DOCKET NO.: A.21-12-007

EXHIBIT NO.: A4NR-1

DATE:

WITNESS: John Geesman

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

PREPARED TESTIMONY OF JOHN GEESMAN ON BEHALF OF THE ALLIANCE FOR NUCLEAR RESPONSIBILITY (“A4NR”)

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I. **<u>INTRODUCTION: DEFICIENCIES IN PG&E'S DCEs.</u>**

Q01: Please state your name and business address for the record.

A01: My name is John Geesman, and my business address is: Dickson Geesman LLP, P.O. Box 177, Bodega, CA 94922.

Q02: Are your professional qualifications included in your testimony?

A02: Yes, my professional qualifications are contained in the Appendix to my testimony.

Q03: Was your testimony prepared by you or under your direction?

A03: Yes, it was.

Q04: Insofar as your testimony contains material that is factual in nature, do you believe it to be correct?

A04: Yes, I do.

Q05: Insofar as your testimony contains matters of opinion or judgment, does it represent your best judgment?

A05: Yes, it does.

Q06: Does this written submittal complete your prepared testimony and professional qualifications?

A06: Yes, it does.

Q07: What is the purpose of your testimony?

A07: The purpose of my testimony is to provide evidence of certain deficiencies in PG&E's 2021 Decommissioning Cost Estimate ("DCE") for the Diablo Canyon Nuclear Power Plant ("DCNPP") and 2021 DCE for the Humboldt Bay Independent Spent Fuel Storage Installation ("HB ISFSI"). These deficiencies concern the underlying assumptions in the DCEs about the radiation cleanup standard to be met at DCNPP to achieve unrestricted site release; the amount of time that spent nuclear fuel ("SNF") is likely to remain onsite at both DCNPP and the HB ISFSI before being removed by the federal government; and the outdated assessment of tsunami risk at the HB ISFSI in light of updated analytic methodologies and projected sea level rise. In each instance, the deficiency is likely to understate the amount of the respective DCE compared to what it would be if properly calculated. I recommend the Commission find each of the two DCEs to be unreasonable unless PG&E takes specific steps to correct, or at least substantially mitigate, these deficiencies.

II. PG&E'S LAX RADIATION CLEANUP GOALS FOR DIABLO CANYON.

Q08: What do you consider to be the primary deficiency in the DCNPP DCE?

A08: Despite knowing better, PG&E has set its target for radiological remediation of the DCNPP site at the 25-millirem per year default baseline allowed by the Nuclear Regulatory Commission ("NRC") in the absence of a more demanding standard specified in a plant's License Termination Plan. The states of New York, Massachusetts, Maine and Vermont all require a 10-millirem cleanup level, with the groundwater pathway restricted to 4-millirem per year, and the NRC has approved and enforced License Termination Plans with these more rigorous objectives.

With an NRC-prescribed calculation methodology extending out 1,000 years, the difference between 25 and 10 is substantial.

Q09: How does PG&E's chosen radiation cleanup standard relate to the DCNPP DCE?

A09: In several ways. First, meeting a tougher standard might arguably cost more than satisfying a weaker one – although PG&E's 2018 **Identification of the Need for Deep Excavations** report favors complete removal of potentially radioactive structures, so any cost difference between standards may already have been minimized. And PG&E admitted in a data response to A4NR that it has not analyzed any prospective cost difference between the 10-millirem cleanup standard required in New York, Massachusetts, Maine and Vermont and the 25-millirem objective identified in the DCNPP DCE.[1]

Second, PG&E has needlessly invited a public controversy (i.e., why shouldn't Californians expect a restored DCNPP site to be as clean as it would be if located in New York, Massachusetts, Maine or Vermont?) likely to increase the contentiousness and extend the time required for the permitting processes at the County of San Luis Obispo, the California Coastal Commission, and the California State Lands Commission. Time is a primary driver of decommissioning costs, although PG&E admitted in a data response to A4NR that uncertainty about the remediation standard has not been included in PG&E's decommissioning Risk Management Plan and that the utility's strategy to address uncertainties associated with the project is to simply rely upon the DCE contingency amount.[2]

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[1] PG&E Data Response NuclearDecomCostTri2021_DR_A4NR_001-Q003.
[2] PG&E Data Response NuclearDecomCostTri2021_DR_A4NR_001-Q002.

Third, the Diablo Canyon Decommissioning Engagement Panel's desire to repurpose as many buildings and assets as is sustainably viable, and PG&E's hope to derive decommissioning costs savings from such repurposing, probably requires as pristine a restored site as possible. The **Repurposing and Reuse Concepts Report** that PG&E transmitted to the County of San Luis Obispo Department of Planning and Building in December 2021 emphasized that those repurposing and land disposition opportunities that present cost savings should also be evaluated as a means to prioritize public, personnel and environmental safety. The Repurposing and Reuse Concepts Report cautioned that public perception of contamination of the site may result in resistance to certain uses.

Embracing the most rigorous cleanup standards established nationally would appear more cost beneficial to the DCNPP decommissioning than the path PG&E is currently on.

Q10: You said PG&E knows better. What do you mean by that?

A10: Despite what seems to have been a much more problematic remediation site than DCNPP, PG&E's performance at Humboldt Bay appears to have been – when measured against a 25-millirem benchmark – exemplary. According to the NRC's November 18, 2021 **Safety Evaluation Report** for termination of the plant's operating license, PG&E's cleanup achieved an average dose of 6 millirem, including a maximum level for the notorious caisson survey unit of less than 10 millirem, and a dose through the groundwater pathway bounded at 1 millirem. As PG&E's testimony in this proceeding and in the past has emphasized, Humboldt Bay presented a number of challenges due to the unique design and construction of the plant; radiological activation and contamination left from the early operation of the facility; and difficult site conditions. PG&E's rebuttal testimony should address why DCNPP should not receive the same level of effort or proficiency, and why the public should not reasonably expect as much.

Q11: What role does the NRC's exclusive jurisdiction over DCNPP radiological matters allow for state or local regulatory authorities?

A11: PG&E has acknowledged in a data response to A4NR that state and public stakeholders elsewhere have worked with nuclear plant licensees to agree to a lower limit than the default NRC 25-millirem criteria to be implemented, and that the License Termination Plan processes and data can be used to validate that the lower release criterion is met.[3] As noted at p. 19 of the California Coastal Commission's 2009 **Final Adopted Findings** for the Humboldt Bay nuclear plant's **Coastal Development Permit E-09-010**:

> The nuclear unit's decommissioning is subject to regulation and oversight by the federal NRC. The NRC has exclusive jurisdiction over radiological aspects of licensed nuclear reactors, storage of materials generated by those reactors, and reactor decommissioning. For projects involving those aspects of the NRC's jurisdiction, the state is preempted from imposing upon nuclear facility operators any regulatory requirements concerning radiation hazards and nuclear safety, though the state may impose requirements related to other issues. [footnote omitted] The facility's current and proposed possession, handling, storage, and transportation of nuclear materials are therefore precluded from state regulation.
>
> The Coastal Commission findings herein address only those state concerns related to conformity to applicable policies of the Coastal Act, and do not evaluate or condition the proposed project with respect to nuclear safety or radiological issues during the term of NRC's regulatory oversight. However, because the project will result in termination of PG&E's NRC-licensed activities for Unit 3, the state has jurisdiction over post-license site conditions, including those related to radiological concerns.

[3] PG&E Data Response NuclearDecomCostTri2021_DR_A4NR_001-Q001.

Q12: How did the site-specific planning for DCNPP decommissioning that PG&E conducted pursuant to the Joint Proposal address radiation cleanup standards?

A12: Somewhat inconsistently. The 2017 **Pre-Project Plan** spoke of benchmarking other plants to identify "the regulatory precedence" (sic) and establish the basis for the DCNPP site restoration schedule; and industry experience in "site release criteria," among other subjects, to develop the DCNPP staffing plan. PG&E has subsequently indicated in a data response to A4NR that it did not research the 35 benchmarked sites for License Termination Plan release criteria.[4] Although the **Pre-Project Plan** assumed that the DCNPP site will be remediated to the 25-millirem level, it emphasized at p. 124 the role of the License Termination Plan ("LTP"):

> The LTP embodies the closure philosophy of the site and includes the agreed-upon criteria for release of the Part 50 license. The LTP provides a single path to focus site resources and efforts and secure the agreement of local and federal regulators. Participation with the public and a Citizens Advisory Board (CAB) is needed to obtain a plan that satisfies associated stakeholders.

Among the stakeholders specifically identified by the **Pre-Project Plan**: local community members, local government, and state regulators. Among the stakeholder interests specifically identified: the radiological consequences of decommissioning activities, environmental impacts of previous plant operations, and the site environmental end state condition.

It is possible that the **Pre-Project Plan's** simultaneous embrace of a 25-millirem standard while emphasizing the role of stakeholder input to "agreed-upon criteria" merely anticipated the outcome of a communication process that had not yet been commenced. The **Pre-Project Plan** at p. 150 recognized the significance of such a process:

[4] PG&E Data Response NuclearDecomCostTri2021_DR_A4NR_001-Q010.

> Information from other decommissioning projects indicates the importance of stakeholder communications … Rigorous and frequent communications with all affected stakeholders is a key to minimizing concerns. Further, industry experience at each of several sites called out communications with stakeholders as key to transparent implementation of decommissioning plans. Finally, communications with stakeholders is an area where many lessons have been learned from previous decommissioning activities…
>
> The public also has a vested interest in the decommissioning process, waste transportation, and end results. Several groups must be engaged to assure that all parties understand the goals, processes, risks, risk mitigation plans, environmental impacts, costs, end state parameters, and schedules associated with the decommissioning…

The **Pre-Project Plan** discussed at pp. 150 – 151 the potential value a Citizens Advisory Board ("CAB") might offer in providing an official communications channel with local officials and residents:

> The NRC has observed that licensees that established a CAB generally had a better relationship with the local community. For example at Maine Yankee, the CAB interactions provided an opportunity for community to provide feedback regarding the decommissioning process and activities. As a result, a level of trust was established with Maine Yankee that did not exist during previous 24 years of plant operations. [references omitted]
>
> Common objectives of CABs established at previous decommissioning plants that should be considered when establishing a DCPP CAB include the following:
>
> • Establish relationships that are transparent, build trust, and establish credibility with community members;
>
> • Educate CAB members on topics related to decommissioning (e.g., radiological concerns, means and methods used during decommissioning); risks associated with decommissioning activities, the economic impacts of decommissioning to the local community; and
>
> • Present and respond to complex or controversial issues directly to community members such that there are potentially fewer contentious issues;

> Due to its public profile, Maine Yankee learned a decommissioning project is not complete until all stakeholders, agree that is it complete. Guiding all concerned parties toward a successful end state requires that teamwork be established as a primary project goal. Experience and lessons learned from Maine Yankee decommissioning are that early and open discussions of issue resolution is critical to successful community relations. [reference omitted]

Q13: Has PG&E communicated with the public about the radiation cleanup standards it intends to use in its License Termination Plan, or the process by which it determined those cleanup standards?

A13: No. PG&E's A.21-12-007 testimony at p. 6-17 heralds the "successful public engagement facilitated through the DCDEP to date" and states:

> In addition to these DCDEP meetings and workshops, PG&E conducted extensive public outreach with customers, community stakeholders, appointed and elected officials, and DCPP employees regarding DCPP operations, potential repurposing of DCPP assets, and proposals for potential future use and/or conservation of DCPP lands.

In a data request, A4NR asked PG&E to summarize any feedback it had received from this outreach that addressed PG&E's proposed site release criteria for Diablo Canyon. PG&E responded that, since the DCDEP's May 2018 inception, there have been no specific public comments regarding proposed release criteria for retiring the Diablo Canyon 10 CFR 50 license.[5]

Q14: Apart from the 2017 **Pre-Project Plan**, how do the other site-specific planning documents that PG&E assembled pursuant to the Joint Proposal address the choice of radiation cleanup standards?

[5] PG&E Data Response NuclearDecomCostTri2021_DR_A4NR_001-Q012.

A14: The 2018 **Identification of the Need for Deep Excavations** report identified evaluation factors to use in assessing excavation options, several of which implicitly overlap with consideration of site release criteria:

- Permitting – Consider what will federal, state and local agencies require, as well as issues unique to the California Coastal zone, and precedence (sic) from other projects.
- Legal – potential liability or other legal issues with lease requirements with both Eureka Energy and California State Lands Commission.
- Community Engagement Panel involvement – Consider public opinion based on California-specific experience with Humboldt Bay Nuclear Power Plant and San Onofre Nuclear Generating Station.
- Benchmarking – what has been done or proposed at other sites. Include CA sites; e.g., Humboldt Bay and San Onofre.

The 2018 **License Termination Scope Plan Project Management Plan** stated that local regulatory officials and public representatives need to be contacted to obtain needed inputs and guidance regarding required decisions and obtain the permits necessary for the license termination process. It further advised that public meetings should be held as required by regulations and as found to be desirable during the license termination process to obtain public input and provide information to the public and other stakeholders. Focused on the NRC process (and ignoring permit processes at the County, the Coastal Commission, and the State Lands Commission), the risk management section of the report included (at p. 67 of the pdf provided to A4NR by PG&E) the following:

Public Engagement:

Description: Public input not favorable regarding site release planning resulting in brand impact; Local political opposition in NRC public meetings; Public evolvement leads to contested licensing issue(s) and public hearing(s). Examples include: Engage political players, engage in PR campaigns, over communicate, and approach “friendlies” first.

Risk Level: Low

Response Strategy: Mitigation. PG&E should seek to have positive engagements with interested public stakeholders and their representatives throughout the license termination process.

The 2018 **Historical Site Assessment** identified potential, likely, or known sources of radioactive and non-radioactive contamination within buildings, on plant structures, and in the DCNPP site’s environs based on existing or derived information. As the report explained (at p. 9 of the pdf provided to A4NR by PG&E),

> The historical information provides the basis for classification decisions following the guidance contained in NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) [footnote omitted]. The collection of historical information and data supports an informed decision-making process regarding the current radiological and hazardous status of structures and open land areas across the site. The collected information serves as the bases for ‘impacted/non-impacted’ decisions regarding the radiological status of structures and open areas at the Diablo Canyon site. As defined in NUREG-1575, a non-impacted area is any area ‘where there is no reasonable possibility (extremely low potential) of residual contamination.’ An impacted area is defined in NUREG-1575 as ‘Any area that is not classified as non-impacted’ and ‘Areas with a possibility of containing residual radioactivity in excess of natural background or fallout levels.’ For chemical (non-radiological) materials, the term ‘Area-of-Concern’ (AOC) is used in lieu of the term ‘impacted.’
>
> Following identification of a radiologically impacted area, the collected historical information further serves as the bases for preliminary MARSSIM classifications as Class 1, 2, and 3 survey areas for those areas identified or assumed to remain after license termination. The impacted/non-impacted classifications, as well as the potential radionuclides-of-concern (ROCs) and identified data gaps, are used to guide and focus the planning activities for subsequent radiological site characterization efforts. Similarly, identified

> AOCs, and their associated contaminant-of-concern (COC) and data gaps, are used to guide subsequent non-radiological characterization efforts.
>
> For the purpose of the HSA effort, the DCPP site was divided into nine study areas. Section 5, Radiological Findings, provides the details of the impact from the use of radioactive materials in each study area whereas Section 6, Chemical Findings, provides the analogous details from the use of chemical (non-radioactive) materials. Seven of the 9 study areas were identified as partially or totally impacted areas due to the historical and/or current use of radioactive materials. The AOCs identified by the potential or historic use of chemical (non-radioactive) materials are also identified within the 9 study areas. Data gaps in historical and current records were identified for each study area. Those data gaps are the drivers for the development of a Site Characterization Plan and associated cost estimate.

The **Historical Site Assessment** described (at pp. 15 – 16 of the pdf provided to A4NR by PG&E) the MARSSIM classification system and the significant role of "the anticipated" derived concentration guideline levels ("DCGLs") as follows:

> The impacted/non-impacted classifications guide subsequent radiological characterization survey efforts. Preliminary MARSSIM Class 1, 2, and 3 classifications may be assigned to structures and areas that are identified or assumed to remain after license termination. If assigned, the classification process will follow guidance in NUREG-1575:
>
> Class 1 Area: Impacted areas that have, or had before remediation, a potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiological surveys) above the anticipated derived concentration guideline level (DCGL), or insufficient historical information and data are available to justify a Class 2 or Class 3 designation.
>
> Class 2 Area: Impacted areas that have a potential for radioactive contamination or known contamination but are not expected to exceed the anticipated DCGL.
>
> Class 3 Area: Impacted areas that are not expected to contain any residual radioactivity, or are expected to contain levels of residual radioactivity at a small fraction of the anticipated DCGL, based on site operating history and previous radiological surveys.

The DCGLs used in the **Historical Site Assessment** were mathematically calculated using PG&E's specified 25-millirem dose-based regulatory release criteria. Use of a 10-millirem level would have produced different DCGLs, and A4NR does not know what specific impacts this would have on the resulting classifications of the impacted areas of the DCNPP site. PG&E testimony in the 2018 NDCTP included the caveat that preliminary MARSSIM classifications criteria corresponding to the assumed 25-millirem standard may change if the final approved Diablo Canyon site release criteria are based on a lower annual dose. A4NR has been unable to find any similar disclaimer in PG&E documents for the current proceeding.

Q15: Making use of the preliminary identification of potential ROCs in the 2018 **Historical Site Assessment**, is there any California benchmark that PG&E might take into consideration when considering the radiological cleanup goals to apply to such radionuclides?

A15: Yes, PG&E should give careful consideration to the recently announced settlement between the California Department of Toxic Substances Control and the Boeing Company for cleanup of the Santa Susana Field Laboratory site, which requires remediation to background threshold values for the majority of potential ROCs identified in the 2018 **Historical Site Assessment**, including Co-60, Cs-134, Fe-55, H-3, Ni-59, Sr-90, and Te-99.[6] Of the primary ROCs identified in the 2018 **Historical Site Assessment**, the settlement with Boeing Company would allow remediation to a level above background only for C-14, Cs-137, and Ni-63.

[6] *See* https://dtsc.ca.gov/boeing-cleanup-settlement-agreement/ , Exhibit 5, Attachment 5.

Q16: What feedback has been offered by plant owners at the decommissioned sites that included the 10-millirem cleanup standard in their License Termination Plans?

A16: Based on published reports by the Electric Power Research Institute ("EPRI"), the experience at both such completed decommissioning sites, Maine Yankee and Yankee Rowe, was quite positive from the perspectives of the plant owners. For its 2005 **Maine Yankee Decommissioning Experience Report** (identified as a reference in both PG&E's 2018 and 2021 DCEs) on lessons learned, EPRI conducted in-person interviews at the Maine Yankee site and corporate offices, as well as supplemental telephone interviews one month later. Interviewees included the President & Chief Executive Officer, Vice President & Chief Nuclear Officer, Chief Financial Officer, Regulatory Affairs Manager, Public Affairs Manager, Site Decommissioning Manager, Engineering Manager, Radiation Protection Manager and selected staff members. In addition to addressing specific decommissioning topics, interviewees were asked questions regarding how their decommissioning experience might be useful for currently operating nuclear reactors as well as for those contemplated to be built in the future.

The EPRI report noted that in addition to its initial prioritization of nuts-and-bolts items (like detailed project plans, schedules, and engineering analysis), a second level of information on so-called soft areas (like stakeholder interaction, regulatory interaction, and project decision methods) was deemed significant to the efficient conduct of the decommissioning. EPRI explained that the aspect of decommissioning which required the greatest interaction with regulators and stakeholders was (not surprisingly, according to the authors) the final criteria the site must meet to be considered clean. Among the Lessons Learned/Recommendations EPRI identified at p. 6 – 1:

> Negotiation is often better than litigation. Although the various negotiated settlements for Maine Yankee required additional tasks to be performed, Maine Yankee's assessment was that if litigation was the overall project selected approach, that the project completion would have been delayed up to two years.

Among the additional recommendations Maine Yankee personnel specifically directed to currently operating plants, under the heading of "Develop a Good Decommissioning Plan" at p. F-2 was the following: "The earlier the facility end state is established the better."

EPRI's **Power Reactor Decommissioning Experience 2008 Technical Report** reflected at p. 3-3 upon two decades of decommissioning experience with the interface between the NRC's 25-millirem standard and more stringent criteria proposed by states:

> Regulatory uncertainty on application of release criteria has led to project delays and increased costs. Use of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) was new and had to be learned by both licensees and regulators. States' jurisdiction for imposing lower release criteria and alternate dose pathway assumptions was a development that often resulted in multi-party protracted negotiations during the course of performing decommissioning work. This uncertainty led to additional costs for Derived Concentration Guideline Level (DCGL) development re-work and increased project durations where decommissioning approaches had to change in response to differing endpoint objectives. With many of these uncertainties now resolved, future decommissioning costs can be better projected and controlled.

In the 2008 Technical Report's judgment, it was more cost effective for a site to remediate to the most stringent standards rather than have to perform more remediation at a later time to meet state standards.

Q17: What is A4NR's recommendation?

A17: A4NR urges PG&E to promptly commit to specifying, in the DCNPP License Termination Plan it eventually files with the NRC, a radiation cleanup standard that achieves the lowest dose-based levels, measured by millirem per year, previously approved by the NRC in an LTP for a commercial nuclear power plant.

III. <u>PG&E'S FLAWED TIMELINE FOR FEDERAL REMOVAL OF SNF.</u>

Q18: Why does A4NR consider PG&E's assumptions about when the federal government will remove spent nuclear fuel from DCNPP and the HB ISFSI to be flawed?

A18: In contrast to past DCEs, where the lack of demonstrable progress on SNF removal was cited to justify a year-for-year slippage from the previous DCE for assumed SNF pickup dates, PG&E's Application states that the assumption for the federal government's initiation of SNF pickup nationally is unchanged from the 2031 commencement assumed by the 2018 DCE. The PG&E Prepared Testimony acknowledges (at p. 5-6) that "there is no new substantive information from DOE [i.e., the U.S. Department of Energy] or any other source since the last NDCTP decision was issued with respect to the timing of the actual date upon which DOE will commence picking up SNF." Nevertheless, without explanation, the conclusion is drawn, "PG&E believes it is reasonable for purposes of developing its DCE to continue to assume a start date of 2031 for DOE initiating transfer of commercial SNF." This assumption envisions SNF staying at the HB ISFSI until 2032 and DCNPP until 2067, as was the case in the 2018 DCE.

Correspondingly, the 2015 DCE assumed commencement of DOE pickups nationally in 2028 and the 2012 DCE assumed 2024. The Commission's approval of the 2015 DCE, D.17-05-020, repeated (at pp. 53 – 54) the simple arithmetic rationale used in the approval of the 2012 DCE's SNF onsite storage assumptions:

> In the 2012 NDCTP the utilities proposed to extend the assumed date for DOE pick-up of SNF by the same amount of time that had passed between 2009 and 2012 NDCTP filings. This assumption was for a pick-up date of 2024. The Commission found in Phase 2 of the 2012 NDCTP that 'the

> record provided for no support for any particular date other than 2024.' [footnote omitted] The Commission therefore concluded that 'It is reasonable to assume for cost estimation purposes that DOE will not begin to accept SNF for long-term storage prior to 2024.' DOE has not provided any substantive information since the last NDCTP decision was issued. PG&E therefore believes it is reasonable to assume another 4-year delay in commencement of DOE SNF pick-up. PG&E testifies that it is reasonable to assume commencement of the DOE pick-up program for SNF of 2028 for cost purposes with SNF pick up beginning in 2029 for HBPP and 2035 for DCPP.
>
> We again find there is little more than speculation in the record to support a projected date for DOE to begin accepting SNF for long-term storage. Many technical, political, and administrative decisions beyond the Commission's authority will drive the development of any interim or long-term storage of SNF. We agree that 2028 is optimistic, and the actual implementation of a permanent geologic repository will be impacted by many considerations outside this proceeding.
>
> However, the sooner the utilities can safely transfer SNF to DOE control the better. The longer the transfer to DOE is delayed, the higher the transfer and storage costs for SNF. The record provides no support for any particular date other than 2028 for initiation of the DOE SNF transfer program. Even if we are skeptical of a near-term political solution, we need to have an assumption to make cost estimates in this NDCTP. It is reasonable to assume that DOE will not begin to accept SNF for long term storage prior to 2028. [footnotes omitted]

PG&E's unexplained departure from the simple arithmetic approach anchoring past DCEs exploits the no-sooner-than-XXXX focus of Commission decisions about DOE removal of SNF. By holding the assumed SNF pickup dates constant, PG&E's 2021 DCEs for Diablo Canyon and Humboldt Bay are able to effectively erase three years of SNF storage costs that would have otherwise been included had PG&E adhered to the prior Commission-approved methodology. Rather than update a finding that "It is reasonable to assume that DOE will not begin to accept SNF for long-term storage prior to ~~2024~~ ~~2028~~ ~~2031~~ XXXX", PG&E has apparently realized that the previous no-sooner-than-XXXX assumption can remain literally accurate despite the passage of time and the absence of any evidence of federal progress.

And it does! The difficulty with such non-empirical, semantic cleverness is that it likely understates the SNF storage costs in both the Diablo Canyon and Humboldt Bay DCEs; transfers the risk of extended SNF storage costs entirely to future customers, notwithstanding intergenerational inequity; and flouts the requirements for periodic updating of the DCEs contained in Cal. Pub. Util. Code § 8326. It may enable PG&E's 2021 Application to posture that the decommissioning trusts are fully funded, a pleasing (even if momentary) result, but with undercurrents from Hans Christian Anderson's fable about an emperor's clothing.

Testimony submitted by Southern California Edison ("SCE") in A.22-02-016, the current NDCTP for the SONGS 2&3 decommissioning, illuminates where the gaping uncertainties inherent in DCE projections of SNF storage costs have led:

> For the short term, SCE and other nuclear plant owners across the industry have assumed that DOE will begin performing in 2031 for purposes of preparing their Decommissioning Cost Estimates (DCE), the purpose of which is to identify the funding needed to cover the cost of spent fuel storage. [footnote omitted] However, since it is uncertain whether DOE will begin meeting its obligations by 2031, SCE recommends that the California Public Utilities Commission (Commission or CPUC) allow SCE to change to a longer-term view of the situation. In particular, SCE recommends that DOE litigation proceeds be deposited in the Non-Qualified Nuclear Decommissioning Trusts (NQNDT) to be available in case DOE's non-performance continues beyond 2031. This approach preserves the integrity of the trusts and, as with other funds in the trusts, any excess will be returned to customers once decommissioning is completed.[7]

[7] A.22-02-016, SCE-07, p. 1.

The SONGS 2&3 decommissioning is further along in its expenditure phase than Diablo Canyon, and SCE's latest DCE projects full SNF removal in 2051 in contrast to DCNPP's 2067. As SCE's testimony notes:

> The 2020 SONGS 2&3 DCE estimates an average annual cost of approximately $22 million (100% share, 2014 $) for the storage, maintenance, and protection of spent fuel at SONGS, which is funded from the NDTs. As reported in Exhibit SCE-06, sufficient funds are currently available to cover the cost of managing spent fuel through 2051. However, the recent change in the assumed DOE start date of 2031 required SCE to allocate approximately $44 million (100% share, 2014 $) from contingency to cover the assumed additional two years of spent fuel storage costs (moving the end date from 2049 to 2051). Continuing to fund the DOE's ongoing delay through an allocation of contingency is not sustainable. If DOE's failure to begin removing fuel from SONGS continues, there will be insufficient funds available in the NDTs to cover the cost of spent fuel storage, maintenance, and protection.[8] [footnote omitted]

PG&E has offered no evidence that the Diablo Canyon and Humboldt Bay DCEs are somehow shielded from a similar cost exposure caused by DOE's ongoing delay. SCE appears to have devised at least a partial mitigation of this risk by recommending that the reimbursement proceeds obtained from DOE by litigation or settlement be deposited into the non-qualified decommissioning trusts. These DOE litigation receipts are intended to reimburse past SNF storage costs that were paid from the decommissioning trusts, which were funded by past ratepayers to complete decommissioning. The logic of gifting such reimbursements to current ratepayers (apart from the universal desire to keep rates down), while the funding sufficiency of the trusts depends upon make-believe assumptions about DOE performance that imperil future ratepayers, has never been clear to A4NR.

Q19: What is A4NR's recommendation?

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[8] A.22-02-016, SCE-07, p. 8.

A19: A4NR urges PG&E to promptly commit to deposit all future reimbursement amounts received from DOE for SNF storage at Diablo Canyon or Humboldt Bay into the appropriate non-qualified decommissioning trust.

IV. <u>PG&E'S OUTDATED TSUNAMI ASSESSMENT AT HUMBOLDT BAY.</u>

Q20: Why does A4NR consider PG&E's assessment of tsunami risk at the HB ISFSI to be relevant to the 2021 DCE for the HB ISFSI?

A20: PG&E states in its Application that it made no changes to the forecast budget or schedule approved in the 2018 NDCTP for the HB ISFSI; that it expects all SNF to be removed from the HB ISFSI by 2032; and that the $153.3 million (2021$) DCE will cover the entire January 2021 through 2033 period. Based upon PG&E's November 4, 2021 filing with the NRC of the HB ISFSI's **Final Safety Analysis Report Update, Revision 11 and Changes to Technical Specification Bases and Report of Changes, Tests, and Experiments for the Period of October 2, 2019, through October 1, 2021** ("November 2021 FSARU"), there have been no updates or changes in PG&E's tsunami hazard assessment since the risk at the then-proposed ISFSI site was dismissed as negligible two decades ago.

PG&E's continued ability to use the current site, without material changes in its physical design, is a core underlying assumption for the $153.3 million 12-year budget. Relocation of the SNF, greater fortification of the ISFSI site area against waves, or modifications required to assure continued road access to the ISFSI, could weigh heavily on the revenue requirements attributable to the HB ISFSI DCE. Advances in the scientific understanding of tsunamigenic earthquakes and sea level rise in the Humboldt Bay region must be expressly addressed before PG&E's analytic inertia can be considered the practice of a reasonable manager.

Q21: How would you characterize PG&E's position regarding the risk of a tsunami overtopping the HB ISFSI?

A21: Although PG&E appears hesitant to come right out and say it, I believe that the company thinks it would be of no consequence. They go to great lengths to dispute that a tsunami runup could get that high but, as the **November 2007 FSARU** concluded (at p. 2.6-125),

> Even if a tsunami runup flowed above the ISFSI elevation, the tsunami hazard at the proposed ISFSI site is negligible, because the casks can be temporarily wetted without harm and they will be contained in underground vaults which protect them from damage by flowing water and damage from water-born debris.

On the other hand, PG&E has been less than forthcoming about the basis for such confidence, offering the following responses to A4NR data requests:

> QUESTION 006 …
>
> a) Please identify any time limits, and the basis therefor, that PG&E's analysis places on the statement, "the casks can be temporarily wetted without harm."
>
> (b) Please describe any analysis PG&E or its contractors have performed on the potential for tsunami debris to obstruct the drainage of the underground vaults.
>
> ANSWER 006 …
>
> (a) PG&E will provide a supplemental response when information is available.
>
> (b) PG&E will provide a supplemental response when information is available.[9]

The **November 2009 FSARU** (at p. 3.2-6) took a slightly different tack in explaining "negligible,"

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[9] PG&E Data Response NuclearDecomCostTri2021_DR_A4NR_002-Q006.

> Even if the tsunami flowed above the ISFSI elevation, the tsunami hazard at the ISFSI site is still considered negligible, because the HI-STAR HB System is designed to withstand the static pressure forces from submergence in 656 ft of water. Furthermore, the HI-STAR HB casks are contained in enclosed underground vaults that are designed to structurally withstand 6 ft of water head and that will protect them from damage by flowing water and water-born debris.

The 656 ft submersion requirement stems from the HI-STAR HB cask's qualification as a transportation cask, and the time duration for this submersion is one hour, making it of questionable relevance for a fugitive cask pulled by tsunami drawdown into the deep ocean. The requirement is probably more pertinent as a proxy for withstanding external pressure of 300 psig for up to one hour than as an effective protection against extended moisture intrusion into the vaults, the overpacks, or the casks.

And it's important to focus on the word "negligible" to understand PG&E's perspective. Merriam-Webster defines negligible to mean, "so small or unimportant or of so little consequence as to warrant little or no attention: trifling."

Q22: Do you think PG&E's prior assessment understates the likelihood of a tsunami runup overtopping the HB ISFSI?

A22: Yes. PG&E has neglected to freshen its assessment based on what is known today, starting with the role of sea level rise in Humboldt Bay. As the Coastal Commission staff report for **CDP 9-15-0531**, the final site restoration for the Humboldt Bay Nuclear Power Plant decommissioning, noted (at pp. 44 – 45) in 2016:

> **Sea Level Rise:** Due to its location on Humboldt Bay, the project site is extremely vulnerable to sea level rise. In California, north of Cape Mendocino, the rate of sea-level rise over the next 100 years is expected to range from 0.3 to 4.7 feet. In Humboldt Bay, subsidence compounds rates of sea level rise, making Humboldt Bay more susceptible to rising sea levels than anywhere else in California. Based on the methodology described in

the Commission's Adopted Sea Level Rise Guidance, including incorporating the recommended local sea-level rise factor for the Humboldt Bay area of 0.16 inches per year, PG&E estimates the project sea-level rise at the site in 2030 and 2050 as follows:

	2030		2050	
	cm	in	cm	in
Low range	5.6	2.2	12.7	5.0
Projected	9.9	3.9	21.8	8.6
High Range	31.8	12.5	63.0	24.8

Recent mapping of the Humboldt Bay Shoreline contributed to a model showing the mean annual maximum water level, and the 10-year and 100-year occurrence interval extreme water levels with a predicted 17.2 inches of sea level rise. PG&E used this model to show the potential effect of sea-level rise on the HBPP site. Although 17.2 inches does not represent the maximum level of sea level rise possible at the site by 2050, it does provide an estimate of the middle to high range of sea level rise expected at the site. Exhibit 17 [10] shows of (sic) map of the site including the areas that will be inundated with 17.2 inches of sea level rise.

As shown in Exhibit 17, within thirty five years, if the middle to high range of sea level rise predictions are realized, the HBPP site will become a veritable island for part of the year. When coupled with King Tides and storm events, significant flooding is inevitable over much of the site, including development associated with the proposed project.

The 2018 **North Coast Regional Report from California's Fourth Climate Change Assessment** struck a similar note (at p. 26) regarding the Humboldt Bay area:

Projections of sea-level rise in the North Coast region are complicated by different rates of vertical land motion. Land subsidence along the Pacific Northwest coast drives sea-level rise in some places to rates of 0.09 inches per year, 34 percent greater than the global average rate of 0.06 per year. Furthermore, in the North Coast region, large interseismic tectonic motions along the southern Cascadia subduction zone create distinct and opposing sea-level trends observed between Humboldt Bay and Crescent City. Probabilistic sea-level rise projections for the Humboldt Bay region have been developed based on the work of Kopp et al. (2014) and the local

[10] Exhibit 17 to the Coastal Commission staff report for CDP 9-15-0531 is Attachment A to this testimony.

> estimates of vertical land motion by Patton et al. (2017). These updated probabilistic projections provide decision makers the most up-to-date and locally relevant information to support planning and developing adaptation strategies for sea-level rise in the Humboldt Bay region.
>
> Most of coastal California is experiencing interseismic uplift, which ameliorates the effect of sea-level rise. Crescent City, for example, is uplifting faster than longterm global sea-level rise, which results in a negative or decreasing local sea-level rise rate (Anderson 2018) In contrast, recent estimates of sea-level rise by Patton et al. (2017) indicate that Humboldt Bay (70 miles to the south) has the highest local sea-level rise rate (0.20 in/yr) in California, greater than both global and regional sea-level rise rates, due to land subsidence in and around the bay. This suggests that global sea-level rise will impact the Humboldt Bay area faster than other parts of the U.S. west coast (Anderson 2018). Further, the findings suggest that accurate measurement of the rate of tectonic land level change will be critical to understanding the impacts of global sea-level rise to the Humboldt Bay region.

The most recent **State of California Sea-Level Rise Guidance, 2018 Update**, from the Ocean Protection Council, describes itself (at p. 3) as a “science-based methodology for state and local governments to analyze and assess the risks associated with sea-level rise, and to incorporate sea-level rise into their planning, permitting, and investment decisions.” Its 2050 estimates for the tidal gauge closest to the HB ISFSI, the North Spit on Humboldt Bay, contains (at p. 48) the following recommended projections “for use in low, medium-high and extreme risk aversion decisions”: low risk aversion, 1.5 ft; medium-high risk aversion, 2.3 ft; extreme risk aversion, 3.1 ft.

PG&E stated in a data response to A4NR that a 2020 assessment of climate-induced sea level rise in the Humboldt region for the next 100 years projected a relative sea level rise at Buhne Hill (adjoining the HB ISFSI) of up to 3 to 5 ft and, “Prorated to the next 30 years (to

2050) the rise would be 1 to 3 feet, a negligible increase with no significant change in the hazard at the ISFSI."[11]

Whether a relative sea level rise of 1 to 3 ft in 2050 can be characterized as a "negligible increase" depends upon several factors. First, it must be added to PG&E's earlier projections for tsunami runup at the HB ISFSI. **Coastal Commission Staff Report E-11-018** (at p. 16) calculated that PG&E's estimate for runup at the HB ISFSI from a Cascadian Subduction Zone earthquake during Mean Higher High Water (MHHW) – PG&E's analysis had used Mean Lower Low Water (MLLW), identified in the **November 2007 FSARU** (at p. 2.6-124) as 2 ft lower than MHHW – would be from about 23 to 38 ft, so the new 2050 range would be 21 to 41 ft and still below the 44 ft elevation of the HB ISFSI. But the Coastal Commission staff report (at pp. 16 – 17) registered additional concerns:

> For several reasons, when considering the ISFSI, the Commission did not concur with PG&E's conclusions regarding the effects of tsunamis … First, similarities between the expected Cascadian Subduction Zone earthquakes, the December 2004 Sumatran earthquake, and the March 2011 Tohoku earthquake raise doubts as to the validity of the expected tsunami runup height at the site.
>
> The Sumatran quake resulted in tsunami runups of as much as 130 feet, which is about three times higher than the runup predicted at HBPP, and the mechanisms for the earthquakes and the generation of tsunamis in each area are similar. The more recent March 2011 Tohoku earthquake in northern Japan, which was of similar magnitude to the Sumatra quake and was a subduction-type earthquake, did not have as high a tsunami runup as the Sumatra quake, but the runup was still higher than had been predicted. Additionally, the proposed 38-foot runup level for the ISFSI site was based only on the height above Mean Higher High Water. It does not include the height increase customarily added to the prediction to account for the tsunami occurring during a 100-year storm surge. This would put the runup at an even higher level …

[11] PG&E Data Response NuclearDecomCostTri2021_DR_A4NR_002-Q001.

How much higher? The **Humboldt Bay Area Plan Sea Level Rise Vulnerability and Risk Assessment Report**, prepared for Humboldt County in 2018 by Trinity Associates, sets MHHW at 6.51 ft (at p. 7); Mean Annual Maximum Water, often referred to as king tides, at 8.78 ft (at p. 7); and reports that the Federal Emergency Management Agency recently adopted new 100-year flood elevation for Humboldt Bay of 10.2 ft (at p. 35). So, applying the 3.7 ft difference between MHHW and the 100-year flood to the 2050 range would project a tsunami runup at the HB ISFSI of 24.7 ft to 44.7 ft – potentially overtopping the 44 ft elevation of the site.

Of greater quantitative significance is whether the runup PG&E attributed to a tsunami caused by a Cascadian Subduction Zone earthquake also incorporated the coseismic "subsidence of up to 6 feet" acknowledged (at pp. 2.6-122, 2.6-123) in the **November 2007 FSARU**. A 2005 supplemental report provided by PG&E to the Coastal Commission – **"Implications of Long-Term Global Warming and Tectonic Displacements at Buhne Hill, Humboldt County, California"** – indicates the projected runup did not, stating (at p. 23):

> Relative sea level change for the next 50 and 100 years is determined by subtracting forecasted sea level change from predicted land level change (Figure 3-12). For land-level change, we assume a constant rate of interseismic uplift of 1.3 ± 0.3 feet per century (4 ± 1 mm/yr) based on level line surveys published in Mitchell and others (1994). We explicitly assume that no major Cascadia subduction zone or Little Salmon fault zone earthquake will occur during this time period. The resulting relative sea level curves show the ISFSI site at 44.0 ± 0.6 feet elevation by 2050 and at 43.8 ± 1.6 feet by the year 2100 A.D. The relative sea level curves show that, over the next century and barring any change in land level due to a major earthquake, the rate of interseismic uplift at Buhne Point will keep up with expected sea level rise. If a major Cascadia subduction zone event occurs within this time, however, land level may abruptly drop by up to about 6 feet (~2 m).

If the tsunami runup associated with a major Cascadia Subduction Zone earthquake were accompanied by the abrupt subsidence associated with the same earthquake, the net effect would be to add "about 6 feet" to the projected overtopping at the HB ISFSI site. When added to the estimated range attributable to the 100-year flood, the upper end of the estimate would be 6.7 ft above the elevation of the HB ISFSI. The **January 2006 FSARU** (at p. 2.4-5) the **November 2007 FSARU** (at pp. 2.6-125), the **November 2009 FSARU** (at p 3.2-5), and the **November 2021 FSARU** (at p. 8.2-17) all dismissed as "not considered credible" the then-maximum value of 49.86 ft for a tsunami coinciding with a design basis storm wave runup and high tide.

Q23: How has PG&E assessed the risk that a local submarine landslide could significantly increase the size of a tsunami at the HB ISFSI?

A23: The **November 2007 FSARU (**at pp. 2.6-108 – 2.6-109) contained the following description of the HB ISFSI offshore environment:

> Landslide-generated tsunamis can contribute to the wave train of a seismic generated tsunami and can cause locally higher runups on the affected coast. The compilation by Lander and others (Reference 220) [*Lander, J. F., Lockridge, P. A., and Kozuch, M. J., 1993, Tsunamis affecting the West Coast of the United States, 1806-1992: National Oceanic and Atmospheric Administration, Boulder, National Geophysical Data Center Key to Geophysical Records, Documentation No. 29, 242 p*.] notes that of fifteen high-quality tsunami reports associated with earthquakes along the west coast of the U.S. since 1812, eight to thirteen were caused by or included submarine landslides. Five of the landslide-related tsunamis affected the coast of southern California; four affected the central California coast or San Francisco Bay. Only one affected the northern California coast, at Crescent City; it was due to an 1873 earthquake north of the Oregon border.
>
> Submarine landsliding is a common and ongoing process off the California coast. Clarke and others (Reference 243) [*Clarke, S. H., Greene, H. G., and Kennedy, M. P., 1985, Identifying potentially active faults and unstable slopes offshore: in J. I. Ziony (ed.), Evaluating earthquake hazards in the Los Angeles region; an earth-science perspective, U. S. Geological Survey Professional Paper, P 1360, p. 347-373*.] note its prevalence in the broad, southern California continental borderland, possibly the reason for the large fraction of landslide-related tsunamis in southern California reported by

Lander and others (Reference 220) [*id.*]. Offshore northern California, high sedimentation rates and steep sea-floor topography are conditions that produce instability and promote submarine landslides. Particularly steep slopes are present along the Mendocino escarpment, along part of the outer continental slope, and in the Eel and Trinity submarine canyons. Mapping of the continental margin offshore of northern California has identified many ancient landslides on the sea floor (Reference 244) [*Field, M. E., Clark, S.H., Jr., and White, M. E., 1980, Geology and geologic hazards of the offshore Eel River Basin, northern California continental margin, U. S. Geological Survey Open File Report 80-1080, 80 pp.*]. Most of these probably were seismically generated. Given the frequent occurrence of strong earthquakes in historical time in the offshore area north of Cape Mendocino, it is surprising there is only one report (1873, Crescent City) of a landslide-related tsunami in this region. This apparent dichotomy may be because the infrequent large long-duration megathrust earthquakes in this area may have already caused failure of any marginally stable slopes leaving few slopes susceptible to additional large landslides and there have been none historically.

Another potential offshore landslide area is the Eel River basin where seismic reflection profiles show an area of ridge and swale topography along the continental slope and gully-type topography (the Humboldt slide) [Reference 245 [*Gardner, J. V., Prior, D.B., and Field, M.E., 1999, Humboldt Slide - a large shear-dominated retrogressive slope failure, Marine Geology, 154, p. 323-338*] – 246) [*Lee, H. J., Syvitski, J. P. M., Parker, G., Orange, D., Locat, J., Hutton, W. E. H., and Imran, J., 2002, Distinguishing sediment waves from slope failure deposits: field examples, including the 'Humboldt slide' and modeling results, Marine Geology, in press*.]. The Humboldt slide was originally been interpreted as a shallow sediment failure along rotated blocks (e.g., submarine landslide) by Field and others (Reference 244) [*id.*] but Gardner and others (Reference 245) [*id.*] has been recently reinterpreted as a series of sediment waves caused by turbidity currents (Reference 246) [*id.*] or internal tidal waves (Reference 247 [*Cacchione, D. A., Pratson, L. F., and Ogston, A. S., 2002, The shaping of continental slopes by internal tides, Science, 296, 724-727*] - Reference 248) [*Garrison, C., Abramson, H. A., and Carver, G. A., 1997, Evidence for repeated tsunami inundation from two freshwater coastal marshes, Del Norte County, California: Geological Society of America, Cordilleran Section, Abstracts with Program, v. 29, no. 5, p. 15.*]. It is also possible that several of the 50 turbiditite deposits reported from in the Eel River basin by Nelson and others (Reference 54) [*Nelson, C. H., Goldfinger, C., and Johnson, J. E., 2000 (in press), Turbidites event stratigraphy - implications for Holocene paleoseismicity of the Cascadia subduction zone and northern San Andreas faults, (abs.): Eos, Transactions American Geophysical Union, v. 81, no. 48, p. F851.*] were triggered by earthquakes on the Cascadia subduction zone. The landslides that caused the turbidities were probably far enough away and not large enough to cause a large landslide generated tsunami at the coast.

Analysis of the paleotsunamis in northern California suggests possible locally high tsunami runup during event "Y" (January 26, 1700) at Orick, where the estimated runup height from native oral histories of 66 to 69 feet (above MLLW) (Figure 2.6-115) exceeds the estimates at Crescent City (higher than 28 to 31 feet MLLW) and Lagoon Creek (26 to 33) to the north and Humboldt Bay (30 to 40 feet) to the south. The Clarke and Field (Reference 249) [*Clarke and Field, 1989, Mapping of the continental margin offshore of northern California has identified many ancient landslides on the sea floor.*] geologic map shows several regions of unstable sediment deposits on the continental shelf between 12 and 31 miles to the northwest and west of Orick. However, the continental slope in this area is generally shallow and not conducive to landslides.

If a landslide originated at one of these locations, it is likely that its tsunami would have affected other areas, as well as Orick. Unfortunately, there are too few locations along the coast where reliable runup-height estimates for the 1700 tsunami have been measured to allow testing of the landslide hypothesis for the anomalous wave height at Orick. Another explanation for this apparently high runup may be a combination of the azimuth of wave arrival, wave amplification, and focusing of the waves caused by local effects from seafloor topography.

Recent high-resolution sea-bottom imaging by Goldfinger and Watts (Reference 250) [*Goldfinger, C., and Watts, P., 2001, Tsunamigenic mega-slides on the southern Oregon Cascadia margin: ITS 2001 Proceedings, Session 3, no. 3-3.*] indicates the presence of very large landslide masses along the Cascadia continental margin, but their subdued geomorphic appearance indicates that they are old, estimated at ~110,00 yrs, 450,000 yrs, and 1.2 million yrs (Reference 65) [*PG&E technical Report TR2002-01, December 2002, Appendix 9A.*]. Although huge slide masses, such as these, could generate very large local tsunamis, no such events, other than possibly Orick, have been preserved in the geologic record for at least the past approximately 3,000 years at the sites studied. Such catastrophic events appear to be infrequent compared with the occurrence of tectonically generated tsunamis from ruptures of the Cascadia subduction zone, even though the long duration of such large events should be effective in triggering large landslides.

And at p. 2.6-112 of the **November 2007 FSARU**:

> With regard to the Cascadia subduction zone, earthquake-triggered submarine landsliding on a very large scale might account for the waves generated by those events for which the tsunami is too large for the earthquake magnitude. As previously discussed (Section 2.6.9.4.7) large submarine landslides have been mapped on the sea floor offshore of northern California. The anomalous high runups reported at Orick possibly resulted from a tsunami that was enhanced by an offshore landslide. Recent detailed bathymetric mapping of the Cascadia continental margin (Reference 250) [*id.*] has revealed several enormous landslide masses off shore of Oregon that have features interpreted as indicative of large and sudden movements of thousands of square miles of the lower continental slope. These appear to have occurred at infrequent intervals and inferred to be hundreds of thousands of years old by the thickness of the overlying sediment and the inferred sedimentation rates. The presence of these large offshore submarine landslides suggests a mechanism for generating anomalously large tsunamis at infrequent intervals. However, no geologic evidence for such tsunamis has been found in the late Holocene coastal stratigraphy in northwestern California or other places along the Cascadia coast.

Despite this narrative detail, PG&E's assessment of submarine landslide risk appears not to have been explicitly factored into PG&E's projected tsunami runup at the HB ISFSI. PG&E indicated in a data response to A4NR that its assessment methodology for local submarine landslides has remained unchanged since 2007.[12]

Q24: How does the tsunamigenic assessment of the Cascadian Subduction Zone PG&E used to license the HB ISFSI compare to post-Fukushima practice?

A24: PG&E's probabilistic assessment was considerably less conservative than the deterministic approach recommended by **NUREG/CR-7723** as part of the NRC's and may have understated the hazard somewhat in terms of earthquake magnitude and the potential for submarine landslides.

[12] PG&E Data Response NuclearDecomCostTri2021_DR_A4NR_006-Q004(b).

According to a paper published in the May 2021 Annual Review of Earth and Planetary Sciences, **"Toward an Integrative Geological and Geophysical View of Cascadia Subduction Zone Earthquakes"** (Walton, et. al), the Cascadia Subduction Zone extends for more than 1,300 km from Cape Mendocino to Vancouver Island and has been accumulating strain for 320 years since the last great M8.7 – 9.2 earthquake in 1700 CE. Geoscientists infer 19–20 full-margin ∼M9 Cascadia Subduction Zone earthquakes over the past 10,000 years from marine and onshore geologic data sets, although controversy remains whether all events in the paleoseismic record were full-margin M9s or a portion of those events may have been a series of smaller M8s occurring in quick succession (especially in southern Cascadia). Without an instrumental record of a great Cascadia Subduction Zone megathrust earthquake, estimating coseismic onshore and offshore ground motion and secondary hazards, such as liquefaction, landslides, and turbidites, often relies on comparison to other subduction zone margins. Additional uncertainty exists about shaking-initiated sediment transport and rupture characteristics, and earthquake-induced tsunamis are sensitive to both the depth and extent of rupture. In the upper coupled zone, earthquakes at depths ~15 km with relatively low amounts of short period energy radiation and low stress drop generate tsunamis that are anomalously large for the corresponding earthquake magnitude and can occur coseismically during megathrust earthquakes. No consensus exists on an appropriate recurrence model for the Cascadia Subduction Zone.

Consistent with these uncertainties, as guidance to the NRC staff, in December 2016 the NRC Office of Nuclear Regulatory Research published **NUREG/CR-7273, "Tsunami Hazard**

Assessment: Best Modeling Practices and State-of-the-Art Technology." As stated (at p. v) in **NUREG/CR-7273**:

> This NUREG/CR will provide the NRC staff with the means and criteria to assess evaluations and analyses for the tsunami design for nuclear facilities provided by the licensees. This information will permit the NRC staff to: (1) confirm that adequate levels of safety are maintained; (2) improve the effectiveness and efficiency of the review processes; and (3) support the staff's technical decisions in a reasonably conservative and realistic manner thereby increasing public confidence in the staff's actions.

NUREG/CR-7273 noted that, because very low recurrence levels make characterization difficult, a deterministic approach is commonly used to assess tsunami hazard at nuclear facilities. Proper incorporation of submarine landslides, identified as the most common source of the Probable Maximum Tsunami ("PMT"), was considered in **NUREG/CR-7273** as a major hurdle to probabilistic assessment. **NUREG/CR-7273** contrasted the lack of understanding of how small-scale spatial and temporal details generate and evolve in such landslides with the greater ability to quantify epistemic uncertainty for earthquake sources. As **NUREG/CR-7273** recommended (at pp. 7-2 – 7-3):

> … if there is geological evidence of a submarine landslide along the shelf break at a location distant to the NPP [i.e., nuclear power plant] but in a similar geophysical configuration, then that landslide should be considered to possibly occur at the shelf break immediately offshore of the NPP. This approach can be discarded only with a clear and convincing geological argument against permitting a change in the future landslide to a location closer to the NPP. Due to an overall lack in understanding of the evolution of large submarine landslides and the waves that they generate, a highly conservative approach must be employed to initially estimate the waves generated. An initial estimation method is to assume that the vertical change in seafloor elevation due to the postulated landslide is reflected exactly in the water surface elevation.

> … Landslide dimensions, including width, length, and depth should first be estimated from available geophysical data. With this information, and the local bathymetry data, it is possible to construct a "before" and "after" landslide profile. The initial free surface profile is determined from the difference in these two profiles. Fundamentally, this method is assuming an impulsive vertical motion of the landslide, which is conservatively defensible in light of the current state of knowledge for tsunami generation by landslide, and eliminates some of the significant uncertainty inherent in using landside-tsunami initial condition functions found in the literature (e.g. Watts et al., 2003). This 'impulsive' landslide option can be discarded for alternative generation descriptions, such as modeling the time-history of the slide, only with clear and convincing arguments that the alternative approach is conservative as well as a physically reasonable estimation (e.g. Geist et al., 2009).

NUREG/CR-7273 also emphasized the challenges in deterministically identifying a credible worst-case scenario source for a seismically generated PMT at specific coastal locations:

> … one of the major difficulties in assessing the exposure of a coastal location to tsunami damage is the short historical record associated with events of this type. This is particularly true along U.S. coastlines where, at best, historical records date back a few hundred years forcing scientists to resort to paleo-tsunami and sedimentology studies (Atwater, 2005) to evaluate the exposure and recurrence period of tsunamis along our seaboard in an attempt to increase the length of the historical record. However, due to the long recurrence periods that devastating tsunamis can have, even additional information provided by paleo-tsunami science has proven to be insufficient in determining the level of exposure of a particular site as evidenced by the tsunami disasters of Sumatra in 2004 and Japan in 2011. Two major conclusions can be extracted from these events in connection to THA [i.e., Tsunami Hazard Assessment]. First, the evaluation of a PMT should not be based solely on evidence of historical events, even though such information should undoubtedly be included in the analysis. Hazard assessment studies based only on historical evidence of past events to determine a credible worst-case scenario are likely to under-predict such cases, as demonstrated by recent events. Second, limitations on the magnitude of potential tsunami sources based on geophysical analysis of local plate tectonics, such as that proposed by the Japan Society of Civil Engineers (JSCE), the Nuclear Civil Engineering Committee, and the Tsunami Evaluation Subcommittee in Chapter 4 of their report Tsunami Assessment Method for Nuclear Power

Plants in Japan (JSCE, 2002), have led to underestimations of the risk. This was seen during the 2011 Fukushima-Daiichi NPP disaster.

To overcome the short length of the historical record and the past tendency to underestimate the PMT from geophysical or paleo-seismic data, **NUREG/CR-7273** recommended (at p. 9-9) “a new methodology … to identify a more conservative PMT than those selected by existing methods.” Its foundational assumption: “Following the findings of Geist et al. (2007) and Bird and Kagan (2004), a mega-seismic event of magnitude M_w = 9.3 or higher is assumed to be credible from any subduction zone in the Pacific or Atlantic Oceans, unless there is sufficient evidence to the contrary.” In addition to recommending (at pp. 9-11 – 9-12) the inclusion of extreme tides and projected sea level rise in the tsunami hazard assessment, **NUREG/CR-7273** summarized (at p. 11-1) its guidance: “an approach in which the very worst credible source and most conservative set of model parameters are used in the estimation of the impact is recommended.”

While PG&E’s initial HB ISFSI tsunami assessment predated **NUREG/CR-7273** by roughly a decade, none of its subsequent 11 revisions to the FSARU have revised the analysis to include extreme tides or projected sea level rise; substitute a Mw = 9.3 for the Mw = 8.76 assumed in its probabilistic model; re-evaluate the treatment of submarine landslides and coseismic subsidence; or extend the posited 1,100 km length of the Cascadia Subduction Zone to reflect the more than 1,300 km length considered to be a scientific consensus.

Q25: How do you think a reasonable manager would approach the tsunami risk at the HB ISFSI, based upon what PG&E knows or should know today?

A25: I think that depends very much on what time horizon is appropriately applied to evaluate different choices. Is it the “in perpetuity” that the 2005 Coastal Development Permit assumed? Is it the 2032 removal of all SNF by the federal government that PG&E's DCE assumes? Is it the 60-year design life of the facility, of which some 40+ years still remain? Obviously, it's some mix of each of those, but – to the extent that economics always gets injected into weighing different options – one overriding factor may be whether any of the costs of altering the status quo will be recoverable in the ongoing litigation claims for DOE's breach of contract. If so, ratepayers should expect PG&E to vigilantly pursue the federal reimbursement of all reasonable expenditures necessary to provide for safe storage of the SNF.

Accepting PG&E's assertion that "(e)ven if the tsunami flowed above the ISFSI elevation, the tsunami hazard at the ISFSI site is still considered negligible," the potential sea level rise overlooked by PG&E's tsunami assessment may impede the remedial steps envisioned for the "temporarily wetted" condition of the casks.   According to the 2018 **Humboldt Bay Area Plan Sea Level Rise Vulnerability and Risk Assessment Report**, the 8.8 ft king tide elevation is currently equaled or exceeded 4 days per year, but with 1.6 ft (0.5 M) of sea level rise, these high tides would equal or exceed 8.8 ft. 125 days per year. With 3.3 ft (1.0 M) of sea level rise, these same high tides would equal or exceed 8.8 ft 355 days per year. As the Coastal Commission staff reported in 2016, even without adjusting for king tides or storm surges, the site will become a veritable island for part of the year if the middle to high range of 2050 sea level rise predictions is realized. This scenario is vividly illustrated in Attachment A to this testimony.

What if the tsunami overtopped the HB ISFSI under such conditions? If King Salmon Avenue, the only vehicular access to the HB ISFSI, is tidally submerged – as Attachment A indicates it will be "for part of the year" – how quickly will PG&E be able to perform the inspections described (at pp. 4.4-8 – 4.4-9) in the **August 2020 FSARU**? Notwithstanding the extended cooling time the SNF has already experienced, and the low 2kW heat load per cask, how much time could the non-water tight vault storage cells – as described at p. 4.2-1 of the **August 2020 FSARU** – retain standing water before temperature buildup became an issue? And what if the tsunami is accompanied by the abrupt land subsidence of "up to about 6 feet" which PG&E reported in 2005 could be associated with a major Cascadia Subduction Zone event?

Notably, the **Humboldt Bay Area Plan Communities at Risk Strategic Sea Level Rise Adaptation Planning Report**, prepared for Humboldt County in 2019 by Trinity Associates, identifies (at p. 18) creation of a tidal barrier "to protect PG&E facilities" by elevating King Salmon Avenue to 12 feet, removing the bridge over King Salmon Canal, and filling in the canal to support the roadway. According to the report, with 1.6 feet (0.5 meter) of sea level rise, king tides could tidally inundate approximately 950 feet of King Salmon Avenue while the entire 2,500 feet of roadway would be inundated by the mean monthly high water associated with 3.3 feet (1.0 meter) of sea level rise.

Q26: What is A4NR's recommendation?

A26: A4NR urges PG&E to promptly commit to include in its 2024 NDCTP application an updated tsunami hazard assessment for the HB ISFSI which incorporates the most recent projections of sea level rise; relies upon state-of-the-art analyses of Cascadia Subduction Zone earthquakes and landslides; and evaluates alternative options for safe storage of the six casks of SNF and GTCC waste.

APPENDIX: QUALIFICATIONS OF JOHN GEESMAN

John L. Geesman is an attorney with the law firm, Dickson Geesman LLP, and a member in good standing of the California State Bar.

Mr. Geesman served as a member of the California Energy Commission from 2002 to 2008, and was the agency's Executive Director from 1979 to 1983. While a Commissioner, he chaired the Commission's Facilities Siting Committee during a period when nearly two dozen new power plants were approved for construction. Between his two tours at the Energy Commission, Mr. Geesman spent nineteen years as an investment banker focused on the U.S. bond markets and served as a financial advisor to municipal electric utilities throughout the western states.

Mr. Geesman has a long history of engagement with issues related to regulatory compliance, resource planning, environmental policy, financial management, and risk practices. This is demonstrated by his service in numerous leadership capacities, including stints as:

- Co-Chair of the American Council on Renewable Energy;
- Chairman of the California Power Exchange;
- President of the Board of Directors of The Utility Reform Network (nee Toward Utility Rate Normalization);
- Member of the Governing Board of the California Independent System Operator; and,
- Chairman of the California Managed Risk Medical Insurance Board.

Mr. Geesman has testified as an expert witness before the California Public Utilities Commission on many occasions. He is a graduate of Yale College and the University of California Berkeley School of Law.

Attachment A

Exhibit 17 to CDP 9-15-0531

HBPP FINAL SITE RESTORATION PLAN