July 31, 2015

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the matter of	
Pacific Gas and Electric Company	Docket Nos. 50-275-LR
Diablo Canyon Nuclear Power Plant	50-323-LR
Units 1 and 2	

**SAN LUIS OBISPO MOTHERS FOR PEACE'S
MOTION TO FILE AMENDED CONTENTION C
(INADEQUATE CONSIDERATION OF SEISMIC RISK IN SAMA ANALYSIS
AS SUPPLEMENTED BY SHU-SAMA EVALUATION)**

I. INTRODUCTION

Pursuant to U.S. Nuclear Regulatory Commission ("NRC") regulations 10 C.F.R. §§ 2.309(c), 2.309(f)(1), and 2.309(f)(2), San Luis Obispo Mothers for Peace ("SLOMFP") seeks leave to amend Contention C (Inadequate Consideration of Seismic Risk in SAMA Analysis). SLOMFP submitted the original Contention C on April 15, 2015 in San Luis Obispo Mothers for Peace's Motion to File New Contentions Regarding Adequacy of Severe Accident Mitigation Alternatives Analysis for Diablo Canyon License Renewal Application ("SLOMFP Motion").

In the original Contention C, SLOMFP asserted that Pacific Gas & Electric Company's ("PG&Es") Amended Severe Accident Mitigation Alternatives ("SAMA") Analysis for the proposed renewal of the Diablo Canyon operating license, submitted to NRC in February 2015,[1] is inadequate to satisfy the National Environmental Policy Act ("NEPA") because it proposes to rely on the "results" of PG&E's recently-submitted and seriously deficient post-Fukushima seismic risk analysis for its evaluation of the cost-effectiveness of measures to mitigate

[1] PG&E Letter DCL-15-027, "Update to the Diablo Canyon Power Plant License Renewal Application (LRA), Amendment 49 and Appendix E, Applicant's Environmental Report – Operating License Renewal Stage, Amendment 2 (Feb. 25, 2015) ("Amended Environmental Report").

earthquake impacts. On July 1, 2015, PG&E submitted an "Evaluation of the March 2010 Seismic Hazard Update on the February 2015 Severe Accident Mitigation Alternatives Analysis" (SHU-SAMA Evaluation") under cover of DCL-15-0-80, a letter from Barry S. Allen, PG&E to NRC Document Control Desk re: Diablo Canyon Power Plant License Renewal Severe Accident Mitigation Alternatives Analysis Evaluation of the 2015 Seismic Hazard Results SHU-SAMA Evaluation ("SHU-SAMA Evaluation"). The SHU-SAMA Evaluation concludes that "while the use of the updated seismic hazards probabilistic risk assessment model does have a small impact on the maximum averted cost-risk and the averted cost-risk results, it does not change the conclusions of the SAMA analysis." *Id.,* cover letter at 2.

SLOMFP respectfully disputes PG&E's assertion that the conclusions of the SAMA analysis are not affected by the updated seismic hazards assessment. In applying the results of the seismic hazards analysis to its SAMA analysis, PG&E has failed to resolve the concerns raised by the original Contention C regarding the inadequacy of PG&E's underlying seismic hazards analysis. In addition, PG&E has failed to consider a range of earthquake characteristics and intensity measures that could affect the outcome of the SAMA Analysis, even though relevant data and analysis tools are readily available. These issues are discussed in Amended Contention C, set forth in Section II below. SLOMFP requests the Atomic Safety and Licensing Board ("ASLB") to consider Amended Contention C as a restated and supplemented version of the original Contention C.

Amended Contention is supported by the attached Declaration of Dr. David D. Jackson in Support of Amended Contention C (July 31, 2015).

As discussed below in Section II, Amended Contention C meets the NRC's requirements for admissibility of contentions. As further discussed in Section III, SLOMFP also has good cause for filing the contentions after the initial deadline, which passed in 2010.

II. CONTENTIONS

Amended Contention C (Inadequate Consideration of Seismic Risk in SAMA Analysis as Supplemented by SHU-SAMA Evaluation)[2]

1. Statement of Amended Contention

PG&E's SAMA Analysis (Appendix F of PG&E's Amended Environmental Report), as supplemented by the SHU-SAMA Evaluation, is inadequate to satisfy NEPA or NRC implementing regulation 10 C.F.R. § 51.53(c)(ii)(L) because PG&E's evaluation of potential mitigation measures is not based on a sufficiently rigorous or up-to-date analysis of seismic risks. In addition, PG&E fails to take into account all relevant earthquake characteristics that could affect the SAMA analysis, even though PG&E's seismic hazards analysis provides information about these characteristics. As a result of these deficiencies, PG&E's evaluation of the comparative costs and benefits of measures to prevent or mitigate the effects of a severe earthquake does not sufficiently credit the cost-effectiveness of mitigation measures.

While PG&E claims that the "results and insights" of its 2014 "interim" probabilistic risk analysis ("PRA") (labeled "DCO3") are "reasonable for the purposes of a SAMA analysis" (Amended ER at F-34), by PG&E's own admission, DCO3 is only an "interim" PRA. *Id.* In addition, it is not sufficiently rigorous or updated to support the SAMA analysis.

Nor does PG&E's recent "update" of the DCO3 with the "results" of its 2015 seismic hazards analysis[3] cure the inadequacy of DCO3 to support PG&E's SAMA Analysis, because

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[2] Amended Contention C combines SLOMFP's original Contention C with its new claims regarding the SHU-SAMA Evaluation.

PG&E's 2015 seismic hazards analysis is also insufficiently rigorous and relies on outdated or unjustified methods and assumptions. Given the inadequacies of PG&E's seismic hazards analysis, to merely cite its "results" in the SHU-SAMA Evaluation is not sufficient to ensure the adequacy of the SAMA Analysis to evaluate potential mitigation measures for severe seismic accidents. Instead, PG&E must cure the significant defects in the underlying data and analyses.

Finally, the SHU-SAMA Evaluation is unreasonably restricted to the consideration of the effects of spectral acceleration on the Diablo Canyon Nuclear Power Plant. The only information from the SSC or SHS Report that is presented in the SHU-SAMA Evaluation is a table showing seismic initiating event frequencies. Table 1 at page 8. The SHU-SAMA Evaluation fails to consider other measures of ground motion that could cause reasonably foreseeable adverse environmental impacts on Diablo Canyon that are more extreme than or different from the impacts of spectral acceleration. These factors include surface fault rupture, ground displacement, ground velocity, and duration of shaking.

2. Statement of Basis for Amended Contention C

a. NEPA requirements

As stated in SLOMFP's original Contention C:

> The "core" requirement of NEPA is that for any federal action with a significant adverse effect on the human environment, federal agencies must prepare an environmental impact statement ("EIS") which includes a "detailed statement" regarding:

[3] PG&E's 2015 seismic hazards analysis consists of two documents: Pacific Gas and Electric Co., Seismic Hazard and Screening Report, Diablo Canyon Power Plant Units 1 and 2 ("SHS Report"), submitted by letter from Barry S. Allen, PG&E to NRC, re: Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident: Seismic Hazard and Screening Report (Mar. 11, 2015); and PG&E's Seismic Source Characterization for the Diablo Canyon Power Plant, San Luis Obispo County, California; report on the results of a SSHAC level 3 study (Rev. A, March 2015) ("SSC Report").

> (i) the environmental impact of the proposed action, (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented, (iii) alternatives to the proposed action, (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

San Luis Obispo Mothers for Peace, 449 F.3d 1016, 1020 (2006) (citing *Dept. of Transp. v. Pub. Citizen,* 541 U.S. 752, 756 (2004), 42 U.S.C. § 4332(2)(C)). NRC regulations also require that an NRC application for operating license renewal must be supported by an environmental report prepared by the applicant (10 C.F.R. § 51.53(c)) and a supplemental EIS prepared by the NRC Staff. 10 C.F.R. § 51.95(c).

An EIS must provide decision-makers with a reasonable array of alternatives for avoiding or mitigating the environmental impacts of the proposed action. *Idaho Sporting Cong. v. Thomas,* 137 F.3d 1146, 1151 (9th Cir. 1998) (citing *Robertson v. Methow Valley Citizens Council,* 490 U.S. 332, 352 (1989)). With respect to renewal of reactor operating licenses, NRC regulations specifically require a discussion of "alternatives to mitigate severe accidents." 10 C.F.R. §§ 51.53(c)(3)(ii)(L), 51.95(c)(2). "Probability figures" used in a SAMA analysis must be adequate to support the reasoned consideration of alternatives. *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-17, 56 NRC 1, 7 (2002). In addition, the SAMA Analysis must consider relevant information from outside sources. *Id.* at 8*; Pacific Gas and Electric Co.* (Diablo Canyon Nuclear Power Plant, Units 1 and 2), CLI-11-11, 74 NRC 427, 443 (2011). Finally, an Environmental Report or EIS must address "new and significant information" that was not previously addressed in an EIS for the facility. 10 C.F.R. §§ 51.53(c)(iv), 51.92(a)(2).

SLOMFP Motion at 3-4. SLOMFP hereby reiterates those assertions.

b. Inadequacy of DCO3 to support SAMA Analysis

In the original Contention C, SLOMFP stated that:

> PG&E asserts that "the interim results and insights from the DC03 model are reasonable for the purposes of a SAMA analysis" because:
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> > At the time of the 2013 Seismic Peer Review, the Turbine Building Shear Wall fragility had been updated based on the latest hazard spectral information, which was updated with the Shoreline Fault. The fragility analysis for other SSCs was based on the LTSP. The LTSP fragility curves are acceptable for use in DC03 because no scaling is necessary for use with the updated hazard spectral information. The LTSP fragility curves are the same shape (+/-1 0°/o) in the period of interest (3-8.5Hz) and there are no components in the PRA model in the 1-3Hz range. In addition, the 2014 Central Coastal California Seismic Imaging

Project Report (Reference 53) was a deterministic analysis that did not change the inputs to the seismic PRA.

Amended ER at F-34. While PG&E claims to have relied on the "latest hazard spectral information" for its 2013 update to the Turbine Building Shear Wall fragility, that information does not include the 2015 SHS Report or the 2015 SSC Report; and therefore the spectral information is not, in fact, the "latest." As PG&E implicitly acknowledges, the "latest" consists of the probabilistic seismic hazards assessment prepared by PG&E in response to the NRC's post-Fukushima Request for Information. PG&E must consider this information and ensure it is adequate to support the SAMA Analysis. *Duke Energy Corp.,* 56 NRC at 7 (requiring adequate probability figures to support a SAMA analysis); *Pacific Gas and Electric Co.,* 74 NRC at 443 (SAMA Analysis must consider relevant information from outside sources); 10 C.F.R. §§ 51.53(c)(iv), 51.92(a)(2) (Environmental Reports and EISs must address "new and significant information" that was not previously addressed.)

SLOMFP Motion at 4-5. SLOMFP hereby reiterates these claims.

c. Inadequacy of seismic hazards assessment "results" to support SAMA analysis

In the original Contention C, SLOMFP stated that:

The "results" that PG&E proposes to use to update its SAMA Analysis come from a "site-specific probabilistic seismic hazard assessment" that PG&E prepared in response to the NRC's March 12, 2012 Request for Information, issued pursuant to 10 C.F.R. § 50.54(f). As described by PG&E:

> The assessment used an updated seismic source characterization (SSC) model and an updated GMC [ground motion characterization] model as basic inputs. The SSC and GMC studies were undertaken to fulfill the NRC requirement that PG&E conduct a probabilistic seismic hazard assessment using SSHAC [Senior Seismic Hazards Analysis Committee] Level 3 procedures for DCPP, as specified by the NRC (NRC 2012). Thus, the SSC and GMC models were developed using processes that are appropriate for a SSHAC Level 3 study, as described in NUREG/CR-6372 (NRC 1997), and the detailed implementation guidance provided in NUREG-2117 (NRC 2012b). Both the SSC and GMC models represent new or "replacement" models according to the definitions and instructions in NUREG-2117. The SSC model describes the future earthquake potential (e.g., magnitudes, locations, and rates) for the region surrounding the DCPP site, and the GMC model describes the distribution of the ground motion as a function of magnitude, style of faulting, source-to-site geometry and reference site condition.

SHS Report at 15.

> PG&E also states that it will address the effect of the seismic hazards assessment "results" on the SAMA Analysis. Amended ER at F-34. Incorporation of the "results" of the seismic hazards analysis would not satisfy NEPA or NRC implementing regulations, however, because the data and analyses underlying those results are faulty in two fundamental respects: failure to account for nearby earthquakes, and failure to account for potentially large earthquakes.

SLOMFP Motion at 5-6. These deficiencies have not been corrected by PG&E in the SHU-SAMA Evaluation, and therefore SLOMFP stands by the above assertions. Additional explanations are provided below.

(i) Failure to account for nearby earthquakes

SLOMFP's original Contention C stated that:

> PG&E's seismic hazards analysis fails to account for reasonably foreseeable earthquakes located nearer to the DCPP than PG&E has assumed. For instance, the seismic stations used to locate earthquakes on the Shoreline Fault are all onshore, east of the fault, so that the fault's east-west location is highly uncertain. Thus the fault could be closer to or further from DCPP than assumed in DC03. The most effective solution would be to install offshore seismic stations west of the fault and record earthquakes long enough to infer the fault location accurately. Barring that, PGE must consider both nearer and farther locations of the Shoreline fault with realistic weights that reflect the fault location uncertainty.

SLOMFP Motion at 6.

SLOMFP stands by these claims. The probability of occurrence and damaging effects of surface fault rupture and ground displacement at DCPP depend strongly on proximity of an earthquake source, particularly one that ruptures the surface. Therefore the precise location of the Shoreline and other faults are relevant to the environmental hazard at DCPP. Information on the location of that fault comes primarily from locations of small earthquakes on the fault.

In its original Contention C, SLOMFP asserted that PG&E was not able to reliably locate the Shoreline Fault, in part because seismic data used to locate those earthquakes came only from seismographs on land, east of the fault. Since then, PG&E has asserted that "some seismic data was obtained from functioning OBS [ocean bottom seismometer] units." Pacific Gas and

Electric Company's Answer to Motion to Correct False Inference at 3 (July 27, 2015). While PG&E may have collected some data from seismometers located on the west side of the Shoreline Fault, the data provide no information about the location of the Shoreline Fault because the earthquakes identified by the OBS stations west of the Shoreline Fault are not located between the OBS stations and the onshore seismometers. In other words, the OBS stations west of the Shoreline Fault identify earthquakes that are irrelevant to the location of the Shoreline Fault.

PG&E's lack of data on Shoreline Fault earthquakes from seismic stations west of the Fault significantly affects the quality and reliability of the risk assessment presented in Table 1 of the SHU-SAMA Evaluation in two important respects. First, PG&E's estimates regarding the frequency of seismic events of various peak ground motion acceleration rates (measured in "g" values) may be underestimated because g values increase with proximity to a fault. The assumed location of the Shoreline Fault used in PG&Es seismic analysis is illustrated in Figures 7-25, 7-26 , and 7-27 of the SSC Report, indicating a distance of less than 1 km away from DCPP. Hardebeck (2013) estimates a median location uncertainty of about 2km for the recorded earthquakes on the Shoreline fault, which implies that the DCPP lies within the 95% confidence limit of the fault. Hardebeck's earthquake locations and their confidence regions are shown in Figure 5 of Hardebeck (2013). Those confidence regions clearly include the location of DCPP. If, in fact, the Shoreline Fault or another fault is closer to Diablo Canyon than assumed by PG&E in its seismic hazards analysis, the frequency of ground motion values represented in Table 1 of the SHU-SAMA Evaluation may be significantly higher than estimated in Table 1.

Second, if the Shoreline Fault or another fault is located directly beneath the Diablo Canyon nuclear power plant, an earthquake on that fault could cause surface fault rupture, large ground velocity, and large ground displacement as well as strong acceleration. Although ground velocity, ground displacement, and surface rupture data are available to PG&E (*see* section e. below), nothing in the SHS Report, the SSC, or the SHU-SAMA Evaluation suggests that these measures are used to evaluate hazard at DCPP. Furthermore, the sensitivity analyses in Chapter 14 of the SSC fail to consider the unknown proximity of the Shoreline fault, which influences the hazards from ground displacement, ground velocity, and surface fault rupture.

SLOMFP's original Contention C also states that in the context of locating earthquakes, PG&E:

> wrongly assumes that major earthquakes are located exactly on simplified versions of mapped fault traces. While PG&E considers alternative versions of fault geometry models (FGMs) for some faults (*see* SSC Report, section 6.3.1), PG&E makes no provision for large off-fault earthquakes. Smaller earthquakes are accounted for in the Areal Source Zones, but their magnitudes are limited to 6.8 or 6.9 in the Local Areal Zone (*see* SSC Report, Figure 14-1), most relevant to seismic hazard.[4] PG&E disregards that fact that earthquakes larger than those limits could occur within the Local Areal Zone, causing strong ground motion not yet accounted for.
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> In addition, PG&E does not follow the well-established method for California earthquake mapping of showing earthquake locations in a broad zone that covers a few kilometers on either side of major faults. (Hauksson et al, 2012; Powers and Field, UCERF3 Appendix O, 2013; Simpson, et al, 2006).[5] In the Uniform California Earthquake Rupture Forecast (Field, 2014a, 2014b) major faults are considered to have a width 12 km on both sides of major faults, with the implication that earthquakes associated with those faults could occur anywhere in those broad zones. With this understanding, earthquakes associated with the Hosgri fault, for example, could occur much closer to the DCPP than the assumed fault geometry under any of the options considered by PGE.
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> As a result of PG&E's outdated and non-conservative assumptions about the location of earthquakes, the hazard curves in the SSC Report underestimate the shaking that may be caused by nearby earthquakes. The amount of PG&E's underestimate is potentially significant, and therefore must be evaluated by further study before PG&E may reasonably rely on the SSC Report's results in its SAMA Analysis.[6]
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> [4] These imposed limitations on potential magnitude are arbitrary and unjustified, as discussed below in subsection ii.
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> [5] While PG&E estimates most important faults like Hosgri and Los Osos have widths of 2 km or more, its hazard calculations do not include those widths.

[6]PG&E could, for instance, apply a "stochastic fault" model (Hiemer et al., 2014a and 2014b) to deal with these problems. The stochastic fault model is recent, but it overcomes the assumption that major quakes occur exactly on faults, and it has been adopted for use in the SHARE project in Europe (Hiemer et al., 2014b). Alternately, hazard calculations could include earthquake scenarios near but not exactly on mapped faults. This would be most important on nearby faults such as Hosgri and Shoreline.

SLOMFP Motion at 6-7. These deficiencies have not been corrected by PG&E in the SHU-SAMA Evaluation, and therefore SLOMFP stands by the above assertions. The hazard calculations in the SSC Report, used by PG&E to derive the numbers in Table 1 of the SHU-SAMA Evaluation, still rely on the assumption that all earthquakes are on prescribed faults (either previously identified by geological and geophysical means, or assumed arbitrarily in the Local and Regional Area Source Zones). As shown in Figures 7-25, 7-26, and 7-27 of the SSC Report, PGE does consider alternative geometries of some faults including the Hosgri. However, these alternatives in no way cover the width of the region in which potentially damaging earthquakes could result from those faults, and no alternative locations are considered for the Shoreline Fault.

ii. Failure to account for potential large earthquakes

SLOMFP's original Contention C states that:

[E]ven for the faults that PG&E does recognize and analyze, PG&E fails to account for recent data and models showing that earthquakes on given faults may be much larger than previously assumed. For instance, PG&E estimates the most likely maximum magnitude for earthquakes in the Local Areal Zone to be 6.8 (SSC Report, Table 13-9). PG&E does allow that the Shoreline fault might participate as a branch of a larger earthquake on the Hosgri, but the resulting ground shaking is assumed to be less than that of a larger earthquake that extends the Shoreline fault, as it could. Experience shows that earthquake magnitudes may be much larger.

PG&E's understatement of magnitude stems from its reliance on "scaling relations", which are equations relating magnitude to rupture length or rupture area. The most commonly cited equations, which are used heavily by PG&E, are from Wells and Coppersmith (1994). PG&E uses them to estimate the maximum magnitude of a fault from its mapped length. But scaling of earthquake magnitudes from fault geometry has been demonstrated to be unsupportable, because the mapped fault length is no limit to the ultimate rupture length. Many earthquakes have ruptures exceeding the length of the faults on which they started. Even PG&E implicitly acknowledges this: examples listed in the SSC Report at page 6-6 include the 2002 Denali, AK (magnitude 7.9), the 1992 Landers, CA (magnitude 7.3), and the 1999 Hector Mine, CA (magnitude 7.1). Other major earthquakes occur on previously unknown faults, even in areas with extensive prior geological study: the 1989 Loma Prieta earthquake (magnitude 7.1; Spudich, 1996); the 1994 Northridge, CA (magnitude 6.7); and the 2010 Darfield, NZ (magnitude 7.1) earthquakes. Perhaps the most astounding example was the 2012 magnitude 8.6 strike-slip earthquake off the coast of northern Sumatra (Ishii et al., 2013). Nevertheless, PG&E disregards this information and unjustifiably relies on the scaling relationships to estimate maximum magnitude from fault length.

Perhaps the most significant example of PG&E's unjustifiable reliance on the scaling assumption is in the Local Areal Zone, where PG&E has concluded that the "virtual faults" there must be confined to a length of 50 km, implying a most probable maximum magnitude of 6.8 for strike slip earthquakes and 6.9 for reverse slip (thrust) earthquakes (SSC Report, Table 13-9, page 13-29). PG&E's assumption of a 50 km fault "length" is purely subjective, and not based on any observed fault length. More importantly, it is irrelevant because earthquake rupture length could exceed the fault length there just as it has in the cases listed above. Similarly, the length assumed by PG&E for the Shoreline Fault is based only on circumstantial evidence, and there is no evidence that earthquakes could not rupture well beyond its boundaries. PG&E does include in its source model the possibility that the Shoreline Fault might rupture in combination with the Hosgri fault. However, strong ground motion at DCPP due to a simpler large (magnitude above 6.8) earthquake extending the Shoreline Fault may be significantly different. Including such a possible source in a revised SSC is needed to resolve that question.

In some cases, PGE has under-estimated maximum magnitude by applying scaling relationships not just to fault length, but to segment length. Segments are shorter lengths of faults that are assumed to contain the entire rupture; that is, rupture starting within a segment must stop at the next segment boundary. An earthquake presumed to rupture one full segment is referred to as a "characteristic" earthquake. The characteristic earthquake model assumes that most large earthquakes on a fault are characteristic earthquakes. But both the characteristic earthquake model and the segmentation model have been discredited, most notably by the massive Tohoku, Japan earthquake of 2011 (magnitude 9.0), which destroyed the Fukushima Nuclear Power Plant and led to the very seismic hazard analysis that PG&E has reported on in the SSC Report and SHS Report. Before the Tohoku earthquake happened, the Japanese government estimated, based on a segmentation model, that the upper magnitude limit there was on the order of 8.0. The actual magnitude of 9.0 was a surprise to those who held on to the segmentation model (Kagan and Jackson, 2013; Stein, et al., 2011). The catastrophic 2004 Banda Aceh (Sumatra) earthquake (M 9.1; Banerjee, 2004) also violated many so-called segment boundaries and exceeded the scale of magnitudes implied by the characteristic earthquake assumption.

One reason that the segmentation model has been discredited is that it assumes that hazard is greatest near the segment boundaries, because a site there would be shaken strongly by earthquakes on either of the joined segments. A corollary of that assumption is that sites near the middle of a segment are assumed to be less hazardous because they are less shaken by earthquakes on adjoining segments. But there is no direct evidence that ruptures repeatedly stop at the ends of segments, nor is there evidence of more frequent strong shaking near the boundaries. Instead, PG&E's assumptions are purely subjective. In this context, it is important to recognize that the authors of the UCERF3 report took care to eliminate or reduce the effect of the segmentation model and segment boundaries (e.g. Field et al., 2014). As stated in the first two sentences of the abstract:

> The 2014 Working Group on California Earthquake Probabilities (WGCEP14) present the time-independent component of the Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3), which provides authoritative estimates of the magnitude, location, and time-averaged frequency of potentially damaging earthquakes in California. The primary achievements have been to relax fault segmentation and include multifault ruptures, both limitations of UCERF2.

Some boundaries were retained in UCERF3 to minimize the changes from previous models, but not because of empirical evidence. As the authors also stated in the abstract:

> UCERF3 is still an approximation of the system, however, and the range of models is limited (e.g., constrained to stay close to UCERF2) . . . Although UCERF3 fits the data better than UCERF2 overall, there may be areas that warrant further site-specific investigation. [footnote omitted]

UCERF3 maintained some vestiges of segmentation so as not to introduce changes too quickly. The effect of segmentation in the UCERF3 report was not profound because UCERF3 did not intend use for site specific application. In the case of DCPP, the segments and boundaries assumed by PG&E, especially those on the Hosgri Fault, are close enough to the source to artificially increase or decrease the calculated ground motion, PG&E should have abandoned the segmentation model in order to more accurately model earthquake hazards.

The characteristic model implies a higher earthquake rate at "characteristic" magnitudes than predicted by the Gutenberg-Richter ("GR") model, its prime competitor. The GR model posits that the frequency of earthquakes decreases exponentially with increasing magnitude, such that earthquakes of magnitude 7 and above, for example, would be about 10 times less frequent than those of magnitude 6 and above. The GR model is consistent with the magnitudes of quakes in most regional catalogs throughout the world. The characteristic model implies that earthquakes at the characteristic magnitude should be up to 40 times more frequent than predicted by GR (Schwartz and Coppersmith, 1984) and it is generally assumed to apply to individual faults. When both models are fit to the same amount of slip on a known fault, it follows that the characteristic model predicts fewer earthquakes both above and below the characteristic magnitude range. Wesnousky, (1994), Kagan (1996) and many others have debated the issue at length. Page and Felzer (2015, in press) show that the GR model is quite consistent with earthquakes on the San

> Andreas fault. The failure of the segmentation model as noted above, and the very subjective nature of the way segment boundaries must be assigned, makes the characteristic model and its implied magnitude distribution very dubious.
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> To address this deficiency, PG&E should take several measures: give more weight to GR magnitude distribution, using realistic (higher) maximum magnitudes; randomly locate ruptures, with some extending off the ends of faults; and take a stochastic approach as in Hiemer et al (2014, 2015). When both models are constrained to match the same slip rates and a realistic maximum magnitude greater than the "characteristic" magnitude is assigned, the GR model will imply lower rates of characteristic magnitude events but higher rates at smaller and larger magnitudes. Thus replacing the characteristic assumption with a reasonable GR model could increase or decrease the calculated hazard at different spectral frequencies, depending on details that can only be determined with proper modeling. Similarly, the effect of replacing segmentation with randomized locations of earthquakes on faults may increase or decrease hazard at different spectral frequencies depending on the locations of assumed segment geometry relative to DCPP. Again, accurate modeling is required to know the effect. In any case, the assumptions of segmentation and characteristic earthquakes should be abandoned because they are in conflict with observed earthquakes as listed above.

SLOMFP Motion at 7-12. SLOMFP stands by the statements above, because none of PG&E's false assumptions have been corrected by the measures suggested in the original SLOMFP Contention or any other remedies.

d. Failure to consider factors significantly affecting seismic impacts.

PG&E's SAMA Analysis, as supplemented by the SHU-SAMA Evaluation, is unreasonably restricted to the consideration of the effects of spectral acceleration on the Diablo Canyon Nuclear Power Plant. It fails to consider other measures of ground motion that could cause reasonably foreseeable and significant adverse environmental impacts on Diablo Canyon that are more extreme than or different from the impacts of spectral acceleration. Factors particularly relevant to DCPP include surface fault rupture, ground displacement, ground velocity, and duration of shaking. The nature and significance of these earthquake characteristics are described in the following two paragraphs.

Displacement, velocity, and acceleration are different descriptions, called “intensity measures,” of ground motion; and all generally increase with the size and proximity of an earthquake. Ground displacement refers to a change in position of a point on the ground during a particular time interval. As a seismic wave passes, the ground point may trace out a complicated path. Ground displacement is a measurement of the positive or negative changes in eastward, northward, and upward location. Ground displacement varies with time during the passage of seismic waves.

Ground velocity (also comprised of three directional components) is the rate of change of ground displacement; Ground velocity, too, varies with time during the passage of seismic waves. Ground acceleration is the rate of change of the velocities of each of the three directional components (eastward, northward, and upward), and it varies with time as well. Buildings or structures at the particular ground point may respond differently to displacement, velocity, and acceleration depending on the characteristics of the structure. Therefore, any one of these measures may predict the effects of an earthquake on a structure better than the others.

Displacement generally varies from one ground point to another. At some distance from an earthquake, the displacement is generally spatially continuous, meaning that the displacements become more nearly identical as the distance between points gets smaller. When an earthquake breaks the surface, the displacement may differ substantially for two nearby points on opposite sides of the fault. That difference in displacement is often called “surface fault rupture.” For large earthquakes the displacements are commonly measured in meters (m), the velocities in meters per second (“m/s”), and the accelerations in m/s^2. Accelerations are also measured in units of g, the acceleration of gravity, approximately 10 m/s^2.

Surface fault rupture can cause permanent displacements of several meters, resulting in the failure of structural foundations directly above the ruptured fault. As Bray, (2001) observed: "Recent earthquakes have reminded the profession of the devastating effects of earthquake surface fault rupture on engineered structures and facilities."

Surface fault rupture at any particular site is unusual, because buildings are rarely constructed atop or very close to identified earthquake faults. Given the proximity of the Diablo Canyon facility to the general location of the Shoreline Fault and other faults, an objective quantitative estimate of the environmental cost and probability of surface rupture should be included in the SAMA analysis for Diablo Canyon.

Ground velocity and ground displacement, sometimes expressed in the form of spectral velocity and displacement, are commonly used quantitative measures belonging to a large class of "intensity measures" considered by Boore, (2003), Tothong and Luco, (2007), Luco and Cornell, (2007), and many others. Olsen et al., (2009) calculated that displacements from a large nearby earthquake could exceed the tolerance of base isolated structures, and by analogy some components engineered to be isolated from ground motions may be similarly affected. The Electric Power Research Institute ("EPRI") also has recognized the significance of displacement in its "Seismic Evaluation Guidance" for post-Fukushima seismic evaluations such as PG&E's evaluation for Diablo Canyon:

> A screening analysis shall be performed to assess whether in addition to the vibratory ground motion, other seismic hazards, such as fault displacement, landslide, soil liquefaction, or soil settlement, need to be included in the seismic PRA …. The effects of fault displacements should be included in SPRAs if not screened out. The effects of landslides, soil liquefaction, and soil settlement should be included in the SPRA if not screened out.

EPRI, Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic at 6-38 (2013) ("EPRI Seismic Evaluation Guidance").

Ground velocity primarily affects taller buildings, but many analysts believe it is better correlated with overall structural damage than is ground acceleration. EPRI points out that sloshing of fluid in the Spent Fuel Pool is a long-period phenomenon for which the ground velocity or the ground displacement may be the most effective intensity measure. *Id.* at 7-9. Similar considerations may be important for stability of water reservoirs maintained for reactor cooling. The SHU-SAMA Evaluation makes no mention of displacement (in the present context), velocity, or other intensity measures. The Ground Motion Characterization ("GMC")[4] used by PG&E as input to the SSC (*see* SHS Report at 15 and Appendix C) does discuss permanent and spectral displacement for use in validating ground motion prediction equation ("GMPE") calculations (*e.g*., Figure 5.2.1-1, page 5-56), but nowhere does either the SSC Report or SHS Report mention the use of displacement in developing PG&E's hazard calculations.

Duration of shaking has also been an important factor in damage from the Tohoku earthquake of 2011, the Sumatra earthquake of 2004, and many other large earthquakes throughout the world. Jeong and Iwan, (1988) examined the effects on duration of steel frame and reinforced concrete structures. They wrote:

> The level of expected damage is found to be a strong function of both the ductility of response and the duration of the excitation.
>
> ***
>
> The design response spectrum gives the maximum response of a linear single-degree-of-freedom structure with a specified damping and natural frequency to the design earthquake. The response spectrum is a useful design tool since it allows the peak response of a structure to be estimated directly. This will be an adequate representation of the earthquake excitation to the extent that the peak response is the most important factor in the performance of the structure. *However, the safety of the structure may depend upon more than just the peak response. In particular, if the structure fails due to cyclic loading, the safety of the structure will be a function of the entire history of cyclic*

[4] GeoPentech, (2015) Southwestern United States Ground Motion Characterization SSHAC Level 3 - Technical Report Rev. 2, March 2015.

oscillations. In order to determine the likelihood of failure of a given structure, it will be necessary to know more about the history of the response. The response spectrum alone is inadequate for this purpose.

Jeong and Iwan at 1 (emphasis added). Beck and Hall, (1986) found that resonance of seismic waves beneath Mexico City, and the extreme duration of strong shaking, were the two primary factors in the disastrous damage to building in the 1985 earthquake disaster in Mexico City. Large earthquakes in California could cause strong shaking of comparable duration at DCPP. The SAMA analysis therefore should include a quantitative estimate of the consequences at DCPP.

e. PG&E has the means to evaluate surface fault rupture, ground displacement, ground velocity, and duration of shaking.

PG&E already possesses the data and analytical tools to consider the effects of surface fault rupture, ground displacement, ground velocity, and duration of shaking on the SAMA Analysis. For intensity measures displacement, velocity, and duration, PG&E could use appropriate GMPEs to calculate hazard curves at the DCPP site from the earthquake sources in the SSC, just as it does for peak acceleration and spectral acceleration (*see* SSC at 14-1, Appendix C). Published GMPEs for ground velocity are covered in several of the references in Chapter 16 of the GMC: Akkar and Bommer, (2007); Bindi et al, 2014); Boore et al., 2014); Boore and Atkinson, (2008), and Campbell and Bozrognia, (2008). Bora et al., (2013); Gregor et al., (2002), Petersen et al., (2011), and Rupakhety and Sigbjornsson, (2009) have published GMPEs for ground displacement. PG&E has tools for calculating ground displacement for any of its assumed source events, as shown in GMC Section 5.2.1.1, page 5-9; although the calculations are apparently performed for model validation rather than for hazard estimation. Bora et al., (2013) and Sommerville et al., (1997) have calculated GMPEs for duration of strong shaking.

Alternately, region-specific GMPEs can be estimated from existing seismograph data available from USGS and other sources, as well as PG&E's own network.

A more challenging task may be to calculate fragility curves for the DCPP structures, for each of the intensity measures. One method is to construct theoretical seismograms matching the appropriate intensity measure values for the most important source events, and modeling the response of DCPP structures to those events. Computation of hazard curves for the intensity measures would not require new data collection efforts.

Computing the hazard curve for surface fault rupture would involve combining the probability of surface rupturing earthquakes beneath the DCPP, the magnitude distribution for all relevant faults, and the distribution of rupture displacement for a given magnitude. This has been done previously, albeit in a different context: Hecker et al., (2013) applied the methods required to calculate a hazard curve from rupture probability, magnitude distribution, and displacement vs. magnitude relationships. No new data collection efforts would be required. Nevertheless, successful operation of PG&Es OBS program to better locate future earthquakes on the Shoreline fault would help to refine the probability of surface rupturing earthquakes.

Thus, PG&E is capable, without collecting any additional data, of evaluating the effects of surface fault rupture, ground displacement, ground velocity, and duration of shaking on the SAMA Analysis. At the very least, PG&E should follow the EPRI guidelines to determine whether ground displacement is a significant factor given the close proximity of the Diablo Canyon reactors to the Shoreline Fault. If PG&E can justify screening out any of the intensity measures or surface fault rupture, the reasons should be supported by rigorous quantitative analysis. PG&E should discuss the probability of the Shoreline Fault or other fault crossing the DCPP, estimate the size distribution and rate of occurrence of fault surface ruptures on the

Shoreline Fault and other faults within reach of the DCPP, and evaluate the fragility of the structures to fault surface displacements of various sizes.

3. Demonstration that the contention is within the scope of the proceeding

This contention is within the scope of the Diablo Canyon license renewal proceeding because it challenges the adequacy, under NEPA and NRC implementing regulations, of the SAMA Analysis required for the re-licensing of Diablo Canyon.

4. Demonstration that the contention is material to the findings the NRC must make to re-license Diablo Canyon

The contention is material to the findings that the NRC must make in order to license this reactor because it challenges the environmental analysis that the NRC will rely on for its NEPA findings in the DCNPP license renewal proceeding.

5. Concise statement of the facts or expert opinion supporting the contention, along with appropriate citations to supporting scientific or factual materials

The facts and expert opinion on which SLOMFP relies are summarized in Section 2 (basis statement) above. They are supported by the Declaration of Dr. David D. Jackson in Support of Amended Contention C, attached. The following is a list of references relied on in the amended contention:

(Akkar and Bommer, 2007)
Sinan Akkar and Julian Bommer, Empirical Prediction Equations for Peak Ground Velocity Derived from Strong-Motion Records from Europe and the Middle East, Bulletin of the Seismological Society of America, Vol. 97, No. 2, pp. 511–530, April 2007, doi: 10.1785/0120060141.

(Banerjee et al., 2004)
Paramesh Banerjee, Fred Pollitz, B. Nagarajan, and Roland Bürgmann, Coseismic Slip Distributions of the 26 December 2004 Sumatra–Andaman and 28 March 2005 Nias Earthquakes from GPS Static Offsets, Bulletin of the Seismological Society of America, January 2007, v. 97, p. S86-S102,doi:10.1785/0120050609.

(Beck and Hall, 1986)
James L. Beck and John F. Hall, Factors contributing to the catastrophe in Mexico City during the Earthquake of September 19, 1985, GEOPHYSICAL RESEARCH LETTERS, VOL. 13, NO. 6, PAGES 593-596, JUNE 1986.

(Bindi et al, 2014)
Bindi D., Massa M., Luzi L., Ameri G., Pacor F., Puglia R., and Augliera, P. (2014a). Pan European Ground Motion Prediction Equations for the Average Horizontal Component of PGA, PGV, and 5%-Damped PSA at Spectral Periods up to 3.0 s using the RESORCE dataset, *Bull. Earthquake Eng.,* Vol. 12, 391- 430, DOl: 10.1007/s10518-013-9525-5.

(Bird et al., 2004)
Peter Bird, P., and Yan Y. Kagan, "Plate-tectonic analysis of shallow seismicity: apparent boundary width, beta, corner magnitude, coupled lithosphere thickness, and coupling in seven tectonic settings", Bull. Seismol. Soc. Amer., 94(6), 2380-2399, 2004. (plus electronic supplement), doi:10.1785/0120030107.

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David M. Boore, Jonathan P. Stewart, Emel Seyhan, and Gail M. Atkinson, (2014) NGA-West2 Equations for Predicting PGA, PGV, and 5% Damped PSA for Shallow Crustal Earthquakes, Earthquake Spectra, Vol. 30, No. 3, pp. 1057-1085.

(Boore and Atkinson, 2008)
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 O.Ols and 10.0s, *Earthquake Spectra,* Vol. 24(1), 99-138.

(Bora et al., 2013)
Bora, S.S., Scherbaum, F., Kuehn, N., and Stafford, P. (2013). Fourier spectral- and duration models for the generation of response spectra adjustable to different source-, propagation-, and site conditions, *Bull. Earthquake Eng.,* Vol. 12(1),467-493, DOl: 10.1007/s10518-013-9482-z.

(Bray, 2001)
Bray, J. D. “Developing Mitigation Measures for the Hazards Associated with Earthquake Surface Fault Rupture,” inA Workshop on *Seismic Fault-Induced Failures – Possible Remedies for Damage to Urban Facilities*, Research Project 2000 Grant-in-Aid for Scientific Research (No. 12355020), Japan Society for the Promotion of Science, Workshop Leader, Kazuo Konagai, University of Tokyo, Japan, pp. 55-79, January 11-12, 2001.

(Campbell and Bozrognia, 2008)
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,*

Vol. 24(1),139-171.

(Field et al., 2014)
Edward H. Field, Ramon J. Arrowsmith, Glenn P. Biasi, Peter Bird, Timothy E. Dawson, Karen R. Felzer, David D. Jackson, Kaj M. Johnson, Thomas H. Jordan, Christopher Madden, Andrew J.Michael, Kevin R. Milner, Morgan T. Page, Tom Parsons, Peter M. Powers, Bruce E. Shaw, Wayne R. Thatcher, Ray J. Weldon II, and Yuehua Zeng, Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3)—The Time-Independent Model, Bulletin of the Seismological Society of America, Vol. 104, No. 3, pp. 1122–1180, June 2014, doi: 10.1785/0120130164.

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Edward H. Field, Glenn P. Biasi, Peter Bird, Timothy E. Dawson, Karen R. Felzer, David D. Jackson, Kaj M. Johnson, Thomas H. Jordan, Christopher Madden, Andrew J. Michael, Kevin R. Milner, Morgan T. Page, Tom Parsons, Peter M. Powers, Bruce E. Shaw, Wayne R. Thatcher, Ray J. Weldon II, and Yuehua Zeng, Long-Term Time-Dependent Probabilities for the Third Uniform California Earthquake Rupture Forecast (UCERF3), Bulletin of the Seismological Society of America, Vol. 105, No. 2A, pp. 511–543, April 2015, doi: 10.1785/0120140093.

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(Hardebeck, 2013)
Jeanne L. Hardebeck, Geometry and Earthquake Potential of the Shoreline Fault, Central California, Bulletin of the Seismological Society of America, Vol. 103, No. 1, pp. 447–462, February 2013, doi: 10.1785/0120120175.

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Egill Hauksson, Wenzheng Yang, and Peter M. Shearer, Waveform Relocated Earthquake Catalog for Southern California (1981 to June 2011), Bulletin of the Seismological Society of America, Vol. 102, No. 5, pp. 2239–2244, October 2012, doi: 10.1785/0120120010.

(Hecker et al. 2013)
S. Hecker, N. A. Abrahamson, and K. E. Wooddell, Variability of Displacement at a Point: Implications for Earthquake-Size Distribution and Rupture Hazard on Faults, Bulletin of the Seismological Society of America, Vol. 103, No. 2A, pp. 651–674, April 2013, doi: 10.1785/0120120159.

(Hiemer et al., 2013)
Stefan Hiemer, David D. Jackson, Qi Wang, Yan Y. Kagan, Jochen Woessner, Jeremy D. Zechar, and Stefan Wiemer, A Stochastic Forecast of California Earthquakes Based on

Fault Slip and Smoothed Seismicity, Bulletin of the Seismological Society of America, Vol. 103, No. 2A, pp. 799–810, April 2013, doi: 10.1785/0120120168.

(Hiemer et al., 2014)
S. Hiemer, J. Woessner,1 R. Basili, L. Danciu,1 D. Giardini and S. Wiemer , A smoothed stochastic earthquake rate model considering seismicity and fault moment release for Europe, Geophys. J. Int. (2014) 198, 1159–1172 doi: 10.1093/gji/ggu186.

(Ishii et al., 2013)
Miaki Ishii, Eric Kiser, and Eric L. Geist, M_w 8.6 Sumatran earthquake of 11 April 2012: Rare seaward expression of oblique subduction. Geology, March 2013, v. 41, p.319-322 (First published on January 17, 2013).

(Jeong and Iwan, 1988)
Garrett Jeong and Wilfred Iwan, The effect of earthquake duration on the damage of structures, Earthquake Engineering and structural dynamics, 16, 1201 – 1211.

(Kagan, 1996)
Kagan, Y. Y. (1996), Comment on “The Gutenberg-Richter or characteristic earthquake distribution, which is it?,” by S. G. Wesnousky, *Bull. Seismol. Soc. Am.*, *86*, 275–284.

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Kagan, Y. Y., and D. D. Jackson (2013), Tohoku earthquake: a surprise?, Bull. Seismol. Soc. Am.,103, 1181–1194.

(Leonard, 2010)
Mark Leonard, (2010) Earthquake fault scaling: Self-consistent relating of rupture length, width, average displacement, and moment release, Bull. Seismol. Soc.Am. 100**,** no. 5A,1971–1988, 2010

(Luco and Cornell, 2007)
Nickolas Luca and C. Allin Cornell, Structure-Specific Scalar Intensity Measures for Near-Source and Ordinary Earthquake Ground Motions, Earthquake Spectra, Volume 23, No. 2, pages 357–392, May 2007.

(Olsen et al., 2009)
Anna H. Olsen, Brad T. Aagaard, and Thomas H. Heaton, Long-Period Building Response to Earthquakes in the San Francisco Bay Area, Bulletin of the Seismological Society of America, Vol. 98, No. 2, pp. 1047–1065, April 2008, doi: 10.1785/0120060408.

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Petersen, M.D., Dawson, T.E., Chen, R, Cao, T., Wills, C.J., Schwartz, D.P, Frankel, A. D. (2011). Fault displacement hazard for strike-slip faults, Bull. Seism. Soc. Am., Vol. 101(2), 805-825.

(Powers and Jordan, 2010)
Peter M. Powers and Thomas H. Jordan, Distribution of seismicity across strike-slip faults in California, JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 115, B05305, doi:10.1029/2008JB006234, 2010.

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Powers, P., and N. Field, UCERF3 Appendix O, *Gridded Seismicity Sources,* http://pubs.usgs.gov/of/2013/1165/pdf/ofr2013-1165_appendixO.pdf.

(Quigley et al., 2012)
M. Quigley, R. Van Dissen, N. Litchfield, P. Villamor, B. Duffy, D. Barrell, K. Furlong, T. Stahl, E. Bilderback and D. Noble, Surface rupture during the 2010 M_w 7.1 Darfield (Canterbury) earthquake: Implications for fault rupture dynamics and seismic-hazard analysis, Geology, January 2012, v. 40, p. 55-58 (First published on November 23, 2011).

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R. Rupakhety and R. Sigbjornsson, (2009), Ground-motion prediction equations (GMPE's) for inelastic displacement and ductility demands of constant-strength SDOF systems, Bull earthquake Eng, 7, 661 – 679, DOI 10.1007/s10518-009-9117-6.

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Schwartz, D. P., and K. J. Coppersmith (1984), Fault behavior and characteristic earthquakes – examples from the Wasatch and San Andreas fault zones, *J. Geophys. Res.*, *89*, 5681–5698.

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R. W. Simpson, M. Barall, J. Langbein, J. R. Murray, and M. J. Rymer, San Andreas Fault Geometry in the Parkfield, California Region, Bulletin of the Seismological Society of America, September 2006, v. 96, p. S28-S37,doi:10.1785/0120050824.

(Somerville et al., 1997)
Somerville, P.G ., Smith, N.F., Graves, R.W., and Abrahamson, N.A. (1997). Modification of empirical strong ground motion attenuation relations to include the amplitude and duration effects of rupture *directivity,Seismol. Res. Let.,* Vol. 68(1), 199-222.

(Spudich, 1996)
Paul Spudich, editor, The Loma Prieta, California, Earthquake of October 17, 1989—Main Shock Characteristics, U.S. Geological Survey Professional Paper 1550-A 1996.

(Stein et al., 2011)
Seth Stein, Robert Geller, and Mian Liu, Bad Assumptions or Bad Luck: Why Earthquake Hazard Maps Need Objective Testing, Seismological Research Letters, September/October 2011, v. 82, p. 623-626,doi:10.1785/gssrl.82.5.623.

(Thurber et al., 2006)
Clifford Thurber, Haijiang Zhang, Felix Waldhauser, Jeanne Hardebeck, Andrew Michael, and Donna Eberhart-Phillips, Three-Dimensional Compressional Wavespeed Model, Earthquake Relocations, and Focal Mechanisms for the Parkfield, California, Region, Bulletin of the Seismological Society of America, September 2006, v. 96, p. S38-S49, doi:10.1785/0120050825.

(Tothong and Luco, 2007)
Polsak Tothong and Nicolas Luco, Probabilistic seismic demand analysis using advanced motion intensity measures, *Earthquake Engng Struct. Dyn.* 2007; **36**:1837–1860. DOI: 10.1002/eqe.696.

(Wells and Coppersmith, 1994}
Donald L. Wells and Kevin J. Coppersmith, New Empirical Relationships among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement Bulletin of the Seismological Society of America, Vol. 84, No. 4, pp. 974-1002, 1994.

(Wesnousky, 1994)
Wesnousky, S. G. (1994), The Gutenberg-Richter or characteristic earthquake distribution, which is it?, *Bull. Seismol. Soc. Am.*, *84*, 1940–1959.

6. A genuine dispute exists with the applicant on a material issue of law or fact

As set forth in the contention and its basis statement, this contention raises a genuine factual and legal dispute with the applicant regarding the adequacy of PG&E's SAMA Analysis, as supplemented by the SHU-SAMA Evaluation, to support the proposed renewal of PG&E's operating license for Diablo Canyon.

III. AMENDED CONTENTION C IS TIMELY PURSUANT TO 10 C.F.R. §§ 2.309(c) and 2.309(f)(2)

NRC regulations 10 C.F.R. § 2.309(c) and § 2.309(f)(2) call for a showing that:

(i) The information upon which the amended or new contention is based was not previously available;

(ii) The information upon which the amended or new contention is based is materially different than information previously available; and

(iii) The amended or new contention has been submitted in a timely fashion based on the availability of the subsequent information.

This motion satisfies all three of these standards for filing a contention after the initial filing deadline. First, the information upon which Amended Contention C was not previously available, because PG&E did not submit it until recently. The information is contained in SHU-SAMA Evaluation, submitted to NRC on July 1, 2015.

Second, the SHU-SAMA Evaluation contains information that is materially different from previously submitted information. The SHU-SAMA Evaluation constitutes the first document in which PG&E has updated its SAMA Analysis based on the results of the SHA and SSC. PG&E's assertion that its seismic hazards analysis does not affect the conclusions of the SAMA Analysis does not appear in any previous document.

Finally, Amended Contention C is timely, because it is being submitted within 30 days of July 1, 2015, when PG&E submitted the SHU-SAMA Evaluation.

IV. CERTIFICATE REGARDING CONSULTATION

Pursuant to 10 C.F.R. § 2.323(b) undersigned counsel for SLOMFP certifies that on July 30, 2015, she contacted counsel for PG&E and the NRC Staff to seek their consent to the filing of SLOMFP's motion and Amended Contention C. Counsel for PG&E stated that PG&E does not take a position on SLOMFP's motion at this time and will respond to it in due course. Counsel for the NRC Staff stated that the Staff does not object to the filing of the motion and reserves the right to respond at the appropriate time.

V. CONCLUSION

For the foregoing reasons, the ASLB should admit SLOMFP's Amended Contention C.

Respectfully submitted,

[Electronically signed by]
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Counsel to SLOMFP

July 31, 2015

July 31, 2015

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the matter of
Pacific Gas and Electric Company
Diablo Canyon Nuclear Power Plant
Units 1 and 2

Docket Nos. 50-275-LR
50-323-LR

DECLARATION OF DR. DAVID D. JACKSON IN SUPPORT OF SAN LUIS OBISPO MOTHERS FOR PEACE'S AMENDED CONTENTION C

Under penalty of perjury, I, David D. Jackson, declare as follows:

1. My name is David D. Jackson. I am a Professor of Geophysics, Emeritus, at the University of California at Los Angeles ("UCLA"). I am qualified by training and experience as an expert in the fields of geophysics and seismology.

2. On April 15, 2015, on behalf of San Luis Obispo Mothers for Peace ("SLOMFP"), I submitted the Declaration of Dr. David D. Jackson in Support of San Luis Obispo Mothers for Peace's Motion to File New Contention Regarding Adequacy of Severe Accident Mitigation Alternatives Analysis for Diablo Canyon License Renewal Application. My expert qualifications are set forth in the curriculum vitae attached to that Declaration.

3. The purpose of this declaration is to support SLOMFP's Amended Contention C (Inadequate Consideration of Seismic Risk in SAMA Analysis as Supplemented by SHU-SAMA Evaluation). Amended Contention C challenges the adequacy of Pacific Gas & Electric Co.'s ("PG&E's) seismic risk analysis for the Severe Accident Mitigation Alternatives ("SAMA") Analysis in PG&E's Amended Environmental Report (2015) for the proposed re-licensing of Diablo Canyon nuclear power plant. In particular, Amended Contention C addresses PG&E's Evaluation of the March 2010 Seismic Hazard Update on the February 2015 Severe Accident

Mitigation Alternatives Analysis, submitted to the U.S. Nuclear Regulatory Commission ("NRC") on July 1, 2015 ("SHU-SAMA Evaluation").

4. As previously stated, I am familiar with seismic risk aspects of PG&E's SAMA Analysis; PG&E's Seismic Hazard and Screening Report for Diablo Canyon Power Plant Units 1 and 2 (March 2015); and PG&E's Seismic Source Characterization for the Diablo Canyon Power Plant, San Luis Obispo County, California; report on the results of a SSHAC level 3 study (Rev. A, March 2015). I am also familiar with the scientific literature regarding the seismology of California, including the Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3). I am also familiar with PG&E's SHU-SAMA Evaluation.

5. The factual statements in SLOMFP's Amended Contention C, par. 2 (Statement of Basis) are true and correct to the best of my knowledge, and the conclusions therein are based on my best professional judgment.

Under penalty of perjury, I declare that the facts stated or referenced above are true and correct to the best of my knowledge and that the statements of opinion expressed or referenced above are based on my best professional judgment.

David D. Jackson

Prof. David D. Jackson

July 31, 2015

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the matter of
Pacific Gas and Electric Company — Docket Nos. 50-275-LR
Diablo Canyon Nuclear Power Plant — 50-323-LR
Units 1 and 2

SAN LUIS OBISPO MOTHERS FOR PEACE
CERTIFICATE OF SERVICE

I certify that on July 31, 2015, I posted on the NRC's Electronic Information Exchange SAN LUIS OBISPO MOTHERS FOR PEACE'S MOTION TO FILE AMENDED CONTENTION C (INADEQUATE CONSIDERATION OF SEISMIC RISK IN SAMA ANALYSIS AS SUPPLEMENTED BY SHU-SAMA EVALUATION) and the attached DECLARATION OF DR. DAVID D. JACKSON. It is my understanding that as a result, the NRC Commissioners, Atomic Safety and Licensing Board, and parties to this proceeding were served.

Respectfully submitted,

Electronically signed by
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