RIVERKEEPER.

To: Collins, NRR
Ref. G20010508
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AO
RI
OGC
Goldberg, OGC
Subbaratnam, NRR

December 20, 2001

Dr. William D. Travers
Executive Director for Operations
U.S. Nuclear Regulatory Commission
One White Flint North, Mail Stop 16 E15
11555 Rockville Pike
Rockville, MD 20852

Re. *<u>Section 2.206 Request for Emergency Shutdown of Indian Point Units 2 and 3</u>*

Dear Dr. Travers,

On November 7, 2001 Riverkeeper, Inc., joined by other individuals and organizations, submitted a request pursuant to 10 CFR § 2.206(a) asking the Commission to order the immediate shut-down of Units 2 and 3 of the Indian Point Nuclear Power facility.

Further to that request, we hereby submit the enclosed declaration of Dr. Gordon Thomspon, dated December 7, 2001. We respectfully request that Dr. Thompson's declaration be included with our initial Section 2.206(a) request as part of the formal record for your consideration.

Thank you for attention to the matter.

Sincerely,

Jeffrey Odefey
Staff Attorney

Riverkeeper, Inc.
25 Wing and Wing
Garrison, NY 10524

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	:
	:
ENTERGY CORPORATION	:
	:
(Indian Point Nuclear Power Station,	:
Units No. 2 and 3;	:
Facility Operating Licenses DPR-26 and DPR-64)	:

DECLARATION OF 20 DECEMBER 2001
BY DR. GORDON THOMPSON IN SUPPORT OF
A PETITION BY RIVERKEEPER, INC.

I, Gordon Thompson, declare as follows:

I. INTRODUCTION

(I-1) I am the executive director of the Institute for Resource and Security Studies (IRSS), a nonprofit, tax-exempt corporation based in Massachusetts. Our office is located at 27 Ellsworth Avenue, Cambridge, MA 02139. IRSS was founded in 1984 to conduct technical and policy analysis and public education, with the objective of promoting peace and international security, efficient use of natural resources, and protection of the environment. A statement of my professional qualifications is provided in Section II, below.

(I-2) I have been retained by Riverkeeper, Inc. (hereafter referred to as "Riverkeeper") as an expert witness and adviser in connection with the potential threat posed to public health and safety by the Indian Point nuclear power station, Units 1, 2 and 3. In that capacity, I have prepared this declaration.

(I-3) The purpose of this declaration is to support a petition to the US Nuclear Regulatory Commission (NRC) by Riverkeeper, requesting a proceeding to modify, suspend or revoke the operating licenses for Indian Point Units 2 and 3. In its petition, Riverkeeper identifies the threat of a terrorist attack on the Indian Point station as a new, site-specific, hazardous condition that was not previously considered in the licensing of Indian Point Units 2 and 3, and was not accounted for in the design-basis threat that the NRC adopted for these units. In this declaration, I address the threat of a terrorist attack within a wider context. I discuss the vulnerability of the Indian Point station to a variety of influences, including acts of malice or insanity. Terrorist attacks represent one category of potential acts of malice or insanity to which the station may be vulnerable. Also, in discussing the vulnerability of the Indian Point station, I consider the vulnerability of the spent fuel storage facility at Unit 1.

(I-4) In addition to discussing the vulnerability of the Indian Point station to a variety of influences, this declaration discusses options whereby the station's vulnerability could be reduced. Moreover, this declaration sets forth requirements for a thorough, credible review of the vulnerability of the Indian Point station, and of the options whereby the station's vulnerability could be reduced. In addressing vulnerability, I focus on the potential for a large release of radioactive material from the Indian Point station to the environment.

(I-5) This declaration has eleven sections. After this introduction (Section I), the declaration addresses my professional qualifications (Section II). Then, the declaration provides some information (Section III) about the Indian Point nuclear power station. Section IV provides a generic discussion of the potential for occurrence of a reactor accident or the onset of self-sustaining, exothermic oxidation reactions in a spent fuel pool; the latter event is referred to here, for simplicity, as a "pool fire". This is followed by a generic discussion (Section V) of the history of, and potential for, acts of malice or insanity at nuclear facilities. The vulnerability of the Indian Point station to a range of events -- including acts of malice or insanity -- is discussed in Section VI. A brief discussion of the offsite consequences of a reactor accident or pool fire at the Indian Point station is provided in Section VII. Options for reducing the vulnerability of the Indian Point station are discussed in Section VIII. Then follows a discussion (Section IX) about the identification and management of sensitive information relating to the vulnerability of nuclear facilities. Section X sets forth some requirements for a credible review of the vulnerability of the Indian Point station, and of the options whereby the station's vulnerability can be reduced. Conclusions are presented in Section XI.

II. MY PROFESSIONAL QUALIFICATIONS

(II-1) I am an expert in the technical analysis of safety and environmental issues related to nuclear facilities. My Curriculum Vitae is provided here as Attachment A.

(II-2) I received an undergraduate education in science and mechanical engineering at the University of New South Wales, in Australia. Subsequently, I pursued graduate studies at Oxford University and received from that institution a Doctorate of Philosophy in mathematics in 1973, for analyses of plasmas undergoing thermonuclear fusion. During my graduate studies I was associated with the fusion research program of the UK Atomic Energy Authority. My undergraduate and graduate work provided me with a rigorous education in the methodologies and disciplines of science, mathematics, and engineering.

(II-3) Since 1977, a significant part of my work has consisted of technical analyses of safety and environmental issues related to nuclear facilities. These analyses have been sponsored by a variety of nongovernmental organizations and local, state and national governments, predominantly in North America and Western Europe. Drawing upon these analyses, I have provided expert testimony in legal and regulatory proceedings, and have served on committees advising US government agencies. To illustrate my expertise, I provide in the following paragraphs some details of my experience.

(II-4) I have conducted, directed, and/or participated in a number of studies that evaluated aspects of the design and operation of nuclear facilities with respect to severe accident probabilities and consequences. These include generic studies and studies of individual facilities. For instance, with respect to generic studies on the potential for severe accidents at nuclear power plants, I was co-investigator in a study by the Union of Concerned Scientists on the "source term" issue -- the potential for release of radioactive material to the environment.[1] Also, I was one of a team of four scientists who prepared, for Greenpeace International, a comprehensive critique of the state of the art of probabilistic risk assessment (PRA) for nuclear power plants.[2] Our report noted that acts of malice, such as sabotage and acts of war, are not considered in PRAs, despite a history of malicious acts at many nuclear facilities. In addition, I conducted analysis on the relevance of PRA to emergency response planning, as part of a study on emergency planning for nuclear power plant accidents.[3] All of these studies required me to be highly familiar with the design and operation of nuclear power plants, as well as the characteristics of probabilistic risk assessment.

(II-5) I have also done considerable work on the risks posed by individual nuclear facilities. In addition to performing the studies described elsewhere in this declaration, I have studied the risks posed by the Seabrook and Three Mile Island plants (USA), the Darlington and Pickering stations (Canada), the Sizewell B station (UK) and the Dukovany plant (Czech Republic). All of these studies required me to become familiar with the relevant details of the design and operation of the facilities involved.

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[1] Steven Sholly and Gordon Thompson, The Source Term Debate (Cambridge, Massachusetts: Union of Concerned Scientists, January 1986).

[2] H Hirsch et al, IAEA Safety Targets and Probabilistic Risk Assessment (Hannover, Germany: Gesellschaft fur Okologische Forschung und Beratung mbH, August 1989).

[3] D Golding et al, Preparing for Nuclear Power Plant Accidents (Boulder, Colorado: Westview Press, 1995).

(II-6) To a significant degree, my work has been accepted or adopted by relevant governmental agencies. During the period 1978-1979, for example, I served on an international review group commissioned by the government of Lower Saxony (a state in Germany) to evaluate a proposal for a nuclear fuel cycle center at Gorleben. I led the subgroup that examined accident risks and identified alternative options with lower risk.[4] One of the risk issues that I identified and analysed was the potential for self-sustaining, exothermic oxidation reactions of fuel cladding in a high-density spent fuel pool if water is lost from the pool. Hereafter, for simplicity, this event is referred to as a "pool fire".[5] In examining the potential for a pool fire, I identified partial loss of water as a more severe condition than total loss of water. I identified a variety of events that could cause a loss of water from a pool, including aircraft crash, sabotage, terrorism and acts of war. Also, I identified and described alternative fuel storage options with lower risk; these lower-risk options included design features such as spatial separation, natural cooling and underground vaults. The Lower Saxony government accepted my findings about the risk of a pool fire, and ruled in May 1979 that high-density pool storage of spent fuel was not an acceptable option at Gorleben. As a direct result, policy throughout Germany has been to use dry storage in casks, rather than high-density pool storage, for away-from-reactor storage of spent fuel.

(II-7) My work has also influenced decisionmaking by safety officials in the U.S. Department of Energy (DOE). During the period 1986-1991, I was commissioned by environmental groups to assess the safety of the military production reactors at the Savannah River Site, and to identify and assess alternative options for the production of tritium for the US nuclear arsenal. Initially, much of the relevant information was classified or otherwise inaccessible to the public. Nevertheless, I addressed safety issues through analyses that were recognized as accurate by nuclear safety officials at DOE. I eventually concluded that the Savannah River reactors could not meet the safety objectives set for them by DOE.[6] DOE subsequently reached the same conclusion, and scrapped the reactors. The current national policy for tritium production is to employ commercial reactors, an option that I had concluded was technically attractive but problematic from the perspective of nuclear weapons proliferation.

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[4] Jan Beyea, Yves Lenoir, Gene Rochlin and Gordon Thompson (subgroup chair), Report of the Gorleben International Review, Chapter 3: Potential Accidents and their Effects, submitted (in German) to the Government of Lower Saxony, March 1979.

[5] At water-cooled reactors, such as the Indian Point Unit 2 and Unit 3 reactors, the fuel cladding is made from a zirconium alloy that can enter into a vigorous exothermic oxidation reaction with either air or steam. For simplicity, this reaction can be referred to as a "fire".

[6] Gordon Thompson and Steven C Sholly, No Restart for K Reactor (Cambridge, Massachusetts: Institute for Resource and Security Studies, October 1991).

(II-8) In 1977, and again during the period 1996-2000, I examined the safety of nuclear fuel reprocessing and liquid high-level radioactive waste management facilities at the Sellafield site in the UK. My investigation in the latter period was supported by consortia of local governments in Ireland and the UK, and I presented my interim findings at briefings in the UK and Irish parliaments in 1998. I identified safety issues that were not addressed in any publicly available literature about the Sellafield site.[7] As a direct result of my investigation, the UK Nuclear Installations Inspectorate (NII) required the operator of the Sellafield site -- British Nuclear Fuels (BNFL) -- to conduct extensive safety analyses. These analyses confirmed the significance of the safety issues that I had identified, and in January 2001 the NII established a legally binding schedule for reduction of the inventory of liquid high-level radioactive waste at Sellafield.[8] The NII took this action in recognition of the grave offsite consequences of a release to the environment from the tanks in which liquid high-level waste is stored. I had identified a variety of events that could cause such a release, including acts of malice or insanity.

(II-9) In May 2000 I completed a study for Greenpeace International on the hazard potential of the La Hague site in France.[9] Nuclear fuel reprocessing and related activities are conducted at this site. The operator of the site -- COGEMA -- is authorised to store 14,000 tonnes of spent fuel in high-density pools at La Hague, and proposes to increase the capacity of these pools to 17,600 tonnes. My study described the potential for a pool fire at La Hague, and identified events -- including acts of malice or insanity -- that could lead to a pool fire. One of the findings of my study was that neither COGEMA nor the French government had a thorough understanding of La Hague's hazard potential, including the potential for a pool fire. Subsequent to the terrorist events of 11 September 2001 in New York and Washington, media exposure brought La Hague's hazard potential to the attention of the French government. During October 2001 the French government deployed anti-aircraft missiles at La Hague.

(II-10) As stated in paragraph II-6, I determined in the period 1978-1979 that partial loss of water from a high-density spent fuel pool is a more severe condition than total loss of water. This is because convective heat transfer is suppressed by the presence of residual water at the base of the fuel assemblies. During any scenario for loss of water

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[7] Gordon Thompson, High Level Radioactive Liquid Waste at Sellafield: Risks, Alternative Options and Lessons for Policy (Cambridge, Massachusetts: Institute for Resource and Security Studies, June 1998).

[8] Nuclear Installations Inspectorate, "Specification Issued under Licence Condition 32(4) for the Limitation of the Accumulation or Storage of Liquid High Level Radioactive Waste in B215. Licence Instrument 343. January 2001."

[9] Gordon Thompson, Hazard Potential of the La Hague Site: An Initial Review (Cambridge, Massachusetts: Institute for Resource and Security Studies, May 2000).

from a spent fuel pool, there will be a period of time during which residual water is present. As a result, comparatively old fuel -- potentially including fuel aged 10 or more years after discharge from a reactor -- can ignite if water is lost from a high-density spent fuel pool. The NRC Staff failed, for more than two decades, to understand this point. An illustration of the Staff's lack of understanding was provided by its statements during a license amendment proceeding in regard to the expansion of spent fuel pool capacity at the Harris nuclear power plant. I served as an expert witness for Orange County, North Carolina, the intervenor in this proceeding. In filings during March and April 2000, the Staff repeatedly disparaged my statements that comparatively old fuel can ignite. A few months later, however, the Staff adopted my position. In a report dated October 2000, but not published until January 2001, the Staff recognized that the flow of air to exposed fuel assemblies could be blocked by the presence of collapsed structures -- which might be attributable, for example, to a cask drop or an earthquake -- or by the presence of residual water.[10] The Staff analyzed the heat transfer implications of flow blockage and concluded:[11]

> "While the February 2000 [draft] study indicated that for the cases analyzed a required decay time of 5 years would preclude a zirconium fire, the revised analyses show that it is not feasible, without numerous constraints, to define a generic decay heat level (and therefore decay time) beyond which a zirconium fire is not physically possible."

(II-11) On numerous occasions, I have drawn attention in my writings and oral presentations to the vulnerability of nuclear facilities to acts of malice or insanity. I have pointed out that PRAs do not address acts of malice or insanity, with the result that a PRA can, at best, provide a lower bound to the probability of a release of radioactive material.[12] In 1996 I wrote a generic report on war and terrorism as risk factors for nuclear power plants.[13] Among other findings, this report noted that an act of war or terrorism at a nuclear power plant might have as its primary target the spent fuel stored at the plant, rather than the reactor. The report concluded with a statement that supports Riverkeeper's concern about the threat of a terrorist attack at Indian Point. My statement was:

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[10] Timothy Collins et al (authors are all from the NRC Staff), Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants, October 2000.

[11] Ibid, page 2-1.

[12] The strengths and weaknesses of PRA methodology are discussed in Hirsch et al, August 1989 (op cit).

[13] Gordon Thompson, War, Terrorism and Nuclear Power Plants (Canberra: Peace Research Centre, Australian National University, October 1996).

"Public debate about the future operation of existing nuclear power plants, and the construction of new plants, should be broadened to encompass the possible involvement of nuclear plants in war or terrorism."

III. THE INDIAN POINT NUCLEAR POWER STATION

(III-1) The Indian Point nuclear power station has three units, all owned by Entergy. Unit 1 had a rated power of 590 MW (thermal) and operated from 1962 to 1974.[14] Unit 2 has a rated power of 2,760 MW (thermal), commenced operating in 1974, and remains operational. Unit 3 has a rated power of 2,760 MW (thermal), commenced operating in 1976, and remains operational. Unit 2 and Unit 3 each employ a four-loop Westinghouse pressurised-water reactor (PWR) with a large, dry containment. The reactor cores of Unit 2 and Unit 3 each contain 193 fuel assemblies.[15]

(III-2) Unit 2 and Unit 3 are each equipped with one spent fuel pool. The capacity of the Unit 2 pool is 1,374 fuel assemblies, while the capacity of the Unit 3 pool is 1,345 fuel assemblies.[16] It can be assumed that both pools employ high-density racks. As of November 1998, the Unit 2 pool contained 917 fuel assemblies, while the Unit 3 pool contained 672 fuel assemblies.[17] It is likely that the pool inventories have increased since November 1998.

(III-3) The inventory of cesium-137 in a nuclear facility is a useful indicator of the potential, long-term consequences of a release of radioactive material from that facility. Cesium-137 is a radioactive isotope with a half-life of 30 years. This isotope accounts for most of the offsite radiation exposure that is attributable to the 1986 Chernobyl reactor accident, and for about half of the radiation exposure that is attributable to fallout from nuclear weapons tests in the atmosphere.[18] Cesium is a volatile element that would be liberally released during a pool fire. An NRC study has concluded that a generic estimate of the release fraction of cesium isotopes during a pool fire -- that is, the fraction of the pool's inventory of cesium isotopes that would reach the atmosphere

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[14] T J Thompson and J G Beckerley (editors), The Technology of Nuclear Reactor Safety, Volume 2 (Cambridge, Massachusetts: MIT Press, 1973), Table 4-1.
[15] Jay R Larson, Systems Analysis Handbook, NUREG/CR-4041 (Washington, DC: NRC, November 1985), Table A-2.
[16] US Nuclear Regulatory Commission, "Reactor Spent Fuel Storage", table downloaded from NRC Web site, 30 May 2001.
[17] Ibid.
[18] US Department of Energy, Health and Environmental Consequences of the Chernobyl Nuclear Power Plant Accident, DOE/ER-0332 (Washington, DC: DOE. June 1987).

-- is 100 percent.[19] It is reasonable to assume such a high release fraction because cesium is volatile, because a fire in a high-density pool, once initiated, would eventually involve all of the fuel in the pool, and because pool buildings are not designed as containment structures.

(III-4) The inventory of cesium-137 in the Indian Point pools can be readily estimated. Three parameters govern this estimate -- the number of spent fuel assemblies, their respective burnups, and their respective ages after discharge. I have conducted such an estimate, assuming a representative, uniform burnup of 46 GW-days per tonne. The results are provided in the following paragraph.

(III-5) The 917 fuel assemblies that were in the Unit 2 pool in November 1998 now contain about 42 million Curies (460 kilograms) of cesium-137. The 672 fuel assemblies that were in the Unit 3 pool in November 1998 now contain about 31 million Curies (350 kilograms) of cesium-137. Additional amounts of cesium-137 would be present in any fuel assemblies that have been added to these pools since November 1998. The cores of the Indian Point Unit 2 and Unit 3 reactors each contain about 6 million Curies (67 kilograms) of cesium-137.

(III-6) For comparison with the inventory estimates in paragraph III-5, note that the Chernobyl reactor accident of 1986 released about 2.4 million Curies (27 kilograms) of cesium-137 to the atmosphere. That release represented 40 percent of the Chernobyl reactor core's inventory of 6 million Curies (67 kg) of cesium-137.[20] Also, atmospheric testing of nuclear weapons led to the deposition of about 20 million Curies (220 kilograms) of cesium-137 across the land and water surfaces of the Northern Hemisphere.[21]

IV. REACTOR ACCIDENTS AND POOL FIRES: A GENERIC DISCUSSION

(IV-1) Nuclear reactors around the world have experienced a number of accidents, including the 1979 Three Mile Island accident and the 1986 Chernobyl accident. For reactors such as the PWRs at Indian Point Units 2 and 3, there has been a three-decade analytic effort, drawing from operating experience and supported to some extent by experiments, to estimate the probabilities and characteristics of potential future

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[19] V L Sailor et al, Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82, NUREG/CR-4982 (Washington, DC: NRC, July 1987).

[20] Allan S Krass, Consequences of the Chernobyl Accident (Cambridge, Massachusetts: Institute for Resource and Security Studies, December 1991).

[21] US Department of Energy, June 1987 (op cit).

accidents. A probabilistic risk assessment (PRA) for a particular reactor can use the analytic techniques and knowledge that have been developed through this effort, in order to estimate the probabilities and offsite consequences of potential accident scenarios at that reactor. The state of the PRA art is exemplified by NUREG-1150, a study that was performed by the NRC.[22]

(IV-2) PRAs, such as NUREG-1150, consider a variety of types of accident-initiating event. These types of event include equipment failure, operator error and natural hazards (e.g., an earthquake). Explosions and aircraft impacts have been considered in some PRAs. However, PRAs have not considered acts of malice or insanity, such as the deliberate crash of a commercial aircraft on a nuclear power station. This omission means that PRAs have underestimated the probability of reactor accidents. It also means that PRAs have failed to identify accident scenarios that could arise from acts of malice or insanity, but not from other causative events. Note that I am using the word "accident" to encompass any scenario, including a scenario initiated by an act of malice or insanity, that leads to a substantial release of radioactive material to the environment.

(IV-3) In the 1970s, the spent fuel pools of US nuclear power stations were typically equipped with low- or medium-density, open-frame racks. If water were partially or totally lost from such a pool, air or steam could circulate freely throughout the racks, providing cooling to the spent fuel. By contrast, high-density racks -- such as those I assume to be now employed in the Indian Point Unit 2 and Unit 3 pools -- have a closed structure. To suppress criticality, each fuel assembly is surrounded by solid, neutron-absorbing panels, and there is little or no gap between the panels of adjacent cells. This configuration allows only one mode of circulation of air and steam around a fuel assembly -- vertically upward within the confines of the neutron-absorbing panels.

(IV-4) If water is totally lost from a high-density pool, air will pass downward through available gaps such as the gap between the pool wall and the outer faces of the racks, will travel horizontally across the base of the pool, will enter each rack cell through a hole in its base, and will rise upward within the cell, providing cooling to the spent fuel assembly in that cell. If the fuel has been discharged from the reactor comparatively recently, the flow of air may be insufficient to remove all of the fuel's decay heat. In that case, the temperature of the fuel cladding may rise to the point where a self-sustaining, exothermic oxidation reaction with air will begin. In simple terms, the fuel cladding -- which is made of zirconium alloy -- will begin to burn. The zirconium alloy cladding can also enter into a self-sustaining, exothermic oxidation reaction with steam.

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[22] US Nuclear Regulatory Commission, Severe Accident Risks: An Assessment for Five US Nuclear Power Plants, NUREG-1150 (Washington, DC: NRC, December 1990).

Other exothermic oxidation reactions can also occur in a pool if water is lost. For simplicity, the occurrence of one or more of the possible reactions is referred to here as a "pool fire".

(IV-5) In many scenarios for loss of water from a pool, the flow of air that is described in paragraph IV-4 will be blocked. For example, an earthquake or the drop of a shipping cask may distort rack structures, thereby blocking air flow. Alternatively, an earthquake, aircraft impact or explosion may cause objects -- for example, the roof of the fuel handling building -- to fall into the pool, leading to a blockage of air flow. The presence of residual water in the bottom of the pool would also block air flow. In most scenarios for loss of water, residual water will be present for significant periods of time. Blockage of air flow, for whatever reason, will lead to ignition of fuel that has been discharged from a reactor for long periods -- potentially 10 years or longer.[23] The NRC Staff failed to understand this point for more than two decades (see paragraph II-10).

(IV-6) The NRC Staff has prepared or sponsored a number of generic, technical studies related to the potential for a pool fire. The first of these studies was conducted for the Staff by Sandia Laboratories in 1979.[24] The most recent was a Staff study, dated October 2000 but published in January 2001, that addressed the risk of a pool fire at a nuclear power station undergoing decommissioning.[25] In a February 1999 report for Orange County, North Carolina, I reviewed some of the Staff analyses conducted prior to February 1999.[26] I reviewed the Staff's October 2000 study in comments submitted to the NRC Commissioners in February 2001.[27]

(IV-7) Technical documents related to the potential for a pool fire were generated in the course of a license amendment proceeding (see paragraph II-10) in regard to the expansion of spent fuel pool capacity at the Harris nuclear power station. I prepared a report for Orange County, the intervenor in this proceeding.[28] The NRC Staff's

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[23] The role of residual water in promoting ignition of old fuel is discussed in: Gordon Thompson, Risks and Alternative Options Associated with Spent Fuel Storage at the Shearon Harris Nuclear Power Plant (Cambridge, Massachusetts: Institute for Resource and Security Studies, February 1999), Appendix D.

[24] Allan S Benjamin et al, Spent Fuel Heatup Following Loss of Water During Storage, NUREG/CR-0649 (Washington, DC: NRC, March 1979).

[25] Collins et al, October 2000 (op cit).

[26] Thompson. February 1999 (op cit), Appendix D.

[27] Gordon Thompson, Comments on the NRC Staff's Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants (Cambridge, Massachusetts: Institute for Resource and Security Studies, 19 February 2001).

[28] Gordon Thompson, The Potential for a Large, Atmospheric Release of Radioactive Material from Spent Fuel Pools at the Harris Nuclear Power Plant: The Case of a Pool Release Initiated by a Severe Reactor Accident (Cambridge, Massachusetts: Institute for Resource and Security Studies, 20 November 2000).

principal technical document was an affidavit by members of the Staff.[29] The principal technical document proffered by the licensee -- Carolina Power and Light (CP&L) -- was a document prepared by ERIN Engineering.[30] Each of these documents was limited in scope, in the sense that the Atomic Safety and Licensing Board (ASLB) had ordered the three parties to confine their analyses to a single scenario for a pool fire.[31] In the postulated scenario, a severe accident at the Harris reactor would contaminate the Harris site with radioactive material to an extent that would preclude actions needed to supply cooling and makeup to the Harris pools. The Harris station has one reactor and four pools. Two pools were in use at high density prior to the proceeding, and the proceeding addressed the activation of the two remaining pools, also at high density.

(IV-8) In its October 2000 report (see paragraph II-10), the NRC Staff conceded that comparatively long-discharged fuel can ignite in the event of water loss from a high-density pool. In the Harris proceeding, the Staff made the same concession. Staff members stated that loss of water from pools containing fuel aged less than 5 years "would almost certainly result in an exothermic reaction", and also stated: "Precisely how old the fuel has to be to prevent a fire is still not resolved."[32] The Staff assumed -- conservatively, in its view -- that a fire would be inevitable if the water level fell to the top of the racks.[33] Thus, the Staff has conceded that the potential for a pool fire is equivalent to the potential for a loss of water down to the top of the racks.

(IV-9) Partial or total loss of water from a spent fuel pool could occur through leakage, evaporation, siphoning, pumping, displacement by objects falling into the pool, or overturning of the pool. These modes of loss of water could arise from events, alone or in combination, that include: (a) acts of malice or insanity by persons within or outside the station boundary; (b) an aircraft impact, with or without an accompanying fuel-air explosion or fire; (c) an earthquake; (d) dropping of a fuel transfer cask or shipping cask; (e) a severe accident at a nearby reactor or spent fuel pool which, through the spread of radioactive material and other influences, precludes the ongoing provision of cooling and/or water makeup to the affected pool; and (f) an explosion inside or outside the station buildings.

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[29] ASLBP No. 99-762-02-LA, "Affidavit of Gareth W Parry, Stephen F LaVie, Robert L Palla and Christopher Gratton in Support of NRC Staff Brief and Summary of Relevant Facts, Data and Arguments upon which the Staff Proposes to Rely at Oral Argument on Environmental Contention EC-6", 20 November 2000.

[30] ERIN Engineering and Research Inc, "Technical Input for Use in the Matter of Shearon Harris Spent Fuel Pool Before the Atomic Safety and Licensing Board (Docket No. 50-400-LA)", November 2000.

[31] ASLBP No. 99-762-02-LA, "Memorandum and Order (Ruling on Late-Filed Environmental Contention)", 7 August 2000.

[32] Parry et al, November 2000 (op cit), paragraph 29.

[33] Ibid, paragraphs 29 and 124.

(IV-10) Neither the NRC nor any other entity has performed a study (of the potential for a pool fire) that addresses all of the modes of water loss and causative events that are mentioned in paragraph IV-9. Such a study could be performed by extending the analytic techniques that are currently available in the field of PRA. A credible study would consider all of the modes of loss of water from a pool that are mentioned in paragraph IV-9, all of the events that could cause a loss of water that are mentioned in paragraph IV-9, and all physically realisable combinations of causative events and modes of water loss. The study would not be credible if it arbitrarily considered only a subset of the physically realisable combinations of causative events and modes of water loss.[34] Moreover, a credible study would differ from current PRA practice in that it would consider causative events -- including acts of malice and insanity -- for which the estimation of probability has been regarded as difficult or impossible. If a credible, numerical estimate of the probability of a causative event cannot be made, the foreseeability of that event should be addressed through qualitative analysis.

(IV-11) Various studies prepared by or sponsored by the NRC Staff have addressed selected scenarios for a loss of water from a spent fuel pool. For example, a Staff study -- NUREG-1353 -- has drawn upon other literature to provide a generic estimate that the probability of a loss of water from the dropping of a shipping cask is 3.1 per 100 million reactor-years.[35] This estimate assumes that the conditional probability of a loss of water, given the dropping of a cask, is 0.1, with an uncertainty range of 0.01 to 1.0. Acts of malice or insanity are not considered. An alternative formulation of this estimate would be that the probability (per reactor-year) of water loss from a cask drop = [3.1 per 1,000 million to 3.1 per 10 million] + [(0.01 to 1.0) x (the probability that a cask will drop due to an act of malice or insanity)]. In simpler terms, arranging for the drop of a cask could be an option that appeals to a malicious or insane person.

(IV-12) NUREG-1353 also provides an estimate that the probability of a loss of water from a pool due to aircraft impact is 6.0 per 1,000 million reactor-years as a best estimate, with an upper bound of 2.0 per 100 million reactor-years.[36] The same numbers are provided elsewhere in NUREG-1353 as the "hit frequency" of aircraft impact.[37] Thus, NUREG-1353 assumes that the conditional probability of a loss of water from a spent fuel pool, given an aircraft impact, is 1.0 (100 percent). This assumption may have

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[34] The ASLB in the Harris proceeding ordered the parties to analyse only one scenario for water loss from the Harris pools (see paragraph IV-7). Such an arbitrary limitation of the scope of a study guarantees that its findings will provide, at best, a lower bound to the potential for a pool fire.

[35] E D Throm, Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools", NUREG-1353 (Washington, DC: NRC, April 1989), page 4-14.

[36] Ibid, Table 4.7.1 (at page 4-36).

[37] Ibid, page 4-14.

been made thoughtlessly, because NRC analyses typically give little attention to threats that are judged to have very low probability.

(IV-13) The NRC Staff's October 2000 report includes a crude, generic analysis of the conditional probability that aircraft impact will cause a loss of water from a spent fuel pool.[38] The pool is assumed to have a 5-ft-thick reinforced concrete wall. Impacting aircraft are divided into the categories "large" (weight more than 5.4 tonnes) and "small" (weight less than 5.4 tonnes). The Staff estimates that the conditional probability of penetration of the pool wall by a large aircraft is 0.45, and that 50 percent of penetration incidents involve a loss of water which exposes fuel to air. Thus, the Staff estimates that, for impact of a large aircraft, the conditional probability of a loss of water sufficient to initiate a pool fire is 0.23 (23 percent).

(IV-14) The abovementioned Harris proceeding considered a pool fire scenario (see paragraph IV-7) in which the release of radioactive material during a reactor accident precludes actions that are needed to provide cooling and makeup to spent fuel pools. My analysis found that the minimum value for the best estimate of a pool fire, for this scenario, is 1.6 per 100 thousand reactor-years. This estimate did not account for acts of malice, degraded standards of plant operation, or gross errors in design, construction or operation.[39] The NRC Staff estimated, for the same scenario, that the probability of a pool fire is on the order of 2 per 10 million reactor-years.[40] The ASLB accepted the Staff's estimate, thereby concluding that the postulated scenario is "remote and speculative", and terminated the proceeding.[41] In another declaration, I have described numerous deficiencies in the ASLB's ruling.[42]

(IV-15) The Harris fuel handling building contains four pools. In the Harris proceeding, the NRC Staff stated its view that the onset of a pool fire in two of the pools would preclude the provision of cooling and makeup to the other two pools.[43] This view was not supported by any analysis or rationale. ERIN Engineering, on behalf of CP&L, expressed the opinion: "The consequences of loss of water inventory in pools A and B could in turn adversely impact both access and further prevention actions related

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[38] Collins et al, October 2000 (op cit), page 3-23 and Appendix 2D.
[39] Thompson, November 2000 (op cit), page 43.
[40] Parry et al, November 2000 (op cit), paragraph 251.
[41] ASLBP No. 99-762-02-LA, "Memorandum and Order (Denying Request for Evidentiary Hearing and Terminating Proceeding)", 1 March 2001.
[42] US Court of Appeals for the District of Columbia Circuit, No. 01-1246, "Declaration of 31 May 2001 by Dr Gordon Thompson in Support of Orange County's Stay Motion".
[43] Parry et al, November 2000 (op cit), paragraph 29.

to pools C and D."[44] Again, this opinion was not supported by any analysis or rationale. It seems clear, however, that the Staff and ERIN Engineering are in agreement with one of my findings, which was based on analysis. My finding was that the onset of a fire in one or more pools would, through the creation of radioactive contamination of the site and other influences, preclude the provision of cooling and makeup to nearby pools, thereby leading to the onset of fires in the nearby pools.[45]

(IV-16) The observations set forth in the preceding paragraphs of Section IV lead to at least five broad, generic conclusions about reactor accidents and pool fires. First, the probabilities and characteristics of potential reactor accidents have been estimated through PRAs. Second, PRAs have not considered acts of malice or insanity, and therefore provide an incomplete picture of accident risk. Third, a variety of events, including acts of malice or insanity, could lead to a loss of water from a spent fuel pool, thereby initiating a pool fire. Fourth, the potential for pool fires has not been subjected to the depth of analysis that has been devoted to the potential for reactor accidents. Fifth, NRC documents indicate that a pool fire could be readily initiated by a range of events including the drop of a fuel cask, an aircraft impact, or a fire at a nearby pool.

V. ACTS OF MALICE OR INSANITY AT NUCLEAR FACILITIES: A GENERIC DISCUSSION

(V-1) For two decades or more it has been clear to many people that nuclear power stations and other nuclear facilities are potential targets of acts of malice or insanity, including highly destructive acts. The NRC has repeatedly rebuffed suggestions by members of the public that this threat be given the depth of analysis that would be expected, for example, in an environmental impact statement (EIS). This history is illustrated by a September 1982 ruling by the ASLB in the operating license proceeding for the Harris station. The intervenor, Wells Eddleman, had proffered a contention alleging, in part, that the station's safety analysis was deficient because it did not consider the "consequences of terrorists commandeering a very large airplane.....and diving it into the containment." In rejecting this contention the ASLB stated:[46]

> "This part of the contention is barred by 10 CFR 50.13. This rule must be read in pari materia with 10 CFR 73.1(a)(1), which describes the "design basis threat" against which commercial power reactors are required to be protected. Under that provision, a plant's security plan must be designed to cope with a violent

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[44] ERIN Engineering, November 2000 (op cit), page 2-36.

[45] Thompson, November 2000 (op cit), page 40.

[46] Carolina Power and Light Co. (Shearon Harris Nuclear Power Plant, Units 1 and 2), LBP-82-119A, 16 NRC 2069, 2098 (1982), (emphasis in original).

external assault by "several persons," equipped with light, portable weapons, such as hand-held automatic weapons, explosives, incapacitating agents, and the like. Read in the light of section 73.1, the principal thrust of section 50.13 is that military style attacks with heavier weapons are not a part of the design basis threat for commercial reactors. Reactors could not be effectively protected against such attacks without turning them into virtually impregnable fortresses at much higher cost. Thus Applicants are not required to design against such things as artillery bombardments, missiles with nuclear warheads, or kamikaze dives by large airplanes, despite the fact that such attacks would damage and may well destroy a commercial reactor."

(V-2) In the statement quoted in paragraph V-1, the ASLB correctly described the design basis for US nuclear power stations. However, other design bases are possible. In the early 1980s the reactor vendor ASEA-Atom developed a preliminary design for an "intrinsically safe" commercial reactor known as the PIUS reactor. The design basis for the PIUS reactor included events such as equipment failures, operator errors and earthquakes, but also included: (a) takeover of the plant for one operating shift by knowledgeable saboteurs equipped with large amounts of explosives; (b) aerial bombardment with 1,000-pound bombs; and (c) abandonment of the plant by the operators for one week.[47] It seems likely that this design basis would also provide protection against the impact of a large, fuel-laden aircraft. Clearly, ASEA-Atom foresaw a world in which acts of malice could pose a significant threat to nuclear power stations.

(V-3) There is a rich history of events which shows that acts of malice pose a significant threat to nuclear power stations around the world. Many of these events, up to 1996, are summarised in a report that I prepared.[48] Consider some examples. Nuclear stations under construction in Iran were repeatedly bombed from the air by Iraq in the period 1984-1987. Yugoslav Air Force fighters made a threatening overpass of the Krsko nuclear station in Slovenia -- which was operating at the time -- a few days after Slovenia declared independence in 1991. So-called research reactors in Iraq were destroyed by aerial bombing by Israel in 1981 and by the United States in 1991. In 1987, Iranian radio threatened an attack by unspecified means on US nuclear stations if the United States attacked launch sites for Iran's Silkworm antiship missiles. Bombs damaged reactors under construction in Spain in 1977 and in South Africa in 1982. Antitank missiles struck and penetrated the containment of a nuclear station under construction in France in 1982. North Korean commandos were killed while attempting

[47] K Hannerz, Towards Intrinsically Safe Light Water Reactors (Oak Ridge, Tennessee: Institute for Energy Analysis, February 1983).
[48] Thompson, October 1996 (op cit).

to come ashore near a South Korean station in 1985. These and other events illustrate the "external" threat to nuclear power stations. Numerous crimes and acts of sabotage by plant personnel illustrate the "internal" threat.

(V-4) The threat posed to nuclear stations by truck bombs became clearly apparent from an October 1983 attack on a US Marine barracks in Beirut. In a suicide mission, a truck was driven at high speed past a guard post and into the barracks. A gas-boosted bomb on the truck was detonated with a yield equivalent to about 5 tonnes of TNT, destroying the building and killing 241 Marines. In April 1984 a study by Sandia National Laboratories titled "Analysis of Truck Bomb Threats at Nuclear Facilities" was presented to the NRC. According to an NRC summary:[49] "The results show that unacceptable damage to vital reactor systems could occur from a relatively small charge at close distances and also from larger but still reasonable size charges at large setback distances (greater than the protected area for most plants)." Eventually, in 1994, the NRC introduced regulations that require licensees to install defenses (gates, barriers, etc.) against vehicle bombs. The NRC was spurred into taking this action by two incidents in February 1993. In one incident, a vehicle bomb was detonated in a parking garage under the World Trade Center in New York. In the other incident, a man recently released from a mental hospital crashed his station wagon through the security gate of the Three Mile Island nuclear stations and rammed the vehicle under a partly-opened door in the turbine building.

(V-5) The threat of suicidal aircraft attack on symbolic or high-value targets became clearly apparent from three incidents in 1994.[50] In April 1994 a Federal Express flight engineer who was facing a disciplinary hearing was travelling as a passenger on a company DC-10. He stormed the cockpit, severely wounded all three members of the crew with a hammer, and tried to gain control of the aircraft. The crew regained control with great difficulty. Federal Express employees said that the flight engineer was planning to crash into a company building. In September 1994 a lone pilot crashed a stolen single-engine Cessna into the grounds of the White House, just short of the President's living quarters. In December 1994 four Algerians hijacked an Air France Airbus 300, carrying 20 sticks of dynamite. The aircraft landed in Marseille, where the hijackers demanded that it be given a large fuel load -- three times more than necessary for the journey -- before flying to Paris. Troops killed the hijackers before this plan could be implemented. French authorities determined that the hijackers planned to explode the aircraft over Paris or crash it into the Eiffel Tower.

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[49] T A Rehm, memo to the NRC Commissioners, "Weekly Information Report -- Week Ending April 20, 1984".

[50] Matthew L Wald, "US Failed to Learn From Earlier Hijackings", International Herald Tribune, 4 October 2001, page 6.

(V-6) The incident described in paragraph V-5 involving the Federal Express flight engineer illustrates the vulnerability of industrial systems, including nuclear stations, to "internal" threats. That vulnerability is further illustrated by a number of incidents. In December 2000, Michael McDermott killed seven coworkers in a shooting rampage at an office building in Massachusetts. He had worked at the Maine Yankee nuclear station from 1982 to 1988 as an auxiliary operator and operator before being terminated for exhibiting unstable behavior.[51] In 1997, Carl Drega of New Hampshire stockpiled weapons and killed four people -- including two state troopers and a judge -- on a suicide mission. He had passed security clearances at three nuclear power stations in the 1990s.[52] In October 2000 a former US Army sergeant pleaded guilty to assisting Osama bin Laden in planning the bombing of the US embassy in Nairobi, which occurred in 1998.[53] In June 1999, a security guard at the Bradwell nuclear station in Britain hacked into the plant's computer system and wiped out records. It emerged that he had never been vetted and had two undisclosed criminal convictions.[54] These and other incidents demonstrate clearly that it is foolish to ignore or downplay the "internal" threat of acts of malice or insanity at nuclear stations.

(V-7) The events mentioned in the preceding paragraphs occurred against a background of numerous acts of terrorism around the world. Many of these acts have been highly destructive. US facilities have been targets on many occasions, as illustrated by the bombing of the US embassy in Beirut in 1983, the embassies in Nairobi and Dar es Salaam in 1998, and the USS Cole in 2000. There have been repeated warnings that the threat of terrorism is growing and could involve the US homeland. For example, three authors with high-level government experience have written:[55]

> Long part of the Hollywood and Tom Clancy repertory of nightmarish scenarios, catastrophic terrorism has moved from far-fetched horror to a contingency that could happen next month. Although the United States still takes conventional terrorism seriously, as demonstrated by the response to the attacks on its embassies in Kenya and Tanzania in August, it is not yet prepared for the new threat of catastrophic terrorism.

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[51] Anne Barnard and Ross Kerber, "Web posting tells of suspect's firing from Maine plant", The Boston Globe, 5 January 2001, page A12.
[52] Ibid.
[53] John J Goldman, "Former sergeant admits role in bombings of US embassies", The Boston Globe, 21 October 2000, page A2.
[54] Kevin Maguire, "Security checks tightened after high-level alert", The Guardian, 9 January 2001.
[55] A Carter, J Deutch and P Zelikow, "Catastrophic Terrorism", Foreign Affairs, November/December 1998, page 80.

(V-8) A few years ago the US Department of Defense established an advisory commission on national security in the 21st century. This commission -- often known as the Hart-Rudman commission because it was co-chaired by former Senators Gary Hart and Warren Rudman -- issued reports in September 1999, April 2000 and March 2001. The findings in the September 1999 report included the following:[56]

> "America will become increasingly vulnerable to hostile attack on our homeland, and our military superiority will not entirely protect us..............States, terrorists and other disaffected groups will acquire weapons of mass destruction and mass disruption, and some will use them. Americans will likely die on American soil, possibly in large numbers."

(V-9) From the preceding paragraphs in Section V it is clear that the potential for acts of malice or insanity at nuclear power stations -- including highly destructive acts -- has been foreseeable for many years, and has been foreseen. However, the terrorist attacks on the World Trade Center and the Pentagon on 11 September 2001 provided significant new information. These attacks conclusively demonstrated that the threat of highly-destructive acts of malice or insanity is a clear and present danger, and that no reasonable person can regard this threat as remote or speculative. According to recent press reports, US authorities possess information suggesting that the hijackers of United Airlines flight 93, which crashed in Pennsylvania on 11 September 2001, were planning to hit a nuclear station.[57] This may be true or false, or the truth may never be known. Whatever the truth is, it would be foolish to regard nuclear stations as immune from attack.

(V-10) The NRC Staff has conceded that it cannot provide a quantitative assessment of the probability of an act of malice at a nuclear power station. In a SECY paper for the NRC Commissioners, the Staff has stated:[58]

> "The staff, as a result of its ongoing work with the Federal national security agencies, has determined that the ability to quantify the likelihood of sabotage events at nuclear power plants is not currently supported by the state-of-the-art

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[56] US Commission on National Security/21st Century, New World Coming: American Security in the 21st Century, Phase I report, 15 September 1999, page 4.

[57] Nicholas Rufford, David Leppard and Paul Eddy, "Nuclear Mystery: Crashed plane's target may have been reactor", The Sunday Times, London, 20 October 2001.

[58] William D Travers, memo to the NRC Commissioners, "Policy Issues Related to Safeguards, Insurance, and Emergency Preparedness Regulations at Decommissioning Nuclear Power Plants Storing Fuel in Spent Fuel Pools (WITS 200000126), SECY-01-0100", 4 June 2001, pp 5-6.

in PRA methods and data. The staff also believes that both the NRC and the other government stakeholders would need to conduct additional research and expend significant time and resources before it could even attempt to quantify the likelihood of sabotage events. In addition, the national security agencies, Intelligence Community, and Law Enforcement Agencies do not currently quantitatively assess the likelihood of terrorist, criminal, or other malevolent acts."

(V-11) Although the probability of a terrorist attack cannot be assessed quantitatively, it can be assessed qualitatively. From a qualitative perspective, the probability of a terrorist attack within the US homeland appears to be significantly greater in the current period than it was, for example, in the 1980s. There is now a focussed, well-organized and well-financed threat. The United States is taking military action that may provoke further attacks. This new threat environment may persist for many years.

VI. VULNERABILITY OF THE INDIAN POINT STATION

(VI-1) This Section of my declaration addresses the vulnerability of the Indian Point nuclear power station. Units 2 and 3 of the station have operational reactors with attached spent fuel pools. Unit 1 has a spent fuel storage facility. In addressing vulnerability, I focus on the potential for a large release of radioactive material to the environment, from one or more of the two operational reactors and three spent fuel storage facilities.

(VI-2) PRA studies have been performed for the Unit 2 and Unit 3 reactors. A review of these studies is beyond the scope of this declaration. However, as noted in paragraph IV-2, these studies have not considered acts of malice or insanity. As a result, they have underestimated the probability of reactor accidents, and have failed to identify accident scenarios that could arise from acts of malice or insanity but not from other causative events.

(VI-3) There has been no PRA-type study to assess the potential for, or consequences of, a spent fuel pool fire at Indian Point. For Units 2 and 3, the potential for onset of a pool fire is equivalent to the potential for loss of water from a pool. As explained in paragraph IV-8, the NRC Staff has conceded that the potential for a fire in a high-density pool is equivalent to the potential for a loss of water down to the top of the racks.

(VI-4) Modes of water loss from a pool, and events that could cause water loss, are set forth in paragraph IV-9, above. Paragraph IV-10 provides specifications for a credible study of the potential for water loss from a pool, pointing out that a credible study would: (a) consider all physically realisable combinations of causative events and modes of water loss; and (b) include acts of malice or insanity in its consideration of causative events. Any order by a licensing tribunal to limit the scope of a study of the potential for water loss, so that only some modes of water loss and some causative events are considered, would render the findings non-credible. Moreover, the ordering of such a limit would suggest that the tribunal is seeking to evade or distort the truth.

(VI-5) A thorough, credible study of the potential for water loss from the Indian Point pools would require substantial effort by a number of investigators. This declaration does not purport to be such a study. Here, I provide an illustrative discussion of some modes of water loss and some causative events. The discussion focusses on acts of malice or insanity, especially aircraft impact. This focus does not imply that other causative events are unimportant.

(VI-6) Paragraph IV-11 points out that an act of malice or insanity could lead to the drop of a shipping cask, causing a loss of water from a pool. In a report about the Harris station, I have sketched a scenario for the deliberate siphoning of water from a pool.[59] Siphoning could be accomplished by one person equipped with some thick-walled hoses.[60] After the fuel is exposed to air, a fire will begin within a few hours, as explained in paragraph VI-15. A time period sufficient for this scenario could be available if the event were successfully concealed from operators and security staff, or if the pool building were successfully seized and defended by an armed group. Either approach could be accompanied by diversionary activity elsewhere on the station site. Numerous other scenarios could be identified, whereby deliberate actions could potentially lead to a loss of water from an Indian Point pool. Each such scenario deserves detailed analysis, to determine its relevance in the Indian Point context. Detailed information about these scenarios does not necessarily belong in the public domain, as discussed in Section IX of this declaration.

(VI-7) Aircraft impact at the Indian Point site could, through a variety of mechanisms, potentially cause a reactor accident or a loss of water from a spent fuel pool. A scenario involving the hijacking of a commercial aircraft may be less likely now than it was before 11 September 2001, because the airline industry is now aware of this threat. However, according to the physicist Richard Garwin, a scenario involving a rented or stolen cargo aircraft may be no less likely than before 11 September 2001. Garwin, who has served on numerous panels advising the US government, warns that a cargo aircraft

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[59] Thompson, February 1999 (op cit), Appendix C.

[60] After the water level recedes below the effective siphoning depth, water will be lost due to evaporation. This scenario assumes an absence of pool makeup.

may be used against a nuclear plant.[61] Also, one must consider a scenario in which a licensed crew member of a passenger or cargo aircraft engages in a suicide attack. Finally, one must consider the aerial equivalent of a truck bomb, which need not require a large aircraft.

(VI-8) As indicators of the forces that could accompany an aircraft impact, consider the weights and fuel capacities of some typical commercial aircraft.[62] The Boeing 737-300 has a maximum takeoff weight of 56-63 tonnes and a fuel capacity of 20-24 thousand liters. The Boeing 747-400 has a maximum takeoff weight of 363-395 tonnes and a fuel capacity of 204-217 thousand liters. The Boeing 757 has a maximum takeoff weight of 104-116 tonnes and a fuel capacity of 43 thousand liters. The Boeing 767 has a maximum takeoff weight of 136-181 tonnes and a fuel capacity of 63-91 thousand liters.

(VI-9) Commercial jet fuel typically has a heat of combustion of about 38 MJ per liter. For comparison, 1 kilogram of TNT will yield 4.2 MJ of energy. Thus, complete combustion of 1 liter of jet fuel will yield energy equivalent to that from 9 kilograms of TNT. Complete combustion of 100 thousand liters of jet fuel -- about half the fuel capacity of a Boeing 747-400 -- will yield energy equivalent to that from 900 tonnes of TNT. Thus, the impact of a fuel-laden aircraft can lead to a violent fuel-air explosion. Fuel-air munitions have been developed that yield more than 5 times the energy of their equivalent weight in TNT, and create a blast overpressure exceeding 1,000 pounds per square inch.[63] A fuel-air explosion arising from an aircraft impact will be less efficient than a munition in converting combustion energy into blast, but could nevertheless generate a highly-destructive blast, especially if fuel vapor accumulates in a confined space before igniting.

(VI-10) The NRC Staff report NUREG-1353 assumes (see paragraph IV-12) that the impact of an aircraft on a spent fuel pool will cause a loss of water from the pool with a conditional probability of 100 percent. This assumption is not supported by analysis. The NRC Staff's October 2000 report includes a crude, generic analysis of aircraft impact (see paragraph IV-13), yielding an estimate that, for impact of a large aircraft (weight more than 5.4 tonnes), the conditional probability of a loss of water sufficient to initiate a pool fire is 0.23 (23 percent). This estimate ignores the potential for fuel-air explosions and fires. All of the typical, commercial aircraft mentioned in paragraph VI-8 weigh considerably more than 5.4 tonnes.

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[61] Richard Garwin, "The Many Threats of Terror", The New York Review, 1 November 2001, pp 16-18.

[62] Data here are from Paul Jackson (editor), Jane's All the World's Aircraft, 1996-97 (Alexandria, Virginia: Jane's Information Group, 1996).

[63] Tom Gervasi, Arsenal of Democracy (New York: Grove Press, 1977), page 177.

(VI-11) A rough indication of the vulnerability of Indian Point Units 2 and 3 to aircraft impact can be obtained from the PRA for the Seabrook station. The Seabrook station and Indian Point Units 2 and 3 all employ 4-loop Westinghouse PWRs with large, dry containments. Thus, PRA findings for Seabrook are roughly indicative of findings for Indian Point Units 2 and 3. The Seabrook PRA finds that any direct impact on the containment by an aircraft weighing more than 37 tonnes will lead to penetration of the containment and a breach in the reactor coolant circuit. Also, the Seabrook PRA finds that a similar impact on the control building or auxiliary building will inevitably lead to a core melt.[64] All of the typical, commercial aircraft mentioned in paragraph VI-8 weigh considerably more than 37 tonnes. Also, the Seabrook PRA does not consider the effects of a fuel-air explosion and/or fire as an accompaniment to an aircraft impact. Thus, one could plausibly infer from the Seabrook PRA that the impact of a typical, commercial aircraft on Indian Point Unit 2 or Unit 3 could lead to a reactor accident and/or a loss of water from a spent fuel pool, followed by a pool fire.

(VI-12) Analytic techniques are available for estimating the effects that aircraft impact will have on the structures and equipment of a nuclear power station. However, those techniques focus on the kinetic energy of the impacting aircraft. The effects of an accompanying fuel-air explosion and/or fire are given, at best, a crude analysis. A 1982 review by Argonne National Laboratory of the state of the art for aircraft impact analysis stated:[65]

> "Based on the review of past licensing experience, it appears that fire and explosion hazards have been treated with much less care than the direct aircraft impact and the resulting structural response. Therefore, the claim that these fire/explosion effects do not represent a threat to nuclear power plants has not been clearly demonstrated."

My experience in reviewing PRAs and related studies for nuclear facilities leads me to conclude that the Argonne statement remains valid today. Indeed, in view of the large amount of energy that can be liberated in a fuel-air explosion (see paragraph VI-9), I conclude that previous analyses of aircraft impacts may have grossly underestimated the vulnerability of nuclear plants to such impacts.

(VI-13) To my knowledge, there exists no thorough, credible analysis of the vulnerability of any nuclear power station to the impact of a modern commercial

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[64] Pickard, Lowe and Garrick Inc, Seabrook Station Probabilistic Safety Assessment, Main Report (Irvine, California: PLG, December 1983), pp 9.3-10 to 9.3-11.

[65] C A Kot et al, Evaluation of Aircraft Crash Hazards Analyses for Nuclear Power Plants, NUREG/CR-2859 (Washington, DC: NRC, June 1982), page 78.

aircraft. The conduct of such an analysis would be a necessary part of a review of the vulnerability of the Indian Point station. For each spent fuel pool on the site, the analysis would consider the potential for overturning of the pool, causing water to be spilled, and for the creation of a breach in the pool boundary, causing water to leak out. Also, the analysis would consider the potential for water to be displaced from the pool by blast or the falling of objects into the pool. Finally, the analysis would consider the potential for loss of water by evaporation, which would occur over a period of days if pool cooling and makeup were unavailable.

(VI-14) In the context of the spent fuel pools at the Harris plant, the NRC Staff has conceded (see paragraph IV-15) that a fire in one pool would preclude the provision of cooling and makeup to nearby pools. This situation would arise mostly because the initial fire would contaminate the site with radioactive material, generating high radiation fields. An analogous situation could arise in which the release of radioactive material from a damaged reactor precludes the provision of cooling and makeup to nearby pools. For example, an aircraft impact on the Indian Point Unit 2 or Unit 3 reactor could lead to a rapid-onset core melt with an open containment, accompanied by a raging fire. That event would create high radiation fields across the site, potentially precluding any access to the site by personnel. One can envision a variety of "cascading" scenarios, in which there might eventually be fires in the Unit 2 and Unit 3 pools at Indian Point, accompanied by core melt events at Unit 2 and Unit 3. Conceivably, a fire could also occur in the spent fuel storage facility at Unit 1, although the fuel in the Unit 1 reactor used stainless steel cladding, which is less prone to ignite than the zircalloy-clad fuel used in Units 2 and 3.[66] The potential for cascading scenarios should be carefully investigated.

(VI-15) A pool fire could begin comparatively soon after water is lost from a pool. For example, suppose that most of the length of the fuel assemblies is exposed to air, but the flow of air to the base of the racks is precluded by residual water or a collapsed structure. In that event, fuel heatup would be approximately adiabatic. Fuel discharged for 1 month would ignite in less than 2 hours, and fuel discharged for 3 months would ignite in about 3 hours. The fire would then spread to older fuel. Once a fire has begun, it could be impossible to extinguish. Spraying water on the fire would feed an exothermic zirconium-steam reaction which would generate flammable hydrogen. High radiation fields could preclude the approach of firefighters.

(VI-16) Paragraph IV-16, above, summarizes the state of knowledge about the generic potential for reactor accidents and pool fires, and identifies significant deficiencies in knowledge. These generic findings also apply to the Indian Point station, for which

[66] Thompson and Beckerley, 1973 (op cit), Table 4-1.

there is no thorough, credible analysis of the station's vulnerability. In the absence of such an analysis, one is obliged to resort to judgment. In light of the various studies and factors discussed in this declaration, my judgment is that a pool fire and/or core melt accident at Unit 2 and/or Unit 3 could be caused by a variety of potential acts of malice or insanity, including the deliberate impact of a large aircraft.

VII. OFFSITE CONSEQUENCES OF A REACTOR ACCIDENT OR POOL FIRE AT INDIAN POINT

(VII-1) Paragraph III-3 explains that cesium-137 is a useful indicator of the potential, long-term consequences of a release of radioactive material to the environment. The same paragraph shows that it is reasonable to assume that 100 percent of the cesium-137 in a spent fuel pool would be released to the atmosphere in the event of a pool fire. The cesium-137 would be released to the atmosphere in small particles that would travel downwind and be deposited on the ground and other surfaces. The deposited particles would emit intense gamma radiation, leading to external, whole-body radiation doses to exposed persons. Cesium-137 would also contaminate water and foodstuffs, leading to internal radiation doses.

(VII-2) One measure of the scope of radiation exposure attributable to deposition of cesium-137 is the area of land that would become uninhabitable. For illustration, I assume that the threshold of uninhabitability is an external, whole-body dose of 10 rem over 30 years. This level of radiation exposure, which would represent about a three-fold increase above the typical level of background (natural) radiation, was used in the NRC's 1975 Reactor Safety Study as a criterion for relocating populations from rural areas.

(VII-3) A radiation dose of 10 rem over 30 years corresponds to an average dose rate of 0.33 rem per year.[67] The health effects of radiation exposure at this dose level have been estimated by the National Research Council's Committee on the Biological Effects of Ionizing Radiations.[68] This committee has estimated that a continuous lifetime exposure of 0.1 rem per year would increase the incidence of fatal cancers in an exposed population by 2.5 percent for males and 3.4 percent for females.[69] Incidence would scale

[67] At a given location contaminated by cesium-137, the resulting external, whole-body dose received by a person at that location would decline over time, due to radioactive decay and weathering of the cesium-137. Thus, a person receiving 10 rem over an initial 30-year period would receive a lower dose over the subsequent 30 -year period.

[68] National Research Council, Health Effects of Exposure to Low Levels of Ionizing Radiation: BEIR V (Washington, DC: National Academy Press, 1990).

[69] Ibid, Table 4-2.

linearly with dose, in this low-dose region.[70] Thus, an average lifetime exposure of 0.33 rem per year would increase the incidence of fatal cancers by about 8 percent for males and 11 percent for females. About 21 percent of males and 18 percent of females normally die of cancer.[71] In other words, in populations residing continuously at the threshold of uninhabitability (an external dose rate of 0.33 rem per year), about 2 percent of people would suffer a fatal cancer that would not otherwise occur.[72] Internal doses from contaminated food and water could cause additional cancer fatalities.

(VII-4) The increased cancer incidence described in paragraph VII-3 would apply at the boundary of the uninhabitable area. Within that area, the external dose rate from cesium-137 would exceed the threshold of 10 rem over 30 years. At some locations, the dose rate would exceed this threshold by orders of magnitude. Therefore, persons choosing to live within the uninhabitable area would experience an incidence of fatal cancers at a level higher than is set forth in paragraph VII-3.

(VII-5) For a postulated release of cesium-137 to the atmosphere, the area of uninhabitable land can be estimated from calculations done by Dr Jan Beyea. My use of these calculations is described in a report that I prepared for Orange County, North Carolina.[73] Three releases of cesium-137 are postulated here, drawn from paragraph III-5. The first release is 42 million Curies, representing the fuel that was present in the Indian Point Unit 2 pool in November 1998. The second postulated release is 31 million Curies, representing the fuel that was present in the Indian Point Unit 3 pool in November 1998. (Actual, present inventories of cesium-137 in the Unit 2 and Unit 3 pools are higher than these numbers if fuel has been added since November 1998.) The third postulated release is 3 million Curies, representing 50 percent of the cesium-137 inventory in the core of the Unit 2 or Unit 3 reactor. A release fraction of 50 percent -- from the reactor core to the atmosphere -- is a reasonable assumption for certain types of severe reactor accident. Higher release fractions could occur for some accident scenarios, such as a rapid-onset core melt with an open containment.

(VII-6) For typical weather conditions, a release of 42 million Curies of cesium-137 would render about 95,000 square kilometers of land uninhabitable, while a release of 31 million Curies would render about 75,000 square kilometers uninhabitable. A release of 3 million Curies would render uninhabitable about 7,500 square kilometers.

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[70] The BEIR V committee assumed a linear dose-response model for cancers other than leukemia, and a model for leukemia that is effectively linear in the low-dose range. See National Research Council, 1990 (op cit), pp 171-176.

[71] National Research Council, 1990 (op cit), Table 4-2.

[72] For males, 0.08 x 0.21 = 0.017. For females, 0.11 x 0.18 = 0.020.

[73] Thompson, February 1999 (op cit), Appendix E.

For comparison, note that the area of New York state is 127,000 square kilometers. The use of a little imagination shows that a pool fire at Indian Point would be a regional and national disaster of historic proportions, with health, environmental, economic, social and political dimensions. The long-term consequences of a severe reactor accident could also be grave.

(VII-7) The core of an operating reactor contains short-lived radioisotopes that are not present in a spent fuel pool. Notably, the core contains tellurium isotopes with half-lives of up to 3 days, and iodine isotopes with half-lives of up to 8 days. Calculations show -- for an assumed severe reactor accident designated as the SST1 accident -- that tellurium and iodine isotopes account for 70 percent of the whole-body dose received in 1 day by a person downwind of the reactor.[74] By contrast, cesium isotopes -- principally cesium-137 -- account for 66 percent of long-term radiation exposure and cancer deaths.[75]

(VII-8) A severe reactor accident will release to the atmosphere a plume that contains telluriums, iodines and other radioisotopes. The plume will travel downwind. Persons in the path of this plume could receive high radiation doses. For example, consider the plume from a PWR2 release, one of the severe accident releases examined in the NRC's 1975 Reactor Safety Study. Calculations show that the whole-body radiation dose received in 1 day by a person who is unable to shelter or escape from the plume, assuming a windspeed of 6 miles/hr and Class D atmospheric stability, will exceed 100 rem if the person is between 2.5 and 20 miles from the reactor.[76] (In this scenario, the plume passes above persons located within 2.5 miles of the reactor.) Inability to shelter or escape could arise, for example, if a person is caught in a traffic jam.

(VII-9) A guidance document published by the US Department of Health and Human Services states:[77] "Most authorities agree that observation and treatment in a specialized hospital is indicated for whole-body exposures greater than 100 rem." The same document states that the LD 50/60 (the dose that is lethal within 60 days to 50 percent of the persons exposed) is about 450 rem.[78]

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[74] Daniel J Alpert et al, Relative Importance of Individual Elements to Reactor Accident Consequences Assuming Equal Release Fractions, NUREG/CR-4467 (Washington, DC: NRC, March 1986), page 14.
[75] Ibid.
[76] T S Margulies and J A Martin, Dose Calculations for Severe LWR Accident Scenarios, NUREG-1062 (Washington, DC: NRC, May 1984), page 36.
[77] Bernard Shleien, Preparedness and Response in Radiation Accidents (Washington, DC: US Department of Health and Human Services, August 1983), page 91.
[78] Ibid.

(VII-10) The preceding paragraphs provide some illustrative information about the potential consequences of a reactor accident. These potential consequences have been examined in great detail in a number of studies. The findings show that a variety of adverse health effects can occur, their incidence depending upon: (a) the nature of the accident; (b) weather conditions, including wind direction and speed; and (c) the ability of persons to reduce their exposure by actions such as sheltering, evacuation, respiratory protection, avoidance of contaminated food and water, and the ingestion of potassium iodide pills. Health effects can be roughly divided into two categories according to the timing of their onset. "Early" health effects are manifested over a period of days or weeks, while "late" health effects, principally cancers, are manifested years after the exposure.

VIII. OPTIONS FOR REDUCING THE VULNERABILITY OF THE INDIAN POINT STATION

(VIII-1) Populations in the vicinity of Indian Point could be protected from some of the consequences of a reactor accident by emergency response measures such as sheltering and evacuation. The effectiveness of these measures could be enhanced by increasing the scope of emergency response planning. However, emergency response measures would provide little protection from the land contamination that would arise from a reactor accident or pool fire. Also, decontamination of radioactively contaminated land and structures is difficult and expensive. Thus, the primary means of protecting populations from radiation exposure from contaminated land would be to relocate populations from the contaminated areas.

(VIII-2) In this declaration I focus on reducing the vulnerability of the Indian Point station, rather than on protecting populations from the effects of a release of radioactive material. Reducing the station's vulnerability would require the use of measures that reduce the probability and/or magnitude of a release of radioactive material as a result of a reactor accident or pool fire.

(VIII-3) Defensive measures could be taken to reduce the probability that the perpetrator of an act of malice or insanity will be able to obtain access. Measures of this kind include stronger guard forces, closer supervision of employees, vehicle barriers, no-fly zones and anti-aircraft missiles. Such measures are equally applicable to reactors and spent fuel storage facilities.

(VIII-4) Comparatively little can be done to harden the Indian Point reactors so that they are inherently more robust against acts of malice or insanity. There is, however, one option that would quickly and substantially reduce the vulnerability of the reactors.

That option would be to shut down the reactors. Their vulnerability would be reduced in two ways. First, the propensity of a reactor core to melt, if the flow of cooling water to the core is interrupted, is substantially reduced within a few hours of shutdown. Second, a reactor core's inventory of short-lived radioisotopes is substantially reduced within a few days of shutdown, thus reducing the potential incidence of early health effects and thyroid cancers in surrounding populations if an accident occurs.

(VIII-5) Practical options are available for providing more robust storage of spent fuel. In illustration, note from paragraph V-2 the design basis that was used by ASEA-Atom in developing a preliminary design for the PIUS reactor. The PIUS design basis included takeover of the plant by saboteurs, aerial bombardment, and abandonment by operators. A similar or more robust design basis could be specified for a spent fuel storage facility. Such a facility could, for example, be explicitly designed to withstand the impact of a fully-fueled Boeing 747. Meeting that requirement would not be difficult from an engineering standpoint. However, greater robustness would typically involve greater cost, and could have other implications.

(VIII-6) In examining options for storing spent fuel, the design basis for a particular storage facility is only one consideration. Other considerations include: (a) the timeframe required to implement the option; (b) whether the option involves facilities that store fuel from more than one reactor or site; (c) the extent to which the option involves transport of spent fuel between sites; (d) the closeness of storage sites to population centers; (e) security aspects of storage sites (e.g., proximity to highways, air corridors or nearby high ground); (f) the relationship of a storage option to the national strategy for long-term management of radioactive waste; and (g) cost. These and other considerations would be addressed in a credible review of options for reducing the vulnerability of the Indian Point station.

(VIII-7) Here, by way of illustration, I sketch a storage option that might be implemented at the Indian Point site. I do not recommend this option above others, but offer it as a storage option that might, upon closer examination, prove to be quickly implementable. The option would involve dry storage of spent fuel in metal casks that are robust against fire and explosion. Some of the casks that are now approved by the NRC for dry storage of spent fuel may be sufficiently robust.[79] A fuel assembly that has been discharged from the reactor comparatively recently would be stored in a low-density, open-frame rack in a pool, and would be transferred to a cask when its heat output fell to an appropriate level. Each cask would be placed on an individual concrete pad, and would be completely surrounded by a high, earth-and-gravel berm.

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[79] NRC-approved designs for dry storage of spent fuel are listed in: US Nuclear Regulatory Commission, Information Digest, NUREG-1350 (Washington, DC: NRC, annual).

(The berm would be completed after placement of the cask on its pad.) The storage facility would be surrounded by a security fence, would be guarded, and would be equipped with cameras and motion detectors. The facility would not be adjacent to the Indian Point reactors.

(VIII-8) The storage option sketched in paragraph VIII-7 would be safe against a wide variety of influences, but it would not prevent a release of radioactive material in the event of a severe attack from the air. However, the magnitude of the release could be limited. For example, the release of cesium-137 as a result of an aircraft impact might be limited to the inventory in one cask. Metal casks approved by the NRC for dry storage of PWR fuel have capacities ranging from 21 assemblies to 56 assemblies.[80] At present, as described in paragraph III-2, the Indian Point Unit 2 and Unit 3 pools contain at least 917 and 672 fuel assemblies, respectively.

(VIII-9) It would be possible to construct a spent fuel storage facility at the Indian Point site that would be more robust against attack from the air than the storage option sketched in paragraph VIII-7. Meeting this objective could require placement of spent fuel storage containers in underground vaults. An option of this kind should be included in any review of options for reducing the vulnerability of the Indian Point station.

IX. SENSITIVE INFORMATION ABOUT THE VULNERABILITY OF NUCLEAR FACILITIES

(IX-1) A perpetrator of an act of malice or insanity at a nuclear facility will typically seek information about the facility's vulnerability, before committing the act. Information of this kind could improve the perpetrator's likelihood of damaging the facility, and could increase the magnitude of the radioactive release that is caused by his act. Thus, some items of information about a facility's vulnerability to acts of malice or insanity may be inappropriate for general distribution. Hereafter, such items of information are referred to as "sensitive". In the following paragraphs of Section IX, I identify a category of information that is potentially sensitive, and I sketch a process whereby sensitive information could be managed in the context of an NRC license proceeding. None of the information in this declaration is sensitive, and the declaration is appropriate for general distribution.

(IX-2) Before considering the potential need to limit the distribution of information in the context of an NRC license proceeding, it is important to consider the countervailing need for openness. There are two powerful arguments for openness about the issues

[80] NUREG-1350 (op cit), 1998 edition, Appendix G.

that are addressed in NRC license proceedings. First, experience shows that the safety of nuclear facilities is significantly and adversely affected by a culture of secrecy. Second, secrecy about civil nuclear facilities is incompatible with democracy.

(IX-3) I have studied, observed and written about the adverse effects that a culture of secrecy has on the safety of nuclear facilities.[81] One of my findings is that the culture of secrecy in the former USSR was a major factor contributing to the occurrence of the 1986 Chernobyl reactor accident. Through direct experience, I have observed the adverse effects that a culture of secrecy has on the safety of nuclear facilities. Secrecy inhibits the development of accurate knowledge about safety problems, promotes complacency, and discourages actions that are needed to address safety problems. My direct experience has been in three contexts. In each instance, the culture of secrecy has been less intense than in the USSR, but the effects on safety have been significant and adverse. One context has been the operation of defense materials production reactors at the Savannah River site in South Carolina. The second context has been the operation of the Sellafield site in Britain. The third context has been the operation of the La Hague site in France.

(IX-4) The US nuclear industry exists to supply a commercial product -- electricity -- to the citizens of a democracy. Thus, the nuclear industry should exhibit, at a minimum, the level of openness that is expected for any industry. In addition, the operation of nuclear facilities raises significant issues related to public safety and environmental protection. Moreover, the industry's liability for damages is limited, and state governments have no power over the industry in regard to safety issues. Thus, if the operation of the nuclear industry is to be compatible with democracy, then the industry and the NRC must exhibit a level of openness that is much greater than that of other industries.

(IX-5) In light of the considerations addressed in paragraphs IX-3 and IX-4, any action to limit the distribution of information generated during the course of an NRC license proceeding must be regarded as a temporary measure under emergency conditions, and restriction of the distribution of information must be applied sparingly. The information that I define as "sensitive" is not commercially confidential information, classified information or safeguards information. Instead, it is information that would enter the public record during a normal licensing proceeding. The NRC Staff has stated that "discussion of the potential vulnerabilities of SFPs [spent fuel pools] to radiological

[81] Gordon Thompson, "Science, democracy and safety: why public accountability matters", in F Barker (editor), Management of Radioactive Wastes: Issues for local authorities (London: Thomas Telford, 1998). See also: Thompson, June 1998 (op cit), Appendix E; and Thompson, May 2000 (op cit).

sabotage is Safeguards Information (SGI)......."[82] This statement shows that the Staff uses a narrow definition of "sabotage", and does not understand the full potential for acts of malice or insanity to cause a pool fire. There are many similarities between: (a) pool fire scenarios that have been thought of as "accidents"; and (b) pool fire scenarios that are initiated by acts of malice or insanity. For example, pool fire scenarios initiated by cask drop or aircraft impact have been thought of by the Staff as "accidents", and have been examined accordingly. The Staff has never categorised information about these scenarios as safeguards information. Yet, similar scenarios could be initiated by the deliberate dropping of a cask or the deliberate impact of an aircraft.

(IX-6) If a license proceeding were to address the Riverkeeper petition that this declaration supports, the proceeding would generate a flow of information. A portion of this flow of information would relate to the potential for an act of malice or insanity to initiate a reactor accident or pool fire at Indian Point, and the consequences of such an event. All items of information that are sensitive, as defined in paragraph IX-1, would be found within this portion of the overall flow of information. Within this portion, there would be three major categories of information. The first category of information would pertain to the consequences of acts of malice or insanity. Information in this category should be generally distributed. The second category of information would pertain to the potential for acts of malice or insanity to be undertaken. For example, information about the history of terrorist events would fall into this category. Information in the second category should be generally distributed, with one possible exception. The possible exception would be detailed information about specific vulnerabilities that were exploited during past acts of malice or insanity. The third category of information would pertain to the vulnerabilities of facilities on the Indian Point site. Information in this category would be potentially sensitive. It may be appropriate to limit the distribution of some information in this category.

(IX-7) Paragraph IX-6 identifies a category of information that is potentially sensitive. The category encompasses information pertaining to the vulnerabilities of nuclear facilities. However, there is already a large body of related information in the public domain. For example, there is a large, widely-available engineering literature about explosions and aircraft impacts, in general and in the context of nuclear facilities. Limiting the distribution of such literature, in the context of a license proceeding, would be a fruitless and unnecessary exercise. Instead, efforts to identify sensitive information should focus on detailed, highly-specific information. For example, a drawing showing the precise location of a vulnerable component could be sensitive information. Judgment would have to be exercised in identifying the items of information that are

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[82] SECY-01-0100, 4 June 2001 (op cit), page 8.

sensitive. Cooperation and mutual respect among the parties to a license proceeding would make the process of identifying sensitive information go more smoothly.

(IX-8) Items of information that are determined to be sensitive would be freely available to individuals who are designated by each party to a license proceeding. Sensitive information would not be generally distributed. A separate, limited-distribution record would be made of any oral or written arguments that disclose sensitive information.

X. REQUIREMENTS FOR A CREDIBLE REVIEW OF THE VULNERABILITY OF THE INDIAN POINT STATION, AND OF OPTIONS FOR REDUCING ITS VULNERABILITY

(X-1) In 1979, the NRC published a generic EIS for the handling and storage of spent fuel.[83] This EIS did not mention the potential for a pool fire. In fact, the NRC has never published an EIS that addresses the potential for a pool fire. Thus , there exists no EIS or equivalent document that provides useful guidance about the risks associated with high-density storage of spent fuel in pools. Nor is there any EIS or equivalent document that provides useful guidance about the risks associated with potential acts of malice or insanity at commercial nuclear reactors.

(X-2) At various points in this declaration, I discuss requirements for a credible review of the vulnerability of the Indian Point station, and of options for reducing its vulnerability. Here, I summarize these requirements. These are necessary but not sufficient requirements for a credible review. I focus on requirements that address: (a) the potential for a reactor accident or pool fire; (b) the offsite consequences of a reactor accident or pool fire; and (c) options for reducing Indian Point's vulnerability.

(X-3) Paragraph IV-10 sets forth requirements for a thorough, credible study of the potential for a pool fire, and the importance of these requirements is discussed in paragraph VI-4. Such a study would be an essential part of a broader study of the vulnerability of the Indian Point station. This broader study should consider the factors mentioned in paragraph VI-13. Also, the broader study should consider potential interactions among facilities at the Indian Point site, including the potential for "cascading" scenarios that is discussed in paragraph VI-14. It is possible that sensitive information, as defined in Section IX of this declaration, would contribute to the findings of the study. In that case, the sensitive information should be cited in the study, and the sensitive information itself should be made available to authorised

[83] US Nuclear Regulatory Commission, Final Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel, NUREG-0575 (Washington, DC: NRC, August 1979).

persons. Authorised persons would include individuals designated by the parties to any license proceeding related to the vulnerability of the Indian Point station.

(X-4) Section VII of this declaration provides a limited, illustrative discussion of the offsite consequences of a reactor accident or pool fire at Indian Point. A credible review of the site's vulnerability would provide a much more detailed examination of potential consequences. Analytic techniques suitable for such an examination are readily available. It is especially important that the review provides a thorough analysis of the long-term effects of contaminating the environment with radioactive material. Relevant effects include health, environmental, economic and social effects.

(X-5) Section VIII of this declaration provides a limited, illustrative discussion of options for reducing the vulnerability of the Indian Point station. A credible review would identify, and examine in detail, a range of options, including the spent fuel storage options sketched in paragraphs VIII-7 and VIII-9. The examination of spent fuel storage options should consider, among other factors, the issues mentioned in paragraph VIII-6. The overall review should assess the risk profiles of the various options and the present configuration of the Indian Point station, on a common basis. The risk profiles should be assessed by estimating the radioactive release potential for each option, for a common set of influences, and the attendant consequences.

XI. CONCLUSIONS

(XI-1) The Indian Point Unit 2 and Unit 3 spent fuel pools now contain at least 917 and 672 fuel assemblies, respectively; these pool inventories are equivalent to about 4.8 and 3.5 reactor cores, respectively. The Unit 2 pool now contains at least 42 million Curies of cesium-137, and the Unit 3 pool contains at least 31 million Curies. Each of the Unit 2 and Unit 3 reactors contains about 6 million Curies of cesium-137. For comparison, the 1986 Chernobyl accident released about 2.4 million Curies of cesium-137.

(XI-2) The NRC Staff concedes that a loss of water from a high-density spent fuel pool, exposing the top of the fuel racks, will lead to a fire in the pool. The Staff assumes that such a fire would release to the atmosphere 100 percent of the cesium-137 in the pool.

(XI-3) The NRC has never performed an EIS or equivalent document that addresses the potential for a pool fire. In defense of this omission, the NRC has asserted that a pool fire is a "remote and speculative" event.

(XI-4) The NRC Staff has conducted a number of studies related to the potential for a pool fire. There are numerous deficiencies and omissions in these studies. Notably, the

Staff's studies have neglected the potential for a pool fire to be caused by an act of malice or insanity. Similarly, neither the NRC nor any of its licensees has conducted a credible study of the potential for a reactor accident to be caused by an act of malice or insanity.

(XI-5) The occurrence of a highly-destructive act of malice or insanity at a nuclear power station has been foreseeable for many years, and has been foreseen. The terrorist attacks of 11 September 2001 on the World Trade Center and the Pentagon provide additional information. These attacks demonstrate conclusively that a highly-destructive act of malice or insanity at the Indian Point site is not a remote and speculative event.

(XI-6) Available information indicates that acts of malice or insanity at the Indian Point site, including but not limited to the deliberate impact of a large aircraft, could initiate a reactor accident and/or pool fire at Unit 2 and/or Unit 3.

(XI-7) The offsite consequences of a pool fire at Indian Point Unit 2 could include the rendering uninhabitable of a land area of about 95,000 square kilometers, and a pool fire at Unit 3 could render uninhabitable a land area of about 75,000 square kilometers. For comparison, the area of New York state is 127,000 square kilometers.

(XI-8) Options for reducing the vulnerability of the Indian Point station are available. The vulnerability of the Unit 2 and Unit 3 reactors could be quickly and substantially reduced by shutting them down. Options are available for storing spent fuel that would be much more robust than the Indian Point Unit 2 and Unit 3 pools in terms of their ability to withstand accidents or acts of malice or insanity.

(XI-9) The vulnerability of the Indian Point station, and options for reducing its vulnerability, should be systematically reviewed. Some necessary, but not sufficent, requirements for such a review are set forth in Section X of this declaration.

I declare, under penalty of perjury, that the foregoing facts are true and correct to the best of my knowledge and belief, and that the opinions expressed above are based on my best professional judgment.

Executed on 20 December 2001.

G. R. Thompson
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Gordon Thompson