. Angular acceleration and angular displacements reported relatively small values, indicating a relatively rigid behavior of the ISFSI pad.

The worst-case scenarios for absolute amplitudes occurred for Diablo Canyon, which experienced a ZPA more than double that of any other scenario and peak displacement of between 2 and 3 feet in each direction, an order of magnitude larger than most other displacements, consistent with the very high input ground motion amplitudes. However, the acceleration amplification reported for Diablo Canyon were not as high as for other analysis cases, particularly the soil cases. Besides Diablo Canyon, WUS soil and WUS soft rock cases reported relatively high displacement amplitudes (between 1 and 10 inches), while the

CEUS soil and CEUS soft rock cases reported, in general, displacement amplitudes smaller than 1 inch.

The fact that soil cases reported higher acceleration amplification than soft rock cases is consistent and supportive of the project decision not to include hard rock profiles in the SSI investigation.

8 Recommendations for Future Consideration

Alignment of the Equivalent Linear SSI model (from SC Solutions) with the nonlinear (NL) model (from PNNL). The seismic simulations for the project have a phased implementation, with this report documenting the initial phase 1, consisting of equivalent linear SSI analyses. The future phase 2 is schedule to include nonlinear structural analysis using the input motions obtained from phase 1. Alignment between two models needs to be verified: the (simplified) equivalent linear model used for SSI simulations (from phase 1) and the NL detailed model capable to reproduce global sliding/uplift behavior (from phase 2). Despite the differences in model details (one being a relatively simple model and the other being a detailed model), it is needed to verify that both models (particularly at the casks center of gravity) behave very similar (or identical) under similar conditions. In detail, nonlinear features of the detailed model need to be linearized first, and then the responses of the two models need to be compared. Besides, consistent input parameters particularly on the input ground motions (amplitude and frequency content), damping, and other key parameters should be verified, which might require an iterative process, to confirm that equivalent input conditions provide similar or identical responses from the two models.

Verification of the Equivalent Linear Behavior Assumptions in SSI Models. After the alignment of the linear SSI model with the NL model is completed, equivalent linear SSI results need to be assessed, by comparing the response at the top of the concrete pad between both models. Significant deviations between both responses could indicate that the linear SSI assumptions (particularly the linear cask-pad interface behavior) may not be valid for that case. This would mean that that case needs to be further evaluated with a nonlinear SSI model, that could be built with a nonlinear structural model augmented by a soil domain and a nonlinear contact definition.

Re-evaluation of ground motions and structural systems for low frequency energy content in ground motions. In general, dry fuel casks, canisters and baskets are known to be relatively rigid components, which should not respond to low frequency ground motions. Spent fuel bundles could be low-frequency systems on their own; however, the boundary conditions and load transfer between spent fuel bundles and baskets is not well understood. A systematic and detailed evaluation of the structural system of the spent fuel casks and internals is recommended, particularly the support conditions for the spent fuel bundles, through drawing inspections, numerical modeling, including modal analysis and seismic simulations. If the structural system is found to be sensitive to low frequency motions, a re-evaluation of the current ground motions is recommended, as the current CEUS ground motions show little differences between soil sites and soft rock sites in the low frequency range; besides the structural systems is recommended to be re-evaluated with a focus on low-frequency response, as the current evaluation is focused on the relatively rigid cask behavior (high frequency response).

9 References

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Appendix A

Low-Strain Soil

Properties

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-1 of 12

Appendix Table A-1 Dynamic Soil Profile for CEUS Soil Site used in Site Response Analysis

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V_s (ft/sec)	Small Strain damping (%)
1	2	0.123	638	1.0
2	2	0.123	817	1.0
3	2	0.123	983	1.0
4	2	0.123	1,037	1.0
5	2	0.123	1,037	1.0
6	4	0.123	1,192	1.0
7	4	0.123	1,300	1.0
8	2.5	0.123	1,362	1.0
9	2.5	0.123	1,362	1.0
10	2	0.123	1,430	1.0
11	4	0.123	1,430	1.0
12	3.5	0.123	1,463	1.0
13	3.5	0.123	1,463	1.0
14	3.5	0.123	1,532	1.0
15	3.5	0.123	1,532	1.0
16	3.5	0.123	1,567	1.0
17	3.5	0.123	1,567	1.0
18	5	0.123	1,629	1.0
19	5	0.133	1,629	1.0
20	5	0.133	1,688	1.0
21	5	0.133	1,688	1.0
22	5	0.133	1,718	1.0
23	5	0.133	1,718	1.0
24	4	0.133	1,753	1.0
25	4	0.133	1,753	1.0
26	5	0.115	1,926	1.0
27	3	0.115	2,130	1.0
28	5	0.115	2,318	1.0
29	5	0.115	2,578	1.0
30	4	0.115	2,691	1.0
31	8	0.115	2,836	1.0
32	4	0.115	3,012	1.0
33	6	0.115	3,123	1.0
34	8	0.115	3,194	1.0
35	8	0.115	3,194	1.0
36	9	0.115	3,194	1.0
37	3	0.115	3,410	1.0
38	8	0.123	2,511	1.0
39	7	0.123	2,174	1.0

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-2 of 12

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V_s (ft/sec)	Small Strain damping (%)
40	7	0.123	2,174	1.0
41	7	0.123	2,174	1.0
42	7	0.123	2,174	1.0
43	7	0.123	2,174	1.0
44	7	0.123	2,174	1.0
45	7	0.123	2,174	1.0
46	7	0.123	2,174	1.0
47	8	0.128	2,449	1.0
48	8	0.128	2,449	1.0
49	8	0.128	2,787	1.0
50	9	0.128	2,787	1.0
51	9	0.128	2,787	1.0
52	9	0.128	2,787	1.0
53	9	0.128	2,787	1.0
54	7.5	0.128	2,684	1.0
55	7.5	0.128	2,684	1.0
56	7.5	0.128	2,684	1.0
57	7.5	0.128	2,684	1.0
58	9	0.128	2,684	1.0
59	9	0.128	2,684	1.0
60	6	0.128	2,407	1.0
61	6	0.128	2,407	1.0
62	10	0.127	2,857	1.0
63	10	0.127	2,857	1.0
64	10	0.127	2,857	1.0
65	10	0.127	2,857	1.0
66	7	0.127	2,857	1.0
67	10	0.127	2,857	1.0
68	10	0.127	2,857	1.0
69	10	0.127	2,857	1.0
70	10	0.127	2,857	1.0
71	10	0.127	2,857	1.0
72	10	0.127	2,857	1.0
73	9	0.127	3,275	1.0
74	10	0.127	3,275	1.0
75	10	0.127	3,275	1.0
76	10	0.127	3,275	1.0
77	12	0.127	3,693	1.0
78	12	0.127	3,693	1.0
79	12	0.127	3,693	1.0
80	12	0.127	3,693	1.0
81	12	0.127	3,693	1.0

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-3 of 12

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V_s (ft/sec)	Small Strain damping (%)
82	12	0.127	3,693	1.0
83	12	0.127	3,693	1.0
84	13	0.127	3,693	1.0
85	13	0.127	3,693	1.0
86	7.5	0.127	3,972	1.0
87	7.5	0.127	3,972	1.0
88	14	0.127	3,972	1.0
89	14	0.127	3,972	1.0
90	14	0.127	3,972	1.0
91	14	0.127	3,972	1.0
92	14	0.127	3,972	1.0
93	14	0.127	3,972	1.0
94	14	0.127	3,972	1.0
95	14	0.127	3,972	1.0
96	14	0.127	3,972	1.0
97	14	0.127	3,972	1.0
98	14	0.127	3,972	1.0
99	14	0.127	3,972	1.0
100	14	0.127	3,972	1.0
101	14	0.127	3,972	1.0
102	12	0.127	4,000	1.0
103	12	0.127	4,000	1.0
104	12	0.127	4,000	1.0
105	12	0.127	4,000	1.0
106	12	0.127	4,000	1.0
107	9	0.127	3,777	1.0
108	13	0.127	3,777	1.0
109	13	0.127	3,777	1.0
110	13	0.127	3,777	1.0
111	13	0.127	3,777	1.0
112	13	0.127	3,777	1.0
113	13	0.127	3,777	1.0
114	13	0.127	3,777	1.0
115	13	0.127	3,777	1.0
116	13	0.127	3,777	1.0
117	13	0.127	3,777	1.0
118	13	0.127	3,777	1.0
119	13	0.127	3,777	1.0
120	13	0.127	3,777	1.0
121	13	0.127	3,777	1.0
Base Rock		0.127	5,714	0.5

Appendix Table A-2 Dynamic Soil Profile for CEUS Soft Rock Site used in Site Response Analysis based on [4]

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V _s (ft/sec)	Small Strain damping (%)
1	2.25	0.1185	705	1.0
2	2.25	0.1185	705	1.0
3	3.5	0.1185	705	1.0
4	3.5	0.1185	705	1.0
5	3.5	0.1185	705	1.0
6	5	0	1,711	1.0
7	2	0.1185	1,711	1.0
8	7	0.1185	1,711	1.0
9	7	0.1185	1,711	1.0
10	7	0.1185	1,711	1.0
11	7	0.1185	1,711	1.0
12	8.5	0.1185	1,711	1.0
13	8.5	0.1185	1,711	1.0
14	8	0.1185	1,711	1.0
15	5	0.121	1,711	1.0
16	5	0.121	1,711	1.0
17	5	0.121	1,711	1.0
18	5	0.121	1,711	1.0
19	6	0.121	1,711	1.0
20	4	0.121	2,981	1.0
21	7	0.121	2,981	1.0
22	7	0.121	2,981	1.0
23	1	0.121	1,894	1.0
24	6	0.121	1,894	1.0
25	7	0.121	1,894	1.0
26	8	0.121	1,894	1.0
27	11.3	0.121	2,297	1.0
28	11.3	0.121	2,297	1.0
29	11.3	0.131	2,297	1.0
30	9	0.131	1,894	1.0
31	9	0.131	1,894	1.0
32	9	0.131	1,894	1.0
33	9	0.131	1,894	1.0
34	9	0.131	1,894	1.0
35	9	0.131	1,894	1.0
36	8	0.131	1,894	1.0
37	6.5	0.128	1,300	1.0
38	6.5	0.128	1,300	1.0

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-5 of 12

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V_s (ft/sec)	Small Strain damping (%)
39	6.5	0.128	1,300	1.0
40	6.5	0.128	1,300	1.0
41	6.5	0.128	1,300	1.0
42	6.5	0.128	1,300	1.0
43	6.5	0.128	1,300	1.0
44	6.5	0.128	1,300	1.0
45	6.5	0.128	1,300	1.0
46	6.5	0.128	1,300	1.0
47	3.1	0.128	1,300	1.0
48	5	0.125	1,300	1.0
49	5	0.125	1,300	1.0
50	5.4	0.125	1,300	1.0
51	8.7	0.125	1,741	1.0
52	8.7	0.125	1,741	1.0
53	8.7	0.125	1,741	1.0
54	6.2	0.125	1,354	1.0
55	6.2	0.125	1,354	1.0
56	6.2	0.125	1,354	1.0
57	6.3	0.125	1,354	1.0
58	5.85	0.125	1,894	1.0
59	5.85	0.125	1,894	1.0
60	9	0.13	1,894	1.0
61	9	0.13	1,894	1.0
62	9	0.13	1,894	1.0
63	9	0.13	1,894	1.0
64	9	0.13	1,894	1.0
65	9	0.131	1,894	1.0
66	9	0.132	1,894	1.0
67	7.2	0.13	1,894	1.0
68	8	0.13	1,673	1.0
69	8	0.13	1,673	1.0
70	8	0.13	1,673	1.0
71	8	0.13	1,673	1.0
72	8	0.13	1,673	1.0
73	6.6	0.13	1,673	1.0
74	8	0.13	1,673	1.0
75	8	0.13	1,673	1.0
76	8	0.13	1,673	1.0
77	8	0.13	1,673	1.0
78	7.3	0.13	1,673	1.0
79	8	0.135	1,673	1.0
80	8	0.135	1,673	1.0

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-6 of 12

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V_s (ft/sec)	Small Strain damping (%)
81	8	0.135	1,673	1.0
82	8	0.135	1,673	1.0
83	8	0.135	1,673	1.0
84	8	0.135	1,673	1.0
85	8	0.135	1,673	1.0
86	8	0.135	1,673	1.0
87	8	0.135	1,673	1.0
88	8	0.135	1,673	1.0
89	8	0.135	1,673	1.0
90	8	0.135	1,673	1.0
91	8	0.135	1,673	1.0
92	8	0.135	1,673	1.0
93	8	0.135	1,673	1.0
94	8	0.135	1,673	1.0
95	8	0.135	1,673	1.0
96	8	0.135	1,673	1.0
97	8	0.135	1,673	1.0
98	8	0.135	1,673	1.0
99	8	0.135	1,673	1.0
100	8	0.135	1,673	1.0
101	8	0.135	1,673	1.0
102	8	0.135	1,673	1.0
103	8	0.135	1,673	1.0
104	8	0.135	1,673	1.0
105	8	0.135	1,673	1.0
106	8	0.135	1,673	1.0
107	8	0.135	1,673	1.0
108	8	0.135	1,673	1.0
109	8	0.135	1,673	1.0
110	8	0.135	1,673	1.0
111	8	0.135	1,673	1.0
112	8	0.135	1,673	1.0
113	7	0.135	1,673	1.0
114	10	0.135	2,000	1.0
115	10	0.135	2,000	1.0
116	10	0.135	2,000	1.0
117	10	0.135	2,000	1.0
118	10	0.135	2,000	1.0
119	10	0.135	2,000	1.0
120	10	0.135	2,000	1.0
121	10	0.135	2,000	1.0

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-7 of 12

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V_s (ft/sec)	Small Strain damping (%)
122	10	0.135	2,000	1.0
123	10	0.135	2,000	1.0
124	10	0.135	2,000	1.0
125	10	0.135	2,000	1.0
126	10	0.135	2,000	1.0
127	10	0.135	2,000	1.0
128	10	0.135	2,000	1.0
129	10	0.135	2,000	1.0
130	10	0.135	2,000	1.0
131	10	0.135	2,000	1.0
132	10	0.135	2,000	1.0
133	10	0.135	2,000	1.0
134	10	0.135	2,000	1.0
135	10	0.135	2,000	1.0
136	10	0.135	2,000	1.0
137	10	0.135	2,000	1.0
138	10	0.135	2,000	1.0
139	10	0.135	2,000	1.0
140	10	0.135	2,000	1.0
141	10	0.135	2,000	1.0
142	10	0.135	2,000	1.0
143	10	0.135	2,000	1.0
144	10	0.135	2,000	1.0
145	10	0.135	2,000	1.0
146	10	0.135	2,000	1.0
147	10	0.135	2,000	1.0
148	10	0.135	2,000	1.0
149	10	0.135	2,000	1.0
150	10	0.135	2,000	1.0
151	10	0.135	2,000	1.0
152	10	0.135	2,000	1.0
153	10	0.135	2,000	1.0
154	10	0.135	2,000	1.0
155	10	0.135	2,000	1.0
156	10	0.135	2,000	1.0
Baserock		0.135	2,327	1.0

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-8 of 12

Appendix Table A-3 Dynamic Soil Profile for WUS Soil Site used in Site Response Analysis

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V _s (ft/sec)	Small Strain damping (%)
1	1.5	0.105	360	1.0
2	1.5	0.105	360	1.0
3	1.5	0.105	360	1.0
4	1.5	0.105	360	1.0
5	2.2	0.105	485	1.0
6	2.4	0.105	485	1.0
7	2.4	0.105	485	1.0
8	2.6	0.105	582	1.0
9	2.6	0.105	582	1.0
10	1.8	0.105	582	1.0
11	1	0.105	582	1.0
12	3	0.105	624	1.0
13	3	0.105	624	1.0
14	3	0.105	624	1.0
15	3	0.105	624	1.0
16	3	0.105	624	1.0
17	3	0.105	624	1.0
18	3	0.105	624	1.0
19	3	0.105	624	1.0
20	3	0.141	915	1.0
21	2	0.141	915	1.0
22	2	0.141	915	1.0
23	4	0.141	915	1.0
24	5	0.145	1,414	1.0
25	6	0.145	1,414	1.0
26	6	0.145	1,414	1.0
27	6	0.145	1,414	1.0
28	6	0.145	1,414	1.0
29	5	0.145	3,285	1.0
30	16	0.145	3,285	1.0
31	14	0.145	3,285	1.0
32	2	0.145	3,285	1.0
33	16	0.145	3,285	1.0
34	16	0.145	3,285	1.0
35	16	0.145	3,285	1.0
36	16	0.145	3,285	1.0
37	16	0.145	3,285	1.0
38	16	0.145	3,285	1.0
39	16	0.145	3,285	1.0
40	16	0.145	3,285	1.0

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-9 of 12

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V_s (ft/sec)	Small Strain damping (%)
41	5	0.145	1,594	1.0
42	7.5	0.145	1,594	1.0
43	7.5	0.145	1,594	1.0
44	7.5	0.145	1,594	1.0
45	7.5	0.145	1,594	1.0
46	7.5	0.145	1,594	1.0
47	7.5	0.145	1,594	1.0
48	8	0.145	2,259	1.0
49	8	0.145	2,259	1.0
50	9	0.145	2,259	1.0
51	7.5	0.145	1,525	1.0
52	7.5	0.145	1,525	1.0
53	7.5	0.145	1,525	1.0
54	7.5	0.145	1,525	1.0
55	7.5	0.145	1,525	1.0
56	7.5	0.145	1,525	1.0
57	7.5	0.145	1,525	1.0
58	7.5	0.145	1,525	1.0
59	7.5	0.145	1,525	1.0
60	7.5	0.145	1,525	1.0
61	7.5	0.145	1,525	1.0
62	7.5	0.145	1,525	1.0
63	7.5	0.145	1,525	1.0
64	7.5	0.145	1,525	1.0
65	7.5	0.145	1,525	1.0
66	7.5	0.145	1,525	1.0
67	7.5	0.145	1,525	1.0
68	7.5	0.145	1,525	1.0
69	7.5	0.145	1,525	1.0
70	7.5	0.145	1,525	1.0
71	7.5	0.145	1,525	1.0
72	7.5	0.145	1,525	1.0
73	7.5	0.145	1,525	1.0
74	7.5	0.145	1,525	1.0
75	7.5	0.145	1,525	1.0
76	7.5	0.145	1,525	1.0
77	5	0.145	1,525	1.0
Base Rock		0.175	5,250	1.0

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-10 of 12

Appendix Table A-4 Dynamic Soil Profile for WUS Soft Rock Site used in Site Response Analysis

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V _s (ft/sec)	Small Strain damping (%)
1	5	0.12	1,247	1.0
2	5	0.12	1,247	1.0
3	5	0.12	1,247	1.0
4	6	0.12	1,247	1.0
5	4	0.12	1,277	1.0
6	5	0.12	1,277	1.0
7	5	0.12	1,277	1.0
8	5	0.12	1,410	1.0
9	5	0.12	1,410	1.0
10	7	0.12	1,448	1.0
11	7	0.125	1,481	1.0
12	7	0.125	1,481	1.0
13	7	0.125	1,481	1.0
14	7	0.125	1,481	1.0
15	7	0.125	1,481	1.0
16	7	0.125	1,481	1.0
17	7	0.125	1,481	1.0
18	7	0.125	1,481	1.0
19	4	0.125	1,481	1.0
20	6	0.125	1,586	1.0
21	6	0.125	1,586	1.0
22	6	0.125	1,586	1.0
23	7	0.125	1,586	1.0
24	7	0.125	1,706	1.0
25	7	0.125	1,706	1.0
26	8	0.125	1,706	1.0
27	8	0.126	1,756	1.0
28	6	0.125	1,773	1.0
29	6	0.125	1,773	1.0
30	7	0.125	1,773	1.0
31	6	0.126	1,789	1.0
32	6	0.126	1,789	1.0
33	7	0.126	1,789	1.0
34	5	0.125	1,852	1.0
35	10	0.125	2,136	1.0
36	10	0.125	2,136	1.0
37	8	0.126	2,243	1.0
38	10	0.125	2,568	1.0
39	10	0.125	2,568	1.0
40	10	0.125	2,568	1.0

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-11 of 12

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V_s (ft/sec)	Small Strain damping (%)
41	10	0.125	2,568	1.0
42	12	0.125	2,568	1.0
43	10.5	0.125	2,568	1.0
44	10.5	0.125	2,568	1.0
45	10	0.13	2,568	1.0
46	10	0.13	2,568	1.0
47	10	0.13	2,568	1.0
48	17	0.14	4,000	1.0
49	17	0.14	4,000	1.0
50	17	0.14	4,000	1.0
51	17	0.14	4,000	1.0
52	18	0.14	4,000	1.0
Base Rock		0.14	5,500	1.0

Appendix Table A-5 Dynamic Soil Profile for Diablo Canyon Site used in Site Response Analysis

Layer ID	Thickness (ft)	Unit weight (kips/ft ³)	Shear Wave Velocity, V_s (ft/sec)	Small Strain damping (%)
1	10.0	0.124	2,235	1.0
2	10.0	0.131	2,485	1.0
3	10.0	0.131	2,703	1.0
4	10.0	0.131	3,102	1.0
5	10.0	0.131	3,423	1.0
6	10.0	0.131	3,645	1.0
7	10.0	0.131	3,770	1.0
8	10.0	0.131	3,853	1.0
9	10.0	0.131	3,913	1.0
10	10.0	0.131	3,985	1.0
11	20.0	0.131	4,115	1.0
12	20.0	0.131	4,132	1.0
13	15.0	0.131	4,001	1.0
14	15.0	0.131	3,750	1.0
15	15.0	0.131	3,560	1.0
16	15.0	0.131	3,547	1.0
17	15.0	0.131	3,645	1.0
18	15.0	0.131	3,748	1.0
19	15.0	0.131	3,847	1.0
20	5.0	0.131	3,916	1.0
21	10.0	0.131	3,916	1.0
22	15.0	0.131	3,944	1.0
23	15.0	0.131	3,970	1.0

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: A-12 of 12

24	20.0	0.131	4,026	1.0
25	20.0	0.131	4,088	1.0
26	20.0	0.131	4,152	1.0
27	20.0	0.131	4,214	1.0
28	20.0	0.131	4,232	1.0
29	20.0	0.131	4,234	1.0
30	20.0	0.131	4,241	1.0
31	20.0	0.131	4,242	1.0
32	12.6	0.131	4,242	1.0
33	18.0	0.131	4,331	1.0
34	18.0	0.131	4,331	1.0
35	1.4	0.131	4,331	1.0
36	16.7	0.131	4,331	1.0
37	20.0	0.131	4,577	1.0
38	20.0	0.131	4,577	1.0
39	20.0	0.131	4,577	1.0
40	20.0	0.131	4,577	1.0
41	20.0	0.131	4,577	1.0
42	20.0	0.131	4,913	1.0
43	20.0	0.131	4,913	1.0
44	20.0	0.131	4,913	1.0
45	20.0	0.131	4,913	1.0
46	20.0	0.131	4,913	1.0
47	25.0	0.137	5,109	1.0
48	25.0	0.137	5,109	1.0
49	25.0	0.137	5,109	1.0
50	25.0	0.137	5,109	1.0
51	25.0	0.137	5,520	1.0
52	25.0	0.137	5,520	1.0
53	25.0	0.137	5,520	
54	25.0	0.137	5,520	
Base Rock		0.137	5,907	1.0

Appendix B

Strain-Compatible

Soil Profiles

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-1 of 61

Appendix Table B-1 Strain-Compatible Soil Properties for Case 2, CEUS Soil $PGA = 0.31g$

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, V_s (ft/s)	Strain Compatible Shear Wave Velocity, V_s (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	1	0.00162	0.012	638	630.94	1519	0.977
2	3	0.00298	0.014	817	796.04	2423	0.950
3	5	0.00334	0.014	983	955.18	3489	0.945
4	7	0.00417	0.016	1037	997.56	3801	0.926
5	9	0.00543	0.018	1037	981.53	3681	0.896
6	12	0.00528	0.018	1192	1129.86	4881	0.899
7	16	0.00574	0.018	1300	1226.74	5745	0.890
8	19.2	0.00607	0.019	1362	1280.25	6262	0.884
9	21.8	0.00667	0.020	1362	1272.26	6189	0.873
10	24	0.00642	0.019	1430	1339.50	6857	0.878
11	27	0.00646	0.012	1430	1381.96	7298	0.934
12	30.8	0.00664	0.012	1463	1413.15	7624	0.933
13	34.2	0.00711	0.012	1463	1409.35	7585	0.928
14	37.8	0.00686	0.012	1532	1477.11	8339	0.930
15	41.2	0.00723	0.012	1532	1474.33	8306	0.927
16	44.8	0.00715	0.012	1567	1508.28	8697	0.927
17	48.2	0.00737	0.012	1567	1506.65	8677	0.925
18	52.5	0.00712	0.012	1629	1569.08	9403	0.928
19	57.5	0.00692	0.012	1629	1571.18	10193	0.930
20	62.5	0.00668	0.012	1688	1629.80	10979	0.933
21	67.5	0.00689	0.012	1688	1628.67	10956	0.931
22	72.5	0.00687	0.012	1718	1658.07	11352	0.931
23	77.5	0.00718	0.012	1718	1654.96	11308	0.928
24	82	0.00719	0.012	1753	1688.53	11767	0.928
25	86	0.00747	0.012	1753	1685.36	11729	0.924

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-2 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
26	90.5	0.0073	0.026	1926	1864.97	12423	0.938
27	94.5	0.00606	0.024	2130	2073.51	15365	0.948
28	98.5	0.00519	0.023	2318	2267.39	18368	0.957
29	103.5	0.00427	0.022	2578	2536.81	22986	0.968
30	108	0.00398	0.021	2691	2654.02	25149	0.973
31	114	0.00365	0.021	2836	2801.99	28041	0.976
32	120	0.00331	0.020	3012	2980.81	31730	0.980
33	125	0.00314	0.020	3123	3092.74	34160	0.981
34	132	0.00308	0.020	3194	3163.93	35744	0.981
35	140	0.00319	0.020	3194	3161.50	35688	0.980
36	148.5	0.00328	0.020	3194	3159.08	35639	0.978
37	154.5	0.00297	0.020	3410	3378.75	40775	0.982
38	160	0.00531	0.011	2511	2488.14	23645	0.982
39	167.5	0.00743	0.012	2174	2138.58	17471	0.968
40	174.5	0.00758	0.012	2174	2138.03	17454	0.967
41	181.5	0.00765	0.012	2174	2136.92	17445	0.966
42	188.5	0.00768	0.012	2174	2136.93	17440	0.966
43	195.5	0.00779	0.012	2174	2135.82	17427	0.965
44	202.5	0.00784	0.012	2174	2135.83	17420	0.965
45	209.5	0.00802	0.012	2174	2134.72	17403	0.964
46	216.5	0.00837	0.013	2174	2133.06	17371	0.963
47	224	0.00654	0.012	2449	2414.87	23185	0.973
48	232	0.00685	0.012	2449	2412.38	23140	0.971
49	240	0.00543	0.011	2787	2759.43	30267	0.980
50	248.5	0.00563	0.011	2787	2758.02	30225	0.979
51	257.5	0.00581	0.011	2787	2755.90	30190	0.978
52	266.5	0.00595	0.011	2787	2755.20	30160	0.977

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-3 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
53	275.5	0.0061	0.011	2787	2753.79	30129	0.976
54	283.8	0.00672	0.012	2684	2645.78	27826	0.972
55	291.2	0.00684	0.012	2684	2644.42	27804	0.971
56	298.8	0.00692	0.012	2684	2644.42	27790	0.971
57	306.2	0.00695	0.012	2684	2643.74	27783	0.970
58	314.5	0.00714	0.016	2684	2616.32	27198	0.950
59	323.5	0.0072	0.016	2684	2614.95	27185	0.949
60	331	0.00919	0.018	2407	2326.15	21506	0.934
61	337	0.00923	0.018	2407	2325.52	21497	0.934
62	345	0.00646	0.015	2857	2793.54	30774	0.956
63	355	0.00648	0.015	2857	2792.81	30767	0.956
64	365	0.0065	0.015	2857	2792.81	30761	0.956
65	375	0.00651	0.016	2857	2792.81	30758	0.956
66	383.5	0.00635	0.012	2857	2819.74	31356	0.974
67	392	0.00632	0.012	2857	2819.74	31361	0.974
68	402	0.00631	0.012	2857	2820.47	31360	0.975
69	412	0.0064	0.012	2857	2819.02	31341	0.974
70	422	0.00655	0.012	2857	2817.57	31311	0.973
71	432	0.00671	0.012	2857	2816.12	31279	0.972
72	442	0.00681	0.012	2857	2815.40	31258	0.971
73	451.5	0.00516	0.011	3275	3245.64	41559	0.982
74	461	0.00516	0.011	3275	3245.64	41557	0.982
75	471	0.00513	0.011	3275	3247.29	41568	0.983
76	481	0.00508	0.011	3275	3247.29	41584	0.983
77	492	0.00388	0.010	3693	3680.42	53426	0.993
78	504	0.00379	0.010	3693	3681.35	53455	0.994
79	516	0.00375	0.010	3693	3681.35	53448	0.994

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-4 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
80	528	0.00375	0.010	3693	3681.35	53443	0.994
81	540	0.00382	0.010	3693	3680.42	53416	0.993
82	552	0.00388	0.010	3693	3679.49	53392	0.993
83	564	0.00394	0.010	3693	3678.56	53373	0.992
84	576.5	0.004	0.010	3693	3678.56	53356	0.992
85	589.5	0.00404	0.010	3693	3677.64	53343	0.992
86	599.8	0.00351	0.009	3972	3964.17	61979	0.996
87	607.2	0.00353	0.009	3972	3964.17	61970	0.996
88	618	0.00357	0.009	3972	3963.17	61955	0.996
89	632	0.00363	0.010	3972	3963.17	61932	0.996
90	646	0.00368	0.010	3972	3962.17	61907	0.995
91	660	0.00375	0.010	3972	3961.17	61886	0.995
92	674	0.0038	0.010	3972	3960.17	61867	0.994
93	688	0.00386	0.010	3972	3957.19	61761	0.993
94	702	0.00392	0.010	3972	3956.19	61744	0.992
95	716	0.00398	0.010	3972	3956.19	61731	0.992
96	730	0.00402	0.010	3972	3956.19	61723	0.992
97	744	0.00406	0.010	3972	3956.19	61717	0.992
98	758	0.00413	0.010	3972	3955.19	61705	0.992
99	772	0.00419	0.010	3972	3954.20	61663	0.991
100	786	0.00424	0.010	3972	3953.20	61634	0.991
101	800	0.00429	0.010	3972	3952.20	61604	0.990
102	813	0.00426	0.010	4000	3979.94	62497	0.990
103	825	0.00427	0.010	4000	3979.94	62487	0.990
104	837	0.00429	0.010	4000	3979.94	62478	0.990
105	849	0.00429	0.010	4000	3979.94	62478	0.990
106	861	0.0043	0.010	4000	3979.94	62469	0.990

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-5 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
107	871.5	0.00484	0.011	3777	3748.56	55422	0.985
108	882.5	0.00485	0.011	3777	3748.56	55418	0.985
109	895.5	0.00485	0.011	3777	3748.56	55416	0.985
110	908.5	0.00487	0.011	3777	3748.56	55408	0.985
111	921.5	0.00491	0.011	3777	3746.65	55386	0.984
112	934.5	0.00496	0.011	3777	3746.65	55364	0.984
113	947.5	0.00499	0.011	3777	3746.65	55350	0.984
114	960.5	0.00501	0.011	3777	3745.70	55340	0.984
115	973.5	0.00503	0.011	3777	3745.70	55330	0.984
116	986.5	0.00503	0.011	3777	3745.70	55328	0.984
117	999.5	0.00502	0.011	3777	3745.70	55334	0.984
118	1012.5	0.00501	0.011	3777	3745.70	55339	0.984
119	1025.5	0.00498	0.011	3777	3746.65	55354	0.984
120	1038.5	0.00495	0.011	3777	3746.65	55369	0.984
121	1051.5	0.00493	0.011	3777	3746.65	55377	0.984

Appendix Table B-2 Strain-Compatible Soil Properties for Case 3 - CEUS Soil, PGA =0.1g

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	1	0.00052	0.010	638	638.01	1554	0.999
2	3	0.00093	0.010	817	815.91	2545	0.998
3	5	0.00102	0.011	983	980.61	3677	0.996
4	7	0.00126	0.011	1037	1030.69	4059	0.988
5	9	0.00161	0.012	1037	1025.20	4014	0.978
6	12	0.00157	0.012	1192	1178.46	5309	0.978

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-6 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
7	16	0.00169	0.012	1300	1283.99	6296	0.975
8	19.2	0.00181	0.012	1362	1342.82	6889	0.973
9	21.8	0.00204	0.013	1362	1339.01	6852	0.967
10	24	0.00201	0.013	1430	1406.54	7557	0.968
11	27	0.00219	0.008	1430	1418.84	7692	0.985
12	30.8	0.00234	0.008	1463	1451.29	8041	0.984
13	34.2	0.00257	0.009	1463	1449.81	8026	0.982
14	37.8	0.00255	0.009	1532	1517.47	8802	0.982
15	41.2	0.00275	0.009	1532	1516.70	8789	0.981
16	44.8	0.0028	0.009	1567	1550.81	9191	0.980
17	48.2	0.00297	0.009	1567	1549.62	9181	0.979
18	52.5	0.00292	0.009	1629	1612.07	9925	0.979
19	57.5	0.0029	0.009	1629	1612.48	10734	0.980
20	62.5	0.00286	0.009	1688	1670.41	11528	0.980
21	67.5	0.003	0.009	1688	1669.75	11517	0.979
22	72.5	0.00302	0.009	1718	1699.89	11928	0.979
23	77.5	0.00313	0.009	1718	1699.46	11920	0.978
24	82	0.00309	0.009	1753	1733.92	12415	0.978
25	86	0.00314	0.009	1753	1733.92	12410	0.978
26	90.5	0.00305	0.020	1926	1907.75	12998	0.981
27	94.5	0.00252	0.019	2130	2113.05	15950	0.985
28	98.5	0.00214	0.019	2318	2302.65	18943	0.987
29	103.5	0.00174	0.018	2578	2566.77	23514	0.991
30	108	0.00161	0.017	2691	2680.50	25655	0.992
31	114	0.00146	0.017	2836	2827.00	28542	0.994
32	120	0.00132	0.016	3012	3005.06	32253	0.996
33	125	0.00125	0.016	3123	3117.87	34708	0.997

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-7 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
34	132	0.00121	0.016	3194	3189.63	36321	0.997
35	140	0.00124	0.016	3194	3188.83	36308	0.997
36	148.5	0.00127	0.016	3194	3188.03	36293	0.996
37	154.5	0.00113	0.016	3410	3407.04	41448	0.998
38	160	0.00197	0.008	2511	2511.50	24085	1.000
39	167.5	0.00268	0.009	2174	2174.22	18054	1.000
40	174.5	0.00273	0.009	2174	2174.22	18054	1.000
41	181.5	0.00278	0.009	2174	2174.22	18054	1.000
42	188.5	0.00285	0.009	2174	2174.22	18054	1.000
43	195.5	0.00291	0.009	2174	2174.22	18054	1.000
44	202.5	0.00297	0.009	2174	2172.58	18029	0.999
45	209.5	0.00303	0.009	2174	2172.58	18029	0.999
46	216.5	0.00309	0.009	2174	2172.58	18028	0.999
47	224	0.00239	0.008	2449	2448.78	23841	1.000
48	232	0.00245	0.008	2449	2448.78	23841	1.000
49	240	0.00194	0.008	2787	2787.46	30877	1.000
50	248.5	0.00199	0.008	2787	2787.46	30877	1.000
51	257.5	0.00203	0.008	2787	2787.46	30877	1.000
52	266.5	0.00208	0.008	2787	2787.46	30877	1.000
53	275.5	0.00213	0.008	2787	2787.46	30877	1.000
54	283.8	0.00234	0.008	2684	2684.32	28636	1.000
55	291.2	0.00238	0.008	2684	2684.32	28636	1.000
56	298.8	0.00241	0.008	2684	2684.32	28636	1.000
57	306.2	0.00244	0.008	2684	2684.32	28636	1.000
58	314.5	0.00249	0.012	2684	2674.91	28434	0.993
59	323.5	0.00251	0.012	2684	2674.91	28432	0.993
60	331	0.00314	0.012	2407	2396.11	22826	0.991

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-8 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
61	337	0.00317	0.012	2407	2396.11	22825	0.991
62	345	0.00228	0.011	2857	2848.56	31988	0.994
63	355	0.0023	0.011	2857	2848.56	31986	0.994
64	365	0.00233	0.011	2857	2847.12	31983	0.993
65	375	0.00235	0.011	2857	2847.12	31981	0.993
66	383.5	0.00235	0.008	2857	2857.14	32194	1.000
67	392	0.00237	0.008	2857	2857.14	32194	1.000
68	402	0.00239	0.008	2857	2857.14	32194	1.000
69	412	0.00241	0.008	2857	2857.14	32194	1.000
70	422	0.00244	0.008	2857	2857.14	32194	1.000
71	432	0.00247	0.008	2857	2857.14	32194	1.000
72	442	0.00251	0.009	2857	2857.14	32194	1.000
73	451.5	0.00194	0.008	3275	3275.26	42303	1.000
74	461	0.00196	0.008	3275	3275.26	42303	1.000
75	471	0.00199	0.008	3275	3275.26	42303	1.000
76	481	0.00201	0.008	3275	3275.26	42303	1.000
77	492	0.0016	0.008	3693	3693.38	53791	1.000
78	504	0.00161	0.008	3693	3693.38	53791	1.000
79	516	0.00163	0.008	3693	3693.38	53791	1.000
80	528	0.00166	0.008	3693	3693.38	53791	1.000
81	540	0.0017	0.008	3693	3693.38	53791	1.000
82	552	0.00174	0.008	3693	3693.38	53791	1.000
83	564	0.00177	0.008	3693	3693.38	53791	1.000
84	576.5	0.00181	0.008	3693	3693.38	53791	1.000
85	589.5	0.00184	0.008	3693	3693.38	53791	1.000
86	599.8	0.00161	0.008	3972	3972.13	62225	1.000
87	607.2	0.00163	0.008	3972	3972.13	62225	1.000

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-9 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
88	618	0.00165	0.008	3972	3972.13	62225	1.000
89	632	0.00169	0.008	3972	3972.13	62225	1.000
90	646	0.00171	0.008	3972	3972.13	62225	1.000
91	660	0.00174	0.008	3972	3972.13	62225	1.000
92	674	0.00176	0.008	3972	3972.13	62225	1.000
93	688	0.00179	0.008	3972	3972.13	62225	1.000
94	702	0.00182	0.008	3972	3972.13	62225	1.000
95	716	0.00184	0.008	3972	3972.13	62225	1.000
96	730	0.00187	0.008	3972	3972.13	62225	1.000
97	744	0.0019	0.008	3972	3972.13	62225	1.000
98	758	0.00193	0.008	3972	3972.13	62225	1.000
99	772	0.00196	0.008	3972	3972.13	62225	1.000
100	786	0.00198	0.008	3972	3972.13	62225	1.000
101	800	0.002	0.008	3972	3972.13	62225	1.000
102	813	0.00199	0.008	4000	4000.00	63106	1.000
103	825	0.002	0.008	4000	4000.00	63106	1.000
104	837	0.00201	0.008	4000	4000.00	63106	1.000
105	849	0.00202	0.008	4000	4000.00	63106	1.000
106	861	0.00203	0.008	4000	4000.00	63106	1.000
107	871.5	0.00229	0.008	3777	3777.00	56266	1.000
108	882.5	0.0023	0.008	3777	3777.00	56266	1.000
109	895.5	0.00231	0.008	3777	3777.00	56266	1.000
110	908.5	0.00234	0.008	3777	3777.00	56266	1.000
111	921.5	0.00238	0.008	3777	3777.00	56266	1.000
112	934.5	0.00241	0.008	3777	3777.00	56266	1.000
113	947.5	0.00245	0.008	3777	3777.00	56266	1.000
114	960.5	0.00248	0.008	3777	3777.00	56266	1.000

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-10 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
115	973.5	0.00251	0.008	3777	3777.00	56266	1.000
116	986.5	0.00254	0.008	3777	3777.00	56266	1.000
117	999.5	0.00257	0.009	3777	3777.00	56266	1.000
118	1012.5	0.00259	0.009	3777	3777.00	56266	1.000
119	1025.5	0.00261	0.009	3777	3777.00	56266	1.000
120	1038.5	0.00264	0.009	3777	3777.00	56266	1.000
121	1051.5	0.00266	0.009	3777	3777.00	56266	1.000

Appendix Table B-3 Strain-Compatible Soil Properties for Case 1 - CEUS Soil, PGA =0.56g

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	1	0.00283	0.014	638	623	1481	0.953
2	3	0.00517	0.017	817	775	2299	0.902
3	5	0.00555	0.0175	983	929	3299	0.894
4	7	0.00654	0.019	1037	970	3598	0.876
5	9	0.00811	0.021	1037	957	3501	0.852
6	12	0.00741	0.02	1192	1107	4681	0.863
7	16	0.00735	0.02	1300	1209	5577	0.864
8	19.2	0.00733	0.0195	1362	1266	6125	0.864
9	21.8	0.00792	0.0205	1362	1259	6062	0.855
10	24	0.00747	0.02	1430	1328	6731	0.862
11	27	0.00731	0.0115	1430	1376	7231	0.926
12	30.8	0.00734	0.0115	1463	1408	7566	0.926
13	34.2	0.00753	0.0115	1463	1406	7550	0.924
14	37.8	0.00698	0.0115	1532	1476	8325	0.929

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-11 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
15	41.2	0.00709	0.0115	1532	1475	8315	0.928
16	44.8	0.00677	0.0115	1567	1511	8729	0.931
17	48.2	0.00689	0.0115	1567	1510	8719	0.930
18	52.5	0.00662	0.0115	1629	1573	9451	0.933
19	57.5	0.00665	0.0115	1629	1573	10215	0.932
20	62.5	0.00671	0.0115	1688	1629	10961	0.932
21	67.5	0.00714	0.0115	1688	1625	10910	0.927
22	72.5	0.00725	0.0115	1718	1654	11289	0.926
23	77.5	0.00756	0.012	1718	1651	11253	0.923
24	82	0.00743	0.012	1753	1685	11731	0.924
25	86	0.00754	0.012	1753	1684	11717	0.923
26	90.5	0.00716	0.025	1926	1866	12436	0.939
27	94.5	0.00575	0.024	2130	2077	15414	0.952
28	98.5	0.00495	0.0225	2318	2271	18419	0.960
29	103.5	0.0041	0.021	2578	2540	23043	0.971
30	108	0.00383	0.0205	2691	2657	25204	0.975
31	114	0.00351	0.0205	2836	2803	28071	0.977
32	120	0.00316	0.0195	3012	2983	31770	0.981
33	125	0.00297	0.0195	3123	3094	34193	0.982
34	132	0.00288	0.0195	3194	3166	35785	0.982
35	140	0.00292	0.0195	3194	3166	35774	0.982
36	148.5	0.00297	0.0195	3194	3165	35764	0.982
37	154.5	0.00266	0.019	3410	3382	40842	0.984
38	160	0.00469	0.01	2511	2494	23753	0.987
39	167.5	0.00657	0.0115	2174	2144	17555	0.972
40	174.5	0.00674	0.0115	2174	2143	17538	0.972
41	181.5	0.00683	0.0115	2174	2142	17531	0.971

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-12 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
42	188.5	0.00695	0.0115	2174	2142	17521	0.971
43	195.5	0.0071	0.0115	2174	2141	17505	0.970
44	202.5	0.00721	0.0115	2174	2140	17493	0.969
45	209.5	0.00729	0.012	2174	2140	17485	0.969
46	216.5	0.00737	0.012	2174	2139	17476	0.968
47	224	0.00562	0.0105	2449	2423	23340	0.979
48	232	0.0057	0.0105	2449	2422	23323	0.978
49	240	0.00454	0.0095	2787	2770	30497	0.988
50	248.5	0.00471	0.01	2787	2769	30449	0.987
51	257.5	0.00486	0.0105	2787	2766	30411	0.985
52	266.5	0.00504	0.0105	2787	2764	30370	0.984
53	275.5	0.00512	0.0105	2787	2764	30352	0.983
54	283.8	0.0056	0.0105	2684	2657	28051	0.980
55	291.2	0.00567	0.011	2684	2656	28039	0.979
56	298.8	0.00576	0.011	2684	2655	28024	0.979
57	306.2	0.00578	0.011	2684	2655	28019	0.979
58	314.5	0.0059	0.0145	2684	2633	27556	0.963
59	323.5	0.00584	0.0145	2684	2634	27575	0.963
60	331	0.00737	0.016	2407	2345	21854	0.949
61	337	0.00735	0.016	2407	2344	21855	0.949
62	345	0.00509	0.014	2857	2815	31245	0.971
63	355	0.00503	0.014	2857	2815	31258	0.971
64	365	0.00501	0.014	2857	2815	31261	0.971
65	375	0.00514	0.014	2857	2813	31217	0.970
66	383.5	0.00513	0.0105	2857	2833	31647	0.983
67	392	0.0052	0.0105	2857	2832	31634	0.983
68	402	0.00523	0.01	2857	2832	31629	0.983

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-13 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
69	412	0.00523	0.01	2857	2832	31631	0.983
70	422	0.00521	0.01	2857	2832	31639	0.983
71	432	0.00517	0.01	2857	2833	31650	0.983
72	442	0.00515	0.01	2857	2833	31654	0.984
73	451.5	0.00397	0.0095	3275	3262	41975	0.992
74	461	0.00411	0.0095	3275	3261	41947	0.992
75	471	0.00426	0.0095	3275	3257	41852	0.989
76	481	0.00441	0.01	3275	3256	41813	0.989
77	492	0.00357	0.009	3693	3682	53472	0.994
78	504	0.00371	0.0095	3693	3680	53418	0.993
79	516	0.00383	0.0095	3693	3679	53378	0.993
80	528	0.00389	0.0095	3693	3679	53349	0.992
81	540	0.00395	0.0095	3693	3678	53330	0.992
82	552	0.00398	0.0095	3693	3678	53327	0.992
83	564	0.00397	0.0095	3693	3678	53335	0.992
84	576.5	0.0039	0.0095	3693	3679	53353	0.992
85	589.5	0.00379	0.0095	3693	3679	53388	0.993
86	599.8	0.00317	0.0085	3972	3965	61998	0.997
87	607.2	0.00314	0.0085	3972	3966	62029	0.997
88	618	0.00314	0.0085	3972	3967	62077	0.998
89	632	0.00319	0.0085	3972	3968	62098	0.998
90	646	0.0033	0.009	3972	3967	62064	0.998
91	660	0.00338	0.009	3972	3966	62041	0.997
92	674	0.00346	0.009	3972	3965	62004	0.997
93	688	0.0036	0.0095	3972	3962	61925	0.995
94	702	0.00372	0.0095	3972	3960	61848	0.994
95	716	0.00382	0.0095	3972	3958	61786	0.993

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-14 of 61

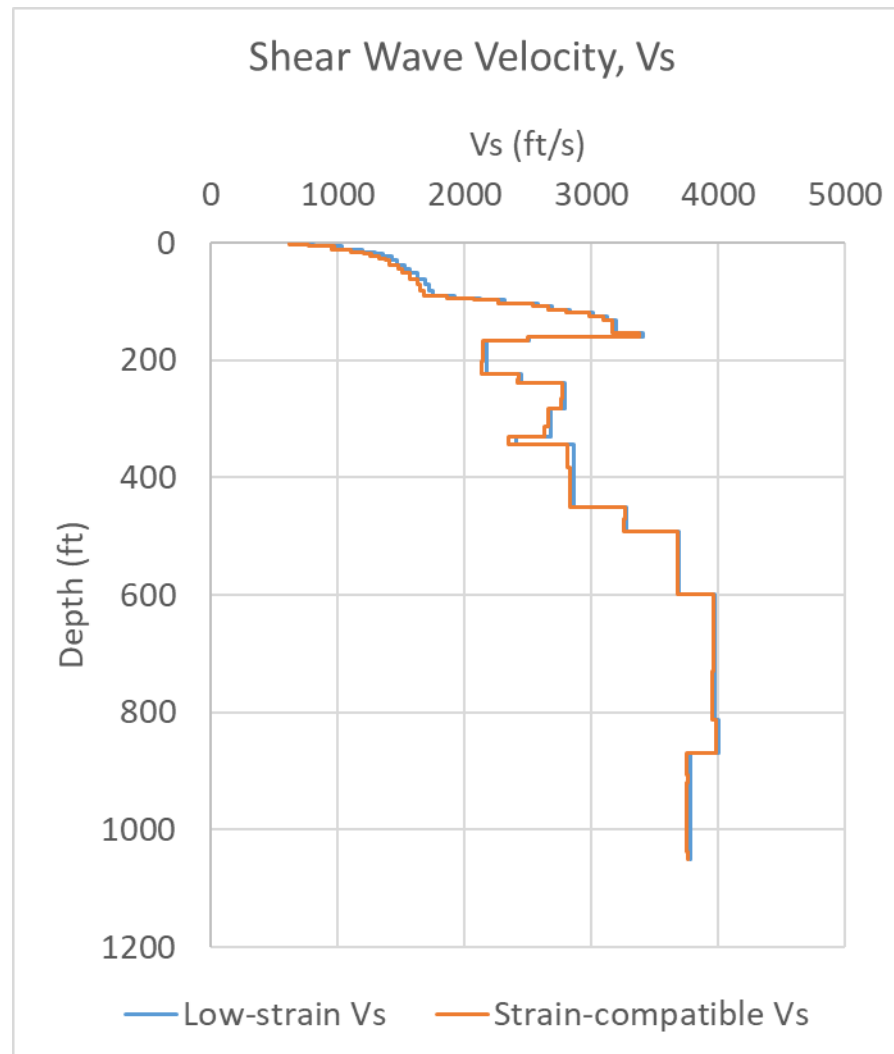
Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
96	730	0.00392	0.0095	3972	3956	61734	0.992
97	744	0.00401	0.0095	3972	3955	61690	0.992
98	758	0.00406	0.0095	3972	3954	61659	0.991
99	772	0.00407	0.0095	3972	3953	61641	0.991
100	786	0.00404	0.0095	3972	3953	61640	0.991
101	800	0.00402	0.0095	3972	3954	61657	0.991
102	813	0.00392	0.0095	4000	3983	62578	0.992
103	825	0.00387	0.0095	4000	3984	62610	0.992
104	837	0.00382	0.0095	4000	3985	62635	0.993
105	849	0.0038	0.0095	4000	3985	62641	0.993
106	861	0.00382	0.0095	4000	3985	62632	0.993
107	871.5	0.00435	0.01	3777	3754	55612	0.988
108	882.5	0.00439	0.01	3777	3754	55592	0.988
109	895.5	0.00444	0.01	3777	3753	55573	0.988
110	908.5	0.00448	0.01	3777	3756	55634	0.989
111	921.5	0.00453	0.01	3777	3752	55547	0.987
112	934.5	0.00459	0.01	3777	3752	55535	0.987
113	947.5	0.00461	0.01	3777	3752	55532	0.987
114	960.5	0.00461	0.01	3777	3752	55530	0.987
115	973.5	0.00458	0.01	3777	3752	55539	0.987
116	986.5	0.00455	0.01	3777	3752	55548	0.987
117	999.5	0.00451	0.01	3777	3753	55568	0.988
118	1012.5	0.00444	0.01	3777	3754	55591	0.988
119	1025.5	0.00434	0.01	3777	3755	55626	0.989
120	1038.5	0.0042	0.0095	3777	3760	55747	0.991
121	1051.5	0.00408	0.0095	3777	3761	55800	0.992

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-15 of 61



Appendix Figure B-1 Shear Wave Velocity for Case 1 - CEUS Soil, $PGA=0.56g$.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-16 of 61

Appendix Table B-4 Strain-Compatible Soil Properties for Case 4 - CEUS Soft Rock, PGA =0.25 g

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	1.1	0.00113	0.01	0.019	705	692	1763	0.964
2	3.4	0.0034	0.01	0.03	705	668	1643	0.899
3	6.2	0.00608	0.01	0.0405	705	639	1502	0.822
4	9.8	0.00843	0.01	0.047	705	622	1423	0.778
5	13.2	0.00925	0.01	0.0495	705	616	1398	0.764
6	17.5	0.00123	0.01	0.02	1711	1676	10340	0.960
7	21	0.00141	0.01	0.017	1711	1669	10256	0.952
8	25.5	0.00172	0.01	0.018	1711	1659	10137	0.941
9	32.5	0.00205	0.01	0.019	1711	1651	10031	0.931
10	39.5	0.00217	0.01	0.0195	1711	1648	10000	0.928
11	46.5	0.00237	0.01	0.02	1711	1644	9945	0.923
12	54.2	0.00251	0.01	0.016	1711	1666	10213	0.948
13	62.8	0.0027	0.01	0.017	1711	1663	10179	0.945
14	71	0.00281	0.01	0.017	1711	1662	10160	0.943
15	77.5	0.00281	0.01	0.017	1711	1662	10376	0.944
16	82.5	0.00284	0.01	0.017	1711	1662	10370	0.943
17	87.5	0.00283	0.01	0.017	1711	1661	10372	0.943
18	92.5	0.00286	0.01	0.017	1711	1661	10369	0.943
19	98	0.00296	0.01	0.017	1711	1660	10351	0.941
20	103	0.00096	0.01	0.0125	2981	2958	32863	0.985
21	108.5	0.00097	0.01	0.013	2981	2957	32857	0.984
22	115.5	0.00098	0.01	0.013	2981	2957	32854	0.984
23	119.5	0.00259	0.01	0.0165	1894	1842	12760	0.947
24	123	0.00255	0.01	0.013	1894	1874	13204	0.980
25	129.5	0.00263	0.01	0.0135	1894	1874	13198	0.980

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-17 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
26	137	0.00268	0.01	0.0135	1894	1874	13194	0.979
27	146.6	0.00183	0.01	0.012	2297	2279	19530	0.985
28	157.9	0.00181	0.01	0.0115	2297	2279	19535	0.985
29	169.2	0.00163	0.01	0.0115	2297	2282	21187	0.987
30	179.4	0.00254	0.01	0.0135	1894	1875	14299	0.980
31	188.4	0.00263	0.01	0.0135	1894	1874	14291	0.979
32	197.4	0.00277	0.01	0.0135	1894	1873	14277	0.978
33	206.4	0.00283	0.01	0.0135	1894	1872	14271	0.978
34	215.4	0.00288	0.01	0.0135	1894	1873	14266	0.978
35	224.4	0.00298	0.01	0.0135	1894	1871	14251	0.977
36	232.9	0.00316	0.01	0.0145	1894	1869	14215	0.974
37	240.1	0.00761	0.01	0.0205	1300	1246	6161	0.918
38	246.6	0.00763	0.01	0.0205	1300	1245	6159	0.917
39	253.1	0.00721	0.01	0.0175	1300	1264	6348	0.945
40	259.6	0.00718	0.01	0.017	1300	1264	6349	0.946
41	266.1	0.00722	0.01	0.017	1300	1264	6347	0.945
42	272.6	0.00706	0.01	0.017	1300	1265	6355	0.946
43	279.1	0.00662	0.01	0.0165	1300	1267	6377	0.949
44	285.6	0.00594	0.01	0.016	1300	1271	6416	0.956
45	292.1	0.0058	0.01	0.016	1300	1271	6425	0.956
46	298.6	0.00594	0.01	0.016	1300	1271	6414	0.955
47	303.4	0.00602	0.01	0.016	1300	1270	6410	0.954
48	307.5	0.00604	0.01	0.016	1300	1270	6259	0.954
49	312.5	0.00583	0.01	0.016	1300	1271	6272	0.956
50	317.7	0.00591	0.01	0.016	1300	1271	6269	0.956
51	324.7	0.00348	0.01	0.013	1741	1724	11530	0.980
52	333.4	0.00383	0.01	0.013	1741	1721	11495	0.977

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-18 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
53	342.1	0.00409	0.01	0.0135	1741	1719	11460	0.974
54	349.6	0.00715	0.01	0.017	1354	1317	6733	0.946
55	355.8	0.00714	0.01	0.017	1354	1317	6733	0.946
56	362	0.00708	0.01	0.017	1354	1317	6734	0.946
57	368.3	0.00712	0.01	0.0175	1354	1316	6730	0.946
58	374.3	0.00352	0.01	0.013	1894	1875	13656	0.981
59	380.2	0.00355	0.01	0.013	1894	1875	13649	0.980
60	387.6	0.00349	0.01	0.013	1894	1875	14208	0.981
61	396.6	0.00343	0.01	0.0125	1894	1876	14220	0.982
62	405.6	0.00329	0.01	0.0125	1894	1877	14235	0.983
63	414.6	0.00321	0.01	0.0125	1894	1878	14246	0.984
64	423.6	0.00344	0.01	0.0125	1894	1876	14213	0.982
65	432.6	0.00385	0.01	0.013	1894	1871	14141	0.977
66	441.6	0.00415	0.01	0.014	1894	1868	14091	0.973
67	449.7	0.00423	0.01	0.0135	1894	1867	14085	0.973
68	457.3	0.00546	0.01	0.0155	1673	1640	10851	0.961
69	465.3	0.00551	0.01	0.0155	1673	1639	10842	0.960
70	473.3	0.00556	0.01	0.0155	1673	1638	10828	0.959
71	481.3	0.00536	0.01	0.0155	1673	1639	10846	0.960
72	489.3	0.00523	0.01	0.0155	1673	1640	10860	0.961
73	496.6	0.00522	0.01	0.015	1673	1640	10862	0.962
74	503.9	0.00523	0.01	0.008	1673	1653	11028	0.976
75	511.9	0.00536	0.01	0.008	1673	1652	11018	0.975
76	519.9	0.00525	0.01	0.008	1673	1653	11026	0.976
77	527.9	0.00505	0.01	0.008	1673	1654	11043	0.977
78	535.6	0.0048	0.01	0.008	1673	1656	11070	0.980
79	543.2	0.0046	0.01	0.008	1673	1657	11515	0.982

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-19 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
80	551.2	0.00461	0.01	0.008	1673	1657	11513	0.982
81	559.2	0.00466	0.01	0.008	1673	1657	11504	0.981
82	567.2	0.00453	0.01	0.008	1673	1657	11514	0.981
83	575.2	0.00419	0.01	0.008	1673	1659	11545	0.984
84	583.2	0.00379	0.01	0.0075	1673	1661	11566	0.986
85	591.2	0.0036	0.01	0.0075	1673	1662	11579	0.987
86	599.2	0.00383	0.01	0.0075	1673	1661	11567	0.986
87	607.2	0.00411	0.01	0.008	1673	1660	11554	0.985
88	615.2	0.00415	0.01	0.008	1673	1660	11549	0.985
89	623.2	0.00399	0.01	0.0075	1673	1660	11557	0.985
90	631.2	0.0039	0.01	0.0075	1673	1661	11561	0.986
91	639.2	0.00393	0.01	0.0075	1673	1660	11559	0.985
92	647.2	0.00403	0.01	0.0075	1673	1660	11551	0.985
93	655.2	0.00413	0.01	0.0075	1673	1660	11543	0.984
94	663.2	0.00416	0.01	0.0075	1673	1659	11540	0.984
95	671.2	0.0041	0.01	0.0075	1673	1659	11540	0.984
96	679.2	0.00417	0.01	0.0075	1673	1659	11536	0.983
97	687.2	0.00437	0.01	0.008	1673	1658	11529	0.983
98	695.2	0.0045	0.01	0.008	1673	1657	11518	0.982
99	703.2	0.00444	0.01	0.008	1673	1658	11522	0.982
100	711.2	0.00427	0.01	0.008	1673	1659	11540	0.984
101	719.2	0.00415	0.01	0.008	1673	1659	11544	0.984
102	727.2	0.00415	0.01	0.008	1673	1660	11544	0.984
103	735.2	0.00421	0.01	0.008	1673	1659	11542	0.984
104	743.2	0.00426	0.01	0.008	1673	1659	11541	0.984
105	751.2	0.00425	0.01	0.008	1673	1659	11541	0.984
106	759.2	0.0042	0.01	0.008	1673	1659	11544	0.984

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-20 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
107	767.2	0.00417	0.01	0.008	1673	1660	11547	0.984
108	775.2	0.00418	0.01	0.008	1673	1660	11546	0.984
109	783.2	0.00417	0.01	0.008	1673	1660	11545	0.984
110	791.2	0.0041	0.01	0.008	1673	1660	11551	0.985
111	799.2	0.00402	0.01	0.008	1673	1660	11559	0.985
112	807.2	0.00407	0.01	0.008	1673	1660	11555	0.985
113	814.7	0.00419	0.01	0.008	1673	1660	11543	0.984
114	823.2	0.003	0.01	0.0075	2000	1991	16623	0.991
115	833.2	0.0031	0.01	0.0075	2000	1991	16618	0.991
116	843.2	0.00335	0.01	0.0075	2000	1989	16594	0.990
117	853.2	0.00356	0.01	0.0075	2000	1988	16566	0.988
118	863.2	0.00365	0.01	0.0075	2000	1987	16555	0.987
119	873.2	0.00365	0.01	0.0075	2000	1987	16555	0.987
120	883.2	0.00352	0.01	0.0075	2000	1988	16572	0.988
121	893.2	0.0034	0.01	0.0075	2000	1989	16591	0.990
122	903.2	0.00343	0.01	0.0075	2000	1989	16592	0.990
123	913.2	0.00346	0.01	0.0075	2000	1989	16590	0.990
124	923.2	0.00348	0.01	0.008	2000	1989	16589	0.989
125	933.2	0.00348	0.01	0.008	2000	1989	16591	0.989
126	943.2	0.00348	0.01	0.008	2000	1989	16592	0.989
127	953.2	0.00354	0.01	0.008	2000	1988	16583	0.989
128	963.2	0.00356	0.01	0.008	2000	1988	16578	0.989
129	973.2	0.00352	0.01	0.0075	2000	1989	16581	0.989
130	983.2	0.00342	0.01	0.0075	2000	1989	16592	0.990
131	993.2	0.00348	0.01	0.008	2000	1989	16590	0.989
132	1003.2	0.00358	0.01	0.008	2000	1988	16582	0.989
133	1013.2	0.00355	0.01	0.008	2000	1989	16586	0.989

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-21 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
134	1023.2	0.0035	0.01	0.008	2000	1989	16588	0.989
135	1033.2	0.00348	0.01	0.0075	2000	1989	16582	0.989
136	1043.2	0.00349	0.01	0.0075	2000	1988	16574	0.989
137	1053.2	0.0035	0.01	0.0075	2000	1988	16571	0.988
138	1063.2	0.00354	0.01	0.0075	2000	1988	16575	0.989
139	1073.2	0.00351	0.01	0.008	2000	1988	16584	0.989
140	1083.2	0.00342	0.01	0.008	2000	1990	16596	0.990
141	1093.2	0.00334	0.01	0.0075	2000	1990	16606	0.991
142	1103.2	0.00335	0.01	0.0075	2000	1990	16605	0.991
143	1113.2	0.00344	0.01	0.008	2000	1989	16596	0.990
144	1123.2	0.00347	0.01	0.008	2000	1989	16592	0.989
145	1133.2	0.00341	0.01	0.0075	2000	1989	16590	0.990
146	1143.2	0.00336	0.01	0.0075	2000	1989	16590	0.989
147	1153.2	0.00338	0.01	0.0075	2000	1989	16591	0.990
148	1163.2	0.00328	0.01	0.0075	2000	1990	16603	0.990
149	1173.2	0.00314	0.01	0.0075	2000	1991	16617	0.991
150	1183.2	0.00307	0.01	0.0075	2000	1991	16620	0.991
151	1193.2	0.00306	0.01	0.0075	2000	1991	16621	0.991
152	1203.2	0.00308	0.01	0.0075	2000	1991	16618	0.991
153	1213.2	0.00313	0.01	0.0075	2000	1990	16612	0.991
154	1223.2	0.00316	0.01	0.0075	2000	1990	16605	0.990
155	1233.2	0.00318	0.01	0.0075	2000	1990	16600	0.990
156	1243.2	0.00327	0.01	0.0075	2000	1989	16594	0.990

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-22 of 61

Appendix Table B-5 Strain-Compatible Soil Properties for Case 5 - CEUS Soft Rock, $PGA = 0.08 g$

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, V_s (ft/s)	Strain Compatible Shear Wave Velocity, V_s (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	1.1	0.00037	0.016	705	702	1816	0.993
2	3.4	0.00108	0.019	705	693	1768	0.967
3	6.2	0.00187	0.0235	705	682	1713	0.937
4	9.8	0.00263	0.0265	705	675	1678	0.918
5	13.2	0.00346	0.03	705	667	1639	0.896
6	17.5	0.00066	0.0175	1711	1694	10560	0.981
7	21	0.00076	0.0145	1711	1692	10528	0.978
8	25.5	0.00089	0.0145	1711	1688	10484	0.973
9	32.5	0.00105	0.0155	1711	1683	10413	0.967
10	39.5	0.00117	0.016	1711	1679	10371	0.963
11	46.5	0.00124	0.016	1711	1676	10337	0.960
12	54.2	0.00133	0.014	1711	1689	10501	0.975
13	62.8	0.0015	0.014	1711	1686	10459	0.971
14	71	0.0016	0.0145	1711	1684	10434	0.969
15	77.5	0.00157	0.014	1711	1684	10656	0.969
16	82.5	0.00158	0.0145	1711	1683	10651	0.968
17	87.5	0.00162	0.0145	1711	1683	10638	0.967
18	92.5	0.00165	0.0145	1711	1682	10628	0.966
19	98	0.00165	0.0145	1711	1681	10624	0.966
20	103	0.00054	0.0115	2981	2968	33099	0.991
21	108.5	0.00055	0.0115	2981	2968	33086	0.991
22	115.5	0.00057	0.012	2981	2967	33070	0.991
23	119.5	0.00147	0.014	1894	1865	13078	0.970
24	123	0.00148	0.011	1894	1883	13324	0.989
25	129.5	0.0015	0.0115	1894	1883	13320	0.989

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-23 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
26	137	0.00153	0.0115	1894	1882	13318	0.988
27	146.6	0.00104	0.01	2297	2289	19695	0.994
28	157.9	0.00109	0.01	2297	2289	19693	0.994
29	169.2	0.00102	0.01	2297	2290	21343	0.995
30	179.4	0.00156	0.011	1894	1882	14412	0.988
31	188.4	0.00162	0.0115	1894	1881	14403	0.987
32	197.4	0.00171	0.012	1894	1880	14390	0.986
33	206.4	0.00184	0.012	1894	1879	14372	0.985
34	215.4	0.00193	0.012	1894	1878	14360	0.984
35	224.4	0.00203	0.012	1894	1877	14349	0.983
36	232.9	0.00213	0.013	1894	1876	14337	0.982
37	240.1	0.00492	0.017	1300	1265	6358	0.947
38	246.6	0.005	0.0175	1300	1264	6352	0.945
39	253.1	0.00492	0.015	1300	1277	6476	0.964
40	259.6	0.00487	0.015	1300	1277	6479	0.965
41	266.1	0.00481	0.015	1300	1277	6483	0.965
42	272.6	0.00471	0.0145	1300	1278	6490	0.966
43	279.1	0.00459	0.014	1300	1279	6499	0.968
44	285.6	0.00453	0.014	1300	1279	6503	0.968
45	292.1	0.00442	0.014	1300	1280	6512	0.970
46	298.6	0.00427	0.0135	1300	1281	6524	0.971
47	303.4	0.00425	0.0135	1300	1282	6525	0.972
48	307.5	0.00442	0.014	1300	1280	6360	0.970
49	312.5	0.00446	0.014	1300	1280	6356	0.969
50	317.7	0.00448	0.014	1300	1280	6354	0.969
51	324.7	0.00243	0.011	1741	1732	11635	0.989
52	333.4	0.00239	0.011	1741	1732	11637	0.989

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-24 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
53	342.1	0.00238	0.011	1741	1732	11638	0.989
54	349.6	0.00399	0.013	1354	1336	6935	0.975
55	355.8	0.00389	0.013	1354	1337	6943	0.976
56	362	0.00375	0.013	1354	1338	6957	0.978
57	368.3	0.00367	0.0125	1354	1339	6966	0.979
58	374.3	0.00184	0.0105	1894	1886	13820	0.993
59	380.2	0.00185	0.0105	1894	1886	13819	0.993
60	387.6	0.00177	0.01	1894	1886	14379	0.993
61	396.6	0.00178	0.0105	1894	1886	14379	0.993
62	405.6	0.00181	0.0105	1894	1886	14376	0.993
63	414.6	0.00187	0.0105	1894	1886	14370	0.993
64	423.6	0.00193	0.0105	1894	1885	14364	0.992
65	432.6	0.00199	0.0105	1894	1885	14358	0.992
66	441.6	0.00202	0.0105	1894	1885	14355	0.991
67	449.7	0.00202	0.0105	1894	1885	14354	0.991
68	457.3	0.00264	0.011	1673	1663	11161	0.988
69	465.3	0.00268	0.0115	1673	1663	11159	0.988
70	473.3	0.0027	0.0115	1673	1663	11158	0.988
71	481.3	0.00269	0.0115	1673	1663	11159	0.988
72	489.3	0.00266	0.0115	1673	1663	11161	0.988
73	496.6	0.00269	0.011	1673	1663	11159	0.988
74	503.9	0.00271	0.007	1673	1666	11210	0.992
75	511.9	0.00271	0.007	1673	1666	11210	0.992
76	519.9	0.00274	0.007	1673	1666	11209	0.992
77	527.9	0.00274	0.007	1673	1666	11208	0.992
78	535.6	0.00273	0.007	1673	1666	11209	0.992
79	543.2	0.00266	0.007	1673	1666	11643	0.992

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-25 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
80	551.2	0.00269	0.007	1673	1666	11641	0.992
81	559.2	0.00273	0.007	1673	1666	11640	0.992
82	567.2	0.00273	0.007	1673	1666	11640	0.992
83	575.2	0.0027	0.007	1673	1666	11641	0.992
84	583.2	0.00268	0.007	1673	1666	11642	0.992
85	591.2	0.00267	0.007	1673	1666	11642	0.992
86	599.2	0.00264	0.007	1673	1666	11643	0.992
87	607.2	0.00265	0.007	1673	1666	11643	0.992
88	615.2	0.00266	0.007	1673	1666	11643	0.992
89	623.2	0.00267	0.007	1673	1667	11642	0.993
90	631.2	0.00266	0.007	1673	1667	11643	0.993
91	639.2	0.00259	0.007	1673	1667	11645	0.993
92	647.2	0.0025	0.007	1673	1667	11648	0.993
93	655.2	0.00242	0.007	1673	1667	11652	0.993
94	663.2	0.00236	0.007	1673	1668	11654	0.994
95	671.2	0.00232	0.007	1673	1668	11655	0.994
96	679.2	0.00229	0.007	1673	1668	11657	0.994
97	687.2	0.00225	0.007	1673	1668	11658	0.994
98	695.2	0.00222	0.007	1673	1668	11660	0.994
99	703.2	0.00221	0.007	1673	1668	11661	0.994
100	711.2	0.00227	0.007	1673	1668	11658	0.994
101	719.2	0.00232	0.007	1673	1668	11656	0.994
102	727.2	0.0024	0.007	1673	1667	11653	0.993
103	735.2	0.00248	0.007	1673	1667	11650	0.993
104	743.2	0.00252	0.007	1673	1667	11649	0.993
105	751.2	0.00251	0.007	1673	1667	11649	0.993
106	759.2	0.0025	0.007	1673	1667	11650	0.993

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-26 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
107	767.2	0.00247	0.007	1673	1667	11651	0.993
108	775.2	0.00242	0.007	1673	1667	11652	0.993
109	783.2	0.00238	0.007	1673	1667	11654	0.993
110	791.2	0.00234	0.007	1673	1667	11655	0.993
111	799.2	0.00233	0.007	1673	1667	11655	0.993
112	807.2	0.00234	0.007	1673	1667	11655	0.993
113	814.7	0.00235	0.007	1673	1667	11655	0.993
114	823.2	0.00166	0.0065	2000	1996	16703	0.996
115	833.2	0.00168	0.007	2000	1996	16701	0.996
116	843.2	0.00168	0.0065	2000	1996	16701	0.996
117	853.2	0.00166	0.0065	2000	1996	16703	0.996
118	863.2	0.00163	0.0065	2000	1996	16707	0.997
119	873.2	0.00163	0.0065	2000	1996	16707	0.997
120	883.2	0.00163	0.0065	2000	1996	16708	0.997
121	893.2	0.00168	0.0065	2000	1996	16703	0.996
122	903.2	0.00171	0.0065	2000	1996	16699	0.996
123	913.2	0.00174	0.007	2000	1995	16696	0.996
124	923.2	0.00177	0.007	2000	1995	16694	0.996
125	933.2	0.00176	0.007	2000	1995	16694	0.996
126	943.2	0.00175	0.007	2000	1995	16695	0.996
127	953.2	0.00175	0.007	2000	1995	16695	0.996
128	963.2	0.00174	0.007	2000	1995	16696	0.996
129	973.2	0.00174	0.007	2000	1995	16697	0.996
130	983.2	0.00172	0.007	2000	1996	16698	0.996
131	993.2	0.00174	0.007	2000	1995	16697	0.996
132	1003.2	0.00176	0.007	2000	1995	16695	0.996
133	1013.2	0.00177	0.007	2000	1995	16694	0.996

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-27 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
134	1023.2	0.00175	0.007	2000	1995	16695	0.996
135	1033.2	0.00174	0.007	2000	1995	16696	0.996
136	1043.2	0.00171	0.007	2000	1996	16699	0.996
137	1053.2	0.00166	0.0065	2000	1996	16703	0.996
138	1063.2	0.00164	0.0065	2000	1996	16705	0.996
139	1073.2	0.00162	0.0065	2000	1996	16707	0.996
140	1083.2	0.00161	0.0065	2000	1996	16707	0.996
141	1093.2	0.00163	0.0065	2000	1996	16706	0.996
142	1103.2	0.00163	0.0065	2000	1996	16706	0.996
143	1113.2	0.00166	0.0065	2000	1996	16703	0.996
144	1123.2	0.00169	0.007	2000	1996	16700	0.996
145	1133.2	0.00172	0.007	2000	1995	16698	0.996
146	1143.2	0.00177	0.007	2000	1995	16694	0.996
147	1153.2	0.00182	0.007	2000	1995	16691	0.996
148	1163.2	0.00186	0.007	2000	1995	16688	0.995
149	1173.2	0.00189	0.007	2000	1995	16686	0.995
150	1183.2	0.00189	0.007	2000	1995	16686	0.995
151	1193.2	0.00187	0.007	2000	1995	16687	0.995
152	1203.2	0.00186	0.007	2000	1995	16688	0.995
153	1213.2	0.00189	0.007	2000	1995	16686	0.995
154	1223.2	0.00192	0.007	2000	1995	16684	0.995
155	1233.2	0.00193	0.007	2000	1995	16683	0.995
156	1243.2	0.00191	0.007	2000	1995	16684	0.995

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-28 of 61

Appendix Table B-6 Strain-Compatible Soil Properties for Case 6 - CEUS Soft Rock, PGA = 0.29 g

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	1.1	0.00133	0.01	0.021	705	689	1747	0.955
2	3.4	0.00404	0.01	0.033	705	660	1601	0.876
3	6.2	0.00724	0.01	0.044	705	630	1460	0.798
4	9.8	0.01009	0.01	0.0515	705	610	1371	0.750
5	13.2	0.01102	0.01	0.0545	705	604	1342	0.734
6	17.5	0.00142	0.01	0.021	1711	1669	10254	0.952
7	21	0.00164	0.01	0.018	1711	1662	10166	0.944
8	25.5	0.002	0.01	0.019	1711	1652	10048	0.933
9	32.5	0.00237	0.01	0.02	1711	1644	9946	0.923
10	39.5	0.00251	0.01	0.02	1711	1641	9912	0.920
11	46.5	0.00274	0.01	0.0205	1711	1637	9859	0.915
12	54.2	0.00293	0.01	0.017	1711	1660	10142	0.942
13	62.8	0.00314	0.01	0.0175	1711	1658	10111	0.939
14	71	0.00327	0.01	0.018	1711	1655	10078	0.936
15	77.5	0.00325	0.01	0.018	1711	1656	10298	0.937
16	82.5	0.00328	0.01	0.018	1711	1654	10286	0.935
17	87.5	0.00327	0.01	0.0175	1711	1654	10277	0.934
18	92.5	0.00333	0.01	0.018	1711	1653	10260	0.933
19	98	0.00346	0.01	0.0185	1711	1650	10230	0.930
20	103	0.0011	0.01	0.013	2981	2954	32789	0.982
21	108.5	0.00111	0.01	0.013	2981	2954	32786	0.982
22	115.5	0.00113	0.01	0.013	2981	2953	32768	0.981
23	119.5	0.00301	0.01	0.017	1894	1836	12675	0.941
24	123	0.00296	0.01	0.014	1894	1872	13172	0.977
25	129.5	0.00304	0.01	0.0145	1894	1870	13153	0.976

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-29 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
26	137	0.0031	0.01	0.0145	1894	1869	13138	0.975
27	146.6	0.0021	0.01	0.0125	2297	2277	19485	0.983
28	157.9	0.00207	0.01	0.0125	2297	2277	19490	0.983
29	169.2	0.00188	0.01	0.012	2297	2279	21136	0.985
30	179.4	0.00296	0.01	0.014	1894	1870	14232	0.975
31	188.4	0.00311	0.01	0.014	1894	1868	14202	0.973
32	197.4	0.00326	0.01	0.0145	1894	1867	14189	0.973
33	206.4	0.0033	0.01	0.0145	1894	1868	14195	0.973
34	215.4	0.00337	0.01	0.0145	1894	1867	14185	0.972
35	224.4	0.00347	0.01	0.015	1894	1864	14154	0.970
36	232.9	0.00374	0.01	0.0155	1894	1861	14092	0.966
37	240.1	0.00899	0.01	0.0215	1300	1237	6084	0.906
38	246.6	0.00897	0.01	0.0215	1300	1238	6085	0.906
39	253.1	0.00841	0.01	0.0185	1300	1259	6297	0.937
40	259.6	0.00841	0.01	0.018	1300	1259	6296	0.938
41	266.1	0.00843	0.01	0.018	1300	1259	6295	0.937
42	272.6	0.0082	0.01	0.018	1300	1260	6304	0.939
43	279.1	0.00767	0.01	0.0175	1300	1262	6328	0.942
44	285.6	0.00687	0.01	0.017	1300	1266	6369	0.948
45	292.1	0.00684	0.01	0.017	1300	1266	6369	0.948
46	298.6	0.00697	0.01	0.017	1300	1265	6361	0.947
47	303.4	0.00698	0.01	0.017	1300	1265	6360	0.947
48	307.5	0.007	0.01	0.017	1300	1265	6210	0.947
49	312.5	0.00688	0.01	0.017	1300	1266	6218	0.948
50	317.7	0.00703	0.01	0.017	1300	1265	6213	0.947
51	324.7	0.00412	0.01	0.0135	1741	1718	11455	0.974
52	333.4	0.00453	0.01	0.014	1741	1714	11401	0.969

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-30 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
53	342.1	0.00481	0.01	0.0145	1741	1712	11365	0.966
54	349.6	0.00838	0.01	0.018	1354	1311	6676	0.938
55	355.8	0.00834	0.01	0.018	1354	1311	6678	0.939
56	362	0.00826	0.01	0.018	1354	1311	6679	0.939
57	368.3	0.00828	0.01	0.0185	1354	1311	6676	0.938
58	374.3	0.00412	0.01	0.014	1894	1868	13546	0.973
59	380.2	0.0042	0.01	0.014	1894	1867	13533	0.972
60	387.6	0.0041	0.01	0.014	1894	1868	14091	0.973
61	396.6	0.00405	0.01	0.0135	1894	1868	14101	0.974
62	405.6	0.00384	0.01	0.0135	1894	1871	14142	0.977
63	414.6	0.00374	0.01	0.013	1894	1872	14162	0.978
64	423.6	0.00404	0.01	0.0135	1894	1869	14105	0.974
65	432.6	0.00452	0.01	0.014	1894	1863	14026	0.969
66	441.6	0.00487	0.01	0.015	1894	1860	13975	0.965
67	449.7	0.00495	0.01	0.0145	1894	1860	13970	0.965
68	457.3	0.0063	0.01	0.0165	1673	1634	10770	0.954
69	465.3	0.00644	0.01	0.0165	1673	1632	10751	0.952
70	473.3	0.00646	0.01	0.0165	1673	1631	10742	0.951
71	481.3	0.00622	0.01	0.0165	1673	1633	10761	0.953
72	489.3	0.00613	0.01	0.0165	1673	1634	10770	0.954
73	496.6	0.00614	0.01	0.016	1673	1634	10771	0.954
74	503.9	0.00616	0.01	0.0085	1673	1647	10957	0.970
75	511.9	0.00628	0.01	0.0085	1673	1647	10948	0.969
76	519.9	0.00611	0.01	0.0085	1673	1647	10961	0.970
77	527.9	0.00573	0.01	0.0085	1673	1650	10989	0.973
78	535.6	0.00562	0.01	0.0085	1673	1651	10999	0.974
79	543.2	0.00536	0.01	0.0085	1673	1652	11446	0.976

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-31 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
80	551.2	0.00544	0.01	0.0085	1673	1652	11438	0.975
81	559.2	0.00545	0.01	0.008	1673	1652	11437	0.975
82	567.2	0.00516	0.01	0.008	1673	1654	11461	0.977
83	575.2	0.00474	0.01	0.008	1673	1656	11498	0.980
84	583.2	0.00433	0.01	0.008	1673	1659	11534	0.983
85	591.2	0.00427	0.01	0.008	1673	1658	11535	0.983
86	599.2	0.00461	0.01	0.008	1673	1657	11509	0.981
87	607.2	0.0048	0.01	0.008	1673	1656	11490	0.980
88	615.2	0.00482	0.01	0.008	1673	1655	11489	0.979
89	623.2	0.00464	0.01	0.008	1673	1657	11507	0.981
90	631.2	0.00462	0.01	0.008	1673	1657	11509	0.981
91	639.2	0.00471	0.01	0.008	1673	1657	11502	0.981
92	647.2	0.00484	0.01	0.008	1673	1655	11492	0.979
93	655.2	0.00491	0.01	0.008	1673	1655	11488	0.979
94	663.2	0.00486	0.01	0.008	1673	1656	11495	0.980
95	671.2	0.00479	0.01	0.008	1673	1656	11500	0.980
96	679.2	0.00494	0.01	0.008	1673	1655	11487	0.979
97	687.2	0.00518	0.01	0.008	1673	1654	11462	0.977
98	695.2	0.00534	0.01	0.008	1673	1652	11447	0.976
99	703.2	0.00528	0.01	0.008	1673	1653	11450	0.976
100	711.2	0.0051	0.01	0.008	1673	1654	11466	0.977
101	719.2	0.00498	0.01	0.008	1673	1654	11478	0.978
102	727.2	0.005	0.01	0.008	1673	1654	11477	0.978
103	735.2	0.00508	0.01	0.008	1673	1654	11468	0.978
104	743.2	0.0051	0.01	0.008	1673	1654	11466	0.977
105	751.2	0.00503	0.01	0.008	1673	1654	11472	0.978
106	759.2	0.00495	0.01	0.008	1673	1655	11479	0.979

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-32 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
107	767.2	0.00494	0.01	0.008	1673	1654	11479	0.978
108	775.2	0.00493	0.01	0.008	1673	1654	11478	0.978
109	783.2	0.00487	0.01	0.008	1673	1655	11482	0.979
110	791.2	0.00476	0.01	0.008	1673	1656	11491	0.980
111	799.2	0.00472	0.01	0.008	1673	1656	11495	0.980
112	807.2	0.00491	0.01	0.008	1673	1654	11479	0.978
113	814.7	0.00502	0.01	0.008	1673	1654	11470	0.978
114	823.2	0.00352	0.01	0.0075	2000	1988	16578	0.989
115	833.2	0.00365	0.01	0.008	2000	1988	16571	0.988
116	843.2	0.00401	0.01	0.008	2000	1985	16521	0.986
117	853.2	0.00422	0.01	0.008	2000	1983	16494	0.984
118	863.2	0.00429	0.01	0.008	2000	1983	16485	0.983
119	873.2	0.00425	0.01	0.008	2000	1983	16489	0.983
120	883.2	0.00409	0.01	0.008	2000	1984	16510	0.985
121	893.2	0.00402	0.01	0.008	2000	1985	16519	0.985
122	903.2	0.00409	0.01	0.008	2000	1984	16508	0.985
123	913.2	0.00412	0.01	0.008	2000	1984	16503	0.984
124	923.2	0.00411	0.01	0.008	2000	1984	16505	0.984
125	933.2	0.00408	0.01	0.008	2000	1984	16509	0.985
126	943.2	0.00411	0.01	0.008	2000	1984	16504	0.985
127	953.2	0.0042	0.01	0.008	2000	1983	16492	0.983
128	963.2	0.00421	0.01	0.008	2000	1983	16491	0.984
129	973.2	0.00414	0.01	0.008	2000	1984	16501	0.984
130	983.2	0.00403	0.01	0.008	2000	1985	16517	0.985
131	993.2	0.00417	0.01	0.008	2000	1984	16496	0.984
132	1003.2	0.00423	0.01	0.008	2000	1983	16487	0.983
133	1013.2	0.00418	0.01	0.008	2000	1983	16494	0.984

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-33 of 61

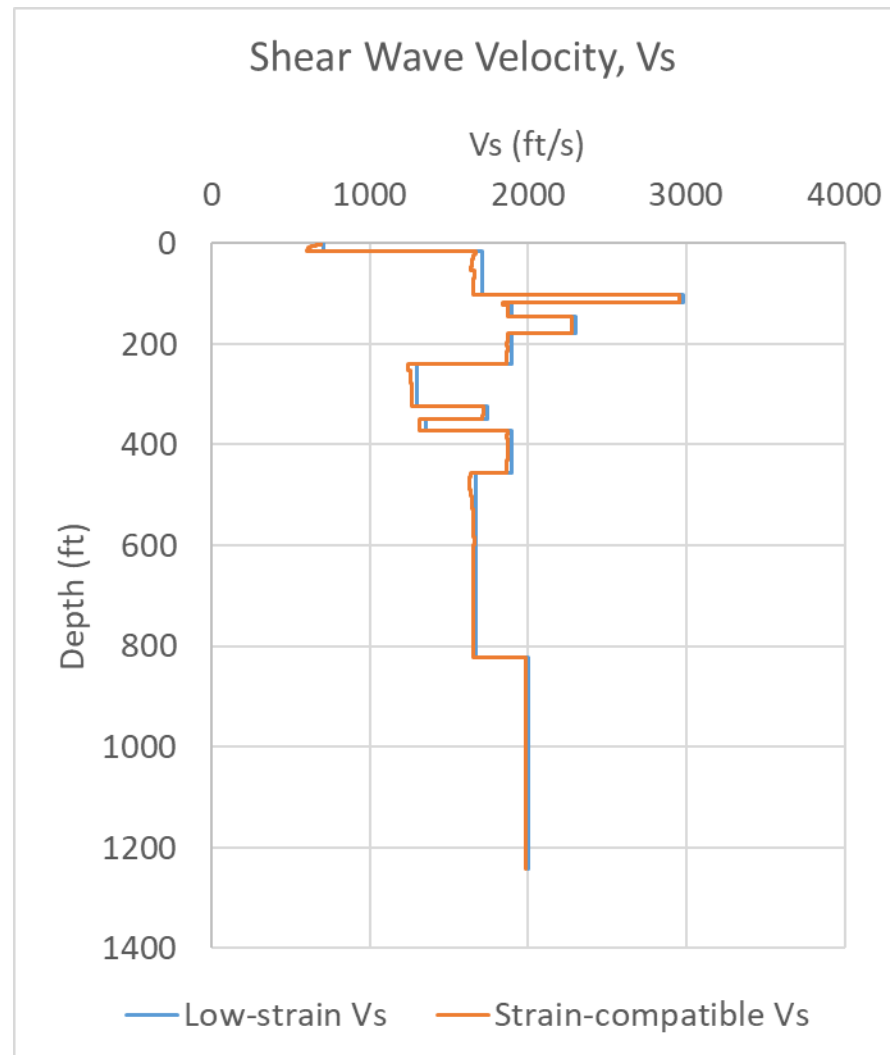
Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
134	1023.2	0.00412	0.01	0.008	2000	1984	16504	0.985
135	1033.2	0.00412	0.01	0.008	2000	1984	16507	0.984
136	1043.2	0.00413	0.01	0.008	2000	1984	16507	0.984
137	1053.2	0.00414	0.01	0.008	2000	1984	16504	0.985
138	1063.2	0.00417	0.01	0.008	2000	1984	16498	0.984
139	1073.2	0.00411	0.01	0.008	2000	1984	16505	0.984
140	1083.2	0.00399	0.01	0.008	2000	1985	16522	0.985
141	1093.2	0.00391	0.01	0.008	2000	1986	16534	0.986
142	1103.2	0.00399	0.01	0.008	2000	1985	16523	0.985
143	1113.2	0.00407	0.01	0.008	2000	1984	16511	0.985
144	1123.2	0.00406	0.01	0.008	2000	1984	16513	0.985
145	1133.2	0.00397	0.01	0.008	2000	1985	16529	0.986
146	1143.2	0.00393	0.01	0.008	2000	1985	16530	0.986
147	1153.2	0.00391	0.01	0.008	2000	1986	16536	0.986
148	1163.2	0.00377	0.01	0.008	2000	1986	16550	0.987
149	1173.2	0.00365	0.01	0.0075	2000	1987	16558	0.988
150	1183.2	0.00359	0.01	0.0075	2000	1987	16560	0.988
151	1193.2	0.00358	0.01	0.0075	2000	1987	16559	0.988
152	1203.2	0.00363	0.01	0.0075	2000	1987	16554	0.987
153	1213.2	0.00369	0.01	0.0075	2000	1986	16547	0.987
154	1223.2	0.00371	0.01	0.0075	2000	1986	16542	0.987
155	1233.2	0.00375	0.01	0.0075	2000	1986	16537	0.986
156	1243.2	0.00387	0.01	0.0075	2000	1986	16531	0.986

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-34 of 61



Appendix Figure B-2 Shear Wave Velocity for Case 6 - CEUS Soft Rock, $PGA=0.29g$.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-35 of 61

Appendix Table B-7 Strain-Compatible Soil Properties for Case 7 - CEUS Soft Rock, $PGA = 0.18 g$

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, V_s (ft/s)	Strain Compatible Shear Wave Velocity, V_s (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	1.1	0.00089	0.018	705	695	1780	0.973
2	3.4	0.00274	0.0265	705	674	1674	0.915
3	6.2	0.00499	0.037	705	649	1550	0.848
4	9.8	0.00761	0.045	705	627	1447	0.791
5	13.2	0.01013	0.0505	705	611	1375	0.752
6	17.5	0.00171	0.023	1711	1660	10140	0.942
7	21	0.00205	0.019	1711	1651	10032	0.931
8	25.5	0.00248	0.02	1711	1642	9917	0.921
9	32.5	0.00306	0.021	1711	1631	9793	0.909
10	39.5	0.00358	0.023	1711	1616	9607	0.892
11	46.5	0.0041	0.025	1711	1599	9411	0.874
12	54.2	0.00437	0.0205	1711	1629	9764	0.907
13	62.8	0.00476	0.0215	1711	1621	9669	0.898
14	71	0.00513	0.022	1711	1614	9588	0.890
15	77.5	0.0052	0.0225	1711	1613	9775	0.889
16	82.5	0.00532	0.0225	1711	1611	9751	0.887
17	87.5	0.00546	0.0225	1711	1608	9721	0.884
18	92.5	0.00558	0.023	1711	1606	9699	0.882
19	98	0.00569	0.023	1711	1605	9680	0.880
20	103	0.00175	0.015	2981	2925	32159	0.963
21	108.5	0.00179	0.015	2981	2924	32127	0.962
22	115.5	0.00184	0.015	2981	2922	32092	0.961
23	119.5	0.00495	0.022	1894	1790	12049	0.894
24	123	0.00469	0.017	1894	1846	12806	0.950
25	129.5	0.00472	0.017	1894	1845	12802	0.950

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-36 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
26	137	0.00471	0.017	1894	1846	12804	0.950
27	146.6	0.00308	0.0145	2297	2267	19328	0.975
28	157.9	0.00317	0.0145	2297	2267	19310	0.974
29	169.2	0.00305	0.014	2297	2269	20954	0.977
30	179.4	0.00482	0.017	1894	1844	13835	0.948
31	188.4	0.00497	0.017	1894	1842	13802	0.946
32	197.4	0.00512	0.018	1894	1840	13774	0.944
33	206.4	0.00538	0.018	1894	1836	13723	0.941
34	215.4	0.00564	0.018	1894	1833	13678	0.937
35	224.4	0.00582	0.0185	1894	1831	13645	0.935
36	232.9	0.00595	0.019	1894	1829	13624	0.934
37	240.1	0.01439	0.029	1300	1198	5701	0.849
38	246.6	0.01451	0.029	1300	1197	5693	0.847
39	253.1	0.01386	0.024	1300	1227	5978	0.890
40	259.6	0.0139	0.024	1300	1226	5976	0.890
41	266.1	0.0139	0.024	1300	1226	5976	0.890
42	272.6	0.0139	0.024	1300	1226	5976	0.890
43	279.1	0.01396	0.024	1300	1226	5972	0.889
44	285.6	0.01408	0.024	1300	1225	5965	0.888
45	292.1	0.0142	0.0245	1300	1225	5959	0.887
46	298.6	0.01434	0.0245	1300	1224	5951	0.886
47	303.4	0.01448	0.0245	1300	1223	5943	0.885
48	307.5	0.015	0.0255	1300	1220	5777	0.881
49	312.5	0.01512	0.0255	1300	1220	5771	0.880
50	317.7	0.01524	0.0255	1300	1219	5764	0.879
51	324.7	0.00802	0.018	1741	1688	11055	0.940
52	333.4	0.00811	0.018	1741	1687	11049	0.939

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-37 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
53	342.1	0.00816	0.018	1741	1687	11045	0.939
54	349.6	0.01428	0.0245	1354	1274	6309	0.887
55	355.8	0.01436	0.0245	1354	1274	6303	0.886
56	362	0.01463	0.025	1354	1272	6287	0.884
57	368.3	0.01486	0.025	1354	1271	6275	0.882
58	374.3	0.00716	0.017	1894	1841	13163	0.946
59	380.2	0.00722	0.0175	1894	1841	13159	0.945
60	387.6	0.00697	0.017	1894	1843	13711	0.947
61	396.6	0.00701	0.017	1894	1843	13711	0.947
62	405.6	0.00709	0.017	1894	1842	13705	0.946
63	414.6	0.00726	0.017	1894	1841	13688	0.945
64	423.6	0.00744	0.017	1894	1840	13672	0.944
65	432.6	0.0076	0.0175	1894	1839	13656	0.943
66	441.6	0.00775	0.0175	1894	1838	13643	0.942
67	449.7	0.0079	0.018	1894	1837	13629	0.941
68	457.3	0.01055	0.02	1673	1604	10386	0.920
69	465.3	0.01072	0.021	1673	1603	10373	0.918
70	473.3	0.01082	0.021	1673	1602	10365	0.918
71	481.3	0.01087	0.021	1673	1602	10362	0.917
72	489.3	0.01088	0.021	1673	1602	10362	0.917
73	496.6	0.01087	0.021	1673	1602	10365	0.918
74	503.9	0.01073	0.012	1673	1624	10650	0.943
75	511.9	0.01096	0.012	1673	1622	10632	0.941
76	519.9	0.0111	0.012	1673	1622	10623	0.940
77	527.9	0.01121	0.0125	1673	1622	10615	0.940
78	535.6	0.01138	0.0125	1673	1620	10603	0.938
79	543.2	0.01111	0.0125	1673	1622	11029	0.940

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-38 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
80	551.2	0.01126	0.0125	1673	1621	11017	0.939
81	559.2	0.01134	0.0125	1673	1621	11011	0.939
82	567.2	0.01139	0.0125	1673	1620	11007	0.938
83	575.2	0.01142	0.0125	1673	1620	11005	0.938
84	583.2	0.01146	0.0125	1673	1620	11003	0.938
85	591.2	0.01147	0.0125	1673	1620	11003	0.938
86	599.2	0.01147	0.0125	1673	1620	11003	0.938
87	607.2	0.01141	0.0125	1673	1620	11008	0.938
88	615.2	0.01128	0.0125	1673	1621	11018	0.939
89	623.2	0.01117	0.012	1673	1622	11027	0.940
90	631.2	0.01112	0.012	1673	1622	11032	0.940
91	639.2	0.01109	0.012	1673	1622	11035	0.941
92	647.2	0.01102	0.012	1673	1622	11041	0.941
93	655.2	0.01094	0.012	1673	1623	11048	0.942
94	663.2	0.01085	0.012	1673	1624	11055	0.942
95	671.2	0.01077	0.012	1673	1624	11060	0.943
96	679.2	0.01071	0.012	1673	1625	11065	0.943
97	687.2	0.01069	0.012	1673	1625	11067	0.943
98	695.2	0.01066	0.012	1673	1625	11070	0.944
99	703.2	0.01063	0.012	1673	1625	11073	0.944
100	711.2	0.01056	0.0115	1673	1626	11079	0.945
101	719.2	0.01056	0.0115	1673	1625	11080	0.944
102	727.2	0.01061	0.0115	1673	1625	11077	0.944
103	735.2	0.01062	0.0115	1673	1625	11077	0.944
104	743.2	0.01056	0.0115	1673	1625	11079	0.944
105	751.2	0.01053	0.012	1673	1626	11080	0.945
106	759.2	0.01056	0.012	1673	1625	11078	0.944

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-39 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
107	767.2	0.01062	0.012	1673	1625	11075	0.944
108	775.2	0.0107	0.012	1673	1625	11071	0.944
109	783.2	0.01079	0.012	1673	1625	11066	0.943
110	791.2	0.01077	0.012	1673	1625	11067	0.943
111	799.2	0.01067	0.012	1673	1625	11072	0.944
112	807.2	0.01056	0.012	1673	1625	11078	0.944
113	814.7	0.01044	0.012	1673	1626	11085	0.945
114	823.2	0.00711	0.009	2000	1963	16152	0.963
115	833.2	0.00708	0.009	2000	1963	16156	0.963
116	843.2	0.0071	0.009	2000	1963	16154	0.964
117	853.2	0.00712	0.009	2000	1963	16151	0.963
118	863.2	0.00718	0.009	2000	1962	16144	0.963
119	873.2	0.00726	0.0095	2000	1962	16135	0.962
120	883.2	0.00736	0.0095	2000	1961	16125	0.962
121	893.2	0.00744	0.0095	2000	1961	16115	0.961
122	903.2	0.00752	0.01	2000	1960	16106	0.961
123	913.2	0.00766	0.01	2000	1959	16092	0.960
124	923.2	0.00784	0.01	2000	1958	16073	0.959
125	933.2	0.00804	0.01	2000	1957	16053	0.958
126	943.2	0.00822	0.01	2000	1956	16035	0.956
127	953.2	0.00836	0.01	2000	1955	16021	0.956
128	963.2	0.00845	0.0105	2000	1954	16012	0.955
129	973.2	0.00852	0.0105	2000	1954	16006	0.955
130	983.2	0.00857	0.0105	2000	1954	16002	0.955
131	993.2	0.00859	0.0105	2000	1953	15999	0.954
132	1003.2	0.00861	0.0105	2000	1953	15998	0.954
133	1013.2	0.00862	0.0105	2000	1953	15996	0.954

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-40 of 61

Sublayer#	Depth (ft)	Strain	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
134	1023.2	0.00865	0.0105	2000	1953	15995	0.954
135	1033.2	0.00868	0.0105	2000	1953	15993	0.954
136	1043.2	0.00872	0.0105	2000	1953	15990	0.954
137	1053.2	0.00878	0.0105	2000	1953	15986	0.954
138	1063.2	0.00887	0.0105	2000	1952	15977	0.953
139	1073.2	0.00895	0.0105	2000	1952	15970	0.953
140	1083.2	0.00898	0.0105	2000	1952	15966	0.953
141	1093.2	0.009	0.0105	2000	1951	15964	0.952
142	1103.2	0.00902	0.0105	2000	1951	15961	0.952
143	1113.2	0.00898	0.0105	2000	1951	15964	0.952
144	1123.2	0.00895	0.011	2000	1951	15966	0.952
145	1133.2	0.00891	0.011	2000	1952	15970	0.953
146	1143.2	0.00884	0.011	2000	1952	15976	0.953
147	1153.2	0.00869	0.0105	2000	1953	15990	0.954
148	1163.2	0.00855	0.0105	2000	1954	16004	0.955
149	1173.2	0.00859	0.0105	2000	1954	15999	0.955
150	1183.2	0.00863	0.0105	2000	1953	15996	0.954
151	1193.2	0.00864	0.0105	2000	1953	15995	0.954
152	1203.2	0.00862	0.0105	2000	1953	15997	0.954
153	1213.2	0.00859	0.0105	2000	1953	16000	0.954
154	1223.2	0.00855	0.0105	2000	1953	16004	0.954
155	1233.2	0.0085	0.0105	2000	1954	16008	0.955
156	1243.2	0.00847	0.0105	2000	1954	16011	0.955

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-41 of 61

Appendix Table B-8 Strain-Compatible Soil Properties for Case 8 - WUS Soil, PGA =0.23 g

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	0.8	0.00306	0.01	0.028	360	344	384	0.909
2	2.2	0.0112	0.01	0.0545	360	308	309	0.731
3	3.8	0.02284	0.01	0.0815	360	275	246	0.582
4	5.2	0.03934	0.01	0.104	360	246	197	0.468
5	7.1	0.02287	0.01	0.081	485	370	446	0.582
6	9.4	0.03504	0.01	0.098	485	340	377	0.492
7	11.8	0.05117	0.01	0.1175	485	311	316	0.412
8	14.3	0.03401	0.01	0.0965	582	411	550	0.498
9	16.9	0.04235	0.01	0.108	582	391	498	0.452
10	19.1	0.04986	0.01	0.116	582	376	461	0.418
11	20.5	0.03888	0.01	0.08	582	438	626	0.567
12	22.5	0.03507	0.01	0.075	624	478	747	0.589
13	25.5	0.04009	0.01	0.0805	624	468	716	0.564
14	28.5	0.04462	0.01	0.0845	624	460	693	0.546
15	31.5	0.04859	0.01	0.087	624	455	678	0.534
16	34.5	0.04142	0.01	0.0805	624	469	833	0.570
17	37.5	0.04511	0.01	0.083	624	464	816	0.558
18	40.5	0.04971	0.01	0.087	624	456	789	0.540
19	43.5	0.05396	0.01	0.09	624	449	767	0.524
20	46.5	0.01799	0.01	0.0515	915	780	2296	0.730
21	49	0.01539	0.01	0.0475	915	794	2767	0.755
22	51	0.01454	0.01	0.036	915	826	2990	0.816
23	54	0.01529	0.01	0.0365	915	822	2967	0.809
24	58.5	0.00585	0.01	0.0225	1414	1355	8265	0.918
25	64	0.0065	0.01	0.024	1414	1347	8171	0.908

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-42 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
26	70	0.00712	0.01	0.025	1414	1341	8094	0.899
27	76	0.0077	0.01	0.0255	1414	1335	8029	0.892
28	82	0.00824	0.01	0.026	1414	1330	7973	0.886
29	87.5	0.00145	0.01	0.0145	3285	3260	47882	0.985
30	98	0.00161	0.01	0.0145	3285	3256	47766	0.983
31	113	0.00181	0.01	0.015	3285	3253	47638	0.981
32	121	0.0019	0.01	0.012	3285	3260	47832	0.985
33	130	0.00201	0.01	0.012	3285	3258	47787	0.984
34	146	0.0022	0.01	0.013	3285	3255	47714	0.982
35	162	0.00246	0.01	0.013	3285	3252	47626	0.980
36	178	0.00271	0.01	0.0135	3285	3250	47550	0.979
37	194	0.00293	0.01	0.014	3285	3248	47490	0.978
38	210	0.0031	0.01	0.0145	3285	3245	47404	0.976
39	226	0.00324	0.01	0.0145	3285	3240	47274	0.973
40	242	0.00341	0.01	0.015	3285	3236	47149	0.971
41	252.5	0.01678	0.01	0.0265	1594	1485	9937	0.869
42	258.8	0.01703	0.01	0.0265	1594	1484	9920	0.867
43	266.2	0.0173	0.01	0.027	1594	1482	9900	0.865
44	273.8	0.01747	0.01	0.0275	1594	1482	9889	0.864
45	281.2	0.01754	0.01	0.027	1594	1482	9886	0.865
46	288.8	0.01763	0.01	0.027	1594	1482	9883	0.864
47	296.2	0.01762	0.01	0.027	1594	1482	9887	0.865
48	304	0.00796	0.01	0.0175	2259	2192	21622	0.941
49	312	0.00791	0.01	0.0175	2259	2192	21633	0.941
50	320.5	0.00785	0.01	0.0175	2259	2193	21646	0.942
51	328.8	0.01904	0.01	0.028	1525	1411	8970	0.857
52	336.2	0.01895	0.01	0.028	1525	1411	8978	0.857

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-43 of 61

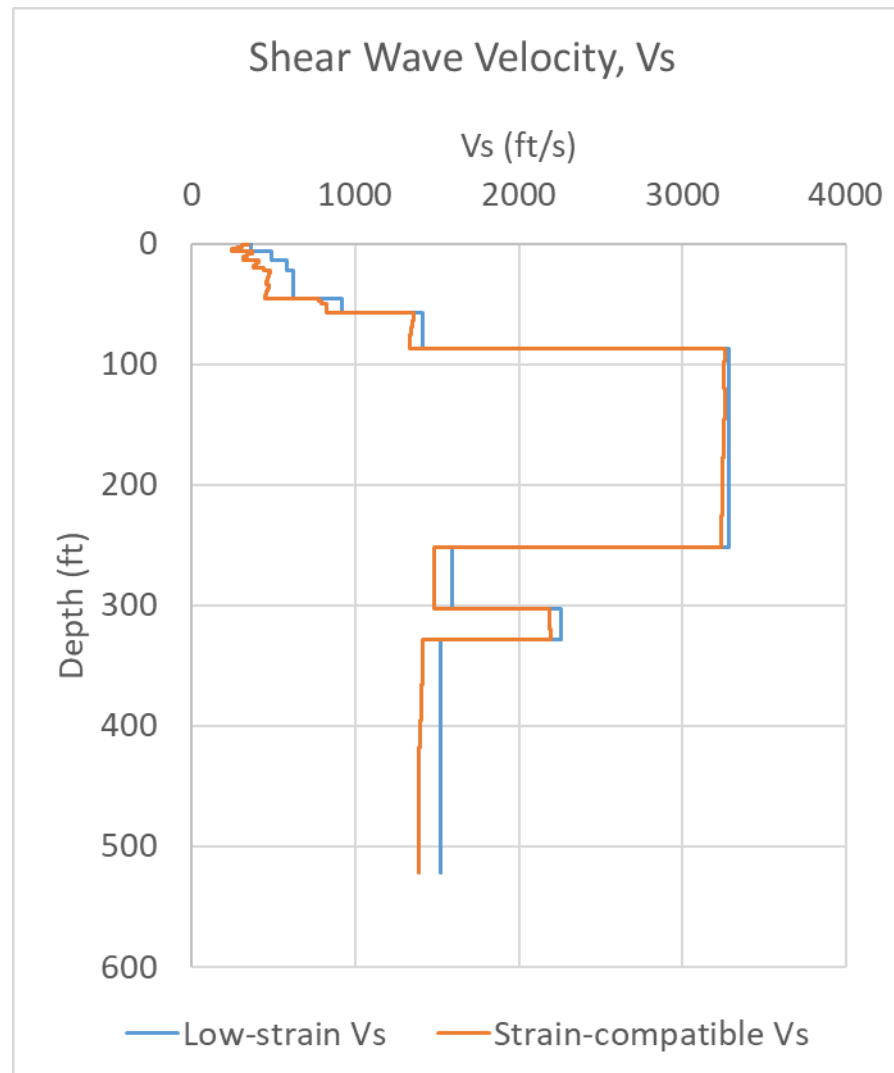
Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
53	343.8	0.0191	0.01	0.028	1525	1411	8968	0.857
54	351.2	0.01925	0.01	0.028	1525	1410	8957	0.856
55	358.8	0.01942	0.01	0.028	1525	1409	8947	0.854
56	366.2	0.01981	0.01	0.0285	1525	1407	8919	0.852
57	373.8	0.02022	0.01	0.029	1525	1405	8892	0.849
58	381.2	0.02056	0.01	0.029	1525	1403	8874	0.847
59	388.8	0.02102	0.01	0.029	1525	1401	8850	0.845
60	396.2	0.02146	0.01	0.03	1525	1400	8827	0.843
61	403.8	0.0221	0.01	0.03	1525	1396	8787	0.839
62	411.2	0.0227	0.01	0.03	1525	1394	8754	0.836
63	418.8	0.02322	0.01	0.031	1525	1392	8726	0.834
64	426.2	0.0236	0.01	0.031	1525	1390	8706	0.832
65	433.8	0.02392	0.01	0.031	1525	1389	8689	0.830
66	441.2	0.02417	0.01	0.031	1525	1388	8678	0.829
67	448.8	0.02432	0.01	0.031	1525	1387	8671	0.828
68	456.2	0.02448	0.01	0.0315	1525	1386	8665	0.827
69	463.8	0.0245	0.01	0.0315	1525	1387	8665	0.828
70	471.2	0.02438	0.01	0.0315	1525	1387	8674	0.828
71	478.8	0.02429	0.01	0.0315	1525	1388	8681	0.829
72	486.2	0.02409	0.01	0.031	1525	1389	8695	0.830
73	493.8	0.02384	0.01	0.031	1525	1390	8712	0.832
74	501.2	0.02366	0.01	0.031	1525	1391	8726	0.833
75	508.8	0.02377	0.01	0.031	1525	1391	8719	0.833
76	516.2	0.02399	0.01	0.031	1525	1390	8704	0.831
77	522.5	0.02425	0.01	0.031	1525	1388	8686	0.830

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-44 of 61



Appendix Figure B-3 Shear Wave Velocity for Case 8 - WUS Soil, $PGA=0.23g$.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-45 of 61

Appendix Table B-9 Strain-Compatible Soil Properties for Case 9 - WUS Soil, PGA =0.14 g

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax	Poisson	Initial Vp (ft/s)
1	0.8	0.00179	0.01	0.023	360	349	397	0.939	0.35	750.224
2	2.2	0.00612	0.01	0.041	360	326	347	0.820	0.35	750.224
3	3.8	0.01141	0.01	0.055	360	307	307	0.727	0.35	750.224
4	5.2	0.01845	0.01	0.0735	360	285	265	0.626	0.35	750.224
5	7.1	0.01174	0.01	0.056	485	412	553	0.721	0.35	1009.917
6	9.4	0.0171	0.01	0.0705	485	389	492	0.642	0.35	1009.917
7	11.8	0.02317	0.01	0.0815	485	369	444	0.579	0.35	1009.917
8	14.3	0.01718	0.01	0.0705	582	466	708	0.641	0.35	1211.902
9	16.9	0.0215	0.01	0.0785	582	449	656	0.594	0.35	1211.902
10	19.1	0.02554	0.01	0.0855	582	435	616	0.558	0.35	1211.902
11	20.5	0.02263	0.01	0.0605	582	477	741	0.671	0.35	1211.902
12	22.5	0.02089	0.01	0.058	624	516	870	0.686	0.35	1298.465
13	25.5	0.02433	0.01	0.0625	624	506	834	0.657	0.35	1298.465
14	28.5	0.02792	0.01	0.067	624	496	802	0.632	0.35	1298.465
15	31.5	0.03168	0.01	0.071	624	486	772	0.608	0.35	1298.465
16	34.5	0.02901	0.01	0.0675	624	493	914	0.625	0.35	1298.465
17	37.5	0.03251	0.01	0.072	624	484	882	0.603	0.35	1298.465
18	40.5	0.03614	0.01	0.076	624	476	853	0.583	0.35	1298.465
19	43.5	0.03991	0.01	0.0805	624	468	824	0.564	0.35	1298.465
20	46.5	0.01466	0.01	0.0475	915	794	2367	0.753	0.33	1816.195
21	49	0.0128	0.01	0.044	915	807	2851	0.778	0.33	1816.195
22	51	0.01243	0.01	0.033	915	835	3057	0.834	0.33	1816.195
23	54	0.01339	0.01	0.035	915	829	3013	0.822	0.33	1816.195

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-46 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax	Poisson	Initial Vp (ft/s)
24	58.5	0.00525	0.01	0.022	1414	1360	8328	0.925	0.39	3329.472
25	64	0.00583	0.01	0.023	1414	1353	8245	0.916	0.39	3329.472
26	70	0.00651	0.01	0.024	1414	1346	8159	0.906	0.39	3329.472
27	76	0.0072	0.01	0.025	1414	1339	8078	0.897	0.39	3329.472
28	82	0.00788	0.01	0.026	1414	1333	8006	0.890	0.39	3329.472
29	87.5	0.0014	0.01	0.014	3285	3262	47918	0.986	0.36	7023.943
30	98	0.00158	0.01	0.0145	3285	3258	47788	0.984	0.36	7023.943
31	113	0.00183	0.01	0.015	3285	3252	47627	0.980	0.36	7023.943
32	121	0.00195	0.01	0.0125	3285	3259	47811	0.984	0.36	7023.943
33	130	0.0021	0.01	0.0125	3285	3256	47754	0.983	0.36	7023.943
34	146	0.00236	0.01	0.013	3285	3254	47661	0.981	0.36	7023.943
35	162	0.00262	0.01	0.0135	3285	3250	47580	0.979	0.36	7023.943
36	178	0.00287	0.01	0.0135	3285	3248	47507	0.978	0.36	7023.943
37	194	0.00312	0.01	0.0145	3285	3244	47373	0.975	0.36	7023.943
38	210	0.00338	0.01	0.0145	3285	3238	47209	0.972	0.36	7023.943
39	226	0.00363	0.01	0.0155	3285	3231	47014	0.968	0.36	7023.943
40	242	0.00388	0.01	0.0155	3285	3224	46796	0.963	0.36	7023.943
41	252.5	0.01949	0.01	0.0285	1594	1470	9726	0.850	0.36	3408.242
42	258.8	0.01997	0.01	0.0295	1594	1467	9693	0.847	0.36	3408.242
43	266.2	0.02052	0.01	0.0295	1594	1464	9657	0.844	0.36	3408.242
44	273.8	0.02104	0.01	0.0295	1594	1462	9623	0.841	0.36	3408.242
45	281.2	0.02155	0.01	0.0305	1594	1460	9591	0.839	0.36	3408.242
46	288.8	0.02204	0.01	0.0305	1594	1457	9560	0.836	0.36	3408.242
47	296.2	0.02252	0.01	0.0305	1594	1455	9530	0.833	0.36	3408.242
48	304	0.01028	0.01	0.02	2259	2171	21217	0.923	0.36	4830.813
49	312	0.01053	0.01	0.02	2259	2169	21172	0.922	0.36	4830.813
50	320.5	0.01083	0.01	0.0205	2259	2166	21122	0.919	0.36	4830.813

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-47 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax	Poisson	Initial Vp (ft/s)
51	328.8	0.0277	0.01	0.0335	1525	1371	8464	0.809	0.36	3260.058
52	336.2	0.02837	0.01	0.034	1525	1368	8434	0.806	0.36	3260.058
53	343.8	0.02902	0.01	0.0345	1525	1366	8405	0.803	0.36	3260.058
54	351.2	0.02966	0.01	0.035	1525	1363	8373	0.800	0.36	3260.058
55	358.8	0.03025	0.01	0.0355	1525	1361	8342	0.797	0.36	3260.058
56	366.2	0.03075	0.01	0.0355	1525	1359	8316	0.794	0.36	3260.058
57	373.8	0.03123	0.01	0.0365	1525	1357	8292	0.792	0.36	3260.058
58	381.2	0.03168	0.01	0.0365	1525	1355	8269	0.790	0.36	3260.058
59	388.8	0.03207	0.01	0.0365	1525	1353	8250	0.788	0.36	3260.058
60	396.2	0.03238	0.01	0.0365	1525	1352	8235	0.787	0.36	3260.058
61	403.8	0.03265	0.01	0.037	1525	1351	8223	0.785	0.36	3260.058
62	411.2	0.03282	0.01	0.037	1525	1350	8216	0.785	0.36	3260.058
63	418.8	0.03299	0.01	0.0375	1525	1350	8209	0.784	0.36	3260.058
64	426.2	0.03312	0.01	0.0375	1525	1349	8201	0.783	0.36	3260.058
65	433.8	0.03318	0.01	0.037	1525	1349	8197	0.783	0.36	3260.058
66	441.2	0.03316	0.01	0.037	1525	1349	8197	0.783	0.36	3260.058
67	448.8	0.0331	0.01	0.0375	1525	1349	8201	0.783	0.36	3260.058
68	456.2	0.03298	0.01	0.0375	1525	1350	8208	0.784	0.36	3260.058
69	463.8	0.0328	0.01	0.037	1525	1351	8218	0.785	0.36	3260.058
70	471.2	0.03254	0.01	0.037	1525	1352	8234	0.786	0.36	3260.058
71	478.8	0.03224	0.01	0.0365	1525	1354	8252	0.788	0.36	3260.058
72	486.2	0.03194	0.01	0.0365	1525	1355	8270	0.790	0.36	3260.058
73	493.8	0.03171	0.01	0.036	1525	1356	8281	0.791	0.36	3260.058
74	501.2	0.03153	0.01	0.036	1525	1356	8288	0.791	0.36	3260.058
75	508.8	0.03137	0.01	0.036	1525	1357	8295	0.792	0.36	3260.058
76	516.2	0.03125	0.01	0.036	1525	1358	8300	0.793	0.36	3260.058
77	522.5	0.03118	0.01	0.036	1525	1358	8303	0.793	0.36	3260.058

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-48 of 61

Appendix Table B-10 Strain-Compatible Soil Properties for Case 10 - WUS Soil, PGA =0.19 g

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	0.8	0.0025	0.01	0.026	360	346	389	0.921
2	2.2	0.00877	0.01	0.0475	360	317	326	0.772
3	3.8	0.01715	0.01	0.0705	360	289	271	0.642
4	5.2	0.02828	0.01	0.089	360	264	227	0.537
5	7.1	0.01719	0.01	0.0705	485	389	492	0.642
6	9.4	0.02553	0.01	0.085	485	362	428	0.558
7	11.8	0.03604	0.01	0.1	485	338	372	0.486
8	14.3	0.0253	0.01	0.0845	582	435	618	0.560
9	16.9	0.03106	0.01	0.0925	582	418	571	0.517
10	19.1	0.03616	0.01	0.1	582	405	535	0.485
11	20.5	0.02977	0.01	0.0685	582	458	684	0.620
12	22.5	0.02716	0.01	0.066	624	498	809	0.637
13	25.5	0.03109	0.01	0.0705	624	488	777	0.612
14	28.5	0.0346	0.01	0.0745	624	480	753	0.593
15	31.5	0.03773	0.01	0.0775	624	474	736	0.580
16	34.5	0.03264	0.01	0.072	624	487	894	0.611
17	37.5	0.03461	0.01	0.074	624	484	885	0.605
18	40.5	0.03743	0.01	0.0765	624	479	868	0.593
19	43.5	0.04067	0.01	0.0795	624	472	845	0.578
20	46.5	0.01442	0.01	0.0455	915	799	2405	0.765
21	49	0.01249	0.01	0.043	915	810	2876	0.785
22	51	0.01202	0.01	0.033	915	838	3077	0.840
23	54	0.01272	0.01	0.0335	915	834	3051	0.833
24	58.5	0.00488	0.01	0.021	1414	1367	8422	0.936

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-49 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
25	64	0.00545	0.01	0.0225	1414	1359	8321	0.925
26	70	0.00604	0.01	0.023	1414	1352	8231	0.914
27	76	0.00659	0.01	0.024	1414	1346	8156	0.906
28	82	0.00711	0.01	0.025	1414	1340	8093	0.899
29	87.5	0.00127	0.01	0.0135	3285	3266	48036	0.989
30	98	0.0014	0.01	0.014	3285	3262	47925	0.986
31	113	0.00158	0.01	0.0145	3285	3258	47787	0.984
32	121	0.00166	0.01	0.012	3285	3263	47935	0.987
33	130	0.00176	0.01	0.012	3285	3261	47889	0.986
34	146	0.00194	0.01	0.012	3285	3259	47816	0.984
35	162	0.00212	0.01	0.013	3285	3256	47745	0.983
36	178	0.00228	0.01	0.013	3285	3255	47686	0.982
37	194	0.00243	0.01	0.013	3285	3253	47638	0.981
38	210	0.00257	0.01	0.013	3285	3250	47590	0.979
39	226	0.00269	0.01	0.0135	3285	3250	47556	0.979
40	242	0.00281	0.01	0.0135	3285	3249	47525	0.978
41	252.5	0.01332	0.01	0.023	1594	1508	10239	0.895
42	258.8	0.01342	0.01	0.0235	1594	1507	10231	0.894
43	266.2	0.01348	0.01	0.0235	1594	1507	10227	0.894
44	273.8	0.01357	0.01	0.0235	1594	1506	10218	0.893
45	281.2	0.01364	0.01	0.0235	1594	1506	10213	0.893
46	288.8	0.01368	0.01	0.024	1594	1506	10211	0.893
47	296.2	0.01372	0.01	0.024	1594	1506	10210	0.893
48	304	0.00637	0.01	0.016	2259	2204	21866	0.952
49	312	0.00634	0.01	0.016	2259	2204	21873	0.952
50	320.5	0.00631	0.01	0.016	2259	2204	21883	0.952
51	328.8	0.01499	0.01	0.025	1525	1433	9251	0.883

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-50 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
52	336.2	0.01498	0.01	0.0245	1525	1433	9257	0.884
53	343.8	0.01521	0.01	0.0245	1525	1432	9241	0.883
54	351.2	0.01544	0.01	0.025	1525	1431	9225	0.881
55	358.8	0.01567	0.01	0.025	1525	1430	9210	0.880
56	366.2	0.01602	0.01	0.0255	1525	1428	9184	0.877
57	373.8	0.01647	0.01	0.026	1525	1425	9149	0.874
58	381.2	0.01689	0.01	0.026	1525	1423	9119	0.871
59	388.8	0.0173	0.01	0.0265	1525	1420	9090	0.868
60	396.2	0.01762	0.01	0.027	1525	1419	9070	0.867
61	403.8	0.01791	0.01	0.027	1525	1417	9052	0.865
62	411.2	0.01838	0.01	0.027	1525	1415	9018	0.861
63	418.8	0.01879	0.01	0.028	1525	1412	8990	0.859
64	426.2	0.01912	0.01	0.028	1525	1411	8968	0.857
65	433.8	0.01935	0.01	0.028	1525	1410	8953	0.855
66	441.2	0.01956	0.01	0.028	1525	1408	8939	0.854
67	448.8	0.01973	0.01	0.028	1525	1408	8929	0.853
68	456.2	0.01982	0.01	0.0285	1525	1408	8924	0.853
69	463.8	0.01984	0.01	0.0285	1525	1408	8926	0.853
70	471.2	0.01974	0.01	0.0285	1525	1408	8935	0.854
71	478.8	0.01961	0.01	0.0285	1525	1409	8947	0.854
72	486.2	0.01944	0.01	0.0285	1525	1410	8961	0.856
73	493.8	0.0192	0.01	0.0275	1525	1411	8978	0.857
74	501.2	0.01897	0.01	0.0275	1525	1412	8993	0.859
75	508.8	0.01874	0.01	0.0275	1525	1414	9008	0.860
76	516.2	0.01872	0.01	0.0275	1525	1414	9010	0.861
77	522.5	0.01873	0.01	0.0275	1525	1414	9010	0.861

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-51 of 61

Appendix Table B-11 Strain-Compatible Soil Properties for Case 11 - WUS Soft Rock, $PGA = 0.22 g$

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, V_s (ft/s)	Strain Compatible Shear Wave Velocity, V_s (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	2.5	0.00077	0.01	0.018	1247	1233	5660	0.977
2	7.5	0.00234	0.01	0.0255	1247	1199	5354	0.924
3	12.5	0.00383	0.01	0.032	1247	1172	5115	0.883
4	18	0.00545	0.01	0.039	1247	1140	4843	0.836
5	23	0.00604	0.01	0.03	1277	1193	5309	0.874
6	27.5	0.00701	0.01	0.0315	1277	1183	5219	0.859
7	32.5	0.00801	0.01	0.0335	1277	1174	5139	0.846
8	37.5	0.00706	0.01	0.032	1410	1307	6364	0.859
9	42.5	0.00761	0.01	0.0325	1410	1302	6312	0.852
10	48.5	0.00802	0.01	0.0335	1448	1332	6613	0.847
11	55.5	0.0073	0.01	0.0315	1481	1430	7943	0.933
12	62.5	0.00785	0.01	0.033	1481	1425	7882	0.926
13	69.5	0.00825	0.01	0.0335	1481	1422	7846	0.922
14	76.5	0.00849	0.01	0.034	1481	1420	7823	0.919
15	83.5	0.0086	0.01	0.0345	1481	1419	7814	0.918
16	90.5	0.00861	0.01	0.034	1481	1419	7818	0.918
17	97.5	0.00892	0.01	0.0345	1481	1416	7785	0.915
18	104.5	0.00915	0.01	0.0355	1481	1414	7761	0.912
19	110	0.00926	0.01	0.0355	1481	1413	7750	0.911
20	115	0.00798	0.01	0.033	1586	1525	9032	0.925
21	121	0.00801	0.01	0.033	1586	1524	9029	0.925
22	127	0.00803	0.01	0.0335	1586	1524	9025	0.925
23	133.5	0.00804	0.01	0.033	1586	1524	9020	0.924
24	140.5	0.00683	0.01	0.0305	1706	1653	10609	0.939

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-52 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
25	147.5	0.00679	0.01	0.0305	1706	1654	10616	0.940
26	155	0.00673	0.01	0.0305	1706	1654	10624	0.941
27	163	0.00635	0.01	0.019	1756	1693	11215	0.930
28	170	0.00633	0.01	0.0295	1773	1724	11530	0.945
29	176	0.00652	0.01	0.03	1773	1721	11503	0.943
30	182.5	0.00668	0.01	0.03	1773	1720	11481	0.941
31	189	0.00673	0.01	0.019	1789	1722	11595	0.926
32	195	0.00684	0.01	0.0195	1789	1720	11582	0.925
33	201.5	0.00698	0.01	0.02	1789	1719	11565	0.924
34	207.5	0.00653	0.01	0.03	1852	1797	12548	0.942
35	215	0.00491	0.01	0.0265	2136	2094	17015	0.961
36	225	0.0051	0.01	0.027	2136	2092	16982	0.959
37	234	0.00478	0.01	0.017	2243	2185	18686	0.949
38	243	0.00365	0.01	0.0235	2568	2536	24971	0.976
39	253	0.00373	0.01	0.0235	2568	2535	24944	0.975
40	263	0.00377	0.01	0.0235	2568	2534	24928	0.974
41	273	0.0038	0.01	0.024	2568	2534	24915	0.974
42	284	0.00379	0.01	0.024	2568	2533	24913	0.973
43	295.2	0.00374	0.01	0.024	2568	2534	24925	0.974
44	305.8	0.00368	0.01	0.024	2568	2534	24945	0.974
45	316	0.00345	0.01	0.0125	2568	2544	26134	0.982
46	326	0.00344	0.01	0.0125	2568	2545	26141	0.982
47	336	0.00351	0.01	0.0125	2568	2543	26111	0.981
48	349.5	0.00138	0.01	0.009	4000	3992	69286	0.996
49	366.5	0.00148	0.01	0.01	4000	3990	69220	0.995
50	383.5	0.00159	0.01	0.01	4000	3988	69160	0.994
51	400.5	0.00169	0.01	0.01	4000	3986	69106	0.993

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-53 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
52	418	0.00179	0.01	0.01	4000	3986	69056	0.993

Appendix Table B-12 Strain-Compatible Soil Properties for Case 12 - WUS Soft Rock, PGA =0.52 g

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	2.5	0.00186	0.01	0.024	1247	1207	5427	0.937
2	7.5	0.00621	0.01	0.041	1247	1128	4740	0.818
3	12.5	0.01094	0.01	0.0535	1247	1070	4265	0.736
4	18	0.01608	0.01	0.068	1247	1010	3799	0.656
5	23	0.01584	0.01	0.05	1277	1096	4482	0.737
6	27.5	0.01934	0.01	0.056	1277	1068	4254	0.701
7	32.5	0.02403	0.01	0.062	1277	1037	4010	0.660
8	37.5	0.02165	0.01	0.059	1410	1162	5031	0.679
9	42.5	0.02477	0.01	0.063	1410	1140	4846	0.654
10	48.5	0.02589	0.01	0.0645	1448	1164	5045	0.646
11	55.5	0.02023	0.01	0.0505	1481	1339	6956	0.817
12	62.5	0.02179	0.01	0.052	1481	1329	6848	0.805
13	69.5	0.02358	0.01	0.053	1481	1316	6724	0.790
14	76.5	0.02558	0.01	0.0545	1481	1304	6595	0.775
15	83.5	0.02735	0.01	0.0555	1481	1293	6490	0.762
16	90.5	0.02879	0.01	0.056	1481	1285	6409	0.753
17	97.5	0.02983	0.01	0.057	1481	1279	6353	0.746
18	104.5	0.0305	0.01	0.0575	1481	1276	6322	0.743
19	110	0.03083	0.01	0.0575	1481	1275	6309	0.741
20	115	0.02597	0.01	0.0545	1586	1393	7537	0.772

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-54 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
21	121	0.0264	0.01	0.055	1586	1390	7508	0.769
22	127	0.0268	0.01	0.0555	1586	1388	7480	0.766
23	133.5	0.02704	0.01	0.0555	1586	1386	7463	0.765
24	140.5	0.02244	0.01	0.0525	1706	1524	9025	0.799
25	147.5	0.02256	0.01	0.0525	1706	1524	9014	0.798
26	155	0.02254	0.01	0.0525	1706	1524	9016	0.798
27	163	0.02111	0.01	0.0365	1756	1567	9602	0.796
28	170	0.02036	0.01	0.0505	1773	1602	9962	0.817
29	176	0.02021	0.01	0.0505	1773	1603	9974	0.818
30	182.5	0.02005	0.01	0.0505	1773	1605	9992	0.819
31	189	0.01991	0.01	0.035	1789	1604	10067	0.804
32	195	0.0196	0.01	0.035	1789	1606	10094	0.806
33	201.5	0.01915	0.01	0.0345	1789	1609	10134	0.809
34	207.5	0.01751	0.01	0.048	1852	1693	11123	0.836
35	215	0.01315	0.01	0.042	2136	1991	15380	0.869
36	225	0.0138	0.01	0.0435	2136	1985	15283	0.863
37	234	0.01297	0.01	0.027	2243	2084	16988	0.863
38	243	0.00969	0.01	0.0365	2568	2440	23118	0.903
39	253	0.00998	0.01	0.037	2568	2436	23041	0.900
40	263	0.01046	0.01	0.038	2568	2429	22910	0.895
41	273	0.0109	0.01	0.039	2568	2423	22791	0.891
42	284	0.01143	0.01	0.0395	2568	2416	22657	0.885
43	295.2	0.012	0.01	0.0405	2568	2408	22522	0.880
44	305.8	0.01278	0.01	0.042	2568	2399	22330	0.873
45	316	0.01249	0.01	0.0225	2568	2439	24030	0.903
46	326	0.01318	0.01	0.023	2568	2431	23857	0.896
47	336	0.01375	0.01	0.024	2568	2424	23720	0.891

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-55 of 61

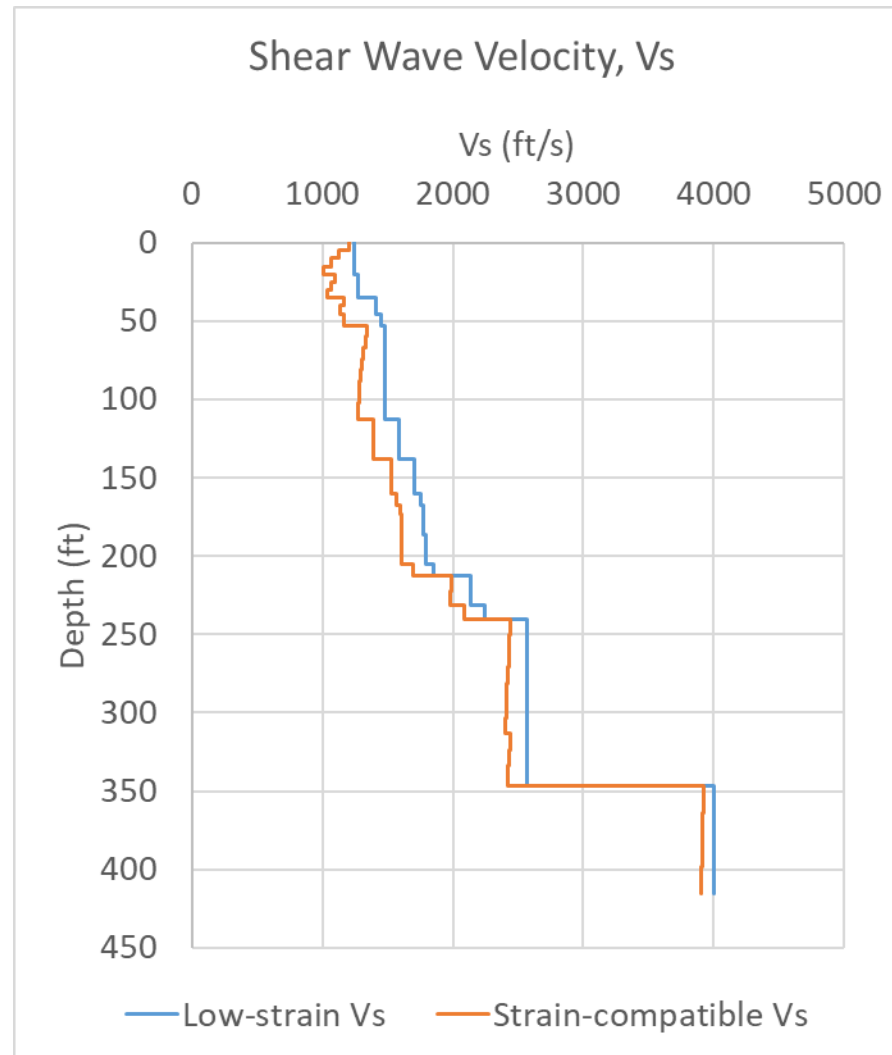
Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
48	349.5	0.00511	0.01	0.015	4000	3923	66922	0.962
49	366.5	0.00544	0.01	0.015	4000	3917	66703	0.959
50	383.5	0.00575	0.01	0.016	4000	3911	66512	0.956
51	400.5	0.00604	0.01	0.016	4000	3906	66338	0.954
52	418	0.00636	0.01	0.016	4000	3901	66163	0.951

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-56 of 61



Appendix Figure B-4 Shear Wave Velocity for Case 12 - WUS Soft Rock, $PGA=0.52g$.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-57 of 61

Appendix Table B-13 Strain-Compatible Soil Properties for Case 13 - Diablo Canyon, PGA =0.92 g

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	5	0.00214	0.01	0.0505	2235	2119	17294	0.899
2	15	0.00585	0.01	0.075	2485	2136	18559	0.739
3	25	0.00832	0.01	0.08	2703	2265	20869	0.702
4	35	0.00822	0.01	0.0795	3102	2604	27585	0.705
5	45	0.00795	0.01	0.0785	3423	2887	33906	0.712
6	55	0.00777	0.01	0.0715	3645	3172	40939	0.757
7	65	0.00874	0.01	0.0745	3770	3237	42617	0.737
8	75	0.00994	0.01	0.078	3853	3256	43119	0.714
9	85	0.01123	0.01	0.082	3913	3249	42952	0.690
10	95	0.01233	0.01	0.086	3985	3261	43246	0.670
11	110	0.01343	0.01	0.0895	4115	3319	44832	0.651
12	130	0.01398	0.01	0.081	4132	3453	48524	0.699
13	147.5	0.01725	0.01	0.089	4001	3237	42612	0.655
14	162.5	0.02272	0.01	0.099	3750	2895	34112	0.596
15	177.5	0.02918	0.01	0.1085	3560	2626	28033	0.544
16	192.5	0.03137	0.01	0.111	3547	2579	27040	0.529
17	207.5	0.02996	0.01	0.109	3645	2673	29094	0.538
18	222.5	0.02851	0.01	0.1075	3748	2776	31353	0.549
19	237.5	0.02679	0.01	0.105	3847	2881	33801	0.561
20	247.5	0.0255	0.01	0.1035	3916	2961	35666	0.572
21	255	0.02121	0.01	0.082	3916	3251	42983	0.689
22	267.5	0.02095	0.01	0.0815	3944	3278	43752	0.691

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-58 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
23	282.5	0.02074	0.01	0.081	3970	3306	44462	0.694
24	300	0.02012	0.01	0.08	4026	3367	46116	0.700
25	320	0.01934	0.01	0.079	4088	3437	48068	0.707
26	340	0.0185	0.01	0.0775	4152	3512	50184	0.716
27	360	0.01779	0.01	0.0765	4214	3583	52232	0.723
28	380	0.01754	0.01	0.076	4232	3606	52880	0.726
29	400	0.01749	0.01	0.076	4234	3609	52968	0.727
30	420	0.01728	0.01	0.0755	4241	3620	53315	0.729
31	440	0.01705	0.01	0.075	4242	3628	53537	0.732
32	456.3	0.01672	0.01	0.074	4242	3637	53812	0.735
33	471.6	0.01562	0.01	0.072	4331	3747	57103	0.749
34	489.6	0.0162	0.01	0.073	4331	3728	56563	0.741
35	499.3	0.01681	0.01	0.0745	4331	3710	56013	0.734
36	508.3	0.01242	0.032	0.032	4331	4331	76312	1.000
37	526.7	0.01163	0.032	0.032	4577	4577	84484	1.000
38	546.7	0.01207	0.032	0.032	4577	4577	84484	1.000
39	566.7	0.0125	0.032	0.032	4577	4577	84484	1.000
40	586.7	0.01287	0.032	0.032	4577	4577	84484	1.000
41	606.7	0.01327	0.032	0.032	4577	4577	84484	1.000
42	626.7	0.01169	0.032	0.032	4913	4913	98199	1.000
43	646.7	0.01189	0.032	0.032	4913	4913	98199	1.000
44	666.7	0.01246	0.032	0.032	4913	4913	98199	1.000
45	686.7	0.01306	0.032	0.032	4913	4913	98199	1.000
46	706.7	0.01369	0.032	0.032	4913	4913	98199	1.000
47	729.2	0.01261	0.032	0.032	5109	5109	111055	1.000

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-59 of 61

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
48	754.2	0.01317	0.032	0.032	5109	5109	111055	1.000
49	779.2	0.01362	0.032	0.032	5109	5109	111055	1.000
50	804.2	0.01402	0.032	0.032	5109	5109	111055	1.000
51	829.2	0.01233	0.032	0.032	5520	5520	129641	1.000
52	854.2	0.0126	0.032	0.032	5520	5520	129641	1.000
53	879.2	0.01283	0.032	0.032	5520	5520	129641	1.000
54	904.2	0.01312	0.032	0.032	5520	5520	129641	1.000

Appendix Table B-14 Strain-Compatible Soil Properties for Case 14 - Diablo Canyon, PGA = 1.3 g

Sublayer#	Depth (ft)	Strain	Initial Damping (%)	Strain Compatible Damping (%)	Initial Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Wave Velocity, Vs (ft/s)	Strain Compatible Shear Modulus (KSF)	G/Gmax
1	5	0.00315	0.01	0.056	2235	2074	16580	0.862
2	15	0.00942	0.01	0.0895	2485	1993	16161	0.643
3	25	0.01351	0.01	0.0985	2703	2098	17910	0.603
4	35	0.0131	0.01	0.097	3102	2422	23872	0.610
5	45	0.01276	0.01	0.0955	3423	2685	29339	0.616
6	55	0.01236	0.01	0.086	3645	2980	36149	0.669
7	65	0.01433	0.01	0.092	3770	3009	36822	0.637
8	75	0.01655	0.01	0.098	3853	2999	36588	0.606
9	85	0.01887	0.01	0.103	3913	2973	35972	0.578
10	95	0.02073	0.01	0.107	3985	2974	35996	0.557
11	110	0.02245	0.01	0.1105	4115	3024	37189	0.540
12	130	0.02235	0.01	0.0985	4132	3200	41657	0.600

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-60 of 61

13	147.5	0.02762	0.01	0.1065	4001	2981	36147	0.555
14	162.5	0.03822	0.01	0.1175	3750	2612	27756	0.485
15	177.5	0.0511	0.01	0.127	3560	2312	21749	0.422
16	192.5	0.05601	0.01	0.1305	3547	2250	20588	0.403
17	207.5	0.05237	0.01	0.128	3645	2353	22517	0.417
18	222.5	0.04763	0.01	0.125	3748	2478	24963	0.437
19	237.5	0.04331	0.01	0.122	3847	2602	27533	0.458
20	247.5	0.0406	0.01	0.1195	3916	2689	29410	0.472
21	255	0.0313	0.01	0.0935	3916	3068	38289	0.614
22	267.5	0.03087	0.01	0.0935	3944	3095	39010	0.616
23	282.5	0.03036	0.01	0.0925	3970	3125	39731	0.620
24	300	0.02907	0.01	0.0915	4026	3190	41415	0.628
25	320	0.02761	0.01	0.09	4088	3265	43377	0.638
26	340	0.02666	0.01	0.0885	4152	3335	45222	0.645
27	360	0.02623	0.01	0.088	4214	3392	46811	0.648
28	380	0.02593	0.01	0.088	4232	3412	47375	0.650
29	400	0.02551	0.01	0.087	4234	3423	47654	0.654
30	420	0.02578	0.01	0.088	4241	3424	47666	0.652
31	440	0.02625	0.01	0.088	4242	3413	47429	0.648
32	456.3	0.02789	0.01	0.0905	4242	3384	46569	0.637
33	471.6	0.02773	0.01	0.09	4331	3458	48627	0.638
34	489.6	0.02931	0.01	0.0915	4331	3428	47814	0.627
35	499.3	0.0303	0.01	0.093	4331	3410	47323	0.620
36	508.3	0.01916	0.032	0.032	4331	4331	76312	1.000
37	526.7	0.0185	0.032	0.032	4577	4577	84484	1.000
38	546.7	0.01915	0.032	0.032	4577	4577	84484	1.000
39	566.7	0.02033	0.032	0.032	4577	4577	84484	1.000
40	586.7	0.02008	0.032	0.032	4577	4577	84484	1.000
41	606.7	0.02072	0.032	0.032	4577	4577	84484	1.000

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: B-61 of 61

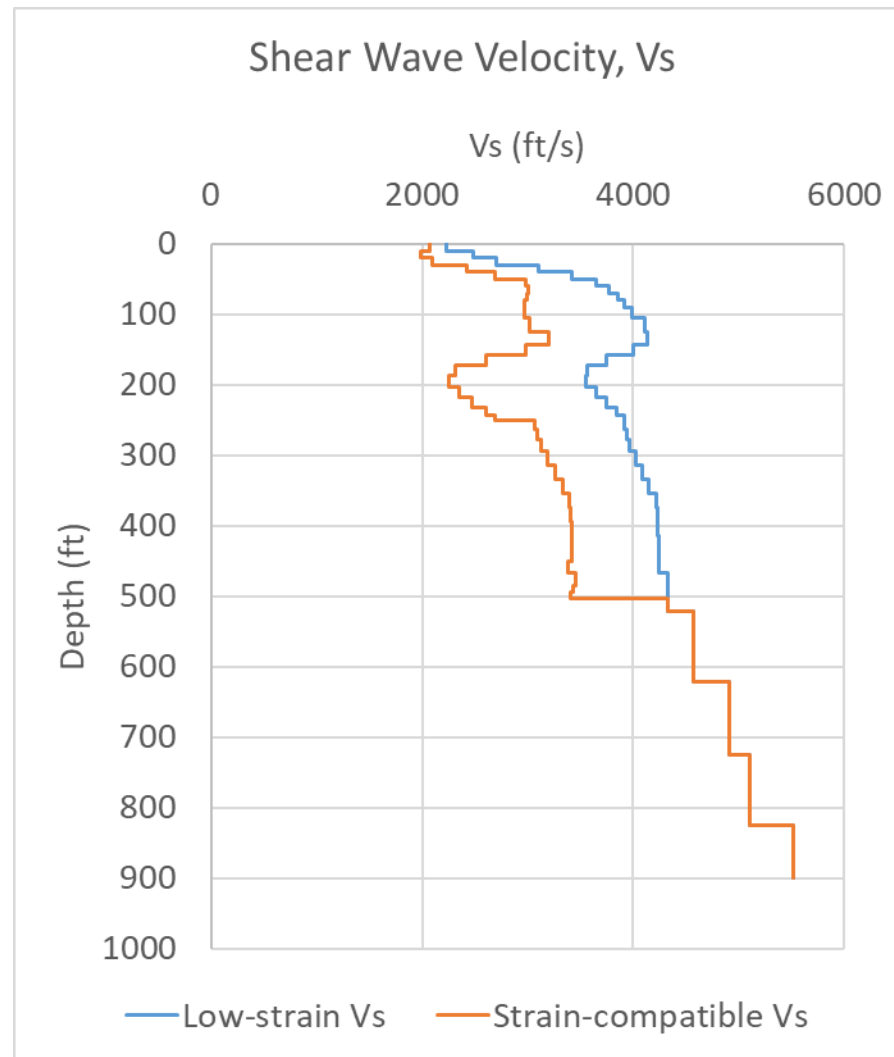
42	626.7	0.01891	0.032	0.032	4913	4913	98199	1.000
43	646.7	0.02021	0.032	0.032	4913	4913	98199	1.000
44	666.7	0.02091	0.032	0.032	4913	4913	98199	1.000
45	686.7	0.02152	0.032	0.032	4913	4913	98199	1.000
46	706.7	0.02185	0.032	0.032	4913	4913	98199	1.000
47	729.2	0.01982	0.032	0.032	5109	5109	111055	1.000
48	754.2	0.02058	0.032	0.032	5109	5109	111055	1.000
49	779.2	0.02111	0.032	0.032	5109	5109	111055	1.000
50	804.2	0.02171	0.032	0.032	5109	5109	111055	1.000
51	829.2	0.01904	0.032	0.032	5520	5520	129641	1.000
52	854.2	0.01952	0.032	0.032	5520	5520	129641	1.000
53	879.2	0.0197	0.032	0.032	5520	5520	129641	1.000
54	904.2	0.02007	0.032	0.032	5520	5520	129641	1.000

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

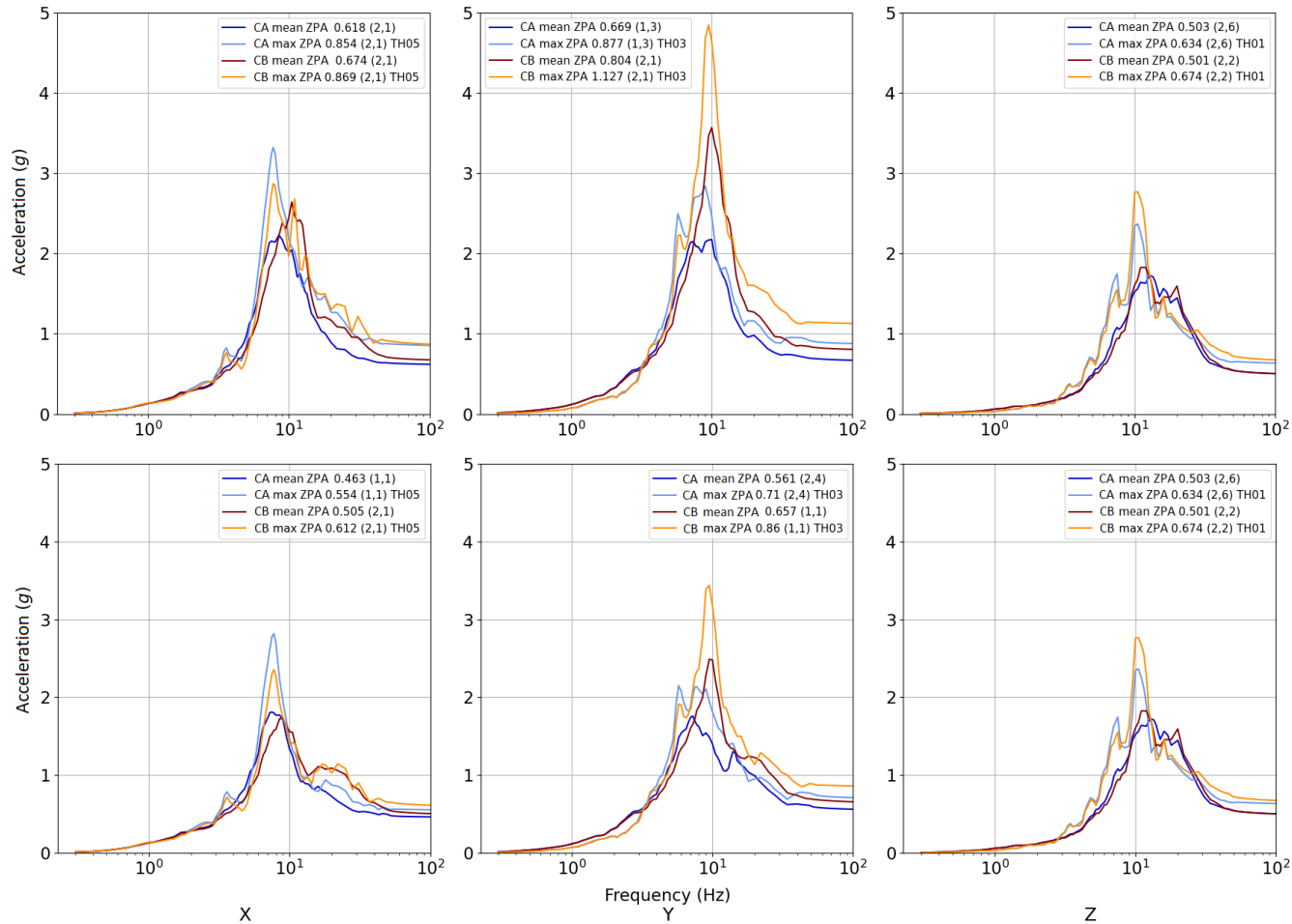
| Rev. 0

Page: B-62 of 61

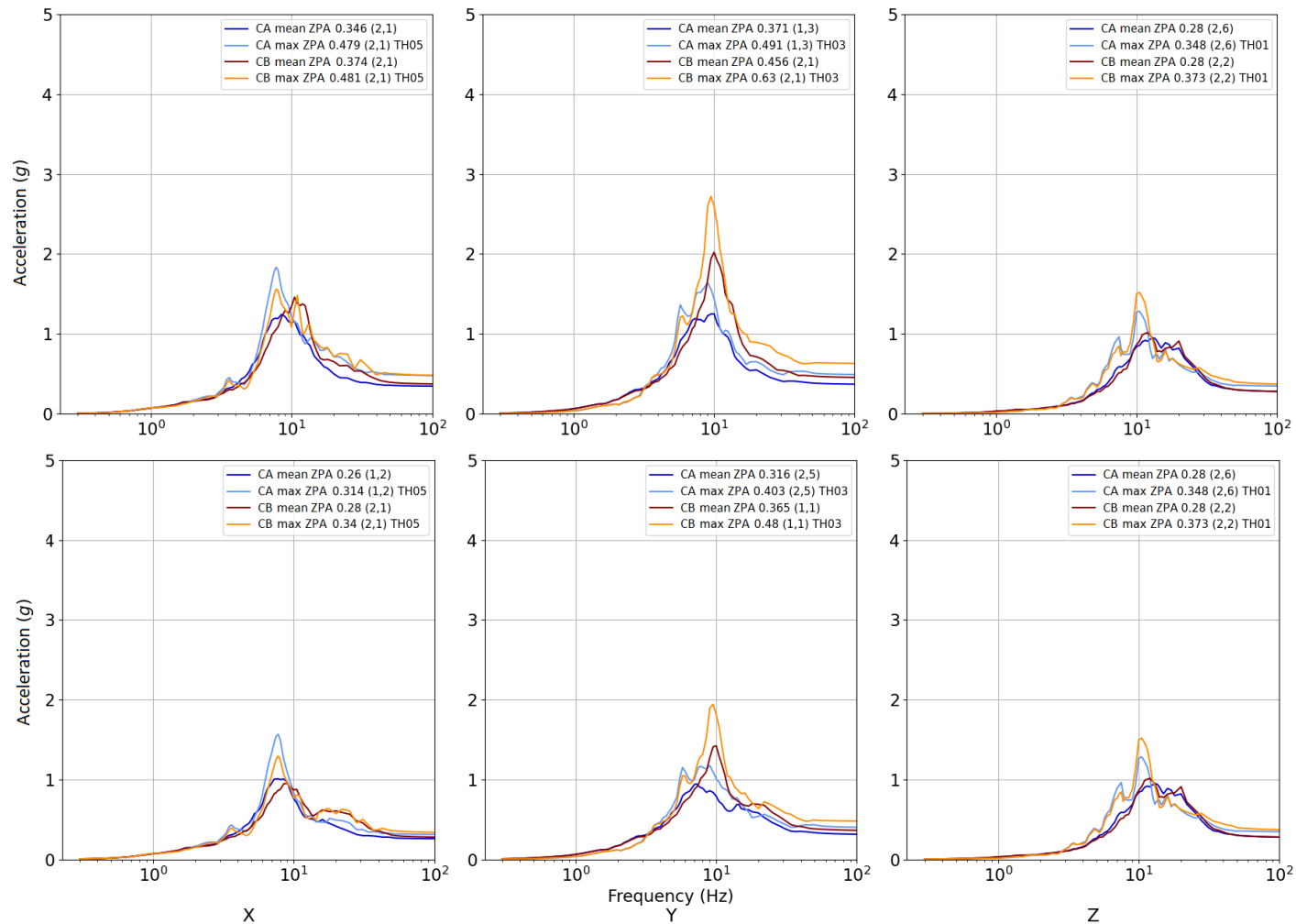


Appendix Figure B-5 Shear Wave Velocity for Case 14 – Diablo Canyon, $PGA=1.3g$.

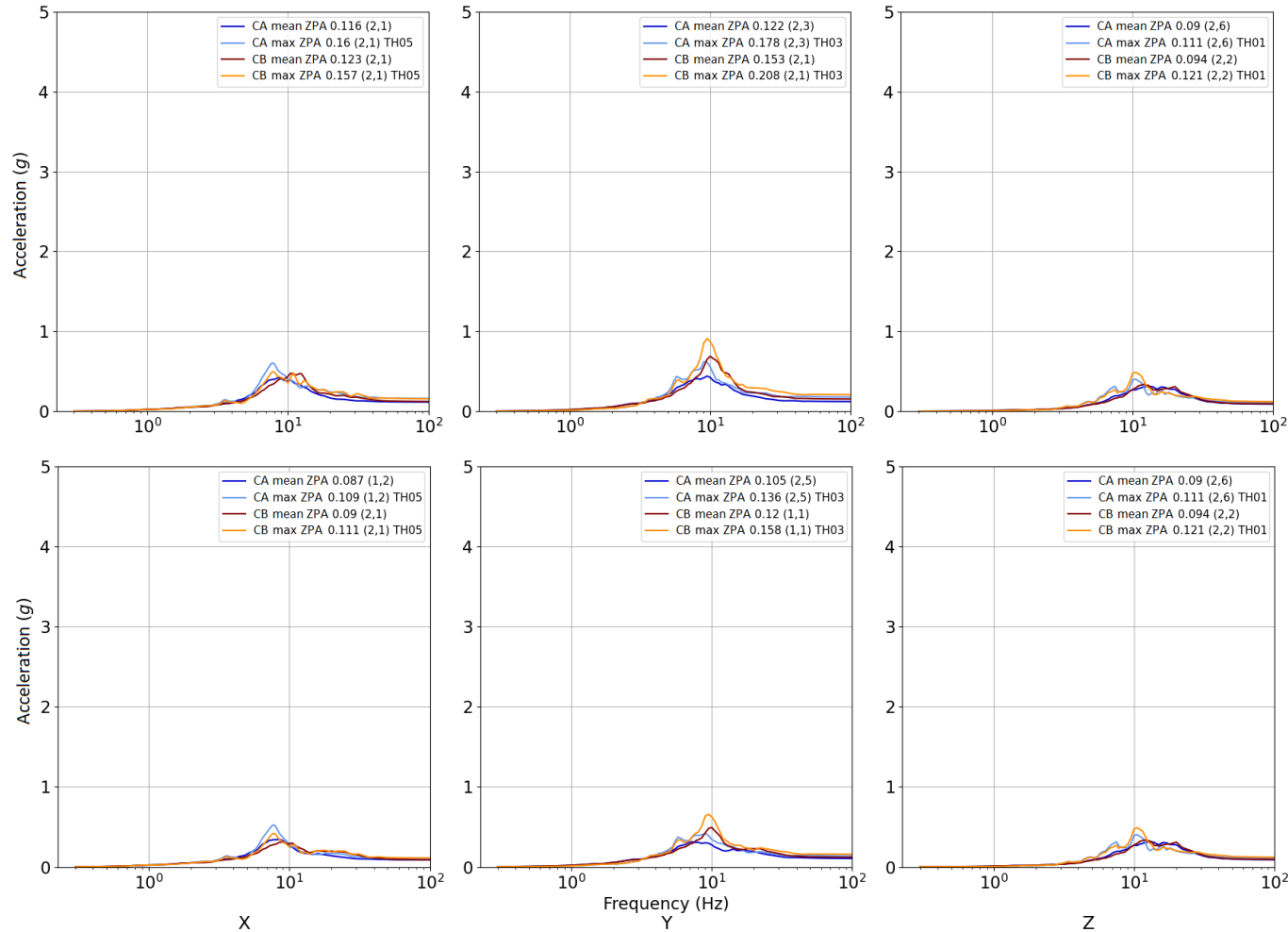
Appendix C ISFSI Pad Maximum Cask Responses



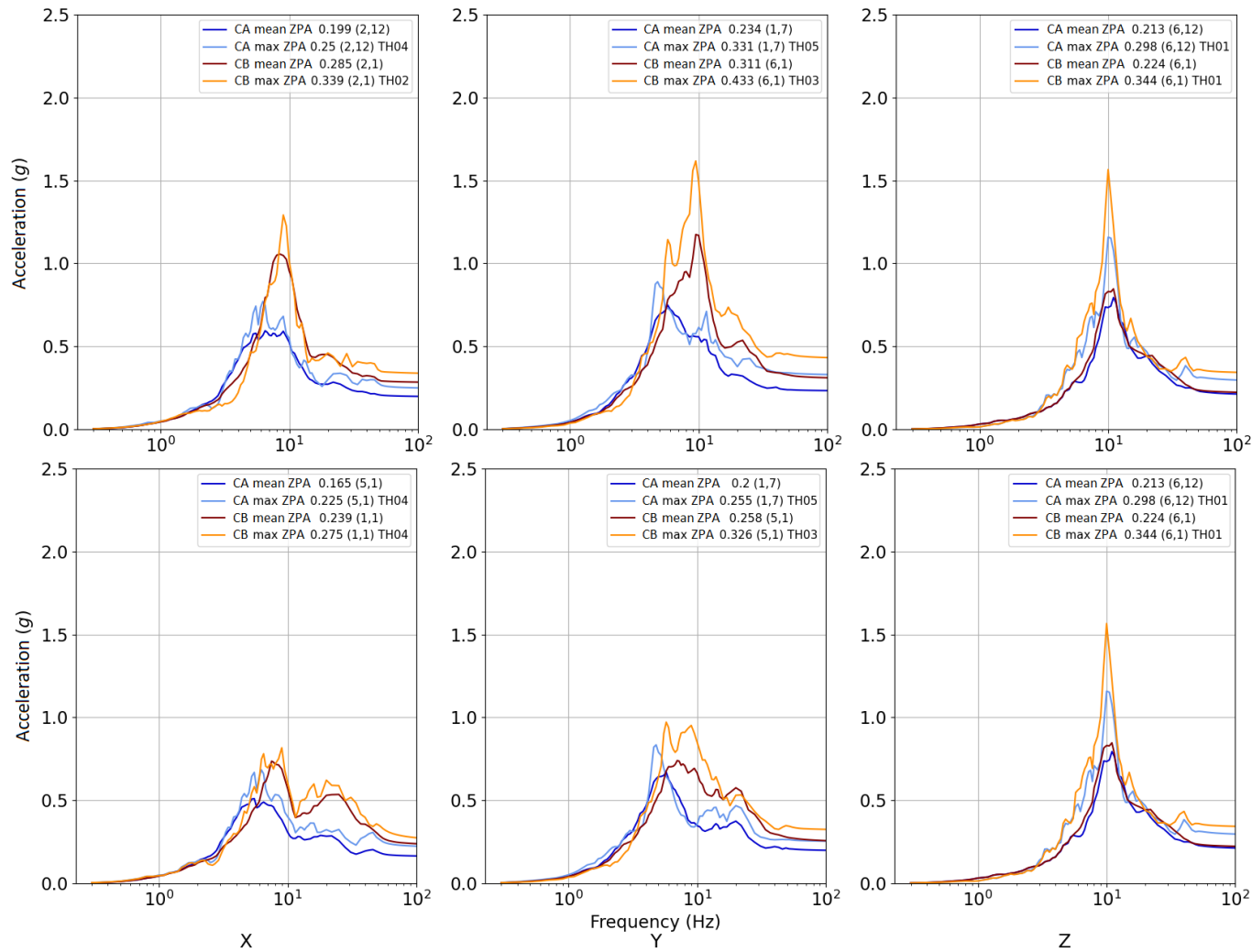
Appendix Figure C-1 Cask Maximum Responses for the CEUS Soil 15km 0.56g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.



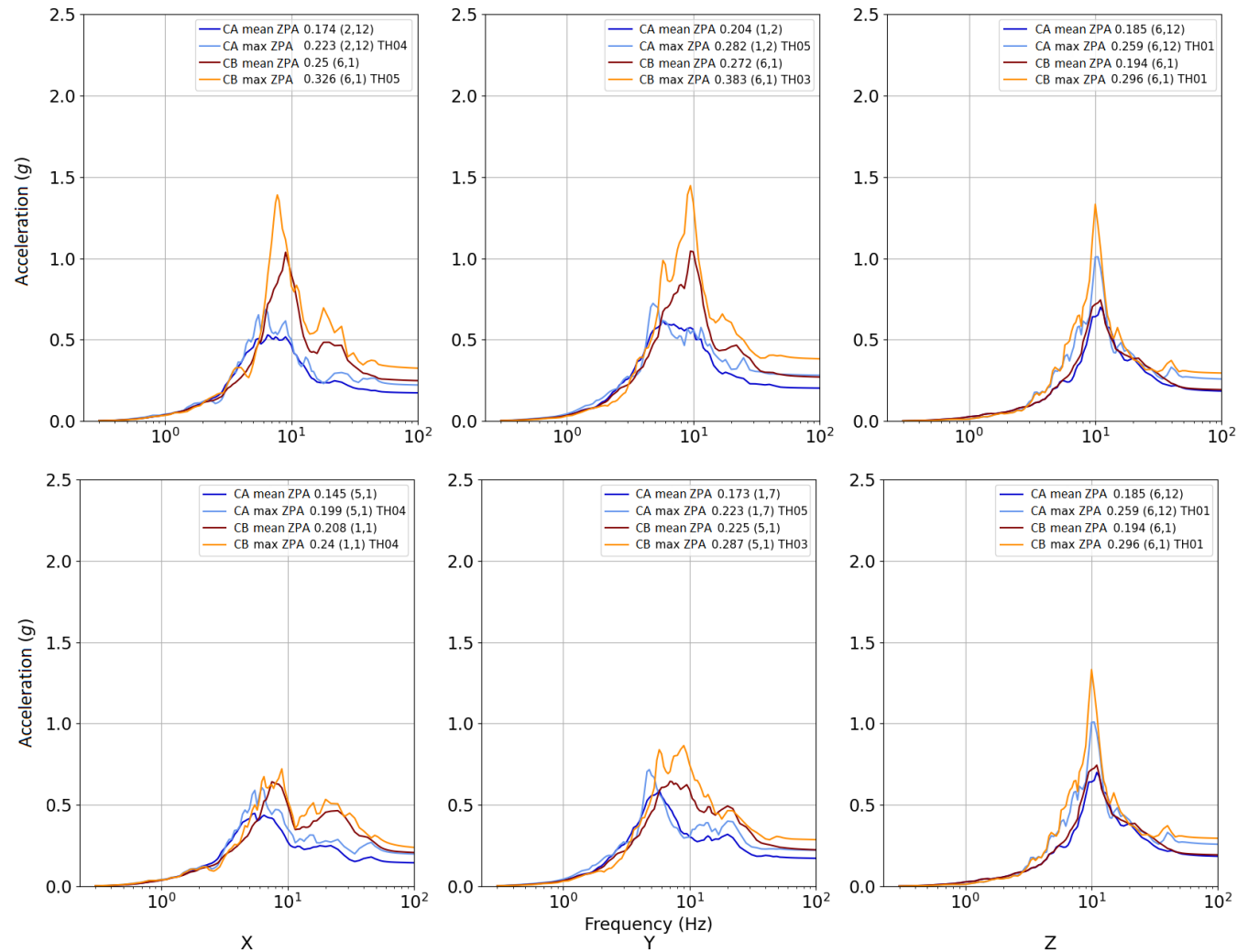
Appendix Figure C-2 Cask Maximum Responses for the CEUS Soil 40km 0.31g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.



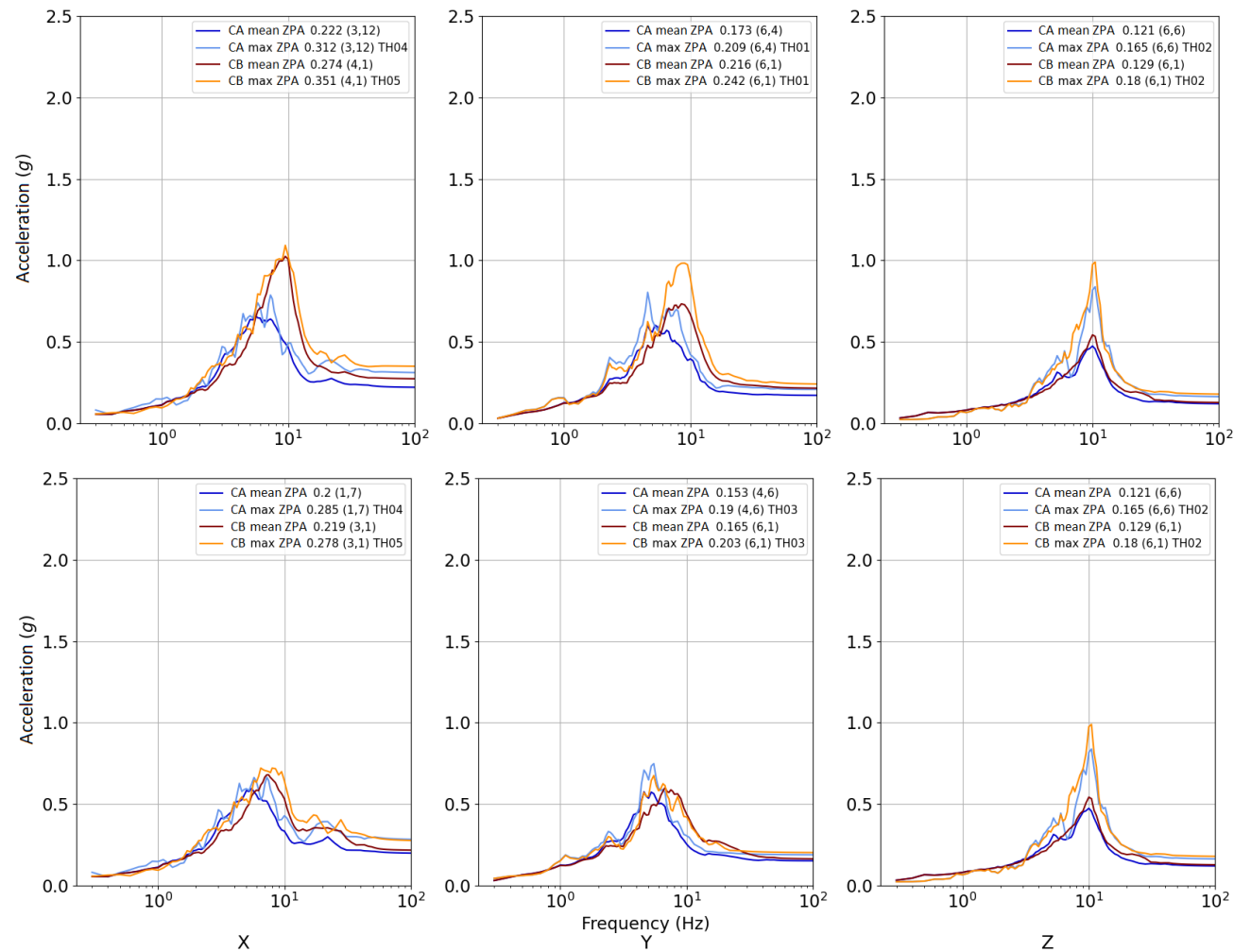
Appendix Figure C-3 Cask Maximum Responses for the CEUS Soil 200km 0.1g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.



Appendix Figure C-4 Cask Maximum Responses for the CEUS Soft Rock 15km 0.29g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.



Appendix Figure C-5 Cask Maximum Responses for the CEUS Soft Rock 15km 0.25g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.



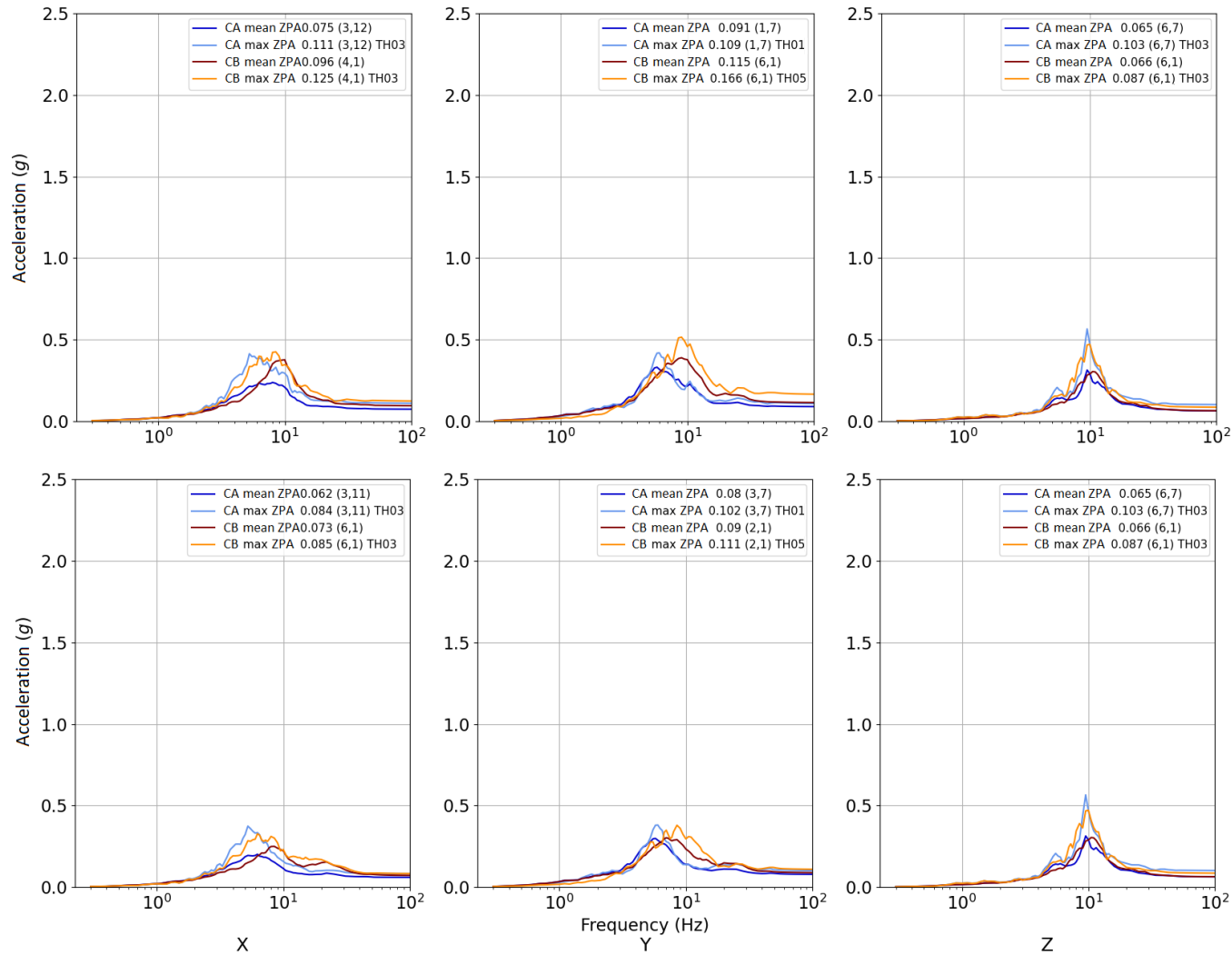
Appendix Figure C-6 Cask Maximum Responses for the CEUS Soft Rock 200km 0.18g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-8 of 33



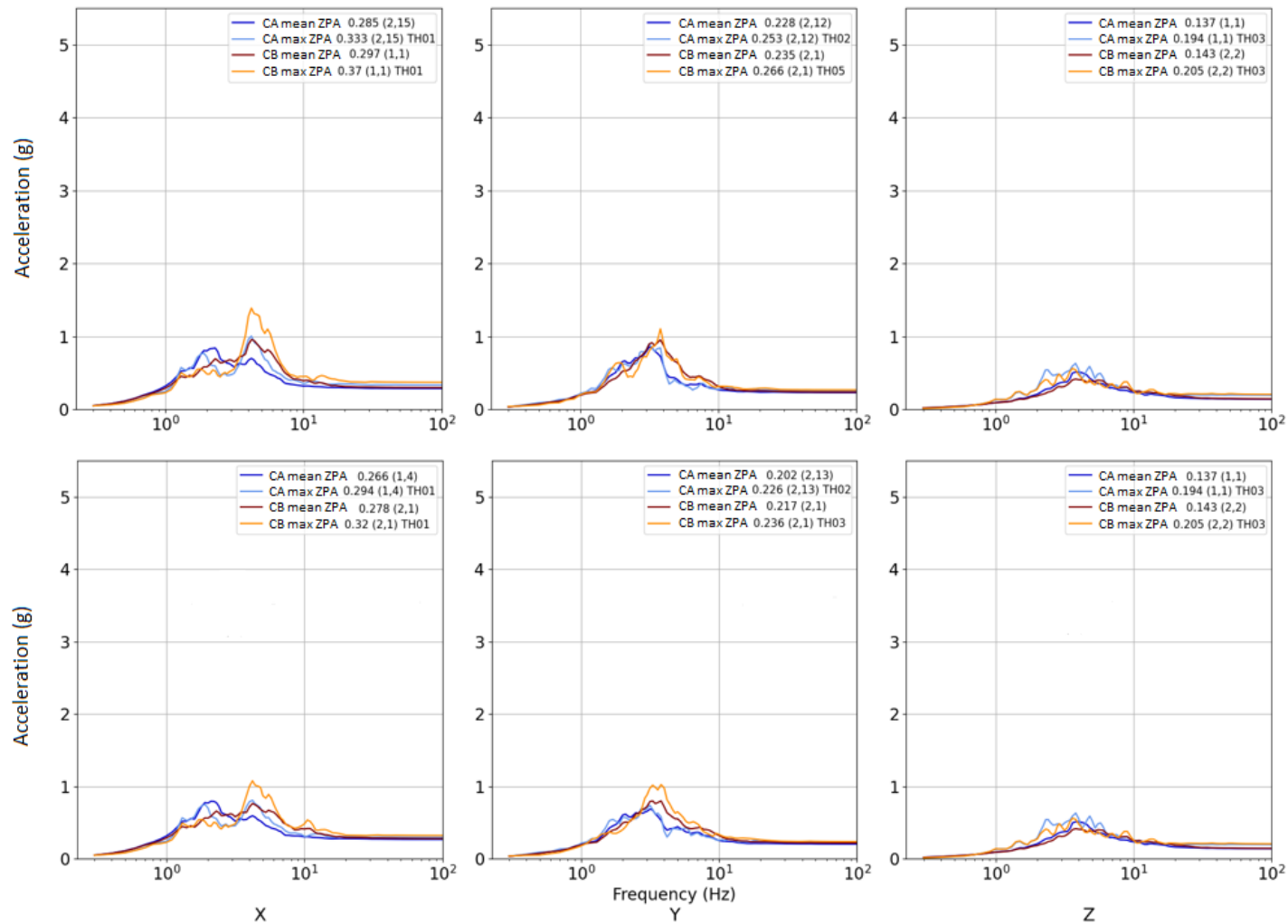
Appendix Figure C-7 Cask Maximum Responses for the CEUS Soft Rock 40km 0.08g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.

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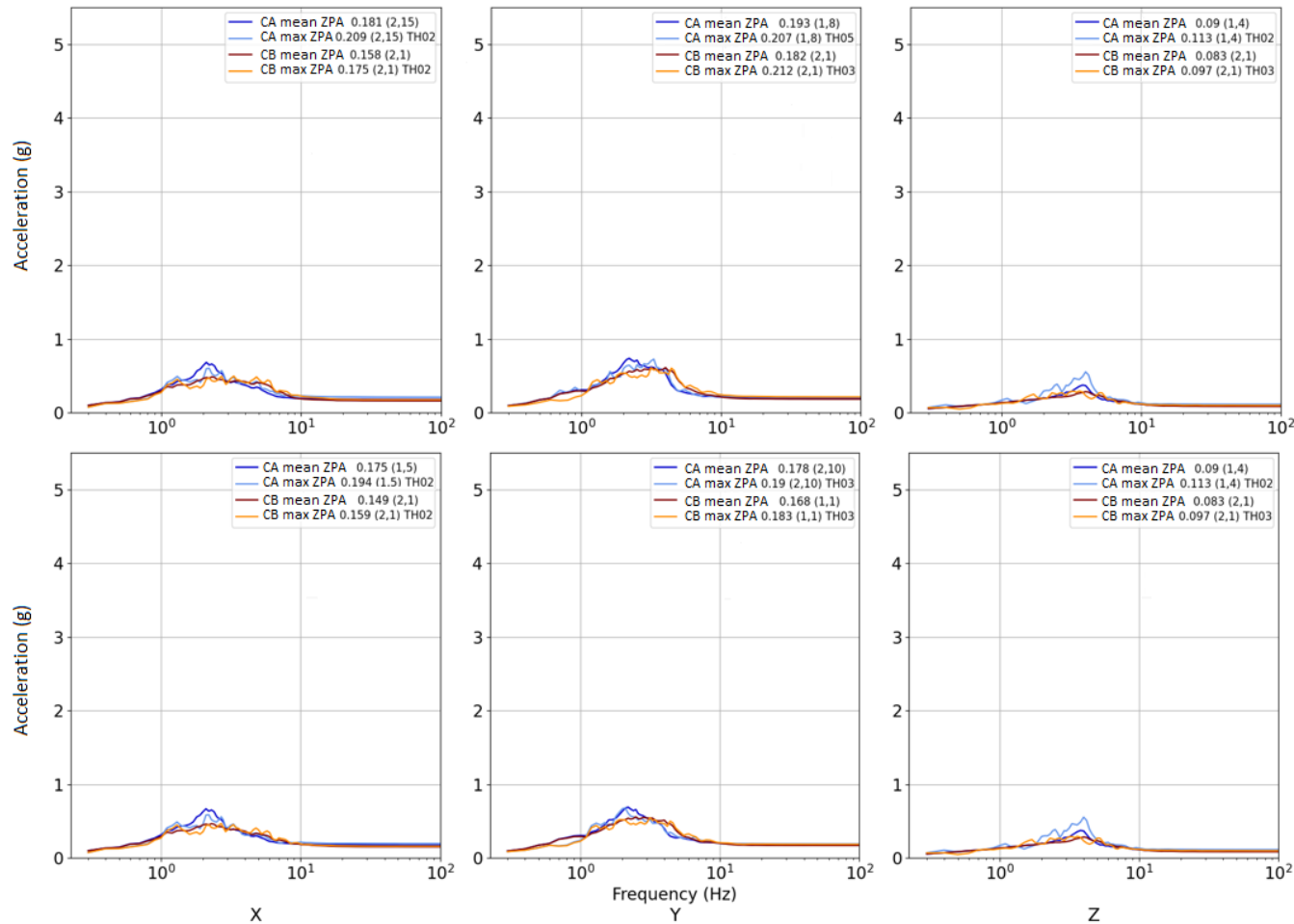
Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-9 of 33



Appendix Figure C-8 Cask Maximum Responses for the WUS Soil 10km 0.23g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.



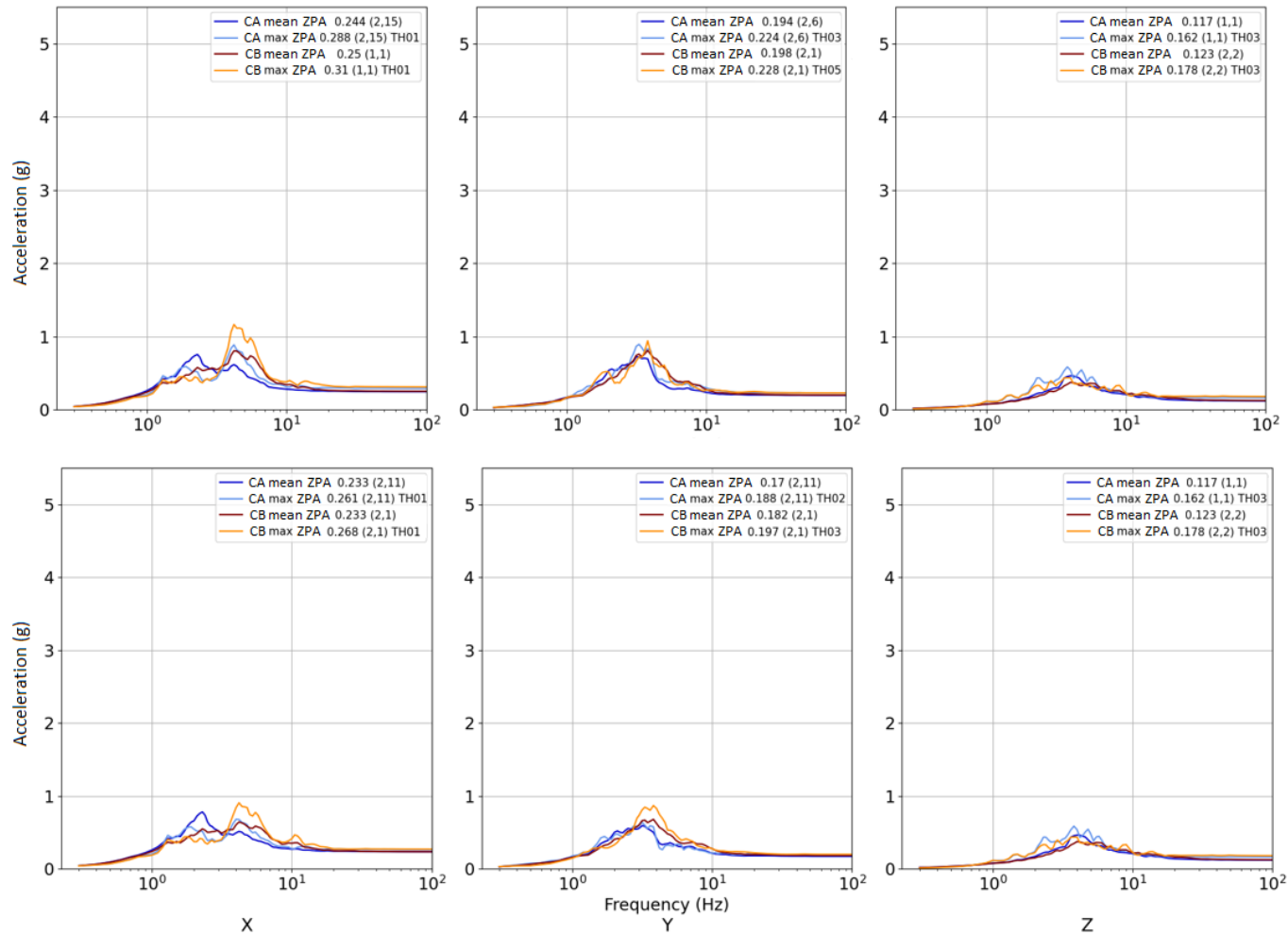
Appendix Figure C-9 Cask Maximum Responses for the WUS Soil 200km 0.14g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-11 of 33



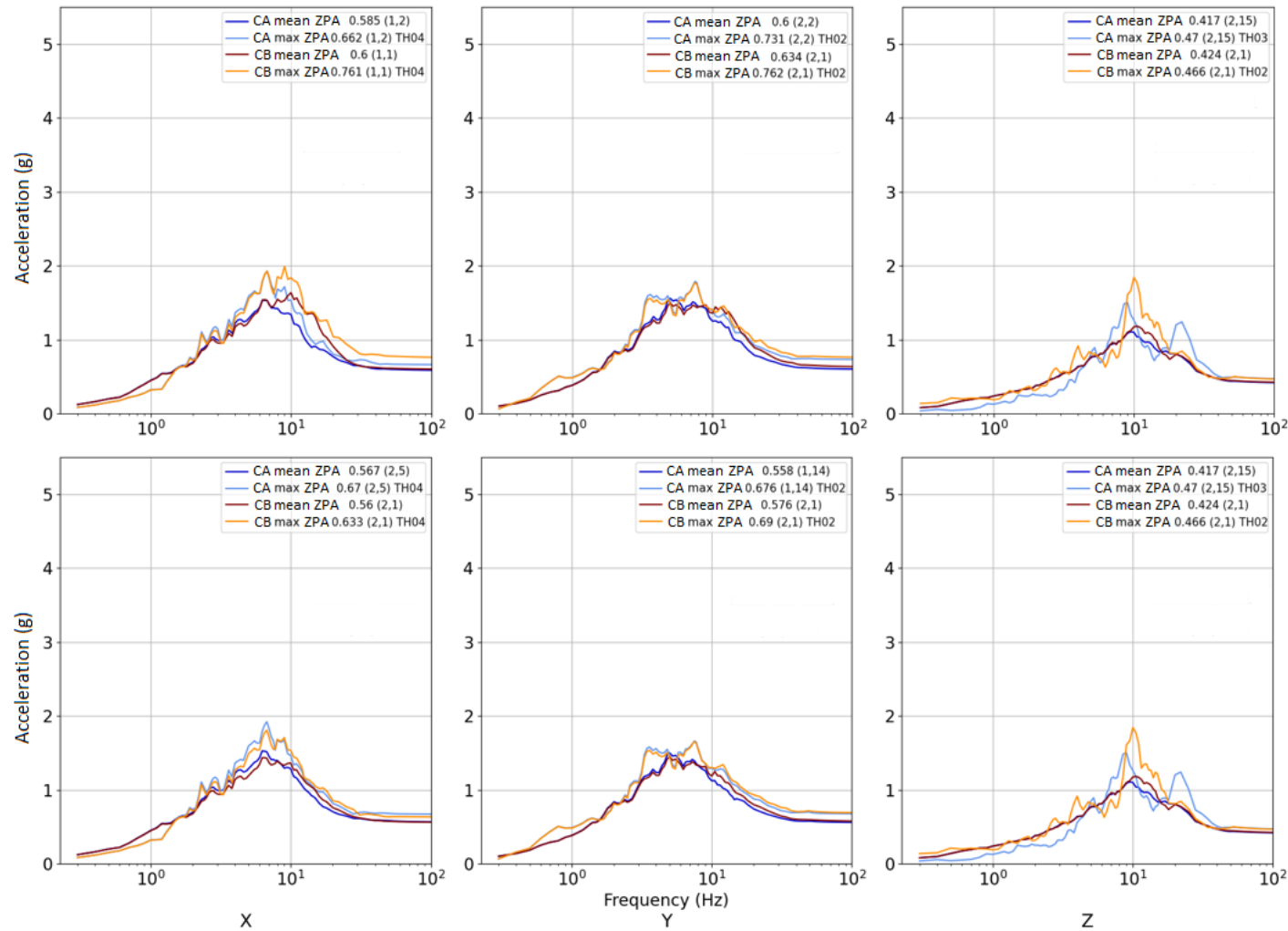
Appendix Figure C-10 Cask Maximum Responses for the WUS Soil 10km 0.19g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-12 of 33



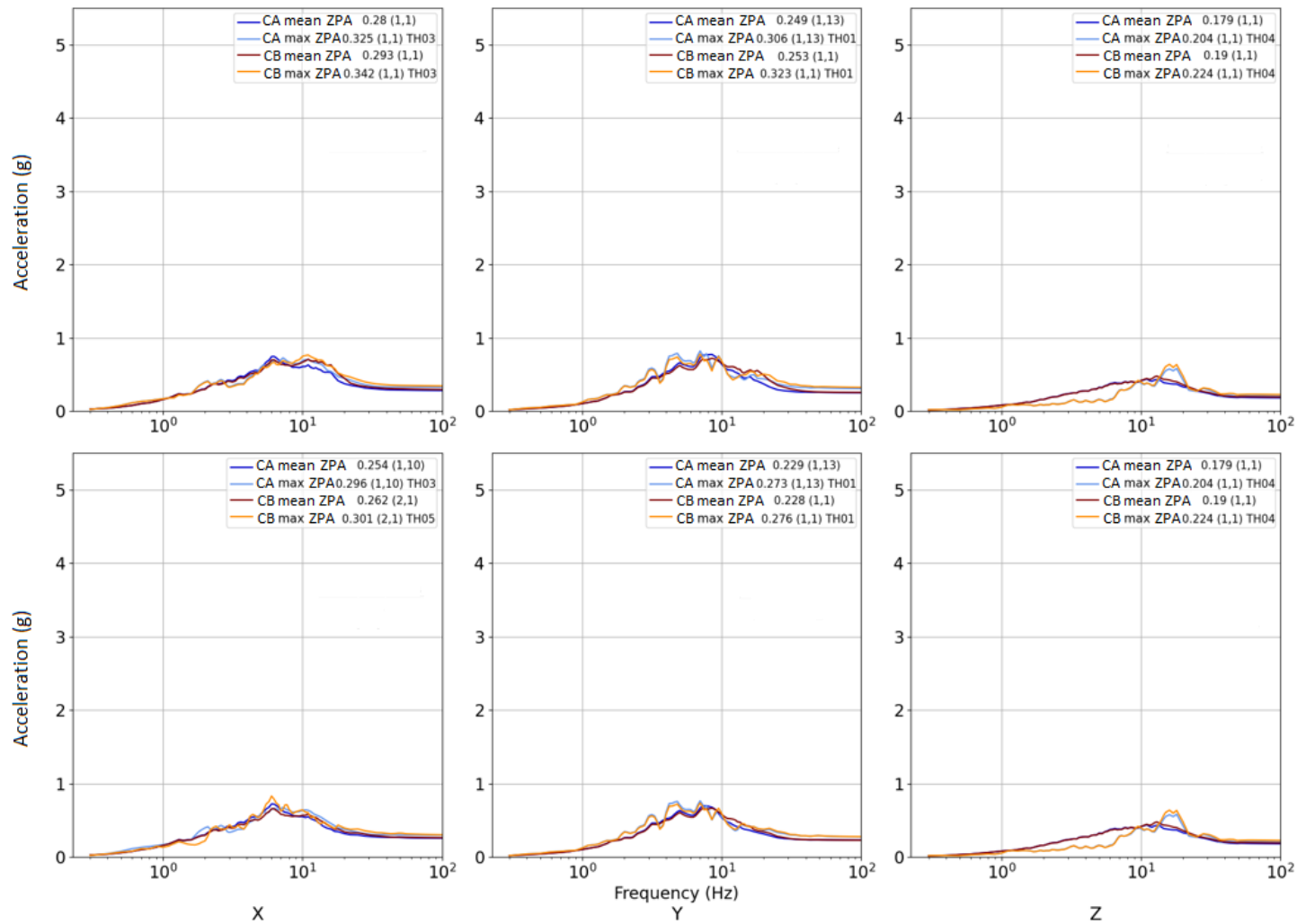
Appendix Figure C-11 Cask Maximum Responses for the WUS Soft Rock 5km 0.52g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-13 of 33



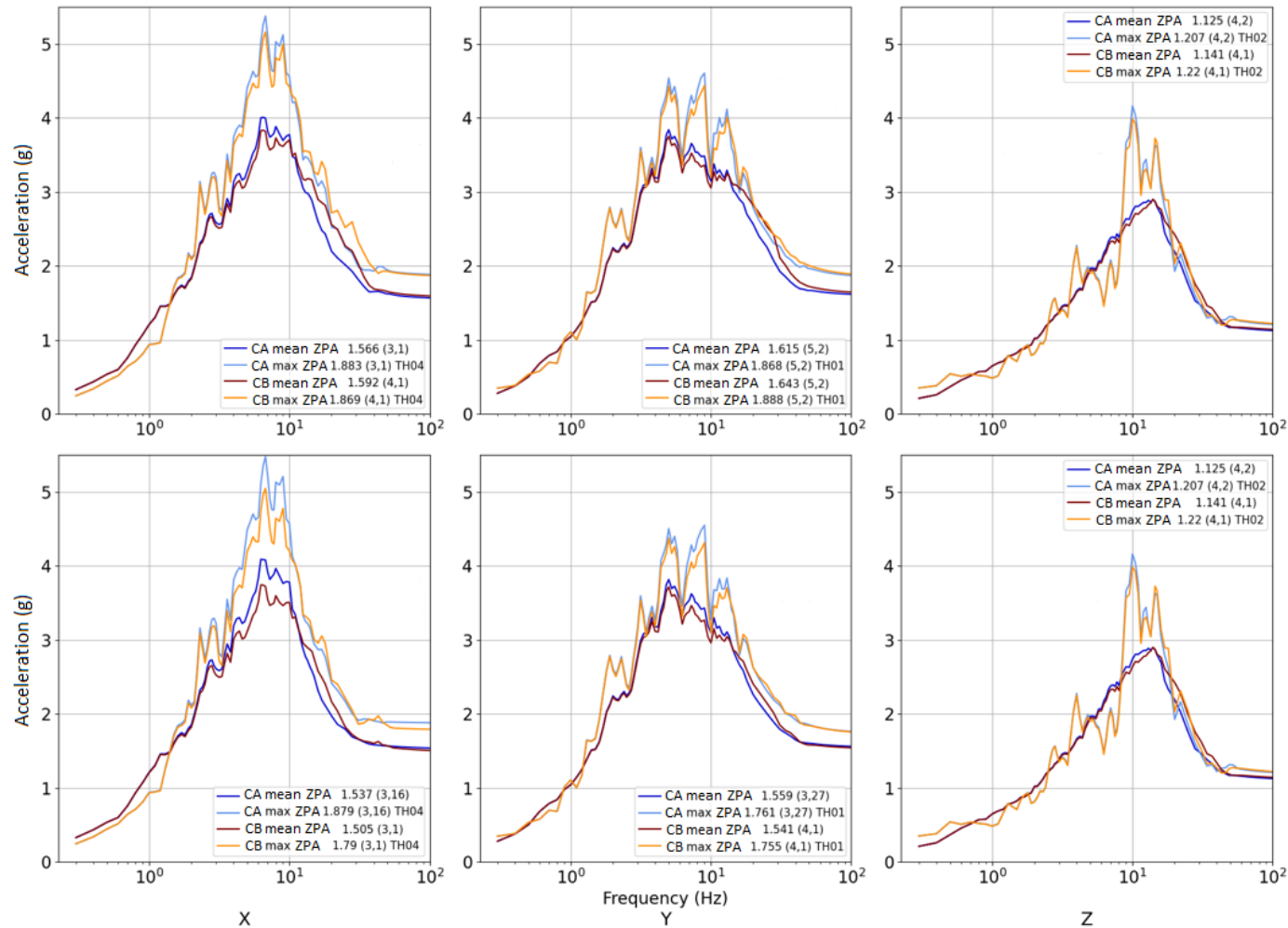
Appendix Figure C-12 Cask Maximum Responses for the WUS Soft Rock 10km 0.22g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-14 of 33



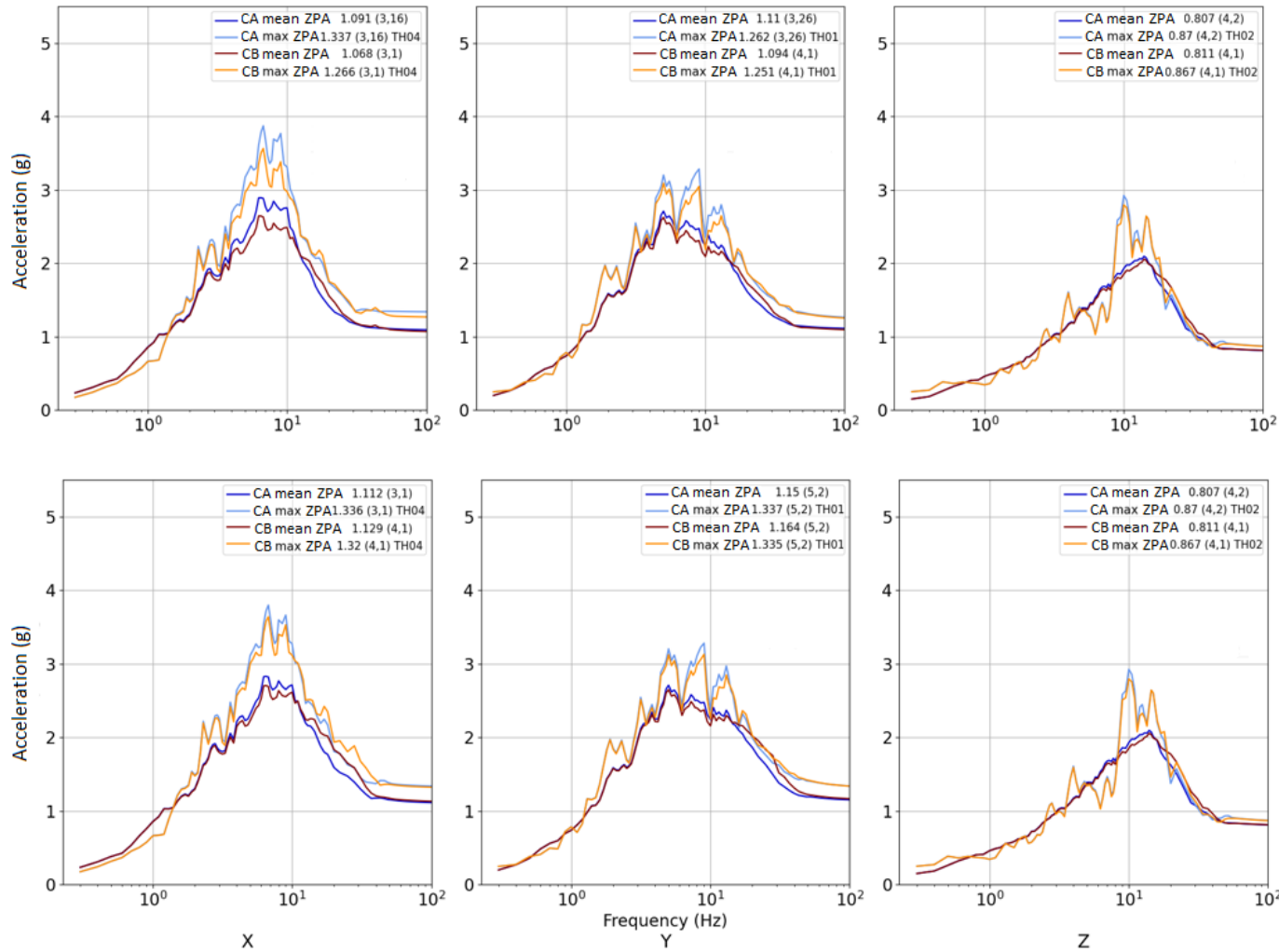
Appendix Figure C-13 Cask Maximum Responses for the WUS Diablo 5km 1.3g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-15 of 33



Appendix Figure C-14 Cask Maximum Responses for the WUS Diablo 5km 0.92g Seismic Case. Top: Cask Center of Gravity; Bottom: Cask Base.

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-16 of 33

Appendix Table C-1 Cask X Direction Maximum PGA Base Responses.

No.	Case	Target PGA (g)	Pad Size	Config	Mean ZPA (g)	TH ID	TH PGA (g)	TH PGD (in)	Max ZPA (g)	ZPD (in)	Ratio Max ZPA/TH-PGA	Ratio ZPD/PGD
1	CEUS Soil	0.56	2x6	1	0.463	TH05	0.509	0.641	0.554	0.663	1.088	1.035
				4	0.505	TH05	0.509	0.641	0.612	0.656	1.201	1.024
2	CEUS Soil	0.31	2x6	1	0.260	TH05	0.282	0.355	0.314	0.367	1.113	1.035
				4	0.280	TH05	0.282	0.355	0.340	0.363	1.206	1.023
3	CEUS Soil	0.1	2x6	1	0.087	TH05	0.091	0.114	0.109	0.119	1.198	1.036
				4	0.090	TH05	0.091	0.114	0.111	0.117	1.220	1.022
4	CEUS SR	0.29	6x12	1	0.165	TH04	0.325	0.257	0.225	0.266	0.692	1.037
				4	0.239	TH04	0.325	0.257	0.275	0.265	0.845	1.031
5	CEUS SR	0.25	6x12	1	0.145	TH04	0.280	0.221	0.199	0.230	0.709	1.038
				4	0.208	TH04	0.280	0.221	0.240	0.228	0.856	1.032
6	CEUS SR	0.18	6x12	1	0.200	TH04	0.218	3.920	0.285	3.943	1.310	1.006
				4	0.219	TH05	0.221	3.894	0.278	3.901	1.259	1.002
7	CEUS SR	0.08	6x12	1	0.062	TH03	0.086	0.337	0.084	0.336	0.978	0.996
				4	0.073	TH03	0.086	0.337	0.085	0.335	0.989	0.992
8	WUS Soil	0.23	2x15	1	0.266	TH01	0.278	2.009	0.294	2.119	1.059	1.055
				4	0.278	TH01	0.278	2.009	0.320	2.039	1.152	1.015
9	WUS Soil	0.14	2x15	1	0.175	TH02	0.132	6.275	0.194	6.355	1.471	1.013
				4	0.149	TH02	0.132	6.275	0.159	6.297	1.205	1.004
10	WUS Soil	0.19	2x15	1	0.233	TH01	0.229	1.660	0.261	1.739	1.138	1.048
				4	0.233	TH01	0.229	1.660	0.268	1.683	1.168	1.014
11	WUS SR	0.52	2x15	1	0.567	TH04	0.553	9.338	0.670	9.346	1.212	1.001
				4	0.560	TH04	0.553	9.338	0.633	9.341	1.145	1.000
12	WUS SR	0.22	2x15	1	0.254	TH03	0.237	1.153	0.296	1.162	1.249	1.008

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-17 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Mean ZPA (g)	TH ID	TH PGA (g)	TH PGD (in)	Max ZPA (g)	ZPD (in)	Ratio Max ZPA/TH-PGA	Ratio ZPD/PGD
				4	0.262	TH05	0.279	1.825	0.301	1.827	1.079	1.001
13	Diablo Canyon	1.3	5x28	1	1.537	TH04	1.625	20.476	1.879	20.501	1.156	1.001
				4	1.505	TH04	1.625	20.476	1.790	20.483	1.102	1.000
14	Diablo Canyon	0.92	5x28	1	1.091	TH04	1.150	14.491	1.337	14.507	1.163	1.001
				4	1.068	TH04	1.150	14.491	1.266	14.495	1.101	1.000

Appendix Table C-2 Cask Y Direction Maximum PGA Base Responses

No.	Case	Target PGA (g)	Pad Size	Config	Mean ZPA (g)	TH ID	TH PGA (g)	TH PGD (in)	Max ZPA (g)	ZPD (in)	Ratio Max ZPA/TH-PGA	Ratio ZPD/PGD
1	CEUS Soil	0.56	2x6	1	0.561	TH03	0.688	0.406	0.710	0.410	1.031	1.010
				4	0.657	TH03	0.688	0.406	0.860	0.418	1.249	1.028
2	CEUS Soil	0.31	2x6	1	0.316	TH03	0.381	0.225	0.403	0.227	1.058	1.007
				4	0.365	TH03	0.381	0.225	0.480	0.231	1.260	1.027
3	CEUS Soil	0.1	2x6	1	0.105	TH03	0.123	0.073	0.136	0.073	1.106	1.007
				4	0.120	TH03	0.123	0.073	0.158	0.075	1.285	1.030
4	CEUS SR	0.29	6x12	1	0.200	TH05	0.311	0.324	0.255	0.339	0.819	1.047
				4	0.258	TH03	0.357	0.213	0.326	0.213	0.914	1.001
5	CEUS SR	0.25	6x12	1	0.173	TH05	0.268	0.279	0.223	0.292	0.831	1.046
				4	0.225	TH03	0.308	0.183	0.287	0.183	0.933	1.001
6	CEUS SR	0.18	6x12	1	0.153	TH03	0.180	3.105	0.190	3.104	1.054	1.000
				4	0.165	TH03	0.180	3.105	0.203	3.105	1.126	1.000
7	CEUS SR	0.08	6x12	1	0.080	TH01	0.089	0.199	0.102	0.204	1.140	1.023
				4	0.090	TH05	0.103	0.193	0.111	0.194	1.076	1.004

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-18 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Mean ZPA (g)	TH ID	TH PGA (g)	TH PGD (in)	Max ZPA (g)	ZPD (in)	Ratio Max ZPA/TH-PGA	Ratio ZPD/PGD
8	WUS Soil	0.23	2x15	1	0.202	TH02	0.221	1.619	0.226	1.685	1.024	1.041
				4	0.217	TH03	0.208	1.253	0.236	1.274	1.135	1.016
9	WUS Soil	0.14	2x15	1	0.178	TH03	0.141	12.670	0.190	13.191	1.348	1.041
				4	0.168	TH03	0.141	12.670	0.183	12.694	1.298	1.002
10	WUS Soil	0.19	2x15	1	0.170	TH02	0.182	1.338	0.188	1.400	1.031	1.046
				4	0.182	TH03	0.172	1.035	0.197	1.052	1.147	1.016
11	WUS SR	0.52	2x15	1	0.558	TH02	0.572	7.816	0.676	7.847	1.182	1.004
				4	0.576	TH02	0.572	7.816	0.690	7.829	1.207	1.002
12	WUS SR	0.22	2x15	1	0.229	TH01	0.237	1.079	0.273	1.081	1.153	1.002
				4	0.228	TH01	0.237	1.079	0.276	1.080	1.165	1.001
13	Diablo Canyon	1.3	5x28	1	1.559	TH01	1.555	34.683	1.761	34.692	1.132	1.000
				4	1.541	TH01	1.555	34.683	1.755	34.688	1.128	1.000
14	Diablo Canyon	0.92	5x28	1	1.110	TH01	1.101	24.545	1.262	24.551	1.146	1.000
				4	1.094	TH01	1.101	24.545	1.251	24.548	1.136	1.000

Appendix Table C-3 Cask Z Direction Maximum PGA Base Responses

No.	Case	Target PGA (g)	Pad Size	Config	Mean ZPA (g)	TH ID	TH PGA (g)	TH PGD (in)	Max ZPA (g)	ZPD (in)	Ratio Max ZPA/TH-PGA	Ratio ZPD/PGD
1	CEUS Soil	0.56	2x6	1	0.503	TH01	0.368	0.386	0.634	0.384	1.724	0.995
				4	0.501	TH01	0.368	0.386	0.674	0.392	1.832	1.016
2	CEUS Soil	0.31	2x6	1	0.280	TH01	0.204	0.214	0.348	0.214	1.709	0.999
				4	0.280	TH01	0.204	0.214	0.373	0.217	1.832	1.014
3	CEUS Soil	0.1	2x6	1	0.090	TH01	0.066	0.069	0.111	0.071	1.690	1.034

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-19 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Mean ZPA (g)	TH ID	TH PGA (g)	TH PGD (in)	Max ZPA (g)	ZPD (in)	Ratio Max ZPA/TH-PGA	Ratio ZPD/PGD
				4	0.094	TH01	0.066	0.069	0.121	0.070	1.842	1.014
4	CEUS SR	0.29	6x12	1	0.213	TH01	0.197	0.147	0.298	0.155	1.509	1.053
				4	0.224	TH01	0.197	0.147	0.344	0.156	1.742	1.063
5	CEUS SR	0.25	6x12	1	0.185	TH01	0.170	0.127	0.259	0.134	1.522	1.054
				4	0.194	TH01	0.170	0.127	0.296	0.134	1.739	1.059
6	CEUS SR	0.18	6x12	1	0.121	TH02	0.095	2.063	0.165	2.068	1.735	1.002
				4	0.129	TH02	0.095	2.063	0.180	2.064	1.895	1.001
7	CEUS SR	0.08	6x12	1	0.065	TH03	0.053	0.226	0.103	0.229	1.945	1.016
				4	0.066	TH03	0.053	0.226	0.087	0.220	1.643	0.972
8	WUS Soil	0.23	2x15	1	0.137	TH03	0.143	0.480	0.194	0.495	1.358	1.031
				4	0.143	TH03	0.143	0.480	0.205	0.535	1.435	1.115
9	WUS Soil	0.14	2x15	1	0.090	TH02	0.064	4.294	0.113	4.306	1.760	1.003
				4	0.083	TH03	0.062	6.121	0.097	6.042	1.567	0.987
10	WUS Soil	0.19	2x15	1	0.117	TH03	0.118	0.397	0.162	0.409	1.373	1.031
				4	0.123	TH03	0.118	0.397	0.178	0.437	1.509	1.102
11	WUS SR	0.52	2x15	1	0.417	TH03	0.423	4.459	0.470	4.423	1.112	0.992
				4	0.424	TH02	0.420	9.602	0.466	9.606	1.109	1.000
12	WUS SR	0.22	2x15	1	0.179	TH04	0.156	0.806	0.204	0.807	1.305	1.001
				4	0.190	TH04	0.156	0.806	0.224	0.807	1.434	1.000
13	Diablo Canyon	1.3	5x28	1	1.125	TH02	1.082	21.032	1.207	21.037	1.115	1.000
				4	1.141	TH02	1.082	21.032	1.220	21.035	1.127	1.000
14	Diablo Canyon	0.92	5x28	1	0.807	TH02	0.766	14.885	0.870	14.886	1.136	1.000
				4	0.811	TH02	0.766	14.885	0.867	14.886	1.132	1.000

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-20 of 33

Appendix Table C-4 Cask X Rotation Maximum PGA Base Responses

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean PGA (rad/ s ²)	Max PGA (rad/ s ²)	Max PGD (deg)
1	CEUS Soil	0.56	2x6	1	2,5	3.82e-2	4.66e-2	3.80E-03
				4	2,2	5.15e-2	7.25e-2	2.54E-03
2	CEUS Soil	0.31	2x6	1	1,5	2.15e-2	2.38e-2	1.27E-03
				4	2,2	2.87e-2	4.07e-2	1.46E-03
3	CEUS Soil	0.1	2x6	1	1,5	7.31e-3	7.92e-3	4.38E-04
				4	2,2	9.46e-3	1.35e-2	5.03E-04
4	CEUS SR	0.29	6x12	1	1,2	1.34e-2	1.71e-2	2.18E-03
				4	6,2	2.05e-2	2.59e-2	1.12E-03
5	CEUS SR	0.25	6x12	1	1,2	1.18e-2	1.48e-2	1.88E-03
				4	6,2	1.79e-2	2.26e-2	9.97E-04
6	CEUS SR	0.18	6x12	1	1,2	6.64e-3	1.25e-2	1.03E-04
				4	6,1	9.14e-3	1.13e-2	1.04E-04
7	CEUS SR	0.08	6x12	1	6,11	3.90e-3	4.30e-3	3.65E-05
				4	6,1	5.84e-3	8.45e-3	6.80E-05
8	WUS Soil	0.23	2x15	1	2,4	7.84e-3	9.72e-3	5.25E-04
				4	2,1	8.14e-3	1.07e-2	2.70E-04
9	WUS Soil	0.14	2x15	1	2,9	4.51e-3	7.08e-3	3.06E-04
				4	2,1	3.86e-3	5.55e-3	2.03E-04
10	WUS Soil	0.19	2x15	1	2,4	6.55e-3	7.88e-3	4.09E-04
				4	2,1	7.15e-3	9.40e-3	2.29E-04

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-21 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean PGA (rad/s ²)	Max PGA (rad/s ²)	Max PGD (deg)
11	WUS SR	0.52	2x15	1	2,2	1.60e-2	2.08e-2	1.06E-04
				4	2,2	2.25e-2	2.97e-2	1.17E-04
12	WUS SR	0.22	2x15	1	1,2	7.60e-3	1.06e-2	1.06E-04
				4	1,1	8.71e-3	1.18e-2	1.17E-04
13	Diablo Canyon	1.3	5x28	1	5,28	2.35e-2	3.32e-2	7.17E-05
				4	5,2	3.91e-2	5.40e-2	8.82E-05
14	Diablo Canyon	0.92	5x28	1	5,28	1.66e-2	2.41e-2	4.78E-05
				4	5,2	2.77e-2	3.94e-2	5.79E-05

Appendix Table C-5 Cask Y Rotation Maximum PGA Base Responses

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean PGA (rad/s ²)	Max PGA (rad/s ²)	Max PGD (deg)
1	CEUS Soil	0.56	2x6	1	2,6	3.26e-2	4.16e-2	2.51E-04
				4	1,1	4.72e-2	5.32e-2	2.74E-04
2	CEUS Soil	0.31	2x6	1	2,6	1.84e-2	2.39e-2	1.39E-04
				4	1,1	2.65e-2	2.99e-2	1.48E-04
3	CEUS Soil	0.1	2x6	1	2,6	6.06e-3	8.49e-3	4.54E-05
				4	1,1	8.73e-3	9.77e-3	4.60E-05

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-22 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean PGA (rad/s ²)	Max PGA (rad/s ²)	Max PGD (deg)
4	CEUS SR	0.29	6x12	1	2,12	1.03e- 2	1.18e-2	1.04E-04
				4	1,1	1.99e- 2	2.40e-2	1.23E-04
5	CEUS SR	0.25	6x12	1	5,1	9.17e- 3	1.20e-2	9.83E-05
				4	1,1	1.74e- 2	2.12e-2	1.08E-04
6	CEUS SR	0.18	6x12	1	5,1	6.36e- 3	9.25e-3	7.92E-05
				4	3,1	1.52e- 2	1.66e-2	1.74E-04
7	CEUS SR	0.08	6x12	1	2,12	3.31e- 3	4.64e-3	4.39E-05
				4	5,1	6.22e- 3	7.82e-3	5.85E-05
8	WUS Soil	0.23	2x15	1	1,1	5.08e- 3	6.37e-3	3.72E-04
				4	2,1	1.28e- 2	1.83e-2	4.59E-04
9	WUS Soil	0.14	2x15	1	1,15	2.11e- 3	2.66e-3	1.66E-04
				4	2,1	4.11e- 3	5.06e-3	1.45E-04
10	WUS Soil	0.19	2x15	1	2,1	4.56e- 3	5.87e-3	2.05E-04
				4	2,1	1.11e- 2	1.58e-2	3.55E-04
11	WUS SR	0.52	2x15	1	1,15	1.27e- 2	1.80e-2	7.22E-05
				4	1,1	1.77e- 2	2.34e-2	9.32E-05

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-23 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean PGA (rad/s ²)	Max PGA (rad/s ²)	Max PGD (deg)
12	WUS SR	0.22	2x15	1	2,1	7.24e-3	1.05e-2	4.75E-05
				4	1,1	1.05e-2	1.63e-2	6.85E-05
13	Diablo Canyon	1.3	5x28	1	5,1	1.84e-2	2.98e-2	6.04E-05
				4	2,1	3.17e-2	4.99e-2	8.44E-05
14	Diablo Canyon	0.92	5x28	1	2,1	1.34e-2	1.88e-2	5.69E-05
				4	2,1	2.25e-2	3.61e-2	5.94E-05

Appendix Table C-6 Cask Z Rotation Maximum PGA Base Responses

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean PGA (rad/s ²)	Max PGA (rad/s ²)	Max PGD (deg)
1	CEUS Soil	0.56	2x6	1	1,6	3.05e-3	3.49e-3	2.28E-05
				4	2,2	7.59e-3	1.14e-2	3.75E-05
2	CEUS Soil	0.31	2x6	1	1,6	1.81e-3	2.13e-3	1.29E-05
				4	2,2	4.26e-3	6.40e-3	2.15E-05
3	CEUS Soil	0.1	2x6	1	1,6	6.47e-4	7.80e-4	4.04E-06
				4	2,2	1.43e-3	2.10e-3	7.45E-06
4	CEUS SR	0.29	6x12	1	6,1	8.68e-4	1.02e-3	1.84E-05
				4	6,2	2.25e-3	3.07e-3	1.02E-05

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-24 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Cask Positi on	Mean PGA (rad/s ²)	Max PGA (rad/s ²)	Max PGD (deg)
5	CEUS SR	0.25	6x12	1	6,1	7.71e-4	8.85e-4	1.59E-05
				4	6,2	1.96e-3	2.64e-3	8.73E-06
6	CEUS SR	0.18	6x12	1	1,12	4.99e-4	5.75e-4	6.82E-06
				4	6,2	1.05e-3	1.20e-3	7.82E-06
7	CEUS SR	0.08	6x12	1	6,12	3.08e-4	3.80e-4	5.29E-06
				4	6,2	5.83e-4	6.76e-4	3.45E-06
8	WUS Soil	0.23	2x15	1	2,15	3.94e-4	4.45e-4	3.97E-05
				4	2,2	1.28e-3	1.58e-3	3.86E-05
9	WUS Soil	0.14	2x15	1	1,4	3.00e-4	4.06e-4	3.64E-05
				4	2,2	5.97e-4	8.36e-4	3.51E-05
10	WUS Soil	0.19	2x15	1	2,15	3.42e-4	3.82e-4	3.30E-05
				4	2,2	1.11e-3	1.37e-3	3.51E-05
11	WUS SR	0.52	2x15	1	2,1	1.74e-3	2.41e-3	2.30E-05
				4	2,2	2.58e-3	3.54e-3	1.49E-05
12	WUS SR	0.22	2x15	1	1,15	8.53e-4	1.14e-3	9.93E-06
				4	1,1	1.29e-3	2.30e-3	4.64E-06
13	Diablo Canyon	1.3	5x28	1	5,28	5.60e-3	9.02e-3	3.28E-05
				4	5,2	5.16e-3	7.40e-3	1.15E-05
14	Diablo Canyon	0.92	5x28	1	5,28	4.08e-3	6.65e-3	2.14E-05
				4	5,2	3.69e-3	5.53e-3	8.04E-06

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-25 of 33

Appendix Table C-7 Cask X Direction Maximum PGA CG Responses

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (g)	Max ZPA (g)
1	CEUS Soil	0.56	2x6	1	2,1	0.618	0.854
				4	2,1	0.674	0.869
2	CEUS Soil	0.31	2x6	1	2,1	0.346	0.479
				4	2,1	0.374	0.481
3	CEUS Soil	0.1	2x6	1	2,1	0.116	0.16
				4	2,1	0.123	0.157
4	CEUS SR	0.29	6x12	1	2,12	0.199	0.25
				4	2,1	0.285	0.339
5	CEUS SR	0.25	6x12	1	2,12	0.174	0.223
				4	6,1	0.25	0.326
6	CEUS SR	0.18	6x12	1	3,12	0.222	0.312
				4	4,1	0.274	0.351
7	CEUS SR	0.08	6x12	1	3,12	0.075	0.111
				4	4,1	0.096	0.125
8	WUS Soil	0.23	2x15	1	2,15	0.285	0.333
				4	1,1	0.297	0.37
9	WUS Soil	0.14	2x15	1	2,15	0.181	0.209
				4	2,1	0.158	0.175
10	WUS Soil	0.19	2x15	1	2,15	0.244	0.288
				4	1,1	0.25	0.31
11	WUS SR	0.52	2x15	1	1,2	0.585	0.662

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-26 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (g)	Max ZPA (g)
				4	1,1	0.6	0.761
12	WUS SR	0.22	2x15	1	1,1	0.28	0.325
				4	1,1	0.293	0.342
13	Diablo Canyon	1.3	5x28	1	3,1	1.566	1.883
				4	4,1	1.592	1.869
14	Diablo Canyon	0.92	5x28	1	3,1	1.112	1.336
				4	4,1	1.129	1.32

Appendix Table C-8 Cask Y Direction Maximum PGA CG Responses

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (g)	Max ZPA (g)
1	CEUS Soil	0.56	2x6	1	1,3	0.669	0.877
				4	2,1	0.804	1.127
2	CEUS Soil	0.31	2x6	1	1,3	0.371	0.491
				4	2,1	0.456	0.63
3	CEUS Soil	0.1	2x6	1	2,3	0.122	0.178
				4	2,1	0.153	0.208
4	CEUS SR	0.29	6x12	1	1,7	0.234	0.331
				4	6,1	0.311	0.433
5	CEUS SR	0.25	6x12	1	1,2	0.204	0.282
				4	6,1	0.272	0.383
6	CEUS SR	0.18	6x12	1	6,4	0.173	0.209
				4	6,1	0.216	0.242

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-27 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (g)	Max ZPA (g)
7	CEUS SR	0.08	6x12	1	1,7	0.091	0.109
				4	6,1	0.115	0.166
8	WUS Soil	0.23	2x15	1	2,12	0.228	0.253
				4	2,1	0.235	0.266
9	WUS Soil	0.14	2x15	1	1,8	0.193	0.207
				4	2,1	0.182	0.212
10	WUS Soil	0.19	2x15	1	2,6	0.194	0.224
				4	2,1	0.198	0.228
11	WUS SR	0.52	2x15	1	2,2	0.6	0.731
				4	2,1	0.634	0.762
12	WUS SR	0.22	2x15	1	1,13	0.249	0.306
				4	1,1	0.253	0.323
13	Diablo Canyon	1.3	5x28	1	5,2	1.615	1.868
				4	5,2	1.643	1.888
14	Diablo Canyon	0.92	5x28	1	5,2	1.15	1.337
				4	5,2	1.164	1.335

Appendix Table C-9 Cask Z Direction Maximum PGA CG Responses

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (g)	Max ZPA (g)
1	CEUS Soil	0.56	2x6	1	2,6	0.503	0.634
				4	2,2	0.501	0.674
2	CEUS Soil	0.31	2x6	1	2,6	0.28	0.348

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-28 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (g)	Max ZPA (g)
				4	2,2	0.28	0.373
3	CEUS Soil	0.1	2x6	1	2,6	0.09	0.111
				4	2,2	0.094	0.121
4	CEUS SR	0.29	6x12	1	6,12	0.213	0.298
				4	6,1	0.224	0.344
5	CEUS SR	0.25	6x12	1	6,12	0.185	0.259
				4	6,1	0.194	0.296
6	CEUS SR	0.18	6x12	1	6,6	0.121	0.165
				4	6,1	0.129	0.18
7	CEUS SR	0.08	6x12	1	6,7	0.065	0.103
				4	6,1	0.066	0.087
8	WUS Soil	0.23	2x15	1	1,1	0.137	0.194
				4	2,2	0.143	0.205
9	WUS Soil	0.14	2x15	1	1,4	0.09	0.113
				4	2,1	0.083	0.097
10	WUS Soil	0.19	2x15	1	1,1	0.117	0.162
				4	2,2	0.123	0.178
11	WUS SR	0.52	2x15	1	2,15	0.417	0.47
				4	2,1	0.424	0.466
12	WUS SR	0.22	2x15	1	1,1	0.179	0.204
				4	1,1	0.19	0.224
13	Diablo Canyon	1.3	5x28	1	4,2	1.125	1.207
				4	4,1	1.141	1.22

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-29 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (g)	Max ZPA (g)
14	Diablo Canyon	0.92	5x28	1	4,2	0.807	0.87
				4	4,1	0.811	0.867

Appendix Table C-10 Cask X Rotation Maximum PGA CG Responses

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (rad/s ²)	Max ZPA (rad/s ²)
1	CEUS Soil	0.56	2x6	1	2,5	3.82e-2	4.66e-2
				4	2,2	5.15e-2	7.25e-2
2	CEUS Soil	0.31	2x6	1	1,5	2.15e-2	2.38e-2
				4	2,2	2.87e-2	4.07e-2
3	CEUS Soil	0.1	2x6	1	1,5	7.31e-3	7.92e-3
				4	2,2	9.46e-3	1.35e-2
4	CEUS SR	0.29	6x12	1	1,2	1.34e-2	1.71e-2
				4	6,2	2.05e-2	2.59e-2
5	CEUS SR	0.25	6x12	1	1,2	1.18e-2	1.48e-2
				4	6,2	1.79e-2	2.26e-2
6	CEUS SR	0.18	6x12	1	1,2	6.64e-3	1.25e-2
				4	6,1	9.14e-3	1.13e-2
7	CEUS SR	0.08	6x12	1	6,11	3.90e-3	4.30e-3
				4	6,1	5.84e-3	8.45e-3
8	WUS Soil	0.23	2x15	1	2,4	7.84e-3	9.72e-3

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-30 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (rad/s ²)	Max ZPA (rad/s ²)
				4	2,1	8.14e-3	1.07e-2
9	WUS Soil	0.14	2x15	1	2,9	4.61e-3	7.08e-3
				4	2,1	3.86e-3	5.55e-3
10	WUS Soil	0.19	2x15	1	2,4	6.55e-3	7.88e-3
				4	2,1	7.15e-3	9.40e-3
11	WUS SR	0.52	2x15	1	2,2	1.60e-2	2.08e-2
				4	2,2	2.25e-2	2.97e-2
12	WUS SR	0.22	2x15	1	1,2	7.60e-3	1.06e-2
				4	1,1	8.71e-3	1.18e-2
13	Diablo Canyon	1.3	5x28	1	5,28	2.35e-2	3.32e-2
				4	5,2	3.91e-2	5.40e-2
14	Diablo Canyon	0.92	5x28	1	5,28	1.66e-2	2.41e-2
				4	5,2	2.77e-2	3.94e-2

Appendix Table C-11 Cask Y Rotation Maximum PGA CG Responses

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (rad/s ²)	Max ZPA (rad/s ²)
1	CEUS Soil	0.56	2x6	1	2,6	3.26e-2	4.16e-2
				4	1,1	4.72e-2	5.32e-2
2	CEUS Soil	0.31	2x6	1	2,6	1.84e-2	2.39e-2
				4	1,1	2.65e-2	2.99e-2
3	CEUS Soil	0.1	2x6	1	2,6	6.06e-3	8.49e-3
				4	1,1	8.73e-3	9.77e-3

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-31 of 33

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (rad/s ²)	Max ZPA (rad/s ²)
4	CEUS SR	0.29	6x12	1	2,12	1.03e-2	1.18e-2
				4	1,1	1.99e-2	2.40e-2
5	CEUS SR	0.25	6x12	1	5,1	9.17e-3	1.20e-2
				4	1,1	1.74e-2	2.12e-2
6	CEUS SR	0.18	6x12	1	5,1	6.36e-3	9.25e-3
				4	3,1	1.52e-2	1.66e-2
7	CEUS SR	0.08	6x12	1	2,12	3.31e-3	4.64e-3
				4	5,1	6.22e-3	7.82e-3
8	WUS Soil	0.23	2x15	1	1,1	5.08e-3	6.37e-3
				4	2,1	1.28e-2	1.83e-2
9	WUS Soil	0.14	2x15	1	1,15	2.11e-3	2.66e-3
				4	2,1	4.11e-3	5.06e-3
10	WUS Soil	0.19	2x15	1	2,1	4.56e-3	5.87e-3
				4	2,1	1.11e-2	1.58e-2
11	WUS SR	0.52	2x15	1	1,15	1.27e-2	1.80e-2
				4	1,1	1.77e-2	2.34e-2
12	WUS SR	0.22	2x15	1	2,1	7.24e-3	1.05e-2
				4	1,1	1.05e-2	1.63e-2
13	Diablo Canyon	1.3	5x28	1	5,1	1.84e-2	2.98e-2
				4	2,1	3.17e-2	4.99e-2
14	Diablo Canyon	0.92	5x28	1	2,1	1.34e-2	1.88e-2
				4	2,1	2.25e-2	3.61e-2

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-32 of 33

Appendix Table C-12 Cask Z Rotation Maximum PGA CG Responses

No.	Case	Target PGA (g)	Pad Size	Config	Cask Position	Mean ZPA (rad/s ²)	Max ZPA (rad/s ²)
1	CEUS Soil	0.56	2x6	1	1,6	3.05e-3	3.49e-3
				4	2,2	7.59e-3	1.14e-2
2	CEUS Soil	0.31	2x6	1	1,6	1.81e-3	2.13e-3
				4	2,2	4.26e-3	6.40e-3
3	CEUS Soil	0.1	2x6	1	1,6	6.47e-4	7.8e-4
				4	2,2	1.43e-3	2.10e-3
4	CEUS SR	0.29	6x12	1	6,1	8.68e-4	1.02e-3
				4	6,2	2.25e-3	3.07e-3
5	CEUS SR	0.25	6x12	1	6,1	7.71e-4	8.85e-4
				4	6,2	1.96e-3	2.64e-3
6	CEUS SR	0.18	6x12	1	1,12	4.99e-4	5.75e-4
				4	6,2	1.05e-3	1.20e-3
7	CEUS SR	0.08	6x12	1	6,12	3.08e-4	3.80e-4
				4	6,2	5.83e-4	6.76e-4
8	WUS Soil	0.23	2x15	1	2,15	3.95e-4	4.45e-4
				4	2,2	1.28e-3	1.58e-3
9	WUS Soil	0.14	2x15	1	1,4	3.00e-4	4.06e-4
				4	2,2	5.97e-4	8.36e-4
10	WUS Soil	0.19	2x15	1	2,15	3.42e-4	3.82e-4
				4	2,2	1.11e-3	1.37e-3
11	WUS SR	0.52	2x15	1	2,1	1.74e-3	2.41e-3

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: C-33 of 33

				4	2,2	2.58e-3	3.54e-3
12	WUS SR	0.22	2x15	1	1,15	8.53e-4	1.14e-3
				4	1,1	1.29e-3	2.30e-3
13	Diablo Canyon	1.3	5x28	1	5,28	5.60e-3	9.02e-3
				4	5,2	5.16e-3	7.40e-3
14	Diablo Canyon	0.92	5x28	1	5,28	4.08e-3	6.65e-3
				4	5,2	3.69e-3	5.53e-3

Appendix D

List of Electronic Files

1. CEUS Soil, D15 0.56g

1.1. Configuration A

04/12/2022	04:53 PM	198,556 CEUS_Soil_D15_056g_Config1_sp_s_accel_base_TH01.csv
04/12/2022	05:13 PM	198,556 CEUS_Soil_D15_056g_Config1_sp_s_accel_base_TH02.csv
04/12/2022	05:33 PM	198,556 CEUS_Soil_D15_056g_Config1_sp_s_accel_base_TH03.csv
04/12/2022	05:53 PM	198,556 CEUS_Soil_D15_056g_Config1_sp_s_accel_base_TH04.csv
04/12/2022	06:13 PM	198,556 CEUS_Soil_D15_056g_Config1_sp_s_accel_base_TH05.csv
04/12/2022	04:43 PM	198,592 CEUS_Soil_D15_056g_Config1_sp_s_accel_TH01.csv
04/12/2022	05:03 PM	198,592 CEUS_Soil_D15_056g_Config1_sp_s_accel_TH02.csv
04/12/2022	05:23 PM	198,592 CEUS_Soil_D15_056g_Config1_sp_s_accel_TH03.csv
04/12/2022	05:43 PM	198,592 CEUS_Soil_D15_056g_Config1_sp_s_accel_TH04.csv
04/12/2022	06:03 PM	198,592 CEUS_Soil_D15_056g_Config1_sp_s_accel_TH05.csv
04/12/2022	04:53 PM	32,703,437 CEUS_Soil_D15_056g_Config1_th_s_accel_base_TH01.csv
04/12/2022	05:13 PM	32,703,437 CEUS_Soil_D15_056g_Config1_th_s_accel_base_TH02.csv
04/12/2022	05:33 PM	32,703,437 CEUS_Soil_D15_056g_Config1_th_s_accel_base_TH03.csv
04/12/2022	05:53 PM	32,703,437 CEUS_Soil_D15_056g_Config1_th_s_accel_base_TH04.csv
04/12/2022	06:12 PM	32,703,437 CEUS_Soil_D15_056g_Config1_th_s_accel_base_TH05.csv
04/12/2022	04:43 PM	32,703,473 CEUS_Soil_D15_056g_Config1_th_s_accel_TH01.csv
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04/12/2022	05:23 PM	32,703,473 CEUS_Soil_D15_056g_Config1_th_s_accel_TH03.csv
04/12/2022	05:43 PM	32,703,473 CEUS_Soil_D15_056g_Config1_th_s_accel_TH04.csv
04/12/2022	06:03 PM	32,703,473 CEUS_Soil_D15_056g_Config1_th_s_accel_TH05.csv
04/12/2022	04:53 PM	32,703,437 CEUS_Soil_D15_056g_Config1_th_s_displ_base_TH01.csv
04/12/2022	05:13 PM	32,703,437 CEUS_Soil_D15_056g_Config1_th_s_displ_base_TH02.csv
04/12/2022	05:33 PM	32,703,437 CEUS_Soil_D15_056g_Config1_th_s_displ_base_TH03.csv
04/12/2022	05:53 PM	32,703,437 CEUS_Soil_D15_056g_Config1_th_s_displ_base_TH04.csv
04/12/2022	06:13 PM	32,703,437 CEUS_Soil_D15_056g_Config1_th_s_displ_base_TH05.csv
04/12/2022	04:43 PM	32,703,473 CEUS_Soil_D15_056g_Config1_th_s_displ_TH01.csv
04/12/2022	05:03 PM	32,703,473 CEUS_Soil_D15_056g_Config1_th_s_displ_TH02.csv
04/12/2022	05:23 PM	32,703,473 CEUS_Soil_D15_056g_Config1_th_s_displ_TH03.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-2 of 33

04/12/2022 05:43 PM	32,703,473 CEUS_Soil_D15_056g_Config1_th_s_displ_TH04.csv
04/12/2022 06:03 PM	32,703,473 CEUS_Soil_D15_056g_Config1_th_s_displ_TH05.csv

1.2. Configuration B

04/12/2022 02:46 PM	117,991 CEUS_Soil_D15_056g_Config4_sp_s_accel_base_TH01.csv
04/12/2022 02:58 PM	117,991 CEUS_Soil_D15_056g_Config4_sp_s_accel_base_TH02.csv
04/12/2022 03:11 PM	117,991 CEUS_Soil_D15_056g_Config4_sp_s_accel_base_TH03.csv
04/12/2022 03:23 PM	117,991 CEUS_Soil_D15_056g_Config4_sp_s_accel_base_TH04.csv
04/12/2022 03:35 PM	117,991 CEUS_Soil_D15_056g_Config4_sp_s_accel_base_TH05.csv
04/12/2022 02:40 PM	117,997 CEUS_Soil_D15_056g_Config4_sp_s_accel_TH01.csv
04/12/2022 02:52 PM	117,997 CEUS_Soil_D15_056g_Config4_sp_s_accel_TH02.csv
04/12/2022 03:05 PM	117,997 CEUS_Soil_D15_056g_Config4_sp_s_accel_TH03.csv
04/12/2022 03:17 PM	117,997 CEUS_Soil_D15_056g_Config4_sp_s_accel_TH04.csv
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04/12/2022 02:58 PM	19,432,022 CEUS_Soil_D15_056g_Config4_th_s_accel_base_TH02.csv
04/12/2022 03:11 PM	19,432,022 CEUS_Soil_D15_056g_Config4_th_s_accel_base_TH03.csv
04/12/2022 03:23 PM	19,432,022 CEUS_Soil_D15_056g_Config4_th_s_accel_base_TH04.csv
04/12/2022 03:35 PM	19,432,022 CEUS_Soil_D15_056g_Config4_th_s_accel_base_TH05.csv
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04/12/2022 02:52 PM	23,855,837 CEUS_Soil_D15_056g_Config4_th_s_accel_TH02.csv
04/12/2022 03:05 PM	23,855,837 CEUS_Soil_D15_056g_Config4_th_s_accel_TH03.csv
04/12/2022 03:17 PM	23,855,837 CEUS_Soil_D15_056g_Config4_th_s_accel_TH04.csv
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04/12/2022 02:46 PM	19,432,022 CEUS_Soil_D15_056g_Config4_th_s_displ_base_TH01.csv
04/12/2022 02:58 PM	19,432,022 CEUS_Soil_D15_056g_Config4_th_s_displ_base_TH02.csv
04/12/2022 03:11 PM	19,432,022 CEUS_Soil_D15_056g_Config4_th_s_displ_base_TH03.csv
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04/12/2022 03:35 PM	19,432,022 CEUS_Soil_D15_056g_Config4_th_s_displ_base_TH05.csv
04/12/2022 02:40 PM	23,855,837 CEUS_Soil_D15_056g_Config4_th_s_displ_TH01.csv
04/12/2022 02:52 PM	23,855,837 CEUS_Soil_D15_056g_Config4_th_s_displ_TH02.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-3 of 33

04/12/2022 03:05 PM	23,855,837 CEUS_Soil_D15_056g_Config4_th_s_displ_TH03.csv
04/12/2022 03:17 PM	23,855,837 CEUS_Soil_D15_056g_Config4_th_s_displ_TH04.csv
04/12/2022 03:29 PM	23,855,837 CEUS_Soil_D15_056g_Config4_th_s_displ_TH05.csv

2. CEUS Soil, D40 0.31g

2.1. Configuration A

04/12/2022 04:55 PM	198,556 CEUS_Soil_D40_031g_Config1_sp_s_accel_base_TH01.csv
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04/12/2022 05:55 PM	198,556 CEUS_Soil_D40_031g_Config1_sp_s_accel_base_TH04.csv
04/12/2022 06:14 PM	198,556 CEUS_Soil_D40_031g_Config1_sp_s_accel_base_TH05.csv
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04/12/2022 05:05 PM	198,592 CEUS_Soil_D40_031g_Config1_sp_s_accel_TH02.csv
04/12/2022 05:25 PM	198,592 CEUS_Soil_D40_031g_Config1_sp_s_accel_TH03.csv
04/12/2022 05:45 PM	198,592 CEUS_Soil_D40_031g_Config1_sp_s_accel_TH04.csv
04/12/2022 06:05 PM	198,592 CEUS_Soil_D40_031g_Config1_sp_s_accel_TH05.csv
04/12/2022 04:55 PM	32,703,437 CEUS_Soil_D40_031g_Config1_th_s_accel_base_TH01.csv
04/12/2022 05:15 PM	32,703,437 CEUS_Soil_D40_031g_Config1_th_s_accel_base_TH02.csv
04/12/2022 05:35 PM	32,703,437 CEUS_Soil_D40_031g_Config1_th_s_accel_base_TH03.csv
04/12/2022 05:55 PM	32,703,437 CEUS_Soil_D40_031g_Config1_th_s_accel_base_TH04.csv
04/12/2022 06:14 PM	32,703,437 CEUS_Soil_D40_031g_Config1_th_s_accel_base_TH05.csv
04/12/2022 04:45 PM	32,703,473 CEUS_Soil_D40_031g_Config1_th_s_accel_TH01.csv
04/12/2022 05:05 PM	32,703,473 CEUS_Soil_D40_031g_Config1_th_s_accel_TH02.csv
04/12/2022 05:25 PM	32,703,473 CEUS_Soil_D40_031g_Config1_th_s_accel_TH03.csv
04/12/2022 05:45 PM	32,703,473 CEUS_Soil_D40_031g_Config1_th_s_accel_TH04.csv
04/12/2022 06:04 PM	32,703,473 CEUS_Soil_D40_031g_Config1_th_s_accel_TH05.csv
04/12/2022 04:55 PM	32,703,437 CEUS_Soil_D40_031g_Config1_th_s_displ_base_TH01.csv
04/12/2022 05:15 PM	32,703,437 CEUS_Soil_D40_031g_Config1_th_s_displ_base_TH02.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-4 of 33

04/12/2022 05:35 PM	32,703,437 CEUS_Soil_D40_031g_Config1_th_s_displ_base_TH03.csv
04/12/2022 05:55 PM	32,703,437 CEUS_Soil_D40_031g_Config1_th_s_displ_base_TH04.csv
04/12/2022 06:14 PM	32,703,437 CEUS_Soil_D40_031g_Config1_th_s_displ_base_TH05.csv
04/12/2022 04:45 PM	32,703,473 CEUS_Soil_D40_031g_Config1_th_s_displ_TH01.csv
04/12/2022 05:05 PM	32,703,473 CEUS_Soil_D40_031g_Config1_th_s_displ_TH02.csv
04/12/2022 05:25 PM	32,703,473 CEUS_Soil_D40_031g_Config1_th_s_displ_TH03.csv
04/12/2022 05:45 PM	32,703,473 CEUS_Soil_D40_031g_Config1_th_s_displ_TH04.csv
04/12/2022 06:05 PM	32,703,473 CEUS_Soil_D40_031g_Config1_th_s_displ_TH05.csv

2.2. Configuration B

04/12/2022 04:56 PM	117,991 CEUS_Soil_D40_031g_Config4_sp_s_accel_base_TH01.csv
04/12/2022 05:08 PM	117,991 CEUS_Soil_D40_031g_Config4_sp_s_accel_base_TH02.csv
04/12/2022 05:20 PM	117,991 CEUS_Soil_D40_031g_Config4_sp_s_accel_base_TH03.csv
04/12/2022 05:32 PM	117,991 CEUS_Soil_D40_031g_Config4_sp_s_accel_base_TH04.csv
04/12/2022 05:45 PM	117,991 CEUS_Soil_D40_031g_Config4_sp_s_accel_base_TH05.csv
04/12/2022 04:50 PM	117,997 CEUS_Soil_D40_031g_Config4_sp_s_accel_TH01.csv
04/12/2022 05:02 PM	117,997 CEUS_Soil_D40_031g_Config4_sp_s_accel_TH02.csv
04/12/2022 05:14 PM	117,997 CEUS_Soil_D40_031g_Config4_sp_s_accel_TH03.csv
04/12/2022 05:27 PM	117,997 CEUS_Soil_D40_031g_Config4_sp_s_accel_TH04.csv
04/12/2022 05:39 PM	117,997 CEUS_Soil_D40_031g_Config4_sp_s_accel_TH05.csv
04/12/2022 04:55 PM	19,432,022 CEUS_Soil_D40_031g_Config4_th_s_accel_base_TH01.csv
04/12/2022 05:08 PM	19,432,022 CEUS_Soil_D40_031g_Config4_th_s_accel_base_TH02.csv
04/12/2022 05:20 PM	19,432,022 CEUS_Soil_D40_031g_Config4_th_s_accel_base_TH03.csv
04/12/2022 05:32 PM	19,432,022 CEUS_Soil_D40_031g_Config4_th_s_accel_base_TH04.csv
04/12/2022 05:45 PM	19,432,022 CEUS_Soil_D40_031g_Config4_th_s_accel_base_TH05.csv
04/12/2022 04:50 PM	23,855,837 CEUS_Soil_D40_031g_Config4_th_s_accel_TH01.csv
04/12/2022 05:02 PM	23,855,837 CEUS_Soil_D40_031g_Config4_th_s_accel_TH02.csv
04/12/2022 05:14 PM	23,855,837 CEUS_Soil_D40_031g_Config4_th_s_accel_TH03.csv
04/12/2022 05:27 PM	23,855,837 CEUS_Soil_D40_031g_Config4_th_s_accel_TH04.csv
04/12/2022 05:39 PM	23,855,837 CEUS_Soil_D40_031g_Config4_th_s_accel_TH05.csv
04/12/2022 04:56 PM	19,432,022 CEUS_Soil_D40_031g_Config4_th_s_displ_base_TH01.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-5 of 33

04/12/2022	05:08 PM	19,432,022 CEUS_Soil_D40_031g_Config4_th_s_displ_base_TH02.csv
04/12/2022	05:20 PM	19,432,022 CEUS_Soil_D40_031g_Config4_th_s_displ_base_TH03.csv
04/12/2022	05:32 PM	19,432,022 CEUS_Soil_D40_031g_Config4_th_s_displ_base_TH04.csv
04/12/2022	05:45 PM	19,432,022 CEUS_Soil_D40_031g_Config4_th_s_displ_base_TH05.csv
04/12/2022	04:50 PM	23,855,837 CEUS_Soil_D40_031g_Config4_th_s_displ_TH01.csv
04/12/2022	05:02 PM	23,855,837 CEUS_Soil_D40_031g_Config4_th_s_displ_TH02.csv
04/12/2022	05:14 PM	23,855,837 CEUS_Soil_D40_031g_Config4_th_s_displ_TH03.csv
04/12/2022	05:27 PM	23,855,837 CEUS_Soil_D40_031g_Config4_th_s_displ_TH04.csv
04/12/2022	05:39 PM	23,855,837 CEUS_Soil_D40_031g_Config4_th_s_displ_TH05.csv

3. CEUS Soil, D200 0.1g

3.1. Configuration A

04/12/2022	04:55 PM	198,556 CEUS_Soil_D200_01g_Config1_sp_s_accel_base_TH01.csv
04/12/2022	05:15 PM	198,556 CEUS_Soil_D200_01g_Config1_sp_s_accel_base_TH02.csv
04/12/2022	05:35 PM	198,556 CEUS_Soil_D200_01g_Config1_sp_s_accel_base_TH03.csv
04/12/2022	05:55 PM	198,556 CEUS_Soil_D200_01g_Config1_sp_s_accel_base_TH04.csv
04/12/2022	06:14 PM	198,556 CEUS_Soil_D200_01g_Config1_sp_s_accel_base_TH05.csv
04/12/2022	04:45 PM	198,592 CEUS_Soil_D200_01g_Config1_sp_s_accel_TH01.csv
04/12/2022	05:05 PM	198,592 CEUS_Soil_D200_01g_Config1_sp_s_accel_TH02.csv
04/12/2022	05:25 PM	198,592 CEUS_Soil_D200_01g_Config1_sp_s_accel_TH03.csv
04/12/2022	05:45 PM	198,592 CEUS_Soil_D200_01g_Config1_sp_s_accel_TH04.csv
04/12/2022	06:05 PM	198,592 CEUS_Soil_D200_01g_Config1_sp_s_accel_TH05.csv
04/12/2022	04:55 PM	32,703,437 CEUS_Soil_D200_01g_Config1_th_s_accel_base_TH01.csv
04/12/2022	05:15 PM	32,703,437 CEUS_Soil_D200_01g_Config1_th_s_accel_base_TH02.csv
04/12/2022	05:35 PM	32,703,437 CEUS_Soil_D200_01g_Config1_th_s_accel_base_TH03.csv
04/12/2022	05:55 PM	32,703,437 CEUS_Soil_D200_01g_Config1_th_s_accel_base_TH04.csv
04/12/2022	06:14 PM	32,703,437 CEUS_Soil_D200_01g_Config1_th_s_accel_base_TH05.csv
04/12/2022	04:45 PM	32,703,473 CEUS_Soil_D200_01g_Config1_th_s_accel_TH01.csv
04/12/2022	05:05 PM	32,703,473 CEUS_Soil_D200_01g_Config1_th_s_accel_TH02.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-6 of 33

04/12/2022	05:25 PM	32,703,473 CEUS_Soil_D200_01g_Config1_th_s_accel_TH03.csv
04/12/2022	05:45 PM	32,703,473 CEUS_Soil_D200_01g_Config1_th_s_accel_TH04.csv
04/12/2022	06:05 PM	32,703,473 CEUS_Soil_D200_01g_Config1_th_s_accel_TH05.csv
04/12/2022	04:55 PM	32,703,437 CEUS_Soil_D200_01g_Config1_th_s_displ_base_TH01.csv
04/12/2022	05:15 PM	32,703,437 CEUS_Soil_D200_01g_Config1_th_s_displ_base_TH02.csv
04/12/2022	05:35 PM	32,703,437 CEUS_Soil_D200_01g_Config1_th_s_displ_base_TH03.csv
04/12/2022	05:55 PM	32,703,437 CEUS_Soil_D200_01g_Config1_th_s_displ_base_TH04.csv
04/12/2022	06:14 PM	32,703,437 CEUS_Soil_D200_01g_Config1_th_s_displ_base_TH05.csv
04/12/2022	04:45 PM	32,703,473 CEUS_Soil_D200_01g_Config1_th_s_displ_TH01.csv
04/12/2022	05:05 PM	32,703,473 CEUS_Soil_D200_01g_Config1_th_s_displ_TH02.csv
04/12/2022	05:25 PM	32,703,473 CEUS_Soil_D200_01g_Config1_th_s_displ_TH03.csv
04/12/2022	05:45 PM	32,703,473 CEUS_Soil_D200_01g_Config1_th_s_displ_TH04.csv
04/12/2022	06:05 PM	32,703,473 CEUS_Soil_D200_01g_Config1_th_s_displ_TH05.csv

3.2. Configuration B

04/12/2022	04:55 PM	117,991 CEUS_Soil_D200_01g_Config4_sp_s_accel_base_TH01.csv
04/12/2022	05:08 PM	117,991 CEUS_Soil_D200_01g_Config4_sp_s_accel_base_TH02.csv
04/12/2022	05:20 PM	117,991 CEUS_Soil_D200_01g_Config4_sp_s_accel_base_TH03.csv
04/12/2022	05:32 PM	117,991 CEUS_Soil_D200_01g_Config4_sp_s_accel_base_TH04.csv
04/12/2022	05:45 PM	117,991 CEUS_Soil_D200_01g_Config4_sp_s_accel_base_TH05.csv
04/12/2022	04:50 PM	117,997 CEUS_Soil_D200_01g_Config4_sp_s_accel_TH01.csv
04/12/2022	05:02 PM	117,997 CEUS_Soil_D200_01g_Config4_sp_s_accel_TH02.csv
04/12/2022	05:14 PM	117,997 CEUS_Soil_D200_01g_Config4_sp_s_accel_TH03.csv
04/12/2022	05:26 PM	117,997 CEUS_Soil_D200_01g_Config4_sp_s_accel_TH04.csv
04/12/2022	05:39 PM	117,997 CEUS_Soil_D200_01g_Config4_sp_s_accel_TH05.csv
04/12/2022	04:55 PM	19,432,022 CEUS_Soil_D200_01g_Config4_th_s_accel_base_TH01.csv
04/12/2022	05:08 PM	19,432,022 CEUS_Soil_D200_01g_Config4_th_s_accel_base_TH02.csv
04/12/2022	05:20 PM	19,432,022 CEUS_Soil_D200_01g_Config4_th_s_accel_base_TH03.csv
04/12/2022	05:32 PM	19,432,022 CEUS_Soil_D200_01g_Config4_th_s_accel_base_TH04.csv
04/12/2022	05:45 PM	19,432,022 CEUS_Soil_D200_01g_Config4_th_s_accel_base_TH05.csv
04/12/2022	04:50 PM	23,855,837 CEUS_Soil_D200_01g_Config4_th_s_accel_TH01.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-7 of 33

04/12/2022	05:02 PM	23,855,837 CEUS_Soil_D200_01g_Config4_th_s_accel_TH02.csv
04/12/2022	05:14 PM	23,855,837 CEUS_Soil_D200_01g_Config4_th_s_accel_TH03.csv
04/12/2022	05:26 PM	23,855,837 CEUS_Soil_D200_01g_Config4_th_s_accel_TH04.csv
04/12/2022	05:39 PM	23,855,837 CEUS_Soil_D200_01g_Config4_th_s_accel_TH05.csv
04/12/2022	04:55 PM	19,432,022 CEUS_Soil_D200_01g_Config4_th_s_displ_base_TH01.csv
04/12/2022	05:08 PM	19,432,022 CEUS_Soil_D200_01g_Config4_th_s_displ_base_TH02.csv
04/12/2022	05:20 PM	19,432,022 CEUS_Soil_D200_01g_Config4_th_s_displ_base_TH03.csv
04/12/2022	05:32 PM	19,432,022 CEUS_Soil_D200_01g_Config4_th_s_displ_base_TH04.csv
04/12/2022	05:45 PM	19,432,022 CEUS_Soil_D200_01g_Config4_th_s_displ_base_TH05.csv
04/12/2022	04:50 PM	23,855,837 CEUS_Soil_D200_01g_Config4_th_s_displ_TH01.csv
04/12/2022	05:02 PM	23,855,837 CEUS_Soil_D200_01g_Config4_th_s_displ_TH02.csv
04/12/2022	05:14 PM	23,855,837 CEUS_Soil_D200_01g_Config4_th_s_displ_TH03.csv
04/12/2022	05:26 PM	23,855,837 CEUS_Soil_D200_01g_Config4_th_s_displ_TH04.csv
04/12/2022	05:39 PM	23,855,837 CEUS_Soil_D200_01g_Config4_th_s_displ_TH05.csv

4. CEUS Soft Rock, D15 0.25g

4.1. Configuration A

04/03/2022	11:28 PM	735,814 CEUS_SR_D15_025g_Config1_sp_s_accel_base_TH01.csv
04/04/2022	12:48 AM	735,814 CEUS_SR_D15_025g_Config1_sp_s_accel_base_TH02.csv
04/04/2022	02:10 AM	735,814 CEUS_SR_D15_025g_Config1_sp_s_accel_base_TH03.csv
04/04/2022	03:29 AM	735,814 CEUS_SR_D15_025g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	04:46 AM	735,814 CEUS_SR_D15_025g_Config1_sp_s_accel_base_TH05.csv
04/12/2022	03:13 PM	744,841 CEUS_SR_D15_025g_Config1_sp_s_accel_TH01.csv
04/04/2022	12:13 AM	744,841 CEUS_SR_D15_025g_Config1_sp_s_accel_TH02.csv
04/04/2022	01:34 AM	744,841 CEUS_SR_D15_025g_Config1_sp_s_accel_TH03.csv
04/04/2022	02:53 AM	744,841 CEUS_SR_D15_025g_Config1_sp_s_accel_TH04.csv
04/04/2022	04:12 AM	744,841 CEUS_SR_D15_025g_Config1_sp_s_accel_TH05.csv
04/03/2022	11:28 PM	121,179,695 CEUS_SR_D15_025g_Config1_th_s_accel_base_TH01.csv
04/04/2022	12:48 AM	121,179,695 CEUS_SR_D15_025g_Config1_th_s_accel_base_TH02.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-8 of 33

04/04/2022	02:09 AM	121,179,695 CEUS_SR_D15_025g_Config1_th_s_accel_base_TH03.csv
04/04/2022	03:28 AM	121,179,695 CEUS_SR_D15_025g_Config1_th_s_accel_base_TH04.csv
04/04/2022	04:46 AM	121,179,695 CEUS_SR_D15_025g_Config1_th_s_accel_base_TH05.csv
04/12/2022	03:12 PM	227,351,255 CEUS_SR_D15_025g_Config1_th_s_accel_TH01.csv
04/04/2022	12:12 AM	227,351,255 CEUS_SR_D15_025g_Config1_th_s_accel_TH02.csv
04/04/2022	01:33 AM	227,351,255 CEUS_SR_D15_025g_Config1_th_s_accel_TH03.csv
04/04/2022	02:52 AM	227,351,255 CEUS_SR_D15_025g_Config1_th_s_accel_TH04.csv
04/04/2022	04:11 AM	227,351,255 CEUS_SR_D15_025g_Config1_th_s_accel_TH05.csv
04/03/2022	11:28 PM	121,179,695 CEUS_SR_D15_025g_Config1_th_s_displ_base_TH01.csv
04/04/2022	12:48 AM	121,179,695 CEUS_SR_D15_025g_Config1_th_s_displ_base_TH02.csv
04/04/2022	02:10 AM	121,179,695 CEUS_SR_D15_025g_Config1_th_s_displ_base_TH03.csv
04/04/2022	03:29 AM	121,179,695 CEUS_SR_D15_025g_Config1_th_s_displ_base_TH04.csv
04/04/2022	04:46 AM	121,179,695 CEUS_SR_D15_025g_Config1_th_s_displ_base_TH05.csv
04/12/2022	03:13 PM	227,351,255 CEUS_SR_D15_025g_Config1_th_s_displ_TH01.csv
04/04/2022	12:13 AM	227,351,255 CEUS_SR_D15_025g_Config1_th_s_displ_TH02.csv
04/04/2022	01:34 AM	227,351,255 CEUS_SR_D15_025g_Config1_th_s_displ_TH03.csv
04/04/2022	02:53 AM	227,351,255 CEUS_SR_D15_025g_Config1_th_s_displ_TH04.csv
04/04/2022	04:12 AM	227,351,255 CEUS_SR_D15_025g_Config1_th_s_displ_TH05.csv

4.2. Configuration B

04/04/2022	08:22 AM	153,805 CEUS_SR_D15_025g_Config4_sp_s_accel_base_TH01.csv
04/04/2022	08:35 AM	153,805 CEUS_SR_D15_025g_Config4_sp_s_accel_base_TH02.csv
04/04/2022	08:47 AM	153,805 CEUS_SR_D15_025g_Config4_sp_s_accel_base_TH03.csv
04/04/2022	09:00 AM	153,805 CEUS_SR_D15_025g_Config4_sp_s_accel_base_TH04.csv
04/04/2022	09:12 AM	153,805 CEUS_SR_D15_025g_Config4_sp_s_accel_base_TH05.csv
04/04/2022	08:16 AM	162,766 CEUS_SR_D15_025g_Config4_sp_s_accel_TH01.csv
04/04/2022	08:29 AM	162,766 CEUS_SR_D15_025g_Config4_sp_s_accel_TH02.csv
04/04/2022	08:41 AM	162,766 CEUS_SR_D15_025g_Config4_sp_s_accel_TH03.csv
04/04/2022	08:54 AM	162,766 CEUS_SR_D15_025g_Config4_sp_s_accel_TH04.csv
04/04/2022	09:06 AM	162,766 CEUS_SR_D15_025g_Config4_sp_s_accel_TH05.csv
04/04/2022	08:22 AM	25,330,436 CEUS_SR_D15_025g_Config4_th_s_accel_base_TH01.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-9 of 33

04/04/2022	08:34 AM	25,330,436 CEUS_SR_D15_025g_Config4_th_s_accel_base_TH02.csv
04/04/2022	08:47 AM	25,330,436 CEUS_SR_D15_025g_Config4_th_s_accel_base_TH03.csv
04/04/2022	09:00 AM	25,330,436 CEUS_SR_D15_025g_Config4_th_s_accel_base_TH04.csv
04/04/2022	09:12 AM	25,330,436 CEUS_SR_D15_025g_Config4_th_s_accel_base_TH05.csv
04/04/2022	08:16 AM	37,127,276 CEUS_SR_D15_025g_Config4_th_s_accel_TH01.csv
04/04/2022	08:29 AM	37,127,276 CEUS_SR_D15_025g_Config4_th_s_accel_TH02.csv
04/04/2022	08:41 AM	37,127,276 CEUS_SR_D15_025g_Config4_th_s_accel_TH03.csv
04/04/2022	08:54 AM	37,127,276 CEUS_SR_D15_025g_Config4_th_s_accel_TH04.csv
04/04/2022	09:06 AM	37,127,276 CEUS_SR_D15_025g_Config4_th_s_accel_TH05.csv
04/04/2022	08:22 AM	25,330,436 CEUS_SR_D15_025g_Config4_th_s_displ_base_TH01.csv
04/04/2022	08:35 AM	25,330,436 CEUS_SR_D15_025g_Config4_th_s_displ_base_TH02.csv
04/04/2022	08:47 AM	25,330,436 CEUS_SR_D15_025g_Config4_th_s_displ_base_TH03.csv
04/04/2022	09:00 AM	25,330,436 CEUS_SR_D15_025g_Config4_th_s_displ_base_TH04.csv
04/04/2022	09:12 AM	25,330,436 CEUS_SR_D15_025g_Config4_th_s_displ_base_TH05.csv
04/04/2022	08:16 AM	37,127,276 CEUS_SR_D15_025g_Config4_th_s_displ_TH01.csv
04/04/2022	08:29 AM	37,127,276 CEUS_SR_D15_025g_Config4_th_s_displ_TH02.csv
04/04/2022	08:41 AM	37,127,276 CEUS_SR_D15_025g_Config4_th_s_displ_TH03.csv
04/04/2022	08:54 AM	37,127,276 CEUS_SR_D15_025g_Config4_th_s_displ_TH04.csv
04/04/2022	09:06 AM	37,127,276 CEUS_SR_D15_025g_Config4_th_s_displ_TH05.csv

5. CEUS Soft Rock, D15 0.29g

5.1. Configuration A

04/03/2022	11:28 PM	735,814 CEUS_SR_D15_029g_Config1_sp_s_accel_base_TH01.csv
04/04/2022	12:47 AM	735,814 CEUS_SR_D15_029g_Config1_sp_s_accel_base_TH02.csv
04/04/2022	02:07 AM	735,814 CEUS_SR_D15_029g_Config1_sp_s_accel_base_TH03.csv
04/04/2022	03:27 AM	735,814 CEUS_SR_D15_029g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	04:44 AM	735,814 CEUS_SR_D15_029g_Config1_sp_s_accel_base_TH05.csv
04/12/2022	03:13 PM	744,841 CEUS_SR_D15_029g_Config1_sp_s_accel_TH01.csv
04/04/2022	12:12 AM	744,841 CEUS_SR_D15_029g_Config1_sp_s_accel_TH02.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-10 of 33

04/04/2022	01:31 AM	744,841 CEUS_SR_D15_029g_Config1_sp_s_accel_TH03.csv
04/04/2022	02:52 AM	744,841 CEUS_SR_D15_029g_Config1_sp_s_accel_TH04.csv
04/04/2022	04:10 AM	744,841 CEUS_SR_D15_029g_Config1_sp_s_accel_TH05.csv
04/03/2022	11:27 PM	121,179,695 CEUS_SR_D15_029g_Config1_th_s_accel_base_TH01.csv
04/04/2022	12:46 AM	121,179,695 CEUS_SR_D15_029g_Config1_th_s_accel_base_TH02.csv
04/04/2022	02:06 AM	121,179,695 CEUS_SR_D15_029g_Config1_th_s_accel_base_TH03.csv
04/04/2022	03:27 AM	121,179,695 CEUS_SR_D15_029g_Config1_th_s_accel_base_TH04.csv
04/04/2022	04:44 AM	121,179,695 CEUS_SR_D15_029g_Config1_th_s_accel_base_TH05.csv
04/12/2022	03:12 PM	227,351,255 CEUS_SR_D15_029g_Config1_th_s_accel_TH01.csv
04/04/2022	12:11 AM	227,351,255 CEUS_SR_D15_029g_Config1_th_s_accel_TH02.csv
04/04/2022	01:30 AM	227,351,255 CEUS_SR_D15_029g_Config1_th_s_accel_TH03.csv
04/04/2022	02:51 AM	227,351,255 CEUS_SR_D15_029g_Config1_th_s_accel_TH04.csv
04/04/2022	04:09 AM	227,351,255 CEUS_SR_D15_029g_Config1_th_s_accel_TH05.csv
04/03/2022	11:28 PM	121,179,695 CEUS_SR_D15_029g_Config1_th_s_displ_base_TH01.csv
04/04/2022	12:47 AM	121,179,695 CEUS_SR_D15_029g_Config1_th_s_displ_base_TH02.csv
04/04/2022	02:07 AM	121,179,695 CEUS_SR_D15_029g_Config1_th_s_displ_base_TH03.csv
04/04/2022	03:27 AM	121,179,695 CEUS_SR_D15_029g_Config1_th_s_displ_base_TH04.csv
04/04/2022	04:44 AM	121,179,695 CEUS_SR_D15_029g_Config1_th_s_displ_base_TH05.csv
04/12/2022	03:13 PM	227,351,255 CEUS_SR_D15_029g_Config1_th_s_displ_TH01.csv
04/04/2022	12:12 AM	227,351,255 CEUS_SR_D15_029g_Config1_th_s_displ_TH02.csv
04/04/2022	01:31 AM	227,351,255 CEUS_SR_D15_029g_Config1_th_s_displ_TH03.csv
04/04/2022	02:52 AM	227,351,255 CEUS_SR_D15_029g_Config1_th_s_displ_TH04.csv
04/04/2022	04:10 AM	227,351,255 CEUS_SR_D15_029g_Config1_th_s_displ_TH05.csv

5.2. Configuration B

04/04/2022	08:22 AM	153,805 CEUS_SR_D15_029g_Config4_sp_s_accel_base_TH01.csv
04/04/2022	08:35 AM	153,805 CEUS_SR_D15_029g_Config4_sp_s_accel_base_TH02.csv
04/04/2022	08:47 AM	153,805 CEUS_SR_D15_029g_Config4_sp_s_accel_base_TH03.csv
04/04/2022	09:00 AM	153,805 CEUS_SR_D15_029g_Config4_sp_s_accel_base_TH04.csv
04/04/2022	09:12 AM	153,805 CEUS_SR_D15_029g_Config4_sp_s_accel_base_TH05.csv
04/04/2022	08:17 AM	162,766 CEUS_SR_D15_029g_Config4_sp_s_accel_TH01.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-11 of 33

04/04/2022	08:29 AM	162,766 CEUS_SR_D15_029g_Config4_sp_s_accel_TH02.csv
04/04/2022	08:42 AM	162,766 CEUS_SR_D15_029g_Config4_sp_s_accel_TH03.csv
04/04/2022	08:54 AM	162,766 CEUS_SR_D15_029g_Config4_sp_s_accel_TH04.csv
04/04/2022	09:06 AM	162,766 CEUS_SR_D15_029g_Config4_sp_s_accel_TH05.csv
04/04/2022	08:22 AM	25,330,436 CEUS_SR_D15_029g_Config4_th_s_accel_base_TH01.csv
04/04/2022	08:35 AM	25,330,436 CEUS_SR_D15_029g_Config4_th_s_accel_base_TH02.csv
04/04/2022	08:47 AM	25,330,436 CEUS_SR_D15_029g_Config4_th_s_accel_base_TH03.csv
04/04/2022	09:00 AM	25,330,436 CEUS_SR_D15_029g_Config4_th_s_accel_base_TH04.csv
04/04/2022	09:12 AM	25,330,436 CEUS_SR_D15_029g_Config4_th_s_accel_base_TH05.csv
04/04/2022	08:16 AM	37,127,276 CEUS_SR_D15_029g_Config4_th_s_accel_TH01.csv
04/04/2022	08:29 AM	37,127,276 CEUS_SR_D15_029g_Config4_th_s_accel_TH02.csv
04/04/2022	08:41 AM	37,127,276 CEUS_SR_D15_029g_Config4_th_s_accel_TH03.csv
04/04/2022	08:54 AM	37,127,276 CEUS_SR_D15_029g_Config4_th_s_accel_TH04.csv
04/04/2022	09:06 AM	37,127,276 CEUS_SR_D15_029g_Config4_th_s_accel_TH05.csv
04/04/2022	08:22 AM	25,330,436 CEUS_SR_D15_029g_Config4_th_s_displ_base_TH01.csv
04/04/2022	08:35 AM	25,330,436 CEUS_SR_D15_029g_Config4_th_s_displ_base_TH02.csv
04/04/2022	08:47 AM	25,330,436 CEUS_SR_D15_029g_Config4_th_s_displ_base_TH03.csv
04/04/2022	09:00 AM	25,330,436 CEUS_SR_D15_029g_Config4_th_s_displ_base_TH04.csv
04/04/2022	09:12 AM	25,330,436 CEUS_SR_D15_029g_Config4_th_s_displ_base_TH05.csv
04/04/2022	08:17 AM	37,127,276 CEUS_SR_D15_029g_Config4_th_s_displ_TH01.csv
04/04/2022	08:29 AM	37,127,276 CEUS_SR_D15_029g_Config4_th_s_displ_TH02.csv
04/04/2022	08:42 AM	37,127,276 CEUS_SR_D15_029g_Config4_th_s_displ_TH03.csv
04/04/2022	08:54 AM	37,127,276 CEUS_SR_D15_029g_Config4_th_s_displ_TH04.csv
04/04/2022	09:06 AM	37,127,276 CEUS_SR_D15_029g_Config4_th_s_displ_TH05.csv

6. CEUS Soft Rock, D40 0.08g

6.1. Configuration A

04/03/2022	11:28 PM	735,814 CEUS_SR_D40_008g_Config1_sp_s_accel_base_TH01.csv
04/04/2022	12:48 AM	735,814 CEUS_SR_D40_008g_Config1_sp_s_accel_base_TH02.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-12 of 33

04/04/2022	02:11 AM	735,814 CEUS_SR_D40_008g_Config1_sp_s_accel_base_TH03.csv
04/04/2022	03:31 AM	735,814 CEUS_SR_D40_008g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	04:51 AM	735,814 CEUS_SR_D40_008g_Config1_sp_s_accel_base_TH05.csv
04/12/2022	03:12 PM	744,841 CEUS_SR_D40_008g_Config1_sp_s_accel_TH01.csv
04/04/2022	12:13 AM	744,841 CEUS_SR_D40_008g_Config1_sp_s_accel_TH02.csv
04/04/2022	01:34 AM	744,841 CEUS_SR_D40_008g_Config1_sp_s_accel_TH03.csv
04/04/2022	02:55 AM	744,841 CEUS_SR_D40_008g_Config1_sp_s_accel_TH04.csv
04/04/2022	04:15 AM	744,841 CEUS_SR_D40_008g_Config1_sp_s_accel_TH05.csv
04/03/2022	11:27 PM	121,179,695 CEUS_SR_D40_008g_Config1_th_s_accel_base_TH01.csv
04/04/2022	12:48 AM	121,179,695 CEUS_SR_D40_008g_Config1_th_s_accel_base_TH02.csv
04/04/2022	02:10 AM	121,179,695 CEUS_SR_D40_008g_Config1_th_s_accel_base_TH03.csv
04/04/2022	03:31 AM	121,179,695 CEUS_SR_D40_008g_Config1_th_s_accel_base_TH04.csv
04/04/2022	04:50 AM	121,179,695 CEUS_SR_D40_008g_Config1_th_s_accel_base_TH05.csv
04/12/2022	03:12 PM	227,351,255 CEUS_SR_D40_008g_Config1_th_s_accel_TH01.csv
04/04/2022	12:12 AM	227,351,255 CEUS_SR_D40_008g_Config1_th_s_accel_TH02.csv
04/04/2022	01:34 AM	227,351,255 CEUS_SR_D40_008g_Config1_th_s_accel_TH03.csv
04/04/2022	02:54 AM	227,351,255 CEUS_SR_D40_008g_Config1_th_s_accel_TH04.csv
04/04/2022	04:14 AM	227,351,255 CEUS_SR_D40_008g_Config1_th_s_accel_TH05.csv
04/03/2022	11:28 PM	121,179,695 CEUS_SR_D40_008g_Config1_th_s_displ_base_TH01.csv
04/04/2022	12:48 AM	121,179,695 CEUS_SR_D40_008g_Config1_th_s_displ_base_TH02.csv
04/04/2022	02:11 AM	121,179,695 CEUS_SR_D40_008g_Config1_th_s_displ_base_TH03.csv
04/04/2022	03:31 AM	121,179,695 CEUS_SR_D40_008g_Config1_th_s_displ_base_TH04.csv
04/04/2022	04:51 AM	121,179,695 CEUS_SR_D40_008g_Config1_th_s_displ_base_TH05.csv
04/12/2022	03:12 PM	227,351,255 CEUS_SR_D40_008g_Config1_th_s_displ_TH01.csv
04/04/2022	12:13 AM	227,351,255 CEUS_SR_D40_008g_Config1_th_s_displ_TH02.csv
04/04/2022	01:34 AM	227,351,255 CEUS_SR_D40_008g_Config1_th_s_displ_TH03.csv
04/04/2022	02:55 AM	227,351,255 CEUS_SR_D40_008g_Config1_th_s_displ_TH04.csv
04/04/2022	04:15 AM	227,351,255 CEUS_SR_D40_008g_Config1_th_s_displ_TH05.csv

6.2. Configuration B

04/04/2022	08:23 AM	153,805 CEUS_SR_D40_008g_Config4_sp_s_accel_base_TH01.csv
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SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-13 of 33

04/04/2022	08:36 AM	153,805 CEUS_SR_D40_008g_Config4_sp_s_accel_base_TH02.csv
04/04/2022	08:48 AM	153,805 CEUS_SR_D40_008g_Config4_sp_s_accel_base_TH03.csv
04/04/2022	09:01 AM	153,805 CEUS_SR_D40_008g_Config4_sp_s_accel_base_TH04.csv
04/04/2022	09:13 AM	153,805 CEUS_SR_D40_008g_Config4_sp_s_accel_base_TH05.csv
04/04/2022	08:17 AM	162,766 CEUS_SR_D40_008g_Config4_sp_s_accel_TH01.csv
04/04/2022	08:30 AM	162,766 CEUS_SR_D40_008g_Config4_sp_s_accel_TH02.csv
04/04/2022	08:42 AM	162,766 CEUS_SR_D40_008g_Config4_sp_s_accel_TH03.csv
04/04/2022	08:55 AM	162,766 CEUS_SR_D40_008g_Config4_sp_s_accel_TH04.csv
04/04/2022	09:08 AM	162,766 CEUS_SR_D40_008g_Config4_sp_s_accel_TH05.csv
04/04/2022	08:23 AM	25,330,436 CEUS_SR_D40_008g_Config4_th_s_accel_base_TH01.csv
04/04/2022	08:36 AM	25,330,436 CEUS_SR_D40_008g_Config4_th_s_accel_base_TH02.csv
04/04/2022	08:48 AM	25,330,436 CEUS_SR_D40_008g_Config4_th_s_accel_base_TH03.csv
04/04/2022	09:01 AM	25,330,436 CEUS_SR_D40_008g_Config4_th_s_accel_base_TH04.csv
04/04/2022	09:13 AM	25,330,436 CEUS_SR_D40_008g_Config4_th_s_accel_base_TH05.csv
04/04/2022	08:17 AM	37,127,276 CEUS_SR_D40_008g_Config4_th_s_accel_TH01.csv
04/04/2022	08:30 AM	37,127,276 CEUS_SR_D40_008g_Config4_th_s_accel_TH02.csv
04/04/2022	08:42 AM	37,127,276 CEUS_SR_D40_008g_Config4_th_s_accel_TH03.csv
04/04/2022	08:55 AM	37,127,276 CEUS_SR_D40_008g_Config4_th_s_accel_TH04.csv
04/04/2022	09:08 AM	37,127,276 CEUS_SR_D40_008g_Config4_th_s_accel_TH05.csv
04/04/2022	08:23 AM	25,330,436 CEUS_SR_D40_008g_Config4_th_s_displ_base_TH01.csv
04/04/2022	08:36 AM	25,330,436 CEUS_SR_D40_008g_Config4_th_s_displ_base_TH02.csv
04/04/2022	08:48 AM	25,330,436 CEUS_SR_D40_008g_Config4_th_s_displ_base_TH03.csv
04/04/2022	09:01 AM	25,330,436 CEUS_SR_D40_008g_Config4_th_s_displ_base_TH04.csv
04/04/2022	09:13 AM	25,330,436 CEUS_SR_D40_008g_Config4_th_s_displ_base_TH05.csv
04/04/2022	08:17 AM	37,127,276 CEUS_SR_D40_008g_Config4_th_s_displ_TH01.csv
04/04/2022	08:30 AM	37,127,276 CEUS_SR_D40_008g_Config4_th_s_displ_TH02.csv
04/04/2022	08:42 AM	37,127,276 CEUS_SR_D40_008g_Config4_th_s_displ_TH03.csv
04/04/2022	08:55 AM	37,127,276 CEUS_SR_D40_008g_Config4_th_s_displ_TH04.csv
04/04/2022	09:08 AM	37,127,276 CEUS_SR_D40_008g_Config4_th_s_displ_TH05.csv

7. CEUS Soft Rock, D200 0.18g

7.1. Configuration A

04/03/2022	11:27 PM	735,814 CEUS_SR_D200_018g_Config1_sp_s_accel_base_TH01.csv
04/12/2022	01:38 PM	735,814 CEUS_SR_D200_018g_Config1_sp_s_accel_base_TH02.csv
04/04/2022	12:47 AM	735,814 CEUS_SR_D200_018g_Config1_sp_s_accel_base_TH03.csv
04/04/2022	02:07 AM	735,814 CEUS_SR_D200_018g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	03:27 AM	735,814 CEUS_SR_D200_018g_Config1_sp_s_accel_base_TH05.csv
04/12/2022	02:37 PM	744,841 CEUS_SR_D200_018g_Config1_sp_s_accel_TH01.csv
04/12/2022	01:02 PM	744,841 CEUS_SR_D200_018g_Config1_sp_s_accel_TH02.csv
04/04/2022	12:12 AM	744,841 CEUS_SR_D200_018g_Config1_sp_s_accel_TH03.csv
04/04/2022	01:31 AM	744,841 CEUS_SR_D200_018g_Config1_sp_s_accel_TH04.csv
04/04/2022	02:52 AM	744,841 CEUS_SR_D200_018g_Config1_sp_s_accel_TH05.csv
04/03/2022	11:27 PM	121,179,695 CEUS_SR_D200_018g_Config1_th_s_accel_base_TH01.csv
04/12/2022	01:37 PM	121,179,695 CEUS_SR_D200_018g_Config1_th_s_accel_base_TH02.csv
04/04/2022	12:47 AM	121,179,695 CEUS_SR_D200_018g_Config1_th_s_accel_base_TH03.csv
04/04/2022	02:07 AM	121,179,695 CEUS_SR_D200_018g_Config1_th_s_accel_base_TH04.csv
04/04/2022	03:27 AM	121,179,695 CEUS_SR_D200_018g_Config1_th_s_accel_base_TH05.csv
04/12/2022	02:36 PM	227,351,255 CEUS_SR_D200_018g_Config1_th_s_accel_TH01.csv
04/12/2022	01:01 PM	227,351,255 CEUS_SR_D200_018g_Config1_th_s_accel_TH02.csv
04/04/2022	12:11 AM	227,351,255 CEUS_SR_D200_018g_Config1_th_s_accel_TH03.csv
04/04/2022	01:31 AM	227,351,255 CEUS_SR_D200_018g_Config1_th_s_accel_TH04.csv
04/04/2022	02:51 AM	227,351,255 CEUS_SR_D200_018g_Config1_th_s_accel_TH05.csv
04/03/2022	11:27 PM	121,179,695 CEUS_SR_D200_018g_Config1_th_s_displ_base_TH01.csv
04/12/2022	01:38 PM	121,179,695 CEUS_SR_D200_018g_Config1_th_s_displ_base_TH02.csv
04/04/2022	12:47 AM	121,179,695 CEUS_SR_D200_018g_Config1_th_s_displ_base_TH03.csv
04/04/2022	02:07 AM	121,179,695 CEUS_SR_D200_018g_Config1_th_s_displ_base_TH04.csv
04/04/2022	03:27 AM	121,179,695 CEUS_SR_D200_018g_Config1_th_s_displ_base_TH05.csv
04/12/2022	02:37 PM	227,351,255 CEUS_SR_D200_018g_Config1_th_s_displ_TH01.csv
04/12/2022	01:02 PM	227,351,255 CEUS_SR_D200_018g_Config1_th_s_displ_TH02.csv
04/04/2022	12:12 AM	227,351,255 CEUS_SR_D200_018g_Config1_th_s_displ_TH03.csv
04/04/2022	01:31 AM	227,351,255 CEUS_SR_D200_018g_Config1_th_s_displ_TH04.csv

04/04/2022 02:52 AM 227,351,255 CEUS_SR_D200_018g_Config1_th_s_displ_TH05.csv

7.2. Configuration B

04/04/2022 08:22 AM	153,805 CEUS_SR_D200_018g_Config4_sp_s_accel_base_TH01.csv
04/12/2022 12:32 PM	153,805 CEUS_SR_D200_018g_Config4_sp_s_accel_base_TH02.csv
04/04/2022 08:35 AM	153,805 CEUS_SR_D200_018g_Config4_sp_s_accel_base_TH03.csv
04/04/2022 08:48 AM	153,805 CEUS_SR_D200_018g_Config4_sp_s_accel_base_TH04.csv
04/04/2022 09:00 AM	153,805 CEUS_SR_D200_018g_Config4_sp_s_accel_base_TH05.csv
04/04/2022 08:17 AM	162,766 CEUS_SR_D200_018g_Config4_sp_s_accel_TH01.csv
04/12/2022 12:27 PM	162,766 CEUS_SR_D200_018g_Config4_sp_s_accel_TH02.csv
04/04/2022 08:29 AM	162,766 CEUS_SR_D200_018g_Config4_sp_s_accel_TH03.csv
04/04/2022 08:42 AM	162,766 CEUS_SR_D200_018g_Config4_sp_s_accel_TH04.csv
04/04/2022 08:55 AM	162,766 CEUS_SR_D200_018g_Config4_sp_s_accel_TH05.csv
04/04/2022 08:22 AM	25,330,436 CEUS_SR_D200_018g_Config4_th_s_accel_base_TH01.csv
04/12/2022 12:32 PM	25,330,436 CEUS_SR_D200_018g_Config4_th_s_accel_base_TH02.csv
04/04/2022 08:35 AM	25,330,436 CEUS_SR_D200_018g_Config4_th_s_accel_base_TH03.csv
04/04/2022 08:48 AM	25,330,436 CEUS_SR_D200_018g_Config4_th_s_accel_base_TH04.csv
04/04/2022 09:00 AM	25,330,436 CEUS_SR_D200_018g_Config4_th_s_accel_base_TH05.csv
04/04/2022 08:17 AM	37,127,276 CEUS_SR_D200_018g_Config4_th_s_accel_TH01.csv
04/12/2022 12:27 PM	37,127,276 CEUS_SR_D200_018g_Config4_th_s_accel_TH02.csv
04/04/2022 08:29 AM	37,127,276 CEUS_SR_D200_018g_Config4_th_s_accel_TH03.csv
04/04/2022 08:42 AM	37,127,276 CEUS_SR_D200_018g_Config4_th_s_accel_TH04.csv
04/04/2022 08:54 AM	37,127,276 CEUS_SR_D200_018g_Config4_th_s_accel_TH05.csv
04/04/2022 08:22 AM	25,330,436 CEUS_SR_D200_018g_Config4_th_s_displ_base_TH01.csv
04/12/2022 12:32 PM	25,330,436 CEUS_SR_D200_018g_Config4_th_s_displ_base_TH02.csv
04/04/2022 08:35 AM	25,330,436 CEUS_SR_D200_018g_Config4_th_s_displ_base_TH03.csv
04/04/2022 08:48 AM	25,330,436 CEUS_SR_D200_018g_Config4_th_s_displ_base_TH04.csv
04/04/2022 09:00 AM	25,330,436 CEUS_SR_D200_018g_Config4_th_s_displ_base_TH05.csv
04/04/2022 08:17 AM	37,127,276 CEUS_SR_D200_018g_Config4_th_s_displ_TH01.csv
04/12/2022 12:27 PM	37,127,276 CEUS_SR_D200_018g_Config4_th_s_displ_TH02.csv
04/04/2022 08:29 AM	37,127,276 CEUS_SR_D200_018g_Config4_th_s_displ_TH03.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-16 of 33

04/04/2022 08:42 AM	37,127,276 CEUS_SR_D200_018g_Config4_th_s_displ_TH04.csv
04/04/2022 08:55 AM	37,127,276 CEUS_SR_D200_018g_Config4_th_s_displ_TH05.csv

8. WUS Soil, D200 0.14g

8.1. Configuration A

04/03/2022 11:25 PM	359,686 WUS_Soil_D200_014g_Config1_sp_s_accel_base_TH01.csv
04/04/2022 12:26 AM	359,686 WUS_Soil_D200_014g_Config1_sp_s_accel_base_TH02.csv
04/04/2022 01:25 AM	359,686 WUS_Soil_D200_014g_Config1_sp_s_accel_base_TH03.csv
04/04/2022 02:23 AM	359,686 WUS_Soil_D200_014g_Config1_sp_s_accel_base_TH04.csv
04/04/2022 03:22 AM	359,686 WUS_Soil_D200_014g_Config1_sp_s_accel_base_TH05.csv
04/03/2022 11:01 PM	359,776 WUS_Soil_D200_014g_Config1_sp_s_accel_TH01.csv
04/03/2022 11:59 PM	359,776 WUS_Soil_D200_014g_Config1_sp_s_accel_TH02.csv
04/04/2022 01:00 AM	359,776 WUS_Soil_D200_014g_Config1_sp_s_accel_TH03.csv
04/04/2022 01:58 AM	359,776 WUS_Soil_D200_014g_Config1_sp_s_accel_TH04.csv
04/04/2022 02:57 AM	359,776 WUS_Soil_D200_014g_Config1_sp_s_accel_TH05.csv
04/03/2022 11:25 PM	59,246,267 WUS_Soil_D200_014g_Config1_th_s_accel_base_TH01.csv
04/04/2022 12:25 AM	59,246,267 WUS_Soil_D200_014g_Config1_th_s_accel_base_TH02.csv
04/04/2022 01:25 AM	59,246,267 WUS_Soil_D200_014g_Config1_th_s_accel_base_TH03.csv
04/04/2022 02:23 AM	59,246,267 WUS_Soil_D200_014g_Config1_th_s_accel_base_TH04.csv
04/04/2022 03:22 AM	59,246,267 WUS_Soil_D200_014g_Config1_th_s_accel_base_TH05.csv
04/03/2022 11:00 PM	103,484,417 WUS_Soil_D200_014g_Config1_th_s_accel_TH01.csv
04/03/2022 11:59 PM	103,484,417 WUS_Soil_D200_014g_Config1_th_s_accel_TH02.csv
04/04/2022 12:59 AM	103,484,417 WUS_Soil_D200_014g_Config1_th_s_accel_TH03.csv
04/04/2022 01:58 AM	103,484,417 WUS_Soil_D200_014g_Config1_th_s_accel_TH04.csv
04/04/2022 02:56 AM	103,484,417 WUS_Soil_D200_014g_Config1_th_s_accel_TH05.csv
04/03/2022 11:25 PM	59,246,267 WUS_Soil_D200_014g_Config1_th_s_displ_base_TH01.csv
04/04/2022 12:26 AM	59,246,267 WUS_Soil_D200_014g_Config1_th_s_displ_base_TH02.csv
04/04/2022 01:25 AM	59,246,267 WUS_Soil_D200_014g_Config1_th_s_displ_base_TH03.csv
04/04/2022 02:23 AM	59,246,267 WUS_Soil_D200_014g_Config1_th_s_displ_base_TH04.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-17 of 33

04/04/2022	03:22 AM	59,246,267 WUS_Soil_D200_014g_Config1_th_s_displ_base_TH05.csv
04/03/2022	11:01 PM	103,484,417 WUS_Soil_D200_014g_Config1_th_s_displ_TH01.csv
04/03/2022	11:59 PM	103,484,417 WUS_Soil_D200_014g_Config1_th_s_displ_TH02.csv
04/04/2022	01:00 AM	103,484,417 WUS_Soil_D200_014g_Config1_th_s_displ_TH03.csv
04/04/2022	01:58 AM	103,484,417 WUS_Soil_D200_014g_Config1_th_s_displ_TH04.csv
04/04/2022	02:57 AM	103,484,417 WUS_Soil_D200_014g_Config1_th_s_displ_TH05.csv

8.2. Configuration B

04/04/2022	08:37 AM	117,985 WUS_Soil_D200_014g_Config4_sp_s_accel_base_TH01.csv
04/04/2022	08:57 AM	117,985 WUS_Soil_D200_014g_Config4_sp_s_accel_base_TH02.csv
04/04/2022	09:16 AM	117,985 WUS_Soil_D200_014g_Config4_sp_s_accel_base_TH03.csv
04/04/2022	09:35 AM	117,985 WUS_Soil_D200_014g_Config4_sp_s_accel_base_TH04.csv
04/04/2022	09:54 AM	117,985 WUS_Soil_D200_014g_Config4_sp_s_accel_base_TH05.csv
04/04/2022	08:28 AM	117,991 WUS_Soil_D200_014g_Config4_sp_s_accel_TH01.csv
04/04/2022	08:47 AM	117,991 WUS_Soil_D200_014g_Config4_sp_s_accel_TH02.csv
04/04/2022	09:07 AM	117,991 WUS_Soil_D200_014g_Config4_sp_s_accel_TH03.csv
04/04/2022	09:25 AM	117,991 WUS_Soil_D200_014g_Config4_sp_s_accel_TH04.csv
04/04/2022	09:45 AM	117,991 WUS_Soil_D200_014g_Config4_sp_s_accel_TH05.csv
04/04/2022	08:37 AM	19,432,016 WUS_Soil_D200_014g_Config4_th_s_accel_base_TH01.csv
04/04/2022	08:56 AM	19,432,016 WUS_Soil_D200_014g_Config4_th_s_accel_base_TH02.csv
04/04/2022	09:16 AM	19,432,016 WUS_Soil_D200_014g_Config4_th_s_accel_base_TH03.csv
04/04/2022	09:35 AM	19,432,016 WUS_Soil_D200_014g_Config4_th_s_accel_base_TH04.csv
04/04/2022	09:54 AM	19,432,016 WUS_Soil_D200_014g_Config4_th_s_accel_base_TH05.csv
04/04/2022	08:28 AM	25,330,430 WUS_Soil_D200_014g_Config4_th_s_accel_TH01.csv
04/04/2022	08:47 AM	25,330,430 WUS_Soil_D200_014g_Config4_th_s_accel_TH02.csv
04/04/2022	09:06 AM	25,330,430 WUS_Soil_D200_014g_Config4_th_s_accel_TH03.csv
04/04/2022	09:25 AM	25,330,430 WUS_Soil_D200_014g_Config4_th_s_accel_TH04.csv
04/04/2022	09:45 AM	25,330,430 WUS_Soil_D200_014g_Config4_th_s_accel_TH05.csv
04/04/2022	08:37 AM	19,432,016 WUS_Soil_D200_014g_Config4_th_s_displ_base_TH01.csv
04/04/2022	08:57 AM	19,432,016 WUS_Soil_D200_014g_Config4_th_s_displ_base_TH02.csv
04/04/2022	09:16 AM	19,432,016 WUS_Soil_D200_014g_Config4_th_s_displ_base_TH03.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-18 of 33

04/04/2022	09:35 AM	19,432,016	WUS_Soil_D200_014g_Config4_th_s_displ_base_TH04.csv
04/04/2022	09:54 AM	19,432,016	WUS_Soil_D200_014g_Config4_th_s_displ_base_TH05.csv
04/04/2022	08:28 AM	25,330,430	WUS_Soil_D200_014g_Config4_th_s_displ_TH01.csv
04/04/2022	08:47 AM	25,330,430	WUS_Soil_D200_014g_Config4_th_s_displ_TH02.csv
04/04/2022	09:06 AM	25,330,430	WUS_Soil_D200_014g_Config4_th_s_displ_TH03.csv
04/04/2022	09:25 AM	25,330,430	WUS_Soil_D200_014g_Config4_th_s_displ_TH04.csv
04/04/2022	09:45 AM	25,330,430	WUS_Soil_D200_014g_Config4_th_s_displ_TH05.csv

9. WUS Soil, D10 0.19g

9.1. Configuration A

04/03/2022	11:22 PM	359,686	WUS_Soil_D10_019g_Config1_sp_s_accel_base_TH01.csv
04/04/2022	12:19 AM	359,686	WUS_Soil_D10_019g_Config1_sp_s_accel_base_TH02.csv
04/04/2022	01:15 AM	359,686	WUS_Soil_D10_019g_Config1_sp_s_accel_base_TH03.csv
04/04/2022	02:13 AM	359,686	WUS_Soil_D10_019g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	03:09 AM	359,686	WUS_Soil_D10_019g_Config1_sp_s_accel_base_TH05.csv
04/03/2022	10:57 PM	359,776	WUS_Soil_D10_019g_Config1_sp_s_accel_TH01.csv
04/03/2022	11:54 PM	359,776	WUS_Soil_D10_019g_Config1_sp_s_accel_TH02.csv
04/04/2022	12:50 AM	359,776	WUS_Soil_D10_019g_Config1_sp_s_accel_TH03.csv
04/04/2022	01:48 AM	359,776	WUS_Soil_D10_019g_Config1_sp_s_accel_TH04.csv
04/04/2022	02:44 AM	359,776	WUS_Soil_D10_019g_Config1_sp_s_accel_TH05.csv
04/03/2022	11:22 PM	59,246,267	WUS_Soil_D10_019g_Config1_th_s_accel_base_TH01.csv
04/04/2022	12:19 AM	59,246,267	WUS_Soil_D10_019g_Config1_th_s_accel_base_TH02.csv
04/04/2022	01:15 AM	59,246,267	WUS_Soil_D10_019g_Config1_th_s_accel_base_TH03.csv
04/04/2022	02:13 AM	59,246,267	WUS_Soil_D10_019g_Config1_th_s_accel_base_TH04.csv
04/04/2022	03:09 AM	59,246,267	WUS_Soil_D10_019g_Config1_th_s_accel_base_TH05.csv
04/03/2022	10:57 PM	103,484,417	WUS_Soil_D10_019g_Config1_th_s_accel_TH01.csv
04/03/2022	11:54 PM	103,484,417	WUS_Soil_D10_019g_Config1_th_s_accel_TH02.csv
04/04/2022	12:50 AM	103,484,417	WUS_Soil_D10_019g_Config1_th_s_accel_TH03.csv
04/04/2022	01:48 AM	103,484,417	WUS_Soil_D10_019g_Config1_th_s_accel_TH04.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-19 of 33

04/04/2022 02:44 AM	103,484,417 WUS_Soil_D10_019g_Config1_th_s_accel_TH05.csv
04/03/2022 11:22 PM	59,246,267 WUS_Soil_D10_019g_Config1_th_s_displ_base_TH01.csv
04/04/2022 12:19 AM	59,246,267 WUS_Soil_D10_019g_Config1_th_s_displ_base_TH02.csv
04/04/2022 01:15 AM	59,246,267 WUS_Soil_D10_019g_Config1_th_s_displ_base_TH03.csv
04/04/2022 02:13 AM	59,246,267 WUS_Soil_D10_019g_Config1_th_s_displ_base_TH04.csv
04/04/2022 03:09 AM	59,246,267 WUS_Soil_D10_019g_Config1_th_s_displ_base_TH05.csv
04/03/2022 10:57 PM	103,484,417 WUS_Soil_D10_019g_Config1_th_s_displ_TH01.csv
04/03/2022 11:54 PM	103,484,417 WUS_Soil_D10_019g_Config1_th_s_displ_TH02.csv
04/04/2022 12:50 AM	103,484,417 WUS_Soil_D10_019g_Config1_th_s_displ_TH03.csv
04/04/2022 01:48 AM	103,484,417 WUS_Soil_D10_019g_Config1_th_s_displ_TH04.csv
04/04/2022 02:44 AM	103,484,417 WUS_Soil_D10_019g_Config1_th_s_displ_TH05.csv

9.2. Configuration B

04/04/2022 08:37 AM	117,985 WUS_Soil_D10_019g_Config4_sp_s_accel_base_TH01.csv
04/04/2022 08:55 AM	117,985 WUS_Soil_D10_019g_Config4_sp_s_accel_base_TH02.csv
04/04/2022 09:14 AM	117,985 WUS_Soil_D10_019g_Config4_sp_s_accel_base_TH03.csv
04/04/2022 09:33 AM	117,985 WUS_Soil_D10_019g_Config4_sp_s_accel_base_TH04.csv
04/04/2022 09:51 AM	117,985 WUS_Soil_D10_019g_Config4_sp_s_accel_base_TH05.csv
04/04/2022 08:28 AM	117,991 WUS_Soil_D10_019g_Config4_sp_s_accel_TH01.csv
04/04/2022 08:46 AM	117,991 WUS_Soil_D10_019g_Config4_sp_s_accel_TH02.csv
04/04/2022 09:05 AM	117,991 WUS_Soil_D10_019g_Config4_sp_s_accel_TH03.csv
04/04/2022 09:24 AM	117,991 WUS_Soil_D10_019g_Config4_sp_s_accel_TH04.csv
04/04/2022 09:42 AM	117,991 WUS_Soil_D10_019g_Config4_sp_s_accel_TH05.csv
04/04/2022 08:37 AM	19,432,016 WUS_Soil_D10_019g_Config4_th_s_accel_base_TH01.csv
04/04/2022 08:55 AM	19,432,016 WUS_Soil_D10_019g_Config4_th_s_accel_base_TH02.csv
04/04/2022 09:14 AM	19,432,016 WUS_Soil_D10_019g_Config4_th_s_accel_base_TH03.csv
04/04/2022 09:33 AM	19,432,016 WUS_Soil_D10_019g_Config4_th_s_accel_base_TH04.csv
04/04/2022 09:51 AM	19,432,016 WUS_Soil_D10_019g_Config4_th_s_accel_base_TH05.csv
04/04/2022 08:28 AM	25,330,430 WUS_Soil_D10_019g_Config4_th_s_accel_TH01.csv
04/04/2022 08:46 AM	25,330,430 WUS_Soil_D10_019g_Config4_th_s_accel_TH02.csv
04/04/2022 09:05 AM	25,330,430 WUS_Soil_D10_019g_Config4_th_s_accel_TH03.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-20 of 33

04/04/2022	09:23 AM	25,330,430 WUS_Soil_D10_019g_Config4_th_s_accel_TH04.csv
04/04/2022	09:42 AM	25,330,430 WUS_Soil_D10_019g_Config4_th_s_accel_TH05.csv
04/04/2022	08:37 AM	19,432,016 WUS_Soil_D10_019g_Config4_th_s_displ_base_TH01.csv
04/04/2022	08:55 AM	19,432,016 WUS_Soil_D10_019g_Config4_th_s_displ_base_TH02.csv
04/04/2022	09:14 AM	19,432,016 WUS_Soil_D10_019g_Config4_th_s_displ_base_TH03.csv
04/04/2022	09:33 AM	19,432,016 WUS_Soil_D10_019g_Config4_th_s_displ_base_TH04.csv
04/04/2022	09:51 AM	19,432,016 WUS_Soil_D10_019g_Config4_th_s_displ_base_TH05.csv
04/04/2022	08:28 AM	25,330,430 WUS_Soil_D10_019g_Config4_th_s_displ_TH01.csv
04/04/2022	08:46 AM	25,330,430 WUS_Soil_D10_019g_Config4_th_s_displ_TH02.csv
04/04/2022	09:05 AM	25,330,430 WUS_Soil_D10_019g_Config4_th_s_displ_TH03.csv
04/04/2022	09:24 AM	25,330,430 WUS_Soil_D10_019g_Config4_th_s_displ_TH04.csv
04/04/2022	09:42 AM	25,330,430 WUS_Soil_D10_019g_Config4_th_s_displ_TH05.csv

10. WUS Soil, D10 0.23g

10.1. Configuration A

04/03/2022	11:22 PM	359,686 WUS_Soil_D10_023g_Config1_sp_s_accel_base_TH01.csv
04/04/2022	12:19 AM	359,686 WUS_Soil_D10_023g_Config1_sp_s_accel_base_TH02.csv
04/04/2022	01:15 AM	359,686 WUS_Soil_D10_023g_Config1_sp_s_accel_base_TH03.csv
04/04/2022	02:13 AM	359,686 WUS_Soil_D10_023g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	03:09 AM	359,686 WUS_Soil_D10_023g_Config1_sp_s_accel_base_TH05.csv
04/03/2022	10:57 PM	359,776 WUS_Soil_D10_023g_Config1_sp_s_accel_TH01.csv
04/03/2022	11:54 PM	359,776 WUS_Soil_D10_023g_Config1_sp_s_accel_TH02.csv
04/04/2022	12:50 AM	359,776 WUS_Soil_D10_023g_Config1_sp_s_accel_TH03.csv
04/04/2022	01:48 AM	359,776 WUS_Soil_D10_023g_Config1_sp_s_accel_TH04.csv
04/04/2022	02:44 AM	359,776 WUS_Soil_D10_023g_Config1_sp_s_accel_TH05.csv
04/03/2022	11:22 PM	59,246,267 WUS_Soil_D10_023g_Config1_th_s_accel_base_TH01.csv
04/04/2022	12:19 AM	59,246,267 WUS_Soil_D10_023g_Config1_th_s_accel_base_TH02.csv
04/04/2022	01:15 AM	59,246,267 WUS_Soil_D10_023g_Config1_th_s_accel_base_TH03.csv
04/04/2022	02:13 AM	59,246,267 WUS_Soil_D10_023g_Config1_th_s_accel_base_TH04.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-21 of 33

04/04/2022	03:09 AM	59,246,267 WUS_Soil_D10_023g_Config1_th_s_accel_base_TH05.csv
04/03/2022	10:57 PM	103,484,417 WUS_Soil_D10_023g_Config1_th_s_accel_TH01.csv
04/03/2022	11:54 PM	103,484,417 WUS_Soil_D10_023g_Config1_th_s_accel_TH02.csv
04/04/2022	12:50 AM	103,484,417 WUS_Soil_D10_023g_Config1_th_s_accel_TH03.csv
04/04/2022	01:48 AM	103,484,417 WUS_Soil_D10_023g_Config1_th_s_accel_TH04.csv
04/04/2022	02:44 AM	103,484,417 WUS_Soil_D10_023g_Config1_th_s_accel_TH05.csv
04/03/2022	11:22 PM	59,246,267 WUS_Soil_D10_023g_Config1_th_s_displ_base_TH01.csv
04/04/2022	12:19 AM	59,246,267 WUS_Soil_D10_023g_Config1_th_s_displ_base_TH02.csv
04/04/2022	01:15 AM	59,246,267 WUS_Soil_D10_023g_Config1_th_s_displ_base_TH03.csv
04/04/2022	02:13 AM	59,246,267 WUS_Soil_D10_023g_Config1_th_s_displ_base_TH04.csv
04/04/2022	03:09 AM	59,246,267 WUS_Soil_D10_023g_Config1_th_s_displ_base_TH05.csv
04/03/2022	10:57 PM	103,484,417 WUS_Soil_D10_023g_Config1_th_s_displ_TH01.csv
04/03/2022	11:54 PM	103,484,417 WUS_Soil_D10_023g_Config1_th_s_displ_TH02.csv
04/04/2022	12:50 AM	103,484,417 WUS_Soil_D10_023g_Config1_th_s_displ_TH03.csv
04/04/2022	01:48 AM	103,484,417 WUS_Soil_D10_023g_Config1_th_s_displ_TH04.csv
04/04/2022	02:44 AM	103,484,417 WUS_Soil_D10_023g_Config1_th_s_displ_TH05.csv

10.2. Configuration B

04/04/2022	08:38 AM	117,985 WUS_Soil_D10_023g_Config4_sp_s_accel_base_TH01.csv
04/04/2022	08:56 AM	117,985 WUS_Soil_D10_023g_Config4_sp_s_accel_base_TH02.csv
04/04/2022	09:14 AM	117,985 WUS_Soil_D10_023g_Config4_sp_s_accel_base_TH03.csv
04/04/2022	09:33 AM	117,985 WUS_Soil_D10_023g_Config4_sp_s_accel_base_TH04.csv
04/04/2022	09:51 AM	117,985 WUS_Soil_D10_023g_Config4_sp_s_accel_base_TH05.csv
04/04/2022	08:29 AM	117,991 WUS_Soil_D10_023g_Config4_sp_s_accel_TH01.csv
04/04/2022	08:47 AM	117,991 WUS_Soil_D10_023g_Config4_sp_s_accel_TH02.csv
04/04/2022	09:05 AM	117,991 WUS_Soil_D10_023g_Config4_sp_s_accel_TH03.csv
04/04/2022	09:24 AM	117,991 WUS_Soil_D10_023g_Config4_sp_s_accel_TH04.csv
04/04/2022	09:42 AM	117,991 WUS_Soil_D10_023g_Config4_sp_s_accel_TH05.csv
04/04/2022	08:38 AM	19,432,016 WUS_Soil_D10_023g_Config4_th_s_accel_base_TH01.csv
04/04/2022	08:56 AM	19,432,016 WUS_Soil_D10_023g_Config4_th_s_accel_base_TH02.csv
04/04/2022	09:14 AM	19,432,016 WUS_Soil_D10_023g_Config4_th_s_accel_base_TH03.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-22 of 33

04/04/2022	09:33 AM	19,432,016	WUS_Soil_D10_023g_Config4_th_s_accel_base_TH04.csv
04/04/2022	09:51 AM	19,432,016	WUS_Soil_D10_023g_Config4_th_s_accel_base_TH05.csv
04/04/2022	08:28 AM	25,330,430	WUS_Soil_D10_023g_Config4_th_s_accel_TH01.csv
04/04/2022	08:47 AM	25,330,430	WUS_Soil_D10_023g_Config4_th_s_accel_TH02.csv
04/04/2022	09:05 AM	25,330,430	WUS_Soil_D10_023g_Config4_th_s_accel_TH03.csv
04/04/2022	09:24 AM	25,330,430	WUS_Soil_D10_023g_Config4_th_s_accel_TH04.csv
04/04/2022	09:42 AM	25,330,430	WUS_Soil_D10_023g_Config4_th_s_accel_TH05.csv
04/04/2022	08:38 AM	19,432,016	WUS_Soil_D10_023g_Config4_th_s_displ_base_TH01.csv
04/04/2022	08:56 AM	19,432,016	WUS_Soil_D10_023g_Config4_th_s_displ_base_TH02.csv
04/04/2022	09:14 AM	19,432,016	WUS_Soil_D10_023g_Config4_th_s_displ_base_TH03.csv
04/04/2022	09:33 AM	19,432,016	WUS_Soil_D10_023g_Config4_th_s_displ_base_TH04.csv
04/04/2022	09:51 AM	19,432,016	WUS_Soil_D10_023g_Config4_th_s_displ_base_TH05.csv
04/04/2022	08:29 AM	25,330,430	WUS_Soil_D10_023g_Config4_th_s_displ_TH01.csv
04/04/2022	08:47 AM	25,330,430	WUS_Soil_D10_023g_Config4_th_s_displ_TH02.csv
04/04/2022	09:05 AM	25,330,430	WUS_Soil_D10_023g_Config4_th_s_displ_TH03.csv
04/04/2022	09:24 AM	25,330,430	WUS_Soil_D10_023g_Config4_th_s_displ_TH04.csv
04/04/2022	09:42 AM	25,330,430	WUS_Soil_D10_023g_Config4_th_s_displ_TH05.csv

11. WUS Soft Rock, D5 0.52g

11.1. Configuration A

04/04/2022	12:16 AM	359,686	WUS_SR_D5_052g_Config1_sp_s_accel_base_TH01.csv
04/04/2022	12:56 AM	359,686	WUS_SR_D5_052g_Config1_sp_s_accel_base_TH02.csv
04/04/2022	01:37 AM	359,686	WUS_SR_D5_052g_Config1_sp_s_accel_base_TH03.csv
04/04/2022	02:18 AM	359,686	WUS_SR_D5_052g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	03:00 AM	359,686	WUS_SR_D5_052g_Config1_sp_s_accel_base_TH05.csv
04/03/2022	11:58 PM	359,776	WUS_SR_D5_052g_Config1_sp_s_accel_TH01.csv
04/04/2022	12:39 AM	359,776	WUS_SR_D5_052g_Config1_sp_s_accel_TH02.csv
04/04/2022	01:19 AM	359,776	WUS_SR_D5_052g_Config1_sp_s_accel_TH03.csv
04/04/2022	02:00 AM	359,776	WUS_SR_D5_052g_Config1_sp_s_accel_TH04.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-23 of 33

04/04/2022 02:42 AM	359,776 WUS_SR_D5_052g_Config1_sp_s_accel_TH05.csv
04/04/2022 12:16 AM	59,246,267 WUS_SR_D5_052g_Config1_th_s_accel_base_TH01.csv
04/04/2022 12:56 AM	59,246,267 WUS_SR_D5_052g_Config1_th_s_accel_base_TH02.csv
04/04/2022 01:37 AM	59,246,267 WUS_SR_D5_052g_Config1_th_s_accel_base_TH03.csv
04/04/2022 02:18 AM	59,246,267 WUS_SR_D5_052g_Config1_th_s_accel_base_TH04.csv
04/04/2022 03:00 AM	59,246,267 WUS_SR_D5_052g_Config1_th_s_accel_base_TH05.csv
04/03/2022 11:58 PM	104,959,016 WUS_SR_D5_052g_Config1_th_s_accel_TH01.csv
04/04/2022 12:38 AM	104,959,016 WUS_SR_D5_052g_Config1_th_s_accel_TH02.csv
04/04/2022 01:19 AM	104,959,016 WUS_SR_D5_052g_Config1_th_s_accel_TH03.csv
04/04/2022 02:00 AM	104,959,016 WUS_SR_D5_052g_Config1_th_s_accel_TH04.csv
04/04/2022 02:42 AM	104,959,016 WUS_SR_D5_052g_Config1_th_s_accel_TH05.csv
04/04/2022 12:16 AM	59,246,267 WUS_SR_D5_052g_Config1_th_s_displ_base_TH01.csv
04/04/2022 12:56 AM	59,246,267 WUS_SR_D5_052g_Config1_th_s_displ_base_TH02.csv
04/04/2022 01:37 AM	59,246,267 WUS_SR_D5_052g_Config1_th_s_displ_base_TH03.csv
04/04/2022 02:18 AM	59,246,267 WUS_SR_D5_052g_Config1_th_s_displ_base_TH04.csv
04/04/2022 03:00 AM	59,246,267 WUS_SR_D5_052g_Config1_th_s_displ_base_TH05.csv
04/03/2022 11:58 PM	104,959,016 WUS_SR_D5_052g_Config1_th_s_displ_TH01.csv
04/04/2022 12:39 AM	104,959,016 WUS_SR_D5_052g_Config1_th_s_displ_TH02.csv
04/04/2022 01:19 AM	104,959,016 WUS_SR_D5_052g_Config1_th_s_displ_TH03.csv
04/04/2022 02:00 AM	104,959,016 WUS_SR_D5_052g_Config1_th_s_displ_TH04.csv
04/04/2022 02:42 AM	104,959,016 WUS_SR_D5_052g_Config1_th_s_displ_TH05.csv

11.2. Configuration B

04/04/2022 08:21 AM	117,985 WUS_SR_D5_052g_Config4_sp_s_accel_base_TH01.csv
04/04/2022 08:34 AM	117,985 WUS_SR_D5_052g_Config4_sp_s_accel_base_TH02.csv
04/04/2022 08:46 AM	117,985 WUS_SR_D5_052g_Config4_sp_s_accel_base_TH03.csv
04/04/2022 08:59 AM	117,985 WUS_SR_D5_052g_Config4_sp_s_accel_base_TH04.csv
04/04/2022 09:12 AM	117,985 WUS_SR_D5_052g_Config4_sp_s_accel_base_TH05.csv
04/04/2022 08:15 AM	117,991 WUS_SR_D5_052g_Config4_sp_s_accel_TH01.csv
04/04/2022 08:28 AM	117,991 WUS_SR_D5_052g_Config4_sp_s_accel_TH02.csv
04/04/2022 08:40 AM	117,991 WUS_SR_D5_052g_Config4_sp_s_accel_TH03.csv
04/04/2022 08:53 AM	117,991 WUS_SR_D5_052g_Config4_sp_s_accel_TH04.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-24 of 33

04/04/2022	09:06 AM	117,991 WUS_SR_D5_052g_Config4_sp_s_accel_TH05.csv
04/04/2022	08:21 AM	19,432,016 WUS_SR_D5_052g_Config4_th_s_accel_base_TH01.csv
04/04/2022	08:33 AM	19,432,016 WUS_SR_D5_052g_Config4_th_s_accel_base_TH02.csv
04/04/2022	08:46 AM	19,432,016 WUS_SR_D5_052g_Config4_th_s_accel_base_TH03.csv
04/04/2022	08:59 AM	19,432,016 WUS_SR_D5_052g_Config4_th_s_accel_base_TH04.csv
04/04/2022	09:11 AM	19,432,016 WUS_SR_D5_052g_Config4_th_s_accel_base_TH05.csv
04/04/2022	08:15 AM	25,330,430 WUS_SR_D5_052g_Config4_th_s_accel_TH01.csv
04/04/2022	08:27 AM	25,330,430 WUS_SR_D5_052g_Config4_th_s_accel_TH02.csv
04/04/2022	08:40 AM	25,330,430 WUS_SR_D5_052g_Config4_th_s_accel_TH03.csv
04/04/2022	08:53 AM	25,330,430 WUS_SR_D5_052g_Config4_th_s_accel_TH04.csv
04/04/2022	09:05 AM	25,330,430 WUS_SR_D5_052g_Config4_th_s_accel_TH05.csv
04/04/2022	08:21 AM	19,432,016 WUS_SR_D5_052g_Config4_th_s_displ_base_TH01.csv
04/04/2022	08:34 AM	19,432,016 WUS_SR_D5_052g_Config4_th_s_displ_base_TH02.csv
04/04/2022	08:46 AM	19,432,016 WUS_SR_D5_052g_Config4_th_s_displ_base_TH03.csv
04/04/2022	08:59 AM	19,432,016 WUS_SR_D5_052g_Config4_th_s_displ_base_TH04.csv
04/04/2022	09:12 AM	19,432,016 WUS_SR_D5_052g_Config4_th_s_displ_base_TH05.csv
04/04/2022	08:15 AM	25,330,430 WUS_SR_D5_052g_Config4_th_s_displ_TH01.csv
04/04/2022	08:28 AM	25,330,430 WUS_SR_D5_052g_Config4_th_s_displ_TH02.csv
04/04/2022	08:40 AM	25,330,430 WUS_SR_D5_052g_Config4_th_s_displ_TH03.csv
04/04/2022	08:53 AM	25,330,430 WUS_SR_D5_052g_Config4_th_s_displ_TH04.csv
04/04/2022	09:06 AM	25,330,430 WUS_SR_D5_052g_Config4_th_s_displ_TH05.csv

12. WUS Soft Rock, D10 0.22g

12.1. Configuration A

04/04/2022	12:16 AM	359,686 WUS_SR_D10_022g_Config1_sp_s_accel_base_TH01.csv
04/04/2022	12:56 AM	359,686 WUS_SR_D10_022g_Config1_sp_s_accel_base_TH02.csv
04/04/2022	01:37 AM	359,686 WUS_SR_D10_022g_Config1_sp_s_accel_base_TH03.csv
04/04/2022	02:17 AM	359,686 WUS_SR_D10_022g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	02:59 AM	359,686 WUS_SR_D10_022g_Config1_sp_s_accel_base_TH05.csv
04/03/2022	11:58 PM	359,776 WUS_SR_D10_022g_Config1_sp_s_accel_TH01.csv
04/04/2022	12:38 AM	359,776 WUS_SR_D10_022g_Config1_sp_s_accel_TH02.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-25 of 33

04/04/2022 01:19 AM	359,776 WUS_SR_D10_022g_Config1_sp_s_accel_TH03.csv
04/04/2022 02:00 AM	359,776 WUS_SR_D10_022g_Config1_sp_s_accel_TH04.csv
04/04/2022 02:41 AM	359,776 WUS_SR_D10_022g_Config1_sp_s_accel_TH05.csv
04/04/2022 12:16 AM	59,246,267 WUS_SR_D10_022g_Config1_th_s_accel_base_TH01.csv
04/04/2022 12:56 AM	59,246,267 WUS_SR_D10_022g_Config1_th_s_accel_base_TH02.csv
04/04/2022 01:36 AM	59,246,267 WUS_SR_D10_022g_Config1_th_s_accel_base_TH03.csv
04/04/2022 02:17 AM	59,246,267 WUS_SR_D10_022g_Config1_th_s_accel_base_TH04.csv
04/04/2022 02:59 AM	59,246,267 WUS_SR_D10_022g_Config1_th_s_accel_base_TH05.csv
04/03/2022 11:58 PM	104,959,016 WUS_SR_D10_022g_Config1_th_s_accel_TH01.csv
04/04/2022 12:38 AM	104,959,016 WUS_SR_D10_022g_Config1_th_s_accel_TH02.csv
04/04/2022 01:19 AM	104,959,016 WUS_SR_D10_022g_Config1_th_s_accel_TH03.csv
04/04/2022 01:59 AM	104,959,016 WUS_SR_D10_022g_Config1_th_s_accel_TH04.csv
04/04/2022 02:40 AM	104,959,016 WUS_SR_D10_022g_Config1_th_s_accel_TH05.csv
04/04/2022 12:16 AM	59,246,267 WUS_SR_D10_022g_Config1_th_s_displ_base_TH01.csv
04/04/2022 12:56 AM	59,246,267 WUS_SR_D10_022g_Config1_th_s_displ_base_TH02.csv
04/04/2022 01:37 AM	59,246,267 WUS_SR_D10_022g_Config1_th_s_displ_base_TH03.csv
04/04/2022 02:17 AM	59,246,267 WUS_SR_D10_022g_Config1_th_s_displ_base_TH04.csv
04/04/2022 02:59 AM	59,246,267 WUS_SR_D10_022g_Config1_th_s_displ_base_TH05.csv
04/03/2022 11:58 PM	104,959,016 WUS_SR_D10_022g_Config1_th_s_displ_TH01.csv
04/04/2022 12:38 AM	104,959,016 WUS_SR_D10_022g_Config1_th_s_displ_TH02.csv
04/04/2022 01:19 AM	104,959,016 WUS_SR_D10_022g_Config1_th_s_displ_TH03.csv
04/04/2022 02:00 AM	104,959,016 WUS_SR_D10_022g_Config1_th_s_displ_TH04.csv
04/04/2022 02:41 AM	104,959,016 WUS_SR_D10_022g_Config1_th_s_displ_TH05.csv

12.2. Configuration B

04/04/2022 08:20 AM	117,985 WUS_SR_D10_022g_Config4_sp_s_accel_base_TH01.csv
04/04/2022 08:33 AM	117,985 WUS_SR_D10_022g_Config4_sp_s_accel_base_TH02.csv
04/04/2022 08:45 AM	117,985 WUS_SR_D10_022g_Config4_sp_s_accel_base_TH03.csv
04/04/2022 08:58 AM	117,985 WUS_SR_D10_022g_Config4_sp_s_accel_base_TH04.csv
04/04/2022 09:10 AM	117,985 WUS_SR_D10_022g_Config4_sp_s_accel_base_TH05.csv
04/04/2022 08:15 AM	117,991 WUS_SR_D10_022g_Config4_sp_s_accel_TH01.csv
04/04/2022 08:27 AM	117,991 WUS_SR_D10_022g_Config4_sp_s_accel_TH02.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-26 of 33

04/04/2022	08:39 AM	117,991 WUS_SR_D10_022g_Config4_sp_s_accel_TH03.csv
04/04/2022	08:52 AM	117,991 WUS_SR_D10_022g_Config4_sp_s_accel_TH04.csv
04/04/2022	09:04 AM	117,991 WUS_SR_D10_022g_Config4_sp_s_accel_TH05.csv
04/04/2022	08:20 AM	19,432,016 WUS_SR_D10_022g_Config4_th_s_accel_base_TH01.csv
04/04/2022	08:33 AM	19,432,016 WUS_SR_D10_022g_Config4_th_s_accel_base_TH02.csv
04/04/2022	08:45 AM	19,432,016 WUS_SR_D10_022g_Config4_th_s_accel_base_TH03.csv
04/04/2022	08:58 AM	19,432,016 WUS_SR_D10_022g_Config4_th_s_accel_base_TH04.csv
04/04/2022	09:10 AM	19,432,016 WUS_SR_D10_022g_Config4_th_s_accel_base_TH05.csv
04/04/2022	08:15 AM	25,330,430 WUS_SR_D10_022g_Config4_th_s_accel_TH01.csv
04/04/2022	08:27 AM	25,330,430 WUS_SR_D10_022g_Config4_th_s_accel_TH02.csv
04/04/2022	08:39 AM	25,330,430 WUS_SR_D10_022g_Config4_th_s_accel_TH03.csv
04/04/2022	08:52 AM	25,330,430 WUS_SR_D10_022g_Config4_th_s_accel_TH04.csv
04/04/2022	09:04 AM	25,330,430 WUS_SR_D10_022g_Config4_th_s_accel_TH05.csv
04/04/2022	08:20 AM	19,432,016 WUS_SR_D10_022g_Config4_th_s_displ_base_TH01.csv
04/04/2022	08:33 AM	19,432,016 WUS_SR_D10_022g_Config4_th_s_displ_base_TH02.csv
04/04/2022	08:45 AM	19,432,016 WUS_SR_D10_022g_Config4_th_s_displ_base_TH03.csv
04/04/2022	08:58 AM	19,432,016 WUS_SR_D10_022g_Config4_th_s_displ_base_TH04.csv
04/04/2022	09:10 AM	19,432,016 WUS_SR_D10_022g_Config4_th_s_displ_base_TH05.csv
04/04/2022	08:15 AM	25,330,430 WUS_SR_D10_022g_Config4_th_s_displ_TH01.csv
04/04/2022	08:27 AM	25,330,430 WUS_SR_D10_022g_Config4_th_s_displ_TH02.csv
04/04/2022	08:39 AM	25,330,430 WUS_SR_D10_022g_Config4_th_s_displ_TH03.csv
04/04/2022	08:52 AM	25,330,430 WUS_SR_D10_022g_Config4_th_s_displ_TH04.csv
04/04/2022	09:04 AM	25,330,430 WUS_SR_D10_022g_Config4_th_s_displ_TH05.csv

13. WUS Soft Rock Diablo, D5 1.3g

13.1. Configuration A

04/03/2022	11:22 PM	1,344,772 WUS_Diablo_D5_13g_Config1_sp_s_accel_base_TH01.csv
04/04/2022	03:02 AM	1,344,772 WUS_Diablo_D5_13g_Config1_sp_s_accel_base_TH02.csv
04/04/2022	06:44 AM	1,344,772 WUS_Diablo_D5_13g_Config1_sp_s_accel_base_TH03.csv
04/04/2022	10:24 AM	1,344,772 WUS_Diablo_D5_13g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	02:11 PM	1,344,772 WUS_Diablo_D5_13g_Config1_sp_s_accel_base_TH05.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-27 of 33

04/03/2022 09:39 PM	1,345,222 WUS_Diablo_D5_13g_Config1_sp_s_accel_TH01.csv
04/04/2022 01:22 AM	1,345,222 WUS_Diablo_D5_13g_Config1_sp_s_accel_TH02.csv
04/04/2022 05:03 AM	1,345,222 WUS_Diablo_D5_13g_Config1_sp_s_accel_TH03.csv
04/04/2022 08:46 AM	1,345,222 WUS_Diablo_D5_13g_Config1_sp_s_accel_TH04.csv
04/04/2022 12:28 PM	1,345,222 WUS_Diablo_D5_13g_Config1_sp_s_accel_TH05.csv
04/03/2022 11:21 PM	221,452,853 WUS_Diablo_D5_13g_Config1_th_s_accel_base_TH01.csv
04/04/2022 03:01 AM	221,452,853 WUS_Diablo_D5_13g_Config1_th_s_accel_base_TH02.csv
04/04/2022 06:43 AM	221,452,853 WUS_Diablo_D5_13g_Config1_th_s_accel_base_TH03.csv
04/04/2022 10:24 AM	221,452,853 WUS_Diablo_D5_13g_Config1_th_s_accel_base_TH04.csv
04/04/2022 02:10 PM	221,452,853 WUS_Diablo_D5_13g_Config1_th_s_accel_base_TH05.csv
04/03/2022 09:38 PM	427,897,931 WUS_Diablo_D5_13g_Config1_th_s_accel_TH01.csv
04/04/2022 01:21 AM	427,897,931 WUS_Diablo_D5_13g_Config1_th_s_accel_TH02.csv
04/04/2022 05:02 AM	427,897,931 WUS_Diablo_D5_13g_Config1_th_s_accel_TH03.csv
04/04/2022 08:45 AM	427,897,931 WUS_Diablo_D5_13g_Config1_th_s_accel_TH04.csv
04/04/2022 12:27 PM	427,897,931 WUS_Diablo_D5_13g_Config1_th_s_accel_TH05.csv
04/03/2022 11:22 PM	221,452,853 WUS_Diablo_D5_13g_Config1_th_s_displ_base_TH01.csv
04/04/2022 03:02 AM	221,452,853 WUS_Diablo_D5_13g_Config1_th_s_displ_base_TH02.csv
04/04/2022 06:44 AM	221,452,853 WUS_Diablo_D5_13g_Config1_th_s_displ_base_TH03.csv
04/04/2022 10:24 AM	221,452,853 WUS_Diablo_D5_13g_Config1_th_s_displ_base_TH04.csv
04/04/2022 02:11 PM	221,452,853 WUS_Diablo_D5_13g_Config1_th_s_displ_base_TH05.csv
04/03/2022 09:39 PM	427,897,931 WUS_Diablo_D5_13g_Config1_th_s_displ_TH01.csv
04/04/2022 01:22 AM	427,897,931 WUS_Diablo_D5_13g_Config1_th_s_displ_TH02.csv
04/04/2022 05:03 AM	427,897,931 WUS_Diablo_D5_13g_Config1_th_s_displ_TH03.csv
04/04/2022 08:46 AM	427,897,931 WUS_Diablo_D5_13g_Config1_th_s_displ_TH04.csv
04/04/2022 12:28 PM	427,897,931 WUS_Diablo_D5_13g_Config1_th_s_displ_TH05.csv

13.2. Configuration B

04/03/2022 07:54 PM	144,868 WUS_Diablo_D5_13g_Config4_sp_s_accel_base_TH01.csv
04/03/2022 08:09 PM	144,868 WUS_Diablo_D5_13g_Config4_sp_s_accel_base_TH02.csv
04/03/2022 08:24 PM	144,868 WUS_Diablo_D5_13g_Config4_sp_s_accel_base_TH03.csv
04/03/2022 08:40 PM	144,868 WUS_Diablo_D5_13g_Config4_sp_s_accel_base_TH04.csv
04/03/2022 08:56 PM	144,868 WUS_Diablo_D5_13g_Config4_sp_s_accel_base_TH05.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-28 of 33

04/03/2022 07:47 PM	144,874 WUS_Diablo_D5_13g_Config4_sp_s_accel_TH01.csv
04/03/2022 08:02 PM	144,874 WUS_Diablo_D5_13g_Config4_sp_s_accel_TH02.csv
04/03/2022 08:17 PM	144,874 WUS_Diablo_D5_13g_Config4_sp_s_accel_TH03.csv
04/03/2022 08:32 PM	144,874 WUS_Diablo_D5_13g_Config4_sp_s_accel_TH04.csv
04/03/2022 08:48 PM	144,874 WUS_Diablo_D5_13g_Config4_sp_s_accel_TH05.csv
04/03/2022 07:54 PM	23,855,849 WUS_Diablo_D5_13g_Config4_th_s_accel_base_TH01.csv
04/03/2022 08:08 PM	23,855,849 WUS_Diablo_D5_13g_Config4_th_s_accel_base_TH02.csv
04/03/2022 08:24 PM	23,855,849 WUS_Diablo_D5_13g_Config4_th_s_accel_base_TH03.csv
04/03/2022 08:40 PM	23,855,849 WUS_Diablo_D5_13g_Config4_th_s_accel_base_TH04.csv
04/03/2022 08:56 PM	23,855,849 WUS_Diablo_D5_13g_Config4_th_s_accel_base_TH05.csv
04/03/2022 07:46 PM	32,703,479 WUS_Diablo_D5_13g_Config4_th_s_accel_TH01.csv
04/03/2022 08:01 PM	32,703,479 WUS_Diablo_D5_13g_Config4_th_s_accel_TH02.csv
04/03/2022 08:16 PM	32,703,479 WUS_Diablo_D5_13g_Config4_th_s_accel_TH03.csv
04/03/2022 08:32 PM	32,703,479 WUS_Diablo_D5_13g_Config4_th_s_accel_TH04.csv
04/03/2022 08:48 PM	32,703,479 WUS_Diablo_D5_13g_Config4_th_s_accel_TH05.csv
04/03/2022 07:54 PM	23,855,849 WUS_Diablo_D5_13g_Config4_th_s_displ_base_TH01.csv
04/03/2022 08:09 PM	23,855,849 WUS_Diablo_D5_13g_Config4_th_s_displ_base_TH02.csv
04/03/2022 08:24 PM	23,855,849 WUS_Diablo_D5_13g_Config4_th_s_displ_base_TH03.csv
04/03/2022 08:40 PM	23,855,849 WUS_Diablo_D5_13g_Config4_th_s_displ_base_TH04.csv
04/03/2022 08:56 PM	23,855,849 WUS_Diablo_D5_13g_Config4_th_s_displ_base_TH05.csv
04/03/2022 07:47 PM	32,703,479 WUS_Diablo_D5_13g_Config4_th_s_displ_TH01.csv
04/03/2022 08:02 PM	32,703,479 WUS_Diablo_D5_13g_Config4_th_s_displ_TH02.csv
04/03/2022 08:17 PM	32,703,479 WUS_Diablo_D5_13g_Config4_th_s_displ_TH03.csv
04/03/2022 08:32 PM	32,703,479 WUS_Diablo_D5_13g_Config4_th_s_displ_TH04.csv
04/03/2022 08:48 PM	32,703,479 WUS_Diablo_D5_13g_Config4_th_s_displ_TH05.csv

14. WUS Soft Rock Diablo, D5 0.92g

14.1. Configuration A

04/03/2022 11:19 PM	1,344,772 WUS_Diablo_D5_092g_Config1_sp_s_accel_base_TH01.csv
04/04/2022 02:59 AM	1,344,772 WUS_Diablo_D5_092g_Config1_sp_s_accel_base_TH02.csv
04/04/2022 06:41 AM	1,344,772 WUS_Diablo_D5_092g_Config1_sp_s_accel_base_TH03.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-29 of 33

04/04/2022	10:22 AM	1,344,772 WUS_Diablo_D5_092g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	02:09 PM	1,344,772 WUS_Diablo_D5_092g_Config1_sp_s_accel_base_TH05.csv
04/03/2022	09:39 PM	1,345,222 WUS_Diablo_D5_092g_Config1_sp_s_accel_TH01.csv
04/04/2022	01:20 AM	1,345,222 WUS_Diablo_D5_092g_Config1_sp_s_accel_TH02.csv
04/04/2022	05:01 AM	1,345,222 WUS_Diablo_D5_092g_Config1_sp_s_accel_TH03.csv
04/04/2022	08:43 AM	1,345,222 WUS_Diablo_D5_092g_Config1_sp_s_accel_TH04.csv
04/04/2022	12:28 PM	1,345,222 WUS_Diablo_D5_092g_Config1_sp_s_accel_TH05.csv
04/03/2022	11:19 PM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_accel_base_TH01.csv
04/04/2022	02:59 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_accel_base_TH02.csv
04/04/2022	06:40 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_accel_base_TH03.csv
04/04/2022	10:21 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_accel_base_TH04.csv
04/04/2022	02:08 PM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_accel_base_TH05.csv
04/03/2022	09:38 PM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_accel_TH01.csv
04/04/2022	01:19 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_accel_TH02.csv
04/04/2022	05:00 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_accel_TH03.csv
04/04/2022	08:42 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_accel_TH04.csv
04/04/2022	12:27 PM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_accel_TH05.csv
04/03/2022	11:19 PM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_displ_base_TH01.csv
04/04/2022	02:59 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_displ_base_TH02.csv
04/04/2022	06:41 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_displ_base_TH03.csv
04/04/2022	10:22 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_displ_base_TH04.csv
04/04/2022	02:09 PM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_displ_base_TH05.csv
04/03/2022	09:39 PM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_displ_TH01.csv
04/04/2022	01:20 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_displ_TH02.csv
04/04/2022	05:01 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_displ_TH03.csv
04/04/2022	08:43 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_displ_TH04.csv
04/04/2022	12:28 PM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_displ_TH05.csv

14.2. Configuration B

04/03/2022	11:19 PM	1,344,772 WUS_Diablo_D5_092g_Config1_sp_s_accel_base_TH01.csv
04/04/2022	02:59 AM	1,344,772 WUS_Diablo_D5_092g_Config1_sp_s_accel_base_TH02.csv
04/04/2022	06:41 AM	1,344,772 WUS_Diablo_D5_092g_Config1_sp_s_accel_base_TH03.csv

SC SOLUTIONS

Soil Structure Interaction (SSI) Simulations Supporting Shake Table Testing of Dry Storage Casks

| Rev. 0

Page: D-30 of 33

04/04/2022	10:22 AM	1,344,772 WUS_Diablo_D5_092g_Config1_sp_s_accel_base_TH04.csv
04/04/2022	02:09 PM	1,344,772 WUS_Diablo_D5_092g_Config1_sp_s_accel_base_TH05.csv
04/03/2022	09:39 PM	1,345,222 WUS_Diablo_D5_092g_Config1_sp_s_accel_TH01.csv
04/04/2022	01:20 AM	1,345,222 WUS_Diablo_D5_092g_Config1_sp_s_accel_TH02.csv
04/04/2022	05:01 AM	1,345,222 WUS_Diablo_D5_092g_Config1_sp_s_accel_TH03.csv
04/04/2022	08:43 AM	1,345,222 WUS_Diablo_D5_092g_Config1_sp_s_accel_TH04.csv
04/04/2022	12:28 PM	1,345,222 WUS_Diablo_D5_092g_Config1_sp_s_accel_TH05.csv
04/03/2022	11:19 PM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_accel_base_TH01.csv
04/04/2022	02:59 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_accel_base_TH02.csv
04/04/2022	06:40 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_accel_base_TH03.csv
04/04/2022	10:21 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_accel_base_TH04.csv
04/04/2022	02:08 PM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_accel_base_TH05.csv
04/03/2022	09:38 PM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_accel_TH01.csv
04/04/2022	01:19 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_accel_TH02.csv
04/04/2022	05:00 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_accel_TH03.csv
04/04/2022	08:42 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_accel_TH04.csv
04/04/2022	12:27 PM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_accel_TH05.csv
04/03/2022	11:19 PM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_displ_base_TH01.csv
04/04/2022	02:59 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_displ_base_TH02.csv
04/04/2022	06:41 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_displ_base_TH03.csv
04/04/2022	10:22 AM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_displ_base_TH04.csv
04/04/2022	02:09 PM	221,452,853 WUS_Diablo_D5_092g_Config1_th_s_displ_base_TH05.csv
04/03/2022	09:39 PM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_displ_TH01.csv
04/04/2022	01:20 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_displ_TH02.csv
04/04/2022	05:01 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_displ_TH03.csv
04/04/2022	08:43 AM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_displ_TH04.csv
04/04/2022	12:28 PM	427,897,931 WUS_Diablo_D5_092g_Config1_th_s_displ_TH05.csv