November 19, 1999

MEMORANDUM TO: Gary M. Holahan, Director
Division of System Safety and Analysis
Office of Nuclear Regulatory Research

FROM: John W. Craig, Director
Division of Engineering Technology
Office of Nuclear Regulatory Research

SUBJECT: REVIEW OF DRAFT TECHNICAL STUDY OF SPENT FUEL POOL ACCIDENTS FOR DECOMMISSIONING PLANTS (TAC NO. MA5099)

Your letter dated August 18, 1999, requested the Engineering Research Applications Branch (ERAB/DET/RES) staff and consultants to perform an independent review of the seismic part of your technical working group's (TWG) technical study of spent fuel pool accidents for decommissioning plants as well as the input from the Nuclear Energy Institute (NEI) on the seismic check list for technical soundness and scope.

The requested review comments and recommendations are contained in a review report entitled "Comments Concerning Seismic Screening and Seismic Risk of Spent Fuel Pools for Decommissioning Plant" (see attachment). The report specifically comments on TWG's draft study, and on the input from NEI on the seismic check list. It also provides review evaluation for the seismic risk for plants, using both LLNL & EPRI hazard curves. In addition, the report makes specific recommendations on practical measures to mitigate the effects of seismic vulnerability that would be adopted by the decommissioning plants. We have reviewed the report and support the comments and recommendations.

We have been interacting with Goutam Bagchi during the review period, and appreciate his comments on the draft report. The report should be helpful in developing a risk-informed technical basis for establishing spent fuel pool decommissioning regulations.

Attachments: As stated

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Comments Concerning Seismic Screening And Seismic Risk of Spent Fuel Pools for Decommissioning Plants

by

Robert P. Kennedy

October 1999

prepared for

Brookhaven National Laboratory

1. Introduction

I have been requested by Brookhaven National Laboratory, in support of the Engineering Research Applications Branch of the Nuclear Regulatory Commission, to review and comment on certain seismic related aspects of References 1 through 4. Specifically, I was requested to comment on the applicability of using seismic walkdowns and drawing reviews conducted following the guidance provided by seismic screening tables (seismic check lists) to assess that the risk of seismic-induced spent fuel pool accidents is adequately low. The desire is to use these seismic walkdowns and drawing reviews in lieu of more rigorous and much more costly seismic fragility evaluations. It is my understanding that the primary concern is with a sufficiently gross failure of the spent fuel pool so that water is rapidly drained resulting in the fuel becoming uncovered. However, there may also be a concern that the spent fuel racks maintain an acceptable geometry. It is also my understanding that any seismic walkdown assessment should be capable of providing reasonable assurance that seismic risk of a gross failure of the spent fuel pool to contain water is less than the low 10^{-6} mean annual frequency range. My review comments are based upon these understandings.

2. Background Information

The NRC Draft Technical Study of Spent Fuel Pool Accidents (Ref. 1) assumes that spent fuel pools are seismically robust. Furthermore, it is assumed that High-Confidence-Low-Probability-of Failure (HCLPF) seismic capacity of these pools is in the range of 0.4 to 0.5g peak ground acceleration (PGA). This HCLPF capacity (C_{HCLPF}) corresponds to approximately a 1% mean conditional probability of failure capacity ($C_{1\%}$), i.e.:

$$C_{HCLPF} \approx C_{1\%} \qquad (1)$$

as shown in Ref. 10.

In Ref. 5, detailed seismic fragility assessments have been conducted on the gross structural failure of spent fuel pools for two plants: Vermont Yankee (BWR), and Robinson (PWR). The following HCLPF seismic capacities are obtained from the fragility information in Ref. 5:

Vermont Yankee (BWR): $C_{HCLPF} = 0.48g$ PGA

Robinson (PWR): $C_{HCLPF} = 0.65g$ PGA (2)

These two fragility estimates provide some verification of the HCLPF capacity assumption of 0.4 to 0.5g PGA used in Ref. 1.

I am confident that a set of seismic screening tables (seismic check lists) can be developed to be used with seismic walkdowns and drawing reviews to provide reasonable assurance that the HCLPF capacity of spent fuel pools is at least in the range of 0.4 to 0.5g PGA for spent fuel pools that pass such a review. However, in order to justify a HCLPF capacity in the range of 0.4 to 0.5g PGA, these screening tables will have rather stringent criteria so that I am not so confident that the vast majority of spent fuel pools will pass the screening criteria. The screening criteria (seismic check lists) summarized in Ref. 4 provides an excellent start. The subject of screening criteria is discussed more thoroughly in Section 3.

Once the HCLPF seismic capacity (C_{HCLPF}) has been estimated, the seismic risk of failure of the spent fuel pool can be estimated by either rigorous convolution of the seismic fragility (conditional probability of failure as a function of ground motion level) and the seismic hazard (annual frequency of exceedance of various ground motion levels), or by a simplified approximate method. This subject is discussed more thoroughly in Ref. 10.

A simplified approximate method is used in Ref. 1 to estimate the annual seismic risk of failure (P_F) of the spent fuel pool given its HCLPF capacity (C_{HCLPF}). The approach used in Ref. 1 is that:

$$P_F = 0.05\, H_{HCLPF} \quad (3)$$

where H_{HCLPF} is the annual frequency of exceedance of the HCLPF capacity. Ref. 1 goes on to state that for most Central and Eastern U.S. (CEUS) plants, the mean annual frequency of exceeding 0.4 to 0.5g PGA is on the order of or less than $2x10^{-5}$ based on the Ref. 8 hazard curves. Thus, from Eqn. (3), the annual frequency of seismic-induced gross failure (P_F) of the spent fuel pool is on the order of $1x10^{-6}$ or less for most CEUS plants.

Unfortunately, the approximation of Eqn. (3) is unconservative for CEUS hazard curves that have shallow slopes. By shallow slopes, I mean that it requires more than a factor of 2 increase in ground motion to correspond to a 10-fold reduction in the annual frequency of exceedance. For most CEUS sites, Ref. 8 indicates that a factor of 2 to 3 increase in ground motion is required to reduce the hazard exceedance frequency from $1x10^{-5}$ to $1x10^{-6}$. Over this range of hazard curve slopes, Eqn. (3) is always unconservative and will be unconservative by a factor of 2 to 4. Therefore, a HCLPF capacity in the range of 0.4 to 0.5g PGA is not sufficiently high to achieve a spent fuel pool seismic risk of failure on the order of 1×10^{-6} or less for most CEUS plants. However, HCLPF capacities this high are sufficiently high to achieve seismic risk estimates less than 3×10^{-6} for most CEUS plants based upon the Ref. 8 hazard curves. This subject is further discussed in Section 4.

In lieu of using a simplified approximate method, Ref. 2 has estimated the seismic risk of spent fuel pool failure by rigorous convolution of the seismic fragility and seismic hazard estimates for the 69 CEUS sites for which seismic hazard curves are given in Ref. 8. Ref. 2 has divided the sites into 26 BWR sites and 43 PWR sites.

For the 26 BWR sites, Ref. 2 used the fragility curve defined in Ref. 5 for Vermont Yankee with the following properties:

<u>BWR Sites</u>

Median Capacity	$C_{50} = 1.4$	PGA	
HCLPF Capacity	$C_{HCLPF} = 0.48g$	PGA	(4)

Using the Ref. 8 seismic hazard estimates and the Eqn. (4) fragility, Ref. 2 obtained spent fuel pool mean annual failure probabilities ranging from 12.0×10^{-6} to 0.11×10^{-6} and averaging 1.6×10^{-6} for the 26 BWR sites. In my judgment, seismic screening criteria (seismic check lists) can be developed which are sufficiently stringent so as to provide reasonable assurance that the seismic capacity of spent fuel pools which pass the seismic screening roughly equals or exceeds that defined by Eqn. (4). With such a fragility estimate, based on the Ref. 8 seismic hazard estimates, for most CEUS sites, the estimated spent fuel pool seismic-induced failure probability will be less than 3×10^{-6} as further discussed in Section 4.

For the 43 PWR sites, Ref. 2 used the fragility curve defined in Ref. 5 for Robinson with the following properties:

<u>PWR Sites</u>

Median Capacity	$C_{50} = 2.0$	PGA	
HCLPF Capacity	$C_{HCLPF} = 0.65g$	PGA	(5)

Using the Ref. 8 seismic hazard estimates and the Eqn. (5) fragility, Ref. 2 obtained spent fuel pool mean annual failure probabilities ranging from 2.5×10^{-6} to 0.03×10^{-6} and averaging 0.48×10^{-6} for the 43 PWR sites. A fragility curve as high as that defined by Eqn. (5) is necessary to achieve an estimated spent fuel pool seismic-induced failure probability as low as 1×10^{-6} for nearly all CEUS sites. However, I don't believe realistic seismic screening criteria can be developed which are sufficiently stringent to provide reasonable assurance that the Eqn. (5) seismic fragility is achieved. In my judgment, a more rigorous seismic margin evaluation performed in accordance with the CDFM method described in Refs. 6 or 7 would be required to justify a HCLPF capacity as high as that defined by Eqn. (5).

3. Development and Use of Seismic Screening Criteria

Screening criteria are very useful to reduce the number of structure, system, and component (SSC) failure modes for which either seismic fragilities or seismic margin HCLPF capacities need to be developed. Screening criteria are presented in Ref. 6 for SSCs for which failures might lead to core damage. These screening criteria were established by an NRC sponsored "Expert Panel" based upon their review of seismic fragilities and seismic margin HCLPF capacities computed for these SSCs at more than a dozen nuclear power plants, and their review of earthquake experience data. These screening criteria were further refined in Ref. 7.

The screening criteria of Refs. 6 and 7 are defined for two seismic margin HCLPF capacity levels which will be herein called Level 1 and Level 2. Refs. 6 defines these two HCLPF capacity levels in terms of the PGA of the ground motion. However, damage to critical SSCs does not correlate very well to PGA of the ground motion. Damage correlates much better with the spectral acceleration of the ground motion over the natural frequency range of interest which is generally between 2.5 and 10 Hz for nuclear power plant SSCs. For this reason, Ref. 7 defines these same two HCLPF capacity levels in terms of the peak 5% damped spectral acceleration (PSA) of the ground motion. The two HCLPF capacity screening levels defined in Refs 6 and 7 are:

	HCLPF Screening Levels	
	Level 1	Level 2
PGA (Ref. 6)	0.3g	0.5g
PSA (Ref. 7)	0.8g	1.2g

These two definitions (PGA and PSA) are consistent with each other based upon the data upon which these screening levels are based. However, in my judgment, it is far superior to use the Ref. 7 PSA definition for the two screening levels when convolving a fragility estimate with CEUS seismic hazard estimates. For these CEUS seismic hazard estimates from Ref. 8, the ratio PSA/PGA generally lies in the range of 1.8 to 2.4 which is lower than the PSA/PGA ratio of the data from which the screening tables were developed. A more realistic and generally lower estimate of the annual probability of failure will result when the seismic fragility is defined in terms of PSA and convolved with a PSA hazard estimate in which the PSA hazard estimate is defined in the 2.5 to 10 Hz range.

In the past, a practical difficulty existed with defining the seismic fragility in terms of PSA instead of PGA. The Ref. 8 PSA hazard estimates are only carried down to 10^{-4} annual frequency of exceedance whereas the PGA hazard estimates are extended down to about 10^{-6}. Since it is necessary for the hazard estimate to be extended to at least a factor of 10 below the annual failure frequency being predicted, it has not been practical to use the PSA seismic fragility definition with the Ref. 8 hazard estimates. However, this difficulty has been overcome by Ref. 9 prepared by the Engineering Research Applications Branch of the Nuclear Regulatory Commission which extends the PSA seismic hazard estimates also down to 10^{-6}. Ref. 9 is attached herein as Appendix A.

In order to achieve a seismic induced annual failure probability P_F in the low 10^{-6} range for nearly all of the CEUS spent fuel pools with the Ref. 8 hazard estimates, it is necessary to apply the Level 2 screening criteria of Refs. 6 or 7, i.e., screen at a HCLPF seismic capacity of 1.2g PSA (equivalent to 0.5g PGA). The seismic screening criteria presented in Ref. 4 is properly based upon screening to Level 2. Furthermore, Ref. 4 appropriately summarizes the guidance presented in Ref. 7 for screening to Level 2. In general, I support the screening criteria defined in Ref. 4. However, I do have three concerns which are discussed in the following subsections.

3.1 Out-of-Plane Flexural and Shear Failure Modes for Spent Fuel Pool Concrete Walls and Floor

The screening criteria for concrete walls and floor diaphrams were developed to provide seismic margin HCLPF capacities based upon in-plane flexural and shear failures of these walls and diaphrams. For typical auxiliary buildings, reactor buildings, diesel generator buildings, etc., it is these in-plane failure modes which are of concern. For normal building situations, seismic loads are applied predominately in the plane of the wall or floor diaphram. Out-of-plane flexure and shear are not of significant concern. As one the primary authors of the screening criteria in both Refs. 6 and 7, I am certain that these screening criteria do not address out-of-plane flexure and shear failure modes.

For an aboveground spent fuel pool in which the pool walls (and floor in some cases) are not supported by soil backfill, it is likely that either out-of-plane flexure or shear will be the expected seismic failure mode. These walls and floor slab must carry the seismic-induced hydrodynamic pressure from the water in the pool to their supports by out-of-plane flexure and shear. It is true that these walls and floor are robust (high strength), but they may not be as ductile for out-of-plane behavior as they are for in-plane behavior. For an out-of-plane shear failure to be ductile requires shear reinforcement in regions of high shear. Furthermore, if large plastic rotations are required to occur, the tensile and compression steel needs to be tied together by closely spaced stirrups. I question whether such shear reinforcement and stirrups exist at locations of high shear and flexure in the spent fuel pool walls and floor. As a result, I suspect that only limited credit for ductility can be taken.

Without taking credit for significant ductility, it is not clear to me that spent fuel pool walls and floors not supported by soil can be screened at a seismic HCLPF capacity level as high as 1.2g PSA (equivalent to 0.5g PGA). I am aware of only one seismic fragility analysis having been performed on such unsupported spent fuel pool walls. That analysis was the Vermont Yankee spent fuel pool analysis reported in Ref. 5 for which the reported seismic HCLPF capacity was 0.48g PGA. A single analysis case does not provide an adequate basis for establishing a screening level for all other cases, particularly when the computed result is right at the desired screening level. The screening criteria in Refs 6 and 7 are based upon the review of many cases at more that a dozen plants.

In my judgement, it will be necessary to have either seismic fragility or seismic margin HCLPF computations performed on at least six different aboveground spent fuel pools with walls not supported by soil before out-of-plane flexure and shear HCLPF capacity screening levels can be established for such spent fuel pools.

3.2 Spent Fuel Pool Racks

I don't know whether a gross structural failure of the spent fuel racks is of major concern. This is a topic outside of my area of expertise. However, if such a failure is of concern, no seismic HCLPF capacity screening criteria is available for such a failure. The screening criteria of Refs. 6 and 7 were never intended to be applied to spent fuel pool racks. Since I have never seen a seismic fragility or seismic margin HCLPF capacity evaluation of a spent fuel pool rack, I have no basis for deciding whether these racks can be screened at a seismic HCLPF capacity as high as 1.2g PSA (equivalent to 0.5g PGA).

3.3 Seismic Level 2 Screening Requirements

In order to screen at a seismic HCLPF capacity of 1.2g PSA (0.5g PGA), the Level 2 screening criteria for concrete walls and diaphrams requires that such walls and diaphrams essentially comply with the ductile detailing and rebar development length requirements of either ACI 318.71 or ACI 349.76 or later editions. It is not clear to me how many CEUS spent fuel pool walls and floors essentially comply with such requirements since earlier editions of these codes had less stringent requirements. Therefore, it is not clear to me how many spent fuel pool walls and floors can actually be screened at Seismic Level 2 even for in-plane flexure and shear failure mode.

4. Seismic Risk Associated With Screening Level 2

4.1 Simplified Approaches for Estimating Seismic Risk Given the HCLPF Capacity

As mentioned in Section 2, the seismic risk of failure of the spent fuel pool can be estimated by either rigorous convolution of the seismic fragility and the seismic hazard, or by a simplified approximate method. The simplified approximate method defined by Eqn. (3) was used in Ref. 1. However, as also mentioned in Section 2, this approximate method understates the seismic risk by a factor of 2 to 4 for typical CEUS hazard estimates.

Ref. 10 presents an equally simple approach for estimating the seismic risk of failure of any component given its HCLPF capacity C_{HCLPF} and a hazard estimate. This approach tends to introduce from 0% to 25% conservative bias to the computed seismic risk when compared with rigorous convolution. Given the HCLPF capacity C_{HCLPF} this approach consists of the following steps:

Step 1: Estimate the 10% conditional probability of failure capacity $C_{10\%}$ from:

$$C_{10\%} = F_\beta C_{HCLPF}$$
$$F_\beta = e^{1.044\beta} \quad (6)$$

where β is the logarithmic standard deviation of the fragility estimate and 1.044 is the difference between the 10% non-exceedance probability (NEP) standard normal variable (-1.282) and the 1% NEP standardized normal variable (-2.326). F_β is tabulated below for various fragility logarithmic standard deviation β values.

β	Median/CDFM Capacity ($C_{50\%}/C_{CDFM}$)	$F_\beta=(C_{10\%}/C_{HCLPF})$
0.3	2.01	1.37
0.4	2.54	1.52
0.5	3.20	1.69
0.6	4.04	1.87

For structures such as the spent fuel pool, β typically ranges from 0.3 to 0.5. Ref. 10 shows that over this range of β, the computed seismic risk is not very sensitive to β. Therefore, I recommend using a midpoint value for β of 0.4.

Step 2: Determine hazard exceedance frequency $H_{10\%}$, that corresponds to $C_{10\%}$ from the hazard curve.

Step 3: Determine seismic risk P_F from:

$$P_F = 0.5\, H_{10\%} \quad (7)$$

Table 1 presents the Peak Spectral Acceleration PSA seismic hazard estimates from Ref. 8 and 9 (LLNL93 results) for the Vermont Yankee and Robinson sites. In order to accurately estimate the seismic risk for a seismic HCLPF capacity C_{HCLPF} of:

$$C_{HCLPF} = 1.2g \text{ PSA} = 1176 \text{ cm/sec}^2 \text{ PSA} \quad (8)$$

associated with Screening Level 2 for the Vermont Yankee site by rigorous convolution, it is necessary to extrapolate the Ref. 9 hazard estimates down to the 2×10^{-8} exceedance frequency. Also, intermediate values in Table 1 have been obtained by interpolation.

Table 2 compares the seismic risk of spent fuel pool failure for these two sites as estimated by the following three methods:

1. Ref. 1 simplified approach, i.e., Eqn. (3).

2. Ref. 10 simplified approach, i.e., Steps 1 through 3 above.

3. Rigorous convolution of the hazard and fragility estimates.

For all three approaches the Screening Level 2 HCLPF capacity defined by Eqn. (8) was used. In addition, for both the Ref. 10 and rigorous convolution approaches, a fragility logarithmic standard deviation β of 0.4 was used.

From Table 2, it can be seen that the Ref. 1 method (Eqn. (3)) underestimates the seismic risk by factors of 2.3 and 3.5 for Vermont Yankee and Robinson, respectively. The simplified approach recommended in Ref. 10 and described herein overestimates the seismic risk by 20% and 5% respectively for these two cases. These results are consistent with the results I have obtained for many other cases.

4.2 Estimated Seismic Risk of Spent Fuel Pools Screened at Screening Level 2 Using Mean LL93 Hazard Estimates from Ref. 8 and 9

Using the Ref. 10 simplified approach described in the previous subsection, I have estimated the spent fuel pool seismic risk of failure corresponding to Screening Level 2 for all 69 CEUS sites with LLNL93 seismic hazard estimates defined in Refs. 8 and 9. These sites are defined in terms of an NRC site number code (OCSP_) used in Ref. 9. For each site, I assumed that the HCLPF capacity C_{HCLPF} was defined by Eqn. (8). A total of 35 of the 69 sites had estimated seismic risks of spent fuel pool failure associated with Screening Level 2 of greater than 1x10-6. The estimated seismic risk of 26 of these sites exceeded 1.25×10^{-6}. These 26 sites with their estimated seismic risk corresponding to Screening Level 2 are listed in Table 3. As can be seen in Table 3, only 8 of the 69 sites had estimated seismic risks of spent fuel pool failure exceeding 3×10^{-6}. One of these sites is Shoreham at which no fuel exists.

It should be noted that the seismic risks of spent fuel pool failure tabulated in Table 3 are based on the assumption that the HCLPF capacity of the spent fuel pool exactly equals the Screening Level 2 HCLPF capacity of 1.2g PSA (equivalent to 0.5g PGA). In actuality, spent fuel pools which pass the appropriately defined screening criteria are likely to have capacities higher than the screening level capacity. Therefore these are upper bound seismic risk estimates for spent fuel pools that pass the to-be established screening criteria. Furthermore, the simplified approach used to estimate the seismic risks in Table 3 overestimates these risks by 0% to 25%.

4.3 Estimated Seismic Risk of Spent Fuel Pools Screened at Screening Level 2 Using Mean EPRI89 Hazard Estimates

Following the exact same Ref. 10 simplified approach which I followed for the LLNL93 hazard estimates, Ref. 11 provides the corresponding seismic risk of spent fuel pool failure estimates based upon EPRI89 hazard estimates for 60 of the 69 CEUS sites.

Table 3 shows the corresponding seismic risk computed in Ref. 11 for the EPRI89 hazard estimates.

From Table 3, it can be seen that the EPRI89 hazard estimates produce generally much lower seismic risk estimates corresponding to Screening Level 2 than do the LLNL93 hazard estimates. Based on the EPRI89 hazard estimates, only one site has a seismic risk exceeding $1 x 10^{-6}$. Only three other sites have seismic risks exceeding $0.5 x 10^{-6}$. Table 3 includes all sites for which the computed seismic risk exceeds $0.5 x 10^{-6}$ based on the mean EPRI89 hazard estimates.

5. Conclusions

If based on the mean LLNL93 hazard estimates (Ref. 8 and 9) it is acceptable to have up to a mean $3 x 10^{-6}$ annual seismic risk of spent fuel pool failure at the screening level, then Screening Level 2 defined in Section 3 represents a practical screening level. Only 8 of the 69 sites have computed seismic risks greater than $3 x 10^{-6}$ at this screening level. Screening Level 2 is set at a peak 5% damped spectral acceleration (PSA) level of 1.2g (equivalent to a PGA level of 0.5g).

Based on the mean EPRI89 hazard estimates (Ref. 11), Screening Level 2 would generally result in seismic risk of spent fuel pool failure estimates less than $0.5 x 10^{-6}$ for spent fuel pools which passed the screening criteria. Only 4 out of 60 sites have computed seismic risks greater than $0.5 x 10^{-6}$ at this screening level.

The screening criteria given in Refs. 4 and 7 represent a good start on developing screening criteria for spent fuel pools at Screening Level 2. However, I have three significant concerns which are discussed in Sections 3.1 through 3.3. In my judgment, a detailed fragility review of a few spent fuel pools will be necessary in order to address my concerns. These reviews should concentrate on aboveground spent fuel pools with walls not backed by soil backfill. I believe these reviews need to be performed before a set of screening criteria can be finalized at Screening Level 2.

<u>References</u>

1. *Preliminary Draft Technical Study of Spent Fuel Pool Accidents for Decommissioning Plants*, Nuclear Regulatory Commission, June 16, 1999

2. *Draft EPRI Technical Report: Evaluation of Spent Fuel Pool Seismic Failure Frequency in Support of Risk Informed Decommissioning Energy Planning*, Duke Engineering and Services

3. *A Review of Draft NRC Staff Report: Draft Technical Study of Spent Fuel Pool Accidents for Decommissioning Plants*, NEI, August 27, 1999

4. *Seismic Screening Criteria for Assessing Potential Fuel Pool Vulnerabilities at Decommissioning Plants*, NEI, August 18, 1999

5. *Seismic Failure and Cask Drop Analyses of the Spent Fuel Pools at Two Representative Nuclear Power Plants*, NUREG/CR-5176, Prepared for Nuclear Regulatory Commission, January 1989

6. *An Approach to the Quantification of Seismic Margins in Nuclear Power Plants*, NUREG/CR-4334, Prepared for Nuclear Regulatory Commission, August 1985

7. *A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)*, (EPRI NP-6041-SL), August 1991

8. *Revised Livermore Seismic Hazard Estimates for 69 Nuclear Power Plant Sites East of the Rocky Mountains*, NUREG-1488, Nuclear Regulatory Commission, October 1993

9. *Extension to Longer Return Periods of LLNL Spectral Acceleration Seismic Hazard Curves for 69 Sites*, provided by Engineering Research Applications Branch, Nuclear Regulatory Commission, September, 1999

10. Kennedy, R.P., *Overview of Methods for Seismic PRA and Margin Assessments Including Recent Innovations*, CSNI Seismic Risk Workshop, Tokyo, Japan, August 1999

11. Personal Communication from Tom O'Hara, Duke Engineering and Services to Robert Kennedy, October 19, 1999

Table 1
Seismic Hazard Estimates for Peak Spectral Acceleration for PSA From Refs. 8 and 9 (LLNL 93 Results)

	Peak Spectral Acceleration PSA (cm/sec.^{2})		
Exceedance Frequency H	Vermont Yankee	Robinson	
$1x10^{-3}$	93	232	
$5x10^{-4}$	151	369	
$2x10^{-4}$	246	676	
$1x10^{-4}$	354	991	
$5x10^{-5}$	501	1349	*
$2x10^{-5}$	759	2054	*
$1x10^{-5}$	1058	2801	
$5x10^{-6}$	1396	3915	*
$2x10^{-6}$	1884	6096	*
$1x10^{-6}$	2308	8522	
$5x10^{-7}$	2661	--	**
$2x10^{-7}$	3330	--	**
$1x10^{-7}$	3802	--	**
$5x10^{-8}$	4266	--	**
$2x10^{-8}$	5248	--	**

* By Interpolation

** By Extrapolation

Table 2
Comparison of Seismic Risk Estimated by Various Approaches

$C_{HCLPF} = 1.2g$ PSA, $\beta = 0.4$

	Computed Seismic Risk P_F (to be multiplied by 10^{-6})		
Site	Ref. 1 Method Eqn. (3)	Ref. 10 Method Steps 1 through 3	Rigorous Convolution
Vermont Yankee	0.38	1.07	0.89
Robinson	3.7	13.6	13.0

Table 3
Seismic Risk Associated With Screening Level 2

C_{HCLPF} = 1.2g Peak Spectral Acceleration

Site Number	Annual Seismic-Induced Probability of Failure P_F (to be multiplied by 10^{-6})	
	LLNL93 Hazard	EPRI89 Hazard
36	13.6	0.14
18	8.3	1.9
25	6.6	0.57
8	5.5	0.21
43	4.5	0.12
59	4.4	*
21	4.2	*
62	4.1	*
27	2.9	0.38
49	2.8	0.27
40	2.5	0.10
16	2.5	0.14
38	2.3	0.21
63	2.2	0.06
54	2.2	0.26
19	1.8	0.17
32	1.8	0.17
28	1.7	0.04
4	1.6	*
50	1.5	0.20
44	1.5	*
20	1.5	0.55
31	1.4	0.06
39	1.4	0.14
14	1.3	0.60
13	1.3	0.33

* Not Available

Appendix A

Extension to Longer Return Periods of LLNL Spectral Acceleration Seismic Hazard Curves for 69 Sites

Spectral Acceleration Hazard Estimates
For 69 Sites Listed by Site
Number (OCSP_)

*spectral accelerations are given in $cm/sec.^2$ units

*** Spectral Accelerations for: PSHC-output/ocsp1 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	83.127	10.807	22.997	100.531
2.5	271.277	36.443	86.237	339.293
5.0	348.089	68.487	157.080	417.833
10.0	346.267	107.443	221.797	455.532
25.0	386.888	118.124	245.045	519.935
Return Period = 100000.				
1.0	317.239	25.384	60.193	333.638
2.5	855.772	99.903	216.770	874.936
5.0	1053.693	191.638	361.284	1115.268
10.0	939.967	313.532	596.276	1061.861
25.0	888.287	337.722	589.050	1058.719
Return Period = 1000000.				
1.0	809.276	53.659	128.806	735.134
2.5	2117.438	218.341	505.798	1837.836
5.0	2210.744	383.275	779.117	2038.898
10.0	1810.190	710.002	1130.976	1790.712
25.0	1767.150	579.625	1052.436	1837.836

*** Spectral Accelerations for: PSHC-output/ocsp2 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	59.433	9.990	22.557	83.567
2.5	173.259	30.159	71.628	252.899
5.0	231.662	52.779	108.699	323.585
10.0	231.850	72.885	155.823	319.187
25.0	245.359	65.659	171.217	337.722
Return Period = 100000.				
1.0	196.036	21.991	55.041	257.611
2.5	575.541	76.498	166.505	692.723
5.0	699.320	130.691	256.355	857.657
10.0	632.718	205.461	411.550	797.966
25.0	617.324	199.492	453.961	739.847
Return Period = 1000000.				
1.0	515.348	46.370	105.558	577.426
2.5	1314.288	143.571	370.709	1357.171
5.0	1501.685	249.443	537.214	1624.207
10.0	1272.348	435.426	867.082	1420.003
25.0	1171.188	414.691	717.856	1374.450

*** Spectral Accelerations for: PSHC-output/ocsp3 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	52.685	10.116	24.881	68.487
2.5	141.435	22.148	56.235	183.784
5.0	197.921	30.913	87.022	249.757
10.0	208.791	35.563	122.522	276.461
25.0	222.739	25.918	133.989	293.740
Return Period = 100000.				
1.0	173.793	21.363	56.737	187.239
2.5	513.652	50.737	133.832	538.784
5.0	644.342	73.828	221.483	691.152
10.0	601.993	109.328	345.576	760.267
25.0	609.156	115.140	391.129	703.718
Return Period = 1000000.				
1.0	495.242	44.611	103.044	418.461
2.5	1267.007	101.317	292.169	1069.715
5.0	1499.800	166.505	464.957	1363.454
10.0	1278.003	270.806	772.834	1394.870
25.0	1238.733	243.474	667.590	1358.742

*** Spectral Accelerations for: PSHC-output/ocsp4 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	42.085	7.100	17.907	57.303
2.5	178.129	18.693	60.005	202.633
5.0	239.516	23.688	85.137	287.456
10.0	236.374	24.756	106.814	307.877
25.0	224.467	24.347	111.213	336.151
Return Period = 100000.				
1.0	150.985	14.200	47.187	166.505
2.5	828.126	47.909	169.646	670.732
5.0	1057.463	69.429	263.266	933.055
10.0	911.692	97.390	369.452	1030.445
25.0	821.685	101.631	439.824	1066.573
Return Period = 1000000.				
1.0	494.739	28.400	88.593	405.895
2.5	2761.466	108.228	420.974	1570.800
5.0	2971.953	175.301	675.444	1925.801
10.0	2341.120	256.355	911.064	1928.942
25.0	2115.868	270.178	879.648	2230.536

*** Spectral Accelerations for: PSHC-output/ocsp5 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	73.576	11.561	37.071	91.735
2.5	165.091	18.850	55.763	174.359
5.0	165.468	18.284	53.407	182.213
10.0	128.743	15.645	52.905	158.337
25.0	153.671	16.493	51.208	174.359
Return Period = 100000.				
1.0	244.416	27.520	78.540	257.611
2.5	739.218	43.354	139.330	556.063
5.0	677.643	49.637	152.996	552.922
10.0	482.424	55.041	179.071	481.293
25.0	575.070	52.308	199.492	524.647
Return Period = 1000000.				
1.0	759.639	53.282	153.938	584.966
2.5	2525.846	92.834	314.160	1240.932
5.0	2077.854	116.553	333.010	1259.781
10.0	1332.667	129.434	422.231	1105.843
25.0	1693.322	160.222	477.523	1038.299

*** Spectral Accelerations for: PSHC-output/ocsp6 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	40.533	9.802	20.923	50.831
2.5	106.390	20.735	41.783	131.005
5.0	154.818	31.730	60.947	179.385
10.0	151.865	35.877	84.195	204.832
25.0	162.264	30.474	84.352	204.204
Return Period = 100000.				
1.0	129.183	20.169	49.260	133.204
2.5	393.485	46.496	102.259	384.846
5.0	478.780	73.199	169.332	477.523
10.0	449.060	110.584	246.930	530.302
25.0	485.848	108.228	271.748	532.501
Return Period = 1000000.				
1.0	379.128	41.406	84.823	319.187
2.5	1000.914	95.348	215.200	862.369
5.0	1211.087	163.677	342.434	1080.710
10.0	1053.693	258.868	572.399	1074.427
25.0	960.858	241.903	554.492	984.892

*** Spectral Accelerations for: PSHC-output/ocsp7 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	92.552	15.959	44.108	122.522
2.5	280.074	44.139	101.474	383.275
5.0	357.828	71.000	171.217	468.098
10.0	366.248	110.584	255.726	510.196
25.0	404.010	120.952	282.744	530.930
Return Period = 100000.				
1.0	309.573	37.071	86.080	340.549
2.5	836.922	106.029	238.762	920.489
5.0	1037.042	180.328	380.134	1143.542
10.0	959.445	300.337	653.453	1143.542
25.0	885.146	295.310	625.178	1074.427
Return Period = 1000000.				
1.0	760.267	65.974	169.018	722.568
2.5	1991.774	216.770	508.939	1884.960
5.0	2105.814	358.142	804.250	2023.190
10.0	1768.092	647.170	1181.242	1872.394
25.0	1687.039	534.072	1074.427	1853.544

*** Spectral Accelerations for: PSHC-output/ocsp8 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	293.740	24.379	72.885	308.505
2.5	668.847	48.852	166.505	620.466
5.0	663.192	61.261	194.151	640.886
10.0	425.750	71.000	181.584	476.267
25.0	462.758	67.544	190.067	505.798
Return Period = 100000.				
1.0	862.683	57.743	175.301	741.418
2.5	1858.256	120.637	405.266	1379.162
5.0	1721.597	163.049	427.258	1438.853
10.0	1130.976	191.638	440.452	1086.994
25.0	1180.770	185.354	472.811	1099.560
Return Period = 1000000.				
1.0	2374.421	104.301	370.709	1595.933
2.5	5182.069	252.899	753.984	3063.060
5.0	4077.797	287.771	870.223	2532.129
10.0	2387.616	372.594	911.064	1853.544
25.0	2613.811	309.448	758.696	1994.916

*** Spectral Accelerations for: PSHC-output/ocsp9 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	84.069	10.053	23.374	96.133
2.5	269.235	30.631	83.724	292.169
5.0	351.545	55.606	150.483	398.983
10.0	351.922	84.195	209.231	464.957
25.0	389.715	87.651	227.766	507.368
Return Period = 100000.				
1.0	327.103	20.609	58.559	311.018
2.5	868.652	81.210	212.058	815.245
5.0	1096.418	151.425	348.718	1058.719
10.0	977.666	242.532	556.063	1105.843
25.0	932.741	263.894	559.205	1077.569
Return Period = 1000000.				
1.0	855.144	42.160	123.151	691.152
2.5	2202.261	158.651	474.382	1759.296
5.0	2380.076	277.403	747.701	1928.942
10.0	1949.677	544.125	1074.427	1872.394
25.0	1943.080	515.222	951.905	1963.500

*** Spectral Accelerations for: PSHC-output/ccsp10 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	83.944	13.760	31.416	89.850
2.5	260.910	41.155	94.876	301.594
5.0	339.607	69.744	159.279	386.417
10.0	344.194	103.044	223.054	458.674
25.0	370.080	101.474	241.903	491.660
Return Period = 100000.				
1.0	298.012	31.165	72.257	268.921
2.5	813.989	100.374	229.337	747.701
5.0	1014.423	179.385	367.567	1017.878
10.0	934.940	281.487	576.169	1105.843
25.0	886.088	279.602	576.484	1055.578
Return Period = 1000000.				
1.0	773.462	59.125	147.655	621.408
2.5	2020.049	205.775	510.510	1586.508
5.0	2192.522	348.718	794.825	1869.252
10.0	1840.349	625.807	1105.843	1884.960
25.0	1803.278	527.789	1000.600	1932.084

*** Spectral Accelerations for: PSHC-output/ocsp11 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	69.681	10.242	22.368	73.513
2.5	204.832	26.861	66.759	232.478
5.0	263.706	44.925	97.704	289.341
10.0	250.260	64.717	139.487	285.257
25.0	235.777	48.538	133.989	265.465
Return Period = 100000.				
1.0	217.022	20.420	52.339	207.346
2.5	619.995	61.890	147.027	612.612
5.0	742.046	100.531	224.310	738.276
10.0	648.426	153.310	330.496	684.869
25.0	592.820	147.655	344.005	598.475
Return Period = 1000000.				
1.0	545.570	40.527	92.363	442.337
2.5	1411.835	115.611	306.306	1151.396
5.0	1613.526	191.952	430.399	1385.446
10.0	1350.260	295.310	691.152	1262.923
25.0	1231.350	246.616	609.470	1113.697

*** Spectral Accelerations for: PSHC-output/ocsp12 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	75.901	9.173	19.164	87.336
2.5	236.720	24.033	60.319	282.744
5.0	307.060	40.212	98.018	355.001
10.0	296.504	48.569	143.885	331.753
25.0	308.348	42.097	156.766	333.010
Return Period = 100000.				
1.0	278.220	17.342	46.936	270.806
2.5	756.183	53.250	142.472	741.418
5.0	934.312	91.106	233.735	920.489
10.0	829.382	136.974	367.567	804.250
25.0	774.404	140.901	391.129	728.851
Return Period = 1000000.				
1.0	693.037	32.673	86.080	571.143
2.5	1781.287	104.144	314.160	1405.866
5.0	1971.982	185.040	474.382	1658.765
10.0	1663.791	311.018	779.117	1438.853
25.0	1602.216	276.461	650.311	1374.450

*** Spectral Accelerations for: PSHC-output/ocsp13 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	87.902	10.242	25.950	105.558
2.5	282.430	30.945	85.923	322.014
5.0	364.111	55.606	144.828	424.116
10.0	360.970	84.195	209.231	485.063
25.0	397.098	90.321	221.483	515.222
Return Period = 100000.				
1.0	337.722	21.049	63.460	329.240
2.5	894.885	81.210	215.200	846.661
5.0	1125.007	152.053	339.293	1124.693
10.0	1000.914	238.133	546.638	1137.259
25.0	952.847	254.470	548.209	1124.693
Return Period = 1000000.				
1.0	879.648	43.291	131.947	716.285
2.5	2274.519	158.651	475.952	1806.420
5.0	2431.598	271.748	735.134	1994.916
10.0	1983.606	513.337	1080.710	1947.792
25.0	1974.495	496.373	944.051	2026.332

*** Spectral Accelerations for: PSHC-output/ocsp14 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	88.656	10.870	26.704	125.664
2.5	286.200	36.600	94.719	411.550
5.0	365.996	65.974	169.332	496.373
10.0	353.304	108.699	246.301	495.116
25.0	389.715	120.480	263.894	523.076
Return Period = 100000.				
1.0	340.172	24.316	65.345	392.072
2.5	902.739	94.562	232.478	989.604
5.0	1129.719	175.615	380.134	1250.357
10.0	982.064	290.284	628.320	1124.693
25.0	941.380	292.169	595.333	1135.688
Return Period = 1000000.				
1.0	885.931	50.140	135.089	829.382
2.5	2294.939	186.925	505.798	2057.748
5.0	2461.129	320.443	791.683	2177.129
10.0	1985.491	618.267	1130.976	1947.792
25.0	1982.350	526.218	1016.308	2073.456

*** Spectral Accelerations for: PSHC-output/ocsp15 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	69.555	10.242	22.180	73.513
2.5	204.361	26.861	66.602	230.908
5.0	263.297	44.925	97.390	290.284
10.0	249.946	64.717	138.230	284.001
25.0	235.620	48.538	133.204	263.894
Return Period = 100000.				
1.0	217.022	20.358	52.025	206.089
2.5	619.838	61.732	146.084	609.470
5.0	742.046	99.275	223.368	738.276
10.0	649.055	151.425	329.240	684.869
25.0	594.234	148.126	342.434	595.333
Return Period = 1000000.				
1.0	546.764	40.401	91.735	440.452
2.5	1414.191	115.611	303.164	1146.684
5.0	1617.610	190.067	430.399	1379.162
10.0	1354.030	293.425	684.869	1256.640
25.0	1240.775	248.186	607.900	1099.560

*** Spectral Accelerations for: PSHC-output/ocsp16 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	126.041	13.383	36.631	157.708
2.5	365.682	33.301	98.175	413.120
5.0	368.196	45.553	129.120	402.125
10.0	268.670	49.512	131.319	331.753
25.0	286.043	55.292	158.651	356.572
Return Period = 100000.				
1.0	495.116	32.798	85.452	494.488
2.5	1266.536	92.049	260.753	1021.020
5.0	1218.941	124.407	317.302	1080.710
10.0	824.984	146.399	350.603	879.648
25.0	814.303	179.071	444.536	862.369
Return Period = 1000000.				
1.0	1440.109	64.717	188.496	1105.843
2.5	3925.429	193.208	600.046	2293.368
5.0	2746.073	244.102	713.143	1994.916
10.0	1790.084	309.762	753.984	1589.650
25.0	1851.973	326.726	727.280	1696.464

*** Spectral Accelerations for: PSHC-output/ocsp17 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	85.514	10.367	22.054	107.443
2.5	279.602	34.872	83.252	370.709
5.0	356.257	65.345	153.624	442.966
10.0	345.450	106.814	224.939	464.328
25.0	388.616	120.480	251.328	521.506
Return Period = 100000.				
1.0	325.093	24.630	58.245	355.629
2.5	872.894	97.547	212.058	906.352
5.0	1078.511	186.297	358.142	1171.817
10.0	940.595	309.762	599.417	1068.144
25.0	892.057	336.151	609.470	1066.573
Return Period = 1000000.				
1.0	824.356	52.590	123.151	747.701
2.5	2161.421	212.058	474.382	1884.960
5.0	2266.036	370.709	775.975	2089.164
10.0	1834.066	684.869	1137.259	1784.429
25.0	1770.292	574.913	1083.852	1869.252

*** Spectral Accelerations for: PSHC-output/ocsp18 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	126.732	12.378	33.929	131.319
2.5	545.225	54.664	160.222	592.192
5.0	801.422	94.248	274.576	801.108
10.0	747.072	127.549	350.603	917.347
25.0	815.088	124.722	408.408	929.914
Return Period = 100000.				
1.0	482.361	28.651	80.425	388.302
2.5	1691.752	135.560	449.249	1437.282
5.0	2240.903	238.447	731.993	1803.278
10.0	1835.951	353.744	955.046	1853.544
25.0	2291.797	383.275	947.192	2167.704
Return Period = 1000000.				
1.0	1371.623	55.795	175.301	835.666
2.5	5125.520	303.164	912.635	3471.468
5.0	5658.022	499.514	1432.569	3707.088
10.0	4124.921	797.966	1602.216	3568.857
25.0	4616.581	636.174	1727.880	3047.352

*** Spectral Accelerations for: PSHC-output/ocsp19 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	124.470	13.886	37.259	149.540
2.5	363.012	37.071	101.945	428.828
5.0	338.036	53.407	141.058	427.258
10.0	284.252	62.204	158.965	338.036
25.0	293.268	66.916	161.792	378.563
Return Period = 100000.				
1.0	488.959	34.997	87.965	442.337
2.5	1146.370	104.301	274.890	1097.989
5.0	1059.976	152.053	336.151	1124.693
10.0	842.577	182.841	416.576	898.498
25.0	802.679	197.921	419.404	892.214
Return Period = 1000000.				
1.0	1411.835	66.602	197.921	967.613
2.5	3204.432	235.620	606.329	2513.280
5.0	2320.071	294.368	738.276	2064.031
10.0	1818.358	379.505	892.214	1583.366
25.0	1776.575	364.426	710.002	1696.464

*** Spectral Accelerations for: PSHC-output/ocsp20 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	104.427	13.697	31.416	106.186
2.5	343.063	41.626	105.087	356.572
5.0	434.169	70.372	188.496	499.514
10.0	452.390	109.328	270.806	580.568
25.0	503.913	118.438	301.594	612.612
Return Period = 100000.				
1.0	373.725	32.924	73.513	314.788
2.5	988.033	107.129	263.894	860.798
5.0	1221.768	190.067	433.541	1096.418
10.0	1102.702	320.443	697.435	1237.790
25.0	1056.363	325.156	653.453	1308.476
Return Period = 1000000.				
1.0	930.542	61.575	152.053	710.002
2.5	2459.873	223.054	576.484	1837.836
5.0	2488.775	376.992	882.790	1963.500
10.0	2056.491	703.718	1237.790	2060.869
25.0	1925.801	560.776	1154.538	2042.040

*** Spectral Accelerations for: PSHC-output/ocsp21 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	166.945	15.143	45.679	196.664
2.5	440.766	38.013	112.626	538.784
5.0	497.629	55.606	163.992	537.214
10.0	363.295	65.974	170.903	449.249
25.0	430.399	77.283	194.779	507.368
Return Period = 100000.				
1.0	677.957	37.825	105.558	549.780
2.5	1429.585	101.317	303.164	1266.065
5.0	1652.482	157.708	411.550	1338.322
10.0	1072.542	187.239	443.594	1093.277
25.0	1190.038	216.770	494.802	1129.405
Return Period = 1000000.				
1.0	2244.359	72.257	243.160	1212.658
2.5	4313.417	221.483	672.302	2905.980
5.0	4228.594	295.939	879.648	2406.465
10.0	2166.447	368.196	936.197	1834.694
25.0	2598.103	402.125	827.812	2136.288

*** Spectral Accelerations for: PSHC-output/ocsp22 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	66.288	9.111	20.106	71.000
2.5	209.388	25.918	70.058	223.054
5.0	279.037	46.810	115.611	313.218
10.0	280.922	68.487	165.248	363.797
25.0	304.735	64.403	175.930	422.545
Return Period = 100000.				
1.0	260.250	19.101	51.648	214.257
2.5	732.150	69.429	171.217	651.882
5.0	886.245	127.235	280.231	848.232
10.0	799.223	211.116	441.709	898.498
25.0	760.110	215.200	471.240	857.657
Return Period = 1000000.				
1.0	706.232	40.024	101.788	524.647
2.5	1862.969	139.958	397.412	1341.463
5.0	1973.867	248.186	609.470	1564.517
10.0	1620.437	457.417	955.046	1551.950
25.0	1547.709	475.952	780.688	1586.508

*** Spectral Accelerations for: PSHC-output/ocsp23 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	90.038	10.179	22.557	115.611
2.5	296.567	33.301	85.137	372.280
5.0	373.536	62.204	152.368	471.240
10.0	360.467	99.903	216.142	477.523
25.0	407.937	106.186	243.474	529.360
Return Period = 100000.				
1.0	329.428	24.065	59.376	355.001
2.5	883.889	93.777	216.770	915.776
5.0	1094.533	180.956	358.142	1203.233
10.0	961.330	295.939	587.479	1099.560
25.0	917.975	322.014	601.616	1082.281
Return Period = 1000000.				
1.0	818.073	51.397	126.921	747.701
2.5	2142.571	199.492	501.085	1916.376
5.0	2249.071	355.001	791.683	2104.872
10.0	1835.951	659.736	1143.542	1822.128
25.0	1804.849	574.913	1088.564	1869.252

*** Spectral Accelerations for: PSHC-output/ocsp24 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	89.536	12.755	30.536	114.354
2.5	277.875	40.684	94.876	383.275
5.0	354.058	68.173	154.881	477.523
10.0	343.126	102.416	217.399	459.302
25.0	356.100	96.447	219.912	480.665
Return Period = 100000.				
1.0	316.736	27.709	68.487	344.948
2.5	851.688	97.547	216.770	871.794
5.0	1057.777	165.876	329.868	1149.826
10.0	942.480	254.470	530.930	1112.126
25.0	879.648	245.045	523.076	1036.728
Return Period = 1000000.				
1.0	823.728	53.219	134.460	728.851
2.5	2139.429	188.496	463.386	1822.128
5.0	2308.134	301.908	688.010	2029.473
10.0	1911.349	552.293	1049.294	1891.243
25.0	1858.256	485.377	892.214	1947.792

*** Spectral Accelerations for: PSHC-output/ocsp25 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	140.681	12.127	35.060	150.168
2.5	615.911	58.905	160.222	700.577
5.0	704.661	78.854	215.514	713.143
10.0	548.461	107.443	248.815	691.152
25.0	536.271	116.396	274.890	666.019
Return Period = 100000.				
1.0	505.483	26.641	78.540	420.974
2.5	1954.075	136.817	406.837	1633.632
5.0	2030.416	191.952	508.939	1611.641
10.0	1370.994	280.859	627.692	1394.870
25.0	1497.129	287.456	642.457	1602.216
Return Period = 1000000.				
1.0	1461.472	52.402	163.992	860.798
2.5	6195.235	290.598	816.816	3817.044
5.0	5149.082	370.709	1093.277	3031.644
10.0	2899.068	605.701	1181.242	2500.713
25.0	3386.645	526.218	1223.653	2670.360

*** Spectral Accelerations for: PSHC-output/ocsp26 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	98.144	17.027	55.543	121.266
2.5	237.505	42.883	113.726	309.448
5.0	294.682	64.403	156.766	351.859
10.0	294.556	84.195	189.124	370.709
25.0	290.127	70.529	166.505	372.280
Return Period = 100000.				
1.0	279.540	39.961	108.699	311.018
2.5	702.148	92.363	243.474	686.440
5.0	847.604	142.943	299.394	845.090
10.0	775.347	201.062	405.895	867.082
25.0	721.783	190.067	400.554	764.980
Return Period = 1000000.				
1.0	658.479	63.460	212.372	598.161
2.5	1657.194	155.666	468.098	1277.060
5.0	1814.274	232.164	571.771	1495.401
10.0	1510.481	376.992	797.966	1476.552
25.0	1460.844	348.718	656.594	1374.450

*** Spectral Accelerations for: PSHC-output/ocsp27 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	90.038	8.357	29.154	99.903
2.5	298.138	27.175	96.447	351.859
5.0	466.213	60.319	181.899	521.506
10.0	544.816	101.788	253.841	653.453
25.0	439.667	85.609	230.908	563.917
Return Period = 100000.				
1.0	312.778	20.043	72.257	290.912
2.5	936.354	79.640	246.616	873.365
5.0	1392.985	168.704	458.674	1300.622
10.0	1460.216	285.257	722.568	1526.818
25.0	1291.198	281.173	655.024	1617.924
Return Period = 1000000.				
1.0	829.382	46.307	151.425	628.320
2.5	2547.837	163.363	540.355	1916.376
5.0	3484.034	345.576	1027.303	2563.545
10.0	3354.600	666.019	1388.587	3003.369
25.0	2788.170	584.338	1372.879	2780.316

*** Spectral Accelerations for: PSHC-output/ocsp28 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	111.087	12.441	34.181	135.717
2.5	320.757	32.830	92.834	380.134
5.0	319.187	44.611	120.323	373.850
10.0	255.978	47.815	126.921	309.762
25.0	261.695	51.679	143.257	325.156
Return Period = 100000.				
1.0	443.531	30.222	79.797	422.859
2.5	1082.910	88.279	241.903	970.754
5.0	1061.547	116.239	297.510	999.029
10.0	792.940	139.487	341.806	823.099
25.0	756.497	168.076	387.988	782.258
Return Period = 1000000.				
1.0	1312.560	60.193	169.018	923.630
2.5	3163.591	182.213	554.492	2120.580
5.0	2426.572	234.678	666.019	1903.810
10.0	1710.287	299.709	753.984	1482.835
25.0	1732.592	328.297	681.727	1555.092

*** Spectral Accelerations for: PSHC-output/ocsp29 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	89.410	12.064	32.924	103.673
2.5	263.894	36.285	90.635	317.302
5.0	329.868	62.518	147.341	392.700
10.0	318.684	91.735	207.974	409.036
25.0	330.339	91.106	215.200	446.107
Return Period = 100000.				
1.0	293.048	26.578	69.744	293.425
2.5	782.887	88.122	201.062	764.980
5.0	941.852	155.509	314.160	973.896
10.0	838.807	241.903	505.798	955.046
25.0	782.415	252.899	523.076	852.944
Return Period = 1000000.				
1.0	735.763	51.271	130.691	625.807
2.5	1886.531	163.363	428.828	1498.543
5.0	2063.717	280.545	653.453	1724.739
10.0	1753.641	527.161	999.029	1614.782
25.0	1602.216	499.514	832.524	1504.826

*** Spectral Accelerations for: PSHC-output/ocsp30 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	37.165	9.362	20.169	50.140
2.5	92.740	19.478	39.741	117.653
5.0	133.078	27.175	56.863	170.903
10.0	136.157	28.274	71.628	196.664
25.0	150.247	22.305	69.901	213.629
Return Period = 100000.				
1.0	132.827	19.981	50.705	133.832
2.5	383.746	43.825	104.772	394.271
5.0	485.063	67.230	162.107	508.939
10.0	474.884	86.080	226.195	589.364
25.0	516.008	75.084	246.616	611.041
Return Period = 1000000.				
1.0	432.850	42.726	96.761	344.319
2.5	1105.529	92.677	235.620	882.790
5.0	1375.707	158.965	348.718	1225.224
10.0	1205.746	217.399	555.435	1225.224
25.0	1233.863	210.487	545.068	1258.211

*** Spectral Accelerations for: PSHC-output/ocsp31 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	147.907	19.164	54.538	172.160
2.5	266.722	30.945	101.631	337.722
5.0	312.683	41.155	110.270	361.284
10.0	216.331	38.830	108.071	268.921
25.0	222.582	35.657	109.328	300.023
Return Period = 100000.				
1.0	523.202	48.381	115.611	517.736
2.5	848.703	81.525	248.186	848.232
5.0	1053.693	98.018	269.549	945.622
10.0	644.028	113.098	285.257	710.002
25.0	676.229	113.098	312.589	766.550
Return Period = 1000000.				
1.0	1594.676	83.567	244.416	1130.976
2.5	2280.802	156.138	526.218	1853.544
5.0	2750.471	203.576	596.904	1800.137
10.0	1475.924	251.328	634.603	1369.738
25.0	1650.911	234.049	614.183	1526.818

*** Spectral Accelerations for: PSHC-output/ocsp32 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	126.167	13.697	38.013	148.912
2.5	359.870	37.385	105.872	422.545
5.0	344.005	51.836	143.571	427.258
10.0	286.388	64.089	158.337	342.434
25.0	295.625	67.387	164.934	378.563
Return Period = 100000.				
1.0	491.095	34.243	91.106	440.452
2.5	1124.379	105.715	281.173	1054.007
5.0	1073.485	145.142	342.434	1124.693
10.0	845.719	186.611	420.346	892.214
25.0	808.334	197.921	441.395	887.502
Return Period = 1000000.				
1.0	1406.180	65.974	208.602	961.330
2.5	3099.188	243.474	631.462	2387.616
5.0	2349.603	284.315	757.126	2064.031
10.0	1822.128	378.249	904.781	1570.800
25.0	1790.712	369.138	727.280	1680.756

*** Spectral Accelerations for: PSHC-output/ocsp33 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	80.865	12.252	31.353	97.390
2.5	240.175	35.657	86.865	304.735
5.0	304.233	63.460	139.173	364.426
10.0	294.933	92.991	202.947	374.479
25.0	306.306	91.263	210.487	414.691
Return Period = 100000.				
1.0	262.763	26.515	67.230	270.806
2.5	720.369	86.080	188.496	730.422
5.0	862.369	157.708	299.080	885.931
10.0	766.550	243.788	482.550	892.214
25.0	710.002	251.328	513.652	797.966
Return Period = 1000000.				
1.0	648.426	50.580	124.407	556.063
2.5	1672.902	161.792	395.842	1333.609
5.0	1799.823	282.430	618.895	1589.650
10.0	1504.826	514.594	955.046	1520.534
25.0	1377.592	502.656	801.108	1404.295

*** Spectral Accelerations for: PSHC-output/ocsp34 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	74.896	10.116	19.792	100.531
2.5	241.746	35.343	78.540	337.722
5.0	314.788	66.288	136.974	408.408
10.0	317.867	109.956	214.885	406.523
25.0	361.127	120.480	243.474	458.674
Return Period = 100000.				
1.0	276.021	22.934	51.082	319.187
2.5	762.466	95.033	182.213	821.528
5.0	931.484	180.014	312.903	1046.153
10.0	836.922	297.195	556.063	961.330
25.0	798.123	295.310	562.346	912.635
Return Period = 1000000.				
1.0	685.497	48.255	100.531	628.320
2.5	1790.712	186.925	413.120	1561.375
5.0	1912.292	326.726	669.161	1815.845
10.0	1587.765	621.408	1074.427	1595.933
25.0	1534.200	521.506	911.064	1633.632

*** Spectral Accelerations for: PSHC-output/ocsp35 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	85.389	14.766	37.385	109.328
2.5	262.481	43.197	95.505	347.147
5.0	335.837	70.058	164.620	430.399
10.0	333.826	103.044	235.620	452.390
25.0	359.242	103.044	248.186	485.377
Return Period = 100000.				
1.0	289.655	33.552	77.283	310.390
2.5	787.756	102.573	227.766	827.812
5.0	968.869	177.815	355.001	1043.011
10.0	877.763	280.231	578.054	1043.011
25.0	819.643	279.602	549.780	917.347
Return Period = 1000000.				
1.0	720.683	61.010	148.912	627.063
2.5	1859.827	205.775	494.802	1586.508
5.0	2037.013	342.434	731.993	1796.995
10.0	1692.066	622.037	1080.710	1683.898
25.0	1625.778	527.789	885.931	1564.517

*** Spectral Accelerations for: PSHC-output/ocsp36 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	445.605	22.180	73.513	361.284
2.5	860.484	54.036	169.646	706.860
5.0	991.175	65.031	202.005	691.152
10.0	567.624	74.770	196.036	544.753
25.0	688.482	76.498	207.346	589.050
Return Period = 100000.				
1.0	1372.251	54.161	179.071	829.382
2.5	2695.493	126.921	424.116	1540.955
5.0	2801.679	165.248	449.249	1379.162
10.0	1407.437	195.408	469.983	1130.976
25.0	1825.270	201.062	505.798	1292.768
Return Period = 1000000.				
1.0	4204.089	96.133	375.735	1840.978
2.5	8521.590	262.324	812.104	3361.512
5.0	7618.379	286.514	901.639	2528.988
10.0	2908.493	373.222	955.046	1922.659
25.0	3370.937	347.147	804.250	2481.864

*** Spectral Accelerations for: PSHC-output/ocsp37 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	92.740	15.331	44.548	132.576
2.5	279.602	41.626	101.160	402.125
5.0	356.886	70.372	170.275	493.231
10.0	363.357	108.071	258.240	513.966
25.0	402.439	119.852	290.598	538.784
Return Period = 100000.				
1.0	309.510	35.877	85.452	371.965
2.5	833.466	102.102	241.903	948.763
5.0	1031.387	181.584	380.134	1212.658
10.0	950.020	302.222	659.736	1130.976
25.0	883.732	292.169	633.032	1082.281
Return Period = 1000000.				
1.0	757.126	64.717	164.620	741.418
2.5	1977.637	208.916	516.793	1916.376
5.0	2086.965	361.284	813.674	2079.739
10.0	1748.615	672.302	1193.808	1859.827
25.0	1683.898	527.789	1077.569	1837.836

*** Spectral Accelerations for: PSHC-output/ocsp38 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	145.142	13.132	37.197	143.257
2.5	428.828	37.856	102.573	420.974
5.0	513.023	65.031	164.306	496.373
10.0	452.579	98.018	219.912	505.169
25.0	450.348	95.505	224.624	504.227
Return Period = 100000.				
1.0	461.438	30.599	78.540	385.788
2.5	1159.879	93.934	224.624	929.914
5.0	1382.618	167.133	339.293	1124.693
10.0	1137.887	259.496	543.497	1099.560
25.0	1029.188	246.616	529.360	980.179
Return Period = 1000000.				
1.0	1121.551	55.920	153.938	735.134
2.5	2888.701	172.788	463.386	1759.296
5.0	2961.272	293.425	688.010	1900.668
10.0	2339.235	539.099	1036.728	1796.995
25.0	2208.545	479.094	827.812	1680.756

*** Spectral Accelerations for: PSHC-output/ocsp39 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	103.359	12.127	33.866	128.806
2.5	276.147	32.516	82.781	328.297
5.0	270.775	41.469	111.527	289.656
10.0	251.014	45.616	114.354	285.886
25.0	245.673	50.109	130.533	289.027
Return Period = 100000.				
1.0	423.802	28.400	82.310	400.868
2.5	979.080	91.106	223.054	873.365
5.0	929.285	113.412	287.456	813.674
10.0	799.223	130.691	325.470	797.966
25.0	751.157	172.788	373.850	741.418
Return Period = 1000000.				
1.0	1232.135	57.868	182.841	923.630
2.5	2866.710	191.638	530.930	1869.252
5.0	2217.655	237.819	656.594	1633.632
10.0	1774.376	285.257	735.134	1476.552
25.0	1792.283	312.589	678.586	1481.264

*** Spectral Accelerations for: PSHC-output/ocsp40 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	45.239	7.666	17.279	50.203
2.5	167.761	18.850	52.465	161.792
5.0	367.881	40.841	112.783	345.576
10.0	380.008	54.224	163.992	462.444
25.0	339.607	42.097	160.222	417.833
Return Period = 100000.				
1.0	154.504	14.451	44.485	130.062
2.5	679.528	44.139	129.748	486.948
5.0	1363.454	104.615	287.456	958.188
10.0	1171.188	161.478	490.090	1206.374
25.0	1050.394	149.854	501.085	1107.414
Return Period = 1000000.				
1.0	468.664	27.395	80.425	324.213
2.5	1968.212	94.876	290.598	1032.016
5.0	3370.937	218.341	662.878	1888.102
10.0	2540.298	349.346	1099.560	2268.235
25.0	2448.877	323.585	961.330	2104.872

*** Spectral Accelerations for: PSHC-output/ocsp41 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	27.634	3.625	9.990	34.558
2.5	101.489	11.247	32.673	126.292
5.0	172.254	21.112	67.859	222.425
10.0	216.393	26.829	97.390	276.461
25.0	186.925	21.834	84.666	268.607
Return Period = 100000.				
1.0	128.114	8.545	24.504	114.354
2.5	529.360	30.788	98.646	444.536
5.0	731.050	58.748	215.514	722.568
10.0	900.383	97.390	335.523	955.046
25.0	703.090	93.777	359.713	849.803
Return Period = 1000000.				
1.0	483.367	15.708	54.161	329.240
2.5	1796.995	77.755	234.049	1022.591
5.0	1986.748	144.828	515.222	1627.349
10.0	2423.430	251.956	841.949	1809.562
25.0	1861.398	245.045	758.696	1963.500

*** Spectral Accelerations for: PSHC-output/ocsp42 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	57.900	8.608	21.300	62.581
2.5	169.961	16.965	51.522	172.788
5.0	235.054	23.845	81.996	238.762
10.0	233.798	28.149	118.124	287.771
25.0	249.914	25.604	133.047	339.293
Return Period = 100000.				
1.0	217.524	17.844	51.585	175.930
2.5	643.243	40.212	130.848	534.072
5.0	776.289	66.602	225.253	684.869
10.0	689.267	106.186	351.231	804.250
25.0	669.161	124.407	403.696	763.409
Return Period = 1000000.				
1.0	610.287	37.008	91.735	441.709
2.5	1592.791	89.850	293.740	1121.551
5.0	1758.668	167.133	483.806	1379.162
10.0	1460.844	278.974	791.683	1445.136
25.0	1394.870	262.324	656.594	1432.569

*** Spectral Accelerations for: PSHC-output/ocsp43 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	180.642	22.180	65.974	199.806
2.5	473.125	58.120	161.792	519.935
5.0	590.307	64.403	189.124	568.630
10.0	385.788	56.800	152.053	498.258
25.0	419.718	42.569	141.372	482.236
Return Period = 100000.				
1.0	541.298	49.951	139.487	490.718
2.5	1364.083	116.868	372.280	1192.237
5.0	1712.172	146.399	395.842	1297.481
10.0	1060.604	133.204	375.107	1118.410
25.0	1171.974	114.040	386.417	1008.454
Return Period = 1000000.				
1.0	1386.074	77.912	288.399	967.613
2.5	3755.783	207.346	706.860	2638.944
5.0	4106.071	260.124	785.400	2346.775
10.0	2173.359	270.806	816.816	1847.261
25.0	2574.541	227.766	702.148	1900.668

*** Spectral Accelerations for: PSHC-output/ocsp44 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	58.138	9.362	26.201	70.372
2.5	247.715	28.274	83.881	262.324
5.0	295.813	41.155	114.354	342.434
10.0	315.479	46.810	140.744	357.514
25.0	255.255	32.987	132.576	342.434
Return Period = 100000.				
1.0	195.219	19.101	59.376	191.009
2.5	921.902	66.445	202.633	777.546
5.0	1076.940	98.960	295.939	1055.578
10.0	1090.764	137.602	426.001	1068.144
25.0	840.378	107.757	464.957	1014.737
Return Period = 1000000.				
1.0	586.788	39.019	107.443	452.390
2.5	2866.710	131.319	457.103	1806.420
5.0	2617.895	203.890	700.577	2098.589
10.0	2759.581	311.018	1024.161	1985.491
25.0	2109.584	251.328	901.639	2057.748

*** Spectral Accelerations for: PSHC-output/ocsp45 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	78.477	8.545	19.666	70.372
2.5	253.841	19.949	58.120	213.629
5.0	322.014	33.615	95.819	290.912
10.0	300.337	38.516	136.974	362.541
25.0	314.003	35.657	151.111	424.116
Return Period = 100000.				
1.0	274.890	17.404	49.512	209.231
2.5	774.719	47.595	150.954	611.041
5.0	933.683	79.168	251.328	760.267
10.0	795.453	121.266	380.762	917.347
25.0	731.993	114.668	414.691	845.090
Return Period = 1000000.				
1.0	685.497	35.374	94.248	507.683
2.5	1823.699	101.631	351.859	1233.078
5.0	1967.270	175.301	549.780	1545.667
10.0	1607.242	278.346	848.232	1570.800
25.0	1463.986	252.899	694.294	1533.101

*** Spectral Accelerations for: PSHC-output/ocsp46 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	54.299	9.739	25.070	73.513
2.5	150.545	21.206	58.591	201.062
5.0	211.461	30.222	92.677	268.921
10.0	222.614	37.197	130.691	299.709
25.0	243.788	27.803	140.901	348.718
Return Period = 100000.				
1.0	190.255	20.860	58.371	215.514
2.5	563.446	50.109	144.671	622.037
5.0	702.462	74.770	235.306	741.418
10.0	652.196	118.752	371.965	797.966
25.0	652.039	118.124	427.258	779.117
Return Period = 1000000.				
1.0	538.030	44.359	109.328	478.151
2.5	1375.078	101.474	333.010	1201.662
5.0	1597.189	171.846	499.514	1473.410
10.0	1347.746	291.540	810.533	1426.286
25.0	1319.472	251.328	706.860	1448.278

*** Spectral Accelerations for: PSHC-output/ocsp47 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	59.207	8.419	17.593	58.371
2.5	182.056	18.535	49.480	172.788
5.0	242.155	28.463	79.168	238.133
10.0	228.269	31.542	118.752	277.717
25.0	229.023	29.374	126.921	293.740
Return Period = 100000.				
1.0	202.759	17.090	45.490	172.788
2.5	612.455	44.611	130.219	537.214
5.0	729.794	72.257	213.943	681.727
10.0	630.833	99.275	341.178	728.851
25.0	602.088	88.279	369.138	692.723
Return Period = 1000000.				
1.0	561.718	34.746	84.195	439.824
2.5	1478.280	97.861	296.881	1104.272
5.0	1667.561	169.961	455.532	1404.295
10.0	1382.304	245.045	766.550	1376.021
25.0	1283.344	218.341	653.453	1377.592

*** Spectral Accelerations for: PSHC-output/ocsp48 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	30.015	4.637	13.635	44.045
2.5	94.719	10.147	36.600	133.361
5.0	198.455	19.321	73.828	249.443
10.0	199.240	23.625	112.469	296.567
25.0	182.527	21.363	97.390	262.324
Return Period = 100000.				
1.0	121.706	10.053	36.820	134.460
2.5	452.547	27.332	108.699	460.244
5.0	867.710	58.120	226.509	854.515
10.0	756.497	94.876	384.532	967.613
25.0	685.340	89.536	384.846	865.511
Return Period = 1000000.				
1.0	436.305	18.850	71.628	371.337
2.5	1432.884	65.502	265.465	1013.166
5.0	2449.191	157.708	537.214	1765.579
10.0	1887.473	260.753	973.896	1815.845
25.0	1826.840	241.903	769.692	1979.208

*** Spectral Accelerations for: PSHC-output/ocsp49 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	81.493	11.498	34.809	89.850
2.5	341.649	39.113	108.228	397.412
5.0	377.934	42.726	126.292	389.558
10.0	359.839	42.097	165.876	428.514
25.0	363.797	37.856	175.930	474.382
Return Period = 100000.				
1.0	309.573	24.442	72.885	258.868
2.5	1203.390	92.834	274.890	1058.719
5.0	1394.556	103.673	314.160	1096.418
10.0	1164.277	126.292	473.753	1149.826
25.0	1106.157	147.027	523.076	1192.237
Return Period = 1000000.				
1.0	953.790	48.381	137.602	567.373
2.5	3757.354	175.930	598.475	2497.572
5.0	3528.017	205.461	713.143	2164.562
10.0	2595.590	297.195	1005.312	2067.173
25.0	2528.988	287.456	945.622	2199.120

*** Spectral Accelerations for: PSHC-output/ocsp50 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	51.887	8.294	23.122	65.974
2.5	213.943	23.719	71.628	245.045
5.0	291.855	35.500	100.845	339.293
10.0	254.344	35.060	114.983	340.549
25.0	223.996	28.589	110.270	300.023
Return Period = 100000.				
1.0	171.154	16.211	54.790	174.045
2.5	790.741	55.135	175.930	714.714
5.0	1106.786	90.792	264.837	1036.728
10.0	852.630	109.328	357.514	999.029
25.0	772.205	106.500	397.412	947.192
Return Period = 1000000.				
1.0	523.830	31.730	98.646	420.974
2.5	2379.762	115.297	408.408	1696.464
5.0	2823.042	199.492	634.603	2101.730
10.0	1928.314	260.753	879.648	1922.659
25.0	1988.633	249.757	826.241	1994.916

*** Spectral Accelerations for: PSHC-output/ocsp51 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	52.000	7.037	15.645	55.104
2.5	158.651	14.671	44.611	166.505
5.0	220.854	25.101	74.142	235.934
10.0	219.912	32.170	104.929	273.948
25.0	233.107	28.431	105.872	307.877
Return Period = 100000.				
1.0	193.523	13.949	41.092	178.443
2.5	584.966	38.170	120.166	552.922
5.0	716.599	67.544	206.089	684.869
10.0	638.373	108.071	316.045	728.851
25.0	630.833	106.343	345.576	727.280
Return Period = 1000000.				
1.0	551.853	27.458	79.168	424.116
2.5	1433.355	90.635	281.173	1110.556
5.0	1633.004	165.562	446.107	1401.154
10.0	1368.481	262.009	753.984	1350.888
25.0	1298.109	230.908	645.599	1423.145

*** Spectral Accelerations for: PSHC-output/ocsp52 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	30.134	4.825	13.823	44.297
2.5	94.232	10.132	36.914	131.005
5.0	197.010	21.017	74.142	245.987
10.0	200.246	23.499	108.071	294.054
25.0	183.627	21.206	94.405	260.753
Return Period = 100000.				
1.0	119.318	10.116	37.134	127.549
2.5	446.264	27.018	110.741	460.244
5.0	855.458	63.774	224.939	832.524
10.0	757.126	94.876	370.709	942.480
25.0	687.225	87.336	381.704	885.931
Return Period = 1000000.				
1.0	422.608	18.787	71.628	336.780
2.5	1406.023	63.617	273.319	1010.024
5.0	2416.519	167.447	527.789	1749.871
10.0	1886.845	259.496	948.763	1784.429
25.0	1825.270	238.762	785.400	2010.624

*** Spectral Accelerations for: PSHC-output/ocsp53 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	28.821	4.562	12.441	45.176
2.5	128.491	13.650	45.239	205.775
5.0	203.638	20.326	83.567	276.461
10.0	203.073	17.404	109.956	289.656
25.0	198.078	17.279	107.914	298.452
Return Period = 100000.				
1.0	123.402	10.870	34.243	140.115
2.5	621.723	38.799	138.545	708.431
5.0	897.869	66.916	263.266	904.781
10.0	781.630	78.540	382.647	973.896
25.0	742.360	92.991	435.112	959.759
Return Period = 1000000.				
1.0	445.793	22.745	72.885	387.045
2.5	1886.531	97.390	367.567	1649.340
5.0	2523.961	179.071	669.161	1884.960
10.0	1859.827	239.390	942.480	1840.978
25.0	1943.080	278.032	852.944	2057.748

*** Spectral Accelerations for: PSHC-output/ocsp54 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	59.571	9.362	24.002	73.513
2.5	232.793	23.876	86.708	279.602
5.0	358.142	35.500	131.633	414.691
10.0	338.036	42.537	167.133	430.399
25.0	332.381	33.301	164.934	468.098
Return Period = 100000.				
1.0	210.487	19.666	57.491	208.602
2.5	892.686	57.963	218.341	829.382
5.0	1294.025	91.421	345.576	1215.799
10.0	1117.153	143.257	486.948	1149.826
25.0	1087.779	157.080	512.081	1255.069
Return Period = 1000000.				
1.0	629.577	41.281	108.071	485.063
2.5	2679.785	119.381	502.656	1869.252
5.0	3151.025	194.779	807.391	2255.669
10.0	2521.448	323.585	1093.277	2060.889
25.0	2654.652	307.877	969.184	2309.076

*** Spectral Accelerations for: PSHC-output/ocsp55 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	109.579	18.598	55.606	122.522
2.5	290.912	45.396	116.553	296.881
5.0	360.656	65.345	166.505	345.576
10.0	345.011	80.425	201.062	401.496
25.0	355.158	54.350	174.359	463.386
Return Period = 100000.				
1.0	338.225	46.998	109.956	303.479
2.5	874.150	103.359	265.465	689.581
5.0	1077.883	153.310	348.718	848.232
10.0	936.825	191.638	466.842	973.896
25.0	878.234	160.222	472.811	978.608
Return Period = 1000000.				
1.0	841.320	79.797	217.399	601.302
2.5	2188.125	191.638	530.930	1357.171
5.0	2261.324	262.638	719.426	1627.349
10.0	1781.287	387.045	961.330	1677.615
25.0	1796.995	306.306	830.953	1806.420

*** Spectral Accelerations for: PSHC-output/ocsp56 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	94.688	16.336	49.009	125.036
2.5	265.622	45.396	107.443	378.563
5.0	338.979	76.655	165.876	458.674
10.0	347.335	108.071	240.647	474.382
25.0	383.589	114.040	265.465	516.793
Return Period = 100000.				
1.0	296.693	39.710	95.505	334.895
2.5	796.553	105.558	251.328	838.807
5.0	982.064	189.124	376.992	1080.710
10.0	913.577	298.452	618.267	1105.843
25.0	852.159	311.018	601.616	1039.870
Return Period = 1000000.				
1.0	724.453	69.115	187.239	653.453
2.5	1888.102	205.775	519.935	1586.508
5.0	2003.398	361.284	804.250	1866.110
10.0	1688.296	666.019	1143.542	1809.562
25.0	1633.632	554.492	1022.591	1806.420

*** Spectral Accelerations for: PSHC-output/ocsp57 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	90.415	18.724	50.705	109.328
2.5	226.195	43.825	103.202	278.032
5.0	274.419	62.832	139.173	323.585
10.0	265.717	80.425	165.876	322.328
25.0	233.892	59.219	137.602	279.602
Return Period = 100000.				
1.0	241.526	45.679	97.390	265.151
2.5	620.309	93.934	213.629	639.316
5.0	712.829	134.775	274.576	722.568
10.0	630.205	188.496	361.284	716.285
25.0	552.450	160.222	331.439	606.329
Return Period = 1000000.				
1.0	548.586	67.859	187.868	515.222
2.5	1378.534	158.651	416.262	1151.396
5.0	1512.052	229.023	518.364	1332.038
10.0	1261.038	348.089	735.134	1294.339
25.0	1111.498	282.744	598.475	1163.963

*** Spectral Accelerations for: PSHC-output/ocsp58 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	27.753	8.608	15.959	38.013
2.5	74.692	16.965	36.285	101.788
5.0	105.338	25.761	54.664	133.518
10.0	106.060	30.913	73.513	150.797
25.0	108.998	25.604	66.916	157.080
Return Period = 100000.				
1.0	85.891	17.907	40.275	106.186
2.5	251.485	41.312	96.761	312.589
5.0	319.815	68.173	153.938	376.992
10.0	320.129	101.160	221.797	435.426
25.0	345.105	89.850	235.620	483.806
Return Period = 1000000.				
1.0	269.612	37.322	76.027	280.231
2.5	737.805	93.463	210.487	741.418
5.0	910.121	164.934	323.585	917.347
10.0	832.524	253.213	537.214	999.029
25.0	794.039	230.908	532.501	896.927

*** Spectral Accelerations for: PSHC-output/ocsp59 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	77.158	9.173	24.253	82.310
2.5	248.658	22.777	70.686	311.018
5.0	481.293	43.668	141.686	468.098
10.0	529.862	62.832	216.770	678.586
25.0	504.698	56.706	219.912	615.754
Return Period = 100000.				
1.0	302.159	19.478	58.497	246.301
2.5	855.301	57.963	182.213	812.104
5.0	1683.898	123.465	370.709	1275.490
10.0	1396.127	204.204	672.302	1463.985
25.0	1526.189	226.195	620.466	1566.088
Return Period = 1000000.				
1.0	810.533	41.532	108.699	561.718
2.5	2228.965	121.737	420.974	1649.340
5.0	4724.966	255.098	854.515	2302.793
10.0	2906.608	487.576	1269.206	2745.758
25.0	2987.662	496.373	1240.932	2607.528

*** Spectral Accelerations for: PSHC-output/ocsp60 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	25.956	4.580	10.430	30.159
2.5	72.225	8.765	25.447	79.168
5.0	101.851	11.530	38.013	120.952
10.0	107.129	12.692	47.878	147.027
25.0	110.616	7.870	48.381	168.076
Return Period = 100000.				
1.0	116.805	10.430	27.018	91.106
2.5	354.372	25.133	77.598	265.465
5.0	435.112	37.385	122.208	370.709
10.0	414.503	43.731	188.496	465.585
25.0	440.924	37.385	210.487	512.081
Return Period = 1000000.				
1.0	438.128	20.106	59.439	248.186
2.5	1112.755	58.905	177.500	678.586
5.0	1352.145	92.049	284.629	948.763
10.0	1151.710	143.885	468.098	1074.427
25.0	1109.456	166.505	499.514	1068.144

*** Spectral Accelerations for: PSHC-output/ocsp61 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	33.364	7.603	17.090	46.747
2.5	80.818	15.520	35.029	102.416
5.0	110.898	20.295	50.894	151.111
10.0	112.658	24.756	71.000	148.912
25.0	112.108	22.777	70.058	164.934
Return Period = 100000.				
1.0	110.333	15.520	43.543	120.637
2.5	314.631	35.500	90.949	350.288
5.0	390.187	56.235	152.996	433.541
10.0	369.389	86.708	235.620	453.019
25.0	389.087	84.823	260.753	502.656
Return Period = 1000000.				
1.0	349.346	31.793	76.027	300.337
2.5	941.223	80.425	196.350	801.108
5.0	1131.918	139.173	320.443	1005.312
10.0	978.294	223.682	574.284	1055.578
25.0	884.203	213.629	554.492	988.033

*** Spectral Accelerations for: PSHC-output/ocsp62 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	95.630	7.917	19.352	67.859
2.5	332.853	17.279	54.664	223.054
5.0	482.864	35.500	122.208	389.558
10.0	628.320	54.727	180.328	529.674
25.0	586.851	44.611	175.930	518.364
Return Period = 100000.				
1.0	421.163	16.085	51.208	202.947
2.5	1180.142	42.726	153.153	695.864
5.0	1595.933	96.447	342.434	1159.250
10.0	1661.906	170.275	556.691	1338.322
25.0	1688.610	171.217	560.776	1407.437
Return Period = 1000000.				
1.0	1110.870	32.735	96.761	473.125
2.5	3545.295	95.662	376.992	1409.008
5.0	3879.876	214.885	826.241	2258.811
10.0	3614.097	393.328	1174.958	2544.696
25.0	3207.573	359.713	1165.534	2591.820

*** Spectral Accelerations for: PSHC-output/ocsp63 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	130.816	17.467	54.790	141.372
2.5	316.987	28.589	86.708	273.319
5.0	288.210	32.044	79.168	257.925
10.0	183.281	25.133	68.487	195.408
25.0	230.593	22.934	68.173	199.492
Return Period = 100000.				
1.0	476.644	45.930	116.239	379.505
2.5	1168.047	68.958	188.496	730.422
5.0	1054.007	71.943	195.722	735.134
10.0	585.657	76.027	196.664	557.320
25.0	776.603	79.954	229.337	573.342
Return Period = 1000000.				
1.0	1409.950	77.912	246.930	772.834
2.5	3793.482	127.863	403.696	1570.800
5.0	2638.001	159.593	398.983	1498.543
10.0	1407.437	191.638	454.904	1174.958
25.0	2067.173	193.208	512.081	1140.401

*** Spectral Accelerations for: PSHC-output/ocsp64 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	33.037	2.469	9.048	40.150
2.5	104.600	7.084	36.285	157.080
5.0	208.414	17.467	80.425	281.173
10.0	244.291	21.740	130.691	351.231
25.0	228.394	19.635	117.182	322.014
Return Period = 100000.				
1.0	179.888	6.849	25.007	142.000
2.5	483.492	23.876	115.140	567.059
5.0	886.559	59.690	251.642	936.197
10.0	929.914	94.876	471.240	1105.843
25.0	876.506	95.819	464.957	1010.024
Return Period = 1000000.				
1.0	737.648	13.509	59.816	422.231
2.5	1424.087	68.330	287.456	1250.357
5.0	2610.669	165.248	631.462	1922.659
10.0	2189.067	268.293	1099.560	2073.456
25.0	2375.050	270.178	873.365	2104.872

*** Spectral Accelerations for: PSHC-output/ocsp65 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	51.755	8.796	21.112	60.570
2.5	142.173	18.535	42.569	158.651
5.0	200.654	23.279	64.403	225.567
10.0	197.858	29.657	89.850	254.470
25.0	204.204	24.347	86.865	256.040
Return Period = 100000.				
1.0	176.746	18.410	50.768	163.992
2.5	527.789	38.956	107.914	477.523
5.0	658.165	59.690	178.443	603.187
10.0	579.311	98.018	266.408	672.302
25.0	577.269	95.348	292.169	629.891
Return Period = 1000000.				
1.0	498.760	38.579	88.593	392.700
2.5	1268.578	80.896	237.191	1013.166
5.0	1502.313	142.629	367.567	1281.773
10.0	1243.445	241.275	623.922	1275.490
25.0	1202.762	226.195	582.767	1247.215

*** Spectral Accelerations for: PSHC-output/ocsp66 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	48.123	5.146	15.017	62.141
2.5	111.919	9.268	30.631	133.989
5.0	136.220	11.655	45.553	187.868
10.0	97.075	9.550	43.228	153.310
25.0	116.176	8.152	46.339	172.788
Return Period = 100000.				
1.0	235.683	12.315	44.862	236.877
2.5	578.054	29.060	99.903	497.944
5.0	573.970	39.898	158.651	600.046
10.0	378.751	35.751	169.018	484.435
25.0	475.481	35.971	199.492	541.926
Return Period = 1000000.				
1.0	810.533	27.206	92.363	591.249
2.5	1773.433	78.226	251.328	1137.259
5.0	1596.247	102.102	355.001	1363.454
10.0	1072.542	109.328	429.771	1074.427
25.0	1182.341	126.764	488.519	1121.551

*** Spectral Accelerations for: PSHC-output/ocsp67 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	43.473	6.227	14.200	57.491
2.5	102.023	8.247	30.474	132.576
5.0	128.586	9.613	39.898	181.899
10.0	91.798	8.482	38.390	140.115
25.0	108.244	8.042	43.668	174.359
Return Period = 100000.				
1.0	210.676	13.320	43.982	213.000
2.5	530.930	25.290	100.845	508.939
5.0	589.364	34.558	137.916	581.196
10.0	363.609	32.987	149.540	464.328
25.0	479.565	38.799	196.350	554.492
Return Period = 1000000.				
1.0	817.444	28.400	92.363	557.948
2.5	1770.292	60.947	252.899	1244.073
5.0	1746.729	90.164	323.585	1347.746
10.0	1052.436	109.956	382.019	1093.277
25.0	1304.235	144.357	488.519	1204.804

*** Spectral Accelerations for: PSHC-output/ocsp68 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	16.801	1.967	6.723	24.944
2.5	51.475	3.597	17.907	80.582
5.0	77.755	5.121	34.243	117.182
10.0	87.902	6.283	46.119	143.257
25.0	87.776	4.351	47.752	164.934
Return Period = 100000.				
1.0	89.347	6.912	17.153	94.248
2.5	286.671	14.530	63.303	301.594
5.0	363.483	22.871	117.496	395.842
10.0	356.886	29.468	191.009	473.753
25.0	385.003	32.044	212.058	510.510
Return Period = 1000000.				
1.0	359.713	13.383	43.731	300.965
2.5	947.978	37.699	155.038	793.254
5.0	1172.445	68.173	272.377	1039.870
10.0	1039.870	114.354	471.240	1112.126
25.0	968.241	134.932	497.944	1032.016

*** Spectral Accelerations for: PSHC-output/ocsp69 ***

freq. Hz	mean	15th%	median	85th%
Return Period = 10000.				
1.0	80.865	10.179	32.170	93.620
2.5	183.784	16.022	47.909	171.217
5.0	185.669	15.331	54.036	195.722
10.0	145.645	12.566	49.072	191.009
25.0	186.454	9.629	49.794	208.916
Return Period = 100000.				
1.0	294.431	23.688	74.142	255.098
2.5	838.964	36.757	128.334	548.209
5.0	726.966	42.726	170.589	622.037
10.0	517.799	42.537	174.673	564.860
25.0	651.254	38.956	197.921	576.484
Return Period = 1000000.				
1.0	912.949	49.260	150.797	549.152
2.5	2791.311	82.938	309.448	1192.237
5.0	2044.867	97.075	364.426	1335.180
10.0	1306.906	122.522	419.718	1156.109
25.0	1727.880	137.916	458.674	1173.388