Independent Peer Review Panel

A multi-agency panel of seismic hazard specialists
established by the California Public Utilities Commission
California Geological Survey, California Coastal Commission,
California Energy Commission, California Seismic Safety Commission,
California Public Utilities Commission, County of San Luis Obispo,
Governor's Office of Emergency Services

Independent Peer Review Panel **Response** **To PG&E's 2024 Updated Seismic Assessment**

Staff Contributions from: Gordon Seitz, Tim Dawson, and Phil Johnson
Date: February 19, 2026

Senate Bill (SB) 846 (Dodd, 2022) extended operations of the Diablo Canyon Power Plant (DCPP) through 2030 and included a requirement for PG&E to perform an updated seismic assessment. In March 2024, Pacific Gas & Electric Company (PG&E) issued that updated seismic assessment, referred to herein as the "Update." The Update was a stand-alone requirement of SB 846 separate from Nuclear Regulatory Commission (NRC) licensing.

Under California regulations, the Independent Peer Review Panel (IPRP) must review DCPP seismic studies.[1] The IPRP's initial review (Report No. 16) of the Update identified sections that required additional clarification and documentation. PG&E provided comments to IPRP Report No. 16 in January 2025. All documents – the Update, IPRP Report No. 16, and PG&E's response – are available at the CPUC website.

The IPRP has produced this document to provide its review comments to PG&E's January 2025 response. We emphasize that the IPRP review is not a proponent model or comprehensive evaluation of all available data, but rather a technical review.[2] PG&E is responsible for the comprehensive evaluation and integration of all "…technically defensible interpretations of both new, and previously available data, models and methods."[3] We also emphasize that the comments in this document need to be considered in the context of both IPRP Report No. 16 and the PG&E response to Report No. 16, because a full awareness of previous reports is crucial to understanding the nature of these requests.

[1] California Public Utilities Code Section 712(c).
[2] PG&E's response to IPRP Report No. 16 gives the impression that the IPRP is responsible for the evaluation of various models considered for inclusion in the Update (e.g. PG&E DCL-25-003, Page 15 "The alternative is not mentioned in the IPRP review."). The IPRP is not a technical integrator. The comprehensive evaluation and documentation of models considered in the Update is the responsibility of PG&E.
[3] PG&E's response to IPRP Report No. 16 at page 2.

Our expectation is that PG&E will share responses to this document with full supporting documents, followed by presentations at a future IPRP or DCISC meeting in the Spring of 2026.[4] The IPRP recognizes that PG&E's Long Term Seismic Program (LTSP) is the mechanism for addressing other issues identified in Report No. 16 through future studies. We look forward to PG&E reporting on LTSP priorities and progress in response to our Report No. 16 comments.

Request 1

We request that PG&E provide documentation of the Ground Motion Response Spectrum (GMRS) based on their evaluation of the impact of using the Hosgri fault slip rate of 2.6 mm/yr +-0.9 mm/yr (Kluesner et al, 2023, and further supported by: Johnson et al., 2014, Medri et al. 2022).

The IPRP's review of the Update (IPRP Report #16) concluded that recently developed slip rate information on the Hosgri fault at the Cross-Hosgri Slope (CHS) site by Kluesner, et al (2023), is far more robust than other available slip rate information, and that PG&E's weighting does not adequately account for the high confidence of this slip rate estimate relative to the other lower confidence sites with larger uncertainties and lower quality data. In contrast to the CHS site, which has the fundamental parameters needed for a high confidence slip rate estimate (a well-defined feature offset by the fault and a quantitative age estimate), the IPRP concluded that other sites are less reliable and have much larger uncertainties due to less well-defined features, lack of quantitative age estimates, and reliance on speculative age models not relevant for seismic hazard analysis in the current tectonic regime. Based on this, the IPRP recommended that these other sites be significantly down-weighted, as these are based on low quality data, or are based on slip rates that are so uncertain they should be rejected as viable models. The IPRP concluded that the Hosgri fault slip rate for Probabilistic Seismic Hazard Analysis (PSHA) purposes is best represented by a rate of 2.6 mm/yr (IPRP report #16), based on the rate reported by Kluesner et al. (2023).

At the February 19-20, 2025, Diablo Canyon Independent Safety Committee (DCISC) meeting, PG&E stated they included this higher mean slip rate as part of a hazard sensitivity analysis. In their analysis, the ground motion response spectrum (GMRS) increased from their 2015 model to their 2024 model by 3%. Furthermore, PG&E stated that our assessed Hosgri fault mean slip rate of 2.6 mm/yr would result in a doubling of the increase rate of the GMRS to 6%. Figure 5-41 in the PG&E Update presents the corresponding Source Hosgri Fault slip rates with the means of 1.68 mm/yr in 2015, 2.07 mm/yr in 2023. We ask PG&E to provide the results of this sensitivity analysis using this higher slip rate. We also ask that, given the growing body of published information, developed but not necessarily available during the Update process, that supports higher slip rates along the Hosgri fault (e.g. Nishenko et al., 2025), PG&E

[4] The next DCISC meeting is scheduled for June 16-17, 2026. The next IPRP meeting will be scheduled in the Spring of 2026.

should provide a statement on the implications of this higher slip rate in their seismic hazard assessment for the safety and operational reliability of the DCPP.

Request 2

We request that PG&E provide additional documentation regarding the inputs used for the Hosgri fault slip rate and slip rate weighting. We further request that PG&E consider revision of the Hosgri fault slip rate in the context of all available studies, including those not considered in the Update, and the issues described below.

Relevance of studies not considered

It is the implicit responsibility of PG&E, as part of their Seismic Update, to identify and address all new seismic hazard related developments that postdate the 2015 seismic study.[5] Regardless of how the studies ultimately influence the hazard model, they still need to be documented and considered by PG&E. Inclusion of new information by PG&E in the Update is not discretionary nor can that responsibility be negated by stating they will be considered in the LTSP.

For example, in Report #16, the IPRP raised concerns about studies that were made available between 2015 and 2024 and were not fully considered in the Update. One such study is the Center for Nuclear Waste Regulatory Analyses (CNWRA, 2016) study. While PG&E was aware of this study, it was not used:

> *"The study was not used in the 2024 seismic assessment because it has many simplifying assumptions and sources of uncertainty that would need to be evaluated further before integrating into the PG&E model. The TI Team viewed it as a preliminary check, or verification, of the rate used in the 2015 study. It is interesting to note that the center of the 1.5 to 2.5 mm/yr rate developed in the CNWRA study is approximately equivalent to the weighted mean Hosgri slip rate (2.1 mm/yr) for the four sites used in the 2024 PG&E assessment."* (PG&E Letter DCL-25-003, page 19)

The IPRP notes that the reason for exclusion is inconsistent with PG&E's stated motivation of the Update, which was to "…*review the center, body, and range of the technically defensible interpretations of both new, and previously available data, models and methods.*" In the IPRP's opinion, PG&E has not evaluated the CNWRA (2016) study to this standard, nor have they adequately documented why it and other studies (e.g. McGregor and Onderdonk (2021), see Request #3) should be excluded from the Update.

[5] The IPRP recognizes that other relevant studies (e.g. Nishenko et al., 2025) not available at the time of the Update, are now available since the first version of the Update was provided. The IPRP encourages PG&E to consider these studies as well in the context of these requests.

Apparent legacy data bias

The exclusion of the CNWRA (2016) study highlights another potential issue illustrating an inconsistent approach and potential bias towards legacy data. With respect to the CNWRA 2016 study, PG&E states: "*The TI Team viewed it as a preliminary check, or verification of the rate used in the 2015 study"* (PG&E Letter DCL-25-003, page 19) and, as already noted in this response, the study was not considered due to many "simplifying assumptions" and alternative interpretations. The IPRP agrees that the CNWRA study has some simplifying assumptions and sources of uncertainty that would need to be evaluated before integration into the PG&E model. However, this is true of all models that have been, or should have been, included in the Update. This begs the question whether older models included in the seismic assessment, especially those that are highly uncertain, that rely on simplifying assumptions, or regarded as simply being less reliable, are better used as checks on more reliable models, rather than directly in the weighting scheme for the Hosgri fault slip rate.

For example, the San Simeon slip rate site (Hanson and Lettis, 1994; Rockwell et al., 1994) used in PG&E's seismic assessment is highly model driven, using global analogies and paleographic reconstructions to reconstruct the original geometry of the strandline feature offset by the Hosgri fault. In the Update, PG&E reports the relative "Confidence in Site Interpretation" as "Moderate" (Table 5-16). Arguably, given the number of underlying assumptions in the reconstruction of this feature, and in the context of other recently developed sites with more straightforward interpretations, the confidence in the site could be regarded as "Low." At the Estero Bay slip rate site, the matching of offset paleo-channels across the fault is highly uncertain, and the dating of the paleo-channels is likely incorrect based on the new correlations by Nishenko et al. (2025). Thus, the quality of data from the San Simeon and Estero Bay sites is low. This raises the question whether PG&E is biased towards using legacy, lower confidence slip rate estimates, and whether these should be used as "checks" rather than direct inputs in the Hosgri fault slip rate weighting scheme. The IPRP recommends that PG&E reassess the legacy slip rates used in the Update and consider demoting the lower confidence slip rate data from low quality sites (San Simeon and Estero Bay) from primary inputs to the Hosgri fault slip rate weighting and use them instead as consistency checks on the other inputs. The criteria for using a slip rate input either as a direct input into the weighting scheme or, as a second order validation "check" on other rates, should also be explicitly defined by PG&E.

Appropriate slip rate timeframe for PSHA

It has been a traditional assumption that slip rates, or the mean rate of earthquake occurrence, do not change over time scales of interest to the PSHA. However, advances in fault characterization indicate that many faults have temporally variable slip rates (Styron, 2019; and references therein). For this reason, PSHA should include selection of a time frame for slip rates that best represents the current seismic hazard regime. In the Hosgri fault case, an average of lower slip rate estimates based on older features may underestimate the seismic hazard. The IPRP considers this a critical criterion in the assessment and weighting of slip rates. In PG&E's response to IPRP concerns, they report:

> *"PG&E is not aware of a documented standard that recommends use of only Holocene averaged slip rates for site-specific seismic hazard studies, has guidelines for time intervals to consider based on fault slip rate, or finds slip rates averaged over hundreds of thousands of years unreliable or low quality. On the contrary, NRC guidelines consider Quaternary fault data to be high quality and pre-Quaternary data to be low quality (NRC, 1997)."* (PG&E Letter DCL-25-003, page 14).

We agree that slip rate data derived from pre-Quaternary piercing points would be of lower quality for PSHA than Quaternary slip rate data. However, the specific passage in the referenced NRC (1997) report states: "*For example, if fault sources are being identified, a map of young (Quaternary) faults is judged to provide a strong basis for defining fault sources in hazard assessment, whereas a map of older (pre-Quaternary) faults is judged to provide a relatively weak basis for defining fault sources*." Pre-Quaternary data are not part of the data set in question, and the Hosgri fault is clearly a Quaternary active fault; therefore, the NRC (1997) reference is not relevant. The relevant question is not between pre-Quaternary slip rates and Quaternary slip rates; the relevant issue is selecting the slip rate most representative to the current seismic hazard.

The IPRP is focused on whether the PG&E seismic assessment update incorporates the best available science, our current scientific understanding of seismic hazards, and new information that has become available since 2015. There are many examples of other faults that have temporally variable slip rates (selected examples: Bergen et al, 2017; Lifton et al, 2015), where using a long-term average slip rate, instead of a more recent slip rate that is representative of current tectonics, would significantly underestimate the seismic hazard. We recognize that uncertainties diminish with time spans of multiple seismic cycles, but that doesn't overcome the fundamental data quality problems with the older San Simeon and Estero Bay sites or the larger uncertainties with the Point Sal site (Nishenko, et al., 2025).

For example, the CNWRA (2016) study presents the possibility that the Hosgri fault slip rate has increased over time specifically in the age range of the available slip rate estimates used by PG&E. The authors conclude: "*The results show an increase in slip rate of 0.21 mm/yr for the oldest unconformity (2.58 Ma) to 2.17 mm/yr for the youngest unconformity (0.02 Ma)".* If this is true, then the inclusion of older, pre-Holocene slip rates leads to an underestimate of the current slip rate and is unrepresentative of the current hazard.

One can envision two clear slip rate models: an end member model that assumes the slip rate is constant over long-term periods or an alternative where slip rates have increased through time, as shown in two figures of the CNWRA study (fig. 3-3, 3-4). The IPRP has identified two observations of the slip rate data that can be explained by a slip rate increase: 1) the CNWRA study, and 2) the Hosgri fault slip rate site data used

by PG&E in the Update. PG&E has not refuted the interpretations with the rigor we believe is required for dismissing these possibilities.

The IPRP considers these interpretations of a slip rate increase over time to be "technically defensible" interpretations. As such, one would expect them to influence the slip rate site weighting scheme by additional down weighting of older sites. We fully acknowledge that the CNWRA study does not conclude this is the only possibility, but rather a possibility that has not been excluded by the data, or refuted by PG&E.

With respect to the use of longer-term slip rates, PG&E also asserts:

> *"Because the charge of the TI Team is to capture the Center, Body and Range of Technically Defensible Information to develop a mean-centered model, Hosgri slip rates from older features were still included in the model because they represent a possible correct average fault slip rate for use in the PSHA. For a moderate slip rate fault such as the Hosgri fault, the number of recurrence intervals over hundreds of thousands of years may be more statistically meaningful than the number of recurrence intervals over 10,000 years. Slip rates averaged over hundreds of thousands of years may average out slip rate variations that can occur on the scale of thousands to tens of thousands of years due to complex fault interactions (e.g. Dolan et al, 2016) or sea level changes (e.g. Rockwell and Klinger, 2023)."* (PG&E Letter DCL-25-003, pages 15-16)

We recognize an estimate with more intervals may be statistically robust. However, we disagree that this estimate is more meaningful or hazard relevant. We have presented evidence that the older slip rate site estimates may be technically difficult to defend as relevant to the current seismic hazard, or of such poor quality that the uncertainty ranges make the constraint they provide dubious. For example, the Point Sal site has an improved evaluation of the slip rate (Nishenko et al., 2025) that similarly casts doubt on PG&E's 2015 and 2024 offshore stratigraphic framework for ages of Estero Bay data.

<u>Ad Hoc Adjustments to Published Slip Rates</u>

The IPRP is also concerned with *ad hoc* and undocumented adjustments by PG&E to published slip rate estimates, namely the offsets reported by Johnson et al. (2014). PG&E has reevaluated the offset measurement and significantly expanded the uncertainties. Compared to the original publication (Johnson et al., 2014), which has detailed documentation of the offset measurement (figs. 9,10,11, and 12), PG&E has provided no documentation and appears to have arbitrarily added additional 10m uncertainty to the minimum and maximum estimates (PG&E Update, 2024, Table 5-13). PG&E should provide detailed documentation justifying these adjustments to demonstrate this is technically defensible. The IPRP also encourages PG&E to vet adjustments with the authors of the Kluesner, et al. (2023), study, as they likely possess detailed knowledge of the site and can assess whether these adjustments are reasonable.

Request 3

We request PG&E evaluate the implications of a Casmalia fault study (McGregor and Onderdonk. 2021) that reports an order of magnitude increase in slip rate over previous estimates to a reported rate of 5.6 - 6.7 mm/yr and assess potential kinematic linkages and fault interactions with the Hosgri fault. This evaluation should be part of the seismic hazard Update regardless of planned future work that is part of the LTSP or whether the fault is considered a stand-alone seismic source.

Although the Casmalia fault is outside the area of interest for individual seismic sources with respect to ground motions at DCPP, the IPRP's interest in the recently published slip rate of McGregor and Onderdonk (2021) is in the implications with respect to kinematic linkages to faults that are in the immediate vicinity of DCPP and the potential for the Casmalia fault slip rate to feed into the slip rate budget of these faults. For example, PG&E has alluded to slip from the Hosgri fault possibly bleeding into the Los Osos fault and other structures, implying a slip rate gradient along strike of the Hosgri fault, and this has apparently, directly or indirectly, factored into the weighting of the Hosgri fault slip rate. By this logic, and for consistency, reported slip rates on the Casmalia fault should also be considered in the weighting of the slip rate budget of the Hosgri and other structures in the vicinity of Diablo Canyon, due to its location near the southern terminus of the Hosgri fault. The IPRP is aware that PG&E has flagged concerns it has with the McGregor and Onderdonk (2021) study, and we agree that these concerns are best addressed as follow up work in the PG&E LTSP. However, until the McGregor and Onderdonk (2021) results are shown to be in error, they should be considered as a technically defensible model and considered in the Update.

The IPRP considers the results of this study no less relevant to DCPP than other lower confidence slip rate studies used by PG&E in their 2015 seismic hazard assessment and 2025 update. PG&E has also considered proximity to DCPP and the interpretation of an increasing south-to-north slip rate gradient along the Hosgri fault in the weighting of the Hosgri fault slip rate.

> "*This additional slip rate is consistent with the interpretation that the Hosgri-San Gregorio fault system slip rate increases from south to north as fault-parallel motion is transferred to the fault system from intersecting faults to the east.*" (PG&E Letter DCL-25-003, page 13")

The IPRP notes that this model is largely speculative and is not supported by quantitative slip rate estimates on these structures. The exception to this is now the McGregor and Onderdonk (2021) study. PG&E's omission of this study in the Update represents an inconsistency in the treatment of available data that potentially has direct implications to their model of slip rate changes along strike of the Hosgri fault system.

The IPRP reiterates that the Update should include full documentation and evaluation of studies available *at the time of the update*. It is the IPRP's opinion that this study should

be explicitly considered in the weighting of slip rates as a potential kinematic connection and contributor to the slip rate budget of the Hosgri and other faults in the vicinity of DCPP.

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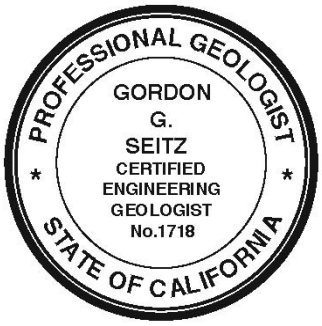

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