PREFILED STAFF EXHIBIT 62

March 5, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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 SUPPLEMENTAL TESTIMONY OF JAMES DURHAM,
AMITAVA GHOSH, AND JOHN STAMATAKOS

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 was filed as Exhibit 6 with the NRC Staff's initial testimony.

Q.2: Please explain the CNWRA's role and your duties in connection with the Staff's environmental review of the license application submitted by Pa'ina Hawaii, LLC.

A.2: (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. At the NRC, I worked closely with Matt Blevins, who was the NRC technical project manager for the EA.

Q.3: Please state your name, occupation, and by whom you are employed.

A.3: My name is Amitava Ghosh. I am employed as a Staff Engineer for the Center for Nuclear Waste Regulatory Analyses in the Geosciences and Engineering Division of the Southwest Research Institute. A statement of my professional qualifications was filed as Exhibit 5 with the NRC Staff's initial testimony.

Q.4: Please explain your duties in connection with the Staff's environmental review of the license application submitted by Pa'ina Hawaii, LLC.

A.4: (A. Ghosh) 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).

Q.5: Please state your name, occupation, and by whom you are employed.

A.5: My name is John Stamatakos. I am employed as the Director of the Washington Technical Support Office in the Geosciences and Engineering Division of the Southwest Research Institute. A statement of my professional qualifications was filed as Exhibit 7 with the NRC Staff's initial testimony.

Q.6: Please explain your duties in connection with the Staff's environmental review of the license application submitted by Pa'ina Hawaii, LLC.

A.6: (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.7: Are you familiar with the Supplemental Testimony provided by the Intervenor, Concerned Citizens of Honolulu filed on February 2, 2009?

A.7: (J. Durham, A. Ghosh, J. Stamatakos) The CNWRA has reviewed the testimony of Dr. Marvin Resnikoff, Dr. Mete Sozen, and Dr. George Pararas-Carayannis, which was submitted on February 2, 2009. In addition, the CNWRA has reviewed Dr. Resnikoff's rebuttal testimony dated September 16, 2008.

Q.8: What is the purpose of your testimony?

A.8: (J. Durham, A. Ghosh, J. Stamatakos) The purpose of the CNWRA's testimony is to respond to the portions of the testimony from Dr. Resnikoff, Dr. Sozen, and Dr. Pararas-Carayannis on which the Intervenor relies in its Supplemental Statement of Position. Specifically, the CNWRA will address the portions of the supplemental testimony challenging the CNWRA's testimony in this proceeding and its analysis of aviation accidents and natural phenomena in the Final Topical Report.

Q.9: Let's start with the supplemental testimony of Dr. Resnikoff dated February 2, 2009. In his testimony at A.9, Dr. Resnikoff discusses the differences between the CNWRA's calculations of the likelihood of an aviation accident and his own calculations. Dr. Resnikoff states that the CNWRA mischaracterized the analysis he conducted, but also states that you "arrived at the same order of magnitude of risk as [he] did," so there is no point in discussing your disagreements in detail. However, Dr. Resnikoff also states that "one could reduce the probability of an accident by a factor of 1,000, avoiding unnecessary risk" if the irradiator were built ten miles from the airport. How would you address those statements?

A.9: (A. Ghosh) The frequency that I calculated in the Final Topical Report (approximately 1 in 5,000 annually) accounts for the shadow area of the facility and the skid area of the aircraft in addition to the wingspan of the aircraft (Equations 2-2 through 2-4 in the Final Topical Report, at page 2-8). The inherent assumption is that the facility is located in an isolated place with no structures or any topographic features to impede the skidding of a crashing aircraft. Staff Exhibit 69 shows the skid area around the proposed site of the facility assuming there is no shadow area. The area is shown for three different aircraft types: (1) Air Carrier/Air Taxi (1,440 ft), (2) Small Military Aircraft Landing (447 ft), and (3) Small Military Aircraft Taking off (247 ft). General aviation aircraft has a skid distance of 60 ft (Final Topical Report, Table 2-6). It is obvious from the overhead views of Pa'ina's facility included in Staff Exhibits 15–17 and 69 that a major portion of the skid area cannot be realizable. Any aircraft striking there cannot reach the facility due to the presence of other structures or the lagoon.

NUREG–0800 methodology assumes 10 CFR Part 100 radiological consequences if an aircraft strikes anywhere the effective area of a structure. This is a conservative assumption, as even if one wing of an aircraft passes through this area, a strike to the facility with 10 CFR Part 100 radiological consequences is assumed. Similarly, a strike at a nearby structure is taken as a strike to the facility with 10 CFR Part 100 radiological consequences if the structure is within the shadow or skid zone. DOE Standard DOE–STD–3014–96 (Accident Analysis for Aircraft Crash into Hazardous Facilities, p. B–29) suggests that the analysis to estimate the annual frequency of aircraft crashes may take credit for the layout of the facility and its location with respect to other facilities; "otherwise, the conservatism in the analysis might unnecessarily overburden the evaluations." (Staff Exhibit 69.)

Q.10: How is this relevant to your assessment of aircraft crash frequency?

A.10: (A. Ghosh) I mention this to emphasize that the frequency stated in the Final Topical Report—which the CNWRA believes to be low but Dr. Resnikoff claims is quite high—is actually a very conservative estimate.

In claiming that the crash frequency is high, Dr. Resnikoff appears to be equating a crash into any part of Pa'ina's facility with a crash that strikes the irradiator pool. They are not one and the same. As the CNWRA explains in Section 1.2 of the Final Topical Report, the irradiator facility will be significantly larger than the footprint of the irradiator pool, which is only approximately 2.05 × 2.41 meters, or 81 × 95 inches. This is a mere one percent of the facility's floor area. To explain this point, I have calculated the annual frequency of an aircraft striking a pool with an area of 56 ft^2 at the proposed location. I used an area of this size because the dimensions of Pa'ina's irradiator pool will be approximately 7' by 8'. For reference, the effective area of the facility for Air Carrier calculations is 419,892 ft^2 with skid and shadow areas included. (Staff Exhibit __.) Using the actual area of the pool reduces the frequency by a factor of approximately 10,000 for the Air Carrier scenario. Taking this into account, the estimated annual frequency of an aircraft crash would then be 6×10^{-8} (Staff Exhibit 67), a reduction of annual frequency by a factor of approximately 3,500.

The estimated annual frequency may still be conservative even with these numbers, because an aircraft landing or taking off from certain runways can reach the pool only from a small zone. As discussed in my previous testimony dated August 26, 2008, at A.17, an aircraft would have to move backwards or turn abruptly at a sharp angle to reach the facility. Either scenario would be extremely unlikely. I would note that, at A.7 of his testimony dated February 2, 2009, Dr. Resnikoff acknowledged that a reduction of "the probability of an accident by a factor of 1,000" would be sufficient to avoid unnecessary risk. Taking into account the actual size of the irradiator pool gives us an accident probability even less than that deemed acceptable by Dr. Resnikoff.

Q.11: Why didn't the CNWRA provide a separate calculation in the Final Topical Report for the irradiator pool?

A.11: (A. Ghosh) We did not provide this calculation because we deemed the probability of an aircraft crashing anywhere into Pa'ina's facility to be sufficiently low that it should not be

considered reasonably foreseeable. We also knew that, if an aircraft were to crash into the facility and strike the area above the irradiator pool, there would not be any significant radiological impact. Based on our initial probability calculation and the lack of significant impacts, we saw no need to include a separate a calculation for the irradiator pool. If there were the possibility of significant environmental impacts, we would likely have included additional calculations. When Dr. Resnikoff states in A.7 that the probability of 1 in 5,000 annually is "unusually high," he is obviously taking into account what he views as the potential impacts resulting from an aircraft crash. A probability of 1 in 5,000 cannot be deemed "high" or "low" without considering the significance of the event it describes. In this case, the CNWRA and Dr. Resnikoff disagree strongly on whether there would be significant impacts from an aircraft crash.

Q.12: Dr. Resnikoff suggests that, as the result of a plane crash, a jet engine might enter the irradiator pool and either strike a cobalt-60 source or pierce the irradiator pool. Have you considered these possibilities?

A.12: (A. Ghosh) I have reviewed the sizes of engines used in different types of aircraft. They are listed in Staff Exhibit 66. In most cases, the fan of the engine is larger than the pool opening. It should be noted that engines are larger than fans. Therefore, it would be extremely unlikely that an engine could enter the pool, if not impossible. A commercial jet engine (GE model CF6-80C2) is larger than the pool and, therefore, this engine dropping onto a source in the pool, as claimed by Dr. Resnikoff at A.9 of his rebuttal testimony and in Exhibit 22, would not occur. As stated in my previous testimony, the expected angle an aircraft would strike the facility is 5º–8º from horizontal, based on the DOE Standard DOE–STD–3016–2006. Therefore, a GE CF6-80C2 engine dropping vertically into the pool is not a possible scenario.

Q.13: In A.8 of his testimony, Dr. Resnikoff disputes the CNWRA's testimony that an explosion occurring above the pool would not remove a significant amount of water from the pool. He

analogizes the event to a diver doing a cannonball into a pool, causing water to splash out of the pool. How would you address these statements?

A.13: (J. Durham, A. Ghosh) Dr. Resnikoff's analogy, which he admitted to be imperfect, is actually inappropriate. As shown in Staff Exhibit 66, in the case of an aircraft engine, the object attempting to enter the irradiator pool is much larger than a "diver doing a cannonball dive" into a pool. Indeed, in this case the object is larger than the pool opening, so it would act more as a lid to prevent water from escaping than as a diver removing water from the pool. Returning to his diver analogy, even a diver performing a cannonball dive removes only a small fraction of the water from the pool, an amount on the order of the amount of water the diver displaced. And, of course, some of the displaced water returns to the pool. Thus, it is unlikely that the splash from an aircraft component entering the pool would lower the water level more than minimally.

Q.14: In A.8. Dr. Resnikoff also argues that "the CNWRA staff should have, but failed to, calculate the potential for such an explosion to remove substantial amounts of shielding water from the irradiator pool." Do you agree with that statement?

A.14: (J. Durham) No. There is no requirement for such a calculation in an Environmental Assessment. The qualitative look at such an event that was included in the Topical Report found that such an event was not only unlikely, but also would not have significant consequences.

Q.15: Dr. Resnikoff discussed explosions in his September 2008 testimony as well, on page 6. He disputed the CNWRA's conclusion that, if an explosion removed water from the pool and there was a breach in the pool liners below the water table, the water would refill the pool with at least ten feet of water. How would you address Dr. Resnikoff's assertions?

A.15: (J. Durham) Dr. Resnikoff quotes me as saying the pool would refill with water "immediately." But that is not what I said at A.22 of my initial testimony. I merely noted that the pool would, in fact, refill to at least 10 feet of water, without referring to a timeframe. The time it

takes for the pool to refill would, of course, be related to the extent of the breach in the pool liners. In my initial testimony, I also stated that it would be wholly implausible an explosion would remove all water from the pool and the pool liners would remain intact. Dr. Resnikoff does not seem to dispute that statement. I believe it is equally speculative that, in the event an explosion removes all 29 tons of water from the pool, there would not be a significant breach in the pool liners. In that case, water would refill the pool fairly quickly. I would emphasize, however, that the underlying assumption—that an explosion of that magnitude would occur directly over the pool—is pure speculation.

Q.16: Please turn your attention to A.9 of Dr. Resnikoff's supplemental testimony. Dr. Resnikoff argues that the CNWRA has no basis for assessing the likelihood of a cobalt source shattering or being pulverized because it did not perform calculations, as he has. Do you agree with that statement?

A.16: (J. Durham) Dr. Resnikoff suggests that "an aviation accident could shatter the sources themselves, contaminating the water." This statement indicates that Dr. Resnikoff does not understand the nature of the sources. The sources are activated iron or steel plugs encapsulated in a nickel shell to resist corrosion. These slugs are contained in one or two layers of stainless steel that are welded shut. At temperatures above -200 degrees Celsius, they cannot be "pulverized." Instead, iron and steel are ductile materials, which means that they have the ability to be deformed and elongated without fracturing. Even if a very heavy object fell on a source with great force, the source would merely deform, much as a penny becomes deformed by a railroad car when the penny is placed on the track. The forces required to pulverize an iron or steel source to the extent that it could be suspended or dissolved in water are well beyond the forces that could be generated by an aircraft component striking the source, even if the collision occurred on solid ground with no intervening material. I would note that the outer shell of flight data recorders is typically made of either stainless steel or titanium, and these are expected to withstand extremely violent airplane crashes.

In any event, once a falling object enters the pool, it will rapidly slow to a terminal velocity that would be much less than the speed at which the object hit the water. As an example, a bullet fired from a gun penetrates water only to a depth of about 30 centimeters before slowing to a harmless speed. Thus, the falling object would not have the velocity necessary to pulverize the source material to the point at which it would be soluble or could be suspended in water. Again, the detailed calculation that Mr. Resnikoff is demanding is not required for an Environmental Assessment unless the possibility of such an event is likely and credible.

Q.17: In A.9 of his supplemental testimony, Dr. Resnikoff cites calculations he performed that allegedly show a jet engine dropping onto a source would far exceed the performance criteria for sealed sources. Could you address his claim?

A.17: (J. Durham) Dr. Resnikoff's calculations provide no scientific support for his claim that a source might be pulverized. Dr. Resnikoff appears to be suggesting that the damage to the source can be equated with "pulverization." That is clearly unwarranted. The performance criteria for sealed sources are intended to protect against even minor damage to the source encapsulation that might, for example, increase the potential for corrosion. These criteria say nothing about the force required to pulverize a source, and Dr. Resnikoff's calculations are therefore irrelevant to that issue.

Q.18: Assuming Dr. Resnikoff's argument in A.9 that a source's nickel shell were breached and the source came in direct contact with the pool water, would the water become contaminated?

A.18: (J. Durham) No. As explained in my initial testimony at A.8 and in the Topical Report at Section 1.2, in order for a cobalt source to contaminate the pool water, it would have to be left in water for at least two and a half years before even one mil of its surface would become corroded. Even then, most of the corrosion products would remain adhered to the cobalt. Cobalt would not contaminate water merely by touching it.

Q.19: Please turn to Dr. Resnikoff's rebuttal testimony from September 2008. In A.4, Dr. Resnikoff disputes your conclusion that it is not foreseeable a seaplane or helicopter would damage the irradiator pool or sources. According to Dr. Resnikoff, "[w]hy Dr. Ghosh assumes an accident involving a seaplane striking the proposed irradiator would not cause any damage is a mystery, since he presents no calculations to demonstrate the factors he enumerates—*e.g.*, size, weight, fuel capacity and flight speed—would ensure against adverse impacts." Could you address his argument?

A.19: (A. Ghosh) Dr. Resnikoff seems to be arguing that I should have taken into account seaplanes when calculating the likelihood of an aircraft striking Pa'ina's facility. This seems to be inconsistent with his more recent testimony stating that he is not disputing probability. Additionally, as stated in Table 10 of his February 7, 2007 report, Dr. Resnikoff himself discounted the contribution of seaplane crashes to the total annual crash frequency at Pa'ina's site.

In any event, my conclusion regarding seaplanes is supported both by the factors I identified in my initial testimony, and by the analysis in Section 2.1.1 of the Final Topical Report, which specifically addresses seaplanes. Seaplanes are fixed wing aircraft capable of taking off and landing on water. Seaplanes use the sea lanes at HNL, 8W–26W and 4W–22W, in the Ke'ehi lagoon. Both sea lanes end at some distance from the proposed irradiator facility, which will be near the fire station shown in Figure 2-1 of the Final Topical Report. Seaplanes will take off away from the direction of the proposed site. When landing in the sea lanes, on the other hand, if a seaplane is unable to stop, it will strike the embankment formed by the elevation difference between the sea water and land surface. That will stop the seaplane from reaching the irradiator facility. I would note that there is approximately 1,000 feet between the irradiator site and the edge of the water, and that other industrial structures sit between the water and the irradiator site. In the unlikely event that a seaplane reaches land, the plane will not go much farther. That is because the landing gears on seaplanes are floats—they do not have wheels.

Therefore, these aircraft will not skid for a significant distance, and any small undulations of the ground surface will topple the aircraft. Exhibit A shows that there would be numerous obstructions for the seaplane if it were to reach land traveling in the direction of the irradiator site. For these reasons, it is simply not feasible that a seaplane would strike the irradiator facility, much less the irradiator pool.

Q.20: What about helicopter crashes?

A.20: DOE Standard DOE–STD–3014–2006, at page 45 (Staff Exhibit 68), states that crashes of non-local helicopter flights would have insignificant contribution to impact frequencies. As for local helicopter flights, several helicopter companies operate at HNL and provide sightseeing services for tourists. These companies are located near the shore of Ke'ehi lagoon and close to the intersection of runway 4R–22L and runway 8L–26R, a distance of approximately one mile from Pa'ina's site. Popular destinations of the helicopter tours may include Ke'ehi lagoon, Aloha Tower, Waikiki beach, Honolulu downtown, Diamond Head, Hanuma Bay, Koko Head, Ala Moana Beach Park, North Shore, and Pearl Harbor. All these points of interest are located on the O'ahu Island in directions away from the proposed site. Therefore, there would not be a need for a sightseeing helicopter to travel over Pa'ina's facility.

DOE Standard DOE–STD–3014-2006 further states, at page 46 (Staff Exhibit 68), that "the lateral variations in crash locations for a helicopter are conservatively assumed to be one-quarter a mile on the average from the centerline of its flight path." Because most of the helicopter flights would be away from the direction of Pa'ina's site, and because the distance of the proposed site from the helicopter flight paths is more than one quarter mile, the annual frequency of helicopter crashes into the proposed site, and especially into the 81" by 95" irradiator pool, would be insignificant. I note that, in Table 10 of his February 2007 report, Dr. Resnikoff likewise did not include any contribution of helicopter crashes in his estimate of the annual crash frequency at the proposed site.

I would add that the maximum speed of helicopters is low compared to airplanes. For example, the maximum speed of a Bell 206 helicopter is 132 mph. A helicopter that is taking off or landing at HNL would not reach a speed anywhere near its maximum speed. Additionally, the reach Pa'ina's irradiator pool, a helicopter would have to crash through the facility's superstructure, which would reduce the helicopter's speed significantly.

Q.21: In A.3 of his supplemental testimony and at pages 4–5 of his rebuttal testimony, Dr. Resnikoff claims that persons responding to an aircraft crash at Pa'ina's facility would be at risk of receiving radiation overexposures, through either the collimated beam projected by the sources or through skyshine. Dr. Pararas-Carayannis, at A.5 of his testimony, makes a similar claim with respect to natural phenomena. How did you address these scenarios?

A.21: (J. Durham) As I stated in my initial testimony at A.25, Pa'ina's operating procedures specifically provide for training of emergency response personnel. This training will include representatives from local police, fire and rescue departments. I'm referring to page 22 of Pa'ina's license application.

Q.22: Dr. Resnikoff, Dr. Pararas-Carayannis and Dr. Sozen all claim that the Staff should have considered the possibility that emergency responders would fail to follow their training. Did you consider that?

A.22: (J. Durham) The Intervenor's experts provide absolutely no scientific or other support for their claim. This is mere speculation on their part.

Q.23: Please turn your attention to the rest of Dr. Pararas-Carayannis's testimony. In A.4, Dr. Pararas-Carayannis challenges the CNWRA's testimony regarding the potential for a wave or tsunami surge to cause radiological impacts. How would you address Dr. Pararas-Carayannis's claims?

A.23: (J. Stamatakos) The CNWRA evaluated the only potential scenario that we deemed to be even remotely credible, a scenario that we also believe is bounding. That scenario is one in which a cobalt-60 source could somehow be removed from the pool by storm or tsunami wave

action. Both of the additional scenarios Dr. Pararas-Carayannis mentions in A.4 of his testimony—the possibility that tsunami or hurricane waves could lift and damage the irradiator pool, causing shielding water to spill or drain—are highly improbable and purely speculative. He does not cite any basis or case study to support his assertions. The CNWRA continues to believe that these scenarios are too unlikely to warrant additional consideration or to justify performing numerical modeling, which Dr. Pararas-Carayannis suggests would be appropriate. As I explained in A.30 of my initial testimony, while 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 or storm surge might have on Pa'ina's irradiator, here there is no plausible scenario in which these events might lift and damage the irradiator pool.

More specifically, regarding pool integrity, Dr. Pararas-Carayannis provides no evidence that buoyancy pressures could damage the pool. As noted in the CNWRA's prior testimony at A.31, these forces are quite small when comparing the relative densities of salt water and pool water. Even if certain pressures could somehow damage the pool, most of the pool and the cobalt sources are underwater, and would be even more underwater during a flood. The lower 10.5 feet of the pool is below the water table even under normal circumstances. So, it begs the question, how can the pool "drain below the minimum level needed to shield the cobalt-60 sources" if it is underwater?

Second, regarding lifting or tilting of the pool, Dr. Pararas-Carayannis provides no evidence that this could occur or would even be likely to occur. Dr. Pararas-Carayannis has not performed any calculation to demonstrate that the pool could actually be lifted by buoyancy.

Q.24: Now please turn to A.7 of Dr. Pararas-Carayannis's testimony, where he asserts that the CNWRA's reliance on historical data is flawed because there have been changes to the Ke'ehi Lagoon since some of the data were generated. Do you agree with his assertions?

A.24: (J. Stamatakos) No. First, the CNWRA did not overlook the potential for greater hurricane runups than were indicated by the data. For that reason, we relied on a 30-meter

wave as a bounding calculation, a wave height that is very conservative when compared to the past runup data. Dr. Pararas-Carayannis provides no evidence, just speculation, that the past historical data is not indicative of future conditions, and he cites no evidence suggesting that our 30-meter bounding calculation is inappropriate.

Second, Dr. Pararas-Carayannis's reference to Hurricane Katrina is both inaccurate and irrelevant. By all accounts, most researchers and emergency personnel knew that a category 4 or 5 hurricane would lead to the storm surges that did occur and that, as a result, the New Orleans levees were likely to fail. Moreover, the levees are not appropriate analogues for the Pa'ina facility and the irradiator pool. The levees were above-grade structures of earthen mounds with embedded floodwalls. Lateral forces of the floodwaters caused the earthen foundations to erode and the floodwalls to then collapse. The Pa'ina irradiator pool will be built below grade and not subjected to lateral forces of flood waters.

Finally, the CNWRA did not overlook the fact that the site is situated in a tsunami evacuation zone. Dr. Pararas-Carayannis fails to show how tsunami runups or wave heights in this zone would challenge the radiological safety of the facility. Dr. Pararas-Carayannis dismisses one scenario we evaluated in the Topical Report—the possibility that a wave might pull a source out of the irradiator pool—as a "red herring." In our judgment, this scenario represents the most likely of any of the very unlikely scenarios that might dislodge or expose cobalt-60 sources from the pool. Dr. Pararas-Carayannis provides no evidence that the buoyancy forces necessary to somehow lift and tilt the pool and then drain it of shielding water could occur under any circumstances, much less with the types of hazards that might foreseeably affect Pa'ina's site.

Q.25: Now please turn your attention to A.8 of Dr. Pararas-Carayannis's testimony, in which he disputes your finding that an earthquake occurring in the area around the proposed irradiator site would not cause a significant environmental impact. First, Dr. Pararas-Carayannis claims your testimony is at odds with basic principles pertaining to seismology and to Hawaii's seismic

potential and history. He disputes your testimony that the available data provide "no evidence of focusing effects at or near the Pa'ina irradiator."

According to Dr. Pararas-Carayannis, you overlook that the Modified Mercalli Intensity (MMI) scale expresses descriptively only the effects and damage caused by an earthquake, rather than its size or energy release. Dr. Pararas-Carayannis claims that, because the available seismic records do not show intensity, and because there are no known accelerometer readings for O'ahu generally or the Pa'ina site specifically, you have no basis for stating that all areas of O'ahu, including the recently reclaimed land underlying Pa'ina's proposed irradiator, cannot experience intensities greater than MMI-V or VI. Could you address Dr. Pararas-Carayannis's claim?

A.25: (J. Stamatakos) My answer is fully consistent with basic principles pertaining to seismology. My response is based on available seismic data for O'ahu. The value of MMI force values is that they show the distribution of actual damage to the island from past earthquakes. The pattern of MM force values indicates several important seismic characteristics. Isoseismal maps, which map MM force intensity values, generally indicate how far a particular site is from an earthquake. That is because the closer the site is to the focus or epicenter, the greater the MM force intensity. Isoseismal maps show the location of zones that are especially susceptible to seismic shaking because of site conditions that amplify earthquake energy.

The fact that past earthquakes have led to maximum MM intensity values of no more than force intensity VI supports a finding that O'ahu has not experienced significant ground motions from past earthquakes. If there were zones that focused or greatly amplified earthquake energy, these would be obvious from the isoseismal maps of past earthquakes.

Dr. Pararas-Carayannis mischaracterizes my testimony when he claims that I said "O'ahu, including the recently reclaimed land underlain with unconsolidated silts and sediments where Pa'ina proposes to locate its irradiator, cannot experience intensities greater than V, VI or more." What I said in the Topical Report and in my initial testimony was that evidence from past

earthquakes shows maximum MM intensity force values of V or VI. It is entirely speculative to conclude, as Dr. Pararas-Carayannis apparently has, that Pa'ina's site will experience much higher ground motions than any included in the existing earthquake record merely because the site could possibly focus earthquake energy. Dr. Pararas-Carayannis cites no evidence to support his claim.

Q.26: Next, Dr. Pararas-Carayannis claims you provide no justification for basing your analysis on U.S. Geological Survey (USGS) data for "firm rock conditions" where the irradiator site consists of reclaimed land, not firm rock.

A.26: (J. Stamatakos) The USGS hazard data is the most recent comprehensive hazard assessment for O'ahu. While site conditions might amplify the ground motions to higher values, there is no evidence that these amplifications will be so large as to challenge the CNWRA's conclusions. Typical amplification for a soft soil site is about a factor of two over the firm rock values. Given the relatively small ground motions predicted by the USGS for this site, even a doubling of the ground shaking due to site response effects would lead to peak ground accelerations of only approximately 0.5g (2% probability of exceedence in 50 years or 2,500 year return period).

Q.27: Dr. Pararas-Carayannis further claims that you had no basis for ignoring the potential for unusually high ground accelerations like those experienced during the January 17, 1994 earthquake in Northridge, California. He claims that while different earthquakes at different areas may differ in the level of seismic energy released, the focusing effects and potential for ground liquefaction are the same everywhere.

A.27: (J. Stamatakos) Dr. Pararas-Carayannis does not show how the Northridge earthquake or the other earthquakes he cites are in any way relevant to assessing hazards at Pa'ina's site. Isoseismal maps from past earthquakes in Hawaii and O'ahu specifically do not show any evidence for the kind of focusing effects that Dr. Pararas-Carayannis speculates might occur at Pa'ina's site.

Q.28: Dr. Pararas-Carayannis disputes your testimony that "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." He claims that in addition to thrust faulting, normal faulting and lateral faulting can generate extremely high intensities. He cites as an example the 1976 Tangshan earthquake in China, which killed close to 650,000 people and destroyed 90% of the city occurred along a strike-slip fault that ruptured only a 5-mile section of a 25-mile long fault.

A.28: (J. Stamatakos) The 1976 Tangshan earthquake was a magnitude 7.8 (some researchers suggest it may have been magnitude 8.2) earthquake that ruptured the Tan-Lu fault, which is part of the Yan Shan fold-thrust belt. The rupture was largely strike-slip motion, but also included a thrust component consistent with the compressional tectonic setting of northern China. Dr. Pararas-Carayannis provides no evidence or rationale explaining how this earthquake is relevant to O'ahu. The great destruction and large death toll was due to the fact that the epicenter was in the middle of a large city and the earthquake struck without warning in the early morning, with many people still asleep in their beds. Most of the buildings were poor quality mud constructions without any reinforcement. Dr. Pararas-Carayannis does not show how this earthquake is relevant to the Pa'ina's site.

Q.29: Dr. Pararas-Carayannis states that, "while Hawai'i does experience earthquakes along volcanic rifts that are hotspot related, it has also, throughout its geologic history, experienced tectonic events and large-scale flank failures. Such events occurred in 1868 and 1975, and, most recently, in the October 2006 event, which resulted from tectonic subsidence of a large block of the Hualalai volcano." Could you comment?

A.29: (J. Stamatakos) The flank failures to which Dr. Pararas-Carayannis refers were in fact related to the hot-spot tectonic setting of the Hawaiian islands. These flank failures reflected extensional deformation and resulting dip-slip motion along normal faults caused by the growing volcano edifices. Normal faulting and extension are common to many hotspot environments.

Q.30: According to Dr. Pararas-Carayannis, "[t]he historic record makes clear that a future earthquake has the potential to amplify ground motions within unconsolidated sediments such as those present at the proposed irradiator site. . . . The CNWRA and NRC Staff failed to perform any calculation to back up their claim the irradiator pool could withstand these ground motions, avoiding all cracks and potential leakage." As examples, Dr. Pararas-Carayannis cites (1) the 1948 earthquake in Hawaii, which he claims had ground motions causing cracks and other damage to many Honolulu buildings; (2) the 1871 earthquake near Lana'i, which damaged "every building on the Punahou School campus in Honolulu"; and (3) an October 2006 earthquake, where the epicenter of the earthquake was located hundreds of miles away from O'ahu, but which was still strongly felt on O'ahu and resulted in power failures.

A.30: (J. Stamatakos) The evidence Dr. Pararas-Carayannis cites actually contradicts his claim that Pa'ina's site is susceptible to greatly amplified ground motions. The observed power failures and building cracks in O'ahu are entirely consistent with MM force V to VI intensities and peak ground accelerations of 0.25. They are not indicative of the potential for greatly amplified ground motions. They are also inconsistent with his speculation of damage to strongly reinforced structures like the irradiator pool. The earthquakes cited by Dr. Pararas-Carayannis provide no basis for questioning the analysis in the Topical Report.

Q.31: Now please turn your attention to A.9 of Dr. Pararas-Carayannis's testimony, where he disputes your initial testimony that liquefaction at Pa'ina's site is not a foreseeable scenario. Do Dr. Pararas-Carayannis's assertions here accurately reflect your analysis?

A.31: (J. Stamatakos) No. First, in my initial testimony, I did not claim that earthquakes in Hawaii behave differently than in other parts of the world. I said that the tectonic conditions that led to the San Fernando earthquake were very different from those at Hawaii. The tectonic setting of Hawaii and past evidence of earthquakes and their effects all show that the ground motions from earthquakes on O'ahu are much smaller than any of the examples Dr. Pararas-

Carayannis mentions in his testimony. As discussed in the Topical Report, the larger-magnitude events in Hawaii were all located near the Big Island and away from O'ahu.

Second, Dr. Pararas-Carayannis's claim that Pa'ina's site might suffer extensive liquefaction from an earthquake is speculative. Liquefaction requires ideal soil conditions coupled with relatively large vibratory ground motions from an earthquake. Dr. Pararas-Carayannis does not present any evidence of past liquefaction on O'ahu. He bases his argument on the simple premise that because soil conditions might be susceptible enough to liquefy, liquefaction would occur, independent of the actual seismic hazard conditions at the site.

Third, Dr. Pararas-Carayannis ignores what we wrote in Section 3.1 of the Topical Report with regard to liquefaction:

> The irradiator pool will be fabricated and installed in accordance with applicable industry codes, including an evaluation of the sufficient load-bearing capability of the soil during the pool excavation phase. Although the irradiator pool will be installed to mitigate the consequences of a seismic event, including liquefaction, the proposed facility is not mechanically connected to the source assemblies.

Dr. Pararas-Carayannis provides no evidence that, in the unlikely event of liquefaction, this would cause a cobalt-60 source to become dislodged from the pool or result in shielding water spilling or draining from the pool.

Q.32: Also at A.9 of his testimony, Dr. Pararas-Carayannis argues that even in the absence of liquefaction, ground motions could exhume the irradiator pool and drain its shielding water. Do you agree with Dr. Pararas-Carayannis's analysis?

A.32: (J. Stamatakos) No, I disagree with Dr. Pararas-Carayannis's claim that Pa'ina's site will experience the level of strong ground motions necessary to exhume the pool and drain its shielding water. I do not dispute that site amplification effects might occur at the site. In some cases, these site effects lead to up to a factor-of-two increase in ground motions. Given the relatively small ground motions predicted by the USGS for this site, however, even a doubling of the ground shaking due to site response effects would lead to peak ground accelerations of only about 0.5g (2% probability of exceedence in 50 years or 2,500 year return period).

I also disagree with Dr. Pararas-Carayannis's claim that surface waves might cause significant damage to the irradiator pool. While the long-period motions from surface waves can damage very tall structures like skyscrapers, most earthquake damage is caused by body waves (mainly shear waves), not surface waves. Seismic hazard studies focus on shear waves when developing inputs for seismic design or seismic performance assessments.

"Directivity," which Dr. Pararas-Carayannis also mentions, is the focusing of earthquake energy along the fault and in the direction of fault rupture. It is caused by the constructive interference of the shear waves as the fault rupture propagates along the length of the fault. Directivity has been observed for strike-slip and thrust-fault earthquakes, but the conditions under which directivity would be felt at a site are relatively rare; the site has to be located along the path of the earthquake rupture near the fault but at an optimal distance from the hypocenter or epicenter. The rupture velocity has to be almost as rapid as the velocity of the shear waves. If the site is too close to the hypocenter or epicenter or the rupture velocity is too slow, then the shear waves won't constructively interfere. I am unaware of directivity effects in surface waves.

As with other examples of distant earthquakes cited by Dr. Pararas-Carayannis in his testimony (*e.g.,* San Fernando, Loma Prieta, Tangshan), his reference to the 1985 Mexico City earthquake is irrelevant. This was a massive magnitude 8.1 earthquake caused by the thrust motion along the Cocos Plate subduction zone. Subduction zone earthquakes are the most devastating of all earthquakes on Earth. Similar conditions do not exist at the Pa'ina site. O'ahu is thousands of miles from any subduction zone and thus not subject to these very devastating earthquakes. With the exception of the 1871 Lanai earthquake, the largest earthquakes in Hawaii have occurred in and around the Island of Hawaii which is hundreds of kilometers away from O'ahu. Typical Hawaiian earthquakes are on normal or strike-slip faults, not thrust faults. Thrust faults are known to pose the greatest seismic risks. Thus, the San Fernando, Mexico City and Tangshan earthquakes cited by Dr. Pararas-Carayannis are

irrelevant to the Pa'ina analysis because they occurred along thrust faults, which are not present in Hawaii.

Q.33: In A.9, Dr. Pararas-Carayannis asserts that you were wrong in concluding that, even if liquefaction were to occur, a cobalt-60 source would have to be dislodged from the irradiator pool in order to cause environmental impacts. How would you address this testimony?

A.33: (J. Stamatakos) As explained in Section 3.1 of the Topical Report, at page 3-4, the irradiator will be constructed to mitigate any consequences from the unlikely possibility of liquefaction. But even if shielding water spilled or drained from the irradiator pool, there would not be any significant environmental impact. Dr. Pararas-Carayannis claims that, if water drains from the pool, emergency responders might unknowingly expose themselves to the area of elevated radiation above the pool. But Pa'ina's procedures, which are mentioned on page 22 of their application, should ensure that emergency responders are trained on how to approach Pa'ina's irradiator following an event like an earthquake, hurricane or tsunami. Dr. Pararas-Carayannis provides no support, only speculation, for his claim that emergency responders would fail to follow their training.

Q.34: Also in A.9, Dr. Pararas-Carayannis argues that you should have analyzed the possibility liquefaction might crack the irradiator pool and allow shielding water to escape. Dr. Resnikoff makes a similar argument in his September 2008 testimony. Do you agree with those assertions?

A.34: (J. Stamatakos) No. Even if liquefaction were to crack the irradiator pool, the pool is below the water table, so the water level in the pool would only go as low as the water table. The water table is eight feet below the surface and the pool is eighteen-and-a-half feet deep. Accordingly, ten-and-a-half feet of shielding water would remain in place.

Q.35: Do you agree with Dr. Pararas-Carayannis's testimony at A.9 that the CNWRA should have performed additional studies to determine what the risk of liquefaction is at the irradiator site?

A.35: (J. Stamatakos) The CNWRA concluded that even in the unlikely event of liquefaction at the site, there would be no release or environmental consequence. Dr. Pararas-Carayannis provides no evidence to the contrary. As stated in the Topical Report at page 3-4, the irradiator will be constructed to mitigate any consequences of liquefaction. Therefore, the CNWRA did not need to further analyze the potential for liquefaction.

Q.36: Turning now to A.10 of Dr. Pararas-Carayannis's testimony, do you agree with his assertion that you cannot rely on building codes to ensure adequate protection against earthquakes?

A.36: (J. Stamatakos) No, I believe it was entirely proper to take into account building codes when I analyzed the potential damage that could be caused by earthquakes. Building codes are updated and maintained to provide safety, based on the current state of knowledge. Dr. Pararas-Carayannis surmises that the current building codes are insufficient, with no basis except his own speculation that these codes are inadequate. His opinion is antithetical to the prevailing opinion among seismic engineers, who rely on them all the time.

Setting aside any reliance on building codes, the more important point is that the CNWRA looked at the potential for damage from earthquakes, even assuming failure of the structures, and found that no significant radiological environmental impact would result.

Q.37: Please turn your attention to A.11 of Dr. Pararas-Carayannis's testimony. Here, Dr. Pararas-Carayannis challenges your initial testimony that there has been "a maximum water-level rise of only 0.78 meters/2.6 feet at O'ahu since the 1950's." He claims that this statement is inaccurate and that the CNWRA should have considered the possibility that much larger waves would reach Pa'ina's facility, causing the irradiator pool to become buoyant. Do you agree?

A.37: (J. Stamatakos) No. A.11 repeats an argument Dr. Pararas-Carayannis made in declarations previously filed in this proceeding, and he still provides no evidence to support his buoyancy argument. The CNWRA's judgment is that this is a highly implausible scenario. As I

explained in our initial testimony, at A.31 and A.34, the irradiator pool is too heavy and potential forces from storms, hurricanes, tsunamis, and earthquakes too weak to buoy the pool in the case of flooding.

Q.38: Now please turn your attention to A.12 of Dr. Pararas-Carayannis's testimony, where he claims you misinterpreted a citation in his February 2007 report as referring to wave height instead of tsunami runup. Could you comment?

A.38: (J. Stamatakos) Regardless of whether we consider a wave height of 30 meters or tsunami runup of 30 meters, the analysis is still bounded by the 30-meter water height used in the CNWRA's fluid dynamics calculation. In other words, the CNWRA's conclusion does not change.

Q.39: Please turn your attention to A.13 of Dr. Pararas-Carayannis's testimony in which he challenges the proposed site of the irradiator. Do you agree with that testimony?

A.39: (J. Stamatakos) Dr. Pararas-Carayannis speculates that the inherent risks of this site are too high compared to the unevaluated risks of other, allegedly safer sites. Yet, Dr. Pararas-Carayannis provides only speculation that Pa'ina's proposed site is not safe for its facility. The CNWRA found that, at the proposed site, neither aircraft crashes nor natural phenomena will cause any significant radiological consequences, let alone the severe consequences suggested by Dr. Pararas-Carayannis. Accordingly, there was no need for the CNWRA to analyze allegedly safer sites.

Q.40: Does this conclude your testimony?

A.40: (J. Durham, A. Ghosh, J. Stamatakos) Yes.

March 4, 2009

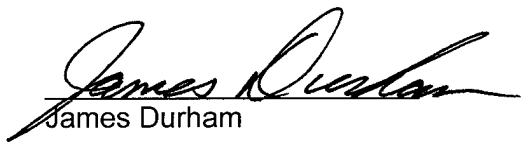
UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

AFFIDAVIT OF JAMES DURHAM

I, James Durham, do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.



James Durham

Executed in San Antonio, Texas
this 4th day of March, 2009.

March 4, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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	)	
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	)	

AFFIDAVIT OF AMITAVA GHOSH

I, Amitava Ghosh, do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.

AGhosh
Amitava Ghosh

Executed in San Antonio, Texas
this 4th day of March, 2009.

March 4, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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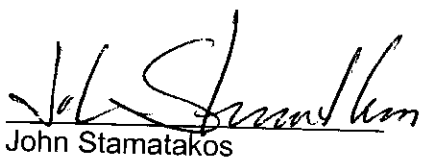
	)	

AFFIDAVIT OF JOHN STAMATAKOS

I, John Stamatakos, do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.



John Stamatakos

Executed in Rockville, Maryland
this 4th day of March, 2009.