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Mendiola, Doris

Subject: FW: NYS OAG Comments re DSEIS
Attachments: 2016 03 04 NYS OAG Comments on NRC Draft Supplement FINAL.pdf

12/29/2015
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From: John J. Sipos [mailto:John.Sipos@ag.ny.gov]
Sent: Friday, March 04, 2016 3:20 PM
To: Bladey, Cindy <Cindy.Bladey@nrc.gov>
Cc: Laura Heslin <Laura.Heslin@ag.ny.gov>
Subject: [External_Sender] NYS OAG Comments re DSEIS

Hello Ms. Bladey:

Attached please find comments submitted by the State of New York Office of the Attorney General in connection with the December 2015 Draft Supplemental EIS concerning the Indian Point facilities.

Respectfully submitted,

John Sipos

John Sipos
Assistant Attorney General
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tel. 518-776-2380

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Add= M. Wentzel (MSW2)

STATE OF NEW YORK
OFFICE OF THE ATTORNEY GENERAL

ERIC T. SCHNEIDERMAN
ATTORNEY GENERAL

DIVISION OF SOCIAL JUSTICE
ENVIRONMENTAL PROTECTION BUREAU

March 4, 2016

Cindy Bladey, Chief,
Rules, Announcements and Directives Branch
Office of Administration
Nuclear Regulatory Commission
Mail Stop OWFN-12-H08
11555 Rockville Pike
Rockville, Maryland 20852-2738

Re: Indian Point Nuclear Generating Station, Unit 2 and Unit 3
Docket ID NRC–2008–0672
Docket Nos. 50-247-LR/50-286-LR

Dear Ms. Bladey:

In accordance with the notice published in the December 29, 2015 edition of the Federal Register, enclosed please find comments submitted by the State of New York Office of the Attorney General concerning the NRC Staff Draft Supplemental Environmental Impact Statement, Draft Report for Comment, Second Supplement – Vol. 5 (December 2015). 80 Fed. Reg. 81,377-78.

If you encounter any difficulties in opening this submission, please contact this office.

Respectfully submitted,

Signed (electronically) by

Laura Heslin
John J. Sipos
Assistant Attorneys General

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COMMENTS SUBMITTED BY THE ATTORNEY GENERAL OF THE STATE OF NEW YORK ON THE DRAFT SECOND SUPPLEMENT TO THE FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT PREPARED BY THE STAFF OF THE NUCLEAR REGULATORY COMMISSION FOR THE RENEWAL OF OPERATING LICENSES FOR INDIAN POINT UNITS 2 AND 3

Docket ID NRC–2008–0672
Docket Nos. 50-247-LR / 50-286-LR

Submitted on March 4, 2016

Office of the Attorney General
for the State of New York
The Capitol
State Street
Albany, New York 12224

Table of Contents

Note about Citations and References Contained in this Document

All citations and references mentioned in this document are hereby incorporated by reference. Should NRC Staff have difficulty obtaining any such citations and references, they are requested to contact the Office of the Attorney General for the State of New York for assistance.

INTRODUCTION

On December 22, 2015, the NRC published its draft second supplement to the Final Supplemental Environmental Impact Statement for license renewal of Indian Point Units 2 and 3 (draft Supplement).[1] The Attorney General of the State of New York (NY Attorney General) appreciates the opportunity to submit these comments on the draft Supplement.

The draft Supplement was issued in response to NRC's Continued Storage Rule, 10 C.F.R. § 51.23, and the generic environmental impact statement regarding the continued storage of spent fuel at plants, NUREG-2157 (GEIS), on which it is based. The draft Supplement incorporates the generic findings of the GEIS, concluding that these findings satisfy NRC's National Environmental Policy Act (NEPA) obligation to examine the impacts of the continued storage of spent nuclear fuel. However, the NY Attorney General has challenged the Continued Storage Rule and GEIS in the United States Court of Appeals for the District of Columbia Circuit (D.C. Circuit), and argued, among other things, that the GEIS fails to consider the site-specific impacts of continued storage at Indian Point. *New York v. NRC* (*New York II*), Brief for States of New York, Vermont, Connecticut, and Massachusetts, and the Prairie Island Indian Community (D.C. Cir. Nos. 14-1210, 14-1212) (States' D.C. Cir. Br.) at 24-34. These comments discuss those impacts.

The draft Supplement fails to consider alternatives to and mitigation measures for the continued storage of spent nuclear fuel at Indian Point. Yet, in its brief to the D.C. Circuit in *New York II*, NRC represented that alternatives and mitigation measures would be considered as part of the site-specific licensing process. NRC may not defer discussion of continued storage

[1] 80 Fed. Reg. 81,377 (Dec. 29, 2015) (notice of release of Draft FSEIS Supplement 2 and request for comment by March 4, 2016).

alternatives and mitigation measures to its Record of Decision—NEPA requires that such analysis must be included in the Environmental Impact Statement. In particular, NRC must consider alternatives and mitigation measures to reduce the likelihood and impacts of a severe fuel pool accident at Indian Point. Throughout the continued storage proceeding, New York has requested that NRC conduct a transparent, objective, and comprehensive site-specific severe accident mitigation alternatives analysis of spent fuel pool accidents at Indian Point—and conduct a site-wide analysis of severe accidents at Indian Point and identify the alternative measures to mitigate the site-wide risks.

The importance of examining the unique impacts of continued storage at Indian Point, as well as alternatives and mitigation measures, is reinforced by recent events at the facility. On February 5, 2016, Indian Point notified the NRC of a new onsite tritium leak based on a January 26 sample taken from a monitoring well adjacent to the Unit 2 Fuel Handling Building, which houses the spent fuel pool for Unit 2. Even before this event, the groundwater beneath Indian Point was already contaminated with radionuclides stemming from other long-running undetected leaks from the spent fuel pool and transfer canal for Unit 1 and Unit 2. Particularly given the history of radioactive leaks from in and around Indian Point's spent fuel pools, NRC should examine site-specific impacts, alternatives, and mitigation measures for spent fuel storage at Indian Point.

BACKGROUND

In September 2014, NRC issued the final Continued Storage Rule and GEIS. The Continued Storage Rule provides, among other things, that the "impact determinations" in the GEIS "shall be deemed incorporated" into other environmental impact statements that are required in NRC's plant-licensure process. *See* 10 C.F.R. § 51.23(b). In October 2014, the

States and Tribe filed a petition for review of the Continued Storage Rule in the D.C. Circuit, as did a coalition of environmental groups led by the Natural Resources Defense Council. The matter has been fully briefed and oral argument took place on February 22, 2016.

The States and Tribe presented three primary arguments in their challenge to the Continued Storage Rule. First, NRC's generic analysis does not adequately account for site-specific risks of indefinitely storing spent nuclear fuel. Second, NRC used unreasonable assumptions to exclude consideration of foreseeable environmental impacts from continued storage. Third, NRC did not adequately analyze mitigation measures or alternatives to its current licensing requirements.

In response, NRC asserted that it will cure certain of these deficiencies in individual licensing proceedings. It argued that intervenors in a plant licensing proceeding may use the waiver provision at 10 C.F.R. § 2.335(b) to obtain an exception from the Continued Storage Rule—and that this will ensure it considers the site-specific impacts of indefinite onsite spent fuel storage before a plant is licensed. NRC also asserted that alternatives and mitigation measures will be addressed as part of the site-specific component of its environmental reviews.

On December 22, 2015, the NRC published its draft Supplement.[2] NRC's Draft Supplement states, at page iii, that it "incorporates the impact determinations of NUREG-2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel*, in accordance with the requirements in 10 CFR 51.23(b)." The result of incorporating the impact determinations from the GEIS is that the draft Supplement does not examine any site-specific impacts of continued storage at Indian Point. The December 29 Federal Register notice of the

[2] 80 Fed. Reg. 81,377 (Dec. 29, 2015) (notice of release of Draft FSEIS Supplement 2 and request for comment by March 4, 2016).

release of the draft Supplement states that written comments on the draft Supplement are due on March 4, 2016.

COMMENTS

I. INDIAN POINT PRESENTS UNIQUE SITE CHARACTERISTICS THAT MUST BE CONSIDERED IN THE DRAFT SUPPLEMENT

18-L13-1

The following unique characteristics of the Indian Point site demonstrate why it is essential to conduct a site-specific analysis of the potential environmental impacts from the continued storage of spent fuel at the Indian Point facilities and of alternatives to mitigate those potential impacts.

A. Population

The analysis of the consequences of pool fires in the GEIS relies mainly on NRC's NUREG-1738 study, which evaluates this concern primarily through data from a plant in Surry, Virginia, where the population density is 300 people per square mile. As the GEIS acknowledges, "the use of the Surry site means that the accident consequences could be greater at higher population sites." GEIS F-8. The study also partly relies on data from the Zion plant on Lake Michigan, where the population density is 860 people per square mile.

To compound the problem, the remaining studies on which the GEIS relies to analyze the health and economic costs of a fire are based on a computer code called MACCS2, which also uses input data from the Surry site. GEIS D-317. NRC recognizes that "these studies were generic in nature, and not intended for application to specific sites," *Id.*, but the GEIS nonetheless uses the Surry data to calculate risks for Indian Point, where the consequences of a fire would be substantially greater.

The area around Indian Point has a population density of 2,138 people per square mile. GEIS 2-4 to 2-5. Indian Point's fifty-mile radius is also densely populated and contains some of the most expensive real estate in the country, along with landmarks, parks, arenas, universities, and transportation facilities.[3] The Indian Point power reactors, spent fuel pools, and dry storage casks are 24 miles north of New York City, 35 miles from Times Square, and approximately 38 miles from Wall Street. The U.S. Census Bureau recognizes that New York City is the largest city in the Nation—with more than 8,000,000 residents. The facilities are approximately 3 miles southwest of Peekskill, with a population of 22,441, 5 miles northeast of Haverstraw, with a population of 33,811, 16 miles southeast of Newburgh, with a population of 31,400, and 17 miles northwest of White Plains, with a population of 52,802, 23 miles northwest of Greenwich, Connecticut, 37 miles west of Bridgeport, Connecticut, and 37-39 miles north northeast of Jersey City and Newark, New Jersey. 18-L13-1 cont'd

With approximately 17 million people currently living within 50 miles of Indian Point, no other operating reactor site in the country comes close to Indian Point in terms of surrounding population.[4] NRC and FEMA confirm that substantially more people live within 10 and 50 miles of the Indian Point reactors, spent fuel pools, and waste storage facilities than at any other operating power reactor in the nation. According to NRC:

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[3] *See* LIST OF VARIOUS SITE SPECIFIC IMPROVEMENTS, INCLUDING LANDMARKS, PARKS, ARENAS, UNIVERSITIES, AND TRANSPORTATION FACILITIES WITHIN 50 MILES OF INDIAN POINT POWER REACTORS AND SPENT FUEL POOL FACILITIES, attached hereto as Exhibit A.

[4] *See* NUREG-1437 (1996) at §2.2 & Table 2.1 (based on 1990 census); NUREG-1437, Rev. 1 (2013) at §3.1, Figure 3.1.1, Table 3.1.1 (based on 2000 census). Indian Point's current operator projects that the population living within 50 miles of the plant will grow to 19.2 million people by 2035. *See* Environmental Report for License Renewal of Indian Point Unit 2 and Unit 3 (2007) at 2-35 ("The total population (including transient populations) within a 50-mile radius of the site is projected to be 19,228,712 in 2035.").

> Typically, nuclear power plant sites and the surrounding area are flat-to-rolling countryside in wooded or agricultural areas. More than 50 percent of the sites have 80-km (50-mile) population densities of less than 200 persons per square mile, and over 80 percent have 80-km (50-mile) densities of less than 500 persons per square mile. The most notable exception is the Indian Point Station, located within 80 km (50 miles) of New York City, which has a projected 1990 population density within 80 km (50 miles) of almost 2000 persons per square mile.

18-L13-1 cont'd

NUREG-1437 (1996) at p. 2-2. Moreover, each day tens of thousands of additional people commute or travel into Indian Point's 50 mile radius.

In 1979, NRC's Director of State Programs said of the Indian Point site "I think it is insane to have a three-unit reactor on the Hudson River in Westchester County, 40 miles from Times Square, 20 miles from the Bronx." Robert Ryan, NRC Director of State Programs, *quoted in* STAFF REPORTS TO THE PRESIDENT'S COMMISSION ON THE ACCIDENT AT THREE MILE ISLAND (Oct. 1979), Report of the Office of Chief Counsel on Emergency Preparedness, at p. 8.

The GEIS attempts to justify the use of the Surry data on the ground that "the risk to the average individual" would not be greater at a site with a higher population density. GEIS F-8. But that overlooks the common-sense point that a fire affecting a hyper-urbanized area with 2,000 people per square mile plainly will have greater public health and other consequence than a fire affecting a rural area with only 300 or 800 people per square mile. The report prepared by International Safety Research, Inc. and submitted to NRC with New York's comments on the GEIS, proposes a method to determine risk to society, which depends on population density around a site, and therefore, is a more accurate depiction of severe accident risk at a given site. ISR Report, attached hereto as Exhibit B, at page 10. NRC should utilize such a method to determine to true consequences of a pool fire at Indian Point. 18-L13-1 cont'd

B. Drinking Water Resources

The reactors and fuel pools are also 6 miles west of the New Croton Reservoir in Westchester County, which is part of the New York City reservoir system and provides drinking water to New York City residents. They are also in close proximity to other reservoirs in the New York metropolitan area. *See* Map: DISTANCE TO NEW YORK RESERVOIRS FROM INDIAN POINT SPENT FUEL POOLS AND REACTORS (below).

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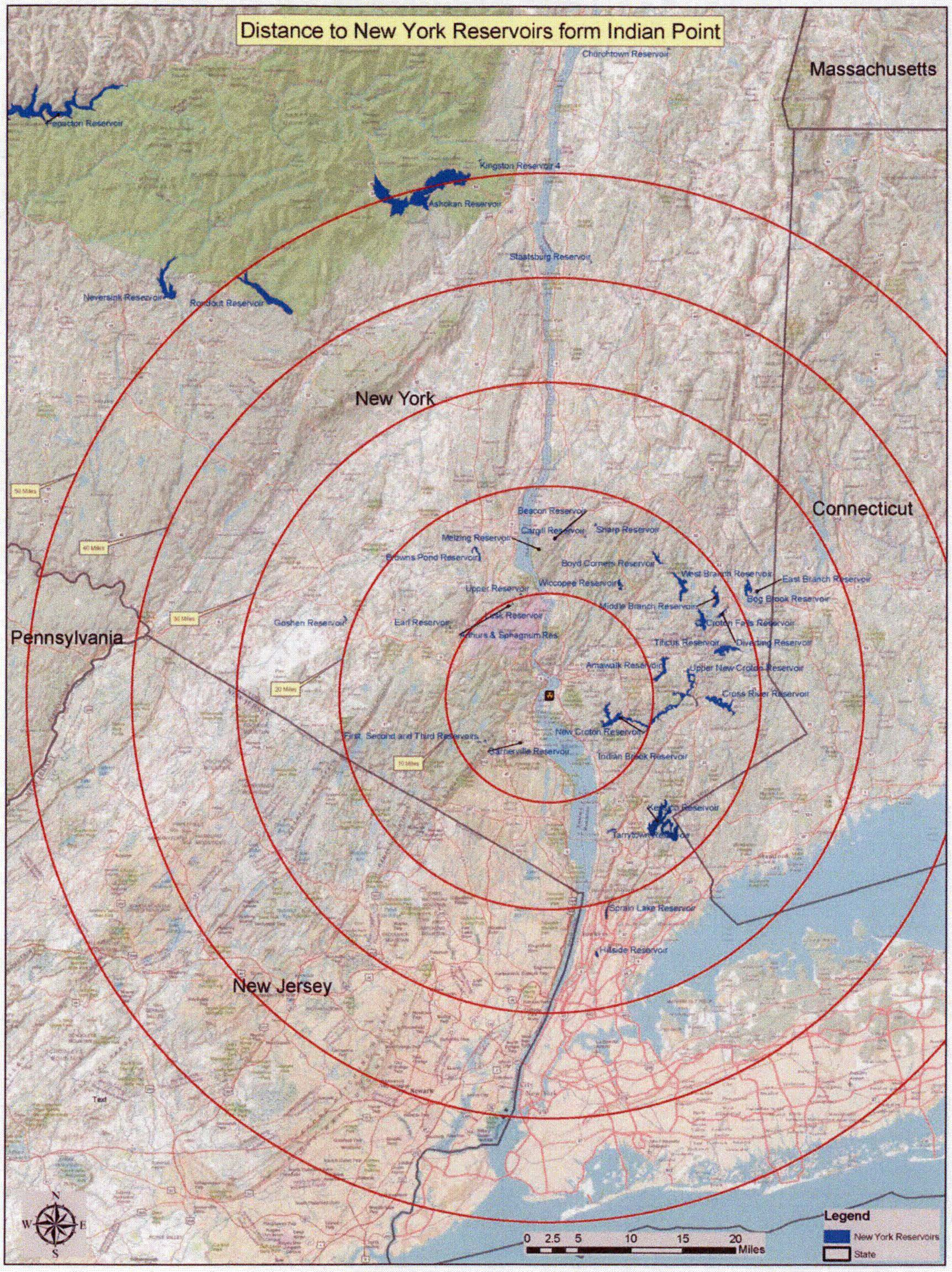
cont'd

DISTANCE TO NEW YORK RESERVOIRS FROM INDIAN POINT SPENT FUEL POOLS AND REACTORS



18-L13-1 cont'd

The draft Supplement does not analyze the cost to replace these drinking water resources that play a critical role in the daily life of New York City's residents. Replacing radionuclide-contaminated drinking water resources for millions of City residents would likely represent a substantial cost. To comply with NEPA, NRC should expand its analysis to include the impact of severe spent fuel pool accidents on drinking water resources within NRC's designated 50-mile Emergency Planning Zone around the Indian Point facilities.

C. Economic Costs

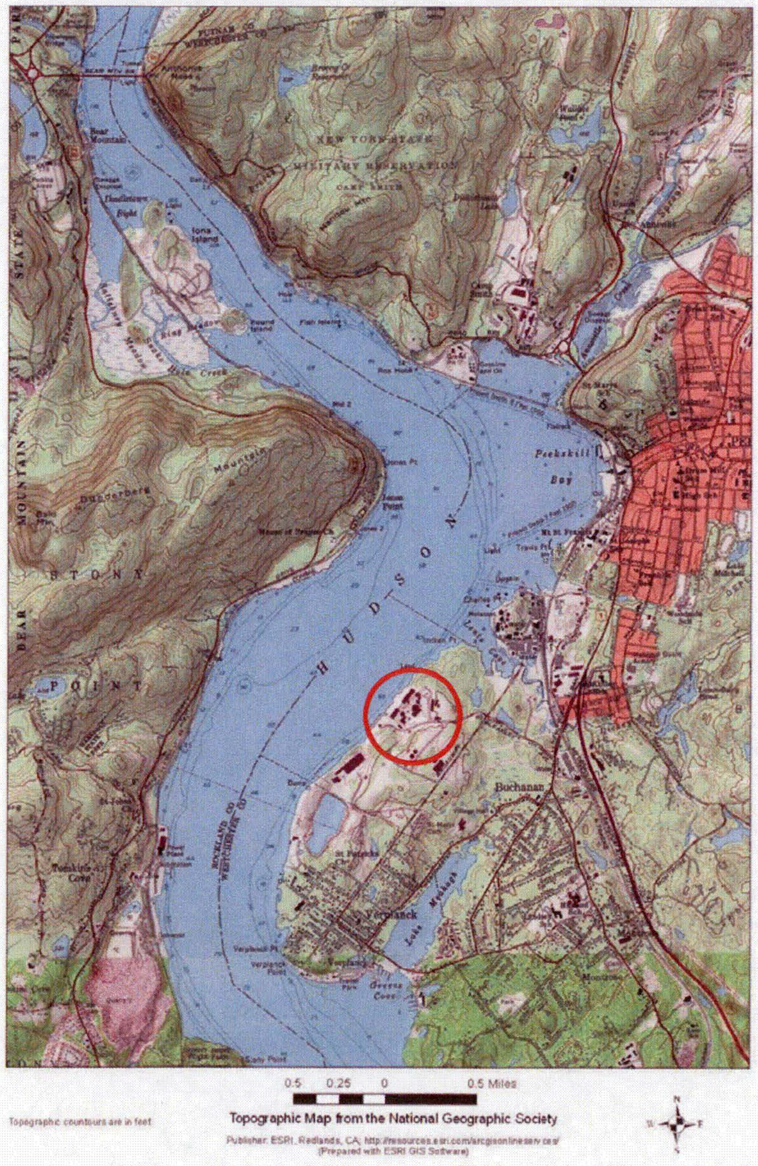
The economic cost model of the MACCS2 code is intended to estimate the direct offsite costs from a severe nuclear accident. If other indirect costs were included such as medical expenses, adverse health effects, permanent income loss, costs of disposal of contaminated wastes, and economic impact of losing a resource—including the loss of drinking water and replacement for reservoirs during interdiction—the total economic cost would increase. *See, e.g.*, Transcript of Evidentiary Hearing, Indian Point License Renewal Proceeding (Tr.) 2278:7-8 (Bixler) (MACCS2 code "does not consider the migration through the ground water."); Tr. 2284:6-10 (Bixler) (MACCS2 code "does not account any economic value to the loss of the water. I think what would probably happen in reality is that people would buy bottled water in that area, and consume that. . . . [but it] is not factored in."); Tr. 2285:5-8 (Ghosh) ("[A]re we accounting for the economic impact of losing some resource? I just want to comment on that. Certainly, MACCS does not do that."); Tr. 1975:9-20 (J. McDade/Bixler) (While an input parameter called per capita cost of long-term relocation (POPCST) does address unemployment for 20 weeks under Sample Problem A, it does not address permanent salary loss.).

18-L13-1 cont'd

D. Topography and Meteorology

The Indian Point facilities were constructed close to the river bank and are located at a relatively low point in the valley formed by the Hudson River. The hills of the Hudson River Valley in the vicinity of the Indian Point facilities are illustrated in the following two topographical presentations.

The first topographical map depicts the area within five miles of the facilities:

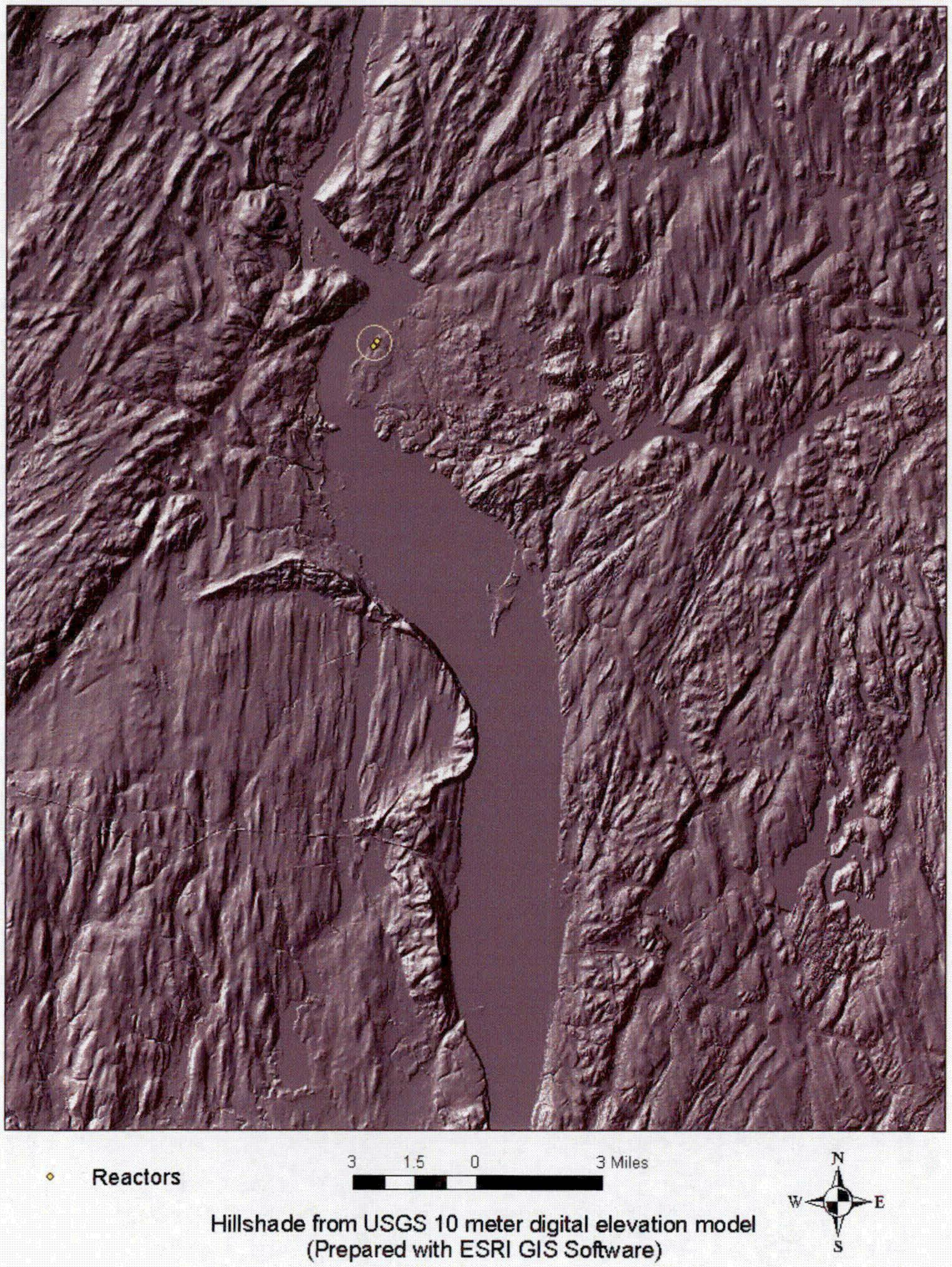


Topographic countours are in feet

Topographic Map from the National Geographic Society

Publisher: ESRI, Redlands, CA; http://resources.esri.com/arcgisonlineservices/
(Prepared with ESRI GIS Software)

The following "hillshade" topographical map depicts the lower Hudson River Valley in the vicinity of the Indian Point site: 18-L13-1 cont'd



Hillshade from USGS 10 meter digital elevation model
(Prepared with ESRI GIS Software)

These river, hills, and topography tend to concentrate wind direction to the south (toward the New York City metropolitan area) or to the north toward the U.S. Military Academy at West Point or Hudson River cities and towns. The following wind rose, prepared by Indian Point's owner, illustrates the dominant wind direction. 18-L13-1 cont'd

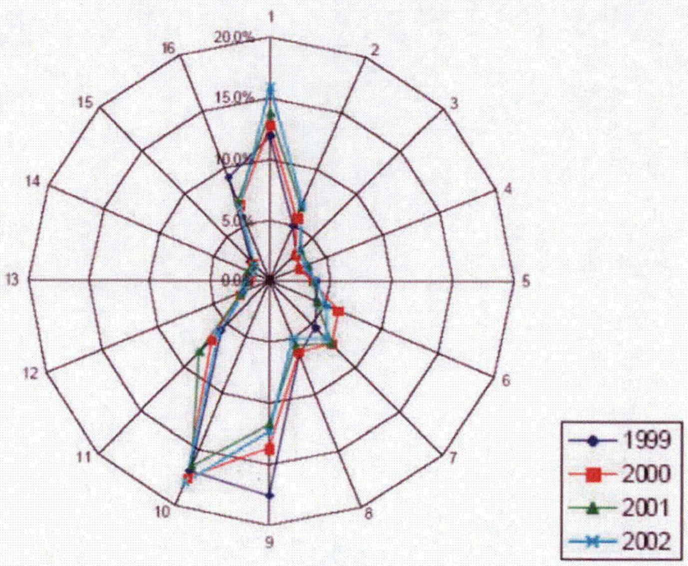


Figure 3: Plot of Weather for Years 1999 – 2002 from the site 10 meter tower showing wind direction (percent by direction).

Source: color version of figure available on ADAMS, ML093020492. During an evidentiary hearing concerning the application to renew Indian Point's two operating license, Entergy agreed that for the area surrounding Indian Point, the wind blows predominantly from the north to the south. Tr. 2294:1-20 (J. Wardwell/Lemay/O'Kula).

The following population rose depicts the relative population densities in the various sectors around Indian Point.

18-L13-1 cont'd

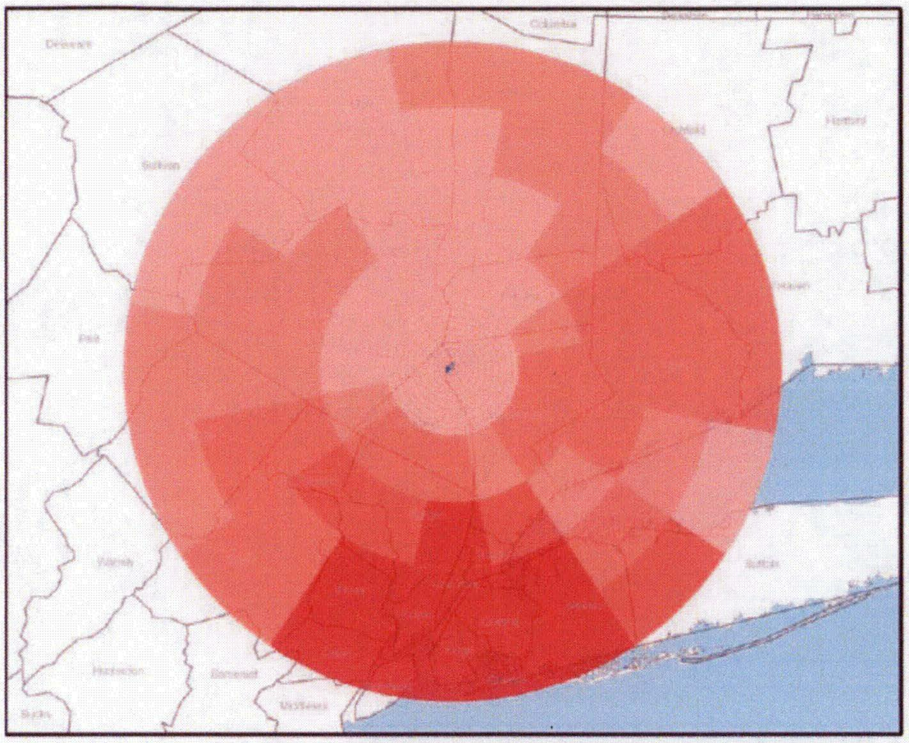


Figure 2.1 2035 projected total population by spatial element (dark red indicates highest population).

Source: Site Specific MACCS2 Input Data for Indian Point Energy Center, Rev. 1, (December 1, 2009), Enercon Services, Inc. Prepared for Entergy Nuclear Northeast, at 2-7. As noted, winds blow from the Indian Point facilities southward—toward the New York City metropolitan area.

E. Improvements and Unique Sites within 50 miles

The communities within the 50-mile radius around Indian Point also contain some of the most densely-developed and expensive real estate in the country, critical natural resources, centers of national and international commerce, transportation arteries and hubs, and historic sites. By way of example, Wall Street, the Nation's financial center, is 38 miles away. These unique sites are identified on the accompanying list in Exhibit A. Many of the historic sites are on the national historic preservation list and are protected under the National Historic Preservation Act.[5]

18-L13-1 cont'd

F. The Hudson River Ecosystem

The Indian Point facilities are located on the eastern bank of the Hudson River (at river mile 43). The Native American name for the river, Mahicantuck, means "great waters in constant motion" or "river that flows two ways." This name highlights the fact that this waterway is more than a river—it is a tidal estuary. The Hudson River is an important regional resource of significant aesthetic value in addition to providing transportation, recreation, and water supply. More than 200 species of fish are found in the Hudson and its tributaries. Bald eagles, herons, waterfowl, and other birds feed from the river's bounty. Tidal marshes, mudflats, and other significant habitats in and along the estuary support a diversity of life. Tidal freshwater wetlands near Indian Point support this life web. The Hudson River is one of the Nation's fourteen American Heritage Rivers.

G. Seismic Hazard

Risk is a function of two components: the probability that the harm will occur and the severity of the consequences if it does.[6] The probability of a pool fire depends in substantial part on the geography of the location, including the likelihood of earthquakes, as the GEIS recognizes. *See* GEIS F-10. The GEIS uses an average site seismicity corresponding to a frequency exceeding 1.2 g of $2\text{x}10^{-7}$ per year to $2\text{x}10^{-6}$ per year. The ISR Report notes that

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[5] *See, e.g.,* Letter from Thomas Lyons, New York State Office of Parks, Recreation, and Historic Preservation, to David Wrona, NRC (Oct. 26, 2010) ML103060210 (as part of NEPA and SAMA review, discussing the Revolutionary War Stony Point Battlefield site, which has been designated a National Historical Landmark by the U.S. Department of the Interior, and stating that "the Stony Point Battlefield is an irreplaceable asset to the people of New York State and the Nation."). The battlefield is on the west bank of the Hudson River, 2 miles south of the Indian Point site.

[6] *See*, e.g., *New York v. NRC*, 681 F.3d 471, 481-82 (D.C. Cir. 2012) (*New York I*); *Limerick Ecology Action, Inc. v. NRC (Limerick)*, 869 F.2d 719, 738 (3d Cir. 1989); GEIS 11-18.

although the actual frequency of exceeding 1.2 g at Indian Point is not quoted in the GEIS or NUREG-1738, the data shown in Figure 10 of COMSECY-2013-0030 (p.81, reproduced below) suggests that this frequency is greater than $2x10^{-6}$ per year. *See* figure below:

18-L13-1 cont'd

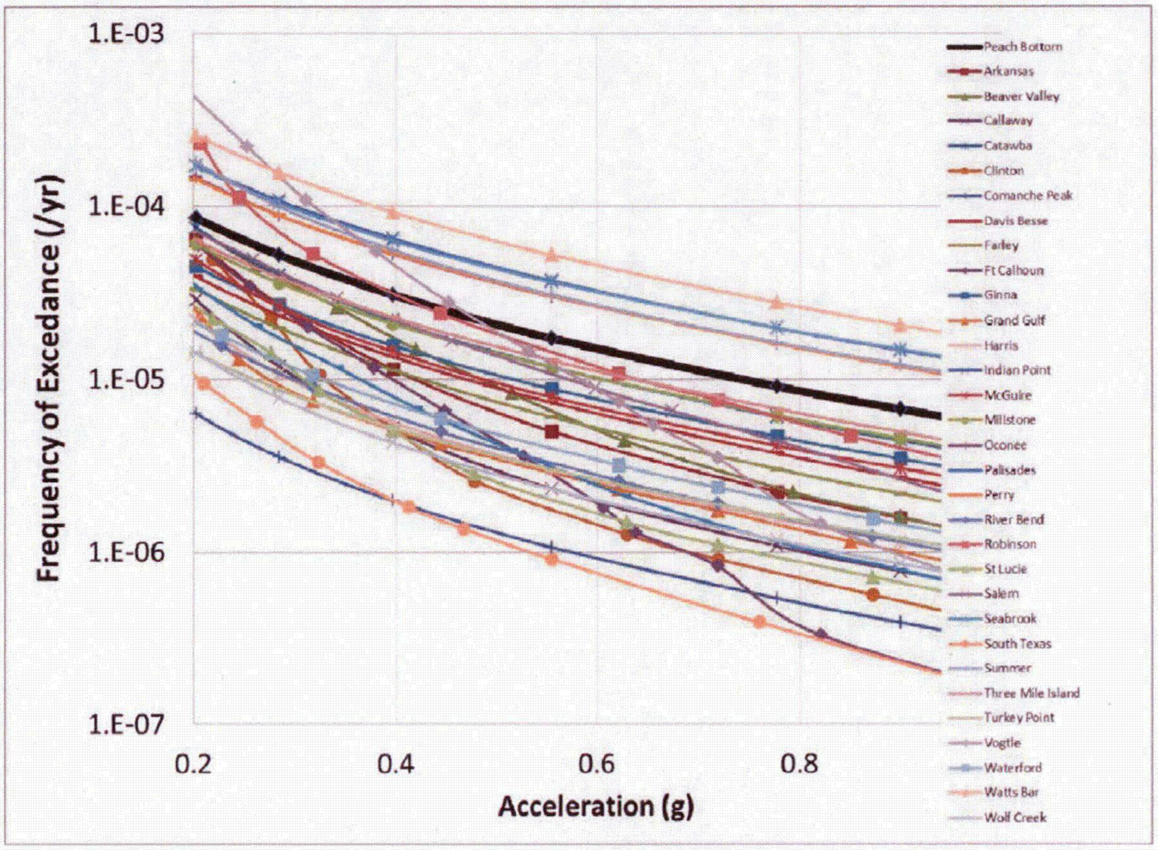


Figure 10 Comparison of annual PGA exceedance frequencies for U.S. PWR and BWR Mark III reactors (USGS 2008 model)

Moreover, the data in COMSECY-2013-0030 may be underestimating the frequency because it does not account for new seismic hazards recently discovered at Indian Point. Since the probability of a pool fire at Indian Point is likely higher than the probability considered in the GEIS, the GEIS does not analyze the risk of a pool fire at Indian Point.

Indian Point is susceptible to earthquake damage since it was initially designed to withstand an earthquake and ground acceleration that are now deemed to be below the reasonably predictable earthquake and ground acceleration for the site and its environs.[7] In 2008, the Bulletin of the Seismological Society of America published a peer-reviewed article by Dr. Sykes, Mr. Seeber, and others, identifying a new seismic feature in the vicinity of Indian Point.[8] The article concluded:

18-L13-1 cont'd

> Two nuclear power plants at Indian Point (near Peekskill in Fig. 2) are located closer to more people at any given distance than any other similar facilities in the United States. Entergy, their owner, recently applied for 20-yr extensions of their existing 40-yr licenses. Much new seismological information is available since their initial approvals in 1973 and 1975. Nevertheless, the U.S. Nuclear Regulatory Commission so far has not permitted any new information to be used or old information on which the original licenses were based to be contested in considering extensions of licenses. Indian Point is situated at the intersection of the two most striking linear features marking the seismicity (Fig. 3) and also in the midst of a large population that is at risk in case of an accident to the plants. This is clearly one of the least favorable sites in our study area from an earthquake hazard and risk perspective.

Id. at 1717.

There is substantial new evidence that there is earthquake risk that NRC did not take into consideration when approving operation licenses for existing reactors and spent fuel storage facilities. In 2004, United States Geological Survey (USGS) told NRC that earthquake hazards in the Central and Eastern United States (CEUS), the portion of the lower 48 states east of the Rocky Mountains, were higher than previously understood. In May 2005, NRC staff acknowledged that earthquake risk for reactors and spent fuel storage in CEUS may be greater

[7] *See generally*, Declaration of Lynn R. Sykes, Ph.D., and Declaration of Leonardo Seeber and accompanying Exhibits, (Nov. 2007), available at ML073400205 (Volume I of II); Letter from Attorney General Schneiderman to NRC Commissioners, Seismic Risk at Indian Point Nuclear Generating Station, (March 18, 2011) ML110820058; *see also* Comments Concerning the Proposed Generic Communication "Draft NRC Generic Letter 2011-XX: Seismic Risk Evaluations for Operating Reactors," Docket ID NRC-2011-0202, at 14-19 (Dec. 15, 2011) ML11354A231.

[8] *Observations and Tectonic Setting of Historic and Instrumentally Located Earthquakes in the Greater New York City–Philadelphia Area*, Bulletin of the Seismological Society of America, Vol. 98:1696-1719 (Aug. 2008).

18-L13-1 cont'd

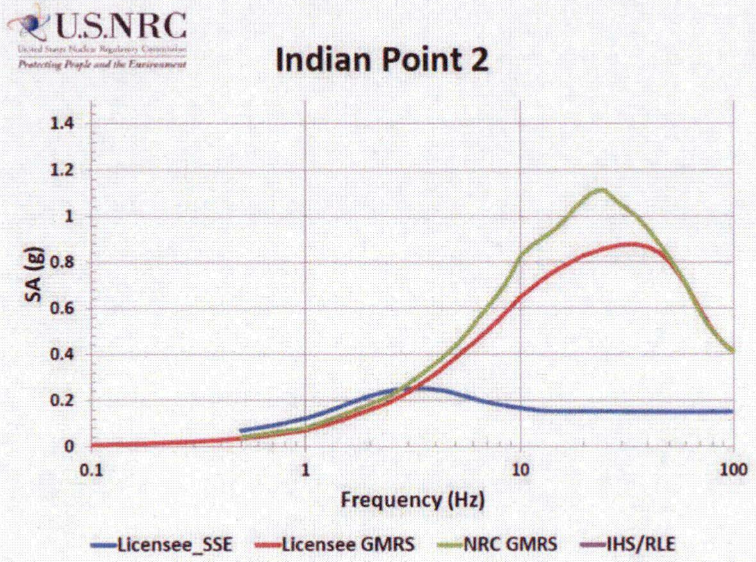
than NRC assumed when it approved operating licenses for these facilities. *See, e.g.,* May 26, 2005 NRC Staff memorandum re: Identification of a Generic Seismic Issue (ML051450456). NRC staff's response to the new USGS earthquake hazard information was to consider issuing a "generic letter" on the subject of "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States." On June 9, 2005 NRC staff memorandum Generic Issue 199, "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States" (ML051600272). This memorandum contained an estimate that "the initial screening technical analysis will be completed within three months of receipt of the necessary information from [NRC's Office of Nuclear Reactor Regulation]." *Id.*

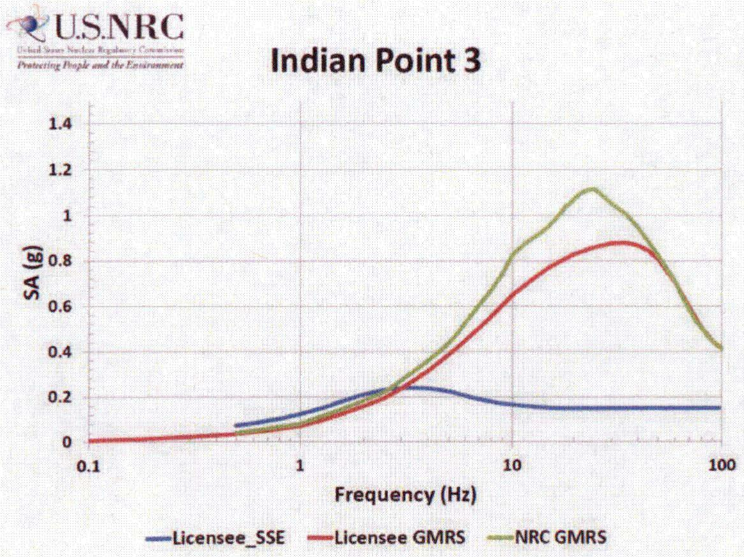
The summary of the February 6, 2008 NRC staff public meeting relates that a seismologist working on Generic Issue 199 stated that for some CEUS areas the current earthquake frequency estimates were several times larger than those used in the 1980's, and that revised ground motion predictive equations generally produced higher estimates of uncertainty about the effect of earthquakes at these sites.[9]

Following the March 2011 Japan earthquake and multi-unit Fukushima Dai-ichi nuclear accident, NRC moved the GI-199 review to the Fukushima Near-Term Task Force group examining seismic hazards. In 2014, Entergy provided an updated seismic hazard analysis for IP2 and IP3. That analysis shows that the anticipated ground motion is larger for higher

[9] February 8, 2008 NRC staff memorandum Subject: Summary of February 6, 2008, Category 2 Public Meeting with the Public and Industry to Discuss Generic Issue 199, "Implications of Updated Seismic Hazard Estimates in Central and Eastern United States on Existing Plants," p. 2 (ML080350189). The summary also related that a representative of the Electric Power Research Institute (EPRI), a private organization funded by the electric power industry, stated that it had "calculated mean seismic spectra for the 28 sites used in [NRC Regulatory Guide] 1.165." *Id.* However, EPRI has prevented public review of information and has delayed NRC's reassessment of earthquake hazards. *See, e.g.*, February 1, 2008 Screening Analysis for GI-199, "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants," p. 2 (ML073400477) (EPRI unwilling to share a report with NRC contractor.).

frequency events than was understood when the two units received their operating licenses. After receiving the Entergy updated analysis, NRC Staff performed its own analysis. The recently-produced ground motion curves appear to be higher than the Safe Shutdown Earthquake (or SSE) design curves that resulted from licensing hearings in the 1970s and were adopted by the Commission at that time. *See* NRC Staff, Slides, Near-Term Task Force Recommendation 2.1: Entergy, at 6 (June 19, 2014) (ML14169A489). 18-L13-1 cont'd





Id. The new revised seismic curves reflect a significantly greater seismic risk for certain systems, structures, and components at both units when compared to their original safe shutdown earthquakes.

18-L13-1 cont'd

Accordingly, Staff placed IP2 and IP3 in the "Priority Group 1" for additional review. According to Staff, "Group 1 plants are generally those that have the highest re-evaluated hazard relative to the original plant seismic design basis as well as ground motions in the 1-10Hz range that are generally higher in absolute magnitude. Group 1 plants are expected to conduct a seismic risk evaluation and submit it by June 30, 2017." NRC Staff, Support Document for Screening and Prioritization Results Regarding Seismic Hazard Re-Evaluations for Operating Reactors in the Central and Easter United Sates, at 2 (May 21, 2014) (ML14136A126).

In late 2015, NRC staff concluded that additional in-depth seismic risk analysis is needed for certain facilities, including the Point Unit 2 and Unit 3 spent fuel pools:

- 2 -

Table 1a. Recommendation 2.1 Seismic – Information Requests[1]

Plant Name	Seismic Probabilistic Risk Assessment Submittal Date[2,3]	Limited-Scope Evaluations			IPEEE Screening Evaluation
		High Frequency[2]	Low Frequency	Spent Fuel Pool	Relay Chatter
Davis-Besse Nuclear Power Station, Unit 1		x		x	
Diablo Canyon Power Plant, Unit Nos. 1 and 2	9/30/17			x	
Donald C. Cook Nuclear Plant, Units 1 and 2	6/30/18			x	
Dresden Nuclear Power Station, Units 2 and 3	6/30/19			x	
Duane Arnold Energy Center		x			
Edwin I. Hatch Nuclear Plant, Units 1 and 2		x	x	x	
Fermi, Unit 2		x		x	
Fort Calhoun Station, Unit 1				x	x
Grand Gulf Nuclear Station, Unit 1					
H. B Robinson Steam Electric Plant, Unit No. 2	3/31/19			x	
Hope Creek Generating Station		x[5]			
Indian Point Nuclear Generating, Unit No. 2	6/30/17			x	
Indian Point Nuclear Generating, Unit No. 3	6/30/18			x	
James A. FitzPatrick Nuclear Power Plant	See Table 1b.				
Joseph M. Farley Nuclear Plant, Units 1 and 2		Footnote 6	Footnote 6		
LaSalle County Station, Units 1 and 2		x		x	
Limerick Generating Station, Units 1 and 2		x			
McGuire Nuclear Station, Units 1 and 2	12/31/19			x	
Millstone Power Station, Units 2 and 3	See Table 1b.				
Monticello Nuclear Generating Plant		x		x	

[5] By letter dated March 28, 2014, the licensee committed to complete an IPEEE relay review in lieu of a high frequency confirmation.
[6] Evaluation no longer expected based on de minimis exceedance above the design-basis SSE.

Taken from NRC document entitled, "Final Determination of Licensee Seismic Probabilistic Risk Assessments Under the Request for Information Pursuant to Title 10 of the Code of Federal

Regulations 50.54(f) Regarding Recommendation 2.1 'Seismic' of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," Oct. 27, 2015 (ML15194A015). In so doing, NRC Staff extended IP3's deadline to submit the information out to June 2018. 18-L13-1 cont'd

H. Interaction with the Existing Algonquin Pipeline

In 1951, the federal government authorized the Algonquin Gas Transmission Corporation to construct and operate an interstate pipeline from New Jersey to Massachusetts designed to convey natural gas to New England.[10] The Federal Power Commission, authorized the Algonquin pipeline to traverse southern New York State, cross the Hudson River near river mile 43 between the Town of Stony Point and the Village of Buchanan, cross the property of what was then the Indian Point amusement park, and continue on through the Village of Buchanan and the Towns of Cortlandt and Southeast, before heading into Connecticut.[11] Today, the Algonquin pipelines convey large amounts of natural gas through the Indian Point site to the northeast states.

When the Atomic Energy Commission later authorized the Consolidated Edison Company (Con Edison) to construct the first nuclear power reactor at the Indian Point park site,[12] the federal government did not have siting regulations or restrictions for nuclear reactors to address site-specific issues such as nearby hazards, seismicity, sabotage, and population risks. One site-specific risk factor at the Indian Point site is the pre-existing Algonquin gas pipelines. In the 1960s, the Atomic Energy Commission authorized Con Edison to construct two additional

[10] *In re United Gas Pipe Line Co., Texas Eastern Transmission Corp., and Algonquin Gas Transmission Corp.*, 10 F.P.C. 35, 1951 FPC LEXIS 3 at * 72-74 (Mar. 27, 1951).

[11] The Algonquin pipeline's Hudson River crossing includes three separate pipes: two 24-inch-diameter pipelines and one 30-inch-diameter pipeline. FERC DEIS at 3-18.

[12] 21 Fed. Reg. 3,085 (May 9, 1956) (Indian Point Unit 1 construction permit).

nuclear power facilities at site, one of which (Indian Point Unit 3) was located even closer to the Algonquin pipelines.[13]

18-L13-1 cont'd

The public record in this licensing proceeding does not reflect whether the federal Pipeline and Hazardous Materials Administration (PHMSA) or NRC have conducted a meaningful site specific hazards analysis of the existing Algonquin pipelines with respect to Indian Point Unit 3 spent fuel pool and reactor and other Indian Point structures and electrical systems. Moreover, as noted in today's comments, the understanding of site-specific seismological hazards has evolved since the authorization and construction of the Algonquin pipelines 60 years ago. *See* above at pp. 14-20. NRC documents released in 2014 reflect a higher seismic hazard risk for the Indian Point site than was accounted for during the initial licensing proceedings for the Indian Point facilities. *Id.* That revised seismic risk hazard would apply with equal force to the 60-year-old Algonquin pipelines that cross the Indian Point site. To be valid, any site hazards analysis of the risk posed to the Indian Point facilities by the existing Algonquin pipelines would necessarily have to incorporate and analyze the impact of the updated seismic hazard forces on the pipelines. In light of the changing understanding of the seismic hazard risk at the Indian Point site, NRC should consult with the United States Geological Service and PHMSA concerning the site-specific hazard and severe accident analysis—and in a transparent manner that allows public input, interaction, and observation.

I. Lack of Site-Specific Analysis of Severe Spent Fuel Pool Accident

Given their regulatory history, the three power reactors and their spent fuel pools located at Indian Point were not subjected to a severe accident mitigation alternatives analysis when AEC and NRC issued the construction permits and operating licenses for those facilities.

[13] 31 Fed. Reg. 13,616-17 (Oct. 21, 1966) (Indian Point Unit 2 construction permit); 34 Fed. Reg. 13,437 (Aug. 20, 1969) (Indian Point Unit 3 construction permit).

According to AEC and NRC documents, Con Edison received the following construction permits and operation licenses on the following dates:

18-L13-1 cont'd

	CONSTRUCTION PERMIT ISSUED	OPERATING LICENSE ISSUED
IP Unit 1	May 4, 1956	March 26, 1962
IP Unit 2	October 14, 1966	September 28, 1973
IP Unit 3	August 13, 1969	December 12, 1975

Source: Federal Register and NRC Information Digest.[14] When Con Edison announced its selection of the Indian Point site back in March 1955 and filed an application for the necessary construction permit, the AEC did not have site selection regulations that addressed population or seismic issues.

To place this initial siting decision in perspective, Con Edison selected, and AEC approved, Indian Point as the site for a power reactor before the Windscale - Sellafield (1957), Three Mile Island (1979), Chernobyl (1986), and site-wide multi-unit Fukushima (2011) events. The 1955 selection of Indian Point also came before the enactment of NEPA (1970), the promulgation of CEQ regulations (1978), the Third Circuit's *Limerick* decision (1989), and NRC promulgation of the 10 C.F.R. § 51.53 regulation (1996) that collectively require an analysis of ways to mitigate the impacts of severe accidents at nuclear facilities. In addition, AEC approved the construction of the first reactor and spent fuel pool before Congress enacted in the Price Anderson Act (1957).

[14] *See* 21 Fed. Reg. 3,085 (May 9, 1956); 27 Fed. Reg. 4,844 (May 23, 1962); 31 Fed. Reg. 13,616-17 (Oct. 21, 1966); 34 Fed. Reg. 13,437 (Aug. 20, 1969); 38 Fed. Reg. 27,636 (Oct. 5, 1973); 40 Fed. Reg. 50,263 (Dec. 22, 1975); NUREG-1350, Volume 20, *2008 - 2009 Information Digest*, at 103, 113 (Aug. 2008).

NRC confirms that severe accidents and consequences were not taken into account when selecting and approving the Indian Point site. In its 1979 Siting Study Report, NRC stated:

18-L13-1 cont'd

> The maximum credible accident concept was carried into Part 100 in which an analysis of the consequences of the accident was used as a test of suitability of a proposed site and plant design. In Part 100, the maximum credible accident is defined as "...a major accident, hypothesized for purposes of site analysis or postulated from considerations of possible accidental events, 'that would result in potential hazards not exceeded by those from any accident considered credible" [10 CFR §100.11(a), footnote 1]. Although more severe accidents (now generally referred to as Class 9 accidents) are conceivable, the consequences of such accidents were normally not analyzed for assessing the suitability of a proposed site and plant design.'

NRC, Report of the Siting Policy Task force, NUREG-0625 (Aug. 1979) at p. 10, ML12187A284. Moreover, severe accidents to spent fuel pools were not considered by AEC or NRC at the initial licensing stages for Indian Point—and were not analyzed in the Siting Study Report.

J. Storage and Accumulation of Spent Nuclear Fuel at Indian Point

When the federal government first licensed the operation of Indian Point Unit 2 and Indian Point Unit 3 it authorized each unit's single spent fuel pool to hold 241 spent fuel assemblies. NRC subsequently authorized the pools to hold five times (5x) the original limit. The following charts summarize how NRC has authorized increasing amounts of spent nuclear fuel to be stored in the spent fuel pools for Indian Point Unit 2 and Unit 3:

IP2 Spent Fuel Pool Storage Limits[15]	
Date	Fuel Assemblies
1973	264
1980	482
1985	980
1989	1,376

IP3 Spent Fuel Pool Storage Limits[16]	
Date	Fuel Assemblies
1975	264
1978	840
1989	1,345

18-L13-1 cont'd

Indian Point currently has—and is expected continue to have—substantial amounts of radioactive spent nuclear fuel waste on site. During the May 8, 2012 site visit to the Indian Point facilities by the Atomic Safety and Licensing Board, Entergy representatives made the following statements about Entergy's plans for spent nuclear fuel at Indian Point:

(A) All of the spent fuel generated during since the start of commercial operation of Indian Point Unit 3 remains in the Indian Point Unit 3 spent fuel pool (as of the date of the May 2012 site visit);

(B) Entergy has no current plans to construct an additional dry cask storage area (in addition to the existing dry cask storage area); and

(C) At the end of electricity generation operations under any 20-year extension of the current operating licenses, Entergy estimates that the existing dry cask storage area would be filled to capacity and that the Indian Point Unit 2 spent fuel pool and the Indian Point Unit 3 spent fuel pool would be filled to capacity as well.

This means that under Entergy's plan the site's two operating spent fuel pools will continue the site's dense pool storage practices into the future.

[15] Consolidated Edison, *Final Design Report for Reracking the Indian Point Unit No. 2 Spent Fuel Pool,* at 1, ML100200292 (May 1980); Consolidated Edison, *Supplemental Spent Fuel Safety Analysis,* at 3-1, ML100350310 (Nov. 1985); and Consolidated Edison, *Indian Point Unit 2 Spent Fuel Pool Increased Storage Capacity Licensing Report,* at 1-2, ML100200114 (June 1989).

[16] USAEC, *Safety Evaluation Report by the Directorate of Licensing U.S. AEC In the Matter of Consolidated Edison Co. of New York, Inc. Indian Point Nuclear Generating Unit No. 3*, at 4-1, 9-2, ML072260465 (Sept. 21, 1973); USNRC, *Indian Point, Unit 3, Amendment 13, Authorizing Modifications to the Spent Fuel Pool, Increasing Capacity from 264 to 840 Fuel Assemblies*, attached to *Letter from A. Schwencer, NRC to New York State Power Authority*, ML003778668 (Mar. 22, 1978); and USNRC, *Indian Point, Unit 3, Amendment 90, Allowing for the Expansion of the Spent Fuel Pool Storage Capacity*, attached to *Letter from Joseph Neighbors, NRC to New York Power Authority*, ML003778816 (Oct. 12, 1989).

18-L13-1 cont'd

K. History of Leaks at Indian Point

Although NRC has described spent fuel pools as "leak tight," events at Indian Point have shown that description to be inaccurate. In 2005, Indian Point identified leakage of radionuclide-contaminated water from cracks in two different spent fuel pools and subsequently discovered tritium, strontium, and other radionuclides in groundwater underneath the site.[17] Strontium and tritium from Indian Point's spent fuel pools have reached the Hudson River.[18]

Existing radioactive leaks at Indian Point have already far exceeded national drinking water standards.[19] All fresh groundwater in New York State is "Class GA," the best use of which is as a source of potable water supply.[20] Indian Point groundwater concentrations have exceeded national drinking water standards for tritium in six locations, sometimes by more than four times the tritium concentrations considered harmful to human health, and exceed national drinking water standards for Strontium-90 in ten locations, by almost five times in some locations.[21]

While NRC has acknowledged tritium leaks, it has been reluctant to acknowledge leaks of strontium and other radionuclides. In November 2010, the State of New York sought to draw

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[17] Nuclear Regulatory Commission, NRC Talking Points Slide Entitled, "Tritium at Nuclear Power Plants in the United States, Slide 3: Background," ML063260464 (Nov. 7, 2006); Nuclear Regulatory Commission Office of Nuclear Reactor Regulation, *Ground-Water Contamination Due to Undetected Leakage of Radioactive Water*, NRC Information Notice 2006-13, at 3-4 (*Ground-Water Contamination*) ML060540038 (July 10, 2006).

[18] *Ground-Water Contamination* at 3-4; Entergy, Indian Point License Renewal Application, Environmental Report at 5-4, ML071210530 (Apr. 23, 2007).

[19] *See* GZA GeoEnvironmental, Inc., *Hydrogeologic Site Investigation Report, Indian Point Energy Center* (*GZA Report*), at 90, 126, ML080320540 (Jan. 7, 2008); *see also* 40 C.F.R. § 141.66 (establishing drinking water standard for tritium at 20,000 pCi per liter and strontium at 8 pCi per liter).

[20] 6 N.Y.C.R.R. § 701.15.

[21] *GZA Report* at 125-26.

the Commission's attention to the fact that radionuclides in addition to tritium have leaked from reactors.[22] Moreover, the subsurface radiation plumes have exceeded EPA drinking water standards.[23] And in January 2016, a new onsite tritium leak from the Unit 2 Fuel Handling Building was discovered.[24] The long history of leaks at Indian Point supports treating groundwater contamination as a site-specific environmental impact.

18-L13-1 cont'd

L. Decontamination Costs

In 2010, the NRC informed the Environmental Protection Agency and the Federal Emergency Management Agency (FEMA) that the industry-funded account established under the Price Anderson Act would likely not be available to pay for offsite decontamination in the event of a severe accident at a nuclear plant.[25] In its August 20, 2012 comments on an earlier draft FSEIS supplement for Indian Point, the State identified and discussed the issue of funding for environmental restoration following a major radiological release at Indian Point.[26]

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[22] State of New York Comment Letter on Groundwater Task Force Report, Docket ID NRC-2010-0302, 75 Fed. Reg. 57987 (Sept. 23, 2010), ML103080060 (Nov. 1, 2010).

[23] *Id.*

[24] NRC, *Event Notification Report for February 11, 2016*, OFFSITE NOTIFICATION VIA NEWS RELEASE CONCERNING TRITIUM LEVELS IN GROUNDWATER MONITORING WELLS, Event Number: 51724, *available at* http://www.nrc.gov/reading-rm/doc-collections/event-status/event/2016/20160211en.html (last visited Mar. 4, 2016).

[25] Douglas P. Guarino, *Agencies Struggle To Craft Offsite Cleanup Plan For Nuclear Power Accidents (Guarino Article)*, Inside EPA (Nov. 10, 2010).

[26] *See* Comments by the New York State Office of the Attorney General on the Draft Supplement to Supplement 38 to the Generic Environmental Impact Statement For License Renewal of Nuclear Plants, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment Dated June 26, 2012 (State Comments) at 4, ML12235A409 (Aug. 20, 2012).

The State's Comments cited a presentation by NRC Commissioner William D. Magwood, IV at the Health Physics Society Mid-Year Meeting on February 6, 2012.[27] In the presentation, at slide 15, Commissioner Magwood noted that "[t]here is no regulatory framework for environmental restoration following a major radiological release." Based on this information, the State commented that "it [is] not clear that NRC has the desire, capability, or financial resources to respond to a serve accident at Indian Point and ensure the thorough decontamination of the New York metropolitan area including, but not limited to, its water resources—and drinking water resources—in the wake of such an accident." State Comments at 4.

18-L13-1 cont'd

In response to the State's Comments, NRC Staff stated that "NRC has technical leadership for the Federal government's response to the event," but it also listed eight other federal agencies "who may respond to an event at an NRC-licensed facility, or involving NRC-licensed material."[28] Staff's response did not address Commissioner Magwood's statement regarding the lack of a regulatory framework for environmental restoration following a major radiological release. Nor did Staff explain which federal agency is responsible for decontaminating the New York metropolitan area following a severe accident at Indian Point, or which agency's decontamination standards will apply to a cleanup.

Staff noted that "[c]osts associated with nuclear incidents are governed by the Price-Anderson Nuclear Industries Indemnity Act" and that "[t]he main purpose of the Act is to provide prompt and orderly compensation to the public who may incur damages from a nuclear incident, no matter who might be liable." June 2013 FSEIS Supplement at A-32. Staff added

[27] *See* Commissioner Magwood, Nuclear Issues in the Post Fukushima World - Presentation at the Health Physics Society Mid-Year Meeting (Magwood Presentation), Feb. 6, 2012.

[28] Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38 Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3 Final Report, Supplemental Report and Comment Responses (June 2013 FSEIS Supplement) at A-32, ML13162A616 (June 2013).

that there is a combined level of protection under the Price Anderson Act of $12 billion, and if a nuclear accident involves damages in excess of this amount, the Act "includes a provision that obligates Congress to take appropriate action to provide compensation for public liability claims." *Id.* at A-33. However, while Staff's response explains how the public will be compensated for damages incurred as a result of an accident, such as hotel stays, lost wages and property replacement costs, it does not explain how NRC will fund *decontamination* costs in the event of a severe accident at the Indian Point spent fuel pools. 18-L13-1 cont'd

Given the unique characteristics of Indian Point, it is especially important that the public have access to this information. As discussed above, the Indian Point reactors are located 24 miles north of New York City. More than 17 million people live within 50 miles of Indian Point, a total that is projected to approach 20 million by 2035. According to the Atomic Energy Commission, the NRC, and FEMA, more people live within 10 and 50 miles of the Indian Point reactors than at any other operating power reactor in the nation. The communities within the 50-mile radius around Indian Point also contain some of the most densely-developed and expensive real estate in the country, critical natural resources, centers of national and international commerce, transportation arteries and hubs, and historic sites. Thus, the decontamination costs of a severe accident at Indian Point have the potential to be larger than an accident at any other reactor in the country.

Documents disclosed by the NRC and other federal agencies indicate that there are conflicting responsibilities of multiple federal agencies for offsite restoration after a nuclear incident and that NRC may not lead cleanup oversight in the event that an accident at a nuclear power plant dispersed radioactive contamination off the reactor site and into the surrounding area. *See Guarino Article.*

These documents also indicate that money set aside by the Price Anderson Act would not be available to fund decontamination. *Id.* If there is no regulatory framework or source of funding in place to decontaminate the New York metropolitan area in the event of a severe accident at Indian Point's spent fuel pools, that fact should be disclosed by NRC Staff to the public. Therefore, in light of Commissioner Magwood's statements and NRC's statements to EPA, the State requests that NRC answer the following questions in the draft Supplement:

1. Which federal agency is responsible for decontaminating radiation released offsite by a severe accident at the Indian Point spent fuel pools?
2. Would the Price Anderson Act fund decontamination in the event that that an accident at Indian Point caused radioactive contamination to be dispersed off the reactor site and into the surrounding area?

18-L13-1 cont'd

M. Sabotage

Any site-specific review of the environmental impacts at Indian Point must examine the impacts of sabotage on the facilities. On September 11, 2001, nineteen terrorists hijacked four jet airliners and crashed three of them into their intended targets. The impact of the fuel-laden planes caused explosions and large, long-lasting fires. Those explosions and fires destroyed a portion of the Pentagon in northern Virginia and caused the collapse of the World Trade Center towers and nearby buildings in New York City. *See* Nat'l Comm'n on Terrorist Attacks Upon the U.S. (9/11 Commission), *The 9/11 Commission Report* (2004).

Minutes before hitting the World Trade Center, two of the hijacked planes flew near or over Indian Point. *See id.* at 32 (American Airlines Flight 11, United Airlines Flight 175). The wind direction at the time of the attacks was towards the southeast—that is, from Indian Point toward New York City. *See id.* at 285.

The 9/11 Commission's report revealed that Khalid Sheikh Mohammad, the mastermind of the 9/11 attacks, originally planned to hijack additional aircraft to crash into targets on both coasts, including nuclear power plants. *The 9/11 Commission Report,* at 154. As late as July 2001, the terrorists were considering attacking a specific nuclear facility in New York, which one of the pilots "had seen during familiarization flights near New York." *Id.* at 245. This was likely Indian Point.

18-L13-1 cont'd

When Congress disbanded the Atomic Energy Commission and created the Nuclear Regulatory Commission in 1974, it charged the new agency with the responsibility to ensure the security of commercial nuclear power plants and nuclear material. Energy Reorganization Act of 1974, § 204, 42 U.S.C. § 5844 (Commission shall provide and maintain "safeguards against threats, thefts, and sabotage of such licensed facilities, and materials"). Congress added this responsibility in the wake of increasing sabotage and terrorism events in the early 1970s—such as the 1972 attack at the Munich Olympics and hijackings of commercial jets in the U.S. and abroad. To this end, within NRC there is an Office of Nuclear Security and Incident Response.

From time to time, the Nuclear Regulatory Commission has promulgated regulations identifying the threat which nuclear power plants must protect against. This is known as the "design basis threat" or "DBT" regulation. 10 C.F.R. § 73.1. The DBT describes the adversary force that operating power reactors must defend against. It is based on realistic assessments of the tactics, techniques, and procedures used by international and domestic terrorist groups and organizations. Over the past 35 years, as sabotage threats have evolved, the Nuclear Regulatory Commission has successively increased the security threat against which power plants must defend. *Compare* 42 Fed. Reg. 10,836 (Feb. 24, 1977) *with* 59 Fed. Reg. 38,889, 38,891 (Aug. 1, 1994). In 1994, the Commission revised the DBT rule in response to an intrusion at a nuclear power plant, the 1993 vehicle bomb attack on the World Trade Center, and intelligence that showed "a conspiracy with ties to the Middle East extremists clearly demonstrated the capability and motivation to organize, plan, and successfully conduct a major vehicle bomb attack." 59 Fed. Reg. at 38,891.

18-L13-1 cont'd

The most recent revision to the design basis threat regulation took place in 2007 following the September 11, 2001 attacks. 72 Fed. Reg. 12,705 (Mar. 19, 2007); 42 U.S.C. § 2210e (Energy Policy Act of 2005 provision directing Commission to evaluate the design basis threat rule). In that regulatory revision, NRC instructed nuclear power plants to defend against cyber-attacks, water-borne attacks, and truck-based attacks. However, despite the September 11, 2001 airplane attacks on the Pentagon and the World Trade Center Towers, NRC did not require nuclear power plants to take defensive measures against airplane-based attacks. The United States Court of Appeals for the Ninth Circuit upheld NRC's decision not to include airplane-based attacks in the revised design basis threat rule. *Public Citizen v. NRC*, 573 F.3d 916 (9th Cir 2009). While the current DBT rule does not include airplane threats, "No one disputes that there is a credible threat of terrorists using commercial aircraft to attack nuclear power plants." *Id.*, at 929 (Thomas, C.J., concurring in part and dissenting in part).

Also in response to September 11, NRC directed designers of new nuclear power plants to perform a rigorous assessment that could avoid or mitigate the effects of an aircraft impact. Specifically, in 2009, NRC promulgated a new regulation requiring applicants for new power reactors to assess the ability of their reactor designs to avoid or mitigate "the effects of the impact of a large, commercial aircraft." 74 Fed. Reg. 28112 (June 12, 2009). That rule, however, only applies to *new* reactors; it does not apply to the *existing* fleet of 100 reactors and pools currently operating, including the Indian Point facilities. In that rulemaking proceeding, New York opposed the exemption for existing plants and identified several concerns specific to the Indian Point facilities.[29]

18-L13-1 cont'd

In 2005, the National Academy of Sciences released a report from a study it conducted at the request of Congress, with the sponsorship of the NRC and the Department of Homeland Security, of the security risks posed by the storage of spent fuel at nuclear plant sites. *See* Nat'l Acad. of Sciences, *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report* (2006). Based upon information provided by the NRC, the National Academy of Sciences judged that "attacks with civilian aircraft remain a credible threat." *Id.* at 30. It noted that terrorists might choose to attack spent fuel pools because they are "less well protected structurally than reactor cores" and "typically contain inventories of medium- and long-lived radionuclides that are several times greater than those contained in individual reactor cores." *Id.* at 36. The National Academy of Sciences concluded that the storage pools are susceptible to fire and radiological release from a wide range of conditions, including intentional attacks with large civilian aircraft. *Id.* at 49, 57.[30]

The Federal Emergency Management Agency has taken actions signifying that it considers an aircraft attack on a nuclear power plant to be a credible threat. For instance, during a June 2004 exercise to assess emergency preparedness at Indian Point, the agency simulated a suicide attack by a large cargo jet. *Fed. Emergency Mgmt. Agency, Final Exercise Report:*

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[29] New York State's Comments Concerning NRC Proposed Rulemaking to Amend 10 C.F.R. Part 52 to Require Certain Applicants to Consider Aircraft Impacts to Future Nuclear Power Plants, ML073530552 (Dec. 17, 2007).

[30] A fully loaded Boeing 767 weighs nearly 400,000 pounds. *See* Boeing, Technical Characteristics-Boeing 767-200ER, *available at* http://www.boeing.com/commercial/767family/pf/pf 200prod.html. The A-380, Airbus's new superjumbo airliner, has a maximum takeoff weight of 1,235,000 pounds. *See* Airbus, Aircraft Families/A380Specifications, *available at* http://www.airbus.com/en/aircraftfamilies/a380/ a380/specifications.html. According to the NRC webpage, in May 2008 NRC Chairman Dale Klein attended a security drill at San Onofre Nuclear Generating Station involving a hijacked plane approaching the facility.

Indian Point Energy Center, at 101-02 (Oct. 25, 2004). In that drill scenario, the plane missed the facilities and crashed into a parking lot.

18-L13-1 cont'd

As summarized in the NRC's *A Short History of Nuclear Regulation* 1946-2009, NUREG/BR-0175, Revision 2, ML102980443 (Oct. 2010), the September 11 airplane attacks revealed a weakness at U.S. commercial nuclear power plants, namely that the commercial U.S. nuclear facilities were not designed to withstand aircraft crashes and that the densely packed spent fuel pools were located outside of the concrete containment shell were potentially vulnerable to sabotage.

> As the NRC was working on the protection of plants from a commando strike, it was also considering another problem that was equally difficult and even more ethereal—the effects of an airplane hitting a reactor building or spent fuel pool. Shortly after terrorists flew airplanes into the World Trade Center and the Pentagon on September 11, 2001, the NRC acknowledged that nuclear plant builders "did not specifically contemplate attacks by aircraft such as Boeing 757s and 767s, and nuclear plants were not designed to withstand such crashes." The only operating plant designed to guard against the impact of a large airplane was TMI, located 3 miles from Harrisburg International Airport. It was designed to protect against a plane of about 200,000 pounds accidentally hitting the plant at a speed of 230 miles per hour; the planes that terrorists hijacked on September 11, 2001, were heavier and hit their targets at speeds of 350 to 537 miles per hour. Although the NRC pointed out that containment buildings were "extremely rugged structures," it could not predict with certainty what the consequences would be "if a large airliner, fully loaded with jet fuel…crashed into a nuclear power plant." The critical issue that industry and the NRC then faced was to assess the vulnerability of plants to an air attack that could produce a massive release of radiation.

NUREG/BR-0175, Rev. 2, at 86; *see also id.* at 87 (discussing spent fuel pools, which are located outside of the containment shell).

Consistent with its statutory responsibilities, the NRC has analyzed sabotage events in previous documents. For example, the 1996 GEIS for License Renewal Applications discussed the effects of sabotage—albeit in a pre-9/11 world.[31]

18-L13-1 cont'd

The GEIS contains a few brief generic phrases about the environmental impacts that could result from sabotage or terrorism. GEIS 4-91 to 4-97. The document contains conclusory statements to the effect that "[t]he environmental impacts of a successful terrorist attack, if one occurs, could be significant and destabilizing." GEIS 4-91; 4-94 (consequences of sabotage could be "severe"). These statements and the remainder of § 4-19 provide no real descriptive analysis of the impacts beyond noting that the economic damages could exceed $50 billion and lead to "191 early fatalities." GEIS at 4-94. It is not clear how these passing observations would apply to the Indian Point facilities and the New York City metropolitan area. Equally important, § 4-19 does not identify, discuss, and evaluate alternatives and mitigation measures. Given these omissions, the GEIS's discussion of the environmental impacts of sabotage events does not comply with NEPA. Moreover, the GEIS fails to account for cumulative impacts, segments review, and does not address site-specific issues relevant to Indian Point and the New York City metropolitan area.

N. Need for Objective Site-Specific Analysis

Given the combination of site-specific characteristics, the decontamination costs and resource replacement costs following a severe accident at Indian Point have the potential to be substantially larger than an accident at any other reactor in the country. Furthermore, in light of the site-specific characteristics and the considerable costs associated with a severe nuclear

[31] NUREG-1437, Vol. 1, at 5-18 (1996); *see, e.g.,* NUREG-0179, *Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes*, (Dec. 1977) (discussing potential sabotage impacts). In 1981, NRC published NUREG/CR-1345, *Nuclear Power Plant Design Concepts for Sabotage Protection,* Vols. 1 & 2 (Jan. 1981).

18-L13-1 cont'd

accident in the New York metropolitan area, mitigation alternatives are likely to be more cost effective at the Indian Point facilities.

II. THE DRAFT SUPPLEMENT MUST INCLUDE A DISCUSSION OF ALTERNATIVES TO AND MITIGATION MEASURES FOR THE CONTINUED STORAGE OF SPENT NUCLEAR FUEL AT INDIAN POINT

A. The Draft Supplement Must Examine Site-Specific Alternatives and Mitigation Measures

18-L13-2

The NY Attorney General argued in the proceedings in the District of Columbia Circuit that the GEIS fails to adequately analyze mitigation measures and licensing alternatives. States' D.C. Cir. Br. 38-45. In response, NRC stated in its brief that alternatives are properly considered under NEPA at the time of reactor licensing, NRC D.C. Cir. Br. at 20-21, and that "mitigation would be addressed as part of the site-specific component of its environmental reviews," *id.* at 62. NRC concluded that "discussion of these issues will be incorporated within the Record of Decision for each licensing decision." *Id.* at 63.

Despite NRC's statements that alternatives and mitigation measures would be considered on a site-specific basis, the draft Supplement does not contain any discussion of either. NRC may not defer this site-specific analysis to its Record of Decision—instead, it must be done in an EIS, which is subject to public comment. 40 C.F.R. §§ 1502.14(a), (f), 1503.1; 10 C.F.R. § 51.71(d). A record of decision is not an EIS nor is it subject to public comment. Instead, it is the culmination of NRC's environmental review, and states how "the EIS was used in arriving at the decision." *Implementation of Procedural Provisions*, 43 Fed. Reg. 55,978, 55,980 (Nov. 29, 1978).

There are a wide array of mitigation measures and alternatives that the draft Supplement is obligated to consider as part of its site-specific NEPA review for Indian Point, including measures and alternatives that address both leaks and fires. NRC is obligated to assure that the

Commission has taken all practicable measures within its jurisdiction to avoid or minimize environmental harm from the alternative selected, and if not, to explain why those measures were not adopted. 10 C.F.R. § 51.103(a)(4). 18-L13-2 cont'd

B. NRC Must Consider Alternatives and Mitigation Measures that Reduce the Risk of a Zirconium Fire at Indian Point

18-L13-3

The review of alternatives and mitigation measures in the draft Supplement should consider alternatives to the current storage scheme at Indian Point that reduce the risk of a zirconium fire, which may occur if the cooling water in a spent fuel pool boils or drains away and the zirconium cladding that forms the spent fuel rods ignites. A zirconium fire has the potential to cause a major release of radiation and have catastrophic environmental impacts, a fact which NRC does not dispute. Indeed, it has acknowledged that "a zirconium fire event can have public health and safety consequences similar to a severe core damage accident with a large off-site release."[32] These issues must be considered on a site-specific basis, since plant-specific factors may make facilities more or less vulnerable to such fires, may require different mitigation measures, and may lead to different environmental impacts.[33]

The following alternatives should be considered in a site-specific review of Indian Point's spent fuel pools.

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[32] Nuclear Regulatory Commission, Policy Issues Related to Safeguards, Insurance, and Emergency Preparedness Regulations at Decommissioning Nuclear Power Plants Storing Fuel in Spent Fuel Pools (WITS 200000126), NRC SECY-01-0100, at 5 (June 4, 2001).

[33] This fact was recognized by Congress when it directed NRC to implement the recommendations of the 2006 NAS Report on spent nuclear fuel storage. In particular, Congress asked NRC to prepare site-specific models to mitigate the risks associated with spent fuel storage. U.S. Congress, Conference Report 108-792, *Making Appropriations for Foreign Operations, Export Financing, and Related Programs for the Fiscal Year Ending September 30, 2005, and For Other Purposes,* at 982 (Nov. 20, 2004). Former NRC Commissioner Victor Gilinsky also recommended that spent fuel storage be examined on a site-specific basis in his *Separate Views Regarding Proposed Amendments to 10 CFR Parts 50 and 51, Waste Confidence Proceeding,* 48 Fed. Reg. 22,730 (May 20, 1983) ("While I agree that there is no obstacle in principle to extended on-site storage, I think it is clear that each power reactor site will have to be examined in detail.").

18-L13-3 cont'd

1. Thinning of Spent Fuel Pools and Use of Dry Cask Storage

One alternative that should be considered is the thinning of spent fuel pools. Densely packed spent fuel heats up faster in the event of the loss of cooling water than sparsely packed fuel,[34] giving workers and emergency crews less time to respond to prevent fire or other damage to the fuel assemblies.[35]

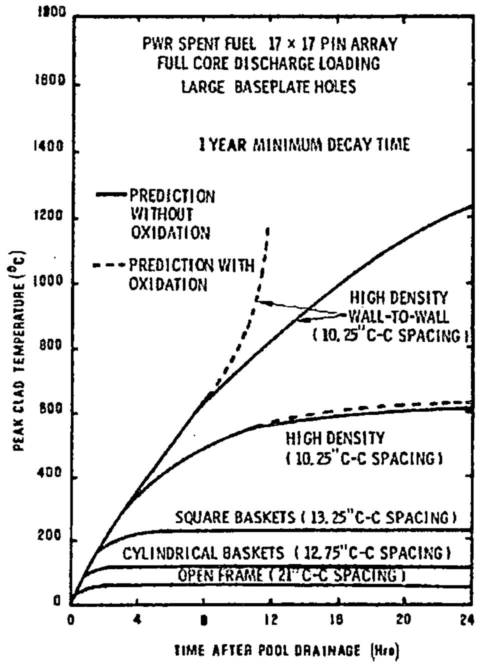

Figure: Effect of Storage Rack Configuration on Heatup of PWR Spent Fuel, Well-Ventilated Room. *Source*: *1979 Sandia Report* at 51.

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[34] Allan S. Benjamin et al., *Spent Fuel Heatup Following Loss of Water During Storage* (Sandia National Laboratory, NUREG/CR-0649, SAND77-1371) (*1979 Sandia Report*), at 50 (Mar. 1979) ("The high density holders . . . are the least well-suited to heat removal, as expected, particularly if the spent fuel is packed wall-to-wall so as to preclude a down-comer space at the edge of the pool.").

[35] *See* Sandia National Laboratories, *Mitigation of Spent Fuel Pool Loss-of-Coolant Inventory Accidents and Extension of Reference Plant Analyses to Other Spent Fuel Pools*, at viii (Nov. 2006) ([D]ispersed configurations [of spent fuel assemblies] provided additional time for mitigative actions before the release of fission products versus a non-dispersed configuration.); *see also* National Academy of Sciences, *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report* (*NAS Report*), The National Academies Press, at 103 (2006) ("[M]odifying the storage racks to provide for closer spacing of the fuel assemblies. . . . can make it more difficult to cool the freshly discharged fuel if there is catastrophic loss of the fuel pool water.").

Alvarez et al. recommend moving away from the current "dense-pack" configurations and returning to open-rack configurations, for which the spent fuel pools were originally designed.[36] The figures below illustrate the different designs.[37]

18-L13-3 cont'd

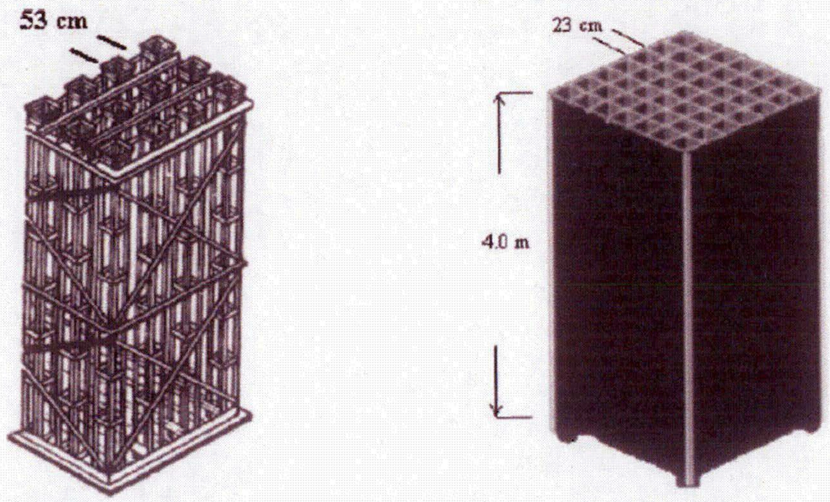

Figure 7: Open and dense-pack PWR spent-fuel racks (*Sources:* Left: NUREG/CR-0649, SAND77-1371, 1979; right: authors).

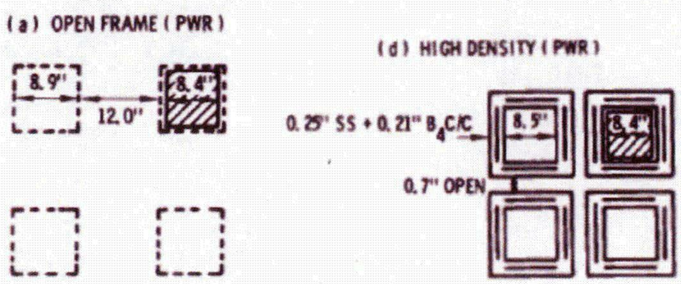

Figure 3. Cross Sectional Dimensions of Spent Fuel Holders Shown in Fig. 2.

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[36] Robert Alvarez, et. al., *Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States (Reducing the Hazards)*, Science and Global Security, Vol. 11:1-51, at 23.

[37] First figure: *Reducing the Hazards* at 17. Second figure: *1979 Sandia Report* at 20.

In the original design for pressurized-water reactor spent fuel pools, fuel assemblies were packed 53 cm apart, allowing the cooling water to channel between them.[38] In the densely packed design, fuel assemblies are only 23 cm apart (close to the 21.4 cm spacing in reactor cores),[39] allowing about five times as many assemblies to be stored in the pool.[40] To keep these closely packed fuel rods sub-critical, they are placed in metal boxes containing neutron-absorbing boron.[41] In a loss of coolant accident, where pool water is lost, these boxes would prevent the horizontal circulation of cooling air.[42] The 1979 Sandia report prepared for NRC found that with an open frame storage configuration in a well-ventilated facility, spent fuel in a drained storage pool would not overheat if it was cooled for five days before being transferred to the pool.[43] Another Sandia study also found that low density racking is the spent fuel configuration that is least vulnerable to zirconium fires.[44] 18-L13-3 cont'd

If there is not enough room in the pool to permit open frame storage—because too much fuel is unloaded from a reactor during a given five year period—Alvarez et al. recommend considering: "(1) an arrangement where one fifth of the fuel assemblies are removed in a pattern in which each of the remaining fuel assemblies has one side next to an empty space; (2) an

[38] *Reducing the Hazards* at 17.

[39] *Id.* at 16.

[40] *NAS Report* at 43.

[41] *Id.*

[42] *Id.* at 17.

[43] *Reducing the Hazards* at 23.

[44] Samuel G. Durbin and Eric R. Lindgren of Sandia National Laboratories, Investigations of Zirconium Fires During Spent Fuel Pool LOCAs (Slideshow), ML120380359 (Feb. 7, 2012).

arrangement where alternate rows of fuel assemblies are removed from the rack."[45] The first suggestion is illustrated in the figure below.[46]

18-L13-3 cont'd

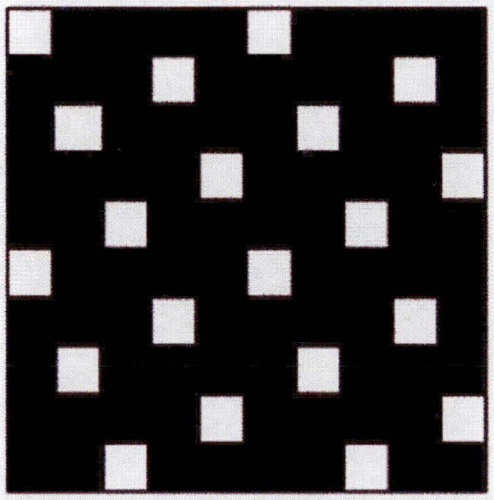

Figure 2: Removal of one fifth of the spent-fuel assemblies could result in every fuel assembly having one side exposed to an empty channel.

Similarly, a report by the National Academy of Sciences recommended that, space permitting, empty slots be arranged throughout the pool to promote natural air convection in the event that the pool is completely drained.[47] That report also found that spent fuel is less at risk from accident or attack in dry cask storage than in a fuel pool.[48] This is because the spent fuel stored in dry casks has been cooled for at least five years, and is therefore, not prone to zirconium cladding fires.[49] Moreover, the dry cask system divides the spent fuel between many different casks—each cask stores only 10 to 15 tons of fuel, as opposed to a pool, which stores

[45] *Reducing the Hazards* at 23.

[46] Figure is taken from: Beyea, Lyman, von Hippel, *Damages from a Major Release of 137Cs into the Atmosphere of the United States*, Science and Global Security, Vol. 12:125-136, at 133 (Jan. 21, 2004).

[47] *NAS Report* at 55.

[48] *NAS Report* at 68.

[49] *NAS Report* at 69.

hundreds of tons—so if an individual cask is compromised, there is less potential radiation to be released. Additionally, since dry cask storage relies on natural air circulation for cooling, a breach would not release contaminated water into the environment and emergency crews would not need to find an alternative source of water with which to fill them.

18-L13-3 cont'd

However, Alvarez and others recommend that all spent fuel be removed from pools and placed in dry cask storage after it has cooled for five years. In March 2011, David Lochbaum, of the Union of Concerned Scientists, stated before the U.S. Senate Energy and Natural Resources Committee, "A better strategy would be to reduce the inventory of irradiated fuel in the pools to the minimum amount, which would be only the fuel discharged from the reactor core within the past five years."[50] This, he said, would lower the risk of fire by decreasing the heat load of the pool, giving workers more time to respond in the event of the loss of cooling water. Also, if radiation was released, it would be significantly lower in a less densely packed pool. That same month at a meeting on Capitol Hill, Energy Secretary Steven Chu recognized that the storage of spent nuclear fuel in dry casks is much safer than storage in pools.[51] In May 2011, the Institute for Policy Studies released a report authored by Robert Alvarez, also recommending that all

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[50] Statement by David Lochbaum, Director of Nuclear Safety Project, Before the U.S. Senate Energy and Natural Resources Committee, at 2 (Mar. 29, 2011), *available at* http://www.ucsusa.org/assets/documents/nuclear_power/lochbaum-senate-energy-3-29-2011.pdf (last visited Mar. 3, 2016).

[51] Hearing on the Fiscal Year 2012: Department of Energy and Nuclear Regulatory Commission Budgets, House of Representatives, Subcommittee on Energy and Power joint with the Subcommittee on Environment and the Economy Committee on Energy and Commerce, at 77 (Mar. 16, 2011), *available at*: http://democrats.energycommerce.house.gov/sites/default/files/image_uploads/031611%20EP-EE%20Fiscal%20Year%202012%20DOE%20and%20NRC%20Budgets.pdf (Chu stated: "After you take the fuel rods out of the reactor, immediately you put them in a pool of water for a period of time where they are actually still dissipating a considerable amount of heat. But then after that, the next stage is that you can put them in dry cask storage, which is much safer.").

spent fuel that has been in pools for five years be removed and placed in dry storage.[52] Additionally, in April 2011, U.S. Senator Diane Feinstein called upon the NRC Commissioners to enact regulatory policies that reduce the amount of spent fuel stored in pools.[53] 18-L13-3 cont'd

In August 2011, Chairman Jaczko acknowledged the benefits of transferring spent fuel to dry cask and said the Commission should consider this alternative:

> I also believe the Commission should consider in the long term if there should be new regulations to require licensees to move spent fuel to dry cask storage within a specific timeframe. This step, recognizing the inherent safety benefits of dry storage and combining that knowledge with the new ISFSI security regulations under development, may provide a safer and more secure disposition for spent fuel. I also believe that an NRC-developed pilot probabilistic risk assessment provides additional supporting evidence of the benefits of having more of the spent fuel held in dry storage.[54]

Sandia National Laboratories has also acknowledged that reducing the volume of spent fuel in spent fuel pools would mitigate the risks posed by dense storage. On February 7 and 8, 2012, NRC Staff made publically available three documents discussing the safety of spent fuel pools. The first is a slideshow explaining the findings of a study conducted by Sandia National Laboratories, which investigated zirconium fires during spent fuel pool loss of coolant accidents (LOCAs).[55] The study found that low density racking is the spent fuel configuration that is least vulnerable to zirconium fires:[56]

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[52] Robert Alvarez, *Spent Nuclear Fuel Pools in the U.S.: Reducing the Deadly Risks of Storage*, at 21 (May 2011).

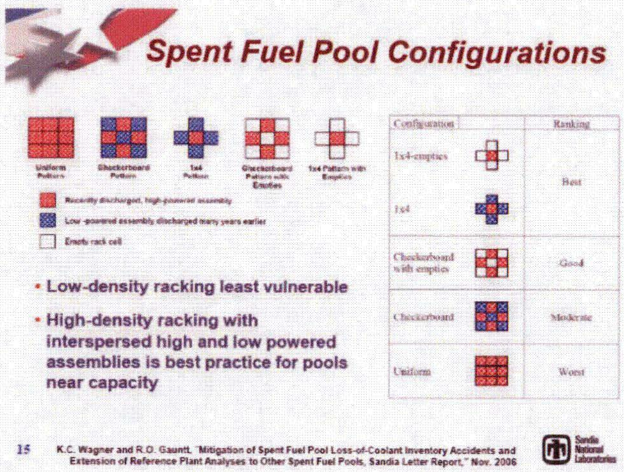
[53] Letter from Senator Feinstein to NRC Chairman Jaczko, ML11108A038 (April 8, 2011).

[54] Nuclear Regulatory Commission, Commission Voting Record: Near-Term Report and Recommendations for Agency Actions Following the Events in Japan, at PDF page 9, ML112310746 (Aug. 19, 2011).

[55] Samuel G. Durbin and Eric R. Lindgren of Sandia National Laboratories, Investigations of Zirconium Fires During Spent Fuel Pool LOCAs (Slideshow), ML120380359 (Feb. 7, 2012).

[56] *Id.* at slide 15.

18-L13-3 cont'd



The NRC recently undertook a study to determine if it is cost-beneficial to expedite the transfer of spent fuel from high-density spent fuel pools to dry storage casks by analyzing the probabilities and consequences of severe accidents originating from a spent fuel pool.[57] It relied on MACCS2 calculations using a reference site to determine the collective dose and various economic costs (*i.e.*, costs associated with decontamination, interdiction and property condemnation) and thus ignores the unique, site-specific consequences that would occur as a result of a severe accident at Indian Point. The ISR Report details those consequences, but some of the general conclusions are summarized here:

- In the reference case of Peach Bottom used in the Spent Fuel Pool Consequence Study, the total population within a 50-mile radius is 5.7 million. By comparison, the total population within a 50-mile radius surrounding the Indian Point site is more than 17 million.

- The wind rose (*i.e.*, probability of wind directions) of the site has a direct correlation to the probability of certain areas being contaminated and thus requiring mitigative actions. In the Spent Fuel Pool Consequence Study, the reference plant's wind rose was such that the predominant wind directions were

[57] *See* Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor (Consequence Study). On October 9, 2013, in SECY-13-0112 (ML13256A339), the US-NRC Staff provided the US-NRC Commissioners with the final Spent Fuel Pool Study, noting Staff's intention to make the report public and subsequently publish it as a NUREG. On November 12, 2013, the US-NRC issued COMSECY-13-0030 (ML13273A601), which incorporates results of the Spent Fuel Pool Consequence Study.

towards lower population areas (Spent Fuel Pool Consequence Study, Section A.2). By comparison, the predominant wind directions at the Indian Point site are to the North/North-Northwest and to the South; the latter would affect the New York City metropolitan area, one of the most populated areas in the United States.

18-L13-3 cont'd

- The value of nonfarm wealth (VALWNF) includes all public and private property not associated with farming that would be unusable if the region was rendered either temporarily or permanently uninhabitable. This value should include the cost of land, buildings, infrastructure, and the cost of any non-recoverable equipment or machinery (MACCS2 manual). The value chosen for the Consequence Study, which uses the Peach Bottom site as the reference case, is \$210,000/person (2012 USD). By its definition, this value is site-specific. As a comparison, in its submission for a license renewal for Indian Point Units 2 and 3, Entergy calculated VALWNF to be \$209,000 (2004 USD). In 2012 USD, this value is approximately \$250,000, which is 20% higher than the value used in the Spent Fuel Pool Consequence Study.

- The per capita cost of long-term relocation (POPCST) takes into account both personal and corporate income losses, as well as moving expenses, for a transitional period. The value chosen for the Spent Fuel Pool Consequence Study is \$12,000/person (2012 USD). This value is site-specific. For example, in the state of New York, the average per capita income is approximately \$32,000 (2011 USD). Using an interdiction period of 140 days as recommended in NUREG/CR-4551, the total amount of lost wages is \$12,600/person (2012 USD). With the addition of corporate income losses and moving expenses, this amount is expected to be higher than the value used in the Spent Fuel Pool Consequence Study.

- The cost and time for decontamination, CDNFRM and TIMDEC respectively, are not site-specific, and do not take into account the differences in decontamination efforts required for varied land use surrounding the site (e.g., rural, semi-urban and urban).

18-L13-3 cont'd

Table 1: Summary of site-specific MACCS2 input parameters relevant to Indian Point

Parameter	Value used in the Consequence Study reference site	Minimum appropriate value for the Indian Point site	Minimum Ratio (Indian Point/reference site)	Applicable to the population dose cost	Applicable to the economic cost
Population within a 50-mile radius	5.7 million	17 million	3.0	Yes	Yes
Predominant wind direction	Towards lesser populated	Towards heavily populated areas	N/A	Yes	Yes
Value of nonfarm wealth (2012 USD)	$210,000/person	$345,000/person*	1.6	No	Yes
Relocation costs (2012 USD)	$12,000/person	$12,500/person*	1.04	No	Yes
Cost of decontamination (DF=3,15) (2012 USD)	$7,110/person $19,000/person	$17,630/person* $83,500/person*	2.5 4.4	No	Yes
Time of decontamination (DF=3,15)	1 year (DF=3) 1 year (DF=15)	1 year (DF=3)* 2 years (DF=15)*	1 2	No	Yes

* The ISR Report and updated tables submitted in the context of the Indian Point relicensing proceeding provided a suggested range of appropriate values for each of these parameters. For the sake of simplicity, and for illustrative purposes in this DGEIS proceeding, only the minimum value is represented here in Table 3. Values were CPI-adjusted to 2012 USD. The reader is directed to ISR Report 13014-01-01: Review of Indian Point Severe Accident Off Site Consequence Analysis (Dec. 21, 2011) (ML12334A761) as modified in Revisions to Tables in ISR Report 13014-01-01 (Jun. 28, 2012) (ML12340A648) for a complete discussion of site-specific input parameters for Indian Point, which also include higher input values.

2. Other Alternatives

While removing spent fuel and placing it in dry cask storage remains the safer alternative, there are other steps that can also contribute to reducing the risk of zirconium cladding fires in spent nuclear fuel pools. For example, the fuel assemblies in pools can be arranged in a checkerboard pattern so that newly discharged fuel is surrounded by older, cooler fuel. The cooler fuel will act as heat sink, absorbing the heat from the newer fuel.[58] Similarly, newly discharged fuel can be placed near the walls of the pool, which will also act as a heat sink. Water spray systems can be installed to cool fuel in the case of loss of pool coolant and pool walls can be reinforced to prevent their damage.[59] Also, limiting the frequency of full core offloads into pools and delaying the transfer of fuel into a pool after a reactor shutdown would reduce the heat-load in the pool.[60]

18-L13-3 cont'd

In the briefing on the proposed GEIS, held on January 11, 2012, Chairman Jaczko indicated that license renewal is an opportunity to get requirements implemented at nuclear facilities.[61]

C. NRC Must Also Conduct Severe Accident Mitigation Alternatives Analyses For Spent Fuel Pools at Indian Point

18-L13-4

Since no legally sufficient prior analysis of spent fuel pool severe accident mitigation alternatives has been completed, NRC is obligated to assure that such an analysis has occurred for Indian Point and that all reasonable severe accident scenarios and mitigation measures have been evaluated. The destruction of multiple facilities at Fukushima demonstrates that severe accidents can occur and can have significant, real world consequences.[62]

The State calls on NRC to revise its approach to severe accident mitigation alternatives (or SAMA) analyses. Under 10 C.F.R. § 51.53(c)(3)(ii)(L), NRC must conduct a site-specific

[58] *NAS Report* at 54.

[59] *NAS Report* at 55.

[60] *NAS Report* at 55.

[61] U.S. Nuclear Regulatory Commission, Briefing on Proposed Rule to Revise the Environmental Review for Renewal of Nuclear Power Plant Operating Licenses (Part 51), Transcript of Proceedings, at 86, ML120180209 (Jan. 11, 2012).

[62] NRC Chairman Gregory Jaczko, *Looking to the Future*, S-12-002 (Feb. 9. 2012).

review of alternatives to mitigate a severe accident at a reactor that seeks to renew its operating license. NRC promulgated this regulation in 1996 in response to the court ruling in *Limerick.* However, while NRC purports to examine alternatives to mitigate severe accidents that occur in the *reactor,* applicants and NRC do not review alternatives to mitigate severe accidents that occur in the *spent fuel pool* that is adjacent to the reactor but outside of the containment shell. In fact, the SAMA analyses only take into account releases from the reactor core. Releases from spent fuel pools that would occur during a severe accident are not taken into consideration at all in the SAMA analyses. Thus, there has not been a comprehensive review of all severe accidents at Indian Point or the available means to mitigate the environmental effects of such severe accidents. It is important that radionuclide releases from spent fuel pools be considered as part of the SAMA analyses because the offsite cost risks of these releases can be higher than those from the reactor core.[63]

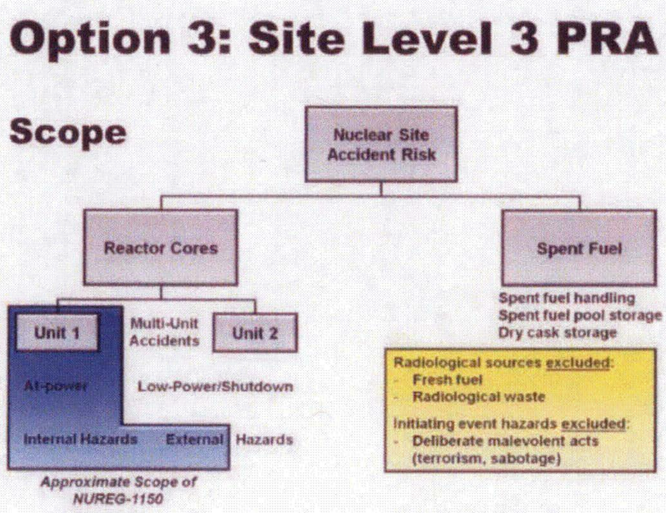
18-L13-4 cont'd

Not only should NRC examine the severe accident mitigation alternatives for severe spent fuel pool accidents, but it should integrate that analysis with an overall site-wide risk analysis. Such an approach would be consistent with the suggestion by former NRC Commission Apostolakis. In the wake of the Fukushima disaster, Commissioner Apostolakis recommended NRC consider conducting site-specific reviews of the risks involved with spent fuel pools as part of a Level 3 Probabilistic Risk Assessment (PRA). In the policy position paper on options for PRA activities, NRC wrote, "To be complete, estimation of total site accident risk should also include an assessment of the risk from accidents involving other site radiological

[63] Gordon R. Thompson, *Risk-Related Impacts from Continued Operation of the Indian Point Nuclear Power Plants*, at 28 (Nov. 28, 2007).

18-L13-4 cont'd

sources, to include spent nuclear fuel."[64] The scope of the proposed PRA is depicted in the diagram below, which was prepared by NRC staff.[65]



Indeed, under the dense storage regime in place today at Indian Point, the spent fuel pools hold considerably more fuel assemblies than the reactor core. The NEPA review of severe accident mitigation alternatives at Indian Point should include releases from these spent fuel pools and alternatives that could mitigate severe spent fuel pool accidents or releases. This SAMA review should also not be limited to a severe accident at a single reactor or a single pool, but should examine the consequences of, and mitigation alternatives for, a severe accident that affects more than one reactor or pool at Indian Point.

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[64] Nuclear Regulatory Commission, *Options for Proceeding with Future Level 3 Probabilistic Risk Assessment Activities*, SECY-11-0089, at 6, ML11090A042 (July 7, 2011).

[65] Figure taken from slides prepared by NRC Staff: Nuclear Regulatory Commission Office of Nuclear Regulatory Research, *Severe Accidents and Options for Proceeding with Level 3 PRA Activities*, ML11209B927 (July 28, 2011).

18-L13-4 cont'd

1. The Severe Accident Mitigation Alternatives Analysis Should be Based on Site-Specific Data and Not Simply Replicate Inputs from Another Reactor

In addition, the SAMA analysis must reflect the true, site-specific costs of an accident involving a spent fuel pool or resulting in a release from a spent fuel pool at Indian Point. As discussed in the accompanying report from ISR, NRC and Entergy did not use site-specific data to calculate the economic costs of a severe nuclear reactor accident at Indian Point. Instead, NRC Staff and Entergy relied on data from "Sample Problem A" to calculate the economic costs associated with a severe nuclear reactor accident in its SAMA analysis. Sample Problem A was one of fourteen sample problems provided with the MACCS2 code as an example for users to check whether the MACCS2 software was installed and operating properly. Sample Problem A is an example set of inputs that were developed for the Surry reactor site located in rural Virginia and was not meant to serve as default input values in the MACCS2 program.[66] Yet NRC Staff and Entergy rely on Surry's Sample Problem A in conducting SAMA analyses for Indian Point, even though Indian Point differs markedly from Surry and its environs. The SAMA analysis for spent fuel pools must rely on site-specific data Indian Point and its surrounding community and environment, not from Surry and its inputs in Sample Problem A.

Use of accurate, site-specific cost is especially important in light of a recent inter-agency dispute among federal agencies over which agency is responsible for ensuring the clean-up and decontamination of contaminated property and the funding source of such decontamination. The November 2010 *Guarino Article* reported:

[66] The "Sample Problem A" values were derived from the Surry facility and discussed in NUREG-1150, *Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants* (Dec. 1990).

> EPA, the Nuclear Regulatory Commission (NRC) and the Federal Emergency Management Agency (FEMA) are struggling to determine which agency—and with what money and legal authority—would oversee cleanup in the event of a large-scale accident at a nuclear power plant that disperses radiation off the reactor site and into the surrounding area.
>
> The effort, which the agencies have not acknowledged publicly, was sparked when NRC recently informed the other agencies that it does not plan to take the lead in overseeing such a cleanup and that money in an industry-funded insurance account for nuclear accidents would likely not be available . . . .
>
> [T]he NRC officials also indicated during the meetings that the industry-funded account established under the Price Anderson Act—which Congress passed in 1957 in an effort to limit the industry's liability—would likely not be available to pay for such a cleanup.[67]

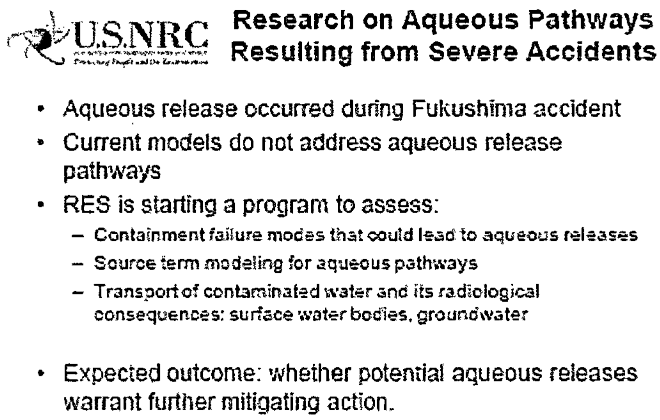
18-L13-4 cont'd

2. The Site-Specific Severe Accident Mitigation Alternatives Analysis for Indian Point's Spent Fuel Pools Should Consider Aqueous Releases

In light of the ongoing aqueous releases at Fukushima, aqueous releases should be considered in the SAMA analysis of the impacts associated with a severe accident at Indian Point's spent fuel pools. A presentation by the Director of NRC's Research Office from NRC's March 2013 Regulatory Information Conference makes it clear that the MACCS2 computer code used to examine severe accidents lacks the ability to analyze the impacts to water resources and the environment resulting from aqueous radiological releases accompanying such an accident.[68] In slide 7 of that presentation (reproduced below), NRC notes (1) aqueous releases occurred during Fukushima accident, and (2) current models do not address aqueous release pathways.

[67] *Supra* note 25.

[68] International Session - Post-Fukushima Research, Brian Sheron, Director, NRC Office of Nuclear Regulatory Research (March 13, 2013), *available at* https://ric.nrc-gateway.gov/m/Docs/Abstracts/sheronb-rev1-hv-w15.pdf.



18-L13-4 cont'd

The term "current models," as used in the slide, would include computer codes such as MACCS2, which Entergy and NRC Staff used to analyze severe reactor accidents in connection with the applications for renewed operating licenses for the Indian Point facilities.

Events at Fukushima show that aqueous releases can have severe environmental consequences. News reports from two years after the start of the severe accidents that damaged four of the Dai-ichi nuclear facilities, show that there are continuing radiological aqueous releases at the Fukushima site. According to news articles, the receptacles holding radiation contaminated fluids at the Fukushima site have leaked and have released radiological material to the environment.[69]

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[69] *See, e.g.*, *Damaged Nuclear Plant in Japan Leaks Toxic Water*, Martin Fackler, New York Times (April 6, 2013); *Japan Nuclear Plant Finds New Leaks, Mari Iwata*, Wall Street Journal (April 7, 2013); *Nuclear Plant in Japan Has Leak in Other Tank*, Hiroko Tabuchi, New York Times (April 9, 2013); *Fukushima Nuclear Plant is Still Unstable, Japanese Official Says*, Hiroko Tabuchi, New York Times (April 10, 2013); *Fukushima Plant Has 300-Ton Water Leak*, Associated Press, New York Times (Web Edition) (Aug. 20, 2013) ("The operator of Japan's tsunami-crippled nuclear power plant said Tuesday that about 300 tons (300,000 liters, 80,000 gallons) of highly radioactive water have leaked from one of the hundreds of storage tanks there — its worst leak yet from such a vessel.").

At a December 2012 subcommittee meeting of the Advisory Committee on Reactor Safeguards (ACRS), Alan Kuritzky from NRC's Office of Research, Division of Risk Analysis, explained:

18-L13-4 cont'd

> Aqueous transport and dispersion of radioactive materials, this is something very big given the Fukushima event, but something we simply are not going to address in our study, but the Agency as a whole is looking into it.[70]

Aqueous releases following a severe accident would be of particular concern at Indian Point, which sits on the Hudson River. Aqueous releases have the potential to contaminate the Hudson River's waters, riverbanks, riverbed and sediment, adjacent freshwater tidal wetlands, and fish and other aquatic organisms and impacts to the environment and human health could exceed the impacts flowing from the aqueous releases into the Pacific Ocean at Fukushima. The unique, site-specific conditions at Indian Point warrant an analysis of the aqueous release issue in the context of a spent fuel pool SAMA analysis.

CONCLUSION

18-L13-5

The GEIS fails to consider site-specific impacts as well as migration measures and alternatives to long-term continued storage in spent fuel pools. Those deficiencies include the failure to conduct a site-specific severe accident mitigation alternatives analysis for the Indian Point spent fuel pools. Since no legally sufficient prior analysis of spent fuel pool severe accident mitigation alternatives has been completed, NRC is obligated to assure that such an analysis has occurred for Indian Point and that all reasonable severe accident scenarios and mitigation measures have been evaluated. Instead of focusing on only one pool at a time, that analysis should take into account both spent fuel pools as well as the specific site-wide profile presented

[70] July 30, 2013 Memorandum to ACRS Members regarding Certified Minutes of the ACRS Reliability and PRA Subcommittee Meeting on Level 3 PRA on December 4, 2012 (ML13211A477) (ACRS Transcript) at 43:17-21.

by entire set of operations authorized by the operating licenses. Such site-specific mitigation alternatives analysis must be completed and incorporated into a revised draft environmental impact statement. Accordingly, Staff should withdraw the draft Supplement and complete such an analysis. 18-L13-5 cont'd

Respectfully submitted,

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March 4, 2016

Exhibit A

List of Various Site Specific Improvements, Including Landmarks, Parks, Arenas, Universities, and Transportation Facilities Within 50 Miles of Indian Point Power Reactors and Spent Fuel Facilities

List of Various Site Specific Improvements,
Including Landmarks, Parks, Arenas, Universities, and Transportation Facilities
Within 50 Miles of Indian Point Power Reactors and Spent Fuel Facilities

National Historic Landmarks:

- Brooklyn Bridge
- Carnegie Hall
- Central Synagogue
- Central Park
- Cooper Union
- New York Stock Exchange
- Grand Central Terminal
- Guggenheim Museum
- Metropolitan Museum of Art
- New York Public Library
- New York Botanical Garden
- Governors Island
- New York City Hall
- Union Square
- St Patrick's Cathedral
- Trinity Church
- Stony Point Battlefield

National Parks:

- Statue of Liberty National Monument
- Saint Paul's Church National Historic Site
- Appalachian National Scenic Trail
- General Ulysses S. Grant National Memorial
- Home of Franklin D. Roosevelt National Historic Site
- Vanderbilt Mansion National Historic Site
- African Burial Ground National Monument
- Castle Clinton National Monument
- Governors Island National Monument
- Federal Hall National Memorial
- Hamilton Grange National Memorial
- Gateway National Recreation Area
- Sagamore Hill National Historic Site

Other

- One World Trade Center (under construction)
- Brooklyn Navy Yard
- Jacob K Javits Convention Center
- Flushing Meadows–Corona Park
- Lincoln Center for the Performing Arts
- Manhattan Municipal Building

Outdoor Sports Venues

- Yankee Stadium
- Citi Field
- USTA Billie Jean King National Tennis Center Icahn Stadium
- Aviator Arena
- Barclay's Center (under construction)
- Hamilton-Metz Field
- MCU Park
- Arnold and Marie Schwartz Athletic Center
- Aqueduct Racetrack
- Metropolitan Oval

Universities

- United States Military Academy (West Point)
- US Merchant Marine Academy
- Columbia University
- New York University
- Fordham University
- The Juliard School
- Culinary Institute of America
- St. John's University
- Yeshiva University
- Brooklyn Law School
- Brooklyn College
- CUNY (all campuses)
- Vassar College
- Pace University
- Pratt Institute
- Yeshiva University

Transportation

- South Ferry Terminal
- Howland Hook Marine Terminal
- Red Hook Container Terminal
- Brooklyn Marine Terminal
- New York Passenger Ship Terminal
- Brooklyn Cruise Terminal
- Newburgh-Beacon Bridge
- Bear Mountain Bridge
- Mid Hudson Bridge
- Verrazanno Narrows Bridge
- George Washington Bridge
- Brooklyn Bridge
- Manhattan Bridge
- Williamsburg Bridge
- Throgs Neck Bridge
- Robert F. Kennedy Bridge
- Queensboro Bridge
- Bronx-Whitestone Bridge
- Dutchess County Airport
- Stewart Airport
- Teterboro Airport
- Laguardia Airport
- JFK Airport
- Westchester County Airport
- Pennsylvania Station
- World Trade Center PATH Station
- Interstate I-95, I-287, I-87 (NYS Thruway), I-84, NYS Route 9, Taconic Parkway

New York City Parks:

- Randalls Island Park
- Battery Park
- Washington Square Park
- Madison Park
- Fort Tyron Park
- The High Line

List of Various Site Specific Improvements,
Including Landmarks, Parks, Arenas, Universities, and Transportation Facilities
Within 50 Miles of Indian Point Power Reactors and Spent Fuel Facilities

- Highbridge Park
- The Cloisters
- Bronx Zoo
- Van Cortlandt Park
- Prospect Park
- Bryant Park
- Jacob Purdy House
- Fort Wadsworth
- Jamaica Bay Wildlife Refuge

State Parks:

- Bayswater Point
- Clay Pit Ponds
- East River
- Empire-Fulton Ferry
- Gantry Plaza
- Riverbank
- Roberto Clemente
- Clarence Fahnestock
- Fahnestock Winter Park
- Franklin D. Roosevelt
- Hudson Highlands
- James Baird
- Mills Norrie (Margaret Lewis Norrie)
- Ogden Mills & Ruth Livingston Mills
- Old Croton Aqueduct
- Rockefeller
- Walkway Over the Hudson (Poughkeepsie)
- Clinton House
- John Jay Homestead
- Philipse Manor Hall
- Staatsburgh State Historic Site
- Anthony Wayne Recreation Area
- Bear Mountain
- Beaver Pond Campgrounds
- Blauvelt
- Goosepond Mountain
- Harriman
- High Tor
- Highland Lakes
- Lake Sebago Beach
- Lake Tiorati Beach
- Lake Welch Beach
- Minnewaska Preserve
- Nyack Beach
- Rockland Lake
- Schunnemunk
- Silver Mine
- Sterling Forest
- Storm King
- Tallman Mountain
- Fort Montgomery
- Knox's Headquarters
- National Purple Heart Hall of Honor
- New Windsor Cantonment
- Stony Point Battlefield
- Washington's Headquarters
- Bethpage Golf Course
- Caumsett
- Planting Fields Arboretum
- Walt Whitman Birthplace

Prepared by Adam Solomon

Exhibit B

International Safety Research Inc. Report:

Review of Waste Confidence Generic Environmental Impact Statement

Dated: December 20, 2013

REVIEW OF WASTE CONFIDENCE GENERIC ENVIRONMENTAL IMPACT STATEMENT

ISR Report 13014-01-02

20 December 2013

presented to

Office of the Attorney General - State of New York
120 Broadway, New York, NY 10271-0332

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International Safety Research Inc.

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1. INTRODUCTION

1.1 Scope

The Office of the Attorney General of the State of New York requested that International Safety Research (ISR) perform a technical review of the US-NRC NUREG-2157, Waste Confidence Generic Environmental Impact Statement Draft Report for Comment (DGEIS), and supporting documents. US-NRC released the DGEIS for public comment in September 2013. In the DGEIS, US-NRC aims to analyze the environmental impacts of the continued storage of spent nuclear fuel beyond a reactor's licensed life for operation and prior to ultimate disposal.

In addition to the DGEIS, US-NRC released another document assessing the environmental impacts of continued fuel storage, entitled Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor (Spent Fuel Pool Consequence Study). On October 9, 2013, in SECY-13-0112 (ML13256A339), the US-NRC Staff provided the US-NRC Commissioners with the final Spent Fuel Pool Study, noting Staff's intention to make the report public and subsequently publish it as a NUREG. On November 12, 2013, the US-NRC issued COMSECY-13-0030 (ML13273A601), which incorporates results of the Spent Fuel Pool Consequence Study.

Although the DGEIS does not currently cite to the Spent Fuel Pool Consequence Study, the US-NRC has stated publicly that, if the study is finalized before the final GEIS is published, it will be added as a reference to the GEIS.[1] To date, the Spent Fuel Pool Consequence study has not yet been published as a NUREG.

This report will discuss all of these recent documents, and the storage of spent nuclear fuel in spent fuel pools. These recent US-NRC reports rely upon earlier reports, including NUREG-1738, a computer code (MACCS2), and various other documents.

The results of ISR's review of the aforementioned documents are recorded in this report. The review was limited to these documents, and did not include carrying out MACCS2 calculations, or proposing alternative studies or analyses for this type of risk assessment.

1.2 Background

This report concerns the storage of spent nuclear fuel in spent fuel pools, and NRC's assessment of the potential environmental impacts of continued storage of fuel at nuclear power plant sites, given the uncertainty surrounding a permanent repository.

[1] *See, e.g,,* NRC, *Two Separate NRC Efforts Address Spent Fuel Safety*, http://public-blog.nrc-gateway.gov/2013/06/24/two-separate-nrc-efforts-address-spent-fuel-safety/ (June 24, 2013) ("The draft GEIS [for the Waste Confidence rule] does not explicitly reference the pool study, though the waste confidence staff worked closely with the staff preparing the pool study while developing relevant chapters of the draft GEIS. If a final version of the [Spent Fuel Pool Consequence] study is published before the final waste confidence GEIS, the staff will incorporate a reference to it in the final GEIS.").

A nuclear power reactor's core contains zirconium-clad rods filled with enriched uranium pellets that fuel the atomic process. Over time, that fuel produces a less efficient nuclear reaction and must be replaced and removed from the reactor. Because spent-fuel rods generate several MW of heat and contain highly radioactive material, the rods are removed from the reactor and the containment area, transported through a transfer canal, and placed on racks in a pool adjacent to the reactor building to cool down. At operating U.S. PWR nuclear power plants, the pool is located outside of the containment structure that surrounds the reactor.

The US-NRC, and its predecessor the U.S. Atomic Energy Commission, have examined severe accidents at U.S. nuclear power plants. Earlier studies focused on potential reactor accidents, based on the assumption that spent nuclear fuel would be stored at an off-site, permanent repository and would only be temporarily stored on-site in spent fuel pools until a repository became available. As time went on without a permanent repository, spent nuclear fuel began to accumulate in spent fuel pools in quantities that exceeded the volume of fuel inside the reactor. A permanent repository has still not been developed.

The DGEIS is NRC's latest effort aimed at generically establishing that continued storage of spent nuclear fuel is safe in the absence of and uncertainty surrounding a permanent repository. The Spent Fuel Pool Consequence Study is NRC's effort to assess whether the expedited transfer of spent fuel to dry cask storage is warranted, given the reality of continued on-site storage. US-NRC's prior relevant risk assessments include assessments of spent fuel pool accident risk and reactor accident risk.

The following documents focus on spent fuel pool accidents:

1989 NUREG-1353, Regulatory Analysis for the Resolution of Generic Issue 82, Beyond Design Basis Accidents in Spent Fuel Pools (US-NRC 1989)

2001 NUREG-1738 Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants (US-NRC 2001)

2006 Wagner and Gauntt, redacted (Sandia 2006) and classified Sandia Studies discussed in the Denial of Petitions for Rulemaking PRM-51-10 and PRM-51-12, 73 Federal Register 46,204 (US-NRC 2008)

The following documents focus on reactor accidents:

1957 WASH-740, Theoretical Possibilities and Consequence of Major Accidents in Large Nuclear power Plants (BNL 1957)

1975 WASH-1400, also referred to as NUREG-75/014, Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants (US-NRC 1975)

1987 NUREG-1150, *Reactor Risk Reference Document (Draft for Comment)* - Main Report (Volume 1), Appendices A-I (Volume 2), and Appendices J-O (Volume 3) (US-NRC 1987)

1989 NUREG-1150, *Severe Accident Risks: An Assessment for Five Us. Nuclear Power Plants (Second Draft for Peer Review)* -Summary Report (Volume 1), Appendices (Volume 2) (US-NRC 1989a)

1990 NUREG-1150, *Severe Accident Risks: An Assessment for Five Us. Nuclear Power Plants* - Final Summary Report (Volume 1), Appendices A, B, and C (Volume 2), Appendices D and E (Volume 3) (US-NRC 1990)

1990 NUREG/CR-4551, J. L. Sprung, et al., *Evaluation of Severe Accident Risks: Quantification of major input parameters -MACCS Input,* Volume 2, Revision 1, Part 7 (Sandia 1990)

2012 NUREG/CR-7110, *State-of-the-Art Reactor Consequence Analyses (SOARCA) Project* (US-NRC 2012)

The MACCS2 code, which was publicly released in 1997, is a computer modeling tool developed by Sandia to evaluate impacts of severe accidents at nuclear power plants on the surrounding public. The MACCS2 code simulates the atmospheric release of radioactivity following a severe accident based on meteorological inputs, and calculates radiological health and economic impacts based on user-defined inputs. The MACCS2 code can model, among other things, economic costs of an accident. The latest of a series of computer modeling tools developed for this purpose, the MACCS2 code is an improved version of the MACCS code, which itself replaced the earlier CRAC2 code.

In many of the documents cited above, US-NRC utilized the MACCS2 code, and its predecessor codes, to assess the consequences of severe accidents at spent fuel pools and reactors. The MACCS2 code has also been utilized by applicants and NRC Staff as part of NRC's analysis in license renewal proceedings of site-specific severe accident mitigation alternatives for severe accidents affecting a specific reactor.[2] In running the MACCS2 code, US-NRC and applicants have chiefly relied upon an example set of economic cost inputs listed as "Sample Problem A" in the MACCS2 User Guide.[3] The input parameters for Sample Problem A were taken from NUREG-1150, and incorporate site-specific data for the Surry site in rural Virginia.

[2] A small subset of 6 U.S. reactors examined severe accidents during their initial operating license application.

[3] Sample Problem A is one of fourteen sample problems containing example sets of inputs included in the MACCS2 User Guide. US-NRC and applicants often adjust these input values for inflation using the Consumer Price Index.

2. NRC SPENT FUEL POOL ENVIRONMENTAL ASSESSMENT

2.1 Scope of the DGEIS

According to the DGEIS (p. iii), NRC's objective was:

- *"to examine the potential environmental impacts that could occur as a result of the continued storage of spent nuclear fuel (spent fuel) at at-reactor and away-from-reactor sites until a repository is available.*
- *establish generic impact determinations that would be applicable to a wide range of existing and potential future spent fuel storage sites.*
- *improve the efficiency of the NRC's licensing processes by*
    - *(1) providing an evaluation of the environmental impacts that may occur as a result of continuing to store spent fuel at at-reactor or away-from-reactor sites until a repository is available,*
    - *(2) identifying the types and assessing the magnitude of environmental impacts where generic findings can be established, and*
    - *(3) providing the regulatory basis for the NRC's proposed amendments to regulations"*

The NRC stated that it sought to address deficiencies identified by the U.S. Court of Appeals for the D.C. Circuit (US-NRC 2013, pp. 1-3):

> *"The Court identified three deficiencies in the NRC's environmental analysis:*
>
> *1. Related to the Commission's conclusion that permanent disposal will be available 'when necessary,' the Court held that the Commission needed to evaluate the environmental effects of failing to secure permanent disposal, given the uncertainty about whether a repository would be built.*
>
> *2. Related to 60 years of continued storage, the Court concluded that the Commission had not adequately examined the risk of spent fuel pool leaks in a forward-looking fashion.*
>
> *3. Also related to continued storage, the Court concluded that the Commission had not adequately examined the consequences of potential spent fuel pool fires."*

In the DGEIS, US-NRC includes an analysis of the environmental impacts of spent fuel pool leaks, spent fuel pool fires, and long term spent fuel storage on site. The DGEIS determines that a spent fuel pool fire is the bounding accident, i.e., that a spent fuel pool fire accident results in the highest potential consequences among the credible accidents analyzed in the DGEIS. US-NRC concludes that the risk of spent fuel pool fires is "small" for all plants. In summary, the DGEIS aimed to analyze the probability-weighted population doses and economic consequences of a spent fuel fire during the short-term storage timeframe, i.e., 60 years after a reactor license has expired.

The DGEIS also aims to address terrorist acts (US-NRC 2013, p. 4-84).

2.2 Technical basis

The DGEIS Appendix F relies extensively on previous studies of severe accident risks,[4] factoring in the probability of occurrence as well as the potential consequences, to reach the conclusion that potential health and economic impacts from severe accidents in spent fuel pools are "small" (US-NRC 2013, p. 4-82). For spent fuel pool fires, NRC derives "a significant portion" of its analysis from its Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants, NUREG-1738 (US-NRC 2001), asserting that it is the most complete and consistent recent study regarding this topic.

NUREG-1738, prepared in connection with decommissioning rulemaking for permanently shutdown nuclear power plants, contains the results of the NRC's evaluation of the potential accident risk in a spent fuel pool at decommissioning plants. *See also* SECY-01-0100, *Policy Issues Related to Safeguards, Insurance, and Emergency Preparedness Regulations at Decommissioning Nuclear Power Plants Storing Fuel in Spent Fuel Pools* (US-NRC 2001a). The NUREG-1738 study includes the results of MACCS2 calculations carried out for the spent fuel pool at the Surry site, which is surrounded by farmland in rural Virginia. For the economic costs of a spent fuel pool fire, NUREG-1738 quoted results obtained from the MACCS code for the Zion site in Illinois from NUREG-1353 (US-NRC 1989) and from NUREG/BR-0184 (US-NRC 1997). The analysis for the Zion site was chosen since consequence assessment results were available for both the reactor and the spent fuel pool; the same was not true for the Surry site.

NUREG-1738 was published before both the September 11 terrorist attacks and the severe accident at the Fukushima Dai-ichi nuclear power plants. Since the DGEIS relies on NUREG-1738 for the assessment of the consequences of a spent fuel pool fire, the quantitative analysis of consequences in the DGEIS does not include lessons learned from these two later events.

The DGEIS Appendix F qualitatively discusses NRC's orders following the September 11 terrorist attacks and the "lessons learned" NRC is developing and implementing in response to accident at Fukushima Dai-ichi. NRC's consideration of these safety enhancements is solely in the context of the probability that a spent fuel pool fire would occur. *See* DGEIS at F-12 ("These measures further reduce the probability of a spent fuel pool fire, and thus further increase the conservatism of NUREG–1738."). The DGEIS, however, does not quantify the reduction in probability or clearly explain which post-September 11 or post-Fukushima measures generically reduce the probability. Nor does the DGEIS effectively identify, discuss, and evaluate other available mitigation measures to reduce or minimize the impacts of a severe spent fuel pool accident. For example, although the DGEIS relies upon NUREG/BR-0184's calculation of the consequences of pool fire accidents, including protective measures such as the use of a spray system, post-Fukushima US-NRC Order EA-12-049 does not mandate the

[4] The DGEIS Appendix F defines risk as the quantitative measure of the severity of the accident that accounts for the likelihood of the occurrence, i.e., risk is the probability-weighted consequence.

installation of fixed spray systems in spent fuel pools. Similarly, the DGEIS does not examine the alternative of reducing the volume of spent nuclear fuel (and hence the potential accident source term) in spent fuel pools, although this information is available in other documents (US-NRC 2013a).

In addition to NUREG-1738 and the other documents discussed above, the DGEIS relies on the technical assessment carried out in support of the Denial of Petitions for Rulemaking, 73 Fed. Reg. 46,204, (US-NRC 2008), which denied two states' petitions for rulemaking concerning the environmental impacts of the high-density storage of spent nuclear fuel in spent fuel pools. In DGEIS Appendix F, NRC references this document's discussion of measures that have been integrated since 2001 to reduce the probability of a spent fuel pool fire. 73 Fed. Reg. 46,204 relies on the Sandia letter report of Wagner and Gauntt (Sandia 2006) to conclude that post-2001 measures have reduced the likelihood that loss of water inventory in a spent fuel pool could lead to a spent fuel pool fire. The publicly-available version of this study has been heavily redacted and does not contain information necessary to quantify the reduction in risk.

A more recent analysis of the risk of spent fuel pool storage is contained in COMSECY-13-0030, *Staff evaluation and recommendation for Japan lessons-learned tier 3 issue on expedited transfer of spent fuel* (US-NRC 2013a), which incorporates the final version of *Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor*, SECY-13-0112, (US-NRC Oct. 9, 2013). As stated in Section 1.1 above, the DGEIS does not currently cite to the Spent Fuel Pool Consequence Study, but US-NRC stated its intention to include reference to the study in the final GEIS if it is published as a NUREG before the GEIS is finalized.

2.3 Site Specificity

The NRC states that the purpose of the DGEIS is to provide a regulatory basis for a proposed revision of the NRC's Waste Confidence rule. The DGEIS attempts to develop an environmental impact statement concerning the storage of spent nuclear fuel that would apply generically to all reactor and storage sites in the U.S. As discussed in Section 2.2 above, it does so by relying mostly on NUREG-1738, a generic study of the risks from spent fuel pools at decommissioning plants.

To quote the DGEIS (p. xxiv):

> *"The NRC considers the continued storage of spent fuel a generic activity that is similar for all commercial nuclear power plants and storage facilities."*

Later, in the same document (p. 1-5), US-NRC explains its intent:

> *"The GEIS [...] if adopted, would provide a regulatory basis for the NRC's proposed amendment to 10 CFR 51.23."*
>
> *"Further, the revision would state that because the impacts of continued storage have been generically assessed in this draft GEIS and codified in a Rule, NEPA analyses for future reactor and spent fuel storage facility licensing actions would not need to separately consider the environmental impacts of continued storage."*

The authors of NUREG-1738 were very careful to spell out the limitations of their generic approach for decommissioning plants. Subsequent documents like DGEIS and the Denial of Rulemaking Petitions in 73 Fed. Reg. 46,204 do not repeat these warnings. The following are examples of limitations that are identified in NUREG-1738.

Regarding the age of the fuel beyond which a spent fuel pool fire can be ruled out (US-NRC 2001, p. 2-1):

> *"...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. Heat removal is very sensitive to these constraints, and two of these constraints, fuel assembly geometry and spent fuel pool rack configuration, are plant specific."*

See also SECY-01-0100. Regarding the pool fire frequencies for all initiators (US-NRC 2001, p. 3.7):

> *"Plant-specific frequency estimates in some cases could be as much as an order of magnitude higher or lower because of the seismic hazard at the plant site."*

Regarding the possibility for air cooling following damage caused by severe weather (US-NRC 2001, p. 3-10):

> *"For loss of offsite power events caused by severe weather, the staff assumed a 90 percent partition for the high airflow case. This is based on a staff assumption that openings in the SFP building (e.g., doors and roof hatches) are large enough that, if forced circulation is lost, natural circulation cooling will provide at least two building volume of air per hour to the SFP. This assumption may need to be confirmed on a plant-specific basis."*

Regarding the low initiating event frequency[5] for the loss of pool inventory (US-NRC 2001, p. 3-12):

> *"These assumptions may be nonconservative on a plant-specific basis depending on SFP configuration and commitments for configuration control."*

Regarding the likelihood of loss of cooling, loss of inventory, and loss of off-site power (US-NRC 2001, p. 3-12):

> *"Initiating event frequencies for loss of cooling, loss of inventory, and loss of offsite power are based on generic data. In addition, the probability of power recovery is also based on generic information. Site-specific differences will proportionately affect the risk from these initiating events."*

Regarding the assumption that leaks are self-limiting (US-NRC 2001, p. A2A-67):

> *"For the loss of inventory event tree, the assumption that the leak is self-limiting after a drop in level of 15 feet, may be a more significant assumption that, on a site specific basis may be non-conservative, and requires validation."*

[5] Throughout this report, the terms probability and frequency are used. Frequency is simply probability, expressed on a per-year basis. Thus, the event frequency is the probability that an event will occur within one year.

In addition, NUREG-1738 relies on a series of Industry Decommissioning Commitments (IDC) and Staff Decommissioning Assumptions (SDA) that are spelled out and are assumed to apply generically to all plants (US-NRC 2001, p. 4-11 and 4-12). NUREG-1738 bases its analysis on the assumption that these commitments and assumptions are met. It they are not, the analysis carried out in NUREG-1738 may not be valid at a specific site.

By contrast, the authors of the DGEIS use less definite language (US-NRC 2013, p. F-8):

> *"In general, health impacts could be higher than the values reported in these studies if the amount of spent fuel involved in a fire (and, thus, the amount of radioactive material that could be released) was higher than assumed in these studies or the total population and population density were higher."*

Later, in the DGEIS (US-NRC 2013, p. F-7):

> *"As with health impacts, the economic impacts would vary for different facilities. For example, higher total population or population density could result in higher relocation costs, and land use (e.g., whether land is used as farmland or not) could also impact decontamination and condemnation costs."*

In summary, it seems that the US-NRC's critique in the Denial of the Petition for Rulemaking of petitioners' assertion that fuel will burn regardless of age, quoted below (US-NRC 2008), is equally applicable to the conclusions of the DGEIS:

> *"This conclusion, however, was in no sense a statement of certainty and was made in order to reach a conclusion on a generic basis, without relying on any plant-specific analyses."*

Likewise, US-NRC's assessment of spent fuel pool fire risk in the DGEIS Appendix F and determination that such risk is "small" is in no sense a statement of certainty regarding the risk at any given plant.

2.4 Acceptance Criteria

In NUREG-1738, US-NRC adopted the US-NRC's Policy Statement on Safety Goals for the Operation of Nuclear Power Plants. The Policy Statement expressed the Commission's policy regarding the acceptable level of radiological risk from nuclear power plant operation as follows:

- *"Individual members of the public should be provided a level of protection from the consequences of nuclear power plant operation such that individuals bear no significant additional risk to life and health."*
- *"Societal risks to life and health from nuclear power plant operation should be comparable to or less than the risks of generating electricity by viable competing technologies and should not be a significant addition to other societal risks."*

The following sections describe the various criteria used by the US-NRC in its assessment of the risk from spent fuel pools in the DGEIS.

2.4.1 Risk Criteria

In section 3.7.3 of NUREG-1738, the US-NRC describes the Commission's Safety Goals that were used to derive risk acceptability criteria. The risk criteria for the spent fuel pool were derived from the existing severe reactor accident criteria. Both the spent fuel pool criteria and the severe reactor accident criteria are discussed here.

The US-NRC has created a pool performance guideline of 10^{-5} pool fire events per year, based on the need to meet quantitative health objectives with a severe spent fuel pool accident source term (US-NRC 2001, p. A4C-1). The logic behind this decision is that spent fuel pool fires have comparable health effect consequences to those of a severe reactor accident (US-NRC 2001, p. 4-4). Thus, the resulting pool performance guideline is compatible with the risk criteria guidelines for nuclear power plants.

The risk criteria guidelines for nuclear power plants are described in RG 1.174 and relate to core damage frequency and large early release frequency. Changes to the license are acceptable if they result in frequency changes smaller than one tenth of the baseline frequency. In the case of the spent fuel pool, US-NRC has adopted the large early release frequency as an acceptance criterion for spent fuel pool fires. If the baseline large early release frequency is below the 10^{-5} per year, then plant changes can be approved if they increase the large early release frequency by up to 10^{-6} per year.

2.4.2 Quantitative Health Objective

The following quantitative health objectives are used in determining achievement of the two safety goals set forth in the policy document discussed above in Section 2.2 (US-NRC 2001, p. A4C-2):

- *"The risk to an average individual in the vicinity of a nuclear power plant of prompt fatalities that might result from reactor accidents should not exceed one-tenth of 1 percent (0.1 percent) of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed."*
- *"The risk to the population in the area near a nuclear power plant of cancer fatalities that might result from nuclear power plant operation should not exceed one-tenth of 1 percent (0.1 percent) of the sum of cancer fatality risks resulting from all other causes."*

These objectives have been translated into two numerical objectives as follows:

- *"The individual risk of a prompt fatality from all 'other accidents to which members of the U.S. population are generally exposed,' such as fatal automobile accidents, is about 5×10^{-4} per year. One-tenth of one percent of this figure implies that the individual risk of prompt fatality from a reactor accident should be less than 5×10^{-7} per reactor year."*
- *"The sum of cancer fatality risks resulting from all other causes for an individual is taken to be the cancer fatality rate in the U.S. which is about 1 in 500 or 2×10^{-3} per year. One tenth of 1 percent of this implies that the risk of cancer to the*

population in the area near a nuclear power plant because of its operation should be limited to 2×10^{-6} per reactor year."

The numerical objectives above are compared to the early fatality risk to an average individual within 1.6 km (1 mi) and the latent cancer fatality risk to an average individual within 16 km (10 mi) of the plant.

When NRC established these criteria, it developed them to be applicable to all sites since individual prompt fatality risks are the same regardless of the population density surrounding a reactor. Although the policy statement mentions societal risks, the numerical objectives do not. The risk to society should be comprised of, at minimum, the latent health effects (i.e., the radiological impact to the population) and economic costs.

One possible quantitative objective for the radiological component of societal risk may be obtained by multiplying the objective for latent fatalities (2×10^{-6} latent fatalities per reactor year) by the nominal risk of latent fatalities (assumed to be 5% per person-Sv based on guidance from the International Commission on Radiological Protection (ICRP 2007)). This results in a numerical objective for collective dose of 4×10^{-5} person-Sv per reactor year, or 4×10^{-3} person-rem per reactor year.

If the DGEIS had adopted societal risk criteria, the analysis would have been dependent on the population density around the site, making it impossible to develop a generic approach that applies at all sites.

2.4.3 Site-Specific Analysis of Spent Fuel Pool Fire Costs

NUREG-1738 contains two cost analyses. In the first, US-NRC determines the cost of a spent fuel pool fire at the Zion site. The costs include both health costs and economic costs. Health costs refer to the collective radiation dose to members of the public, which is then converted to a dollar value. Economic costs include those costs associated with property decontamination or condemnation, and population relocation. The input parameters associated with these costs were the same as the offsite economic cost inputs proposed in NUREG-1150.To accomplish this, the authors of NUREG-1738 used the MACCS2 code to estimate economic costs associated with a severe nuclear reactor accident using inputs entered by the user. For Zion, NUREG-1738 used an 80-km (50 mi) average population density of 860 people per square mile from NUREG-1353 (US-NRC 1989).

The DGEIS adjusted the Zion costs from 1988 USD to 2010 USD using the Consumer Price Index. In NUREG-1353, the offsite health effect costs are based on $1000 per person-rem, and account for more than 75% of the total economic cost. The cost of off-site property damage for the Zion site is a little over 5% of the total economic cost. It should be noted that the current US-NRC benchmark for health effect costs is $2000 per person-rem; this is approximately equal to the 2013 USD-equivalent amount used in NUREG-1353, i.e., $1000 per person rem adjusted to 2013 USD using the Consumer Price Index.

The other cost analysis used in NUREG-1738 is based on NUREG/BR-0184 (US-NRC 1997), which calculates cost using MACCS and the NUREG-1150 offsite economic cost inputs. In NUREG/BR-0184 the costs were expressed in 1983 USD. The DGEIS adjusted those costs to 2010 USD. The NUREG/BR-0184 analysis is based on the Zion site like the NUREG-1353 analysis. Thus in NUREG/BR-0184 and NUREG-1353, the same population density is used.

With respect to site specific characteristics, it should be noted that as of 1990, the Indian Point site had 15.1 million people living within 50 miles of the site – more than twice the number that lived within 50 miles of the Zion site. (US-NRC 1996, p. 2-2 to 2-8 stating that Indian Point had "almost 2000 persons per square mile"). These population totals have increased since 1990. US-NRC reports that as of 2000, 16.8 million people lived within 50 miles of Indian Point (US-NRC 2013, p. 3-8), and that as of 2010 approximately 17 million people lived within 50 miles of Indian Point.[6] To ISR's knowledge, US-NRC has not disclosed or released the results of any site-specific MACCS2 analysis of a severe accident at the Indian Point spent fuel pools. Thus, it is not possible to compare the results of the Zion assessment to an Indian Point-specific assessment, and determine whether the differences are significant.

After reporting the results of NUREG-1738, NUREG/BR-0184, and NUREG-1353, the DGEIS attempts to benchmark the radiation dose consequences and the economic cost of a spent fuel pool accident against values for severe reactor accidents. Based on these results, the US-NRC concludes (US-NRC 2013, p. F-10):

> *"This analysis shows that the probability-weighted consequences for a spent fuel pool fire, as analyzed in NUREG–1738, are comparable to the probability-weighted consequences for severe power reactor accidents analyzed in the 1996 and 2013 License Renewal GEIS (NRC 1996, 2013)."*

Based on this conclusion, it is reasonable to expect that US-NRC would implement similar requirements for severe reactor accidents and spent fuel pool accidents. This would include the conduct and documentation of a Severe Accident Mitigation Alternatives (SAMA) analysis that is based on a site-specific cost-benefit comparison of the costs of implementing mitigation alternatives with the benefits achieved by those mitigation alternatives. Furthermore, risk assessments and SAMA analyses for reactor and spent fuel pool accidents at the same site should not be conducted independently; an integrated, site-wide analysis is the way to quantitatively assess the risks posed by all operations conducted on a single site.

In conclusion, although US-NRC reports the similarities between spent fuel pool fires and reactor accidents, the DGEIS does not actually use this information. The DGEIS does not contain societal dose acceptance criteria or a SAMA analysis considering the costs and benefits of mitigation alternatives given the cost of a spent fuel pool fire.

[6] The population within 50 miles of Indian Point is based on 2010 census data obtained from reference (US-NRC 2012b).

3. ACCIDENT ASSESSMENT

3.1 Selection of accidents

The DGEIS includes sections on spent fuel leaks, spent fuel pool fires, and terrorist acts. The DGEIS concludes that the consequences of these accidents are bounded by the consequences of a spent fuel pool fire and this is the only accident that is completely analyzed.

3.1.1 Event reports and accident precursors

In the DGEIS, US-NRC has relied upon a compilation of event reports such as NUREG-1275 Vol. 12 (US-NRC 1997a) to identify relevant spent fuel events. The DGEIS mentions that US-NRC staff also performs annual reviews of U.S. and international operating experience with spent fuel storage and handling (US-NRC 2013a), although this does not appear to be documented in an official document.

Section E.3 of the DGEIS discusses historical data on spent fuel pool leaks. It discusses the 13 sites where occurrences of spent fuel leaks that have been documented. However, the DGEIS does not include an exhaustive look at event reports and accidents precursors that should inform the assessment of environmental risks from the spent fuel pools. Since the publication of NUREG-1275 in 1997, there have been many event reports that could inform the DGEIS, and that should be described in the DGEIS.

As an example, one of the assumptions included in the DGEIS is that pool drainage is not credible, based on the configuration of spent fuel pools.

NUREG-1738, p. 3-5 (and again on p. 3-11, p. 3-15):

> *"Plants do not have drain paths in their SFPs that could lower the pool level (by draining, suction, or pumping) more than 15 feet below the normal pool operating level, and licensees must initiate recovery using offsite sources."*

NUREG-1738, p. 3-6:

> *"IDC #6 Spent fuel pool seals that could cause leakage leading to fuel uncovery in the event of seal failure shall be self-limiting to leakage or otherwise engineered so that drainage cannot occur."*

These assumptions may not be compatible with the configuration of some of the spent fuel pools, as the event report shown in Figure 1 shows.

While NUREG-1738 is clear that plants that do not pass the seismic checklist would not qualify for the exemptions on emergency preparedness (EP), indemnification or security, the DGEIS is far from clear on what would happen in a specific plant could not meet some of the conditions listed in NUREG-1738. Neither the DGEIS, nor NUREG-1738, lists exactly which plants meet the NUREG-1738 conditions and which plants do not.

Figure 1: Event report from Lacrosse Spent Fuel Pool

```
+------------------------------------------------------------------------------+
|Power Reactor                                 |Event Number:   35444          |
+------------------------------------------------------------------------------+
+------------------------------------------------------------------------------+
| FACILITY: LACROSSE                 REGION:  3  |NOTIFICATION DATE: 03/05/1999|
|    UNIT:  [1] [] []                 STATE:  WI |NOTIFICATION TIME: 18:04[EST]|
|   RXTYPE: [1] AC (ALLIS CHAMBERS)              |EVENT DATE:        03/05/1999|
+----------------------------------------------+EVENT TIME:        15:45[CST]|
| NRC NOTIFIED BY:  MIKE JOHNSEN                 |LAST UPDATE DATE:  03/05/1999|
|  HQ OPS OFFICER:  JOHN MacKINNON               +-----------------------------+
+----------------------------------------------+PERSON          ORGANIZATION |
|EMERGENCY CLASS:          N/A                   |JAMES CREED            R3    |
|10 CFR SECTION:                                 |                             |
|ADAS 50.72(b)(2)(i)      DEG/UNANALYZED COND    |                             |
|                                                |                             |
|                                                |                             |
|                                                |                             |
+-----+----------+-------+--------+-----------------+--------+-----------------+
|UNIT |SCRAM CODE|RX CRIT|INIT PWR|    INIT RX MODE |CURR PWR|   CURR RX MODE  |
+-----+----------+-------+--------+-----------------+--------+-----------------+
|1     N           N       0        Decommissioned  |0        Refueling        |
|                                                   |                          |
|                                                   |                          |
+------------------------------------------------------------------------------+
                                  EVENT TEXT
+------------------------------------------------------------------------------+
| SEISMIC CONCERN WITH MAINTAINING SPENT FUEL POOL WATER LEVEL IF THE SPENT    |
| FUEL POOL RETURN LINE (ENTERS BOTTOM OF THE SPENT FUEL POOL)  RUPTURES       |
| DURING A SEISMIC EVENT.                                                      |
|                                                                              |
| The spent fuel pool has a return line which enters through the bottom of the |
| spent fuel pool. During surveillance testing of the spent fuel pool it was   |
| determined that two in series 4 inch check valves (58-26-007, 008; fuel      |
| storage well return check valves) have back leakage of between 15 to 16      |
| gallons per minute.  Makeup capacity to the spent fuel pool (fuel storage    |
| well system) is 5 gallons per minute.  If a seismic event (they have never   |
| had a seismic event) caused the spent fuel pool return line to rupture the   |
| spent fuel pool water inventory could be decreasing between 15 to 16 gallons |
| per minute and regular makeup to the spent fuel pool would be 5 gallons per  |
| minute.                                                                      |
|                                                                              |
| The spent fuel pool contains 333 fuel assemblies.  The cladding for the      |
| spent fuel rods is made of stainless steel and the fuel has been in the      |
| spent fuel pool since 1987.  The temperature of the spent fuel pool is       |
| between 110 to 111 degrees F with no spent fuel pooling cooling.             |
|                                                                              |
| Contingency actions being taken by the license:                              |
|                                                                              |
| Isolate manual isolation valves as close to the check valves as possible if  |
| the line breaks.                                                             |
| Reduce spent fuel pool temperature (this weekend) from 110 degrees to        |
| between 70 and 80 degrees F.                                                 |
|                                                                              |
|                                                                              |
| An LER will be submitted within 30 days concerning the potential loss of     |
| spent fuel pool water inventory via the return line if it is ruptured during |
| a seismic event.                                                             |
+------------------------------------------------------------------------------+
```

3.2 Source term

With the exception of ruthenium and fuel fines, the DGEIS relies upon release fractions for all radionuclides (e.g., cesium-137 and iodine-131) from NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants". The DGEIS ages the source term for decay times of 60 days, 1 year, 2 years, 5 years and 10 years.

In NUREG-1738, US-NRC carried out a sensitivity analysis for ruthenium and fuel fines based on comments from the Advisory Committee on Reactor Safeguards (ACRS). In the DGEIS, US-NRC states that it now believes NUREG-1738's high ruthenium source term to be very conservative and that the low ruthenium release fractions are more representative of the consequences of a spent fuel pool fire (US-NRC 2013, p. F-5).

3.3 Event frequencies

3.3.1 Initiating events

Initiating events include (US-NRC 2001, p. 3-2, 3-3):

The staff identified nine initiating event categories to investigate as part of the quantitative assessment on SFP risk:

1. Loss of offsite power from plant centered and grid-related events
2. Loss of offsite power from events initiated by severe weather
3. Internal fire
4. Loss of pool cooling
5. Loss of coolant inventory
6. Seismic event
7. Cask drop
8. Aircraft impact (as an accident scenario)
9. Tornado missile

Criticality events are analyzed separately.

These initiating events are assumed to lead to a loss of cooling or a catastrophic failure of the spent fuel pool. In both cases, the resulting end-state is a spent fuel pool fire. US-NRC calculates a frequency for each of these events. The DGEIS then discusses frequency based on information presented in NUREG-1738 for the two most important initiating events: seismic events and heavy drop load events.

<u>Seismic events</u>

Two different seismic hazard estimates have been developed for U.S. reactor sites, one developed by Lawrence Livermore National Laboratories (LLNL) and one by the Electric Power Research Institute (EPRI). Using the site-specific LLNL seismic hazard estimates, the mean spent fuel pool failure probability for the sites analyzed by LLNL is about 2×10^{-6} per year and covers a range 6×10^{-7} per year to 1.5×10^{-5} per year (US-NRC 2001, p. 3-22). For the EPRI hazard estimates, the mean value of the pool failure frequency is about 2×10^{-7} per year and it covers the range 3×10^{-9} per year to 2×10^{-6} per year (US-NRC 2001, p. 3-21). The plants that have the lowest and highest seismic risks are not identified in the analysis.

Based on the frequencies listed in Table 3.7-3 (US-NRC 2001, p. 3-35) the frequency of boil down events does not seem to consider loss of offsite power, and internal fire triggered by seismic events.

NUREG-1738 considers the risk contribution of earthquakes that damages pool support systems in the seismic risk of pool fire (US-NRC 2001, p. 3-9, A2B-3). The return frequency of the earthquakes is assumed to be 1 : 4000 years and a failure to obtain off-site resources in a timely manner is assumed to be $1\text{x}10^{-4}$.

If loss of offsite power and internal fires triggered by seismic events were considered at the same earthquake return frequency as for the damage to pool support systems, the probability of these initiating events could increase.

The total probability of pool drainage from NUREG-1353 (2×10^{-6} events per year) is based on best estimates of the frequency of various event sequences, and is dominated by the seismic risk of structural failure (US-NRC 1989, p. 4-36). It should be noted that NUREG-1738 uses the average probabilities for the seismic events (p. 3-9) and acknowledges that site-specific values could be ten times higher or lower (p. 3-7). The DGEIS relies upon these average probabilities from NUREG-1738, reporting them in Table F-1 (US-NRC 2013, p. F-4). The DGEIS, however, does not include the caveat from NUREG-1738 that site-specific probabilities could vary by a factor of ten. Nor does the DGEIS provide examples of sites that would have higher or lower probabilities, or explain how or if the probabilities reported in NUREG-1738 conservatively bound the range of accident probabilities.

Heavy load drop events

For the cask drop event, NUREG-1738 bases the calculation of the probability of pool failure on Navy data and NUREG-0612 heavy loads evaluation (US-NRC 1980). For single failure-proof system, the frequency of catastrophic pool failure is 2×10^{-7} events per year. The frequency of catastrophic pool failure for non-single failure-proof system is 2.1×10^{-5} events per year, which exceeds the proposed pool performance guideline of 1×10^{-5} events per year. US-NRC believes that the frequency of pool failure can be reduced by performing a comprehensive and rigorous load drop analysis. For this reason, NUREG-1738 (Table 3.1, p. 3-9) and DGEIS quote the probability of cask drop as 2×10^{-7} events per year and ignores the calculation of the probability of cask drop for non-single failure-proof system. The US-NRC needs to show how the load drop analysis will change the human error rate calculation and reduce the frequency of cask drop events.

In addition, the calculation presented on page 3-17 of NUREG-1738 is unclear.

For the single-failure-proof handling system, the load drop frequency is $9.6\text{x}10^{-6}\ y^{-1}$ and the catastrophic failure is $2\text{x}10^{-7}\ y^{-1}$, for a ratio of $2.08\text{x}10^{-2} = 0.13 \text{ x } 0.16$. This matches the description given in the text.

For non-single-failure-proof handling system the frequency of load drop is $3.4x10^{-4}$ y^{-1} and the mean value for the catastrophic failure rate is $2.1x10^{-5}$ y^{-1}. The ratio is $6.2x10^{-2}$ catastrophic failure per transfer. How US-NRC arrived at this value is not clear.

3.3.2 Summary

According to the DGEIS, the dominant events for rapid drain down of a spent fuel pool are seismic events (5.8×10^{-7} to 2.4×10^{-6} events per year) and heavy load drop (2×10^{-7} events per year). However, the details of the analysis show that the seismic risk could be up to ten times higher at specific sites and the heavy load drop frequency is calculated to be higher than the pool performance guideline for non-single failure-proof system.

The DGEIS argues that the probabilities calculated in NUREG-1738 are conservative because post-September 11 and post-Fukushima measures have been and are being implemented at nuclear plants. As discussed above, the DGEIS does not specify what measures have been implemented at which plants. Because some of the measures are not mandatory or only apply to specific plants, any reduction in risk will differ on a plant-by-plant basis. The DGEIS does not quantify what the reduction in spent fuel pool fire risk would be, either in general or on a plant-by-plant basis.

3.4 Consequence assessment

The consequence assessment presented in Appendix F of the DGEIS and the Spent Fuel Pool Consequence Study (US-NRC 2013b) is based on CRAC2 calculations (1989), MACCS calculations (1997), and MACCS2 calculations (2001). The most detailed set of data comes from NUREG-1738 (US-NRC 2001) and is based on MACCS2 calculations.

The following subsections discuss the atmospheric and liquid releases assumed in the DGEIS and the Spent Fuel Pool Consequence Study for the purpose of calculating accident consequences. The following subsections also discuss the key MACCS2 input parameters used in the Consequence Study to determine the total offsite cost of a spent fuel pool accident.

3.4.1 Atmospheric releases

DGEIS Appendix F reports the results of previous US-NRC studies of consequences of atmospheric releases from one type of spent fuel pool accidents, spent fuel pool fires. These results are summarized in DGEIS Table F-1 (p. F-4), reproduced below in Table 1.

Table 1: Spent Fuel Pool Accident Probability and Consequences

Study	Accident frequency (per year)	Individual risk per event		Total person-Sv per event (50 mi)	Collective early fatality per event (10 mi)	Latent fatality (0 – 500 mi)	Total onsite and offsite economic (M$ per event)
		Early fatality (1 mi)	Latent fatality (10 mi)				
NUREG-1738 (hi Ru)	5.8×10^{-7} – 2.4×10^{-6}	4.68×10^{-3} – 4.43×10^{-2}	6.39×10^{-2} – 8.49×10^{-2}	1.34×10^{5} – 2.37×10^{5}	< 1 – 191	-	-
NUREG-1738 (lo Ru)		1.63×10^{-3} – 1.27×10^{-2}	1.29×10^{-2} – 1.88×10^{-2}	4.72×10^{4} – 5.58×10^{4}	< 1 – 2	2.0×10^{4} – 2.7×10^{4}	-
NUREG-1353	2×10^{-6}	-	-	2.6×10^{5}	-	-	5.57×10^{4}
NUREG/BR-0184	-	-	-	2.6×10^{5}	-	-	5.78×10^{4}

The only consequences the DGEIS compares to quantitative risk criteria (discussed in Sections 2.4.1 and 2.4.2 above) are the early and latent fatalities under the individual risk per event, listed in the third and fourth columns of Table 1.

The calculation of the societal risk quantities, including collective dose, collective early fatality, and latent fatality, as well as total economic costs is heavily dependent on the population density surrounding a particular site. The values in Table 1 were all calculated for the Zion site, using a population density of 860 people per square mile surrounding the site, as reported in US-NRC's 1996 GEIS for License Renewal. Zion's population density is not representative of some sites such as Indian Point, which had a population density of "almost 2000 persons per square mile," as reported in US-NRC's 1996 GEIS for License Renewal (US-NRC 1996, p. 2-2 to 2-8). Because Indian Point is surrounded by more than double the population density of Zion, the accident consequences would most certainly be significantly higher for Indian Point than the consequences reported for Zion in Table 1. The DGEIS does not discuss differences in population density among sites, or calculate the effect those differences would have on the consequence calculations.

Table F-2 (p. F-8) of the DGEIS presents a comparison of frequency-weighted consequences from severe reactor accidents and spent fuel pool fires. For spent fuel pool fires, Table F-2 multiplies the consequences presented in Table 1 by the average frequency for accident presented in Table 1, to produce frequency-weighted consequences. Multiplying the average values for the frequency and the consequences is acceptable if the probability distributions are un-correlated (see elaboration provided in Annex A). If the same plants that have a higher frequency of severe earthquakes also have the highest density of population around the site, the values calculated in Table F-2 of the DGEIS may under-represent the average risk.

US-NRC should calculate the correlation coefficient between the frequency of seismic events for the Zion site and the density of the population around the Zion site and use this correlation coefficient to correct the frequency-weighted probabilities presented in Table F-2 of the DGEIS. Alternatively, the US-NRC should calculate the collective dose-risk and the economic cost-risk for each site and re-calculate the average.

3.4.2 Liquid releases

One of the lessons learned from the Fukushima accident is that mitigation measures that stop the progression of a severe accident may have clear benefits in the short term, but may create longer term hazards from liquid or aqueous releases to the environment.

At Fukushima, the emergency workers pumped water into the damaged reactors. This water became contaminated on contact with the damaged fuel elements, and leaked out into the basement of the reactors.

The employees of TEPCO also pumped water into the spent fuel pools to compensate for evaporation and boil-off. In the days following the accident, the pumping was successful because the spent fuel pools remained intact, the spent fuel rods were not damaged, and the spent fuel pools did not leak contaminated water into the environment (TEPCO 2013). This event shows the importance of additional measures to cool the fuel since this is what averted further releases.

Within weeks after the accident, however, it became clear that the water pumped into the reactors was leaking into the Pacific Ocean. Within a month, TEPCO started to pump the contaminated water into tanks to store the contaminated water on-site, in an attempt to prevent more contaminated water from leaking into the ocean. Even with those storage tanks, some contaminated water still leaked into the ocean. According to TEPCO, as of 2013, the activity that flowed into the ocean was roughly estimated as 7×10^{11} to 1×10^{13} Bq (27 to 540 Ci) for strontium and 1×10^{12} to 2×10^{13} Bq (19 to 270 Ci) for cesium, respectively.

In addition to the water pumped into the reactors at Fukushima, ground water that would normally drain into the ocean is contaminated when it migrates through the reactor buildings. TEPCO had to build wells to intercept this ground water before it became contaminated. By October 2013, there were several hundred tanks holding some 340 000 tons of contaminated water. In 2013, more tanks are still added daily and TEPCO plans a total tank capacity of 800 000 tons by 2016. TEPCO is currently commissioning cesium removing equipment (SARRY – Toshiba, KURION – USA, and AREVA – France), plus a water treatment plant (Advanced Liquid Processing System) to decontaminate this water. The cost of managing the liquid releases has been very high. Japan has pledged $475 million to build an ice wall and processing plant to stop radioactive water from contaminating the ocean (Wall Street Journal 2013).

Although two and a half years have passed since the Fukushima accident, radioactive water continues to flow into the ocean (New York Times 2013).

Thus, the unfolding experience at Fukushima shows that liquid or aqueous releases caused by a severe accident can have a significant environmental impact, resulting in health and economic consequences that should be addressed in the DGEIS's discussion of severe spent fuel pool accident impacts. If water is added to spent fuel pools at a sufficient rate early in the severe accident event, it may be possible to avoid damaging the spent fuel rods and minimize the amount of contaminated water leaking into the environment. On the other hand, if water is added after the onset of fuel damage, or after a spent fuel pool fire, the water leaking out of the spent fuel pool will be heavily contaminated. For the more severe events, where on-site infrastructure is damaged, it may take months before remediation measures such as construction of storage tanks, pump and treat, diversion, or containment can be put in place. The DGEIS should contain a discussion of how aqueous releases can occur during a severe accident, and the potential consequences of aqueous releases during a severe accident, given the unfolding experience at Fukushima.

The MACCS2 code does not model "aqueous release pathways." NRC Regulatory Information Conference (RIC) International Session - Post-Fukushima Research, NRC Office of Nuclear Regulatory Research (March 13, 2013) slide 7; *see also* Certified Minutes of the ACRS Reliability and PRA Subcommittee Meeting on Level 3 PRA on December 4, 2012 (ML13211A477). The DGEIS should acknowledge this limitation of the code, and discuss options for determining and mitigating the effects of aqueous releases.

Since hydrological and geological properties vary from site to site, as does the proximity of sites to bodies of water and the configuration of the reactor(s) and spent fuel pool(s), the consequences of contaminated water leaking into ground water and surface water should be assessed on a site-specific basis.

3.4.3 MACCS2 input parameters to determine offsite cost

The MELCOR Accident Consequence Code System 2, or MACCS2 code, is the computer model generally used in the U.S. for calculating the consequences of a severe accident. MACCS2 is a Gaussian plume model for calculation of radiological atmospheric dispersion and consequences, developed by Sandia National Laboratories. The MACCS2 code is the latest in a series of computer modeling tools developed to evaluate impacts of severe accidents at nuclear power plants on the surrounding public. MACCS2 was released in 1997 and developed as an improved version of the MACCS code, which itself replaced the earlier CRAC2 code.

The MACCS2 code simulates the atmospheric release of radioactivity, the direction, speed of travel, and dispersion (spread and dilution) of the plume based on meteorological inputs; and ultimately, MACCS2 calculates radiological health and economic impacts. It can model, among other things, the offsite population dose and the offsite economic costs of an accident.

The MACCS2 code evaluates several major factors which contribute to the costs of a severe nuclear accident. For example, MACCS2 evaluates release characteristics, weather pattern, population profile, clean-up costs, and other factors which affect the cost of a severe accident. MACCS2 is executed in three steps. The first module, ATMOS, calculates air and ground concentrations, plume size, and timing information for all plume segments as a function of downwind distance. The next module, EARLY, calculates the consequences due to exposure to radiation in the first seven days, which is the emergency phase of the accident. The last module, CHRONC, calculates the consequence of the long-term effects of radiation and computes the decontamination and economic impacts incurred due to the accident.

As discussed above, the DGEIS reports the quantitative consequence assessments performed in NUREG-1738 and references cited therein. NUREG-1738 relies upon the MACCS2 economic cost input parameters from NUREG-1150.

The Spent Fuel Pool Consequence Study (US-NRC 2013b) reports its own consequence calculations based on MACCS2 runs US-NRC Staff performed in November 2012. The central purpose of the Consequence Study is to determine whether it is cost-beneficial to expedite the transfer of spent fuel from high-density spent fuel pools to dry storage casks by analyzing the probabilities and consequences of severe accidents originating from a spent fuel pool. The Consequence Study uses the Peach Bottom site as a reference case, so the frequencies and consequences reported in the study are for that site and the population density surrounding it.

The total offsite cost of a given spent fuel pool accident can be calculated by:

Total offsite cost = cost equivalent of the offsite population dose + offsite economic cost

The key MACCS2 input parameters that dictate the population dose and economic cost are discussed below. Where information exists, the corresponding values chosen in the Consequence Study are analyzed in terms of their origin and appropriateness as a site-independent value. Like NUREG-1738, which is reported in the DGEIS, the Consequence Study also used many MACCS2 economic cost input parameters from NUREG-1150.

NUREG-1150 reported economic cost inputs that were included in an example problem, Sample Problem A, in the MACCS2 User Guide. The NUREG-1150 authors chose five commercial nuclear plants of different design to estimate the risks of a severe accident. One of these, the Surry reactor, is a Westinghouse designed three-loop pressure water reactor in a large, dry containment building located near Williamsburg, Virginia. Thus, the NUREG-1150 values incorporate site-specific information for the Surry site. Neither the MACCS nor MACCS2 documentation suggests that the input values of the code sample problems be considered recommended or default values.

Population and meteorology

Two of the most important site-specific parameters in the MACCS2 input data are the population and meteorology. There is a direct correlation between these parameters and the offsite population dose and economic costs.

The offsite economic cost is calculated by multiplying the per capita parameters (e.g., VALWNF, CDNFRM, POPCST) by the population to which the mitigative action (e.g., condemnation, decontamination, interdiction respectively) is applied. Thus, in general, the total economic cost is directly proportional to the population.

The wind rose (i.e., probability of wind directions) of the site has a direct correlation to the probability of certain areas being contaminated in the event of a severe accident and thus requiring mitigative actions. In the Consequence Study, the reference plant Peach Bottom's wind rose was such that the predominant wind directions were towards lower population areas (US-NRC 2013b, Section A.2). By comparison, the predominant wind directions at the Indian Point site are to the North/North-Northwest and to the South; the latter would affect the New York City metropolitan area, one of the most populated areas in the U.S (see Figure 2 below, showing the highest population concentrations surrounding Indian Point and the wind rose).

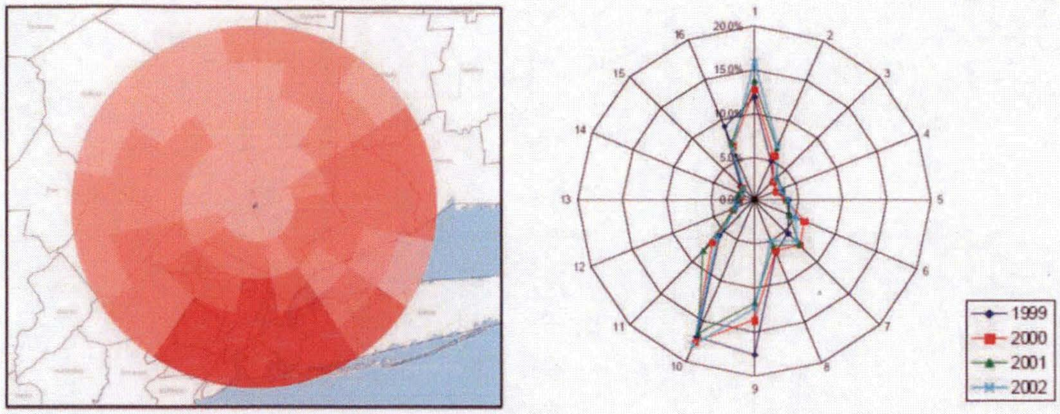

Figure 2: Population and wind rose for the Indian Point site. LEFT - Population by grid element (darker colors represent higher population) (ML13073A555 at p. 2-7), RIGHT – Wind rose for years 1999-2002 (ML12334A743).

The impact of the wind rose at the reference plant Peach Bottom is acknowledged by the authors of the Consequence Study:

> *"Thus, if a release were to occur [at the reference plant Peach Bottom], it is more likely that a relatively small population would be affected than if the release occurred at a facility near a major city"* (US-NRC 2013b, Section A.2).

As detailed in Section C.2.12 of COMSECY-13-0030, which adopts the Consequence Study, a sensitivity analysis was carried out as part of the Consequence Study to analyze the effect of population density on the offsite consequences. A summary of this analysis is shown in Table 2 below. The COMSECY contains the following warning regarding the Consequence Study's results:

> *"...the results are not representative of any specific site because site specific meteorology for these sites is not used."* (US-NRC 2013a, p. 99)

Despite this disclaimer, the conclusion of the COMSECY's sensitivity analysis is that population density is not a key parameter, i.e., US-NRC has decided that population density is not a variable that can significantly affect consequence calculation results (US-NRC 2013a, p. 21).

Because many plants are located in low population areas, Peach Bottom's population may be representative of some plants. Given the combination of Indian Point's population and predominate wind direction, the results of US-NRC's Peach Bottom analysis are not applicable to Indian Point. As shown in Figure 3 below, the population density within 50 miles of the Indian Point site is far greater than even those considered in the Consequence Study's sensitivity analysis.[7] With the combination of higher population and a dominant wind direction toward the most populated areas, it is reasonable to expect that the consequences to the public surrounding Indian Point may

[7] The population density within 50 miles of the Indian Point site is derived from the 2010 census data presented in reference (US-NRC 2012b).

be over 100% greater than the base case used in the Consequence Study. This increase is equally applicable for the calculation of economic costs, which does not appear to be included in the sensitivity analysis for population density.

There are several factors that must be considered alongside a significantly larger population, such as those who reside within 50 miles of the Indian Point reactor; building density is one such factor. With a larger building density than that of the reference site used in the Consequence Study, there are many more surfaces in urban environments that effectively deplete the amount of contamination in an airborne plume. This results in higher levels of contamination and thus greater radiological and economic costs (e.g., the cost of decontamination). Annex B provides a discussion of surface roughness as it relates to deposition velocity of radioactive particulate in urban environments.

Table 2: Summary of the population density sensitivity analysis (US-NRC 2013a)

Case	Statistical parameter	Representative site	Average 2010 population density within 50 miles	Net percent change in public health from the base case
High estimate	90th percentile	Peach Bottom	722	25% - 28% increase
Mean estimate	Mean	Surry	303	No change
Median estimate	Median	Palisades	183	21% - 37% decrease
Low estimate	20th percentile	Point Beach	102	67% - 73% decrease

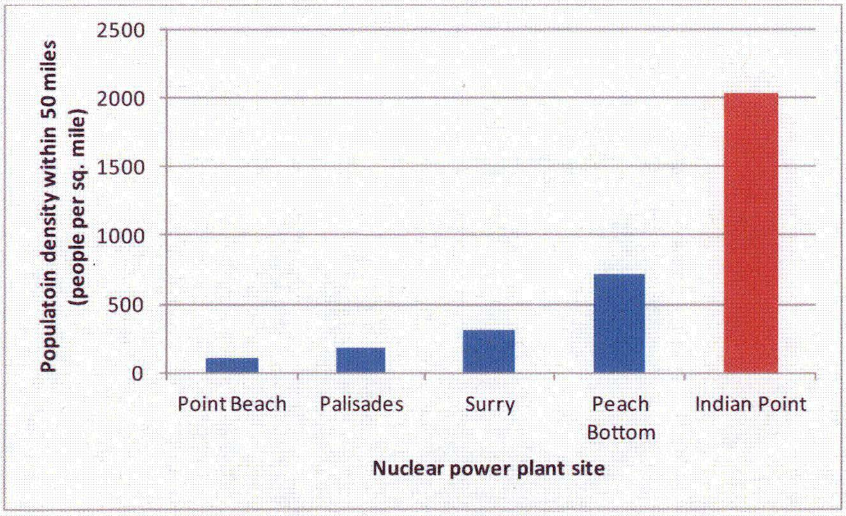

Figure 3: Comparison of population densities

Offsite population dose

The majority of the MACCS2 input parameters related to the calculation of population dose are site-independent, and are based on guidance published in:

- NUREG/CR-7009: MACCS2 Best Practices as Applied in the State-of-the-Art Reactor Consequence Analyses Project (expected to be published in 2013)
- NUREG/CR-7161: Synthesis of Distributions Representing Important Non-Site-Specific Parameters in Off-site Consequence Analyses
- NUREG-1935: State-of-the-Art Reactor Consequence Analyses (SOARCA) research project
- NUREG/CR-6613: Code Manual for MACCS2 User's Guide
- NUREG-1150: Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants

The Consequence Study employed a factor of $2,000/person-rem to convert the offsite collective dose to a monetary value. This factor was obtained from NUREG-1530: Reassessment of NRC's Dollar per Person-Rem Conversion Factor Policy. Due the uncertainty of this value, and based on recently updated ICRP risk coefficients, a sensitivity analysis that incorporates a values of $4,000/person-rem is carried out in the Consequence Study (Section D.3.3.2).

Offsite economic cost

Aside from population and wind rose, the most sensitive MACCS2 input parameters in determining the total economic cost are listed below with the most sensitive parameter listed first. This list was the result of ISR's sensitivity analysis of all parameters used in the CHRONC (i.e. long-term phase) module of the MACCS2 code.

1) GWHLF – Long-term groundshine coefficients
2) DSCRLT – Long-term phase dose criterion (Sv)
3) VALWNF – Value of nonfarm wealth ($/person)
4) TMPACT – Time action period ends (seconds)
5) DSRATE – Societal discount rate for property (/year)
6) FRNFIM – Nonfarm wealth improvements fraction
7) TGWHLF – Groundshine weathering half-lives (seconds)
8) DPRATE – Property depreciation rate (/year)
9) POPCST – Per capita cost of long-term relocation ($/person)
10) CDNFRM – Nonfarm decontamination cost ($/person)
11) TIMDEC – Decontamination times (for all decontamination levels) (seconds)

In the Consequence Study, US-NRC adopted the values for the groundshine parameters, GWHLF and TGWHLF, from the guidance it published. These groundshine parameters are radionuclide-specific, calculated from first physical principles and are not time or location-dependent.

The Consequence Study includes a sensitivity analysis of the habitability criterion, which is the combination of input parameters DSCRLT and TMPACT (US-NRC 2013b, Section D.3.2.2.8). The Consequence Study reports a range of possible values and the corresponding impact on the results.

The Consequence Study's value of nonfarm wealth (VALWNF) includes all public and private property not associated with farming that would be unusable if the region was rendered either temporarily or permanently uninhabitable. This value includes the cost of land, buildings, infrastructure, and the cost of any non-recoverable equipment or machinery (MACCS2 manual). The value chosen for the Consequence Study, which uses the Peach Bottom site as the reference case, is $210,000/person (2012 USD). By its definition, this value is site-specific. As a comparison, in its submission for a licence renewal for Indian Point Units 2 and 3, the operator of the Indian Point reactors, Entergy, calculated VALWNF to be $209,000/person (2004 USD) for the site. Entergy's value is approximately $250,000/person in 2012 USD, which is 20% higher than the value used in the Consequence Study. As a further comparison, the corresponding value for VALWNF deemed appropriate in ISR Report 13014-01-01 is approximately $284,000/person (2004 USD).[8] In 2012 USD, this equates to $345,000/person, which is 64% higher than the value used in the Consequence Study.

The Consequence Study based the parameters DSRATE, FRNFIM, and DPRATE on guidance published in WASH-1400 and NUREG/CR-4551. Given the limited range of these values (i.e., between 0 and 1), and the large uncertainty associated with them, the study's choice of these values is likely reasonable and appropriate.

The Consequence Study's per capita cost of long-term relocation (POPCST) takes into account both personal and corporate income losses, as well as moving expenses, for a transitional period. The value chosen for the Consequence Study is $12,000/person (2012 USD). This value is site-specific. For example, in the state of New York, the average per capita income is approximately $32,000 (2011 USD). Using an interdiction period of 140 days as recommended in NUREG/CR-4551, the total amount of lost wages is $12,500/person (2012 USD). With the addition of corporate income losses and moving expenses, this amount for Indian Point is expected to be higher than the value used in the Consequence Study.

The cost and time for decontamination, CDNFRM and TIMDEC respectively, are entered for two levels of decontamination in the Consequence Study: light and heavy decontamination. Light decontamination generally refers to the removal of approximately one-half to two-thirds of the contamination; heavy decontamination generally refers to the removal of over 90% of the contamination, often using much more intensive and possibly destructive methods. The costs entered for each decontamination level are $7,110/person and $19,000/person respectively. These values are obtained from NUREG/CR-7009 and are deemed to be consistent with both NUREG-1150 and NUREG-1935 (US-NRC 2013b, Section 7.1.5). Section 3.4.4 provides an examination of the ultimately unsubstantiated analyses that led to the determination of CDNFRM in NUREG-1150.

In the Consequence Study, the decontamination time for both decontamination levels is entered as one year. The selection of one year differs from the decontamination times used in NUREG-1150 of 60 and 120 days for light and heavy decontamination, respectively. The Consequence Study does not explain why one year was selected instead of 60 and 120 days. In any event, decontamination time is also site-specific and the decontamination efforts required particularly for urban areas could increase the

[8] Appropriate value for Indian Point derived from ISR Report 13014-01-01: Review of Indian Point Severe Accident Off Site Consequence Analysis (Dec. 21, 2011) (ML12334A761) as modified in Revisions to Tables in ISR Report 13014-01-01 (Jun. 28, 2012) (ML12340A648).

decontamination time beyond one year. Furthermore, the Consequence Study should have discussed and considered the unfolding experience of decontamination following the 2011 Fukushima accident. As of the date of this report (December 2013), the Fukushima decontamination has not been completed even though two and a half years have passed since the accident occurred. Indeed, it is expected to take several more years. Thus, it is questionable to use one year for the TIMDEC input for both light and heavy decontamination in the Spent Fuel Consequence Study MACCS2 analysis; the decision to use one year should be explained and substantiated.

3.4.4 NUREG-1150 cost of decontamination for non-farmland

Nonfarm Decontamination Cost ("CDNFRM") is a MACCS2 input that defines the cost of decontaminating land that is not farmland. MACCS2 requires the user to input a CDNFRM value in dollars per person for each dose reduction factor specified by the user. NRC has used NUREG-1150 values, adjusted for inflation using the Consumer Price Index, as CDNFRM inputs.

NUREG-1150, however, contains a gaping hole—the source of the decontamination cost parameters in NUREG-1150, and thus the source of the decontamination cost parameters used in Sample Problem A, simply does not exist. Neither NUREG-1150 itself nor its companion, NUREG/CR-4551, explain how the Sample Problem A costs were obtained. NUREG/CR-4551 cites NUREG/CR-3673, as a reference for the Sample Problem A decontamination cost values, but NUREG/CR-3673 states only that:

> *"The cost estimates used in this study for various levels of decontamination effort in an area are taken from a detailed review of decontamination effectiveness and costs performed at Sandia National Laboratories (SNL) [Os84]."*

"Os84" is listed as "Ostmeyer, R.M., and G.E. Runkle, An Assessment of Decontamination Costs and Effectiveness for Accident Radiological Releases, Albuquerque, N.M.: Sandia National Laboratories, *to be published*," in NUREG/CR-3673's references section. NUREG/CR-3673 at p. 8-8 (emphasis added). The Os84 document does not exist, at least in any available form. Os84 appears to have never been published, nor peer-reviewed.

Even if Os84 did still exist, the author of NUREG/CR-3673 (which cites to Os84) made it clear that these were tentative results:

> *"Little data exist which are directly applicable to the small particle sizes (0.1-10 μm) and soluble materials which are anticipated in releases from the LWR accidents. The cost and effectiveness estimates for decontamination contain large uncertainties, and results of future experimentation with decontamination techniques should be used to update models for decontamination."* (NUREG/CR-3673 at p. 4-15)

No one knows the origin of the NUREG-1150 decontamination cost values, other than a cryptic description that they were based upon "national average statistics." NUREG/CR-3673 at p. 4-17. Public comments on a draft of NUREG-1150 state "Decontamination costs used in the calculations may be based on *decontamination of test sites in deserts* instead of agricultural, residential, and commercial property." NUREG-1150 at D-32.

The comments received on a draft of NUREG-1150 suggest that its authors expected that site-specific estimates of decontamination costs would be developed. NUREG-1150 states:

> *"[PUBLIC] COMMENT: The models used in calculating the cost of a severe accident lack many factors that should be taken into account. Many of the assumptions are questionable and unfounded. The models have not been benchmarked. Some interpretations and conclusions that were made in draft NUREG-1150 are questionable. The cost estimates need to be more thoroughly documented to understand and evaluate the calculations.*
>
> *[NRC] RESPONSE: The present version of NUREG-1150 provides a limited set of risk-reduction calculations, principally related to the potential benefits of accident management strategies in reducing core damage frequency. It does not assess the cost of these or other improvements. Such analyses are more properly considered in the context of specific regulatory action.*
>
> * * *
>
> *[PUBLIC] COMMENT: Decontamination costs used in the calculations may be based on decontamination of test sites in deserts instead of agricultural, residential, and commercial property.*
>
> *[NRC] RESPONSE: The draft NUREG-1150 cost/benefit analyses reflected the conventional NRC methods for assessing costs and benefits. Because cost/benefit analyses are more properly considered in the context of specific regulatory activities, they are not provided in this version of NUREG-1150."*

These comments support the notion that reliance on Sample Problem A instead of developing site-specific inputs is unreasonable.

In the 1980s, NRC commissioned a site-specific case study to estimate the costs associated with a severe accident at Indian Point—Tawil 1990. NUREG/CR-5148, Chapter 5 (Tawil 1990). The results of Tawil 1990 show that NRC has actually conducted a site-specific analysis of the decontamination costs associated with a severe accident at Indian Point, without using NUREG-1150 values, and, therefore, without relying upon Sample Problem A.

Unlike the generic NUREG-1150 values that provide the MACCS2 code with two decontamination costs, one for land that's farmland and land that's not farmland, Tawil 1990 contains detailed analysis of land use and decontamination techniques to produce site-specific decontamination costs. The following table, Figure 4, lists Tawil 1990's analysis of surface types *for a single grid element* that lies in Westchester County with a population of just over 1,000 and a "pre-accident real property value estimated at $65 million" (*Id.* at 4.32). Tawil 1990 explains each column and each surface description in detail (*Id.* at 4.32 – 4.35). Tawil notes that "although this particular report applies to a grid element, a similar report can be generated for an exposure area" (*Id.* at 4.32).

DETAILED SURFACE RESULTS FOR GRID ELEMENT 8, FOR PERIOD 30.

*** EXTERNAL PATHWAY ***

SURFACE	AREA (ha) 1/	EXPOSURE (Sv)	METH 2/	3/	RESIDUAL (Sv)	AVG.COST ($/ha)	TOT.COST ($)	RATE (m**2/hr)
AGRICULTURAL FIELDS	5.91E+00	9.63E+00	Tx		5.39E-02	9.14E+04	5.40E+05	8.75E+02
ORCHARDS	2.90E-01	9.63E+00	TRx		9.24E-02	1.24E+05	3.60E+04	9.80E+01
VACANT LAND	3.42E+01	9.63E+00	TNx		5.39E-02	1.34E+05	4.59E+06	5.20E+01
WOODED LAND	2.54E+01	9.63E+00	T	~	8.67E+00	1.21E+04	3.07E+05	5.60E+03
ASPHALT STRTS/PRKNG	8.70E+00	9.63E+00	vCF		1.58E-01	2.11E+04	1.84E+05	4.30E+03
OTHER PAVED ASPHALT	5.88E-01	9.63E+00	vCF		1.58E-01	2.19E+04	1.29E+04	2.15E+03
CNCRETE STRTS/PRKNG	6.08E+00	9.63E+00	vCF		1.58E-01	2.11E+04	1.29E+05	4.30E+03
OTHER PAVED CNCRETE	2.35E+00	9.63E+00	VC	#	1.85E-01	2.04E+04	4.79E+04	2.15E+03
LAWNS	5.03E+01	9.63E+00	R		1.93E-01	1.42E+05	7.13E+06	4.00E+01
RESERVOIRS	9.53E+00	9.63E+00	rxr		1.54E-01	9.38E+04	8.94E+05	6.56E+02
ROOFS	8.16E+01	9.63E+00	R		9.63E-02	4.71E+05	3.85E+07	2.40E+01
EXT. WOOD WALLS	1.17E+01	9.63E-01	W		1.44E-01	2.43E+03	2.84E+04	2.03E+02
EXT. BRICK WALLS	2.48E+00	9.63E-01	W		1.44E-01	2.43E+03	6.04E+03	2.03E+02
EXT. CONCRETE WALLS	1.54E+01	9.63E-01	W		1.06E-01	2.43E+03	3.75E+04	2.03E+02
INT'R WOOD/PL WALLS	3.69E+01	4.81E-01	V		2.41E-02	4.76E+03	1.76E+05	6.90E+01
INT'R CNCRETE WALLS	7.58E+00	4.81E-01	V		1.69E-01	4.76E+03	3.61E+04	6.90E+01
CARPETED FLOORS	7.22E+00	4.82E+00	VTR		2.60E-02	4.41E+05	3.19E+06	3.70E+00
LINOLEUM FLOORS	8.56E+00	4.82E+00	v		1.81E-01	9.52E+03	8.14E+04	6.90E+01
WOOD FLOORS	2.03E+00	4.82E+00	vF		1.73E-01	3.13E+04	6.35E+04	4.00E+01
CONCRETE FLOORS	1.17E+01	4.82E+00	vF		1.85E-01	3.13E+04	3.66E+05	4.00E+01
HARD-SURF FURNSHNGS	3.56E+03	4.82E+00	vR		1.44E-01	2.02E+04	7.21E+07	8.00E-03
SOFT-SURF FURNSHNGS	2.42E+03	4.82E+00	vR		6.50E-02	4.49E+03	1.09E+07	1.59E-01
ELECTRONIC EQUIP	3.97E+03	4.81E-01	V		1.69E-01	1.99E+02	7.90E+05	2.19E-01
PAPER PRODUCTS	3.78E+03	9.63E-01	k		1.93E-02	1.95E+03	7.35E+06	1.50E-01
AUTO EXTERIORS	8.91E+02	9.63E+00	TJJ		6.93E-02	4.82E+02	4.30E+05	2.50E-01
AUTO INTERIORS	8.91E+02	2.89E+00	Vz		8.67E-02	7.60E+02	6.77E+05	1.25E-01
AUTO TIRES, (PER 4)	8.91E+02	9.63E+00	R		9.63E-03	3.19E+02	2.84E+05	1.00E+00
AUTO ENG/DRV TRAIN	8.91E+02	9.63E+00	IEE		1.01E-01	2.56E+02	2.28E+05	1.00E+00

NOTES:
1/ Area measures do not apply to autos and building contents; values are the number of automobiles and the number of building contents units.
2/ ---- = Decontamination not required //// = Unable to decontaminate surface
3/ + = Method is required \ = Restricted operation is in effect
Quick-Vac: # = in effect * = w/restricted operation ~ = w/required method

Figure 4: Detailed surface analysis report (Tawil 1990, p. 4.33)

Tawil 1990 supports a detailed, site-specific approach that takes into account the land use in great detail. For example, in urban areas—unlike the rural Virginia area used to create NUREG-1150—the cost of decontaminating the contents of a building can exceed the cost of decontaminating land and structures (Tawil 1990 Figure 4.3, at 4.26 - 4.28). Additionally, Tawil 1990 makes the point that decontaminating building contents is labor intensive and labor costs constitute a large portion of the cost of decontamination (Tawil 1990 at 2.8 - 2.71).

4. RELEVANCE FOR INDIAN POINT

This section discusses the relevance of the findings on the impact on the environment of spent fuel pool storage for the Indian Point site.

4.1 Configuration of Spent Fuel Pool

The DGEIS assumes that the generic spent fuel pool described in Section 2 of the DGEIS is representative of most spent fuel pools. The US-NRC has adopted as its reference spent fuel pool, one that has 700 MTU storage capacity that reaches its licensed dense storage capacity limit in about 35 years into licensed life for operation of a reactor.

The total capacity of the spent fuel pools at Indian Point Unit 2 and Unit 3 is 1374 and 1375 fuel assemblies. Using 0.45 MTU per assembly, this is equivalent to about 620 MTU per pool, which is comparable to the reference spent fuel pool.

Since 2004, IP-2 has a single failure proof spent fuel pool gantry crane (Entergy 2004), therefore the analysis for the probability of a cask drop event contained in NUREG-1738 is directly applicable. A similar upgrade to the IP-3 cask handling crane was evaluated and found to be not feasible, therefore the spent fuel from the IP-3 spent fuel pool is transferred to the IP-2 spent fuel pool before being loaded into casks (NRC 2012a).

The DGEIS uses the risk assessment from NUREG-1738, which relies on a series of Industry Decommissioning Commitments (IDC) and Staff Decommissioning Assumptions (SDA) that are spelled out and are assumed to apply generically to all plants (US-NRC 2001, p. 4-11 and 4-12).

Since Indian Point Unit 2 and 3 have not been decommissioned, it is not known which of these assumptions are actually met in the operating plants. The consequences of not meeting these assumptions should be spelled out in the DGEIS.

4.2 Seismicity

The DGEIS uses an average site seismicity corresponding to a frequency of exceeding 1.2 g of 2×10^{-7} per year to 2×10^{-6} per year. The actual frequency of exceeding 1.2 g at the Indian Point site is not quoted in the DGEIS or NUREG-1738; although the data shown in Figure 10 of COMSECY-2013-0030 (p.81) suggests that this frequency is greater than 2×10^{-6} per year. The recent US-NRC GI-199 report (US-NRC 2010, p. B-7) reports the safe shutdown earthquake, SSE_{PGA} = 0.15 g for the Indian Point site, and the high confidence of a low probability of failure, $HCLPF_{PGA}$ = 0.3 g for IP-2 and 0.15 g for IP-3. The safe shutdown earthquake is the largest earthquake that must be considered in the design. The high confidence of a low probability of failure earthquake takes into account the fragility of the plant. .

Chapter 9 of the IP2 and IP3 Final Safety Analysis Reports (FSARs) indicates that the SFP structures are classified as Seismic Category I. The IP2 FSAR is specific regarding the design criteria, and indicates that the IP2 SFP was designed in accordance with the provisions of American Concrete Institute (ACI)-318, "Building Code Requirements for

Reinforced Concrete" (see Section 9.5.2.1.4 of the IP2 FSAR). The 1989 license amendment issued for IP3 SFP re-rack indicates that the design criteria used to evaluate the SFP structure are based on the provisions in ACI 349-80, "Code Requirements for Nuclear Safety-Related Concrete Structures."

Based the classification of these structures indicated above, they are required to be designed against bounding loading combinations which include loads due to a safe shutdown earthquake. As such, the structural analyses are performed to ensure that the SFPs will remain functional during and after a safe shutdown earthquake (Boska 2011).

4.3 MACCS2 Input Parameters

Section 3.4.3 of this report discusses the importance of various MACCS2 input parameters in determining the offsite population dose cost and offsite economic cost following a severe accident at a spent fuel pool. The following table summarizes those input parameters and values used in the Consequence Study that are site-specific to the Peach Bottom reference plant and compares them to appropriate values for Indian Point.

Table 3: Summary of site-specific MACCS2 input parameters relevant to Indian Point

Parameter	Value used in the Consequence Study reference site	Minimum appropriate value for the Indian Point site	Minimum Ratio (Indian Point/reference site)	Applicable to the population dose cost	Applicable to the economic cost
Population within a 50-mile radius	5.7 million	17 million	3.0	Yes	Yes
Predominant wind direction	Towards lesser populated areas	Towards heavily populated areas	N/A	Yes	Yes
Value of nonfarm wealth (2012 USD)	$210,000/person	$345,000/person*	1.6	No	Yes
Relocation costs (2012 USD)	$12,000/person	$12,500/person*	1.04	No	Yes
Cost of decontamination (DF=3,15) (2012 USD)	$7,110/person $19,000/person	$17,630/person* $83,500/person*	2.5 4.4	No	Yes
Time of decontamination (DF=3,15)	1 year (DF=3) 1 year (DF=15)	1 year (DF=3)* 2 years (DF=15)*	1 2	No	Yes

* The ISR Report and updated tables submitted in the context of the Indian Point relicensing proceeding provided a suggested range of appropriate values for each of these parameters. For the sake of simplicity, and for illustrative purposes in this DGEIS proceeding, only the minimum value is represented here in Table 3. Values were CPI-adjusted to 2012 USD. The reader is directed to ISR Report 13014-01-01: Review of Indian Point Severe Accident Off Site Consequence Analysis (Dec. 21, 2011) (ML12334A761) as modified in Revisions to Tables in ISR Report 13014-01-01 (Jun. 28, 2012) (ML12340A648) for a complete discussion of site-specific input parameters for Indian Point, which also include higher input values.

Furthermore, the DGEIS uses the population density around the Zion plant, 860 people per square mile, while the population density surrounding Indian Point is over 2100 people per square mile.

5. CONCLUSIONS

Based upon ISR's review of the DGEIS and supporting documents, US-NRC should address the following comments before finalizing the DGEIS:

1. Ensure that the conclusions of the DGEIS are based on actual practices and conditions at spent fuel pools at various sites around the U.S. Explicitly list and describe those sites that have spent fuel pools that do not meet an assumption or condition included in the DGEIS or documents relied upon by the DGEIS. The DGEIS should either employ conservative bounding or direct site-specific review for certain plants like Indian Point.

2. Develop a quantitative health risk acceptance criteria compatible with the Commission's Policy Statement regarding societal risk (in addition to the criteria for individual risk).

3. Analyze alternatives to mitigate the potential severe accident impacts. This should be done in a site-wide manner that integrates all hazards and corresponding risks that exist on the site (i.e., all reactor units and spent fuel pools are assessed in a single risk assessment). The DGEIS should either employ conservative bounding or direct site-specific review for certain plants like Indian Point.

4. Document explicitly how the assessment of event frequencies includes the contribution of seismic events to loss of offsite power and internal fire.

5. Show how the load drop analysis required for non-single failure proof cranes changes the human error rate calculation from 2.1×10^{-5} per year to 2×10^{-7} per year for cask drop events.

6. Revise the calculation of the societal risk-dose and the economic risk-cost to account for the possible correlation between the seismic risk and the population density.

7. Include an analysis of the impact of new monitoring, and post-accident response measures put in place for intentional, malevolent actions since 9/11 and the Fukushima event, listing which plants have implemented which measures and quantify how those measures affect risk.

8. Include an assessment of the environmental consequences and cost of liquid releases during a spent fuel pool accident, with specific reference to and discussion of the unfolding events at Fukushima.

9. Revise the MACCS2 consequence assessment to be conservative and bounding or make it site-specific and compatible with the current practices for severe accident mitigation alternative analyses for reactors. Include a re-assessment of the time and cost of decontamination for severe accidents, which are higher for areas with higher population densities.

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ANNEX A – AVERAGE RISK CALCULATED OVER ALL REACTOR SITES

When multiplying the average values of two probability distributions, such as the frequency F_i and the consequence C_i, the correct product is given by Equation A.1 since the covariance of F and C is the difference between the mean product and the product of the means:

$$\overline{R} = \overline{F} \times \overline{C} + Cov(F,C) \qquad \text{(Equation A.1)}$$

where:

$\overline{F} = \frac{1}{N}\sum_{i=1}^{N} F_i$ is the average over all reactor sites of the frequency of an event

$\overline{C} = \frac{1}{N}\sum_{i=1}^{N} C_i$ is the average over all reactor sites of the consequences of an event

$Cov(F,C) = \frac{1}{N}\sum_{i=1}^{N} (F_i - \overline{F})(C_i - \overline{C})$ is the covariance over all reactor sites

Table A.1 below illustrates how neglecting the covariance term can bias the results. First, assume that two different reactor sites, A and B, have frequency and consequences that are perfectly correlated. This means that site A has a low frequency and low consequences and site B has a high frequency and high consequences. If the average frequency of these two sites and average consequences of these two sites are used to calculate the average risk (last row in Table A.1 below), the value obtained is 0.5 × 50 = 25. This is the method used by US-NRC in the DGEIS, but it is wrong.

If the risk for each site is calculated separately, and then the average over all sites is calculated from the separately calculated risk for each site, the resulting value is (0 + 100) / 2 = 50. This is the correct way to calculate the average risk. It is possible to obtain the correct answer from the average values if Equation A.1, which includes a covariance term, is used. The result is 0.5 × 50 + 25 = 50.

Table A.1: Frequency, consequences and risks for two reactor sites

Site	Frequency (Ry^{-1})	Consequences	Risk (consequence Ry^{-1})
A	0	0	0
B	1	100	100
Average	**0.5**	**50**	**25 / 50**

ANNEX B – COST OF DECONTAMINATION IN URBAN ENVIRONMENTS

The contamination left behind after an airborne release is function of the deposition velocity "v_d", a parameter that describes the ratio of the activity on the ground to the activity in the air.

In reality, the deposition velocity varies with the ground cover. The activity removed from the cloud and deposited on the ground is larger when the drag from large objects is bigger and when more surfaces can capture the contamination in the air. This is captured by the dependence of the deposition velocity with ground-roughness length z_0.

To quote NUREG/CR-2300 v2, p 9-29:

> "*For particles, v_d depends on a variety of parameters: the chemical properties of the material being deposited, the size and shape of the particles, the surface-roughness length z_0, the nature of the vegetation, the atmospheric stability category, and so on. As a result, a survey of published data on the value of v_d produces figures varying between 0.0001 and 20 cm/sec (Hosker, 1974). Since this remains an area of great uncertainty, it is discussed in some depth in Appendix D, where it is shown that, for particulate matter emitted in the aftermath of a reactor accident, it is reasonable to expect v_d to be in the range 0.1 to 10 cm/sec. Hence, the value of 1 cm/sec chosen for use in the Reactor Safety Study seems as good as any other.*"

Later in NUREG/CR-2300 v2, p.D-15, the effect of ground-roughness length is described.

> "*Figure D-6 gives a typical example of Sehmel's theoretical predictions for v_d as a function of d for various roughness lengths and particle densities. These predictions are based on correlations derived from wind-tunnel data for the surface mass-transfer resistance for depositing particles. Also shown are some examples of the effect of density. This figure clearly shows that, for particle diameters of 1 to 10 pm, the dry-deposition velocity is a sensitive function of z_0.*"

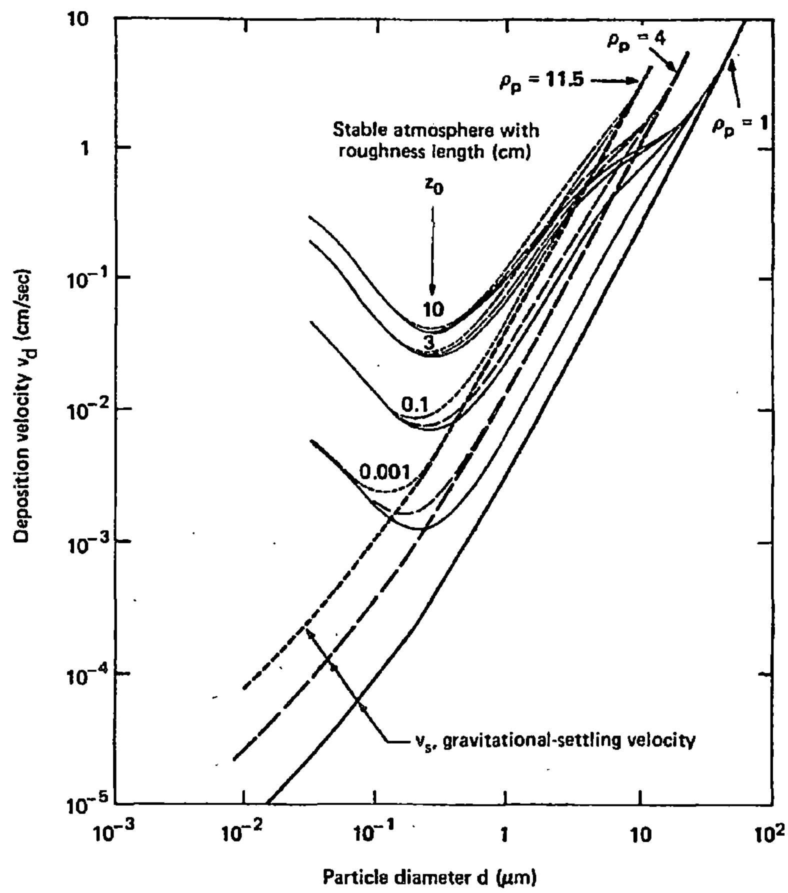

Figure D-6. Effect of the meteorological roughness length z_0 and particle density ρ_p on deposition velocity. From Sehmel (1980).

The section on dry deposition velocity ends with the following remark (NUREG/CR 2300 v2, p.D-17):

> "*In conclusion, for the consequence models that use a single deposition velocity for particulate matter released during a reactor accident, it is reasonable to assume that v_d is in the range 0.1 to 1 cm/sec. Over rough or heavily vegetated surfaces, deposition velocities of up to 10 cm/sec may be appropriate.*"

An urban environment qualifies as a rough surface. The following table is taken from the MACCS2 Guide, page A-20.

Table A-4. Surface Roughness Lengths for Characteristic Surface Types
(See Jow (1990) – Volume 2. MELCOR Accident Consequence Code System (MACCS), Model Description, NUREG/CR-4691, SAND86-1562, Sandia National Laboratories, Albuquerque, NM (1990)

Surface Type	Surface Roughness Length z_0 (cm)	Roughness Factor (Eqn. 10)	Scaling Factor for Dilution Factor
Tall Grass, Cropland	10 – 15	1.27 – 1.38	0.79 – 0.72
Countryside	30	1.58	0.63

Surface Type	Surface Roughness Length z_0 (cm)	Roughness Factor (Eqn. 10)	Scaling Factor for Dilution Factor
Suburban	100	2.02	0.50
Forests	20 – 200	1.46 – 2.32	0.68 – 0.43
Urban	100 - 300	2.02 – 2.51	0.50 – 0.40

The table shows that the surface roughness length is highest for an urban environment and more contamination will be removed from the cloud and deposited on surfaces than for other types of ground cover.

There are two methods that have been used by atmospheric dispersion codes to address this fact.

The first method consists of allowing the deposition velocity to vary with the ground-roughness. This is the method that has been implemented in the European Union consequence assessment code COSYMA [Haserman and Jones 1995]. When the consequences are calculated for an urban environment, the deposition velocity can be increased locally by a factor 10 - 100 to account for the increased removal rate from the cloud due to the larger ground-roughness length (see Figure D-6). When this method is used, the activity removed from the cloud must be distributed on all the surfaces of the buildings, which means that the actual contamination on each surface is lower than the nominal value per square meter calculated by COSYMA. This distribution of the contamination ensures that mass is conserved (there is no more contamination on surfaces than what was removed from the cloud).

The second method consists of using a single average deposition velocity that does not vary with ground-roughness. This is the method implemented in the MACCS2 code. In most calculations, the deposition velocity is set to VDEPOS=0.01 m/s (1 cm/s). So, in a farmland area with *low surface roughness*, MACCS2 will overestimate the amount of contamination removed from the cloud and deposited on the ground. On the other hand, in an urban area with *high surface roughness*, MACCS2 will underestimate the amount of contamination removed from the cloud and deposited on the ground. Since MACCS2 uses a single average deposition velocity value for the whole 50 mile area around the reactor, the actual contamination removed from the cloud and available to contaminate all the surfaces in an urban area is actually higher than the nominal value per square meter calculated by the MACCS2 code.

In this context, it is inappropriate to claim that conservation of mass dictates that the nominal ground contamination value must be distributed on all surfaces of a building. If the ground contamination value calculated by MACCS2 was distributed among all surfaces of a building, the procedure would underestimates the true contamination on the surfaces of the building. On the contrary, it is appropriate to directly use the value calculated by MACCS2 on all surfaces of the building since the value calculated by MACCS2 does not account for, and underestimates the enhanced deposition in an urban environment.

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