PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
TECHNICAL REPORT

Report Number: GEO. DCPP.TR.14.06
Report Revision: 0
Report Date: 8/6/2014
Quality Related: Y


REPORT TITLE: Site Conditions Evaluation

SIGNATORIES

PREPARED BY: [signature] DATE: 8/6/2014

Norman Abrahamson — PG&E
Printed Name — Organization

VERIFIED BY: [signature] DATE: 08/08/2014

Kathryn Wooddell — PG&E
Printed Name — Organization

APPROVED BY: [signature] DATE: 09/10/2014

Richard Klimczak — PG&E - Geosciences
Printed Name — Organization

## RECORD OF REVISIONS

| Rev. No. | Reason for Revision | Revision Date |
|---|---|---|
| 0 | Initial Report - this work is being tracked under Notification SAPN 50638425-1 | 8/6/2014 |
| | | |
| | | |
| | | |
| | | |
| | | |

# TABLE OF CONTENTS

**Page**

# LISTS OF TABLES AND FIGURES

## Tables



## Figures

# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| 1D | one-dimensional |
| 3D | three-dimensional |
| DCPP | Diablo Canyon Power Plant |
| GMPE | ground-motion-prediction equation |
| Hz | hertz |
| km | kilometer |
| m | meter |
| m/s | meters per second |
| NGA | Next Generation Attenuation |
| NRC | U.S. Nuclear Regulatory Commssion |
| PEER | Pacific Earthquake Engineering Research Center |
| RIL | Research Information Letter |
| SSHAC | Senior Seismic Hazard Analysis Committee |
| SWUS | Southwestern United States |
| $V_S$ | shear-wave velocity |
| $V_{S30}$ | shear-wave velocity for the top 30 m |
| $Z_1$ | depth to $V_S$ = 1.0 km/s |

# 1.0 INTRODUCTION

As part of the onshore geophysical studies, new information was collected related to the site conditions at the Diablo Canyon Power Plant (DCPP). PGEQ-PR-16 of this Central Coastal California Seismic Imaging Project Report, *DCPP P- and S-Wave Foundation Velocity Model* (Report PGEQ-PR-16; Fugro, 2014), describes the shear-wave-velocity ($V_S$) profiles estimated in the DCPP site region. As described in Report PGEQ-PR-16, there is large variability of the $V_{S30}$ over the DCPP region. The $V_S$ profile is parameterized by the shear-wave velocity in the top 30 meters (m), called $V_{S30}$. The average $V_{S30}$ values for the power-block foundation level and the turbine-building foundation level are 1,260 meters per second (m/s) and 980 m/s, respectively. The two free-field strong-motion recording sites (called ESTA27 and ESTA28) at the DCPP have $V_{S30}$ values of 570 m/s and 753 m/s (Report GEO.DCPP.TR14.08; PG&E, 2014).

As discussed in the 2011 Shoreline Fault Zone Report (PG&E, 2011), based on the available site information at the time. the average $V_S$ profile for the rock type under the power block and turbine building was used for the DCPP region. At the free-field strong-motion site elevation of 85 feet (ft), the $V_{S30}$ was estimated to be 1100 m/s, and for the power-block foundation level, embedded at elevation 53 ft, the $V_{S30}$ was estimated to be 1200 m/s. The $V_{S30}$ for the foundation level of the turbine building was assumed to be the same as that of the power block. The comparison of the $V_{S30}$ values from the 2011 Shoreline Fault Zone Report and the PGEQ-PR-16 report is shown in Table 1-1. This Table also includes the depth to a shear-wave velocity of 1 km/s, called $Z_1$.

**Table 1-1. Comparison of the $V_{S30}$ Values from the 2011 Shoreline Fault Zone Report with the $V_{S30}$ and $Z_1$ values from the PGEQ-PR-16 Report**

| | 2011 Shoreline Report | PGEQ-PR-16 | |
|---|---|---|---|
| Site | Average $V_{S30}$ (m/s) | Average $V_{S30}$ (m/s) | Average $Z_1$ (m) |
| Power Block Foundation (elev. 53 ft) | 1200 | 1260 ± 100 | 0 |
| Turbine Building Foundation (elev. 62 ft) | 1200 | 980 ± 100 | 15 |
| Free-Field Ground-Motion Sites (elev. 85 ft) | 1,100 | 570 (ESTA27)<br>753 (ESTA28) | 32 (ESTA27)<br>65* (ESTA28) |

* Due to a velocity reversal, there are three depths at which the $V_S$ is equal to 1 km/s. The deepest $Z_1$ is used as the deeper depth affects the low frequency amplification.

In addition to the new information on the shear-wave-velocity profiles, there are also new models for the ground-motion-prediction equations (GMPEs). The 2011 Shoreline Fault Zone Report used the five 2008 Next Generation Attenuation (NGA) GMPEs (now called NGA-West1), as follows:

- Abrahamson and Silva (2008)

- Boore and Atkinson (2008)
- Campbell and Bozorgnia (2008)
- Chiou and Youngs (2008)
- Idriss (2008)

These models were all recently updated as part of a study by the Pacific Earthquake Engineering Research (PEER) Center. The updated GMPEs, listed below, are called NGA-West2:

- Abrahamson et al. (2014)
- Boore et al. (2014)
- Campbell and Bozorgnia (2014)
- Chiou and Youngs (2014)
- Idriss (2014)

The Idriss (2014) model is not used for computing the residuals because, although it has some VS30 scaling, its application is limited to rock sites whereas most of the empirical data are recorded on soil sites.

Because the empirical site response is measured relative to the ground motion for a reference rock condition, a change in the GMPEs used to define the reference rock will also affect the evaluation of the site response. A complete evaluation of the new NGA-West2 GMPEs is being conducted as part of the Southwestern United States (SWUS) SSHAC[1] ground-motion study.

This report describes the computation of site amplification for the power block and turbine building using the new shear-wave-velocity profiles and the new NGA-West2 GMPEs. This study was conducted under PG&E DCPP QA program, as required by 10CFR appendix B.

---

[1] Senior Seismic Hazard Analysis Committee.

## 2.0 SITE RESPONSE METHODOLOGY

Several different methodologies can be used to estimate the site response amplification. The four main approaches are listed in Table 2-1. The 2011 Shoreline Fault Zone Report (PG&E, 2011) used analytical generic models to first adjust a reference rock condition of $V_{S30}$ = 760 m/s from the GMPEs to $V_{S30}$ = 1,100 m/s for the free-field site. Next, taking advantage of the availability of recorded ground motions at the DCPP, the empirical site-specific approach was used to develop site-specific site factors relative to $V_{S30}$ = 1,100 m/s. Finally, the analytical generic method was used to develop factors to adjust from elevation 85 ft ($V_{S30}$ = 1,100 m/s) to the power-block foundation elevation 53 ft ($V_{S30}$ = 1200 m/s).

**Table 2-1. Site Response Methodologies**

| Method | Description |
|---|---|
| Empirical Generic | Uses simple generic site factors, such as the $V_{S30}$ and $Z_1$ scaling given in GMPEs. |
| Empirical Site-Specific | Uses recordings of ground motion at the site relative to a reference rock motion from GMPEs. |
| Analytical Generic | Uses existing analytical modeling of the site response for generic site profiles for a given $V_{S30}$ and soil depth. |
| Analytical Site-Specific | Uses analytical modeling of the site response for the site-specific profile. |

For the evaluation in this report, the site response methodology used in the 2011 Shoreline Fault Zone Report is applied with the following changes: the empirical site-specific factors for free-field station ESTA28 are developed relative to the reference rock condition ($V_{S30}$ = 760 m/s) and then the analytical method is used to develop factors to adjust from the ESTA28 site condition at elevation 85 ft ($V_{S30}$ of 750 m/s) to the power-block foundation level (elevation 53 ft) with $V_{S30}$ = 1,260 m/s and to the turbine-building foundation level (elevation 62 ft) with $V_{S30}$ = 980 m/s.

Alternative approaches to site response, including three-dimensional (3D) analytical modeling using the site-specific 3D shallow velocity structure are being addressed as part of the NRC-required hazard evaluation update for the DCPP that is due in March 2015. The 3D site-response modeling requires some calibration with the available recorded ground motions. In particular, the two free-field recordings from the 2004 Parkfield earthquake provide information on different site conditions that can be used to test the analytical modeling.

Site-specific empirical ground-motion data provide the best information on the site response because they sample the actual conditions at the DCPP. In particular, the data provide a better representation of the effects of the deeper structure (top 0.5–1 kilometer [km]) that are important to the kappa and to the low-frequency response. A disadvantage of using site-specific empirical data is the limited number of recordings; however, estimating the epistemic uncertainty in the site response factors addresses this limitation. In the 2011 Shoreline Fault Zone Report, this additional epistemic uncertainty was incorporated into the aleatory standard deviation of the ground-motion model. When used in a deterministic analysis, this approach of combining the epistemic uncertainty of the site response with the aleatory variability of the rock ground motion has the advantage that, for the case in which there are no site-specific ground motions available, the 84th percentile ground motion becomes equal to the ergodic approach.

In the current evaluation, the epistemic uncertainty is incorporated in the standard deviation for the deterministic ground-motion calculations, but the epistemic uncertainty is also shown in terms of the site amplification for later use as a logic tree in the probabilistic analyses. This also has the advantage of making the treatment of the site term epistemic uncertainty more transparent to the reader.

# 3.0 SITE TERM CALCULATION

There are two parts to the site terms. The first is an empirical site-specific site term for the free-field strong-motion sites relative to a reference rock ground-motion model. This term accounts for the differences in the observed ground motions at the DCPP and the global GMPE. The second is a term to account for the differences between shallow $V_S$ profiles at the free-field strong-motion sites and the shallow $V_S$ profiles for the power-block and turbine-building foundation levels. These two terms are described in sections 3.1 and 3.2 below.

## 3.1 Empirical Site-Specific Site Term

Following the methodology described in the 2011 Shoreline Fault Zone Report (PG&E, 2011), the free-field recordings at the DCPP are used to estimate the site-specific effects on the ground motions relative to the reference rock GMPEs. Ground motions from the 2003 San Simeon and 2004 Parkfield earthquakes were selected for use in this evaluation. The recording from the 2003 Deer Canyon earthquake is not used in this evaluation because the source and attenuation effects could not be reliably removed: there were not enough recordings at short distances to constrain the path and event terms at short disances. If additional modeling of this event leads to constraints on the source and attenuation effects, then this recording will be incorporated into the March 2015 evaluation.

The ground motions at a site from a given earthquake reflect the event-specific source and attenuation effects in addition to the site-specific site effects. To isolate the site effects, the differences in the event-specific source and event-specific attenuation effects from the average effects captured in the GMPEs are removed. This is done by computing the mean residual at each spectral frequency over a subset of recorded ground motions from a representative distance range and then developing a source-specific estimate of the ground motion at the DCPP by adding the the mean residual to the median ground motion from each of the GMPEs. To avoid having the DCPP site effects influence the correction, the mean residual is computed without the DCPP data.

The mean residuals are computed for each of the five NGA-West2 GMPEs. Following the method used in the 2011 Shoreline fault report, the residuals are computed for distance ranges of 0–100 km for the San Simeon earthquake and for distances of 50–150 km for the Parkfield earthquake to capture the event term in the relevant distance ranges (35 km for San Simeon and 85 km for Parkfield). This mean residual is used to adjust the NGA-West2 GMPEs to the event-specific values. The residuals of the free-field spectral accelerations recorded at the DCPP are computed with respect to the event-specific spectral accelerations.

The 2003 San Simeon earthquake was recorded at one free-field station at the DCPP: ESTA27 (shown on Figure 3-1). Following the San Simeon earthquake, additional seismic instrumentation was installed, including an additional free-field station: ESTA28 (shown on Figure 3-1). The 2004 Parkfield earthquake has two free-field recordings. Station ESTA27 is located close to $V_S$ profiles A1200 and B1200, and station ESTA28 is located close to $V_S$ profile A100 (see Fugro, 2014).

A comparison of the shear-wave-velocity profiles for the two free-field sites and the power-block and turbine-building foundation levels is shown on Figure 3-2. The velocity profile for ESTA28 becomes similar to the power block and turbine building profiles at depths of about 100 m. Therefore, the main difference between the profile for the free-field station ESTA28 and the profiles for the power-block and turbine-building foundation levels is in the shallow part of the profile. The profile for free-field station ESTA27 shows a different gradient and does not merge with the power block and turbine building profiles at depth as seen with the profile for ESTA28. Because the profile at station ESTA28 is more consistent with the power block and turbine building profiles at depth, this station is selected as the reference free-field site. To account for the average effect of the $V_{S30}$ at ESTA27 (570 m/s) being lower than at ESTA28 (753 m/s), the ground motion recorded at ESTA27 is adjusted for the expected difference using the $V_{S30}$ scaling given in the NGA-West2 GMPEs. This factor is shown on Figure 3-3. While the $V_{S30}$ scaling for hard rock in the GMPEs was not considered reliable, the $V_{S30}$ scaling in the GMPEs is reliable in this $V_{S30}$ range (570–750 m/s).

The residuals for the two free-field recordings were computed for each of the four NGA-West2 models for a reference rock with $V_{S30}$ = 760 m/s. The average residuals over the five GMPEs are shown on Figure 3-4. Overall, the frequency-dependent residuals are consistent between the two recordings over most of the frequency range, but there is a large difference at 0.5 hertz (Hz). In particular, the San Simeon residuals are much larger. Examination of the ESTA27 time histories from this earthquake show that the 0.5 Hz ground motion is coming from late-arriving surface waves, indicating different path effects for these two earthquakes. This is not seen in the Parkfield recordings at either ESTA27 or ESTA28, so it likely due to different path effects.

A smoothed site term is developed by smoothing the average site term shown in Figure 3-4. The smoothing follows the average residual at the high frequencies, but as the mean is not well constrained at low frequencies and it is close to zero, an average site term value of zero is used at frequencies less than or equal to 1 Hz, reflecting that the site term is not as well resolved due to apparent path effects.

The epistemic uncertainty in the DCPP site term is computed using the standard deviation of the site terms from worldwide data sets, divided by $\sqrt{N}$, where $N$ is the number of recordings. The standard error of the DCPP site term is listed in Table 3-1. To capture the uncertainty, a simple three-point logic tree is used with ±1.64 times the standard deviation, as is typically used for a three-point distribution.

**Table 3-1. DCPP Site-Specific Site Amplification Terms for Reference Free-Field**

| Frequency (Hz) | DCPP Site Term for Reference Free-Field Station ESTA28 (natural log units) | | | |
|---|---|---|---|---|
| | Standard Deviation of DCPP Site Term | Median | Upper Range | Lower Range |
| 100 | 0.200 | -0.300 | 0.028 | -0.628 |
| 50 | 0.199 | -0.320 | 0.006 | -0.646 |
| 34 | 0.201 | -0.360 | -0.030 | -0.690 |
| 20 | 0.205 | -0.520 | -0.184 | -0.856 |
| 13.5 | 0.209 | -0.520 | -0.178 | -0.862 |
| 10 | 0.211 | -0.520 | -0.174 | -0.866 |
| 6.7 | 0.212 | -0.500 | -0.152 | -0.848 |
| 5 | 0.214 | -0.380 | -0.028 | -0.732 |
| 4 | 0.214 | -0.240 | 0.112 | -0.592 |
| 3.3 | 0.216 | -0.130 | 0.224 | -0.484 |
| 2.5 | 0.217 | 0.190 | 0.546 | -0.166 |
| 2 | 0.219 | 0.190 | 0.549 | -0.169 |
| 1.3 | 0.222 | 0.190 | 0.555 | -0.175 |
| 1 | 0.227 | 0.000 | 0.372 | -0.372 |
| 0.67 | 0.230 | 0.000 | 0.378 | -0.378 |
| 0.5 | 0.233 | 0.000 | 0.383 | -0.383 |

## 3.2 Adjustments to Power Block and Turbine Building

Average $V_S$ profiles for the power-block and turbine-building foundation levels were computed. For the power block, the average was computed using profiles A400 through A800, C400 through C600, and D400 through D600 (see Fugro, 2014). For the turbine building, the average was computed using profiles B200 through B1000, C200 through C400, and D200 through D400. The average $V_S$ profiles are shown on Figure 3-2. The profiles closest to the two free-field sites (profile A100 for ESTA28 and profiles A1200 and B1200 for ESTA27) are also shown on Figure 3-2.

The effect of these differences in the $V_S$ profiles can evaluated using analytical modeling of the site response. Report PGEQ-PR-16 shows that there is large variability in the velocity profiles in the DCPP site region. 3D site-response analyses are currently being conducted and the results will be included in the March 2015 results. As noted previously, the recordings at two free-field sites with different $V_S$ profiles will provide an opportunity to check the 3D analytical model results.

As part of the review of the 2011 Shoreline Fault Zone Report, the U.S. Nuclear Regulatory Commission (NRC) developed analytical amplification factors, from a generic shallow site with $V_{S30}$ = 760 m/s to the power block foundation with $V_{S30}$ = 1200 m/s (NRC, 2012). The amplification was developed for the profiles shown on Figure 3-6. This figure shows that the the difference in the profiles is only at the shallow depths, similar to the differences between the profiles for ESTA28 and the power block foundation shown on Figure 3-2 (750–1260 m/s), indicating that the model used by the NRC is applicable to the amplification from ESTA28 to the power block foundation, with the exception that the amplification at low frequencies may be different as discussed below. The effect of differences in the $V_{S30}$ for the power block foundation based on the new information (1260 m/s) and the $V_{S30}$ used for the power block (1200 m/s) in the NRC's Research Information Letter (RIL 12-01; NRC, 2012) will be small and is not considered. The amplification given in RIL 12-01 is shown on Figure 3-5.

Comparing the profiles for ESTA28 and the reference $V_{S30}$ = 760 m/s profiles used in RIL 12-01 shows there is a difference in the $Z_1$ values: for the $V_{S30}$ = 560 profile used in RIL 12-01, $Z_1$ = 32 m; for station ESTA28, $Z_1$ = 68 m (see Figure 3-6). To correct for this difference in $Z_1$ values, a simplified approach is used based on the $Z_1$ scaling in existing site-amplification calculations by Kamai et al. (2013) described in PG&E (2014). Kamai et al. (2013) do not include $Z_1$ scaling between 32 m and 68 m for 760 m/s, but they do include $Z_1$ scaling spanning this depth range for $V_{S30}$ = 560. The low-frequency $Z_1$ scaling for shallow soil sites with $V_{S30}$ = 560 is assumed to be similar to the low-frequency $Z_1$ scaling for shallow soil sites with $V_{S30}$ = 750 m/s. The effects of this $Z_1$ scaling factor on the amplification given in RIL 12-01 are shown on Figure 3-7. The amplification is smoothed as shown on Figure 3-7, and the values are listed in Table 3-2.

The velocity profiles for the turbine-building foundation level has a $V_{S30}$ of 980 m/s and lies about midway between the profiles for the ESTA28 and the power block. The amplication for the turbine building is estimated by linear interpolation on a log scale for a $V_{S30}$ value between 760 and 1200 m/s. This is consistent with the form of the amplification used in empirical ground-motion model and is reasonable there is not a strong impedance contrast in the shallow layers. The resulting amplification from the reference free-field station ESTA28 to the turbine building is also listed in Table 3-2.

The total site-specific amplification for the power block with respect to the NGA-West2 models for a reference rock site condition of $V_{S30}$ = 760 m/s is the sum of the DCPP site term for ESTA28 and the amplification from ESTA28 to the power block (both in LN units). The total amplification is given in Table 3-3.

**Table 3-2. Site Amplification from Reference Free-Field Station ESTA28 to the Power-Block and Turbine-Building Foundation Levels**

| Frequency (Hz) | Amplification in Natural Log Units | |
|---|---|---|
| | Power Block Foundation | Turbine Building Foundation |
| 100 | -0.206 | -0.116 |
| 50 | -0.200 | -0.113 |
| 34 | -0.186 | -0.105 |
| 20 | -0.186 | -0.105 |
| 13.5 | -0.198 | -0.111 |
| 10 | -0.231 | -0.130 |
| 6.7 | -0.285 | -0.160 |
| 5 | -0.324 | -0.182 |
| 4 | -0.311 | -0.175 |
| 3.3 | -0.290 | -0.163 |
| 2.5 | -0.205 | -0.115 |
| 2 | -0.170 | -0.096 |
| 1.3 | -0.125 | -0.070 |
| 1 | -0.099 | -0.056 |
| 0.67 | -0.060 | -0.034 |
| 0.5 | -0.046 | -0.026 |

**Table 3-3. Total Site-Specific Amplification from the NGA-West2 GMPEs for a Reference Site with $V_{S30}$ = 760 m/s to the Power-Block and Turbine-Building Foundation Levels**

| Frequency (Hz) | Amplification (Natural Log Units) | | |
|---|---|---|---|
| | Power Block Foundation | Turbine Building Foundation | Epistemic Uncertainty (One Standard Deviation) |
| 100 | -0.506 | -0.416 | 0.200 |
| 50 | -0.520 | -0.433 | 0.199 |
| 34 | -0.546 | -0.465 | 0.201 |
| 20 | -0.706 | -0.625 | 0.205 |
| 13.5 | -0.718 | -0.631 | 0.209 |
| 10 | -0.751 | -0.650 | 0.211 |
| 6.7 | -0.785 | -0.660 | 0.212 |
| 5 | -0.704 | -0.562 | 0.214 |
| 4 | -0.551 | -0.415 | 0.214 |
| 3.3 | -0.420 | -0.293 | 0.216 |
| 2.5 | -0.015 | 0.075 | 0.217 |
| 2 | 0.020 | 0.094 | 0.219 |
| 1.3 | 0.065 | 0.120 | 0.222 |
| 1 | -0.049 | -0.006 | 0.227 |
| 0.67 | -0.010 | 0.016 | 0.230 |
| 0.5 | 0.004 | 0.024 | 0.233 |

## 4.0 LIMITATIONS AND IMPACT EVALUATIONS

The amplification factors developed in this calculation are based on simplified methods using existing site response results. A full set of updated analytical modeling of the site response has not been conducted because the amplification will depend on the input ground motion and the ground motion characterization being conducted under the SSHAC process is not yet complete. An updated set of amplification factors that includes 3-D site response calculations will be conducted as part of the response to the 2012 50.54(f) letter which is scheduled to be completed in March 2015.

The impact of these ground motion factors on the ground motions are DCPP are evaluated in the GEO>DCPP.TR.14.08.

## 5.0 REFERENCES

Abrahamson, N., and Silva, W., 2008. Summary of the Abrahamson & Silva NGA ground-motion relations, *Earthquake Spectra* **24** (1): 67–97.

Abrahamson, N.A., Silva, W.J., and Kamai, R., 2014. Summary of the ASK14 ground-motion relation for active crustal regions, *Earthquake Spectra*, in press.

Boore, D.M., and Atkinson, G.M., 2008. Ground-motion prediction equations for the average horizontal component of PGA, PGV, and 5% damped PSA at spectral periods between 0.01 s and 10.0 s, *Earthquake Spectra* **24** (1): 99–138.

Boore, D.M., Stewart, J.P., Seyha, E., and Atkinson, G.M., 2014. NGA-West2 equations for predicting PGA, PGV, and 5% damped PSA for shallow crustal earthquakes, *Earthquake Spectra*, in press.

Campbell, K.W., and Bozorgnia, Y., 2014. NGA-West2 ground motion model for the average horizontal component of PGA, PGV, and 5% damped linear acceleration response spectra, *Earthquake Spectra*, in press.

Campbell, K.W., and Bozorgnia, Y., 2008. NGA ground motion model for the geometric mean horizontal component of PGA, PGV, PGD and 5% damped linear elastic response spectra for periods ranging from 0.01 to 10 s, *Earthquake Spectra* **24** (1): 139–171.

Chiou, B.S.-J., and Youngs, R.R., 2008. An NGA model for the average horizontal component of peak ground motion and response spectra, *Earthquake Spectra* **24** (1): 173–215.

Chiou, B.S.-J., and Youngs, R.R., 2014. Update of the Chiou and Youngs NGA model for the average horizontal component of peak ground motion and response spectra, *Earthquake Spectra*, in press.

Fugro Consultants, Inc. (Fugro), 2014. *Central Coastal California Seismic Imaging Project DCPP P- and S-Wave Foundation Velocity Report*, Project Report PGEQ-PR-16.RO.

Idriss, I.M., 2008. An NGA empirical model for estimating the horizontal spectra values generated by shallow crustal earthquakes, *Earthquake Spectra* **24** (1): 217–242.

Idriss, I.M., 2014. An NGA-West2 empirical model for estimating the horizontal spectral values generated by shallow crustal earthquakes, *Earthquake Spectra*, in press.

Kamai, R., Abrahamson, N.A., and Silva, W.J., 2013. *Nonlinear Horizontal Site Response for the NGA-West2 Project*, Pacific Earthquake Engineering Research Center Report PEER 2013/12, May.

Pacific Gas and Electric Company (PG&E), 2011. *Shoreline Fault Zone Report: Report on the Analysis of the Shoreline Fault Zone, Central Coastal California*, report to the

U.S. Nuclear Regulatory Commission, January; www.pge.com/myhome/edusafety/systemworks/dcpp/shorelinereport/.

Pacific Gas and Electric Company (PG&E), 2014. Site Response Factors for Hazard Sensitivity, Calculation GEO.DCPP.14.03.

U.S. Nuclear Regulatory Commission (NRC), 2012. *Confirmatory Analysis of Seismic Hazard at the Diablo Canyon Power Plant From the Shoreline Fault Zone*, Research Information Letter 1

VERIFICATION SUMMARY REPORT

| Item | Parameter | Yes | No* | N/A* |
|---|---|---|---|---|
| 1 | Purpose is clearly stated and the report satisfies the Purpose. | ✓ | | |
| 2 | Data to be interpreted and/or analyzed are included or referenced. | ✓ | | |
| 3 | Methodology is appropriate and properly applied. | ✓ | | |
| 4 | Assumptions are reasonable, adequately described, and based upon sound geotechnical principles and practices. | ✓ | | |
| 5 | Software is identified and properly applied. Validation is referenced or included, and is acceptable. Input files are correct. | | | N/A* |
| 6 | Interpretation and/or Analysis is complete, accurate, and leads logically to Results and Conclusions. | ✓ | | |
| 7 | Results and Conclusions are accurate, acceptable, and reasonable compared to the Data, interpretation and/or analysis, and Assumptions. | ✓ | | |
| 8 | The Limitation on the use of the Results has been addressed and is accurate and complete. | ✓ | | |
| 9 | The Impact Evaluation has been included and is accurate and complete. | ✓ | | |
| 10 | References are valid for intended use. | ✓ | | |
| 11 | Appendices are complete, accurate, and support text. | | | N/A* |

*All calculations were done by hand using Excel, and no specialized software was used for the calculations in this chapter.
* There are no appendices or supporting documents.

Comments:

- Table 3-1 was verified against Table 9.2-8 in GEO.DCPP.14.03 rev0.
- Table 3-2 was verified against Table 9.3-3 in GEO.DCPP.14.03 rev0.
- Table 3-3 was verified against Table 10.1-1 in GEO.DCPP.14.03 rev0.
- Figure 3-1 was verified to be taken from the 2011 Shoreline Fault report (Figure 7, Appendix L).
- Figure 3-2 was verified to be taken from Figure 9.3-1 in GEO.DCPP.14.03 rev0.
- Figure 3-3 was verified to be taken from Figure 9.2-1 in GEO.DCPP.14.03 rev0.
- Figure 3-4 was verified to be taken from Figure 9.2-2 in GEO.DCPP.14.03 rev0.
- Figure 3-5 was verified to be a plot of the data from Table 6.3-1 in GEO.DCPP.14.03 rev0.
- Figure 3-6 was verified to be taken from Figure 9.3-2 in GEO.DCPP.14.03 rev0.
- Figure 3-7 was verified to be taken from Figure 9.3-4 in GEO.DCPP.14.03 rev0.

There are no supporting documents to this ITR report.

There are no supporting documents to this ITR report.

Verifier (ITR): ______________________ (name/signature)  08/08/14 (date)