

DIABLO CANYON INDEPENDENT SAFETY COMMITTEE**Report on****Fact-Finding Meeting on May 30, 2024
and Update to the May 5, 2023, Comprehensive Seismic Safety Update****by****Robert J. Budnitz, Member, and
Richard D. McWhorter and R. Ferman Wardell, Consultants****1.0 SUMMARY**

The results of the DCISC May 30, 2024, Fact-Finding Meeting for the Diablo Canyon Power Plant (DCPP) and of the DCISC's latest comprehensive review of seismic safety are presented. The activities of the Fact-Finding Team (FFT) consisted of (a) participating in an open and public meeting of the Independent Peer Review Panel (IPRP) and then of (b) accounting for IPRP comments and for other recent seismic-safety information since May 2023 to develop a comprehensive DCISC update on the topic of seismic safety. The subjects addressed and summarized in Section 3 are as follows:

1. Independent Peer Review Panel Meeting on May 30, 2024
2. Update to the May 5, 2023, Comprehensive Seismic Safety Update

2.0 INTRODUCTION

This Fact-Finding Meeting for the DCPP was held to evaluate specific safety matters for the DCISC. The objective of the evaluation was to determine if PG&E's performance is appropriate and whether any areas revealed observations which are important enough to warrant further review, follow-up, or presentation at a public meeting. These safety matters include follow-up and/or continuing review efforts by the Committee, as well as those identified as a result of reviews of various safety-related documents.

Section 4 – Conclusions, highlights the conclusions of the FFT based on items reported in Section 3 - Discussion. These highlights also include the team's suggested follow-up items for the DCISC, such as scheduling future Fact-Finding Meetings on the topic, presentations at future public meetings, and requests for future updates or information from DCPP on specific areas of interest, etc.

Section 5 – Recommendations, presents specific recommendations to PG&E proposed by the FFT. These recommendations will be considered by the DCISC. After review and approval by the

DCISC, this Fact-Finding Report, including its recommendations, will be provided to PG&E. The Fact-Finding Report will also appear in the DCISC Annual Report.

2.1 The Role of Peer Review

Peer review is the process of subjecting technical work to the scrutiny of outside experts in the same field. Peer review is intended to evaluate the validity and significance of the work and identify any errors. Many widely-followed engineering analysis methodologies, which provide step-by-step guidance on how to perform a specific analysis, also contain detailed peer-review guidance tailored to the technical issues involved.

The State of California’s Independent Peer Review Panel (IPRP) was created for just such a purpose: “to conduct an independent review of enhanced seismic studies and surveys of the Diablo Canyon Units 1 and 2 powerplant, including the surrounding areas of the facility and areas of nuclear waste storage” (CA Public Utilities Code §712). The California Public Utilities Commission, the California Energy Commission, the California Geological Survey of the Department of Conservation, the California Coastal Commission, the Alfred E. Alquist Seismic Safety Commission, the California Office of Emergency Services, and the County of San Luis Obispo are all represented by members of the IPRP and provide their respective expertise.

As discussed below the IPRP plays an important role in both the DCISC’s review of seismic safety at DCCP, as mandated by Senate Bill 846, and in the Committee’s review of the PG&E-supported new “Diablo Canyon Updated Seismic Assessment, Response to Senate Bill 846.”

Many of the conclusions in the following Fact-Finding Report which accept the PG&E position or the NRC position (or both) are based on the following premise: expert peer review is the best way to gain high confidence in the quality of a piece of difficult and complex technical work. Hence, credibility is given to the following reports, cited heavily here throughout:

- The original PG&E Senior Seismic Hazard Analysis Committee (SSHAC, 2015) study, which had extensive strong, credible peer review start to finish using SSHAC guidance on how to do the peer review.
- The PG&E Seismic Probabilistic Risk Assessment (SPRA, 2018), which had extensive peer review that followed the guidance in the ASME-ANS PRA standard.
- The new PG&E-supported Diablo Canyon Updated Seismic Assessment (DCUSA, 2024), which had two different outside peer review groups

The first two of the three listed just above also had technically strong reviews by competent NRC staffers, which helped the DCISC to reach its own conclusions on those reports.

3.0 DISCUSSION

3.1 Independent Peer Review Panel Meeting on May 30, 2024

DCISC Member Dr. Robert Budnitz, Consultants Ferman Wardell and Richard McWhorter, and Counsel Robert Rathie attended the May 30, 2024, remote public meeting of the State of California's Independent Peer Review Panel (IPRP)¹ for seismic studies at DCP. The DCISC last observed an IPRP meeting on November 9, 2023, and reported on it in its November 2023 Fact-Finding Meeting report (Reference 6.1.1), when it concluded the following:

The meeting on November 9, 2023 of the California Public Utility Commission's "Independent Peer Review Panel" (IPRP), charged with periodically reviewing the seismic safety at DCP, has not yet resulted in a written report that, if issued, will be reviewed by the DCISC.

This meeting's topics were as follows:

1. Panel Member Comments on "Diablo Canyon Updated Seismic Assessment, Response to Senate Bill 846" (the "Updated Seismic Assessment," Reference 6.1.2)
2. PG&E Presentation: Long-Term Seismic Program
3. Presentation by Dr. Peter Bird, Consultant for the San Luis Obispo Mothers for Peace

The meeting was called to order and chaired by David Zizmor, California Public Utilities Commission (CPUC) Regulatory Analyst. Besides the several IPRP members from various California government agencies, the attendees included several PG&E experts on seismology and seismicity, two of whom (Chris Madugo, Geosciences Consultant, and Albert Kottke, Principal Geotechnical Earthquake Engineer) gave the PG&E presentation, having been introduced by PG&E's Jeffrey Bachhuber, Geosciences Director. In addition, there were about 30 other attendees who were members of the public or representatives of various other organizations.

At the outset, Mr. Zizmor noted that because of directives contained in California legislation in 2022, Senate Bill 846 (SB846), the IPRP and the DCISC now have a specific mandate to interact in the context of evaluating seismic-safety aspects of the proposal to extend the Diablo Canyon plant's licenses beyond the current expiration dates in 2024 and 2025. Specifically, SB846 by its enactment of Public Utilities Code §712.1 includes language that reads, "The DCISC shall ... consult with and incorporate into its assessments and recommendations the independent peer review panel established pursuant to Section 712."

The first item on the agenda was then introduced by Mr. Zizmor, who noted that various IPRP members had been reviewing the Updated Seismic Assessment individually in the last couple of

¹ In 2015 the California State Legislature by enacting Public Utilities Code §712 directed the California Public Utilities Commission to convene an independent peer review panel to conduct an independent review of enhanced seismic studies and surveys of DCP Units 1 and 2, including the surrounding area of the facility and areas of nuclear waste storage.

months and had begun to develop an IPRP evaluation report on that Assessment, with the goal of completing that report and making it public by about the end of June 2024. This IPRP meeting was understood to be an important component of the IPRP's work in developing that evaluation report. Mr. Zizmor also noted that because the DCISC will need to review the IPRP report in the course of its own evaluation of the Updated Seismic Assessment, the IPRP was hopeful that a draft version might be made available to the DCISC in mid-June 2024, prior to its June 20-21, 2024, Public Meeting.

Technical presentations then followed by IPRP members Gordon Seitz, California Geological Survey; Philip Johnson, California Coastal Commission; and Rui Chen, California Geological Survey, and each provided a review of and commentary on the Updated Seismic Assessment. Mr. Seitz's presentation concentrated on seismic-source-characterization issues related to the Hosgri Fault offshore as well as other source-characterization issues. Mr. Johnson's presentation concentrated on on-shore seismic information, related to seismicity in the Irish Hills and other on-shore features and data. Ms. Chen's presentation concentrated on ground-motion propagation and characterization issues.

Throughout these presentations, there was discussion and questioning from other IPRP members as well as from members of the public. The general conclusion of the presentations was a broad concurrence that the Updated Seismic Assessment represented a good quality report, although several specific technical issues were raised and discussed in detail. How these technical issues will be evaluated by the IPRP will emerge when their final report is issued in June 2024.

The next agenda topic consisted of a technical presentation by PG&E experts on their Long-Term Seismic Program (LTSP), a technical research program that is mandated as a license condition as part of the NRC's operating license for DCPD and is regularly reviewed by the IPRP. PG&E's experts described several ongoing LTSP technical research projects and their results, insights, and schedules. They described the principal motivation for this ensemble of LTSP projects as being to continue to increase the depth of understanding for the various underlying seismic phenomena and to reduce the uncertainties where feasible.

The final agenda topic consisted of a guest presentation by Dr. Peter Bird, who summarized the principal technical points that he has raised in recent technical papers that have been submitted to the NRC and the CPUC (References 6.1.4, 6.1.5, and 6.1.6) and in a recent letter to the DCISC (Reference 6.1.7). The major thrust of Dr. Bird's work and of his presentation to the IPRP was to explain his claim that PG&E's seismic-hazard analysis for Diablo Canyon completed in 2015 (Reference 6.1.3) significantly underestimated the seismic hazard, and that the Updated Seismic Assessment is also thereby incomplete or in error.

The agenda did not offer enough time for the IPRP members or the other attendees to discuss Dr. Bird's presentation thoroughly. From the discussion, it emerged that the IPRP would be reviewing Bird's technical work further, although that review would await additional input including what may arise from an NRC public meeting on the subject in late June. No commitments were made as to the schedule or depth of any IPRP review of Dr. Bird's work.

The DCISC will review the IPRP's evaluation report on the Updated Seismic Assessment when it is provided, and will also review any additional evaluations of Dr. Bird's work by the IPRP or the NRC when they become available.

No specific date was announced for the next IPRP meeting.

Conclusions: The May 30, 2024, meeting of the Independent Peer Review Panel (IPRP) was successful in discussing the major items on its agenda, including a technical discussion of the recent Updated Seismic Assessment Report, a PG&E presentation on their Long-Term Seismic Program, and a presentation by Dr. Peter Bird on behalf of the San Luis Obispo Mothers for Peace. The DCISC should take into account the IPRP's evaluations as the Committee continues its reviews and develops conclusions on seismic safety at DCP. The DCISC should also continue to attend future IPRP meetings and consult with the IPRP concerning the IPRP's deliberations, findings, and recommendations.

Recommendations: None

3.2 Update to the May 5, 2023, Comprehensive Seismic Safety Update

This report has been prepared based on information gathered by DCISC Member Dr. Robert Budnitz with support from Consultants Ferman Wardell and Richard McWhorter, as well as Counsel Robert Rathie. At the DCISC's public meeting on June 29, 2023, the Committee approved the May 5, 2023, Fact Finding report (Reference 6.2.1) that contained as its principal section a "Comprehensive Seismic Safety Update." That report represented the DCISC's position on seismic safety as of the date it was adopted.

In that report the DCISC concluded the following:

As background, when the DCISC reviewed the PG&E probabilistic seismic hazard analysis (PSHA) in 2016 and the seismic probabilistic risk assessment (SPRA) in 2018, the Committee was satisfied that the seismic safety achieved by DCP was acceptable at that time – indeed, the DCISC believed that it represented industry-leading performance in the seismic safety achieved by the facility.

Based on its review as reported here, the DCISC has developed the following broad conclusion:

After reviewing the new and updated information presented by PG&E in the November 2022 Fact-Finding Meeting, supplemented by earlier DCISC Fact-Finding Meetings and Public Meeting presentations, by other industry-wide information, and by information arising from both the October 2022 IPRP meeting and the May 2023 IPRP meeting, the DCISC concludes that the seismic safety of the DCP reactors is fully adequate now, and requires no additional upgrades or other changes to bring it up-to-date or to improve it. The DCISC also concludes that no upgrades or improvements to seismic safety would be necessary to assure that the

seismic safety of the DCPD reactors would be adequate for extended operation beyond 2025, if so authorized.

Based on its review, the DCISC has three recommendations for its own future reviews:

First, the DCISC should review any new seismic-related information that could be forthcoming when PG&E submits a new (updated) License Renewal Application to the NRC at the end of 2023. The DCISC should undertake a thorough review of that submittal's sections relevant to seismic safety, as well as any underlying information that PG&E will rely on in that submittal.

Second, the DCISC should review the seismic-safety review that PG&E will conduct as required by California legislation SB846.

Third, the DCISC should review any analyses that may be performed by the NRC or other entities in response to the May 2, 2023, SLOMFP filing with the NRC claiming that PG&E has underestimated the seismic hazard at DCPD. It is currently understood that this filing will be evaluated by PG&E as a part of the SB846-mandated seismic-safety review and the DCISC should review PG&E's evaluation of this filing following its completion.

Since that time, new information has been developed that is directly relevant to the technical substance of the May 5, 2023, Fact-Finding report (Reference 6.2.1). As noted, this report consists of an update to that earlier DCISC-approved report. Some of the text herein has been taken directly from the earlier report; other sections of earlier text have been modified; and other sections are new. This report should therefore be read and understood as a revision of and a replacement for the May 5, 2023, Fact-Finding report. It represents the DCISC's latest comprehensive report and its up-to-date position on plant seismic safety.

Additional DCISC Fact-Finding Meetings Related to Seismic Safety: In the period since the November 2022 DCISC Fact-Finding Meeting, the DCISC conducted several additional Fact-Finding meetings that included reports covering reviews of topics related to DCPD seismic safety. They were the:

- January 2023 Fact-Finding report (Reference 6.2.2)
- March 2023 Fact-Finding report (Reference 6.2.3)
- July 2023 Fact-Finding report (Reference 6.2.4)
- August 2023 Fact-Finding report (Reference 6.2.5)
- November 2023 Fact-Finding report (Reference 6.2.6)
- December 2023 Fact-Finding report (Reference 6.2.7)
- March 2024 Fact-Finding report (Reference 6.2.8)
- May 2024 Fact-Finding report (Reference 6.2.9)

The topics covered in these Fact-Finding Meetings included (a) details about PG&E's plans to perform the updated seismic assessment required to be completed by SB846 (in the January 2023

report); (b) FLEX equipment capabilities and procedures after a large earthquake (in the January 2023, July 2023, December 2023, and May 2024 reports); (c) a review of the 2010 Enercon Services report regarding seismic vulnerabilities of non-safety structures and equipment (in the March 2023 report); and (d) reviews of progress and content of the PG&E-sponsored Updated Seismic Assessment (in the August 2023, November 2023, and March 2024 reports). The DCISC has also reported in Fact-Finding reports periodically when its representatives have attended various IPRP meetings. The DCISC also heard a presentation by PG&E during its February 2024 Public Meeting.

Other Additional Information: In addition to the DCISC activity associated with the various Fact-Finding Meetings, the DCISC has reviewed important new information that has arisen since May 2023. That information includes the following:

- PG&E has submitted a License Renewal Application (LRA) to the NRC (Reference 6.2.10), seeking a 20-year extension to the current licenses. The DCISC has reviewed the LRA to ascertain whether important information relevant to seismic safety is contained therein. (See Section 3.2.6.1 below.)
- PG&E has led the development of a new “Diablo Canyon Updated Seismic Assessment” (Reference 6.2.11), in response to a requirement in California Senate Bill 846. That assessment was completed in February 2024 and contains important information in the form of an analysis of extensive new technical information that has arisen in the period since PG&E completed their last comprehensive seismic-safety studies in 2015 and 2018 (Reference 6.2.12 and 6.2.13). (See Section 3.2.6.2 below.)
- The Independent Peer Review Panel is in the process of performing an additional seismic review, described in Section 3.1 earlier in this FF report. The DCISC will review the IPRP’s review when it becomes available. (See Section 3.2.6.3 below.)
- Dr. Peter Bird has submitted three different technical reports, included in filings in various different legal or procedural forums, that contain analyses and technical positions relevant to the seismic hazard at the DCPP site. He also sent a letter to the DCISC dated May 16, 2024 (Reference 6.2.14). The DCISC has reviewed Dr. Bird’s reports and the analyses by others of Bird’s technical arguments. (See Section 3.2.6.4 below.)

As noted above, in this report the DCISC has revised and updated the seismic-safety section of its May 5, 2023, Fact-Finding report after considering the relevant new seismic-safety information since that time.

This review (as is true of all DCISC safety reviews) was based on the experience and judgment of the DCISC members, assisted by the Committee’s consultants. The plant’s operational safety is the primary focus of the DCISC’s work, and the DCISC does not use as a criterion a specific set of NRC safety regulations or guidance documents. Also, even though high reliability for many major equipment items may contribute to achieving safety, whether the plant achieves high

reliability in producing electricity is not a primary factor that informs the DCISC’s findings or recommendations.

The scope of the DCISC’s review of seismic safety is limited, based on its charter, to those aspects of DCP’s seismic design and seismic performance that are related to operational safety. As noted above, the DCISC believes that its scope in reviewing seismic safety does not extend to evaluating seismic damage that can significantly disrupt the plant’s ability to produce electricity, if the scenario of concern poses little or no threat to “operational safety.” That said, the DCISC has concluded that to the extent that workspace seismic safety could affect the response to a radiological accident, it is important to operational safety, so seismic safety in some non-safety-related structures and workspaces has been regularly evaluated by the DCISC.

Another issue about the scope of the DCISC’s safety reviews is important to emphasize. The DCISC has always understood its charter as reviewing the safety of the plant as it sits today and as it is operated today. Whether the plant met a specific regulatory requirement in times past, such as a design-basis requirement while it was under construction, has not generally been a question that the DCISC has considered as within its purview, except insofar as understanding the original design criteria or the original regulatory requirements can help a reviewer today to understand how safe the plant is today.

In the past the DCISC has extensively reviewed the DCP plant’s seismic safety in multiple Fact-Finding meetings and through presentations at numerous DCISC Public Meetings. Also, the DCISC has had the benefit of presentations by PG&E on the seismic-hazard and seismic ground-motion aspects at several meetings of the IPRP. However, the DCISC’s seismic safety reviews since autumn 2022, taken as a whole and reported on herein, have been prompted mainly by the proposed extension of power operations and directives contained in California legislation SB846.

3.2.1 Senate Bill 846 Direction

The motivation for this comprehensive seismic safety review that the DCISC began in fall 2022 was primarily California Senate Bill 846 (SB846), enacted into law in early September 2022, which directed the DCISC to review and evaluate seismic safety in the context of inquiring as to whether important seismic-safety upgrades would be needed to support safe operation if the plant’s operating period were to be extended beyond the current NRC licenses that end in late 2024 (Unit 1) and mid 2025 (Unit 2). Several subsequent DCISC Fact-Finding meetings and public meetings have provided important information to support the DCISC review and evaluation required by SB846. The scope of this report not only includes information that has emerged from those meetings and from reviewing the several sources of new information outlined above, but also includes the broad conclusions of the DCISC on the mandate of SB846 concerning whether important seismic safety upgrades would be needed to support safe operation after 2025. A summary of the DCISC’s conclusions on this question is found in Section 3.2.9.

3.2.2 Seismic Safety Analysis Process

To analyze the level of seismic safety achieved by the design of a nuclear power reactor one needs the following types of information:

- a. The analysis needs to identify each potential accident sequence that could be initiated by a large earthquake and that could lead to a core-damaging accident.
- b. The analysis needs to be able to differentiate among the core-damaging sequences so as to identify, for each one, whether it would lead to a small or no release of radioactivity, or would lead to a significant release of radioactivity (what the NRC has called a “large release”), and if so whether that large release would occur relatively quickly (what the NRC has called a “large early release”) or would occur only after a significant delay.
- c. For those seismic-initiated accident sequences of concern that are associated with a radioactive release, the analysis needs to characterize the release in terms of timing, energy content, radioactivity content, and a few other parameters required to fully describe how the potential release would ensue and why.
- d. The analysis needs to identify, for each sequence being analyzed, the “size” of the earthquake ground motion at the site that causes the sequence. Here the word “size” is intended as shorthand for a variety of different characteristics of the earthquake ground motion at the site, such as the amplitude of the acceleration, its duration, its frequency spectrum, whether the acceleration is associated with significant displacement or velocity, and a few other features.
- e. Because earthquake ground motion can arrive at the site with different “sizes,” the analysis needs to include the likelihood of occurrence as a function of “size,” which is commonly known as and tabulated or displayed as the family of “seismic hazard curves.” This likelihood is generally characterized by its annual probability of occurrence.
- f. For each seismic accident sequence of interest, the analysis needs to include the various contributing failures, including not only the seismic-caused failures but also any human errors or non-seismic failures that contribute or participate in the accident sequence.
- g. The accident sequence and their temporal relationships need to be described in the analysis; also, each failure of a structure or component needs to be characterized in a way that allows an understanding of how and why it participates in the sequence of events, which specific failure mode of each earthquake-damaged item is the issue, and any correlations among the various failures. The general understanding of what “failure” means for a structure or component is a failure to perform the item’s safety function or cause another structure or component to fail to perform its safety function.
- h. Crucially, for each identified accident sequence, the analysis needs to quantify the sequence’s likelihood, characterized by its annual probability of occurrence.
- i. Because each of the many issues mentioned above is typically not known exactly, but only known with some uncertainty, the analysis needs to include a quantification of the uncertainty, how it arises, what is its character, and why. Unless the characterization of

the uncertainties is done appropriately, the usefulness of the analysis information for decision-making about safety can in some circumstances be seriously diminished.

After each seismic accident sequence has been identified and analyzed as above, the analysis needs to “roll up” the ensemble – essentially summing up the various accident sequences. The result is the development of broad measures of seismic safety such as the overall annual frequency of sequences that involve seismic-induced core damage, approaches by which original plant safety systems, workplace seismic safety for plant employees, and, ultimately, FLEX² equipment and other recovery capabilities could mitigate damage and prevent core damage, the overall annual frequency of a large seismic-caused radiological release, and any other figures-of-merit that a decision-maker might wish to know about. Workplace seismic safety for plant employees is not explicitly developed by this analysis but a separate analysis can be done to identify workplace-safety issues.

One crucial use of the information is that, depending on the risk level, possible improvements in the seismic safety of the design and operation can be identified, including workplace seismic safety for employees and specific actions that could be taken under the FLEX program. Insights such as these are very important outputs of the analysis described above.

3.2.3 Background on Previous DCPD Seismic Safety Analyses

a. DCPD Probabilistic Seismic Hazard Analysis

The most comprehensive information about the various sources of earthquakes that might threaten the DCPD plant (Sections 3.2.2.d. and e. above), about the ground motion at the site arising when any of those earthquakes might occur, and about the uncertainties in the various aspects of the analysis is found in PG&E’s most recent seismic study, the “Diablo Canyon Probabilistic Seismic Hazard Analysis” (PSHA) study published in 2015 (Reference 6.2.12). Since that study was completed, additional research has been completed to supplement that study which provides additional valuable information.

b. DCPD Seismic Probabilistic Risk Assessment

The bulk of the rest of the needed information (Sections 3.2.2.a. to c. and f. to h. above) is found in PG&E’s “Diablo Canyon Seismic Probabilistic Risk Assessment” (SPRA), published in 2018 (Reference 6.2.13). The SPRA’s analysis has information about how the earthquake ground motion affects (and potentially damages) each important structure and component at DCPD; about how likely that damage is, as a function of the “size” of the ground motion; about each seismic-initiated accident sequence, including the contributing failures, the timing, and the phenomena; about whether each sequence involves important radioactive releases, and if so how those releases are characterized; and about the uncertainties in the various aspects of the analysis.

² FLEX is not an acronym but describes a strategy developed by the nuclear industry to provide diverse and flexible coping strategies to address the loss of safety-related systems due to certain beyond design basis events. It is a group of supplemental components, many of them portable, which are seismically stored, and can be made available for timely attachment to permanent plant systems for accident mitigation.

As discussed below, both the PSHA and the SPRA were subject to extensive outside peer review during their development and were reviewed by the NRC and the DCISC after their completion.

c. DCPD Long Term Seismic Program

Since the plant started operation in the 1980s, PG&E has been carrying out a Long-Term Seismic Program (LTSP), a program under which PG&E has undertaken a large number of projects to assure that DCPD is adequately designed and operated to provide safety against potential very large earthquakes. The LTSP is required by the NRC as a license condition for operating DCPD. The DCISC has reviewed the LTSP several times in recent years (References 6.2.15 and 6.2.16), as has the IPRP.

The LTSP program involves four different technical areas, covering an understanding of the following:

1. The seismic hazard (the various seismic sources)
2. The seismic ground motion arising at the site and the in-structure energy propagation
3. The seismic fragility of components and structures
4. The plant seismic response (an analysis of the plant's various systems and the role of the operators)

d. Nuclear Industry Activities Affecting DCPD Seismic Programs

In addition to the above, important activity in the broader nuclear industry has occurred over the years to inform and support the development of Diablo Canyon's PSHA and its SPRA, as follows:

In the mid-1990s, a major advance occurred when a new methodology was developed, known now as the "Senior Seismic Hazard Analysis Committee (SSHAC) methodology" (Reference 6.2.17). It has since been used and adopted worldwide for the performance of major PSHA studies like that done at DCPD. This methodology includes specific guidance on how to structure a peer review, which the methodology requires. The SSHAC methodology has been endorsed by the NRC for such use (References 6.2.18 and 6.2.19), and the DCISC agrees that this endorsement is appropriate.

Starting in the early 1990s, another major advance occurred when the American Society of Mechanical Engineers (ASME), later joined by the American Nuclear Society (ANS), developed standards with requirements for performing a nuclear power reactor Probabilistic Risk Analysis (PRA), including a seismic PRA (Reference 6.2.20). It too has been used and adopted worldwide for the performance of major SPRA studies like that done at DCPD. This standard also includes specific requirements on peer reviews. It has also been endorsed by the NRC for such use (Reference 6.2.21), and the DCISC agrees that this endorsement is appropriate.

Also, significant research activity worldwide has occurred over the years, and continues today, that has provided additional understanding of each of the major technical areas involved in the above. Keeping abreast of that activity is important, and the DCISC believes that the PG&E scientists and engineers involved in the various seismic studies have done that (and are and have long been acknowledged as being among the industry leaders in both the PSHA and the SPRA areas).

3.2.4 Topics Reviewed by the DCISC Since the Passage of SB 846

The DCISC Fact-Finding Meeting in November 2022 (Reference 6.2.22) was the first opportunity to review seismic safety issues after the passage by the California legislature of SB846 authorizing potential extension of the DCCP operating licenses. The DCISC Fact-Finding Team requested that PG&E discuss two broad topics during its November 2022 Fact-Finding Meeting:

- Provide a general update on the status of seismic hazard evaluations, seismic fragility evaluations, and the SPRA for DCCP.
- Provide any new information or developments in this area that could affect license renewal and/or the proposed extension of operations beyond 2025.

Most of the technical topics were covered within the scope of the LTSP. Also, most of the technical topics were encompassed in various major PG&E technical reports developed several years ago in response to a 2012 NRC Request for Information (Reference 6.2.23) after the Fukushima nuclear accident in Japan.

Specifically, as mentioned above, the plant undertook a major and comprehensive new evaluation of the seismic hazard, known as the Diablo Canyon Probabilistic Seismic Hazard Assessment (PSHA), published in 2015 (Reference 6.2.12). That evaluation, which was performed according to the universally adopted methodology for such PSHA studies (References 6.2.17, 6.2.18, 6.2.19), was reviewed by the NRC, and also by the DCISC. The NRC review was published in 2016 (Reference 6.2.24). The NRC's overall conclusion in that review was, "Based on this review, the NRC staff concludes that the licensee conducted the seismic hazard reevaluation using present-day methodologies and regulatory guidance, it appropriately characterized the DCCP site given the information available, and it met the intent of the guidance for determining the reevaluated seismic hazard." The DCISC's review was also favorable (References 6.2.25, 6.2.26).

Also in the same period, PG&E undertook a modern update of their plant SPRA, which had first been developed in the late 1980s, and had been kept up to date throughout the intervening years. That most recent SPRA was published in 2018 (Reference 6.2.13). That SPRA was also reviewed and found acceptable by the NRC staff (Reference 6.2.27). The DCISC also reviewed that report favorably at that time and found it to have been of excellent quality. Concerning the SB846 direction to the DCISC, it is important to note that the DCISC did not at the time of the SPRA's completion identify any important safety improvements that would be needed, and the plant was judged to be adequately safe in the area of seismic safety (Reference 6.2.28).

Given this history, the purpose of the several DCISC Fact-Finding Meetings, starting with the November 2022 meeting (Reference 6.2.22) and continuing with other meetings on March 14, 15 and 27, 2023 (Reference 6.2.29), August 29-30, 2023 (Reference 6.2.30), November 14-15, 2023 (Reference 6.2.31), and March 18-20, 2024 (Reference 6.2.32), was principally to ask and to discuss, in each of the technical areas encompassed by overall seismic safety, the following question: “What is new since those comprehensive and thoroughly-reviewed evaluations were completed in the mid- to late 2010s?”

3.2.5 Results of the November 2022 Fact-Finding Meeting and DCISC’s Follow-on Activities

The Fact-Finding Team found in November 2022 that in recent years a good deal of new information continued to be developed in the areas of seismic hazard and seismic ground-motion characterization, because those are “fast moving” areas of technical work. This includes both research work specifically relevant to the DCPD plant site and its regional setting along with work elsewhere in the US and worldwide that advances the community’s understanding and its analysis capabilities. However, rather little new information has been developed in the areas of seismic fragilities and the plant’s SPRA model, in part because those are not “fast moving” areas where significant technical advances are occurring now.

a. Understanding of Seismic Hazard and Seismic Site Ground Motion

PG&E, through their LTSP studies, continues to develop new information about several technical topics within the broader scope. The DCISC has reviewed the broader LTSP program several times over the past decade. Concerning the seismic sources, the topics now being studied include:

- Studies of fault locations, geometries, stress distributions, and potential fault linkages
- Research on slip rates on the major nearby faults (mainly but not exclusively the Hosgri and Shoreline Faults)
- Studies of potential earthquakes that could occur off of recognized fault sources
- Seismic fault displacement modeling
- Advances in ground-motion modeling to incorporate non-ergodic approaches and potential time-dependency of the hazard
- Studies of paleoseismic data on the eastern Los Osos Fault
- Studies of deformed marine terraces to constrain the uplift rate of the Irish Hills
- Studies using modern Global Positioning System geodetic data
- Studies of nearby precariously balanced rocks
- Studies and evaluations of the numerous very small earthquakes that continue to occur both near the DCPD site and in the broader region of interest

Concerning characterizing the ground motion as it propagates from source to site, research continues on:

- Using improved data from recent small-magnitude earthquakes
- Improving the models

- Matching models more closely to the regional and local-site data
- Accounting more accurately for various directivity effects

Concerning local site effects, research continues on:

- Using improved data, both local site data from recent small-magnitude earthquakes and information from broader data sets
- Local site characterization
- The effects associated with potentially very long-duration earthquakes

On many of these topics, PG&E's LTSP personnel collaborate with groups and agencies unaffiliated with PG&E that have important research projects and data-gathering programs. Some of these are collaborations with the US Geological Survey or various California state agencies, and some of them are collaborations with other groups around the US and around the world. PG&E also continues to maintain its own network of seismic monitoring instruments both on and offshore in the area near the Diablo Canyon plant and also in the broader region.

As noted above, the DCISC has been reviewing the LTSP program for many years and has also had the benefit of over a decade of meetings and reviews by the State of California's IPRP. The DCISC continues to find this very extensive program to be of excellent quality. The overall approach is satisfactory to the DCISC and has also been reviewed by the NRC (Reference 6.2.24) with the same general conclusion.

Concerning the impact of any recent new information that would supplement the previous work, the DCISC evaluation of the new information since May 5, 2023, is in Section 3.2.6 below.

The DCISC recognizes that new seismic data (both local and worldwide) and new analyses and interpretations of existing data emerge continually, as has always been the case and as will continue in the future. The DCISC's review of PG&E's geosciences team and its work has supported the DCISC's conclusion that PG&E is continually and competently working to analyze this new information and respond to it as needed.

Some important new technical information on seismic safety that has arisen in the past year is contained in three documents recently filed in three different legal venues, containing in part technical information developed by Dr. Peter Bird claiming that PG&E's seismic-hazard analysis for Diablo Canyon completed in 2015 (Reference 6.2.12) underestimated the seismic hazard. One filing, by the San Luis Obispo Mothers for Peace (SLOMFP), is in an NRC generic environmental-impact proceeding (Reference 6.2.33). Another filing with the NRC (Reference 6.2.34), by SLOMFP, Friends of the Earth (FOE), and Environmental Working Group (EWG), requests a hearing on the DCP license renewal and cites in part Dr. Bird's technical work. A third filing with the NRC (Reference 6.2.35), by SLOMFP, FOE, and EWG, petitions the NRC to shut down the DCP plant due to seismic safety concerns, again citing Dr. Bird's technical work. Another important piece

of technical input from Dr. Bird is in a fourth document, a recent letter from him to the DCISC (Reference 6.2.14).

These four pieces of new technical information from Dr. Bird on seismic safety are discussed below in Section 3.2.6.4. These new interpretations are good examples of how new information needs to be reviewed and understood as it arises.

b. Understanding of Seismic In-structure Energy Propagation and the Seismic Fragility of Components and Structures

The SPRA of 2018 (Reference 6.2.13) included a reevaluation of the way seismic energy, once it arrives at the base mats (foundations) or anchorages of the various DCCP structures, affects those structures and propagates through them to the individual components. It also included a major reanalysis or reevaluation of the probabilistic seismic capacities or fragilities of the many individual structures and components, using standard methodologies and following the requirements of the NRC-endorsed ASME-ANS SPRA standard (Reference 6.2.20), including that standard's peer review requirements. PG&E reported to the DCISC that those earlier structural analyses and models along with the data on which they were based remain valid today, in part because the techniques for developing the underlying structural models are considered quite mature and have not changed. PG&E also reported that this is true of the methods now used for analyzing the seismic fragilities of individual structures and components, which provide the likelihood that a given earthquake load would cause enough damage to the item so that it could not perform its safety function. Although there is some irreducible uncertainty due to aleatory variability, arising from the intrinsic irreducible variability in some of the issues or phenomena, PG&E reported that the methodology for analyzing seismic fragilities is well defined, widely used, and very mature. On both of these topics, the structural analyses and the fragilities analyses, the DCISC concurs.

From time to time a new analysis is required when the configuration of equipment changes, unless a scoping study concludes that the change is unimportant. PG&E reported that in all of the relevant areas, nothing new or different has emerged of importance, meaning that the previous safety insights remain valid. The DCISC concludes that there is nothing new with regards to energy propagation in structures or the fragilities of structures and components that would modify the insights of the most recent SPRA in these areas.

c. The Seismic Probabilistic Risk Assessment Systems Model

The information about the seismic hazard, ground motion, and fragilities all feed into the SPRA's systems model, which identifies the many different potential seismic-initiated accident sequences of concern and analyzes each of them. That work is done using what is called the SPRA systems model. There is an underlying SPRA "internal initiators" systems model for the various accident sequences, most of which can be initiated by non-seismic upset conditions or events ("internal initiators") as well as by a large earthquake. That systems model then needs to be modified and adapted to analyze each earthquake-initiated sequence of interest. The methodology for this aspect of the overall SPRA

analysis is widely used worldwide, quite mature, and embedded in both international and domestic standards. Specifically in regard to the DCPD analysis, the 2018 SPRA analysis (Reference 6.2.13) used standard methodologies and followed the requirements of the NRC-endorsed ASME-ANS PRA Standard (Reference 6.2.20), including the peer review requirements.

As with the seismic-hazard analyses, PG&E reported that those earlier systems models and analyses are still valid today. Of course, occasionally a new analysis is required when a procedure has changed, or the underlying failure rate data (including human-error data) have changed. However, as with the other areas, PG&E reported that in the systems-modeling area nothing new has emerged of importance, meaning that the previous safety insights remain valid. The DCISC concludes that there is nothing new with regards to system modeling and analysis that would modify the insights of the most recent SPRA in that area.

d. Uncertainties in the Analysis

As mentioned above, the overall analysis must deal with and incorporate an analysis and discussion of the various uncertainties. Many of the uncertainties are in the numerical values used in or arising from the analysis, but some of them are more qualitative in nature. In both the PSHA analyses of seismic hazard and the SPRA analyses of overall seismic risk, the various uncertainties are typically divided into two different types, so-called “epistemic” uncertainties (arising from uncertainty in a measurement or from incomplete knowledge about a phenomenon) and “aleatory variability” uncertainties (arising from the intrinsic random variability in some of the issues or phenomena, such as the unknowable location where the next large earthquake might occur on one of the nearby faults). These distinctions are explained and standard methods for their analysis in both the PSHA and the SPRA are contained in the ASME-ANS PRA standard (Reference 6.2.20). Also as noted earlier, if the characterization of the uncertainties is not done appropriately, the usefulness of the analyses can in some circumstances be seriously diminished. The DCISC’s recent reviews continue to conclude that the seismic PRA’s uncertainty analyses are competently performed, clearly explained, and very useful to support decision-making. The current research work that PG&E is performing under the LTSP, as described above, will likely continue to reduce overall uncertainties, fill in gaps, and enhance confidence in the validity of the underlying understanding. And if unexpected new areas of information arise, these will need to be incorporated fully. The DCISC will continue to be alert to these developments in the ongoing course of its safety reviews.

e. Other Seismic-Safety Information: Spent Fuel Pool Safety and Mitigating Strategies Assessment

Three other sources of information, concerning Spent Fuel Pool seismic safety and a Mitigating Strategies Assessment, have provided additional insights to assist the DCISC in this evaluation.

1) One recent report is the PG&E review of the adequacy of the seismic design of DCP's Spent Fuel Pools. This review was performed as part of the post-Fukushima analyses required by the NRC and was reported in a separate PG&E report to the NRC in 2017 (Reference 6.2.36). PG&E concluded, using assessment criteria that the NRC had approved, that the new seismic-hazard information developed in the previous few years did not lead to any additional compromises to the seismic safety of the spent fuel pools.

2) Another important analysis was completed in 2020 by B.J. Garrick and D. Wakefield at University of California at Los Angeles (UCLA), supported by PG&E (Reference 6.2.37). That UCLA study examined Spent Fuel Pool safety, the safety of onsite transportation of spent fuel and radioactive waste from the reactor area to the Independent Spent Fuel Storage Installation (ISFSI) area, and the safety of the ISFSI facility itself. Its analysis, which evaluated the Holtec system that comprises the existing ISFSI storage system design, covered seismic safety along with other potential accident scenarios and provided important information and insights about risks at the Spent Fuel Pools and the ISFSI arising from large earthquakes. Its broad conclusion regarding seismic safety was that the overall risk to the public arising from challenges to the Spent Fuel Pools or the ISFSI at that time was well within acceptable levels. The DCISC was briefed on this study during a DCISC public meeting on July 1, 2020, reviewed it, and concurred in its results (Reference 6.2.38).

3) The third additional source of information is the 2018 PG&E "Mitigating Strategies Assessment" report (Reference 6.2.39). This report, required by the NRC (Reference 6.2.40), asked whether any safety backfits or other changes would be necessary in light of the new seismic-hazard information developed in the previous few years. PG&E's analysis identified none, and this was concurred in by the NRC. The conclusions in these reports appeared satisfactory to the DCISC.

3.2.6 Evaluation of the New Information that has Become Available since May 2023

a. Seismic-Safety Information in the PG&E License Renewal Application

PG&E has submitted a License Renewal Application (LRA) to the NRC (Reference 6.2.10), seeking a 20-year extension to the current licenses. The DCISC has reviewed the seismic aspects of the submittal. The DCISC review found that it contains very little information directly related to the seismic safety design of the plant. This is because issues of whether the plant has been adequately designed against earthquakes are not an area required to be addressed by the license renewal process. Instead, the license renewal process focuses on providing adequate assurance that structures and equipment will continue to perform their safety functions during the period of extended operations. Stated another way, the LRA focuses upon managing equipment aging so that equipment will continue to be able to withstand earthquake forces and does not require any additional reviews of the adequacy of the original seismic aspects of the design.

b. Seismic-Safety Information in the New Diablo Canyon Updated Seismic Assessment

PG&E has supported a new Diablo Canyon Updated Seismic Assessment (DCUSA) (Reference 6.2.11), in response to a requirement in SB846. That assessment was completed in February 2024 and contains important information in the form of an analysis of extensive new technical information that has arisen in the period since PG&E completed their last comprehensive seismic-safety studies in 2015 and 2018. (References 6.2.12, 6.2.13). The DCISC has reviewed it to ascertain whether important information relevant to seismic safety is contained therein. Also, PG&E made a presentation that covered the technical issues at the DCISC's February 2024 Public Meeting. Several important issues that arose during the DCISC review of the DCUSA are discussed in the next several subsections.

1) The use of the SSHAC process for the DCUSA:

The DCUSA was structured to use the widely employed "SSHAC process" (Reference 6.2.17) that has been endorsed by the US NRC (References 6.2.18, 6.2.19), has been used broadly not only in the US but internationally, and is understood to provide a rigorous framework for such an assessment. The DCUSA project analysts, guided by PG&E, selected a Level-One SSHAC process as the framework for the project, with the rationale that this new assessment was understood to be an update of the earlier 2015 Seismic Hazard Screening Report that PG&E completed and then submitted to the NRC (Reference 6.2.12). That earlier assessment followed a SSHAC Level Three process. The guidance for updating an earlier SSHAC Level Three study with a Level One assessment is contained in the NRC's most recent broad SSHAC methodology guidance (Reference 6.2.19).

The DCUSA project team did its work in the second half of calendar year 2023. Several DCISC representatives observed each of the four DCUSA team meetings that were made available for observation and also had access to draft material before the final report was issued. This made many elements of the process transparent to the DCISC. In the DCISC review of the DCUSA process, the DCISC found that the DCUSA process used a mixed approach that combined some elements of SSHAC Level One and some elements of SSHAC Level Two, such as enhanced outreach to proponents and resource experts, participatory peer reviewers observing working meetings and study team interactions with external experts, and use of a larger-than-typical technical-integrator team. The other major elements of the SSHAC Level One process were followed, most importantly the emphasis on developing a thoroughly vetted center-body-and-range of the technically feasible interpretations for each technical topic, as well as an emphasis on a thorough exploration of uncertainties.

The DCISC is satisfied that the selection of a SSHAC Level One process for this assessment (enhanced as noted above) was appropriate given that it was analogous to an update of an earlier SSHAC Level Three study. The DCISC is also satisfied that the study was implemented effectively.

2) The major DCUSA conclusions on the overall seismic hazard at the site:

The major DCUSA conclusion on the site seismic hazard was that a modest change in the annual frequency of the Hosgri Fault is supported by the new information, but that almost nothing else in the previous seismic hazard analyses developed for the DCP site was found to require modification. Small changes in understanding emerged concerning the Los Osos Fault, but they are too small to make a difference in our understanding. There is new information concerning the understanding of ground motion propagation from the various sources to the site and of the site effects, but all of it reinforces (with better data and higher confidence) the understanding and insights from earlier technical analyses. Furthermore, no new information was uncovered that might modify the understanding of how seismic energy propagates through the structures to excite seismic responses in equipment and structures. The DCISC has reviewed each of these areas and concurs with the major conclusions of the DCUSA.

The Seismic PRA has been updated since the 2018 version reported on in Reference 6.2.13, but all of the changes were modest and had no important effects on the plant's understanding of the seismic risk, the major contributors to that risk, or the uncertainties in the above. The DCISC has reviewed each of these areas and concurs.

3) DCUSA's findings on the two major risk indices, SCDF (Seismic Core Damage Frequency) and SLERF (Seismic Large Early Release Frequency):

As noted, the DCUSA concluded that the only important change in the seismic hazard for the DCP site was that the slip rate on the Hosgri Fault is now believed to be slightly larger than previously thought. However, no other characteristics of the Hosgri Fault were thought to be significantly different, such as the frequency spectrum of the seismic energy from earthquakes emerging from that fault, the earthquakes' durations, or other characteristics. Although much new information is available for the several other nearby faults that contribute somewhat to the overall seismic hazard at DCP, none of that information included any characteristics identified as significantly different compared to what had been previously understood. The DCISC has reviewed this aspect of the DCUSA analysis and concurs.

4) DCUSA's use of a scaling approximation for developing an estimate of the SCDF and SLERF risk indices:

This change in the Hosgri Fault slip rate discussed above, in turn, modifies the overall frequencies of the seismic-initiated accident sequences caused by that fault source. The DCUSA analysts chose to analyze the effect of these changes on the seismic PRA's analyses of SCDF and SLERF by doing a simple scaling of the seismic annual frequencies. This scaling, which is an approximation, increased the overall SCDF and SLERF numbers by factors in the range of about 10% to 25%, which by itself was found not to modify any of the important safety insights arising from the SPRA, such as the relative importances of the various seismic equipment failures to the risk. The DCUSA team chose not to expend major resources fine-tuning the factors of increase by determining slightly different factors across

the response frequency spectrum (for example, from 0.3 hertz to 50 hertz), because the differences would be small compared to the uncertainties in the frequencies of the earthquakes.

The largest contributors to the overall uncertainties in the SPRA analyses arise from the ground-motion models that analyze how the motion moves from source to site, and these uncertainties did not change. Hence honing the other analyses minutely for changes modest compared to those other uncertainties would not provide any significant new insights. The DCISC has reviewed these analyses and the judgments underlying them and concurs.

5) The role of site factors in the analysis of seismic hazard:

Two methods are available to develop so-called site factors, which capture how the seismic motion arriving at the site from the source is modified by the properties of the site itself. There are two different approaches, the analytical site-factor approach and the empirical site factor approach, both of which have been used at Diablo Canyon. The DCUSA concluded that although new site-specific data have become available in recent years, no update of the 2015 analyses was judged to be appropriate. Given that much of the new information is very site-specific or region-specific rather than more generic, the study team put extra effort into understanding the effects of the new site-specific (so called “non-ergodic”) data. In the end, the DCUSA team concluded that including or not including these data made little difference. The DCISC has reviewed this issue and concurs.

6) The role of EPHR (Equivalent Poisson Hazard Ratio) factors in the seismic hazard analysis:

In analyses of the nearby faults, account is taken of the fact that the rate of earthquake occurrence is not a strictly stationary-Poisson process (in which the likelihood of an earthquake occurring would be the same from one year to the next). A small correction factor, the so-called Equivalent Poisson Hazard Ratio (EPHR) factor, is introduced to account for this phenomenon. In the DCUSA analyses, the EPHR factor for the Hosgri fault was found to be slightly different (a few percent different) than previously thought, and the EPHR factor’s small change was introduced into the analysis. Because the correction factors are small, this effect is thought to make little (if any) difference to the insights. The use of the EPHR factors is innovative, but because the changes are quite small, the DCUSA analyses included them without concern about how uncertain the corrections are. The DCISC concurs with the judgments made in this aspect of the DCUSA analyses.

7) The role of directivity effects:

Directivity effects are effects on the ground motion that depend on whether, say, a north-south fault ruptures starting at the north end and propagating south or *vice versa*. It is commonly understood that such effects must be present in many fault systems, even though the data to support a detailed understanding of them is often not available. In seismic regimes like that at Diablo Canyon, these effects are generally believed to be only modest in the overall understanding of seismicity, although not every expert agrees on the matter.

Different models have been developed for the Diablo Canyon site vicinity, but there is a lot of disagreement among experts on how important the directivity effects might be. However, most modeling shows that these effects are likely to be most important for seismic shaking at very low frequencies (0.3 to 0.1 hertz or lower), which are motions to which most nuclear-plant equipment and structures are not very sensitive.

After exploring the issues, the DCUSA analysts did not include these effects, claiming in part that their influence would be modest if included. The DCISC believes that this is an area where more research is needed, but that the omission from the current analyses is acceptable because the effects are likely to be small.

c. Seismic-Safety Information Developed by the IPRP

As reported in Section 3.1 of this Fact-Finding report, the IPRP met most recently on May 30, 2024, and during that meeting technical discussions ensued about the seismic hazard at the DCP site, along with discussions related to the new DCUSA. The IPRP also heard a presentation by Dr. Peter Bird describing his own interpretations and analyses related to the site's seismic hazard. The IPRP is expected to provide its evaluations, conclusions, and recommendations (if any) on the subjects covered in that meeting sometime soon. The DCISC, in turn, has committed to reviewing whatever additional information or recommendations may result from the IPRP's work.

d. Seismic-safety information developed by Dr. Peter Bird

As discussed above in Section 3.2.5.a, Dr. Peter Bird has recently submitted three different technical reports that are contained in three different legal or procedural filings (References 6.2.33, 6.2.34, 6.2.35). Another technical input from Dr. Bird was provided in a recent letter to the DCISC (Reference 6.2.14). Each of these documents contains analyses and technical positions relevant to understanding the seismic hazard at the DCP site. The DCISC has reviewed the documents and has also reviewed analyses in the DCUSA report covering issues raised in the first of the three documents (Reference 6.2.33). The DCISC has also had the benefit of reviewing a response by the NRC's Petition Review Board (Reference 6.2.41) to one of the three documents mentioned above (Reference 6.2.35) that relied on Dr. Bird's technical analyses. That petition, which was denied on an interim basis, had asked the NRC to shut down the DCP reactors immediately due to a postulated safety concern.

Of the issues raised by Dr. Bird, the most recent are in the procedural filings (References 6.2.34, 6.2.35) and in his letter to the DCISC (Reference 6.2.14), where it is argued that a very recent large earthquake in Japan, the Noto Peninsula earthquake in early January 2024, is sufficiently analogous to the seismic-tectonic setting near the DCP site that its thrust-fault phenomena can be used to support Dr. Bird's contention that the earlier PG&E seismic hazard analyses are in error. On that specific technical issue, the DCISC has an insufficient basis for judgment at this time because the DCISC has not seen a thorough review of Dr. Bird's interpretation by other seismic experts that could help the DCISC to understand the

claim's validity, and the DCISC itself is not specifically familiar with the tectonic setting at that location in Japan.

On each of the other technical issues raised by Dr. Bird, the DCUSA performed a review that has been helpful to the DCISC in performing its review. The NRC staff has also weighed in as part of its Petition Review Board initial assessment (Ref. 6.2.41). These other technical issues are as follows, A to F. (Quotation marks in the following text subsections A to F represent direct quotes from the DCUSA report.)

A. Dr. Bird argues for the use of on-fault deformation rates from geodetic and kinematic based numerical models. The DCUSA report concludes that a principal basis for not including the Bird model for on-fault deformation is that "Slip rates calculated from existing regional deformation models were not considered technically defensible." Also, while the models may be adequate for studies over large regions of the western U.S., the DCUSA report claims that it is "more appropriate" to use local and site-specific geological slip rate data for the DCP site. Finally, the modeled rates using Dr. Bird's hypothesis are "generally consistent" in their final fault slip rates, so the difference is not important anyway. The DCISC has reviewed the issue evaluation and concurs with the DCUSA's evaluation.

B. Dr. Bird argues for the use of off-fault deformation rates from geodetic and kinematic deformation models. The DCUSA concludes that these rates are "poorly understood and not yet mature enough for use in regional and site-specific or regional seismic hazard models." The DCUSA's argument here cites U.S. Geological Survey studies that claim that using geodetic based off-fault deformation models is not technically defensible today, because "the methodology is not yet mature" and needs "long term research" before the insights should be included in an overall evaluation. The DCISC has reviewed the issue and concurs with the DCUSA's evaluation.

C. Dr. Bird argues for using seismicity rates developed using the Seismic Hazard Inferred From Tectonics (SHIFT) model. The DCUSA report claims that seismicity rates from the SHIFT model "are not yet accepted or used by the seismic hazard community and are currently not considered appropriate substitutes for site-specific seismic hazard assessments where fault slip rates and seismicity are well characterized." The report states that the SHIFT model, relying as it does on the ergodic assumption to an important degree, has not been accepted by the community of experts, and is "of academic interest" but "not sufficiently evaluated or tested" to be used. The DCISC has reviewed the issue and concurs with the DCUSA's evaluation.

D. Dr. Bird argues that "dips for primary faults beneath the Irish Hills, including the Los Osos and San Luis Bay faults should be less than 30 degrees based on geologic structure and the orientation of the regional stress field." According to the DCUSA, "Given that no new data were provided by Dr. Bird to support the existence of significant seismogenic faults with dips of less than 30 degrees beneath the Irish Hills, we [the DCUSA report] consider the 2015 SSC [seismic source characterization] to adequately capture geometry of faults beneath the Irish Hills." Dr. Bird's argument for smaller dip angles for faults

beneath the Irish Hills is similar to models proposed and evaluated in the 2015 SSHAC Seismic Source Characterization study. The DCUSA says that those models were adequately incorporated in 2015, and that no new data have emerged to challenge the earlier interpretation. Further, the report claims that faults with lower dips are not hazard-significant because they are constrained by the width of the Irish Hills. The DCISC has reviewed the issue and concurs with the DCUSA's evaluation.

E. Dr. Bird argues for the use of long-term geologic slip rates for the Shoreline fault. The DCUSA states that this time frame "exceeds the time frame relevant to seismic hazard assessment and is inconsistent with the Late Quaternary style of deformation on the Shoreline fault." According to the DCUSA report, an important argument against inclusion of this approach, which relies on estimates of vertical throw of Pliocene age (a few million years before present) across the Shoreline fault, is that it uses a proposed or calculated very long-term slip rate for the Shoreline Fault or a low-angle equivalent. However, the DCUSA concludes that slip rates over that long time frame are probably not applicable to the current tectonic framework. Also, the DCUSA states that "There is no evidence for significant Late Quaternary uplift across the Shoreline Fault." The DCISC has reviewed the issue and concurs with the DCUSA's evaluation.

F. Dr. Bird proposes using a model of uplift mechanisms for the Irish Hills that invokes Airy isostasy. The DCUSA states that this use is "not consistent with site specific gravity data." That is, the most recent gravity data and geophysical modeling in the Irish Hills region are argued as not being consistent with the Bird model. For this reason, in the DCUSA the Bird model is considered to be "not technically viable." The NRC staff's Petition Review Board initial assessment (Reference 6.2.41) reached a similar conclusion. The DCISC has reviewed the issue and concurs with the DCUSA's evaluation.

3.2.7 Seismic Events and Reactor Vessel Pressurized Thermal Shock

Among questions asked in the context of the May 5, 2023, IPRP meeting was a question related to reactor vessel material coupons which are used in support of analyses used to understand the radiological damage to the vessel over time and also the susceptibility of the reactor vessel to Pressurized Thermal Shock (PTS). Technical analyses performed in support of NRC rulemaking activities related to PTS have demonstrated that earthquakes are not a significant contributor to the overall risk of occurrence of a PTS event (Reference 6.2.42). The DCISC has reviewed these analyses and concurs with their conclusions. Accordingly, the DCISC believes that the issue of reactor vessel coupons at DCP is being appropriately addressed in other forums not related to seismic issues and need not be addressed as a part of its seismic safety reviews.

3.2.8 Summary

Concerning the impact of all of the new seismic-hazard information, taken as a whole, the DCISC has concluded that there is nothing in any of it on either seismic hazard or seismic ground motion that would change the broader understanding of those topics as embedded in the earlier 2015 PG&E report (Reference 6.2.12), or that could lead to new safety insights. Concerning the understanding of overall seismic-induced risk at the plant, the DCISC has similarly concluded that

the broad understanding of risk has not changed in light of the updated SPRA analysis, compared to the 2018 SPRA study (Reference 6.2.13) that the DCISC reviewed at that time. In each area of study, the DCISC believes that the recent new information has either reinforced previous understanding or added new insights that reinforce earlier conclusions about overall seismic safety. In the DCISC's view, none of the new information that has become available since those earlier studies were completed has challenged any of those reports' major conclusions. Uncertainties are being reduced, small changes in some technical details have emerged, and some of the research has pointed out where additional studies can help to reduce the uncertainties still further. That work is beneficial and continues, but it does not affect any existing conclusions or insights.

3.2.9 Conclusions

When the DCISC reviewed the PG&E Probabilistic Seismic Hazard Analysis (PSHA) in 2016 and the Seismic Probabilistic Risk Assessment (SPRA) in 2018, the Committee was satisfied that DCP's seismic safety was acceptable and represented industry-leading performance in the seismic safety achieved at the facility.

After reviewing the new and updated information presented by PG&E in several Fact-Finding Meetings and Public Meetings, supplemented by information in the PG&E License Renewal Application, the Diablo Canyon Updated Seismic Assessment (performed in response to Senate Bill 846), information from the PSHA and the SPRA, information from the Independent Peer Review Panel (IPRP), information in submittals by Dr. Peter Bird, and other new information from various sources, the DCISC concludes that the seismic safety of the DCP reactors is currently fully adequate and requires no additional upgrades or improvements. The DCISC also concludes that no upgrades or improvements to seismic safety would be needed to assure that the seismic safety of the DCP reactors will be adequate for extended operations beyond 2025, if so authorized.

The DCISC has the following recommendation for its own future work: The DCISC should review any analyses that may be performed by the NRC or other entities in response to various filings in regulatory or legal proceedings claiming that PG&E has underestimated the seismic hazard or seismic risk at DCP. Also, the DCISC should review new technical information from the IPRP when it becomes available as well as any other information arising during relevant proceedings. It is currently understood that any new technical information will be evaluated by PG&E, and the DCISC should review any new PG&E evaluations as they become available.

3.2.10 Recommendations

None.

4.0 CONCLUSIONS

4.1 The May 30, 2023, meeting of the Independent Peer Review Panel (IPRP) was successful in discussing the major items on its agenda, including a technical discussion

of the recent Updated Seismic Assessment Report, a PG&E presentation on their Long-Term Seismic Program, and a presentation by Dr. Peter Bird on behalf of the San Luis Obispo Mothers for Peace. The DCISC should take into account the IPRP's evaluations as the Committee continues its reviews and develops conclusions on seismic safety at DCP. The DCISC should also continue to attend future IPRP meetings and consult with the IPRP concerning the IPRP's deliberations, findings, and recommendations.

- 4.2 When the DCISC reviewed the PG&E Probabilistic Seismic Hazard Analysis (PSHA) in 2016 and the Seismic Probabilistic Risk Assessment (SPRA) in 2018, the Committee was satisfied that DCP's seismic safety was acceptable and represented industry-leading performance in the seismic safety achieved at the facility.

After reviewing the new and updated information presented by PG&E in several Fact-Finding Meetings and Public Meetings, supplemented by information in the PG&E License Renewal Application, the Diablo Canyon Updated Seismic Assessment (performed in response to Senate Bill 846), information from the PSHA and the SPRA, information from the Independent Peer Review Panel (IPRP), information in submittals by Dr. Peter Bird, and other new information from various sources, the DCISC concludes that the seismic safety of the DCP reactors is currently fully adequate and requires no additional upgrades or improvements. The DCISC also concludes that no upgrades or improvements to seismic safety would be needed to assure that the seismic safety of the DCP reactors will be adequate for extended operations beyond 2025, if so authorized.

The DCISC has the following recommendation for its own future work: The DCISC should review any analyses that may be performed by the NRC or other entities in response to various filings in regulatory or legal proceedings claiming that PG&E has underestimated the seismic hazard or seismic risk at DCP. Also, the DCISC should review new technical information from the IPRP when it becomes available as well as any other information arising during relevant proceedings. It is currently understood that any new technical information will be evaluated by PG&E, and the DCISC should review any new PG&E's evaluations as they become available.

5.0 RECOMMENDATIONS

- 5.1 None.

6.0 REFERENCES

- 6.1.1 "Diablo Canyon Independent Safety Committee Thirty-Fourth Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2023 – June 30, 2024,"

Approved October 9, 2024, Volume II, Exhibit D.4, Section 3.8, “Independent Seismic Assessment Update.”

- 6.1.2 “Diablo Canyon Updated Seismic Assessment, Response to Senate Bill SB 846,” Pacific Gas and Electric Company, March 6, 2024
- 6.1.3 “Seismic Hazard Screening Report, Diablo Canyon Power Plant Units 1 and 2,” submitted to the Nuclear Regulatory Commission as an attachment to PG&E letter DCL-15-035, “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,” March 11, 2015, NRC ADAMS Accession Numbers ML15070A607 and ML15070A608.
- 6.1.4 Bird, P., “Declaration of Peter Bird, Ph.D, submitted to the U.S. Nuclear Regulatory Commission in support of Comments by San Luis Obispo Mothers for Peace on Proposed Rule and Draft Generic Environmental Impact Statement For Renewing Nuclear Power Plant Licenses”, Docket No. 2018-0296, filed 2 May 2023, NRC ADAMS Accession No. ML23123A410.
- 6.1.5 Bird, P., “Opening Testimony of Dr. Peter Bird on Behalf of San Luis Obispo Mothers for Peace on Phase 1 Track 2 Issues: Testimony before the California Public Utilities Commission regarding Implementing Senate Bill 846 Concerning Potential Expansion of Diablo Canyon Power Plant Operations,” CPUC Docket No. R.23-01-007, 30 June 2023.
- 6.1.6 Bird, P., “Declaration of Peter Bird, Ph.D, submitted to the U.S. Nuclear Regulatory Commission in support of Comments by San Luis Obispo Mothers for Peace, Friends of the Earth and Environmental Working Group for Hearing on Pacific Gas & Electric Company’s License Renewal Application for the Diablo Canyon Nuclear Plant and Petition by San Luis Obispo Mothers for Peace, Friends of the Earth and Environmental Working Group for Shutdown of Diablo Canyon Nuclear Power Plant Due to Unacceptable Risk of Seismic Core Damage Accident,” filed March 4, 2024, NRC ADAMS Accession No. ML24065A434.
- 6.1.7 Bird, P., “Re: Response to PG&E SSC and 2024 Update,” letter from Dr. Peter Bird to the DCISC, May 16, 2024.
- 6.2.1 “Diablo Canyon Independent Safety Committee Thirty-Third Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2022 – June 30, 2023,” Approved September 13, 2023, Volume II, Exhibit D.11, Section 3.2, “Comprehensive Seismic Safety Update.”
- 6.2.2 Ibid., Exhibit D.7, Section 3.9, “FLEX Program Capabilities During a Seismic Event,” and Section 3.14, “California Senate Bill 846 Requirements Regarding an Updated Seismic Assessment.”

- 6.2.3 Ibid., Exhibit D.8, Section 3.9, “Review of the 2010 Enercon Services Report Regarding Seismic Vulnerabilities.”
- 6.2.4 “Diablo Canyon Independent Safety Committee Thirty-Fourth Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2023 – June 30, 2024,” To Be Approved October 8, 2024, Volume II, Exhibit D.1, Section 3.8, “Post-earthquake Procedures for Plant Access and the Use of FLEX Equipment.”
- 6.2.5 Ibid., Exhibit D.3, Section 3.10, “Seismic and Geosciences Update,”
- 6.2.6 Ibid., Exhibit D.4, Section 3.8, “Independent Seismic Assessment Update.”
- 6.2.7 Ibid., Exhibit D.5, Section 3.3, “Response to DCISC Recommendation on the Use of Earthquake Response Procedures.”
- 6.2.8 Ibid., Exhibit D.7, Section 3.1, “Review of the Updated Seismic Assessment Required by Senate Bill 846.”
- 6.2.9 Ibid., Exhibit D.9, Section 3.2, “Response to DCISC Recommendation on the Use of Earthquake Response Procedures.”
- 6.2.10 “License Renewal Application,” submitted to the Nuclear Regulatory Commission as an enclosure to PG&E Letter DCL-23-118, November 7, 2023, NRC ADAMS Accession Number ML23311A154.
- 6.2.11 “Diablo Canyon Updated Seismic Assessment, Response to Senate Bill SB 846,” Pacific Gas and Electric Company, March 6, 2024
- 6.2.12 “Seismic Hazard Screening Report, Diablo Canyon Power Plant Units 1 and 2,” submitted to the Nuclear Regulatory Commission as an attachment to PG&E letter DCL-15-035, “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,” March 11, 2015, NRC ADAMS Accession Numbers ML15070A607 and ML15070A608.
- 6.2.13 “Seismic Probabilistic Risk Assessment for the Diablo Canyon Power Plant. Units 1 and 2 - Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1: Seismic of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident,” submitted to the US Nuclear Regulatory Commission as an attachment to PG&E letter DCL-18-027, April 24, 2018, NRC ADAMS Accession Number ML18120A201.
- 6.2.14 P. Bird, “Re: Response to PG&E SSC and 2024 Update,” Letter from Dr. Peter Bird to the DCISC, May 16, 2024.

- 6.2.15 “Diablo Canyon Independent Safety Committee Twenty-Ninth Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2018 – June 30, 2019,” Approved October 23, 2019, Volume II, Exhibit D.7, Section 3.4, “Long Term Seismic Program Update.”
- 6.2.16 “Diablo Canyon Independent Safety Committee Thirty-Third Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2022 – June 30, 2023,” Approved September 13, 2023, Volume II, Exhibit D.3, Section 3.5, “Long Term Seismic Program Update.”
- 6.2.17 "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts", R.J. Budnitz (chair), G. Apostolakis, D.M. Boore, L.S. Cluff, K.J. Coppersmith, C.A. Cornell, and P.A. Morris (comprising the “Senior Seismic Hazard Analysis Committee,” “SSHAC”), Report NUREG/CR-6372, Lawrence Livermore National Laboratory, sponsored by the U.S. Nuclear Regulatory Commission, U.S. Department of Energy, and Electric Power Research Institute (1997), NRC ADAMS Accession Numbers ML080090003 and ML080090004.
- 6.2.18 "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies," US Nuclear Regulatory Commission, Report NUREG-2117 (February 2012), NRC ADAMS Accession Number ML12118A445.
- 6.2.19 “Updated Implementation Guidelines for SSHAC Hazard Studies,” US Nuclear Regulatory Commission, Report NUREG-2213 (October 2018), NRC ADAMS Accession Number ML18282A082.
- 6.2.20 “Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications,” Standard ASME/ANS RA-Sa-2009, American Society of Mechanical Engineers/American Nuclear Society (2009). *Note: This standard has been updated recently, but the Diablo Canyon PRA, including the Seismic PRA, was done according to this earlier version of the standard, which remains valid.*
- 6.2.21 “An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities,” US Nuclear Regulatory Commission, Regulatory Guide 1.200, Revision 2 (March 2009), NRC ADAMS Accession Number ML090410014.
- 6.2.22 “Diablo Canyon Independent Safety Committee Thirty-Third Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2022 – June 30, 2023,” Approved September 13, 2023, Volume II, Exhibit D.5, Section 3.4, “Comprehensive Review of the Seismic Safety Program.”
- 6.2.23 "Request for Information Pursuant to Title 10, Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," US Nuclear Regulatory Commission letter to all power reactor licensees (March 12, 2012), NRC ADAMS Accession Number ML12053A340.

- 6.2.24 “Diablo Canyon Nuclear Power Plant, Unit Nos. 1 and 2, – Staff Assessment of Information Provided under Title 10 of the Code of Federal Regulations Part 50, Section 50.54(f), Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima-Dai-ichi Accident,” NRC letter to PG&E (December 21, 2016), NRC ADAMS Accession Number ML16341C057.
- 6.2.25 “Diablo Canyon Independent Safety Committee Twenty-Fifth Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2014 – June 30, 2015,” Approved October 20, 2015, Volume II, Exhibit D.7, Section 3.2 “PG&E Seismic Study.”
- 6.2.26 Ibid., Exhibit B.15, “Minutes of the DCISC Public Meeting June 16 and 17, 2015.”
- 6.2.27 “Diablo Canyon Nuclear Power Plant, Unit Nos. 1 and 2 – Staff Review of Seismic Probabilistic Risk Assessment Associated with Reevaluated Seismic Hazard - Implementation of the Near-Term Task Force Recommendation 2.1, Seismic,” US Nuclear Regulatory Commission letter to PG&E (January 22, 2019), NRC ADAMS Accession Number ML18254A040.
- 6.2.28 “Diablo Canyon Independent Safety Committee Twenty-Ninth Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2018 – June 30, 2019,” Approved October 23, 2019, Volume II, Exhibit B.6.
- 6.2.29 “Diablo Canyon Independent Safety Committee Thirty-Third Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2022 – June 30, 2023,” Approved September 13, 2023, Volume II, Exhibit D.8, Section 3.8, “Seismic Safety Issues.”
- 6.2.30 “Diablo Canyon Independent Safety Committee Thirty-Fourth Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2023 – June 30, 2024,” To Be Approved October 8, 2024, Volume II, Exhibit D.3, Section 3.10, “Seismic and Geosciences Update.”
- 6.2.31 Ibid., Exhibit D.4, Section 3.8, “Independent Seismic Assessment Update.”
- 6.2.32 Ibid., Exhibit D.7, Section 3.1, “Review of the Updated Seismic Assessment Required by Senate Bill 846.”
- 6.2.33 “Comment (0021) from Diane Curran on behalf of San Luis Obispo Mothers for Peace on PR-51 – Renewing Nuclear Power Plant Operating Licenses – Environmental Review,” submitted to the US Nuclear Regulatory Commission on May 2, 2023, NRC ADAMS Accession Number ML23123A410.
- 6.2.34 “Request by San Luis Obispo Mothers For Peace, Friends of the Earth, and Environmental Working Group for Hearing on Pacific Gas and Electric Company’s License Renewal

Application for the Diablo Canyon Nuclear Plant,” filed with the U.S. Nuclear Regulatory Commission in Dockets No. 50-275-LR and 50-323-LR (March 4, 2024).

- 6.2.35 “Petition by San Luis Obispo Mothers For Peace, Friends of the Earth, and Environmental Working Group for Shutdown of Diablo Canyon Nuclear Power plant Due to Unacceptable Risk of Seismic Core Damage Accident,”, filed with the U.S. Nuclear Regulatory Commission in Dockets No. 50-275 and 50-323, March 4, 2024, NRC ADAMS Accession Number ML24065A434.
- 6.2.36 “Spent Fuel Pool Evaluation Supplemental Report. Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident,” submitted to the US Nuclear Regulatory Commission as an attachment to PG&E letter DCL-17-108, December 18, 2017, NRC ADAMS Accession Number ML17352A703.
- 6.2.37 “Probabilistic Risk Assessment of Nuclear Power Plant Spent Fuel Handling and Storage Programs: Methodology and Application to the Diablo Canyon Power Plant,” B. John Garrick and Donald J. Wakefield, Report GIRS-2020-3/L, published by the UCLA B. John Garrick Institute for the Risk Sciences, Los Angeles (February 17, 2020).
- 6.2.38 “Diablo Canyon Independent Safety Committee Thirtieth Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2019 – June 30, 2020,” Approved September 30, 2020, Exhibit B.9.
- 6.2.39 “Mitigating Strategies Assessment (MSA) report for the New Seismic Hazard Information,” submitted to the US Nuclear Regulatory Commission as an attachment to PG&E letter DCL-18-026 (April 24, 2018), NRC ADAMS Accession Number ML18120A119.
- 6.2.40 "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigating Strategies for Beyond-Design-Basis External Events," US Nuclear Regulatory Commission, NRC Interim Staff Guidance JLD-ISG-2012-01, Revision 2, (February 2017), NRC ADAMS Accession Number ML17005A188.
- 6.2.41 “Diablo Canyon Seismic Core Damage 2.206 Petition – Initial Assessment,” P. Buckberg (NRC staff), email to D. Curran, H. Templeton, and C. Leary, May 15, 2024, NRC ADAMS Accession Number ML24136A162.
- 6.2.42 “Estimate of External Events Contribution to Pressurized Thermal Shock (PTS) Risk,” A. M. Kolaczowski, D. Kelly, and D. W. Whitehead, Sandia Letter Report to the NRC, October 1, 2004, NRC ADAMS Accession Number ML042880476.