Prefiled Staff Exhibit 2

August 26, 2008

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

<u>BEFORE THE ATOMIC SAFETY AND LICENSING BOARD</u>

In the Matter of	)	
	)	
PA'INA HAWAII, LLC	)	Docket No. 30-36974-ML
	)	
(Materials License Application)	)	ASLBP No. 06-843-01-ML

NRC STAFF'S TESTIMONY OF JAMES DURHAM, AMITAVA GHOSH, JOHN STAMATAKOS
<u>AND KAUSHIK DAS CONCERNING AMENDED ENVIRONMENTAL CONTENTION 3</u>

Q.1. Please state your name, occupation and employer.

A.1. My name is James Durham. I am employed by the Southwest Research Institute in San Antonio, Texas. I am a principal engineer and project manager in the performance assessment group of the Center for Nuclear Waste Regulatory Analyses (CNWRA), in the Geosciences and Engineering Division. A statement of my professional qualifications is attached to my testimony. (Staff Exhibit 6.)

Q.2. What is the CNWRA's role?

A.2. Founded in 1987, the CNWRA is a federally funded research and development center sponsored by the Nuclear Regulatory Commission. The CNWRA is managed by the non-profit Southwest Research Institute located in San Antonio, Texas. It provides dedicated, free-from-conflict-of-interest, independent and high-quality technical assistance and research support to the NRC. The CNWRA, however, serves no regulatory function.

Q.3. Please explain the CNWRA's role and your own duties in connection with the Staff's environmental review of the license application submitted by Pa'ina Hawaii, LLC.

A.3. (J. Durham) In 2006, the CNWRA entered into a contract with the NRC to review natural and aircraft hazards potentially affecting the irradiator proposed by Pa'ina Hawaii, LLC. The CNWRA conducted a review that included a site visit, review of material provided in Pa'ina's license application, and the use of independent confirmatory technical analyses. The CNWRA prepared draft and final versions of its "Topical Report on the Effects of Potential Aviation Accidents and Natural Phenomena at the Proposed Pa'ina Hawaii, LLC, Irradiator Facility" (Topical Report) (Staff Exhibits 13 and 14). The results from the Draft and Final Topical Reports were incorporated into the NRC Staff's Draft and Final Environmental Assessments (EAs) for the Pa'ina irradiator. (Staff Exhibits 11 and 12.) I was project manager for the Draft and Final Topical Reports. As project manager, I directed, coordinated, and reviewed work performed by Amit Ghosh, John Stamatakos, and Kaushik Das in their respective areas of expertise. Cynthia Dinwiddie, whose name also appears on the cover of the Final Topical Report, was a technical reviewer who provided extensive comments on the nomenclature used in the Draft Topical Report, primarily in the sections associated with aviation accidents. At the NRC, I worked closely with Matt Blevins, who was the NRC technical project manager for the EA.

Q.4. What is the purpose of your testimony?

A.4. (J. Durham) The purpose of the CNWRA's testimony is to respond to portions of the Intervenor's amended environmental contention 3. Specifically, the CNWRA will address the portions of amended environmental contention 3 challenging the analysis of aviation accidents and natural phenomena in the Final Topical Report.

Q.5. Before turning to the Intervenor's contention, could you explain how you determined the scope of the topical report?

A.5. (J. Durham) The NRC Staff contracted with the CNWRA to develop a topical report in mid-2006, after the Staff entered into a settlement agreement with the Intervenor. As part of that agreement, the Staff agreed to prepare an EA for the proposed Pa'ina irradiator. The NRC asked the CNWRA to prepare a topical report analyzing the potential impacts of aviation accidents and natural phenomena. This report was to be used for the development of a Draft EA. As stipulated in the Statement of Work, we reviewed the license application and supporting reports submitted by Pa'ina; collected and reviewed information related to the proposed site and its environs, natural phenomena and aviation accidents, including information provided by the NRC technical project manager. The CNWRA then prepared a draft topical report on the effects of natural phenomena, including tsunami, hurricane, and seismic hazards, and aircraft crash hazards on the Pa'ina irradiator. The Statement of Work also stipulated that the topical report was to be consistent with NUREG-0800, Section 3.5.1 (Aircraft Hazards) to the extent practical. The report focused on credible and reasonable scenarios and provided some background on scenarios that were not credible, After receiving comments from the Intervenor and other members of the public, we considered the comments and revised the draft report as a Final Topical Report that would be incorporated into a Final EA.

Q.6. Could you elaborate on how the CNWRA considered comments received on the Draft EA and Topical Report?

A.6. (J. Durham) In preparing the Final Topical Report, the CNWRA considered public comments submitted in response to the Draft Topical Report and EA. As described in more detail below, in light of the comments, the CNWRA verified its data, methods, and conclusions. In some instances, the CNWRA changed certain portions of the Topical Report in order to clarify areas of concern. However, the CNWRA's underlying conclusion—that a loss of control of radioactive material is not a foreseeable consequence of an aircraft crash or natural phenomenon involving the Pa'ina irradiator—did not change even after we considered all comments.

In addition, after considering the comments, the CNWRA decided that certain areas of analysis in the Topical Report could be explained more clearly. For example, the CNWRA added Section 1.2, "Scenarios To Be Considered," to explain what consequences could possibly lead to a loss of control of radioactive material in the irradiator. We decided to add this section at the beginning of the Final Topical Report because it identified a key factor underlying our analyses of aviation accidents and natural phenomena. We also added this section because a number of the public comments suggested that certain other scenarios could lead to a loss of control of radioactive material. For the reasons set forth in Section 1.2 of the Final Topical Report—reasons that we elaborate on in other sections of the Topical Report—we concluded that those other scenarios simply were not plausible.

Q.7. What are the events that might cause a loss of control of radioactive material?

A.7. (J. Durham) As stated in Section 1.2, loss of control of radioactive material could occur if the sources are physically removed from the irradiator pool or if the pool water became contaminated by destruction of a source capsule and the source material corroded. The CNWRA did not identify any forces, either from an aviation accident or from natural phenomena, strong enough to dislodge a source from the bottom of the pool and lift it out of the pool. This will be discussed in more detail below as we address each segment of the Intervenor's contentions.

For a cobalt source to corrode, its inner and outer containment capsules must be breached, and the nickel plating surrounding the cobalt slugs must also be breached. Then, the exposed cobalt must remain in the pool water for years. Only under these circumstances could the pool water could become contaminated. If contaminated water then escaped through a breach in the pool's concrete-and-steel liner, there could be offsite consequences. However, the CNWRA found no plausible scenario to damage a cobalt source to the point where corrosion could occur and the source would remain to corrode in the pool water. In the event of an aircraft crash or natural phenomenon involving the irradiator, it is not plausible that a damaged source would remain in a damaged pool long enough for water to be released into the environment. I should mention that the pool's liner consists of two layers of steel and an intermediate layer of concrete that is six inches thick. So, you would need an accident so severe that it breaches both the source and the pool liner, and you would need for the damaged pool and source to be left unattended for a significant period of time. Therefore, the CNWRA concluded that a release of contaminated water into the environment simply is not a plausible scenario for the proposed irradiator.

Some of the public comments also suggested that loss of control of radioactive material could occur if the sources were dislodged from the irradiator, either through a wave, storm surge, or seismic event. The CNWRA analyzed each of these scenarios and concluded that none was plausible. Specifically, the CNWRA performed fluid dynamics calculations and analyzed seismic data to determine whether any of these scenarios could occur. For reasons stated in Sections 3.1 and 3.2.2 and summarized in Section 4 of the Final Topical Report, the CNWRA concluded there was no potential for loss of radioactive material from any of these scenarios.

Q.8. How long would it take for a cobalt source to corrode to the point where it might contaminate the pool water?

A.8. (J. Durham) In Section 1.2 of the Final Topical Report, we explain that cobalt has a very low corrosion rate of 108 μm/yr (0.004 in/yr) in acid. In water, the corrosion rate is expected to be at least one order of magnitude smaller. It would take at least two and a half years for one mil of the surface to corrode, and most of the corrosion products would remain adhered to the cobalt. Thus, it would take a very long time for the source material to corrode enough to contaminate the water. (Staff Exhibit 18.) This small amount of corrosion would then be diluted in the large volume of water and probably would not be detectable for several more years.

Q.9. The CNWRA concluded it was not plausible that a source might be removed from the irradiator pool by a wave resulting from a tsunami or hurricane. Why is that?

A.9. (J. Durham) The CNWRA performed a computational fluid dynamics analysis to determine the wave velocity required to remove a source. That analysis showed that a source could not be removed at a wave velocity below 200 mph, which far exceeds the velocity of any wave that might plausibly strike the Pa'ina irradiator. The CNWRA summarizes its analysis in Section 3.2.2 of the Final Topical Report. Kaushik Das performed the fluid dynamics calculations, and he will further explain his calculations in the context of responding to the Intervenor's contentions.

Q.10. At this time we'll turn to the Intervenor's contentions. In amended environmental contention 3, the Intervenor alleges that the final EA does not comply with NEPA because the Staff failed to take a "hard look" at the potential environmental impacts of the proposed irradiator. Could you explain which parts of this contention relate to the analysis in the CNWRA's analysis in the Final Topical Report?

A.10. (J. Durham) The CNWRA's role in preparing the EA was to analyze risks and impacts associated with aircraft crashes and various natural phenomena that could potentially affect the Pa'ina irradiator. Accordingly, most of the first and third portions of amended environmental contention 3 relate to the CNWRA's analysis. I say "most" of these portions relate to the CNWRA's analysis because there are a few issues in each portion that do not relate directly to aircraft crashes or natural phenomena, such as the Intervenor's claims that the NRC did not respond to comments regarding terrorism and transportation accidents. The second portion of the Intervenor's contention relates to the Staff's analysis in the EA, and the fourth and fifth portions of amended environmental contention 3 likewise do not involve issues that were addressed in the Topical Report. Nor does amended environmental contention 4, which challenges the alternatives analysis in the EA, involve issues that were addressed in the Topical Report.

Q.11. For the sake of clarity, I'm going to summarize the issues raised by the Intervenor in the first and third portions of amended environmental 3 that appear to relate to the CNWRA's analysis of aircraft crashes and natural phenomena.

In the first portion of contention 3, the Intervenor claims that the Final EA does not respond to its comments on the draft EA. In those comments the Intervenor claimed the Draft EA failed to:

> [1] consider significant factors in evaluating the likelihood the proposed irradiator would be involved in an aviation accident;
>
> [2] quantify the impact of flying airplane and building debris following an aviation accident to determine if sources would be breached;

> [3] quantify hurricane storm surge and tsunami inundation runup potential;
>
> [4] consider the effects on the irradiator pool of increases in buoyancy forces due to hurricane surge or tsunami inundation;
>
> [5] consider potential consequences of hurricane winds;
>
> [6] evaluate unique features of Ke'ehi Lagoon that might increase the potential for tsunami-related impacts;
>
> [7] consider potential focusing effects of seismic energy on O'ahu; [and]
>
> [8] evaluate properly the threat of liquefaction[.]

The Intervenor makes these arguments on pages 7 and 8 of its amended environmental contentions. According to the Intervenor, the comments are set forth in the following documents: the February 8, 2007 Earthjustice Letter, with enclosed expert reports; the Sozen/Hoffmann Report; the February 7, 2007 Resnikoff Report; the Pararas-Carayannis Report; the Thompson Declaration; the July 9, 2007 Earthjustice Letter, with enclosed reports; the July 6, 2007 Resnikoff Report; and the August 24, 2007 Resnikoff Declaration.

In the third portion of amended environmental contention 3, the Intervenor claims the EA fails to adequately consider the impact of natural disasters and aviation accidents on the Pa'ina irradiator. Specifically, the Intervenor claims:

> [1] The Final EA fails to consider potential impacts associated with major flooding;
>
> [2] The Final EA fails to quantify the risk of tsunamis and hurricanes through numerical modeling or, at a minimum, analyze the range of environmental impacts likely to result in the event of a major tsunami, including the impacts resulting from hurricane storm and tsunami inundation;
>
> [3] The Final EA fails to consider numerous other potential impacts related to natural disasters, such as the potential for increased buoyancy due to hurricane storm surge or tsunami inundation to compromise the irradiator pool's integrity or allow shielding water to drain out, damage from hurricane-force winds, and liquefaction during an earthquake;
>
> [4] The Final EA failed to consider credible scenarios under which an aircraft crash might result in exposures above regulatory limits, including, but not limited to, damage to the irradiator pool structure at or below the groundwater level,

> resulting in a loss of vital pool shielding water, and release of water contaminated with radioactive cobalt through a tear in the pool lining, contaminating groundwater and nearby Ke'ehi Lagoon;
>
> [5] Although the Final EA presents the results—but not the underlying data—of calculations regarding the increase in radiation dosage associated with a six-foot loss of shielding water, it provides no justification for considering only this scenario, which dramatically understates potential impacts;
>
> [6] The Final EA was obliged to evaluate situations in which more shielding water is removed from the irradiator, either from the force of an explosion or through evaporation in a fuel fire, which would result in far higher radiation doses;
>
> [7] The Final EA inaccurately assumes the irradiator pool water could become contaminated only if the Co-60 sources were allowed to corrode following a breach in the source encapsulation. The analysis ignores the potential for physical destruction of the sources to contaminate pool water or allow dispersal of pulverized Co-60 via breaches in the pool lining.
>
> [8] The Final EA improperly dismisses the potential for significant impacts in the event an airplane crash destroys all monitoring equipment or incapacitates irradiator personnel.

The Intervenor raises these issues on pages 15 through 18 of its contentions, citing various reports or declarations from George Pararas-Carayannis, Ph.D., and Marvin Resnikoff, Ph.D.

I'll refer to these issues as the "segments" of the first and third portions of amended environmental contention 3. Does this cover all of the segments relating to the CNWRA's analysis?

A.11. (J. Durham) Yes. Obviously, the NRC Staff may have relied on our analysis in parts of the EA that are challenged in other portions or segments of the Intervenor's contentions. However, the segments identified above are the ones that relate directly to the Topical Report.

Q.12. The Topical Report addresses aircraft crashes and natural phenomena in separate sections, and the segments of contention 3 alleging deficiencies in the Topical Report can be grouped according to which part of the report they challenge. Therefore, instead of going through those segments in numerical order, we'll first obtain testimony on the segments that relate to the CNWRA's aircraft crash analysis. Then, we'll turn to the segments alleging deficiencies in the CNWRA's analysis of natural phenomena.

A.12. (J. Durham) That's fine. For the segments pertaining to aircraft crashes, Amitava Ghosh and I will be giving testimony. For the segments pertaining to natural phenomena, John Stamatakos, Kaushik Das and I will provide the testimony.

Q.13. Please state your name, occupation, and by whom you are employed.

A.13. My name is Amitava Ghosh. I am employed as a Staff Scientist for the Center for Nuclear Waste Regulatory Analyses in the Geosciences and Engineering Division of the Southwest Research Institute. I have attached a statement of my professional qualifications.

Q.14. Did you have a role in preparing the Final Topical Report for the Pa'ina irradiator?

A.14. (A. Ghosh) Yes. I prepared the analysis in Section 2 of the Topical Report, which pertains to aircraft crashes. In analyzing aircraft crash scenarios, I estimated the annual frequency of aircraft crashes at the Pa'ina irradiator by considering realistic crash scenarios at the Honolulu International Airport, which I'll refer to by the Federal Aviation Administration code "HNL." As described in detail at pages 2-1 through 2-18 of the Final Topical Report, I analyzed the most likely crash events that might occur during takeoff or landing. I looked at the potential for landing or takeoff crashes for each of the runways, and I estimated the frequency of crashes using the methodology in NUREG-0800, (NRC, 1981, pages 3.5.1.6-1 through 3.5.1.6-7) (Staff Exhibit 56). NUREG-0800 employs a methodology under which the probability of an aircraft crashing into a facility is determined by considering the product of three factors: the probability per square mile of an aircraft crash, the number of aircraft performing landings or takeoffs per year, and the effective area of the facility.

Q.15. Starting with the first segment in the first portion of the contention, the Intervenor claims that the Staff failed to consider significant factors in evaluating the likelihood the Pa'ina irradiator will be involved in an aviation accident. The Intervenor cites three sources that dispute the NRC's analyses regarding the likelihood of aircraft crashes: the February 7, 2007 Resnikoff Report; the July 6, 2007 Resnikoff Report; and the August 24, 2007 Resnikoff Declaration. Did the CNWRA respond to the comments in those documents?

A.15. (A. Ghosh) Yes. It is Dr. Resnikoff who claims the CNWRA failed to consider significant factors in arriving at the likelihood the Pa'ina irradiator might be involved in an aircraft crash. First, Dr. Resnikoff claims we improperly relied on the methodology for determining aircraft crash probabilities stated in NUREG-0800, which was published in 1981. He suggests the airplane crash data in NUREG-0800 are obsolete and states that we should have used the Department of Energy's methodology, which he used in his calculations. I am referring to paragraph 10 of his February 9, 2007 Declaration.

In response to Dr. Resnikoff's claim, I analyzed the probability of a crash at the airport using both methodologies when preparing the analysis in the Final Topical Report. I found that the probability of an aircraft crash involving the Pa'ina irradiator obtained by using the Department of Energy (DOE) methodology is similar to the probability we obtained by using NUREG-0800. While the probability of a crash during takeoffs and landings on certain runways is slightly higher under the DOE methodology, the probability of a crash during takeoffs and landings on other runways is lower. I have attached calculations comparing the rates using both methodologies. (Staff Exhibit 30.) The cumulative probability for takeoffs and landings on all runways is not significantly different, regardless of which methodology is used. Additionally, Dr. Resnikoff has acknowledged that the "DOE standard is similar to the NRC methodology" (Resnikoff report at page 1 and February 9, 2007 Declaration at paragraph 9). I would note that Dr. Resnikoff used the NRC method in the proceedings associated with the Private Fuel Storage Facility at Skull Valley Utah. (Resnikoff report at page 1 and February 9, 2007 Declaration at paragraph 9).

Second, Dr. Resnikoff claims HNL has an unusually high crash rate, which the CNWRA failed to consider. He makes this claim in paragraph 11 of his February 9, 2007 Declaration. However, I learned from Ben Schlapak, HNL's Airport Director, that there have been only two major aircraft accidents at HNL in recent memory, one in 1962, and the other in the mid-90s.

Mr. Schlapak's e-mail response is attached (Staff Exhibit 31). It was also added as a reference in the Final Topical Report, at the bottom of page 5-3.

Also in response to Dr. Resnikoff's claim that HNL has an unusually high crash rate, I re-examined all data from the National Transportation Safety Board (NTSB) for HNL since 1976. I had originally looked at these data when preparing the Draft Topical Report, but I re-examined the NTSB data in response to Dr. Resnikoff's claim. The NTSB data is attached to my testimony. (Staff Exhibit 22.) These data show that there has been only one fatal aircraft crash at HNL since 1976, an accident occurring in 1994. I would note that the NTSB data also shows there have been a number of fatal aircraft crashes and aviation-related fatalities associated with HNL since 1976. However, with the exception of the 1994 accident, which involved a general aviation aircraft, these fatal accidents did not involve airplanes crashing at HNL. The NTSB data includes all flights originating at HNL, as well as all flights for which HNL is the destination. So, for example, a fatal crash involving a flight departing from HNL and crashing approximately 45 miles north of Maui is captured by the NTSB data. That happened in 1992 and involved five fatalities. Helicopter and seaplane crashes are also included, as are accidents in which the fatality resulted from an accident not actually causing the aircraft to be destroyed—a rough landing, for example, or a person on the ground being struck by an aircraft.

In his February 9, 2007 Declaration, and again in his August 24, 2007 Declaration, Dr. Resnikoff also claims the Draft Topical Report understates the number of current operations and fails to take into account a possible increase in the number of operations at HNL. For current operations, we provided numbers from three different sources in Table 2-2 of the Final Topical Report, at page 2-5. The numbers are essentially the same regardless of which source is used. As for a potential increase or decrease in the number of flights, in the Draft Topical Report we stated that flight operations at HNL would likely increase twenty percent during Pa'ina's ten-year license term. That was based on an FAA projection from 1998. However, as we explain on page 2-18 of the Final Topical Report, recent data show that the number of operations at HNL actually decreased by more than 58,000 from the 1998 number. This creates substantial uncertainty over whether the number of operations will increase significantly during Pa'ina's ten-year license term.

In paragraph 14 of his February 9, 2007 Declaration, Dr. Resnikoff suggests the recent decrease in operations at HNL was limited to a few years immediately following the events of September 11, 2001, and he states that the number of operations has begun to increase. For the Final EA, we considered the most recent available data from three separate sources. As explained on page 2-6, we used FAA data in our calculations because it is publicly available data from a recognized authority. (Staff Exhibit 19.) Information from the FAA obtained recently shows the same number of flights. (Staff Exhibit 20.) In any event, the numbers from our other sources were very similar to the FAA data. The FAA data are for the twelve month period ending November 21, 2005. These were the most recent data available, and it still showed 58,000 fewer operations than in 1998. We therefore concluded that it is highly uncertain whether operations for HNL will reach the FAA's 1998 projection, or even return to 1998 levels, by the end of Pa'ina's license term.

Staff Exhibit 21 shows the variation of operations (both takeoffs and landings) at HNL using information provided by the State of Hawaii, Department of Transportation. This data is also presented in Table 2-2 of the Final Topical Report. The claim by Dr. Resnikoff regarding an increase in aircraft operations at HNL in recent years is not substantiated by the information provided by the State of Hawaii, Department of Transportation. Additionally, Staff Exhibit 23 shows the difference in operations at HNL from the previous year. Again, information from the State of Hawaii, Department of Transportation, has been used. This exhibit again does not substantiate the claim of Dr. Resnikoff regarding a recent increase in operations at HNL.

Dr. Resnikoff also advocated using current operational levels in determining the probability of an aircraft crash involving Pa'ina's facility. (February 9, 2007 Declaration at paragraph 14.) However, Dr. Resnikoff himself does not use the most recent data. Instead, he uses FAA operational data for the 30-year period between 1975 and 2005. (Resnikoff Report at page 3.) Moreover, Dr. Resnikoff incorrectly states the average number of operations during that period. As reflected in Table 1 of his report (page 5), the average number of operations for the past 30 years is 329,756. This number is lower than 356,772, which is the number he used in his calculations. In any event, Dr. Resnikoff does not use more recent data, as he advocated in his declaration.

Q.16. The CNWRA finds that the annual probability of an aircraft crash involving the Pa'ina irradiator is 2.1×10^{-4}, or approximately 1 in 5000. Dr. Resnikoff asserts that, using HNL-specific crash rates, the probability is 5.69×10^{-4}, or approximately 1 in 1757. I'm referring to paragraph 10 of his February 9, 2007 Declaration, as well as paragraph 5 of his August 24, 2007 Declaration. What accounts for the difference?

A.16. (A. Ghosh) Dr. Resnikoff appears to arrive at his much higher estimate by assuming an accident rate for HNL that is much higher than that for accidents potentially affecting the Pa'ina irradiator. I'm referring to pages 4–10 of his February 9, 2007 Report, where he explains this part of his methodology. First, he takes into account any accident at HNL between 1975 and 2005 that is listed in NTSB data as resulting in a fatality. As I explained above, this includes accidents that did not occur at HNL, but which merely involved aircraft departing from or scheduled to arrive at HNL. Second, Dr. Resnikoff also includes fatalities from accidents that did not result in the aircraft being destroyed, such as rough landings. Third, his definition takes into account helicopter crashes. Helicopters and seaplanes have a higher crash rate than airplanes, and there are a number of fatal helicopter and seaplane accidents listed in the NTSB data. However, due to numerous factors—size, weight, fuel capacity and flight speed among them—it is not feasible that a helicopter or seaplane would cause the type of accident that might damage the Pa'ina irradiator pool or sources. At most, a helicopter or seaplane might damage the building that houses the irradiator.

As I mentioned above, there have been only two fatal airplane crashes at HNL since 1962. This is supported by both the NTSB data and the communications with Ben Schlapak, HNL's Airport Director. By defining "fatal accident" to broadly include accidents that would not pose any threat to the Pa'ina facility, Dr. Resnikoff obtains an unjustifiably high HNL-specific crash rate.

Q.17. Is there anything else that might account for the difference between your numbers and those of Dr. Resnikoff?

A.17. (A. Ghosh) Yes. Dr. Resnikoff apparently failed to take into account the angles at which aircraft will take off from and land at HNL. In Table 2-8, I provide crash probabilities for both takeoff and landing for each of the eight runways near the Pa'ina irradiator. In all, there are sixteen separate calculations. The reason I did this is because, for takeoffs or landings from certain runways, it will be all but impossible for a plane to accidentally strike the Pa'ina building at sufficient speed to cause damage. For example, on Runway 8L, planes exit at taxiway S or H. Nearly all narrow-body aircraft would exit the runway at either taxiway L or G, as described in the Final Topical Report, page 2-13. A photo of this runway is marked as Staff Exhibit 15. An aircraft landing at this runway would have to exit the runway at the opposite side of the terminals and skid toward the proposed facility while decelerating. It must pass through a wooded area and the control tower facility, then cut across two runways, two taxiways and several other structures to reach the facility. A photo is attached as Staff Exhibit 16. The probability of an aircraft crashing into the proposed facility while attempting to land at this runway is, therefore, negligible. Similarly, a plane taking off from Runway 26R (other side of Runway 8L) would pass the Pa'ina building soon after it begins its acceleration. At that point it has to almost turn back and go through the runways, wooded area, and the control tower facility to reach the Pa'ina facility. It is therefore not feasible that a plane would strike the building on takeoff from this runway. Nor is it feasible that a plane would strike the Pa'ina facility immediately after takeoff, because the flight pattern takes the plane directly forward, over the ocean. For these reasons, I assigned an insignificant probability to an accident involving a plane taking off from Runway 26R and landing at Runway 8L and striking the Pa’ina facility.

Similarly, a plane taking off from Runway 26L would pass the Pa’ina facility soon after acceleration. At that point, it has to travel almost in the backward direction to the right to reach Pa’ina’s building, possibly passing through a lagoon in between the runway and the buildings. An aircraft landing at Runway 8R (other side of Runway 26L) would have to travel almost two miles from the runway threshold to reach the facility while passing through a taxiway and other structures, and possibly a lagoon. A photo of these runways has been attached as Exhibits 15 and 17. For these reasons, I assigned an insignificant probability to an aircraft crashing into the proposed facility while landing at Runway 8L and taking off from Runway 26L.

On pages 2-13 through 2-15, I address the strike potential for planes taking off from, and landing on, each runway. Figures 2-2 through 2-5 of the Final Topical Report show the orientation of each runway and the Pa’ina facility. I have also provided photographs showing the runways and the Pa’ina building. This analysis affects the crash rate probability in the Topical Report. This type of analysis appears to be lacking from Dr. Resnikoff’s Report.

Q.18. Is there anything else you’d like to add on this issue?

A.18. (A. Ghosh) I would emphasize that the probability of an aircraft crash into the Pa’ina facility does not reflect the potential for loss of control of radioactive material. We say this on page 2-23 of the Topical Report. This is important because any disagreement over accident probability rates should not obscure the fact that, even in the event of an accident, it is not foreseeable that there would be a loss of control. In other words, even if we assume there is an accident, it is not foreseeable that there will be significant environmental consequences.

Q.19. In the second segment of the first portion of contention 3, the Intervenor claims the NRC failed to quantify the impact of flying airplane and building debris following an aviation accident to determine if sources would be breached. This is similar to the issue raised in the fourth segment of the third portion, where the Intervenor claims the Staff “failed to consider credible scenarios under which an aircraft crash might result in exposures above regulatory limits, including, but not limited to, damage to the irradiator pool structure at or below the groundwater level, resulting in a loss of vital pool shielding water, and release of water contaminated with radioactive cobalt through a tear in the pool lining, contaminating groundwater and nearby Ke'ehi Lagoon." The Intervenor cites the February 7, 2007 Resnikoff Report at page 20, the February 9, 2007 Resnikoff Declaration at paragraphs 17-18, the August 24, 2007 Resnikoff Declaration at paragraphs 9 and 13–15; and the February 9, 2007 Pararas-Carayannis Declaration at paragraph 31. Did you address these issues?

A.19. (A. Ghosh) Yes. As we explain in Section 2.4 of the Topical Report, in the event of an aircraft crash at the Pa'ina facility, a portion of the force generated by the crash might damage the irradiator building and the pool structure. Most likely, the aircraft would strike the building at an angle low to the ground, an angle of approximately 5–8º; it is not feasible that an aircraft would nose-dive directly into the 7' by 8' pool opening. After the aircraft strikes the building, it is possible that airplane or building debris could fall into the irradiator pool. However, it is highly unlikely this debris will be moving at the same speed the plane was moving prior to striking the irradiator building, and any debris falling into the pool will be limited in size by the pool opening. Even if we assume that debris falls into the irradiator pool, it is simply not feasible that airplane or building debris would simultaneously pierce the steel-and-concrete pool liner below the water table and damage the sources to the extent where Co-60 could escape through the breach in the liner. If the debris pierces the pool liner, it will not thereafter have sufficient force to damage a source; most likely, the debris will be embedded in the pool liner.

I would emphasize that, even if debris struck a source and the source's encapsulation was breached, the source would remain intact. For that reason, even if the pool liner were breached below the water table, no radioactive material would be released into the environment. Contrary to Dr. Resnikoff's suggestion, it is simply not plausible that flying debris would disperse a source. Co-60 is a metal, and thus is not a readily dispersible material. The CNWRA responds to Dr. Resnikoff's claims on page 1-3 of the Final Topical Report, where we state that for pool contamination to occur, the source must corrode. Dispersal of Co-60 is not a plausible consequence of an aircraft crash.

Q.20. If an aircraft crash resulted in water escaping the pool, wouldn't there be an increased dose rate above the pool surface?

A.20. (J. Durham) We concluded that if debris from an aircraft crash somehow pierced the steel-and-concrete liner, the water level could drop to the water table, which is eight feet below the pool surface. In that case, there would be an increased dose rate above the pool. But the increased dose rate would take the form of a well-collimated beam above the pool. We did not consider the resulting dose rate to be a significant environmental impact because it would affect only a small area above the pool and it would not cause any long-term impacts. The only part of the environment affected would be the open air above the irradiator. The sources would remain in position, and employees or emergency workers could easily shield the sources with water, dirt or other material. We also considered the possibility of skyshine—radiation scattered from the beam—but based on my experience as a health physicist, I concluded that any skyshine associated with the well collimated beam would be minimal.

Q.21. Could you elaborate on what you mean by a "well-collimated beam"?

A.21. (J. Durham) A visual depiction might help. Staff Exhibit 25 provides a representation of a collimated beam. What I've done is depict the beam over the cross-sectional drawing of the irradiator pool that appears in Figure A-2 on page A-3 of the Final EA.

Q.22. In the fifth segment of the third portion of the contention, the Intervenor argues that although the Final EA considers the increase in radiation dose associated with a six-foot loss of shielding water, it provides no justification for considering only this scenario. Then, in the sixth segment of the third portion, the Intervenor argues that the Staff "was obliged to evaluate situations in which more shielding water is removed from the irradiator, either from the force of an explosion or through evaporation in a fuel fire, which would result in far higher radiation doses." The Intervenor relies on the February 7, 2007 Resnikoff Report at page 21, as well as the August 24, 2007 Resnikoff Declaration at paragraphs 13 and 14. Did the CNWRA consider the situations raised by the Intervenor?

A.22. (J. Durham) Yes. First, it is my understanding that the NRC considered not only a six-foot loss of water, but also an eight-foot loss. I believe this is an issue Matt Blevins will be addressing in his testimony. Second, the CNWRA concluded that an explosion or fuel fire would not plausibly lead to more than an eight-foot water loss. It is not foreseeable that an aircraft would explode directly above the irradiator pool. In response to the Intervenor's comments, the CNWRA re-examined the NTSB data from 1976 to 2007. We did not find any evidence of an exploding aircraft involving any flight either departing from or scheduled to arrive at HNL. We also considered an e-mail from Ben Schlapak, the Airport Manager at HNL, reporting that there have been only two fatal aircraft crashes at HNL since 1962. Neither accident involved an explosion. Given that there has not been an aircraft explosion anywhere at HNL in at least 45 years, it is simply not plausible that there would be an explosion directly above the Pa'ina irradiator pool, which measures only seven by eight feet at the surface.

I would note that, even if an explosion above the pool were plausible, the force generated by an exploding aircraft would not remove a significant amount of water from the irradiator pool. For an explosion to exert sufficient force to remove all water—the pool, when full, will contain 1036 cubic feet of water, or approximately 29 tons—the force would have to be directed straight down into the irradiator pool. But in that case, the object causing the force would be directly above the pool, preventing all but a small amount of water from leaving the pool.

There is no support for Dr. Resnikoff's claim that an explosion could remove all water from the irradiator pool, resulting in a dose of 107,000 R/hr at the pool surface. For this to happen, the explosion would have to leave the pool liner largely intact; if the liner were breached below the water table, the pool would refill with ten feet of water. Dr. Resnikoff appears to be suggesting that an explosion could both remove all water and, at the same time, keep the pool liner intact, such that the pool would not be refilled. This scenario is wholly implausible. Further, even if such an event could occur, the resulting dose would be in a well-collimated beam directly above the irradiator pool. This well-collimated beam would not have a significant impact on the environment, and the dose could easily be returned to normal levels, given that the irradiator pool would be intact.

The CNWRA also looked at the possibility of a fuel fire at the facility, as explained in Section 2.4 of the Final Topical Report. Jet fuel is less dense than water; therefore, jet fuel would burn above the pool water, preventing water from evaporating until the fuel is almost depleted, at which point water evaporation would be minimal. The CNWRA concluded that a fuel fire would not cause a significant environmental impact because water evaporation would be minimal, dose rates would not increase significantly, and, in any event, the elevated area of radiation would be directly above the irradiator pool.

In addition, after considering the Intervenor's comments, the CNWRA looked at the worst-case scenario of all water being removed from the pool, such that the plenum is completely exposed to the air. As explained above, there would be a high dose of radiation emitted, but it would be in a well-collimated beam directly above the irradiator pool. This radiation would not affect any person or any significant portion of the environment. Even doses to workers very near the edges of the pool would not increase significantly because of the collimated nature of the radiation beam.

Q.23. In the seventh segment of the third portion of the contention, the Intervenor argues that the Staff "inaccurately assumes the irradiator pool water could become contaminated only if the Co-60 sources were allowed to corrode following a breach in the source encapsulation. The analysis ignores the potential for physical destruction of the sources to contaminate pool water or allow dispersal of pulverized Co-60 via breaches in the pool lining." The Intervenor cites the

February 7, 2007 Resnikoff Report at pages 20–21 and the August 24, 2007 Resnikoff Declaration at paragraph 9. Could you address this claim?

A.23. (J. Durham) As stated above, and as explained in Section 1.2 of the Final Topical Report, the only way for Co-60 to contaminate the pool water is for Co-60 to corrode in the water. This could occur only if the outer and inner containment of a Co-60 source were breached and the source plating, which is nickel and thus non-corrosive, were also breached. In addition, the source would have to be exposed to water for an extended period of time. (Staff Exhibit 18.) Considering these factors, as well as the location of the sources—the sources will be under 12 to 18 feet of water—the CNWRA concluded it is highly speculative that any debris from an aircraft crash would breach a Co-60 source. Further, the CNWRA found that, even if a damaged source were left in the pool for the period of time required for the Co-60 to corrode and contaminate the water, this contamination would not cause offsite consequences unless there was also a breach in the pool's steel-and-concrete liner.

Dr. Resnikoff suggests that "pulverizing" the sources would cause contamination of the pool water. This is incorrect. "Pulverizing" the Co-60 sources is all but impossible. Co-60 is a metal, not a salt or other readily dispersible material. Even if Co-60 were somehow crushed at the bottom of the pool, because it is a metal, it would remain intact. The CNWRA did not find any feasible scenario in which Co-60 could be pulverized. Even if a projectile fell directly into the pool, the water in the pool would stop or slow the projectile so that it would not damage the plenum to the point that the source would be crushed.

Q.24. What about an engine component falling into pool, a scenario Dr. Resnikoff identifies in his Declarations and Report?

A.24. (J. Durham) It is not feasible that an engine component would fall into the pool, exert enough energy to breach the pool liner, and thereafter fall to the bottom of 18 feet of water with enough energy to significantly damage the sources, which will still be encapsulated and underneath the plenun. In the first instance, it is not credible that an aircraft component would pierce the pool liner. Such a component would be falling from the airplane, not moving at the same speed the airplane was moving prior to contact with the irradiator building. If a component were to strike the pool liner below the water level, it would do so only after falling through at least eight feet of water. It is highly unlikely the component would be moving fast enough to breach the pool liner. Further, it is simply not plausible that, after piercing the pool liner, the component would then exert sufficient force to "pulverize" the sources. In fact, it is not plausible that they would exert enough force to significantly damage the sources. The sources Pa'ina will use are designed to withstand a two-kilogram steel weight dropped from a height of one meter in air. This is a requirement in 10 C.F.R. § 36.21(d). Dr. Resnikoff claims this is insufficient to guard against damage to the sources. However, as the CNWRA notes in language at page 1-2 of the Final Topical Report, Pa'ina will be using sources that have also passed ANSI test E65646, which includes a 20-kilogram weight dropped from a height of one meter.

In any event, damage to the source should not be equated with "pulverization," which is what Dr. Resnikoff suggests could occur. A metal will not shatter like glass. Although a metal may become more brittle at temperatures well below zero degrees Celsius, it will not shatter or catastrophically fail at room temperatures. It is not foreseeable that an aircraft crash would cause the temperature in the irradiator pool to drop significantly. In any event, that is not a claim that Dr. Resnikoff makes.

Q.25. In the eighth segment of the third portion of the contention, the Intervenor claims that the Staff improperly dismissed the potential for significant impacts in the event an airplane crash destroyed all monitoring equipment or incapacitated irradiator personnel. The Intervenor cites the February 7, 2007 Resnikoff Report at page 21, the February 9, 2007 Resnikoff Declaration at paragraph 19, and the August 24, 2007 Resnikoff Declaration at paragraph 17. Did you consider these possibilities?

A.25. (J. Durham) First, the loss of emergency personnel and monitoring equipment would not necessarily result in any increased dose. The sources would still be fully shielded under 12–18 feet of water. Emergency workers would likely respond promptly to an aircraft crash at the Pa'ina facility, which is adjacent to HNL, and the dose rate when they arrive would be the normal rate, which is close to background. The Intervenor seeks to bolster its arguments by suggesting that the loss of personnel and monitoring equipment would be combined with a fuel fire or explosion, which could expose emergency personnel to higher doses. However, a fuel fire simply is not a credible scenario for removing shielding water. An explosion is also not a credible scenario because the force necessary to remove water would come from directly above the pool, which would prevent water from escaping. In any event, even if water were removed, emergency workers responding to an aircraft crash at the Pa'ina facility would be well aware that the source is radioactive. Pa'ina's operating procedures specifically provide for training of emergency response personnel, including representatives from local police, fire and rescue departments. That is on page 22 of Pa'ina's license application. In any event, workers and emergency responders would essentially have to linger directly above the pool for an extended period of time to even reach the NRC's dose limits, assuming a loss of eight feet of water. That is not a plausible scenario.

Q.26. We'll now turn to the segments of the contention 3 in which the Intervenor challenges the CNWRA's analysis of risks associated with natural phenomena. Please state your name, occupation and employer.

A.26. My name is John Stamatakos. I am employed as the Assistant Director of the Washington Technical Support Office in the Geosciences and Engineering Division of the Southwest Research Institute.

Q.27. Please explain your duties in connection with the Staff's environmental review of the license application submitted by Pa'ina Hawaii, LLC.

A.27. (J. Stamatakos) I wrote Section 3 of the topical report, "Natural Phenomena," which documents my analysis of the potential effects of earthquakes, tsunamis, and hurricanes on the proposed irradiator.

Q.28. What is the purpose of your testimony?

A.28. (J. Stamatakos) My testimony will address the segments of the Intervenor's contention that challenge the Staff's analysis of the potential effects of natural phenomena on the proposed irradiator. Specifically, I will address segments 3–8 in the first portion of contention 3, as well as segments 1–3 in the third portion. I would note that a number of these segments raise similar issues and rely on the same documents from the Intervenor's purported experts.

Q.29. Before turning to the specific segments involved here, could you explain in general how the CNWRA responded to the comments alleging deficiencies in the Draft Topical Report's analyses of natural phenomena?

A.29. (J. Stamatakos) The CNWRA reviewed the comments submitted by the Intervenor and its experts on the Draft Topical Report while we were preparing the Final Report. As explained in Section 1.2 of the Final Topical Report, and as I'll discuss in more detail below, the CNWRA did not find that any of the scenarios identified by the Intervenor's experts would result in a cobalt source being removed from the irradiator pool. The CNWRA also concluded that none of those scenarios would result in a damaged source corroding, contaminating pool water, and then being released into the environment. While some of the scenarios identified by the Intervenor's experts could possibly lead to damage to the irradiator building, or a loss of water from the pool, the pool water is not contaminated, so there would not be a radiological impact. As explained in Jim Durham's testimony above, in a situation where there is a loss of pool water, the increased dose would be in a collimated beam directly above the pool, and for that reason it would not significantly affect any person or the environment.

Q.30. Starting with the third segment in the first portion of contention 3, the Intervenor argues that the Staff failed to respond to comments alleging that the Draft EA did not quantify hurricane storm surge and tsunami inundation runup potential. Then, in the second segment of the third portion, the Intervenor claims the Final EA fails "to quantify the risk of tsunamis and hurricanes through numerical modeling or, at a minimum, analyze the range of environmental impacts likely to result in the event of a major tsunami, including the impacts resulting from hurricane storm and tsunami inundation." The Intervenor relies on the February 9, 2007 Pararas-Carayannis Declaration at paragraphs 12-18 and 29. Did the CNWRA consider these issues?

A.30. (J. Stamatakos) Dr. Pararas-Carayannis suggests we should have evaluated tsunami and storm surge runup through numerical modeling. Numerical modeling could have been used to obtain a more accurate calculation if our initial calculations had not been clear as to the effect a wave might have on the Pa’ina irradiator. In this case, however, we determined that 30 meters is a bounding value for wave heights and that the velocity generated by that wave height would have no effect on the sources in the Pa’ina irradiator. There was no need for a more complicated calculation because we found that a wave, whether generated by a tsunami or hurricane storm surge, would not attain the velocities needed to lift a source out of the Pa’ina irradiator and cause environmental impacts.

Q.31. In the fourth and fifth segments of the first portion of the contention, the Intervenor claims the Staff failed to respond to comments stating that it needed to consider the effects on the irradiator pool of increases in buoyancy forces due to hurricane surge or tsunami inundation (fourth segment) and consider potential consequences of hurricane winds (fifth segment). These issues are raised again in the third segment of the third portion, where the Intervenor argues that the Staff failed to consider “numerous other potential impacts related to natural disasters, such as the potential for increased buoyancy due to hurricane storm surge or tsunami inundation to compromise the irradiator pool's integrity or allow shielding water to drain out, damage from hurricane-force winds, and liquefaction during an earthquake.” The Intervenor relies on the February 9, 2007 Pararas-Carayannis Report at pages 10–11 and 17–20. Did the CNWRA consider the factors identified by the Intervenor?

A.31. (J. Durham) With regard to buoyancy, the Intervenor appears to be suggesting a scenario where saltwater replaces the freshwater in the pool, making anything in the pool more buoyant. While saltwater is denser than freshwater, it is only marginally denser. Whereas freshwater has a density of 1.0, saltwater has a density of 1.025; in other words, the density is only 2.5% greater. Given this marginal increase, it is not plausible that saltwater would cause sources to float out of the pool. Even if the pool were completely filled with saltwater, a source would not float.

Dr. Pararas-Carayannis also appears to suggest saltwater infiltration could cause the irradiator pool itself to become buoyant, tilt on its side, and release “radioactive effluent.” I’m referring to his February 9, 2007 Report, at the top of page 11. This is incorrect. The effluence to which he refers is pool water, which is not radioactive. Again, unless the sources were dislodged, there would not be any loss of control of radioactive material. Increased buoyancy, whether of the sources or the pool itself, would not cause such a loss of control.

As for hurricane winds, Dr. Pararas-Carayannis appears to be concerned with winds uprooting trees and converting grounded airplanes and other debris into projectiles that might damage the Pa’ina irradiator. While wind-generated projectiles could potentially damage the irradiator building, the sources would not be damaged by these projectiles. That is because the sources would remain at the bottom of the pool, covered by 12–18 feet of water. The sources would also be covered by the plenum and possibly by one or more product bells. Any projectile falling into the pool would be slowed or stopped by the pool water and would not damage the source. In the unlikely event that a projectile pierced the pool below the water level, water could drain out of the pool. There would not be any environmental impact, however, because the pool water would not be contaminated.

Q.32. In the sixth segment in the first portion of contention 3, the Intervenor claims the Staff failed to respond to comments suggesting it should evaluate unique features of Ke'ehi Lagoon that might increase the potential for tsunami-related impacts. Did you consider those comments?

A.32. (J. Stamatakos) Yes. The Intervenor is referring to the Pararas-Carayannis Report, which states that the unique features of the Ke’ehi Lagoon could exacerbate tsunami-generated or hurricane surge runups and currents at the proposed site. In the Pararas-Carayannis Report, the authors conclude that potential runups and coastal flooding could be more significant than historical values we referred to from past events. For example, the Pararas-Carayannis Report concludes that maximum flooding of 5 to 6 feet will occur if a Category 3 or Category 4 hurricane makes landfall on O’ahu, near the time of highest astronomical spring tides, in contrast to the 2.6 feet surge produced by Hurricane Iniki. The Pararas-Carayannis Report also cites the past tsunami-generated wave heights of up to 9 feet on the south shore of O’ahu . While these wave heights remain in debate given the data we cite in the Topical Report, we did not address them in the revision because, even if such flooding were to take place, it would not generate the high water velocities and large lifting forces necessary to remove the cobalt sources from the pool. The details of the calculations used to support this conclusion are provided in subsequent answers to questions on the next pages of this testimony. However, I’ll note that the CNWRA conducted extensive research into the historical data relating to tsunamis, storm surges and wave heights that might be relevant to assessing hazards to Pa’ina’s irradiator. (Staff Exhibits 49, 51, 57.)

Q.33. In the seventh segment in the first portion of the contention, the Intervenor claims the Staff failed to respond to comments suggesting it should consider potential focusing effects of seismic energy on O'ahu. Did you consider potential focusing effects?

A.33. (J. Stamatakos) I considered the Intervenor’s comments regarding focusing effects on O’ahu. However, looking at the available data, I found no evidence of focusing effects at or near the Pa’ina irradiator. If there were focusing effects, the seismic records would show higher intensity values reported for areas affected by recent earthquakes. There are very few intensity values higher than Modified Mercalli Intensity Force V reported for O’ahu. Force VI damage occurred a few miles south of Honolulu during a 1948 earthquake, but this was a small earthquake and the damage was limited to the area nearest the epicenter. I addressed the relevant data on page 3-3 of the Final Topical Report. I also relied on the United States

Geological Survey data presented in Figure 3-1, which depicts ground accelerations for O'ahu based on firm rock conditions. The data I reviewed includes that identified or summarized in Staff Exhibits 48, 52–53, 56 and 59.

Dr. Pararas-Carayannis suggests there might be focusing effects with very high intensities that could affect the irradiator site. This suggestion is doubly speculative. First, he is speculating that there might be focusing effects; second, he is speculating that those focusing effects might have markedly higher intensities. Dr. Pararas-Carayannis presents no data to refute the CNWRA's conclusions. Instead, he cites focusing effects that were reported in California's San Fernando Valley, which is approximately 2500 miles from Honolulu. Moreover, this earthquake is an inappropriate analog for seismicity on O'ahu. The tectonic conditions and resulting thrust faulting that led to the San Fernando Valley earthquake are very different from the hot-spot generated earthquakes in Hawaii.

Q.34. In the eighth segment of the first portion, the Intervenor claims the Staff did not respond to comments stating that it needed to evaluate the threat of liquefaction. Did you consider those comments?

A.34. (J. Stamatakos) The CNWRA considered the possibility of liquefaction during an earthquake, but we dismissed this scenario as speculative because there is no evidence of liquefaction from past earthquakes at or near the Pa'ina site. (Staff Exhibits 48, 52–53, 56.) I would note that, in suggesting that liquefaction is a possibility, Dr. Pararas-Carayannis relies on evidence of liquefaction during the 1994 Northridge Earthquake in San Fernando Valley. The San Fernando Valley is in a "seismic area," which is defined at 10 C.F.R. § 36.2 to mean "any area where the probability of a horizontal acceleration in rock of more than 0.3 times the acceleration of gravity in 250 years is greater than 10 percent, as designated by the U.S. Geological Survey." Honolulu, on the other hand, is not in a seismic area. Dr. Pararas-Carayannis fails to explain why evidence of liquefaction in a seismic area some 2500 miles from Honolulu is relevant to assessing whether liquefaction will occur at the Pa'ina site.

As noted in the Final Topical Report, Pa'ina will follow International Building Code requirements and conduct soil stability testing before setting the foundation for its irradiator. This will ensure that, when constructing the irradiator, Pa'ina takes into account any factors that could increase the potential for liquefaction. Even assuming that liquefaction were to occur, this would at most result in the irradiator pool being pushed out of the ground and tilted, causing some water to spill. Due to the weight of the pool—the pool will have a concrete-and-steel liner and contain 29 tons of water—that is highly improbable. In any event, the sources would remain intact in the pool, partially shielded by water, so there would be no radiological impact. I would note that Dr. Pararas-Carayannis seems to suggest radioactive effluence could be released if liquefaction occurs. This is incorrect, because the irradiator water will not be radioactive. The source itself would have to be dislodged, which is completely implausible.

Q.35. In the first segment of the third portion of its contention, the Intervenor argues that the Staff failed to consider potential impacts associated with major flooding. The Intervenor relies on the February 9, 2007 Pararas-Carayannis Declaration at paragraphs 15–16 and 18. Can you address this claim?

A.35. (J. Stamatakos) Major flooding would not result in Co-60 sources being removed from the irradiator pool. The CNWRA based its analysis on historical data, and we conservatively assumed a storm surge much larger than can reasonably be expected to affect the Pa'ina facility. As explained in Section 3.3 of the Final Topical Report, we considered publicly available data and studies by the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration, and the National Hurricane Center of the National Weather Service of NOAA. This data shows a maximum water-level rise of only 0.78 meters/2.6 feet at O'ahu since the 1950s. I cite this data on page 3-11 of the Final Topical Report. Even so, I conservatively assumed a much larger storm surge might affect the Pa'ina facility. I assumed a 10-meter/33.8-foot wave, which bounds any plausible wave height for O'ahu. I would note that, although Dr. Pararas-Carayannis claims a 31-foot wave reached the southern coast of O’ahu in 1946, he appears to be citing his own research. I’m referring to the February 9, 2007 Pararas-Carayannis Declaration at paragraph 25. Dr. Pararas-Carayannis does not cite any publicly available data. In fact, he disputes Hawaii Department of Transportation reports that the south shore of O’ahu has not sustained more than a 3-foot wave since 1837.

In any event, even if we assume a 33-foot wave covered the Pa’ina facility, this would not cause a loss of control of radioactive material. That is because the storm surge would not have sufficient velocity to remove a source from the irradiator pool. This conclusion is supported by the computational fluid dynamics calculations performed by Kaushik Das. As explained in Section 3.2.2 of the Final Topical Report, those calculations show that for a cylinder equivalent to a full-sized source assembly, a vertical velocity of 0.9 m/s (2 mph) is required to induce a drag force sufficient to lift the assembly. This vertical velocity could only be generated by a shear velocity of between 90 m/s (203 mph) and 180 m/s (406 mph).

As stated in Section 3.2.2 of the Final Topical report, tsunami waves up to 10 m/32.8 ft can reach velocities up to 13 m/s, or 29 mph. This is far below the minimum velocity needed to remove a source from the irradiator pool. Because a wave resulting from a storm surge will be traveling at a lower velocity than a tsunami wave, a storm surge will similarly be unable to remove a source from the irradiator pool. In other words, a 32.8-foot storm surge is less likely to exert the force necessary to remove a source than a 32.8-foot tsunami wave. For that reason, major flooding and storm surge inundation would not lead to the removal of cobalt sources. Dr. Pararas-Carayannis acknowledges this in paragraph 30 of this Declaration, where he states that “[o]ver land, there is no structured wave form, but rather a chaotic turbulent water mass that is unlikely to create wave velocities sufficient to pull a cobalt-60 source assembly out of the irradiator pool.” This is correct. But Dr. Pararas-Carayannis is wrong in stating that the CNWRA “lack[s] an understanding of a tsunami’s terminal characteristics when it moves over land." Rather, the CNWRA simply took a conservative approach, knowing that wave velocities over land would be bounded by the results of our fluid dynamics calculations.

Q.36. At this point, maybe the CNWRA can provide more information on how you determined it would take a wave velocity of between 203 and 406 mph to lift a source assembly from the irradiator pool. Could you provide an overview of the methodology underlying the CNWRA's computational fluid dynamics calculations?

A.36. (K. Das) Certainly. By way of introduction, my name is Kaushik Das. I am a research engineer in the hydrology group of the CNWRA, in the Geosciences and Engineering Division. A statement of my professional qualifications is attached.

The CNWRA's calculations modeled a single cylindrical source lying at the bottom of the pool. The weight, diameter, and length of an actual source were included in the modeling. I calculated the force needed to lift the source from the bottom of the pool to the top of the pool, and then calculated the wave velocity required to deliver that force. I found the required circulation velocity to be 0.9 m/s (2 mph). I then calculated the velocity of a wave passing over the top of the irradiator pool that would produce a lifting velocity of 0.9 m/s (2 mph). When a water wave passes over a pool of water, it will generate circulation inside the pool. This is analogous to blowing across the top of a straw to cause the liquid level in the straw to rise. The velocity near the bottom of the pool is one to two order of magnitude less compared to the driving velocity depending on specific configuration. My calculations determined that the velocity of the wave passing across the top of the pool must be between 90 m/s (203 mph) and 180 m/s (406 mph) in order to produce a circulation velocity of 0.9 m/s (2 mph) in the pool. (Staff Exhibit 58.)

Q.37. Does the Intervenor identify any other potential impacts associated with major flooding?

A.37. (J. Durham) The Intervenor also argues that the Topical Report fails to consider a loss of electricity, the destruction of backup generators, infiltration of saltwater into the irradiator pool, and buoyancy forces. I'm referring to paragraph 15 of the Pararas-Carayannis Declaration. In fact, the CNWRA considered all of these scenarios. We simply concluded that none would plausibly lead to loss of control of radioactive material, regardless of the extent of the flooding.

In the event of major flooding, the failure of electricity or backup generators would have no impact on the sources. The sources, which are contained in the source assembly, would remain at the bottom of the pool, and they would actually have additional shielding. Although the pool water purification system could be rendered inoperable during a major flood, this would not have any short-term environmental impact, and we can assume that the system would be repaired after the flooding subsides. Second, mixing saltwater with the freshwater in the irradiator pool would not have any environmental impact. The saltwater would function as a slightly more effective shield than freshwater because of its slightly higher density as stated earlier. After the flooding subsided, the Licensee would be required to replace the saltwater with freshwater, but there would be no environmental impact from the saltwater infiltration.

Q.38. What about buoyancy forces?

A.38. (J. Durham) For reasons stated above, it is not plausible that major flooding would cause either the sources or the irradiator pool to become buoyant such that there would be any environmental impact. Even if saltwater completely replaced the freshwater in the pool, the marginal increase in density would not cause sources to float out of the pool. Nor, for that matter, would there be an increase in buoyancy sufficient to cause the pool to lift and tilt, thereby spilling water. And, even if it did so, the pool would not release radioactive effluence, as Dr. Pararas-Carayannis suggests in his February 9, 2007 Report, at the top of page 11. Unless the sources are removed, there will not be any loss of control of radioactive material, and increased buoyancy is not going to remove the sources.

Q.39. In paragraph 29 of his February 9, 2007 Declaration, Dr. Pararas-Carayannis argues that the NRC should have quantified tsunami and storm surge runup potential with a proper numerical modeling study. Why didn’t the CNWRA do such a study?

A.39. (J. Durham) As explained above, numerical modeling is useful where there is uncertainty that might be resolved with more precise information. In this case, there is no uncertainty over whether a tsunami or hurricane might cause a loss of control of radioactive material. Even if we assume that a historic record 33-foot tsunami wave strikes the Pa’ina facility, the wave will not come close to the velocity necessary to remove a source from the pool. Accordingly, the wave will not result in the loss of control of radioactive material. There was simply no reason to perform numerical modeling where the results would not have aided our analysis.