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June 8, 2011

Mr. James Borchardt
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
By email: Mr. Siva Lingam, NRC Petition Manager, Siva.Lingam@nrc.gov

**SUPPLEMENTAL FILING OF BEYOND NUCLEAR
10 CFR 2.206 PETITION TO IMMEDIATELY SUSPEND THE
OPERATING LICENSES OF GE BWR MARK I UNITS
PENDING FULL NRC REVIEW
WITH INDEPENDENT EXPERT AND PUBLIC PARTICIPATION
FROM AFFECTED EMERGENCY PLANNING ZONE COMMUNITIES**

Mr. Borchardt:

Beyond Nuclear (the Petitioner) submits the following supplement to its request for emergency enforcement action submitted on April 13, 2011 as provided by Section 2.206 of Title 10 of the Code of Federal Regulation ([10 CFR 2.206](#)). The Petitioner submit this supplement to the requested enforcement action to update some of the key developments arising out of the Fukushima Dai-Ichi nuclear power plant accident with regard to unduly risking the public health and safety by the continued operations at twenty three (23) General Electric Boiling Water Reactors Mark I units that rely upon a fundamentally flawed combination of the pressure suppression containment system, the installation of the “hardened vent system,” or not, and the addition of the mothballed Millstone Unit 1 for a combined total of twenty four (24) units which rely upon used radioactive fuel storage pools (also known as “spent fuel pools” elevated to the top the reactor building outside and above the rated containment structure without

safety-related back-up electric power (Class E1) systems to cool high-density storage of thermally hot and highly radioactive nuclear waste in the event of loss of grid power.

[The Beyond Nuclear emergency enforcement petition](#) of April 13, 2011 requests the suspension of operations of all US General Electric Mark I Boiling Water Reactors (BWR) pending the following emergency enforcement actions:

1) The NRC is requested to convene a public meeting in each of the Emergency Planning Zones for each of GE Mark I BWR nuclear power plants to take and transcribe public comment and independent experts as part of the agency's March 2011 chartered review of the implications of the Fukushima Dai-Ichi nuclear power plant accident;

2) The NRC is requested to revoke all prior pre-approvals of the installation of the Mark I containment (Fukushima style reactors) "hardened vent system" as granted in Generic Letter 89-16 (September 1989) under 10 CFR 50.59 and instead require all GE Mark I Boiling Water Reactor operators to submit to the formal license amendment process accorded with full public hearing rights;

3) The NRC is requested to require all owner operators to retrofit the Mark I "spent fuel" pools with Class E1 emergency back-up power systems (including independent AC power generators and DC battery backup to 72 hours) to assure the reliable operation of cooling systems for hundreds of tons of thermally hot and highly radioactive used nuclear fuel stored underwater in elevated storage pools in the event of loss of offsite electrical power.

June 8, 2011 marks the 90th day of ongoing multiple severe nuclear accidents at the Fukushima Dai-Ichi nuclear power plant complex as result of extended station blackout caused by the Great Eastern Japan Earthquake and Tsunami of March 11, 2011. More than twenty four (24) miles of the Japan's eastern coastline and twelve (12) miles inland devastated by the earthquake and the

tsunami will not be reconstructed or inhabitable for the foreseeable future because of the significant radioactive contamination that continues to escape from the GE Mark I reactors at the Fukushima Dai-Ichi nuclear power plant. The radiation contamination levels in area groundwater and into the sea continue to spike and rise as the result of multiple failed and breached Mark I containment systems which continue to leak millions of gallons of radioactive water injected into the three reactor vessels and four spent fuel pools in the ongoing and desperate attempt to keep the significant multiple reactor core and spent fuel damage under control.

Specifically, the Emergency Enforcement Petition focuses on the now demonstrated unreliability of General Electric Boiling Water Reactor Mark I containment system to mitigate a severe accident and the lack of emergency power systems to cool high density storage pools each containing hundreds of tons thermally hot and extremely radioactive used reactor fuel assemblies located atop the reactor buildings and outside a rated containment.

Sincerely,

-----/s/-----

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-----/s/-----

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June 8, 2011

UNITED STATES OF AMERICA
BEFORE THE
NUCLEAR REGULATORY COMMISSION
EXECUTIVE DIRECTOR OF OPERATIONS

SUPPLEMENTAL TO THE
BEYOND NUCLEAR PETITION
FOR
EMERGENCY ENFORCEMENT ACTION
PER
10 CFR 2.206

IN THE MATTER OF
BROWNS FERRY 1, 2 & 3 (AL)
BRUNSWICK 1 & 2 (NC)
COOPER 1 (NE)
DRESDEN 2 & 3 (IL)
DUANE ARNOLD 1 (IA)
FERMI 2 (MI)
FITZPATRICK 1 (NY)
HATCH 1 & 2 (GA)
HOPE CREEK 1 (NJ)
MONTICELLO 1 (MN)
MILLSTONE 1 (CT)
NINE MILE POINT 1 (NY)
OYSTER CREEK 1 (NJ)
PEACH BOTTOM 2 & 3 (PA)
PILGRIM 1 (MA)
QUAD CITIES 1 & 2 (IL)
VERMONT YANKEE 1 (VT)

**SUPPLEMENT TO THE APRIL 13, 2011
PETITION FOR EMERGENCY ENFORCEMENT ACTION
FOR GE BOILING WATER REACTORS UTILIZING
MARK 1 PRIMARY CONTAINMENT SYSTEMS
AND WITHOUT DEDICATED CLASS E1 POWER FOR COOLING
ELEVATED IRRADIATED USED FUEL STORAGE POOLS
OUTSIDE A RATED CONTAINMENT STRUCTURE**

Beyond Nuclear (the Petitioner) hereby submits a first supplement to its petition of April 13, 2011 to the United States Nuclear Regulatory Commission (NRC) requesting that the agency suspend the operating licenses of all General Electric Boiling Water Reactors (BWR) that utilize the Mark I primary containment system pending a complete and thorough [near term and long term review](#)¹ by NRC to include statements by public and independent experts in public meetings convened by NRC within each of the emergency planning zones on the unreliability and inadequacy of current accident mitigation modifications, the need for further changes or the permanent revocation of the captioned BWR operating licenses.

The Petitioners assert that new information and analyses generated by the Fukushima Dai-Ichi nuclear accident in Japan that has come to light since its April 13, 2011 filing continues to raise this request to the level of an emergency enforcement petition for all US reactors where the public health and safety relies upon the same Mark I primary containment system based on the pressure suppression concept now demonstrated to have experienced multiple failures at Fukushima Dai-Ichi.

The Petitioner supplements its April 13 petition to add the two units at the Brunswick nuclear power station in Southport, NC. The initial petition identified

¹ Charter for the Nuclear Regulatory Commission Task Force To Conduct A Near Term Evaluation of the Need for Agency Actions Following the Events in Japan, USNRC, Undated March 2011, ML11089A045

that the Brunswick units while classified as GE Mark I BWRs, according to NRC technical report “Containment Integrity Research at Sandia National Laboratory: An Overview” ([NUREG /CR-6906, Sandia National Labs, July 2006](#)) the units were differentiated from the other 21 Mark I free standing pressure suppression containments by a drywell and torus constructed of reinforced concrete with a steel liner.² The Petitioner has since documented through the NRC Public Document Room ADAMS Legacy file that despite the different construction, the operator installed the “hardened vent system” per NRC Generic Letter 89-16.³

As now supplemented, the nuclear reactor units located within the jurisdiction of the NRC are identified as Browns Ferry 1, 2, and 3 (AL), Brunswick 1 & 2 (NC), Cooper 1 (NE), Dresden 2 & 3 (IL), Duane Arnold 1 (IA), Fermi 2 (MI), Fitzpatrick 1 (NY), Hatch 1 & 2 (GA), Hope Creek 1 (NJ), Monticello 1 (MN), Nine Mile Point 1 (NY), Oyster Creek 1 (NJ), Peach Bottom 2 & 3 (PA), Pilgrim 1 (MA), Quad Cities 1 & 2 (IL) and Vermont Yankee 1 (VT).

PETITIONER’S SUPPLEMENTAL INFORMATION ON THE MARK I SUBSTANDARD CONTAINMENT

The Mark I licensees were initially licensed under the premise that the pressure suppression system with “*essentially leak tightness*”. NRC technical report “Containment Integrity Research at Sandia National Laboratory: An Overview” ([NUREG /CR-6906, Sandia National Labs, July 2006](#)) identifies that “*Beginning in the 1950’s, the US Atomic Energy Commission and its successor, the NRC, established the safety requirements for US nuclear power reactors. The safety strategy that emerged became known as ‘defense in depth’. The elements of ‘defense in depth’ included accident prevention, redundancy of safety systems, **containment**, accident management and remote siting/emergency planning*”

² “Containment Integrity Research at Sandia National Laboratory: An Overview,” US NRC, NUREG/CR 6909, July 2006 Table 3, p. 9

³ Carolina Power & Light and NRC communications dated 10/27/1989 (Microfiche 51756:034-035), 01/30/1990 (Microfiche 52467:112-113) and 04/13/1993 (Microfiche 74882:223-223).

*(sheltering and evacuation)... The containments are designed to accommodate the pressures associated with a loss of coolant accident by either having large volumes, as in the large dry and sub-atmospheric containments, or by utilizing a pressure suppression system to reduce the volume, as in the ice-condenser or the Mark-I-II, or –III boiling water reactors which include a suppression pool filled with water.”⁴ NUREG/CR 6909 states ““Following World War II, peaceful uses of nuclear energy included plans to construct commercial reactors for electric power generation. The Atomic Energy Act of 1946 established the Atomic Energy Commission (AEC) and provided the statutory basis for the development of commercial nuclear power plants in the US.”⁵ It goes on“An early exception to this siting approach and the first use of containment in the US was the Submarine Intermediate Reactor Mark A at the Knolls Atomic Power Laboratory which was only 19 miles from Schenectady, NY. The entire reactor was enclosed in a gas-tight steel sphere, or **containment** (although this term was not applied to this structure), designed to withstand ‘a disruptive core explosion’ and to contain radionuclides that might be released in a reactor accident.”⁶*

The NUREG states “The advent of containment was a decisive step in moving large power reactors closer to populated electrical load centers. Containment provided a barrier to the release of radionuclides that was desirable for public safety and public acceptance of nuclear power. All commercial nuclear power plants approved for construction in the US have containments.”⁷

However, NUREG/CR-6909 goes on to state that “Containments were not designed to withstand a gross rupture of the reactor pressure vessel since this was not considered to be a credible event.”⁸

The NRC technical report goes on to state that “There are six basic containment types in the fleet. Four of these designs primarily use the passive pressure suppression concept, and two rely primarily on large, strong volumes. All of these containments are constructed of either steel or concrete with a steel liner for leak

⁴ NUREG/CR-6909, p. XV

⁵ Ibid, p. 3

⁶ Ibid, p. 3

⁷ Ibid, p. 4

⁸ Ibid, p. 4

tightness. BWR designs, which have evolved from the Mark I to the Mark III design, all use a pressure suppression pool.”⁹

In point of fact, NUREG/CR-6909 identifies, ‘In 1965, the AEC issued the first draft of the General Design Criteria, Appendix A of 10 CFR 50. (10 CFR Part 50 specifies the regulations promulgated by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954 to provide for the licensing of production and utilization facilities.) The final version of Appendix A, published in 1971, did not require the containment to be designed to withstand a full core meltdown (as the original draft had). The first five criteria define overall requirements for quality assurance and protection against natural phenomena, fire, environmental and dynamic effects (including loss of coolant accidents), and sharing of systems, structures and components.’”

The Petitioner responds that the assumption that gross rupture of the pressure vessel or “full core meltdown” accident has been mistakenly considered by the agency not to be a credible event. As identified as recently as [June 06, 2011 by CNN News Service](#) , all three GE Mark I BWRs are now confirmed to have experienced full core meltdowns in a nuclear accident that is still in progress. As such, the integrity of any one or all three of the Fukushima Dai-Ichi Mark I containment systems can be reasonably considered to be in significant doubt, if not practically declared to have already failed as evidenced by the significant radioactive contamination to released to the atmosphere, the land, groundwater and pouring into the sea. The contamination has currently rendered an area as uninhabitable now extending beyond a 12 mile radius around the stricken reactor site. In point of fact, the contamination levels seeping from the shattered Fukushima Dai-Ichi reactor site continue to dramatically rise and are now [reported as of June 7, 2011](#) to have doubled from Japan’s original estimations where “According to the latest estimates, 770,000 terabequerels – about 20% as

⁹ NUREG/CR 6909, p. 6

much as the official estimate for Chernobyl – of radiation seeped from the plant in the week after the tsunami, more than double the initial estimate of 370,000.”¹⁰

The NRC technical report goes on to identify that Appendix A “Criterion 1, *Quality standards and records*, requires, in part, that ‘*Structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Where **generally recognized codes and standards are used**, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function.*’ Criterion 16, *Containment Design* states: ‘*Reactor containment and associated systems shall be provided to establish an **essentially leak-tight barrier** against the uncontrolled release of radioactivity to the environment and to assure that the containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.*”¹¹

The Petitioners supplement their April 13 petition assertions that the Mark I containment system is an unreliable and dangerous containment component as represented by Dr. Steven Hanauer (AEC) in 1972 that to the Atomic Energy Commission should adopt a policy to “discourage further use of the pressure suppression system” and the assertions of Dr Harold Denton (NRC) in 1986 that the Mark I containment system had a 90% chance of failure if challenged by severe accident.

The Petitioners offer the following excerpts from the “Testimony of Dale G. Bridenbaugh, Richard B. Hubbard and Gregory C. Minor before the Joint Committee on Atomic Energy, February 18, 1976.”

¹⁰ “Japan Doubles Fukushima radiation leak estimate,” The Guardian, June 7, 2011, <http://www.guardian.co.uk/world/2011/jun/07/japan-doubles-fukushima-radiation-leak-estimate>

¹¹ Ibid p. 22

“On February 2, 1976, we simultaneously resigned our management positions from the General Electric Company. We did so because we no longer justify devoting our life energies to the continued development and expansion of nuclear fission power---a system we believe to be so dangerous that it now threatens the very existence of life on this planet.

“We could no longer rationalize away the fact that our daily labor would result in a radioactive legacy for our children and grandchildren for hundreds of thousands of years. We could no longer resolve our continued participation in an industry which will depend upon the production of plutonium, a material known to cause cancer and produce genetic effects, and which facilitates the continued proliferation of atomic weapons throughout the world.

“We know that this Committee has heard abundant testimony over the past 30 years on these aspects of nuclear power, but we feel it is important to express our deep concern about the entire technology before turning to the specifics of our experience.”¹²

The GE engineers' testimony provided specific concerns with regard to the substandard GE Mark I BWR pressure suppression system.

“The consequences of failure of the primary containment are frightening. The primary containment system provides the most basic defense to public health and safety by preventing the release of highly radioactive fission products into the biosphere should a loss-of-coolant accident occur. In addition, the torus portion of the primary containment system provides the source of cooling water for the emergency core cooling system, and is in the life-line that prevents disastrous core meltdown following loss-of-coolant accident. If the torus support structure fails in the initial phases of the loss-of-coolant accident, it could result in failure of the emergency core cooling system piping systems attached to it, and in loss of the supply of cooling water for the core.

¹² “Testimony of Dale G. Bridenbaugh, Richard B. Hubbard and Gregory C. Minor before the Joint Committee on Atomic Energy, February 18, 1976,” *The Silent Bomb: A Guide to the Nuclear Energy Controversy*, Vintage Books, 1977, Appendix A, p.281.

“The integrity of this portion of the primary containment, then, is an absolute requirement for the protection of the public health and safety and should be an absolute requirement for continued operation of the plant. It is unthinkable that plant operation can be continued on the very tenuous argument that the probability of the accident occurring is low; even the NRC’s Rasmussen Report (WASH-1400) postulates that a loss-of-coolant accident will occur within the foreseeable future. It is more probable that such an accident would occur in the time period considered by WASH-1400, because the techniques, materials, know-how, and design improvement made in later plants have not been incorporated in the early plants (GE Mark I BWR).”¹³

So the Petitioners thus assert that the Mark 1 pressure suppression containment system was initially federally licensed under the criterion that it would be “*an essentially leak-tight barrier*” in keeping with the NRC’s “*defense in depth*” regulatory policy. The Petitioners further assert that Mark I’s lack of structural integrity and that it is prone to failure with potentially catastrophic consequence has been widely documented by federal regulators and industry experts for decades.

However, rather than embark upon a “containment improvement program” that strengthened the Mark I containment’s ability to withstand a severe accident, the industry and the agency chose an experimental “fix” that deliberately compromises containment by venting the consequences of a severe nuclear accident in order to save it.

SUPPLEMENTAL INFORMATION ON THE DEMONSTRATED FAILURE OF THE MARK I HARDENED VENT SYSTEM AND IMPLICATIONS FOR THE US MARK I REACTORS

The April 13, 2011 Beyond Nuclear petition argues that the experimental hardened vent system as pre-approved by NRC in Generic Letter 89-16 by a

¹³ Ibid, p. 298

voluntary industry initiative under 10 CFR 50.59 is documented to have failed at the Fukushima nuclear facility and poses significant safety implications for US Mark I reactors. The Petitioners now submit the following supplemental documentation with regard to the failure of the Mark I “hardened vent systems” as installed in the Fukushima Dai-Ichi units and as installed in US Mark I reactors.

On May 17, 2011, [The New York Times reported](#) that “*Emergency vents that American officials have said would prevent devastating hydrogen explosions at nuclear plants in the United States were put to the test in Japan — and failed to work, according to experts and officials with the company that operates the crippled Fukushima Daiichi plant.*”¹⁴ The news article goes on to identify, “*The failure of the vents calls into question the safety of similar nuclear power plants in the United States and Japan. After the venting failed at the Fukushima plant, the hydrogen gas fueled explosions that spewed radioactive materials into the atmosphere, reaching levels about 10 percent of estimated emissions at Chernobyl, according to Japan’s nuclear regulatory agency.*”¹⁵

Again in point of fact, as of June 7, 2011, Japan has officially now doubled its estimate of the radioactive releases from the hydrogen gas fueled explosions to have now [reached 20%](#) of the estimated releases from the Chernobyl nuclear disaster.¹⁶ Given the unreliability of ongoing and increasing radiation release estimates coming out of Japan, the Petitioners thus point out the irrationality of the regulatory retreat from an all important containment defense-in-depth regulatory standard and the unacceptable compromises imposed on public health and safety through the approval of experimental retrofit venting systems that “temporarily” defeats the weak and substandard containment design with the

¹⁴ “In Japan Reactor Failings, Danger Signs for the US,” Matt Wald, New York Times, May 17, 2011

¹⁵ Ibid

¹⁶ “Japan Doubles Fukushima radiation leak estimate,” The Guardian, June 7, 2011, <http://www.guardian.co.uk/world/2011/jun/07/japan-doubles-fukushima-radiation-leak-estimate>

justification compromising the containment concept was in order to save this principle barrier system from permanent rupture.

The Times story further states *“American officials had said early on that reactors in the United States would be safe from such disasters because they were equipped with new, stronger venting systems. But Tokyo Electric Power Company, which runs the plant, now says that Fukushima Daiichi had installed the same vents years ago. Government officials have also suggested that one of the primary causes of the explosions was a several-hour delay in a decision to use the vents, as Tokyo Electric managers agonized over whether to resort to emergency measures that would allow a substantial amount of radioactive materials to escape into the air. But the release this week of company documents and interviews with experts provides the most comprehensive evidence yet that mechanical failures and design flaws in the venting system also contributed to delays. The documents paint a picture of increasing desperation at the plant in the early hours of the disaster, as workers who had finally gotten the go-ahead to vent realized that the system would not respond to their commands.”*¹⁷

“The venting system is designed to be operated from the control room, but operators’ attempts to turn it on failed, most likely because the power to open critical valves was out. The valves are designed so they can also be opened manually, but by that time, workers found radiation levels near the venting system at Reactor No. 1 were already too high to approach, according to Tokyo Electric’s records.

“At Reactor No. 2, workers tried to manually open the safety valves, but pressure did not fall inside the reactor, making it unclear whether venting was successful, the records show. At Reactor No. 3, workers tried seven times to manually open the valve, but it kept closing, the records say.

“The results of the failed venting were disastrous.

¹⁷ Ibid

“Reactor No. 1 exploded first, on Saturday, the day after the earthquake. Reactor No. 3 came next, on Monday. And No. 2 exploded early Tuesday morning.

“With each explosion, radioactive materials surged into the air, forcing the evacuation of tens of thousands of earthquake survivors living near the plant, contaminating crops and sending a faint plume of radioactive isotopes as far as the United States within days. Aerial photos of the reactor buildings showed No. 1 and 3 had been blown apart and another was seriously damaged.”¹⁸

The New York Times discloses that the hardened vents that failed multiple times to mitigate the severe accident at Fukushima were based on designs and NRC approvals provided in Generic Letter 89-16 through industry voluntary initiatives.

“Tokyo Electric in recent days has acknowledged that damage at the plant was worse than previously thought, with fuel rods most likely melting completely at Reactors 1, 2 and 3 in the early hours of the crisis, raising the danger of more catastrophic releases of radioactive materials. The company also said new evidence seemed to confirm that at Reactor No. 1, the pressure vessel, the last layer of protection, was broken and leaking radioactive water.

“The improved venting system at the Fukushima plant was first mandated for use in the United States in the late 1980s as part of a “safety enhancement program” for boiling-water reactors that used the Mark I containment system, which had been designed by General Electric in the 1960s. Between 1998 and 2001, Tokyo Electric followed suit at Fukushima Daiichi, where five of six reactors use the Mark I design.

“The company said that was the case this week, after a review of Japanese regulatory filings made in 2002 showed that the vents had been installed.

“The fortified venting system addressed concerns that the existing systems were not strong enough to channel pent-up pressure inside the reactors in an

¹⁸ Ibid

emergency. Pressure would be expected to rise along with temperature, damaging the zirconium cladding on the fuel rods at the reactor core and allowing them to react chemically with water to produce zirconium oxide and hydrogen gas.

“The new vents were designed to send steam and gas directly from the reactor’s primary containment, which houses the reactor vessel, racing past the usual filters and gas treatment systems that would normally slow releases of gas and eliminate most radioactive materials.”¹⁹

The New York Times disclosure essentially describes the NRC approved “hardened vent systems” pre-approved by GL 89-16.

The news article concludes that “a redesign of the venting system itself might also be necessary. [Emphasis added]

“The design is the result of conflicting schools of thought among United States nuclear officials, said Michael Friedlander, a former senior operator at several American nuclear power plants.

“Mr. Friedlander said, referring to the Nuclear Regulatory Commission: “You have the N.R.C. containment isolation guys who want containment closed, always, under every conceivable accident scenario, and then you’ve got the reactor safety guys who need containment to be vented under severe accident scenarios. It is a very controversial system.”²⁰

The Petitioners find it increasingly alarming that the news article concludes with the expert statement that there is apparently not even a consensus within the NRC over this very controversial compromise of the agency’s fundamental defense-in-depth philosophy and thus the public’s health and safety.

¹⁹ Ibid

²⁰ Ibid

On June 5, 2011, an additional [Japanese news story](#) describes that “TEPCO executives admitted flaws in the design for the exhaust system could have been a factor leading to the hydrogen explosion.”²¹

The news article further states that “According to internal TEPCO documents, the No. 1 reactor has two emergency exhaust systems. One is the standby gas treatment system (SGTS), which releases gas from the reactor building through a filter to the outer atmosphere.

“The other system is a pressure-resistant vent pipe, which releases gas from within the containment vessel to the outer atmosphere.

“The two separate systems eventually join into a single pipe which is connected to the exhaust cylinder that releases all gas into the atmosphere.”

The Petitioners assert that the overall lack of internal regulatory consensus and evidence of the dangerous failure of the experimental hardened vent at Fukushima has significant implications for US Mark I reactors and warrants the requested suspension of operations of the Mark I and the prompt enforcement of the requested emergency enforcement actions.

The admission that the experimental “fix” or hardened vent system on the substandard Mark I containment may itself need to be redesigned moves the Petitioners contend that it is even more justified to suspend the operation of the GE Mark I BWRS. Moreover, such a finding further justifies the Petitioners’ requested enforcement action to require Mark I operators to submit to the NRC license amendment request process for any further modifications, changes or experiments on the containment system and afford the public its full hearing rights.

²¹ “TEPCO eyes design flaw in hydrogen explosion,” Asahi Shimbun, 06/05/2011 <http://www.asahi.com/english/TKY201106040165.html>

**SUPPLEMENTAL INFORMATION TO THE REQUEST TO REVOKE THE
PRE-APPROVAL OF THE HARDENED VENT PER 10 CFR 50.59 AND
REQUIRE LICENSEES TO SUBMIT LICENSE AMENDMENT REQUESTS
THAT ARE ACCORDED FULL PUBLIC HEARINGS RIGHTS**

The Mark I containment experimental hardened venting system was pre-approved by the NRC in Generic Letter 89-16 issued in September 1989 essentially by an industry voluntary initiative (10 CFR 50.59).

The provisions of making changes to nuclear power plants systems, structures and components is currently allowed through the 50.59 without going through a the NRC's prior approval, review or the license amendment process (10 CFR 50.90) and therefore subject to a public hearing, if the change, modification or experiment only if it does not result in "more than a minimal increase" in a risk of the occurrence of an accident, malfunction of a component important to safety, in the consequences of a malfunction of the component, or create the possibility of an accident of a different type.

The Petitioners assert that the catastrophic nuclear accident at the Fukushima Dai-Ichi nuclear power and the failure of the Mark I containment system and hardened vent which is now under the NRC's chartered review process, raises the issue that the changes to the Mark I containment with the installation of the hardened vent should be revoked and all such modifications be submitted to the license amendment process with full public hearing rights.

Therefore, the Petitioners' request that NRC publicly disclose the status of each GE Mark I reactor in the US and update the status of installation, or not, of the now controversial containment hardened vent system. The Petitioners request that the NRC revoke pre-approvals granted in 1989 to Mark I operators for these experimental hardened vent systems and require the operators to now submit

any further design modifications or new designs for mitigating the failure of the fundamental flawed Mark I containment system.

The Petitioners remain concerned that the Mark I containment has long been known to be too small to contain severe accident loads. Therefore, the first and most rational remedy would be to permanently revoke the operation licenses of these dangerous reactors. However, any further proposed operational changes should be subject to the federal license amendment process and provide the public with full hearing rights and independent expert evaluation of any design and technical specification changes.

Beyond Nuclear has reviewed the NRC correspondence and industry responses to Generic Letter 89-16 which are stored in the NRC Public Document Room.

The publicly available records for documenting containment venting changes to US Mark I reactors are scant, inconsistent and incomplete. Some inspections findings are available, others are not. Some records end such as with Hope Creek in NJ end with findings of inspection violations. Some records are more than 100 pages, where Fermi 2 public available documents add up to seven pages. In at least the case of Oyster Creek as disclosed at the May 26, 2011 NRC Performance Inspection Exit meeting in Toms River, NJ, the bulk of the site specific documentation on the oldest Mark I in the US is being held back from public disclosure as “proprietary” information. If this information is being held back as a trade or business secret, the dramatic March explosions at Fukushima Units 1, 2 and 3 are no longer effective selling points for public confidence for industry keeping secrets.

PLEASE NOTE that Beyond Nuclear requests its petition be supplemented with a request for the full public disclosure of all site specific and Boiling Water Reactor Owner Group documentation related to the design, analysis, installation

and inspection for all of the Mark I docket that regard their hardened vent systems.

In responses to the NRC, in October 1989, the operators of five (5) Mark I reactors declined to commit to the voluntarily install the requested hardened vent system. These Mark I reactors were identified as Millstone Unit 1 (CT), Oyster Creek (NJ), Dresden Units 2 & 3 (IL) and Fitzpatrick (Declined) (NY).

As an example, General Public Utility Nuclear argued that the Oyster Creek Mark I containments already had “low pressure” venting systems already in place and that the existing system would be adequate even under a high pressure accident. The NRC responded by saying that the agency would issue an Order to install the new hardened vent.

In another example, the public record for the two unit Dresden nuclear power plant ends with a September 25, 1992 document from Commonwealth Edison to NRC stating that the installation of the hardened vent was on schedule for Unit 3 to be completed by January 1, 1993 and Unit 2 was being rescheduled from completion in 1992 to 1993. The public record ends here.

In another example, in a October 27, 1989 communication from the New York Power Authority’s Fitzpatrick Mark I unit to the NRC, the Power Authority stated, “*The Authority will not volunteer to install a hardened vent at Fitzpatrick at this time. This position is based on several points.*

“First, the NRC staff has not justified why this issue should be given unique or special treatment. Rather it should be resolved in the same way other SECY-89-017 issues are being resolved—as part of the Individual Plant Evaluation/Probabilistic Risk Assessment currently in progress. Any decision to install a hardened wetwell ven at Fitzpatrick should not be made until after the completion of the plant specific IPE/PRA.

“Second, the Authority’s current analysis, together with the unique circumstances and features of the Fitzpatrick plant, do not justify installation of a hardened wetwell vent for the TW sequence. The Generic Letter inappropriately prescribes a generic modification for a decidedly plant-specific severe accident issue. Third, SECY 89-017 (upon which Generic Letter 89-16 is based) contradicts both itself and other NRC sponsored studies on several technical issues.”²²

A September 14, 1990 NRC communication conveys that on September 9, 1990, the licensees for Oyster Creek, Millstone 1, Dresden 2 & 3 communicated to NRC that they would commit to the voluntary installation and obviate the need for NRC to issue orders. The same September 14 NRC communication found that in matter of Fitzpatrick’s refusal to voluntarily install the vent, “The staff is acting on new information provided by the New York Power Authority regarding the existing hardened vent path at Fitzpatrick. On August 22, 1990, the staff visited the Fitzpatrick facility to inspect the plant’s vent piping and to review the plant’s procedures for venting. Based on the findings of that visit, the staff believes that the existing vent path at Fitzpatrick facility may meet the objectives of a hardened vent path. However, questions remain regarding the consequences of a ground level release outside the reactor building that would result if the vent were used. When the staff completes its reviews regarding Fitzpatrick, it will communicate its conclusions to the New York Power Authority and will advise the Commission.”²³ By September 28, 1992, the NRC staff found that the New York Power Authority had concluded that its pre-existing vent path did not need to fully meet all of the criteria, hardware modifications for the hardened vent system, it “represents an acceptable deviation from the other.”²⁴ Based on the information provided by the Power Authority and a walk down of the containment vent pathway, the NRC

²² New York Power Authority Letter, October 27, 1989 to US NRC, Subject: James A. Fitzpatrick Nuclear Power Plant , Generic Letter 89-16, Installation of the Hardened Wetwell Vent,” Summary

²³ Memorandum from James M. Taylor to the Chairman Carr, Commissioners Rogers, Curtiss, Remick, Subject: Mark I Containment Performance Improvement Program, September 14, 1990,

²⁴ Steven Varga, US NRC to Ralph Beedle, New York Power Authority, September 28, 1992, NRC Public Document Room, Microfiche 63395:298-307

accepted this Mark I's pre-existing vent path without the same hardware and installation of the hardened vent as on other Mark I containments.

While no NRC Orders were ultimately issued to any Mark I licensee, the Petitioners are concerned that because this was conducted as a voluntary industry initiative that effectively evaded public and independent expert scrutiny and the lack of a complete and consistent record, nor the demonstration of a thorough of NRC inspection, oversight or absence of any enforcement action, the current containment vent system or any new modifications to the Mark I containment system need to be independently verified and scrutinized through a more complete and transparent public record and process. At minimum, given the evidence of multiple failures and public health and safety consequences, we believe that this requires the NRC to revoke the approval of the containment vent installations and that the licensees be required to resubmit through the license amendment process with the opportunity for the impacted public with standing to have full hearing rights afforded for their health and safety.

The Petitioner asserts that the failure of both the Mark I containment and the hardened vent system at Fukushima Dai-Ichi are essentially at the root of the current NRC's near-term and long-term review which is looking at all US reactors. The above captioned Mark I units, the failed containment, the failed experimental venting system and how the process by which the installation was approved all need to be a principle focus of the chartered review and as such the review needs to include the input from the most immediately impacted communities and their experts and the process going forward accorded with full public hearing rights.

**Supplemental submission to NRC 2.206 emergency enforcement petition
re: need for safety upgrades at 24 U.S. GE BWR Mark 1 high-level
radioactive waste storage pools in light of lessons learned from the
Fukushima nuclear disaster**

**By Kevin Kamps, Radioactive Waste Specialist, Beyond Nuclear, to the
NRC Petition Review Board on June 8, 2011**

The risks of storing high-level radioactive waste (also known as irradiated nuclear fuel, or, euphemistically, as “spent” or “used” nuclear fuel) in GE BWR Mark 1 elevated storage pools are many, and potentially catastrophic. Such risks have come into sharp focus in light of the loss of electricity to run cooling water circulation pumps at the Fukushima Daiichi nuclear power plant’s multiple GE BWR Mark 1 storage pools for high-level radioactive waste in the aftermath of the March 11, 2011 earthquake and tsunami. Nearly three months later, desperate, often ad hoc attempts to keep the storage pools filled with water in order to thermally cool (and radiation shield) the high-level radioactive wastes are ongoing.

As Robert Alvarez at Institute for Policy Studies has written in the Introduction to his recent report, “Spent Nuclear Fuel Pools in the U.S.: Reducing the Deadly Risks of Storage”ⁱ:

“As the nuclear crisis at the Dai-ichi reactors in Japan's Fukushima prefecture continue to unfold, the severe dangers of stored spent nuclear fuel in pools are taking center stage. It is now clear that at least one spent fuel pool lost enough water to expose highly radioactive material, which then led to a hydrogen explosion and a spent fuel fire that destroyed the reactor building of Unit 4. Radioactive fuel debris was expelled up to a mile away. A second pool at Unit 3 experienced significant damage from a hydrogen explosion from the venting of the reactor vessel.

In a desperate effort to prevent another explosion and catastrophic fire, lead-shielded helicopters and water cannons dumped thousands of tons of water onto

Unit 4's pool. Nearly two months later, the pool remains close to boiling and is still emitting high doses of radiation. Pool water sampling indicates that the spent fuel rods are damaged to the point where uranium fission is taking place. Spent fuel pools at two of the Fukushima Dai-Ichi reactors are exposed to the open sky.

On April 12, the Japanese government announced that the Dai-Ichi nuclear disaster in Fukushima was as severe as the 1986 Chernobyl accident. According to Japan's Nuclear and Industrial Safety Agency, between March 11 and early April, between 10 and 17 million curies (270,000 – 360,000 TBq) of radioiodine and radiocesium were released to the atmosphere — an average of 417,000 curies per day. The average daily atmospheric release between April 5 and 25 was estimated at 4,200 curies per day (154 TBq). The radioactivity discharged into the sea from Unit 2 alone was estimated at 127,000 curies (4,700 TBq).” [pages 4 to 6, internal references and citations omitted here, but included in the Alvarez report]

In fact, the frightening news from Fukushima Daiichi's high-level radioactive waste storage pools has grown even worse. Frighteningly, the Unit 4 pool needs to be shored up, lest it collapse completely – a disaster that could lead to a complete loss of cooling water, and a consequent radioactive inferno in short order, releasing its deadly poisons directly into the atmosphere.ⁱⁱ Damage to another pool, and the high-level radioactive wastes contained within, is also feared. Unit 3 suffered a devastating hydrogen explosion that left the secondary containment building largely a pile of collapsed rubble. This begs the question, what is the status of the Unit 3 high-level radioactive waste storage pool, and what is the status of the irradiated nuclear fuel itself? Photos of the Unit 3 storage pool for high-level radioactive waste show it largely filled with debris.ⁱⁱⁱ Similarly, the high-level radioactive waste storage pool at Unit 1, located immediately adjacent to the top of the reactor pressure vessel and primary containment system, and just below the ceiling of the secondary containment building, was subjected to the first massive hydrogen explosion, on March 12th. Did it, and the

high-level radioactive wastes within, survive intact? Although Tokyo Electric Power Company (Tepco) assured the world that it had – and the Japanese federal government repeated the claim – their credibility is very suspect at this point, given revelations just in recent days about major bad news from the very first days of the catastrophe that is just now being divulged, nearly three months later.

As but one example, only on June 6 to 7 did the Japanese federal Nuclear and Industrial Safety Administration (NISA) admit that radioactivity releases during the first week of the Fukushima nuclear catastrophe (from March 11th to mid-March) were twice the amount previously reported to have been released during the entire first *month* of the catastrophe.^{iv} Undoubtedly, at least a fraction – if not a significant fraction – of these hazardous radioactivity releases from Fukushima Daiichi's GE BWR Mark 1s originated in one or more storage pools for high-level radioactive waste. However, given the chaos that still reigns at the site, as well as the nearly three month delay in the release of basic information by Tepco and various Japanese federal agencies, it may be some time until the details of how much radioactivity escaped from exactly where at the Fukushima Daiichi nuclear power plant. This assumes, however, that Tepco and the Japanese federal government want the truth to be revealed. And members of and presenters at the U.S. Nuclear Regulatory Commission's (NRC) Advisory Committee on Reactor Safeguards (ACRS) subcommittee charged with analyzing the Fukushima nuclear catastrophe have warned that evidence and data could easily be lost during frantic attempts to quell the radioactivity releases, and then to clean them up.^v

It seems reasonable to allow for the possibility, however -- given the severe damage to Fukushima Daiichi Units 1 to 4's secondary reactor containment buildings from massive hydrogen explosions, and the disconcerting questions that still linger nearly three months later about the structural integrity of the various storage pools, and the high-level radioactive wastes they contain – that

at least a part, and perhaps a significant part, of the escaping radioactivity originated from one or more storage pools. After all, they were not located within primary containment structures to begin with, given the GE BWR Mark 1 design. And, they have been subjected to not only the destructive force of the 9.0 earthquake, but also the destructive force of overheating irradiated nuclear fuel, massive hydrogen explosions, falling debris, and perhaps also irradiated nuclear fuel fires, and even accidental nuclear chain reactions within the pools themselves.

In the earliest days of the Fukushima nuclear catastrophe, the theory that Daiichi Unit 4's pool had boiled dry, and the irradiated nuclear fuel had caught on fire, was shared at the highest levels – including by the Chairman of the NRC, Greg Jaczko. The theory held that irradiated nuclear fuel rod cladding, made of zirconium, had chemically interacted with steam, to form hydrogen gas, which then detonated.

However, more recent reviews have begun to advance alternative theories for the “mystery” of Unit 4's explosion that badly damaged the secondary containment building. For example, at a May 26th meeting of the NRC ACRS subcommittee charged with reviewing the Fukushima nuclear catastrophe, a DOE spokesman theorized that perhaps not the entire pool, but rather an isolated section of it, boiled dry, generating hydrogen gas. But he stated that another, more compelling theory may be that hydrogen gas generated by the reactor meltdown in Unit 3 traveled through a common venting system shared by Unit 3 and Unit 4, and rather than being discharged up and out of their common smokestack, instead was discharged into Unit 4's secondary containment building, causing the explosion that severely damaged it. Other theories behind the “mystery” explosion in Unit 4 include the potential presence of explosive materials (such as acetylene tanks), but this has been largely ruled out at this point. But the faster than expected boiling away of the Unit 4 storage pool water could also be partly explained by such things as loss of three feet of the cooling

water cover via sloshing caused by the earthquake, the inadvertent opening of pool gates, tears in the pool's steel liner, and/or cracks in the pool's concrete walls, and/or other large-volume water escape pathways yet to be discovered, in combination with the thermally hot high-level radioactive wastes' boiling away of the remaining cooling water supply.^{vi} Despite the uncertainties, it is fair to say that these GE BWR Mark 1 high-level radioactive waste storage pools have not smoothly withstood the natural disasters, loss of electricity to run cooling water circulation pumps, and the consequent nuclear catastrophe to which they have been subjected.

It is incredible, disconcerting, and alarming that nearly three months into the Fukushima nuclear catastrophe, not only the U.S. Nuclear Regulatory Commission and Department of Energy, but even Tokyo Electric Power Company and the Japanese federal government, are unable to clearly explain what caused the Unit 4 explosion, and what role, if any, high-level radioactive waste storage pools played. Given the desperate, ongoing, ad hoc attempts to keep the multiple high-level radioactive waste storage pools at the Fukushima Daiichi nuclear power plant filled with cooling water (unsuccessful helicopter drops, somewhat more successful but still challenging ad hoc blasts of water from fire truck hoses, water cannons designed for dispersing riots, and concrete truck pumps), given the continued lack of circulation pumping, it seems fair to say that the pools remain at potential risk of catastrophic radioactivity releases. After all, the pools are not located within primary containment structures, and the secondary containment buildings have been visibly damaged (Unit 2), severely damaged (Units 1 and 4) or utterly destroyed (Unit 3). Unit 4's pool appears at risk of collapse – and there is the danger of powerful seismic aftershocks from the March 11th earthquake that could be the straw that breaks the camel's back. The emergency cooling measures have had to be performed from some distance, and behind radiation shielding such as lead lined helicopters and vehicles, given the severe on-site radiological hazards associated with three leaking reactor melt downs, two damaged primary containment structures, and

multiple storage pools with insufficient cooling water -- and hence radiation shielding -- covering the high-level radioactive waste.

The main tenet of Alvarez's May 2011 report – and the motivation behind Beyond Nuclear's 2.206 enforcement petition vis a vis GE BWR Mark 1 high-level radioactive waste storage pool risks – is that it could very well happen here. But this has been known, and warned about, long before the Fukushima nuclear catastrophe.

In fact, in January 2001, the U.S. Nuclear Regulatory Commission (NRC) staff itself published its final draft of the “Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants,” NUREG-1738.^{vii} Although this report focused on accidental heavy load drops into high-level radioactive waste storage pools at decommissioned nuclear power plants, the consequences of instantaneous pool drain downs can be equal to the consequences of gradual pool boil downs, as due to loss of electricity at GE BWR Mark 1s for a long enough period of time. Loss of the electric grid to run the cooling water circulation pumps would begin an overheating and boiling away of pool water, which, if not corrected, could lead to an uncovering of the irradiated nuclear fuel in a matter of days at operating (and even permanently shut down) GE BWR Mark 1 nuclear power plants. That is why our 2.206 emergency enforcement petition calls for NRC to immediately issue Confirmatory Action Orders to all GE BWR Mark I high-level radioactive waste storage pool operators in the U.S. to promptly install a dedicated Class E1 power system to assure: the prompt and reliable availability of standby backup electrical power from redundant Alternating Current (AC) emergency power systems (i.e. bunkered AC emergency onsite generators), and that additional standby emergency backup power be provided by Direct Current (DC) battery systems rated to provide sufficient power for a minimum of 72 hours to assure the operation of cooling water circulation pumps until main grid power and/or emergency standby generators can be restored, or additional battery power can be made available.

Incredibly, as revealed by questions raised during the ACRS subcommittee meeting mentioned above, it seems that water level gauges and temperature gauges are not in place at the Fukushima Daiichi nuclear power plant's high-level radioactive waste storage pools – adding to the confusion about the status of the pools and the high-level radioactive wastes contained within. The questions indicated that a similar situation exists at U.S. GE BWR Mark 1 high-level radioactive waste storage pools (and pools of other designs, for that matter). If water level gauges do exist, they may be at the *top* of the pool, to warn against pool *overflow* accidents. Given the risks, safety features as basic as water level and temperature gauges must be required by NRC to be installed by GE BWR Mark 1 high-level radioactive waste storage pool operators in the U.S. Given the fear that inadvertent nuclear chain reactions may have taken place in one or more of Fukushima Daiichi's high-level radioactive waste storage pools, NRC should also require GE BWR Mark 1 pool operators to install neutron monitors, and other appropriate radiation monitoring devices, in the U.S. And given the destructive forces – earthquake, tsunami, overheating, boiling, fires, explosions, nuclear chain reactions – to which Fukushima Daiichi's high-level radioactive waste storage pools have been subjected to, and to which U.S. GE BWR Mark 1 pools could also be subjected to under various accident conditions, these various gauges – to check water level, temperature, radiological emissions, etc. – should be designed and built to withstand such destructive forces.

The loss of the cooling water cover in high-level radioactive waste storage pools at Fukushima Daiichi nuclear power plant has precluded Tepco personnel and other emergency responders (including the Japanese military) from approaching the pools to take corrective emergency actions and observations, due to the fatal gamma radiation fields due to the loss of adequate radiation shielding that had previously been provided by the pools' cooling water cover. A similar development must be precluded at U.S. GE BWR Mark 1 pools. NRC must require that adequate make-up water supplies are in place, and robust enough to

survive potential accident conditions, so that the pools' cooling water cover is not lost in the first place, whether due to sudden drain down, or slow motion boil off.

Loss of the cooling capability could also lead to irradiated nuclear fuel overheating and then spontaneous combustion, or ignition, of the zirconium cladding encasing the irradiated nuclear fuel rods. Such a fire could ignite within hours of the loss of the cooling water cover over the irradiated nuclear fuel. Such a high-level radioactive waste fire could then propagate, exothermically, from "younger" (irradiated nuclear fuel more recently discharged from the operating reactor core) to "older" (irradiated nuclear fuel that has been longer removed from an operating reactor core, and is thus more radioactively decayed and thermally cooled) irradiated nuclear fuel. Significantly, in its 2001 report cited above, NRC could not rule out that irradiated nuclear fuel that had been removed from a reactor core for *decades* be declared immune from catching fire. Such accident scenarios may have very well already occurred at Fukushima Daiichi. They must be prevented from ever occurring in the U.S. Adequate precautions as called for in this emergency enforcement petition – robust emergency backup power, water level gauges, temperature gauges, radiation monitors, and make-up water systems and supplies -- must be required by NRC at U.S. GE BWR Mark 1s, to preclude such catastrophic consequences from ever occurring here.

NRC reported in its 2001 study that "the consequences of a zirconium fire could be serious," that the loss of cooling water in a high-level radioactive waste storage pool could lead to around 25,000, or more, latent fatal cancers downwind, with deaths occurring as far as 500 miles away. The NRC report's Appendix 2D, "STRUCTURAL INTEGRITY OF SPENT FUEL POOL STRUCTURES SUBJECT TO AIRCRAFT CRASHES," focuses on the consequence of an accidental aircraft crash on an irradiated nuclear fuel storage pool. Deliberate attack is not considered by the report. However, this section of the report – as in the report's Section 3.5.2 -- notes that the 32 General Electric Mark 1 and 2 Boiling Water Reactors "do not appear to have any significant

structures that would reduce the likelihood of penetration” of the irradiated nuclear fuel storage pool by an aircraft. The study characterizes a “large aircraft” as weighing just 12,000 pounds, or 6 tons. But the takeoff weight of the large jumbo commercial aircraft that hit the World Trade Center on September 11, 2001 was on the order of 150 tons. The NRC report’s APPENDIX 4, “CONSEQUENCE ASSESSMENT FROM ZIRCONIUM FIRE,” focuses on the radioactive inventory releases and human health consequences of a zirconium fire in an irradiated nuclear fuel storage pool. Due to the appendix on aircraft crashes in particular, this report was withdrawn from public access by NRC following the 9/11 terrorist attacks. It was later returned, with the caveat that NRC would not publicize its existence. The risks of sudden pool drain downs, whether due to accidents or attacks, should be defended against by NRC security and safety regulations. But so should the risk of more gradual pool boil downs, due to loss of electricity supply. The consequences of loss of cooling water covering in GE BWR Mark 1 high-level radioactive waste storage pools would be equivalent, whether due to sudden drain down, or more gradual boil down.

Also moved by the 9/11 attacks to warn the U.S. public and decision makers about high-level radioactive waste storage pool security risks (especially at particularly vulnerable GE BWR Mark 1s, with elevated pools), in January 2003, Robert Alvarez *et al.* reported that a terrorist attack successfully draining the cooling water from an irradiated nuclear fuel storage pool could cause a catastrophic radioactivity release that would dwarf the Chernobyl nuclear disaster in scope.^{viii} Alvarez *et al.* summed up the potential consequences:

A 1997 study done for the NRC estimated the median consequences of a spent-fuel fire at a pressurized water reactor that released 8 to 80 mega-curies of cesium-137. The consequences included 54,000-143,000 extra cancer deaths, 2,000-7,000 square kilometers of agricultural land condemned, and economic costs due to evacuation of US\$117-566 billion. It is

obvious that all practical measures must be taken to prevent the occurrence of such an event. In short, "The long-term land-contamination consequences of such an event could be significantly worse than those from Chernobyl," they concluded.

The Alvarez *et al.* report made abundantly clear, to an ever widening audience, that irradiated nuclear fuel storage pools represent one of the worst security vulnerabilities in the U.S. In 2005, the National Academies of Science concluded that Alvarez *et al.*'s warning held merit, and should be addressed.^{ix} Incredibly, the NRC responded by trying to block the public release of a redacted version of the NAS report. If not given adequate consideration by NRC, and appropriate enforcement action as suggested in this emergency enforcement petition, such security risks, as well as safety risks highlighted by the Fukushima nuclear catastrophe in the aftermath of a natural disaster, could persist for decades to come in the U.S.

Given their configuration, GE BWR Mark 1 high-level radioactive waste storage pools are also vulnerable to the risks of heavy load drop accidents leading to rapid pool drain downs. Such an accident nearly occurred on the Lake Michigan shoreline, at Palisades nuclear power plant (a pressurized water reactor) in Covert, Michigan, in October 2005. For several months, because the nuclear utility and NRC did not disclose the incident, it remained unknown to the public and even local elected officials. NRC claimed that this near-disaster was "not a reportable event." After submitting a Freedom of Information Act (FOIA) request, Nuclear Information and Resource Service was able to document what had happened and why.^x Palisades had come precariously close to dropping a 107 ton, fully loaded high-level radioactive waste transfer cask back into the storage pool. This risked breaching the pool floor, and suddenly draining away the cooling water supply. As described by the 2001 NRC study cited above, that could have led within a short period of time to a catastrophic radioactive waste inferno. Given similar close calls at Prairie Island nuclear power plant in

Minnesota (another long duration dangle of a fully loaded cask above the pool at a pressurized water reactor, in the 1990s), and at Vermont Yankee (a fully loaded cask drop that came precariously close to striking the loading platform floor, in more recent years at a GE BWR Mark 1), the potential for such an incident at any of the 24 U.S. GE BWR Mark 1 high-level radioactive waste storage pools is certainly a credible risk. NRC must address the risk of heavy load drops into irradiated nuclear fuel storage pools causing sudden drain downs of the cooling water supply, and thus sudden loss of the radiation shielding it also provides.

David A. Lochbaum, now with Union of Concerned Scientists, had warned about the risk of heavy load drops into high-level radioactive waste storage pools five years earlier than the 2001 NRC report. In his 1996 book "Nuclear Waste Disposal Crisis,"^{xi} he also warned about many other risks of high-level radioactive waste pool storage, including at BWR Mark 1s. In Chapter 8, "Spent Fuel Risks," Lochbaum wrote [note, Lochbaum's citations, indicated within parentheses below, are omitted here, but are viewable in his book excerpt – a link to the UCS website is included in my endnote 11]:

"The NRC first evaluated the spent fuel risk in the Reactor Safety Study (RSS) released in October 1975.(1) The NRC had assumed that a spent fuel accident would only involve one-third of a reactor core's inventory, because the fuel assemblies discharged each refueling outage would be shipped offsite for reprocessing shortly thereafter. The NRC considered the spent fuel risk to be small compared to the risk from accidents involving the reactor core. The National Environmental Policy Act of 1969 compelled the NRC to release an environmental impact statement for spent fuel storage in August 1979. The NRC reaffirmed its conviction that the "storage of spent fuel in water pools is a well established technology, and under the static conditions of storage represents a low environmental impact and low potential risk to the health and safety of the public.(2)

The NRC recognized that certain actions had eroded the basis for its original spent fuel risk analysis: after reprocessing was eliminated, utilities had expanded spent fuel storage capacities at nuclear power plants and disposal had been indefinitely deferred. The RSS had not considered so many spent fuel assemblies being stored for so many years. In addition, studies demonstrated that fire could propagate between irradiated fuel assemblies in the storage racks, a mechanism not contemplated in the RSS analysis. The NRC undertook a study in the early 1980s to determine if the interim spent fuel storage role presented unanalyzed accident scenarios or more severe consequences than previously analyzed. The study involved a probabilistic risk analysis of postulated spent fuel pool accidents initiated by random system failures, seismic events and dropping heavy loads. The analysis considered initiating event frequencies, system responses, and accident consequences such as cladding fires to evaluate the health effects from the postulated accidents.(3)

The NRC's study reported that a spent fuel pool accident involving fuel damage could result in an [8,000,000] person-rem total radiation exposure to the 667,588 people living within a 50 mile radius of the plant. This radiological dose averages 11.98 Rem per person, equivalent to 479.2 times the maximum dose that federal regulations permit any member of the public to receive in an entire year. The study estimated that such an accident could result in off-site property damage totalling \$3.4 billion in 1983 dollars. As in the RSS, the study assumed that the accident involved only the fuel discharged during the most recent refueling outage (i.e, one-third of a reactor core).(4) However the NRC's study also reported that the chances of a spent fuel pool accident resulting in fuel damage were [1.5/10,000,000] per reactor year, or less than one accident every 60,000 years given the 109 plants currently operating. Due to the accident's

perceived low probability, the NRC concluded that it represented an acceptable risk to public health and safety despite the severe consequences.(5)

The heart of probabilistic risk assessment (PRA) is statistical analysis. Such ciphering has valuable applications, but PRA proponents quantifying nuclear safety risks should consider the fact that a NRC statistician published this conclusion on March 9, 1979:

The probability is less than 0.5 that the next (i.e., the first) major accident occurs within the next 400 reactor years. The probability is less than .05 that the next major accident occurs in the next 21 reactor years. The probability is larger than 0.5 that the next major accident will occur after the next 400 reactor years.(6)

The major accident at Three Mile Island Unit 2 occurred on March 28, 1979- fewer than 500 hours later.

The primary faults of PRAs include not addressing all credible initiating events and using invalid assumptions. It is exceedingly difficult to cover every conceivable failure mode and effect in a PRA for something as complex as a nuclear power plant. According to a consultant to the NRC who reviewed 25 Individual Plant Examinations featuring PRA, "attention to detail makes safe plants--lack of attention to details kills people."(7)

The nuclear power industry has not evaluated the integrated risk from nuclear power plant operation with the on-site storage of significantly more spent fuel assemblies than had been considered when the plants were designed. Spent fuel risk assessments assume that only one-third of a reactor core's inventory will be damaged, yet spent fuel pools now contain upwards of seven

reactor cores of irradiated fuel assemblies as shown in Table 7-1. These details demand proper attention.

The spent fuel risk assessments dismiss the severe consequences from a spent fuel accident primarily due to the perceived long time that the operating staff has to perform mitigating actions. However, these risk assessments fail to account for the single most important element in any mitigation effort namely, the problem's detection. The instrumentation used to monitor spent fuel pool temperature and level is almost always nonemergency equipment. This means that it is not designed, procured, installed, maintained, or tested with the same high standards applied to emergency system components to guarantee their performance. As repeatedly illustrated by the following incidents, the initiating event frequently goes undetected for hours or even days due to inoperable spent fuel pool instrumentation. It seems prudent, if not mandatory, to provide reasonable assurance that spent fuel pool problems will be readily detected before their grave consequences are dismissed based on remedial actions.

Loss of Water Inventory

The principal spent fuel accident concern is losing spent fuel pool water and the capability to cool the irradiated fuel assemblies. If the spent fuel pool drains, the spent fuel assemblies discharged within the past three to four years still produce sufficient decay heat to cause meltdown. In addition, the fuel's cladding could initiate and sustain rapid oxidation (often referred to as "fire" outside the nuclear power industry) during heatup prior to melting. The resulting cladding fire in a spent fuel pool equipped with high-density storage racks could spread to every spent fuel assembly.

The probability that the cladding would catch on fire after the spent fuel pool completely drains has been estimated at 100% for PWRs and 25% for BWRs.(8) The BWR probability is significantly lower because it was assumed

that the BWR spent fuel assemblies are stored with their fuel channels in place, thus acting as barriers preventing the fire from spreading. Storing BWR spent fuel assemblies with the fuel channels in place significantly reduces spent fuel risk, yet the NRC does not require or even recommend that BWR plants implement this inexpensive safety precaution.

The loss of spent fuel pool water inventory event has the potential for contaminating the environment worse than would occur from a reactor core accident due to the significantly larger quantity of radioactive material available for release.(9) Additionally, the loss of spent fuel pool water inventory event is inherently worse than the reactor core accident because the fuel damage and radioactivity release occur *outside* the major barrier protecting the public, the primary containment. Therefore, it is more likely that radioactive material released in a spent fuel pool accident would reach the environment.

Several failure modes causing spent fuel pool water inventory to be lost were considered during the design process. The predominant failure mode is structural integrity damage that drains the spent fuel pool water at a rate exceeding makeup capability. The events producing this failure mode include earthquakes, heavy loads dropping into the pool or onto its wall, and turbine generated missiles. The secondary failure mode involves fuel pool cooling system malfunctions enabling accelerated water loss from the pool. The events producing this failure mode include a fuel pool cooling system pipe break and a failure of the system's heat removal function. Another failure mode, typically not considered during the design process but proving to be rather troublesome nonetheless, involves seal failure that allows water to leak from the pool into adjacent areas such as the containment, the shipping cask pit, and the fuel transfer tube.

The spent fuel pools at nuclear power plants in the United States are designed to withstand earthquakes without loss of integrity. The NRC evaluated the spent

fuel pools at the Vermont Yankee and the H. B. Robinson plants to determine their vulnerability to earthquakes more severe than considered during design. They concluded that the spent fuel pools would probably survive an earthquake three times larger than they were designed to handle. They also concluded that it would take an earthquake nearly ten times greater than the design basis earthquake to cause the spent fuel pools to fail catastrophically.(10)

Spent fuel pools are not designed to withstand a shipping cask weighing 75 to 110 tons dropping onto their floors or walls. A dropped cask will probably cause the spent fuel pool to fail catastrophically. Although the consequences from a cask dropping into the spent fuel pool are significant, the probability that such an event will occur has been considered to be sufficiently low as to effectively manage this risk factor.

While the nuclear power industry has not experienced the prototypical cask drop event, there have been precursors. On December 28, 1994, a core shroud head bolt dropped into the Unit 1 spent fuel pool at Georgia Power Company's Edwin L Hatch Nuclear Plant from one foot above the water surface when the sling holding the bolt broke. The bolt, 17 feet long by three inches in diameter and weighing 365 pounds, glanced off the side wall and fell to the bottom of the spent fuel pool without hitting the storage racks or irradiated fuel assemblies. The bolt tore a three inch gash in the 3/16 inch thick stainless steel liner.

Approximately 2,000 gallons leaked through the hole and through a drain line to the radwaste system before valves in the drain line were manually closed. The SFP level dropped nearly two inches in 23 minutes, causing the fuel pool cooling system pumps to trip on low suction pressure. Operators restored level after the leakage path was isolated, then returned the fuel pool cooling system to service. Georgia Power removed the bolt and placed a large rubber mat (i.e., a nuclear-sized sink stopper) over the hole to limit leakage until underwater welding repairs were completed.

The Hatch incident occurred less than a year after a screwdriver dropped into the spent fuel pool at a foreign nuclear power plant with similar results. On January 31, 1994, workers at Tricastin Unit 1 in France were removing the control rod cluster guide tube from a spent fuel assembly. A 15 foot long screwdriver weighing 44 pounds fell into the spent fuel pool and punctured the stainless steel liner. The level in the spent fuel pool dropped nearly four inches. A stainless steel plate was welded over the hole.

Spent fuel pools are not designed to withstand the impact from a turbine generated missile. A turbine generated missile can result from the main turbine's gross failure. The detached blading or shroud from a large turbine spinning at 1,800 rpm can be extremely detrimental to whatever it impacts. The probability that a turbine generated missile will cause spent fuel pool integrity failure has been estimated to be $[4.1/10,000,000]$ per reactor year. This probability is predicated on a $[1/10,000]$ per reactor year probability that a turbine failure event generates a missile combined with a $[4.1/1,000]$ probability that such a missile strikes the spent fuel pool with sufficient energy to be destructive.(11)

Following the main turbine failure at Fermi Unit 2 on Christmas Day, 1993, Detroit Edison Company determined that a high trajectory missile generated by the turbine could damage the spent fuel pool. The conditional probability of this occurrence, given the turbine failure, was estimated to be $[1.0/10,000]$ per year.(12) As with the cask drop event, while the consequences from a turbine generated missile striking the spent fuel pool are significant, the probability that such an event would occur was considered to be sufficiently low as to effectively control this risk factor.

Spent fuel pools are designed to handle a loss of fuel pool cooling. This initiating event culminates in appreciable loss of spent fuel pool water inventory only when the spent fuel pool boils without makeup. This failure mode has been discounted

in safety studies due to the extended period (relative to traditional reactor accident analysis time frames) available to restore cooling or provide makeup.

On January 25, 1994, Commonwealth Edison Company discovered considerable water in the basement of the containment structure at its Dresden Unit 1 plant. Dresden Unit 1 shutdown in October 1978 and remains virtually abandoned next to the operating Dresden Unit 2 and 3 plants. A service water system pipe in the unheated Unit 1 containment had frozen and ruptured, draining about 55,000 gallons from the system into the basement. Commonwealth Edison determined that piping in the spent fuel pool transfer system was also susceptible to freezing. If this piping had broken, the spent fuel pool would have drained to two feet below the top of the 660 irradiated fuel assemblies in the storage racks. At that level, the dose rate at the spent fuel pool railing was estimated at 733 Rem/hr, radiation levels that could have impaired operations on Dresden Units 2 and 3.¹³ Dresden Unit 1 was not equipped with spent fuel pool level instrumentation to detect inventory loss.¹⁴ This event had significant potential radiological consequences even though only 660 irradiated spent fuel assemblies resided in the spent fuel pool and these assemblies had undergone over 15 years of radioactive decay.

Failure of inflatable and mechanical seals is the most frequent reason that spent fuel pool water inventory is lost. Figure 8-1 illustrates various seal applications used in BWRs. Mechanical seals are used between the reactor pressure vessel and the containment structure (labeled "RPV to Drywell Bellows Seal" in Figure 8-1) and between the drywell and the refueling cavity (labelled "Drywell to Reactor Building Bellows" in Figure 8-1). Inflatable seals are used around removable gates (labeled "Gates" and "Double Gates" in Figure 8-1). Inflatable seals are like bicycle tire intertubes when filled with air, they form a nearly leak tight barrier. The problem occurs when the inflatable seal loses air pressure and the barrier becomes rather porous.

The refueling cavity water mechanical seal (comparable to the "Drywell to Reactor Building Bellows" shown in Figure 8-1) at the Haddam Neck plant suffered a gross failure in August 1984 when mechanical interference significantly displaced the seal. At the time of the failure, the refueling cavity was flooded in preparation for refueling. The refueling cavity water level decreased 23 feet to the reactor vessel flange level within 20 minutes, flooding the containment with approximately 200,000 gallons. If a spent fuel assembly had been in transit at the time, it could have been partially or completely uncovered with potentially high radiation levels, fuel cladding failure and radioactivity release. In addition, if the fuel transfer tube had been open, the spent fuel pool could have drained to a level that would have uncovered the top of the irradiated fuel assemblies in the storage racks.(15)

The inflatable seal on the gate to the transfer canal between the Unit 1 and the Unit 2 spent fuel pools at the Edwin I. Hatch Nuclear Plant deflated in December 1986 after the air supply to the seals was mistakenly isolated. Nearly 141,000 gallons leaked from the spent fuel pools into the transfer canal, lowering the SFP level five feet. The leak was not identified for several hours because a leak detection instrument was inoperable at the time. Georgia Power determined that the leakage path could have drained the spent fuel pool to the bottom of the transfer canal, leaving only two feet of water over the top of irradiated fuel assemblies in the storage racks. The radiation field at the spent fuel pool railing would have been 100 Rem/hr in that condition, primarily from the control blades stored on the side of the spent fuel pool.(16) Several other incidents involving seal failure are described in Appendix A.

After the Haddam Neck event, the NRC required the postulated gross failure of the refueling cavity water seals to be evaluated for every nuclear power plant. The evaluation results varied due to different seal designs and refueling cavity geometries. Some plants required modifications to reduce the gross failure risk or provide seal leakage indication.

The results from the Northeast Utilities' evaluation of the Millstone Units 1, 2, and 3 plants for the Haddam Neck event represent typical findings. Northeast Utilities determined that in the unlikely event that the seal experienced catastrophic failure, the Millstone Unit 1 SFP level would drop to 20 inches above the irradiated fuel assemblies in 11 minutes with the resulting radiation field estimated to be $[2.4 \times 10(6)]$ Rem/hr at the spent fuel pool railing and 65 Rem/hr on the refueling floor. For the same postulated event on Millstone Unit 2, the SFP level would drop to 12 inches above the irradiated fuel assemblies in 80 minutes with the resulting radiation field estimated to be $[4.0 \times 10(6)]$ Rem/hr at the pool railing and 54 Rem/hr on the refueling floor. For the same postulated event on Millstone Unit 3, the SFP level would drop to 21 inches above the irradiated fuel assemblies in 120 minutes with the resulting radiation field estimated to be $[1.9 \times 10(6)]$ Rem/hr at the pool railing and 37 Rem/hr on the refueling floor.(17)

To put these radiation fields in perspective, a worker exposed to 37 Rem/hr receives the maximum annual radiation dose permitted by federal law in about 49 seconds, while a worker exposed to $[1.9 \times 10(6)]$ Rem/hr receives a fatal radiation dose in about one second. Because the probability that the refueling cavity water seal suffers catastrophic failure is considered to be negligibly small (despite already happening once), these potentially devastating consequences have been accepted by the NRC at Millstone and other nuclear power plants...

These spent fuel pool near-misses share many causal factors. In the majority of cases, the failure of a nonemergency system or component without the availability of a backup resulted in water inventory loss from the spent fuel pool. In many cases, the inventory loss was not promptly detected due to inoperable level instrumentation. The potential consequences from these events include high radiation fields and uncovering irradiated fuel assemblies outside primary containment. Given that federal regulations require the assumption that nonemergency systems and components fail or are unavailable following design

basis events, the frequency of these spent fuel pool seal failures should warrant heightened attention, especially as more and more irradiated fuel assemblies are placed into the spent fuel pools.”

The reason I have included such a long extract from Lochbaum’s 1996 book is to show that high-level radioactive waste storage pool risks have long been known – and warned about. In fact, Lochbaum’s examples of numerous near-misses involving pools includes a disconcerting number of GE BWR Mark 1 pools. This lends strength to our emergency enforcement petition’s demand that NRC significantly increase safety and security regulations on GE BWR Mark 1 pools as a matter of utmost priority for public health, safety, environmental protection, and national and homeland security importance.

A recent report by Robert Alvarez at the Institute for Policy Studies (“Spent Nuclear Fuel Pools in the U.S.: Reducing the Deadly Risks of Storage,” May 2011, posted online at http://www.ipsdc.org/reports/spent_nuclear_fuel_pools_in_the_us_reducing_the_deadly_risks_of_storage) shows that most of the 24 GE BWR Mark 1s in this country are located at nuclear power plants which have generated the most radioactivity of any nuclear power plant sites in the U.S. This radioactivity comes in the form of high-level radioactive waste, also known as irradiated nuclear fuel. This is the case because, many times, these GE BWR Mark 1s are amongst the oldest operating nuclear power plants in the U.S. They have operated for so many decades, that they have some of the largest inventories of high-level radioactive wastes of any nuclear power plant sites in the country.

These massive inventories of high-level radioactive waste are stored on-site, either within the elevated indoor pools outside primary containment structures, or else in outdoor dry casks. However, most pools are kept at maximum capacity, with high density storage of irradiated nuclear fuel. This means that these Mark 1 pools are often packed full of high-level radioactive waste, even if some have

offloaded a small fraction of the older (more thermally cooled and radioactively decayed) irradiated nuclear fuel into outdoor dry casks.

Although almost all of the 24 GE BWRs in the U.S. have already received dry cask storage licenses from NRC (Pilgrim in Massachusetts is an exception), this does not mean pool risks have been adequately addressed. Far from it. Alvarez reports that “U.S. reactors have generated about 65,000 metric tons of spent fuel, of which *75 percent is stored in pools, according to Nuclear Energy Institute data.*” (page 1, emphasis added). Thus, only 25% of GE BWR Mark 1 irradiated fuel has been transferred from the extremely risky pools into less risky (but themselves not risk-free – actually, far from it) dry storage casks. In fact, a tendency amongst nuclear utilities in the U.S. is to keep their high-level radioactive waste storage pools as full as possible, for as long as possible, in order to defer dry cask storage costs into the future.

This same practice is carried out at GE BWR Mark 1s. Millstone Unit 1 is a particularly egregious example. As reported by NRC, “[Millstone] Unit 1 was shut down on November 4, 1995, and transfer of the spent fuel to the pool was completed on November 19, 1995.” (Millstone – Unit 1, 2.0 Site Status Summary, posted online at <http://www.nrc.gov/info-finder/decommissioning/power-reactor/millstone-unit-1.html>) Incredibly, that’s where the irradiated nuclear fuel has remained ever since, for over 15 years now, despite the elevated risk. Fermi Unit 2 in Michigan (at 1,122 Megawatts-electric the largest GE BWR Mark 1 in the world), despite already having obtained a license to establish a so-called Independent Spent Fuel Storage Installation (or ISFSI; see NRC’s map entitled “U.S. Independent Spent Fuel Storage Installations,” posted online at <http://www.nrc.gov/waste/spent-fuel-storage/locations.pdf>), has taken much longer to do so than previously planned and announced. This has left nearly 550 metric tons of high-level radioactive waste at risk in its elevated storage pool.

Nine Mile Point 1 in New York, although pursuing an ISFSI license, does not yet have it. Thus, all of the high-level radioactive waste it has ever generated is still currently stored in its elevated pool.

Pilgrim in Massachusetts has no license for dry cask storage yet – and NRC reports that it has not yet announced its intentions regarding an ISFSI (see NRC’s map entitled “U.S. Independent Spent Fuel Storage Installations,” posted online at <http://www.nrc.gov/waste/spent-fuel-storage/locations.pdf>). The Pilgrim pool was originally designed to store 880 irradiated nuclear fuel assemblies, but NRC has granted it permission to store a maximum of 3,859 irradiated nuclear fuel assemblies in order to accommodate 40 years of operations by 2012 (personal communication to Kevin Kamps by Mary Lampert of Pilgrim Watch, June 7, 2011). After that, Pilgrim would likely remove only the minimum number of irradiated nuclear fuel assemblies from the pool to make room for the next offload of thermally and radioactively hot irradiated fuel from the reactor core during re-fueling, all in an effort to defer dry cask storage expenses for as long as possible. However, this greatly increases the risks of elevated pool storage.

In his Figure 9, “Spent Fuel Inventories Greater Than 200 Million Curies,” Alvarez lists the following 15 U.S. Mark 1s that store amongst the most radioactivity in the form of high-level radioactive waste of any nuclear power plant sites in the country:

Millstone Unit 1 in Connecticut, which, when taken together as a whole with Millstone Units 2 and 3 (which happen to be pressurized water reactors), comprises nearly 500 million curies of radioactivity, the most of any nuclear power plant in the U.S.; as Millstone Unit 1 “went into commercial operation on December 28, 1970,” its still operational (and largely full) pool is now over 40 years old;

Dresden Units 2 and 3 in Illinois (which began operations in 1970 and 1971, respectively), which along with Dresden Unit 1 (which began operations in 1960,

was permanently shut down in 1978, and is currently mothballed, awaiting eventual decommissioning), have generated a grand total of about 350 million curies of irradiated nuclear fuel thus far; storing nearly 2,200 metric tons of high-level radioactive waste altogether at the Dresden nuclear power plant and the immediately adjacent General Electric-Morris ISFSI (an aborted reprocessing facility that broke ground in the late 1960s, the pool of which contains 772 tons of high-level radioactive waste) make this perhaps the single most concentrated square mile of commercial irradiated nuclear fuel storage in the U.S.; NRC reports that “[c]urrently, 108 spent fuel assemblies and one fuel rod basket from Unit 1 are stored in the DNPS [Dresden Nuclear Power Station] Unit 3 SFP [Spent Fuel Pool].” Thus, some of the risks of Dresden Unit 1’s irradiated nuclear fuel will persist in the Dresden Unit 3 storage pool for decades to come: “The licensee plans that decontamination and dismantlement of DNPS Unit 1, including removal of any remaining Unit 1 spent fuel that is stored in the Unit 3 SFP, will take place from 2029 through 2031.” [Dresden – Unit 1, 2.0 Site Status Summary, posted online at <http://www.nrc.gov/info-finder/decommissioning/power-reactor/dresden-nuclear-power-station-unit-1.html>];

Browns Ferry Units 1, 2, and 3 in Alabama, which have generated about 325 million curies of radioactivity in the form of high-level radioactive waste; Despite their different names, the co-located Mark 1s **FitzPatrick Unit 1** and **Nine Mile Point Unit 1**, along with Nine Mile Point Unit 2 (a GE BWR Mark II), in New York State, have generated very nearly 300 million curies of radioactivity in the form of irradiated nuclear fuel;

Peach Bottom Units 2 and 3 in Pennsylvania, which have generated over 250 million curies of radioactivity in the form of high-level radioactive waste;

Edwin I. Hatch Units 1 and 2 in Georgia, which have generated nearly 250 million curies of radioactivity in the form of high-level radioactive waste;

Hope Creek Unit 1 in New Jersey, which along with Salem Units 1 and 2 (which happen to be pressurized water reactors) has generated nearly 250 million curies of radioactivity in the form of high-level radioactive waste;

Quad Cities Units 1 and 2 in Illinois, which have generated nearly 225 million curies of radioactivity in the form of high-level radioactive waste.

To give some perspective on how much radioactivity this is, consider that a large medical center, such as the one at Washington University in St. Louis, with as many as 1,000 laboratories in which radioactive materials are used, may have a combined inventory of only about *two* curies. And the storage and handling of those two curies is very carefully controlled to protect the health and safety of doctors, nurses, students, patients, and visitors. (see “Routine Radioactive Releases from Nuclear Power Plants in the United States: What Are the Dangers?”, Beyond Nuclear, January 2009, point number 2, posted online at <http://www.beyondnuclear.org/storage/documents/rrus.pdf>).

Also providing valuable perspective on radioactivity quantities and the associated risks is the work of Dr. Gordon Thompson. In May, 2008, Dr. Thompson published “Scope of the EIS [Environmental Impact Statement] for New Nuclear Power Plants at the Bruce Site in Ontario: Assessment of Accidents and Malfunctions” (prepared under the sponsorship of Greenpeace Canada, Institute for Resource and Security Studies, Cambridge, Massachusetts). In it, he very clearly articulated the serious safety and security risks associated with both pool storage and dry cask storage of irradiated nuclear fuel. For example, he provided clear, concise accountings of how much radioactivity would be where at new nuclear power plants. At page 27, he used the Indian Point nuclear power plant (pressurized water reactors) very near New York City to make comparisons of radioactivity content of reactor cores, pools, and dry casks. He used radioactive cesium-137 content to make these comparisons.

Thompson reported that each pool at Indian Point contains 2,500,000 TeraBecquerels (TBq) of Cesium-137 (equivalent to over 67,000,000 curies). By way of comparison, he reported that each Indian Point PWR operating reactor core contains 420,000 TBq of Cesium-137 (equivalent to over 11,000,000 curies). The Chernobyl nuclear catastrophe, by way of comparison, released “only” 90,000 TBq of Cesium-137 (about 2.4 million curies) into the environment, and yet devastated vast regions with such radioactivity contamination. The Canadian Nuclear Safety Commission defines a “Large Release” of radioactivity as exceeding 100 TBq of Cesium-137 (2,700 curies).

In May, 2006, Dr. Thompson prepared a report relevant to GE BWR Mark 1s, “Risks of Pool Storage of Spent Fuel at Pilgrim Nuclear Power Station [near Boston] and Vermont Yankee.” (A Report for the Massachusetts Attorney General by IRSS, May 2006, NRC Electronic Library, NRC Adams Accession Number ML061630088)

Just as Dr. Thompson articulated radioactivity risks in terms of cesium-137, so does Robert Alvarez in his recent report. Alvarez writes:

Nearly 40 percent of the radioactivity in U.S. spent fuel is cesium-137 (4.5 billion curies) — roughly 20 times more than released from all atmospheric nuclear weapons tests. U.S. spent pools hold about 15-30 times more cesium-137 than the Chernobyl accident released. For instance, the pool at the Vermont Yankee reactor, a BWR Mark I, currently holds nearly three times the amount of spent fuel stored at Dai-Ichi's crippled Unit 4 reactor. The Vermont Yankee reactor also holds about seven percent more radioactivity than the combined total in the pools at the four troubled reactors at the Fukushima site. (page 1)

Certainly, the potential for an atmospheric release containing hundreds of millions of curies of radioactivity, likely including tens of millions of curies of

Cesium-137 – as from GE BWR Mark 1 high-level radioactive waste storage pools -- represents a huge radiological risk.

Providing yet more valuable perspectives on various radiological risks of concern, Thompson also cites a 2007 study by Cousins and Reichmuth, sponsored by Defence Research and Development Canada, about a radiological dispersal device (RDD) or “dirty bomb” open air attack at the CN Tower in downtown Toronto. (Tom Cousins and Barbara Reichmuth, “Preliminary Analysis of the Economic Impact of Selected RDD Events in Canada,” presentation at the CRTI Summer Symposium 2007, Gatineau, Quebec, 11 – 14 June 2007. CRTI is the CBRNE Research and Technology Initiative, a program of Defence Research and Development Canada. The conference proceedings (available from CRTI) list the presentation as CRTI 05-0043RD, entitled “Economic Impact of Radiological Terrorist Events.”) The study assumes a “mere” 37 TBq (1,000 curie) release from the RDD attack, yet calculates that from a cleanup standard of 500 millirem [mrem] per year, “the estimated economic impact would be \$28 billion, whereas for a cleanup standard of 15 mrem per year the impact would be \$250 billion.” It should be noted that a 500 mrem/year “clean up standard” would pose quite significant risks for human health for persons inhabiting such a contaminated area; a 15 mrem/year “clean up standard” would itself still pose increased risk to human health, as all radioactive exposures, even small ones, carry a risk; the risk increases with increasing dose, and the risks are cumulative over a lifetime. Thus, a “successful” terrorist attack upon an irradiated nuclear fuel storage pool at a GE BWR Mark 1, or an accident, could unleash “hundreds of thousands of TBq of cesium-137,” (or several millions of curies). The releases could even be in the millions of TBq (or tens of millions of curies), since, as Thompson in 2003 and 2008, NRC staff in 2001, and Alvarez *et al.* in 2003 have documented, up to **100%** of the volatile Cesium-137 could be released into the environment from a zirconium cladding fire in an irradiated nuclear fuel pool (Dr. Gordon Thompson, Institute for Resource and Security Studies (IRSS), “Robust Storage of Spent Nuclear Fuel: A Neglected Issue of Homeland Security,”

January 2003, posted online at <http://www.nirs.org/reactorwatch/security/sechossrpt012003.pdf>; the report's executive summary is posted online at <http://www.nirs.org/reactorwatch/security/sechosses012003.pdf>; Dr. Gordon Thompson, "Scope of the EIS for New Nuclear Power Plants at the Bruce Site in Ontario: Assessment of Accidents and Malfunctions," Prepared under the sponsorship of Greenpeace Canada, Institute for Resource and Security Studies, Cambridge, Massachusetts, May 2008; In January 2001, NRC published its final draft of "Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants," (NUREG-1738). The October 2000 draft of this report is posted online at <http://www.nirs.org/reactorwatch/security/secnrscfpstudy102000.pdf>. Although this report focused on accidental heavy load drops into waste storage pools at decommissioned nuclear power plants, the risk consequences of a pool drain down are equally applicable to terrorist attacks at operating nuclear power plants. NRC reported that "the consequences of a zirconium fire could be serious," that the loss of cooling water in a waste storage pool could lead to around 25,000, or more, latent fatal cancers downwind, with deaths occurring as far as 500 miles away. The report's Appendix 2D, "STRUCTURAL INTEGRITY OF SPENT FUEL POOL STRUCTURES SUBJECT TO AIRCRAFT CRASHES," is posted online at <http://www.nirs.org/reactorwatch/security/secnrscfpstudy2000aircraft.pdf>; Robert Alvarez, Jan Beyea, Klaus Janberg, Jungmin Kang, Ed Lyman, Allison Macfarlane, Gordon Thompson, and Frank N. von Hippel published "Reducing the hazards from stored spent power-reactor fuel in the United States" in *Science & Global Security*, Vol. 11, No. 1, 2003, p. 6. This article is posted online at http://www.princeton.edu/%7Eglobsec/publications/pdf/11_1Alvarez.pdf. *Science & Global Security* is published by the Program on Science and Global Security (SGS), based at Princeton University's Woodrow Wilson School of Public and International Affairs in New Jersey, U.S.A. SGS has carried out research and policy analysis and education and training in nuclear arms control and nonproliferation for more than three decades.

Clearly, the release of millions, tens of millions, or even hundreds of millions of curies of volatile, radioactive cesium-137 from GE BWR Mark 1 high-level radioactive waste storage pools could spell continental-scale catastrophe.

Alvarez's Figure 10, "Spent Fuel Inventories Between 100 – 200 Million Curies," shows that two of the very oldest GE BWR Mark 1s – and thus two of the oldest atomic reactors in the U.S. -- are not very far behind their above mentioned identical twins in terms of high-level radioactive waste generation and storage. Age related degradation of systems, structures, and components increases the risks of break down phase accidents, including at GE BWR Mark 1 elevated high-level radioactive waste storage pools.

Oyster Creek Unit 1 in New Jersey, the oldest still-operating atomic reactor in the U.S. (1969 to 2011), has generated about 125 million curies of radioactivity in the form of high-level radioactive waste.

Vermont Yankee Unit 1 on the Connecticut River border with New Hampshire, just 8 miles upstream from Massachusetts, has generated 100 million curies of radioactivity in the form of high-level radioactive waste.

Alvarez's Figure 11, "Spent Fuel Inventories Between 10 – 100 Million Curies," shows that:

Fermi Unit 2 in Michigan, alongside the partially melted down -- and long shut -- Fermi Unit 1 experimental sodium-cooled plutonium-breeder reactor, has generated nearly 90 million curies of radioactivity in the form of high-level radioactive waste;

Duane Arnold Unit 1 in Iowa has generated nearly 80 million curies of radioactivity in the form of high-level radioactive waste;

Cooper Unit 1 in Nebraska has generated around 75 million curies of radioactivity in the form of high-level radioactive waste;

Likewise, **Brunswick Units 1 and 2** in North Carolina, taken together, have generated around 75 million curies of radioactivity in the form of high-level radioactive waste;

Monticello Unit 1 in Minnesota has generated over 70 million curies of radioactivity in the form of high-level radioactive waste;

Likewise, **Pilgrim Unit 1** in Massachusetts has generated over 70 million curies of radioactivity in the form of high-level radioactive waste.

An insight that can be gained from Alvarez's report is that GE BWR Mark 1 high-level radioactive waste storage pool risks are actually greater in the U.S. than they are in Japan. Figure 8 on page 11 of his report, "Spent Fuel Assemblies in Pools at the Dai-Ichi Nuclear Complex in Fukushima and Individual U.S. Boiling Water Reactors" shows that Duane Arnold, Pilgrim, and Vermont Yankee's GE BWR Mark 1 pools contain significantly more high-level radioactive waste than Fukushima Daiichi's Units 1 to 4 pools. Thus, these pools in the U.S. could boil dry that much more quickly, and the radiological consequences downwind and downstream from a pool fire could be that much more catastrophic.

In conclusion, NRC should require not only emergency backup power on GE BWR Mark 1 pools, as demanded by our emergency enforcement petition, but also emergency makeup water systems and supplies, as well as water level gauges, temperature gauges, and radiation monitors that would survive and continue to function despite even severe natural disasters and nuclear catastrophes as shown by Fukushima Daiichi to be all too possible. In addition to vital safety and security upgrades on GE BWR Mark 1 high-level radioactive storage pools in the U.S., the NRC should require, as a matter of homeland

security, national security, and public health, safety and environmental protection policy of the highest priority, the replacement of unnecessarily and indefensibly risky high density storage of high-level radioactive wastes in GE BWR Mark 1 pools with Hardened On-Site Storage, as urged by nearly 200 environmental groups across the U.S. since 2002.^{xii}

Respectfully submitted,

-----/s/-----

Paul Gunter
Reactor Oversight Project

-----/s/-----

Kevin Kamps
Radioactive Waste Specialist

June 8, 2011

ⁱRobert Alvarez, Introduction, “Spent Nuclear Fuel Pools in the U.S.: Reducing the Deadly Risks of Storage,” Institute for Policy Studies, Washington, D.C., May, 2011, posted online at http://www.ips-dc.org/reports/spent_nuclear_fuel_pools_in_the_us_reducing_the_deadly_risks_of_storage.

ⁱⁱ See the NHK story at <http://www.beyondnuclear.org/radioactive-waste-whatsnew/2011/6/7/work-continues-to-shore-up-fukushima-daiichi-unit-4-high-lev.html>, as well as the RT story at <http://www.beyondnuclear.org/home/2011/5/10/is-fukushima-unit-4-about-to-collapse.html>.

ⁱⁱⁱ <http://www.beyondnuclear.org/home/2011/5/10/is-fukushima-unit-3-spent-fuel-pool-gone-some-experts-think.html>.

^{iv} See citations posted at <http://www.beyondnuclear.org/home/2011/6/7/twice-as-much-radioactivity-released-from-fukushima-daiichi.html>, including BBC, the U.K. *Guardian*, and the *Wall Street Journal*.

^v See the transcript, as well as the DOE presenter’s powerpoint slides, posted online at <http://pbadupws.nrc.gov/docs/ML1114/ML11147A075.pdf>.

^{vi} See the transcript, as well as the DOE presenter’s powerpoint slides, posted online at <http://pbadupws.nrc.gov/docs/ML1114/ML11147A075.pdf>.

^{vii} “Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants,” (NUREG-1738). The October 2000 draft of this report is posted online at <http://www.nirs.org/reactorwatch/security/secnrcsfstudy102000.pdf>.

^{viii} Robert Alvarez, Jan Beyea, Klaus Janberg, Jungmin Kang, Ed Lyman, Allison Macfarlane, Gordon Thompson, and Frank N. von Hippel published “Reducing the hazards from stored spent power-reactor fuel in the United States” in *Science & Global Security*, Vol. 11, No. 1, 2003, p. 6. This article is posted online at http://www.princeton.edu/%7Eglobsec/publications/pdf/11_1Alvarez.pdf. *Science &*

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^{ix} The National Academy of Sciences Report on "Safety and Security of Commercial Spent Nuclear Fuel," April 06, 2005.

^x For further information on this incident, see

<http://www.nirs.org/reactorwatch/licensing/caskdanglesummaryreport4406.pdf>, the April 4, 2006 "Summary Report on High-Level Atomic Waste Mishap at Palisades Nuclear Reactor Risks Radioactive Inferno with Casualty Potential of Thousands of Deaths Downwind, Based Upon U.S. Nuclear Regulatory Commission Freedom of Information Act (FOIA) Response Documents."

^{xi} David A. Lochbaum, "Nuclear Waste Disposal Crisis," Penn Well Publishing Company, Tulsa, Oklahoma, 1996, portions posted online at

http://www.ucsus.org/assets/documents/nuclear_power/nuclear-waste-disposal-crisis-excerpts.pdf ; see especially pages 109 to 116.

^{xii} See the Statement of Principles for Safeguarding Nuclear Waste at Reactors, including the list of signatories, at

http://www.ieer.org/reports/DOE_WasteContracts2010/HOSS_PRINCIPLES_3-23-10x.pdf.