5. Hazard for the Control Point

5.1 SWUS Reference Rock Hazard Curves

Hazard curves for the SWUS reference rock condition were interpolated to finer sampling in frequency so that the site resonances can be captured. The interpolated hazard curves are listed in Table B-1 in Appendix B.

5.2 Weights for the Empirical and Analytical Approaches

The two approaches for estimating the site terms are applied using a logic tree approach. The technical justification for selecting the logic tree weights for the empirical and analytical approaches is given in this section.

5.2.1 Empirical Approach Strengths and Weaknesses

A key advantage of the empirical approach is that the recorded ground motions at DCPP include the actual site effects; however, the event-corrected residuals may still contain some source and path effects in addition to the site effects. The event-corrected residuals in Figure 4-2 show that at high frequencies, the residuals are consistent between the three recordings, indicating that the mean residual is a robust estimate of a repeatable site effect. In contrast, at low frequencies (2.5 Hz and below), there is much larger scatter between the residuals for the three recordings, indicating that low-frequency event-corrected residuals may still contain path effects: the procedure to remove the region-specific distance scaling may not fully capture the path effects. An alternative interpretation of the larger scatter at low frequencies is that there are strong 3-D site response effects which depend on the azimuth and incidence angle of the input ground motion.

A key limitation of the empirical approach is that the mean site term is based on only three recordings from two earthquakes. This limitation is directly addressed through the SE of the empirical site term.

5.2.2 Analytical Approach Strengths and Weaknesses

A key advantage of the analytical approach is that it can represent the average site term over a large number of earthquake scenarios. The extensive site data at DCPP provides a well constrained velocity model down to depths of 3000 m. With such a deep velocity profile, the analytical site response modeling can capture both high -frequency and low-frequency site effects. The QWL amplification (Figure 2-5) shows that the site-specific amplification at low frequencies is similar, on average, to the amplification from a generic reference rock site representative of the SWUS ground motion model.

The analytical approach also allows for the consideration of nonlinear site effects that cannot be addressed by the weak motion available for the empirical approach; however, the available site-specific laboratory data is limited to studies from the 1970s. The results from the available lab studies (Figures 3-4 and 3-5) show a wide range of material properties from linear to significantly nonlinear.

An important limitation of the analytical approach is that it is based on 1-D layered models of the site, but the 3-D velocity model developed by Fugro (Reference 4) shows that there are strong lateral heterogeneities in the velocity structure so that the 3-D site response may differ from the 1-D site response.

5.2.3 Selected Weights

A common approach to evaluating weights for models is to consider the relative sizes of uncertainties of the alternative models. In this case, the epistemic uncertainty in the site terms using the analytical approach and the empirical approach are similar (about 0.25 LN units) for frequencies greater than 5 Hz. At low frequencies, the analytical modeling has much smaller uncertainty due to the use of a single deep velocity profile (below 125 m). Based only on the epistemic uncertainties, the two approaches would be given equal weight at the high frequencies and the analytical approach would be given higher weight for the low frequencies.

In our judgment, in general, data at a site is preferred over results from models because the empirical data capture more complex effects that are not considered in site response models such as 3-D effects. While the empirical method is based on only three recordings, the residuals are consistent for frequencies greater than 3 Hz. Therefore, we favor the empirical approach over the analytical approach in the high-frequency range.

In the low-frequency range, the empirical site terms (Figure 4-2) show that, on average, there is amplification in the 1.5 to 2.5 Hz range. This site resonance, relative to a reference rock site, is not seen in the analytical results. Given the larger scatter in the corrected residuals in the frequency band, some of the 2 Hz amplification seen in the empirical site terms may actually be path effects rather than site effects; however, there may also be low-frequency 3-D SA that is not captured in the 1-D site response analysis, but is captured in the empirical factors, but with more variability than in the high-frequency range.

The key frequency range for safety-related systems, structures, and components at DCPP are above 3 Hz for which the empirical approach is well constrained. Given that the empirical site factors represent the actual linear SA, the residuals are consistent at high frequencies, and the rock properties are not highly nonlinear, we judge that the empirical approach should be favored over the analytical approach. Therefore, the weights favoring the empirical approach (weight = 2/3) over the analytical approach (weight = 1/3) are selected for the entire frequency range.

5.2.4 Sensitivity

The sensitivity of the 1E-4 and 1E-5 uniform hazard spectra (UHS) to the approach used for the SA is shown in Figure 5-1. The main differences are at 10 Hz and 2 Hz: the analytical approach shows a site resonance near 10 Hz which is not seen in the residuals; the empirical approach shows a site resonance near 2 Hz that is not seen in the analytical results.

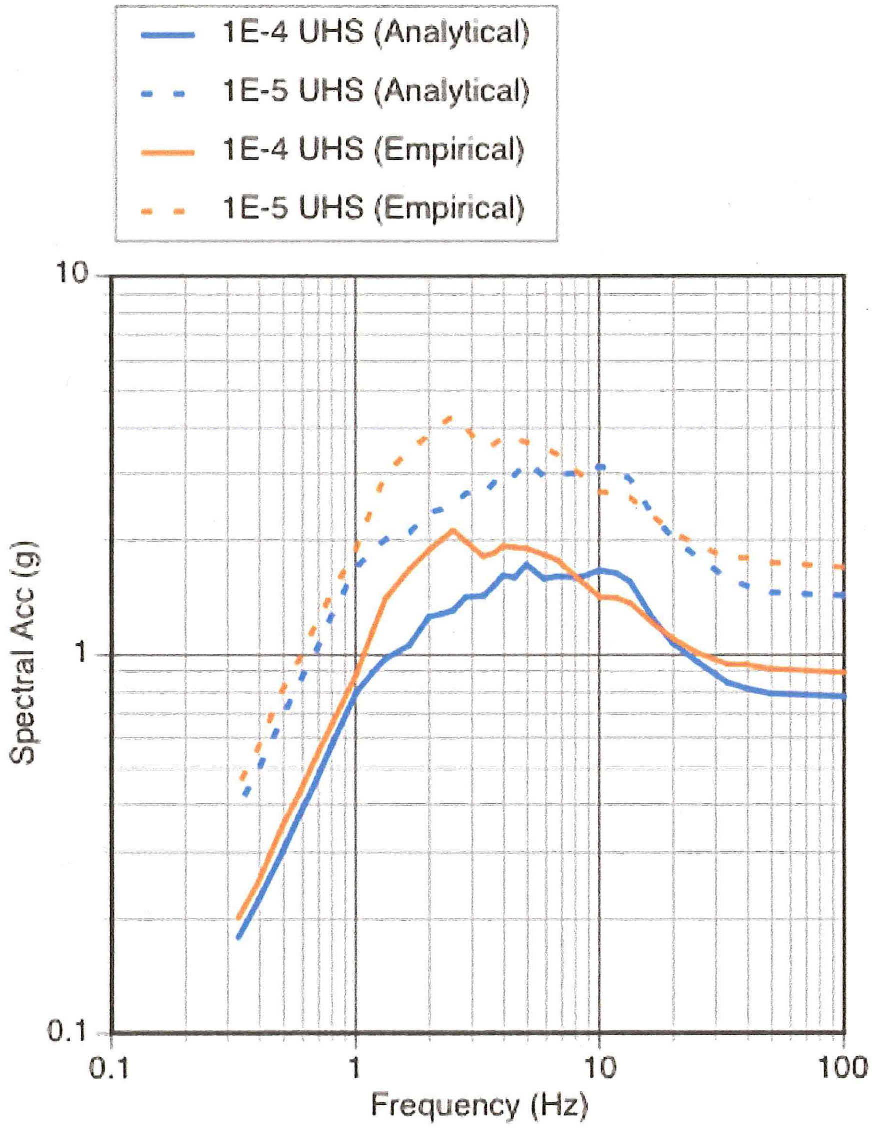

Figure 5-1 - Sensitivity of the UHS to the Site Term Approach
(From Reference 9)

5.3 Application of Analytical Site Amplification Factors to the Reference Ground Motion Models

The GMPEs, on which the reference rock hazard is based, include nonlinearity in the site terms and standard deviation, but only based on the nonlinearity at the median ground motion level. The trend of the nonlinearity (slope of the log amplification as a function of the log SA) at the median ground motion level is assumed to apply to higher ground motion levels. Due to this assumption, tor the empirical GMPEs, the site term is close to linear at VS30=760 m/s for all epsilon values.

In contrast, the analytical SA was computed relative to a reference rock site condition with VS30=760 m/s, a generic VS profile based on California rock sites, a kappa of 0.03 sec, and the Peninsula Range nonlinear properties. The analytical modeling will have different levels of nonlinearity as the ground motion level increases from the median level (epsilon = 0) to above median levels (epsilon > 0). So the nonlinearity for the reference rock condition in the analytical model, which is consistent with the expected physical behavior of the soil, is inconsistent with the nonlinearity in the GMPEs for VS30=760 m/s that was used to compute the hazard. That is, the computed hazard for the SWUS reference rock condition does not capture nonlinear behavior for ground motion levels above the median. To correct for this inconsistency, a set of SA factors between a linear VS30=760 and a nonlinear VS30=760 site condition were also computed.

Figure 5-2 is a schematic illustration of this process. The simulated ground motion for the reference rock condition of 760_NL case is called $SA_0(f)$. The simulated ground motion for the control point is called $SA_1(f)$ and depends on the amplitude of the reference rock ground motion. If the hazard had been computed for the 760_NL, it would be straightforward to compute the soil hazard, but because the hazard was run with a linear 760 GMPE, a correction to account for the limitation of the lack of nonlinearity in the GMPEs used for the hazard calculation is needed.

Two amplifications are given from the analytical modeling: the amplification of the DCPP soil relative to the 760_NL case (called Amp1) and the amplification of the 760_LIN case relative to the 760_NL case (called Amp2). The desired amplification of the DCPP soil relative to the 760_LIN case (called Amp3) is given by the ratio of these two amplifications.

$$Amp_1(f, SA_0(f)) = \frac{SA_1(f, SA_0(f))}{SA_0(f)}$$

$$Amp_2(f, SA_0(f)) = \frac{SA_2(f, SA_0(f))}{SA_0(f)}$$

$$Amp_3(f,SA_0(f)) = \frac{AMP_1(f,SA_0(f))}{AMP_2(f,SA_0(f))} = \frac{SA_1(f,SA_0(f))}{SA_2(f,SA_0(f))}$$

Amp3 gives the amplification from the linear 760 case to the site-specific case, but it is a function of the ground motion level for the non-linear 760 case (SA_0). The hazard calculation gives the rate of ground motions as a function of the ground motion for the 760 linear case (SA_2). Therefore, the reference rock ground motion is changed from SA_0 to SA_2:

$$SA_2(f,SA_0(f)) = SA_0(f)AMP_2(f,SA_0(f))$$

With these two relations, the amplification is relative to the reference rock condition used in the hazard calculation. The soil hazard can then be computed as described in Section 5.3.

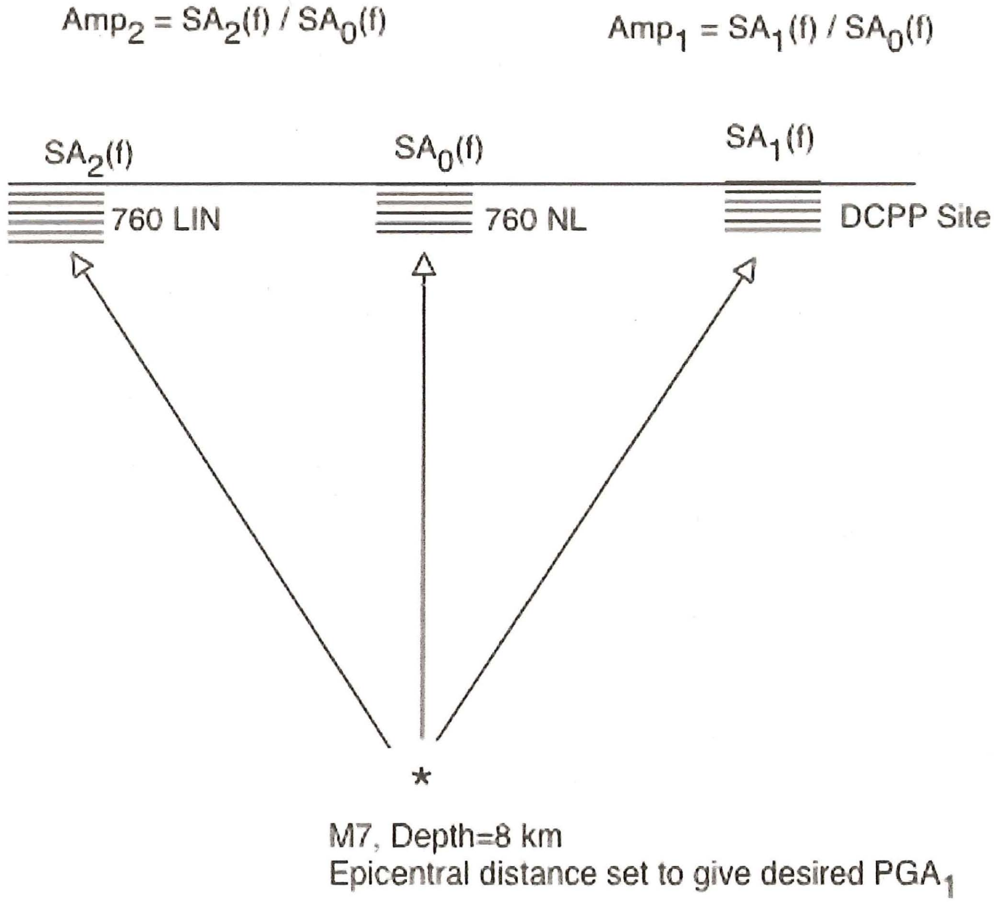

Figure 5-2 - Notation used to Compute the Site Amplification

5.4 Methodology for Applying Approach 3

The hazard for the reference site condition is computed using the global model and the single-station sigma. The site-specific hazard is computed using Approach 3, which requires estimating the site-specific $\hat{Amp}(f, PSA_{REF})$ term and the epistemic uncertainty in the $\hat{Amp}(f, PSA_{REF})$. The $\hat{Amp}(f, PSA_{REF})$ term is an average site term and does not include aleatory variability of the SA that may arise from different input ground motions. Because the single-station sigma only removed the effects of the average SA from the ergodic standard deviation, the aleatory variability of the SA is still part of the single-station sigma. The standard deviation for GMPEs is computed from ground motions that are mainly in the linear range, so the single-station sigma represents the aleatory SA in the linear range. If there is increased variability for highly nonlinear cases, then that additional aleatory variability is not captured in the single-station sigma model. This additional aleatory variability at high ground motion levels is to be included in the soil hazard calculation.

The hazard on soil is given by:

$$Haz(PSA_{soil} > z, f) = \int \frac{-dHaz(z_{REF})}{dz_{REF}} P\left(PSA_{soil} > z \mid \hat{A}mp(z_{REF}, f), \phi_{amp\_NL}(z_{REF}, f)\right) dz_{REF}$$

where Haz(z_{REF}) is the hazard for the SA_2(f) corresponding to the hazard for the SWUS reference rock condition,

$$P\left(PSA_{soil} > z \mid \hat{A}mp(z_{REF}, f), \phi_{amp\_NL}(z_{REF}, f)\right) = 1 - \Phi\left(\frac{\ln(z) - \ln\left(z_{REF}\,\hat{A}mp(z_{REF}, f)\right)}{\phi_{amp\_NL}(z_{REF}, f)}\right)$$

and $\Phi(x)$ is the standard normal cumulative distribution. As described in section 5.2, the amplification used in the soil hazard calculation is Amp_3.

The hazard integral is solved numerically.

$$Haz(PSA_{soil} > z, f) = \sum_{i=1}^{N} rate\left(z_{REF_i}, f\right) P\left(PSA_{soil} > z \mid \hat{A}mp_3(z_{REF_i}, f), \phi_{amp\_NL}(z_{REF_i}, f)\right)$$

where

$$rate\left(z_{REF_i}, f\right) = Haz\left(z_{REF_j}, f\right) - Haz\left(z_{REF_{j+1}}, f\right)$$

and

$$z_{REF_i} = \frac{z_{REF_j} + z_{REF_{j+1}}}{2}$$

The $rate(zREF_i, f)$ is the rate of occurrence of reference rock ground motion level $zREF_i$ computed from the hazard curves, and the aleatory term, $\phi_{amp\_NL}(zREF, f)$, is given by the increase in the variance of the computed SA due to nonlinear effects. The increase in the variance is computed by subtracting the variance from 0.1 g input motion, which is taken to represent the linear range. The aleatory term used in the soil hazard is given by:

$$\phi_{amp\_NL}(zREF,f) = \begin{cases} \sqrt{\phi_{Amp}^2(zREF,f) - \phi_{Amp}^2(zREF=0.1g,f)} & for\,\phi_{Amp}^2(zREF,f) > \phi_{Amp}^2(zREF=0.1g,f) \\ 0 & for\,\phi_{Amp}^2(zREF,f) \le \phi_{Amp}^2(zREF=0.1g,f) \end{cases}$$

where $\phi_{Amp}^2(zREF,f)$ is the standard deviation of the SA due to the randomization of the soil properties. If the aleatory variability at high ground motion levels is smaller than at low ground motion levels, then the aleatory term is zero.

5.5 Soil Hazard Curves

The soil hazard is computed using the methodology described in Section 5.4, which is consistent with Approach 3. The soil hazard curves are shown in Figure 5-3.

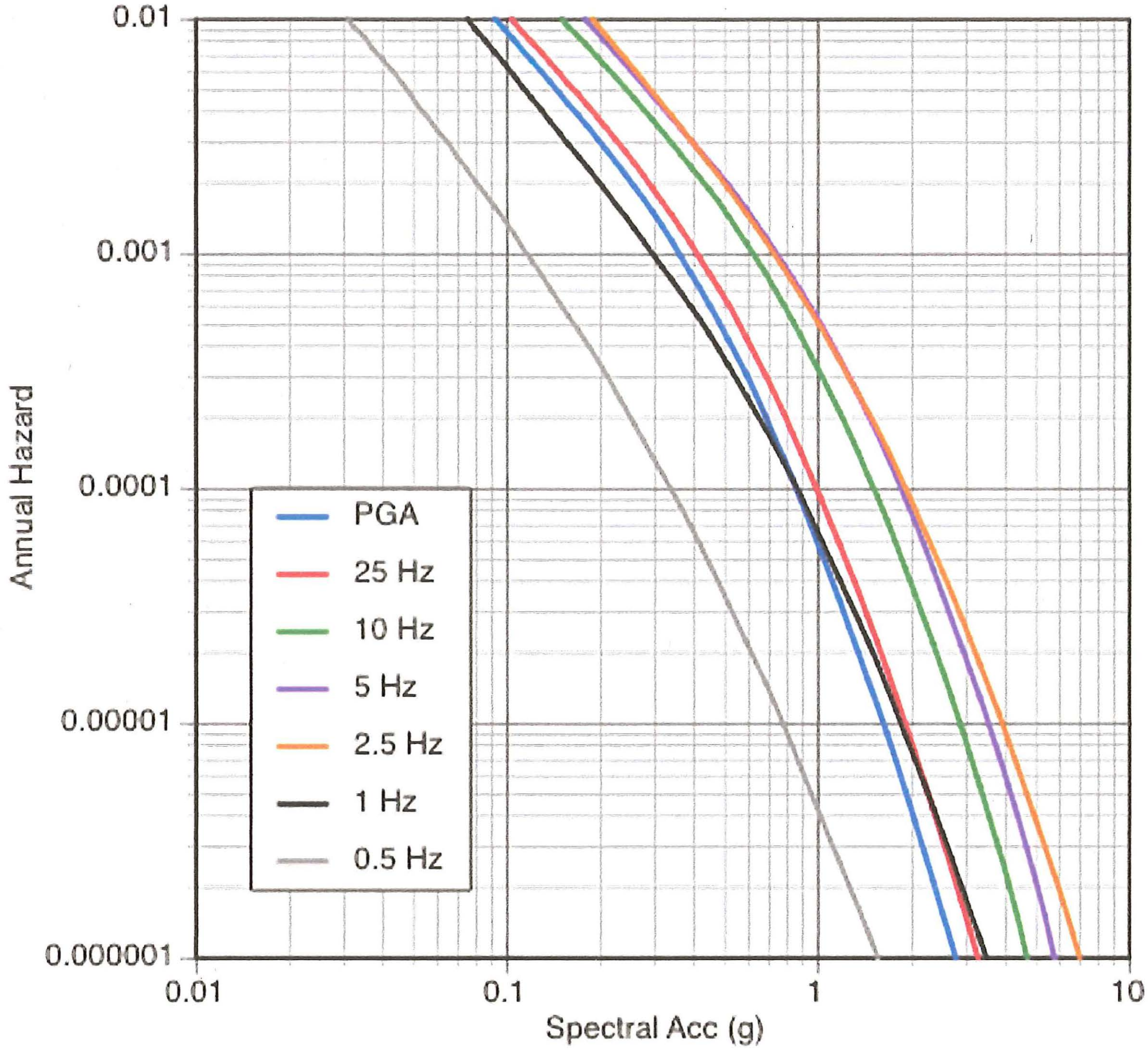

Figure 5-3 - Soil Hazard Curves for the Control Point
(From Reference 9)

6. Uniform Hazard Spectra and Ground Motion Response Spectrum

The resulting UHS at 1E-4 and 1E-5 and the GMRS are listed in Table 6-1 and are plotted in Figure 6-1.

Table 6-1 - GMRS for the Control Point
(From Reference 9)

Frequency (Hz)	UHS 1E-4 (g)	UHS 1E-5 (g)	GMRS (g)
100	0.856	1.621	0.856
50	0.878	1.665	0.879
39.84	0.902	1.720	0.907
33.33	0.912	1.737	0.916
25.13	0.994	1.905	1.004
20	1.088	2.075	1.094
16.58	1.217	2.322	1.224
13.33	1.437	2.718	1.437
11.75	1.489	2.822	1.490
10	1.509	2.863	1.511
8.32	1.583	3.002	1.585
6.67	1.723	3.277	1.729
5.89	1.762	3.368	1.775
5	1.850	3.528	1.861
4.47	1.817	3.511	1.847
4	1.842	3.562	1.873
3.71	1.755	3.401	1.788
3.33	1.701	3.305	1.736
2.82	1.825	3.652	1.907
2.5	1.913	3.899	2.029
2.24	1.816	3.697	1.924
2	1.716	3.460	1.804
1.66	1.507	3.154	1.633
1.33	1.283	2.753	1.418
1.17	1.074	2.299	1.185
1	0.859	1.844	0.950
0.79	0.626	1.398	0.714
0.67	0.499	1.122	0.572
0.58	0.410	0.928	0.473
0.5	0.337	0.773	0.393
0.4	0.243	0.549	0.280
0.33	0.195	0.434	0.222

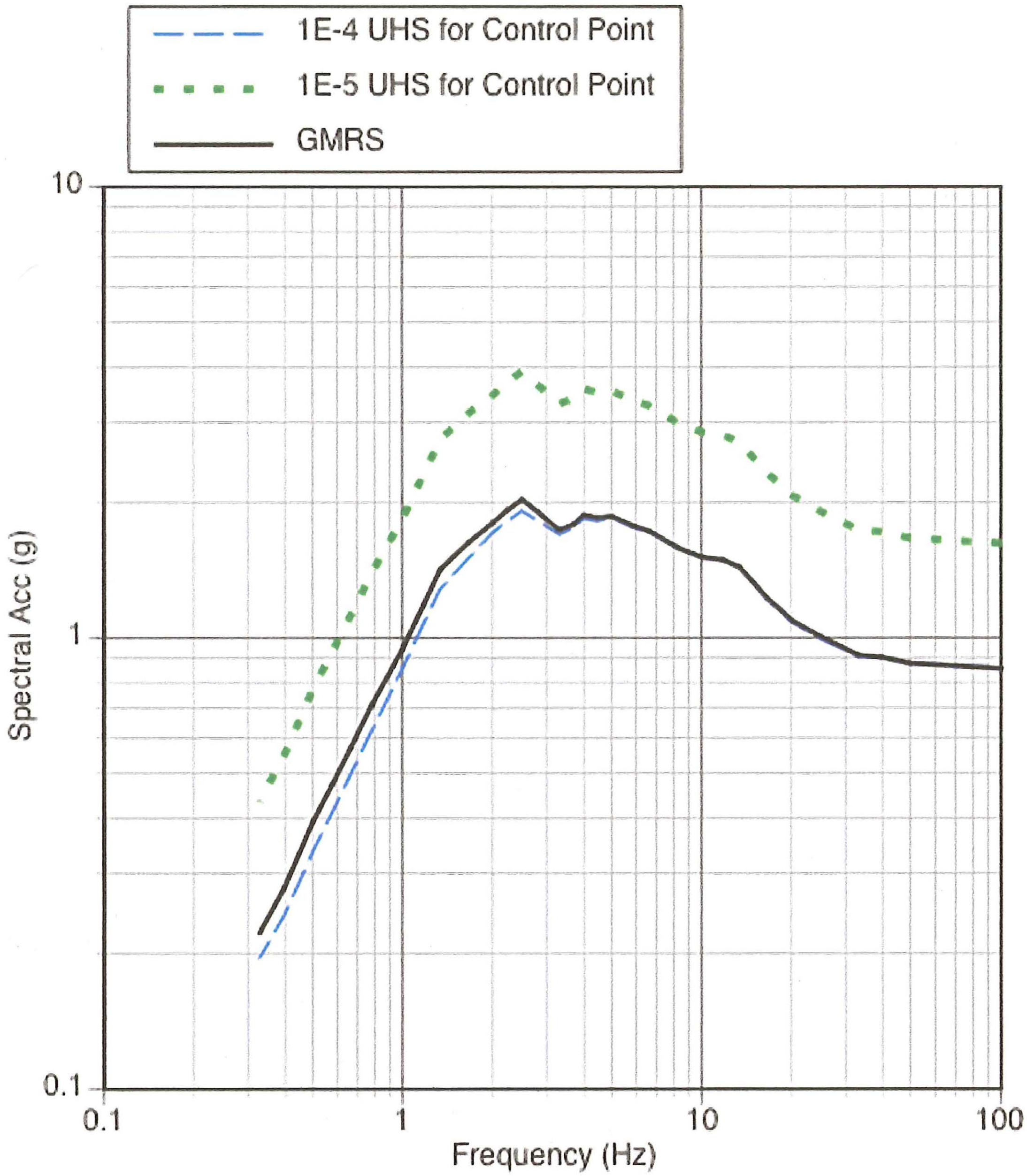

Figure 6-1 - UHS for the Control Point and the GMRS
(From Reference 9)

7. Conclusions

The approach to the development of the GMRS given in this RAI response differs from the approach used in the DCPP SHSR (Reference 3) in two key aspects: (1) the control point was changed from the a single location (ESTA28) to average site condition over the plant region, and (2) both the empirical and analytical approaches were used, rather than just the empirical approach.

The GMRS given in Table 6-1 replaces the GMRS given in the DCPP SHSR (Reference 3). This GMRS represents PG&E's final GMRS for the response to Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident. Note that the GMRS given in Table 6-1 is for the average site condition over the plant region and will be used for screening purposes.

An interim assessment of the updated GMRS described above is consistent with the conclusions of the screening and interim evaluations performed by PG&E and reported to the NRC in the SHSR (Reference 3). DCPP continues to screen "in" for additional risk evaluation (i.e., the performance of an updated/enhanced Seismic Probabilistic Risk Assessment) and there is reasonable assurance that DCPP remains safe to operate without undue risk to the public while an updated risk evaluation is being performed. The updated GMRS given in Table 6-1 remains bounded by the Long Term Seismic Program Margin Spectrum.

8. References

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Appendix A

A1. Velocity Profile, Density, and Scale-Factor Tables

Table A-1 - Host Velocity Profile and Density
(From Reference 8)

Layer Thickness (m)	VS (m/s)	Density (gm/cm^3)
1.524	477.18	1.8
1.219	520.04	1.9
2.286	583.38	1.9
2.286	643	1.9
3.353	704.81	2.1
4.572	771.49	2.1
5.486	858.16	2.1
6.705	944.84	2.1
7.62	1030.18	2.1
10.057	1133.8	2.1
12.801	1264.86	2.1
10.667	1377.63	2.1
10.668	1377.63	2.1
10.159	1456.87	2.1
10.16	1456.87	2.1
10.16	1456.87	2.1
14.223	1484.31	2.1
14.223	1484.31	2.1
14.224	1484.31	2.1
100	1530	2.17
115	1720	2.23
160	1890	2.28
237	2070	2.33
228	2300	2.4
550	2550	2.47
800	2760	2.53
1100	2970	2.59
1550	3150	2.64
2400	3320	2.69
6100	3500	2.75

Table A-2 - Target Velocity Profile and Density
(From Reference 8)

Layer Thickness (m)	Central Profile VS (m/s)	Central Profile Density (gm/cm^3)	Lower Profile VS (m/s)	Lower Profile Density (gm/cm^3)	Upper Profile VS (m/s)	Upper Profile Density (gm/cm^3)
0.51	640.5	1.92	505.2	1.92	812.2	2.1
0.51	657.7	1.92	519.3	1.92	832.9	2.1
0.5	675.7	1.92	534.7	1.92	853.8	2.1
0.51	688.3	1.92	541.2	1.92	875.3	2.1
0.51	707.8	2.1	559.3	1.92	895.6	2.1
0.51	724.4	2.1	572.8	1.92	916	2.1
0.51	733.7	2.1	573.9	1.92	938	2.1
0.5	742.5	2.1	573.5	1.92	961.3	2.1
0.51	749.1	2.1	568.7	1.92	986.8	2.1
0.51	759	2.1	569	1.92	1012.4	2.1
0.51	777.2	2.1	583.1	1.92	1035.9	2.1
0.51	785.7	2.1	582.4	1.92	1060	2.1
0.5	794.7	2.1	582.4	1.92	1084.5	2.1
0.51	804.4	2.1	584	1.92	1108.2	2.1
0.51	815.1	2.1	586.6	1.92	1132.6	2.1
0.51	827.1	2.1	591.1	1.92	1157.4	2.1
0.51	842.8	2.1	602.1	1.92	1179.9	2.1
0.5	863.5	2.1	621.5	1.92	1199.9	2.1
0.51	887	2.1	646.1	1.92	1217.8	2.1
0.51	910.6	2.1	672.1	1.92	1233.7	2.1
0.51	938.1	2.1	705.6	2.1	1247.3	2.1
0.51	965.5	2.1	739	2.1	1261.4	2.1
0.5	984.8	2.1	758.8	2.1	1278.2	2.1
0.51	998.2	2.1	768.8	2.1	1296	2.1
0.51	1010.3	2.1	777	2.1	1313.7	2.1
0.51	1022.9	2.1	786.4	2.1	1330.6	2.1
0.51	1036	2.1	797.6	2.1	1345.7	2.1
0.5	1050.1	2.1	812.4	2.1	1357.3	2.1
0.51	1064.8	2.1	828.3	2.1	1368.8	2.1
0.51	1078.5	2.1	842.9	2.1	1379.9	2.1
0.51	1089.7	2.1	855.8	2.1	1387.5	2.1
0.51	1099.5	2.1	867.2	2.1	1394	2.1
0.5	1108.5	2.1	877.6	2.1	1400	2.1
0.51	1116.5	2.1	887.8	2.1	1404.3	2.1
0.51	1123.5	2.1	896.7	2.1	1407.5	2.1
0.51	1130.1	2.1	905.3	2.1	1410.6	2.1
0.51	1135.9	2.1	913.6	2.1	1412.3	2.1

Table A-2. Target Velocity Profile and Density (continued)

Layer Thickness (m)	Central Profile VS (m/s)	Central Profile Density (gm/cm^3)	Lower Profile VS (m/s)	Lower Profile Density (gm/cm^3)	Upper Profile VS (m/s)	Upper Profile Density (gm/cm^3)
0.5	1140.5	2.1	920	2.1	1413.9	2.1
0.51	1145.5	2.1	926.9	2.1	1415.7	2.1
0.51	1151.4	2.1	935.5	2.1	1417	2.1
0.51	1158.1	2.1	946.5	2.1	1417.1	2.1
0.51	1163.7	2.1	955.6	2.1	1417.3	2.1
0.5	1168.5	2.1	963	2.1	1417.8	2.1
0.51	1172.7	2.1	969.6	2.1	1418.4	2.1
0.51	1175.6	2.1	974	2.1	1418.9	2.1
0.51	1175.8	2.1	974.1	2.1	1419.4	2.1
0.51	1176.2	2.1	974.3	2.1	1419.8	2.1
0.5	1177.8	2.1	975.8	2.1	1421.7	2.1
0.51	1181.5	2.1	979	2.1	1426	2.1
0.51	1185.8	2.1	982.8	2.1	1430.6	2.1
0.51	1191.1	2.1	987.5	2.1	1436.7	2.1
0.51	1195.9	2.1	991.2	2.1	1442.9	2.1
0.5	1199.1	2.1	991.5	2.1	1450.1	2.1
0.51	1202.3	2.1	991.5	2.1	1457.9	2.1
0.51	1205.5	2.1	990	2.1	1467.9	2.1
0.51	1208.2	2.1	987.1	2.1	1478.7	2.1
0.51	1211.9	2.1	985.8	2.1	1489.8	2.1
0.5	1216.3	2.1	984.6	2.1	1502.5	2.2
0.51	1220.8	2.1	984.1	2.1	1514.5	2.2
0.51	1225.8	2.1	984	2.1	1526.9	2.2
0.51	1231.2	2.1	984	2.1	1540.7	2.2
0.51	1236.4	2.1	982.9	2.1	1555.3	2.2
0.5	1240.9	2.1	980.6	2.1	1570.2	2.2
0.51	1245.9	2.1	979.8	2.1	1584.3	2.2
0.51	1250.5	2.1	978.1	2.1	1598.8	2.2
0.51	1255.3	2.1	976.9	2.1	1613.2	2.2
0.51	1259.2	2.1	975	2.1	1626.3	2.2
0.5	1262.7	2.1	973	2.1	1638.7	2.2
0.51	1266.1	2.1	970.8	2.1	1651.2	2.2
0.51	1267.6	2.1	967.7	2.1	1660.6	2.2
0.51	1268.7	2.1	964.3	2.1	1669.2	2.2
0.51	1269.7	2.1	960.9	2.1	1677.6	2.2
0.5	1269.2	2.1	957.2	2.1	1682.9	2.2
0.51	1268.5	2.1	953.5	2.1	1687.5	2.2
0.51	1267.7	2.1	949.9	2.1	1691.8	2.2

Layer Thickness (m)	Central Profile		Lower Profile		Upper Profile	
	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)
0.51	1265.3	2.1	945.2	2.1	1693.7	2.2
0.51	1262.7	2.1	941.6	2.1	1693.5	2.2
0.5	1260.8	2.1	938.4	2.1	1694.1	2.2
0.51	1258.9	2.1	935.1	2.1	1694.7	2.2
0.51	1256.7	2.1	931.5	2.1	1695.4	2.2
0.51	1255.2	2.1	929.1	2.1	1695.7	2.2
0.51	1252.3	2.1	924.9	2.1	1695.6	2.2
0.5	1249.3	2.1	920.8	2.1	1694.9	2.2
0.51	1246.3	2.1	917.6	2.1	1692.7	2.2
0.51	1242.3	2.1	914.4	2.1	1687.8	2.2
0.51	1237.9	2.1	911	2.1	1681.9	2.2
0.51	1233.5	2.1	909	2.1	1673.8	2.2
0.5	1228.3	2.1	907.9	2.1	1661.6	2.2
0.51	1222.6	2.1	907	2.1	1647.9	2.2
0.51	1216.1	2.1	906.4	2.1	1631.7	2.2
0.51	1207.9	2.1	906.6	2.1	1609.4	2.2
0.51	1199.3	2.1	907.5	2.1	1584.9	2.2
0.5	1190.3	2.1	907.6	2.1	1561.1	2.2
0.51	1180.3	2.1	906.5	2.1	1536.7	2.2
0.51	1170.5	2.1	906.4	2.1	1511.5	2.2
0.51	1160.9	2.1	906.6	2.1	1486.5	2.1
0.51	1151.4	2.1	906.7	2.1	1462.2	2.1
0.5	1142.2	2.1	907	2.1	1438.4	2.1
0.51	1133.4	2.1	907.2	2.1	1416.1	2.1
0.51	1125.7	2.1	908.1	2.1	1395.5	2.1
0.51	1117.8	2.1	908.4	2.1	1375.5	2.1
0.51	1110	2.1	908.2	2.1	1356.5	2.1
0.5	1103.5	2.1	908.6	2.1	1340.1	2.1
0.51	1097.1	2.1	908.8	2.1	1324.4	2.1
0.51	1091.6	2.1	910.1	2.1	1309.3	2.1
0.51	1087.2	2.1	911.5	2.1	1296.8	2.1
0.51	1082.9	2.1	912.7	2.1	1284.8	2.1
0.5	1079.4	2.1	914.6	2.1	1273.9	2.1
0.51	1077	2.1	916.5	2.1	1265.7	2.1
0.51	1075.1	2.1	919.1	2.1	1257.5	2.1
0.51	1074	2.1	922.8	2.1	1250	2.1
0.51	1074.4	2.1	927.2	2.1	1245.1	2.1
0.5	1074.3	2.1	930.4	2.1	1240.5	2.1
0.51	1074.9	2.1	934.3	2.1	1236.5	2.1
0.51	1076.8	2.1	939	2.1	1234.8	2.1

Layer Thickness (m)	Central Profile		Lower Profile		Upper Profile	
	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)
0.51	1079.3	2.1	944.6	2.1	1233.1	2.1
0.51	1083.4	2.1	952	2.1	1232.9	2.1
0.5	1086.6	2.1	957.4	2.1	1233.3	2.1
0.51	1089.3	2.1	961.9	2.1	1233.6	2.1
0.51	1092.8	2.1	967.3	2.1	1234.7	2.1
0.51	1096.2	2.1	972.1	2.1	1236.1	2.1
0.51	1099.2	2.1	976.3	2.1	1237.7	2.1
0.5	1103.2	2.1	981	2.1	1240.6	2.1
0.51	1106.9	2.1	985.4	2.1	1243.3	2.1
0.51	1111.2	2.1	990.5	2.1	1246.5	2.1
0.51	1115.2	2.1	994.9	2.1	1250.1	2.1
0.51	1119	2.1	999.1	2.1	1253.4	2.1
0.5	1122.5	2.1	1002.6	2.1	1256.7	2.1
0.51	1125.4	2.1	1005.5	2.1	1259.5	2.1
0.51	1128.6	2.1	1008.5	2.1	1263.1	2.1
0.51	1131.9	2.1	1011.6	2.1	1266.5	2.1
0.51	1135.5	2.1	1014.9	2.1	1270.3	2.1
0.5	1138.9	2.1	1018.8	2.1	1273.2	2.1
0.51	1142.2	2.1	1022.2	2.1	1276.2	2.1
0.51	1146.5	2.1	1027.4	2.1	1279.3	2.1
0.51	1150	2.1	1031.4	2.1	1282.2	2.1
0.51	1153.4	2.1	1035.2	2.1	1285.2	2.1
0.5	1156.4	2.1	1038.5	2.1	1287.6	2.1
0.51	1159.8	2.1	1042.7	2.1	1290.2	2.1
0.51	1163.8	2.1	1047.5	2.1	1293	2.1
0.51	1167	2.1	1051.5	2.1	1295.3	2.1
0.51	1170.1	2.1	1055.3	2.1	1297.4	2.1
0.5	1172.7	2.1	1059.1	2.1	1298.5	2.1
0.51	1175.3	2.1	1063	2.1	1299.6	2.1
0.51	1178.6	2.1	1066.4	2.1	1302.5	2.1
0.51	1181.6	2.1	1069.2	2.1	1305.9	2.1
0.51	1183.8	2.1	1071.1	2.1	1308.3	2.1
0.5	1186.2	2.1	1073.3	2.1	1311	2.1
0.51	1188.7	2.1	1075.6	2.1	1313.7	2.1
0.51	1190.9	2.1	1077.6	2.1	1316.2	2.1
0.51	1192.6	2.1	1079.1	2.1	1318	2.1
0.51	1194.3	2.1	1080.7	2.1	1319.9	2.1
0.5	1196.1	2.1	1082.2	2.1	1321.8	2.1
0.51	1197.2	2.1	1083.3	2.1	1323.1	2.1
0.51	1198.2	2.1	1084.2	2.1	1324.3	2.1

Layer Thickness (m)	Central Profile		Lower Profile		Upper Profile	
	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)
0.51	1199.4	2.1	1085.3	2.1	1325.6	2.1
0.51	1200.3	2.1	1086.1	2.1	1326.6	2.1
0.5	1200.7	2.1	1086.4	2.1	1327	2.1
0.51	1200.5	2.1	1086.2	2.1	1326.7	2.1
0.51	1200.4	2.1	1086.2	2.1	1326.7	2.1
0.51	1201.3	2.1	1086.9	2.1	1327.6	2.1
0.51	1202.2	2.1	1087.8	2.1	1328.7	2.1
0.5	1203.1	2.1	1088.6	2.1	1329.6	2.1
0.51	1204	2.1	1089.4	2.1	1330.6	2.1
0.51	1205.6	2.1	1090.9	2.1	1332.4	2.1
0.51	1205.9	2.1	1091.2	2.1	1332.7	2.1
0.51	1206.5	2.1	1091.7	2.1	1333.4	2.1
0.5	1207.4	2.1	1092.5	2.1	1334.4	2.1
0.51	1208	2.1	1093	2.1	1335	2.1
0.51	1209.3	2.1	1094.3	2.1	1336.5	2.1
0.51	1210.9	2.1	1095.7	2.1	1338.3	2.1
0.51	1212.6	2.1	1097.2	2.1	1340.1	2.1
0.5	1214.1	2.1	1098.6	2.1	1341.8	2.1
0.51	1216	2.1	1100.3	2.1	1343.9	2.1
0.51	1217.1	2.1	1101.3	2.1	1345.1	2.1
0.51	1218.5	2.1	1102.5	2.1	1346.6	2.1
0.51	1220.1	2.1	1104	2.1	1348.4	2.1
0.5	1221.8	2.1	1105.5	2.1	1350.3	2.1
0.51	1224.2	2.1	1107.7	2.1	1352.9	2.1
0.51	1226.1	2.1	1109.5	2.1	1355.1	2.1
0.51	1228.1	2.1	1111.3	2.1	1357.3	2.1
0.51	1230	2.1	1113	2.1	1359.4	2.1
0.5	1232.3	2.1	1115	2.1	1361.9	2.1
0.51	1233.4	2.1	1116	2.1	1363.1	2.1
0.51	1235.1	2.1	1117.6	2.1	1365	2.1
0.51	1237.4	2.1	1119.6	2.1	1367.5	2.1
0.51	1239.2	2.1	1121.3	2.1	1369.6	2.1
0.5	1240.4	2.1	1122.4	2.1	1370.9	2.1
0.51	1241.5	2.1	1123.4	2.1	1372.1	2.1
0.51	1242.7	2.1	1124.4	2.1	1373.4	2.1
0.51	1243.4	2.1	1125.1	2.1	1374.2	2.1
0.51	1245	2.1	1126.5	2.1	1375.9	2.1
0.5	1246.3	2.1	1127.7	2.1	1377.4	2.1
0.51	1248.3	2.1	1129.5	2.1	1379.6	2.1
0.51	1249.6	2.1	1130.7	2.1	1381.1	2.1

Layer Thickness (m)	Central Profile		Lower Profile		Upper Profile	
	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)
0.51	1250.6	2.1	1131.6	2.1	1382.1	2.1
0.51	1251.8	2.1	1132.6	2.1	1383.4	2.1
0.5	1253.3	2.1	1134.1	2.1	1385.2	2.1
0.51	1254.6	2.1	1135.2	2.1	1386.5	2.1
0.51	1256.3	2.1	1136.8	2.1	1388.5	2.1
0.51	1258.1	2.1	1138.4	2.1	1390.4	2.1
0.51	1260.1	2.1	1140.2	2.1	1392.7	2.1
0.5	1262.1	2.1	1142	2.1	1394.8	2.1
0.51	1263.9	2.1	1143.7	2.1	1396.9	2.1
0.51	1266.2	2.1	1145.7	2.1	1399.3	2.1
0.51	1268.7	2.1	1148	2.1	1402.1	2.1
0.51	1271	2.1	1150.1	2.1	1404.7	2.1
0.5	1273.5	2.1	1152.3	2.1	1407.5	2.1
0.51	1276	2.1	1154.6	2.1	1410.2	2.1
0.51	1277.9	2.1	1156.3	2.1	1412.2	2.1
0.51	1278.8	2.1	1157.1	2.1	1413.3	2.1
0.51	1280.7	2.1	1158.8	2.1	1415.4	2.1
0.5	1281.9	2.1	1159.9	2.1	1416.7	2.1
0.51	1282.6	2.1	1160.5	2.1	1417.5	2.1
0.51	1283.6	2.1	1161.4	2.1	1418.6	2.1
0.51	1284.3	2.1	1162.1	2.1	1419.4	2.1
0.51	1284.8	2.1	1162.5	2.1	1419.9	2.1
0.5	1285.4	2.1	1163.1	2.1	1420.6	2.1
0.51	1286.5	2.1	1164.1	2.1	1421.8	2.1
0.51	1287.5	2.1	1165	2.1	1422.9	2.1
0.51	1288.6	2.1	1166	2.1	1424.1	2.1
0.51	1289.4	2.1	1166.7	2.1	1425	2.1
0.5	1289.5	2.1	1166.8	2.1	1425.2	2.1
0.51	1289.8	2.1	1167.1	2.1	1425.4	2.1
0.51	1290.3	2.1	1167.5	2.1	1426	2.1
0.51	1290.5	2.1	1167.7	2.1	1426.2	2.1
0.51	1290.6	2.1	1167.8	2.1	1426.4	2.1
0.5	1290.8	2.1	1167.9	2.1	1426.5	2.1
0.51	1290.1	2.1	1167.3	2.1	1425.8	2.1
0.51	1289.3	2.1	1166.6	2.1	1424.9	2.1
0.51	1288.9	2.1	1166.3	2.1	1424.5	2.1
0.51	1289.2	2.1	1166.6	2.1	1424.8	2.1
0.5	1289.7	2.1	1167	2.1	1425.3	2.1
0.51	1290	2.1	1167.3	2.1	1425.7	2.1
0.51	1290	2.1	1167.2	2.1	1425.7	2.1

Layer Thickness (m)	Central Profile		Lower Profile		Upper Profile	
	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)
0.51	1290.1	2.1	1167.4	2.1	1425.8	2.1
0.51	1289.9	2.1	1167.1	2.1	1425.5	2.1
0.5	1289.8	2.1	1167.1	2.1	1425.5	2.1
0.51	1290.1	2.1	1167.3	2.1	1425.7	2.1
0.51	1290.4	2.1	1167.6	2.1	1426.1	2.1
0.51	1290.7	2.1	1167.8	2.1	1426.4	2.1
0.51	1291	2.1	1168.1	2.1	1426.8	2.1
0.5	1291.2	2.1	1168.3	2.1	1427	2.1
0.51	1291.6	2.1	1168.7	2.1	1427.4	2.1
0.51	1291.7	2.1	1168.8	2.1	1427.6	2.1
0.51	1291.6	2.1	1168.7	2.1	1427.4	2.1
0.51	1291.3	2.1	1168.4	2.1	1427.1	2.1
0.5	1292.4	2.1	1169.4	2.1	1428.4	2.1
15.03	1293	2.1	1170	2.1	1429	2.1
16.47	1320	2.1	1200	2.1	1460	2.1
30.48	1395	2.1	1262.3	2.1	1541.7	2.2
30.48	1497.6	2.1	1355.1	2.1	1655.1	2.2
30.48	1557.1	2.2	1408.9	2.1	1720.9	2.2
30.48	1682.6	2.2	1522.5	2.2	1859.6	2.2
30.48	1800.6	2.2	1629.3	2.2	1990	2.2
30.48	1881.3	2.2	1702.3	2.2	2079.2	2.2
30.48	1971.5	2.2	1783.9	2.2	2178.8	2.2
30.48	2011.3	2.2	1819.9	2.2	2222.8	2.2
30.48	2078.1	2.2	1880.3	2.2	2296.7	2.2
30.48	2078.1	2.2	1880.3	2.2	2296.7	2.2
30.48	2146.2	2.2	1942	2.2	2371.9	2.2
30.48	2146.2	2.2	1942	2.2	2371.9	2.2
30.48	2205.4	2.2	1995.5	2.2	2437.3	2.2
30.48	2205.4	2.2	1995.5	2.2	2437.3	2.2
30.48	2260.1	2.2	2045	2.2	2497.8	2.2
30.48	2260.1	2.2	2045	2.2	2497.8	2.2
30.48	2334.5	2.2	2112.3	2.2	2580	2.52
30.48	2334.5	2.2	2112.3	2.2	2580	2.52
30.48	2430.7	2.2	2199.4	2.2	2686.3	2.52
30.48	2430.7	2.2	2199.4	2.2	2686.3	2.52
30.48	2523.5	2.52	2283.4	2.2	2788.9	2.52
30.48	2523.5	2.52	2283.4	2.2	2788.9	2.52
30.48	2526.1	2.52	2285.7	2.2	2791.8	2.52
30.48	2526.1	2.52	2285.7	2.2	2791.8	2.52
30.48	2489.3	2.2	2252.4	2.2	2751.1	2.52

Layer Thickness (m)	Central Profile		Lower Profile		Upper Profile	
	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)
30.48	2489.3	2.2	2252.4	2.2	2751.1	2.52
30.48	2467	2.2	2232.2	2.2	2726.5	2.52
30.48	2467	2.2	2232.2	2.2	2726.5	2.52
30.48	2467.5	2.2	2232.7	2.2	2727	2.52
30.48	2467.5	2.2	2232.7	2.2	2727	2.52
30.48	2487.6	2.2	2250.9	2.2	2749.2	2.52
30.48	2487.6	2.2	2250.9	2.2	2749.2	2.52
30.48	2521.1	2.52	2281.2	2.2	2786.2	2.52
30.48	2521.1	2.52	2281.2	2.2	2786.2	2.52
30.48	2563.1	2.52	2319.2	2.2	2832.7	2.52
30.48	2563.1	2.52	2319.2	2.2	2832.7	2.52
30.48	2611.5	2.52	2363	2.2	2886.2	2.52
30.48	2611.5	2.52	2363	2.2	2886.2	2.52
30.48	2662.3	2.52	2408.9	2.2	2942.3	2.52
30.48	2662.3	2.52	2408.9	2.2	2942.3	2.52
30.48	2712	2.52	2453.9	2.2	2997.2	2.52
30.48	2712	2.52	2453.9	2.2	2997.2	2.52
30.48	2756	2.52	2493.7	2.2	3045.9	2.52
30.48	2756	2.52	2493.7	2.2	3045.9	2.52
30.48	2791.8	2.52	2526.1	2.52	3085.4	2.52
30.48	2791.8	2.52	2526.1	2.52	3085.4	2.52
30.48	2815.8	2.52	2547.8	2.52	3111.9	2.52
30.48	2815.8	2.52	2547.8	2.52	3111.9	2.52
30.48	2826.4	2.52	2557.4	2.52	3123.7	2.52
30.48	2826.4	2.52	2557.4	2.52	3123.7	2.52
30.48	2842.6	2.52	2572.1	2.52	3141.6	2.52
30.48	2842.6	2.52	2572.1	2.52	3141.6	2.52
30.48	2860.8	2.52	2588.6	2.52	3161.7	2.52
30.48	2860.8	2.52	2588.6	2.52	3161.7	2.52
30.48	2882.4	2.52	2608.1	2.52	3185.5	2.52
30.48	2882.4	2.52	2608.1	2.52	3185.5	2.52
30.48	2904	2.52	2627.6	2.52	3209.4	2.52
30.48	2904	2.52	2627.6	2.52	3209.4	2.52
30.48	2924.3	2.52	2646	2.52	3231.9	2.52
30.48	2924.3	2.52	2646	2.52	3231.9	2.52
30.48	2946.7	2.52	2666.3	2.52	3256.6	2.52
30.48	2946.7	2.52	2666.3	2.52	3256.6	2.52
30.48	2966.8	2.52	2684.5	2.52	3278.8	2.52
30.48	2966.8	2.52	2684.5	2.52	3278.8	2.52
30.48	2987.5	2.52	2703.2	2.52	3301.7	2.52

Layer Thickness (m)	Central Profile		Lower Profile		Upper Profile	
	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)	VS (m/s)	Density (gm/cm^3)
30.48	2987.5	2.52	2703.2	2.52	3301.7	2.52
30.48	3008	2.52	2721.8	2.52	3324.4	2.52
30.48	3008	2.52	2721.8	2.52	3324.4	2.52
30.48	3025.8	2.52	2737.9	2.52	3344	2.52
30.48	3025.8	2.52	2737.9	2.52	3344	2.52
30.48	3044.8	2.52	2755	2.52	3365	2.52
30.48	3044.8	2.52	2755	2.52	3365	2.52
30.48	3065.3	2.52	2773.6	2.52	3387.7	2.52
30.48	3065.3	2.52	2773.6	2.52	3387.7	2.52
30.48	3082.9	2.52	2789.5	2.52	3407.1	2.52
30.48	3082.9	2.52	2789.5	2.52	3407.1	2.52
30.48	3098.7	2.52	2803.8	2.52	3424.6	2.52
30.48	3098.7	2.52	2803.8	2.52	3424.6	2.52
30.48	3111.1	2.52	2815	2.52	3438.3	2.52
30.48	3111.1	2.52	2815	2.52	3438.3	2.52
30.48	3122.3	2.52	2825.2	2.52	3450.7	2.52
30.48	3122.3	2.52	2825.2	2.52	3450.7	2.52
30.48	3135.6	2.52	2837.2	2.52	3465.4	2.52
30.48	3135.6	2.52	2837.2	2.52	3465.4	2.52
30.48	3154	2.52	2853.9	2.52	3485.7	2.52
30.48	3154	2.52	2853.9	2.52	3485.7	2.52
30.48	3161	2.52	2860.2	2.52	3493.4	2.52
30.48	3161	2.52	2860.2	2.52	3493.4	2.52
1100	3161	2.52	2970	2.59	3500	2.75
1550	3161	2.52	3150	2.64	3500	2.75
2400	3320	2.69	3320	2.69	3500	2.75
110.281	3500	2.75	3500	2.75	3500	2.75

Table A-3 - Scale Factors Used to Develop the Lower and Upper VS Profiles

Layer Thickness (m)	Scale Factor for Lower Profile VS	Scale Factor for Upper Profile VS
0.51	0.789	1.268
0.51	0.790	1.266
0.5	0.791	1.264
0.51	0.786	1.272
0.51	0.790	1.265
0.51	0.791	1.264
0.51	0.782	1.278
0.5	0.772	1.295
0.51	0.759	1.317
0.51	0.750	1.334
0.51	0.750	1.333
0.51	0.741	1.349
0.5	0.733	1.365
0.51	0.726	1.378
0.51	0.720	1.390
0.51	0.715	1.399
0.51	0.714	1.400
0.5	0.720	1.390
0.51	0.728	1.373
0.51	0.738	1.355
0.51	0.752	1.330
0.51	0.765	1.306
0.5	0.771	1.298
0.51	0.770	1.298
0.51	0.769	1.300
0.51	0.769	1.301
0.51	0.770	1.299
0.5	0.774	1.293
0.51	0.778	1.285
0.51	0.782	1.279
0.51	0.785	1.273
0.51	0.789	1.268
0.5	0.792	1.263
0.51	0.795	1.258
0.51	0.798	1.253
0.51	0.801	1.248

Layer Thickness (m)	Scale Factor for Lower Profile VS	Scale Factor for Upper Profile VS
0.51	0.804	1.243
0.5	0.807	1.240
0.51	0.809	1.236
0.51	0.812	1.231
0.51	0.817	1.224
0.51	0.821	1.218
0.5	0.824	1.213
0.51	0.827	1.210
0.51	0.829	1.207
0.51	0.828	1.207
0.51	0.828	1.207
0.5	0.828	1.207
0.51	0.829	1.207
0.51	0.829	1.206
0.51	0.829	1.206
0.51	0.829	1.207
0.5	0.827	1.209
0.51	0.825	1.213
0.51	0.821	1.218
0.51	0.817	1.224
0.51	0.813	1.229
0.5	0.810	1.235
0.51	0.806	1.241
0.51	0.803	1.246
0.51	0.799	1.251
0.51	0.795	1.258
0.5	0.790	1.265
0.51	0.786	1.272
0.51	0.782	1.279
0.51	0.778	1.285
0.51	0.774	1.292
0.5	0.771	1.298
0.51	0.767	1.304
0.51	0.763	1.310
0.51	0.760	1.316
0.51	0.757	1.321
0.5	0.754	1.326
0.51	0.752	1.330

Layer Thickness (m)	Scale Factor for Lower Profile VS	Scale Factor for Upper Profile VS
0.51	0.749	1.335
0.51	0.747	1.339
0.51	0.746	1.341
0.5	0.744	1.344
0.51	0.743	1.346
0.51	0.741	1.349
0.51	0.740	1.351
0.51	0.739	1.354
0.5	0.737	1.357
0.51	0.736	1.358
0.51	0.736	1.359
0.51	0.736	1.359
0.51	0.737	1.357
0.5	0.739	1.353
0.51	0.742	1.348
0.51	0.745	1.342
0.51	0.751	1.332
0.51	0.757	1.322
0.5	0.762	1.312
0.51	0.768	1.302
0.51	0.774	1.291
0.51	0.781	1.280
0.51	0.787	1.270
0.5	0.794	1.259
0.51	0.800	1.249
0.51	0.807	1.240
0.51	0.813	1.231
0.51	0.818	1.222
0.5	0.823	1.214
0.51	0.828	1.207
0.51	0.834	1.199
0.51	0.838	1.193
0.51	0.843	1.186
0.5	0.847	1.180
0.51	0.851	1.175
0.51	0.855	1.170
0.51	0.859	1.164
0.51	0.863	1.159

Layer Thickness (m)	Scale Factor for Lower Profile VS	Scale Factor for Upper Profile VS
0.5	0.866	1.155
0.51	0.869	1.150
0.51	0.872	1.147
0.51	0.875	1.142
0.51	0.879	1.138
0.5	0.881	1.135
0.51	0.883	1.132
0.51	0.885	1.130
0.51	0.887	1.128
0.51	0.888	1.126
0.5	0.889	1.125
0.51	0.890	1.123
0.51	0.891	1.122
0.51	0.892	1.121
0.51	0.893	1.120
0.5	0.893	1.120
0.51	0.893	1.119
0.51	0.894	1.119
0.51	0.894	1.119
0.51	0.894	1.119
0.5	0.895	1.118
0.51	0.895	1.117
0.51	0.896	1.116
0.51	0.897	1.115
0.51	0.898	1.114
0.5	0.898	1.113
0.51	0.899	1.112
0.51	0.900	1.111
0.51	0.901	1.110
0.51	0.902	1.109
0.5	0.903	1.107
0.51	0.904	1.106
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105

Layer Thickness (m)	Scale Factor for Lower Profile VS	Scale Factor for Upper Profile VS
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105

Layer Thickness (m)	Scale Factor for Lower Profile VS	Scale Factor for Upper Profile VS
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
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0.51	0.905	1.105
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0.51	0.905	1.105
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0.51	0.905	1.105
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0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105

Layer Thickness (m)	Scale Factor for Lower Profile VS	Scale Factor for Upper Profile VS
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.51	0.905	1.105
0.5	0.905	1.105
15.03	0.905	1.105
16.47	0.909	1.106
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105

Layer Thickness (m)	Scale Factor for Lower Profile VS	Scale Factor for Upper Profile VS
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
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30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
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30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105

Layer Thickness (m)	Scale Factor for Lower Profile VS	Scale Factor for Upper Profile VS
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
30.48	0.905	1.105
1100	0.940	1.107
1550	0.997	1.107

Layer Thickness (m)	Scale Factor for Lower Profile VS	Scale Factor for Upper Profile VS
2400	1.000	1.054
110.281	1.000	1.000

A2. Comparison of May 2015 and November 2015 Velocity Models

The November 2015 supplemental report on the Fugro 3-D velocity model (Reference 12) provides an update the May 2015 3-D velocity model (Reference 4) in response to the peer review comments. Using the same selection of locations for the plant region (Figure 2-1), the November 2015 velocity profiles are plotted in Figure A-1 along with the central, upper, and lower profiles described in Section 2.2.

At depths below 15 m, the central profile is consistent with the geometric mean of the VS profiles from the November 2015 model. At shallower depths, the geometric mean from the November 2015 model leads to VS values that are 5 to 10 percent higher than for the central profile. The VS30 for the geometric mean for the November 2015 model is 1006 m/s compared to 968 m/s for the central profile. This increase in VS would lead to a small decrease (about 1-2 percent) in the high-frequency GMRS from the change in the impedance contrast; however, it would also lead to slightly reduced nonlinearity of the amplification, which could increase the high-frequency GMRS slightly, as discussed below.

To estimate the potential effect due to reduced nonlinearity, the mean amplification in the linear range can be compared to the mean amplification at the 1E-4 hazard level. Figure 3-7 shows the analytical amplification in the linear range and Figure 3-8 shows the analytical amplification at the 1E-4 hazard level, which control the GMRS for DCPP. Comparing the mean amplification for 0.2 g and 1.07 g shows that the nonlinearity leads to 5 to 10 percent reduction in the amplification at 10 Hz. Assuming that the logarithm of the change in nonlinear amplification is proportional to the logarithm of the change in the shallow velocity, then a 10 percent increase in the shallow VS would lead to about 1 percent increase in the nonlinear amplification at 10 Hz. Given that the linear model (M1) is given 0.5 weight in the logic tree and the analytical model is given 1/3 weight, the effect on the GMRS at high frequencies would be less than 1 percent.

The change in the impedance contrast and the reduced nonlinearity have opposite effects on the high-frequency hazard. The combined effects of the reduced impedance contrast and the reduced nonlinearity is expected to lead to a small reduction (less than 1 percent) in the GMRS at high frequencies.

The velocity model also affects the empirical site term due to VS30 scaling used to adjust the ground motions recorded at ESTA27 and ESTA28 to the control point VS30. A comparison of the VS30 values based on the May and November velocity models is given in Table A-4. For ESTA27, the VS30 values are very similar. For ESTA28, the November VS30 values are about 2.5 percent smaller than the May VS30 values. For the control point, the November VS30 values are 4 percent higher than the May values. With the small decrease in the VS30 for ESTA28 and the small increase in the VS30 for the control point, there would be a small (less than 2 percent at any frequency) decrease in the adjustment factor (from ESTA27 and ESTA28 to the control point), leading a small decrease in the GMRS compared to the values listed in Table 6-1. Therefore, the use of the May velocity model is conservative relative to the November velocity model for the development of the GMRS.

Table A-4. VS30 Values

Station	May 2015	Nov. 2015
ESTA27	852 m/s	856 m/s
ESTA28	797 m/s	777 m/s
Control Point	968 m/s	1006 m/s

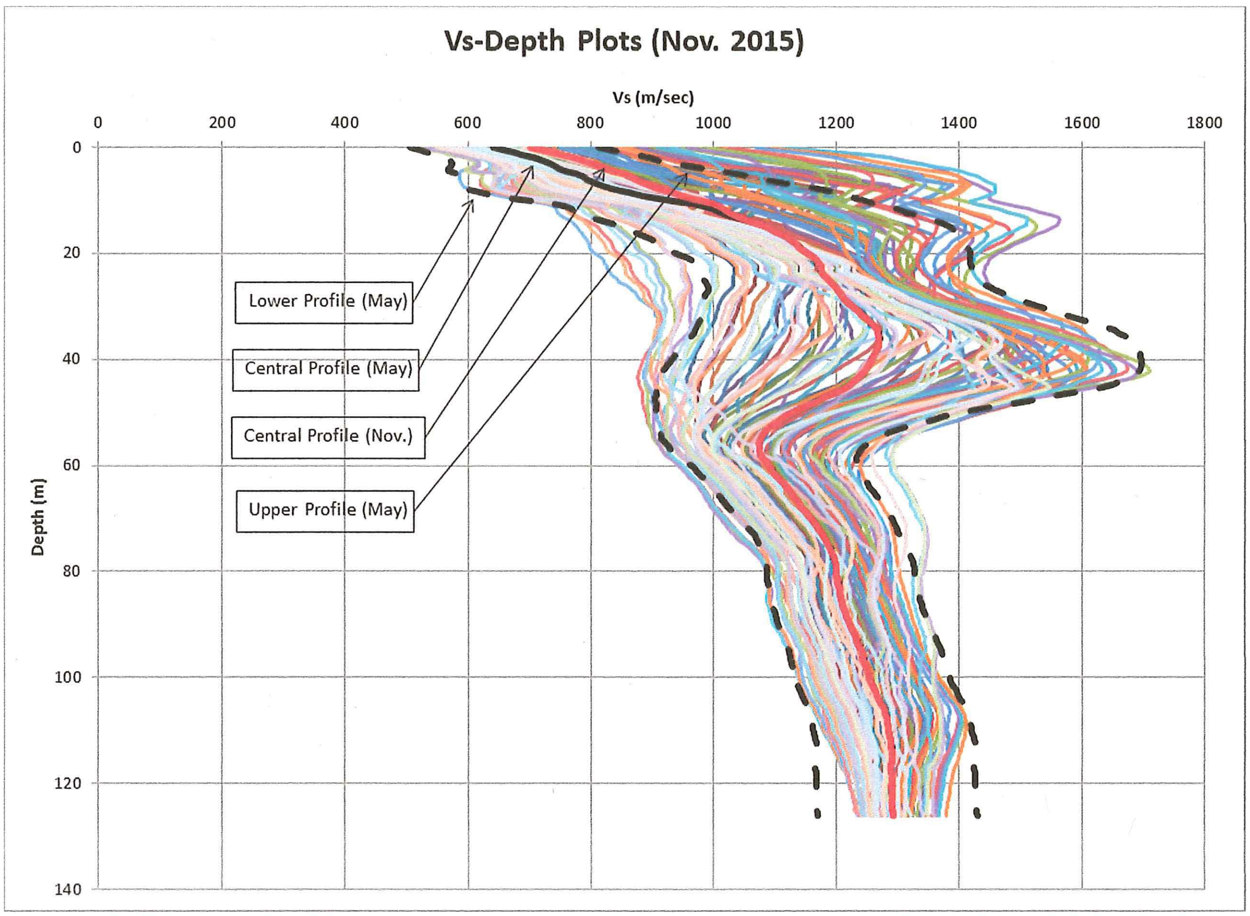

Figure A-1 - Comparison of the November 2015 Velocity Profiles for the Plant Region with the Selected Central, Upper, and Lower Velocity Profiles

Appendix B

Hazard for the Reference Rock Site Condition Tables

Table B-1 - Interpolated Hazard for the Reference Rock Site Condition
(T=0.01 sec. to T=0.085 sec.)
(From Reference 9)

PSA (g)	T=0.01	T=0.02	T=0.025	T=0.03	T=0.040	T=0.05	T=0.060	T=0.075	T=0.085
0.01	2.21E-01	2.24E-01	2.31E-01	2.37E-01	2.52E-01	2.64E-01	2.80E-01	3.01E-01	3.12E-01
0.05	3.31E-02	3.38E-02	3.59E-02	3.76E-02	4.32E-02	4.82E-02	5.45E-02	6.28E-02	6.73E-02
0.1	1.28E-02	1.32E-02	1.42E-02	1.51E-02	1.77E-02	2.01E-02	2.30E-02	2.68E-02	2.87E-02
0.2	4.50E-03	4.70E-03	5.12E-03	5.48E-03	6.55E-03	7.57E-03	8.86E-03	1.07E-02	1.14E-02
0.4	1.42E-03	1.53E-03	1.68E-03	1.82E-03	2.24E-03	2.64E-03	3.15E-03	3.86E-03	4.18E-03
0.8	2.72E-04	3.06E-04	3.55E-04	3.98E-04	5.51E-04	7.17E-04	9.04E-04	1.18E-03	1.32E-03
1.5	3.21E-05	3.79E-05	4.65E-05	5.45E-05	8.79E-05	1.29E-04	1.78E-04	2.58E-04	3.02E-04
2.0	1.04E-05	1.25E-05	1.56E-05	1.86E-05	3.18E-05	4.89E-05	6.98E-05	1.06E-04	1.27E-04
3.0	1.84E-06	2.27E-06	2.92E-06	3.57E-06	6.52E-06	1.06E-05	1.58E-05	2.51E-05	3.12E-05
5.0	1.68E-07	2.13E-07	2.85E-07	3.59E-07	7.12E-07	1.24E-06	1.93E-06	3.23E-06	4.15E-06
10	4.30E-09	5.72E-09	8.10E-09	1.06E-08	2.38E-08	4.56E-08	7.52E-08	1.35E-07	1.82E-07

Table B-1 (continued) - Interpolated Hazard for the Reference Rock Site Condition
(T=0.10 sec. to T=0.30 sec.)

PSA (g)	T=0.1	T=0.12	T=0.15	T=0.17	T=0.2	T=0.22	T=0.25	T=0.27	T=0.3
0.01	3.27E-01	3.38E-01	3.50E-01	3.55E-01	3.62E-01	3.62E-01	3.62E-01	3.60E-01	3.57E-01
0.05	7.36E-02	7.81E-02	8.38E-02	8.41E-02	8.43E-02	8.18E-02	7.94E-02	7.66E-02	7.27E-02
0.1	3.13E-02	3.31E-02	3.53E-02	3.50E-02	3.46E-02	3.30E-02	3.15E-02	3.00E-02	2.78E-02
0.2	1.25E-02	1.32E-02	1.41E-02	1.38E-02	1.34E-02	1.25E-02	1.17E-02	1.10E-02	9.91E-03
0.4	4.62E-03	4.89E-03	5.25E-03	5.06E-03	4.83E-03	4.44E-03	4.09E-03	3.76E-03	3.32E-03
0.8	1.51E-03	1.63E-03	1.79E-03	1.72E-03	1.63E-03	1.46E-03	1.32E-03	1.17E-03	9.87E-04
1.5	3.70E-04	4.21E-04	4.91E-04	4.67E-04	4.38E-04	3.77E-04	3.25E-04	2.72E-04	2.11E-04
2	1.61E-04	1.88E-04	2.26E-04	2.14E-04	2.00E-04	1.68E-04	1.42E-04	1.16E-04	8.63E-05
3	4.11E-05	4.95E-05	6.18E-05	5.83E-05	5.41E-05	4.42E-05	3.63E-05	2.89E-05	2.07E-05
5	5.72E-06	7.09E-06	9.17E-06	8.64E-06	8.00E-06	6.34E-06	5.06E-06	3.93E-06	2.71E-06
10	2.67E-07	3.42E-07	4.60E-07	4.33E-07	4.01E-07	3.06E-07	2.34E-07	1.77E-07	1.17E-07

Table B-1 (continued) - Interpolated Hazard for the Reference Rock Site Condition
(T=0.355 sec. to T=1.26 sec.)

PSA (g)	T=0.355	T=0.40	T=0.45	T=0.5	T=0.60	T=0.75	T=0.85	T=1.00	T=1.26
0.01	3.45E-01	3.36E-01	3.23E-01	3.10E-01	2.72E-01	2.33E-01	2.01E-01	1.66E-01	1.19E-01
0.05	6.42E-02	5.87E-02	5.26E-02	4.70E-02	3.64E-02	2.70E-02	2.14E-02	1.59E-02	1.04E-02
0.1	2.39E-02	2.15E-02	1.89E-02	1.66E-02	1.24E-02	8.85E-03	6.91E-03	5.04E-03	3.19E-03
0.2	8.26E-03	7.26E-03	6.26E-03	5.38E-03	3.95E-03	2.75E-03	2.17E-03	1.60E-03	9.70E-04
0.4	2.69E-03	2.32E-03	1.99E-03	1.70E-03	1.22E-03	8.23E-04	6.30E-04	4.48E-04	2.41E-04
0.8	7.53E-04	6.21E-04	5.09E-04	4.16E-04	2.79E-04	1.75E-04	1.24E-04	8.00E-05	3.72E-05
1.5	1.51E-04	1.19E-04	9.08E-05	6.89E-05	4.45E-05	2.67E-05	1.76E-05	1.04E-05	4.31E-06
2	6.09E-05	4.75E-05	3.51E-05	2.57E-05	1.64E-05	9.72E-06	6.26E-06	3.57E-06	1.41E-06
3	1.46E-05	1.13E-05	7.95E-06	5.54E-06	3.50E-06	2.04E-06	1.27E-06	6.95E-07	2.56E-07
5	1.92E-06	1.50E-06	9.86E-07	6.43E-07	4.00E-07	2.30E-07	1.38E-07	7.16E-08	2.42E-08
10	8.44E-08	6.70E-08	3.97E-08	2.33E-08	1.43E-08	8.08E-09	4.60E-09	2.24E-09	6.68E-10

Table B-1 (continued) - Interpolated Hazard for the Reference Rock Site Condition
(T=1.5 sec. to T=3.0 sec.)

PSA (g)	T=1.5	T=1.74	T=2.0	T=2.5	T=3.0
0.01	9.18E-02	7.10E-02	5.56E-02	3.74E-02	2.74E-02
0.05	7.51E-03	5.61E-03	4.24E-03	2.59E-03	1.75E-03
0.1	2.26E-03	1.63E-03	1.19E-03	6.51E-04	4.05E-04
0.2	6.63E-04	4.35E-04	2.90E-04	1.33E-04	7.22E-05
0.4	1.50E-04	8.65E-05	5.11E-05	1.89E-05	8.66E-06
0.8	2.08E-05	1.10E-05	5.95E-06	1.75E-06	6.72E-07
1.5	2.20E-06	1.11E-06	5.83E-07	1.41E-07	4.65E-08
2	6.93E-07	3.47E-07	1.80E-07	3.99E-08	1.22E-08
3	1.20E-07	5.95E-08	3.05E-08	5.95E-09	1.65E-09
5	1.06E-08	5.25E-09	2.68E-09	4.39E-10	1.06E-10
10	2.66E-10	1.32E-10	6.79E-11	8.37E-12	1.62E-12