BDB Rec'd 1/12/10

Mendiola, Doris

Subject: FW: Riverkeeper Comments on Revised GEIS for NPP License Renewal, RIN3150-AI42 - E-mail 1

Attachments: 2010.01.12.Riverkeeper Comments on Revised GEIS for Nuclear Power Plant License Renewal, RIN3150-AI42.pdf

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From: Deborah Brancato [mailto:DBrancato@riverkeeper.org]
Sent: Tuesday, January 12, 2010 11:57 PM
To: Rulemaking Comments
Subject: Riverkeeper Comments on Revised GEIS for NPP License Renewal, RIN3150-AI42 - E-mail 1

Dear Secretary and Rulemakings and Adjudication Staff,

Attached please find the comments of Riverkeeper, Inc. Riverkeeper in response to the U.S. Nuclear Regulatory Commission's Proposed Rule, "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 74 Fed. Reg. 38,117, 10 C.F.R. Part 51, RIN 3150-AI42, NRC-2008-0608 (July 31, 2009).

The attached comments reference seven (7) exhibits which will follow in separate e-mails to the size of the files.

A hard copy of this submission will follow by mail.

Thank you for your consideration.

7/31/09
74 FR 38239
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Sincerely,

Deborah Brancato
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Riverkeeper, Inc.
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Template = ADM-013

E-RIDS = ADM-03
Add = J. A. DAVIS (JXD10)

Mendiola, Doris

Subject: FW: Riverkeeper Comments on Revised GEIS for NPP License Renewal, RIN3150-AI42

From: Deborah Brancato [mailto:DBrancato@riverkeeper.org]
Sent: Wednesday, January 13, 2010 12:08 AM
To: Rulemaking Comments
Subject: Riverkeeper Comments on Revised GEIS for NPP License Renewal, RIN3150-AI42

Dear Secretary and Rulemakings and Adjudication Staff,

You should now be in receipt of Riverkeeper, Inc.'s Comments on the NRC's "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 74 Fed. Reg. 38,117, 10 C.F.R. Part 51, RIN 3150-AI42, NRC-2008-0608 (July 31, 2009), as well as Riverkeeper Exhibits, A, C, D, E, F, and G. Exhibit B, was too large of a file to be transmitted via e-mail, and will be included in the hard copy which will follow by mail.

Once again, thank you for your consideration. Should you have any questions concerning this transmittal, please do not hesitate to contact me.

Sincerely,

Deborah Brancato
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RIVERKEEPER®

VIA E-MAIL AND FIRST-CLASS MAIL

January 12, 2010

Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
ATTN: Rulemakings and Adjudications Staff
Rulemaking.Comments@nrc.gov

Re: Riverkeeper, Inc.'s Comments on the U.S. Nuclear Regulatory Commission's Proposed Revisions to NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants

Dear Rulemakings and Adjudications Staff:

Riverkeeper, Inc. ("Riverkeeper") hereby respectfully submits the following comments in response to the U.S. Nuclear Regulatory Commission's ("NRC") Proposed Rule, "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 74 Fed. Reg. 38,117, 10 C.F.R. Part 51, RIN 3150-AI42, NRC-2008-0608 (July 31, 2009) (hereinafter "Proposed Rule"), and associated draft documents, including:

- NUREG-1437, Volume 1, Revision 1, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report," Draft Report for Comment (June/July 2009) (hereinafter "Revised GEIS");

- NUREG-1437, Volume 2, Revision 1, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Appendices," Draft Report for Comment (June/July 2009) (hereinafter "Revised GEIS Appendices");

- NUREG-1555, Supplement 1, Revision 1, "Standard Review Plans for Environmental Reviews of Nuclear Power Plants, Supplement 1: Operating License Renewal," Draft Report for Comment (July 2009), (hereinafter "Draft Revised SRP");

- Draft Regulatory Guide DG-4015, "Preparation of Environmental Reports for Nuclear Power Plant License Renewal Applications," Revision 1 (July 2009) ("hereinafter Draft Reg. Guide 4015").

For the reasons set forth below, the proposed regulatory revisions fail to adequately address numerous fundamental deficiencies with the current environmental review process for nuclear

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power plant license renewal. Riverkeeper, therefore, urges the NRC to fully address the concerns identified herein prior to finalizing the proposed changes.

I. RIVERKEEPER'S INTEREST

Riverkeeper is a member-supported, not-for-profit organization dedicated to protecting the Hudson River and its tributaries.[1] Since its inception in 1966, Riverkeeper has used litigation, science, advocacy, and public education to raise and address concerns relating to the Indian Point nuclear power plant, located on the eastern bank of the Hudson River in Buchanan, NY. Riverkeeper is headquartered in Tarrytown, New York, approximately twenty-two (22) miles from the Indian Point facility, and has numerous members that reside within at least fifty (50) miles of the plant.[2]

Riverkeeper has been actively involved in the Indian Point license renewal proceeding due to the serious concerns relating to the continued operation of the facility, including the environmental damage caused by its antiquated once-through cooling system and leaking spent fuel pools, the vulnerability of the plant's spent fuel pools to terrorist attacks and serious accidents, and the failure of any long-term solution for permanent nuclear waste disposal. Riverkeeper filed a successful petition to intervene in Indian Point's relicensing proceeding, raising various environmental and safety concerns, and is currently litigating three contentions which have been admitted for an adjudicatory hearing.[3]

Riverkeeper has consistently raised concerns with the adequacy of the environmental review process the NRC is currently still undertaking in the Indian Point relicensing case. Riverkeeper submitted extensive environmental scoping comments, as well as comments on the supplemental site-specific environmental impact statement prepared in relation to the Indian Point relicensing proceeding, both times heavily criticizing the NRC's improper reliance on the outdated 1996 Generic Environmental Impact Statement for License Renewal of Nuclear Plants (hereinafter "1996 GEIS").[4] The NRC's use of the 1996 GEIS has done a great disservice to the Indian Point license renewal process, by failing to ensure sufficient analysis of all relevant concerns. The

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[1] *See generally,* Riverkeeper.org, Our Story, http://www.riverkeeper.org/ourstory_index.php (last visited Jan. 12, 2010).

[2] *See* Riverkeeper.org, Contact Us, http://www.riverkeeper.org/contact/ (last visited Jan. 12, 2010).

[3] *See* Riverkeeper, Inc.'s Request for Hearing and Petition to Intervene in Indian Point License Renewal Proceeding, November 30, 2007 (hereinafter "Riverkeeper Petition for Hearing"), ADAMS Accession No. ML073410093. Riverkeeper's Petition for Hearing raised many concerns relevant to the issues discussed in the Revised GEIS, and Riverkeeper provides this petition in further support of the comments made herein, for your consideration, as Exhibit B.

[4] Many of the concerns articulated in Riverkeeper's Indian Point license renewal environmental scoping comments and supplemental site-specific environmental impact statement comments would remain unresolved by the NRC's Revised GEIS, and Riverkeeper provides them as exhibits in further support of the comments made herein, for your consideration in the instant rulemaking proceeding: Riverkeeper Comments on Environmental Scoping for the Indian Point License Renewal Proceeding, Docket Nos. 50-247, 50-286 (Oct. 12, 2007), ADAMS Accession No. ML072960455 (hereinafter "Riverkeeper's Scoping Comments), are attached hereto as Exhibit C; Riverkeeper Comments on Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment (March 18, 2009), ADAMS Accession No. ML090860983 (hereinafter "Riverkeeper's IP DSEIS Comments"), are provided herewith as Exhibit D.

NRC's attempt to now belatedly revise the 1996 GEIS continues to fall short of guaranteeing a comprehensive environmental review process in license renewal proceedings. Riverkeeper now offers the following comments to highlight our ongoing concerns, in order to ensure that the NRC carries out adequate environmental reviews in the future.

II. IMPROPER FOCUS ON "STREAMLINING"

The Proposed Rule repeatedly emphasizes that the changes made by the Revised GEIS will "simplify and streamline the NRC review process.[5] Understanding the efficacy of having generic EISs pursuant to the National Environmental Policy Act of 1969 ("NEPA"), i.e., to avoid unnecessary repetition of review, a reading of the Proposed Rule leads one to surmise that the NRC's *primary* concern was how to further streamline the process. Indeed, the NRC proudly touts that "[t]he 1996 GEIS has been effective in focusing NRC resources on important environmental issues and increased efficiency of the environmental review process. Currently, 51 nuclear units at 29 plant sites have received renewed licenses."[6]

Yet, the focus of the NRC should be on performing an objective, NEPA-compliant, comprehensive review and not to efficiently get reviews done at breakneck speed. This misplaced emphasis has manifested itself throughout the Revised GEIS, in the failure of the NRC to provide for adequate review of various environmental issues, as discussed forthwith.

III. INADEQUATE ASSESSMENT OF INADVERTENT RADIOACTIVE RELEASES TO THE ENVIRONMENT

The Revised GEIS acknowledges the problem encountered at various nuclear power plants across the country over the past several years of unplanned releases of radionuclides to the environment. Given this ongoing issue, it is critical that the license renewal environmental review process address all relevant concerns posed by such releases. Unfortunately, the NRC's proposed revisions to the 1996 GEIS do not go far enough toward ensuring that the environmental impacts of such releases will be analyzed in a comprehensive manner.

A History of Inadvertent Radioactive Releases to the Environment

Unplanned releases of radionuclides to the environment have become ubiquitous at nuclear power plants across the United States. To date, leaks from varying plant systems have occurred at 29 plants in the United States, nearly a third of the United States' operating fleet. Riverkeeper has compiled documentation related to these leaks, attached hereto as Exhibit A, for your consideration in this rulemaking proceeding.

It is imperative that the update to the 1996 GEIS fully address any and all relevant concerns. Unfortunately, as discussed below, the Revised GEIS as proposed would not ensure a comprehensive review of this issue.

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[5] *See, e.g.*, Proposed Rule at 38,123, 38,124, 38,126, 38,128.
[6] *Id.* at 38,119.

Revised Assessment of Groundwater Resources

The NRC proposes to add a new Category 2 issue to address radionuclides released to groundwater.[7] It is in this portion of the Revised GEIS that the NRC recognizes the reality of inadvertent releases of radionuclides: "There is a growing concern about radionuclides detected in groundwater at nuclear power plants. These releases have occurred as leaks in at least 14 plants."[8] However, as discussed in more detail below, it is apparent that the Revised GEIS would not require consideration of the environmental impacts of such releases in relation to other "resources areas," i.e. aquatic ecology, terrestrial resources, and threatened/endangered species. Providing for such a narrow assessment related only to impacts to groundwater would lead to a narrow and incomplete analysis of the impacts of such releases to the environment. As discussed below, the NRC must require a comprehensive site-specific analysis of the impacts of accidental releases on all relevant environmental media. This is the only way to ensure a thorough assessment and accurate conclusions as to significance of such inadvertent contamination.

The newly proposed Category 2 issue to address radionuclide releases to groundwater is problematic for other reasons as well. While the Proposed Rule implies a focus on an assessment of public health impacts, the Revised GEIS and associated guidance documents notably fail to provide concrete direction to ensure adequate analysis related to such impacts. Instead, the Draft Revised SRP and Draft Reg. Guide 4015 provide vague directives, mostly emphasizing assessment of groundwater monitoring systems.[9] The Revised GEIS even appears to largely dismiss public health concerns, stating that "[t]he NRC does not consider these tritium releases to be a health risk to the public or onsite workers in any of these [previously reported] cases because the tritiated groundwater is expected to remain onsite."[10] The NRC should provide more specific guidance to ensure that licensees and the NRC accurately assess all reasonably foreseeable impacts to public health at particular plants.

For example, at Indian Point, licensee/license renewal applicant, Entergy Nuclear Operations, Inc., (hereinafter "Entergy") acknowledges groundwater contamination that is slowly leaching through the underlying bedrock to the Hudson River,[11] contrary to the NRC's blanket conclusion stating that groundwater contamination has remained onsite. Currently, there is proposed project that would site a desalination plant in Rockland County, New York, across and slightly downstream from Indian Point, which would withdraw Hudson River water for drinking water.[12] Far from speculative, this proposal is currently in the planning, environmental review, and permitting stages.[13] Accordingly, an appropriate assessment of the impacts of radionuclide releases from the Indian Point facility should include impacts to the public from use of contaminated drinking water. Unfortunately, in the Indian Point relicensing proceeding, the

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[7] *See* Revised GEIS at 4-46 to 4-47; Revised GEIS Appendices at B-12.
[8] *See* Revised GEIS at 4-46; see also Proposed Rule, 74 Fed. Reg. at 38,122.
[9] *See* Draft Revised SRP at 4.4.6-1 to 4.4.6-3; Draft Reg. Guide 4015 at 31-32.
[10] Revised GEIS at 4-47.
[11] *See* Groundwater Investigation Executive Summary (Indian Point Energy Center, Buchanan, N.Y., Jan. 2008), at 2-4, *available at* http://jic.semo.state.ny.us/Resources/ExecutiveSummary%20GW%20final.pdf.
[12] *See generally* Riverkeeper's IP DSEIS Comments at 22-25.
[13] *See generally id.*

NRC Staff's site-specific Draft Supplemental Environmental Impact Statement[14] was completely devoid of assessment of the impacts of license renewal on drinking water quality in regards to the use of the Hudson River as a source of drinking water via the desalination plant.[15] Thus, in the instant rulemaking, the NRC must provide clear direction so that any reasonably foreseeable radionuclide exposure to the public, such as through anticipated drinking water sources, will be assessed.

Revised Assessment of Aquatic Resources

The NRC proposes to add a new issue to address "Exposure of Aquatic Organisms to Radionuclides."[16] While analysis of such impacts is important and necessary, unfortunately, the NRC has misguidedly chosen to label this a Category 1 issue, making a generic determination that such impacts will always be small.[17]

This is problematic because the NRC's consideration of this issue is limited to the impact of radionuclides on aquatic organisms from *normal operations*.[18] Normal operations, by definition, do not include accidental releases of radionuclides from a facility. As such, the NRC's analysis here on its face excludes consideration of the impacts to aquatic biota from inadvertent releases, despite the earlier recognition that this has been a problem.[19] Instead, the NRC relies on past Radiological Environmental Monitoring Program reports of 15 nuclear power plants to conclude that "*normal operations* of these facilities would not result in negative effects on aquatic biota."[20]

With the noted history of accidental releases at the nation's nuclear power plants, it is absolutely necessary to specifically consider such releases when evaluating impacts to aquatic resources. Given the nature of this ongoing problem, and the likelihood of future unplanned releases, this is simply not an issue that is appropriate for one generic determination at this time. Instead, the NRC should make this a Category 2 issue and require licensees and NRC Staff to specifically consider the impacts of any known inadvertent releases to the environment on aquatic biota at the time of license renewal. This would ensure a full assessment of any impacts to aquatic resources, including nearby critical ecosystems, which are not otherwise specifically encompassed by the Revised GEIS's generic analysis.

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[14] Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment, Main Report (U.S. Nuclear Regulatory Commission December 2008) ("Indian Point Draft Supplemental EIS"), *available at*, http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/supplement38/ (last visited Jan. 12, 2010).
[15] *See* Indian Point Draft Supplemental EIS at §§ 2.2.7, 4.3.
[16] Revised GEIS at 4-98 to 4-100; Revised GEIS Appendices at B-22.
[17] Revised GEIS at 4-98 to 4-100; Revised GEIS Appendices at B-22.
[18] *See* Revised GEIS at 4-98 ("The potential impacts of radionuclides on aquatic organisms from *normal operations* of a nuclear power plant during the license renewal term were not identified as an issue in the 1996 GEIS") (emphasis added); *id.* at 4-99 ("Thus, it is anticipated that *normal operations* of these facilities would not result in negative effects on aquatic biota") (emphasis added).
[19] Revised GEIS at 4-46 ("There is a growing concern about radionuclides detected in groundwater at nuclear power plants. These releases have occurred as leaks in at least 14 plants.")
[20] *Id.* at 4-99.

For example, the Indian Point nuclear power plant is adjacent to the ecologically critical area of Haverstraw Bay. Haverstraw Bay is a New York State designated Essential Fish Habitat and Significant Coastal Fish and Wildlife Habitat.[21] Despite the considerable amount of inadvertent radionuclide releases from Indian Point over the past few decades, Entergy and the NRC Staff have consistently refused to assess the impacts to the Hudson River ecosystem in the Indian Point license renewal proceeding.[22] Under the proposed changes to the 1996 GEIS, site-specific impacts of unplanned radionuclide releases on aquatic biota would continue to evade assessment. This is utterly illogical, and completely inconsistent with the NRC's recognition that inadvertent releases are an ongoing issue.

Revised Assessment of Terrestrial Resources

The NRC also proposes a new Category 1 issue to address "Exposure of Terrestrial Organisms to Radionuclides."[23] While the intention of this new issue is admirable, it suffers from the same problems articulated above. In particular, this issue, once again, only applies to radioactive releases from *normal operations*.[24] Based on this assumption, the NRC made a generic determination that impacts to terrestrial resources are small.[25]

However, it is necessary for the NRC to require consideration of radioactive releases that are not part of the normal course of operation.[26] This would be the only way ensure an accurate and complete assessment of impacts to terrestrial biota. Accordingly, the NRC should make this a Category 2 issue and require licensees and the NRC Staff to look at radionuclide impact to terrestrial resources on a site-specific basis.

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[21] *See* Coastal Fish & Wildlife Habitat Rating Form, http://www.nyswaterfronts.com/downloads/pdfs/sig_hab/hudsonriver/Haverstraw_Bay.pdf (last accessed Jan. 12, 2010).

[22] *See* Entergy, Inc., License Renewal Application, Appendix E: Applicant's Environmental Report, Operating License Renewal Stage, Indian Point Energy Center (ER), *available at*, http://www.nrc.gov/reactors/operating/licensing/renewal/applications/indian-point.html; Indian Point Draft Supplemental EIS at §§ 2.2.7, 4.3.

[23] *See* Revised GEIS at 4-55 to 4-58; Revised GEIS Appendices at B-12.

[24] *See* Revised GEIS at 4-55 ("Releases into terrestrial environments often result from deposition of small amounts of radionuclide particulates released from power plant vents during *normal operations*") (emphasis added); *id.* at 4-58 ("[T]he NRC concludes that the impact of *routine radionuclide releases* from past and current operations on terrestrial biota would be small at all nuclear power plants and would not be expected to appreciably change during the renewal period") (emphasis added).

[25] *See* Revised GEIS at 4-58; Revised GEIS Appendices at B-12.

[26] For example, Indian Point has a noted history of unplanned radiological releases which have the potential to affect the surrounding terrestrial environment; in addition to the extensive releases from underground piping and the plants spent fuel pools, which the NRC and Entergy have both acknowledged, the most recent example involved a release of radioactive steam resulting from an unplanned shutdown at the plant. *See* Abby Luby, *Nuclear Steam Leak Intentional: Response to Indian Point Plant Shutdown*, New York Daily News (Jan. 8, 2010), http://www.nydailynews.com/ny_local/2010/01/08/2010-01-08_nuclear_steam_leak_intentional_response_to_indian_point_plant_shutdown.html (last visited Jan. 12, 2010).

Revised Assessment of Threatened/Endangered Species

The Revised GEIS would expand the scope of a existing Category 2 issue related to threatened or endangered species to include "essential fish habitats."[27] Riverkeeper believes this addition is an improvement to this assessment. Riverkeeper further commends the NRC for recognizing that releases of radionuclides to the environment have the potential to impact threatened, endangered, and protected aquatic species, and essential fish habitats. In particular, the Revised GEIS acknowledges that terrestrial and aquatic threatened, endangered, and protected species, and essential fish habitats could be affected by, *inter alia*, "exposure to radionuclides."[28]

While this explicit recognition is a departure from the 1996 GEIS, Riverkeeper remains apprehensive that licensees and the NRC Staff would continue to fail to fully address the impacts of inadvertent radioactive releases to the environment on threatened, endangered, and protected species, and essential fish habitats, since there is no explicit requirement that such impacts be evaluated. For example, the Draft Revised SRP simply requires that site-specific supplemental environmental impact statements present a "list of adverse impacts to listed and proposed threatened or endangered species or critical habitats from continued operations during the renewal term and refurbishment."[29] Given the discussion in the Revised GEIS recognizing potential impacts from radionuclides, license renewal applicants and NRC Staff assessments of this issue should ostensibly include adverse impacts caused by radionuclide contamination, both from normal operations as well as inadvertent releases. However, with the noted history of accidental radioactive contamination at nuclear power plants, and the tendency to evade full review of this issue, as evidenced from the discussion above, a more explicit requirement is preferable.[30]

Failure to specifically require this analysis will lead to inadequate environmental reviews of this issue. For example, in the Indian Point license renewal proceeding, Entergy's Environmental Report and the NRC Staff's Indian Point Draft Supplemental EIS lack any assessment of the potential effects on threatened or endangered species caused by groundwater contamination at the facility. Despite leakage of extensive amounts of highly toxic radionuclides from the IP1 and IP2 spent fuel pools, including strontium-90 and tritium, into the groundwater around the plant, the environmental review documents completed by the license renewal applicant and the NRC Staff at no point assesses the effects of such contamination on the Hudson River's federally listed shortnose sturgeon, or candidate species, Atlantic sturgeon.[31] This is particularly concerning due to the known dangers of exposure to these radioactive substances: strontium-90 imitates calcium by concentrating in fish bones and shells of clams and blue crab; clams are a major part of the diet of sturgeon found in the Hudson River. Therefore, concern that Hudson

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[27] *See* Revised GEIS at 4-71 to 4-77; Revised GEIS Appendices at B-24.

[28] Revised GEIS at 3-73, 4-111, 4-112.

[29] Draft Revised SRP at 4.5.5-5.

[30] In the newly required essential fish habitat assessment under the Magnuson-Stevens Fishery Conservation and Management Act, "adverse impact" is defined as including "direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH." Draft Revised SRP at 4.5.5-2. This would ostensibly cover accidental radionuclide contamination, but once again, an overt requirement in light of the ongoing problem is preferable.

[31] *See* Indian Point Draft Supplemental EIS at 4-49 to 4-53

River sturgeon are being exposed to elevated levels of such dangerous substances, is wholly warranted. It is, therefore clear that the environmental review in the Indian Point relicensing case was lacking in this regard. The NRC must, therefore, explicitly require consideration of radionuclide contamination to avoid such deficient assessments in the future.

Assessment of Decommissioning Impacts

The Revised GEIS proposes to make a generic Category 1 determination as to impacts of relicensing on decommissioning.[32] However, this appears to be inconsistent with the NRC's recognition of the problem of radioactive contamination. Based on the discussion above, past, current, and future inadvertent releases will undoubtedly have an impact on water quality, ecological resources, and aquatic resources at the time of decommissioning. Accordingly, it is necessary to require site-specific analysis of the impacts of any unplanned leaks in regards to this issue as well.

Need for a Comprehensive Framework to Assess Inadvertent Radionuclide Releases

As discerned from the discussion above, it is evident that the Revised GEIS will not ensure a complete evaluation of the environmental impacts of inadvertent radionuclide releases from nuclear power plant facilities. NRC must implement a comprehensive framework to ensure that all aspects of such contamination are properly assessed. At a minimum, NRC must ensure that the impacts of unintended radionuclide releases on groundwater, aquatic ecology, terrestrial resources, and threatened, endangered, and protected species, and essential fish habitats, are all Category 2 issues, with specific requirements for appropriate assessment, as indicated above.

However, preferably, the NRC should put all of these issues under one umbrella issue, to ensure that an all-inclusive review occurs. Indeed, separating all of the individual environmental effects of accidental radioactive contamination does a disservice to the environmental review process by disallowing a look at the overall, collective impacts of this issue.

Notably, the NRC's proposed method of analyzing radionuclide contamination as articulated throughout the Revised GEIS would lead to inconsistencies in the review process. For example, the NRC would apparently require a Category 2 site-specific assessment of radionuclide impact to threatened, endangered, and protected species, and essential fish habitats, however, makes a generic Category 1 determination with respect to the impacts of radionuclides on aquatic organisms. Thus, for example, while the impacts of radioactive contamination to certain federally listed fish species would require extra analysis, the impacts to the majority of fish species would be categorically dismissed as small. This makes no sense, and, in fact, only serves to prove that Category 2 analysis is warranted in relation to effects on aquatic resources from inadvertent radioactive contamination.

Furthermore, instead of a comprehensive review, the NRC's Revised GEIS envisions a narrow assessment of inadvertent releases that would essentially focus on impacts to groundwater and associated public exposure pathways. To the contrary, NEPA requires a broader evaluation of

[32] *See* Proposed Rule at 38,128; Revised GEIS Appendices at B-40.

environmental impacts beyond mere public health concerns.[33] The significance of any radiological release is governed by the CEQ regulation defining "significantly"; this definition requires consideration of the context of the action and intensity or severity of the impacts.[34] Accordingly, in order to accurately evaluate the significance of inadvertent radiological release, license renewal applicants and the NRC Staff must fully assess all of the impacts to the surrounding natural environment. Thus, the need for a comprehensive site-specific review of impacts to all relevant environmental media is apparent.

For example, in the Indian Point license renewal proceeding, Entergy and the NRC Staff's environmental analysis of the leaks from the Indian Point spent fuel pools was seriously deficient. In that proceeding, the relevant environmental analyses focused solely on radiological doses to humans from the proclaimed "only" exposure pathway, i.e., consumption of aquatic foods.[35] By determining that the leaks did not exceed public radiation dose limits via consumption of aquatic foods, the NRC Staff concluded that the leaks did not have a significant impact on "plant workers, the public, *or the environment*."[36] In their reviews, Entergy and the NRC Staff did not perform *any* analysis of the impacts of the contamination to the Hudson River ecosystem. In particular, Entergy's Environmental Report and the NRC Staff's Indian Point Draft Supplemental EIS failed to determine if toxic radionuclides including strontium-90 and cesium-137 are bioaccumulating in the environment; there was no analysis of the contamination to Hudson River fish or shellfish despite sampling showing elevated levels of such radionuclides in fish; there was no assessment of the effects of the contamination to the nearby essential fish habitat and ecologically critical area of Haverstraw Bay; and, as discussed above, there was no assessment of the potential effects of the leaking on the Hudson River's federally listed endangered species, including the short-nosed sturgeon.[37]

If the Revised GEIS is implemented as proposed, such an inadequate review would continue to be acceptable, since no site-specific review of impacts of radionuclides on terrestrial/aquatic/endangered, etc resources would be required. It is, thus, clear that the Revised GEIS must be adjusted to provide for a comprehensive review of impacts of radionuclide releases on all relevant resources.

Moreover, any complete assessment of inadvertent radioactive releases to the environment must specifically include an analysis of the *cumulative impact* of such contamination. For example, in the Indian Point relicensing proceeding, neither Entergy nor the NRC Staff performed any evaluation of the cumulative long-term effects of the contaminated groundwater plumes at Indian Point. The NRC Staff cited Entergy's removal of spent fuel from the IP1 pool as evidence that impacts from the contamination would be minimized.[38] Entergy made further claims that leaking is no longer active at the facility, a claim that is dubious at best, as explained in Riverkeeper's

[33] *See Marsh v. Oregon Natural Resources Counsel*, 490 U.S. 360, 374 (1989).
[34] *See* 40 C.F.R. § 1508.27 (requiring analysis of ten different factors).
[35] Indian Point Draft Supplemental EIS § 2.2.7, at 2-107 to 2-108; § 4.3, § 4.5, § 4.7. In addition to incorrectly relying on dose limits as a sole measurement of the impacts from the leaks, the NRC Staff's assessment of dose limits was also fundamentally flawed since it did not take into consideration the proposed desalination plant, discussed above, that is likely to result in a direct drinking water pathway.
[36] Indian Point Draft Supplemental EIS §§ 4.3, 4.5, 4.7 (emphasis added).
[37] *See generally id.*
[38] *Id.* § 4.3, at 4-36.

Petition for Hearing. However, the extensive leakage that has emanated from the Indian Point spent fuel pools to date is still in the groundwater and will continue to slowly leach into the Hudson River.[39] Whether leaking is active or not, it is undisputed that there has never been an assessment of the environmental impacts of this contamination. Current and future accidental radioactive releases from the plant will only add to the existing plumes. For example, an underground pipe leak at the facility in February 2009 resulted in over 100,000 gallons of tritiated water being released directly into the waterway.[40] It is, therefore, imperative that the NRC specifically require an evaluation of the cumulative environmental impacts of inadvertent radioactive releases at nuclear power plant sites.

In contrast, the Revised GEIS's new Category 2 issue requiring analysis of cumulative impacts[41] would not necessarily require such an assessment. The Revised GEIS explains that an "analysis of cumulative impacts focuses on the resources that could be affected by the incremental impacts from continued operations of the nuclear plant" and that "[p]ast and present actions include all actions up to and including the time of the license renewal application."[42] And yet, despite the fact that repeated inadvertent releases of radionuclides can have an incremental impact on the surrounding environment, this new Category 2 issue does not explicitly require consideration of this issue. Other than stating that the cumulative impacts on terrestrial and aquatic resources would include habitat degradation,[43] the Revised GEIS does not provide any specific guidance that would ensure consideration of the cumulative impact of radioactive contamination. This failure precisely highlights the problem with breaking down this issue into various sections of the Revised GEIS.

Only with an all-inclusive review of the environmental impacts of unplanned radioactive contamination will the NRC ever be able to come to an accurate conclusion as to the degree of the overall impact. Accordingly, the NRC must require site-specific assessment of accidental releases on all pertinent environmental media, including terrestrial animals and plants, soils, river sediments, aquatic biota, and endangered/threatened/protected resources, as well as the cumulative impacts thereto.

In light of the foregoing, it is also clear that the range of impacts, when taking into account all of the potential environmental consequences of inadvertent radiological release, could be anywhere from SMALL to *LARGE*.[44] Given the long history of widespread contamination at nuclear power plant sites across the country, along with the fact that license renewal proceedings involve continually aging facilities, it is reasonably foreseeable that additional tritium leakage will occur

[39] For example, in the months leading up to the completion of draining of the pool at Indian Point Unit 1, Entergy reported it was leaking around 70 gallons per day, contributing thousands and thousands of additional gallons of polluted water into the groundwater and eventually the Hudson River.
[40] *See* Annie Correal, *Indian Pt. Broken Pipe Spurs Safety Worries*, THE NEW YORK TIMES (Feb. 27, 2009).
[41] *See* Revised GEIS at 4-220 to 4-227.
[42] *See id.* at 4-220, 4-221.
[43] *See id.* at 4-223, 4-224.
[44] Thus, the NRC's proposed range of impacts in relation to the new Category 2 issue related to radionuclide release to groundwater, of "small to moderate," is unfounded, (*see* Revised GEIS at 2-9; Revised GEIS Appendices at B-12), and the conclusion of "small" impact in relation to the two Category 1 issues related to radionuclide impact on terrestrial and aquatic resources, is also unsupported (*see* Revised GEIS at 2-9, 2-11; Revised GEIS Appendices at B-12, B-22).

at aging, relicensed plants during their twenty year term of extended operation, and that such leakage could result in "LARGE" impacts to the environment. Indeed, the NRC has offered no support for its assertion that current and future impacts will only be SMALL or MODERATE, beyond simply relying on its belief that the incidences of tritium leakage that have occurred thus far have had no health impacts and minimal environmental impacts, at least according to the NRC's assessment. Riverkeeper strongly disagrees with this assertion, as evidenced by the arguments put forth in our intervention petition, environmental scoping comments, and comments to the Draft Supplemental EIS in the Indian Point relicensing proceeding.[45] Therefore, the NRC should find that impacts on all media, as explained above, from inadvertent radiological releases to groundwater could be "SMALL, MODERATE OR LARGE."

IV. NON-RADIOLOGICAL CONTAMINATION THE ENVIRONMENT

The Revised GEIS would create a new Category 2 issue requiring assessment of non-radiological groundwater and soil contamination resulting from general industrial practices.[46] Riverkeeper supports inclusion of this new issue, however, urges the NRC to specifically require that in the course of the assessment of this issue, licensees provide detailed, publicly available inventories of any and all spills, leaks, and other releases that contributed to any such soil and groundwater contamination. Such a requirement would ensure a more complete evaluation of such contamination.

V. FAILURE TO REQUIRE AN ASSESSMENT OF EMERGENCY PREPAREDNESS

A fundamental flaw with the Revised GEIS is the NRC's continued narrow scope of the environmental review which, *inter alia*, precludes assessment of emergency preparedness at nuclear power plants.[47] The NRC rationalizes that "[b]efore a plant is licensed to operate, the NRC must have 'reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency.'"[48] The Revised GEIS further explains how NRC's finding of reasonable assurance is founded upon compliance with NRC regulations and guidance, which require that nuclear power plant licensees routinely demonstrate effectiveness of their emergency plans.[49]

However, this reasoning is flawed since NRC's emergency preparedness regulatory scheme is inherently deficient, and, as such, reliance upon those regulations is misguided. Indeed, due to the purely procedural nature of the emergency planning standards found in 10 C.F.R. § 50.47(b), which fail to set actual benchmarks for determining what constitutes a workable emergency plan, there is no guarantee that a particular plan would actually be effective in light of site-specific concerns.[50]

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[45] *See* Riverkeeper Exhibits B, C, D.

[46] *See* Revised GEIS at 4-45 to 4-46.

[47] *See id.* at 1-10, 1-11 ("The NRC will not make a decision or any recommendations on the basis of information presented in this GEIS regarding emergency preparedness at nuclear power plants.")

[48] *See id.* at 1-11.

[49] *See id.* 1-11.

[50] Riverkeeper explained at length the deficiencies of the emergency preparedness regulatory scheme in recent comments on a recent proposed update to the emergency planning regulations. *See* Riverkeeper's Comments on NRC's Proposed Enhancements to Emergency Preparedness Regulations (Oct. 19, 2009), ADAMS Accession No.

This is starkly apparent when examining the situation at Indian Point. Of the nations commercial reactor sites, Indian Point, located just 24 miles north of New York City, (35 miles north of Times Square) tops the list as the nuclear power plant with the greatest population density within a 10-mile radius (at least 300,000) and 50-mile radius (approximately 20 million people).[51] This represents nearly a doubling of the population since Indian Point's initial licensing. This high population density, coupled with the nature of the region's infrastructure (prone to severe congestion), present serious impediments to effective emergency evacuation. Indeed, a 2003 traffic study performed for Entergy by KLD Associates determined that evacuation times for the Emergency Planning Zone around Indian Point had doubled since 1994. The original estimate was 2.5 hours for people to proceed with evacuation, with a total of 5.5 hours for complete evacuation. KLD's 2003 estimates increased mobilization time to 4 hours, while complete evacuation of the region in good weather conditions could take up to 9.5 hours and in snow conditions up to 12 hours.[52] Shadow evacuation, which is not adequately addressed by NRC emergency planning regulations and guidance, would further increase this time. Based on these evacuation time estimates, which apply only to the narrow 10-mile Emergency Planning Zone, it is clear that many residents could not be evacuated in time to avoid exposure to high doses of radiation under a traditional release scenario, much less a fast-breaking release.

According to an independent analysis of Indian Point's emergency plan commissioned by former New York Governor George Pataki in 2003 and authored by former FEMA director James Lee Witt, the radiological emergency plan for Indian Point is badly flawed, unworkable and key components are unfixable. Witt found that ". . . the current radiological response system and capabilities are not adequate to . . . protect the people from an unacceptable dose of radiation in the event of a release from Indian Point . . . ."[53]. Even the NRC has voiced concerns associated with the location of Indian Point: in 1979, Robert Ryan, the NRC's Director of the Office of State programs, stated "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 . . . [Indian Point is] one of the most inappropriate sites in existence."[54]

And yet, due to the lack of enforceable standards, NRC consistently finds the requisite "reasonable assurance," in the Indian Point emergency plan, despite the glaring problems that would hinder effective evacuation at the facility.

ML093100527 (hereinafter "Riverkeeper EP Comments"). Riverkeeper provides these comments in further support of the comments made herein, for your consideration in the instant rulemaking proceeding, as Exhibit E.

[51] *See, e.g.,* James Lee Witt Associates, LLC, Review of Emergency Preparedness of Areas Adjacent to Indian Point and Millstone (2003) (hereinafter "Witt Report") at 4, 81-82. The NRC has previously acknowledged that Indian Point has the "highest population within 10, 30 and 50 miles of any nuclear power plant in the U.S. At 50 miles, it population is more than double any other plant site." *See* U.S. Nuclear Regulatory Commission, Consolidated Edison Company of New York: Indian Point, Units 2 and 3, Memorandum and Order, January 8, 1981, at 6; *see also* Indian Point Draft Supplemental EIS" at Table 2-1.

[52] Indian Point Energy Center Evacuation Time Estimate, Tbl. 1-1, p. 1-12, KLD Associates, Inc., 2003.

[53] Witt Report at viii.

[54] Report of the Office of the Chief Counsel on Emergency Preparedness to the President's Commission on the Accident at Three Mile Island, October 31, 1979, p. 5.

The NRC's emergency preparedness regulations are further deficient because they fail to fully consider the effects of accidents or intentional attacks involving onsite nuclear waste. The likelihood for such a scenario is not insignificant given the vulnerabilities of such facilities, for example, those at Indian Point: the spent fuel pools at Indian Point are not housed under containment, but rather in non-reinforced cinderblock industrial buildings which are admittedly penetrable by aircraft; the dry casks in the Indian Point ISFSI are stored on an outdoor concrete pad, lined up in rows that are easily visible from the air and the Hudson River. Moreover, numerous reports indicate that nuclear power plants remain likely targets of terrorist attacks.[55] The results of such an occurrence could potentially be catastrophic. For example, at Indian Point, an attack on the densely packed IP2 or IP3 spent fuel pools would result in contamination of a significant portion of the 10-mile emergency planning zone and the 50-mile ingestion pathway zone. A 2006 National Academy of Sciences Study concluded that storage pools are susceptible to fire and radiological release from intentional attacks.[56] The environmental impacts of a fire in a spent fuel pool may be severe, extending over a geographic area larger than a state's legal boundaries and continuing for decades.[57] Federal government reports note that a radioactive release could begin in less than an hour.

And yet, NRC's emergency preparedness scheme, including the pending proposed update, fails to adequately require that nuclear power plant licensees are capable of dealing with such severe radiological consequences.[58] This simply further demonstrates how emergency plans may not provide the needed "reasonable assurance" that the public would be protected in the event of an emergency.

Therefore, it is clear that compliance with existing emergency preparedness regulations and guidance does not necessarily guarantee adequate emergency preparedness at nuclear power plants in light of all relevant factors. Indeed, the Revised GEIS's statement that "[t]hrough its standards and required exercises, the Commission reviews existing emergency preparedness plans throughout the life of any facility, keeping up with changing demographics and other site-related factors,"[59] is utterly belied by the foregoing. The need to address emergency preparedness during the license renewal environmental review process, thus, quickly becomes apparent.

This becomes even clearer when examining nuclear power plant siting regulations: were Entergy applying for a license to build a new nuclear power plant where Indian Point is now located, it is unlikely they would be allowed to do so, based on its proximity to such a highly populated

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[55] For example, a 2006 study by the National Academy of Sciences on security risks posed by the storage of spent fuel at nuclear plant sites, confirmed that attacks by civilian aircrafts remain a plausible threat. Nat'l Acad. of Sciences., *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report* (2006) (hereinafter "2006 NAS Study"). The study found that attacks on spent fuel pools are attractive targets since they are less protected structurally than reactor cores and typically contain much greater inventories of medium and long-lived radionuclides than reactor cores. *Id.*

[56] *See* 2006 NAS Study at 49, 57.

[57] *See generally* Gordon R. Thompson, "Risk Related Impacts from Continued Operation of the Indian Point Nuclear Power Plants" (Institute for Resource and Security Studies) (November 28, 2007) (hereinafter "Thompson Report"). Riverkeeper provides this report in further support of the comments made herein, for your consideration in the instant rulemaking proceeding, as Exhibit F.

[58] *See generally* Riverkeeper EP Comments.

[59] *See* Revised GEIS at 1-11.

area.[60] The regulations for reactors built *after* 1997 require that every site must have an exclusion area and a low population zone.[61] These regulations define low population zone as "the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken on their behalf in the event of a serious accident."[62] The regulations do not specify a permissible population density or total population within this zone because the situation may vary from case to case.[63] The regulations go on to say whether a specific number of people can, for example, be evacuated from a specific area, or instructed to take shelter, on a timely basis will depend on many factors such as location, number and size of highways, scope and extent of advance planning, and actual distribution of residents within the area.[64] As far as Indian Point is concerned, there is no low population zone, therefore if Entergy were applying to build a new nuclear power plant as opposed to a relicensing it would likely not be permitted.

Therefore, if held to the same standard as a new nuclear power plant, an evaluation of emergency preparedness would likely preclude license approval. It defies logic to then exclude consideration of this issue in a license renewal review, given significant changes to the baseline environment upon which initial evaluations were made. The NRC cannot continue to hide behind a set of deficient regulations. The NRC should, thus, include emergency preparedness as a site-specific Category 2 issue for review, and require an assessment of all relevant concerns, including population changes, transportation/traffic issues, varying radiological consequences, etc.

VI. INADEQUATE ASSESSMENT OF THE ENVIRONMENTAL CONSEQUENCES OF SEVERE ACCIDENTS

Inadequate Consideration of Spent Fuel Pool Accidents

The Revised GEIS recognizes that severe accident analyses in the 1996 GEIS "were limited to consideration of reactor accidents caused by internal events."[65] Proclaiming an understanding that accident risk has naturally evolved since issuance of the 1996 GEIS, the Revised GEIS identifies new sources of postulated severe accidents, including an explicit recognition of spent fuel pool accidents.[66]

However, while this recognition is commendable, the Revised GEIS goes on to draw erroneous conclusions about the potential consequences of spent fuel pool accidents. After weighing new information said to decrease estimated environmental impact against new information (including spent fuel pool accidents) said to increase estimated impacts, the Revised GEIS concludes "that the reduction in environmental impacts from the use of new information outweighs any increases

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[60] *See* 10 C.F.R. Pts. 100.3, 100.10(b), 100.11, & 100.21(h).
[61] 10 C.F.R. § 100.21(h).
[62] 10 C.F.R. § 50.2.
[63] *Id.*
[64] *Id.*
[65] Revised GEIS at 4-153.
[66] *See id.* at 4-153 to 4-154; Revised GEIS Appendices at E-32 ("The 1996 GEIS did not include an explicit assessment of the environmental impacts of accidents at the spent fuel pools (SFPs) located at each reactor site.").

resulting from new considerations. As a result, the findings in the 1996 GEIS remain valid."[67] In particular regard to spent fuel pool accidents, the Revised GEIS concludes that "the environmental impacts from accidents at spent fuel pools . . . can be comparable to those from reactor accidents at full power . . . Subsequent analyses performed, and mitigative measures employed since 2001 have further lowered the risk of this class of accidents."[68] Accordingly, the NRC continues to exclude spent fuel pool accidents from site-specific analysis, including Severe Accident Mitigation Alternatives (SAMAs) related to spent fuel pool accidents.[69]

The NRC's revised assessment here continues to ignore relevant information about the risk of spent fuel pool accidents, which undermines the NRC's continued conclusion that the impact of releases to the environment from severe accidents will always be "small."[70]

While initially, it was assumed that stored spent fuel generally did not pose significant risks, with the introduction of high-density, closed-form storage racks into spent fuel pools beginning in the 1970s, this understanding is no longer valid.[71] The closed-form configuration of the high density racks can create a major problem if water is lost from a spent fuel pool, including disastrous pool fires.[72] Studies conducted after the issuance of the 1996 License Renewal GEIS contradict previous studies that had asserted that complete drainage of spent fuel pools was the most severe case and that aged fuel would not burn.[73] These later studies establish that if the water level in a fuel storage pool dropped to the point where the tops of the fuel assemblies are uncovered, the fuel would burn regardless of its age, and resulting fires can be catastrophic.[74]

Furthermore, the Revised GEIS acknowledges that mitigative measures have been taken to reduce the risk of spent fuel pool fires. However, the existence of such measures at particular nuclear power plant sites completely contradicts the NRC's end conclusion that spent fuel pool accidents do not warrant site-specific consideration.[75]

Accordingly, the NRC conclusion that that all consequences from severe accidents, including those involving spent fuel pools, are "small for all plants," is without proper foundation. The

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[67] Revised GEIS at 4-154.
[68] *Id.* at 4-156.
[69] *See id.* at 4-154 ("[T]he impacts from reactor accidents at full power (including internal and external events) should continue to be considered in assessing Sever Accident Mitigation Alternatives (SAMAs). The impacts of *all other new information* do not contribute sufficiently to the environmental impacts to warrant their inclusion in the SAMA analysis, since the likelihood of finding cost-effective plant improvements is small.") (emphasis added).
[70] *See* Revised GEIS Appendices at B-33.
[71] *See* Thompson Report at 18-27.
[72] *Id.*
[73] *See* Waste Confidence Rule, 55 Fed. Reg. 38,474, 38,481 (Sept. 18, 1990).
[74] NUREG-1738, *Final Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants* (January 2001); 2006 NAS Study at 53-54. The Revised GEIS improperly attempts to underplay the findings of NUREG-1738 at various turns. *See, e.g.*, Revised GEIS Appendices at E-34 ("the impact analysis contained in NUREG-1738 is considered conservative"); *id.* at E-35 ("low ruthenium source term is . . . viewed as the more accurate representation. Therefore, the risk and environmental impact from fires in SFPs as analyzed in NUREG-1738 are expected to be comparable to or lower than those from reactor accidents and are bounded by the 1996 GEIS."); *id* at E-36 ("Based on the more rigorous accident progression analyses, the recent mitigation enhancements, and NRC site evaluations of every SFP in the United States, the risk of an SFP zirconium fire initiation is expected to be less than reported in NUREG-1738").
[75] *See generally* Riverkeeper's IP DSEIS Comments at 26-33.

impacts of severe accidents from spent fuel pool accidents should be addressed in a site-specific manner, with the appropriate potential range of impact being SMALL to LARGE.

In any event, it is crucial that NRC require consideration of spent fuel pool accidents in licensee and NRC Staff SAMA analyses. Failure to do so will lead to highly inaccurate results.[76] For example, in the Indian Point relicensing proceeding, in the first step of the SAMA analysis (establishing the baseline of severe accidents) neither Entergy nor the NRC Staff considered the contribution to severe accident costs by fire in either of the spent fuel pools at IP2 or IP3.[77] No SAMAs that would avoid or mitigate such costs were identified.[78] However, if the costs of pool fires were considered, the value of SAMAs would be significant. Even using unrealistically low probability estimates in NUREG-1353, *Regulatory Analysis for the Resolution of Generic Issue 82, Beyond Design Basis Accidents in Spent Fuel Pools* (1982), the offsite cost risk of a pool fire is substantially higher than the offsite cost risk of an Early High release from a core-damage accident.[79] The present value of cost risk for a conventional pool accident at Indian Point (i.e., an accident not caused by intentional attack), using the unrealistically low probability assumptions in NUREG-1353, is $27.7 million, a significant sum.[80] If more realistic assumptions about the likelihood of a pool fire were used, the cost would be considerably higher.[81] Moreover, the present value of cost risks ("PVCR") for a spent fuel pool fire would increase substantially (i.e., from $27.7 million to $38.7 million) if the discount rate were changed from 7% to 3%, a more appropriate rate for an analysis of the benefits of measures to prevent or mitigate radiological accidents that Entergy used to test the sensitivity of its SAMA analysis.[82] If the discount rate were dropped to zero, a rate that is justified in light of the catastrophic nature of the consequences involved, the PVCR for a spent fuel pool fire would be even higher -- $51.5 million.[83]

Given the potential costs involved, it is essential that such risks are assessed in licensee SAMA analyses.

<u>*Continued Failure to Specifically Address the Risk of Intentional Acts of Sabotage*</u>

The Revised GEIS maintains that "the risk of a successful terrorist attack (i.e., one that results in a zirconium fire) is very low."[84] Notably, the NRC continues to rely upon Sandia National Lab studies that are classified as "sensitive security related" and, thus, not available to the public, to support its conclusion that environmental consequence of a terrorist attack would be adequately mitigated.[85] Accordingly, NRC folds this issue into its generic determination that the impact of severe accidents is "small," and would continue to not require any site specific analysis, including SAMAs related to terrorist attacks.

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[76] *See generally* Thompson Report.
[77] *See* Indian Point Draft Supplemental EIS § 5.2; Entergy's Environmental Report at § 4.21.
[78] Indian Point Draft Supplemental EIS § 5.2
[79] Thompson Report at 28
[80] *Id.* at 49 and Table 7-7.
[81] *Id.* at 51.
[82] *Id.* at 51-52.
[83] *Id.* at 52.
[84] Revised GEIS Appendices at E-35.
[85] *See id.* at E-36.

However, ample evidence undermines the NRC's conclusions here. Firstly, the Revised GEIS downplays the potential risk of terrorist attack on nuclear power plants. Numerous reports indicate that nuclear power plants remain likely targets of terrorist attacks. The 9/11 Commission Report revealed that the mastermind of the 9/11 attacks had originally planned to hijack additional aircrafts to crash into targets, including nuclear power plants, but wrongly believed the plants were heavily defended.[86] This report indicates that the terrorists were considering attacking a specific nuclear facility in New York which one of the pilots had seen during a familiarization flight near New York.[87] This was likely Indian Point, especially given the fact that almost 20 million people live within 50 miles of the facility.[88] In the years since the 9/11 attacks, the federal government, including the NRC, has repeatedly recognized that there is a credible threat of intentional attacks on nuclear power plants.[89] Notably, existing nuclear power plants in the United States were built between the 1950s and the 1980s and were not intended to be able to withstand the impact of aircraft crashes or explosive forces, thus, making success of a potential terrorist attack a credible possibility.[90]

Furthermore, as discussed above, the Revised GEIS continues to underplay the severity of consequences of spent fuel pool fires that could result from an intentional attack. For example, at Indian Point, the impacts of terrorist attack would be far ranging. Such impacts are explained in a report prepared on behalf of Riverkeeper in connection with Riverkeeper's Petition for Hearing in the Indian Point relicensing proceeding by Edwin Lyman, entitled, *Chernobyl on the Hudson? The Health & Economic Impacts of a Terrorist Attack at the Indian Point Nuclear Power Plant*. This report is attached hereto in support of the comments made herein, for your consideration in the instant rulemaking proceeding, as Exhibit G.

Once again, the existence of mitigation measures which have been implemented to reduce the risk of intentional attack only highlight the fact that a comprehensive site-specific assessment as part of the NEPA process has never been performed, and is greatly needed here.[91] The inadequate assessment of intentional attack on nuclear power plants, thus, further erodes the

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[86] Nat'l Comm'n on Terrorist Attacks Upon the U.S., *The 9/11 Commission Report* (2004), at 154 ("9/11 Commission Report").
[87] 9/11 Commission Report at 245.
[88] *See, e.g.*, Witt Report at 4, 81-82.
[89] *See, e.g.*,; *Wide-Ranging New Terror Alerts*, CBS News.com (May 26, 2002), *available at*, http://cbsnews.com/stories/2002/05/24/attack/main510054.shtml (discussing heightened alert of the U.S.'s nuclear power plants as a result of information gained by the intelligence community); *FBI Warns of Nuke Plant Danger*, CBS News.com (May 1, 2003), *available at*, http://www.cbsnews.com/stories/2003/09/04/attack/main571556.shtml (discussing FBI warning to nuclear plant operators to remain vigilant about suspicious activity that could signal a potential terrorist attack); General Accounting Office, *Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to be Strengthened*, GAO-03-752 (2003) (noting that U.S. nuclear power plants are possible terrorist target, and criticizing the NRC's oversight of plant security); *FBI's 4th Warning*, CBS News.com (July 2, 2004) (discussing FBI warning of recent intelligence showing Al-Qaeda interest in attacking nuclear plants).
[90] *In re All Nuclear Power Reactor Licensees*, DD-02-04 (Nov. 1, 2002), *available at* http://www.nrc.gov/reading-rm/doc-collections/petitions-2-206/directors-decision/2002/ml022890031.pdf; *NRC: Nuclear Power Plants Not Protected Against Air Crashes*, Associated Press (Mar. 28, 2002).
[91] *See generally* Riverkeeper's IP DSEIS Comments at 26-33.

NRC's basis for concluding that the consequences from severe accidents are categorically "small for all plants."

Additionally, it is crucial that NRC require consideration of intentional attack in licensee and NRC Staff SAMA analyses. Failure to do so will once again lead to highly inaccurate results.[92] For example, in the Indian Point relicensing proceeding, in the first step the SAMA analysis (i.e., establishing the baseline of severe accidents), Entergy and the NRC Staff did not consider the contribution to severe accident costs made by such intentional attacks at Indian Point.[93] The present value of cost risks for an attack at an Indian Point reactor and its pool exceeds half a billion dollars, which would warrant significant expenditures on SAMAs.[94] The present value of cost risks for an attack on a reactor alone are also significant -- $62 million to $73 million.[95] However, relevant SAMAs with a value of this magnitude were not considered.

It is, thus, clear that the failure to consider the risk of intentional attack renders the required SAMA analysis highly inaccurate.

VII. INADEQUATE ASSESSMENT OF NUCLEAR WASTE STORAGE IMPACTS

Low-Level Waste Storage and Disposal

The Revised GEIS recognizes that the Barnwell disposal facility in South Carolina has stopped accepting waste from States that are not part of the Atlantic compact as of July 2008.[96] The Revised GEIS further acknowledges the difficulty this poses to the 36 States who now have limited options for disposal of low-level waste. And yet, the NRC proposes to once again generically dispose of this as Category 1 issue. However, in light of the closure of the aforementioned disposal facility, it should be incumbent on licensees to perform a site-specific assessment of the environmental impacts of the accumulating volumes of low-level waste, which may now have to remain onsite on a long-term basis. Accordingly this should be re-categorized as a Category 2 issue.

Onsite Storage of Spent Nuclear Fuel

The Revised GEIS continues to hide behind the generic determination of no significant environmental impact in 10 C.F.R. § 51.23(b), stemming from the NRC's Waste Confidence Decision, to avoid requiring site-specific review of onsite nuclear waste storage impacts.[97] This is highly problematic for numerous reasons.

To begin with, a pending proposal, which the Revised GEIS acknowledges, to update the NRC's Waste Confidence Decision, if finalized, would extend the finding of no significant impact an additional 30 years.[98] A concomitant proposed rule change, would omit any reference to how

[92] *See generally* Thompson Report.
[93] Indian Point Draft Supplemental EIS § 5.2; Entergy's Environmental Report at § 4.21.
[94] *See* Thompson Report at 45-46, Table 7-7, Section 9.
[95] *Id.* at 49.
[96] Revised GEIS at 4-165.
[97] *See id.* at 1-9 to 1-10, 4-165 to 4-168.
[98] Waste Confidence Decision Update, 73 Fed. Reg 59,551, 59551, 59563-59569 (Oct. 9, 2008) ("WCD Update").

long spent fuel can safely be stored in "temporary" on- or off-site facilities, and simply state that such waste can be so temporarily stored without significant impact "until a disposal facility can reasonably be expected to be available."[99] Given the status of the Yucca Mountain proposal and lack of a clear long-term disposal solution, it is reasonably foreseeable that spent nuclear fuel and high level waste will have to remain onsite indefinitely. If the proposed rule changes are implemented, the NRC's generic finding of no significant impact would essentially be extended to some indefinable point in the future. Foregoing any analysis of impacts of decades and decades of spent nuclear waste storage because of the NRC's "waste confidence" is, thus, improper.

The NRC's reasonable assurance of safe interim storage, first instituted over a quarter of a century ago and never supported by an environmental assessment or environmental impact statement under NEPA,[100] simply does not hold up given current knowledge and circumstances. Most blatantly, the NRC's generic assurance of benign spent fuel pool storage is completely undermined by the evidence of leaks at reactors across the United States.[101] For example, at Indian Point, the Unit 1 pool began leaking as early as the 1990s, and the leaks from Unit 2 were discovered in 2005.[102] With spent fuel pool degradation already at nuclear plants, it is patently absurd to rely on the generic no impact finding to project the long-term integrity of the pools for decades into the future. Given this circumstance, a generic finding about the impacts of pool storage is simply not appropriate, and a site-specific review should be performed at the license renewal juncture.

The NRC's Waste Confidence Decision also fosters unbridled assurance in the safety of dry cask storage, yet this is also questionable. It is far from clear what environmental impacts will result if dry casks remain loaded with spent fuel beyond their design life.[103] In light of the fact that these casks will remain on the banks of the Hudson River indefinitely into the future, the NRC Staff must perform a site specific assessment of impacts of such long-term storage.

The NRC's generic finding of no significant impact also flies in the face of new information about the risks of accidents at on-site nuclear waste storage facilities. Numerous reports and studies show that fuel storage pools are potentially susceptible to fire and radiological release from natural phenomena.[104] As discussed above, the environmental impacts of a fire in a spent

[99] Proposed Rule on the Consideration of Environmental Impacts of Temporary Storage of Spent Fuel After Cessation of Reactor Operation, 73 Fed. Reg. 59,547, 59551 (Oct. 9, 2008).
[100] Final Waste Confidence Decision, 49 Fed. Reg. 34658 ("[T]he Commission finds that NEPA does not require an EIS to support the [temporary storage] finding"); *see also* 40 C.F.R. § 1508.9 (explaining that environmental assessments under NEPA should provide sufficient evidence and analysis for determining whether to prepare an EIS or a FONSI).
[101] *See Liquid Radioactive Release Lessons Learned Task Force Final Report*, U.S. Nuclear Regulatory Commission, at 5-6 (September 1, 2006) (hereinafter "Radioactive Release Task Force Report").
[102] *See* Entergy's Environmental Report, at 5-4; Groundwater Investigation Executive Summary (Indian Point Energy Center, Buchanan, N.Y., Jan. 2008), *available at* http://jic.semo.state.ny.us/Resources/ExecutiveSummary%20GW%20final.pdf; *see also* Riverkeeper's Exhibit A.
[103] *See* Riverkeeper's Scoping Comments at 9-10.
[104] *See, e.g.*, NUREG-1738, Final Technical Study of 1 Spent Fuel Pool Accident Risk and Decommissioning Nuclear Power Plants (NRC: January 2001); National Academy of Sciences Committee on the Safety and Security of Commercial Spent Nuclear Fuel Storage, Safety and Security of Commercial Spent Nuclear Fuel Storage (The National Academies Press: 2006); Gordon Thompson, Risks and Risk-Reducing Options Associated with Pool

fuel pool may be severe, extending over a geographic area larger than a state's legal boundaries and continuing for decades.[105]

Despite such ominous potential consequences, the Revised GEIS would continue to completely ignore the vulnerability of stored spent fuel to natural phenomenon, such as earthquakes. For example, recent new information from seismologists at Columbia University's Lamont-Doherty Earth Observatory, who published a study in August 2008 on earthquakes in the greater New York City Area, indicates that Indian Point sits on a previously unidentified intersection of two *active* seismic zones.[106] Indeed, several recent earthquakes in New Jersey right near the Ramapo fault, which runs directly underneath Indian Point, starkly demonstrate the active nature of the seismic areas around the facility.[107] The Columbia study further found that historic activity of earthquakes of a magnitude more than 5 has been higher in southeastern New York than in many other areas of the central and eastern United States, and that the fault lengths and stresses suggest magnitude 6 or 7 quakes (which would be 10 and 100 times bigger than magnitude 5, respectively) are "quite possible.[108]

Yet, due to the categorical exclusion of nuclear waste storage impacts, the Revised GEIS would not require consideration of such information. This is notwithstanding the new issue in the Revised GEIS related to new seismological information,[109] which would ostensibly not extend to impacts to nuclear waste in light of NRC's reliance on the Waste Confidence Rule. There is no certainty whatsoever that the dry casks or spent fuel pools at plants like Indian Point are designed so as to be able to withstand such natural occurrences in light of the new seismic information. The existence of such new information highlights why a generic determination of environmental safety for long-term on-site storage of spent fuel is totally inappropriate.

The NRC Staff also relies upon the NRC's generic safety determination to further justify its refusal to consider the risks to spent fuel storage from intentional acts of sabotage.[110] However, the likelihood and seriousness of such risks necessitates a thorough review of the impacts of long-term storage of spent fuel at Indian Point. As discussed above, future terrorist attacks at Indian Point remain reasonably foreseeable, and such risks must be fully assessed in the relicensing proceeding.

Based on the foregoing, it is clear that the NRC's generic determination can not form the basis for continued exclusion of this issue in all future license renewal proceedings. Based on the

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Storage of Spent Nuclear Fuel at the Pilgrim and Vermont Yankee Nuclear Power Plants (May 25, 2006); Jan Beyea, Report to the Massachusetts Attorney General on the Potential Consequences of a Spent-fuel Pool Fire at the Pilgrim or Vermont Yankee Nuclear Plant (May 25, 2006).

[105] *See generally*, Thompson Report.

[106] *See* Lynn R. Sykes, John G. Armbruster, Won-Young Kim, & Leonardo Seeber, *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, No. 4, pp. 1696-1719 (August 2008) ("2008 Columbia Earthquake Study").

[107] *See, e.g.*, Lawrence Ragonese, *Morris County Shows Signs of Stress: Four Quakes*, The Star-Ledger (Feb. 18, 2009), *available at*, http://www.nj.com/news/index.ssf/2009/02/morris_county_shows_sign_of_st.html.

[108] 2008 Columbia Study; *see also* Robert Roy Britt, *Large Earthquakes Could Strike New York City* (Aug. 21, 2008), *available at* http://www.livescience.com/environment/080821-new-york-earthquakes.html.

[109] *See* Revised GEIS at 3-49 to 3-50.

[110] *See* Waste Confidence Decision Update, 73 Fed. Reg. 59,551.

changed landscape, NRC must make this a Category 2 issue and require site-specific analysis of the impacts of long-term on-site storage.

Offsite Radiological Impacts of Spent Nuclear Fuel and High-Level Waste Disposal

The Revised GEIS continues to review the offsite radiological impacts from spent nuclear fuel and high level waste disposal in relation to the use of Yucca Mountain as the future long-term geologic repository. This flies in the face of recent indications that Yucca is no longer a viable option. Indeed, there is no dispute that the current Administration has brought the axe down on the Yucca project. Most recent accounts indicate that the U.S. Department of Energy intends to stop pursuing a license for the Yucca repository by this December.[111] Even the NRC Commissioner's have acknowledged the current plan to eliminate the Yucca Mountain Project.[112]

It is, thus, curious, that a document that will serve as a generic environmental impact statement for decades to come would continue to rely upon this eventuality. Indeed, the Revised GEIS explicitly relies upon dose limits from documents filed in connection with the Department of Energy's Yucca Application.[113] In addition to misguidedly relying upon a pending application, such information was developed specifically in relation to Yucca, and is therefore essentially unusable in light of the aforementioned circumstances.

Given the uncertainly of long-term disposal of nuclear waste, and the likelihood of essentially indefinite on-site storage, it makes far more sense to perform a site specific review to discern the offsite impacts of this waste at particular plants. While the NRC will undoubtedly claim that they are relying in good faith on the Department of Energy's pending application which has not been withdrawn yet, the NRC must not "shut . . . [their] ears to the din of current debate" as Commissioner Svinicki has articulated.[114]

VIII. CONCLUSION

For the foregoing reasons, Riverkeeper respectfully submits that the Revised GEIS for license renewal of nuclear power plants is inadequate and incomplete. The environmental review based on the Revised GEIS would fail to provide for a comprehensive review which is necessary to comply with NEPA.

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[111] *See, e.g.*, Keith Rogers, *Yucca Mountain: Memo casts doubt on license for Yucca repository*, LAS VEGAS REVIEW-JOURNAL (Nov. 10, 2009), http://www.lvrj.com/news/memo-casts-doubt-on-license-for-yucca-repository-69639342.html (last visited Jan. 12, 2009).

[112] *See* Notation Vote of Commissioner Klein, SECY-09-0090 – Final Update of the Commission's Waste Confidence Decision (September 16, 2009), *available at*, http://www.nrc.gov/reading-rm/doc-collections/commission/cvr/2009/2009-0090vtr-dek.pdf; Notation Vote of Commissioner Svinicki, SECY-09-0090 – Final Update of the Commission's Waste Confidence Decision (September 24, 2009), *available at*, http://www.nrc.gov/reading-rm/doc-collections/commission/cvr/2009/2009-0090vtr-kls.pdf ("Svinicki Vote on WCD").

[113] *See* Proposed Rule at 38,127.

[114] Svinicki Vote on WCD at 3.

Thank you for your consideration.

Sincerely,

s/ Phillip Musegaas
Phillip Musegaas, Esq.
Hudson River Program Director

s/ Phillip Musegaas for
Deborah Brancato
Staff Attorney

LIST OF EXHIBITS

Exhibit A – compiled documentation related to nuclear power plant leaks across the United States.

Exhibit B – Riverkeeper, Inc.'s Request for Hearing and Petition to Intervene in Indian Point License Renewal Proceeding, November 30, 2007

Exhibit C – Riverkeeper Comments on Environmental Scoping for the Indian Point License Renewal Proceeding, Docket Nos. 50-247, 50-286 (Oct. 12, 2007)

Exhibit D – Riverkeeper Comments on Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment (March 18, 2009)

Exhibit E – Riverkeeper's Comments on NRC's Proposed Enhancements to Emergency Preparedness Regulations (Oct. 19, 2009)

Exhibit F – Gordon R. Thompson, "Risk Related Impacts from Continued Operation of the Indian Point Nuclear Power Plants" (Institute for Resource and Security Studies) (November 28, 2007)

Exhibit G – Edwin S. Lyman, *Chernobyl on the Hudson? The Health & Economic Impacts of a Terrorist Attack at the Indian Point Nuclear Power Plant* (Union of Concerned Scientists, September 2004)

Mendiola, Doris

Subject: FW: Riverkeeper Comments on Revised GEIS for NPP License Renewal, RIN3150-AI42 - E-mail 2

Attachments: 2010.01.12.Exhibit A to Riverkeeper's Comments on Revised License Renewal GEIS, RIN3150-AI42 - Leak Documentation.pdf

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From: Deborah Brancato [mailto:DBrancato@riverkeeper.org]
Sent: Tuesday, January 12, 2010 11:59 PM
To: Rulemaking Comments
Subject: Riverkeeper Comments on Revised GEIS for NPP License Renewal, RIN3150-AI42 - E-mail 2

Dear Secretary and Rulemakings and Adjudication Staff,

As indicated, attached please Exhibit A to Riverkeeper, Inc.'s Comments on the NRC's "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 74 Fed. Reg. 38,117, 10 C.F.R. Part 51, RIN 3150-AI42, NRC-2008-0608 (July 31, 2009).

Deborah Brancato
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Riverkeeper -- Defending the Hudson. Protecting Our Communities.

Attachment A
Riverkeeper, Inc.
Comments to RIN 3150-AI42, Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, Proposed Rule, 74 FR 38117, July 31, 2009.

List of Currently Operating Nuclear Power Plants in addition to Indian Point with Reported Tritium Leaks

1. Fitzpatrick, NY
2. Vermont Yankee, VT
3. Oyster Creek, NJ*
4. Braidwood, IL*
5. Palisades, MI
6. Beaver Valley, PA
7. Peach Bottom, PA
8. Catawba, SC
9. Brunswick, NC
10. Ft. Calhoun, NE
11. San Onofre, CA
12. Callaway, MO*
13. Byron, IL*
14. Dresden, IL*
15. Salem, NJ*
16. Palo Verde, CA*
17. River Bend, LA
18. Kewaunee, WI
19. Haddam Neck, CT
20. Watts Bar, TN*
21. Three Mile Island, PA*
22. Perry, OH*
23. Point Beach, WI*
24. Seabrook, NH*
25. Hatch, GA*
26. Pilgrim, MA
27. Quad Cities, IL
28. Browns Ferry, AL
29. Sequoyah, TN

Note – Plants marked with an asterisk are referenced in the NRC's Tritium Task Force Report, September 2006.

FITZPATRICK

Unit	SCRAM Code	RX CRIT	Initial PWR	Initial RX Mode	Current PWR	Current RX Mode
1	N	Y	100	Power Operation	100	Power Operation

Event Text

OFFSITE NOTIFICATION FOR ELEVATED TRITIUM LEVELS

"On 12/23/09, station management was notified that a sample taken from [James A. Fitzpatrick] JAFs west storm drain was positive for tritium. The sample results were confirmed at 984 pCi/L. The sensitivity of the analysis is 800 pCi/L. The Offsite Dose Calculation Manual (ODCM) lower limit of detection (LLD) requirement for tritium is 3,000 pCi/L with a reporting level of 30,000 pCi/L. Comparing the confirmed activity level in the sample with the reporting criteria, there is little environmental impact, as the sample is more than an order of magnitude below the reporting criteria.

"Although no regulatory limit was exceeded these results were evaluated against the NEI 07-07 guidance for voluntary informal communication of state/local authorities. Since the storm drains communicate with native soil and Lake Ontario, it has been determined that the voluntary informal communication criteria applies. That determination was made at 1515 [EST] on 12/28/09.

"Since the state and local agencies will be notified of the slightly positive indication in the storm drain sample, reporting criterion 10 CFR 50.72(b)(2)(xi) was reviewed and based on the public sensitivity to tritium issues, it was determined that a notification to the NRC should be made.

"The site has developed an action plan to address locating the source of the tritium [including] potential remediation actions, inclusion in the annual Radiological Environmental Monitoring Program (REMP) report, and evaluation for inclusion as an NRC IN 80-10 pathway. In the interim, both the reactor building perimeter sump and west storm drain have been placed on an increased sampling frequency. The storm drain will be sampled weekly and the reactor building perimeter sump will be sampled daily.

"Background: On 11/03/09 station management was notified that a sample from the reactor building perimeter sump was positive for tritium at 1474 pCi/L. The reactor building perimeter sump was placed on increased monitoring frequency due to the positive indication. Since the sump only communicates with the environment, through the west storm drain, and there was no positive indication of tritium in the west storm drain or in the ground water monitoring wells, it was determined that no 'voluntary informal communication' criteria applied, at that time."

The licensee has notified the NRC Resident Inspector. The licensee will notify the state, local, and other government agencies.

Power Reactor	Event Number: 45613
Facility: VERMONT YANKEE Region: 1 State: VT Unit: [1] [ ] [ ] RX Type: [1] GE-4 NRC Notified By: JAMES KRITZER HQ OPS Officer: STEVE SANDIN	Notification Date: 01/07/2010 Notification Time: 16:55 [ET] Event Date: 01/07/2010 Event Time: 15:30 [EST] Last Update Date: 01/07/2010
Emergency Class: NON EMERGENCY 10 CFR Section: 50.72(b)(2)(xi) - OFFSITE NOTIFICATION	Person (Organization): MARC FERDAS (R1DO)

Unit	SCRAM Code	RX CRIT	Initial PWR	Initial RX Mode	Current PWR	Current RX Mode
1	N	Y	90	Power Operation	90	Power Operation

Event Text

OFFSITE NOTIFICATION TO STATE AND LOCAL AGENCIES CONCERNING RESULTS OF QUARTERLY GROUND WATER ANALYSIS

"On January 6, 2010, Vermont Yankee (VY) was notified that the results of fourth quarter 2009 ground water sampling, performed as part of the voluntary ground water monitoring program, identified a very low concentration of tritium in one well that is used to monitor station ground water. VY has notified state, local and other government agencies of this condition. Since no other wells indicated the presence of tritium and the concentration detected is below the reporting threshold identified in the Off-site Dose Calculation Manual, notifications were considered voluntary consistent with NEI 07-07 'Industry Ground Water Initiative - Final Guidance Document.' This report is being made in accordance with 10 CFR 50.72(b)(2)(xi) to notify the NRC of these voluntary notifications. There is no impact on public health and safety as a result of this event.

"The NRC Resident Inspector has been notified."

Rutland Herald
Article published Jan 12, 2010
Yankee leak triggers visit from top

By Susan Smallheer Staff Writer

BRATTLEBORO — A top-level official from the Nuclear Regulatory Commission was in Vernon Monday, sitting in on meetings with Entergy Nuclear on how to handle the newly discovered radioactive leak at Vermont Yankee.

Donald Jackson, the NRC section chief, was attending the Entergy meetings, according to Neil Sheehan, commission spokesman.

Sheehan said Jackson would be in Vernon today also, as Entergy officials and its special team plot a strategy on what to do about the leak that first showed up on tests taken in November in monitoring wells. Subsequent tests last week showed the tritium levels had risen sharply, from 700 parts to 17,000 parts per liter.

Uldis Vanags, the state's nuclear engineer, said the first priority was locating the source of the tritium, a radioactive isotope that is a byproduct of nuclear power production. He said the state was waiting for Entergy to locate the source and then would be involved in the cleanup process.

Arnie Gundersen, a nuclear engineer who is a consultant to the Vermont Legislature and was a member of the state's Vermont Yankee Oversight Panel, said that in 1976 the plant's condensate storage tank leaked significant amounts of tritium-contaminated water into the Connecticut River.

Gundersen cited a 2006 survey that Entergy Nuclear filled out for the NRC as the source of his information about the condensate tank, which holds hundreds of thousands of gallons of water.

According to Entergy's own letter to the NRC, "a significant spill of tritiated water occurred at Vermont Yankee in 1976." The spill released 507 microcuries of beta-gamma activity, the report stated, as well as 1.6 curies of tritium.

Last week's discovery measured the tritium in picocuries, which is a very small fraction — one trillionth — of a curie. A microcurie is one millionth of a curie.

Vanags said he was aware there had been a significant spill in 1976, but at this time did not have the details.

According to Sheehan, the condensate storage tank sits on a concrete pad and is surrounded by a concrete berm. He said any leak would be visible.

Williams said the condensate tank was being investigated as the potential source of the new tritium reading. He said the tank was south of the reactor building.

"In 1976, 34 years ago, there was a spill of water from the condensate storage tank containing tritium. However, that spilled water drained to the river and it was not a groundwater contamination issue," Williams wrote in a later e-mail. "The investigation that we have under way is a thorough, comprehensive, methodical process with the benefit of industry experience) and we are considering all sources of tritiated water at the plant including the condensate storage tank and its associated connections."

He said the Entergy task force would decide when and where to drill additional monitoring wells, which would be used to help identify the source of the tritium.

In the case of the 1976 spill, the water "flowed through the plant storm drain system to the Connecticut River" but no water entered the groundwater table at the plant site.

Monitoring groundwater at nuclear power plants became a priority for the NRC in 2006 when contamination surfaced at several plants, including Oyster Creek in New Jersey and Indian Point, north of New York City. Tritium problems were identified a couple of weeks ago at another Entergy reactor, the FitzPatrick reactors on Lake Ontario.

Sheehan said the condensate storage tanks hold hundreds of thousands of gallons of water that contain radioactivity. The water has circulated through the reactor and has high levels of tritium, he said.

Sheehan said that after Jackson leaves Vermont Yankee, the NRC's two resident inspectors will be reviewing Entergy's efforts. "We will be developing plans for additional inspections," he said. Williams said he did not know how much water had been spilled in the 1976 incident.

http://www.rutlandherald.com/article/20100112/NEWS04/1120359/1003/NEWS02

See also Dave Gram, **Vt. Yankee Well Tests Shows Radioactive Isotope, Associated Press, January 7, 2010, available at** http://abcnews.go.com/Business/wireStory?id=9507774.

PALISADES

Power Reactor	Event Number: 43832
Facility: PALISADES Region: 3 State: MI Unit: [1] [ ] [ ] RX Type: [1] CE NRC Notified By: TODD MULFORD HQ OPS Officer: JASON KOZAL	Notification Date: 12/10/2007 Notification Time: 22:21 [ET] Event Date: 12/10/2007 Event Time: 18:30 [EST] Last Update Date: 12/10/2007
Emergency Class: NON EMERGENCY 10 CFR Section: 50.72(b)(2)(xi) - OFFSITE NOTIFICATION	Person (Organization): JOHN MADERA (R3)

Unit	SCRAM Code	RX CRIT	Initial PWR	Initial RX Mode	Current PWR	Current RX Mode
1	N	Y	100	Power Operation	100	Power Operation

Event Text

NOTIFICATION TO OFFSITE AGENCIES DUE TO ELEVATED TRITIUM LEVELS "Five new ground water monitoring wells were recently installed at Palisades Nuclear Plant in support of the Nuclear Energy institute (NEI) ground water initiative. The initial sampling of one of these wells displayed a level of tritium that triggered the communication protocol of the NEI initiative on ground water protection. On December 10, 2007, at 1830 hours, Entergy confirmed that the tritium concentration for this well was 22,000 picoCuries per liter (pCi/l). The threshold for initiating the communication protocol is 20,000 pCi/l (Offsite Dose Calculation Manual limit for drinking water). This well is located inside the owner controlled area and inside the protected area. This well is not a drinking water source. Entergy is continuing to investigate the source of tritium identified in this well. Samples from the remaining four wells are below minimum detectable activity levels. There is no indication that tritium has migrated off the Palisades site. The licensee plans to notify the State of Michigan, Van Buren County Office of Domestic Preparedness, City of South Haven, Covert Township, and the South Haven Charter Township. "The licensee has notified the NRC Resident Inspector."

CATAWBA

Duke Energy reports tritium leak at Catawba Nuclear Station

Company says contamination poses no threat to public
By Bruce Henderson - Bruce Henderson

Radioactive tritium has leaked into groundwater from the Catawba Nuclear Station on Lake Wylie, Duke Energy told federal regulators Wednesday.

One well at the Catawba plant had a tritium concentration twice as high as the federal government says is safe in drinking water.

Duke says the contamination poses no threat to the public because it is confined within the plant's boundaries.

The S.C. Department of Health and Environmental Control will sample water from about two dozen residential wells near the plant, spokesman Thom Berry said. Testing will occur in the

Bethel community of York County. The department learned of the leaks late Tuesday or Wednesday.

"We want to know whether any tritium is in the groundwater used by wells outside of the plant's boundary," DHEC's Patrick Walker said.

Tritium occurs naturally and as a byproduct of nuclear plants. It emits a weak form of radiation, but people exposed to it may face increased risks of cancer or pass on genetic abnormalities.

It also can foreshadow the eventual flow of more toxic radioactive materials in groundwater, said David Lochbaum, a nuclear safety expert with the Union of Concerned Scientists in Washington.

At least six other nuclear plants, none in the Carolinas, have reported tritium leaks in recent years. The Nuclear Regulatory Commission says the leaks posed no threats to public health but revised inspection procedures to ferret out potential leaks.

Nuclear reactors produce tritium from the use of a chemical, boron, to help control the chain reaction that produces heat. Boron also is added to the water in which fuel cools after it has been used in a reactor.

Under an industry initiative, Duke spokesman Valerie Patterson said, Catawba installed 30 new wells to monitor groundwater at the plant. One of those wells -- not used for drinking water purposes -- detected the concentration Duke reported Wednesday. It was the only one of 30 test wells to show tritium levels above the EPA's standard of 20,000 picocuries per liter.

"We don't know the source; that is part of the investigation," Patterson said.

Other nuclear plants have traced leaks to spent fuel pools and to valves.

"We have no reason to believe, based on other testing of other wells, that they have elevated levels," Patterson said.

Tritium contamination has been a concern in South Carolina and across the country recently because of leaks at other nuclear plants and from Barnwell County's low-level nuclear waste landfill. The Barnwell site takes nuclear refuse from atomic power plants.

The Catawba plant has had at least three leaks of radioactive material since 1992, according to a report Lochbaum compiled. Most nuclear plants have had some sort of leak since their inception, he said.

In South Carolina, Lochbaum noted nearly 50 "groundwater events," including leaks, at the state's four nuclear plant sites.

In North Carolina, Duke's McGuire nuclear plant on Lake Norman has installed 41 wells and will add nine. It was unclear Wednesday whether reportable levels of tritium had been detected there.

The Oconee plant in northwestern South Carolina will install 28 wells later this year, Patterson said.

http://www.heraldonline.com/109/story/140669.html

FT. CALHOUN

Power Reactor	Event Number: 43355
Facility: FT CALHOUN Region: 4 State: NE Unit: [1] [ ] [ ] RX Type: [1] CE NRC Notified By: KEVIN R BOSTON HQ OPS Officer: JASON KOZAL	Notification Date: 05/10/2007 Notification Time: 20:16 [ET] Event Date: 05/10/2007 Event Time: 15:30 [CDT] Last Update Date: 05/10/2007
Emergency Class: NON EMERGENCY 10 CFR Section: 50.72(b)(2)(xi) - OFFSITE NOTIFICATION	Person (Organization): VINCENT GADDY (R4)

Unit	SCRAM Code	RX CRIT	Initial PWR	Initial RX Mode	Current PWR	Current RX Mode
1	N	Y	100	Power Operation	100	Power Operation

Event Text

OFFSITE NOTIFICATION DUE TO ELEVATED TRITIUM LEVELS

"On May 7, 2007, a horizontal concrete wall crack at approximately 990 ft 6 inch elevation in a radiologically controlled room located inside the protected area, was observed to have water drops forming on the surface. Samples were collected in enough quantity to perform radiological and chemical analysis. The analysis indicated tritium concentration of 110,000 pCi/L. The limits for tritium in the FCS Off-Site Dose Calculation Manual is 20,000 pCi/L. Based on this analysis a conservative decision to notify the state and local agencies was made on 5/10/2007 at 15:30 CDT per the NEI Ground Water Protection Program. These off-site notifications will be made on 5/11/2007. Further investigation is on-going."

The licensee notified the NRC Resident Inspector.

SAN ONOFRE

Authorities Report No Threat To Public Safety

POSTED: 1:57 pm PDT August 16, 2006
UPDATED: 2:24 pm PDT August 16, 2006
SAN ONOFRE, Calif. -- A retired reactor at the San Onofre nuclear power plant has leaked several thousand gallons of radioactive water over an unknown period of time, but there is no threat to public safety, it was reported Wednesday.

An operator at the plant confirmed Tuesday that the water containing tritium, a byproduct of the nuclear fission that produces electricity, has leaked from the reactor, The San Diego Union-Tribune reported. High levels of tritium can cause cancer or birth defects.
The concentration of tritium found in groundwater beneath the retired reactor was higher than standards set by the Environmental Protection Agency for drinking water.
But initial tests showed it was lower than the maximum annual leakage permitted for nuclear power plants by the the Nuclear Regulatory Commission, the newspaper reported.
"There is no danger to public safety," Victor Dricks, the commission's spokesman, told the newspaper.
Crews demolishing the retired reactor discovered the leak last week, and the commission was notified Monday, according to the Union-Tribune.
The leak might have started decades ago, said Ray Golden, a spokesman for the nuclear facility. He emphasized, however, that the nearest well for drinking water is 2 miles uphill at Camp Pendleton, the newspaper reported.
Golden added that if the tritium washes into the ocean, it would be diluted to levels safe for surfers, swimmers and marine life. The power plant is 100 to 200 yards from San Onofre Beach.
If more tests confirm that the concentration of leaked tritium meets the commission's standards, San Onofre officials said, they will release the contaminated water 1 1/2 miles offshore, according to the newspaper.
San Onofre officials said they are investigating the origin of the tritium, according to the Union-Tribune.

http://www.10news.com/news/9690567/detail.html

CALLAWAY

AmerenUE got land before disclosure

By Ken Leiser

ST. LOUIS POST-DISPATCH
08/07/2006

FULTON, MO.

Shortly before announcing that radioactive tritium had leaked along a pipeline near its Callaway nuclear plant, AmerenUE bought more than 120 acres where two of the leaks were found, according to records and interviews.

The utility confirmed that it also is talking to at least one more landowner to secure the remaining property along the six-mile discharge pipe that carries cooling water and some low-level radioactive waste from the 1,190-megawatt power plant to the Missouri River.

St. Louis-based Ameren, which operates the plant, announced in late June that small amounts of tritium were found beneath seven of 17 manholes along the pipeline. The company has characterized the remote contamination as "minor" and said it does not pose a health hazard.

The leaks were detected during a voluntary sampling program Callaway officials began after learning of tritium leaks at the Braidwood Generating Station in northern Illinois. That plant, operated by Exelon Corp., also has a long discharge pipeline.

Tritium is a radioactive isotope of hydrogen that is a byproduct of power generation at nuclear plants like Callaway. The industry's trade group, the Nuclear Energy Institute, and the U.S. Environmental Protection Agency describe tritium as one of the least hazardous radionuclides. In addition to being found in water, it occurs naturally in the upper atmosphere.

Testing continues at Callaway to determine the extent of the soil contamination. So far, none of the material has been found in local water supplies, according to officials at Ameren and the Missouri Department of Natural Resources.

Keith D. Young, manager of regulatory affairs at the Callaway plant, said acquiring the 122 acres was necessary to access the two manholes where small amounts of tritium were found and to take possible remedial action if any is needed in the future.

None of the material was found outside the two manholes on the acquired land, Ameren spokesman Mike Cleary said Monday.

Ameren owns about 7,000 acres around the Callaway plant and seeks to own all the property along the pipeline.

"We just thought it was the right thing to do if we had to do any additional work on the land," Young said. "It would make it a lot easier. There would be less concern by the landowners and so on if we just owned the land."

Cleary said the real estate employee who handled the negotiations did not discuss the tritium issue with the property's previous owner because test results were not complete or the employee "wasn't aware of them" when the agreement was reached.

The landowner, Jose Cruz of Rhineland, in Montgomery County, said Ameren told him that there was going to be "quite a bit of disturbance on the property" and that it was acquiring land between the plant and the Missouri River.

Ameren assured Cruz that there was "no problem" with the land after the deal closed, he said.

The sales price was not disclosed. Under a lease with the utility, Cruz continues to grow corn and soybeans on the land and said he wants to ensure that the land remains safe.

A warranty deed documenting the transaction was filed in Callaway County on June 29. One day later, Ameren and the state Department of Natural Resources issued separate news releases announcing the tritium discovery.

Young said the land deal did not factor in the timing of the announcement.

Escaping water

Cooling water is drawn from the Missouri River to the Callaway power plant each day. Water that doesn't evaporate through the plant's 553-foot cooling tower is cycled back to the river through a separate line. Discharges of low-level radioactive waste also are sent through the 24-inch pipeline two to eight times a month, Young said.

Small amounts of water escaped from some of the air-release valves housed inside the manholes, company officials say. The company has taken corrective steps to contain any leakage.

Ameren has hired a contractor to help "characterize" the extent of the contamination before it proposes a remediation plan to the state, Young said.

Floyd Gilzow, deputy director for policy at the state Department of Natural Resources, said that the Callaway leaks involved far less spillage than seen at Braidwood, where millions of gallons leaked at a time.

Gilzow said testing is being done outside some manholes where tritium was found. Ameren is sharing soil samples with the state to be examined in a contract lab.

"Frankly, based on the numbers, this is not a big issue," Gilzow said. "This doesn't look like a huge plume migrating."

But Paul Gunter, director of the Reactor Watchdog Project at the Nuclear Information and Resource Service, said unplanned, unmonitored radioactive spills like those at Callaway are not supposed to happen.

In addition, he said, federal regulators have given the nuclear power industry permission to in effect police itself when it comes to reporting accidental spills such as those at Callaway and Braidwood.

Timely reporting of the leaks should have been made to farmers and other landowners near the pipeline, Gunter said, to ensure proper response and testing. Owning the land surrounding the pipeline, he said, doesn't account for possible migration of leaked tritium into groundwater.

"Just because a test well doesn't show anything today doesn't mean it won't show something there tomorrow or 10 years from now," he said.

What is tritium?

Tritium is a radioactive isotope of hydrogen. It occurs naturally in the atmosphere but is also a byproduct of nuclear power generation. It is one of the weakest forms of radiation. The primary risk of exposure to tritium's radiation occurs if it is ingested, according to the National Institutes of Health. The U.S. Environmental Protection Agency standard for permissible levels of tritium in drinking water is 20,000 picocuries per liter - far more than is found in nature. Federal regulators say any exposure to radiation poses some health risk. Those risks increase incrementally with the exposure level and can increase the risk of cancer or leukemia at higher doses.

Sources Nuclear Energy Institute, Missouri Department of Natural Resources, Nuclear Resource and Information Service

kleiser@post-dispatch.com **314-340-8215**

Pipe leak found at Callaway

The Fulton plant's pipeline released a radioactive byproduct.

The Missourian
Associated Press
September 4, 2006

ST. LOUIS — St. Louis-based AmerenUE said it is investigating **newly discovered leaks of radioactive tritium from a pipeline at its Callaway** nuclear power plant in Fulton, **following half a dozen leaks from pipe breaks dating to 1987.**

The pipeline runs cooling water and other waste from the plant near Fulton to the Missouri River. So far, no tritium or other radionuclides have been detected in two rounds of testing on private wells that supply drinking water to 20 neighboring properties.

"We don't want to see pipes break," said Floyd Gilzow, deputy director for policy at the state Department of Natural Resources. "We don't want to see these kinds of unplanned releases and I don't think Ameren wants to see them either. Do they concern us? Of course they concern us. But the reality is we live in an imperfect world and occasionally things that are mechanical don't work the way they're supposed to."

Ameren, the plant's operator, said none of the leaks have threatened public health. The most recent leaks were discovered this summer, the St. Louis Post-Dispatch reported Sunday.

Tritium is a byproduct of power generation at nuclear plants like Callaway. It is considered one of the least hazardous radionuclides, or atoms that emit radiation.

In one major pipeline break, in October 1995, two miles north of the Missouri River, water flowing from the broken pipe eroded a channel up to 12 feet wide and 12 feet deep to Logan Creek.

Plant estimates were that the leak began late that summer as a result of periodic flooding that apparently shifted and stressed the pipe.

Ameren is permitted to discharge water containing diluted levels of tritium into the Missouri River, where it mixes with river water and is further diluted.

"While there is no indication that tritium contamination from the Callaway plant poses a health concern to plant employees or the public, AmerenUE does take the tritium issue seriously," company spokeswoman Susan Gallagher said. "We are working with the rest of the nuclear energy industry to develop additional tritium monitoring and control measures."

Low-level contamination was found in about half the soil samples taken this year from the manholes. One soil sample was slightly above the federal safety limit for tritium in drinking water.

Other documented leaks occurred in 1987, '88, '89, '98 and 2005.

HADDAM NECK, PALO VERDE, SALEM

Groundwater leaks at nuclear plants a trend?
Regulators to hear concerns about water tainted by low-level radiation

By Miguel Llanos

Updated: 1:07 p.m. ET April 4, 2006

Public fears about nuclear power plants have usually centered on massive radiation releases into the air, but recent leaks of water contaminated with low-level radiation have raised a new concern: Local groundwater supplies could become a source of long-term radiation exposure with potential health risks.

Are the leaks just a coincidence or signs of a trend? That's what the Nuclear Regulatory Commission will weigh on Wednesday when it hears from petitioners demanding that the nuclear industry disclose all information it has on any such incidents.

"We've accepted the petition ... we agree that they've raised a legitimate issue," says NRC petition manager Bill Reckley. "We will consider what they suggested."

The federal agency agreed to a meeting after a petition by 22 environmental groups last January cited leaks in the last decade at nuclear power sites in Braidwood and Dresden, Ill.; Lynchburg, Va.; Salem, N.J.; Haddam Neck, Conn.; and Indian Point and Long Island, N.Y.

Since the petition was filed:

· Two more plants — at Palo Verde, Ariz., and Byron, Ill. — have reported groundwater leaks.
· Illinois has sued Exelon over the Braidwood spill, caused by a broken concrete pipe.
· A new spill was reported at Indian Point.

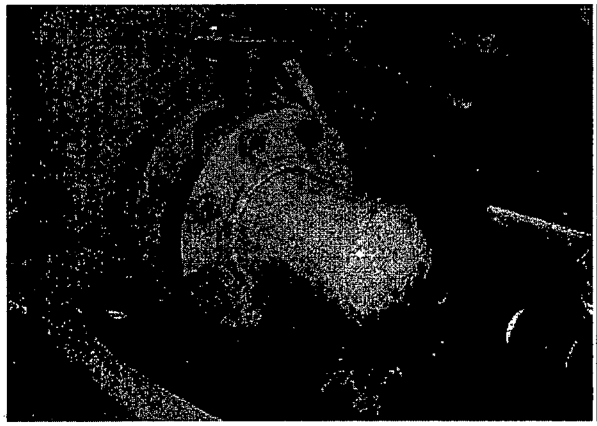
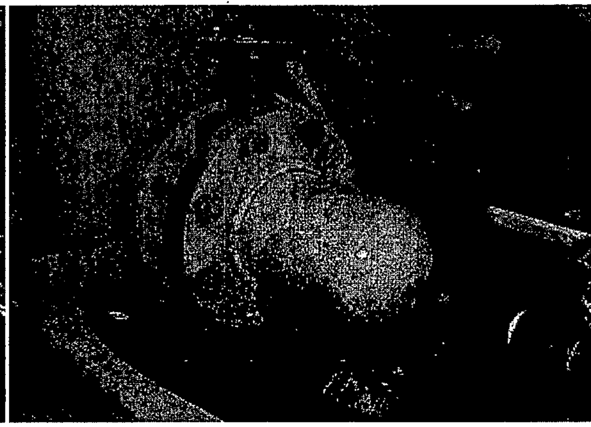
Most of the leaks involve tritium, a byproduct of nuclear power generation. Tritium also occurs naturally at low levels, but large amounts, if ingested, can lead to cancers, birth defects and miscarriages.

The biggest known tritium leak was at Exelon's nuclear reactor at Braidwood, where 3 million gallons of tainted water spilled in 1998 and 2000. Late last year, tests detected tritium in the well of a nearby homeowner, indicating that the leak had spread.

The NRC said the tritium levels were just 10 percent of what the Environmental Protection Agency allows in drinking water, but the finding was significant because it showed the tritium had spread over time.

Task force created
At an industry conference on March 7, NRC Chairman Nils Diaz urged the industry to

"proactively address" what he called releases that were "uncontrolled and identified after the fact."

alt="IMAGE: LEAKING DRAIN AT NUCLEAR PLANT" border=0 v:shapes="_x0000_s1026">Three days later, the NRC's executive director for operations, Luis Reyes, created a "lessons learned task force," stating in his order that "although the measured levels of tritium thus far do not appear to present a health hazard to the public, I believe it is necessary to do a broad review to determine whether this is a generic issue for NRC licensees and to recommend possible agency actions to be taken in this area."

The United States is home to 103 commercial nuclear reactors, all at least 30 years old, and petitioners fear many leaks have gone undetected.

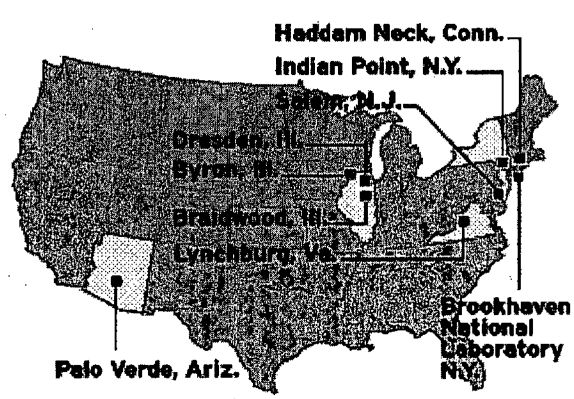
"I fully expect about a quarter of the remaining plants to have leaks," says Dave Lochbaum, a nuclear specialist at the Union of Concerned Scientists, one of the petitioners.

Petitioners: NRC was slow
The petition doesn't claim that the leaks have threatened public health. Instead, it asks the NRC to require that plant operators detail any leaks and their methods for tracking them.

And it accuses the agency of having "treated these leaks as isolated events" by not requiring operators to check for similar leaks at other plants.

Nuclear plant groundwater leaks

Citing public records, petitioners before the Nuclear Regulatory Commission note that nuclear facilities in nine areas reported leaks of contaminated water into the ground since 1997.



"The NRC has not taken steps necessary to ensure that members of the public are not now being exposed to radiation from undetected leaks," the petition stated.

Lochbaum says he doesn't expect any newly reported leaks "to approach or exceed the leak at Braidwood" but feels it's incumbent upon the NRC "to make sure there are no surprises out there" — either with tritium or any other potential contaminant from broken pipes or cracks in pools used to cool off highly radioactive spent nuclear fuel.

Petitioners also question how industry has responded so far, citing photographs submitted by Exelon to the NRC of a temporary wastewater collection at Braidwood. One photo shows a valve covered in duct tape; another shows a catch basin for a leaky pipe.

The demands made on industry, Lochbaum says, could amount to a couple million dollars per plant. "Compared to cost of cleaning it up," he adds, "it's cheap insurance."

Industry perspective
For the industry, the leaks come as nuclear power has gained momentum. After a 20-year construction hiatus in the United States triggered by Chernobyl and Three Mile Island, several companies have said they hope to build reactors in the next decade.

alt="IMAGE: SYSTEM TO COLLECT CONTAMINATED WATER" border=0 v:shapes="_x0000_s1028">Ralph Anderson, director of health policy for the Nuclear Energy Institute, says the industry has been acting on the groundwater issue since a public meeting with the NRC in December.

Operators recognized that the system for reporting and monitoring groundwater spills hasn't worked well, he says.

"Some opportunities for improvement with regards to monitoring on site" exist, he says. "We need a process that identifies things earlier."

"This isn't a significant health and safety issue," he says of low-level radiation in groundwater, but "it clearly is one of trust and confidence."

"That issue of communication is clearly one that we need to deal with," he adds.

Task force goal: Late July
The agency task force has set the end of July as its goal for recommendations.

Lochbaum says he was "very encouraged" after a meeting last month with NRC and industry staff, and agrees with Anderson that the issue comes down to getting neighbors to trust nuclear plants.

"The real question" that the industry needs to answer, he says, "is: 'What is your tritium doing in my well?'"

For Anderson, that's also the heart of the matter. "The fact that it's there and not supposed to be there," he says, "is what we're trying to solve."

But as civil as the discussion, nuclear power is still grist for fireworks.

In Illinois, state prosecutor James Glasgow alleged in filing the lawsuit that Exelon operates within "a culture of greed and deception."

And in New York, Attorney General Elliot Spitzer, a Democrat running for governor, said last month that closing the Indian Point nuclear plant was "an environmental imperative."

URL: http://www.msnbc.msn.com/id/11996239/from/RSS/

Radioactive water found near Palo Verde

http://www.azcentral.com/news/articles/0303paloverde-ON.html

Ken Alltucker

The Arizona Republic

Mar. 3, 2006 07:12 PM

Arizona Public Service Co. discovered radioactive water near a maze of underground pipes at the Palo Verde Nuclear Generating Station this week and plans more tests to ensure that the tainted water hasn't leaked into the area's water supply.

Work crews discovered the tritium-laced water in an underground pipe vault near Palo Verde's Unit 3. Tests confirmed that the water contains more than three times the acceptable amount of tritium.

State officials say there is no immediate evidence that the tritium, a byproduct of nuclear power generation and a relatively weak source of radiation, poses any public health concerns.

"At this point, we don't have any reason to believe there has been any impact on the groundwater," said Steve Owens, director of the Arizona Department of Environmental Quality.

The Phoenix-based utility on Thursday notified the Department of Environmental Quality and the Nuclear Regulatory Commission of its discovery. Now, the utility will work with state and federal officials to pinpoint the source of the contaminated water and determine how far it has spread.

The Department of Environmental Quality will test soil and water at and near the plant in Wintersburg, about 50 miles west of downtown Phoenix. Aquifers about 70 feet and 200 feet underground supply water for the area.

Owens said the nearest public well is at a Wintersburg general store about three miles from the plant. Some homeowners operate private wells closer to the plant. On Wednesday, Palo Verde officials will conduct a public meeting at the plant for nearby residents, who will be notified about the time.

Craig Seaman, APS' director of regulatory affairs, said Palo Verde work crews on Tuesday discovered a small amount of water that appeared to leak into the pipe vault. Crews dug a 13-foot ditch, collected samples and conducted tests Wednesday that confirmed the presence of tritium.

Palo Verde crews discovered no evidence of contamination during past inspections at the plant's aquifers and wells. More tests are being conducted, and initial samples show no signs of tritium, Seaman said.

While a leaking pipe may be the source of the tritium, Seaman said APS could not rule out other sources. According to the plant's operating permit, tritium can be released into the air.

Tritium can be ingested or absorbed in human tissue. Small amounts of tritium pass through the body quickly, usually through urine. Exposure to tritium can increase the risk of cancer and birth defects

Several nuclear power plants around the country have reported tritium leaks.

In Illinois, Exelon pledged to help build a new public water system for a small township after tritium was discovered in groundwater and at least one private well. The utility, which was fined by Illinois environmental officials, also offered to buy bottled water for residents concerned about the water's safety.

Contact the reporter at ken.alltucker@arizonarepublic.com or (602)444-8285

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Free Press Online Newspapers
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Braidwood Journal
Coal City Courant

Wednesday, November 14, 2007

New tritium plume found

Public notified two months after initial discovery

Brandi Watters
Staff writer

Wednesday, November 14, 2007

CONCERNED RESIDENTS questioned Nuclear Regulatory Commission officials during Thursday's Community Information Night.

A new plume of tritiated water was discovered in Custer Park recently, Exelon officials announced Thursday at the company's Community Information Night event. According to Paul Dempsey of Exelon, the discovery was made Oct. 15 when the plume migrated north to the blowdown line located south of Smiley Road.

In November 2005, news broke that over 6 million gallons of tritium had leaked from Exelon's nuclear power plant in Braceville. Tritium is a radioactive hydrogen isotope. Small amounts of tritium occur naturally in water but is created in large quantities as a byproduct of nuclear generation. Tritium is believed to cause cancer.

The leaks occurred at various vacuum breakers along the blowdown line which carries tritiated water to the Kankakee River. The leaks began in 1996. Exelon officials have since admitted the first spills were handled inappropriately. The company has faced public criticism and litigation due to the spills. On Thursday, Al Haeger of Exelon revealed that there were 17 separate spills between 1996 and 2003.

After various plumes of tritiated water were discovered on and off plant property in 2005 and 2006, residents began worrying about the health risks of exposure to tritium.

The majority of wells tested within federal limits for tritium but at least one well contained dangerous amounts of the isotope. In December 2005, a well located at the northwest edge of the station's property contained 230,000 picocuries per liter (pCi/L) of tritium.

The U.S. Environmental Protection Agency's limit for tritium in drinking water is 20,000 pCi/Ls. At 10 times the safe limit for tritium, the site held the highest concentration of tritium in the area. Remediation efforts have since removed the majority of the contaminated water from the location.

Although the newest plume of tritium was discovered over two months ago, Exelon officials did not notify the local media or inform the public. Residents living in a home just north of the plume were immediately notified of its existence.

On Thursday, Haeger explained that area residents were not informed about the plume immediately because Exelon was not required to disclose the information. In fact, the company wasn't even required to notify the Illinois Environmental Protection Agency. Haeger says this is because the plume is not the result of a new spill. The water has been determined to be linked to a 2000 spill from vacuum breaker number two, located just south of Smiley Road in Custer Park.

When asked why the company was disclosing the information now, after waiting two months, Haeger replied. "We figured that here was the time to discuss [this] because we just now have this plan."

The plan, which was only recently formed, is to drill two recovery wells near the plume that will be pumped. Exelon hopes pumping the wells will draw all of the tritiated water into the pumps where it can then be sent down the blowdown line and dumped into the Kankakee River.

The plume currently contains up to 20,700 pcLs of tritium.

According to Haeger, the plume was not discovered in 2005 when most of the spills were revealed because testing near the site showed clear results. A handful of wells just south of the blowdown line were tested and showed acceptable levels of tritium, indicating that the spills were contained to the area north of the wells. Officials were pleased with the testing and did not expand the parameters of their search to the south.

It is now believed that the plume was located just south of the tested wells and has migrated north over the past seven years. Exelon officials plan to monitor the southern boundary of the spill-area but say they have no plans to test other borders surrounding the original plume.

The company has tested wells 1,000 feet north and south of the tritium contaminated area surrounding Smiley Road but say they will not expand their search to the north, east or west. They will focus, for now, on the plume that went unnoticed for seven years.

Related Links

Exelon. Nuclear

News Release

Contact: Bernadette Lauer
717-456-4818 (o)
717-817-1566 (c)

FOR IMMEDIATE RELEASE

Peach Bottom Station Environmental Monitoring Program Identifies Tritium On-site

DELTA, PA (July 10, 2009) - Peach Bottom nuclear plant workers performing environmental monitoring this week identified tritium in a localized area on plant property. The tritium was identified on July 8 from a sample that was drawn on July 6.

"This is not a public or employee health and safety issue, but we are committed to being open about the status of our plant operations," said Peach Bottom Site Vice President Bill Maguire.

The elevated levels of tritium were found in an area adjacent to the Peach Bottom Unit 3 turbine building. The turbine building is centrally located on plant property and a significant distance from plant boundaries. Plant engineering and environmental teams are working to locate the tritium source and make the necessary repairs. Additional sample testing is being performed to verify that the tritium is contained to the area where it was found. No detectable levels of tritium have been found off-site.

The plant maintains an extensive environmental monitoring program, including routine water sampling from 22 on-site dedicated monitoring wells designed to detect unusual levels of tritium in the environment. The highest sample concentration showed tritium levels of approximately 123,000 picocuries per liter of water. A picocurie is one-trillionth of a curie, which is a measurement of radioactivity.

Exelon Nuclear officials notified state and federal authorities on Thursday after tritium in a sample was confirmed. Exelon will keep government regulators and the public informed about the progress the plant makes on finding the source and making the necessary repairs.

"Our environmental monitoring program works," Maguire said. "It alerted us to the presence of tritium early so that we can address the issue quickly."

Tritium is a weak radiation emitter that is used commercially to make luminous dials and instruments, as a source of light for exit and safety signs, as a tracer for biochemical research and in ground water transport measurements, among other uses. A tritium fact sheet from the U.S. Environmental Protection Agency can be downloaded at http://www.epa.gov/radiation/radionuclides/tritium.html.

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Exelon Corporation is one of the nation's largest electric utilities with approximately $19 billion in annual revenues. The company has one of the industry's largest portfolios of electricity generation capacity, with a nationwide reach and strong positions in the Midwest and Mid-Atlantic. Exelon distributes electricity to approximately 5.4 million customers in northern Illinois and Pennsylvania and natural gas to approximately 485,000 customers in the Philadelphia area. Exelon is headquartered in Chicago and trades on the NYSE under the ticker EXC.

June 14, 2007

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE PNO-II-07-005

This preliminary notification constitutes EARLY notice of events of possible safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by Region II staff (Atlanta, Georgia) on this date.

Facility		**Licensee Emergency Classification**
Brunswick Steam Electric Plant		Notification of Unusual Event
Units 1 & 2		Alert
Southport, NC		Site Area Emergency
Dockets/License: 50-325, 50-324		General Emergency
	X	Not Applicable

Subject: Onsite Surface Water and Ground Water Tritium Contamination

On May 7, 2007, plant staff at the Brunswick Steam Electric Plant detected concentrations of tritium (hydrogen-3) in liquids collected from two man-holes located within the owner controlled area (OCA). The man-holes are adjacent to the plant's storm drain stabilization pond which collects water discharge from various locations in the plant as well as onsite storm drains. Additional water samples collected from locations adjacent to the stabilization pond within the OCA also had measurable concentrations of tritium ranging from approximately 30,000 - 900,000 pCi/L.

Licensee analyses of collected surface water samples in offsite areas, including Nancy Creek, which is adjacent to the pond but outside of the OCA, did not exceed background levels.

The licensee has begun implementation of an action plan to monitor and evaluate the extent and potential for movement of detectable tritium in the groundwater from the stabilization pond. This includes planned installation of additional groundwater sampling wells around the perimeter of the stabilization pond. The licensee also plans to continue to monitor Nancy Creek, onsite and offsite standing water for tritium and other radionuclides.

On June 13, 2007, the licensee determined that tritium levels in excess of the Nuclear Energy Institute (NEI) voluntary reporting criteria (greater than 30,000 pCi/L for onsite groundwater - this is an offsite dose calculation manual limit) were confirmed to be present in the new onsite shallow groundwater wells established around the perimeter of the stabilization pond. The highest level observed in the shallow groundwater wells was 506,500 pCi/L at a depth of 5-20 feet. A 10 CFR 50.72 (EN 43420) report was submitted with this information on June 13, 2007 at 11:51 a.m.

In addition to the shallow wells, the licensee has established two new intermediate depth wells (near the stabilization pond) into an aquifer (approximately 32-42 feet in depth) for tritium analysis. Samples from the two on-site wells were taken on June 13, 2007 (One sample from well 20B and two samples from well 19B). The main drinking water aquifer for the area is located at a depth of 150 feet. In conjunction with the licensee's sampling, the NRC obtained a split sample of the water drawn from the wells for independent analysis. The licensee has analyzed their samples and determined the following; Well 19B; first sample - 5073 pCi/L, second sample - 4426 pCi/L; Well 20B; sample - less than lower limit of detection. These sample results contain tritium levels less than the Environmental Protection Agency limit of 20,000 pCi/L for drinking water. Region II continues to inspect the licensee's actions in response to this issue.

On June 13, 2007, the licensee provided information to local residents who live near the plant regarding the discovery of tritium in surface level ground water at the site. The information includes a letter from the Vice President of the Brunswick Nuclear Plant and a Fact Sheet on tritium. The letter also announces an open house and information session that Progress Energy officials will hold on June 19, 2007. Additionally, a local weekly newspaper published an article on June 13, 2007 about this issue. To date, the licensee's analysis of several offsite samples has not identified elevated tritium levels nor gamma emitting radionuclides.

Additional information on groundwater contamination from tritium can be found at the NRC public web site at the following address: http://www.nrc.gov/reactors/operating/ops-experience/grndwtr-contam-tritium.html

Region II received initial notification of onsite surface water tritium contamination on May 11, 2007 when licensee management informed the Resident Inspector. The information presented herein has been discussed with the licensee, and is current as of 8:00 a.m. on June 14, 2007.

The state of North Carolina will be notified.

CONTACTS:	Randall A. Musser (404) 562-4603	George B. Kuzo (404) 562-4658	Brian R. Bonser (404) 562-4653

February 15, 2006

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE -- PNO-RIII-06-004

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by the Region III staff on this date.

Facility
Dresden 2 and 3
Exelon Generation Co.
Morris, Illinois
Docket: 50-237 and 50-249
License: DPR-19; DPR-25
Byron 1 and 2
Exelon Generation Co.
Byron, Illinois
Docket: 50-454 and 50-455
License: NPF-37; NPF-66

Licensee Emergency Classification
___ Notification of Unusual Event
___ Alert
___ Site Area Emergency
___ General Emergency
_X_ Not Applicable

SUBJECT: TRITIUM LEAKAGE

DESCRIPTION:

On February 10, 2006, Exelon's Dresden Station informed the resident inspectors and Region III (Chicago) that elevated levels of tritium (the radioactive isotope of hydrogen) had been measured in a monitoring well located near underground piping. The piping in the area goes from the condensate storage tank (CST) to the High Pressure Coolant Injection (HPCI) system. The pipe is located onsite.

In 2004, leakage was discovered in the CST to HPCI supply line pipe. The pipe is 175 feet long; the licensee replaced approximately 75 feet of piping where leaks had been identified in 2004. The licensee suspects that the current leak is in the 100 feet of piping that was not replaced at that time.

The sample result on February 11, 2006, was 486,000 picocuries per liter (pCi/L), on February 12, 2006, was 529,000 pCi/L, on February 13, 2006, was 680,000 pCi/L, and on February 14, 2006, was 540,000 pCi/L.

The pipe was isolated on February 11, 2006. The licensee plans to drain the pipe. The licensee had planned to replace the pipe in June 2006, but is considering an adjustment to the schedule for replacement.

Also, on February 10, 2006, Exelon's Byron Station informed the resident inspectors and Region III (Chicago) that elevated levels of tritium in water had been identified in several vacuum breaker vaults located along the discharge piping.

CONTACTS:

Mark Mitchell 630/829-9855

Steven Orth 630/829-9827

This piping is on plant property. The piping is approximately 2.5 miles long normally carrying non-radioactive circulating water to the Rock River. The discharge pipe is also used for planned liquid radioactive effluent releases with effluent mixing with the discharge water. The licensee is pursuing installation of monitoring wells adjacent to the piping to determine if tritium has migrated from the vaults.

The licensee sampled water in 5 vaults along the pipeline. The tritium concentrations ranged from 256 pCi/L to 86,000 pCi/L.

Resident inspectors and Region III staff are monitoring the licensee's activities. Based on current information, the effects of the leakage are localized to the immediate area.

The licensee is issuing a news release regarding the tritium issues at Braidwood, Byron, and Dresden and announcing program for tritium assessment at all 10 of the Exelon Nuclear Generating sites.

The State of Illinois has been notified. The information in this preliminary notification has been reviewed with licensee management and is current as of 9 a.m. on February 15, 2006.

August 14, 2006

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE -- PNO-III-06-019

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by the Region III staff on this date.

Facility	Licensee Emergency Classification
Kewaunee Nuclear Power Plant	___ Notification of Unusual Event
Dominion Generation Co.	___ Alert
Kewaunee WI	___ Site Area Emergency
Docket: 50-305	___ General Emergency
License: DPR-43	X Not Applicable

SUBJECT: TRITIUM DETECTED IN GROUNDWATER BENEATH PLANT BUILDINGS

DESCRIPTION:

On August 9, 2006, the plant staff detected measurable tritium (hydrogen-3) in small amounts of ground water found at several locations beneath the auxiliary and turbine buildings. The groundwater had infiltrated into narrow shafts beneath the two buildings which are used to measure possible settling of the structures.

Tritium measurements, detected in four shafts, ranged from 282 picoCuries per liter (near the lower level of detectability) to 103,000 picoCuries per liter. The shafts are not interconnected.

The levels measured do not meet the threshold for reporting to the NRC, but the licensee has informed local and state agencies of the situation. The licensee reported that no detectable levels of tritium have been found in environmental monitoring wells both on and off the plant site.

The licensee is investigating possible sources of the tritium and plans to evaluate the situation further. The onsite NRC resident inspectors and an NRC radiation specialist have reviewed the licensee's analytical results and continue to monitor the licensee's activities.

The information in this preliminary notification has been reviewed with licensee management. The licensee issued a news release on August 11, 2006.

The licensee notified the NRC Operations Center of this situation at 3:40 p.m. CDT on August 10, 2006. This information is current as of 9 a.m. CDT on August 14, 2006.

CONTACTS:

Stephen Burton	Patrick Louden
920-388-3156	630-829-9627

March 17, 2006

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE -- PNO-IV-06-001

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by the Region IV staff on this date.

Facility	Licensee Emergency Classification
Palo Verde Nuclear Generating Station	___ Notification of Unusual Event
Arizona Public Service Company	___ Alert
Tonopah, Arizona	___ Site Area Emergency
Docket: 50-528, 50-529, and 50-530	___ General Emergency
License: NPF-41; NPF-51, and NPF-74	_X_ Not Applicable

SUBJECT: FOLLOWUP FOR TRITIUM CONTAMINATION FOUND IN WATER ONSITE

DESCRIPTION:

On March 1, 2006, a water sample collected by the licensee from a test hole located within the licensee's Unit 3 Protected Area identified tritium levels of 71,400 picocuries/Liter (pCi/L). On March 2, 2006, the licensee notified the Arizona Department of Environmental Quality (ADEQ) that a release of tritium had occurred that had the potential to cause the EPA drinking water limit (20,000 pCi/L) for tritium to be exceeded in a groundwater aquifer. As required by 10 CFR Part 50.72(b)(2)(xi) the licensee also notified the NRC (Event # 42381).

Since February 15, 2006, the licensee has been investigating the source of water leakage into an underground pipe tunnel located within the Protected Area of Units 2 and 3. Test holes were drilled inside the Protected Area in an area between all three Units power block and spray pond in an effort to find the source of the tritiated water. A water sample that contained the elevated tritium levels was from the Unit 3 test hole.

As part of the NRC's followup to the onsite elevated tritium levels, NRC Region IV obtained a split water sample from the Unit 3 test hole for the NRC's independent analysis on March 3, 2006. The NRC's independent laboratory analyzed the spilt sample for tritium and gamma radioactive isotopes and results were consistent with the 71,400 pCi/L value obtained by the licensee.

On March 6, 2006, NRC Region IV, dispatched a Senior Health Physicist to supplement the NRC's onsite resident staff and further review the licensee's actions. To date the NRC's review has determined: (1) The tritiated water at elevated levels is confined onsite; (2) No elevated levels have been found in wells located outside the Protected Area. From a review of the analyzed sample results from both onsite and offsite groundwater monitoring wells, the NRC has found no evidence of an offsite release of the radioactive water.

The apparent cause or source of the elevated tritium levels in the test holes has not been found/determined to date and is still under investigation by the licensee. NRC Region IV health physicists and the resident inspectors continue to monitor the licensee's activities to address the source of the elevated tritium as well as and the licensee's measures to ensure it will be confined onsite. NRC Region IV is in the process of obtaining additional environmental water samples from the Palo Verde site and surrounding areas.

The information presented herein has been discussed with the licensee and is current as of 11 a.m. (CST) on March 17, 2006.

ADAMS ACCESSION NUMBER: ML060760584

CONTACTS: Michael P. Shannon, Chief
Plant Support Branch
817-860-8215
mps1@nrc.gov

Louis C. Carson, II
Senior Health Physicist
817-860-8221
lcc1@nrc.gov

Exhibit B

to

Riverkeeper, Inc.'s Comments on the NRC's "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 74 Fed. Reg. 38,117, 10 C.F.R. Part 51, RIN 3150-AI42, NRC-2008-0608 (July 31, 2009).

Riverkeeper, Inc.'s Request for Hearing and Petition to Intervene in Indian Point License Renewal Proceeding, November 30, 2007*

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* Riverkeeper's internal exhibits to this Petition are omitted, with the exception of Attachment 2 to Riverkeeper Contention EC-1: "The Status of Fish Populations and the Ecology of the Hudson," Pisces Conservation Ltd. (November 2007) and Attachment 3 to Riverkeeper Contention EC-1: "Entrainment, Impingement and Thermal Impacts at Indian Point Nuclear Power Station," Pisces Conservation Ltd. (November 2007).

CONTENTION EC-1

EXHIBITS

1. Declaration of Dr. Peter Henderson in Support of Riverkeeper's Contention EC-1

   Attachment 1: Curriculum Vitae

   Attachment 2: *The Status of Fish Populations and the Ecology of the Hudson* (November 2007)

   Attachment 3: *Entrainment, Impingement and Thermal Impacts at Indian Point Nuclear Power Station* (November 2007)

2. Declaration of Dr. Richard Seaby in Support of Riverkeeper's Contention EC-1

   Attachment 1: Curriculum Vitae

November 30, 2007

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
Lawrence G. McDade, Chairman
Dr. Richard E. Wardwell
Dr. Kaye D. Lathrop

In the Matter of	)	
	)	
Entergy Nuclear Operations, Inc.	)	Docket Nos.
(Indian Point Nuclear Generating	)	50-247-LR
Units 2 and 3)	)	and 50-286-LR

RIVERKEEPER, INC.'S REQUEST FOR HEARING AND PETITION TO INTERVENE IN THE LICENSE RENEWAL PROCEEDING FOR THE INDIAN POINT NUCLEAR POWER PLANT

I. INTRODUCTION

Pursuant to 10 C.F.R. § 2.309 and a notice published by the Nuclear Regulatory Commission ("NRC" or "Commission") at 72 Fed. Reg. 42,134 (August 1, 2007), as amended at 72 Fed. Reg. 60,394, Riverkeeper, Inc. ("Riverkeeper") hereby requests a hearing and petitions to intervene in this proceeding on the adequacy of Entergy Nuclear Operations, Inc.'s ("Entergy's) application for renewal of the operating licenses for the Indian Point nuclear power plant, Units 2 and 3 ("IP2" and "IP3"). As demonstrated below, Riverkeeper has standing to challenge Entergy's license renewal application and has submitted five admissible contentions demonstrating the inadequacy of Entergy's license renewal application to satisfy the NRC's safety regulations and the National Environmental Policy Act ("NEPA") and its implementing regulations.

As set forth in Riverkeeper's contentions, the NRC should reject Entergy's application because it fails to satisfy NRC requirements for the protection of aging equipment from fatigue and flow-accelerated corrosion. *See* Riverkeeper's Contentions TC-1 and TC-2. In addition, Entergy's Environmental Report ("ER") is inadequate to satisfy NEPA because it grossly understates the environmental impacts of continued operation of Indian Point on aquatic life and understates the benefits of alternatives that would mitigate or avoid those impacts. Entergy's ER also underestimates the benefits of severe accident mitigation alternatives ("SAMAs") by understating the severity of the environmental impacts that would be avoided or mitigated by implementing SAMAs. Finally, Entergy's ER is inadequate because it fails to provide an adequate evaluation of the environmental impacts of leakage of radioactive water from the Unit 1 and Unit 2 spent fuel storage pools on groundwater quality and the Hudson River ecosystem.

II. DESCRIPTION OF PROCEEDING

This proceeding concerns Entergy's April 23, 2007, application to renew the operating licenses for the Indian Point nuclear power plant for additional 20-year terms. IP2's operating license is now due to expire on September 9, 2013, and would be extended until 2033. IP3's operating license is now due to expire on December 12, 2015 and would be extended until 2035.

The NRC may not approve Entergy's license renewal application unless and until it finds that Entergy has satisfied the safety requirements of 10 C.F.R. Part 54 with respect to renewal of nuclear power plant licenses. Entergy and the NRC must also comply with NEPA by addressing the environmental impacts of license renewal and weighing the costs and benefits of alternatives for mitigating or avoiding those impacts. 10 C.F.R. § 51.95(c).

II. DESCRIPTION OF PETITIONERS

Riverkeeper is a 501(c)(3) non-profit membership organization whose mission is to safeguard the ecological integrity of the Hudson River, its tributaries, and the watershed of New York City (protecting the city's water supply) by tracking down and stopping polluters. Since 1983, Riverkeeper has investigated and brought to justice more than 300 environmental lawbreakers. Riverkeeper believes in the rights of every citizen to enjoy and defend our nation's water resources.

Riverkeeper is incorporated in the State of New York, with headquarters and property located in Tarrytown, approximately 22 miles from the Indian Point nuclear power plant. Riverkeeper has been involved over the last twenty years in raising environmental concerns regarding Indian Point's operation. Riverkeeper also has numerous members that reside within twenty miles of Indian Point, and others who reside within a fifty mile radius of the plant.

III. RIVERKEEPER HAS STANDING TO REQUEST A HEARING.

The standing requirements for NRC hearings derive from the Atomic Energy Act ("AEA"), which requires the NRC to provide a hearing "upon the request of any person whose interest may be affected by the proceeding." 42 U.S.C. 2239(a)(1)(A). Riverkeeper has standing on its own behalf and on behalf of its members to request a hearing on Entergy's license renewal application. Riverkeeper's members have concrete and particularized interests that will be directly affected by this proceeding.

A. Riverkeeper Has Standing On Its Own Behalf.

As stated in the attached Declaration of Stella LiRosi (November 6, 2007) (Standing Exhibit 1), Riverkeeper's offices are located at 828 South Broadway, Tarrytown, New York, approximately 22 miles from Indian Point. Riverkeeper's offices house the organization's records and archives dating back twenty years. In addition, the offices contain the organization's computer network and servers, Riverkeeper membership database, and the office furnishings and equipment required for the organization to function on a daily basis.

Riverkeeper is concerned that the proposed license renewal of Indian Point increases the risk of an accident or terrorist attack on Indian Point that could result in a catastrophic offsite release of radiation, resulting in long-lasting public health and environmental damage to the Hudson Valley region. Such a release could also result in radiological contamination that would negatively impact the value of the organization's property and interfere with the organization's ability to conduct normal operations. Riverkeeper therefore qualifies for intervention pursuant to 10 C.F.R. §2.309(d).

B. Riverkeeper has representational standing

An organization has standing to sue on behalf of its members when a member would have standing to sue in his or her own right, the interests at issue are germane to the organization's purpose, and participation of the individual is not necessary to the claim or requested relief. *Hunt v. Washington State Apple Advertising Commission,* 432 U.S. 333, 343 (1977). As the Commission has applied this standard, an individual demonstrates an interest in a reactor licensing proceeding sufficient to establish standing by showing that his or her residence is within the geographical area that might be affected by an accidental release of fission products. This "proximity approach" presumes that the elements of standing are satisfied if an individual lives within the zone of possible harm from the source of radioactivity. *See Virginia Elec. and Power Co.* (North Anna Nuclear Power Station, Units 1 ad 2), ALAB-522, 9 NRC 54, 56 (1979)("close proximity [to a facility] has always been deemed to be enough, standing alone, to establish the requisite interest" to confer standing). The Commission's "rule of thumb" in reactor licensing proceedings is that "persons who reside or frequent the area within a 50-mile radius of the facility" are presumed to have standing. *Sequoyah Fuels Corp. and General Atomics* (Gore, Oklahoma Site), CLI-94-12, 40 NRC 64, 75 n.22 (1994). *See also Duke Energy Corp.* (Oconee Nuclear Station, Units 1, 2, and 3), LBP-98-33, 48 NRC 381, 385 n.1 (1998).

The attached declarations demonstrate that Riverkeeper has members that reside within twenty miles of Indian Point, whose particular interests are directly affected by this matter, and who have authorized Riverkeeper to participate in this proceeding on their behalves. *See* Declaration of Alan A. Hemberger (November 6, 2007) (Standing Exhibit 2); Declaration of Andre P. Mele (November 6, 2007) (Standing Exhibit 3); Declaration of Nancy Syrop (November 7, 2007) (Standing Exhibit 4); and Declaration of Glenn Rickles (November 7, 2007) (Standing Exhibit 5). Many additional members live within fifty miles of the plant, and thus are subject to radiological contamination, evacuation, loss of property, or other harms in the event of a significant radiological release at the plant. Members also use and enjoy the Hudson River for recreation and aesthetic enjoyment. *See* declarations of Nancy Syrop and Andre Mele.

As is demonstrated by the above discussion and attached declarations, the members represented by Riverkeeper would all have standing in their own right. The issues are germane to Riverkeeper's purpose. And the individual participation of the members is not necessary to the claims or requested relief.

C. Riverkeeper meets prudential standing requirements

Courts have created a prudential standing requirement that a plaintiffs must interests fall within the "zone of interests" protected by the statute on which the claim is based. *Bennett v. Spear,* 520 U.S. 154, 162 (1997). The AEA and NEPA -- the statutes at issue here -- protect the same interests held by Riverkeeper's members and furthered by Riverkeeper's purpose.

IV. CONTENTIONS

Riverkeeper submits five contentions challenging Entergy's compliance with NRC safety regulations for license renewal and NEPA and its implementing regulations. As directed by the NRC's Federal Register notice of August 8, 2007, "technical" contentions addressing noncompliance with NRC safety regulations are designated with the prefix "TC." "Environmental" contentions addressing noncompliance with NEPA are designated with the prefix "EC."

Riverkeeper's contentions satisfy the requirements of 10 C.F.R. § 2.309(f), because they provide a specific statement of the issues of law and/or fact to be controverted, identifying the particular aspects of the license renewal application or ER with which Riverkeeper has a dispute. The contentions also show the issues raised by the contentions are material to the NRC's license renewal decision and within the scope of this proceeding. Finally, the contentions are supported by documentation and/or expert opinion, sufficient to show that a "genuine dispute exists with the applicant/licensee on a material issue of law or fact."
10 C.F.R. § 2.309(f)(1)(vi).

CONTENTION TC-1: INADEQUATE TIME LIMITED AGING ANALYSES AND FAILURE TO DEMONSTRATE THAT AGING WILL BE MANAGED SAFELY

Contention: Entergy's LRA fails to satisfy 10 C.F.R. § 54.21(c)(1) in the following respects:

1. Tables 4.3-13 and 4.3-14 identify four representative reactor coolant components for which Entergy's evaluation of Time Limited Aging Analyses ("TLAAs") is facially non-compliant with the standard of 10 C.F.R. § 54.21(c)(i)-(ii) for avoiding a demonstration, under 10 C.F.R. § 54.21(c)(iii), that it will adequately manage the effects of aging on the intended functions of the components during the license renewal term. For these four components – pressurizer surge line piping (IP2 & IP3), the RCS piping charging system nozzle (IP2), and pressurizer surge line nozzles (IP3) – the environmentally adjusted cumulative usage factor ("CUF) estimated by Entergy exceeds the regulatory threshold for submitting an aging management program. Yet, Entergy has failed to broaden its TLAA analysis beyond the scope of the representative components identified in Tables 4.3-13 and 4.3-14 to identify other components whose CUF may be greater than one; nor has it submitted any demonstration that it will adequately manage the aging of components with a CUF greater than one. Therefore Entergy's LRA does not satisfy 10 C.F.R. §§ 54.21(c) or (c)(iii).

2. Entergy's list of components with CUFs of less than one in Tables 4.3 -13 and 4.3-14 is incomplete, because Entergy's methods and assumptions for identifying those components are unrealistic and inadequate.

3. For a number of other components subject to the license renewal regulations, which are listed in Tables 4.3-3 through 4.3-12, Entergy has also failed to perform complete TLAAs. The TLAAs for these components are incomplete because

they omit consideration of the exacerbating effects of environmental conditions on the fatigue of metal components. Therefore Entergy has failed to satisfy 10 C.F.R. § 54.21(c)(1)(i)-(ii). Nor has Entergy submitted an aging management program for these components, as required by 10 C.F.R. § 54.21(c)(1)(iii).

Basis:

A. Expert Support for Contention

This contention is supported by the expert Declaration of Dr. Joram Hopenfeld (November 28, 2007). As stated in Dr. Hopenfeld's declaration, the factual assertions in the contention are true and correct to the best of his knowledge, and the expressions of opinion are based on his best professional judgment.

B. Fatigue-related Aging of Nuclear Power plant Components

Aging effects on intended functions of nuclear power plant equipment include fatigue or "cyclic stress" of metal parts due to repeated stresses during plant operation. Material composition, strain rate, temperature and local water chemistry are some of the factors that contribute to fatigue of metal parts. Equipment failures from fatigue may result in small leaks which if not detected in time could result in a pipe rupture. Fatigue may also create small cracks that propagate and cause a given component to malfunction and/or break up and form loose parts which would interfere with the safe operation of the plant. Such failures may occur during steady state or during anticipated or unanticipated transients and may have serious consequences to public health and safety. For example, if one of the feed water distribution nozzles (J-tubes) were to fail from fatigue, pieces from the broken nozzle could be lodged between steam generator tubes, causing the tubes to rupture and leading to a potential core melt. Components which are susceptible to fatigue therefore must have a planned management program to ensure that the plant functions efficiently and safely.

C. NRC Regulations and Guidance Governing Management of Aging Components

1. Regulations

NRC regulation 10 CFR § 54.21(c) requires that each license renewal application must include "an evaluation of time-limited aging analyses" ("TLAA") for components covered by the license renewal regulations.[1] If the applicant is unable to demonstrate that TLAAs "remain valid for the period of extended operation" or that they "have been projected to the end of the period of extended operation," it must demonstrate that "the effects of aging on the intended function(s) will be adequately managed for the period of extended operation." 10 C.F.R. 54.21(c)(1)(i)-(iii). An aging management plan must provide sufficient detail to "*demonstrate*" that the applicant "*will*" adequately manage aging of equipment; it is not sufficient to merely "summarize options for future plans." *Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc.* (Vermont Yankee Nuclear Power Station), LBP-06-20, 64 NRC 131, 186 (2006) (emphasis in original) (admitting contention challenging insufficiency of license renewal applicant's description of program for management of fatigue).

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[1] TLAAs are defined as:

Those licensee calculations and analyses that:

(1) Involve systems, structures, and components within the scope of license renewal, as delineated in § 54.4(a);
(2) Consider the effects of aging;
(3) Involve time-limited assumptions defined by the current operating term, for example, 40 years;
(4) Were determined to be relevant by the licensee in making a safety determination;
(5) Involve conclusions or provide the basis for conclusions related to the capability of the system, structure and component to perform its intended functions, as delineated in § 54.4(b); and
(6) Are contained or incorporated by reference in the CLB [current licensing basis].

2. Regulatory guidance for TLAAs

The NRC provides guidance for the conduct of TLAAs in NUREG-1800, Rev. 1, *Standard Review Plan for Renewal Applications for Nuclear Power Plants* ("SRP"). According to Section 4.3.1.1 of the SRP, metal components may be designed or analyzed based on requirements in the American Society of Metal Engineers ("ASME") Boiler and Pressure Vessel Code or the American National Standards Institute ("ANSI") guidance. An ASME Section III Class I fatigue analysis requires the calculation of the CUF, based on the fatigue properties of the materials and the expected fatigue service of the component." In order to be acceptable, a CUF value must be less than or equal to one. *Id.*, § 4.3.1.1.1. The factors considered in the fatigue analysis must include "the effects of coolant environment on component fatigue life." *Id.*, § 4.3.1.2. Those components with a CUF greater than one are deemed likely to develop cracks and must therefore be subjected to further analysis and management under 10 C.F.R. § 54.21(c)(1)(iii).

NUREG-1801, Rev. 1, *Generic Aging Lessons Learned (GALL) Report* (2005) ("NUREG-1801") also provides guidance for the preparation of TLAAs.[2] NUREG-1801 advises that a license renewal applicant may comply with the regulations by addressing "the effects of the coolant environment on component fatigue life by assessing the impacts of the reactor coolant environment on a sample of critical components for the plant." *Id.*, Vol. 2 at X M-1. Examples of critical components are identified in NUREG/CR-6260, *Application of NUREG/CR-5999 Interim Fatigue Curves to Selected Nuclear Power Plant Components* (1995). The sample of critical components "can be evaluated by applying environmental life correction factors to the

[2] NUREG-1801 is referenced with approval in Regulatory Guide 1.188, Rev. 1, *Standard Format and Content for Applications to Renew Nuclear Power Plant Operating Licenses* (2005) ("Reg. Guide 1.188").

existing ASME Code fatigue analyses." NUREG-1801, Vol. 2 at X M-1. If these components are found not to comply with the acceptance criteria (*i.e.*, CUF less than one), "corrective actions" that must be taken "include a review of additional affected reactor coolant pressure boundary locations." *Id.* at X M-2. As explained further in industry guidance document MRP-47:

> The locations evaluated in NUREG/CR-6260 [2] for the appropriate vendor/vintage plant should be evaluated on a plant-unique basis. For cases where acceptable fatigue results are demonstrated for these locations for 60 years of plant operation including environmental effects, additional evaluation or locations need not be considered. However, plant-unique evaluations may show that some of the NUREG/CR-6260 [2] locations do not remain within allowable limits for 60 years of plant operation when environmental effects are considered. In this situation, plant specific evaluations should expand the sampling of locations accordingly to include other locations where high usage factors might be a concern.

MRP-47, Revision 1, Electric Power Research Institute, *Materials Reliability Program: Guidelines for Addressing Fatigue Environmental Effects in a License Renewal Application* at 3-4 (2005) ("MRP-47").

3. Regulatory guidance for aging management programs

A license applicant that is unable to demonstrate in its TLAAs that CUFs are less than one must develop and submit a methodology to manage fatigue so that public health and safety during the life extension period will be maintained at least at the current level. NUREG-1801 states that the requirements of 10 C.F.R. Part 50 Appendix B set forth "acceptable" corrective actions for components that are subject to aging management. The Part 50 corrective actions are as follows:

> Measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformance are promptly identified and corrected. In the case of significant conditions adverse to quality, the measures shall assure that the cause of the condition is determined and corrective action taken to preclude repetition. The identification of the significant condition adverse to quality, the cause of the condition, and the corrective action shall be documented and reported to appropriate levels of management.

10 C.F.R. Part 50, Appendix B, Section XVI. In Dr. Hopenfeld's professional opinion, therefore, an aging management program should (a) provide a reliable method for detecting cracks in pressure systems, (b) provide for a thorough assessment of the component's condition (which may include stress analysis), and (c) contain criteria for deciding whether the component should be repaired or replaced or merely monitored. If monitoring is selected, the frequency of monitoring must be clearly specified, as required by ASME Section XI, Appendix L (1998).[3]

C. Inadequacy of Entergy's Aging Analysis

1. In Section 4.3 of its LRA, Entergy acknowledges that its TLAAs for selected representative components show the environmentally adjusted CUF for a number of components will exceed one during the license renewal term. *See* LRA at 4.3-22 and Tables 4.3-13, 4.3-14. Therefore, on their faces, the TLAAs for these components do not satisfy 10 C.F.R. § 54.21(c)(1)(i) or (ii). As a result, Entergy must "demonstrate that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation." 10 C.F.R. § 54.21(c)(1)(iii).

Entergy's LRA provides no information about how it will manage the effects of aging, however. Instead, the LRA states that Entergy will choose among three options: (a) "[r]efine" the fatigue analysis to determine CUFs less than one, (b) "[m]anage" the effects of aging by an inspection program, or (c) "[r]epair or replace the affected locations before exceeding a CUF of 1.0" LRA at 4.3-22. But none of these options satisfies the regulations.

Option (a) is unacceptable because the regulations require that either the LRA must show a CUF less than one or submit an aging management plan. The

3 Appendix L is currently being revised.

regulations cannot be satisfied by stating that the applicant will try again later to determine a CUF of less than one. In any event, in the expert view of Dr. Joram Hopenfeld (*see* attached Declaration), Entergy will not be able to reduce CUFs significantly if it tries again, because many CUFs approach unity, even without an environmental correction. By proposing option (a), Entergy also misses the point of the NRC guidance that the components in Tables 4.3-13 and 4.3-14 are merely representative, and if they fail to meet the acceptance criteria Entergy must examine a broader scope of equipment, not just replace or repair a few selected components.

Option (a) is also unacceptable because it is Dr. Hopenfeld's opinion that Entergy will not be able to reduce CUFs significantly since many CUFs without the environmental correction already approach unity and the number of transients could increase as the plant ages.

Options (b) and (c) are also unacceptably vague. In order to demonstrate that aging will be managed effectively, Entergy must provide a description of its monitoring program that includes a clear definition of the type and the frequency of inspections in order to assure that the component is repaired or replaced in a timely manner. Entergy must also specify criteria for repair or replacement. Entergy provides no information abut these key elements that control component replacement and repair.

Entergy's failure to provide an aging management program for these components violates 10 C.F.R. § 54.21(c)(1)(iii). Before Entergy is allowed a license extension it must submit a list of all components with CUF larger than unity and an aging management program that includes clear criteria for determining when a defect in any one of these components is acceptable, when it is acceptable but requires monitoring, and when it is unacceptable and requires repairs.

2. Entergy's list of components with CUFs of less than one in Tables 4.3 -13 and 4.3-14 is incomplete, because its methods and assumptions for identifying those components are unrealistic and inadequate in several key respects. First, based on data in NUREG/CR-6909, Effect of LWR Coolant Environment on Fatigue Life of Reactor Materials , Final Report (February 2007), Dr. Hopenfeld believes that Entergy used an unrealistically low number of 2.45 for an environmental correction factor ("Fen"). In Dr. Hopenfeld's expert judgment, a Fen of 17 would be more consistent with the data in NUREG/CR-6909.

Second, Entergy inappropriately used the "CUF of Record," i.e., the CUF for 40 years in Tables 4.3-13 & 4.3-14 of the LRA. But the regulations and regulatory guides required Entergy to project the number of cycles to 60 years. 10 C.F.R. 54.21(c)(1)(ii), MRP-47 at 3-4.

Finally, Entergy claimed that it did not calculate several NUREG-CR/6260 limiting locations because they were designed to ANSI B3.1.1, and therefore the CUFs were not available for the IP plant. LRA at Tables 4.3-13 and 4.3-14. But Entergy could and should have substituted the unavailable data with generic CUF values from NUREG-CR/6260, *Application of NUREG-CR-5999 Interim Fatigue Curves to Selected Nuclear Power Plant Components* (NRC: 1995).

If appropriate methods and assumptions were used, the number of components that exceed unity would be much larger than depicted by Entergy in Tables 4.3-13 and 4.3-14. At a minimum four components in Tables 4.3-13 and three components in Table 4-14 would exceed unity.

3. Having identified some components in Tables 4.3-13 and 4.3-14 for which the CUF exceeded unity, Entergy was required to expand the scope of the TLAAs in which it considers environmental effects on component fatigue. *See* NUREG-1801,

Vol. 2 at X M-1 – X M-2, MRP-47 at 3-4. Entergy's LRA does not meet this requirement because it fails to show that environmental conditions were taken account in estimating the CUFs for components listed in Tables 4.3-3 – 4.3-12. In essence those tables are based on the assumption that the listed components operate in air alone, while in fact these components operate in very harsh environments that include water and steam, and that are known to reduce fatigue life. In Dr. Hopenfeld's professional opinion, based on Fens which have been reported in the literature regarding component fatigue, (*see* NUREG/CR-6909 and Makoto Higuchi, *Revised Proposal of Fatigue Life Correction Factor Fen for Carbon and Low Alloy Steels in LWR Water Environments*, Transactions of the ASME, Vol. 1126 at 436-38 (November 2004)), it would be reasonable to apply a representative correction factor of seventeen to the CUFs in Tables 4.3-3 through 4.3-12. Applying a factor of seventeen shows that the CUF of many components in those tables would exceed 8.5.

Thus, Entergy's TLAAs for the components in Tables 4.3-3 – 4.3-12 violate 10 C.F.R. § 54.21(c)(1)(i)-(ii) and NRC guidance because they do not take into account environmental factors. Entergy also violates 10 C.F.R. § 54.21(c)(1)(iii) because it has not demonstrated how it will manage the aging of those components.

CONTENTION TC-2- FLOW ACCELERATED CORROSION (FAC)

Contention: Entergy's program for management of Flow Accelerated Corrosion (FAC) -- an aging phenomenon with significant safety implications -- fails to comply with 10 C.F.R. § 54.21(a)(3)'s requirement that:

> For each structure and component identified in paragraph (a)(1) of this section, demonstrate that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the period of extended operation.

Entergy also fails to follow the guidance of NUREG-1800, which requires that an aging management program, including a FAC program for life extension, must address each of the following elements:

(1) Scope
(2) Preventative actions
(3) Parameters monitored or inspected
(4) Detection of aging effects
(5) Trending
(6) Acceptance criteria
(7) Corrective actions
(8) Confirmation processes
(9) Administrative processes
(10) Operating experience

NUREG-1800, § A.1.2.3.

Entergy's program for management of FAC is deficient because it has not demonstrated that components in the Indian Point nuclear power plant that are within the scope of the license renewal rule and are vulnerable to FAC will be adequately inspected and maintained during the license renewal term. In particular, Entergy's program for management of FAC is deficient because it relies on the computer code CHECWORKS, without sufficient benchmarking of the IP operating parameters. In addition, Entergy's license renewal application fails to specify the method and frequency of component inspections or criteria for component repair or replacement.

Basis:

A. Expert Support for Contention

This contention is supported by the expert Declaration of Dr. Joram Hopenfeld (November 29, 2007). As stated in Dr. Hopenfeld's declaration, the factual assertions in the contention are true and correct to the best of his knowledge, and the expressions of opinion are based on his best professional judgment.

B. Nature and Safety Significance of FAC

FAC is a pipe wall thinning phenomena in which the thinning rate is accelerated by flow velocity. FAC includes wall thinning by electrochemical corrosion, erosion-corrosion and cavitation- erosion. Although the mechanism of wall damage is different in each case, all three mechanisms are affected to one degree or another by flow velocities and there is no practical reason to categorized them separately as some have suggested. Although the main causes of FAC (turbulence intensity, steam quality, material compositions, oxygen content and coolant pH) have been identified, the behavior of FAC is not completely understood.

Wall thinning is a local phenomenon. Local geometry, local metal composition and local turbulence affect FAC rates. Grooving and the formation of round holes are a manifestation of the interplay between these parameters. Once local corrosion has begun, geometrical changes as they occur may further intensify the local turbulence, thereby increasing FAC in a non linear rate.[4] The identification of locations where FAC rates are the highest is made difficult by the fact that the local turbulence is not a directly measured quantity, nor is the local flow velocity. In operating plants one must use thermal hydraulic computer codes such as RELAP to calculate average velocities through out the plant. Because of this indirect method of determining turbulence, considerable data must be collected over a period of time to assure that the location with the highest propensity for FAC are properly identified.

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[4] For instance, in a 1986 accident at the Surry nuclear power plant, some areas on the failed feed water pipe elbow were almost completely eroded while adjacent areas were much less affected. The J-tubes on the distribution feed ring exhibited a similar phenomenon. NRC Information Notice No 86-106 " Feed water Line Break" (Dec 16, 1986); NRC Bulletin 87-01 " Thinning Pipe Walls in Nuclear Plants" (July 9, 1987).

If unaddressed, FAC poses a significant safety risk at nuclear power plants, as demonstrated by numerous instances of unaddressed FAC:

- In 1986, FAC caused the rupture of a feed water pipe elbow in the Surry nuclear power plant, resulting in several fatalities. NRC Information Notice No 86-106 " Feed water Line Break" (Dec 16, 1986); NRC Bulletin 87-01 " Thinning Pipe Walls in Nuclear Plants" (July 9, 1987).
- In July 2004 FAC in the secondary loop at the Mihama nuclear power plant resulted in the killing of several workers. NRC Information Notice 2006-008, "Secondary Piping Rupture at Mihama Power Station in Japan" (March 16, 2006) (ML 05291008).
- In 1991 and 1993, the feed ring and the J tubes at San Onofre steam generators failed as a result of FAC. NRC Information Notice 1991-019, "Steam Generator Feed water Distribution Piping Damage" (March 12, 1991) (ML031190553); Morning Report 5-93-0042, "Steam Generator Feedring Nozzle Through Wall Erosion" (June 15, 1993) (ML020630459).
- In 1997, extraction steam piping ruptured at the Fort Calhoun Station. NRC Information Notice 1997-084, "Rupture of Extraction Steam Piping" (December 11, 1997) (ML031050037).

C. NRC Requirements for Identifying and Managing FAC

As discussed above, NRC regulation 10 C.F.R. § 54.21(a)(3) requires license renewal applicants to have a program for effectively managing aging. According to the NRC guidelines in NUREG 1800, § A.1.2.3.4, the detection of wall thinning due to FAC should occur before there is a loss of the structure and the component intended function(s). Wall thinning must be monitored or inspected to ensure that the structure and component intended function(s) will be adequately maintained for license renewal under all CLB design conditions. Sample size and frequency of wall thinning measurements must be conducted in a timely manner so as not to exceed the minimum design thickness of a given component. The licensee must provide information that links the parameters to be monitored or inspected to wall thinning. *Id.*

D. Description of Entergy's Program for Addressing FAC During License Renewal Term

In Sections A.2.1.14 and B.1.15 of the LRA Entergy describes its program for the management of FAC as:

> An existing program that applies to safety-related and non-safety-related carbon and low alloy steel components in systems containing high-energy fluids carrying two-phase or single-phase high-energy fluid ≥ 2% of plant operating time.

Entergy's program is based on EPRI guidelines (NSAC 202L-R2) that outline how to predict, detect, and monitor FAC in piping and other pressure-retaining components. The program includes (a) an evaluation to determine critical locations, (b) initial operational instructions to determine the extent of thinning at these locations, and (c) follow-up inspections to confirm predictions, or repair or replace components as necessary. LRA at A-24 and B-54. Consistent with the EPRI guidelines, the Entergy program is largely based on a computer program known as CHECWORKS, which is used in all operating U.S. nuclear power plants to record plant operating experience and predict timing and locations of wall thinning.

E. Entergy's Program for Managing FAC is Inadequate to Comply With NRC Regulations and Regulatory Guidance.

1. Entergy relies on CHECWORKS without adequate Benchmarking or demonstration of a good track record with use of CHECWORKS.

a. Inadequate benchmarking

The CHECWORKS computer code is not reliable unless it is adequately benchmarked. This is due to the fact that, because of the inherent unpredictability of FAC (*see* discussion above), CHECWORKS is based on empiricism (statistics) rather than on a theoretical model. In other words CHECWORKS is not based on a mechanistic model, but is solely based on a collection of selective data which represents only a fraction of the total flow area. Consequently CHECWORKS must be benchmarked for each component and then updated when plant parameters change. In summary, CHECWORKS can be reliably used to predict pipe wall thinning only so long as:

(a) All relevant locations are benchmarked for relevant plant parameters;

(b) Relevant plant parameters do not change significantly over time; and

(c) Benchmark data on relevant plant parameters are collected for a sufficiently long period of time.

Unless these requirements are satisfied, CHECWORKS is only good for establishing relative inspection priorities and providing a platform for collecting and evaluating plant data on FAC.

The key requirements for benchmarking empirical models are: (1) good data on FAC. And (2) science based algorithm in the structure of the model. The data must be based on sufficiently large number of measured points which were selected on the basis of plant history and knowledge of the FAC phenomena. The data must be free of errors and it must be continuously assessed by impartial experts. In Dr.

Hopenfeld's judgment, for relatively simple geometries and one phase flow in straight pipes where the degree of turbulence is relatively low and stable it would be reasonable to assume that six years of plant operations would be sufficient to bench mark a code for a given set of plant parameters. For complex geometries such as elbows and pipe branching areas where turbulence intensity is considerably higher, less stable and less predictable, a minimum of 10-15 years would be a more appropriate period of benchmarking empirical FAC models.

Entergy does not have a basis for relying on CHECWORKS because it has not adequately re-benchmarked changes in plant operating parameters. On October 2004 and March 2005 IP2 and IP3 were granted a power increase of 3.26% and 4.85%, respectively. These power changes affect velocities, temperatures, coolant chemistry and steam moisture, mainly on the secondary side of the plant where the steam flow and feed flow increases are approximately proportional to the power increase. CHECWORKS or any other data bank on FAC must now be updated.

In discussing service experience at IP in section B.1.15, Entergy states that:

> Operating experience for IP2 and IP3 was accounted for in the most recent updates of the respective CHECWORKS FAC models. This includes inspection data from the outage inspections as well as the changes to FAC wear rates due to the recent power uprates. These updates further calibrate the model, improving the accuracy of the wear predictions.

Entergy is unduly optimistic in believing that one set of data points following the power stretch would improve the accuracy of wear predictions.

b. Failure to demonstrate successful track record using CHECWORKS

In addition to re-benchmarking, it is essential for Entergy to demonstrate that it has a successful track record of using CHECWORKS over a long period of time, because of a long history in which CHECWORKS has not been successful in predicting wall thinning. In 2005, for example, the Advisory Committee on Reactor

Safeguard's ("ACRS's") Subcommittee on Thermal Hydraulics, compared CHECWORKS predictions with actual operating data from the Waterford nuclear power plant. The poor correlation between the CHECWORKS predictions and the operating data prompted an ACRS Subcommittee member to comment: "If you look at that data base, you don't really have too much confidence in CHECWORKS." Statement by Dr. F. Peter Ford, transcript of January 26, 2005, meeting of the ACRS Subcommittee on Thermal Hydraulics at 198 (January 26, 2005) (ML050400613).

The history of CHECWORKS' limited effectiveness to predict wall thinning is further demonstrated in NUREG/CR-6936, PNNL 16186, *Probabilities of Failure and Uncertainty Estimate Information for Passive Components – a Literature Review* (May 2007), which documented the service experience with FAC covering two periods, 1976-1987 and 1988- 2005. Given that CHECWORKS was released to the industry in 1987, and presuming that all plants have been using it, a comparison of the number of pipe failures in the first period with the number of failures in the second period is a measure of CHECWORK success in predicting FAC. The number of through the wall failures in PWR plants was 89 and 150 during the 1976-1987 and 1988-2005 periods respectively. This represents an annual failure rate of 8 and 8.8, clearly demonstrating that CHECWORKS is not effective in reducing the number pipe failures.

In the period following the publication of NUREG/CR-6936 component failure from FAC continued. During the past three years alone pipe thinning events have occurred at Duane Arnold, Hope Creek, Clinton, Braidwood, LaSalle, Peach Bottom, Palo Verde, Palisades, Catawba, Calvert Cliffs, Kewaunee, Browns Ferry, ANO, and Salem. Some of these plants have received a power uprate approval and are operating at increased power levels.

Entergy does not provide information to support its assertion that it has used CHECWORKS successfully in the past (LRA at B-54). For instance, Entergy provides no comparison of CHECWORKS predictions of wall thinning rates with operational data.

2. Failure to specify the method and frequency of component inspections or criteria for component repair or replacement.

In the absence of an adequately benchmarked data base for use of the CHECWORKS computer program, it is important for Entergy to provide detailed information regarding the method and frequency of component inspections and its criteria for component repair or replacements. Instead of adhering to the NUREG-1800 guidelines, Entergy's LRA merely identifies the components which are susceptible to FAC (Table 3.3.2-19) and makes vague statements which appear to indicate that Entergy essentially has no meaningful program to address the FAC aging phenomena.

NUREG-1800, § A.1.2.3.6 also requires that:

> The acceptance criteria of the program and its basis should be described. The acceptance criteria, against which the need for corrective actions will be evaluated, should ensure that the structure and component intended function(s) are maintained under all CLB design conditions during the period of extended operation. The program should include a methodology for analyzing the results against applicable acceptance criteria."

Given the large uncertainties in CHECWORKS it is imperative that Entergy develop criteria which would define when a component should be replaced, what should be the minimum inspection grid size and the frequency of inspection. *See also* 10 C.F.R. § 54.21(c).

CONTENTION EC-1: FAILURE TO ADEQUATELY ANALYZE IMPACTS OF COOLING SYSTEM.

Contention: Entergy's Environmental Report violates the National Environmental Policy Act ("NEPA") and NRC implementing regulations 10 C.F.R. § 51.45 and 10 C.F.R. § 51.53(c)(3)(ii)(B) because it fails to adequately analyze the adverse impacts on aquatic resources from heat shock, impingement and entrainment caused by Indian Point's once-through cooling system. Entergy's Environmental Report also violates NEPA and NRC implementing regulations 10 C.F.R. § 51.45(b), (c), (d) because it fails to provide a complete analysis of the closed cycle cooling alternative for reducing or avoiding adverse environmental effects at Indian Point.

Basis for Contention

A. Expert Support for Contention

This contention was prepared with the expert assistance of Drs. Peter Henderson and Richard Seaby of Pisces Conservation Ltd. (Pisces), whose declarations are attached as Exhibits 1 and 2, respectively. Drs. Henderson and Seaby also prepared two expert reports in support of the contention – "Status of Fish Populations and the Ecology of the Hudson River" and "Entrainment, Impingement and Thermal Impacts at Indian Point Power Station" – which are attached to Dr. Henderson's declaration as Attachments 2 and 3, respectively. As stated in their declarations, the factual statements in the contentions and the expert reports are true and correct to the best of their knowledge, and the expressions of opinion are based on their best professional judgment.

B. Requirements of NEPA and NRC Implementing Regulations

NRC regulations classify the effects of entrainment, impingement and heat shock on the protection and propagation of fish and shellfish as "Category 2" environmental issues which must be assessed in a site-specific Supplemental

Environmental Impact Statement (SEIS). 10 C.F.R. Part 51, Appendix A to Subpart B. Thus, they are subject to NEPA's requirement that the NRC must consider the environmental impacts of its proposed actions before renewing the operating license for Indian Point. 42 U.S.C. § 4332 (2)(C); 10 C.F.R. § 51.45.

In the first instance, Entergy's Environmental Report must "contain sufficient data to aid the Commission in its development of an independent analysis." 10 C.F.R. § 51.45 (c). Notably, "the analyses for environmental reports shall, to the fullest extent practicable, quantify the various factors considered." *Id.* Moreover, the Environmental Report "should not be confined to information supporting the proposed action but should also include adverse information." 10 C.F.R. § 51.45 (e).

NRC regulations also require a discussion of the status of compliance with water quality standards, in particular "thermal and other water pollution limitations or requirements which have been imposed by Federal, State, regional, and local agencies having responsibility for environmental protection." 10 C.F.R. § 51.45 (d). Finally, the regulations require a complete analysis of available alternatives for reducing or avoiding adverse environmental effects. Such analysis must "include a discussion of whether the alternatives will comply with such applicable environmental quality standards and requirements." 10 C.F.R. §§ 51.45 (b), (c), (d).

Finally, NRC's NEPA-implementing regulations specifically require license applicants to evaluate the environmental impacts of once-through cooling systems:

> If the applicant's plant utilizes [a] once-through cooling . . . system[s], the applicant shall provide a copy of current Clean Water Act 316(b) determination[s] and, if necessary, a 316(a) variance in accordance with 40 CFR part 125, or equivalent State permit[] and supporting documentation. If the applicant can not provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from heat shock and impingement and entrainment.

10 C.F.R. § 51.53(c)(3)(ii)(B).

C. Factual and Regulatory Background

Entergy is operating a once-through cooling system at Indian Point under an expired State Pollutant Discharge Elimination System ("SPDES") permit issued by the New York State Department of Environmental Conservation ("NYSDEC") for the period 1987-1992.[5] Therefore it has no valid permit that it can rely on for purposes of satisfying 10 C.F.R. § 51.53(c)(3)(ii)(B), and must instead assess the impacts of impingement, entrainment, and heat shock. *Id.*

1. Status of Entergy's SPDES permit.

Entergy's 1987 SPDES permit has been administratively continued pending issuance of a final SPDES permit currently subject to an adjudicatory process.[6] Actually, the 1987 SPDES permit was a renewal of the initial SPDES permit for Indian Point (1982-1987), which incorporated the provisions of the 1981 Hudson River Settlement Agreement ("HRSA")—a 10-year agreement between the former plant owners, the regulators and various intervenors (including Riverkeeper).[7] The 1981 HRSA imposed conditions for the operation of Indian Point's once-through cooling water system, including plant outages and flow limitations during specific

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[5] NYSDEC, 1987, State Pollutant Discharge Elimination System ("SPDES") Discharge Permit NY-000-4472, Indian Point Generating Stations [hereinafter NYSDEC, 1987 SPDES Permit] (attached to the Environmental Report (ER) as Attachment C). Note that Entergy refers to this permit as the "1992 SPDES permit" (e.g., E.R. at 4-11, 4-17), although it expired in 1992.

[6] NYSDEC, 2003, Draft SPDES Permit for Entergy Nuclear Indian Point Units 2 & 3 [hereinafter NYSDEC, 2003 Draft SPDES Permit] *available at* http://www.dec.ny.gov/docs/permits_ej_operations_pdf/IndianPointSPDES.pdf, last accessed November 30, 2007.NYSDEC, 2003, Fact Sheet - Draft SPDES Permit for Entergy Nuclear Indian Point Units 2 & 3 (November 2003) [hereinafter NYSDEC, 2003 SPDES Fact Sheet], *available at* http://www.dec.ny.gov/docs/permits_ej_operations_pdf/IndianPointFS.pdf, last accessed November 30, 2007.

[7] Copy of the Hudson River Settlement Agreement (HRSA) is attached to the 2003 FEIS, *infra* footnote 12.

times of the year as well as thermal conditions, while additional ecological studies were being undertaken.[8]

The 1981 HRSA resolved disputes arising from the determinations made by federal agencies involved in the initial licensing and permitting proceedings for Indian Point (Units 2 & 3). During the proceedings, the Atomic Energy Commissions ("AEC") and the U.S. Environmental Protection Agency ("EPA") both determined that the installation of closed cycle cooling would be required in order for Indian Point to operate in compliance with Federal law. As a result of the NEPA review of the operating license application for Indian Point Unit 2, the AEC required closed cycle cooling to protect the ecology of the Hudson River. *Consolidated Edison Co. of New York (Indian Point Station Unit No. 2)*, LBP-73-33, 6 AEC 751 (1973). Pursuant to its permitting authority under the Clean Water Act ("CWA"), in 1975, the EPA also required closed cycle cooling at Indian Point in order to reduce environmental impacts on the Hudson River. 42 U.S.C. § 1326(b). That same year, the EPA delegated its CWA permitting authority to the NYSDEC. Consequently, the NYSDEC issued the 1982 SPDES permit for Indian Point, and later the 1987 SPDES permit renewal, both of which incorporated the conditions of the 1981 HRSA.

The HRSA was extended pursuant to Consent Orders effective 1992-1998. Due to NYSDEC's delay to renew the 1987 SPDES permit for Indian Point, in 2002, certain petitioners, including the Hon. Richard L. Brodsky, an assemblyman in the New York State Legislature, commenced a proceeding in Albany County Supreme Court, pursuant to Article 78 of the New York Civil Practice Law and Rules, to

[8] As noted in New York State's Scoping Comments, dated October 31, 2007 (hereinafter NYS, Scoping Comments) at 5-6, "[t]he HRSA required a thorough investigation of the ecology of the River for purposes of future technical decision-making on the SPDES permit application for Indian Point Units 2 and 3 and other Hudson River power plants."

mandate action by NYSDEC on the Indian Point SPDES permit renewal application. *See Matter of Brodsky v. Crotty, Sup. Ct., Albany County*, Keegan, J., Index No. 7136-02. On May 14, 2003, the court issued an order that set a schedule requiring, among other things, that the NYSDEC complete an environmental impact statement for Indian Point (and the other HRSA facilities) by July 1, 2003, and that a draft SPDES permit be issued by November 14, 2003. The court's order also granted a motion by Riverkeeper, Inc. to intervene.

Pursuant to the court order, in 2003, the NYSDEC issued a draft SPDES permit that requires the installation of closed cycle cooling at Indian Point if Entergy seeks and is granted license renewal by NRC.[9] After 25 years of HRSA studies and the completion of the 2003 FEIS for SPDES permit renewal, which are discussed below in section D, the State of New York reached the same conclusion that the federal agencies did 30 years ago: "the dramatic intake and use of Hudson River water has significant adverse environmental impacts and must be mitigated. New York has concluded in its [2003] draft [SPDES] permit that closed cycle cooling shall be required if the license renewal request is granted."[10]

The State of New York also has taken the position that Indian Point's administratively extended SPDES permit, "while technically 'current,' however, does not address the actual significant environmental impacts from once-through cooling and is in the process of being revised."[11] Indeed, providing an outdated SPDES permit, in lieu of a *current* CWA § 316(b) determination and CWA § 316(a) thermal

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[9] NYSDEC, 2003 Draft SPDES Permit, Biological Requirement 28; NYSDEC, 2003 SPDES Fact Sheet, § IV (B-C-D) (at 3-6) and Attachment B, § 4, Determination of Best Technology Available (stating that "the Department [NYSDEC] has determined that in this case closed-cycle cooling represents the best technology available for minimizing adverse environmental impacts from the cooling water intake structure at Indian Point.") (Page 4 of 8).
[10] NYS, Scoping Comments, at 7.

variance, does not satisfy NRC regulations that exempt applicants having a once-through cooling system from conducting entrainment, impingement, and thermal analyses. 10 C.F.R. § 51.53(c)(3)(ii)(B). In other words, Entergy cannot satisfy the required analyses regarding entrainment, impingement, and heat shock by relying on a 20-year-old SPDES permit.

2. Entergy's discussion of impacts in Environmental Report

Because it may not rely on a valid SPDES permit, Entergy's Environmental Report contains an "Entrainment Analysis" (Sections 4.2.5.2 and 4.2.6 (at 4-12 and 4-13)), an "Impingement Analysis" (Sections 4.3.5.2 and 4.3.6 (at 4-17 to 4-19)), and a "Heat Shock Analysis" (Sections 4.4.5.2 and 4.4.6 (at 4-23 to 4-24)). As discussed below in Section D, however, Entergy's analyses of these impacts are grossly incomplete and flawed, and therefore must be rejected.

D. Entergy Has Failed to Provide an Adequate Analysis of Entrainment, Impingement, and Heat Shock

As discussed above in Section B, pursuant to 10 C.F.R. § 51.53(c)(3)(ii)(B), Entergy is required to analyze the environmental impacts of Indian Point's once-through cooling system, specifically heat shock, impingement and entrainment of fish and shellfish. Entergy's Environmental Report contains an "Entrainment Analysis" (Sections 4.2.5.2 and 4.2.6 (at 4-12 and 4-13)), an "Impingement Analysis" (Sections 4.3.5.2 and 4.3.6 (at 4-17 to 4-19)), and a "Heat Shock Analysis" (Sections 4.4.5.2 and 4.4.6 (at 4-23 to 4-24)). However, Entergy's analyses of these impacts in the Environmental Report are grossly incomplete and flawed, and must be rejected. Entergy also neglects to include significant adverse information on entrainment, impingement and thermal discharges, and fails to quantify the adverse factors, which

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[11] *Id.* at 8.

is necessary under 10 C.F.R. 51.45. Riverkeeper's analysis of these deficiencies, as supported by the expert reports of Drs. Henderson and Seaby, are detailed below.

1. Entergy ignores contradictory findings in the 2003 FEIS

Significantly, Entergy's Environmental Report ignores the findings and conclusions on entrainment, impingement, and heat shock contained in NYSDEC's 2003 Final Environmental Impact Statement ("2003 FEIS") regarding the renewal of Indian Point's SPDES permit.[12] In 1992, the NYSDEC required a specific environmental impact statement under the State's Environmental Quality Review Act to consider Indian Point's entrainment, impingement, and thermal impacts.[13] As a result, the prior owners of Indian point and other Hudson River power plant generators prepared the 1999 Draft Environmental Impact Statement ("1999 DEIS") for permit renewal.[14] Four year later, pursuant to the judicial order by the Albany County Supreme Court (Keegan, J.), the NYSDEC issued the 2003 FEIS, which "contradicts the industry-prepared 1999 DEIS in important ways. *This means that as to those points, as a matter of law, the Final EIS supersedes the Draft EIS. Thus, any reliance on the Draft EIS by the applicant in this environmental review is misplaced as a matter of fact and as a matter of law.*"[15] Thus, Entergy's "Entrainment Analysis", "Impingement Analysis", and "Heat Shock Analysis" relying on the 1999 DEIS, and without any reference whatsoever to the findings and conclusions in the 2003 FEIS are incomplete and must be rejected.

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[12] NYSDEC, 2003 Final Environmental Impact Statement Concerning the Applications to Renew SPDES Permits for the Roseton 1 and 2, Bowline 1 and 2 and Indian Point 2 and 3 Electric Generating Stations (hereinafter NYSDEC, 2003 FEIS), *available at* http://www.dec.ny.gov/docs/permits_ej_operations_pdf/FEISHRPP1.pdf, last accessed November 30, 2007.
[13] New York State Environmental Conservation Law, Article 17.
[14] 1999 Draft Environmental Impact Statement Concerning the Applications to Renew SPDES Permits for the Roseton 1 and 2, Bowline 1 and 2 and Indian Point 2 and 3 Electric Generating Stations (hereinafter 1999 DEIS).

The 2003 FEIS concluded that the number of fish killed by the HRSA facilities each year—over 1.2 billion fish from just six species from Indian Point alone —represent a significant mortality and are yet another stress on the Hudson River's fish community.[16] The FEIS also noted that the mortality caused by HRSA facilities must be taken into account when assessing the declines in fish population.[17] The NYSDEC further explained,

> What is clear from the data and analyses presented in the DEIS is that entrainment and impingement, primarily the former, are eliminating a significant portion of the above-listed species in their egg and larval forms, as well as many more species which spawn or spend part of their life stages in the lower Hudson River.[18]

Furthermore, the NYSDEC noted significant failures and concerns regarding the fish population models presented in the 1999 DEIS.[19] Instead, NYSDEC concluded that entrainment and impingement, primarily the former, are eliminating a significant portion of Hudson River fish species in their eggs and larvae form.[20] The NYSDEC also stated that "the impacts associated with power plants are more comparable to *habitat degradation*; the entire natural community is impacted."[21] NYSDEC's analysis is summarized, as follows:

> These "once-through cooling" power plants do not selectively harvest individual species. Rather, impingement and entrainment and warming of the water impact the entire community of organisms that inhabit the water column. ... Once-through cooling mortality "short-circuits" the trophic pyramid and compromises the health of the natural community.[22]

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[15] NYS, Scoping Comments, at 6 (emphasis supplied).
[16] NYSDEC, 2003 FEIS, at 58.
[17] *Id.*
[18] *Id.* at 59.
[19] *Id.* at 60.
[20] *Id.*
[21] *Id.* at 53 (emphasis supplied).
[22] *Id.*

In addition, the 2003 NYSDEC Fact Sheet for the draft SPDES permit provides the following conclusion regarding entrainment and impingement at Indian Point:

> Each year Indian Point Units 2 and 3 (collectively "Indian Point") cause the mortality of more than a billion fish from entrainment of various life stages of fishes through the plant and impingement of fishes on intake screens. ... Losses at Indian Point are distributed primarily among 7 species of fish, including bay anchovy, striped bass, white perch, blueback herring, Atlantic tomcod, alewife, and American shad. Of these, Atlantic tomcod, American shad, and white perch numbers are known to be declining in the Hudson River ... Thus, current losses of various life stages of fishes are substantial.[23]

Thus, the NYSDEC "has determined that in this case closed-cycle cooling represents the best technology available for minimizing adverse environmental impacts from the cooling water intake structure at Indian Point."[24] 42 U.S.C. § 1326(b); 6 N.Y.C.R.R. Part 704.

2. Entergy's Evaluation of Aquatic Ecology Fails to Comply with NEPA

Entergy's Environmental Report—both in the background section on aquatic resources (under section 2) and in the section on entrainment, impingement, and heat shock (section 4)—failed to acknowledge that many species of fish in the Hudson River show trends of declining abundance, and that the ecosystem also appears to be declining in terms of stability. Thus, prior to evaluating heat shock, impingement and entrainment at Indian Point, Pisces prepared an independent expert report on the status of fish populations and the ecology of the Hudson River. This report reviewed the fish populations and ecology of the Hudson using the Year Class Reports for the Hudson River Estuary Monitoring Program, reports and assessments prepared by the

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[23] NYSDEC, 2003 SPDES Fact Sheet, Attachment B, § 1, Biological Effects (Page 1 of 8).
[24] *Id.* Attachment B, § 4 (Page 4 of 8).

NYSDEC and the Atlantic States Marine Fisheries Commission ("ASMFC"), as well as recently published materials and other literature.[25]

a. Entergy's assessment of fish populations impacted by Indian Point is misleading

Pisces points out that Entergy's assessment of fish populations impacted by Indian Point is misleading. Pisces notes that there is continued reference to the 1999 DEIS, and not the FEIS, and furthermore, there is almost no reference to data collected after 1997.[26] "This use of data more than 10 years old is unacceptable when more recent data have been collected and circulated. ...There is an attempt to mislead on the health of fish populations. Yet again this is based on old data and carefully crafted statements."[27] An example of a misleading statement of this type is in section 2 of the Environmental Report, where Entergy states:

> The recent 2004 annual year class report continues to confirm that the conclusions developed in the [1999] DEIS are still relevant and supported.[28]

Also, in section 2 of the Environmental Report, Entergy claims that:

> During the 24-year monitoring period from 1974 to 1997, species richness and overall abundance of PYSL [post yolk-sac larvae] increased in most areas of the estuary. Analysis of the long-term trends in the larval fish community in both the marine brackish regions and the freshwater zone revealed an overall increase in the total number of taxa collected. Increases in overall abundance were due to increases in the abundance of larval striped bass in all areas of the estuary and increases in the abundance of larval bay anchovy in brackish areas.[29]
>
> Overall, observations from the [Year Class Reports] Hudson River Utilities Monitoring Program indicate that the fish community of the Hudson River estuary has experienced relatively small changes in

[25] Pisces, Status of Fish Populations and the Ecology of the Hudson River, § 1, at 1. The preparation of Year Class reports by the operator of Indian Point was a condition of the HRSA.
[26] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 6.3, at 42.
[27] *Id.* § 6.3, at 43.
[28] *Id*; ER at 2-16, 2-17.
[29] ER at 2-16.

> species richness and diversity, although these measures have varied among regions of the river and among fish life stages during the 1974-1997 monitoring period. These changes are also discussed in Section 4 of this ER. Both the species and abundance of post yolk-sac larvae have increased slightly. The number and diversity of juvenile and older fish have decreased slightly.[30]

These statements give the reader the impression that the 1999 DEIS assertion that populations are healthy and flourishing is supported by the Year Class Reports.[31] The opposite is in fact the case as discussed below in section c. Furthermore, Energy's statements are belied by NYSDEC's findings and conclusions in the 2003 FEIS.

Entergy's Environmental Report Section 2.2—Aquatic and Riparian Ecological Communities under "Fish Communities" (Section 2.2.5)—only notes declines in bay anchovy, stating that "[t]he NYSDEC's FEIS noted a decline in bay anchovy abundance and suggested it was linked to power generation plant water intakes on the Hudson River []."[32] But Entergy fails to acknowledge that the 2003 FEIS concluded that "[s]everal species of fish in the Hudson River estuary, such as American shad, white perch, Atlantic tomcod and rainbow smelt, have shown trends of declining abundance."[33] For instance, with respect to the status of white perch, the 2003 FEIS stated:

> However, juvenile and age-1 abundance indices suggest that white perch numbers in the Hudson River are declining. This contrasts with the DEIS conclusion that the population appears resilient enough to sustain its population in the future under similar levels of power plant mortality.[34]

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[30] ER at 2-17.
[31] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 6.3, at 43.
[32] ER at 2-17.
[33] NYSDEC, 2003 FEIS, at 57.
[34] *Id.* at. 62.

The 2003 Fact Sheet for Indian Point's draft SPDES permit also noted that "Atlantic tomcod, American shad, and white perch numbers are known to be declining in the Hudson River."[35]

More recently, the State of New York reiterated its reliance on the conclusions of the 2003 FEIS, as follows:[36]

> • The data show changes in fish species abundance with low species diversity because most of the River's fish production is concentrated in a few species, demonstrating that the "Hudson River estuary is far from equilibrium."
>
> • Long-term trends show declining abundance of common and once abundant species including tomcod, Atlantic sturgeon, bluefish, weakfish, rainbow smelt, white perch, and white catfish.
>
> • For the species that breed in the Hudson River estuary and whose young are vulnerable to entrainment, the estimated impacts from power plant mortality rate are sufficient to cause a substantial reduction in adult numbers.
>
> • The tomcod, a key species to study with regard to power plant impacts, has seen a long-term decline in population, and entrainment losses are likely a factor in their decline.
>
> • Indian Point accounts for more than half of the entrainment from the three plants-- an estimated annual entrainment of 1.2 *billion* fish eggs and larvae.

b. The conclusions in the Year Class Reports are not supported by the data contained in the Reports, and are contradictory and misleading

The data in the Year Class Reports describes many changes in the fish population of the estuary, with several species disappearing, new species being found, major declines and increases in the fish species monitored. And yet despite this information, Entergy still summarizes the results as follows:

> There is no evidence of any substantial long-term changes in composition or abundance of the fish community over the 32-year period, 1974-2005.[37]

[35] NYSDEC, 2003 Fact Sheet, Attachment B, § 1, Biological Effects (Page 1 of 8).
[36] NYS, Scoping Comments, at 6.

Further, Section 4 of the 2005 Year Class Report (section 4.1.2), examines the overall heath of the estuary. At the end of the section, the report reads:

> In all, it appears that the Hudson River estuary has a healthy and robust fish population.[38]

As discussed below, Pisces rejects the conclusions drawn by Entergy in the 2005Year Class Report, relying on reports and assessments prepared by the NYSDEC and the ASMFC as well as other scientific studies.

c. Many Hudson River fish species killed or impacted by Indian Point are in decline

Pisces' reports conclude that many fish species killed or impacted by Indian Point are in decline. Specifically, Pisces reveals serious decline in 10 out of 13 key species considered in the Year Class Reports.[39] There are many other species that have also declined (e.g. American eel). The overall conclusion is that "[t]here are clear indications both at the community and individual population level that the populations of fish in the [Hudson] estuary are becoming less stable and showing greater year to year variation in abundance."[40]

Pisces concludes that of the 13 key species subject to intensive study for several decades, only three species, striped bass, blue fish and spottail shiner have shown a trend of increasing abundance since the 1980s. "The other 10 species have declined in abundance, some greatly."[41] Those other species are: white perch, Atlantic tomcod, bay anchovy,

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[37] 2005 Year Class Report for the Hudson River Estuary Monitoring Program, § 4.1.2, at 4.4. The 2005 Year Class Report for the Hudson River Estuary Monitoring Program estimates the abundance of various species in the Hudson for each year, from the mid 1970s until 2005. The 2005 Year Class Report is the most recent Year Class Report for the Hudson River Estuary Monitoring Program.

[38] *Id.*

[39] Pisces, Status of Fish Populations and the Ecology of the Hudson River, Summary, §§ 3.3 & 6.

[40] *Id.* § 6, at 35.

[41] *Id.* Summary.

American shad, alewife, blueback herring, rainbow smelt, hogchoker, white catfish, and weakfish. Pisces' expert report also noted that there has been a recent increase in average water temperature and a decrease in dissolved oxygen levels.[42] Thus, all the evidence points to the Hudson ecosystem presently experiencing significant changes, with declining stability.[43] Neither the ecosystem as a whole nor many of the individual species' populations are in a healthy state.[44]

3. Entergy's Entrainment Analysis Fails to Comply with NEPA

Entergy's assessment of entrainment is inadequate, and fails to quantify fish entrained and to disclose adverse information, as required by NEPA and NRC regulations. 10 C.F.R. §§ 51.45 (c), (e). Pisces has analyzed and quantified these impacts to support this Petition. In brief, Pisces' expert opinion on entrainment is that "each year [entrainment mortality] is in the order of billions," and thus concludes that the impacts are large.[45]

Specifically, "[f]or the 6 fish species for which data are available—American shad, bay anchovy, river herring (comprising 2 species alewife and blueback herring), striped bass, and white perch—, the stations entrain 1.2 billon eggs and larvae a year."[46] The available data was gathered in the 1980s, and later incorporated in the 1999 DEIS prepared by the prior owners of Indian Point. Subsequently, the NYSDEC—in the 2003 FEIS—calculated average number of organisms entrained at Indian Point for those 6 fish species: 1.2 billion.[47] Recently, the State of New York reaffirmed this quantification of entrainment impacts: "Indian Point accounts for more

[42] *Id.* Summary; § 2, at 1-6.
[43] *Id.* Summary; § 6, at 35-36.
[44] *Id.*
[45] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, Summary.
[46] *Id.*

than half of the entrainment from the three [HRSA] plants -- an estimated annual entrainment of 1.2 *billion* fish eggs and larvae."[48]

Pisces notes that the only data available in the 1999 DEIS regarding estimates of numbers of organisms entrained at Indian Point is found in Appendix VI-1-D-2, Table 2. This table reveals the number and stage of some of the main species entrained at Indian Point between 1981 and 1987. From this table, the NYSDEC calculated the average annual mortality at Indian Point, and included this data in the 2003 FEIS, which is reproduced below:[49]

Number of Fish Entrained	
American Shad	13,380,000
Bay Anchovy	326,666,667
River Herring	466,666,667
Striped Bass	158,000,000
White Perch	243,333,333
Total	**1,208,046,667**

Although the entrainment of very few species was considered in the 1981-1987 studies, the 1999 DEIS (Appendix VI-1-D-2) and the 2003 FEIS reveal that Indian Point's entrainment levels are staggering: over 1.2 billon a year for just 6 fish species. The 1981-1987 studies did not include the Atlantic tomcod, which breeds earlier in the year than the other species.[50] Pisces' expert opinion indicates that the species for which entrainment mortality has been quantified is only a very small proportion of the total species present in the estuary.[51]

[47] NYSDEC, 2003 FEIS, at 2, Table 1.
[48] NYS, Scoping Comments, at 6 (emphasis in the original text).
[49] NYSDEC, 2003 FEIS, at 2, Table 1 (river herring includes blueback herring and alewife); 1999 DEIS, Appendix VI-1-D-2, Table 2; Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 3, Table 1, at 4.
[50] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 3.1, at 5.
[51] *Id.*

In contrast with the approach taken by NYSDEC in the 2003 FEIS—which calculated estimates of the numbers of organisms entrained—the 1999 DEIS focused on Conditional Mortality Rates (CMRs) that "measure the proportion of the available population living in the Hudson Estuary that is killed by entrainment or impingement."[52] Pisces explains that CMRs were used in the 1999 DEIS instead of simple estimates of the number of animals killed, "because they allow insight into the level of impact on the population."[53] Pisces concludes that CMRs due to entrainment at Indian Point are large.[54]

Indeed, Entergy included some CMR entrainment data, from the 1999 DEIS, in the Environmental Report. According to Entergy,

> The estimated average annual CMR due to entrainment for American shad is 0.64%, for Atlantic tomcod is 12.04%, for bay anchovy is 10.38%, for river herring is 1.20%, for striped bass is 7.82%, and for white perch is 4.94%.[55]

Pisces' report notes that in the 2003 FEIS (Fish populations 3 - page 63) the CMR figure for white perch is stated as 21 percent, much higher than the numbers Entergy cites from the 1999 DEIS in the Environmental Report.[56] Reviewing these CMR data, Pisces concludes that "these numbers are notably high, especially when it is remembered that several of the species under consideration are showing long-term declines in abundance in the Hudson."[57]

Moreover, contrary to Entergy's assertions, the Year Class Reports for the Hudson River Estuary Monitoring Program demonstrate that striped bass is the only species in this group not showing declining numbers on the Hudson. American shad,

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[52] *Id.* § 3.2, at 5.
[53] *Id.*
[54] *Id.* Table 3, at 6.
[55] *Id;* ER at 4-12; 1999 DEIS, Section V.
[56] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 3.2, at 7.

Atlantic tomcod, bay anchovy, river herring, and white perch are all declining.[58] Thus, the CMR numbers indicate that Indian Point is killing an appreciable proportion of the Atlantic tomcod, white perch and bay anchovy populations in the estuary, and these deaths will be contributing to the decline of these species.[59]

The State of New York recently noted Indian Point's significant impact on the aquatic resources of the Hudson River based on the finding and conclusions set forth in the 2003 FEIS, discussed above, as well as the findings in New York's Water Quality 2004 report, as follows:

> Water Quality 2004 report states that tens to hundreds of million of eggs, larvae, and juvenile fishes are killed per year by the large volume, once-through users on the Hudson River. The report indicates that based on the data collected, the September 1 young of year (YOY) fish populations have been reduced as much as 25-79% for spottail shiner (1977), 27- 63% for striped bass (1986), 52-60% for American Shad (1992), 44-53% for Atlantic tomcod (1985), 39-45% for alewife and blueback herring combined (1992), 30-44% for white perch (1983), and 33% for bay anchovy (1990). (The higher number assumes no through-plant survival; the lower number incorporates power company estimates of through-plant survival.)[60]

The State of New York also referred to the long-term trends that show declining abundance of common and once abundant species including Atlantic tomcod, Atlantic sturgeon, and white perch, among others: "For the species that breed in the Hudson River estuary and whose young are vulnerable to entrainment, the

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[57] *Id.*
[58] 2005 Year Class Report for the Hudson River Estuary Monitoring Program, Appendix D. Entergy's misleading assertion is, as follows: "In addition, since submission of the DEIS, the generators have continued to provide the annual year-class reports outlining the results of the annual monitoring program for the year in question, as well as all of the raw data collected and an estimate of the abundance (i.e., standing crop) of fish in the River during that period. *This information continues to confirm the absence of any adverse impact on fisheries reasonably attributable to IP2 or IP3* [ASA]." E.R., at 4-12 & 4-13 (emphasis added).
[59] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 3.2, at 7.

estimated impacts from power plant mortality rate are sufficient to cause a substantial reduction in adult numbers."[61] Based on the above, the State of New York concluded that "the impacts of the operation of once-through cooling at Indian Point for an additional 20 years will continue to have a significant impact on the aquatic resources of the Hudson River."[62]

Pisces' expert report clearly shows that, since the 1981-1987 entrainment studies, the estuary has changed considerably, noting that "[t]he data were collected before many significant recent ecological changes in the Hudson had occurred, including the arrival of zebra mussels, the closure of several fisheries and the recovery in striped bass numbers."[63] Thus, to estimate current entrainment impact at Indian Point's once-through cooling system, Pisces utilizes the data in the 2005 Year Class Report in conjunction with the data of entrainment from 1981-1987 studies that were included in DEIS (DEIS Appendix VI-1-D-2).[64]

As explained in the Pisces report, only current entrainment levels of American shad, white perch and striped bass can be estimated with the available information. Based on this approach, present entrainment of American shad, striped bass and white perch would be extremely high.[65] Further, striped bass calculations demonstrate that present entrainment estimates based on the old estimates in the 1999 DEIS would be largely underestimated: the average number of striped bass entrained in 1981-1987

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[60] NYS, Scoping Comment, at 6; New York's Water Quality 2004, Appendix A, Lower Hudson River, A 121- 122, *available at* http://www.dec.ny.gov/chemical/23837.html.
[61] NYS, Scoping Comment, at 6.
[62] *Id.*
[63] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 3.4, at 11.
[64] *Id.* § 3.3, Figures 2-4, at 7-11.
[65] *Id.*

was 46 million; the average number entrained between 1987 and 2005 was 366 million, an increase of over 750 percent.[66]

To analyze the current and future entrainment fully, data are needed on the density of the fish in the vicinity of the power plant. Although densities of each life stage in each part of the estuary for each week are gathered to develop the year class reports, this information is not provided in such reports. With that information a much more detailed and accurate calculation could be made of the number of fish entrained. Pisces has concluded that Indian Point's entrainment impact has not been analyzed or quantified to the best extent possible.[67]

It is important to emphasize that Entergy's "Entrainment Analysis" only relied on the following documents: the 1999 DEIS; the Year Class Reports for the Hudson River Estuary Monitoring Program; and, an unpublished paper by Barnthouse et al., which predates the 2003 FEIS, regarding the status of fish populations on the Hudson River.[68] These documents, however, do not support Entergy's "Entrainment Analysis." First, as discussed above, Pisces' reports show that data in the 1999 DEIS contradict Entergy's entrainment assessment. Second, the Year Class Reports reveal serious declines in the majority of Hudson River fish species studied in those reports, contrary to Entergy's assertions in the Environmental Report. Third, data in the 2003 FEIS and in the Year Class Reports contradict the conclusions in the unpublished paper by Barnthouse et al.[69] Based on this analysis, it is abundantly clear that

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[66] *Id.*
[67] *Id.*
[68] Barnthouse et al., Status and Trends of Hudson River Fish Populations and Communities since the 1970s: Evaluation of Evidence Concerning Impacts of Cooling Water Withdrawals (Unpublished - dated January 2002) (hereinafter Barnthouse et al., Unpublished paper on the Status of Hudson River Fish Populations).
[69] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 3.2, at 7.

Entergy's purported "Entrainment Analysis" is baseless, grossly incomplete, and fatally flawed for purposes of the required NEPA review.

Finally, as discussed further in section E below, Pisces notes that closed cycle cooling, required under the draft SPDES permit for Indian Point, represents about a 95 percent reduction in water use relative to the existing once-through system.[70] This would also reduce entrainment mortality by 95 percent and could, if needed, work in conjunction with other entrainment reducing technologies.[71] "We know of no alternative technology(s) that will result in equivalent protection for aquatic resources to that which can be achieved by closed cycle cooling."[72]

4. Entergy's Impingement Analysis Fails to Comply with NEPA

Entergy's assessment of impingement in the Environmental Report is inadequate. In particular, Entergy failed to quantify the adverse impacts in terms of fish impinged, as required by NEPA and NRC regulations implementing its provisions. 10 C.F.R. § 51.45 (c). Pisces also analyzed and quantified these impacts for the Petitioner. As discussed below, Pisces' expert analysis shows that the number of fish killed annually by impingement at Indian Point is significant.

Surveys of the number of fish impinged at Indian Point that were undertaken from 1981 to 1990 reflect impingement of around 1.2 million.[73] The results of these surveys were incorporated in the 1999 DEIS, but Entergy failed to reveal those numbers.[74] The impingement data presented in the 1999 DEIS concentrated on few species. The impact of impingement on other species is unknown. From this

[70] *Id.* § 3.4, at 11.
[71] *Id.*
[72] *Id.*
[73] *Id.* § 4.1, Table 4, at 12; 1999 DEIS, Appendix VI-2-D.

information, Pisces was able to calculate the average annual impingement at Indian Point, which is reproduced below:[75]

Number of Fish Impinged	
American Shad	12,894
Bay Anchovy	116,372
River Herring	64,354
Striped bass	46,305
Tomcod	239,441
White Perch	760,275
Total	**1,239,624**

Notably, Pisces notes that Indian Point "kill[s] individuals from several species that are in decline."[76]

Before 1990, fish impinged on Indian Point's cooling water filter screens would invariably have been killed, due to the lack of mitigation technology such as Ristroph screens and fish return systems.[77] Therefore, impingement mortality prior to 1990 exceeded the million fish annually on average for the species considered in the surveys. The installation of Ristroph screens and fish return systems at Indian Point between 1990 and 1991, due in part to the efforts of Riverkeeper, reduced this mortality for some species.[78]

Despite the implementation of these mitigation measures, Pisces concludes that impingement levels remain well over 1 million fish a year, and impingement mortality could be between two and five hundred thousand, depending upon the

[74] Pisces' expert report explains that the only data available in the 1999 DEIS regarding estimates of the numbers of organisms impinged at Indian Point is found in the Appendix VI-2-D (1999 DEIS, Appendix VI-2-.

[75] *Id.* § 4.1, Table 4; DEIS Appendix VI-2-D, Table 2. River herring includes blueback herring and alewife.

[76] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, Summary.

[77] *Id.* § 4.1, at 11.

[78] *Id.* § 4.1, at 12.

assumptions used in calculation.[79] Indeed, based on the available data, Pisces has determined that, of the approximately 1.2 million fish being impinged at Indian Point, average impingement mortality is about 200,000, using the most optimistic survival figures, and approximately 500,000 using more conservative survival values.[80] The former estimate is based on a study published in 1990 (Fletcher, 1990), and used in the 1999 DEIS;[81] while the latter estimate is based on more recent impingement survival estimates (LMS, 1997).[82]

In any event, Pisces concludes that impingement mortality estimates based on the 1999 DEIS are unlikely to be a reliable estimate of current or future impingement, as it is based on the number of fish impinged between 1981 and 1990. It is over 17 years since any impingement monitoring data has been published, and the fish community of the Hudson has greatly changed during that , as discussed *supra* in section 1. There is therefore a critical need to update estimates of the number of fish impinged, and their survival rates. In sum, while it is evident that impingement mortality is large, there is a need to update the information on this impact in order to fully assess current and future effects resulting from the proposed action, as required under NEPA.

It is important to underscore that Entergy's "Impingement Analysis" relies on the same documents as the flawed "Entrainment Analysis": the 1999 DEIS; the Year Class Reports for the Hudson River Estuary Monitoring Program; and, the unpublished paper by Barnthouse et al.[83] Contrary to Entergy's assertions, the 1999 DEIS and Year Class Reports reveal that impingement mortality levels at Indian Point

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[79] *Id.* Summary.

[80] *Id.* § 4.2 (Table 8), § 4.4, at 16-19.

[81] *Id.* § 4.2.1, Table 5.

[82] *Id.* §§ 4.2.4, 4.2.5, Tables 7-8.

[83] Barnthouse et al., Status of Hudson River Fish Populations.

are considerably higher than Entergy claims. Furthermore, the unpublished paper by Barnthouse et al. predates the 2003 FEIS and thus is meaningless. Thus, it is evidently clear that Energy's Environmental Report has failed to comply with NEPA with respect to impingement.

Finally, as discussed in section E. below, Pisces states that closed cycle cooling, required under the draft SPDES permit for Indian Point, represents about a 95 percent reduction in water use relative to the existing once-through system.[84] With closed cycle cooling, the smaller volumes of water pumped and the much lower velocities involved would almost eliminate impingement on the station cooling water intake screens.[85] "We know of no alternative technology(s) that will result in equivalent protection for aquatic resources to that which can be achieved by closed cycle cooling."[86]

5. Entergy's Heat Shock Analysis Fails to Comply with NEPA

Instead of assessing the impacts of the thermal discharge as required under NRC regulations due to the lack of a thermal variance, Entergy simply states in the Environmental Report that it is "complying with this [1987-1992 SPDES] permit, including limits and conditions imposed by NYSDEC for thermal discharges."[87] Entergy's Environmental Report also asserts that:

> Compliance with the SPDES Permits over previous years has been excellent. For example, there has never even been an exceedance relative to thermal discharge limits as identified in the Station's SPDES permit.[88]

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[84] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 4.4, at 19.
[85] *Id.*
[86] *Id.*
[87] ER, at 4-23.
[88] ER, at 9-2.

Entergy's self-serving statements have been flatly contradicted in the 2003 FEIS. Entergy's statements are also at odds with the available data on Indian Point's thermal plume, which shows that the facility does not comply with New York water quality standards for thermal discharges. As noted in the scoping comments recently filed by the State of New York:

> The available data -- generated from the applicant and the other Hudson River power plant generators as part of the HRSA -- regarding the thermal discharge at Indian Point demonstrates that state water quality criteria are *not* being met. Specifically, 6 NYCRR Part 704 (Criteria Governing Thermal Discharges) requires that a minimum of one-third of the surface as measured from water edge to water edge at any stage of the tide, shall not be raised to more than 4 degrees Fahrenheit over the temperature that existed before the addition of heat of artificial origin. 6 NYCRR § 704.2(b)(5). The generator's own data indicates that these criteria are not met under flood and ebb tidal conditions.[89]

Accordingly, the 2003 draft SPDES permit for Indian Point would require Entergy to conduct additional thermal studies at Indian Point, precisely to determine whether to grant a variance from thermal criteria.[90]

a. Indian Point's thermal discharge often exceeds New York State's thermal discharge criteria.

The Pisces Report on Entrainment, Impingement and Thermal Impacts also shows that Entergy's analysis of thermal impacts is insufficient to satisfy NEPA. The impact of a thermal discharge depends upon the background temperature of the water body. The potential effects of thermal pollution become more serious as the background temperature increases. As discussed in the Pisces Report, temperature increases in the Hudson River caused by Indian Point's operation have had significant effects on aquatic life.

[89] NYS, Scoping Comments, at 8 (emphasis in original text).
[90] NYSDEC, 2003 Draft SPDES Permit, Condition 7(b); NYSDEC, 2003 SPDES Fact Sheet, § IV (B) (at 3) and Attachment B.

The principal reason for establishing and enforcing thermal water quality criteria is the impact of water temperature on aquatic organisms. The limits on surface width and cross-sectional area in which elevated water temperatures are permissible are designed to ensure zones of passage and regions of habitability for aquatic organisms using the estuary. 6 NYCRR Part 704. Similarly, the establishment of the 90 Fahrenheit (°F) maximum surface water temperature is in recognition of the thermal tolerance limits of various resident and migratory species. *Id.* An accurate assessment of Indian Point's large thermal footprint must encompass both near field and far field effects. It is also important to emphasize that no mixing zone has been defined for Indian Point's thermal discharge.

The thermal modeling prepared by the prior owners of Indian Point indicates that the thermal discharge from Indian Point results in violations of applicable New York State thermal criteria. As noted in the 2003 FEIS:

> *Indian Point:* As of the 1987 - 1992 SPDES permit term, thermal discharges from Indian Point did not meet applicable thermal criteria. ... These provisions alone [the 1987-1992 SPDES permit], however, are not sufficient for Indian Point to meet thermal criteria. Thermal modeling indicates that the thermal discharge from Indian Point causes water temperatures to rise more than allowed, which is four degrees (°F) over the temperature that existed before the addition of heat, or a maximum of 83°F, whichever is less, in the estuary cross sections specified in 6 NYCRR §704.2(b)(5).2 A mixing zone was not specified in the previous SPDES permit for the Indian Point facility.[91]

Further, an infrared aerial image of the Indian Point 3 thermal plume in the 2003 FEIS highlights the degree to which the plume extends over the surface of the river. The image shows the high proportion of the width of the river that is impacted by the Unit 3 discharge of Indian Point, "even with Indian Point running at less than its full capacity."[92]

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[91] NYSDEC, 2003 FEIS, at 19.
[92] *Id.* at 71-72.

The NYSDEC also expressed concern about the vertical distribution of the thermal plume in the 2003 FEIS. In general, heated effluents are buoyant and thus the impacts are mostly restricted to the surface waters and any area of bank which the plume contacts. However, if the plume is sufficiently large then heated water will penetrate to the bed of the river and impact bottom-living and deep-water species. Such deeper water penetration of the thermal plume is always a matter for concern, as it may lead to damage to the benthic food chain and also not allow migrating fish to pass under the heated water plume. It is clear that almost the entire vertical water column in the vicinity of Indian Point holds water heated above background temperatures.[93] The 2003 FEIS stated this problem, as follows:

> A study by HydroQual, Inc., examined passive particle movement and also investigated thermal and salinity profiles in several river reaches, including the portion of the Hudson River where the HRSA plants are located. Figures 6 and 7 of this FEIS (following pages), excerpted from that study, show two vertical temperature profiles of the Hudson River from NYC to just above the northernmost of the HRSA plants, one during a spring and the other during a neap tide. Based on these representations, *it appears that there may be times and conditions where effluent-warmed waters occupy nearly the entire vertical water column.*[94]

The 2003 FEIS also concluded that the thermal plume of Indian Point was inadequately addressed by the prior owners of Indian Point in the 1999 DEIS.

> Thermal discharges were inadequately addressed in the DEIS. The DEIS asserts, with no supporting evidence, that "... [t]he surface water orientation of the plume allows a zone of passage in the lower portions of the water column, the preferred habitat of the indigenous species." Other data and analyses cast doubt on this assertion.[95]

It goes on to say:

> Given the extent of warming shown in the HydroQual graphs, combined with the recent dramatic declines in tomcod and rainbow smelt as discussed previously, the Department believes it prudent to

[93] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 5.2.1, at 23.
[94] NYSDEC, 2003 FEIS, at 71 (emphasis provided).
[95] *Id.*

seek additional thermal discharge data for each facility, including a mixing zone analysis, and anticipates requiring triaxial thermal studies as conditions to each of the SPDES renewals. Depending on the results of those analyses, additional controls may be required to minimize thermal discharges.[96]

Consequently, the 2003 draft SPDES permit for Indian Point required additional thermal discharge data, including a mixing zone analysis and a triaxial thermal study.[97]

Pisces also considered the temperature of the discharge. The average maximum temperatures for each calendar month for the years 2000 to 2007, as appear in the facilities monitoring reports, were compiled and analyzed. Pisces notes that for the summer months the maximum is regularly in excess of 90 degrees Fahrenheit (°F), while the regulations clearly state "*The water temperature at the surface of an estuary shall not be raised to more than 90 degrees Fahrenheit at any point.*" 6 NYCRR § 704.2(b)(5)(i) (emphasis added)?. Further, there are occasions when the temperature exceeds 100°F; this is a temperature at which many aquatic organisms living in the estuary will suffer acute harm or death.

Indian Point's far field thermal predictions can be made using existing temperature measurements or modeling methods. The Massachusetts Institute of Technology (MIT) dynamic network model was used in the 1999 DEIS, where it is referred to as the Far Field Thermal Model (FFTM). Using this model, the 1999 DEIS revealed the appreciable effect of Indian Point, which was predicted to increase river temperature by more than 1°F for more than 10 miles of estuary during the summer 1981.

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[96] *Id.* at 72.
[97] NYSDEC, 2003 Draft SPDES Permit, Condition 7(b); NYSDEC, 2003 SPDES Fact Sheet, § IV (B) (at 3) and Attachment B.

b. The background temperature of the Hudson River has changed significantly since Indian Point began operating, and shows signs of extreme variation.

The Pisces report shows that the water temperatures in the Hudson River are increasing.[98] This is clearly demonstrated by the statistically significant increase in mean average annual water temperature measured at Poughkeepsie Water Treatment Facility. The mean annual temperature in recent years is about 2°C (3.6°F) above that recorded in the 1960s.[99] Examination of the daily temperatures for 2005 plotted against the mean, minimum and maximum temperatures from 1951 to 2004 show that the temperature for several summer months in 2005 was close to the maximum ever recorded. However, in the winter, it also reached some of the lowest temperatures recorded over a 53 year period. In summary, the temperature regime in the Hudson is becoming more extreme, with severe effects to the fish populations and ecology of the Hudson River.

c. Conclusion on thermal impacts

Thermal impacts from Indian Point are large, are likely to exceed the State's thermal standards and criteria, and raise very serious concerns considering the warming trend in river temperature. It is therefore complacent, to say the least, of Entergy to state:

> Entergy concludes that continued operation in the manner required by the current [1982-1992] SPDES permit and the associated agreement to continue implementation of the fourth Consent Decree ensures that thermal impacts will satisfy the requirements of CWA 316(a) and will thus remain SMALL during the license renewal term.[100]

On the contrary, the 1999 DEIS and 2003 FEIS provide evidence of significant adverse environmental impacts to Hudson River biota from Indian Point's thermal

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[98] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 5.3, at 27-29.
[99] *Id.* Figures 15 & 16.

plume. Further, it would be appropriate, when considering the proposed action, to model scenarios with higher river temperatures than those observed in the recent past or even the present. A thorough environmental assessment of Indian Point's thermal impact is therefore warranted in order to comply with NEPA. Entergy's analysis concluding that future thermal impacts of Indian Point will be small is simply unsupported and must be rejected.

Finally, Pisces—noting that closed cycle cooling is required under the draft SPDES permit for Indian Point—states that under the closed-cycle cooling alternative the amount of heat injected into the river would be greatly reduced and thermal impacts would be confined to the discharge canal.[101] Thus, closed-cycle cooling would likely eliminate thermal pollution concerns at Indian Point, as discussed in section E below.

E. Entergy has Failed to Provide a Complete Analysis of the Closed Cycle Cooling Alternative

Entergy's Environmental Report violates NEPA and NRC implementing regulations 10 C.F.R. § 51.45(b), (c), (d) because it fails to provide a complete analysis of the closed cycle cooling alternative for reducing or avoiding adverse environmental effects to aquatic resources at Indian Point.

In the Environmental Report, Section 8.1.1.2.1 Aquatic Ecology, Entergy acknowledges that "[t]he closed-cycle cooling alternative would reduce entrainment and impingement losses when compared with the existing once-through cooling system ... representing a 93-95% reduction in water use relative to the existing once-through system."[102] Entergy also states that "[u]nder the closed-cycle cooling

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[100] ER, at 4-24.
[101] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 5.6, at 36.
[102] ER at 8-9, 8-10.

alternative, most water discharged into the Hudson River would be unheated water. Thus, it would be likely that any thermal impacts would be confined to a small part of the discharge canal and the Hudson River,"[103] and concludes that the aquatic ecological impacts from the construction and operation of the closed cycle cooling alternative at Indian Point 3 would be small.[104] But Entergy fails to address the benefits to aquatic resources resulting from a closed cycle cooling system at Indian Point.

Moreover, Entergy misleads, once again, stating that "although the DEIS concludes that plant operations have not resulted in any negative trend in overall Hudson River aquatic species populations, NYSDEC's draft SPDES permit would require replacement of the existing once-through cooling systems with closed-cycle cooling systems if certain pre-conditions are met." [105] As demonstrated in the previous sections the environmental impacts from entrainment, impingement and heat shock at Indian Point are large and require mitigation.

Pisces states that closed cycle cooling represents about a 95 percent reduction in water use relative to the existing once-through system.[106] This alone would also reduce entrainment mortality by 95 percent and could, if needed allow other entrainment reducing technologies to be used.[107] Pisces also notes that, with closed cycle cooling, the smaller volumes of water pumped and the much lower velocities involved would almost eliminate impingement on the station cooling water intake screens.[108] Further, under the closed-cycle cooling alternative, the amount of heat

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[103] *Id.* at 8-10.
[104] *Id.*
[105] *Id.* at 8-5.
[106] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 3.4, at 11.
[107] *Id.*
[108] *Id.*

injected into the river would also greatly reduce thermal impacts. Thus, closed-cycle cooling would likely eliminate thermal pollution concerns at Indian Point.[109] Thus, the benefit resulting from the closed cycle cooling alternative should be fully analyzed in order to comply with NEPA and NRC implementing regulations 10 C.F.R. § 51.45(b), (c), (d).

CONTENTION EC-2: INADEQUATE ANALYSIS OF SEVERE ACCIDENT MITIGATION ALTERNATIVES

Contention: Entergy's analysis of severe accident mitigation alternatives ("SAMAs") in its Environmental Report fails to satisfy NEPA, 42 U.S.C. § 4321-4370f, because its analysis of the baseline of severe accidents is incomplete, inaccurate, nonconservative, and lacking in the scientific rigor required by NEPA. In particular:

1. Inadequate analysis of probability and scope of severe accidents. In the first step of its analysis, *i.e.*, establishing the baseline of severe accidents, Entergy has failed to address several significant contributors to the costs of severe accidents, which Entergy represents by a "present value of cost risk" indicator. To determine that indicator, Entergy monetizes the estimated consequences of radioactive releases, multiplies those monetized consequences by their estimated probabilities, and sums the resulting values over time with discounting to the present. Entergy uses that indicator to compare the economic costs of particular SAMAs with the benefits to be derived from them (*i.e.*, the averted costs of severe accidents). *See* ER at Section 4.21. In particular:

[109] Pisces, Entrainment, Impingement and Thermal Impacts at Indian Point Power Station, § 5.6, at 36.

(a) Entergy has failed to properly consider the contribution to severe accident costs from severe accidents involving reactor containment bypass via induced failure of steam generator tubes.

(b) Entergy has failed to consider the contribution to severe accident costs by a fire in either of the spent-fuel pools at Indian Point Units 2 and 3.

(c) Entergy has failed to consider the contribution to severe accident costs by intentional attacks on the Indian Point Unit 2 or Unit 3 reactors or respective spent fuel pools.

2. Inadequate consequence analysis for severe accidents. In the radiological consequence calculations performed by Entergy in support of its SAMA analysis, Entergy has significantly (by more than a factor of three) underestimated population doses and other off-site costs resulting from a severe accident at Indian Point. These underestimates are due in part to (a) Entergy's use of a source term that results in unusually low mean off-site accident consequences in comparison to results obtained with source terms vetted by independent experts and recommended for use by NRC; (b) Entergy's failure to adequately consider the uncertainties in its consequence calculations resulting from meteorological variations; and (c) Entergy's inappropriate use of the $2,000/person-rem dose conversion factor. As a result of its underestimate of mean population doses and other off-site costs, and its failure to appropriately incorporate uncertainties due to meteorological variations into its analysis, Entergy has significantly underestimated the off-site costs of severe accidents. Entergy's erroneously low cost estimate has therefore led it to underestimate the benefits of SAMAs that would mitigate or avoid the environmental impacts of severe accidents. Entergy should be required to repeat its SAMA analysis by conducting a consequence assessment incorporating complete and accurate inputs and based on rigorous scientific methods.

Basis:

A. Expert Support for Contention

This contention is supported by the expert declarations and expert reports of Dr. Gordon Thompson and Dr. Edwin S. Lyman. Dr. Thompson's declaration is attached as Exhibit 1 to Contention EC-2. His expert report, *Risk-Related Impacts from Continued Operation of the Indian Point Nuclear Power Plants* (November 28, 2007) ("Thompson Report"), is Attachment 2 to his declaration. As stated in Dr. Thompson's declaration, he assisted Riverkeeper in the preparation of Section 1 of the contention and Section D.1 of the contention's basis. The factual assertions in those sections of the contention's basis are true and correct to the best of his knowledge, and the expressions of opinion are based on his best professional judgment.

Dr. Lyman's declaration is attached as Exhibit 2 to Contention EC-2. His expert report, *A Critique of the Radiological Consequence Assessment Conducted in Support of the Indian Point Severe Accident Mitigation Alternative Analysis* (November 2007) ("Lyman Report"), is Attachment 2 to his declaration. Another report by Dr. Lyman, *Chernobyl on the Hudson? The Health and Economic Consequences of a Terrorist Attack at the Indian Point Nuclear Plant* (September 2004), provides additional background information regarding Dr. Lyman's concerns about the inadequacy of Entergy's analysis of severe accident consequences. It is included as Attachment 3 to Dr. Lyman's declaration. As stated in Dr. Lyman's declaration, he assisted Riverkeeper in the preparation of Section 2 of the contention and Section D.2 of the contention's basis. The factual assertions in those sections of the contention are true and correct to the best of his knowledge, and the expressions of opinion are based on his best professional judgment.

B. Requirements of NEPA and Implementing Regulations

NEPA is the "basic national charter for protection of the environment." 40 C.F.R. § 1500.1. Its fundamental purpose is two-fold:

> It ensures that the agency, in reaching its decision, will have available, and will carefully consider, detailed information concerning significant environmental impacts; it also guarantees that the relevant information will be made available to the larger audience that may also play a role in both the decisionmaking process and the implementation of that decision.

Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc. (Pilgrim Nuclear Power Station), LBP-06-23, 64 NRC 257, 277 (2006) ("LBP-06-23"), quoting *Robertson v. Methow Valley Citizens Council,* 490 U.S. 332, 349 (1989). The primary method by which NEPA ensures that its mandate is met is the "action-forcing" requirement for preparation of an Environmental Impact Statement ("EIS"), which assesses the environmental impacts of the proposed action and weighs the costs and benefits of alternative actions. *Marsh v. Oregon Natural Resources Council,* 490 U.S. 360, 370–71 (1989). An EIS must be searching and rigorous, providing a "hard look" at the environmental consequences of the agency's proposed action. *Marsh,* 490 U.S. at 374. Information about environmental impacts must be subject to a "careful scientific analysis." *Id.* at 385. *See also* 40 C.F.R. § 1502.24 ("Agencies shall insure the professional integrity, including scientific integrity, of the discussions and analyses in environmental impact statements"); 10 C.F.R. § 51.71(d) (draft EIS "considers and weighs the environmental effects of the proposed action). An EIS for a nuclear power plant must also examine "alternatives for reducing or avoiding adverse effects." *Id.*

The NRC has interpreted NEPA to require the preparation of an EIS for decisions regarding whether to renew operating licenses for nuclear power plants. 10 C.F.R. § 51.95(d). The NRC requires the license renewal applicant to prepare the initial environmental analysis in an Environmental Report ("ER"). 10 C.F.R. § 51.53(c).

In 1996, the NRC prepared a generic EIS for license renewal: NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* ("GEIS"). NRC regulations adopting the GEIS characterize environmental impacts as either "Category 1" or "Category 2." *See* Table B-1 of Appendix B to 10 C.F.R. Part 50. The NRC applies Category 1 conclusions generically and allows license renewal applicants to rely on those conclusions, generally forbidding challenges to the conclusions in individual license renewal proceedings. *Florida Power & Light Co.* (Turkey Point Nuclear Generating Plant, Units 3 and 4), CLI-01-17, 54 NRC 3, 12 (2001). Recognizing, however, that NEPA requires it to consider new and significant information or changed circumstances bearing on the environmental impacts of its licensing decision, the NRC makes provision for individual waivers or generic changes to its environmental regulations. *Id.* The NRC also requires license renewal applicants to address new and significant information or changed circumstances in their ERs. 10 C.F.R. § 51.53(c)(3)(iv).

Category 2 environmental issues that must be addressed in each individual license renewal proceeding include "alternatives to mitigate severe accidents" or SAMAs. 10 C.F.R. Part 51, Appendix B, Table B-1. *See also* LBP-06-23, 64 NRC at 279. As an initial matter, the license renewal applicant must address SAMAs in its ER. LBP-06-23, 64 NRC at 279, citing 10 C.F.R. § 51.53(c)(3)(ii)(L). A SAMA analysis, *i.e.*, the "determination of whether a SAMA may be worthwhile to implement," is "based upon a cost-benefit analysis – a weighing of the cost to implement the SAMA with the reduction in risks to public health, occupational health, and offsite and onsite property." *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-17, 56 NRC 1, 8 (2002).

C. Entergy's SAMA Analysis

Entergy's SAMA analysis is presented in the ER in Appendix E, Sections 4.21 through 4.25 and Attachment E to Appendix E. According to Entergy, the SAMA analysis follows five basic steps: (1) establishing the baseline impacts of a severe accident with respect to off-site and on-site exposure and economic costs; (2) identifying SAMA candidates; (3) conducting a preliminary screening of potential SAMA candidates to determine their suitability for the Indian Point site; (4) conducting a final screening and cost-benefit evaluation (measuring benefits in terms of averted consequences against the estimated costs of installing a particular SAMA); and (5) and performing sensitivity analyses on (a) the sensitivity of assuming a 26-year period for the remaining life for IP2 and a 28-year period for the remaining life of IP3, (b) the sensitivity of each analysis case to the discount rate of three percent, and (c) impacts resulting from economic loss due to tourism and business. ER at 4-48 – 4-50.

In carrying out these analytical steps, Entergy estimated the value of averted consequences (expressed as "estimated present dollar value equivalent of internal events core damage frequency) as $1,337,939 for IP2 and $1,340,515 for IP3, before considering external events and uncertainty. ER at 4-62. Entergy analyzed 231 SAMA candidates, eliminating 163 from further consideration in the third step of screening candidates. ER at 4-72. For the remaining 68 candidates, Entergy concluded that 61 did not merit consideration because their costs exceeded their benefits. *Id.* Entergy identified only seven SAMAs that are "potentially" cost-beneficial. *Id.* Table 4-4 shows that the estimated economic cost of these SAMAs ranges from $50,000 to $1,656,000.

D. Deficiencies in Entergy's SAMA Analysis

Entergy's analysis of SAMAs fails to satisfy NEPA because is incomplete, inaccurate, non-conservative, and lacking in the scientific rigor required by NEPA. As a result, Entergy has failed to demonstrate that it took a "hard look" at environmental impacts and alternatives to avoid or mitigate those impacts, or subjected those impacts to "careful scientific analysis." *Marsh,* 490 U.S. at 374, 385. In particular, the SAMA analysis suffers from the following deficiencies:

1. Inadequate analysis of probability and scope of severe accidents.

In the first step of its analysis, *i.e.,* establishing the baseline of severe accidents, Entergy has failed to address several significant contributors to the costs of severe accidents:

(a) Entergy has not properly considered the contribution to severe accident costs made by severe accidents involving reactor containment bypass via induced failure of steam generator tubes. As discussed in Section 5 of the Thompson Report, Entergy has substantially underestimated the potential for containment bypass during a core-damage accident. In light of current knowledge about severe reactor accidents, it is prudent to assume that (i) any High/Dry accident sequence (*i.e.,* accident in which the secondary side dries out due to unavailability of feedwater and the reactor coolant system ("RCS") pressure remains high while primary coolant (*i.e,* water) is lost and the core is uncovered) would involve induced failure of steam generator tubes, and (ii) one or more of the secondary side safety valves downstream of the affected steam generator(s) would remain open after tube failure. Thompson Report at 15-16.

Taking these prudent assumptions into account, Entergy's estimates of the conditional probabilities of atmospheric release categories (in the event of core damage) increase significantly: the conditional probability of an Early High release rises from 3.6 percent to 51.8 percent for the IP2 reactor, and from 8.2 percent to 54.1 percent for the IP3 reactor. *Id.* at 18. Correspondingly, the present value of cost risk associated with atmospheric releases increases by a factor of 5.42 for IP2 and a factor of 3.18 for IP3. *Id.*

As a result, Entergy has underestimated the potential value of relevant SAMAs by $47.3 million for IP2 and $23.4 million for IP3. Thompson Report at 50. If the economic benefit of averted containment bypass accidents were appropriately considered, a number of SAMAs rejected by Entergy as too costly would be cost-effective. *Id.*

(b) Entergy has not considered the contribution to severe accident costs by a fire in either of the spent-fuel pools at Indian Point Units 2 and 3. *See* Thompson Report, Section 6. Entergy has also failed to identify any SAMAs that would avoid or mitigate these costs. *Id.* at 51. If the costs of pool fires were considered, the value of SAMAs would be significant. *Id.* Even using unrealistically low probability estimates in NUREG-1353, *Regulatory Analysis for the Resolution of Generic Issue 82, Beyond Design Basis Accidents in Spent Fuel Pools* (1982), the offsite cost risk of a pool fire is substantially higher than the offsite cost risk of an Early High release from a core-damage accident. Thompson Report at 28. The present value of cost risk for a conventional pool accident at Indian Point (*i.e.*, an accident not caused by intentional attack), using the unrealistically low probability assumptions in NUREG-1353, is $27.7 million, a significant sum. Thompson Report at 49 and Table 7-7. If more realistic assumptions about the likelihood of a pool fire were used, the cost would be considerably higher. *See* Thompson Report at 51. In addition, the present value of costs risks ("PVCR") for a spent-fuel-pool fire would increase substantially (*i.e.,* from $27.7 million to $38.7 million) if the discount rate were changed from 7% to 3%, a more appropriate rate for an analysis of the benefits of measures to prevent or mitigate radiological accidents that Entergy uses to test the sensitivity of its SAMA analysis. *See* Thompson Report at 51-52. If the discount rate were dropped to zero, a rate that is justified in light of the catastrophic nature of the consequences involved, the PVCR for a spent-fuel-pool fire would be even higher -- $51.5 million. *Id.* at 52.

Riverkeeper is aware that the NRC classifies the environmental impacts of pool accidents and related SAMAs as "Category 1" issues that are not subject to consideration in individual license renewal proceedings absent a waiver or change in the regulations. *Florida Power and Light,* 54 NRC at 12. However, the NRC currently is considering two petitions for rulemaking that seek revocation of that prohibition, based on new and significant information showing that the environmental impacts of pool fires are significant. *Massachusetts Attorney General; Receipt of Petition for Rulemaking,* 71 Fed. Reg. 64,169 (November 1, 2006); *State of California; Receipt of Petition for Rulemaking,* 72 Fed. Reg. 27,068 (May 14, 2007). Riverkeeper endorses those petitions for rulemaking and agrees that the new and significant information presented by the Massachusetts Attorney General and the State of California in their rulemaking petitions warrants a re-evaluation of the environmental impacts of spent fuel storage. In fact, essentially the same new and significant information is reviewed in Dr. Thompson's report in Section 6. Therefore Riverkeeper requests that the Atomic Safety and Licensing Board ("ASLB") admits this aspect of the contention and holds it in abeyance pending the outcome of those rulemaking petitions. If and when the NRC changes its finding regarding the environmental impacts of high-density pool storage of spent fuel, then Riverkeeper will either challenge the merits of Entergy's failure to include pool-fire risks in its SAMA analysis under the newly amended regulation, or seek a waiver of the regulation under 10 C.F.R. 2.335(b).

(c) Entergy has not considered the contribution to severe accident costs made by intentional attacks on the Indian Point Unit 2 or Unit 3 reactors or their spent-fuel pools, although such attacks are reasonably foreseeable and indeed are anticipated by the NRC. *See* Thompson Report, Section 7. The Indian Point reactors and spent fuel pools are vulnerable to a range of attack scenarios for which conventional probabilistic risk assessment ("PRA") techniques can be adapted by postulating an initiating event (malicious act) and then examining the outcomes of that event. *Id.* at 42-45.

In adapting PRA techniques in this manner, it is reasonable and prudent to assign a probability estimate of one per 10,000 reactor-years for purposes of evaluating SAMAs. *Id.* at 45. As discussed in Table 7-7 and Section 9 of Dr. Thompson's report, the present value of cost risks for an attack on an Indian Point reactor and its pool exceeds half a billion dollars, warranting significant expenditures on SAMAs. The present value of cost risks for an attack on a reactor alone are also significant -- $62 million to $73 million. *Id.* at 49. Entergy has not considered relevant SAMAs with a value of this magnitude.

Entergy's failure to address the environmental impacts of intentional attacks in its SAMA analysis is inconsistent with the National Infrastructure Protection Plan ("NIPP"), which articulates principles for increasing the inherent robustness of infrastructure facilities against attack. Thompson Report at 58-59. Entergy should address the NIPP principles, especially in the context of storing spent fuel, because enhanced robustness of facilities at Indian Point could significantly reduce the radiological and regulatory risk-related impacts of continued operation of the IP2 and IP3 plants. *Id.* Neither Entergy nor the NRC has proffered any analysis or plan regarding implementation of the NIPP principles at Indian Point. This failure to address the NIPP is inconsistent with federal regulations requiring integration of environmental studies with other environmental agencies. 40 C.F.R. § 1502.25. While NIPP is not technically an environmental agency, its policies have tremendous significance for protection of the environment from the effects of intentional attacks on nuclear facilities.

Riverkeeper is aware that the NRC Commission has refused to consider the environmental impacts of intentional attacks in its EISs for nuclear facilities, despite a recent decision by the U.S. Court of Appeals for the Ninth Circuit that NRC's position is unreasonable. *Amergen Energy Company, L.L.C.* (Oyster Creek Nuclear Generating Station), CLI-07-08, 65 NRC 124 (2007), citing *San Luis Obispo Mothers for Peace v. NRC,* 449 F.3d 1016 (9th Cir. 2006), cert. denied, 127 S.Ct. 1124 (2007). Riverkeeper therefore requests that the ASLB refer this aspect of Contention EC-2 to the Commission, with a request for reconsideration of the *Amergen* decision. For the reasons set forth in *San Luis Obispo Mothers for Peace,* 449 F.3d at 1028-35, the Commission's refusal to consider the environmental impacts of intentional attacks on nuclear facilities is unreasonable. The Commission should also honor the request by the U.S. Environmental Protection Agency ("EPA") to address the impacts of intentional attacks in the EIS for license renewal at Indian Point. Letter from Grace Musumeci, U.S. EPA, to Chief, NRC Rules and Directives Branch (October 10, 2007) (ADAMS Accession No. ML 072960360).

Riverkeeper also seeks Commission reconsideration of two other rationales provided by the Commission for its refusal to consider the environmental impacts of intentional attacks in its environmental review of license renewal applications. First, the Commission should reconsider its rationale that:

> in the case of a license renewal application, where reactor operation will continue for many years regardless of the Commission's ultimate decision, it is sensible not to devote resources to the likely impact of terrorism during the license renewal period, but instead to concentrate on how to prevent a terrorist attack in the near term at the already licensed facilities. As there appears to be little practical benefit in conducting a license renewal terrorism review, the Commission has no duty under NEPA to do so.

Duke Energy Corp. (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-26, 56 NRC 358, 365 (2002) (footnotes omitted). The Commission's reasoning amounts to a conclusion that the benefits of considering the environmental impacts of attacks during a license renewal term would be marginal because those impacts effectively are addressed in the current license term. As discussed in the Thompson Report in Sections 7 and 9, however, the Commission's reasoning is not supportable, because the level of defense required under the NRC's Atomic Energy Act-based security regulations is lighter than the fundamental design changes that may warrant consideration under NEPA if they are cost-effective.

In addition, even assuming for purposes of argument that the security measures now taken by the NRC are equivalent to SAMAs that would be considered under NEPA, the Commission's reasoning is inconsistent with NEPA, which imposes mandatory obligations on the NRC in considering proposals for re-licensing of nuclear plants. The NRC recognized as much in a 2001 decision denying a petition for rulemaking by the Nuclear Energy Institute ("NEI") that would have eliminated the requirement to consider SAMAs, *Nuclear Energy Institute; Denial of Petition for Rulemaking,* 66 Fed. Reg. 10,834 (February 20, 2001). In response to a comment that "the costs of performing the SAMA reviews required by Part 51 are not justified when compared to the small potential safety benefits that result from the reviews," the Commission stated:

> The NRC believes that it should continue to consider SAMAs for individual license renewal applications to continue to meet its responsibilities under NEPA. *That statute requires NRC to analyze the environmental impacts of its actions and consider those impacts in its decisionmaking.* In doing so, Section 102(2)(C) of NEPA implicitly requires agencies to consider measures to mitigate those impacts when preparing an impact statement. *See Robertson v. Methow Valley Citizens Council,* 490 U.S. 332 (1989). *NRC's obligation to consider mitigation exists whether mitigation is ultimately found to be cost-beneficial and whether or not mitigation ultimately will be implemented by the licensee.*

66 Fed. Reg. at 10,836 (emphasis added). The Commission also provided a detailed rebuttal to NEI's argument that license renewal was a mere "continuation" of the current operating term and therefore should not trigger NEPA obligations:

> It would appear that the logical extension of many of the petitioner's arguments go far beyond the mere elimination of SAMAs consideration from license renewal reviews. Indeed, to the extent that license renewal involves a continuation of impacts already experienced at the site under the current operating license, the arguments made by the petitioner would appear to call for the elimination of almost the entire environmental review of impacts from operation during the license renewal term, a position clearly at odds with the Commission's approach to the matter and also, as discussed below, inconsistent with the case law related to relicensing.
>
> The Commission does not dispute that a line of cases exists under NEPA law which excuses agencies from preparing EISs (or considering certain environmental impacts) where the Federal action does not change existing environmental conditions. See for example, *State of North Carolina v. Federal Aviation Administration,* 957 F.2d 1125 (4th Cir. 1992); *Cronin v. Department of Agriculture,* 919 F.2d 439 (7th Cir. 1990). In most of these cases, the Federal action taken does not itself create any additional impacts to activities that are ongoing and will continue with or without the Federal action. None of these cases appears to provide firm support for the petitioner's argument that the NRC can ignore the impacts of its actions in the context of license renewal. In fact, at least one circuit court squarely addressed the issue of relicensing and concluded that there is the need to consider environmental impacts in that context.
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> In *Confederated Tribes and Bands of the Yakima Indian Nation v. Federal Energy Regulatory Commission,* 746 F.2d 466 (9th Cir. 1984), the Ninth Circuit Court of Appeals considered whether the Federal Energy Regulatory

Commission (FERC) was required to prepare an EIS for its relicensing decision for the Rock Island Dam. In response to the FERC's argument that there had been 'no change in the status quo' and thus no EIS was necessary, the court found:

> Relicensing * * * is more akin to an irreversible and irretrievable commitment of a public resource than a mere continuation of the status quo. [Citation omitted]. Simply because the same resource had been committed in the past does not make relicensing a phase in a continuous activity. Relicensing involves a new commitment of the resource, which in this case lasts for a forty-year period.
>
> The court's statements here are consistent with NRC's position and its practice in promulgating and implementing the license renewal rule.

66 Fed. Reg. at 10,836-37. Thus, the Commission's position in *Duke Energy* is inconsistent with both NEPA and the Commission's previous interpretation of NEPA.

Finally, in *Duke Energy* the Commission found that even if NEPA required it to consider the impacts of intentional attacks in license renewal decisions, it had already done so in the 1996 GEIS for license renewal. 56 NRC at 365 n.24. The GEIS contains the conclusion that:

> Although the threat of sabotage events cannot be accurately quantified, the commission believes that acts of sabotage are not reasonably expected. Nonetheless, if such events were to occur, the commission would expect that resultant core damage and radiological releases would be no worse than those expected from internally initiated events.

GEIS at 5-18. This conclusion has been outdated by the significant change in the Commission's analysis of the potential for intentional attacks that has occurred since September 11, 2001. *See San Luis Obispo Mothers for Peace v. NRC,* 449 F.3d at 1031 ("We find it difficult to reconcile the Commission's conclusion that, as a matter of law, the possibility of a terrorist attack is 'remote and speculative,' with its stated efforts to undertake a 'top to bottom' security review against this same threat.")

In addition, in stating that it would expect the core damage from an attack to be the same as for a severe accident, the Commission overlooks the fact that SAMAs designed to avoid or mitigate conventional accidents may be different than SAMAs designed to avoid or mitigate the effects of intentional attacks. Moreover, the radiological consequences of a spent-fuel-pool fire are significantly different from the consequences of a core-damage accident. Thompson Report at 9 n.9. Not only do these impacts warrant independent consideration, but the SAMAs for a spent-fuel-pool fire would be quite different from the SAMAs for a severe core-damage accident. *Id.* at 52.

2. Inadequate consequence analysis for severe accidents.

In the radiological consequence calculations performed by Entergy in support of its SAMA analysis, Entergy has significantly (by more than a factor of three) underestimated mean population doses and other off-site costs resulting from a severe accident at Indian Point, and has ignored uncertainties that could increase its consequence estimates by a factor of ten or more. These underestimates are due in part to (a) Entergy's use of a source term that results in unusually low mean off-site accident consequences in comparison to results obtained with source terms vetted by independent experts and recommended for use by NRC; (b) Entergy's failure to adequately consider the uncertainties in its consequence calculations resulting from meteorological variations; and (c) Entergy's inappropriate use of the $2,000/person-rem dose conversion factor. As a result of these deficiencies in Entergy's analysis, many SAMAs that were rejected on the basis that they were not cost-beneficial may actually be justified when a more realistic and conservative consequence assessment is considered.

In particular:

a) The source term used by Entergy to estimate the consequences of the most severe accidents with early containment failure is based on radionuclide release fractions generated by the MAAP code (a proprietary industry code that has not been validated by NRC), which are smaller for key radionuclides than the release fractions specified in NRC guidance such as NUREG-1465, *Accident Source Terms for Light-Water Nuclear Power Plants* (1995) and its recent reevaluation for high-burnup fuel, ERI/NRC 02-202, Accident Source Terms for Light-Water Nuclear Power Plants: High-Burnup and MOX Fuels (2002). The source term used by Entergy results in lower consequences than would be obtained from NUREG-1465 release fractions and release durations. *See* Lyman Report at 1.

For example, as Dr. Lyman points out, the IP2 cesium release fraction for the "early high" scenario used by Entergy is 0.229, compared to a total of 0.75 for NUREG-1465. Lyman Report at 3. It has been previously observed, however, that MAAP generates lower release fractions than those derived and used by NRC in studies such as NUREG-1150. A Brookhaven National Laboratory study that independently analyzed the costs and benefits of one SAMA in the license renewal application for the Catawba and McGuire plants noted that the collective dose results reported by the applicant for early failures:

> seemed less by a factor between 3 and 4 than those found for NUREG-1150 early failures for comparable scenarios. The difference in health risk was then traced to differences between [the applicant's definitions of the early failure release classes] and the release classes from NUREG-1150 for comparable scenarios ... the NUREG-1150 release fractions for the important radionuclides are about a factor of 4 higher than the ones used in the Duke PRA. The Duke results were obtained using the Modular Accident Analysis Package (MAAP) code, while the NUREG-1150 results were obtained with the Source Term Code Package and MELCOR. Apparently the differences in the release fractions ... are primarily attributable to the use of the different codes in the two analyses."

J. Lehner et al., *Benefit Cost Analysis of Enhancing Combustible Gas Control Availability at Ice Condenser and Mark III Containment Plants* at 17 (Final Letter Report, Brookhaven National Laboratory December 23, 2002) (ADAMS Accession Number ML031700011). In light of the fact that Entergy's use of the MAAP code source term yields significantly lower consequences than use of the NRC's source term, Entergy should be required to repeat its SAMA analysis using source terms that are based on publicly available analysis, such as the one presented in NUREG-1465.

b) Entergy fails to consider the uncertainties in its consequence calculation resulting from meteorological variations by only using mean values for population dose and off-site economic cost estimates. Entergy applies an inconsistent approach to its consideration of the uncertainties in its risk calculations. Entergy conducted an uncertainty analysis for its estimate of the internal events core damage frequency (CDF). As a measure of the uncertainty inherent in the internal events CDF as determined by the PRA, Entergy provides the ratio of the CDF at the 95th percentile confidence level to the mean CDF, which it calculates to be 2.1 for IP2 and 1.4 for IP3 (ER at 4-51). It then bases its SAMA cost-benefit evaluation on the 95th percentile CDF (ER at E.1-31), rather than the mean CDF. However, Entergy omits consideration of the uncertainties associated with other aspects of its risk calculation. In particular, it does not consider the impact of the uncertainties associated with meteorological variations, which are found to be even greater than the CDF uncertainties reported by Entergy. Lyman Report at 4.

As Dr. Lyman discusses in his report, the consequence calculation, as carried out by the MACCS2 code, generates a series of results based on random sampling of a year's worth of weather data. The code provides a statistical distribution of the results. Dr. Lyman's MACCS2 calculations show that that the ratio of the 95th percentile to the mean of this distribution is typically a factor of three to four for outcomes such as early fatalities, latent cancer fatalities and off-site economic consequences. Lyman Report at 4. Because these ratios are greater than the ones considered in Entergy's CDF uncertainty analysis, it is unreasonable for Entergy to ignore them in the SAMA analysis.

For consistency, the "baseline benefit with uncertainty" that Entergy uses in the SAMA cost-benefit evaluation should be based on the 95th percentile of the meteorological distribution in addition to the 95th percentile of the CDF distribution.

c. By using a $2,000/person-rem conversion factor, Entergy underestimates the population-dose related costs of a severe accident at Indian Point because the conversion factor (i) does not take into account the significant loss of life associated with early fatalities from acute radiation exposure that could result from some of the severe accident scenarios included in Entergy's risk analysis; (ii) underestimates the generation of stochastic health effects by failing to take into account the fact that some members of the public exposed to radiation after a severe accident will receive doses above the threshold level for application of a dose- and dose-rate reduction effectiveness factor (DDREF). *See* Lyman Report at 5.

As Dr. Lyman explains, the $2,000/person-rem conversion factor is intended to represent the cost associated with the harm caused by radiation exposure with respect to the causation of "stochastic health effects," that is, fatal cancers, nonfatal cancers, and hereditary effects. NUREG-1530, *Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy* (1995) ("NUREG-1530"). The value was derived by NRC staff by dividing the Staff's estimate for the value of a statistical life, $3 million (presumably in 1995 dollars, the year the analysis was published) by a risk coefficient for stochastic health effects obtained from ICRP 60, *1990 Recommendations of the International Commission on Radiological Protection.*

The use of the $2,000/person-rem conversion factor in Entergy's SAMA analysis is inappropriate in two significant respects:

First, the $2000/person-rem conversion factor is specifically intended to represent only stochastic health effects, and not deterministic health effects. "including early fatalities which could result from very high doses to particular individuals." NUREG-1530 at 1. However, for some of the severe accident scenarios evaluated by Entergy at IP, large numbers of early fatalities (hundreds to thousands) could occur, representing a significant fraction of the total number of projected fatalities, both early and latent.. Therefore it is inappropriate to use a conversion factor that does not include deterministic effects. According to NRC's guidance, "the NRC believes that regulatory issues involving deterministic effects and/or early fatalities would be very rare, and can be addressed on a case-specific basis, as the need arises." NUREG-1530 at 13. The evaluation of severe accident consequences at Indian Point is certainly a case where this need exists.

Second, the $2000/ person-rem factor, as derived by NRC, underestimates the total cost of the latent cancer fatalities that would result from a given population dose because it assumes that all exposed persons receive doses below the threshold at which the dose and dose-rate reduction factor ("DDREF") should be applied.[110] However, as Dr. Lyman points out, for certain severe accident scenarios at IP evaluated by Entergy, considerable numbers of people would receive doses high enough so that the DDREF should not be applied. Lyman Report at 5. Thus a single cost conversion factor, based on a DDREF of 2, is not appropriate when some

[110] The DDREF is a factor that reflects the reduced potency of radiation to cause cancer at low doses or low dose rates. The default MACCS2 model will reduce the likelihood that an individual receiving a dose of radiation will develop a fatal cancer by a factor of 2 (the DDREF0 if the total effective dose equivalent for that individual is below 20 rem. This factor is not applied if the total effective dose equivalent is 20 rem or greater and is delivered within a relatively short period of time. D.I. Chanin and M.L. Young, *Code Manual for MACCS2: Volume 1, User's Guide*, SAND97-0594, Sandia National Laboratories, March 1997.

members of an exposed population receive doses for which a DDREF would not be applied. Lyman Report at 6.

As a result of its inappropriate use of the $2,000/person-rem conversion factor, Entergy underestimates the health-related costs associated with severe accidents. As Dr. Lyman explains, a more accurate and reliable way to evaluate the cost equivalent of the health consequences resulting from a severe accident is simply to sum the total number of early fatalities and latent cancer fatalities, as computed by the MACCS2 code, and multiply by the $3 million figure. This method would eliminate the unreasonable distinction between the loss of a "statistical" life and the loss of a "deterministic" life when calculating the cost of health effects. Lyman Report at 6.

Dr. Lyman has estimated the impact of the above deficiencies in Entergy's methodology by performing an independent assessment, using the MACCS2 code, of the consequences of the highest-impact release scenario (the "early, high" release category) considered by Entergy in its SAMA analysis. Lyman Report at 6. Among other results, Dr. Lyman finds a mean population dose more than three times the value calculated by Entergy and a 95th percentile dose more than ten times Entergy's value. Lyman Report at 8. Dr. Lyman's results for off-site economic impacts of the "early, high" release are more than 20 and more than 70 times greater than Entergy's result for the mean and 95th percentile, respectively. Lyman Report at 10.

These results suggest that Entergy has significantly underestimated the consequences of severe accidents at Indian Point and hence has also significantly underestimated the benefit of certain SAMAs. Entergy should revise the consequence assessment and SAMA analysis by using more credible and conservative source terms, should consider the 95th percentile consequence values of the distribution with respect to weather variations, and should use a methodology for calculating the cost equivalent of off-site health impacts that properly accounts for individuals who receive acute radiation doses above the threshold for early fatalities and for those who receive chronic doses above the threshold for application of a DDREF.

CONTENTION EC-3: FAILURE TO ADEQUATELY ANALYZE IMPACTS OF SPENT FUEL POOL LEAKS

Contention: Entergy's ER fails to satisfy the requirements of NEPA, 42 U.S.C. §4332 *et seq.*, and NRC regulations implementing NEPA, including 10 C.F.R. §51.45(c), and (e), because the ER does not adequately assess new and significant information regarding the environmental impacts of the radioactive water leaks from the Indian Point 1 and Indian Point 2 spent fuel pools on the groundwater and the Hudson River ecosystem.

1. Entergy's claim that the Indian Point 2 ("IP2") spent fuel pool is no longer leaking is unsupported by the facts. Entergy and the NRC have failed to visually inspect nearly half the surface of the pool liner, due to the density of fuel in the pool and the minimal amount of clearance between the fuel racks and the bottom and lower sides of the liner. As a result, Entergy cannot say with reasonable certainty that the remaining, uninspected portions of the pool liner do not contain one or more pinhole leaks that may be contributing to the groundwater contamination. In addition, groundwater sample results indicate that significant tritium contamination of the groundwater in the vicinity of Indian Point 2 occurred between 2000 and 2005, thereby negating Entergy's claim that the current contamination is merely a remnant of historic leakage. Determining the status and duration of the IP2 leak is critical to developing an accurate assessment of the current and future onsite and offsite impacts of the IP2 groundwater contamination.

2. Entergy's claim that only "low concentrations" of certain radionuclides have been detected in onsite groundwater samples is flatly contradicted by the facts. Strontium-90 and cesium-137 have been detected in the groundwater at concentrations many times the maximum contaminant level allowed by the Environmental Protection Agency ("EPA") in drinking water. In fact, Entergy's own internal status reports indicate the presence of at least two groundwater plumes containing highly contaminated water underlying the site, one of tritium, primarily from IP2, and the other of strontium-90 and cesium-137 from Indian Point 1 ("IP1"). An accurate description of the degree of onsite groundwater contamination is critical to determining both the environmental impacts and the future costs of remediation required for decommissioning Indian Point. Entergy has failed to provide sufficient accurate information regarding the degree of groundwater contamination in the ER.
3. Entergy failed to include any assessment of either current or future impacts of the groundwater contamination on Hudson River fish and shellfish in the ER, despite recent sample results showing elevated levels of strontium-90 in several fish samples collected by Entergy from the Hudson River. Entergy only began analyzing fish samples for strontium-90 in 2006, and has publicly released the results of only a single set of fish samples, collected in 2006. Based on the lack of such an assessment in the ER, Entergy cannot say with reasonable certainty that the migration of contaminated groundwater to the Hudson River has not caused an increase in the level of radionuclides such as strontium-90 and cesium-137 in Hudson River fish, shellfish and vegetation.

For the foregoing reasons, the conclusions contained in the ER regarding the significance of the groundwater contamination are misleading, incomplete and legally insufficient for purposes of satisfying the basic tenets of NEPA and NRC regulations. As a result, Entergy's LRA is incomplete and must be rejected.

This contention is supported by the March 16, 2006 NRC Special Inspection Report for Indian Point, the September 1, 2006 NRC Liquid Radioactive Release Lessons Learned Task Force Final Report, internal Entergy memoranda and e-mail correspondence, and groundwater monitoring well sample results obtained by Riverkeeper through Freedom of Information Act (FOIA) requests filed between August 2005 and October 2007.

Basis:

A. Entergy Assessment of Groundwater Contamination

Section 5.0 of the ER contains Entergy's response to the NRC requirement that an applicant for license renewal assess any new and significant information regarding environmental impacts of a plant's operation during the extended license term. 10 C.F.R. §51.53(c)(3)(iv). Entergy identifies groundwater contamination as "one potential issue that could be classified as new information, but not necessarily significant." ER, at 5-2. Section 5.1 contains the assessment of the impacts of groundwater contamination at Indian Point, and refers to both NUREG-1437 and the Supplemental EIS for the D.C. Cook Nuclear Plant renewal as support for its assertion that impacts to groundwater quality have generally been found to be "SMALL," and therefore not significant for purposes of NEPA. *Id.* at 5-4, 5-6.

Entergy then concludes that "the NRC and Entergy have not found any condition that indicates that occupational or public health and safety have been, *or likely will be,* affected by the *current* onsite groundwater contamination. *Id.* at 5-5 (emphasis added). Entergy bases this assertion on information and sampling data collected as of the date of the application. *Id.* To support this conclusion, Entergy posits that contamination caused by the IP2 spent fuel pool is merely a result of "historical pool leakage in the 1990s which has since been repaired." *Id.* at 5-6. In addition, Entergy claims that "Strontium-90, Cesium-137, and Nickel-63 have been detected in *low concentrations* in some onsite groundwater monitoring well samples." *Id.* at 5-4. Finally, Entergy concludes that "The radionuclide release is not anticipated to change environmental considerations, such as water usage, land usage, terrestrial or aquatic ecological conditions, or air quality...as a result of license renewal activities." *Id.* at 5-6.

B. NEPA and NRC Requirements for Assessing New and Significant Information

NRC regulations implementing NEPA require an applicant for license renewal to assess any "new and significant" information regarding the environmental impacts of the plant's operation during the renewal period. 10 C.F.R. §51.53(c)(3)(iv). NRC regulations do not specifically define "significant." However, the Council on Environmental Quality ("CEQ") regulations implementing NEPA contain a lengthy definition of "significantly" that requires consideration of the context in which the proposed action is situated, and the intensity of the impacts. 40 C.F.R. §1508.27. *See also Sierra Club v. Bosworth, 496 F.Supp. 2d 931, 2006 U.S. Dist. LEXIS 67086 (N.D. Cal., 2006)*(Court found Forest Service violated NEPA when it failed to require a supplemental EIS despite significant new information on impacts of timber projects.) When considering the context of a site-specific action, "[S]ignificance would usually depend upon the effects in the locale rather than in the world as a whole. Both short term and long term effects are relevant." §1508.27(a). Analysis of intensity focuses on the severity of the impacts, and the regulation lists ten factors to be assessed in determining significance.[111]

[111] The ten factors that must be considered in evaluating the intensity of the impact are:

1. Impacts that may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial.

2. The degree to which the proposed action affects public health or safety.

3. Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

4. The degree to which the effects on the quality of the human environment are likely to be highly controversial.

5. The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.

6. The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

7. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

8. The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.

9. The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

10. Whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment.

40 C.F.R. §1508.27(b).

NRC requirements for the preparation of an ER are found in 10 C.F.R. §51.45. The ER "should contain sufficient data to aid the Commission in its development of an independent analysis." §51.45(c). In addition, the ER must not be limited to information supporting the proposed action, but should include adverse information. §51.45(e). The Supplemental EIS prepared by the NRC, and based initially on Entergy's ER, must also include a recommendation as to whether the plant's license should be renewed. Section 51.95(c)(4) states

> The supplemental environmental impact statement must contain the NRC staff's recommendation regarding the environmental acceptability of the license renewal action. In order to make its recommendation and final conclusion on the proposed action, the NRC staff, adjudicatory officers, and Commission shall integrate the conclusions, as amplified by the supporting information in the generic environmental impact statement for issues designated Category 1 (with the exception of offsite radiological impacts for collective effects and the disposal of spent fuel and high level waste) or resolved Category 2, information developed for those open Category 2 issues applicable to the plant in accordance with § 51.53(c)(3)(ii), and *any significant new information.* Given this information, the NRC staff, adjudicatory officers, and Commission shall determine whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable. (emphasis added).

Entergy's assessment of new and significant information must be accurate and complete enough to enable the Commission to make such a determination. Riverkeeper's challenge to the adequacy of Entergy's assessment is therefore material to the findings the NRC must make in this proceeding. *See* 10 C.F.R. 2.309(f)(iv).

C. Inadequacy of Entergy's Assessment of Groundwater Contamination

1. Entergy's claim that the Indian Point 2 spent fuel pool is no longer leaking is unsupported by the facts

In Section 5.1 of the ER, Entergy claims that "no leaks have been identified in the IP2 fuel pool liner and the contamination in that area is not consistent with active leakage. This would indicate that the contamination related to the IP2 fuel pool is the result of historical pool leakage in the 1990s which has since been repaired." ER at pg. 5-6. This claim is completely at odds with the following facts, which suggest the IP2 leak source remains unknown and the leak is continuing to contribute to groundwater contamination.

First, Entergy and the NRC have been unable to inspect nearly forty percent of the stainless steel spent fuel pool liner for IP2, due to the density of fuel in the pool and the minimal amount of clearance between the fuel racks and the bottom and lower sides of the liner.[112] Neither Entergy nor the NRC have stated publicly or described in the ER whether it is feasible to inspect the remaining portion. Nor have they explained how or even if they will be able to determine whether a leak is present in the uninspected portions of the pool in the absence of a comprehensive visual inspection. Given these facts, Entergy cannot state with any reasonable certainty that no additional leaks exist.

The lack of accurate information regarding the scope and status of the IP2 pool leakage was reinforced in September 2007, when Entergy reported the discovery of a

[112] Entergy's description of the groundwater investigation can be found on the New York State Emergency Management website at http://jic.semo.state.ny.us/PlantStatus/PlantStatusMain.aspx, last accessed November 29, 2007. *See also* NRC's website on the Indian Point leaks at http://www.nrc.gov/reactors/plant-specific-items/indian-point/on-going-activities.html, last accessed May 30, 2007.

pinhole leak in the IP2 fuel transfer canal that is thought to be contributing to the groundwater contamination.[113] This new evidence undermines Entergy's claim in Section 5.1 of the ER regarding the status of the IP2 tritium leak and reinforces the need for Entergy and the NRC to complete their examination of the IP2 spent fuel pool.

Second, groundwater sample results indicate that significant tritium contamination of the groundwater in the vicinity of Indian Point 2 occurred between 2000 and 2005, thereby negating Entergy's claim that the current contamination is merely a remnant of historic leakage.

The 2006 NRC Special Inspection Report assessing the groundwater contamination at Indian Point describes this factual discrepancy.[114] Page 1 of the report states

> Entergy sampled existing "Due Diligence" wells that were developed in 2000. One of these wells, MW-111 (last sampled for tritium in 2000 with no activity detected) was sampled on September 29, 2005. The analytical result, reported on October 5, 2005, indicated 211,000 pCi/l, tritium.[115]

Monitoring Well-111 ("MW-111") is located in the IP2 transformer yard, near the IP2 fuel storage building.[116] These results clearly indicate that additional tritiated water leaked from the IP2 facility into the groundwater between 2000 and 2005. Neither NRC nor Entergy has suggested that there could be another source of tritium leakage at IP2 besides the IP2 spent fuel pool. These facts simply do not support Entergy's assertion that the IP2 pool is no longer

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[113] Indian Point Energy Center Status Report (September 6, 2007), included here as Exhibit 1. *See also* Brian J. Howard, Westchester County Journal News, *Leak Found in Pipe at Indian Point,* September 7, 2007.
[114] *Indian Point Nuclear Generating Unit 2-Special Inspection Report No. 05000247/2005011* (March 16, 2006), ADAMS Accession No. ML060750842.
[115] *Id.* at 1.

leaking or has not leaked since the 1990s. NRC staff involved in the Indian Point groundwater investigation indicated their disagreement with Entergy on this issue, at the NRC Annual Assessment Meeting for Indian Point held on April 26, 2007.[117]

2. Entergy's claim that only low concentrations of certain radionuclides have been detected in onsite groundwater samples is incorrect.

Strontium-90 and Cesium-137 have been detected in the groundwater at concentrations many times the Maximum Contaminant Level ("MCL") allowed by the EPA in drinking water.[118] In fact, Entergy's own internal status reports indicate the presence of at least two groundwater plumes underlying the site, one of tritium, primarily from IP2, and the other of strontium-90 from IP1.[119]

Recent monitoring well sample results show that the levels of contamination in some areas have remained well above the EPA drinking water limits for both strontium-90 and cesium-137. For example, extremely high levels of cesium-137 have been found in MW-42, a well located near the IP1 fuel storage building. In April 2006, cesium-137 was detected in MW-42 at 51,400 pCi/l, 250 times the

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[116] For monitoring well locations, please refer to the Indian Point site map included here as Exhibit 2, *Monitoring Well Location and Function Zones,* obtained by Riverkeeper through FOIA/PA-2007-0324.

[117] Based on conversation between James D. Noggle, Senior Health Physicist, Division of Reactor Safety, NRC, and Phillip Musegaas, Staff Attorney, Riverkeeper, Inc., during the NRC public meeting, held at Colonial Terrace in Cortlandt, New York on April 26, 2007.

[118] EPA limits for radionuclides in drinking water are as follows; Tritium, 20,000 pCi/l. Strontium-90, 8 pCi/l. Cesium-137, 200 pCi/l. Information on MCLs and health effects of radionuclides can be found on the EPA website at http://www.epa.gov/rpdweb00/radionuclides/index.html, last accessed November 29, 2007. MCLs are also listed in *Radionuclides in Drinking Water, A Small Entity Compliance Guide,* U.S. EPA (February 2002).

[119] E-mail from James Noggle, NRC, to Timothy Rice and Larry Rosenmann of the New York State Department of Environmental Conservation ("DEC") (November 6, 2006), included here as Exhibit 3.

drinking water limit of 200 pCi/l.[120] Cesium-137 was also detected above the EPA limit in MW-65, located east and uphill from the IP1 fuel storage building, and in the IP1 Containment Spray Sump, an underground, unlined concrete tank located west of the IP1 reactor towards the Hudson River.[121]

Strontium-90 continues to be detected well above the EPA limit in a number of onsite monitoring wells, including the following; MW-42, MW-49, MW-65, and MW-54.[122] These wells are generally located near the IP1 reactor on both the east and west sides.[123] MW-49 is located on the western side of the discharge canal near the Hudson River.[124] These results are consistent with Entergy's description of a large groundwater plume extending from the IP1 reactor, west to the Hudson River.

These examples of sample results clearly show that extremely high levels of both strontium-90 and cesium-137 are present in the groundwater at Indian Point, as a result of leakage from the IP1 spent fuel pools. Entergy's claim in the ER that only low concentrations of these highly toxic radionuclides are present in the groundwater is clearly erroneous and misleading, because it attempts to portray the environmental impacts of the IP1 leaks as negligible. On the contrary, the groundwater at Indian Point is highly contaminated with toxic levels of several long-lived radionuclides, as evidenced by these results.

The presence of such high levels of radioactive contamination near the Hudson River also contributes to negative public perceptions regarding the degree of environmental harm caused by these leaks. Inaccurate and misleading information,

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[120] E-mail from James Noggle, NRC to Timothy Rice, DEC with attached NRC Data from Indian Pt. Split Monitoring Well Samples (August 23, 2007), included here as Exhibit 4.
[121] *Id.*
[122] *Id.*
[123] *See* Exhibit 2 for Monitoring well locations.
[124] *Id.* at Note 13.

such as that contained in the ER, exacerbates the public's fears regarding radioactive contamination. The heightened level of public concern surrounding these leaks was addressed by the NRC in its Task Force Report of September 2006.[125] The report commented on the widespread media coverage and concern voiced by State and local officials.[126] Referring to the incidences of leakage at Braidwood and Indian Point, the report noted that "Public meetings in the vicinity of the plants were widely attended, and the opinion expressed by the audiences was generally negative toward both the plant operator and the NRC."[127] Radioactive contamination of any degree is inherently controversial, and no less so when it is occurring unseen and undetected for long periods of time, as the Indian Point leaks were before Entergy "discovered" them in 2005. The inaccuracies found in the ER regarding the degree of contamination further degrade public confidence, and inhibit the public's ability to fully participate in the environmental review process under NEPA.

The long-term impacts of this contamination must be accurately assessed in order to comply with NEPA, and to provide for an accurate assessment of the future costs of remediation, whether during the plant's operation or after decommissioning. Entergy's attempt to deliberately downplay the significance of the groundwater contamination at the expense of factual accuracy violates both the spirit and the letter of NEPA.

3. Entergy failed to include any assessment of either current or future impacts of the groundwater contamination on Hudson River fish and shellfish in the ER.

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[125] *Liquid Radioactive Release Lessons Learned Task Force Final Report,* U.S. Nuclear Regulatory Commission (September 1, 2006), ADAMS Accession No. ML062650312.
[126] *Id.* at ii.
[127] *Id.*

The ER does not contain any analysis regarding the potential contamination of Hudson River fish and shellfish with strontium-90 as a result of the unmonitored leak from the IP1 spent fuel pool. On January 16, 2007 the *Westchester County Journal News* reported that fish samples taken by Entergy in Fall of 2006 showed slightly elevated levels of strontium-90 in their flesh, raising concerns that this radionuclide could potentially bioaccumulate in the Hudson River ecosystem.[128] Out of twelve individual fish and shellfish collected for analysis, four showed detectable levels of strontium-90.[129] The bones of the fish were not sampled for strontium-90, despite the fact that this type of radionuclide mimics calcium and concentrates in bones and teeth.

Entergy launched its own internal investigation in response to these findings which specifically suggests that further studies of Hudson River fish are warranted. In a January 2007 internal Entergy memorandum discussing preliminary dose Assessments from Sr-90 in Hudson River fish and invertebrates, the author concludes that following a conservative analysis of fish consumption based on the 24.5 pCi/kg of Sr-90 in the white perch sample from Roseton, the maximum individual annual dose would equal 44% of the annual allowable bone dose to an Adult male.[130] The memorandum concludes by suggesting that "While we should not discount the value originally determined by AREVA, this evaluation indicates that we must perform additional investigation in an attempt to validate and understand the 25 pCi/L recently

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[128] "Hudson River Fish Found to Contain Radioactive Isotope," Greg Clary, January 16, 2007 Westchester *County Journal News.*
[129] *Id.*
[130] IPEC-CHM-07-002, Memorandum from S. Sandike, Sr. Chemistry Specialist to T. Burns, NEM Supervisor, re: "Dose Assessments from Sr-90 in the Hudson River for Fish and Invertebrates-January 2007 Results" (January 17, 2007), included here as Exhibit 5.

identified at our control location in Roseton."[131] Despite this recommendation, no mention of the dose assessment or need for further studies is included in the ER.

Entergy also neglects to include any information regarding historic strontium-90 levels in fish and shellfish at Indian Point, before the NRC discontinued the requirement that licensees test for strontium-90 in the offsite environment. In January 2007, Entergy shared historic data with NRC staff which shows that both fish and shellfish showed detectable levels of not only strontium-90, but strontium-89, a shorter lived isotope that is not usually found in background radiation resulting from nuclear weapons testing.[132] While this is not definitive evidence of adverse impacts, it supports the need for further assessment of the effect that strontium-90 may have on Hudson River biota. This is particularly critical given the close proximity of Indian Point to Haverstraw Bay, a New York State designated Essential Fish Habitat and Significant Coastal Fish and Wildlife Habitat.[133] Haverstraw Bay certainly qualifies as an "ecologically critical area" for purposes of satisfying the definition of "significantly" under NEPA.[134]

Entergy has failed to provide the NRC with sufficient data to enable the agency to conduct an accurate, independent analysis of all potential future impacts. The omission of any assessment regarding the impact of the groundwater contamination on Hudson River fish and shellfish fails to satisfy NEPA and NRC regulations, in particular 10 C.F.R. 51.45(c) and (e).

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[131] *Id.* at pg. 2

[132] E-mail from Dara Gray, Entergy to James Noggle, NRC, with attached table entitled "Historic Strontium Tritium Results" (January 24, 2007), included here as Exhibit 6.

[133] Information on designated habitats can be found at the New York State Department of State website at http://nyswaterfronts.com/waterfront_natural_narratives.asp#HudsonRiver, last accessed November 29, 2007.

[134] *Id.* at Note 1, Factor 3.

V. CONCLUSION

For the foregoing reasons, the Atomic Safety and Licensing Board should grant Riverkeeper's hearing request and admit its contentions.

Respectfully submitted,

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November 30, 2007

CERTIFICATE OF SERVICE

I certify that on November 30, 2007, copies of the following documents were served on the following by first-class mail and e-mail, as indicated below:

> Riverkeeper, Inc.'s Hearing Request and Petition to Intervene in THE License Renewal Proceeding for the Indian Point Nuclear Power Plant;
> Notice of Appearance for Diane Curran;
> Notice of Appearance for Phillip Musegaas;
> Notice of Appearance for Victor Tarfur.

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Diane Curran

The Status of Fish Populations and the Ecology of the Hudson

Pisces Conservation Ltd, November 2007

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Summary

- The fish community of the Hudson Estuary has been continuously changing since systematic recording began in the 1980s.
- There are clear indications both at the community and individual population level that the populations of fish in the estuary are becoming less stable and showing greater year to year variation in abundance.
- Of the 13 key species subject to intensive study, three species, striped bass, blue fish and spottail shiner have shown a trend of increasing abundance since the 1980s. The other 10 species have declined in abundance, some greatly.
- Many other important species of fish are also showing long-term declines in abundance. For example, the American eel has greatly declined.
- There has been a recent increase in average water temperature and a decrease in dissolved oxygen levels. This may be influencing some of the changes observed and will increase the impact of thermal discharges.
- All the evidence points to the Hudson ecosystem presently being in a state of change, with declining stability. Neither the ecosystem as a whole, nor many of the individual species' populations, are in a healthy state.

Contents

Figures

Tables

1 Introduction

Riverkeeper asked Pisces Conservation to assess the state of the fish in the Hudson, using the latest available data. This report reviews the fish populations and ecology of the Hudson using the 2005 Year Class Report for the Hudson River Estuary Monitoring Program, reports and assessments prepared by the New York State Department of Environmental Conservation (NYSDEC) and the Atlantic States Marine Fisheries Commission (ASMFC), as well as recently published materials and other literature.

2 Large scale and synoptic features

As we will describe below, the fish community is not stable in the Hudson. The ecosystem appears to be declining in terms of stability. The estuary is in a state of flux, with temperatures increasing, dissolved oxygen decreasing, invasive species, including diseases, expanding their range, and indigenous species both increasing and decreasing.

Because the physical environment is the foundation upon which the biological world is built, we first consider recent changes in temperature and oxygen levels in the estuary. Both these variables are influenced by the power plant discharges. The natural temperature regime in the Hudson is notably extreme for a temperate estuary, with one of the largest known seasonal ranges for a large estuarine habitat. This in turn influences the fish community, and makes the species present particularly vulnerable to changes in temperature, or the local effects of a power plant cooling water discharge.

2.1 Temperature in the Hudson

Water temperature in the Hudson is increasing. This is clearly demonstrated by the statistically significant increase in mean average annual water temperature measured at Poughkeepsie Water Treatment Facility (Figure 1). The mean annual temperature in recent years is about 2 °C (3.6 °F) above that recorded in the 1960s.

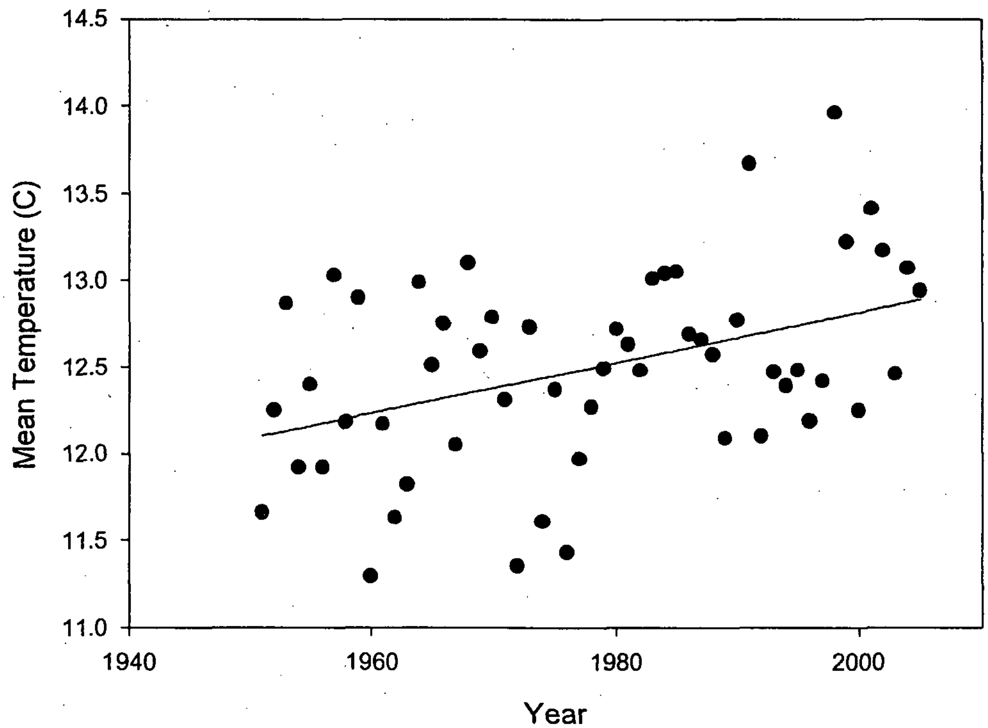


Figure 1: Average Annual Water Temperature (°C) as Measured at Poughkeepsie's Water Treatment Facility, 1951 to 2005.
(a = 0.0146, b = -16.32, F = 11.1157, p = 0.0016) – Data from 2005 Year Class Report – Appendix B Table B - 6

Examination of the daily temperatures for 2005 plotted against the mean, minimum and maximum temperatures from 1951 to 2004, show that the temperature for several summer months in 2005 was close to the maximum ever recorded. However, in the winter, it also reached some of the lowest temperatures recorded over a 53-year period. In summary, the temperature regime is becoming more extreme.

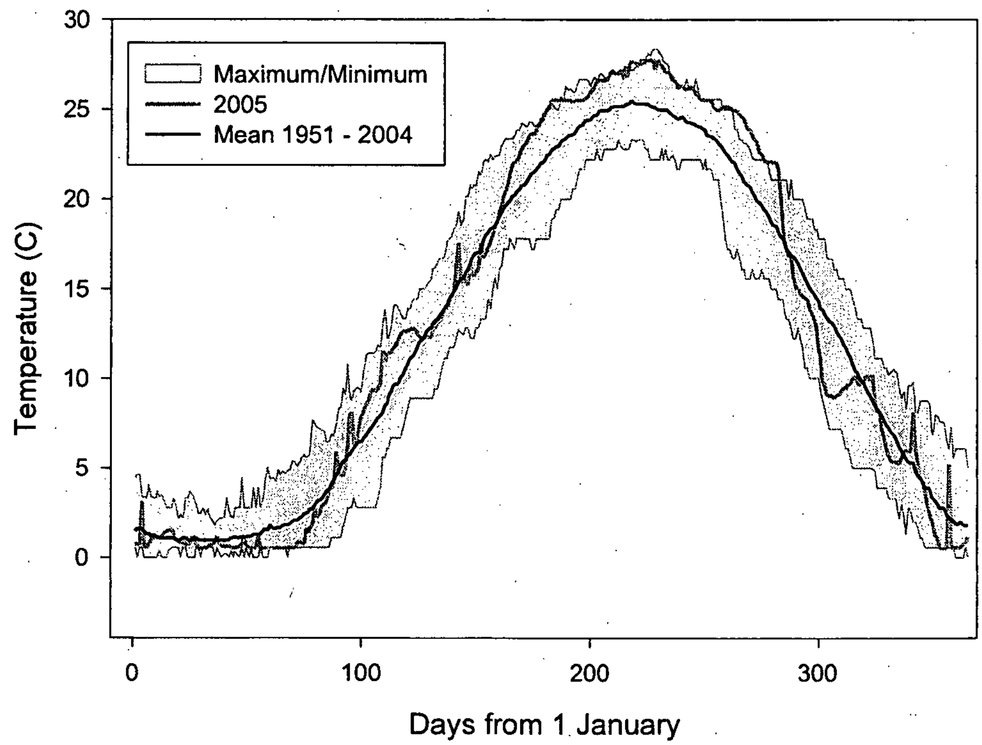


Figure 2: Poughkeepsie's Water Treatment Facility Data, Mean, Minimum, And Maximum Temperature (°C) for Each Day of the Year, 1951 to 2004, with 2005 data plotted in red.
Data from 2005 Year Class Report – Appendix B Table B - 5

2.2 Thermal tolerance of fish species found in the Hudson

The effects of temperature on the biology and ecological requirements of fish have been extensively studied and reviewed. Temperature can affect survival, growth and metabolism, activity, swimming performance and behaviour, reproductive timing and rates of gonad development, egg development, hatching success, and morphology. Temperature also influences the survival of fishes stressed by other factors such as toxins, disease, or parasites. Many of these effects will occur well below the upper lethal temperature, which are tabulated below for a range of common Hudson fish. In Table 1, the upper temperature that a range of Hudson River fish can tolerate is given, together with the acclimation temperature. When no size is given, the values are for adults. Generally, young and small fish are more vulnerable to elevated water temperatures than adults. Maximum summer water temperatures in the Hudson are about 81 °F (27.2 °C), which the table shows most fish can just tolerate. For some, such as the tomcod, it is too hot and they must seek cooler waters (for example head towards the ocean).

The least temperature-tolerant of the species in Table 1 are tomcod, alewife, rainbow smelt, yellow perch and American shad. As will be discussed later, this list includes species that have seen recent large declines in abundance.

Table 1: The upper tolerance limit for common Hudson estuary fish. The temperature at which the fish were acclimated prior to testing is also given.

Species	Latin Name	Acclimatization temperature °C	Upper tolerance limit °C
Carp	*Cyprinus carpio*	20	31-34
Large mouth bass	*Micropterus salmoides*	20	32.5
		30	36.4
Blue gill	*Lepomis macrochirus*	15	30.7
3-spined stickleback	*Gasterosteus aculeatus*	25-26	30.6
Yellow perch	*Perca flavescens*	15	27.7
Alewife	*Alosa pseudoharengus*	15	23
Rainbow smelt	*Osmerus mordax*		21
Sea lamprey	*Petromyzon marinus*		34
Tomcod	*Microgadus tomcod* 2 cm		19-20.9
	14-15 cm		23.5-26.1
	22-29 cm		25.8-26.1
Common shiner	*Notropis cornutus*	15	30.3
Brown bullhead	*Ictalurus nebulosus*	15	31.8
Striped bass	*Morone saxatilis* yolk sac		Mortalities start at 26
	Post yolk sac		Mortalities start at 30
	Early juveniles		Mortalities start at 34
American shad	*Alosa sapidissima*		28
White perch	*Morone americana*		32-34

2.3 Oxygen in the Hudson

The temperature of water has a direct effect on the dissolved oxygen (DO) concentration, which declines with increasing water temperature. This results in many fish and other aquatic organisms living in below-optimal oxygen levels during hot summer periods. As would be predicted, the significant upward trend in temperature has resulted in a statistically significant downward trend in DO (Figure 3) and (Figure 4). The sharp decline in DO in 2004 and 2005 is particularly notable.

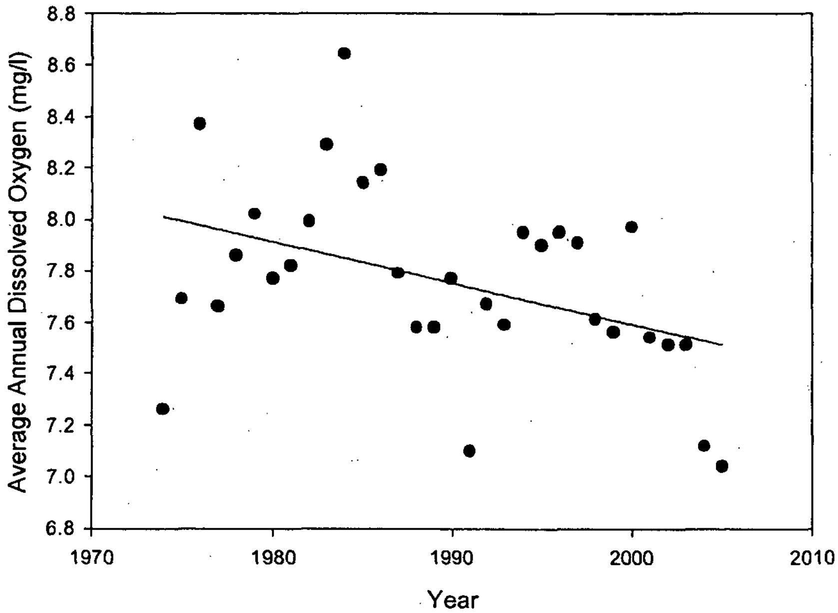


Figure 3: Average Annual Dissolved Oxygen (mg/l) from Long River/Fall Juvenile Surveys, 1974 to 2005 - (a =-0.0161, b = 39.7804, F = 6.4047, p = 0.0169)
Data from 2005 Year Class Report – Appendix B Table B - 14

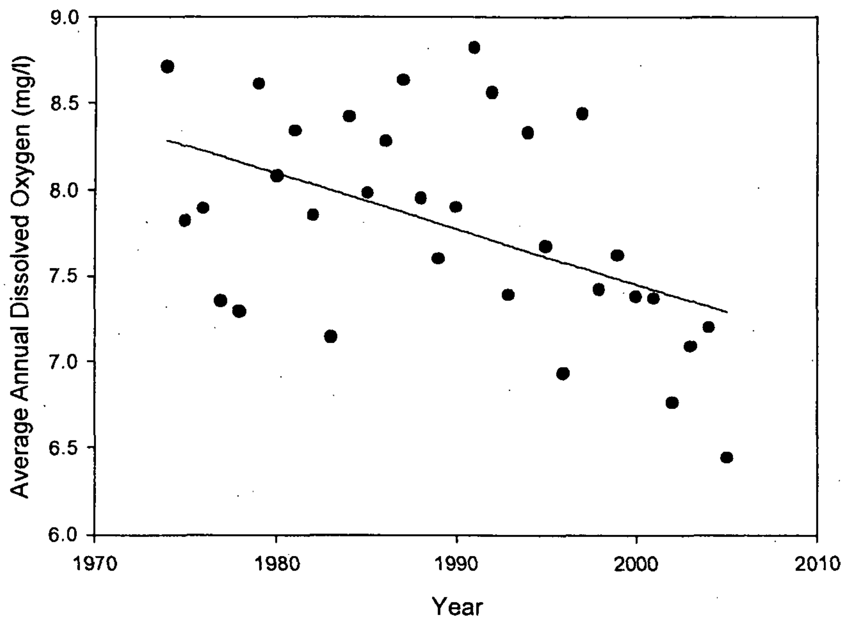


Figure 4 Average Annual Dissolved Oxygen (mg/l) from Beach Seine Surveys, 1974 to 2005 - (a =-0.0322, b = 71., F =9.5142, p = 0.0044)
Data from 2005 Year Class Report – Appendix B Table B - 16

Given the considerable efforts that have been taken to reduce organic pollution, and the great improvement in water quality in the vicinity of New York City, these declines in DO are disappointing, and potentially important indictors of a decline in water quality for fish.

The distribution of DO within the water column is complex. It can be affected by many factors including tidal flow, riverine metabolism, stratification and atmospheric diffusion. A typical profile of DO versus depth is shown in Figure 5.

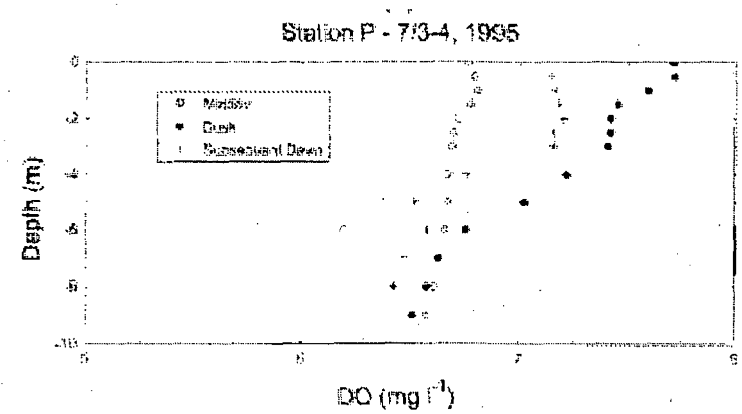


Figure 5: Typical depth profiles of DO measured on 3–4 July 1995 at Haverstraw Bay. Profiles for three sample times are shown for each station. (Swaney *et al* 1999)

This figure shows that the amount of oxygen in the water is often higher at the surface, and is increased during daylight hours as result of oxygen released by photosynthesis. The levels of DO are often reduced overnight as oxygen is metabolised by the organisms in the river.

3 The abundance of fish

3.1 The Annual Year Class Index

Since 1973, data have been collected from the Hudson in an attempt to quantify the size the populations of 16 species of fish that are found in the Hudson. The 16 species of fish were identified by the New York State Department of Environmental Conservation (NYSDEC) as being of interest in relation to the Hudson Settlement Agreement power plant's environmental impact. The data collection changed significantly in 1988, when a new area (Battery) was introduced to the sampling.

The fish of the Hudson live in many different parts of the river, in many different habitats. No single method of surveying fish can adequately represent this variation. The Year Class is therefore estimated from three separate studies (Table 2).

Table 2: Names and lengths of the three surveys that make up the Annual Year Class Index

Name	Dates	Known as
Long River Ichthyoplankton Survey	1974-2005	LRS or Long River Survey
Fall Juvenile Survey	1979-2005	FJS or Fall Shoals Survey,
Beach Seine Survey	1974-2005	BSS

3.1.1 Brief descriptions of each survey.

3.1.1.1 Longitudinal River Ichthyoplankton Survey

Sampling encompassed the entire length of the Hudson River estuary, from River Mile (RM) 1 at the Battery in Manhattan to RM 152 at the Federal Dam in Troy.

The LRS is designed to estimate the numbers, and distribution of eggs, larvae and post yolk sac larvae for selected Hudson River fish species – it also catches some juveniles. The primary species were Atlantic tomcod (*Microgadus tomcod*), American shad (*Alosa sapidissima*), striped bass (*Morone saxatilis*), white perch (*M. americana*) and bay anchovy (*Anchoa mitchilli*). LRS sampling is undertaken during the peak period for the young life stages of the fish, which is spring, summer, and early fall.

The survey is undertaken using a 1m tucker trawl towed upstream. The tucker trawl is mounted on an epibenthic sled to sample the deeper waters. 3,647 trawls of 5 minutes' duration were collected in 2005, of which 2,433 were analysed (where multiple trawls were available for the same area and week only a subset are analysed).

3.1.1.2 Fall Juvenile Survey

Samples are collected every other week from the Battery to the Troy Dam in mid-summer and fall.

The FJS is designed to estimate the number of Young of the Year (YOY) fish in the Estuary and their distribution. The target species are Atlantic tomcod, American shad, striped bass, and white perch.

The survey is undertaken using a 1m tucker trawl and a 3m beam trawl towed upstream. 2,002 5-minute trawls were collected in 2005.

3.1.1.3 Beach Seine Survey (BSS)

Samples were collected in alternate weeks to those of the FJS, using a beach seine from mid-June through October. The samples are taken from George Washington Bridge (RM 12) to the Troy Dam.

The BSS is designed to estimate the number of Young of the Year (YOY) fish in the Estuary and their distribution. The target species are American shad, Atlantic tomcod, striped bass, and white perch during periods when these species were concentrated primarily in the shallow, near-shore areas.

The survey is undertaken using a 30.5m beach seine. The area sampled was approximately 450m^2 per haul. 1000 hauls were collected in 2005.

The methods and scope of the survey are summarised in Table 3.

Table 3: Summary of 2005 Hudson river surveys (2005 Year Class Report Table 2-2).

	Sampling Schedule					Sample Number			
						Collection			
Program Phase	Start Week	End Week	Number of River Runs	Sampling Frequency	Strata Sampled	Projected	Actual	Lab Analysis	Sampling Gear
Longitudinal River Ichthyoplankton Survey	1 MAR	8 OCT	23	Weekly/ Biweekly	Shoal	585	586	554	1.0-m^2 net on epibenthic sled, or 1.0-m^2 Tucker trawl
					Channel	1,670[1]	1,670	987	1.0-m^2 Tucker trawl
					Bottom	1,363	1,363	602	1.0-m^2 net on epibenthic sled
Atlantic Croaker Ichthyoplankton Survey	14 NOV	5 DEC	2	Monthly	Shoal	32	32	32	1.0-m^2 net on epibenthic sled, or 1.0-m^2 Tucker trawl
					Channel	26	26	26	1.0-m^2 Tucker trawl
					Bottom	26	26	26	1.0-m^2 net on epibenthic sled
Fall Juvenile Survey	4 JUL	28 NOV	11	Biweekly	Shoal	427	426		3.0-m beam trawl, or 1.0-m^2 Tucker trawl
					Channel	649	649		1.0-m^2 Tucker trawl
					Bottom	1,055	1,054		3.0-m beam trawl
Beach Seine Survey	13 JUN	17 OCT	10	Biweekly	Shore	1,000	1,000		30.5-m beach seine

[1] Includes 125 samples for striped bass otolith analysis.

3.1.2 Where in the river is sampled

The 13 sections of the river (Figure 6), were divided into four habitat types:

- **Shore** - That portion of the Hudson River estuary extending from the shore to a depth of 10 ft (the stratum defined only for BSS).
- **Shoal** - That portion of the Hudson River estuary extending from the shore to a depth of 20 ft at mean low tide.
- **Bottom** - That portion of the Hudson River estuary extending from the bottom to 10 ft above the bottom where river depth is greater than 20 ft at mean low tide.
- **Channel** - That portion of the Hudson River estuary not considered bottom where river depth is greater than 20 ft at mean low tide.

Sampling is spread among the different habitats and river sections, throughout the year. Table 4 shows where the samples were taken from for each survey type.

Table 4: Habitat samples in the 13 regions of the Hudson in 2005 (- indicates no sampling scheduled)

Region	Abbreviation	River Miles	River Kilometers	2005 Surveys Shore	Shoal	Channel	Bottom
Battery	BT	1-11	1-19	–	–	X	X
Yonkers	YK	12-23	19-39	X	X	X	X
Tappan Zee	TZ	24-33	39-55	X	X	X	X
Croton-Haverstraw	CH	34-38	55-63	X	X	X	X
Indian Point	IP	39-46	63-76	X	X	X	X
West Point	WP	47-55	76-90	X	–	X	X
Cornwall	CW	56-61	90-100	X	X	X	X
Poughkeepsie	PK	62-76	100-124	X	–	X	X
Hyde Park	HP	77-85	124-138	X	–	X	X
Kingston	KG	86-93	138-151	X	–	X	X
Saugerties	SG	94-106	151-172	X	–	X	X
Catskill	CS	107-124	172-201	X	–	X	X
Albany	AL	125-152	201-246	X	–	X	X

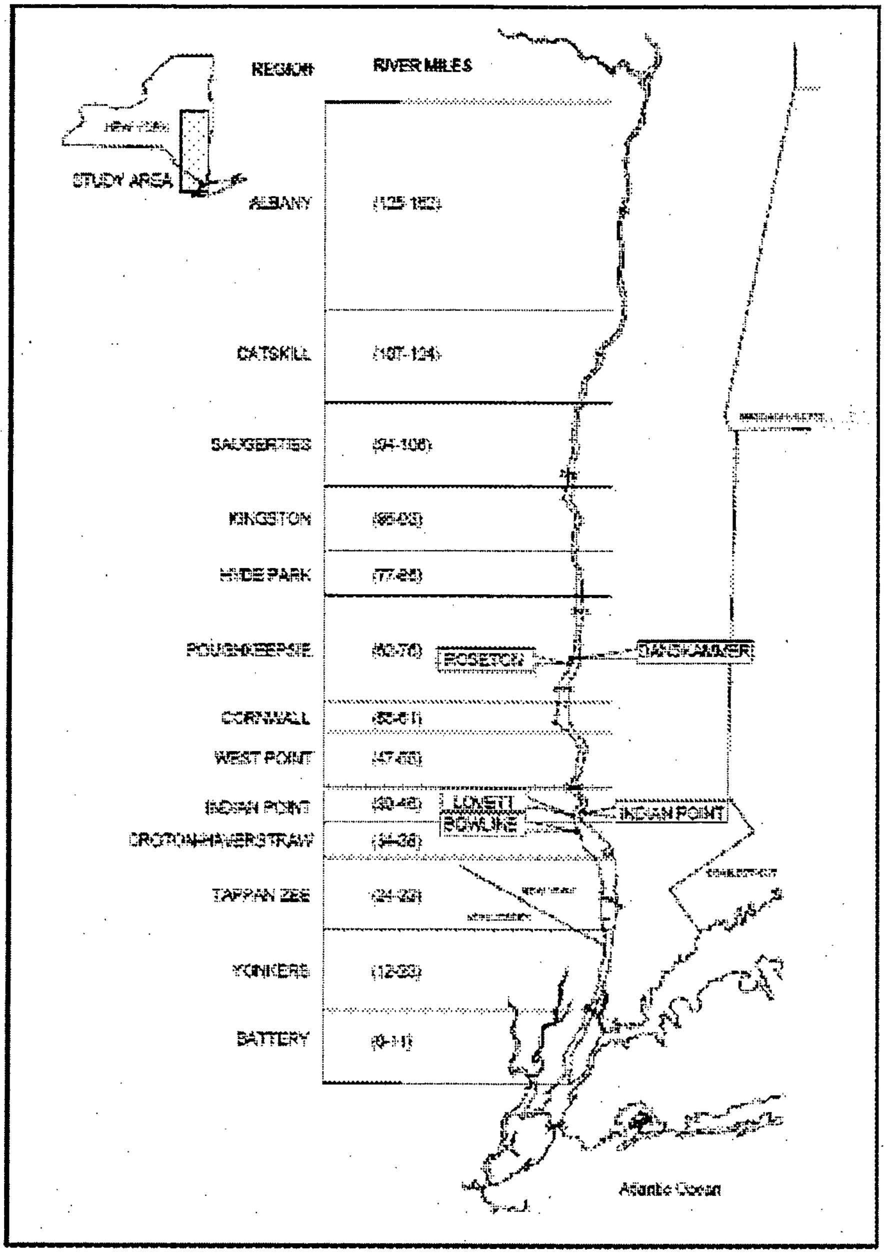


Figure 6: The 13 geographical locations with river mile boundaries used in the 2005 Hudson River Surveys.

3.1.3 What ages of fish are sampled

During the sampling, several different life stages of fish are caught. The definitions for each stage are given in Table 5.

Table 5: Life stages of fish sampled

Egg	Embryonic stage from spawning to hatching
Yolk Sac Larvae (YSL)	From hatching to development of a complete and functional digestive system
Post Yolk Sac Larvae (PYSL)	From development of a complete digestive system to transformation to juvenile form
Young of Year (YOY)	From completed transformation to Age 1.

An index is calculated separately for each of the life stages. For some species only some life stages are well-sampled. For example, bay anchovy breeds at the mouth of the estuary and therefore an index is only calculated for YOY.

3.1.4 How the fish are counted

Each of the three surveys used slightly different methods to catch the fish. Each method has advantages and disadvantages, and a direct one-to-one comparison of the results is not meaningful. Therefore, a series of indices derived from the catch data are used to combine the data into a single value, indicating the population size.

3.1.5 Calculations of the index

Gathering fish sampling data, and processing that information, is not a straightforward procedure. To obtain a reasonable estimation of how many fish of what age are in the Hudson in any year requires three separate surveys, which are undertaken over several months. Combining the data from these surveys is complex, as the efficiency of the fishing gear, effort used in each survey, and the age of the fish is different.

In a survey that is carried out over many years, it is inevitable that some factors will change between years. This can occur in several ways. For example, each year the total number of samples and volume sampled will vary (Figure 7 and Figure 8) due to gear failure, weather and management decisions. In addition, sample sites may be added or removed from the survey, altering the coverage of fish species; for instance the introduction of sampling in the Battery area in the mid-1980s improved the estimate of Bay Anchovy numbers.

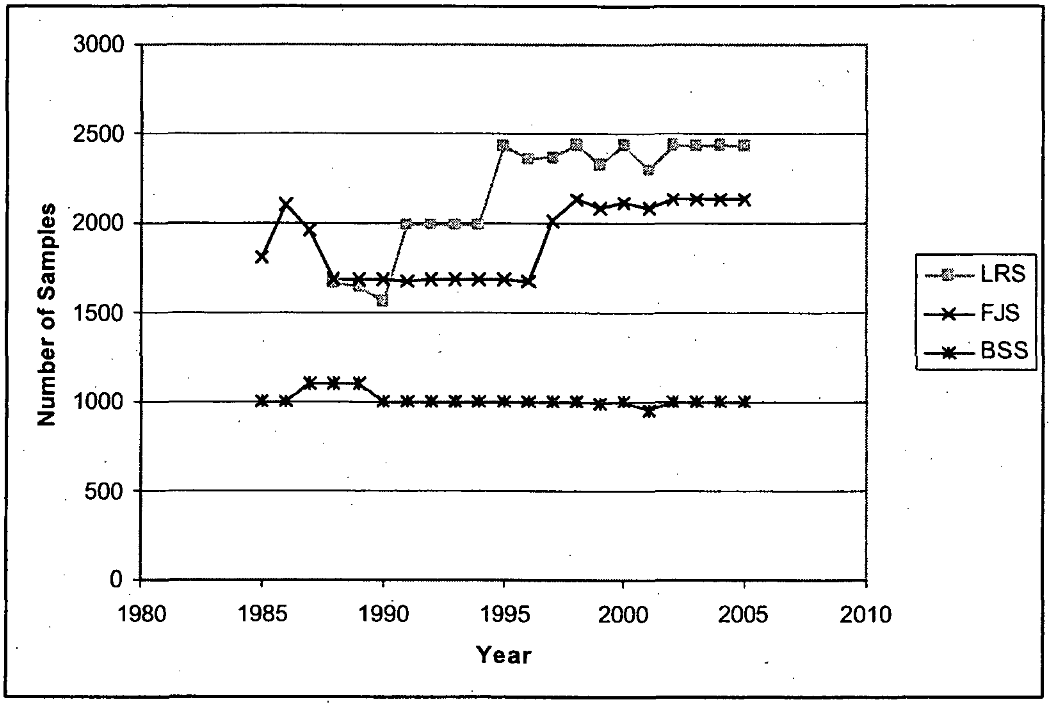


Figure 7: The number of samples per year for the three Hudson River surveys

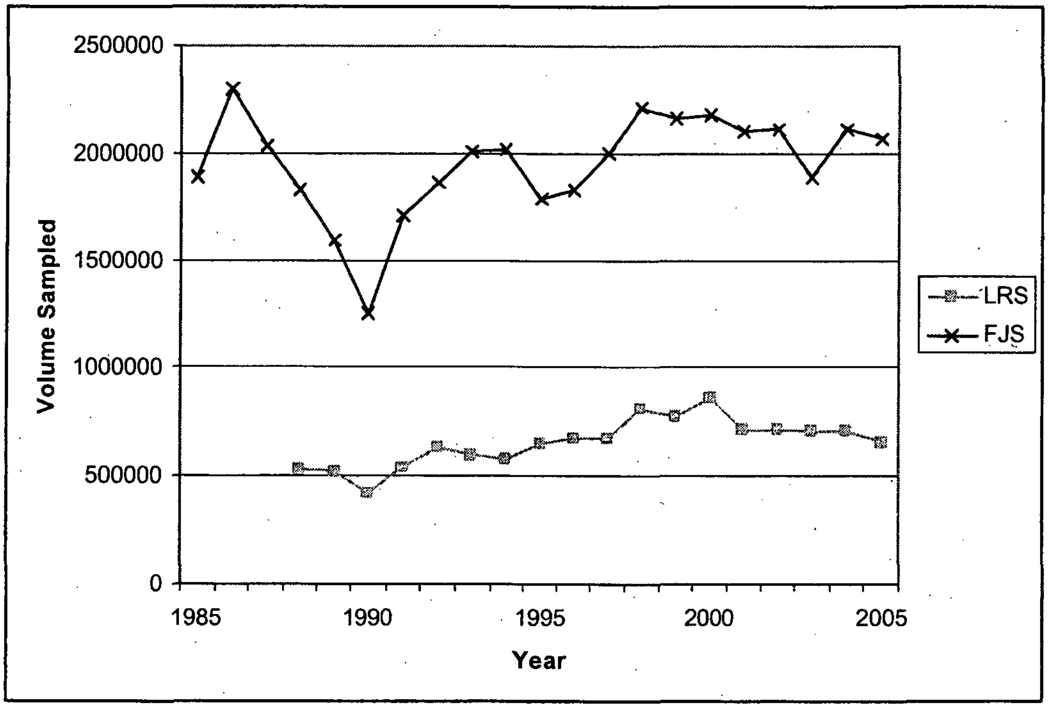


Figure 8: The volume of water sampled in the Long River Survey and the Fall Juvenile Survey.

To cope with the variations in the sampling between years, and also the sampling effort in different areas, an index needs to be calculated that indicates how many fish are present in each year. The actual calculation is complex, but in essence the number of fish actually caught is adjusted in each life stage to a number representing the number caught under some standardized sampling effort.

As a simple example, if 200 fish were caught in a survey of 50 samples in one year, and 100 fish were caught in 10 samples the next year, the index might be standardised at 25 samples, giving an index of 100 for year one and 250 in year two.

Full explanations are given in the 2005 Year Class Report Pages 2-11 to 2-17.

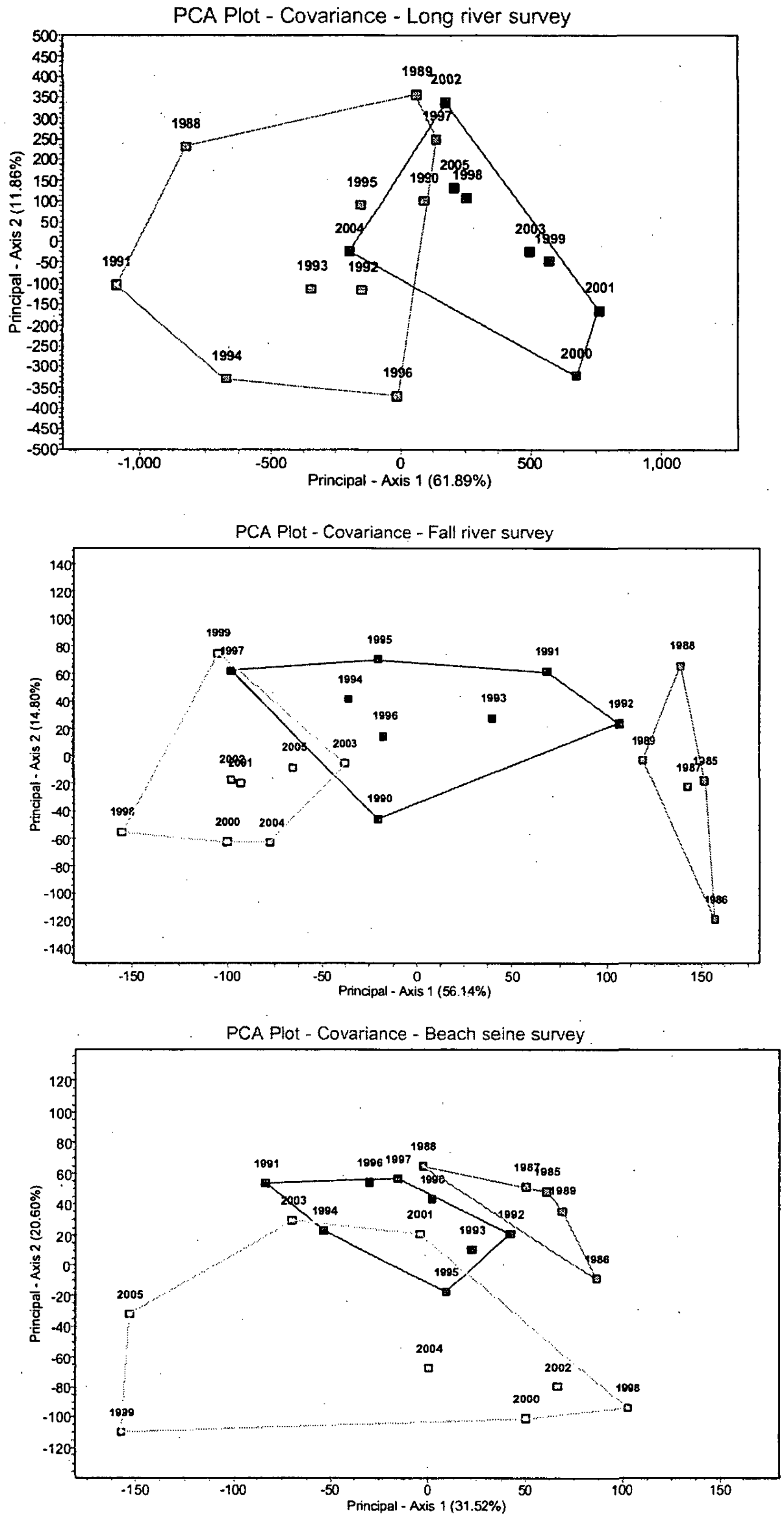
3.2 Changes in community structure

The extensive data sets produced by the Long River, Fall Juvenile and Beach Seine Surveys allow a general analysis of the change in fish community structure since the 1980s.

Since 1985, there is no evidence for an appreciable change in total fish species number in the estuary. However, this apparent stability hides great changes in the actual species present and their relative abundances. To compare the structure of the communities through time the annual abundance data from all three surveys were analysed, using a number of multivariate statistical methods. As all the methods investigated lead to the same conclusion, we use here Principal Components Analysis, which is a standard technique familiar to most scientists.

Figure 9 clearly shows that there has been a progressive change in the fish community sampled by all three surveys. Samples collected in the 1980s form a relatively tight group, indicating that the community during this period changed little from year to year. In comparison, the community post 1997 is considerably different and shows increased between year variability. For example, the plot for the beach seine survey shows that the cluster of points for the 1980s (red points and perimeter), 1990s up to 1997 (blue points and perimeter) and post 1997 to present (green points and perimeter) form clearly different clusters and the area enclosed by their perimeters is gradually increasing in size. It can be concluded that the fish community has been changing rapidly since 1985 and is showing clear signs of increased instability.

Figure 9: Principal Components Analysis of fish survey data show the change in the community from the 1980s to the present.
In each plot the 1980s are in red, later years are plotted in blue or green. – Data from 2005 Year Class Report – Appendix C Tables C-1 to 3



3.3 *Trends in abundance of the 13 key species*

As an index of total fish abundance trends, the average change in the abundance index of the 13 key species reported in the river survey, was calculated (Figure 10). To calculate this index, each species index was rescaled to a maximum of 1. This was done by dividing all the indices for a species by the maximum index for that species. This gives equal weighting to all species and allowing a general trend in abundance to be summarised. If the data had not been standardized the trend would have simply reflected the trend in the most abundant species.

Figure 10 shows a statistically significant downward trend, indicating that the majority of the 13 key species are in long-term decline. Around this declining trend there is considerable variability so that little can be inferred from an examination of a few isolated observations.

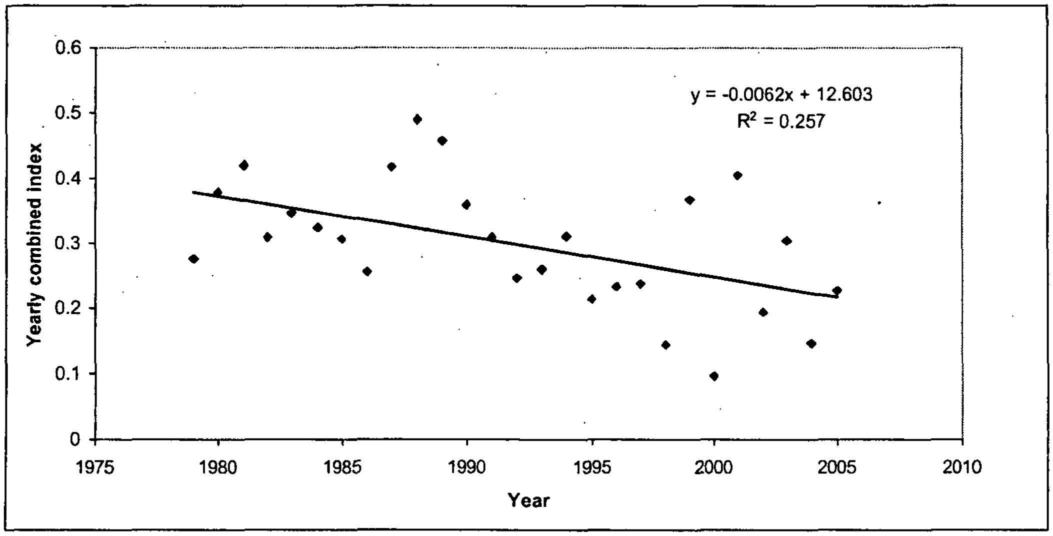


Figure 10: Plot of the average standardised abundance index of the 13 key species recorded in the long river survey - Juvenile data
All species standardized so maximum value = 1 Data from 1979 – 2005. (a = -0.0062, b = 12.60, F = 8.647, p = 0.007) – Data from 2005 Year Class Report – Appendix D Table D – 2 to 14

In terms of the trend in abundance, the 13 key species can be divided into those with an increasing trend, and those showing a decline. The three increasing species are striped bass, spottail shiner and bluefish (Figure 11). All the other 10 species show declining trends (Figure 12).

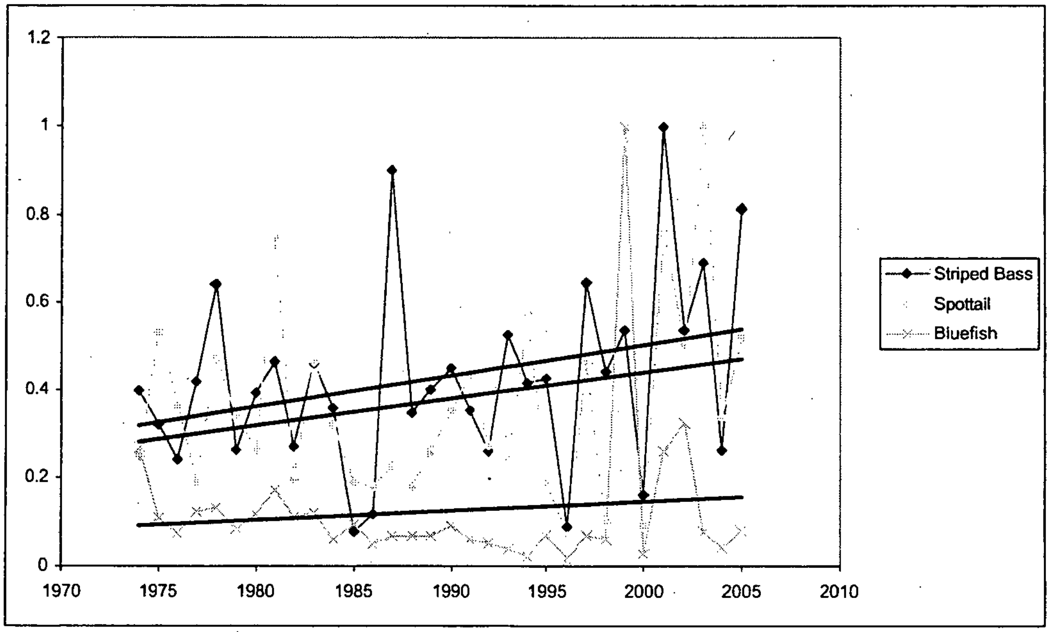


Figure 11: Three positive trends of species – indices standardised to 1

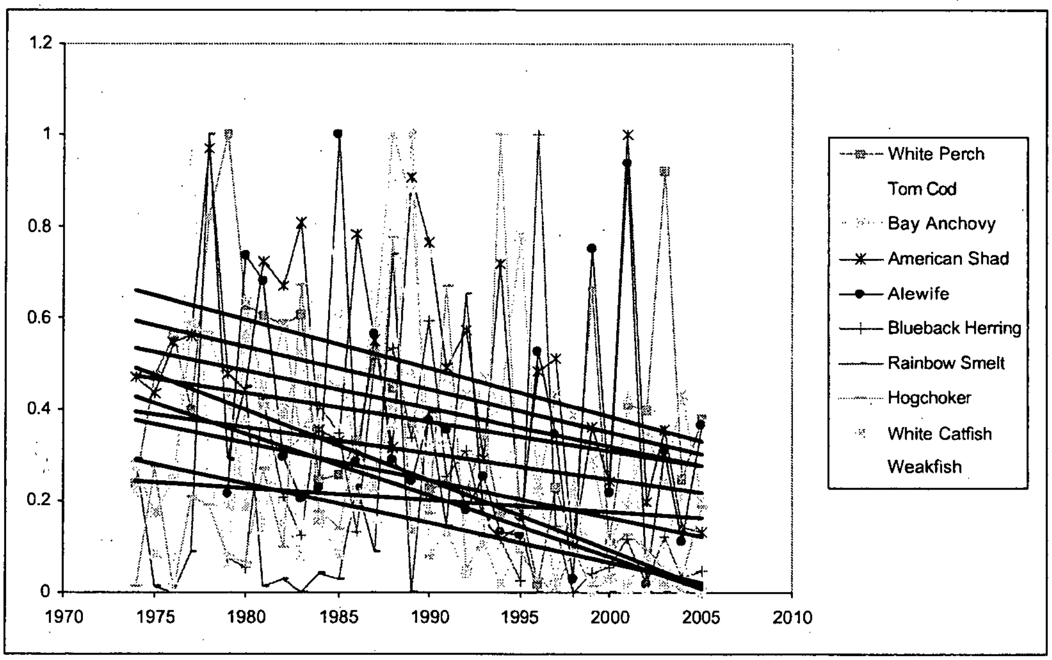


Figure 12: Ten species with negative relationships - indices standardized to 1.

4 Hudson River Fish Populations

4.1 *Striped Bass (*Morone saxatilis*)*

Striped bass are anadromous (marine fish that breed in freshwater) members of the temperate bass family. They are found from the St Lawrence River in Canada to Florida. The species has been introduced successfully into several freshwater systems. The Hudson is one of the main breeding rivers for this species. They breed from 4 years old and can live for many years. In the Hudson, spawning occurs from mid May to mid June in the middle reaches of the river. As adults they are top predators.

Striped bass populations are known to be doing well in the north east coast of the USA, and the population has shown a steady increase from the early 1980s (Figure 13). This improvement is shown in the Hudson River Data (Figure 14). The Hudson's population increase is possibly linked to a number of factors, including the reduction of fishing pressure and the improvement in water quality in the vicinity of New York harbour and Long Island Sound increasing the available nursery habitat.

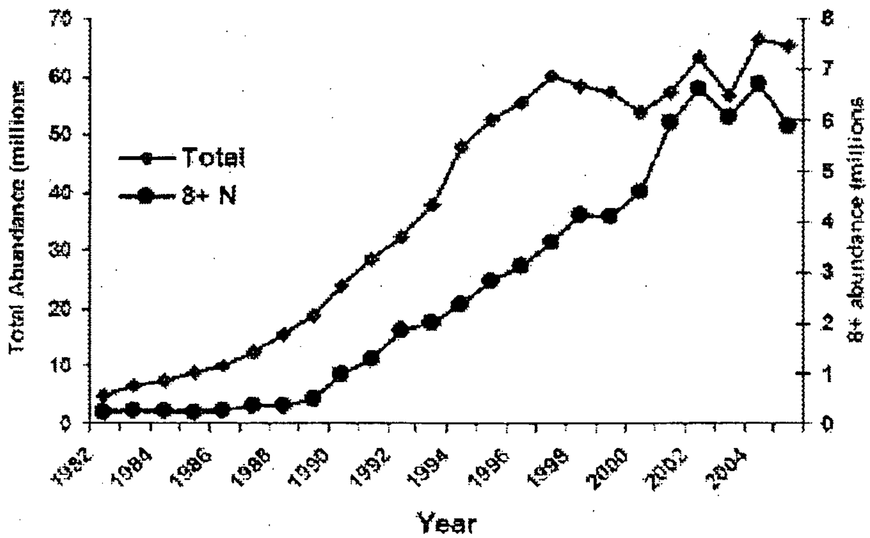


Figure 13: Striped Bass population abundance estimates, from 2004 ADAPT model. (Committee for the Atlantic Striped Bass Management Board 2005)

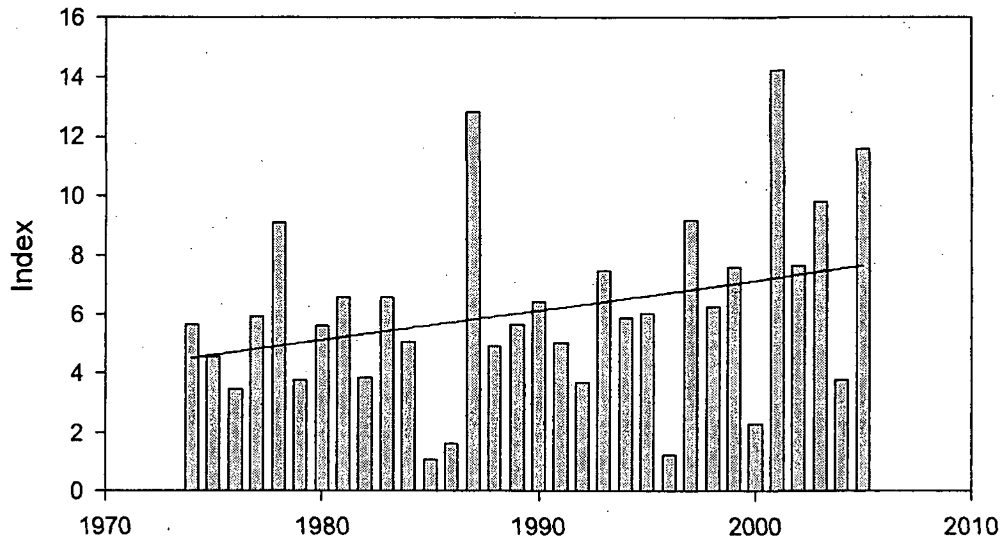


Figure 14: The juvenile index for Striped Bass in the Hudson showing a increasing trend though time.
Data from 2005 Year Class Report – Appendix D Table D – 2

In addition to the Year Class Reports, data is collected by the NYSDEC (2006) on the status of the striped bass in the New York. This data again shows a large increase in the numbers of the young of year (Figure 15), and correlates well with the juvenile index from the Year Class Report (Figure 16).

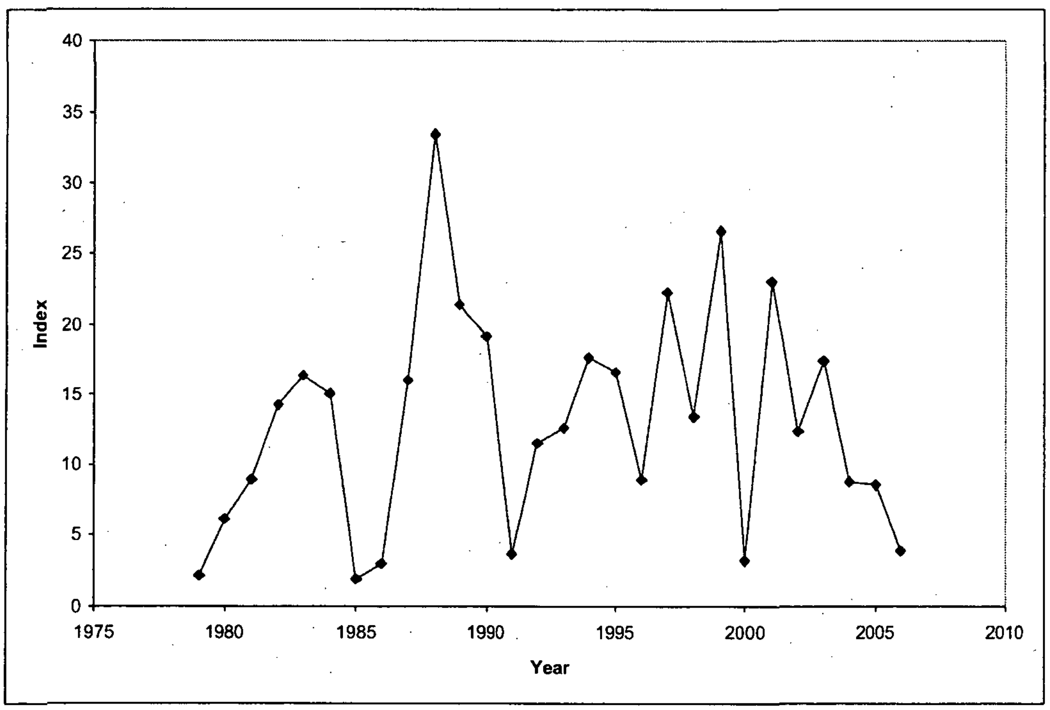


Figure 15: The NY State Hudson River Index of Relative Abundance for YOY Striped Bass (NYSDEC 2006 - table 20)

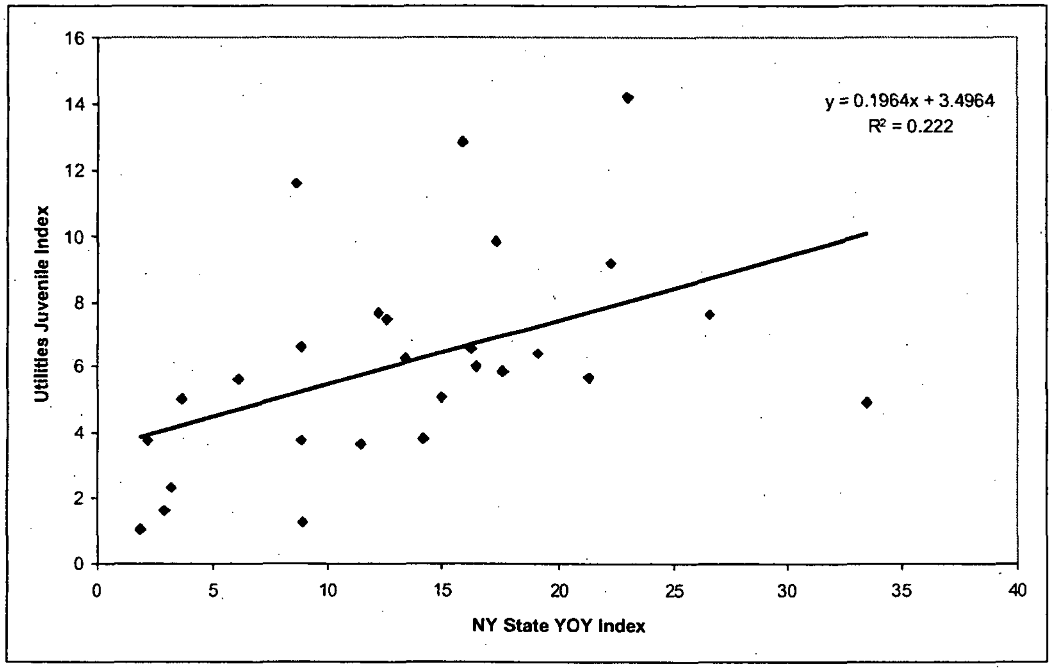


Figure 16: The relationship between the NY State Hudson River Index of Relative Abundance for YOY Striped Bass and the Utilities Striped bass juvenile index.

4.2 *Spottail Shiner* (Notropis hudsonius)

The spottail shiner is a small minnow, which lives in freshwaters in many parts of Canada and the United States. In the Hudson it lives in the middle and upper reaches of the estuary. They are opportunistic predators feeding on a wide range of foods.

The spottail shiner has generally increased in abundance, but has also become far more variable in abundance (Figure 17). This fish particularly favours vegetated shallows, and Strayer *et al.* (2004) showed that species in the Hudson which preferred vegetated habitat have done well since the invasion of zebra mussel, *Dreissena polymorpha.* This mussel is a highly efficient filter feeder, and has made great changes to the ecosystem, increasing light penetration and increasing plant grow. Strayer *et al.* (2004) suggests that this has resulted in both an increased population of spottail shiner, and a change in their distribution.

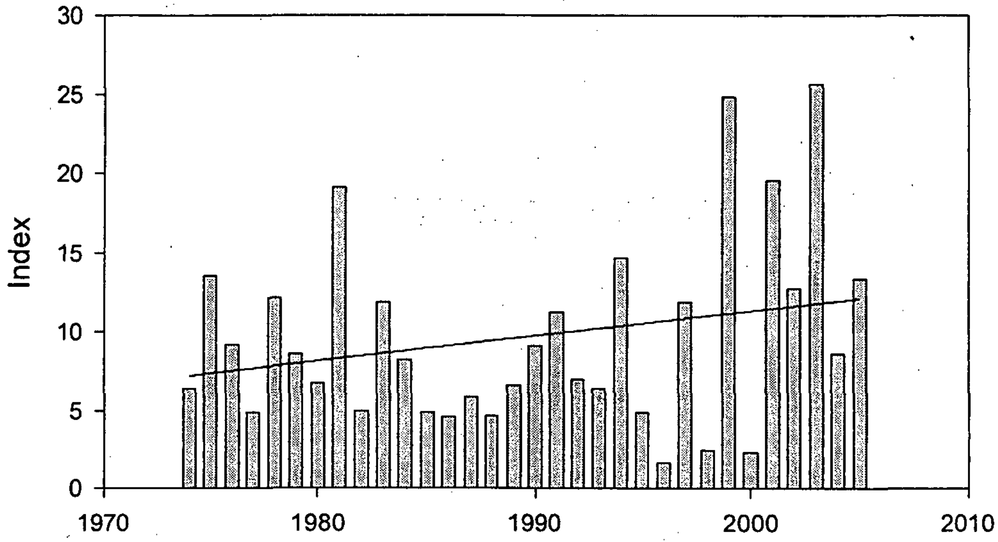


Figure 17: The juvenile index for Spottail Shiner in the Hudson showing a increasing trend though time.
Data from 2005 Year Class Report – Appendix D Table D – 11

4.3 *Bluefish (*Pomatomus saltatrix*)*

The bluefish is a predaceous oceanic fish, which is found in the western Atlantic. It comes inshore from May to November. Juvenile fish migrate into estuaries and bays, which they use as nursery grounds. In the Hudson they are commoner in the higher salinity regions of the estuary.

The index of juvenile bluefish shows a slight increase over the sampling period (Figure 18). The species population was particularly large in 1999, 2001 and 2002. However, abundance has now declined to levels similar to those observed in the 1980s, suggesting that there is no sustainable long-term increase in abundance.

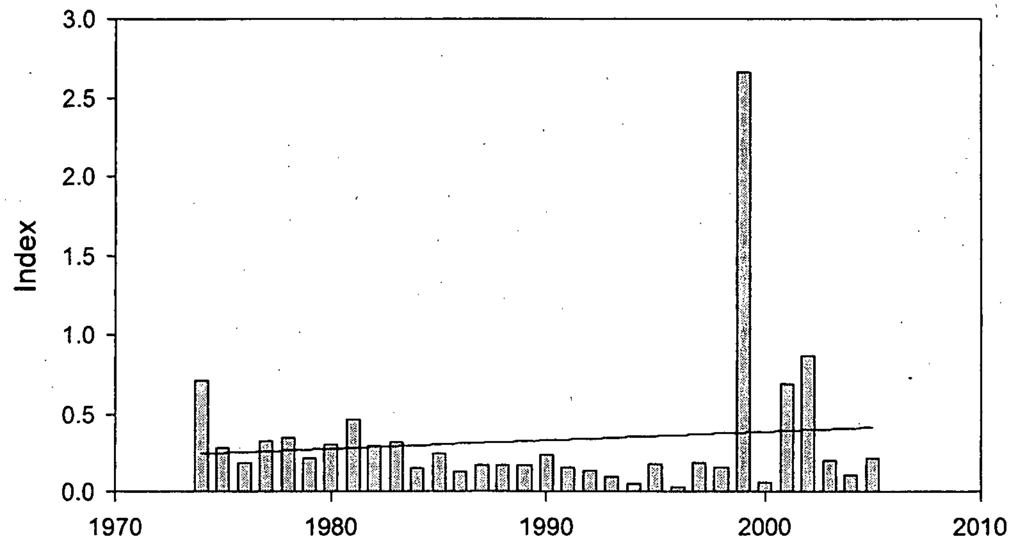


Figure 18: The juvenile index for Bluefish in the Hudson showing a increasing trend though time.
Data from 2005 Year Class Report – Appendix D Table D – 8.

The biomass of bluefish is estimated in the Atlantic each year by the Atlantic States Marine Fisheries Commission. The numbers of fish dropped from 1982 to 1994, but have subsequently been slowly recovering (Figure 19). The juvenile numbers in the Hudson show a similar decline in the mid 1990s but seem to have recovered faster.

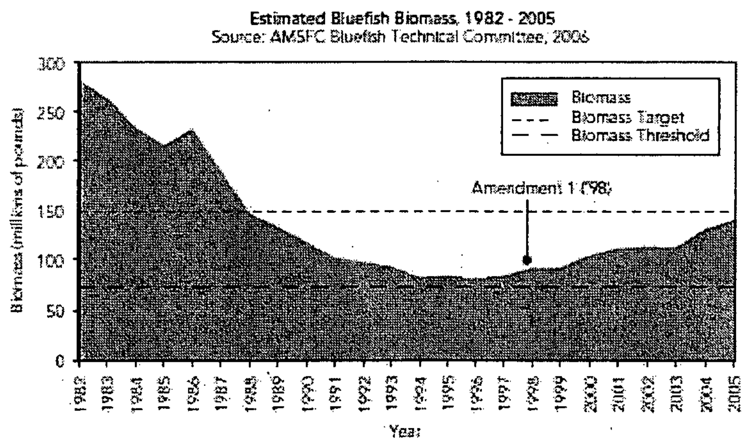


Figure 19: Estimated bluefish biomass – from the 65th Annual Report of the Atlantic States Marine Fisheries Commission 2006 (2007)

4.4 *White Perch (*Morone americana*)*

White perch are similar to striped bass, but only grow to a fraction of the size. White perch are estuarine, and are found from Canada to Carolina, and in fresh waters near the coast. They over-winter in the lower estuary, and migrate upstream to freshwater to breed. In the Hudson, breeding usually occurs between mid May and early July, primarily north of Croton Bay. In the Hudson, some fish mature at 2 but most at 3 to 4 years old.

White perch are showing a decreasing trend in the adjusted index over time (Figure 20). The species reached a particularly low point in the late 1990s, though subsequently it has staged a mild recovery. This species appears to be becoming more variable in abundance since the mid 1990s. In the last 10 years, the white perch abundance index holds the 3 lowest as well as 2 of the highest abundance indices. Increased variation in a population can be an indicator of a species under stress.

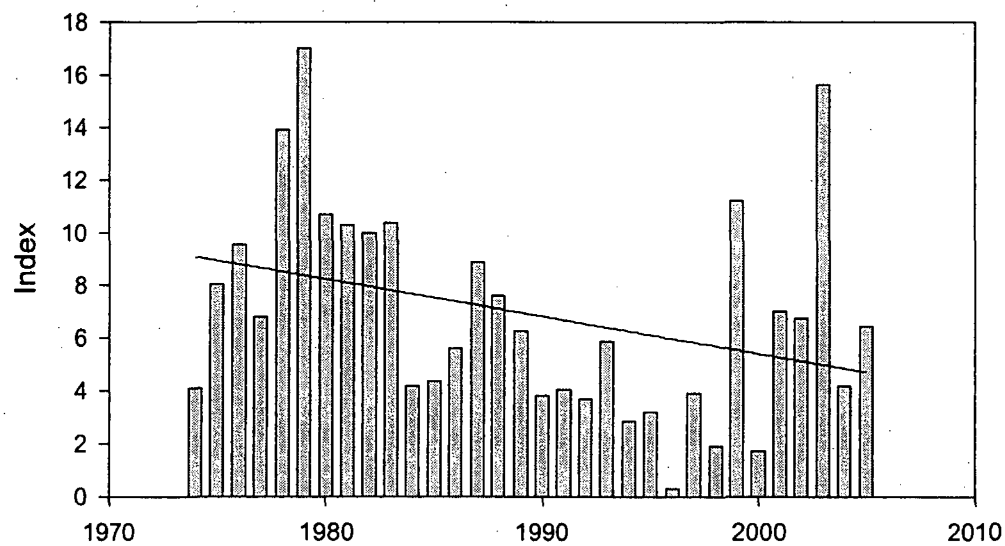


Figure 20: The juvenile index for White Perch in the Hudson showing a decreasing trend though time.
Data from 2005 Year Class Report – Appendix D Table D – 3

The recent decline in white perch abundance is much more clearly shown in the changing abundance of yearling and older age classes (Figure 21). As was the case for juvenile abundance, the between-year variability is highest in the latter part of the time series. As a population becomes dependent on only one or only a few year classes to reproduce, it is inevitable that the between-year variation will become larger. For example, in an extreme case, where there is only a single age class reproducing, say at 5 years old, there will only be recruits after 5 years.

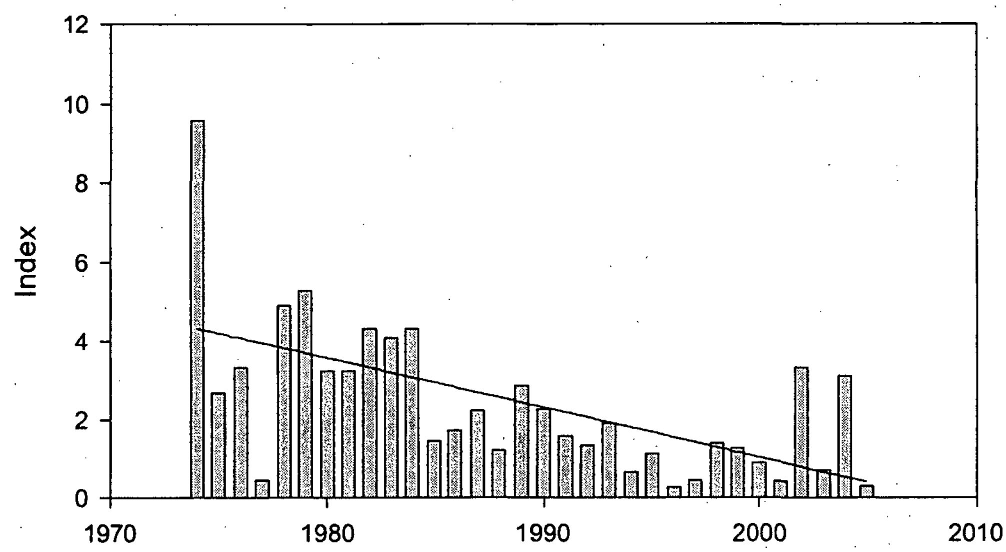


Figure 21: The index for yearling White Perch in the Hudson showing a decreasing trend though time. The trend is significant ($a = -0.1264$, $b = 253.81$, $F = 17.72$, $p = 0.0002$).
Data from 2005 Year Class Report – Appendix D Table D – 3

It is widely accepted that white perch are in decline and the present population size is probably 50% or less of that present in the 1970s and 1980s (See FEIS page 62, NYSDEC 2007).

*4.5 Atlantic tomcod (*Microgadus tomcod*)*

The Atlantic tomcod is an inshore species that ranges from Labrador to the Chesapeake Bay. It is anadromous, and reaches its southern spawning limit in the Hudson. Tomcod enter estuaries in mid winter to spawn in brackish water. The main spawning area in the Hudson is between West Point and Poughkeepsie. They are unusual in that their growth slows and stops as the water temperature rises.

There are no reliable records of tomcod abundance before the 1970s. The Atlantic tomcod population is showing considerable year-to-year variation, but appears to be in long-term decline (Figure 22). The average standardised index from 1975 until 1995 is 0.158, in comparison the index for the last ten years of sampling (1996-2005) is only 0.0617. In the last 10 years only 2001 produced a good recruitment, although there are signs of a recent slight improvement in Atlantic tomcod numbers.

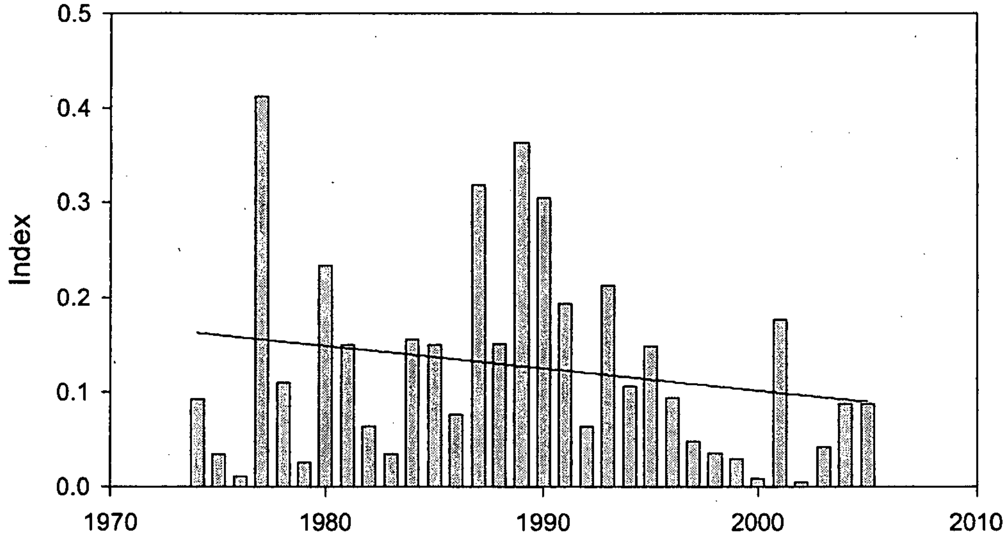


Figure 22: The juvenile index for Atlantic Tomcod in the Hudson showing a decreasing trend though time.
Data from 2005 Year Class Report – Appendix D Table D – 4

There is also an annual survey of the tomcod to estimate its breeding population (Normandeau Associates, 2007). This survey uses a range of techniques to look at the structure and size of the tomcod population. These data are used to estimate the size of the breeding population each year. Figure 23 shows a similar decline in numbers as seen in the juvenile index, above.

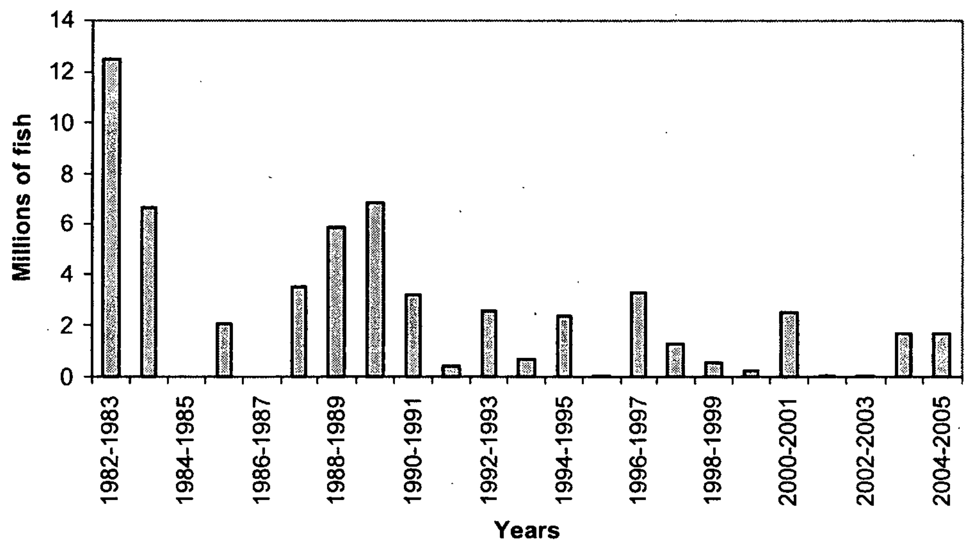


Figure 23: The Petersen estimates of the Hudson River Atlantic tomcod spawning population, winters of 1982-1983 through 2004-2005 (From Normandeau Associates, 2007)

The fate of tomcod may be related to river water temperature. The tomcod is a small, short-lived member of the cod family. Because it is at the southern extremity of its geographical range within the Hudson Estuary, sensitivity to climatic factors, particularly temperature would be anticipated.

*4.6 Bay Anchovy (*Anchoa mitchilli*)*

The bay anchovy is a small fish of inshore waters, found along the whole of the United States coast. It is tolerant of a range of salinities, and will remain in estuaries the whole year. Bay anchovy are a shoaling fish that feed on plankton. They are short lived, rarely living for more than 2 years. They spawn in the lower part of the Hudson, with each female spawning many times in a single year.

Bay anchovy populations can occasionally reach high abundances, as was observed in 1988, 1989 and 1995 (Figure 24), but this cannot hide a long-term declining trend in abundance. The present population abundance is lower than those observed pre-2000. Schultz *et al* (2006) noted that the abundance of adults in the Hudson has declined 10-fold from the peak levels observed in the late 1980s.

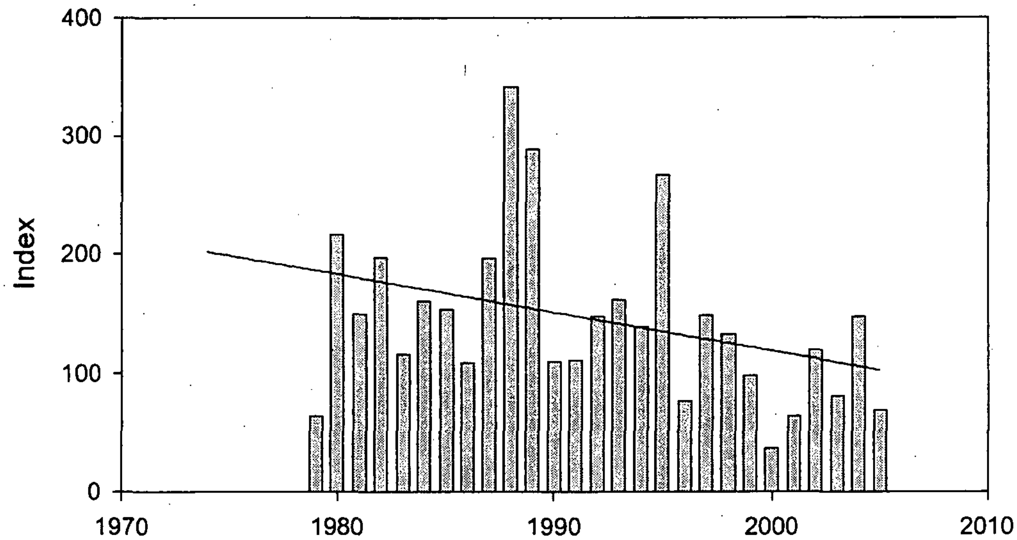


Figure 24: The juvenile index for Bay Anchovy in the Hudson showing a decreasing trend though time.
Data from 2005 Year Class Report – Appendix D Table D – 5

Schultz *et al* (2006) noted a negative correlation of anchovy abundance with that of PYSL striped bass, and a positive correlation with PYSL and juvenile tomcod abundance. They suggest that the positive correlation between tomcod and bay anchovy is probably due to both having negative correlations with striped bass. Thus, the observed decline may be linked to the increase in abundance of the predatory striped bass.

*4.7 American Shad (*Alosa sapidissima*)*

American shad are the largest of the North American species of anadromous herrings. They may live to 13 years and usually become sexually mature after 2-6 years at sea. They have a well-developed homing ability. They are found from Newfoundland to Florida. They return to sea after spawning. Most spawning occurs in May in the upper estuary in the Hudson.

The American shad shows a significant decreasing trend in juvenile abundance (Figure 25). Three of the five lowest indices have been in the last 5 years. The notable exception is 2001, with one of the highest recruitments since regular sampling began.

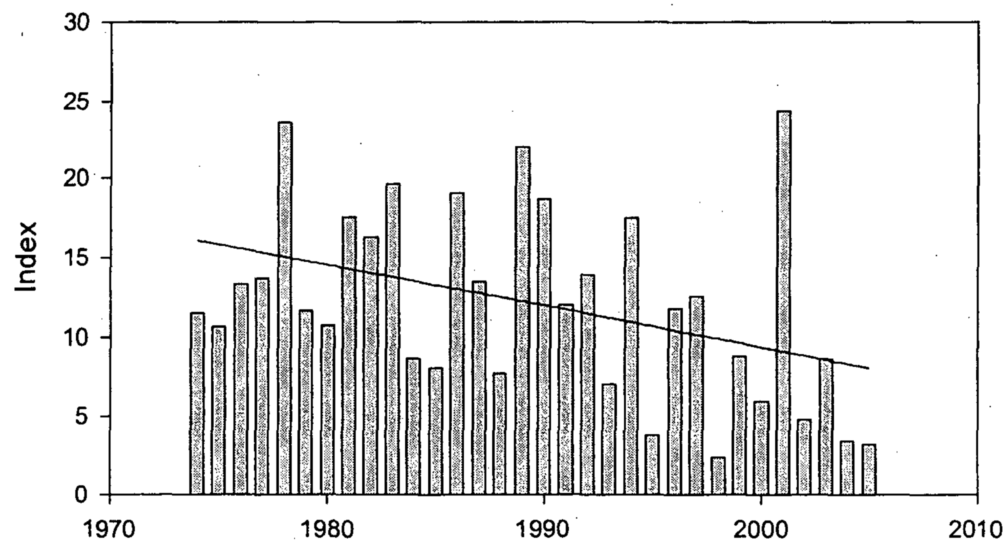


Figure 25: The juvenile index for American Shad in the Hudson showing a decreasing trend though time. The trend is significant (a = -0.2593, b = 527.872, F = 5.8069, p = 0.0223).
Data from 2005 Year Class Report – Appendix D Table D – 6

American shad has been declining in the Hudson for many years because of overfishing, pollution and other anthropomorphic effects (Figure 26). Even in the 1970s and 1980s, the population was a small fraction of historical abundance (see Figure 26 for the trend in commercial landings). In an attempt to allow the shad population to recover, the ocean intercept fishery was closed in 2005, and further restriction on river fishing introduced (Atlantic States Marine Fisheries Commission 2007).

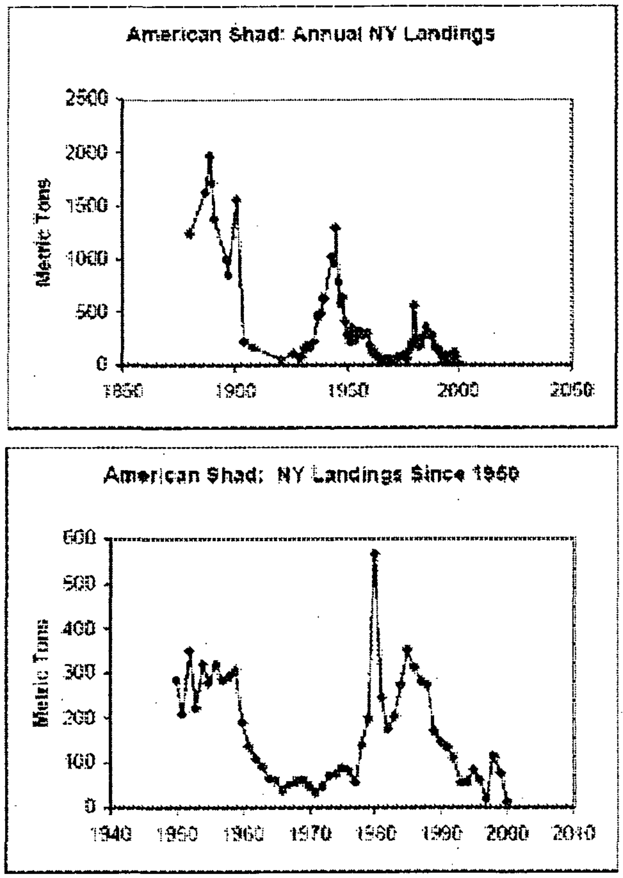


Figure 26: Catches of American shad in New York State. Most of the catches are from the Hudson. Top panel: trends since 1880. Bottom panel: trends since 1950.
Note differences in scale. Sources: National Marine Fisheries Statistics, Walburg and Nichols (1967). Taken from Limburg *et al* 2006.

The Atlantic States Marine Fisheries Commission (2007) also indicates that the American shad is not doing well. The juvenile abundance index showed an increase in the early 1980s. It has since declined and reached its lowest ever value in 2001. It presently remains at this low level (Figure 27).

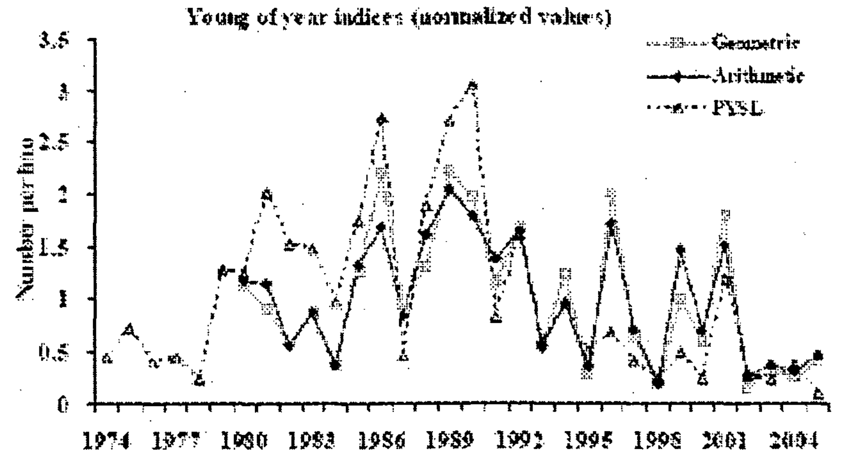


Figure 27: The juvenile abundance indices - American Shad, (beach seine and post-yolk sac larval).
From Atlantic States Marine Fisheries Commission, 2007.

*4.8 Alewife (*Alosa pseudoharengus*)*

Alewife is similar to but smaller than the American shad, and is indistinguishable from blueback herring when young. Alewife spawn most actively when the water is 51-71°F. They prefer slow moving waters, spawning in the upper estuary and spreading to the middle portion of the Hudson as they grow. It is an anadromous species found from Newfoundland to South Carolina, which starts spawning at 3-4 years old and can live for around 9 year. It feeds on plankton but will take small fish and fish eggs.

The Alewife juvenile index shows a declining trend in the Hudson (Figure 28). However, this trend is far from clear and possibly the more important feature has been the increase in between-year variability in juvenile abundance. Alewife had very low abundance indices in 1998 and 2002, and high indices in 1999 and 2001. This suggests a population that is becoming destabilised and more dependent on occasionally good recruitment years.

Daniels *et al* 2005, state that

> *There is a negative correlation between the number of alewife larvae exiting Hudson River tributaries and the degree of watershed urbanization (Limburg and Schmidt 1990). Overfishing of stocks has led to the decline of once abundant commercially important species (e.g., Bain et al. 2000; Limburg et al. in press)*

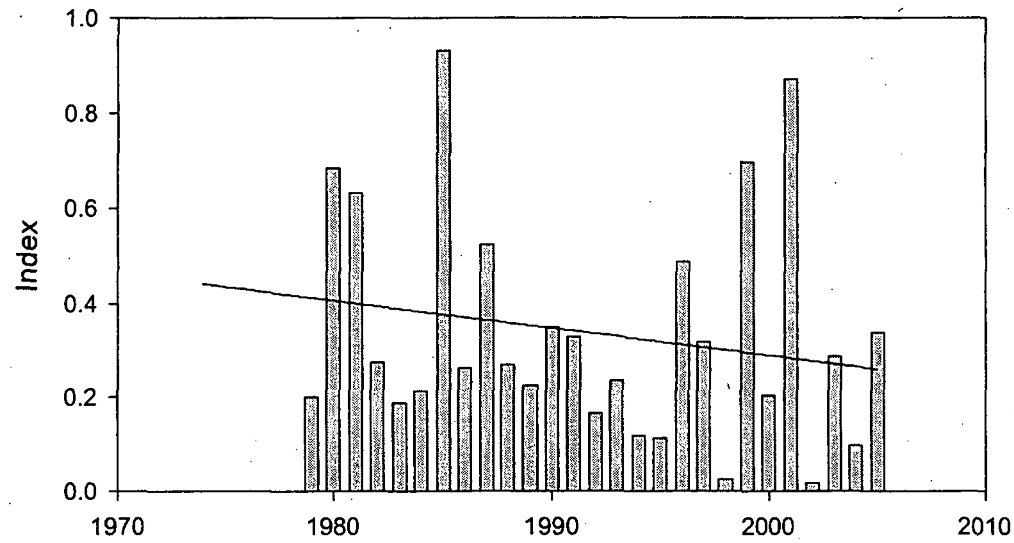


Figure 28: The juvenile index for Alewife in the Hudson showing a decreasing trend though time.
Data from 2005 Year Class Report – Appendix D Table D – 7

*4.9 Blueback Herring (*Alosa aestivalis*)*

Blueback herring is also similar to but smaller than the American shad, and is indistinguishable from Alewife when young. Blueback herring spawn in May, preferring fast flowing waters in the tributaries. They spawn in the upper estuary and spread to the middle portion of the Hudson as they grow. Blueback can be found from Nova Scotia to Florida.

The Blueback herring juvenile index has decreased over the study period (Figure 29), with a particularly marked decline post 1999. Strayer *et al* (2004) suggest that the zebra mussel (*Dreissena polymorpha*) has changed the food web within the Hudson, and that this may have reduced herring food resources. Blueback herring used to feed extensively on planktonic crustaceans, however the changes in primary production caused by the zebra mussels appears to have caused them to switch their diet to littoral and benthic macroinvertebrates (Daniels, 2005). Note that at the threshold to the collapse in population abundance, blueback herring had their largest juvenile abundance.

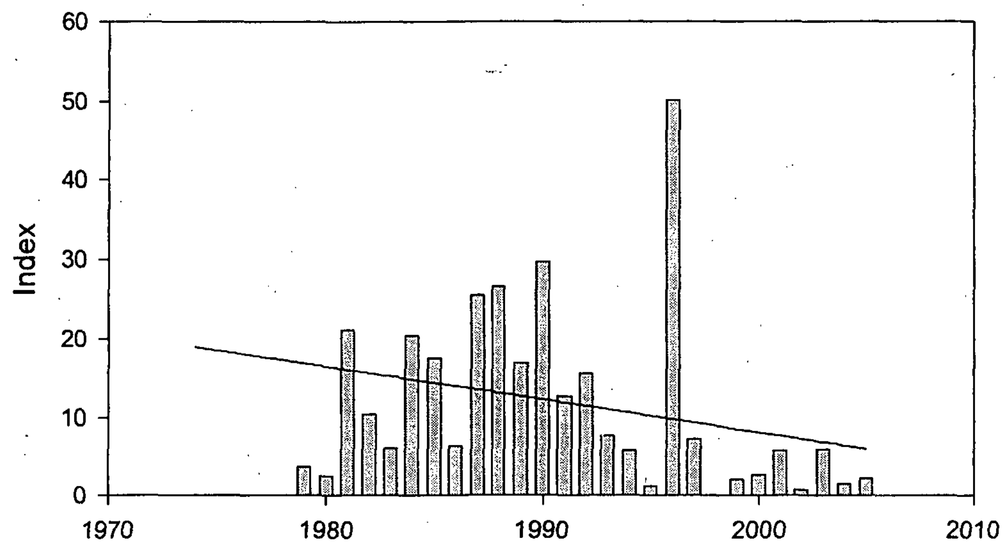


Figure 29: The juvenile index for Blueback Herring in the Hudson showing a decreasing trend though time.
Data from 2005 Year Class Report – Appendix D Table D – 8

*4.10 Rainbow Smelt (*Osmerus mordax*)*

The rainbow smelt is a salmon-like fish which is found from the northern part of the western Atlantic and in many naturally land-locked populations. They can spend most of the year within estuaries. The rainbow smelt spawns in the lower reaches of tributaries at night. They mature at 1 to 5 years old. Historically, juvenile fish were found in mid June to August in the middle and lower estuary.

Juvenile Rainbow smelt have disappeared from the survey since the mid 1990s (Figure 30). This may to be due to a change in their distribution, possibly due to the invasion of zebra mussels, which occurred from 1992 onward (Strayer 2004). However, as shown in Table 1, rainbow smelt has one of the lowest upper temperature tolerances of Hudson fish. It is therefore possible that the species has declined because of rising water temperatures.

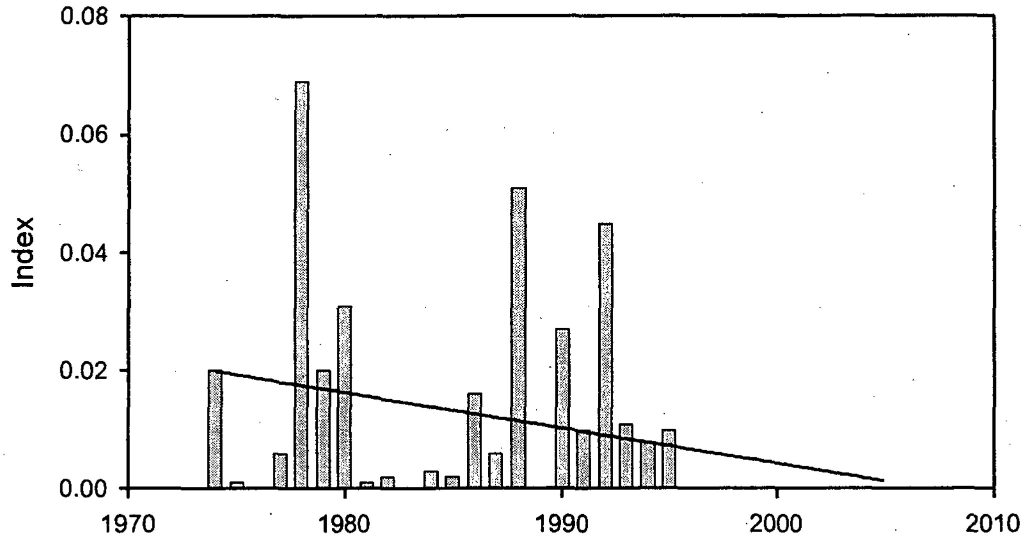


Figure 30: The juvenile index for Rainbow Smelt in the Hudson showing a decreasing *trend though time.*
Data from 2005 Year Class Report – Appendix D Table D – 9

*4.11 Hogchoker (*Trinectes maculatus*)*

The hogchoker is a small flatfish, maturing at around 4.5 in. and growing to about 8 in., which tolerates a wide range of salinities and is found from Massachusetts Bay to Panama. They overwinter in low salinity areas of estuaries, and spawn in the lower reaches of the estuary in spring and summer. The young move upstream after hatching.

The hogchoker has shown little trend in abundance since the 1970s (Figure 31) and there were some large recruitments in the 1980s and 90s. However, recent abundance has been low and it is now 11 years since the last large recruitment.

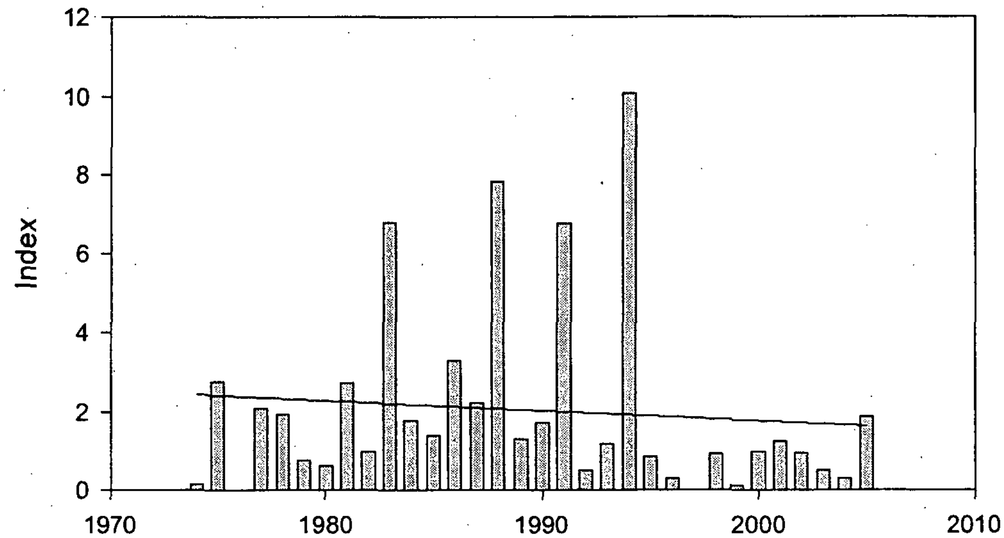


Figure 31: The juvenile index for Hogchoker in the Hudson showing a slight decreasing trend though time.
Data from 2005 Year Class Report – Appendix D Table D – 10

*4.12 White Catfish (*Ameiurus catus*)*

White Catfish are naturally found in freshwater, and are found in all the estuaries along the Atlantic coast from the Hudson to Florida. They are slow growing, maturing at 3-4 years old. They move into freshwater to breed, building nests on sand or gravel. They breed in late June and July when the water temperature reaches 70°F. Young fish eat insects, while larger fish are piscivorous.

White catfish have been in steep decline in abundance from 1990 onwards (Figure 32). The reasons for this loss are unknown.

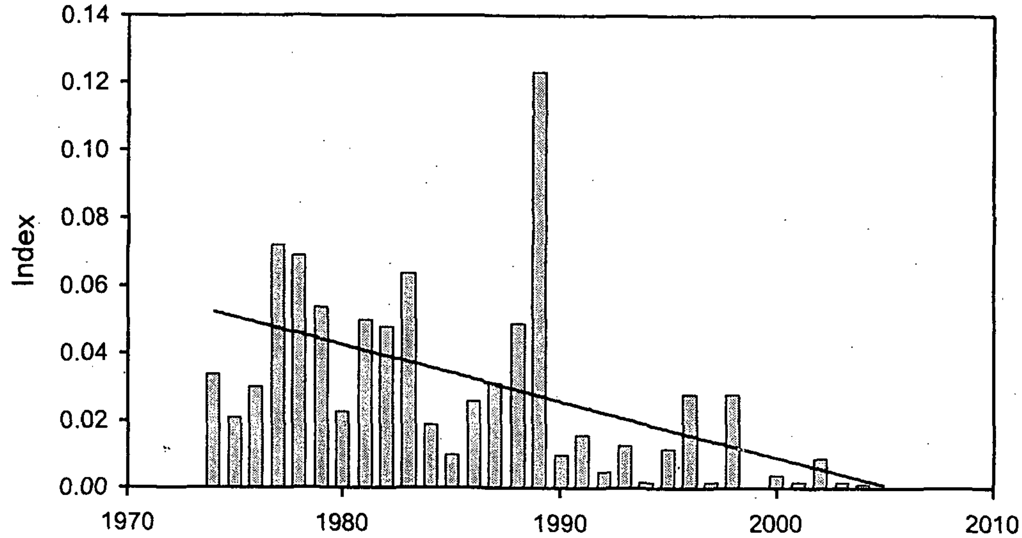


Figure 32: The juvenile index for White Catfish in the Hudson showing a decreasing trend though time. The trend is significant (a = -0.0017, b = 3.3476, F = 14.0414, p = 0.0008).
Data from 2005 Year Class Report – Appendix D Table D – 12

4.13 Weakfish (Cynoscion regalis*)*

Weakfish are found from New York to North Carolina, offshore in the winter, moving inshore during the spring. Spawning occurs inshore, with larvae rarely being found north of the George Washington Bridge. From June to October the juveniles use the Hudson, with the greatest numbers being found in July

Weakfish have been in steep decline in abundance from 1990 onwards (Figure 33). The reasons for this loss are unknown.

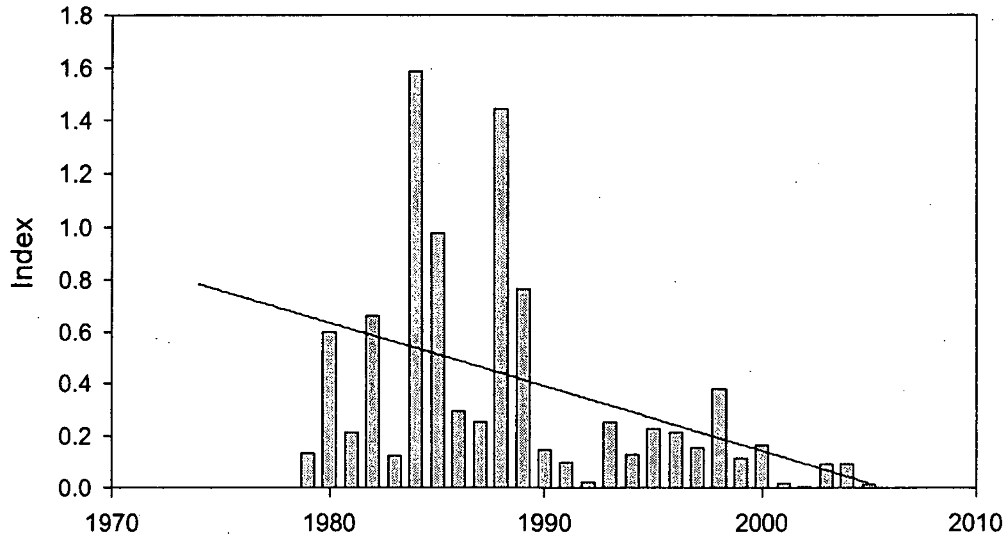


Figure 33: The juvenile index for Weakfish in the Hudson showing a decreasing trend though time. The trend is significant (a = -0.0246, b = 49.2626, F = 7.0811, p = 0.0134). Data from 2005 Year Class Report – Appendix D Table D – 13

5 Comment on the 2005 Year Class Report.

Section 4 of the 2005 Year Class Report (ASA, 2006), section 4.1.2, examines the overall heath of the estuary. At the end of the section the report states:

> *In all, it appears that the Hudson River estuary has a healthy and robust fish population.*

This assertion conflicts with paragraph 5, which mentions that several freshwater fish species have disappeared, and others been found:

> *When the individual species in the freshwater assemblage are examined, there are several species that occurred consistently in the early years and not in the later years, such as cutlips minnow, common shiner, blacknose dace, redfin pickerel, longnose dace, and trout perch. Conversely, there are several species that were not present in the early years but have been recorded recently, such as brook silverside, channel catfish, and freshwater drum.*

The Year Class Report also note increases in the number of marine species found, attributing it to water quality and sampling changes, and several changes in the estuarine species. For anadromous fish, the report again noted declines – this time attributing the decline to effects outside of the Hudson River:

> *Declines in the abundance of this anadromous species appear to have occurred to all stocks throughout their geographic range and appear a result of factors outside of the Hudson River, including overfishing in open ocean waters.*

The report describes many changes in the fish population of the estuary, with several species disappearing, new species being found, major declines and increases in the fish species monitored, and yet still summarises the results as:

> *There is no evidence of any substantial long-term changes in composition or abundance of the fish community over the 32-year period, 1974-2005*

It seems difficult to reach such a conclusion, using the analysis presented in the 2005 Year Class Report. The report notes several significant changes, yet always finds some other potential cause.

The impact of Indian Point is the largest of several impacts from once-through cooling on the Hudson. When all the power plants are considered, the impact is large. Indeed the NYSDEC Water Quality 2006 Report (2007) states

> *Tens- to hundreds-of-millions of eggs, larvae, and juvenile fishes of several species are killed per year for once-through users. The cumulative impact of multiple facilities substantially reduces the young-of-year (YOY) population for the entire river.*

The NYSDEC go on to state that in some years these effects have been very large, and provide examples, shown in Table 6. All the species show between 33 – 79% reductions in Young of Year population.

Table 6: Percentage reduction in selected years in the number of September 1st Young of Year fish attributable to the operation of the power plants in the Hudson (NYSDEC 2007)

Species	Year	% reduction - no through-plant survival	% reduction - power plants estimated through-plant survival
Spottail shiner	1977	79	25
Striped bass	1986	63	27
American Shad	1992	60	52
Atlantic tomcod	1985	53	44
Alewife and blueback herring combined	1992	45	39
White perch	1983	44	30
Bay anchovy	1990	33	33

6 Summary

The fish community of the Hudson Estuary has been well-studied from the mid 1980s. It has been continuously changing since systematic recording began in the 1980s. There have been many environmental changes during the sampling, with significant improvements in water quality in some parts of the estuary.

There are clear indications, both at the community and individual population levels, that the populations of fish in the estuary are becoming less stable and showing greater year to year variation in abundance.

Of the 13 key species subject to intensive study, three species, striped bass, bluefish and spottail shiner, have shown a trend of increasing abundance since the 1980s.

The other 10 species have declined in abundance, some greatly. There were significant negative trends between yearling white perch, and juvenile American shad, white catfish and weakfish. Many other important species of fish are also showing long-term declines in abundance. For example, the American eel has greatly declined.

There has been a recent increase in average water temperature and a decrease in dissolved oxygen levels. This may be influencing some of the changes observed and will increase the impact of thermal discharges. It is important to factor in potentially increasing water temperatures in any discussion of Hudson River fish. Small rises in the background temperature could have a significant effect on the impacts of thermal discharges into the river.

Power companies states that there are not any negative trends in the Hudson River fish populations attributable to the plant operation, this despite the NYSDEC (2007) finding that the power plants can reduce several of the common fish species recruitment by between 33 and 79% in a year. Even if the power companies are not the sole cause of degradation of the Hudson River fish community, the loss of such high proportions of the fish populations must be important.

All the evidence points to the Hudson ecosystem presently being in a state of change, with declining stability. Neither the ecosystem as a whole nor many of the individual species populations are in a healthy state.

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Entrainment, Impingement and Thermal Impacts at Indian Point Nuclear Power Station

Pisces Conservation Ltd,
November 2007

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Entrainment, Impingement and Thermal Impacts at Indian Point Nuclear Power Station.
Pisces Conservation Ltd, November 2007

1. Summary

- The entrainment and impingement mortality of fish caused by the Indian Point power plant is reviewed and quantified.
- Entrainment and impingement mortality each year is in the order of billions and hundreds of thousands of fish respectively.
- The data used recently by Entergy to assess this impact are old, having been gathered between 1980 and 1990. Since then, the estuary has changed considerably, with several species declining in abundance, and some species, most notably striped bass, increasing. There have been large changes in the river environment and important biological invasions.
- For the 6 fish species for which data are available—American shad, bay anchovy, river herring (comprising 2 species alewife and blueback herring), striped bass, and white perch—the station entrain 1.2 billon eggs and larvae a year.
- Entrainment data for Atlantic tomcod are not available, but are likely to be significant, with an estimated conditional mortality rate (CMR) indicating that 12% of the tomcod population are being killed by Indian Point each year.
- Entrainment occurs from February to September, with peaks in March for tomcod, and June for the other species.
- Modern data suggest that striped bass entrainment is likely to have increased by over 750% from the level at the time when the data was gathered.
- The Indian Point stations impinge over 1 million fish a year, and kill between two and five hundred thousand, dependent upon the assumptions used in calculation. They kill individuals from several species that are in decline.
- Peak impingement occurs in over winter, in December and January, and in mid summer.
- The impingement of only eight species has been considered in detail: American shad, Atlantic tomcod, bay anchovy, alewife, blueback herring, spottail shiner, striped bass, and white perch.
- The temperature regime in the Indian Point cooling water discharge and the receiving waters of the Hudson River are reviewed.
- In recent years (2000 to 2007), the discharge temperature regularly exceeded 90°F, and in summer frequently exceeded 100°F. A temperature exceeding 100°F will produce lethal conditions for aquatic life of all kinds, including algae, crustaceans and fish.
- Fish can perceive small differences in temperature, and show behavioural avoidance of even mildly stressful temperatures.
- The spatial and vertical extent of the Indian Point plume is sufficient to raise concerns about the passage of fish and impacts on the benthic life of the river.
- The background temperature of the river is increasing, and this will result in increased harm from thermal pollution if present levels of heat discharge continue into the future.
- Absolute temperatures of riverine heated effluents of 26°C (78°F) or more are potentially lethal to rainbow smelt and Atlantic tomcod.
- There are no data on the movement or migration of fish in the vicinity of the Indian Point plume. It is therefore not possible to quantify the effect of this discharge on fish movement or passage.

- The impact of the mortalities caused by impingement and entrainment and thermal discharges on the fish populations of the Hudson is large.
- Entergy's assessment of entrainment and impingement and thermal discharge is inadequate.
- The impacts that Indian Point is having on the Hudson River fish species are not quantified fully.
- When considering all aspects of the impact of Indian Point on the aquatic ecology of the Hudson estuary, Entergy's reliance on old data results in an inadequate quantification of the impact that Indian Point currently has on the aquatic environment. Further, the use of such old analyses to project into the future would be a serious error.

2. Introduction

The use of direct cooling at power stations kills fish in several ways, most directly through impingement and entrainment. Water taken into the station for cooling is screened to remove large objects, including fish. Fish can sustain injury or death by entering intakes with the cooling water flow and then making physical contact with screens or filters; the death of fish in this way is termed impingement mortality. Water that passes through the screens, and then through the cooling system to be discharged back into the environment, holds small fish, fish eggs and larvae, and other microscopic organisms. These suffer injury or death through physical contact, rapid pressure or temperature change, and chemical poisoning from biocides and other chemicals introduced into the water. The death caused by passage through a power station is termed entrainment mortality.

A heated discharge released to surface waters also has damaging effects. Animals in the receiving water can be suddenly exposed to hot water and biocides in the mixing zone, resulting in death or injury. In addition, the heating of the local environment can influence the distribution and movement of fish and other organisms. Finally, there is the risk that the temperature of the receiving water is raised to a level that excludes some fish and other organisms from living in the area. This is becoming more likely as average summer water temperatures increase.

This document examines the estimates of the numbers of fish impinged and entrained at Indian Point power plant, on the Hudson River. A previous report, *The status of fish populations and the ecology of the Hudson* (Pisces Conservation 2007) gives supporting information.

Indian Point 2 has six two-speed circulating water pumps, designed to pump 140,000 gpm (US gallons per minute) at full speed and 84,000 gpm at reduced speed. Indian Point 3 has six variable-speed circulating water pumps, designed to pump between 64,000 and 140,000 gpm.

This gives the station the ability to intake 2.4 billion gallons of cooling water per day. This is the largest intake on the Hudson estuary and produces the largest plume of heated effluent.

3. Entrainment

Very large numbers of fish are entrained at Indian Point; calculations for five fish species estimate over 1 billion individuals of those species alone to be entrained each year (Table 1). The figures given in Table 1 are the total numbers of entrainable life stages, including eggs, yolk-sac larvae, post-yolk-sac larvae (PYSL), and some juveniles, for the species studied. These data come from utility-sponsored studies on entrainment. (DEIS Appendix VI-1-D-2). Data were collected from 1972 to 1987, with the exception of 1982. The data used in the Draft Environmental Impact Statement (DEIS), prepared by the prior owners of Indian Point, were collected from 1981-1987. The calculations in Table 1 are the average number of fish entrained per year from 1981-87. The original data are in DEIS appendix VI-1-D-2. The Draft Environmental Impact Statement (FEIS), prepared by the prepared by the New York State Department of Environmental Conservation (NYSDEC) included this calculation of annual number of fish entrained at Indian Point to assess the magnitude of the impact (FEIS, Table 1, page 2)

Number of Fish entrained	
American shad	13,380,000
Bay anchovy	326,666,667
River herring	466,666,667
Striped bass	158,000,000
White perch	243,333,333
Total of 5 species	**1,208,046,667**

Table 1: The annual number of fish entrained at Indian Point - based on in-plant sampling 1981-1987; no Atlantic tomcod were sampled, as sampling started too late for young Atlantic tomcod to be caught (From FEIS page 2).

The species for which entrainment mortality has been quantified form only a very small proportion of the total species present in the estuary. As was noted in the FEIS (page 53):

> *Finally, although impingement and entrainment mortality is measured, it is typically measured only for several of the 140 species of fishes found in the Hudson. Information about the impact on the full suite of aquatic organisms is limited.*

The impact on other species is un-quantified and may be significant.

3.1. Numbers of fish entrained

Considerable ecological changes have taken place over the last 20 years, so that entrainment numbers derived from the DEIS can no longer give a reliable guide to present entrainment. In this section, we attempt to estimate recent numbers entrained. Table 2 gives the total entrainment estimates given in the DEIS (DEIS Appendix VI-1-D-2, Table 2).

Species	Eggs	Yolk-sac	PYSL	Juveniles	Total	Years	Average
River herring	1,955,720	935,220,000	1,865,420,000	2,083,000	2,804,678,720	6	467,446,453
Bay anchovy	309,750,000	160,080,000	1,482,500,000	5,799,200	1,958,129,200	6	326,354,867
White perch	8,235,740	46,979,000	1,398,400,000	9,284,500	1,462,899,240	6	243,816,540
Striped bass	1,518,500	89,866,000	850,000,000	6,229,000	947,613,500	6	157,935,583
American shad	119,400	7,290,000	59,000,000	465,190	66,874,590	5	13,374,918
					Total		1,208,928,361

Table 2: The number and stage of some of the main species entrained at Indian Point between 1981 and 1987.

The numbers in Table 1 are slightly different from those in Table 2, since the data in the earlier table have been rounded to three significant figures during the calculation of the averages. For example, for striped bass the total would be 948,000,000 / 6 giving 158,000,000 rather than 947,613,500 / 6 which gives 157,935,583).

The data available do not include Atlantic tomcod, which breeds earlier in the year than the other species. The estimated Conditional Mortality Rate (CMR)[1] for this species is high, at over 12% (Indian Point Energy Center Applicant's Environmental Report Operating License Renewal Stage). This species is already in decline in the estuary (Pisces 2007).

3.2. Annual pattern of entrainment and the conditional mortality rate

There are two main periods of fish entrainment, spring/summer when most species breed and have larvae in the water, and February/March when the tomcod breed (Figure 1). When assessing the impact of any pumping regime on entrainment reduction, it is important to consider the annual pattern of entrainment. Conditional mortality rates (CMR) measure the proportion of the available population living in the Hudson Estuary that is killed by entrainment or impingement (Table 3). In the DEIS, CMR were used instead of simple estimates of the number of animals killed, because they allow insight into the level of impact on the population.

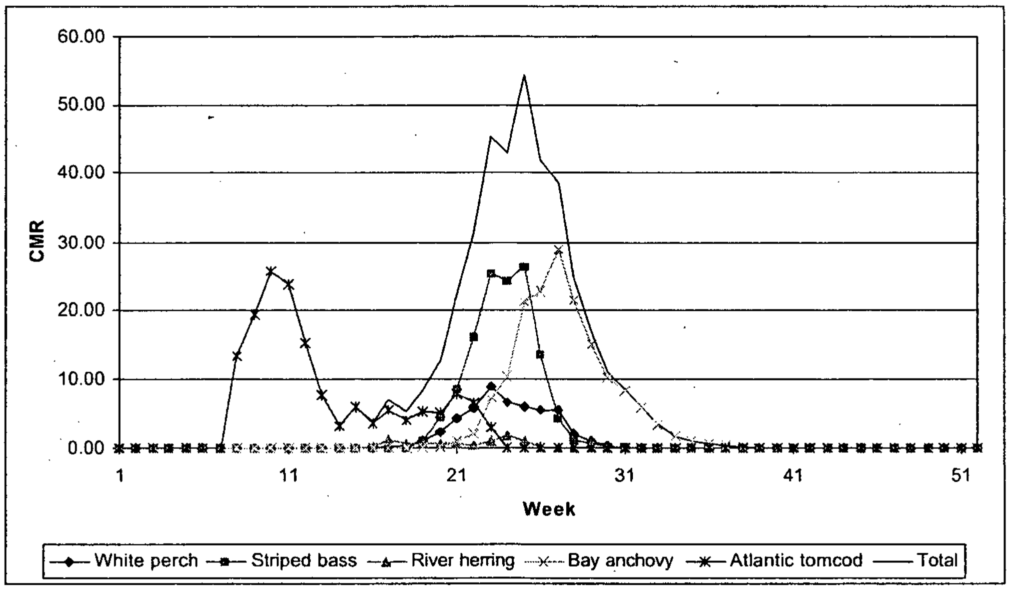

Figure 1: Plot showing the seasonal pattern in entrainment. From Table 3.

[1] CMR - is the probability of a fish dying due to the power plant. It is expressed as a percentage and measures how many fewer Hudson River fish exist at the end of their first year of life (actually at September 1) than would exist if not for the loss to entrainment.

			Entrainment CMR x 1000					
Starting date of week	Week No.	SPDES Permit Flow (gpm)	White perch	Striped bass	River herring	Bay anchovy	Atlantic tomcod	Total
5-Jan	1	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
12-Jan	2	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
19-Jan	3	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
26-Jan	4	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
2~Feb	5	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
9-Feb	6	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
16-Feb	7	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
23-Feb	8	1008	0.00	0.00	0.00	0.00	13.33	**13.33**
1-Mar	9	1008	0.00	0.00	0.00	0.00	19.22	**19.22**
8-Mar	10	1008	0.00	0.00	0.00	0.00	25.75	**25.75**
15-Mar	11	1008	0.00	0.00	0.00	0.00	23.80	**23.80**
22-Mar	12	1008	0.00	0.00	0.00	0.00	15.21	**15.21**
29-Mar	13	1008	0.00	0.00	0.00	0.00	7.65	**7.65**
5-Apr	14	1008	0.00	0.00	0.00	0.00	3.18	**3.18**
12-Apr	15	1008	0.00	0.00	0.00	0.00	5.91	**5.91**
19-Apr	16	1008	0.08	0.00	0.15	0.00	3.67	**3.90**
26-Apr	17	1008	0.22	0.00	1.19	0.00	5.56	**6.97**
3-May	18	1008	0.53	0.07	0.73	0.00	4.01	**5.34**
10-May	19	1024	0.96	1.09	0.64	0.26	5.39	**8.34**
17-May	20	1152	2.34	4.53	0.71	0.14	5.03	**12.75**
24-May	21	1344	4.21	8.50	0.58	1.07	7.84	**22.21**
31-May	22	1440	5.83	16.16	0.44	2.03	6.62	**31.08**
07-Jun	23	1616	8.90	25.32	0.99	7.22	2.97	**45.39**
14-Jun	24	1680	6.67	24.13	1.85	10.47	0.00	**43.13**
21-Jun	25	1680	5.85	26.26	1.03	21.13	0.00	**54.26**
28-Jun	26	1680	5.43	13.62	0.31	22.63	0.00	**41.97**
5-Jul	27	1680	5.42	4.30	0.10	28.75	0.00	**38.57**
12-Jul	28	1680	2.15	1.23	0.10	21.36	0.00	**24.83**
19-Jul	29	1680-	1.12	0.61	0.20	15.00	0.00	**16.94**
26-Jul	30	1680	0.41	0.31	0.10	10.20	0.00	**11.02**
2-Aug	31	1680	0.10	0.20	0.00	8.26	0.00	**8.56**
9-Aug	32	1680	0.00	0.00	0.00	6.01	0.00	**6.01**
16-Aug	33	1680	0.00	0.00	0.00	3.36	0.00	**3.36**
23-Aug	34	1680	0.00	0.00	0.00	1.63	0.00	**1.63**
30-Aug	35	1680	0.00	0.00	0.00	1.02	0.00	**1.02**
6-Sep	36	1680	0.00	0.00	0.00	0.71	0.00	**0.71**
13-Sep	37	1680	0.00	0.00	0.00	0.51	0.00	**0.51**
20-Sep	38	1680	0.00	0.00	0.00	0.20	0.00	**0.20**
27-Sep	39	1584	0.00	0.00	0.00	0.10	0.00	**0.10**
4-Oct	40	1456	0.00	0.00	0.00	0.00	0.00	**0.00**
11 -Oct	41	1456	0.00	0.00	0.00	0.00	0.00	**0.00**
18-Oct	42	1456	0.00	0.00	0.00	0.00	0.00	**0.00**
25-Oct	43	1456	0.00	0.00	0.00	0.00	0.00	**0.00**
l-Nov	44	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
8-Nov	45	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
15-Nov	46	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
22-Nov	47	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
29-Nov	48	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
6-Dec	49	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
13-Dec	50	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
20-Dec	51	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
27-Dec	52	1008	0.00	0.00	0.00	0.00	0.00	**0.00**
Total			**50.22**	**126.32**	**9.12**	**162.08**	**155.15**	**502.89**

Table 3: Conditional mortality rates (CMR) of fish entrained at Indian Point, from DEIS

In the Indian Point Energy Center Applicant's Environmental Report Operating License Renewal Stage (page 4 - 12) it is noted that entrainment impacts are large:

> *The estimated average annual CMR due to entrainment for American shad is 0.64%, for Atlantic tomcod is 12.04%, for bay anchovy is 10.38%, for river herring is 1.20%, for striped bass is 7.82%, and for white perch is 4.94%.*

First it should be noted that in the FEIS (Fish populations 3 - page 62) the CMR figure for white perch is stated as 21%. In general, these numbers are notably high, especially when it is remembered that several of the species under consideration are showing long-term declines in abundance in the Hudson. The CMR numbers indicate that Indian Point is killing an appreciable proportion of the Atlantic tomcod, white perch and bay anchovy populations in the estuary. These deaths will be contributing to the decline of these species.

In the DEIS, it was argued that even mortality rates of this magnitude were unlikely to have any impact on the adult population. In an unpublished report by Barnthouse *et al* (2002), it is stated:

> *As long as key populations are relatively stable, the mix of species present remains relatively constant, and important functional relationships continue, the river can be said to be healthy and can continue to persist in spite of the deaths of individuals*

In this statement, the key populations are presumably common species, and as shown in Pisces (2007), many of these species are showing long term trends. With many species in decline, it is unclear how the observation of a general trend is to be shown to be unrelated to the power plants, if there are direct observational data demonstrating that the power plants are killing the species. For example, it is clear that tomcod are killed by cooling water systems. The Atlantic tomcod population is in decline. It would be almost certain that if these individuals were not killed, the population would be larger.

What is clear, from these data and analyses presented in the DEIS, is that entrainment and impingement, primarily the former, are eliminating a significant portion of the most abundant species in their egg and larval stages. It is probable that similar levels of impact will be felt by the many rarer species that spawn or spend part of their life stages in the lower Hudson River. (see FEIS p. 59).

3.3. Adjusting entrainment estimates with new data

A number of approaches were taken to estimate current entrainment at Indian Point. The 2005 Year Class Report for the Hudson River Estuary Monitoring Program (ASA 2007) estimates the abundance of various species in the Hudson for each year, from the mid 1970s until 2005. To examine the changes in entrainment that must have occurred since 1987, these data were used in conjunction with the estimates of entrainment from 1981-7 (DEIS Appendix VI-1-D-2, Table 2). No more recent entrainment data were available.

The 2005 Year Class Report calculates an index for each of the entrainable stages (egg, larvae, post yolk sac larvae and juvenile fish) for each year. This is an index calculated for the whole Hudson estuary. As the number of fish entrained at Indian Point must be related to the number of fish in the estuary, it is possible to make an estimate of how the number of selected entrained species has changed over time. Details of some of the trends are given in the Pisces Conservation report *The status of fish populations and the ecology of the Hudson* (Pisces 2007).

Of the 5 taxa of fish whose entrainment data are presented in the DEIS, only three could be analysed. River herring is a combination of two fish species, blueback herring and alewife, precluding calculation without further information. Bay anchovy are only recorded as juveniles in the river survey. Since most of the animals entrained at Indian Point are eggs or larvae, this index was unsuitable to estimate entrainment.

The three species for which estimates could be made were American shad, striped bass and white perch. To make the estimate of entrainment in each year, the average number of fish entrained for each life stage for 1981-87 (only including sampled years) was calculated. The average index for each life stage, for the appropriate years, was then calculated. The average number entrained, divided by the average index, gives the number of fish entrained per index unit.

The indices for each life stage and year were multiplied by this factor to estimate the entrainment. The results are given in Figure 2 and Figure 3.

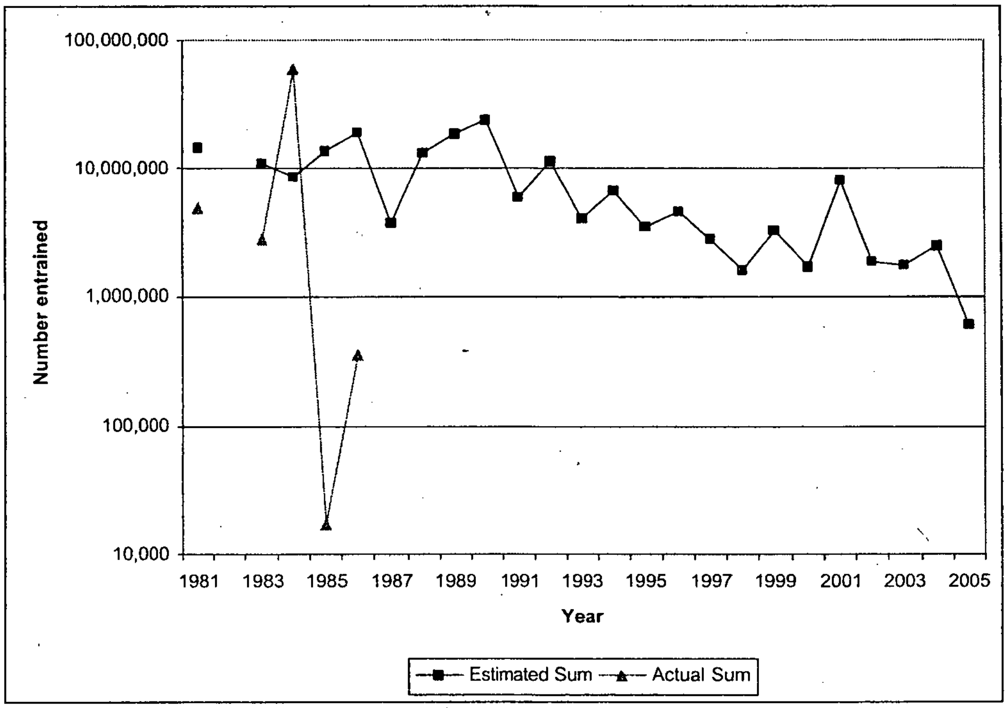

Figure 2: The actual and estimated number of all life stages for American shad at Indian Point. Log scale.

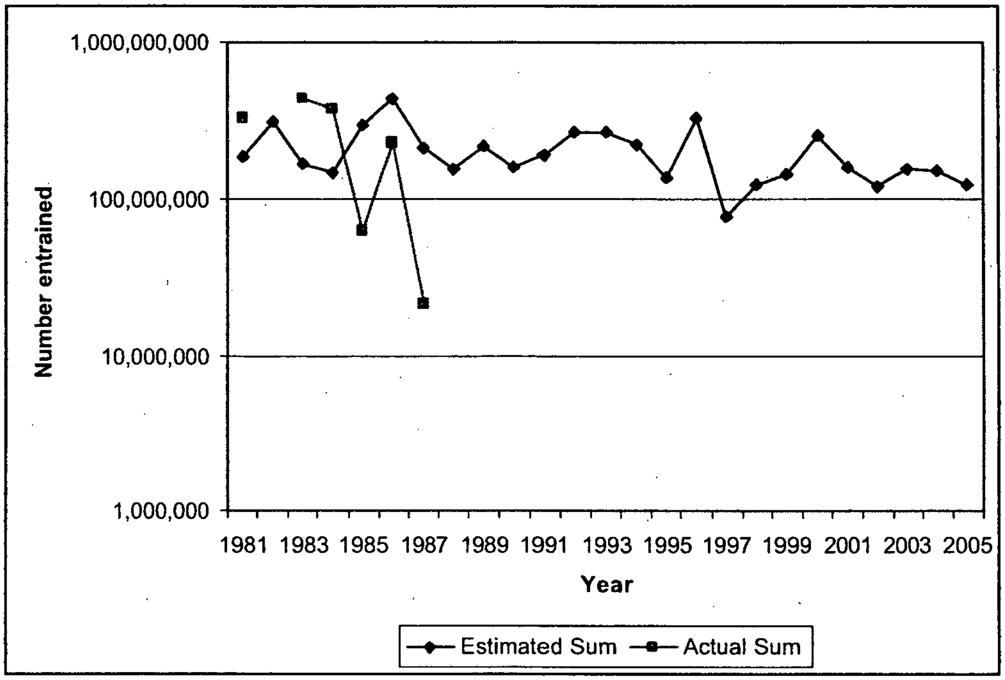

Figure 3: The actual and estimated number of all life stages for white perch at Indian Point. Log scale.

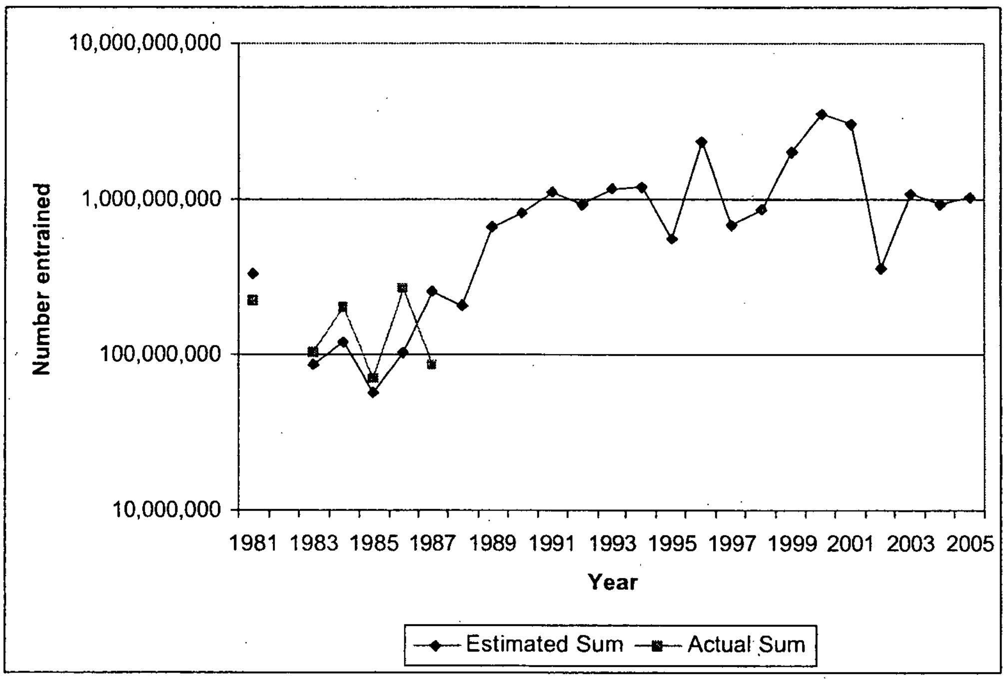

Figure 4: The actual and estimated number of all life stages for striped bass at Indian Point. Log scale.

The fit of the American shad (Figure 2) relationship is poor. American shad breed in the upper regions of the estuary and the numbers found at Indian Point may be related to river flows and vary greatly between years. White perch (Figure 3) also release eggs in the upper estuary, but spread steadily throughout the estuary as they grow. The relationship is better than that for American shad, but is still poor. The relationship for striped bass (Figure 4) is good, as the bass breed close to Indian Point. This is demonstrated in Figure 5, which shows the river regions where various striped bass life stages are found in the estuary.

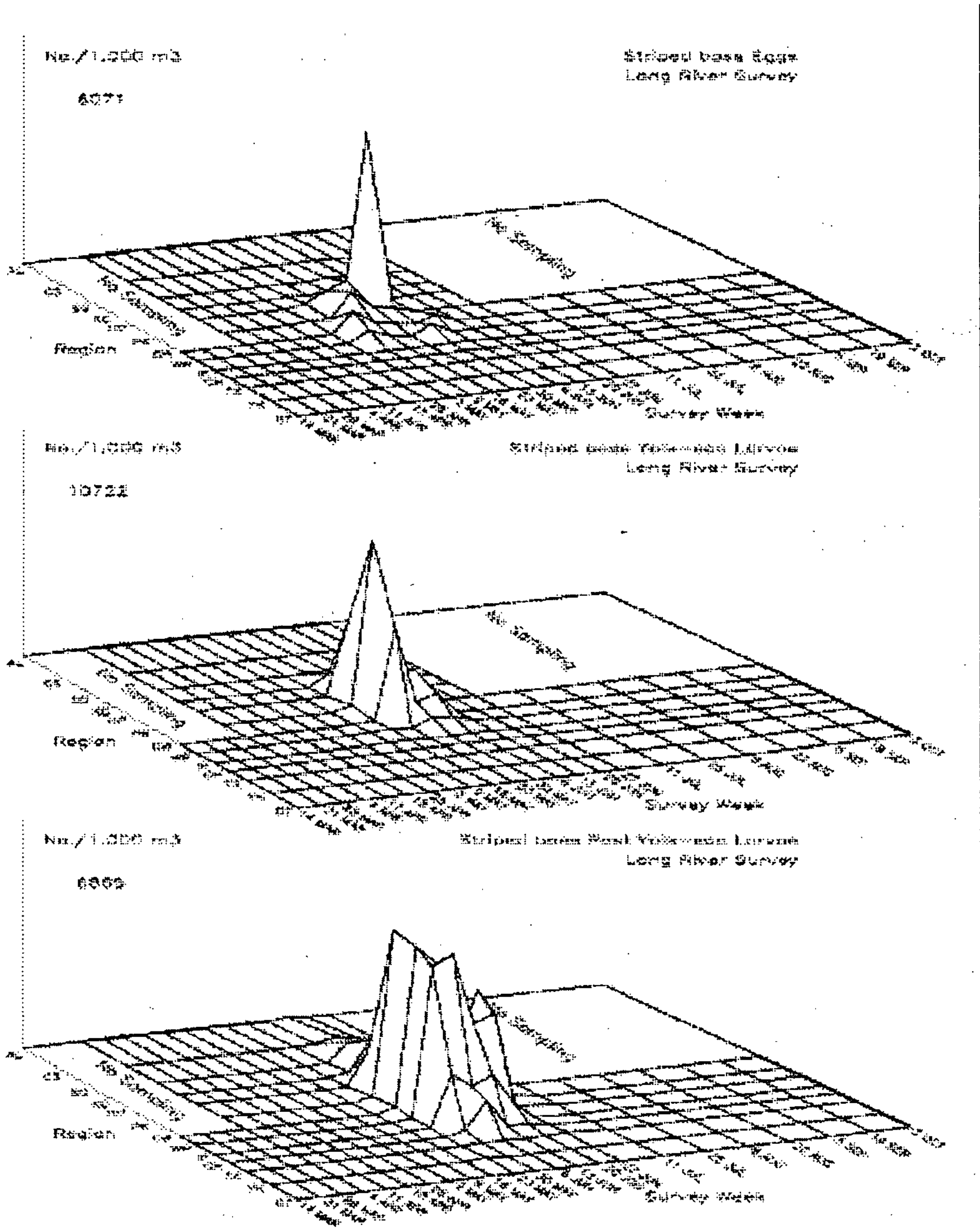

Figure 5: Spatio-temporal distribution of egg, yolk-sac and post yolk-sac larval striped bass in the Hudson River, based on the 2005 Long River Survey. From 2005 year class report figure 4-1.

The striped bass calculations demonstrate that present entrainment estimates based on the old estimates in the DEIS would be underestimated. The average number of striped bass entrained in 1981-7 was 46 million. Using the estimates presented in Figure 4, the average number entrained between 1987 and 2005 was 366 million, an increase of over 750%.

To analyse the relationships fully, data are needed on the density of the fish in the vicinity of the power plant. The year class reports do give the densities of each life stage in each part of the estuary for each week. We believe that these data are gathered for the year class reports; if so, a much more detailed and accurate calculation could be made of the number of fish entrained. We conclude that the entrainment impact has not been quantified to the best extent possible.

3.4. Entrainment - Conclusions

The data used recently by Entergy to assess this impact are old, having been gathered between 1980 and 1990. Since then, the ecology of the estuary has changed considerably, with several species declining in abundance, and some species, most notably striped bass, increasing. There have been large changes in the river environment, and important biological invasions.

For the five fish species for which data are available, the Indian Point stations entrain over 1.2 billon eggs and larvae a year. Entrainment data for Atlantic tomcod are not available, but are likely to be significant, with an estimated conditional mortality rate (CMR) indicating that 12% of the Atlantic tomcod population are being killed by Indian Point each year.

Efforts have not been made to assess current entrainment levels, using the year class reports and existing entrainment data. A rough approximation of the number of striped bass entrained indicates that the number may have increased by 750% over old estimates. Reliance on 20-year old data, in an estuary that has undergone many significant environmental and ecological changes, makes any prediction of the impact highly imprecise. The data were collected before many significant recent ecological changes in the Hudson had occurred, including the arrival of zebra mussels, the closure of several fisheries and the recovery in striped bass numbers.

In a system that is under stress from many sources, the entrainment of 1.2 billion fish attributable to Indian Point is significant. With CMR for Indian Point as high as 12% for Atlantic tomcod, 10% for bay anchovy, 1% for river herring, 8% striped bass and 5% for white perch, the mortalities caused by Indian Point are large.

Closed-cycle cooling, required under the draft SPDES permit for Indian Point, represents about a 95% reduction in water use relative to the existing once-through system. This alone would also reduce entrainment mortality by 95% and could, if needed, allow other entrainment reducing technologies to be used. We know of no alternative technology(s) that will result in equivalent protection for aquatic resources to the level which can be achieved by closed cycle cooling.

4. Impingement

4.1. Numbers impinged at Indian Point power station

Before 1990, fish impinged on the cooling water filter screens would invariably have been killed. The installation of Ristroph screens and fish return systems at Indian Point between 1990 and 1991 reduced this mortality for some species.

Surveys of the impingement at Indian Point were undertaken from 1981 to 1990, and the number of fish impinged was known with good accuracy for this period. Only data for the top 8 species were presented in the DEIS in detail. Because the sampling was undertaken regularly throughout the year, estimates of the total annual catch for the common species were made (Table 4).

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average
American shad	94,529	1,131	8,670	782	2,630	7,746	3,186	479	9,755	32	12,894
Alewife	26,656	1,565	7,715	8,427	5,741	3,170	3,488	1,652	1,633	2,415	6,246
Tomcod	377,320	84,314	142,717	139,136	84,581	65,841	1,356,287	18,046	14,525	111,647	239,441
Bay anchovy	605,163	111,301	193,056	107,527	19,711	59,187	28,065	29,299	10,408	-	116,372
Spottail shiner	2,267	1,032	1,237	2,604	2,148	1,588	3,310	1,793	7,906	-	2,389
White perch	1,315,592	1,113,621	362,652	614,593	780,545	756,219	647,111	747,660	759,042	505,537	760,257
Blueback herring	248,616	1,091	83,450	15,872	28,050	19,146	77,992	26,141	59,477	21,248	58,108
Striped bass	47,719	20,841	28,011	13,838	77,953	8,833	31,302	234,229	326	-	46,305
Totals	**2,717,862**	**1,334,896**	**827,508**	**902,779**	**1,001,359**	**921,730**	**2,150,741**	**1,059,299**	**863,072**	**640,879**	**1,242,013**

Table 4: The number of fish impinged annually at Indian Point from 1981 to 1990 for 8 species. Data from DEIS V1-2-D.

Impingement numbers can still be calculated after the installation of fish return systems, by intercepting the impinged fish before they are returned to the estuary.

4.2. Estimates of the number killed by impingement

4.2.1. Survival rates – Indian Point estimates

Once Ristroph screens and a fish return system were added to the station in 1990-1, some of the impinged fish survived. A key aspect to consider when analysing fish survival data from Ristroph screens is the time after impingement and handling when survival was measured (see section 4.2.2). Some early studies quoted high survival after 10 to 15 minutes in a holding tank. This is clearly of little interest, as most injured fish will take considerably longer to die.

The minimum time at which survival rates are likely to give a fair indication of the eventual survival of the impinged fish will be after 8 hours; Fletcher (1990) gives estimates for the survival of common species at Indian Point in the Hudson Estuary after this time period (Table 5).

Fish species	Survival %
Bay anchovy	77
American shad	65
Blueback herring	74
Striped bass	91
White perch	86
Atlantic tomcod	83
Alewife	38

Table 5: Eight-hour survival rates for Indian Point (Fletcher, 1990).

4.2.2. Survival rates – effects of timing of measurement

The survivals presented in Table 5, and similar results, have been highly influential in guiding the EPA to the conclusion that Ristroph screens could achieve reductions in mortality of at least 70 to 80%. However, there are a number of factors that will likely reduce eventual survival below that observed after 8 hours. It has been found that stressed and damaged fish can take a number of days to die. Experiences in angling and fish farming demonstrate that quite minor damage may lead to bacterial and fungal infections, resulting in eventual death. For example, in an experiment where fish were simply caught from a tank using different types of netting, and returned to a lake, Barthel *et al* (2003) found that the fish often took 2 or 3 days to die.

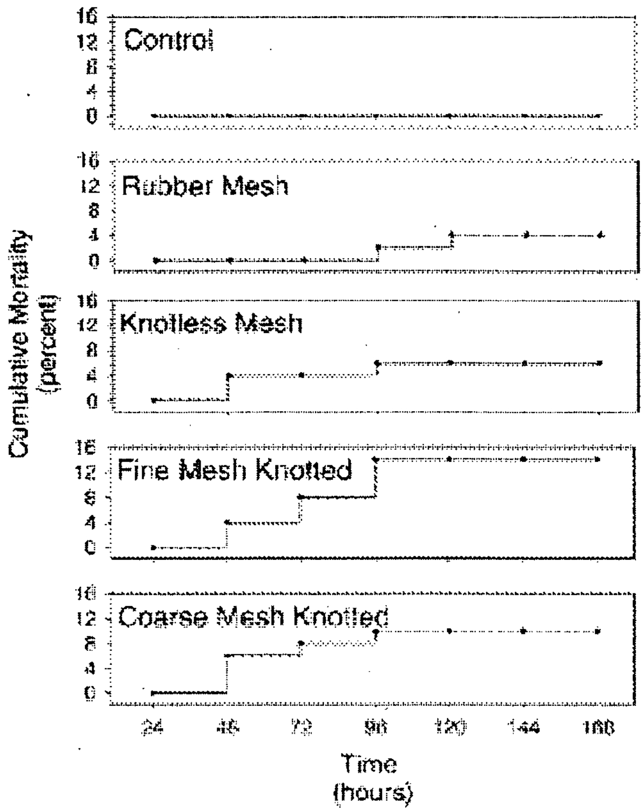

Figure 6: Cumulative mortality for bluegill exposed to four different netting treatments. (Barthel *et al*, 2003)

There is also the problem with all fish return systems that exhausted, disorientated and damaged individuals can be picked off by predators on their return to the main water body. It is normal to observe large predatory fish and piscivorous birds patrolling and feeding at water discharges.

The progressive decline in survival with time following impingement is demonstrated in data collected at Roseton Generating Station in the Hudson estuary (Table 6). Apart from spottail shiner, all other species showed a marked decline in the rate of survival between 2.5 and 96 hours after impingement. This clearly indicates the need to use survival estimates over periods of at least 96 hrs if the post-impingement survival is to be correctly estimated.

Species	Number	Survival Rate through time					
		0 hr	2.5 hr	8 hr	24 hr	48 hr	96 hr
American shad	575	0.689	0.252	0.123	0.080	0.071	0.068
Alewife	1839	0.662	0.229	0.151	0.096	0.073	0.060
Bay anchovy	1093	0.282	0.169	0.110	0.032	0.014	0.004
Blueback herring	8973	0.753	0.335	0.204	0.110	0.090	0.071
Striped bass	899	0.889	0.740	0.578	0.494	0.405	0.345
Spottail shiner	331	0.958	0.931	0.915	0.897	0.873	0.831
White perch	899	0.950	0.909	0.828	0.727	0.648	0.583

Table 6: Data from 1994 impingement mortality studies at Roseton (dualflow screens) (NAI 1995).

When the Roseton survival rates are plotted against time, it can be seen how many individuals are likely to die after 8 hours of survival (Figure 7). A dotted red line has been added to the graph to show the time at which the survival of impinged fish at Indian Point is used in the DEIS. (Note, these are not the survival figures used for Indian Point in the DEIS – but are presented to show the effect of the passage of time on the survival rate).

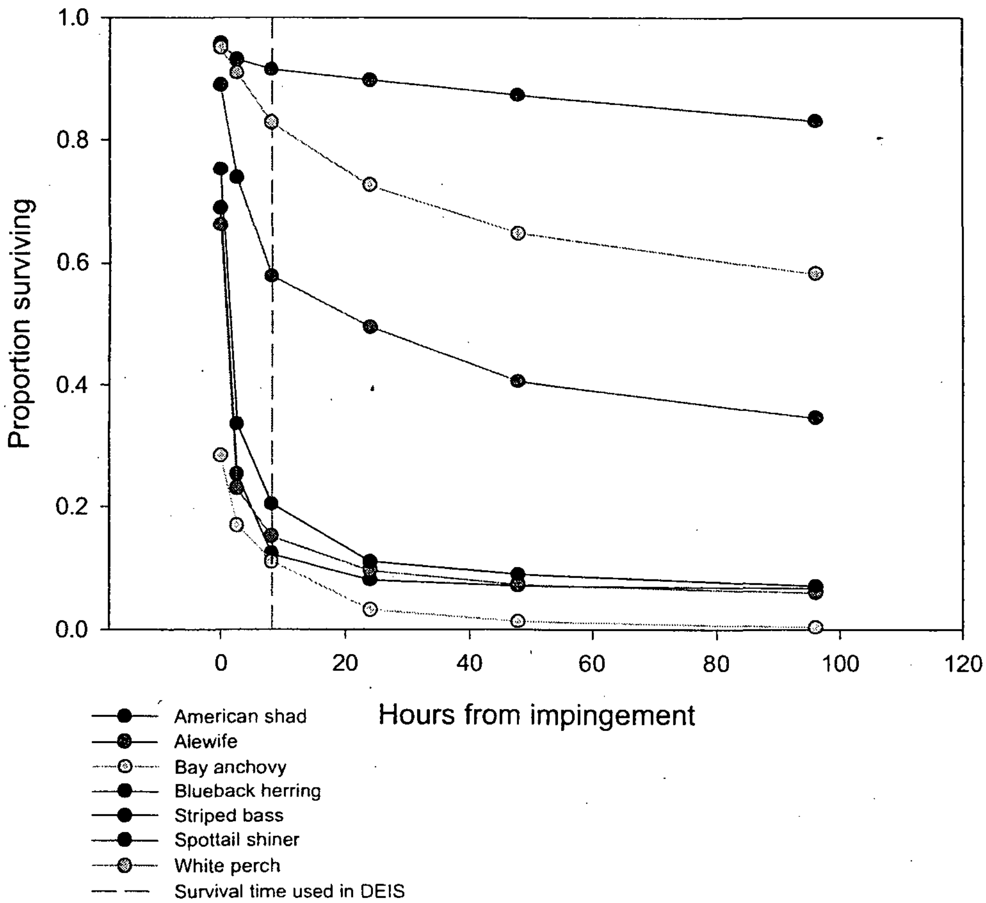

Figure 7: The proportion of fish surviving after 0, 2.5, 8, 24, 48 and 92 hours after impingement at Roseton. (NAI 1995)

4.2.3. Environmental factors affecting survival rates

Temperature and salinity can also change survival rates after impingement. Injured fish are more likely to die at low temperatures and salinities (Muessig *et al.* 1988; Figure 8). Salinity is probably important because damage to the skin results in a loss of osmotic control. While these studies were carried out on conventional, rather than Ristroph, screens, this will not detract from the insight gained into the effects of salinity and temperature upon injured individuals.

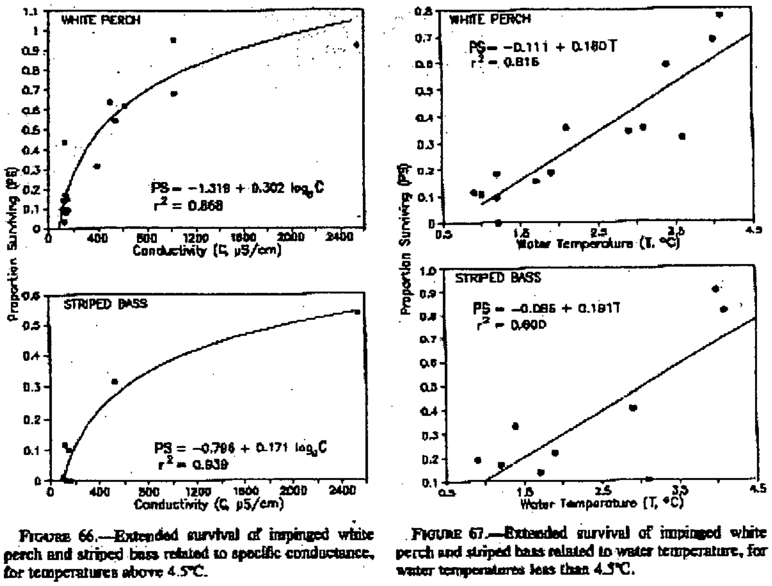

Figure 8: The survival of white perch in relation to water temperature and salinity following impingement. Reproduced from Muessig et al. (1988)

The results of Muessig *et al*'s studies in Figure 8 above indicate that short-term survival rates at intermediate water temperatures and salinities are unlikely to fully reflect the eventual mortality rate for species that are easily injured. For example, for both striped bass and white perch, the survival is much lower at low water temperatures than at high

4.2.4. Survival rates – the PSEG estimates

As only 8-hour survival figures for the Ristroph screens are given in the DEIS, data from other sources were examined. The most recent review of likely survival rates appeared in PSEG Power New York Inc's *Bethlehem Energy Center SPDES Modification, Alternative Cooling Systems Study for Ristroph screens,* (PSEG (from LMS 1998a)); the post-impingement survival rates presented there are given in Table 7 below. This gives the best available survival estimates for American east coast estuarine and marine fish.

Family	Species	Percent Survival	
		Conventional	Ristroph type
Acipenseridae	Atlantic sturgeon	60	80
	Shortnose sturgeon	60	80
Anguillidae	American eel	70	95
Bothidae	Summer flounder	70	95
Catostomidae	White sucker	50	70
Centrarchidae	Black crappie	30	40
	Bluegill	80	80
	Largemouth bass	75	90
	Longear sunfish	70	80
	Pumpkinseed	75	80
	Redbreast sunfish	70	80
	Rock bass	70	80
	Smallmouth bass	75	90
	White crappie	30	40
Clupeidae	Alewife	0	10
	American shad	0	10
	Blueback herring	0	10
	Gizzard shad	5	10
	AW/BBH	0	10
Cyprinidae	Bluntnose minnow	50	90
	Carp	50	80
	Common shiner	50	90
	Creek chub	50	90
	Emerald shiner	50	90
	Fallfish	50	90
	Golden shiner	45	90
	Goldfish	50	80
	Rosyface shiner	50	90
	Silvery minnow	50	90
	Spotfin shiner	50	90
	Spottail shiner	50	90
	Unidentified shiner	50	90
Cyprinodontidae	Banded killifish	85	90
	Mummichog	85	90
Engraulidae	Bay anchovy	0	80
Esocidae	Chain pickerel	70	90
	Northern pike	70	90
	Redfin pickerel	70	90
Gadidae	Atlantic tomcod	10	70
Gasterosteidae	Fourspine stickleback	70	90
	Threespine stickleback	70	90
Ictaluridae	Brown bullhead	65	90
	Channel catfish	70	90
	Tadpole madtom	70	90
	White catfish	75	90
	Yellow bullhead	70	90
Osmeridae	Rainbow smelt	0	85
Percichthyidae	Striped bass	25	70
	White bass	25	70
	White perch	25	70
Percicidae	Logperch	65	80
	Tessellated darter	90	100
	Walleye	65	80
	Yellow perch	65	80
Percopsidae	Trout-perch	15	20
Petromyzontidae	Lamprey spp.	70	95
Salmonidae	Brown trout	60	80
Sciaenidae	Freshwater drum	20	25
Soleidae	Hogchoker	90	95
Umbridae	Central mudminnow	60	80

Table 7: The post-impingement survival of fish on conventional and Ristroph screens Used at Bethlehem Energy Centre (BEC). From PSEG.

4.2.5. Using survival rates to estimate Indian Point impingement mortality

To quantify the impact of impingement at Indian Point, the estimates for impingement in the 1980s were used. By applying mortality rates (1-survival) for each species, the number of individuals of the common fish species killed were computed (see Table 8). Both the mortality rates used in the DEIS and those used in the PSEG Bethlehem power plant were used for the calculations.

		DEIS Mortality Rates		PSEG Mortality Rates	
	Impinged	**Mortality Rate**	**Killed**	**Mortality Rate**	**Killed**
American shad	12,894	0.35	4,513	0.90	11,605
Alewife	6,246	0.62	3,873	0.90	5,622
Tomcod	239,441	0.17	40,705	0.30	71,832
Bay anchovy	116,372	0.23	26,765	0.90	104,735
Spottail shiner	2,389	0.16	370	0.10	239
White perch	760,257	0.14	106,436	0.30	228,077
Blueback herring	58,108	0.26	15,108	0.90	52,297
Striped bass	46,305	0.09	4,167	0.30	13,892
Total	**1,242,013**		**201,938**		**488,298**

Table 8: The mean number impinged and killed using the estimates of mortality of Ristroph screen for Indian Point. Mortality rates from Fletcher (1990) (see Table 5) and PSEC (LMS) (see Table 7). Impingement data from DEIS V1-2-D and VI-2-B.

While the number of fish impinged and killed is large, irrespective of the survival rate applied, the estimate using 8 hr survival rates is less than half that using the rates from the PSEG report. The biggest difference in mortality rates is for the bay anchovy, which is estimated at only 23% in the DEIS and 90% in the PSEG report.

4.3. Seasonality

The impingement of fish at Indian Point is seasonal, with two peaks per year, one in winter (December and January) and second in summer (June and July). This is true for both the total number impinged and for the estimate of the number killed when survival is taken into account (Figure 9 and Figure 10).

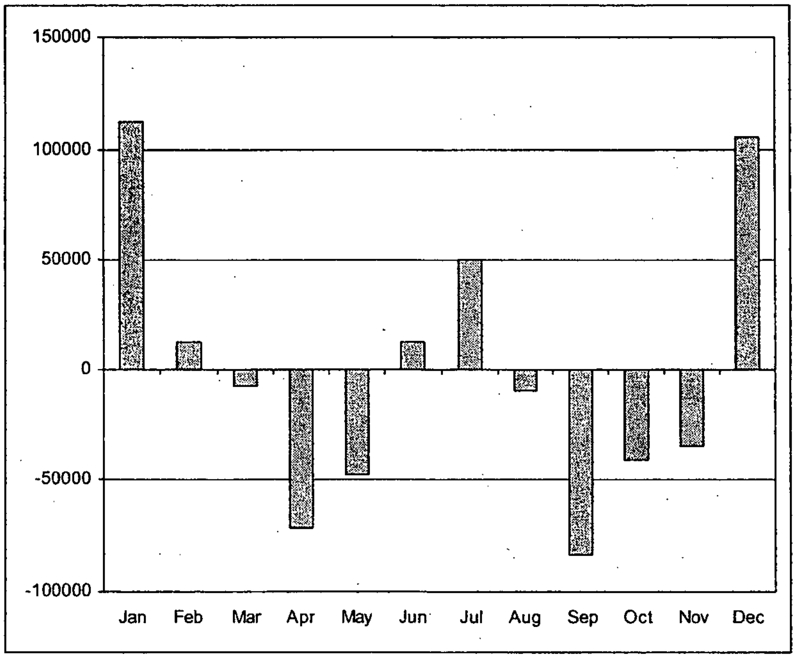

Figure 9: The difference from mean number of fish killed by impingement each month at Indian Point. Data for 8 species (see text) - 8 hr survival DEIS VI-2-D and VI-2-B.

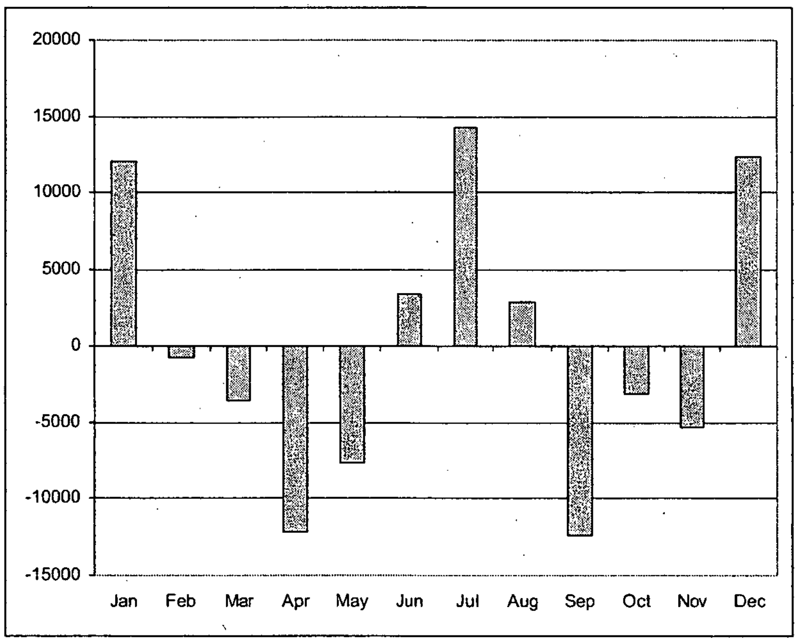

Figure 10: The difference from mean number of fish killed by impingement each month at Indian Point. Data for 8 species (see text) – DEIS VI-2-D and BEC (PSEG) hr survival (Table 7)

4.4. Impingement - Conclusions

The number of fish impinged at Indian Point, as estimated in the DEIS, is large, at over 1.2 million fish. Not all these fish die, but even so, the average number that do die exceeds 200,000, using the most optimistic survival figures, and 400,000 using more conservative survival values. The DEIS' impingement mortality estimate is unlikely to be a reliable estimate of current or future impingement, as it is based on the number of fish being impinged between 1981 and 1990. It is over 17 years since any impingement monitoring data have been published, and the fish community of the Hudson has greatly changed over this time. For further information see *The status of fish populations and the ecology of the Hudson* (Pisces 2007). The data presented by the power plant concentrate on a few abundant species. The impact of impingement on less abundant species is unknown. There is therefore a need to obtain new estimates of the number of fish impinged, and their survival rates.

Closed-cycle cooling, required under the draft SPDES permit for Indian Point, represents about a 95% reduction in water use relative to the existing once-through system. With closed-cycle cooling, the smaller volumes of water pumped and the much lower velocities involved would almost eliminate impingement on the station cooling water intake screens. We know of no alternative technology(s) that will result in equivalent protection for aquatic resources to the level which can be achieved by closed cycle cooling.

5. Thermal Issues

5.1. Introduction

This section describes the thermal impact of the Indian Point generating station cooling water discharge, and briefly reviews the impact of heated water on aquatic life. The impact of a thermal discharge is related to the background temperature of the water body, and the potential effects of thermal pollution become more serious as the background temperature increases. We therefore also briefly review the background temperature of the Hudson River and the recent increase in water temperatures.

The principal reason for establishing and enforcing thermal water quality criteria is to limit the impact of water temperature on aquatic organisms. The limits on surface width and cross-sectional area in which elevated water temperatures are permissible are designed to ensure zones of passage and regions of habitability for aquatic organisms using the estuary. Similarly, the establishment of the 90°F maximum surface water temperature is in recognition of the thermal tolerance limits of various resident and migratory species.

The relevant criteria governing thermal discharges are summarised below:

704.1 Water quality standards for thermal discharges.

(a) All thermal discharges to the waters of the State shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water.

704.2 Criteria governing thermal discharges.

(a) *General criteria*. The following criteria shall apply to all waters of the State receiving thermal discharges, except as provided in section 704.6 of this Part:

(1) The natural seasonal cycle shall be retained.

(2) Annual spring and fall temperature changes shall be gradual.

(3) Large day-to-day temperature fluctuations due to heat of artificial origin shall be avoided.

(4) Development or growth of nuisance organisms shall not occur in contravention of water quality standards.

(6) For the protection of the aquatic biota from severe temperature changes, routine shut down of an entire thermal discharge at any site shall not be scheduled during the period from December through March.

(b) There are also criteria for specific water bodies:

(5) Estuaries or portions of estuaries.

(i) The water temperature at the surface of an estuary shall not be raised to more than 90 degrees Fahrenheit at any point.

(ii) At least 50 percent of the cross sectional area and/or volume of the flow of the estuary including a minimum of one-third of the surface as measured from water edge to water edge at any stage of tide, shall not be raised to more than four Fahrenheit degrees over the temperature that existed before the addition of heat of artificial origin or a maximum of 83 degrees Fahrenheit whichever is less.

(iii) From July through September, if the water temperature at the surface of an estuary before the addition of heat of artificial origin is more than 83 degrees Fahrenheit an increase in temperature not to exceed 1.5 Fahrenheit degrees at any point of the estuarine passageway as delineated above, may be permitted.

(iv) At least 50 percent of the cross sectional area and/or volume of the flow of the estuary including a minimum of one-third of the surface as measured from water edge to water edge at any stage of tide, shall not be lowered more than four Fahrenheit degrees from the temperature that existed immediately prior to such lowering.

704.3 Mixing zone criteria.

The following criteria shall apply to all waters of the State receiving thermal discharges, except as provided in section 704.6 of this Part.

(a) The department shall specify definable, numerical limits for all mixing zones (*e.g.*, linear distances from the point of discharge, surface area involvement, or volume of receiving water entrained in the thermal plume).

(b) Conditions in the mixing zone shall not be lethal in contravention of water quality standards to aquatic biota which may enter the zone.

(c) The location of mixing zones for thermal discharges shall not interfere with spawning areas, nursery areas and fish migration routes.

Under Section 316(a) of the Clean Water Act, and Part 704 of the NYSDEC water quality regulations, regulators are permitted to allow thermal discharges in excess of the established criteria if it can be demonstrated that such a discharge will assure "*the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water receiving the thermal discharge.*"

As noted in the FEIS, it seems clear that Indian Point's thermal discharge does not meet applicable thermal criteria. Furthermore, as the FEIS points out from the DEIS there is no mixing zone definition for Indian Point generating station discharges.

> *Indian Point:* As of the 1987 - 1992 SPDES permit term, thermal discharges from Indian Point did not meet applicable thermal criteria. ... These provisions alone [in the SPDES permit based on the Hudson River Settlement Agreement and Consent Orders], however, are not sufficient for Indian Point to meet thermal criteria. Thermal modelling indicates that the thermal discharge from Indian Point causes water temperatures to rise more than allowed, which is four degrees (F.) over the temperature that existed before the addition of heat, or a maximum of 83°F, whichever is less, in the estuary cross sections specified in 6 NYCRR §704.2(b)(5).2 A mixing zone was not specified in the previous SPDES permit for the Indian Point facility.

(FEIS page 19).

5.2. The thermal footprint of Indian Point

5.2.1. The near field

The term "Near field" is used here to describe the area in the vicinity of the outfall where there is a discrete thermal plume.

Infrared images highlight the surface extent of the thermal plume released from Indian Point (Figure 11). The image below, taken from the FEIS, shows the high proportion of the width of the river that is impacted by the Unit 3 discharge of Indian Point. The following quotation describes the concern:

> "*The surface extent of thermal discharges from the HRSA plants is also a concern. Figure 8 is an aerial thermal image of the plume from Indian Point, Unit 3 only, on the east side of the Hudson plus the smaller plume from Lovett on the west bank. In this image, the two plumes came very close to meeting on the surface, even with Indian Point running at less than its full capacity.*"

(FEIS, Chapter 5 p 71)

In summary, the surface extent of the thermal plume produced by Indian Point covers a high proportion of the width of the river.

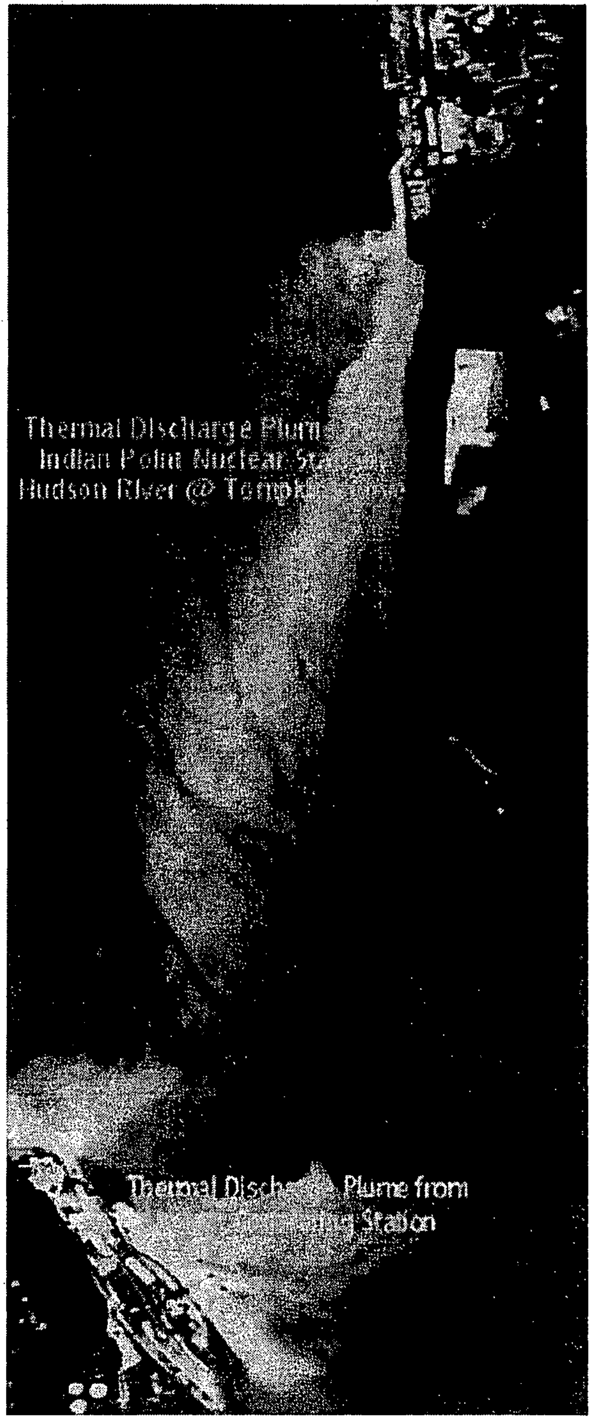

Figure 11: The extent of the thermal plume from the cooling water discharge of Indian Point Unit 3, and the Lovett generating station.

The FEIS also expresses concern about the vertical distribution of the thermal plume. In general, heated effluents are buoyant, and thus the impacts are mostly restricted to the surface waters and any area of bank which the plume contacts. However, if the plume is sufficiently large then heated water will penetrate to the bed of the river and impact bottom-living and deep-water species. Such deeper water penetration of the thermal plume is always a matter for concern, as it may lead to damage to the benthic food chain and also not allow migrating fish to pass under the heated water plume. It is clear that almost the entire vertical water column in the vicinity of Indian Point holds water heated above background temperatures (Figure 12). The FEIS states:

> *"A study by HydroQual, Inc., examined passive particle movement and also investigated thermal and salinity profiles in several river reaches, including the portion of the Hudson River where the HRSA plants are located. Figures 6 and 7 of this FEIS (following pages), excerpted from that study, show two vertical temperature profiles of the Hudson River from NYC to just above the northernmost of the HRSA plants, one during a spring and the other during a neap tide. Based on these representations, it appears that there may be times and conditions where effluent-warmed waters occupy nearly the entire vertical water column."*

(FEIS, Chapter 5 p 71)

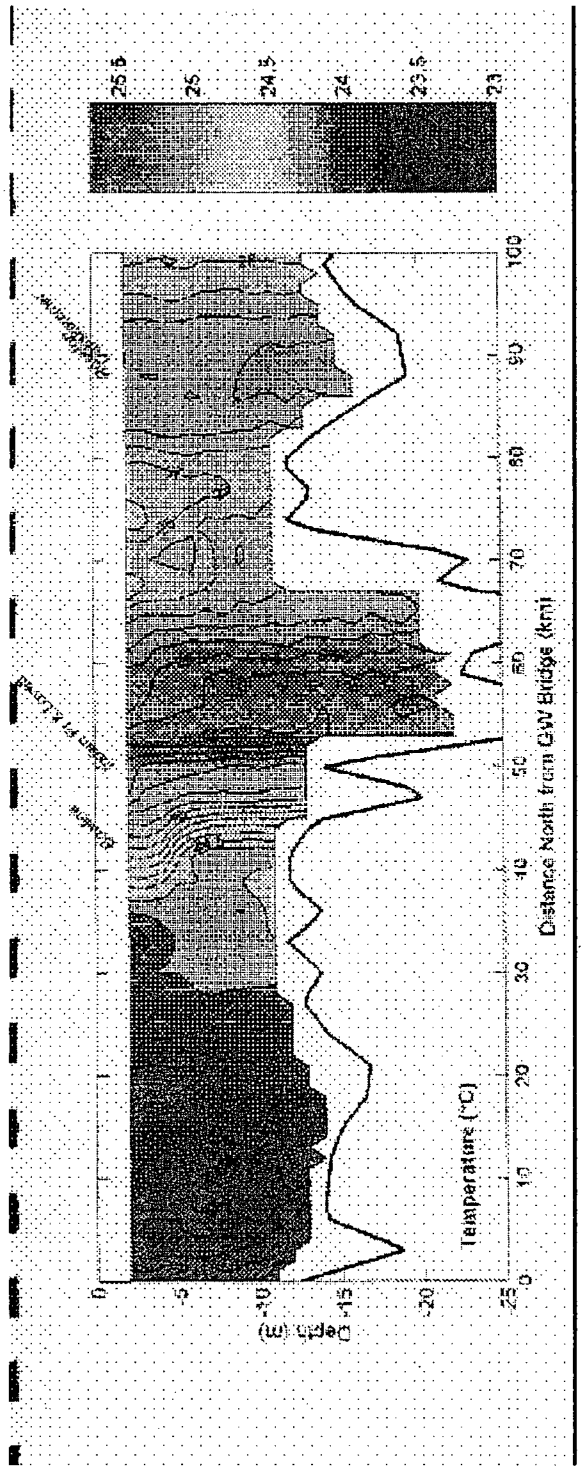

Figure 12: Temperature profile of the Hudson River, NYC to Newburgh, during a neap tide. From the FEIS and originally HydroQual, 1999.

In any event, the FEIS states on page 71:

> *Thermal discharges were inadequately addressed in the DEIS. The DEIS asserts, with no supporting evidence, that "... [t]he surface water orientation of the plume allows a zone of passage in the lower portions of the water column, the preferred habitat of the indigenous species." Other data and analyses cast doubt on this assertion.*

The FEIS goes on to say, on page 72:

> *Given the extent of warming shown in the HydroQual graphs, combined with the recent dramatic declines in tomcod and rainbow smelt as discussed previously, the Department believes it prudent to seek additional thermal discharge data for each facility, including a mixing zone analysis, and anticipates requiring triaxial thermal studies as conditions to each of the SPDES renewals. Depending on the results of those analyses, additional controls may be required to minimize thermal discharges.*

Having briefly introduced evidence on the spatial extent of the thermal plume, we now move on to consider the temperature of the discharge. The average maximum temperatures for each calendar month for the years 2000 to 2007 are given in Table 9. Note that for the summer months the maximum is regularly in excess of 90 degrees Fahrenheit, while the regulations clearly state "*The water temperature at the surface of an estuary shall not be raised to more than 90 degrees Fahrenheit at any point*". Further, there are occasions when the temperature exceeds 100°F; this is a temperature at which many aquatic organisms living in the estuary will suffer acute harm or death.

Figure 13 shows a plot of the maximum daily discharge temperatures at Indian Point, with the 90° and 100°F reference temperatures shown in red. Note that 90°F has been exceeded for extended periods every summer since 2001. Furthermore, 100°F has been exceed in 3 of the 7 summers for which data are plotted.

Month	2000	2001	2002	2003	2004	2005	2006	2007
1	66.38	57.35	70.53	68.45	70.78	70.74	74.78	70.25
2	63.63	67.61	69.76	65.41	69.57	71.88	71.39	67.76
3	64.08	70.57	69.91	65.20	70.46	69.17	69.59	63.29
4	70.05	71.52	74.75	66.00	71.89	72.86	75.54	69.90
5	77.01	78.07	79.85	79.20	82.64	81.92	79.82	83.80
6	79.40	88.82	86.41	84.40	91.81	92.08	89.17	93.30
7	88.66	97.27	98.29	96.68	97.21	87.89	96.95	
8	89.19	100.01	101.29	96.45	97.21	103.58	101.20	
9	86.83	96.11	94.91	94.38	90.27	99.66	94.24	
10	80.62	83.70	85.24	82.56	81.88	83.89	85.34	
11	75.87	77.70	68.06	78.00	76.52	77.68	81.20	
12	64.05	76.80	73.23	74.30	73.95	75.50	77.25	

Table 9: The average maximum discharge temperature (°F) of the Indian Point cooling water discharges for the years 2000 to 2007. Missing numbers are months for which no data are available. (Indian Point Daily Temperature Reports 2000-07)

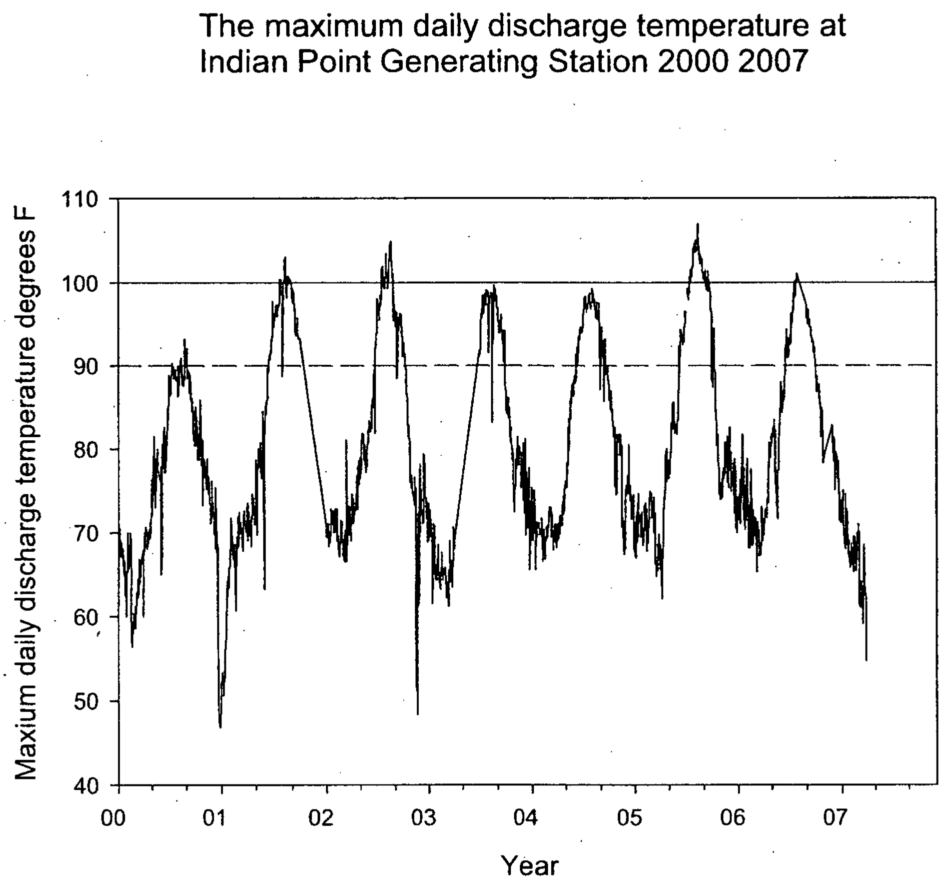

Figure 13: Plot of the maximum daily discharge temperatures at Indian Point 2000-2007. The 90° and 100°F reference levels are shown in red.

5.2.2. The far field

Far field predictions can be made using existing temperature measurements or modelling methods. The Massachusetts Institute of Technology dynamic network model was used in the DEIS for Indian Point, Bowline and Roseton generating stations. In the DEIS this far field model is referred to as the FFTM (Far Field Thermal Model).

There are a variety of natural and anthropogenic heat inputs into the Hudson Estuary, and to assess the far field impact of Indian Point we need to be able to distinguish the impact of Indian Point from these other sources. Fortunately, this is possible and we can give a reasonable estimate of the increase in the far field temperature caused by the Indian Point discharge. The table below is copied from the DEIS, and gives the heat loads from the principal anthropogenic sources. Note that Indian Point at this time injected considerably more heat into the system than the other sources considered at this time.

FACILITY	CAPACITY HEAT LOAD (BBTU/day)
Albany Steam Station	67.7
Danskammer Point	34.3
Roseton	136.0
Peekskill WHR	11.5
Indian Point	328.0
Lovett	71.0
Bowline Point	120.0
World Trade Center	19.9

Table 10: Capacity Heat Loads (Table 23 from DEIS appendix VI-3-A).

The Massachusetts Institute of Technology dynamic network model was reported in the DEIS for a range of power plant discharge scenarios. A typical output is presented in Figure 14. A comparison of lines 3 and 5 show the appreciable effect of Indian Point generating station, which was predicted to increase river temperature by > 1°F for more than 10 miles of estuary.

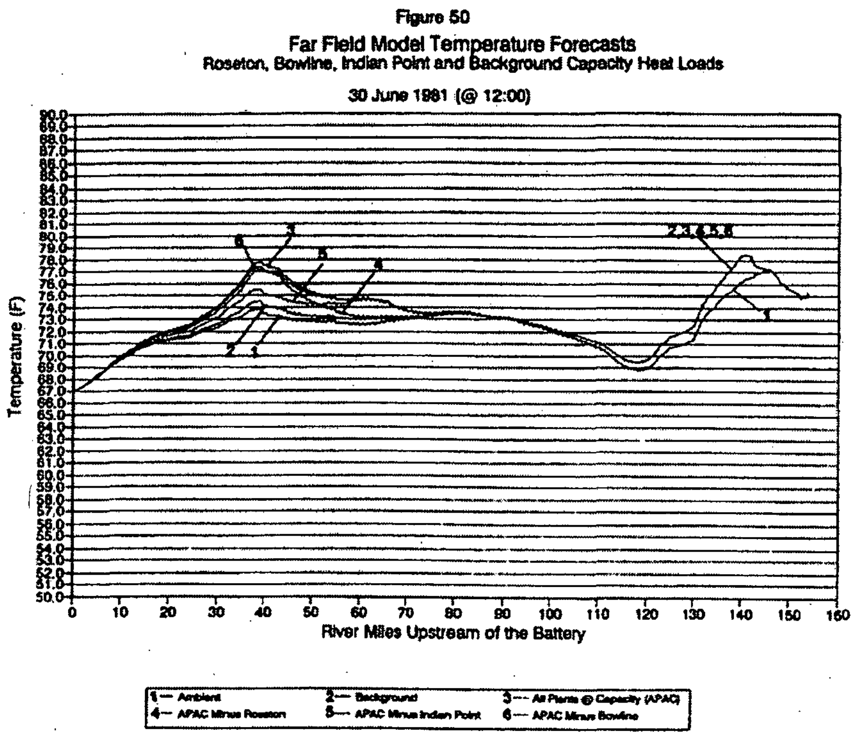

Figure 14: A sample of the results presented for the far field temperature effects of the Hudson Estuary power plants. From the DEIS for Roseton, Bowline and Indian Point generating stations.

5.3. The change in the background temperature of the Hudson River

Water temperatures in the Hudson are increasing. This is clearly demonstrated by the statistically significant increase in mean average annual water temperature measured at Poughkeepsie Water Treatment Facility (Figure 15). The mean annual temperature in recent years is about 2°C (3.6°F) above that recorded in the 1960s.

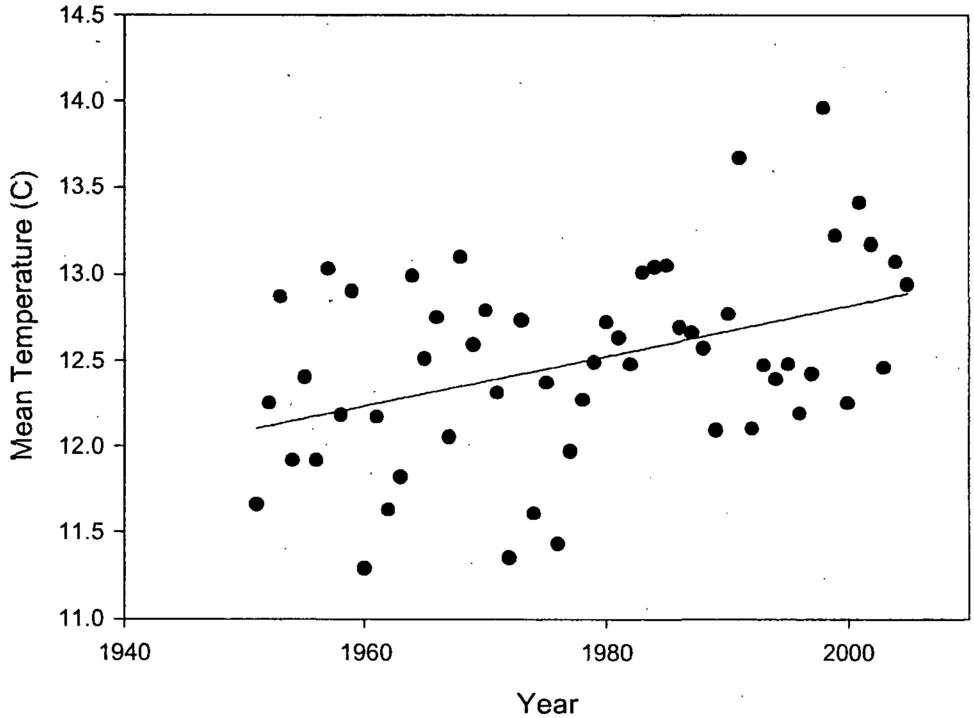

Figure 15: Average annual water temperature (°C) as measured at Poughkeepsie's Water Treatment Facility, 1951 to 2005. (a = 0.0146, b = -16.32, F = 11.1157, p = 0.0016) – Data from 2005 Year Class Report – Appendix B Table B - 6.

Examination of the daily temperatures for 2005 plotted against the mean, minimum and maximum temperatures from 1951 to 2004, show that the temperature for several summer months in 2005 was close to the maximum ever recorded. However, in the winter, it also reached some of the lowest temperatures recorded over a 53 year period. In summary, the temperature regime is becoming more extreme.

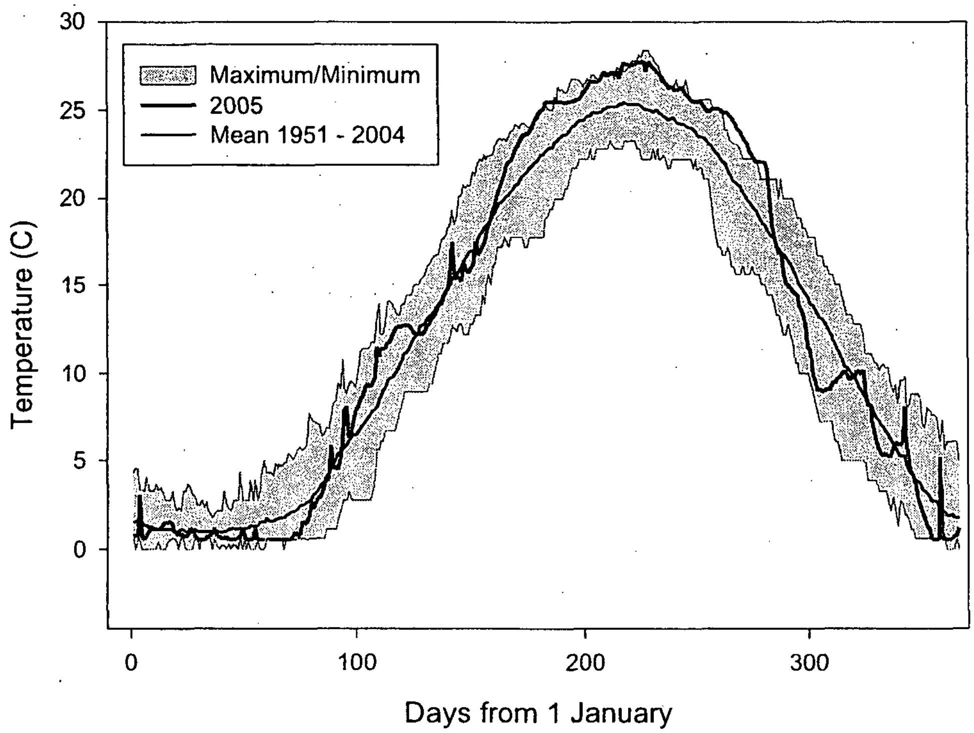

Figure 16: Poughkeepsie Water Treatment Facility data; mean, minimum, and maximum temperature (°C) for each day of the year, 1951 to 2004, with 2005 data plotted in red. – Data from 2005 Year Class Report – Appendix B Table B - 5.

5.4. The effects of heated water on river life

While the term entrainment is commonly used to describe the process in which planktonic animals are drawn into and pass through the condenser circuits of power plants, the term can also be used to describe the capture of organisms in an effluent discharge. When Indian Point discharges warm water into the river, it mixes with the receiving waters. Any small organisms in the receiving water with which it mixes will also be subjected to sudden changes in temperature that are potentially harmful. The importance of these impacts will be in part determined by both the temperature and volume of the discharge. Other factors may also become important. For example, in a tidal body of water, some organisms or populations may be repeatedly exposed to the discharge as the water body in which they live oscillates with the tide past the discharge point.

5.4.1. The temperature sensitivity of aquatic life

Almost all aquatic life is affected by thermal discharges. Below is presented a summary of the impacts on aquatic life in general, and rather more detailed data on thermal tolerance of fish.

5.4.1.1. Thermal impacts on plants

Several studies have shown that species diversity of phytoplankton decreases in areas consistently heated to over 30°C (mid 80s F). The available data indicate that phytoplankton productivity, as measured by carbon assimilation rates, declines with increasing temperatures above about 30°C. Figure 17 from Langford (1990) shows the rapid decline for phytoplankton in lakes. It is likely that a similar response would occur with Hudson River phytoplankton.

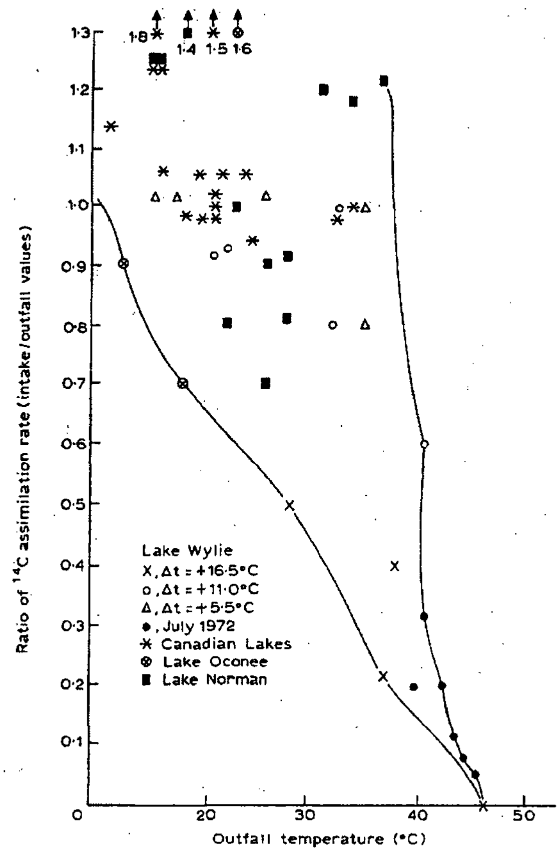

Figure 17: The effect of discharge temperature on the photosynthetic activity of phytoplankton. From Langford (1990).

5.4.1.2. Thermal effects on small crustaceans - zooplankton

When water temperatures reach 35 – 38°C (95 - 100°F) zooplankton abundance declines and mortalities occur (Langford, 1990). Effects on benthic invertebrate life have also been noted, but at Indian Point, the main effect of the discharge will be on planktonic life, because of the depth of the water, since the buoyant plume of heated water remains towards the surface.

5.4.1.3. The thermal tolerance of Hudson fish species

The effects of temperature on the biology and ecological requirements of fish have been extensively studied and reviewed. Temperature can affect survival, growth and metabolism, activity, swimming performance and behaviour, reproductive timing and rates of gonad development, egg development, hatching success, and morphology. Temperature also influences the survival of fishes stressed by other factors such as toxins, disease, or parasites. Many of these effects will occur well below the upper lethal temperature which is given below.

The published information on the temperature requirements of freshwater fishes is found in thousands of documents. It is convenient that several authors have condensed this information into reviews of the literature. The general reviews of fisheries biology by Carlander (1969, 1977) and Scott and Crossman (1973) include some temperature data. Several reviewers have focused on thermobiology, specifically, lethal and/or preference temperatures (Coutant 1977a; Cherry *et al* 1977; Kowalski *et al* 1978; Houston 1982). Others have widened their reviews to include data on growth, preference and lethal temperatures (Leidy and Jenkins 1977; McCauley and Casselman 1980; Jobling 1981). Comprehensive reviews on the whole range of temperature requirements for fishes (i.e., lethal, preference, growth, reproductive) were given by EPA (1974) and Brown (1974).

A summary of thermal effects literature is published each year for aquatic organisms in the June issue of the Journal of the Water Pollution Control Federation (Talmage and Coutant 1978, 1979, 1980; Cravens 1981, 1982; Cravens *et al* 1983; Harrelson *et al* 1984). The temperature requirements of Great Lakes fishes have been reviewed by a number of authors. Firstly, Reutter and Herdendorf (1976) presented lethal and preference temperatures for 46 species of Lake Erie fishes. Secondly, Spotila *et al* (1979) reviewed 80 species covering: thermal requirements for survival, temperature preference, growth, reproduction and early development. Finally, Wismer & Cristie (1988) made a general compilation of the available data.

Below, the upper temperature that a range of Hudson River fish can tolerate is tabulated. When no size is given, the values are for adults. Generally, young and small fish are more vulnerable to elevated water temperatures than adults. A temperature of 81°F (27.2°C) is the highest that most fish can withstand, indicating that they can just tolerate the maximum summer temperature. However, for some fish, such as the tomcod, it is too hot, and they must seek cooler waters (for example, head towards the ocean). The maximum temperature for the outfall can be 100°F, which is 37.8°C. As can be seen from the table below, this is well above the upper temperature that almost all species can tolerate.

Species	Latin Name	Acclimatization temperature °C	Upper tolerance limit °C
Carp	Cyprinus carpio	20	31-34
Large mouth bass	*Micropterus salmoides*	20	32.5
		30	36.4
Blue gill	*Lepomis macrochirus*	15	30.7
3 spined stickleback	*Gasterosteus aculeatus*	25-26	30.6
Yellow perch	*Perca flavescens*	15	27.7
Alewife	*Alosa pseudoharengus*	15	23
Rainbow smelt	*Osmerus mordax*		21
Sea lamprey	*Petromyzon marinus*		34
Tomcod	*Microgadus tomcod* (2 cm)		19-20.9
	(14-15 cm)		23.5-26.1
	(22-29 cm)		25.8-26.1
Common shiner	*Notropis cornutus*	15	30.3
Brown bullhead	*Ictalurus nebulosus*	15	31.8
Striped bass	*Morone saxatilis* - yolk sac		Mortalities start at 26
	- Post yolk sac		Mortalities start at 30
	- Early juveniles		Mortalities start at 34
American shad	*Alosa sapidissima*		28
White perch	*Morone americana*		32-34

Table 11: The upper temperature that a range of Hudson River fish can tolerate – for sources, see text.

When considering the effect of a heated outfall, we must take into account both the temperature and the exposure time. It is quite likely that larger fish will simply avoid entering the warm water plume, and thus will not suffer direct harm. However, these animals will be denied access to warmed areas. The thermal impacts will likely be felt most severely by the eggs and weakly swimming early life stages. Maximum temperatures in the discharge may exceed 35°C. It therefore seems inevitable that the heated discharge will result in the death of, or harm to, any American shad, Atlantic tomcod and river herring early life stages in the region of the discharge.

5.4.2. The influence of the discharge on fish migration.

One of the reasons for the limitation on the cross sectional area and surface width that can be thermally polluted is because of long-held concerns that thermal pollution can interfere with fish migration.

5.4.2.1. The response of fish to temperature

Water has a relatively high thermal capacity, and a fish will gain (or lose) heat quite rapidly by conduction across its entire body surface. Moreover, it must pass this fluid over its gills, in considerable volumes, since the concentration of oxygen in water is comparatively low. Gills are richly supplied with blood and have a substantial surface area to optimize gas exchange. These features also make for efficient heat exchange, and the blood rapidly distributes heat throughout the body (Crawshaw, 1979).

Most organisms can acclimate (i.e. metabolically adjust) to temperatures above or below those to which they are normally subjected. Baldwin and Hochachka (1970) correlated thermal acclimation and the switch to alternative metabolic pathways with changes in the proportions of iso-enzymes. However, as the temperature of the fish rises, coordination in the central nervous system can break down, which eventually manifests itself as "distress" symptoms; ultimately "heat death" will ensue. It was recognised many years ago that various reflexes disappear in a consistent sequence (e.g. Fisher, 1958).

As early as the 1930s, Bull (1936) demonstrated, from a range of marine species covering a number of taxa (not salmonids) and ecotypes, that fish could detect and respond to a temperature front of 0.03 to 0.07°C. Fish will therefore attempt to avoid stressful temperatures by actively seeking water at the preferred temperature, but this becomes increasingly a matter of chance once coordination begins to break down. If an uncoordinated fish is moved to cooler water it may recover, but the chances of recovery decrease with duration of exposure.

At less than stressful levels, increasing temperatures allow increased rates of metabolism, and (notably with regard to migratory activity) increased swimming speeds, but decreased endurance (Turnpenny & Bamber, 1983; Beach, 1984). The temperature at which locomotory activity becomes disorganized, and thus the fish loses its ability to escape from adverse conditions, has been termed the Critical Thermal Maximum (CTM).

Once temperatures exceed 40°C (104°F), heat death ensues: enzymes are inactivated, proteins denature or coagulate and fats melt. The last comprehensive review of this subject, from the molecular to whole organism level, was that of Rose (1967).

The response of fish to temperature is complex. Fish have natural thermal niches (preferenda) and in the temperate zone, freshwater species are either:

cold water species, such as salmon, trout, tomcod & smelt;
cool water species;
warm water species, such as carp;

This categorization tends to fall along taxonomic lines, in that related species and genera have similar thermal niches (Hokanson, 1977).

Superimposed upon this thermal selectivity are temporal variations in preferenda that can be correlated with the age or developmental stage of the fish, its physiological condition, or with various environmental variables. Young fish generally have higher thermal preferences and greater tolerances than do older fish. Feeding activity, reproductive or migratory behaviour and stress (anoxia, turbidity, salinity changes and chemical pollutants) might substantially alter normal thermal responses.

Some species are better than others at adapting their physiology or behaviour: in general, estuarine species are fairly resilient, since they are subject to regular environmental fluctuation.

For any fish there are temperatures that it prefers, temperatures to which it can acclimate, temperatures that it would seek to avoid but at which it can survive for various periods of time, and temperatures that are lethal. Moreover the ability of individuals to survive is not the same as the ability of the species to continue; increased temperatures may advance or delay breeding seasons, encourage breeding in the wrong place, or inhibit fish migration.

5.4.2.2. Temperature and dissolved gases

Indirect effects of temperature on fish include reduced solubility of gases, particularly of oxygen, an effect which can be exacerbated by the elevated temperature simultaneously increasing the rate of oxygen removal by pollutants such as sewage. The sort of temperature elevations that are encountered outside the immediate vicinity of a power station discharge are of between 1° and 3°C, which would decrease the solubility of oxygen by only about 0.5 ppm. Were the water to be 100% saturated with oxygen then this reduction in solubility would lead to outgassing. However most rivers are by no means fully saturated and so this slight decrease in solubility has no effect. On the other hand, the rate at which flowing water absorbs oxygen increases with temperature (Truesdale and Vandyke, 1958) whilst the rate of outgassing is sufficiently slow that any slight supersaturation is redissolved as the temperature decreases through mixing.

As would be predicted, the significant upward trend in temperature of the Hudson River has resulted in a statistically significant downward trend in Dissolved Oxygen (DO) (Figure 18 and Figure 19). The sharp decline in DO in 2004 and 2005 is particularly notable.

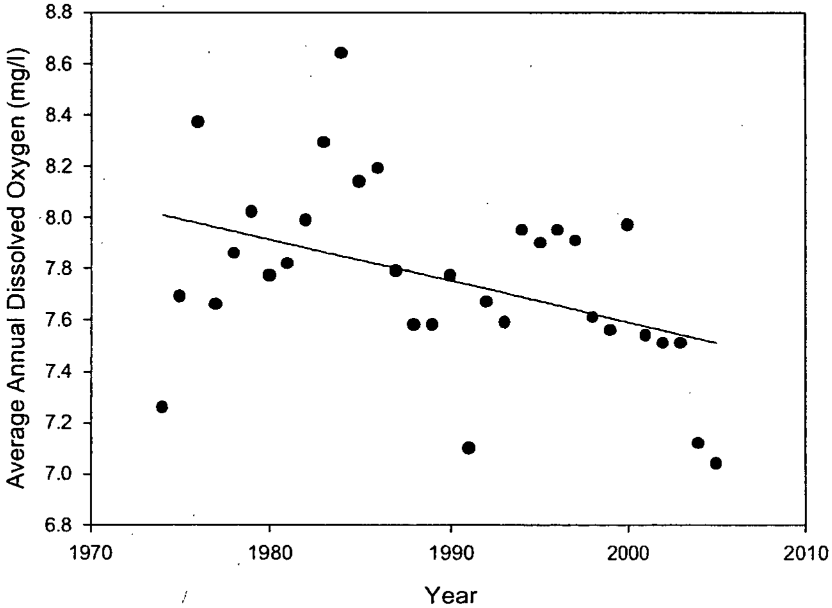

Figure 18: Average annual dissolved oxygen (mg/l) from Long River/Fall Juvenile Surveys, 1974 to 2005 - (a =-0.0161, b = 39.7804, F = 6.4047, p = 0.0169) – Data from 2005 Year Class Report – Appendix B Table B - 14.

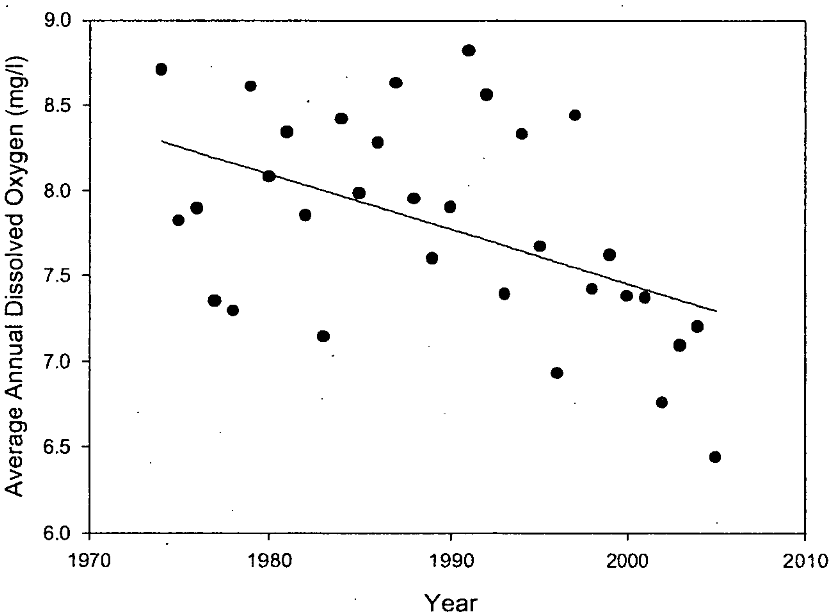

Figure 19: Average annual dissolved oxygen (mg/l) from beach seine surveys, 1974 to 2005 -(a =-0.0322, b = 71., F =9.5142, p = 0.0044) – Data from 2005 Year Class Report – Appendix B Table B - 16.

Given the considerable efforts that have been taken to reduce organic pollution, and the great improvement in water quality in the vicinity of New York City, these declines in DO are disappointing, and potentially important indicators of a decline in water quality for fish.

The distribution of DO within the water column is complex. It can be affected by many factors including tidal flow, riverine metabolism, stratification and atmospheric diffusion. A typical profile of DO versus depth is shown in Figure 20.

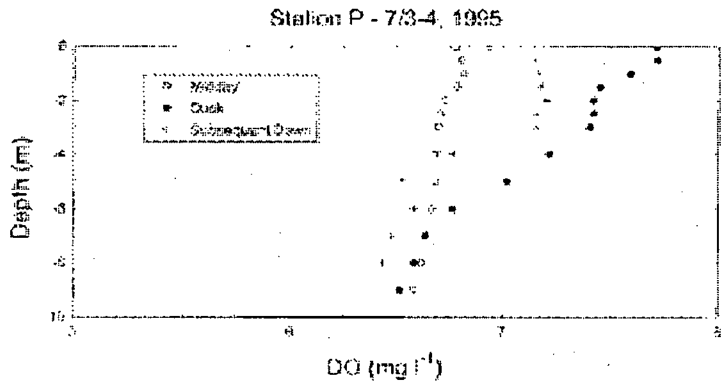

Figure 20: Typical depth profiles of DO measured on 3–4 July 1995 at Haverstraw Bay. Profiles for three sample times are shown for each station. (Swaney *et al* 1999)

This figure shows that the amount of oxygen in the water is often higher at the surface, and is increased during daylight hours as result of oxygen released by photosynthesis. The levels of DO are often reduced overnight as oxygen is metabolised by the organisms in the river.

5.4.2.3. Temperature and migration

Many of the studies of the effects of temperature on migration have been on salmonids, and as such are not relevant to the Hudson. However, shad species which do migrate though the Hudson show similar temperature responses to salmonids. For example the temperature preferences of American shad in Canada are characterised as follows:

> *"The American shad lives for several years at sea before returning to spawn in the stream or river where it hatched. Shad avoid cold temperatures, preferring to stay in water that is 8°C or warmer. Much of their migration and behaviour is determined by water temperature and currents. Each spring, schools of shad, using their sense of smell, begin to migrate up coastal rivers and tributaries when water temperatures reach 12°C. Spawning in the Maritimes occurs during June and July in water temperatures of 13-20°C. Migration stops in temperatures over 20°C."*
> Source http://www.gov.ns.ca/fish/sportfishing/species/shad.shtml

Almost all migratory fish are suspected of using temperature as a trigger to initiate migration. Once migrating, the degree to which they are responsive to temperatures they experience en route is more difficult to determine. However, it is clear that fish such as striped bass are sensitive to water temperature at almost all stages in their life-cycle, including both up-stream and down-stream migrants.

5.5. Heat Shock

Thermal issues are likely to become ever more important over the coming years as we are clearly following a warming trend in river temperature (see Figure 15). It is therefore complacent of Entergy to state on p 4-24:

> *"Entergy concludes that continued operation in the manner required by the current SPDES permit and the associated agreement to continue implementation of the fourth Consent Decree ensures that thermal impacts will satisfy the requirements of CWA 316(a) and will thus remain SMALL during the license renewal term."*

It is appropriate for Entergy, when considering the future, to model scenarios with higher river temperatures than those observed in the recent past or even the present. We have not been presented with an analysis sufficient to prove that future thermal impacts will be small.

5.6. Thermal issues - Conclusions

The cooling water discharge is large and affects the receiving waters of the Hudson River. In recent years (2000 to 2007), the discharge temperature regularly exceeded 90°F and in summer frequently exceeded 100°F. A temperature exceeding 100°F will produce lethal conditions for aquatic life of all kinds, including algae, crustaceans and fish.

Indian Point's thermal discharge does not meet applicable thermal criteria. Furthermore, there is no mixing zone definition for Indian Point generating station discharges. The plume can spreads over a large proportion of the river.

There is an upward trend in the background temperature of the river, and a corresponding trend down in dissolved oxygen. This will result in increased harm from thermal pollution, if present levels of heat discharge continue into the future. Absolute temperatures of riverine heated effluents of 26°C (78°F) or more are potentially lethal to smelt and tomcod. The spatial and vertical extent of the Indian Point plume is sufficient to raise concerns about the passage of fish and impacts on the benthic life of the river.

Fish can perceive small differences in temperature, and show behavioural avoidance of even mildly stressful temperatures. However there are no data on the movement or migration of fish in the vicinity of the Indian Point plume. It is therefore not possible to quantify the effect of this discharge on fish movement or passage.

The changes in the flora and fauna of the Estuary indicate that it would be unwise to allow the statutory temperature limits to be exceeded.

Closed-cycle cooling, required under the draft SPDES permit for Indian Point. Under the closed-cycle cooling alternative, the amount of heat injected into the river would be greatly reduced, and thermal impacts would be confined to the discharge canal. Thus, closed-cycle cooling would likely eliminate thermal pollution concerns at Indian Point. We know of no alternative technology(s) that will result in equivalent protection for aquatic resources to the level which can be achieved by closed cycle cooling.

6. Critique of Entergy analysis given in Indian Point Energy Center Applicant's Environmental Report Operating License Renewal Stage

We discuss below the sections of the Environmental Report relevant to aquatic ecology.

6.1. Section 2.2 - Aquatic and Riparian Communities

This section starts with a standard description of the general physical environment. There can be no doubt that temperature issues (page 2-6) are becoming more important because of climate change. It was therefore notable that the report quotes average water temperatures between 1951 and 1997. This part of the report is therefore 10 years out of date. Further, there is no consideration at all of temperature trends over the last 50 years. Trends become important when considering the future impacts of the thermal plume. It is legitimate to ask how much higher the background temperature of the river is likely to get over the next 10 to 15 years and what effect this could have on the temperature of the plume.

In the section 2.2.2 - Plankton Communities, it is again apparent how out of date this document is. In the final paragraph of page 2-10 Entergy quote work on the phytoplanktonic species present in 1972. Given the large-scale changes in water quality since this time, such data cannot be considered reliable. As a general point, this document both relies on old data and notes the considerable changes that have occurred. The switch from using old data to stating that the system is under rapid change is not justified in the text. The viewpoint is picked for convenience to support their argument.

In the paragraph which follows, at the top of page 2-11, a reference is made to the 1972 FES. What is so striking is the complete lack of reference to the far more recent FEIS.

6.2. Section 2.2.3 - Macroinvertebrate Communities

Page 2-12 states:

> *"Recent studies have shown that the zebra mussel invasion is associated with a decline in open-water shad and herring (pelagic particle feeders), while the littoral fish such as sunfish (benthic feeders) have prospered [IES]."*

This type of statement is a standard way of asserting that declines in species are due to agents other than the power plants. It is an assertion without any underlying empirical or theoretical support.

There is another point of importance here. The zebra mussel is a filter feeder and is well know to radically change the ecosystems it invades. One of the first impacts is on the phytoplankton (which it consumes) and the zooplankton, which it affects by competing for their food. We therefore find here one of the classic inconsistencies that runs through this document, in that it quotes and uses data on the phytoplankton from the 1970s but notes that there have been major changes in the macro-invertebrates which feed on these phytoplankton. It is self-evident that if the zebra mussel has become abundant, then the phyto- and zooplankton must have changed. There are in fact studies which state exactly this. Below is an account of the recent changes linked to zebra mussel. The important point to note is that zebra mussels have changed the system, and data pre-1992 are now of historical interest only.

6.2.1. The arrival of the Zebra mussel

Prior to 1992, the nutrient-rich Hudson River estuary supported abundant phytoplankton populations that constituted a ready food supply for large populations of freshwater zooplankton, including rotifers, cladocerans, and copepods, on a seasonal basis. The introduction and population explosion of zebra mussel (*Dreissena polymorpha*) has depleted the standing stock of phytoplankton and has impacted other components of the food chain. Benthic invertebrates are relatively abundant but the species diversity is low, primarily oligochaetes and chironomids.

In 1986, the Zebra mussel, an inhabitant of fresh and brackish Eurasian waters, arrived via the Great Lakes in the ballast water of ships. First seen in the Hudson at Catskill in May 1991, Zebra mussels now inhabit the Mohawk River and the Hudson River from Albany to Haverstraw Bay. Within little more than a year of their arrival the biomass of the mussels was greater than that of all other heterotrophic animals in the Hudson, and reached an estimated 550 billion individuals, at an average density of 4,000 / m^2 over the freshwater tidal river. A secondary estimate was that, as filter feeders, the mussel population could filter the entire volume of the freshwater Hudson in 1 to 3 days. Their presence poses a number of very considerable threats to the ecosystem of the Hudson:

- Zebra mussels tend to colonize on rocky substrates in shoal areas, replacing or smothering any existing community that is in these habitats. Taxa of particular concern include Unionid and Sphaeriid clams. They also out-compete native mussel species for food and space, leading to a decline in native mussel populations.
- Phytoplankton and detritus are major food sources for lake and river food webs. Excessive removal of the phytoplankton by zebra mussels reduces the zooplankton species that feed upon them and can result in fisheries-related impacts.
- Mussels can filter large amounts of water and reduce the available food in the water column. Their filtering activity increases water clarity and hence light penetration. This, too, can dramatically change the benthic community structure.
- Zebra mussels cause significant biofouling in water intakes. This requires higher levels of biocide to combat the problem and this could lead to secondary effects in relation to the biocide chemical being released in to the environment.

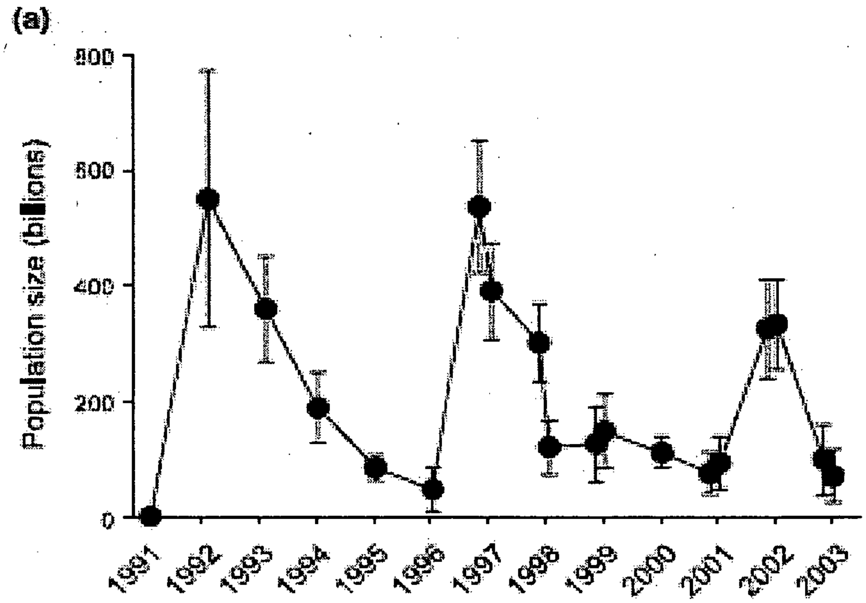

Figure 21: The estimated population of Zebra mussels in the Hudson (from Strayer and Malcom 2006).

Given their considerable numbers and their ecological effects, (lakes and rivers colonized by the mussels often see 50-75% declines in phytoplankton and small zooplankton biomass, rise in water clarity of 50-100%, drop of more than 50% in filter-feeding zooplankton and native bivalves, and increase in macrophyte beds and animals associated with mussels), it is inevitable that their presence will have a profound effect on the food web of the Hudson. This is illustrated in Figures 21a and 21b below (from Pisces Conservation, 2003), which represent a very simplified Hudson river food web, before and after the introduction of Zebra mussels. In Figure 21b, elements of the food web increased by the changes are shown in shades of magenta; and elements suffering a decrease in abundance or strength by shades of light blue.

Long-term reduction of zebra mussels by natural predators has yet to be demonstrated, but at least 17 species of North American fish have been documented to consume attached zebra mussels and quagga mussels (*Dreissena bugenis*). Additional species are likely to consume zebra mussels (particularly fish in the sturgeon, sucker, and catfish families), but cases remain undocumented. Although numerous and widespread, the efficacy of molluscivorous fish as a control mechanism for zebra mussels is unclear. However, zebra mussels are more susceptible to fish predation than native unionids or *Corbicula* spp. because *Dreissena* shells are weaker, adults are smaller in size, and most individuals are exposed to predators. (Kirk, *et al*, 2001).

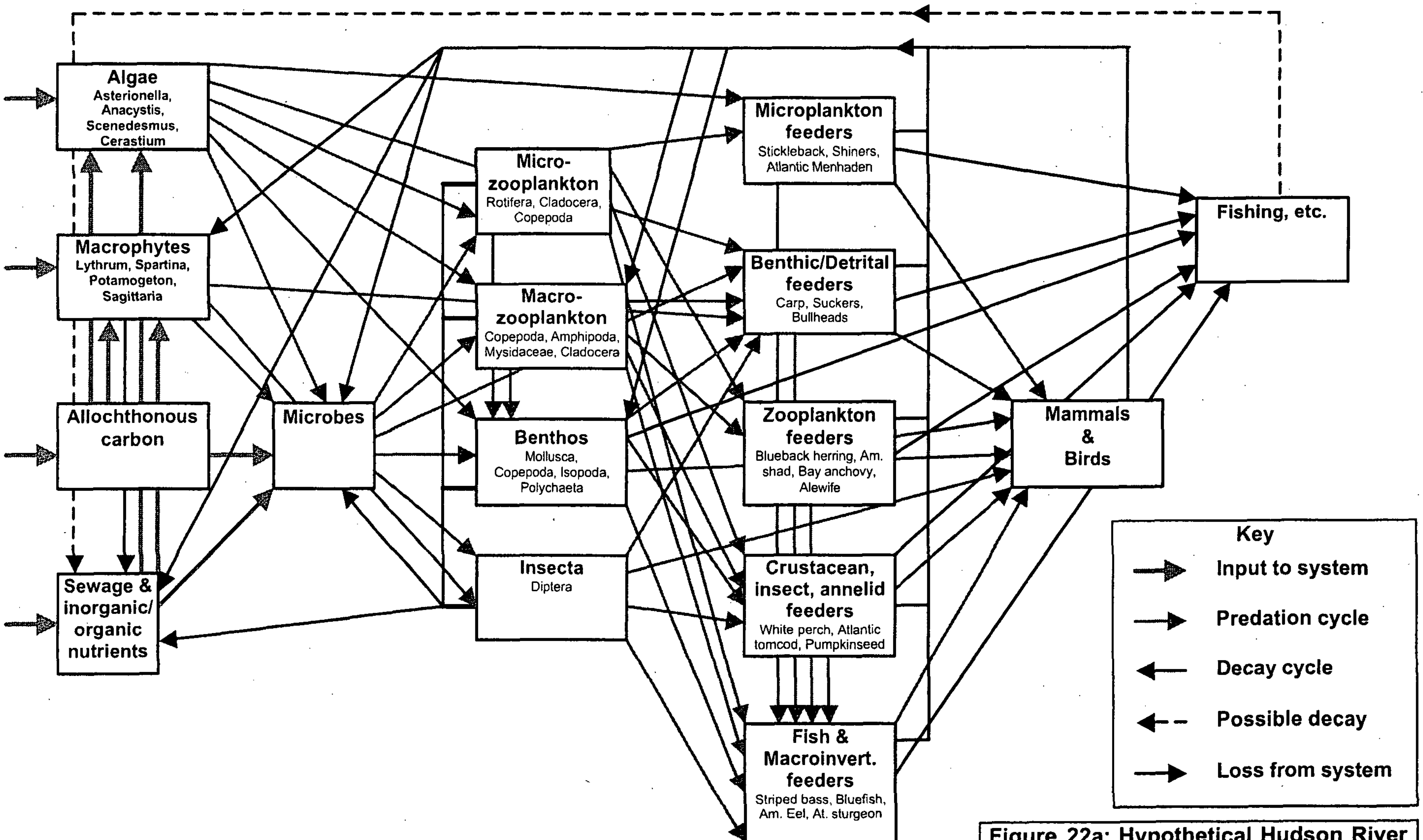

Figure 22a: Hypothetical Hudson River food chain, prior to invasion by Zebra mussel

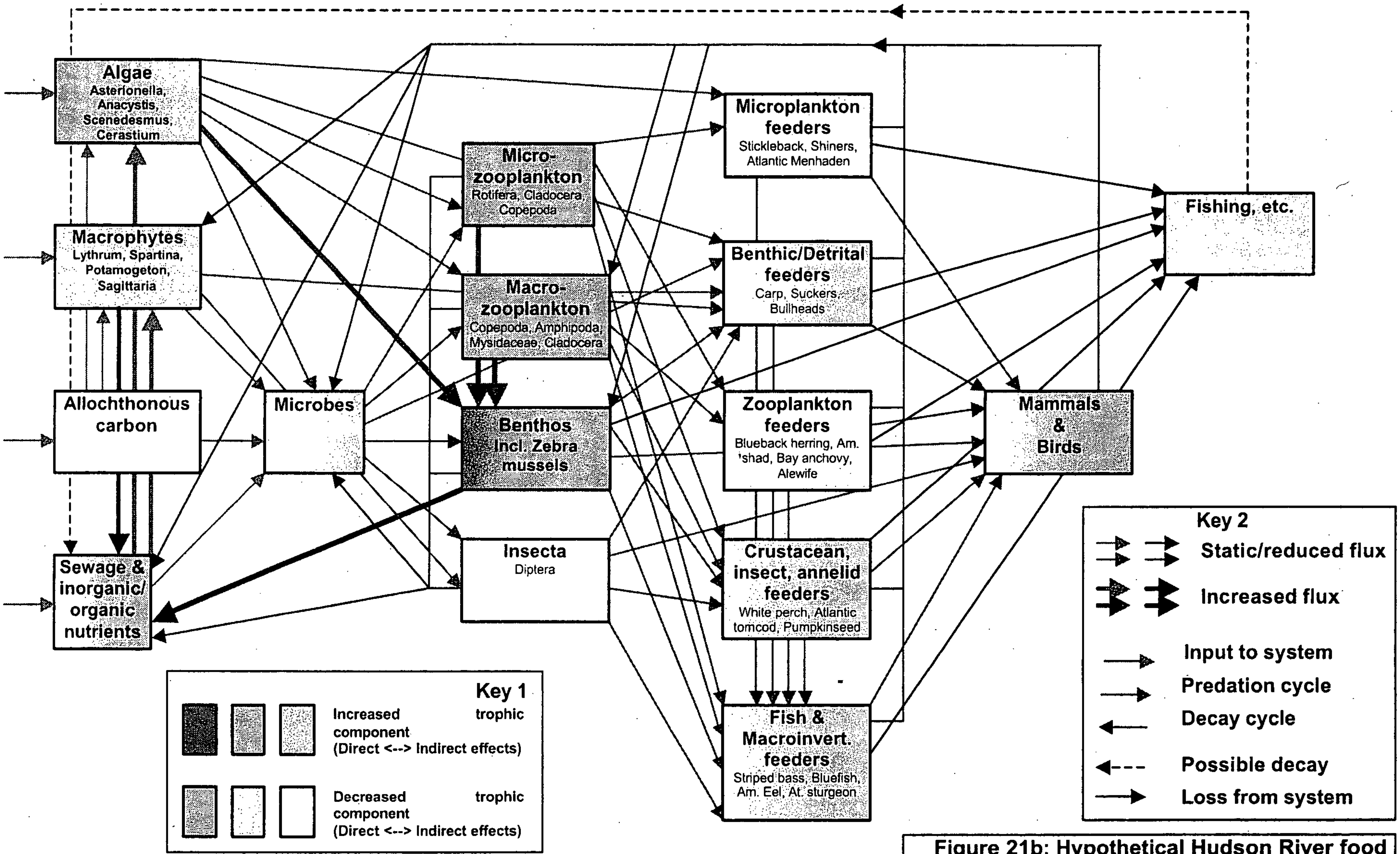

Figure 21b: Hypothetical Hudson River food chain, after invasion by Zebra mussel

6.3. Section 2.2.5 Fish Communities

This section is misleading. There is continued reference to the DEIS, and not the FEIS, and furthermore, there is almost no reference to data collected after 1997. This use of data more than 10 years old is unacceptable when more recent data have been collected and circulated.

For example, p 2-15 states: "*The DEIS emphasized an examination of long-term trends (1974-1997) primarily for the following two life stages of fish representative of impingement (YOY) and entrainment (PYSL).*"

There is an attempt to mislead on the health of fish populations. Yet again this is based on old data and carefully crafted statements. In fact, many species have been in decline. An example of a serious decline is Atlantic tomcod – there are many other species that have also declined. Below is a graph for tomcod abundance.

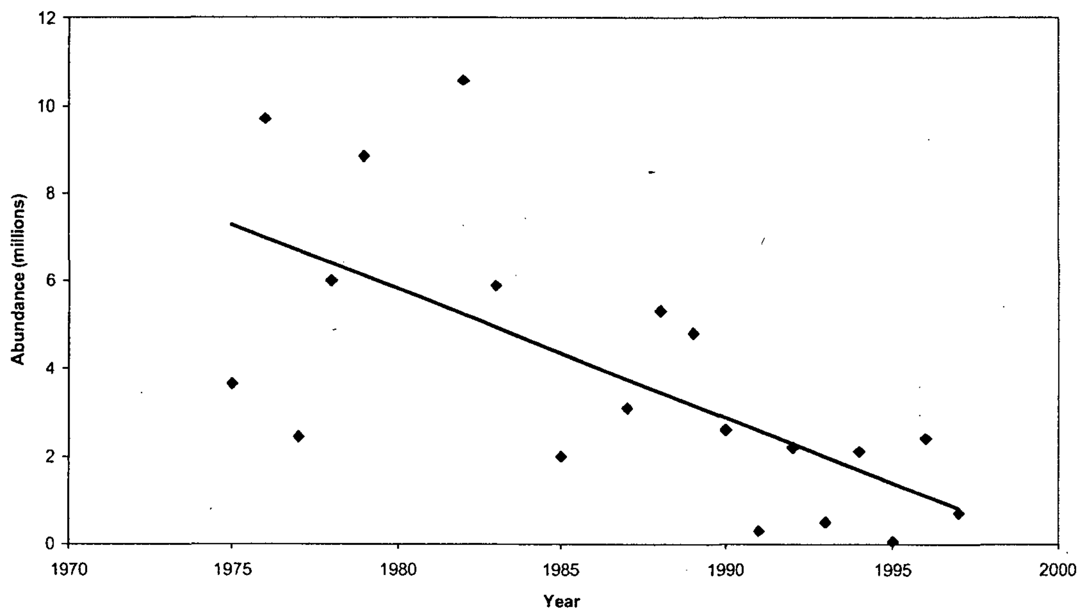

Figure 23: The change in estimated abundance of Atlantic tomcod at age 1. A linear regression has been fitted to the data to show the trend of declining number.

An example of a misleading statement of this type is on p 2-16:

> "*During the 24-year monitoring period from 1974 to 1997, species richness and overall abundance of PYSL increased in most areas of the estuary. Analysis of the long-term trends in the larval fish community in both the marine brackish regions and the freshwater zone revealed an overall increase in the total number of taxa collected. Increases in overall abundance were due to increases in the abundance of larval striped bass in all areas of the estuary and increases in the abundance of larval bay anchovy in brackish areas. [CHGEC, Section V.D.3.i]*"

When more recent work is quoted, no specifics are given, but rather general, misleading and inaccurate statements are made. For example at the bottom of 2-16:

> *"The recent 2004 annual year class report continues to confirm that the conclusions developed in the DEIS are still relevant and supported [ASA]."*

This statement is gives the reader the impression that the DEIS assertion that populations are healthy and flourishing is supported by recent studies. The opposite is in fact the case.

The fish community of the Hudson Estuary has been continuously changing since systematic recording began in the 1980s. There are clear indications both at the community and individual population level that the populations of fish in the estuary are becoming less stable and showing greater year to year variation in abundance. In the report on the status of fish population in the Hudson (Pisces Conservation 2007), of the 13 key species subject to intensive study, three species, striped bass, blue fish and spottail shiner have shown a trend of increasing abundance since the 1980s. The other 10 species have declined in abundance, some greatly. Apart from the species that have been intensively studied in the estuary many other important species of fish are also showing long-term declines in abundance. For example, the American eel has greatly declined.

There has been a recent increase in average water temperature and a decrease in dissolved oxygen levels. This may be influencing some of the changes observed, and will increase the impact of thermal discharges. All the evidence points to the Hudson ecosystem presently being in a state of change, with declining stability. Neither the ecosystem as a whole, nor many of the individual species populations, are in a healthy state.

6.4. Section 4.1 - Water Use Conflicts

When considering entrainment there is clearly an attempt to justify once through cooling. On p 4-13 appears a typical statement:

> *"The results of the studies performed from 1974 to 1997, the period of time covered in the DEIS, are referenced and summarized in the DEIS, and have not shown any negative trend in overall aquatic river species populations attributable to plant operations."*

The important point to note is the phrase "*attributable to plant operations*". There have been many negative trends in aquatic life, but rather than address these issues, they avoid them by simply claiming they are not attributable to the plant. It is clear that species losses are multi-factorial. If more are killed than are produced, then the population of an animal will decline. When this happens, every unnatural activity that is contributing to the mortality must take on some of the responsibility. Further, those that kill the most must take on more of the responsibility. Indian Point kills members of the species that are in decline so it must bear some guilt; since it kills more than most other agents, it must bear a high proportion of the guilt and the responsibility for remedial action.

Exactly the same approach is taken with respect to impingement. On p 4-19 it is stated:

"Therefore, withdrawal of water from the Hudson River for the purposes of once-through cooling at the site does not have any demonstrable negative effect on representative Hudson River fish populations, nor does it warrant further mitigation measures."

This is an extraordinary statement, and contradicts the conclusions of the FEIS that the system and many of its fish are in serious trouble. Species such as the American shad are demonstrably in decline. These declines are clearly because the fish have been unable to produce sufficient young to replace the dying adults. It is known that fish are killed by Indian Point, yet the declines are held to be nothing to do with the station.

7. Discussion

Indian Point has the largest water intakes and discharges on the Hudson. It is known that it killed billions of fish by entrainment and hundreds of thousands by impingement when these were last measured in the 1980s. Since then the ecology of the Estuary has altered, with many species showing large changes in abundance.

Quantifying the impact of entrainment and impingement at Indian Point by simply looking at the numbers of fish killed is not fully quantifying the effect. NYSDEC's position in the FEIS is that the fish kills at a power plant cannot be compared to selective cropping (i.e. removal by fishing or hunting). Instead of one or two species being affected, the entire community is impacted. Indeed, even the thermal impact can be considered in this way. NYSDEC state:

> *These "once-through cooling" power plants do not selectively harvest individual species. Rather, impingement and entrainment and warming of the water impact the entire community of organisms that inhabit the water column.*
>
> *For example, these impacts diminish a portion of the forage base for each species that consumes plankton (drifting organisms in the water column) or nekton (mobile organisms swimming through the water column) so there is less food available for the survivors. In an intact ecosystem, these organisms serve as compact packets of nutrients and energy, with each trophic (food chain) level serving to capture a diffuse resource and make it more concentrated. Ichthyoplankton (fish eggs, larvae and very small fish which drift in the water column) and small fish feed on a base of zooplankton (drifting animal life) and phytoplankton (drifting plant life). The loss of these small organisms in the natural community may be a factor that leads to harmful algal blooms. The small fish themselves serve as forage for the young of larger species, which serve as forage for larger individuals, and so on up the food chain, more correctly understood as a "trophic pyramid".*
>
> *Once-through cooling mortality "short-circuits" the trophic pyramid and compromises the health of the natural community. For example, while an individual bay anchovy might ordinarily serve as food for a juvenile striped bass or even for a common tern, entrainment and passage through a power plant's cooling system would render it useful only as food to lower trophic level organisms. It could no longer provide its other ecosystem functions of consuming phytoplankton, digesting and concentrating it into its tissues, and ranging over a wide area,*

> *distributing other nutrients as manure. This is just a single example from a very complex natural system, where the same basic impact is multiplied millions of times over more than one hundred fish species.* (FEIS page 53-54.)

When considering all aspects of the impact of Indian Point on the aquatic ecology of the Hudson estuary, the reliance by Entergy on old data in their recent reports results in an inadequate quantification of the impact that Indian Point currently has on the aquatic environment. Further, the use of such old analyses to project into the future would be a serious error.

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Mendiola, Doris

Subject: FW: Riverkeeper Comments on Revised GEIS for NPP License Renewal, RIN3150-AI42 - E-mail 4

Attachments: 2010.01.12.Exhibit C to Riverkeeper's Comments on Revised License Renewal GEIS, RIN3150-AI42 - RK Envtl. Scoping Comments.pdf

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From: Deborah Brancato [mailto:DBrancato@riverkeeper.org]
Sent: Wednesday, January 13, 2010 12:00 AM
To: Rulemaking Comments
Subject: RE: Riverkeeper Comments on Revised GEIS for NPP License Renewal, RIN3150-AI42 - E-mail 4

Dear Secretary and Rulemakings and Adjudication Staff,

As indicated, attached please Exhibit C to Riverkeeper, Inc.'s Comments on the NRC's "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 74 Fed. Reg. 38,117, 10 C.F.R. Part 51, RIN 3150-AI42, NRC-2008-0608 (July 31, 2009).

Deborah Brancato
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October 12, 2007

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72 FR 45075
27

Chief, Rules and Directives Branch
Division of Administrative Services
Office of Administration
Mailstop T-6D59
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Re: 72 FR 45075, August 10, 2007 Environmental Scoping Comments for Docket Nos. 50-247, 50-286

Dear Sirs:

I am hereby submitting the attached comments on behalf of Riverkeeper, Inc. in response to the *Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process* filed in the Federal Register on August 10, 2007 regarding the license renewal application for Entergy Nuclear Operations, Inc. Indian Point Nuclear Generating Unit Nos. 2 and 3.

Riverkeeper urges the Nuclear Regulatory Commission (NRC) staff to fully consider the following comments in its preparation of the draft Supplemental Environmental Impact Statement for Indian Point 2 and 3. Riverkeeper's members, local elected officials and the general public continue to have grave concerns regarding the continued operation of this facility, due to the environmental damage caused by its antiquated once-through cooling system and leaking spent fuel pools, the vulnerability of the plant's spent fuel pools to terrorist attack and the failure of the federal government to resolve the question of spent fuel disposal at Yucca Mountain.

Indian Point is a unique plant in a unique location, the most densely populated metropolitan region of the United States. The NRC must make every effort to ensure that the environmental review process for the Indian Point license renewal fully complies with NEPA and affords the public every opportunity to provide well-informed comments at each step in the review. Anything less will further degrade public confidence in the NRC's ability to independently regulate Indian Point's operation.

Riverkeeper looks forward to participating throughout the environmental review process.

Sincerely,

Phillip Musegaas

Phillip Musegaas
Staff Attorney

SUNSI Review Complete
Template = ADM-013

E-RIDS = ADM-03
add = J. Caverly (JSC2)
B. Pham (bmp)

Riverkeeper, Inc.
October 12, 2005

Riverkeeper Comments on Environmental Scoping for the Indian Point License Renewal Proceeding, Docket Nos. 50-247, 50-286

1. **The Nuclear Regulatory Commission (NRC) must include "new and significant information" regarding the environmental impacts of spent fuel storage, potential impacts of a terrorist attack, and use of renewable energy alternatives at Indian Point in its draft Supplemental Environmental Impact Statement (SEIS) for the Indian Point license renewal rather than relying on an outdated Generic Environmental Impact Statement (GEIS) conducted in 1996.**

The GEIS is inadequate if evidence exists of material changes affecting the baseline environment since the GEIS was written.[1] The heightened risk of a terrorist attack on a nuclear plant, especially Indian Point, constitutes a material change affecting an assessment of future environmental impacts during the extended license term. In addition, the failure of the Yucca Mountain repository, the resulting spent fuel disposal crisis, and significant progress in the implementation of renewable energy technologies are all material changes that must be assessed in the NEPA review for Indian Point. The NRC's continued reliance on the 1996 GEIS, coupled with its refusal to consider the aforementioned changes, violates the fundamental requirements of NEPA.

It has been 11 years since the GEIS was written. In that time the United States has experienced the worst terrorist attack on American soil in our history, leading to a heightened risk of a terrorist attack on a nuclear power plant.. In addition, the earliest likely completion date for the Yucca Mountain waste repository has been delayed by two decades, to 2017. The total volume and density of spent fuel stored in Indian Point's spent fuel pools continues to increase as a result. In the past 11 years the amount of spent fuel being stored in the already packed onsite pools has increased. The population around Indian Point power plant has nearly doubled, resulting in significant traffic congestion that would prevent authorities from evacuating the residents living within the ten-mile Emergency Planning Zone (EPZ) in the event of an accident or terrorist attack.

The NRC has failed to update the GEIS within the ten year period prescribed in Appendix B to Subpart A of Part 51. The most recent revised schedule for the issuance of the draft GEIS has been altered since it was proposed in a NRC Policy Issue Information Notice on June 9, 2006. The environmental review process for Indian Point's license renewal should not continue to rely on the GEIS until the NRC has completed the required ten year review and determined whether or not the GEIS will be updated.

[1] Blanco v. Burton, Slip Copy, 2006 WL 2366046 (E.D. La.); League of Wilderness Defenders v. Marquis-Brong, 259 F.Supp.2d 1115 (U.S. Dist. Ct. Or. Apr. 2003).

The NRC published a Notice of Intent to Prepare an Environmental Impact Statement for the License Renewal of Nuclear Power Plants and to Conduct Scoping Process on June 3, 2003.[2] In the Notice, the Commission stated: "[I]n the introductory remarks to Appendix B to Subpart A of Part 51, 'Environmental Effects of Renewing the Operating License of a Nuclear Power Plant,' the Commission stated that, on a 10-year cycle, it intends to review the material in Table B-1 and update it, if necessary."[3] The first 10-year cycle ended in 2006, and contrary to NRC's statements at the four public scoping meetings held in July of 2003 the GEIS Update Project is not close to being complete.

On October 3, 2005 the Commission published a Notice of Extension of the Public Comment Period for Scoping Process to Prepare an EIS for the License Renewal of Nuclear Power Plants[4] which extended the public comment period for the scoping process through December 30, 2005. The NRC's summary of the scoping comments has yet to be published.[5]

On June 9, 2006, in a Policy Issue Information Notice to the Commissioners, Luis A. Reyes laid out the schedule and staff commitments for revising environmental issues to be considered in the license renewal.[6] In the Notice Mr. Reyes stated that the schedule for completion of the GEIS update and the final rulemaking to 10 CFR Part 51 is 34 months from the contract placement. Mr. Reyes laid out the following schedule:

Develop draft GEIS	February 2007
Develop proposed 10 CFR Part 51 rulemaking	August 2007
Commissioner review SECY paper on draft GEIS	November 2007
Issue draft GEIS for comment	January 2008
Address public comments and public meetings	October 2008
Commissioner review SECY on final GEIS	January 2009
Issue final GEIS	February 2009

A. National Environmental Policy Act Requirements

The National Environmental Policy Act, 42 U.S.C § 4321, *et seq.* ("NEPA"), mandates that federal agencies involved in activities that may have a significant impact on the environment must complete a detailed statement of the environmental impacts and project alternatives. NEPA provides, in pertinent part, as follows:

The Congress authorizes and directs that, to the fullest extent possible . . .

[2] 68 FR 33209-01
[3] 10 CFR App. B to Subpart A.
[4] 70 FR 57628-01
[5] September 18, 2007 Phone Conversation between Jennifer Davis, Environmental Project Manager in the Division of License Renewal for the U.S. Nuclear Regulatory Commission, and Marie Quintin, Legal Intern for Riverkeeper, regarding current status of GEIS for the license renewal of nuclear power plants.
[6] SECY-06-0134

> (2) all agencies of the Federal Government shall -- ...
>
> (C) include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on --
>
> (i) the environmental impact of the proposed action,
>
> (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
>
> (iii) alternatives to the proposed action,
>
> (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
>
> (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.[7]

NEPA directs that federal agencies, such as the NRC, must study certain issues and that the reviewing agency must take a "hard look" at these issues, but does not direct what result an agency must reach. Federal appellate courts have made it clear that NEPA is an important federal law and compliance is mandatory. "NEPA was created to ensure that agencies will base decisions on detailed information regarding significant environmental impacts and that information will be available to a wide variety of concerned public and private actors. *Morongo Band of Mission Indians v. Federal Aviation Administration,* 161 F.3d 569, 575 (9th Cir. 1998)" (quoted in *Mississippi River Basin Alliance v. Westphal,* 230 F.3d 170, 175 (5th Cir. 2000)).

Thus, the fundamental goal of an evaluation under NEPA is to require responsible government agencies involved with a given project to undertake a careful and thorough analysis of the need for that project and its impacts before committing to proceed with the project. As the Tenth Circuit has held:

> The purpose of NEPA is to require agencies to consider environmentally significant aspects of a proposed action, and, in so doing, let the public know that the agency's decisionmaking process includes environmental concerns. *Baltimore Gas & Elec. Co. v. Natural Resources Defense Council,* 462 U.S. 87, 97, 76 L. Ed. 2d 437, 103 S. Ct. 2246 (1983); *Sierra Club v. United States Dep't of Energy*, 287 F.3d 1256, 1262 (10th Cir. 2002).

[7] 42 U.S.C. § 4332.

Utahns For Better Transportation v. United States Dept. of Transp., 305 F.3d 1152, 1162 (10th Cir. 2002).

As the District of Columbia Circuit has held:

"NEPA was intended to ensure that decisions about federal actions would be made only after responsible decision-makers had fully adverted to the environmental consequences of the actions, and had decided that the public benefits flowing from the actions outweighed their environmental costs." *Jones v. District of Columbia Redevelopment Land Agency*, 162 U.S. App. D.C. 366, 499 F.2d 502, 512 (D.C. Cir. 1974). . . .

Illinois Commerce Com. v. Interstate Commerce Com., 848 F.2d 1246, 1259 (D.C. Cir. 1988).

It is not only the government decision-makers who are to be served by an EIS, but the citizens of this nation as well. As one court noted: "The purpose of an EIS is to 'compel the decision-maker to give serious weight to environmental factors' in making choices, *and to enable the public to* 'understand and consider meaningfully the factors involved.' *County of Suffolk [v. Secretary of Interior]*, 562 F.2d at 1375 (*citing Sierra Club v. Morton*, 510 F.2d 813, 819 (5th Cir. 1975))." *Town of Huntington v. Marsh*, 859 F.2d 1134, 1141 (2d Cir. 1988)(emphasis added.)

Environmental analysis does not necessarily end with the production of a legally compliant EIS. The agency must prepare a SEIS if "[t]here are significant new circumstances or information relevant to the environmental concerns that bear on the proposed action or its impacts."[8] Agencies are advised to reexamine the original EIS every five years to determine whether a SEIS is needed. [9]

B. Potential Impacts of a Terrorist Attack or Accident

Nuclear power plants remain high level terrorist targets; therefore the potential environmental impacts of a terrorist attack must be assessed by NRC in the draft EIS. The 9/11 Commission Report stated that Al Qaeda considered targeting nuclear power plants in their attack, but wrongly believed the plants were heavily defended. The Report also makes clear that on 9/11, American Airlines Flight 11 flew down the Hudson River passing the Indian Point power plant en route to the World Trade Center.[10] Despite this "new and significant" information the NRC has consistently refused to revise its security requirements to require plant security forces to be able to defend against an air attack, or even the number of attackers that participated in 9/11.

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[8] 40 C.F.R. § 1502.9(c)(1)(ii).

[9] Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, 46 FR 18036.

[10] National Commission on Terrorist Attacks Upon the United States ("9/11 Commission"), July 22, 2004, *available at* http://www.9-11commission.gov/report/911Report.pdf, (last accessed October 10, 2007).

NRC must assess changes in population density and traffic patterns in the draft EIS in the context of assessing the environmental impacts of an accident or attack on Indian Point that results in a radiological release. Clearly the environmental impacts on public health will be far greater if the population within the 10-mile emergency planning zone cannot be evacuated in a timely manner.

Indian Point is a prime example of a plant sited in an area which has undergone tremendous population growth and development over the last thirty years since Indian Point began operating. This increase in population density must be taken into account during the license renewal process. Roads and bridges would not be able to handle the amount of traffic leaving the 10-mile radius and beyond in the event of an accident or attack.[11]

The radiological emergency plan for Indian Point is badly flawed, unworkable and key components are unfixable, according to an independent analysis of Indian Point's emergency plans commissioned by former New York Governor George Pataki in 2003.The author of the report, former FEMA director James Lee Witt found "...the current radiological response system and capabilities are not adequate to ... protect the people from an unacceptable dose of radiation in the event of a release from Indian Point..."[12]

In 2003 KLD Associates conducted a traffic study for Entergy and determined that evacuation times for the Emergency Planning Zone around Indian Point doubled since

[11] *See Lawmakers Urge FEMA to Reject Recertification of Indian Point Evacuation Plans* (Mid-Hudson News Network broadcast Jan. 28, 2006)(describing the emergency preparedness at Indian Point completed by former FEMA Director James Lee Witt in 2003 which uncovered deficiencies, including traffic-related challenges that would likely result during an evacuation in light of recent wind storms which seriously impeded travel flow throughout the area when one major artery was compromised, causing congestion on roadways miles away.); Press Release, Congresswoman Lowey, *Lowey Urges FEMA to Reject Recertification of Indian Point Evacuation Plans* (Jan. 27, 2006) (on file with author)(calling on the FEMA to refuse to recertify Indian Point evacuation plans, which have already been rejected by Westchester, Rockland, and Orange Counties. "Even in the best of circumstances, an orderly and safe evacuation of the area in the event of an accident or, worse, a terrorist attack, is impossible. The recent storms in the area, which blocked some roads and rendered some alert sirens inoperable, demonstrate this."); Report by the NY Public Service Commission, *January 2006 Windstorm Report on Con Edison and NYSEG Electric Restoration and Communication Efforts* (June 2006)(describing the state utilities' response to the January 2006 windstorm that knocked out power residential homes and businesses throughout the County were severely affected, access to roadways was blocked due to fallen trees, making it difficult of emergency responders and utility crews to work. There were 34 major roadways blocked by downed wires and fallen trees creating hazardous conditions that made driving impossible. Over 132,000 people were affected, almost all in Westchester County; *and* Randi Weiner & Steve Lieberman, *Multiple Accidents Close Tappan Zee, Snarl Traffic for Hours*, THE JOURNAL NEWS, July 28, 2007 (reporting two accidents yesterday - one on each side of the Tappan Zee Bridge -and a raft of fender-benders that blocked breakdown lanes and hindered commuters. Police had to close the bridge to allow emergency vehicles to get by, police said. Though both accidents on the bridge were cleared by 4 p.m., Rockland-bound traffic didn't recover from the delays that impinged on the weekend rush hour, stalling traffic across I-287 for hours.).

[12] *Review of Emergency Preparedness of Areas Adjacent to Indian Point and Millstone*, p. viii, James Lee Witt Associates, 2003.

1994. The original estimate was 2.5 hours for people to proceed with evacuation, with a total of 5.5 hours for complete evacuation. KLD estimates increased mobilization time to four hours, while complete evacuation of the region in good weather conditions could take up to 9.5 hours and in snow conditions up to 12 hours.[13] Shadow evacuation would increase this time.

Over twenty years ago, one of your own directors found the placement of Indian Point absurd. In 1979, Robert Ryan, the NRC's Director of the Office of State programs, stated, "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 . . . [Indian Point is] one of the most inappropriate sites in existence."[14] This was before an increase in population around Indian Point and before the terrorist attacks of September 11, 2001.

Were Entergy applying for a license to build a new nuclear power plant where Indian Point is now located, it is unlikely they would be allowed to do so, based on its proximity to such a highly populated area.[15] In fact in the evaluation factors for stationary power reactor site applications *before January 1997* the regulations state that residence within the exclusion area shall normally be prohibited.[16] In exclusion areas with residents, the regulations recommend low population zones - the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident.[17] The regulations state where very large cities are involved, the regulations find that a greater distance may be necessary because of total integrated population dose consideration.[18]

The regulations for reactors built *after 1997* require that every site must have an exclusion area *and* a low population zone.[19] These regulations define low population zone as "the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident."[20] There are 300,000 people living within the ten-mile EPZ of Indian point and the only means of evacuation are primarily one and two lane roads. The regulations do not specify a permissible population density or total population within this zone because the situation may vary from case to case.[21] The regulations go on to say whether a specific number of people can, for example, be evacuated from a specific area, or instructed to take shelter, on a timely basis will depend on many factors such as location, number and size of highways, scope and extent of advance planning, and actual

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[13] *Indian Point Energy Center Evacuation Time Estimate,* Tbl. 1-1, p. 1-12, KLD Associates, Inc., 2003.
[14] *Report of the Office of the Chief Counsel on Emergency Preparedness to the President's Commission on the Accident at Three Mile Island,* October 31, 1979, p. 5.
[15] *See* 10 CFR Pts. 100.3, 100.10(b), 100.11, & 100.21(h).
[16] 10 CFR 100.3.
[17] 10 CFR 100.10(b).
[18] *Id.*
[19] 10 CFR 100.21(h).
[20] 10 CFR 50.2.
[21] *Id.*

distribution of residents within the area.[22] As far as Indian Point is concerned, there is no low population zone, therefore if Entergy were applying to build a new nuclear power plant as opposed to a relicensing it would likely not be permitted.

C. The Long-term Storage of Spent Fuel

Exempting the issue of spent fuel storage from consideration during the license renewal process is completely unreasonable, considering the significant safety, security, and disposal concerns at issue.

i. Failure of Yucca Mountain Repository

Given the continued failure of the federal government to establish a long term repository for nuclear waste at Yucca Mountain, the safety, security, and environmental issues arising from storing spent nuclear fuel should be addressed during the license renewal process, when other aspects of the plant's extended operation are being reviewed. Alternatively, even if Yucca Mountain is eventually approved and put into use, there is only enough space in the repository to store spent fuel produced by all nuclear plants in the U.S. until 2011. At that point the repository will reach its capacity.[23] As a result, all the spent fuel produced during the additional twenty-year life span of a relicensed plant will have to be stored onsite, or in a second, as yet unnamed repository that is potentially decades away from approval.

Although interim storage is ongoing at reactor sites, it is not a means of permanent disposition of spent fuel. Indeed, spent fuel was never intended to be stored permanently at these sites. The federal Department of Energy (DOE) was required by the Nuclear Waste Policy Act to begin taking ownership of spent nuclear fuel from nuclear plant sites starting in January 1998. At present, the best guess for Yucca Mountain's opening is 2017. DOE has yet to submit its license application for Yucca Mountain to the NRC for approval, a proceeding which will undoubtedly result in protracted litigation and opposition from the state of Nevada, public stakeholder groups and additional states through which the waste would be transported on its way to Yucca Mountain.

Under current Yucca Mountain planning, it will take decades to move spent nuclear fuel off of existing plant sites in large quantities. For example, if Yucca opens on schedule in 2017, and if Yucca's statutory limit of 70,000 tons were increased, and if roughly 3,000 metric tons of spent nuclear fuel (SNF) and high-level waste (HLW) are transported there each year then shipments from existing plants would continue until 2054. Consequently, regardless of whether Yucca Mountain opens on schedule or is delayed, interim storage of spent nuclear fuel either at reactors or at one or more consolidated sites will be necessary for at least the next 40 years. Moreover, it is important to note that no

[22] *Id.*

[23] App. A, Tbl. A-7, Vol. II, *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, February, 2002.

consolidated storage facility can eliminate the need for spent nuclear fuel storage at reactor sites.[24]

The potential environmental impacts of storing spent fuel onsite for an additional twenty years are also off the table during relicensing, due to the NRC's "Finding of No Significant Environmental Impact" (FONSI) that applies to all currently licensed ISFSIs. (See 10 CFR §51.23(a)) The FONSI can be extended by the NRC for up to 30 years beyond the licensed term of an operating plant, including the twenty-year renewal term. This means that the NRC has the discretion to independently regulate the storage of spent fuel for fifty years after the renewal of an operating license.

ii. Inventory and Storage of Spent Fuel at Indian Point

The reactors of Indian Point 2 & 3 each contain 200 fuel assemblies when they are in operation. The current refueling/fuel outage cycle is every two years on a rotational basis, meaning that once a year, one of the reactors is refueled. In a typical refueling, about eighty assemblies, or forty percent of the total needed to power the reactor, are removed and replaced. Each year, then, about 80 assemblies are moved into the spent fuel pools. This equals about 55 tons of spent fuel generated each year that the plant operates.[25]

Based on these figures, Indian Point will generate an additional 440 tons of spent nuclear fuel by the time the license for Indian Point 2 expires in 2013. We can assume that Indian Point 3 will probably require another refueling in the two years remaining on its license period, accounting for another 55 tons of spent fuel. In total, Indian Point will have accumulated over 2,000 tons of high level radioactive waste onsite under the current licenses for Indian Point 2 & 3. Twenty more years of operation will add an additional 1,000 tons of spent fuel to the mix. Indian Point has already exceeded its allotted capacity at Yucca Mountain, years before the repository is likely to open. In fact, only 60-70% of the total amount of SNF generated at Indian Point during the initial licensing

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[24] *See* John Ahearne et al., The Nuclear Energy Study Group of the American Physical Society: Consolidated Interim Storage of Commercial Spent Nuclear Fuel: A Technical and Programmatic Assessment, February 2007, *available at* http://www.aps.org/policy/reports/popa-reports/upload/Energy-2007-Report-InterimStorage.pdf.

[25] Memorandum from Phillip Musegaas, Policy Analyst for Riverkeeper, to Alex Matthiessen, Executive Director, Riverkeeper, re: August 23, 2005 Phone Conversation between Jim Steets, Communications Director for Entergy Nuclear Northeast, and Phillip Musegaas, Policy Analyst for Riverkeeper, regarding current inventory of spent nuclear fuel at Indian Point 2 & 3. (Aug. 24, 2005) (on file with author). Jim Steets stated that 160 fuel assemblies from Unit 1 remain onsite in a separate fuel pool, each weighing 1,015 lbs. There are currently approximately 1,000 assemblies of spent fuel stored in each of the fuel pools for units 2 and 3 totaling 2,000 assemblies. Each fuel assembly weighs 1,450 lbs, equal to approximately ¾ ton. Therefore, there are roughly 1,500 tons of spent nuclear fuel accumulated in the two pools. This does not take into account the spent fuel stored onsite from Unit 1, which equals app. 80 tons. *Note* Mr. Steets' quoted weight of 1450 lbs. per fuel assembly was cross checked against the DOE's database on commercial spent fuel, which states that a fuel assembly's total weight is 658 kg, equaling 1450.6 lbs. See *Integrated Data Base Report-1996, U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections and Characteristics, Revision 13, December 1997,* U.S. Department of Energy, Office of Environmental Management, *available at* http://web.em.doe.gov/idb97/contents.html (last accessed August 24, 2005).

period will be shipped to Yucca Mountain, assuming the repository eventually becomes operational. The remaining 30-40% will have to be stored onsite. According to the FEIS prepared by DOE for Yucca Mountain, the repository can only accept 1,283 tons of SNF from Indian Point. At that point, assuming all other plants' shipments follow DOE projections, the repository will have reached its statutorily mandated capacity of 63,000 metric tons of high level waste.[26] It logically follows that all SNF generated from 2005 to 2015, when IP3's current license expires, will have to be stored at the plant, as well as all SNF that will potentially be produced if IP's license is renewed for an additional twenty years by the NRC..

Entergy's plan to begin transferring SNF from the fuel pools to dry cask storage has been plagued with continual delays since Entergy first committed to transferring fuel to dry cask storage in 2004. As of October 2007, Entergy still has not begun the transfer process. In fact, Entergy has not even begun required "dry runs" of the fuel transfer process. Entergy must transfer a certain amount of spent fuel from the IP2 pool before spring 2008, the next refueling outage in order to have enough space to conduct a full-core offload during refueling. It remains unclear whether the NRC will allow Entergy to refuel IP2 in the event the fuel transfer has not begun by that time. In addition, the unlined, leaking IP1 spent fuel pool will remain full until after the transfer of spent fuel from IP2 is complete. The NRC must assess the current and future environmental impacts of the IP1 pool leak, regardless of Entergy's projected plans to empty the pool and alleviate the contamination. It is unreasonable for the NRC to rely on Entergy's dry cask transfer plans until, at a minimum, Entergy begins transferring fuel from the IP2 pool.

As of 2006, site preparation work for a new Independent Spent Fuel Storage Installation (ISFSI) Facility had begun on the north end of the IPEC Site in an area which was previously undeveloped and outside the existing Protected Area. The ISFSI Facility will contain a 96' x 208' concrete storage pad, which will provide storage locations for 78 Holtec International HI-STORM 100S(B) Casks. The HI STORM Casks will be arranged in a 6 x 13 array with 75 storage locations allocated for the casks.[27] These dry casks will be lined up in the open, in plain view from the air and the Hudson River. Clearly, the large accumulation of spent nuclear fuel at Indian Point presents a security and environmental risk to the entire region, even without the specter of another twenty years of operation if the plant is relicensed. This risk, and the potential environmental impacts that could result, must be assessed by the NRC in its SEIS for Indian Point.

iii. NRC must clearly state its position as to the predicted design life span of currently licensed dry casks in use at operating

[26] App. A, Tbl. A-7, Vol. II, *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, February, 2002, available at http://www.ocrwm.doe.gov/documents/feis_2/vol_2/apndx_a/index2_a.htm, (last accessed August 24, 2005).
[27] Environmental Report (ER) at pg. 3-6.

nuclear plants, including Indian Point, and must assess the potential environmental impacts if dry casks remain loaded with spent fuel beyond their design life.

The regulations state that the license term for an Independent Spent Fuel Storage Installations ('ISFSI") must not exceed 20 years from the date of issuance.[28] Despite this limitation, the NRC has concluded that dry cask storage is safe and reliable for up to 100 years.[29] Problems with dry casks surfaced immediately within the first few years that NRC approved 16 different dry cask storage systems for general use at or away from reactors.[30] Internal NRC memoranda show that the NRC's certificate of compliance process has been taken over by cask manufacturers' and nuclear utilities' profit-driven pressure for expediency.[31] The lack of rigorous regulatory oversight by NRC has resulted in a complete lack of field testing of cask designs. In addition, NRC has approved exemptions allowing manufacturers to build casks before receiving the certificate for compliance.

Not a single dry storage cask, once loaded, has ever been unloaded in the U.S. It remains unclear whether dry casks could be safely unloaded back into fuel storage pools or into transport casks for shipment off-site should Yucca Mountain ever become operational. The NRC cannot reasonably rely on a hodge-podge of contradictory licensing regulations and findings as the basis for the agency's refusal to consider this issue during license renewal review. To do so violates the agency's primary mandate under the Atomic Energy Act to protect public health and safety.

iv. NRC must address the findings of the National Research Council report, *The Safety and Security of Commercial Spent Nuclear Fuel Storage* in the SEIS for Indian Point.

The 2006 study by the National Academy of Sciences on security of spent fuel storage at commercial nuclear power plants concluded that a successful terrorist attack on spent fuel pools was possible, and recommended that an assessment of current security measures for protecting spent fuel be performed by an independent organization, outside of the NRC.[32] Based on these findings, the NRC should amend the regulations to require that security of

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[28] 10 CFR 72.42(a).

[29] The Nuclear Regulatory Commission found in 1990 as part of its revised Waste Confidence Decision that spent fuel could be safely stored in spent fuel pools or dry casks without significant environmental impact for at least 100 years, *see* U.S. Nuclear Regulatory Commission. *Waste Confidence Decision Review.* 55 Fed. Reg. 38508. September 18, 1990.

[30] *See* www.nrc.gov/waste/spent-fuel-storage/designs.html (last accessed Oct. 8, 2007).

[31] *See* Memorandum from Dr. Ross Landsman, NRC dry cask inspector for the Midwest regional office headquartered in Chicago, to Bruce L. Jorgensen, NRC Chief Decommissioning Branch, re: Attendance at Holtec Users Group Meeting (Jan. 17, 2001), *available at* http://www.nirs.org/radwaste/atreactorstorage/nrc_holtec.pdf (last accessed Oct. 8, 2007).

[32] National Academy of Sciences, *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report (2006).*

spent fuel pools and dry cask storage be comprehensively assessed during the relicensing process, and that the mitigation measures recommended by the NAS study be considered in the SEIS.

The committee's findings include:

- Less spent fuel is at risk in an accident or attack on a dry storage cask than on a spent fuel pool.
- An accident or attack on a dry cask storage facility would likely affect at most a few casks and put a few tens of metric tons of spent fuel at risk.
- An accident or attack on a spent fuel pool puts the entire inventory of the pool, potentially hundreds of metric tons of spent fuel, at risk.
- The potential consequences of an accident or terrorist attack on a dry cask storage facility are lower than those for a spent fuel pool. There are several reasons for this difference:

    1. There is less fuel in a dry cask than in a spent fuel pool and therefore less radioactive material available for release.
    2. *Measured on a per-fuel-assembly basis,* the inventories of radionuclides available for release from a dry cask are lower than those from a spent fuel pool because dry casks store older, lower decay-heat fuel.
    3. Radioactive material releases from a breach in a dry cask would occur through mechanical dispersion. Such releases would be relatively small. Certain types of attacks on spent fuel pools could result in a much larger dispersal of spent fuel fragments. Radioactive material releases from a spent fuel pool also could occur as the result of a zirconium cladding fire, which would produce radioactive aerosols. Such fires have the potential to release large quantities of radioactive material to the environment.

- The National Research Council studies have shown that the recovery from an attack on a dry cask would be much easier than the recovery from an attack on a spent fuel pool.
- Breaches in dry casks could be temporarily plugged with radiation-absorbing materials until permanent fixes or replacements could be made. The most significant contamination would likely be confined largely to areas near the cask storage pad and could be detected and decontaminated. The costs of recovery could be high, however, especially if the cask could not be repaired or the spent fuel could not be removed with equipment available at the plant. A special facility might have to be constructed or brought onto the site to transfer the damaged spent fuel to other casks.

In the committee's opinion, there are several relatively simple steps that could be taken to reduce the likelihood of releases of radioactive material from dry casks in the event of a terrorist attack:

- Dry casks were designed to ensure safe storage of spent fuel,[33] not to resist terrorist attacks.
- The regulations for these storage systems are designed to ensure adequate passive heat removal and radiation shielding during normal operations, off-normal events, and accidents.[34]
- A terrorist attack that breached a dry cask could *potentially* result in the release of radioactive material from the spent fuel into the environment through one or both of the following two processes: (1) mechanical dispersion of fuel particles or fragments; and (2) dispersion of radioactive aerosols. The latter process would have greater offsite radiological consequences.
- The regulations require that dry cask storage facilities be located within a protected area of the plant site. However, the protection requirements for these installations are lower than those for reactors and spent fuel pools.[35]
- Additional surveillance could be added to dry cask storage facilities to detect and thwart ground attacks.
- Certain types of cask systems could be protected against aircraft strikes by partial earthen berms. Such berms also would deflect the blasts from vehicle bombs.
- Visual barriers could be placed around storage pads to prevent targeting of individual casks by aircraft or standoff weapons; these would have to be designed so that they would not trap jet fuel in the event of an aircraft attack.
- The spacing of vertical casks on the storage pads can be changed, or spacers (shims) can be placed between the casks, to reduce the likelihood of cask-to-cask interactions in the event of an aircraft attack.
- Relatively minor changes in the design of newly manufactured casks could be made to improve their resistance to certain types of attack scenarios.

In addition to assessing mitigation measures in the SEIS, the NRC should consider using the results of the NAS vulnerability analyses for possible upgrades of requirements in 10 C.F.R. 72 for dry casks, specifically to improve their resistance to terrorist attacks.

v. The NRC must comprehensively assess the environmental impacts of the Indian Point 1 and 2 Spent Fuel Pool Leaks

Highly radioactive water has been found leaking from Indian Point spent fuel pools into the groundwater underneath the plant and leaching into the Hudson River for years. The potential environmental impacts of the continuation of spent fuel pool leaks for an additional twenty years is alarming. Entergy and the NRC have confirmed that Indian Point 1 spent fuel pools might also be leaking in addition to Indian Point 2 & 3, and contributing strontium-90 to the groundwater contamination. The NRC has also stated that the radioactive contamination has reached the Hudson. The impact of these leaks on Hudson River ecosystem must be assessed, especially by increased sampling of fish, shellfish and sediment to determine if strontium-90 and cesium-137 are bioaccumulating in the environment.

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[33] *See* 10 CFR Pt. 71.
[34] 10 CFR Pt. 72.
[35] *Id.*

In its Environmental Report (ER), Entergy claims the tritium contamination found in numerous onsite monitoring wells is "the result of historical pool leakage in the 1990s which has since been repaired," based on the assertion that Entergy has not been able to identify leaks in the IP2 pool liner, and the contamination is not consistent with active leakage.[36] However, Entergy failed to note that only about 60% of the IP2 pool liner has actually been examined for leaks, due to the high density of the spent fuel storage racks and the minimal clearance between the bottom of the racks and the floor of the pool.[37] Entergy has failed to provide any explanation in the Environmental Report as to the feasibility of examining the remainder of the pool liner for leaks. Nor does the Environmental Report address what other steps Entergy could take to find the source of the IP2 leak, if in fact it is not feasible to examine the remaining 40% of the pool liner. On the contrary, the Report suggests that because Entergy has looked for the leak and not found it, the pool must not be leaking. This is an arbitrary and illogical conclusion without adequate factual support, and cannot be relied on by NRC in assessing the leaks in the SEIS.

In addition, the claim that the contamination is not consistent with active leakage is not correct. Analysis of soil samples taken in the vicinity of the cracks in the Indian Point 2 pool wall in September 2005 indicate high levels of Cobalt-60, Cesium-134 and Cesium-137 consistent with the activity of these radionuclides in the spent fuel pool water.[38]

Another apparent contradiction between the ER and the NRC's inspection results can be found in the March 16, 2006 NRC Special Inspection Report assessing the groundwater contamination at Indian Point. Page 1 of the report states that "Entergy sampled existing "Due Diligence" wells that were developed in 2000. One of these wells, MW-111 (last sampled for tritium in 2000 with no activity detected) was sampled on September 29, 2005. The analytical result, reported on October 5, 2005, indicated 211,000 pCi/l, tritium."[39] MW-111 is located in the IP2 transformer yard, near the IP2 fuel storage building. If the tritium in the groundwater is indeed from "historical pool leakage in the 1990s" as Entergy claims in the Environmental Report, why was it not detected in MW-111 in 2000? These results clearly indicate that a tritium leak occurred at IP2 between 2000 and 2005. Neither NRC nor Entergy has suggested that there could be another source of tritium leakage at Indian Point 2 besides the Indian Point 2 spent fuel pool. These facts simply do not support Entergy's assertion that the Indian Point 2 pool is no longer leaking or has not leaked since the 1990s. NRC staff involved in the Indian Point

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[36] ER at pg. 5-6.

[37] Entergy's description of the groundwater investigation can be found on the New York State Emergency Management website at http://jic.semo.state.ny.us/PlantStatus/PlantStatusMain.aspx, last accessed May 30, 2007. *See also* NRC's website on the Indian Point leaks at http://www.nrc.gov/reactors/plant-specificitems/indian-point/on-going-activities05.html, (last accessed May 30, 2007).

[38] Information obtained by Riverkeeper through a Freedom of Information Act requests, FOIA/PA 2005-0369, FOIA/PA 2006-0019. Entergy "FSB Sample Log" was attached to an e-mail dated November 22, 2005 from Donald Croulet at Entergy to Jim Noggle of NRC, entitled "FW: Information requested by Mr. Noggle NRC."

[39] *Indian Point Nuclear Generating Unit 2-Special Inspection Report No. 05000247/2005011,* March 16, 2006.

groundwater investigation indicated their disagreement with Entergy on this issue, at the NRC Annual Assessment Meeting for Indian Point held on April 26, 2007.[40]

The issue of whether this leak is ongoing is critical to the license renewal review, since the spent fuel pools qualify as "systems, structures and components" that fall within the scope of aging management review for license renewal.[41] The omission of these soil sample results and the above-referenced section of the NRC Special Inspection Report render this section of the ER incomplete. The NRC must conduct a rigorous, objective analysis of both the onsite and offsite environmental impacts of these leaks. It is unreasonable for the NRC to rely on Entergy's inadequate, fatally flawed ER to prepare the SEIS.

In addition, Entergy's ER does not contain any analysis regarding the potential contamination of Hudson River fish and shellfish with strontium-90 as a result of the unmonitored leak from the Indian Point 1 spent fuel pool. On January 16, 2007 the *Westchester County Journal News* reported that fish samples taken by Entergy in fall of 2006 showed slightly elevated levels of strontium-90 in their flesh, raising concerns that this radionuclide could potentially bioaccumulate in the Hudson River ecosystem.[42] Out of twelve individual fish and shellfish collected for analysis, four showed detectable levels of strontium-90. The bones of the fish were not sampled for strontium-90, despite the fact that this type of radionuclide mimics calcium and concentrates in bones and teeth.

Entergy launched its own internal investigation in response to these findings which specifically suggests that further studies of Hudson River fish are warranted. In a January 2007 internal Entergy memorandum discussing preliminary dose assessments from Sr-90 in Hudson River fish and invertebrates, the author concludes that following a conservative analysis of fish consumption based on the 24.5 pCi/kg of Sr-90 in the white perch sample from Roseton, the maximum individual annual dose would equal 44% of the annual allowable bone dose to an Adult male.[43] The memorandum concludes by suggesting that "While we should not discount the value originally determined by AREVA, this evaluation indicates that we must perform additional investigation in an attempt to validate and understand the 25 pCi/L recently identified at our control location in Roseton."[44] Despite this recommendation, no mention of the dose assessment or need for further studies is included in the ER. Given the fact that much of the Hudson River

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[40] Based on conversation between Jim Noggle of NRC and Phillip Musegaas of Riverkeeper during the NRC public meeting, held at Colonial Terrace in Cortlandt, New York on April 26, 2007.

[41] *See* 10 CFR 54.21. *See also* NUREG-1801, Rev. 1, *Generic Aging Lessons Learned (GALL) Report*, Nuclear Regulatory Commission, September 2005.

[42] "Hudson River Fish Found to Contain Radioactive Isotope," Greg Clary, January 16, 2007 *Westchester County Journal News*.

[43] Memorandum from S. Sandike, Sr. Chemistry Specialist to T. Burns, NEM Supervisor, "Dose Assessments from Sr-90 in the Hudson River for Fish and Invertebrates-January 2007 Results," January 17, 2007, IPEC-CHM-07-002.

[44] *Id.* at pg. 2.

habitat in which these fish exist is designated as significant or essential under state and federal law, the omission of this data from the ER renders it incomplete.

In response to concerns raised over the adequacy of Entergy's offsite sampling program under Indian Point's Radiological Environmental Monitoring Plan (REMP), the New York State Department of Environmental Conservation (DEC) publicly committed to an expanded radiological sampling plan in conjunction with New York's Department of Health. At a March 2, 2007 Roundtable Meeting on the Indian Point leaks, a representative of New York DEC's Bureau of Radiation Protection stated that Entergy's current sampling program under the REMP was not adequate to determine whether the groundwater leaks were affecting the Hudson River environment.

The NRC must assess the potential impacts of the Indian Point 1 strontium-90 leak on Hudson River fish and shellfish in the SEIS. The ER states that "[T]he radionuclide release is not anticipated to change environmental considerations, such as water storage, land usage, terrestrial or aquatic ecological conditions, or air quality... as a result of license renewal activities."[45] This conclusion is based on an incomplete ER that fails to include the most recent results of Entergy' fish sampling under the REMP, any mention of the NYDEC expanded fish sampling plans or any analysis of potential dosage pathways to man form ingesting contaminated Hudson River fish. The NRC cannot reasonably rely on Entergy's findings in its preparation of the SEIS.

NRC should assess the feasibility of requiring Entergy to move more fuel to dry casks given the condition of the IP2 pool, and the likelihood that the IP3 pool could leak during the renewal period. Moving fuel to dry cask would also lower the density of fuel in the pools, lessening the risk of a fire from an accident or attack. NRC must assess this as a reasonable mitigation measure for IP.

D. Energy Alternatives Analysis

The NRC must fully consider the use of alternative energy sources in its analysis of alternatives for Indian Point in order to comply with NEPA.

i. The NRC must fully consider and analyze renewable energy sources together with conservation as an alternative to license renewal of Indian Point 2 and Indian Point 3 separately.

NEPA[46], CEQ regulations[47], NRC regulations[48] and Appendix A to Part 51 mandate that the full and complete environmental impacts of the proposed action, license renewal of IP2and/or license renewal of IP3, be compared to the projected impacts of all reasonable alternatives. As delineated in CEQ regulations, the obligations include rigorously

[45] ER at pgs. 5-6.
[46] NEPA 42 USC sec 4321 et seq.
[47] 40 CFR 1502.1.
[48] 10 CFR 51.45, 51.71, & 51.95.

exploring and objectively evaluating all reasonable alternatives, devoting substantial treatment to each alternative, and including alternatives not within the jurisdiction of the lead agency.[49]

An accurate assessment of reasonable power alternatives to Indian Point 2 and 3 must be considered both separately and collectively. The license renewal of IP2 is a proposed action, as is the license renewal of IP3. Not only does each proposed action need to be dealt with separately, alternatives must also be considered separately.[50]

Throughout the Environmental Report, the applicant has presented the picture of one single applicant applying for one license renewal, when in fact two separate licenses renewals are sought, one license for Indian Point 2 and one for Indian Point 3. The current operating licenses relate to two nuclear power plants that expire at different times – IP2's license[51] expires on September 28, 2013 and IP3's license[52] expires on December 12, 2015. The applicant for each plant is a separate corporate entity – Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC

The applicants' arguments proffered in their Environmental Report state 2,158 MWe as the baseline of power that would need to be replaced in a no-action alternative (non-renewal).[53] This is incorrect. The NRC must consider each application separately and on its own merits. The NRC has the statutory obligation to fully consider a "no-action" alternative and replacement alternatives separately for the re-licensing of IP2 and IP3 whose ratings are 1078MWe and 1080MWe respectfully.

Entergy's application misstates the power rating for each separate license and therefore does not comply with NEPA. NRC's environmental regulations in Part 51 expressly require a review of *each* proposed action – that being the license renewal of IP2 and the license renewal of IP3 separately. The regulations state that *each* applicant for a renewal of *a* nuclear plant shall submit an environmental report containing the environmental impacts of alternatives.[54] Entergy's combined environmental report does not allow the NRC, nor the public to consider the environmental consequences of the "no-action" alternative for each plant or the environmental consequences of the various alternatives for the replacement of generating capacity loss that would be available to a utility or other responsible energy planner for each separate entity.

The applicants dismissively rule out alternative and more environmentally friendly energy sources such as wind, solar and hydroelectric power (or a combination of alternatives). In the environmental report the applicants state that "wind, solar and

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[49] 40 CFR 1502.14(a) – (f).
[50] *See also* NUREG-1437 vol. 1 §§ 1.2, 1.4 & 1.8 (requiring a plant, not plants, specific review and a full analysis of alternatives at <u>individual</u> license renewal reviews.).
[51] DPR-26.
[52] DPR-64.
[53] *See* ER §§ 7.0 &8.0.
[54] 10 CFR §§ 51.53(c)(1) & (2), 51.20(b)(2), 51.30(a) & 51.71(d).

hydroelectric power are not capable of replacing the 2,158 MWe of power."[55] The total 2,158 MWe of power generated from the *combined* plants is not the operative standard to be utilized in reviewing individual plant licenses and therefore does not fulfill the applicant's responsibility under NEPA. Moreover it does not properly inform the public of the relevant standard upon which public comment should be based.

The NRC must fully consider and assess the use of sustainable energy sources in conjunction with conservation and to include energy efficiency measures as an alternative. The NRC must assess the use of a combination of renewable energy sources rather than relying on discrete sources. It is unreasonable and in violation of NEPA for the NRC to assert that the power rating of IP2 or IP3, separately or in combination, to be replaced solely by one discrete renewable energy source.

ii. The NRC must fully consider the impacts from instituting additional conservation resources

The NRC's environmental review regulations require that NRC consider all reasonable alternatives to the proposed license renewal action of both IP2 and IP3 and the cumulative impacts of each.[56] NRC's regulations state that applicants must include in their environmental report "the potential impacts of instituting additional conservation resources to reduce the total demand for power."[57] Not one of the conservation methods available in the regulations is addressed in either IP2 or IP3's Renewal Application Environmental Report.[58] Rather, the applicants dismissively conclude that they have no responsibility to explore conservation options a "the conservation option by itself is not considered a reasonable replacement for the IP2 and IP3 Operating License Renewal alternatives," (the applicants again posit replacement of both IP2 and IP3's energy output as if only one license was sought to be renewed – a wholly deficient standard as previously delineated) and "conservation is neither single nor discrete, nor is it a source of generation."[59]

The applicants' cavalier dismissal of conservation runs in contravention of NEPA as well as the NRC's own regulations.[60] The regulations mandate the analysis of alternatives and mitigation methods to reduce the environmental consequences of relicensing and require meaningful consideration of all reasonable mitigation and conservation methods.[61] Furthermore, the CEQ regulations require a full and fair discussion of reasonable alternatives to minimize environmental impacts (conservation) and devotion of substantial treatment to each alternative.[62]

[55] ER § 7.5.
[56] 10 CFR Pt. 51.
[57] NUREG-1473, vol. 1 at §§ 8.1 & 8.3.14.
[58] ER at § 8.3.11.
[59] *Id.*
[60] 10 CFR 51.71(d).
[61] *See* 10 CFR §§ 51.71(d), 51.95(c)(2) & App. A to Pt. 51 at 5.
[62] *See* 40 CFR Sections1502.1 & 1502.14.

Contrary to Entergy's presentation in its Environmental Report, NUREG-1437 Volume 1, Section 8.1 does not mandate that energy conservation be addressed *if* and *only if* it could replace the MWe of IP2 or IP3. In fact it is quite the contrary. The applicants posit that in the aforementioned regulation when the NRC discusses looking to power generation, "alternatives should be limited to single, discrete electrical sources." Such limitation does not encompass conservation as NUREG-1437 makes abundantly clear. The single, discrete limitation, as specified in the regulation is applicable, by its express terms to power generation, not power conservation.[63] Additionally in the regulations, the NRC states that each of the following is a separate and distinct issue: (1) the potential environmental impacts from electrical generating sources other than nuclear license renewal; and (2) the potential impacts from instituting additional conservation resources to reduce the total demand for power.[64] The simple discrete language used by the applicants relates to generating electricity, not to conservation.

The NRC must fully and explicitly assess all potential conservation methods separately for each license renewal in the SEIS.

iii. The NRC must fully consider and evaluate, as an alternative to license renewal, the replacement of either Indian Point 2 or Indian Point 3's power generation by a portfolio of power sources inclusive of renewable sources in coordination with conservation.

NEPA, CEQ and the NRC all mandate a vigorous exploration and an objective evaluation of all reasonable alternatives to license renewals in its regulations.[65] The regulations also require an assessment of alternative energy sources including sustainable energy sources and energy conservation as a means of replacement for IP2 and/or IP3's current power generation.

In the environmental report, the applicants state that power generated by wind, solar, hydropower, geothermal, biomass and other technologies, conservation or a combination of alternatives "were not considered as reasonable replacement base load power generation."[66] Therefore, the applicants did not consider or address a replacement portfolio of power sources inclusive of sustainable sources in coordination with conservation.

The applicants' conclusions simply fly in the face of recent independent technical and scientific studies regarding energy replacement of Indian Point. The most comprehensive study directly on issue is the National Academy of Sciences (NAS) June 2006 report, "Alternatives to the Indian Point Energy Center for Meeting New York's Electrical

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[63] NUREG-1437 § 8.1.
[64] NUREG-1433 at § 8.1.
[65] 42 USC 4321-4347; 40 CFR Pt. 1400; and 10 CFR Pt. 51.
[66] ER at § 7.5.

Power Needs."[67] The report ultimately concludes that even when considering the combined energy production of IP2 and IP2, the approximately 2000 MWe is replaceable, and "the committee has identified no technical obstacles that it believes present insurmountable barriers to the replacement of Indian Point's capacity, energy and ancillary services."[68] On point, the committee found that "if a decision were definitively made to close all or some part of Indian Point by a date certain, the committee anticipates that a technically feasible replacement strategy for Indian Point would be achievable" and no major disruption would result if both IP2 and IP3 were retired at the conclusion of their current licenses in 2013 and 2015, respectively.

Furthermore, contrary to Entergy's findings, the NAS study states that an achievable replacement strategy would focus on conservation, energy efficiency, improvement of transmission infrastructure and replacement generating capacity including wind, photovoltaic, hydroelectric and other technologies such as natural gas-fired combined cycle plants. The study states that "a replacement strategy for Indian Point would most likely consist of a portfolio of the approaches discussed in this report, including investment in energy efficiency, transmission and new generation" and that regarding wind generation alone: "technically there is sufficient wind resource in New York stat to replace the Indian Point units."[69]

Additionally, the Nuclear Research Institute and the Institute for Energy and Environmental Research recently published a summary of its book to be published in October of 2007; "Carbon Free and Nuclear Free – A Roadmap for U.S. Energy Policy." The overarching finding of the study is that a reliable U.S. electricity sector is achievable without nuclear power through a combination of conservation and alternative sustainable energy sources and thus would reduce environmental risks posed by nuclear proliferation, terrorism, severe accidents nuclear waste and uranium mining and transportation. The report finds that wind or solar capacity individually equals between 2.5 and 3 times the entire electricity production in the U.S. and that each of 6 states have wind energy potential greater than the electricity produced by al l 103 nuclear power plants.[70]

Entergy has grounded its refusal to even consider a reasonable replacement generation scenario to include a portfolio of sources including renewable sources on NUREG-1437 Vol. 1 Section 8.1. However section 8.1 is neither a regulation nor a statue, but merely guidance. It states, in part, that the "NRC has determined that a reasonable set of alternatives should be limited to analysis of single, discrete electrical generating sources." Section 8.1 does not comply with NEPA's mandate to assess all reasonable "alternatives to the proposed action," nor does it comply with Appendix A to Part 51, Section 5, which mandates presentation of "the environmental impacts of the proposal and the alternatives in comparative form," and goes on to require that "all reasonable alternatives will be identified and considered." 10 CFR 51.71(d) requires that the NRC will consider and

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[67] The Board of Energy and Environmental Systems for the National Academy of Sciences, Alternatives to the Indian Point Energy Center for Meeting New York's Electrical Power Needs, June 2006, *see* Chs. 1-5.
[68] *Id.*
[69] *Id* at pgs 59-74.
[70] *Available at* www.ierr.org/carbonfree (last accessed Oct. 10, 2007).

weigh "the environmental impacts of alternatives to the proposed action;" and "will, to the fullest extent practical, quantify the various factors..." Additionally, 51.71(d) states that "due consideration will be given to compliance quality standards and requirements that are imposed by ... State ... agencies."
Section 8.1, in contravention of Section 51.71(d), essentially moots New York State's September 24, 2004 adoption of a Renewable Portfolio Standard with a goal of increasing the proportion of renewable energy used by consumers to at least 25% by 2013.

The above-referenced studies demonstrate the necessity and feasibility of developing and implementing energy portfolios that include renewable energy sources, conservation and energy efficiency measures. The NRC's continued reliance on an outdated GEIS that ignores the significant progress made on energy issues is unreasonable, because it ignores the NEPA mandate to fully consider "new and significant" information in the SEIS.

iv. The NRC must compare Indian Point's cumulative detrimental contribution to climate change and environmental degradation to safe and clean renewable energy sources

NEPA mandates that the full and complete environmental consequences of a proposed action (license renewals) be compared to all reasonable alternatives.[71] As delineated in Sections 1502.14(a) through (f), the obligation includes rigorously exploring and objectively evaluating all reasonable alternatives, devoting substantial treatment to each and including alternatives not within the jurisdiction of the lead agency. The NRC's regulations, inclusive of Section 51.45 mandate the same. The applicants fail to meet applicable statutory and regulatory mandates by:

a. failing to delineate the license renewals' negative affects on climate change;
b. failing to delineate the voluminous production of carbon dioxide within the nuclear power life cycle;
c. failing to address the environmental effects, including cumulative environmental impacts of planned and unplanned radiation releases and leaks;
d. failing to address the cumulative environmental effects of spent fuel storage and proposed transportation; and
e. failing to address the cumulative impacts which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such action.[72]

The applicants, at Section 8.4.3.2.1 of their Environmental Report have stated that to "produce and deliver" nuclear energy, no carbon dioxide is emitted. This statement is completely inaccurate. The applicants have also stated that the "environmental impacts

[71] 40 CFR 1502.14.
[72] *See* 40 CFR 1508.7 (defining cumulative effects).

of the continued operation of IP2 and IP3 ... are significantly smaller than impacts associated with the best case among reasonable alternatives."[73] Again, this statement is simply inaccurate.

Carbon dioxide is a prime contributor to climate change. The United States Supreme Court held in *Massachusetts et al v. Environmental Protection Agency*,[74] that the U.S. government's objective analysis of the relevant science establishes that carbon dioxide precipitated global warming, threatens a precipitous rise in sea levels, severe and irreversible changes to the natural ecosystem, a significant reduction in winter snow pack, increased spread of disease and increased ferocity of weather events. There is no disagreement that carbon dioxide is produced in the nuclear power life cycle, whether it be in the mining and milling of uranium, the refining and enrichment of uranium into fuel, the transportation of uranium, the refurbishment and replacement of major plant structures, (inclusive of Entergy's 2011 and 2012 planned replacement of both reactor vessel heads), and the transportation and disposal of spent fuel.

The NRC, in order to comply with NEPA, must present an accurate comparison of all direct environmental and cumulative impacts of extended operation to utilization of other energy sources including renewable with and without conservation, in the draft SEISs for IP2 and IP3.

2. **The NRC must conduct a rigorous, objective analysis of the impacts of Indian Point's once-through cooling system on Aquatic Ecology, and should not rely on Entergy's incomplete and inaccurate Environmental Report (ER) as the basis for the SEIS.**

With respect to aquatic ecology, it is patently clear that Entergy's Environmental Report (ER) fails to meet the requirements set forth in 10 CFR 51.45 and 10 CFR 51.53(c). There are three main flaws in the ER in this area: 1) Current specific information prepared by the New York State Department of Environmental Conservation (NYSDEC) has not been evaluated regarding aquatic ecology, in particular entrainment, impingement and thermal discharge impacts; 2) Important plant and animal habitats—except for endangered and threatened species—have not been evaluated; and 3) The analysis of available alternatives for reducing or avoiding adverse environmental effects on aquatic resources is grossly incomplete.

A. NRC Requirements for Assessing Aquatic Ecology

The ER must assess Category 2 issues related to aquatic ecology, including entrainment, impingement and thermal discharge.[75] In general, NRC regulations require that the ER "contain sufficient data to aid the Commission in its development of an independent analysis."[76] Specifically, "the analyses for environmental reports shall, to the fullest

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[73] ER at § 8.4.3.2.1.
[74] 127 S.Ct. 1438, 63 ERC 2057, 167 L.Ed.2d 248 (Apr. 2007).
[75] 10 CFR 51.53(c).
[76] 10 CFR 51.45 (c).

extent practicable, quantify the various factors considered."[77] Moreover, the ER "should not be confined to information supporting the proposed action but should also include adverse information."[78]

The ER must also include a discussion of the status of compliance with water quality standards, in particular "thermal and other water pollution limitations or requirements which have been imposed by Federal, State, regional, and local agencies having responsibility for environmental protection."[79] Finally, the regulations require a complete analysis on available alternatives for reducing or avoiding adverse environmental effects and such analysis must "include a discussion of whether the alternatives will comply with such applicable environmental quality standards and requirements."[80]

As discussed further below, Entergy's "Entrainment Analysis," the "Impingement Analysis" and the "Heat Shock Analysis" fail to evaluate and to include significant adverse information contained in NYSDEC documents, which is necessary under 10 CFR 51.45(c), (e) and 10 CFR 51.53(c). In addition, the ER's discussion on the status of compliance with New York water quality standards, required under 10 CFR 51.45 (d), is completely at odds with the information contained in current specific information by the NYSDEC. Thus, the ER contains insufficient data and does not aid the Commission in its development of an independent analysis with regards to aquatic ecology.

B. Aquatic and Riparian Ecological Communities

Relying on the 1999 Draft Environmental Impact Statement regarding the renewal of the SPDES permit for Indian Point (hereinafter 1999 DEIS)[81]—prepared by the prior owners of these stations—instead of consulting current information on this matter, such as the 2003 Final Environmental Impact Statement regarding the renewal of Indian Point's SPDES permit (hereinafter NYSDEC's FEIS)[82]—prepared by the NYSDEC—, the ER contains inaccurate and incomplete information on the status of aquatic and riparian ecological communities of the Hudson River.

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[77] *Id.*
[78] *See* 10 CFR 51.45 (e).
[79] *See* 10 CFR 51.45 (d).
[80] *See* 10 CFR 51.45 (b), (c), (d).
[81] Entergy has referenced this document in the ER, as follows: CHGEC (Central Hudson Gas and Electric Corporation). 1999. Consolidated Edison Company of New York, Inc., New York Power Authority, and Southern Energy New York, Draft Environmental Impact Statement for State Pollutant Discharge Elimination System Permits for Bowline Point, Indian Point 2 and 3, and Roseton Steam Electric Generating Stations. *See e.g.,* sections 2.14 & 4.24.
[82] Entergy has referenced this document in the ER, as follows: NYSDEC (New York State Department of Environmental Conservation). 2003. Final Environmental Impact Statement Concerning the Applications to Renew SPDES Permits for the Roseton 1 and 2, Bowline 1 and 2 and Indian Point 2 and 3 Electric Generating Stations, Orange, Rockland and Westchester Counties, Hudson River Power Plants FEIS. Accepted: June 25, 2003. *See e.g.,* sections 2.14 & 4.24.

For instance, the ER, in the section on "Fish Communities" (Section 2.2.5), states that "[t]he NYSDEC's FEIS noted a decline in bay anchovy abundance and suggested it was linked to power generation plant water intakes on the Hudson River [NYSDEC 2003]."[83] But Entergy omits to say that the NYSDEC's FEIS also considers that "[s]everal species of fish in the Hudson River estuary, such as American shad, white perch, Atlantic tomcod and rainbow smelt, have shown trends of declining abundance."[84]

C. Entrainment, Impingement and Heat Shock

Entergy's "Entrainment Analysis," "Impingement Analysis" and "Heat Shock Analysis" (Sections 4.2.5.2 & 4.2.6 (at 4-12 and 4-13); 4.3.5.2 & 4.3.6 (at 4-17 to 4-19); 4.4.5.2 & 4.4.6, respectively) also fail to evaluate the conclusions and recommendations provided in NYSDEC's FEIS. Similarly, Entergy deliberately neglects to consider the conclusion provided in the NYSDEC's Fact Sheet regarding the renewal of Indian Point's SPDES permit (hereinafter NYSDEC's Fact Sheet).

Although both documents (NYSDEC's FEIS and NYSDEC Fact Sheet) have been included in the "References" section and considered in other sections of the ER, Entergy has purposely avoided an evaluation of these key NYSDEC documents in the sections that purport to develop the entrainment, impingement and thermal analyses. Furthermore, Entergy's Entrainment Analysis, Impingement Analysis, and Heat Shock Analysis fail to include significant adverse information contained in the conclusions and recommendations provided in NYSDEC's FEIS and NYSDEC's Fact Sheet, and to quantify the adverse factors, which is necessary under 10 CFR 51.45 (e), (c).

Since 1975, NYSDEC has delegated authority from the Federal government to administer the SPDES program under the Clean Water Act (CWA). Accordingly, the NYSDEC evaluates and regulates the impact of the applicant's cooling system under the CWA.[85] In addition, New York has established criteria governing thermal discharges.[86] NYSDEC's FEIS and NYSDEC's Fact Sheet contain the most current information by the NYSDEC regarding the applicant's environmental impacts due to entrainment, impingement, and thermal discharges. Thus, these documents must be considered in the ER pursuant to the NRC regulations at 10 CFR 51.45 (a), (c) and 10 CFR 51.53 (c).

Entrainment of Fish and Shellfish in Early Life Stages and Impingement of Fish and Shellfish in Early Life Stages

Pursuant to 10 CFR 51.53(c), Entergy is required to analyze the environmental impact of the proposed action as a result of the entrainment and impingement of fish and shellfish in early life stages from its cooling system. Entergy's "Entrainment Analysis," in sections 4.2.5.2 and 4.2.6 (at 4-12 and 4-13), and the "Impingement Analysis," in section 4.3.5.2

[83] ER p. 2-17.
[84] NYDEC's FEIS, p. 57.
[85] *See* CWA § 316(b).
[86] *See* 6 NYCRR Part 704.

and 4.3.6 (at 4-17 to 4-19), however, are fatally incomplete due to the applicant's failure to evaluate vitally important NYSDEC documents.

Entergy considered entrainment and impingement impacts relying solely on the 1999 DEIS and two other reports prepared by Entergy's consultants, while entirely ignoring NYSDEC's FEIS for its "Entrainment Analysis" and "Impingement Analysis." There is no mention or consideration of the FEIS in Entergy's analyses of entrainment and impingement. The "Entrainment Analysis" and the "Impingement Analysis" lack any discussion or consideration of two basic documents prepared by the NYSDEC: NYSDEC's Fact Sheet and NYSDEC's FEIS. Astutely, Entergy has included both documents in the pertinent "References" section (section 4.26) and also mentions these document in the "Background" discussions (and other sections of the EF). But Entergy has failed to consider these key NYSDEC documents in the required analyses pursuant to 10 CFR 51.45 and 10 CFR 51.53(c).

Significantly, the NYSDEC's FEIS provides not just recommendations and conclusions regarding entrainment impacts and alternatives to minimize such impacts, but quantifies entrainment impacts that have been ignored by Entergy. According to the NYSDEC's FEIS, the station's cumulative entrainment impact is, as follows:[87]

Plant Species	**Indian Point**
American Shad	**13,380,000**
Bay Anchovy	**326,666,667**
River Herring	**466,666,667**
Striped Bass	**158,000,000**
White Perch	**243,333,333**
Total	**1,207,713,334**

NYSDEC's FEIS concludes that the billions of fish that are killed by the stations each year represent a significant mortality and are yet another stress on the River's fish community.[88] The FEIS also notes, contrary to Entergy's assertions, that although the primary cause of these population changes cannot conclusively be attributed entirely to the operation of these stations, the mortality that they cause must be taken into account when assessing these population declines.[89] The NYSDEC also states,

> What is clear from the data and analyses presented in the DEIS is that entrainment and impingement, primarily the former, are eliminating a significant portion of the above-listed species in their egg and larval forms, as well as many more species which spawn or spend part of their life stages in the lower Hudson River.[90]

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[87] *See* NYSDEC's FEIS, Table 1. Estimated Average Numbers of Selected Fish Species Entrained Annually at Roseton, Indian Point, and Bowline Stations, Based on In-plant Abundance Sampling, 1981-1987.
[88] *Id.* p. 58.
[89] *Id.*
[90] *Id.* p. 59.

Furthermore, the NYSDEC has determined not to rely on the fish population models presented in the 1999 DEIS to make conclusions for the FEIS or for the SPDES permits to be issued for the stations.[91] Instead, NYSDEC has concluded that "the impacts associated with power plants are more comparable to habitat degradation; the entire natural community is impacted."[92]
In addition, NYSDEC's Fact Sheet, among other important findings, provides the following conclusion regarding entrainment and impingement at Indian Point that has been totally ignored by Entergy and must be reviewed to completely assess environmental impacts:

> *Each year Indian Point Units 2 and 3 (collectively "Indian Point") cause the mortality of more than a billion fish from entrainment of various life stages of fishes through the plant and impingement of fishes on intake screens.* ... Losses at Indian Point are distributed primarily among 7 species of fish, including bay anchovy, striped bass, white perch, blueback herring, Atlantic tomcod, alewife, and American shad. Of these, Atlantic tomcod, American shad, and white perch numbers are known to be declining in the Hudson River ... *Thus, current losses of various life stages of fishes are substantial.*[93]

D. Heat Shock

Pursuant to 10 CFR 51.53(c), Entergy is also required to analyze the environmental impact of heat shock from its once-through cooling system. Entergy's Analysis of Environmental Impact in connection with heat shock, however, is incomplete and must not be relied on by NRC in preparing the SEIS. As with the entrainment and impingement analyses, the "Thermal Discharge Analysis," in sections 4.4.5.2 & 4.4.6, lacks any discussion or consideration of
NYSDEC's FEIS or NYSDEC's Fact Sheet.

Some of NYSDEC's findings, recommendations and conclusion in the FEIS regarding thermal impacts that have been entirely dismissed by Entergy are:

> *Indian Point:* As of the 1987-1992 SPDES permit term, thermal discharges from Indian Point did not meet applicable thermal criteria. ... These provisions alone [in the SPDES permit based on the Hudson River Settlement Agreement and those in subsequent Consent Orders], however, are not sufficient for Indian Point to meet thermal criteria. Thermal modeling indicates that the thermal discharge from Indian Point causes water temperatures to rise more than allowed, which is four degrees (F.) over the temperature that existed before the addition of heat, or a

[91] *Id.* p. 60.
[92] *Id.* pp. 53-54
[93] *See* NYSDEC's Fact Sheet, Attachment B, p. 1 of 8.

> maximum of 83oF, whichever is less, in the estuary cross sections specified in 6 NYCRR §704.2(b)(5). A mixing zone was not specified in the previous SPDES permit for the Indian Point facility.[94]
>
> Thermal discharges were inadequately addressed in the DEIS. The DEIS asserts, with no supporting evidence, that "... [t]he surface water orientation of the plume allows a zone of passage in the lower portions of the water column, the preferred habitat of the indigenous species." Other data and analyses cast doubt on this assertion.[95]
>
> Given the extent of warming shown ... in the HydroQual graphs, combined with the recent dramatic declines in tomcod and rainbow smelt as discussed previously, the Department believes it prudent to seek additional thermal discharge data for each facility, including a mixing zone analysis, and anticipates requiring triaxial thermal studies as conditions to each of the SPDES renewals. Depending on the results of those analyses, additional controls may be required to minimize thermal discharges.[96]

NYSDEC's Fact Sheet also provides critical facts and analysis regarding the stations' thermal impacts that have been deliberately ignored by Entergy, such as:

> Under Section 316(a) of the Clean Water Act (CWA), a permittee may submit a demonstration that its thermal discharge does not threaten the survival of indigenous aquatic populations even if it does not meet state water quality criteria. Such a study was prepared in 1978 by the prior owners of the Indian Point units, but it was superseded by provisions of the 1981 - 1991 Hudson River Settlement Agreement and subsequent Consent Orders effective 1992 - 1998. Based on that older "316(a) demonstration", the former operators of the Indian Point units asserted that the facility complied with the NYS thermal standard (6 NYCRR Part 704). Based on modeling submitted with the 1999 DEIS by the prior owners of Indian Point (along with owners of two other Hudson River generating stations), *the thermal criteria outlined in 6 NYCRR Part 704.2 are not being consistently maintained under the present operation of the facility. Appendix VI Chapter 6 of the 1999 DEIS, "Near-field Temperature Modeling", concludes that newer analyses of the discharge from Indian Point "... indicate that it is highly likely that the exceedance of the topwidth criterion, and possible the cross-sectional area criterion, would occur under slack conditions. Top-width exceedances occur under all flood scenarios . . . ." In more general terms, this means that temperatures measured at the water surface along a line running from the outfall across*

[94] *See* NYSDEC 2003c, p. 19 (footnote omitted).
[95] *Id.* p. 71.
[96] *Id.* p. 72.

> *the river to the far shore, and measured at varying depths along the cross-section below that line from outfall to far shore, likely exceed the thermal criteria in the Department's regulations during periods with lowest river flow velocities, that is, during the transition between tidal cycles. Furthermore, temperatures at the water surface along that same line from outfall to far shore appear to exceed the thermal criteria at all flow levels classified as "flood", that is, during high tides.*
>
> The permit therefore requires the permittee to conduct additional thermal studies to verify actual in-stream conditions of the thermal component of the discharge. The in-stream tri-axial study mandated by Special Condition 7 will require actual measurement of river and outfall temperatures at multiple points on the surface and at depth, along the surface and in cross-section running from the outfall and across the river to the far shore, as well as temperature measurements on the surface and at various depths at specified points running parallel to the course of the river. *Using this additional data plus existing sources, the Department will be able to determine if the Indian Point facility complies with the thermal standard and whether to grant Indian Point a variance from NYS thermal criteria.*[97]

E. Alternatives to Closed-Cycle Cooling

Although Entergy submits that "substantial feasibility concerns exist" regarding closed-cycle cooling at this site, the ER offers no other alternatives to substantially reduce impacts to a level equivalent to that which can be achieved by closed-cycle cooling at this site. Indeed, the level of protectiveness for aquatic ecology has already been established by the State of New York, which is a level equivalent to that which can be achieved by closed-cycle cooling at this site.

Entergy fails to disclose that NYSDEC would require Indian Point to install and operate a closed-cycle cooling system or to provide "an alternative technology(s) that can minimize adverse environmental impact to a level equivalent to that which can be achieved by closed-cycle cooling at this site"[98] Therefore, Entergy's analysis lacks a complete evaluation on available alternatives for reducing or avoiding adverse environmental effects and fails to "include a discussion of whether the alternatives will comply with such applicable environmental quality standards and requirements."[99]

F. Essential Fish Habitats (EFH)

The Hudson River estuary has Essential Fish Habitat (EFH) designations for the following species: Atlantic sea herring, Atlantic butterfish, Black Sea Bass, Bluefish, Red

[97] NYDEC 2003b, Attachment A, pp. 6 of 8 and 7 of 8.
[98] *See* NYSDEC, Fact Sheet p.4. Note that Riverkeeper Inc. (and other Environmental Petitioners) objects to this permit condition.
[99] *See* 10 CFR 51.45 (b), (c), (d).

hake, Summer flounder, Winter flounder, and Windowpane flounder.[100] As Entergy's ER notes, Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act, as amended by the National Marine Fisheries Service Sustainable Fisheries Act of 1996, provides that Federal agencies must consult with the Secretary of Commerce on all actions or proposed actions authorized, funded, or undertaken by the agency that may
adversely affect essential fish habitat. "Therefore, the NRC staff will also initiate an essential fish habitat consultation with the NMFS."30 However, under 10 CFR 51.53(c) (3) (ii) (E), Entergy is required to include an analysis on "Important Plant and Animal Habitats." Thus, in addition to the NRC-NMFS consultation, the NRC must prepare an EFH analysis—species by species—and include it in the SEIS.

G. Significant Coastal Fish and Wildlife Habitats

Haverstraw Bay, just south of the Indian Point site, is a designated Significant Coastal Fish and Wildlife Habitat by the State of New York. According to the Designation document:

> Haverstraw Bay is a major nursery and feeding area for certain marine Species, most notably bay anchovy, Atlantic menhaden, and blue claw Crab. Depending on location of the salt front, a majority of the spawning and wintering populations of Atlantic sturgeon in the Hudson may reside in Haverstraw Bay. Shortnose sturgeon (E) usually winter in this area as well.
>
> ... Haverstraw Bay is a critical habitat for most estuarine-dependent fisheries originating from the Hudson River. This area contributes directly to the production of in-river and ocean populations of food, game, and forage fish species. Consequently, commercial and recreational fisheries throughout the North Atlantic depend on, or benefit from, these biological inputs from the Hudson River estuary.[101]

The Haverstraw Bay Designation document also states:

> A habitat impairment test must be met for any activity that is subject to consistency review under federal and State laws, or under applicable local laws contained in an approved local waterfront revitalization program. If the proposed action is subject to consistency review, then the habitat protection policy applies, whether the proposed action is to occur within or outside the designated area. The specific habitat impairment test that must be met is as follows. In order to protect and preserve a significant habitat, land and water uses or development shall not be undertaken if such actions would: destroy the habitat; or, significantly impair the viability of a habitat.[102]

[100] *See* Summary of EFH Designations – Estuaries: Hudson River *available* at www.nero.nooa.gov.
[101] *See* NYS, Significant Coastal Fish and Wildlife Habitat Program, Designated Habitat Haverstraw Bay.
[102] *Id.*

Since the proposed action is subject to consistency review, then the Haverstraw Bay habitat protection policy applies and must be assessed in the SEIS.

H. NRC must conduct a rigorous analysis of Important Plant and Animal Habitats

Although applicants for relicensing of nuclear power plants are supposed to analyze the effects on "important plant and animal habitats,"[103] Entergy's ER fails to mention possible impacts on an incredibly significant natural habitat in the near vicinity of Indian Point. Haverstraw Bay, designated as a Significant Coastal Fish and Wildlife Habitat by the State of New York, is located only a mile south of Indian Point. It is a major feeding and nursery area for many species, including the Atlantic sturgeon.[104] The State of New York has deemed it an "irreplaceable" habitat, as it is "the most extensive area of shallow estuarine habitat in the lower Hudson River (and in New York State)."[105] Indian Point's massive intake and discharge of cooling water certainly impacts this exceptional habitat. Indeed, the cumulative impact that all Hudson River power plants with once-through cooling could have on Haverstraw Bay is potentially substantial.

I. Endangered Species

i. Listed Species – Shortnosed Sturgeon

The license renewal of the Indian Point nuclear facility is a federal action which "may affect a listed species or critical habitat."[106] Since Entergy admits to the facility's taking of federally listed shortnose sturgeon without an incidental take permit in its ER[107], and will continue to take these fish if its license is renewed and continues to operate with its once-through cooling system, such renewal is a federal action which may affect a listed species.

Riverkeeper recognizes that Section 7 consultation is based on astute principles designed to further the basic purpose of the Endangered Species Act (ESA), which is to conserve endangered and threatened species and the ecosystems on which they depend.[108] Of particular relevance here are section 7 "philosophies" which encourage reliance on biology first, emphasize the ecosystem approach to species conservation, and stress the importance of the "best available scientific and commercial data."[109] These are

[103] *See* 10 C.F.R. 51.53(c)(3)(ii)(E).
[104] *See* New York State Haverstraw Bay Coastal Fish & Wildlife Habitat Rating Form, *available at* http://nyswaterfronts.com/downloads/pdf/sig_hab/hudsonriver/Haverstraw_Bay.pdf.
[105] *Id.*
[106] 50 C.F.R. § 402.14(a).
[107] *See* Entergy, Inc., License Renewal Application, Appendix E: Applicant's Environmental Report, Operating License Renewal Stage, Indian Point Energy Center (ER) § 4.10.5, at 4-30, *available at* http://www.nrc.gov/reactors/operating/licensing/renewal/applications/indian-point.html.
[108] ESA, 16 U.S.C. 1531, et seq., at § 1531(b).
[109] ESA § 7 Handbook, § 1.1, at 1-2.

commendable standards of practice, and NRC should adhere to them during the relicensing process

Riverkeeper's concerns regarding Indian Point's effects on shortnose sturgeon are echoed in a letter from Mary Colligan, Assistant Regional Administrator for Protected Resources for NMFS Northeast Region, to James Thomas at Enercon Services, a company assisting Entergy in its preparation of its ER.[110] In the letter, Colligan states that NMFS is aware that shortnose sturgeon have been impinged at Indian Point in the past, but that NMFS has no data regarding possible impingement that is more recent then 1998.[111] The letter also notes that such impingement is a "take" under the ESA, and as such, Entergy has been operating in violation of ESA because it does not have an incidental take permit.[112] In addition, Colligan stresses that although Entergy contends that is current systems reduce impingement by 77% and entrainment by 33%, NMFS has *no current information* on how this system may affect impingement or entrainment of sturgeon.[113] Riverkeeper, like NMFS, is concerned about the lack of recent data regarding the death of shortnose sturgeon due to Indian Point's once-through cooling system.

Riverkeeper is also concerned with the adequacy of Entergy's analysis of the potential effects on federally listed species caused by groundwater contamination at Indian Point. The Indian Point 1 and 2 spent fuel pools are confirmed to have leaked strontium-90 and tritium into the groundwater around the plant.[114] Entergy states that the Indian Point 1 and 2 pools are leaking in section 5.1 of the ER, and also concede that "some contaminated groundwater has likely migrated to the Hudson River."[115] However, the ER at no point considers the effects of this toxic contamination on the River's federally listed species. In fact, it does not consider its effects on any part of the natural environment of the Hudson River, nor on human populations which rely on the river for drinking water and recreation. Riverkeeper is highly concerned about the lack of analysis here, particularly because of the known dangers of exposure to radioactive substances such as strontium-90 and tritium. Strontium-90 imitates calcium by concentrating in fish bones and shells of clams and blue crab. Clams are a major part of the diet of sturgeon found in the Hudson River. Riverkeeper is therefore concerned that Hudson sturgeon are being exposed to elevated levels of this dangerous substance. Without reference to additional studies done to scrutinize the effects of such contamination on listed species and humans, Entergy's ER is woefully incomplete.

ii. Candidate Species – Atlantic Sturgeon

The Atlantic sturgeon is currently a candidate species under the ESA, and is thus being considered for listing as threatened or endangered. As such, it does not currently receive

[110] ER Attachment A, Colligan (NMFS) to Thomas (Jan. 23, 2007).
[111] *Id.*
[112] *Id.*
[113] *Id.*
[114] For more information regarding the Indian Point 2 spent fuel pool leak, please see Riverkeeper's letter to NRC requesting rejection of Entergy's application to relicense Indian point, at 13, *available at* http://riverkeeper.org/dyn-content/documents/951466448464c9ba.pdf.
[115] ER § 5.1, at 5-4.

any substantive federal protections. However, if the decision is made to list the Atlantic sturgeon the NRC may have to reinitiate Section 7 consultation with NMFS to assess the effects of relicensing on this species. The changes of reinitiation are particular strong because the listing decision will likely be released well before a final decision is made regarding the relicensing of Indian Point. Entergy has based its conclusions regarding the impact of license renewal on Atlantic sturgeon on the 1999 DEIS prepared by ConEd.[116] Again, this reliance seems to be misplaced, as there was available to the company the more recent 2003 FEIS prepared by New York State

NMFS relayed its own concerns regarding Atlantic sturgeon when providing Entergy technical assistance on the presence of listed species.[117] Because young Atlantic sturgeon have been found close to Indian Point, NMFS emphasized the possibility for these yolk sac larvae and post-yolk sac larvae to become entrained in the once-through cooling system currently in place at the plant.[118] NMFS's concerns are furthered by the findings of the Atlantic Sturgeon Status Review Report, prepared for NMFS by the Atlantic Sturgeon Status Review Team.[119] That report states that, in the Hudson River, the "abundance of young juvenile Atlantic sturgeon has been declining."[120]

Entergy's conclusions regarding the effects of the once-through cooling on Atlantic sturgeon are based, as mentioned above, on the 1999 DEIS.[121] The concerns that Riverkeeper has expressed with regards to reliance on this document apply to its use here. NMFS also expressed concerns with the 1999 DEIS in its 2007 correspondence with Entergy.[122] As noted in the discussion of shortnose sturgeon above, NMFS emphasized that it had no current data regarding impingement or entrainment of sturgeon, nor on the effectiveness of Entergy's impingement/entrainment reduction system in place at Indian Point.[123] NMFS also raised concerns about the effect of "heated effluent, chlorine, and other pollutants or anti-fouling agents" on sturgeon.[124] It appears that the ER completely fails to address the effects of these potentially detrimental pollutants on either species of sturgeon.

[116] *See id.* § 4.10.5, at 4-30.
[117] *See* ER Attachment A, Colligan (NMFS) to Thomas (Jan. 23, 2007) & Colligan (NMFS) to Thomas (March 19, 2007).
[118] *See* ER Attachment A, Colligan (NMFS) to Thomas (Jan. 23, 2007).
[119] Atlantic Sturgeon Status Review Report, prepared by Atlantic Sturgeon Status Review Team for NMFS/NOAA (Feb. 23, 2007).
[120] *Id.* At § 1.3.2, at 14.
[121] *See* ER § 4.10.5, at 4-30.
[122] *See* ER Attachment A, Colligan (NMFS) to Thomas (Jan. 23, 2007) & Colligan (NMFS) to Thomas (March 19, 2007).
[123] *Id.*
[124] *See* ER Attachment A, Colligan (NMFS) to Thomas (Jan. 23, 2007).

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Exhibit D

to

Riverkeeper, Inc.'s Comments on the NRC's "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 74 Fed. Reg. 38,117, 10 C.F.R. Part 51, RIN 3150-AI42, NRC-2008-0608 (July 31, 2009).

Riverkeeper Comments on Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment (March 18, 2009)

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Chief, Rulemaking, Directives and Editing Branch
Division of Administrative Services
Office of Administration
Mailstop T-6D59
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
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Re: Riverkeeper, Inc.'s Comments on the U.S. Nuclear Regulatory Commission's Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment, Docket Nos. 50–247 and 50–286

Dear Rulemaking, Directives and Editing Branch Chief:

Riverkeeper, Inc. ("Riverkeeper") hereby respectfully submits the following comments on the U.S. Nuclear Regulatory Commission Staff's ("NRC Staff") Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment (also known as the Draft Supplemental Environmental Impact Statement, and hereinafter referred to as "DSEIS"). Notice of availability of and opportunity to comment on the DSEIS was published in the Federal Register on December 22, 2008.[1]

Introduction

Riverkeeper has been actively involved in the Indian Point relicensing proceeding due to the serious concerns relating to the continued operation of the facility, including the environmental damage caused by its antiquated once-through cooling system and leaking spent fuel pools, the vulnerability of the plant's spent fuel pools to terrorist attacks and serious accidents, and the failure of any long-term solution for permanent nuclear waste disposal. As the NRC Staff is well aware, Riverkeeper filed a successful petition to intervene in Indian Point's relicensing

[1] Nuclear Regulatory Commission, Indian Point Nuclear Generating Unit Nos. 2 and 3; Notice of Availability of the Draft Supplement 38 to the Generic Environmental Impact Statement for License Renewal of Nuclear Plants and Public Meeting for the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50–247 and 50–286, 73 Fed. Reg. 80,440 (2008).

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proceeding, and is currently litigating three contentions which have been admitted for an adjudicatory hearing.[2] On October 17, 2007, Riverkeeper submitted Scoping Comments to inform the NRC Staff's environmental review pursuant to NEPA in the license renewal proceeding.[3] Disappointingly, the NRC Staff has failed to meaningfully address any of the issues raised by Riverkeeper's comments.

An exhaustive review of the DSEIS reveals glaring deficiencies which wholly undermine the NRC Staff's initial conclusion that the environmental impacts of Indian Point's operation are not severe enough to preclude renewing its operating license.[4] Riverkeeper absolutely disagrees with this determination and submits that if the NRC Staff had performed the proper assessments as outlined in the following comments, then they would have reached the opposite conclusion. Riverkeeper urges the NRC Staff to fully consider and address the following comments prior to issuing the Final Supplemental Environmental Impact Statement for License Renewal of Indian Point ("FSEIS"), in order to come to a more accurate recommendation to the Commission.

DSEIS Section 1.0

1. Improper Reliance on Outdated GEIS

In Section 1.0 of the DSEIS, the NRC Staff explains its use of the 1996 License Renewal Generic Environmental Impact Statement, NUREG-1437 ("GEIS").[5] However, as Riverkeeper's Scoping Comments explained at length, such reliance is misplaced. The GEIS is inadequate if evidence exists of material changes affecting the baseline environment since the GEIS was written.[6] It has been 13 years since the GEIS was written. Since that time, various new circumstances have arisen that have materially changed the baseline environment, including heightened risks of terrorism, the failure of a permanent nuclear waste disposal solution, changes in population density, and progress in the viability of renewable energy technologies. Accordingly, the GEIS is no longer adequate to dispose of such issues, and they must be specifically assessed in the environmental review process for Indian Point. Unfortunately, as discussed in further detail where applicable in the comments herein, the NRC Staff has ignored such new information and continues to rely on the outdated GEIS. The NRC's refusal to consider such material changes violates the fundamental requirements of NEPA.

As explained in Riverkeeper's Scoping Comments, the NRC has failed to update the GEIS in a timely fashion as required by law.[7] The law requires the GEIS to be updated every 10 years.

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[2] Riverkeeper, Inc.'s Request for Hearing and Petition to Intervene in Indian Point License Renewal Proceeding, November 30, 2007 (hereinafter "Riverkeeper Petition for Hearing"); *See Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 and 3), LBP-08-13, 68 NRC __ (slip op. July 31, 2008) ("July 31, 2008 ASLB Order").

[3] Riverkeeper Comments on Environmental Scoping for the Indian Point License Renewal Proceeding, Docket Nos. 50-247, 50-286 (Oct. 12, 2007), *available at* http://www.riverkeeper.org/document.php/642/101207_Scoping_.pdf (hereinafter "Riverkeeper Scoping Comments).

[4] DSEIS, Main Report § 9.3, at 9-8.

[5] *Id.* § 1.2.1.

[6] Blanco v. Burton, Slip Copy, 2006 WL 2366046 (E.D. La.); League of Wilderness Defenders v. Marquis-Brong, 259 F.Supp.2d 1115 (U.S. Dist. Ct. Or. Apr. 2003).

[7] *See* Riverkeeper's Scoping Comments at 1-2; 10 C.F.R. Part 51, Subpart A, Appendix B.

The schedule explained in Riverkeeper's Scoping Comments projected a final GEIS by February 2009. That deadline has obviously passed, without any public notice or mention by the NRC of any pending review or update of the GEIS. Internal communications between DEC and NRC Staff indicates that NRC Staff have thus far failed to complete even a draft for public notice and comment by this coming summer. At this time, the required deadline for the GEIS review is three years overdue, and counting. It is ridiculous that the environmental review process for Indian Point's license renewal relies upon a document which has not been updated as legally required. Accordingly, the NRC Staff should not rely on the GEIS until the NRC has completed "10-year review" and determined whether or not the GEIS will be updated.

Moreover, as discussed in Riverkeeper's Scoping Comments, the mandates of the National Environmental Policy Act ("NEPA") require that federal agencies take a "hard look" at the environmental impacts of a proposed action.[8] This includes assessing "significant new circumstances or information relevant to the environmental concerns that bear on the proposed action or its impacts."[9]

2. Failure to Assess Deficient Emergency Planning Anywhere in the DSEIS

The deficiencies of the DSEIS comes starkly into focus when it comes to the issue of emergency planning. Indeed, the NRC Staff has classified emergency planning issues as outside the realm of license review, and no mention whatsoever of the serious concerns with Indian Point's emergency plan is made in the DSEIS.[10] This flies in the face of logic given the changes in population density and traffic pattern in the area surrounding the facility since the plant started operating. In particular, since Indian Point's initial licensing, the population around the facility has nearly doubled, resulting in significant traffic congestion that would prevent authorities from evacuating the residents living within the ten-mile Emergency Planning Zone ("EPZ") in the event of an accident or terrorist attack. Roads and bridges would not be able to handle the amount of traffic leaving the 10-mile radius and beyond in the event of an accident or attack.[11] Clearly the environmental impacts on public health will be far greater if the population within the 10-mile emergency planning zone cannot be evacuated in a timely manner.

According to an independent analysis of Indian Point's emergency plans commissioned by former New York Governor George Pataki in 2003 and authored by former FEMA director James Lee Witt found, the radiological emergency plan for Indian Point is badly flawed, unworkable and key components are unfixable. Witt found that ". . . the current radiological response system and capabilities are not adequate to . . . protect the people from an unacceptable dose of radiation in the event of a release from Indian Point . . . ."[12]

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[8] *See generally* 42 U.S.C. § 4332; Riverkeeper Scoping Comments at 2-4.
[9] 40 C.F.R. § 1502.9(c)(1)(ii); Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, 46 Fed. Reg. 18036.
[10] Environmental Impact Statement Scoping Process, Summary Report, Indian Point Nuclear Generating Station Unit Nos. 2 and 3 Village of Buchanan, New York, December 2008 ("NRC Staff Scoping Summary Report"), at 260 (finding that "offsite emergency planning is not within the scope of the NRC's environmental review" since the NRC "monitors emergency planning under requirements of the current operating license.").
[11] *See* Riverkeeper Scoping Comments at 5 n.11.
[12] Review of Emergency Preparedness of Areas Adjacent to Indian Point and Millstone, p. viii, James Lee Witt Associates, 2003.

In 2003 KLD Associates conducted a traffic study for Entergy and determined that evacuation times for the Emergency Planning Zone around Indian Point doubled since 1994. The original estimate was 2.5 hours for people to proceed with evacuation, with a total of 5.5 hours for complete evacuation. KLD estimates increased mobilization time to four hours, while complete evacuation of the region in good weather conditions could take up to 9.5 hours and in snow conditions up to 12 hours.[13] Shadow evacuation would increase this time.

The NRC itself has recognized the concerns associated with the location of Indian Point and increased population density, even prior to the September 11th terrorist attacks.[14] Were Entergy applying for a license to build a new nuclear power plant where Indian Point is now located, it is unlikely they would be allowed to do so, based on its proximity to such a highly populated area.[15] In fact, in the evaluation factors for stationary power reactor site applications before January 1997 the regulations state that residences within the exclusion area shall normally be prohibited.[16] In exclusion areas with residents, the regulations recommend low population zones - the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident.[17] The regulations state where very large cities are involved, the regulations find that a greater distance may be necessary because of total integrated population dose consideration.[18]

The regulations for reactors built after 1997 require that every site must have an exclusion area and a low population zone.[19] These regulations define low population zone as "the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident."[20] There are 300,000 people living within the ten-mile EPZ of Indian point and the only means of evacuation are primarily one and two lane roads. The regulations do not specify a permissible population density or total population within this zone because the situation may vary from case to case.[21] The regulations go on to say whether a specific number of people can, for example, be evacuated from a specific area, or instructed to take shelter, on a timely basis will depend on many factors such as location, number and size of highways, scope and extent of advance planning, and actual distribution of residents within the area.[22] As far as Indian Point is concerned, there is no low population zone, therefore if Entergy were applying to build a new nuclear power plant as opposed to a relicensing it would likely not be permitted.

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[13] Indian Point Energy Center Evacuation Time Estimate, Tbl. 1-1, p. 1-12; KLD Associates, Inc., 2003.
[14] Report of the Office of the Chief Counsel on Emergency Preparedness to the President's Commission on the Accident at Three Mile Island, October 31, 1979, p. 5 (Robert Ryan, the NRC's Director of the Office of State programs, stating "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 . . . [Indian Point is] one of the most inappropriate sites in existence.")
[15] *See* 10 C.F.R. Pts. 100.3, 100.10(b), 100.11, & 100.21(h).
[16] 10 C.F.R. § 100.3.
[17] 10 C.F.R. § 100.10(b).
[18] *Id.*
[19] 10 C.F.R. § 100.21(h).
[20] 10 C.F.R. § 50.2.
[21] *Id.*
[22] *Id.*

Based on the foregoing, it is absurd to exclude emergency planning from review during the license renewal process. The NRC Staff must assess the changes to population density and traffic concerns during its environmental review process in the context of assessing the environmental impacts of an accident or attack on Indian Point that results in a radiological release.[23] Failing to do so leaves the DSEIS fundamentally flawed.

DSEIS Section 4.0

After "objectively" describing how Indian Point interacts with the environment in Section 2.0 of the DSEIS, Section 4.0 presents the NRC Staff's assessment of the environmental impacts of continued operation of the facility. This section of the NRC Staff's review is riddled with deficiencies, as follows: (1) improper analysis of the environmental impacts of Indian Point's once-through-cooling system, (2) improper analysis of the impacts to endangered or threatened species, (3) improper analysis of groundwater contamination caused by spent fuel pool leaks, (4) failure to consider the Rockland County Desalination Project, (5) failure to properly consider impacts to the communities utilizing Hudson River water as a supply source, and (6) improper conclusions regarding the cumulative environmental impacts of continued operation.

1. Improper Analysis of Environmental Impacts of Once-Through Cooling System

NRC regulations implementing NEPA classify the effects of entrainment, impingement, and heat shock on the protection and propagation of fish and shellfish as "Category 2" environmental issues which must be assessed in the site-specific SEIS. 10 C.F.R. Part 51, Appendix B to Subpart A. The DSEIS "must contain an analysis of those issues identified as Category 2" in Appendix B to subpart A. 10 C.F.R. 51.71(d). The DSEIS is NRC Staff's independent evaluation of such Category 2 issues. 10 C.F.R. § 51.70. Despite this mandate, as demonstrated below herein, NRC Staff has failed to adequately analyze the adverse impacts on aquatic resources by impingement, entrainment, and heat shock caused by Indian Point's once-through cooling system. As a result, the DSEIS violates NEPA and NRC implementing regulations at 10 C.F.R. §§ 51.70, 51.71.

Riverkeeper's comments regarding NRC Staff's analysis of Indian Point's once-through cooling system were prepared with the expert assistance of Drs. Peter Henderson and Richard Seaby of Pisces Conservation Ltd. ("Pisces"). Pisces' expert report in support of these comments – "Comments Relating to the Indian Point NRC draft EIS on the Cooling System" (herein the "Pisces Report") – is attached as Exhibit ___.[24] In short, Pisces concludes that the NRC Staff's assessment of impingement and entrainment – undertaken on the representative important species ("RIS") of 17 fish species and the blue crab – is based on a scoring system that initially appears objective and quantitative. However, detailed examination of the method shows that it

[23] For details regarding how the NRC Staff incorrectly excluded terrorism and certain accidents from review, see comments on DSEIS Section 5.0 below.

[24] In 2007, Pisces prepared a report entitled "Entrainment, Impingement and Thermal Impacts at Indian Point Power Station" ("2007 Pisces Report"); a copy of the 2007 Pisces Report was provided to NRC Staff in November of 2007 as an attachment to Riverkeeper's Request for a Hearing and Petition to Intervene with respect to the license renewal proceeding for the Indian Point Nuclear Power Station (Attachment 4 to the Declaration of Peter Henderson).

makes assumptions about the statistical properties of populations, the impact of cooling water systems on invertebrates prey species, and the relative importance of local and larger-scale changes in population number, which are unjustified and arbitrary.

Although impingement and entrainment effects are considered together by NRC Staff – an approach that has merit – the impact of Indian Point's cooling system is assessed using a flawed scoring system that takes into account changes in species abundance (the trend) and strength of connection (connection), and which attempts to measure the relationship between abundance in the environment and Indian Point's direct fish mortality. This approach differs significantly from the New York State Department of Environmental Conservation ("NYSDEC") evaluation and overall conclusion regarding these impacts, which focuses on fish mortality rather than fish populations, and has determined that the cooling system results in significant adverse environmental impacts. The NRC Staff should defer to NYSDEC's evaluation pursuant to NRC precedent.

A particular problem with NRC Staff's assessment is the distinction between '*Large*' and '*Small*' population impacts, which is hard to support from an examination of the overall population trend data. The use of both river-wide and river segment 4 data (where Indian Point is located), and the use of population decline criteria that include a measure of the deviation from the mean of a normal distribution produce results that do not necessarily reflect the actual population trends, and have the potential to understate the importance of recent changes in abundance.

Another concern is the scoring method used to assess the strength of connection line of evidence to determine whether operation of the Indian Point cooling system has the potential to influence RIS populations near the facility or within the lower Hudson River; this is a poor measure of the impact of the power plant on the species. The strength of connection is a flawed measure because it is based on rank abundance. Furthermore, the lack of importance given to impacts on invertebrates makes low to moderate levels of impact for many species almost inevitable.

NRC Staff's comparison of species' proportional rank abundance in the power station kill with that living in the river results in potentially misleading conclusions. For example, the fish that contributes the highest proportion of the number of individuals killed by the power plant, and which is also the commonest in the river, only has a medium strength of connection. In Pisces' opinion, such a situation where a fish is killed in high numbers and is locally common would suggest a high degree of linkage. A number of the RIS species have a prey score for impingement and entrainment of 1, and thus are unlikely to score highly for the strength of connection. This feature of the scoring protocol is thus central to the final outcome. Another key underlying point to note about NRC Staff's analysis of impingement and entrainment is the reliance on data collected between 1981 and 1990. These data are old and may not reflect current conditions. In fact, many populations have shown marked changes since that period. This calls into question the reliability of the conclusions when applied to the future.

NRC staff also concludes that thermal impacts associated with the discharge are small to moderate, principally on the grounds that there is no evidence for the scale of the impact. The assertion that, because no appropriate evidence has been collected, there is therefore only a small to moderate impact, is not logical and contrary to NEPA. In addition, NRC staff state that they cannot determine the effects of climate change, particularly in relation to thermal issues. We believe they should have, at the very least, concluded that they needed more data on thermal issues before reaching a conclusion.

a. *NRC Staff's Flawed Assessment of Impingement and Entrainment*

As noted above, impingement and entrainment effects are considered together by NRC Staff, which is an approach that has merit because the goal is to measure the well-being of all fish stages. However, the impact of Indian Point's cooling system is assessed using a faulty scoring system which attempts to measure the relationship between abundance in the environment and Indian Point's direct fish mortality.

NRC Staff's methodology has many problems, which are explained in detail in the Pisces Report. With respect to the trend (the so-called "Assessment of Population Trends–The First Line of Evidence"), the Pisces Report demonstrates that the NRC Staff's distinction between '*Large*' and '*Small*' impingement and entrainment impacts is hard to support.[25] Indeed, the weight of evidence ("WOE") scoring system to measure such impacts, which uses both river-wide and river segment 4 data (where Indian Point is located), and uses population decline criteria that include deviation from the mean of a normal distribution, produces results that do not necessarily reflect the actual population trends, and have the potential to understate the importance of recent changes in abundance.[26] For instance, examination of the river-wide abundance trends for white fish and weakfish indicates that both species have, since 1990, appreciably declined in abundance. Yet while the decline in white catfish is classified as 'Large', that in weakfish is 'Small'.[27] Such differences are more a reflection of the arbitrary nature of the statistical and quantitative approach taken, than a real difference in the state and health of the populations.

Turning to the strength of connection (the so-called "Assessment of Strength of Connection–The Second Line of Evidence"), to determine whether operation of the Indian Point cooling system has the potential to influence RIS populations near the facility or within the lower Hudson River, the Pisces Report also unveils serious problems.[28] NRC Staff's describes how strength of connection is measured, as follows:

> Impingement and/or entrainment can also remove and reintroduce RIS prey into the aquatic system in a manner that alters food web dynamics and produces indirect effects that may result in decreased recruitment, changes in predator-prey relationships, changes in population feeding strategies, or movements of populations closer to or farther away from the cooling system intakes or discharges. Staff based the analysis of impingement on the concordance of two ranked proportions. The first proportion was the ratio of the number of YOY and yearling fish of each

[25] Pisces Report at 2-5.
[26] *Id.* at 4-5.
[27] *Id.* at 2 (citing to DSEIS' Table 4-4).
[28] *Id.* at 5-9.

species impinged in relation to the sum of all fish impinged. The second proportion was the ratio of each species abundance in the river near IP2 and IP3 relative to the total abundance of all 18 RIS. A large rank for both proportions would mean that the proportion impinged for the given RIS and the proportion abundance in the river were both large. The ratio of these two ranks would then be close to 1, suggesting that the stationary sampler was sampling proportionately to the abundance in the river (a medium strength of connection).[29]

The first point to note is that the analysis is undertaken by comparing a species' proportional rank abundance in Indian Point's actual kill with that living in the river. Rather oddly, a fish that contributes the highest proportion to the number of individuals killed by the power plant, and which is also the commonest in the river, only has a medium strength of connection.[30] In Pisces' opinion, such a situation where a fish is killed in high numbers and is locally common would suggest a high linkage.[31] This is a point that needs reconsideration and critical appraisal. The effect is to reduce the assessment of the power plant's impact on abundant, commonly-caught fish.

The second point to note is that a species which is ranked less common in Indian Point's kill than in the river will be scored small to moderate.[32] The key point is that the power plant kill may actually reflect the abundance in the Hudson River, however the rank could decline if other species are killed in unusually high numbers.[33] Thus, each species is not being fairly assessed on its own merits.

To illustrate the weaknesses in NRC Staff's approach, Pisces points to Juvenile rainbow smelt, a species that has disappeared from fish surveys since the mid 1990s.[34] This species is assessed in the trends (the population line of evidence) as '*Large*'.[35] However, NRC Staff considers the impact of Indian Point on this species to be moderate because the strength of connection is assessed as '*Medium*'.[36] The strength of connection is only medium because both the impingement and entrainment prey scores are 1. The example demonstrates that an unsubstantiated and unproven assumption by NRC Staff, that invertebrate prey species are not affected by the cooling water system, leads in turn to the conclusion that the rainbow smelt, a species which has effectively disappeared from the data in recent years and has been assessed as potentially highly impacted by entrainment, is only given a moderate impact. The Atlantic tomcod makes another telling example.[37] The tomcod population shows long-term decline, thus the population line of evidence is large, however, NRC Staff assigns a low-to medium strength of connection and the final conclusion is an impact small to moderate.

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[29] DSEIS, Appendix H, at H-29.
[30] Pisces Report at 6.
[31] *Id.*
[32] *Id.*
[33] *Id.*
[34] *Id.* at 7-8.
[35] *Id.* at 7 (citing to DSEIS' Table 4-4).
[36] *Id.*
[37] *Id.* at 8.

The Pisces Report observes that before conclusions of this nature can be justified, the assertion that the cooling water system has no impact on invertebrate prey species needs to be demonstrated.[38] There is considerable evidence that large numbers of invertebrates are entrained and potentially killed by the cooling water system. There is therefore no reason to believe that invertebrate prey species are not adversely affected. This impact may extend beyond entrainment effects as the heated discharge water may also adversely affect them.

Another problem with NRC Staff impingement and entrainment assessment is the age of the data.[39] NRC Staff is relying on data collected between 1981 and 1990. These data are old, and may not reflect current conditions. Further, there are hints that the NRC staff did wonder if the data reflected present conditions. If impinged data were available for 2008 would we find that entrained and impinged fish had changed even more? The risks inherent with the use of old data are not addressed. In addition, it is worth noting that, although the impingement and entrainment data are over 17 years old, the population data that shows the decline in so many of these species is current. The differences in the population of fish between the 1990s and the present are great.

b. <u>NRC Staff's Improper Analysis of Thermal Impacts</u>

The NRC Staff conclude that thermal impacts associated with the discharge are small to moderate, principally on the grounds that there is no evidence for the scale of the impact:

> In the absence of specific studies, and in the absence of effects sufficient to make a determination of a LARGE impacts, the NRC staff concludes that thermal impacts from IP2 and IP# [sic] could thus range from SMALL to MODERATE depending on the extent and magnitude of the thermal plume, the sensitivity of various aquatic species and lifestages likely to encounter the thermal plume, and the probability of an encounter occurring that could result in lethal or sublethal effects.[40]

The assertion that, because no appropriate evidence has been collected, therefore there is only a small to moderate impact is not logical and contrary to NEPA.[41]

Linked to thermal impacts must be a consideration of climate change impacts. The following conclusion is reached in the DSEIS:

> Thus, the NRC staff has concluded that the cumulative effects of climate change cannot be determined.[42]

Therefore, NRC Staff is willing to conclude that thermal effects are small to moderate and can therefore be dismissed, but Staff cannot determine the effects of climate change. We believe that

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[38] *Id.*
[39] *Id.* at 9.
[40] DEIS, Main Report at 4-27.
[41] Pisces Report at 11.
[42] DSEIS, Appendix H, at H-60.

NRC Staff should have, at the very least, acknowledged that they needed more data on thermal issues before reaching a conclusion.[43]

c. *NRC Staff has Failed to Defer to the New York Department of Environmental Conservation*

The NRC Staff has failed to defer to, and coordinate with the responsible state agency in charge of protecting aquatic impacts under federal delegation and state law – the New York State Department of Environmental Conservation ("NYSDEC") – as required by NRC regulations and precedent. NRC regulations implementing NEPA require that the NRC cooperate "to the fullest extent possible" with State and local agencies to reduce duplication and inconsistencies.[44] Despite this mandate, however, NRC Staff has largely ignored NYSDEC's environmental review and permitting of Indian Point's cooling system under the federal Clean Water Act ("CWA"). NYSDEC's review and re-permitting of Indian Point's cooling system has been ongoing since 1992, and is currently in the final adjudicatory phase. Following the NRC's instructions in the *Seabrook* case, the NRC Staff must defer to NYSDEC's assessment of entrainment and impingement, and its permitting determinations.[45]

Indian Point is operating a once-through cooling system under an administratively extended State Pollutant Discharge Elimination System ("SPDES") permit issued by the NYSDEC for the period 1987-1992.[46] In July 31, 2008, the Atomic Safety and Licensing Board ("ASLB") ruled that Entergy can rely on this permit for purposes of satisfying 10 C.F.R. § 51.53(c)(3)(ii)(B); thus, it need not assess the impacts of impingement, entrainment, and heat shock in the Environmental Report.[47] Indian Point's 1987 SPDES permit has been administratively continued, however, pending issuance of a final SPDES permit currently subject to adjudication by the NYSDEC.

Beginning in 1992, the NYSDEC has required a specific environmental impact statement ("EIS") under the State's Environmental Quality Review Act[48] ("SEQRA") to consider Indian Point's entrainment, impingement, and thermal impacts, as well as mitigation alternatives. As a result, the prior owners of Indian Point and other Hudson River power plant generators prepared the 1999 Draft Environmental Impact Statement for permit renewal.[49] The final environmental impact statement ("SPDES FEIS") was prepared and released by the NYSDEC in 2003, after Hudson River advocates filed an action against the NYSDEC in New York State Supreme Court.[50]

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[43] Pisces Report at 11.
[44] 10 C.F.R. § 51.70 (c); 40 C.F.R. § 1506.2 (b) and (c).
[45] *See Public Service Co. of N.H.* (Seabrook Station, Units 1 and 2), *Seabrook*, CLI-78-1, 7 NRC at 26 (1978); *Entergy Nuclear Vt. Yankee* (Vermont Yankee Nuclear Power Station), CLI-07-16, 65 NRC 371, 389 (2007).
[46] NYSDEC, 1987, State Pollutant Discharge Elimination System ("SPDES") Discharge Permit NY-000-4472, Indian Point Generating Stations (NYSDEC, 1987 SPDES Permit.
[47] July 31, 2008 ASLB Order, *supra*.
[48] New York State Environmental Conservation Law, Article 17.
[49] 1999 Draft Environmental Impact Statement Concerning the Applications to Renew SPDES Permits for the Roseton 1 and 2, Bowline 1 and 2 and Indian Point 2 and 3 Electric Generating Stations (1999 DEIS).
[50] *See Matter of Brodsky v. Crotty, Sup. Ct., Albany County*, Keegan, J., Index No. 7136-02.

In the SPDES FEIS, the NYSDEC determined that Indian Point's dramatic intake and use of Hudson River water has significant adverse environmental impacts and must be mitigated.[51] Consequently, NYSDEC prepared a draft SPDES permit requiring closed cycle cooling at Indian Point.[52] In 2008, the NYSDEC advanced the SPDES proceeding to the evidentiary phase, at the time when it resolved various appeals by the parties to the proceeding. Notably, NYSDEC determined that there is no need to adjudicate whether Indian Point's cooling system results in adverse environmental impacts because this issue has already been established as a matter of law and fact, and required that a supplemental EIS be prepared during the adjudication.[53]

The DSEIS not only contradicts the key findings and conclusions on entrainment and impingement at Indian Point contained in the SPDES FEIS but completely ignores the 2008 NYSDEC Ruling.[54] Tellingly, the 2008 NYSDEC Ruling relied on the United Stated Court of Appeals for the Second Circuit, in its decisions referred to as *Riverkeeper I* (2004) and *Riverkeeper II* (2007).[55] As the 2008 NYSDEC Ruling stated, the Second Circuit "specifically rejected the view that the EPA should only have sought to regulate impingement and entrainment where they have deleterious effects on the overall fish and shellfish populations in the ecosystem and emphasized that the EPA's focus on the number of organisms killed or injured by cooling water intake structures is eminently reasonable.[56] Thus, the NRC Staff's marked reliance on population trends is inconsistent with NYSDEC's and EPA's focus on the number of organisms killed or injured by the cooling system.

The DSEIS also includes, in its alternatives analysis (in Section 8.1.2), a Restoration Alternative that is unlawful based on the Second Circuit rulings in its *Riverkeeper I* and *Riverkeeper II* decisions. Pursuant to *Riverkeeper I* and *Riverkeeper II* "restoration" alternatives both at existing and new facilities are contrary to the CWA. Therefore, Section 8.1.2 should be stricken in its entirety. These failures and inconsistencies runs contrary to NRC's own precedent set forth in *Seabrook*, CLI-78-1, 7 NRC at 26, and *Entergy Nuclear Vt. Yankee*, 65 NRC at 387, indicating that NRC Staff must defer to the responsible permitting authority, here the NYSDEC.

NYSDEC's 2008 Ruling also requires that a supplemental EIS be prepared to examine the environmental impacts that were not already addressed in the SPDES FEIS for closed cycle cooling, the proposed interim measures, and any alternative technologies that Entergy may propose in order to minimize adverse environmental impact at Indian Point.[57] There is no

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[51] NYSDEC, 2003, Final Environmental Impact Statement Concerning the Applications to Renew SPDES Permits for the Roseton 1 and 2, Bowline 1 and 2 and Indian Point 2 and 3 Electric Generating Stations (hereinafter NYSDEC, 2003 FEIS).
[52] NYSDEC, 2003, Draft SPDES Permit for Entergy Nuclear Indian Point Units 2 & 3 (NYSDEC, 2003 Draft SPDES Permit).
[53] *See Matter of Entergy Nuclear Indian Point 2 and Entergy Nuclear Indian Point 3*, Interim Decision of the Assistant Commissioner (August 13, 2008), *at* http://www.dec.ny.gov/hearings/45956.html ("NYSDEC, 2008 Ruling"), at 14-18 & 36-41.
[54] NYSDEC, 2003 FEIS, at 58.
[55] NYSDEC, 2008 Ruling, at 17 (*citing to* Riverkeeper I, [358 F.3d 174] at 196; Riverkeeper II, [475 F.3d 83] at 125.
[56] *Id.* fn 12 (citing to "Riverkeeper II, at 125 (quoting Riverkeeper I, at 196).").
[57] *Id.* at 39.

indication whatsoever that NRC Staff will defer to, and/or coordinate with, the NYSDEC's supplemental EIS, as required by NRC regulations and precedent.[58]

Finally, NRC Staff has not recognized NYSDEC's statements and concerns with respects to Indian Point's thermal impacts. The DSEIS' lack of a thermal analysis (discussed in the previous section) is plainly at odds with the available data on Indian Point's thermal plume, which shows that the facility does not comply with New York water quality standards for thermal discharges. As noted in the scoping comments filed by the State of New York – later incorporated in New York State's Petition to Intervene with respect to aquatic impacts:

> The available data -- generated from the applicant and the other Hudson River power plant generators as part of the HRSA -- regarding the thermal discharge at Indian Point demonstrates that state water quality criteria are *not* being met.[59]

In addition, the 2007 Pisces Report on Entrainment, Impingement and Thermal Impacts, submitted to NRC Staff in November of 2007, clearly shows that temperature increases in the Hudson River caused by Indian Point's operation have had significant effects on aquatic life.

2. Improper Analysis of Impacts to Endangered or Threatened Species

a. *Listed Species – Shortnose Sturgeon*

The license renewal of the Indian Point nuclear facility is a federal action which "may affect a listed species or critical habitat."[60] In the DSEIS, the NRC Staff admits that the license renewal will require consultation under Section 7 of the Endangered Species Act of 1973 ("ESA").[61] Because the operation of the Indian Point nuclear facility has resulted in the taking of the endangered shortnose sturgeon without a permit,[62] and the continued operation will continue to affect the fish if the license is renewed and Indian Point operates without a closed-cycle cooling system, such renewal is a federal action which may affect a listed species.

The shortnose sturgeon was listed under the Endangered Species Preservation Act on March 11, 1967 and remained on the Endangered Species List when the ESA became law in 1973. Females live significantly longer than males; while females have reportedly reached 67 years, males usually will not live past 30.[63] This being the case, the sexes are nearly equal in number when young, but when the shortnose reaches 90 cm, females outnumber males by approximately four to one.[64] Also, because they are long living fish, in the mid-Atlantic region, the males will reach

[58] 10 C.F.R. § 51.70 (c); 40 C.F.R. § 1506.2 (b) and (c); *Seabrook*, CLI-78-1, 7 NRC at 26 (1978); *Entergy Nuclear Vt. Yankee*, CLI-07-16, 65 NRC 371, 389 (2007).
[59] NYS, Scoping Comments, at 8 (emphasis in original text).
[60] 50 C.F.R. § 402.14(a) (2008).
[61] *See* 16 U.S.C. § 1536 (2006); *See also* DSEIS, Main Report § 4.6, at 4-49.
[62] *See id.* § 4.6, at 4-51 (reporting that 714 endangered shortnose sturgeon were impinged at Indian Point from 1975 to 1990).
[63] NOAA Fisheries Office of Protected Resources, Shortnose Sturgeon, http://www.nmfs.noaa.gov/pr/species/fish/shortnosesturgeon.htm (last visited March 13, 2009).
[64] *Id.*

reproductive maturity between four and seven years and the females at approximately eleven years.[65] Even still, while males may spawn every year, females will often go three years between spawning.[66] Because of this slow maturation process, *any* impacts on the shortnose sturgeon will have noticeable effects. It is, thus, critical that impacts on the shortnose species are kept to a minimum.

Riverkeeper recognizes that Section 7 consultation is based on astute principles designed to further the basic purpose of the ESA, which is to conserve endangered and threatened species and the ecosystems on which they depend.[67] Of particular relevance here are section 7 "philosophies" which encourage reliance on biology first, emphasize the ecosystem approach to species conservation, and stress the importance of the "best available scientific and commercial data."[68] These are commendable standards of practice, and NRC Staff should adhere to them during the relicensing process.

Although the NRC Staff admits that the continued operation of the Indian Point nuclear facility will impinge the shortnose sturgeon, the data relied upon in the DSEIS and the NRC Staff's Biological Assessment ("BA") appended thereto for assessing those impacts is incomplete at best.[69] The data provided by Entergy accounts only for shortnose sturgeon impinged at Indian Point Units 2 and 3 from 1975 through 1990.[70] Furthermore, there are several years during this period that have no reported data at all[71] and the data can be questioned due to the fact that over 90% of the recorded impingements occurred in only two years.[72] In a letter from Mary A. Colligan (National Marine Fisheries Service ("NMFS")) to David J. Wrona (NRC), NMFS echoed Riverkeeper's concerns about the lack of reporting data and the inconsistencies in those reports.[73] In Colligan's letter, NMFS instructed the NRC that there was insufficient information provided in the DSEIS and BA to start formal consultation.[74] Specifically, NMFS was concerned with the gaps in the reported impingements at the Indian Point nuclear facility.[75] More importantly, the impingement data provided in the DSEIS was from a period when the Indian Point nuclear facility did not use Ristroph screens to minimize fish impingement, which were installed in 1991.[76]

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[65] *Id.*
[66] *Id.*
[67] 16 U.S.C. § 1531(b).
[68] U.S. Fish and Wildlife Service and National Marine Fisheries Service, ESA § 7 Consultation Handbook, § 1.1, at 1-2, *available at* http://www.fws.gov/endangered/pdfs/Sec7/handbook/CH1-3.PDF.
[69] *See generally* DSEIS § 4.6; *see also id.* Appendix E, Biological Assessment of the Potential Effects on Federally Listed Endangered or Threatened Species from the Proposed Renewal of Indian Point Nuclear Generating Plant, Unit Nos. 2 and 3 ("BA"), at E-88 – E-100.
[70] *Id.*
[71] *Id.* (no reported impingements in 1980-1983, 1985, 1986, 1988-1990).
[72] *Id.* (out of 317 total impinged shortnose sturgeon, 176 were recorded in 1984 and 116 were recorded in 1987).
[73] Colligan (NMFS) to Wrona (NRC), RE: Biological Assessment for License Renewal of the Indian Point Nuclear Generating Unit Nos. 2 and 3 (Feb. 24, 2009), attached to Riverkeeper's Comments as Exhibit __.
[74] *Id.*
[75] *Id.*
[76] DSEIS, Appendix E, BA § 4.3.2, at E-96.

Moreover, the impingement data cited in the BA, which the NRC Staff included in order to comply with Section 7 of the ESA,[77] is self-conflicting and does not create a complete, accurate or current illustration of the status of impinged shortnose sturgeon at the Indian Point nuclear facility. Included in the BA are two impingement reports, one each from NMFS and Entergy.[78] The NRC Staff concluded that because Entergy's reports of impinged sturgeon were larger than those of NMFS, they would disregard the NMFS reports.[79] Although it is important for the BA to be a conservative analysis of the impacts to the sturgeon, the NRC Staff's only reasoning disregarding the NMFS reports was that they were significantly lower than the data supplied by Entergy.[80]

Entergy and the NRC Staff state that the implementation of the Ristroph screens, installed in 1991, may have resulted in reduced the impacts to shortnose sturgeon.[81] Despite these assurances from Entergy and the NRC Staff that these screens are mitigating the impingement of shortnose sturgeon, there is no data to support this conclusion. Because the NRC Staff fails to rely on any impingement monitoring after the screens were installed,[82] it cannot be assumed or concluded that these screens have had any mitigating effects. In order to properly assess the impacts of the Ristroph screens, the NRC Staff must rely on actual impingement data. The NRC Staff even admits that they cannot assess the extent to which the installation of the screens might reduce impacts to the sturgeon.[83]

The lack of complete and recent impingement data significantly limits the NRC Staff's ability to form a conclusion about the actual affects on the shortnose sturgeon. Indeed, the NRC Staff readily admits that it is unable to come to a definitive conclusion based on this incomplete data. Based on its review of the impingement data supplied by Entergy, the NRC Staff finds in the DSEIS that due to "the uncertainty of the current impingement losses of . . . sturgeon and because insufficient data exist to use the [weight of evidence] approach," the effects on endangered shortnose sturgeon due to license renewal could range from "SMALL to LARGE."[84] In fact, the NRC Staff explicitly admits that the supplied data was insufficient and current monitoring is needed to form a conclusion about the effects of impingement on the shortnose sturgeon.[85] However, instead of gathering data to support a rational and reasonable assessment of the affects to the shortnose sturgeon, the NRC Staff was content to leave their analysis as incomplete and uncertain. NMFS has also shown concern with this lack of recording data.[86] Riverkeeper agrees with NMFS that unless the NRC Staff gathers impingement data or studies

[77] 50 C.F.R. § 402.14 (2008).
[78] DSEIS, Appendix E, BA § 4.3.2, at E-96, E-97.
[79] *Id.* at E-97.
[80] *Id.*
[81] *See id.* at E-98.
[82] *See* DSEIS, Main Report Table 4-11 Impingement Data for Shortnose and Atlantic Sturgeon at IP2 and IP3, 1975-1990 (data from Entergy 2007b), at 4-52.
[83] DSEIS, Appendix E, at E-99.
[84] DSEIS, Main Report § 4.6.1, at 4-52.
[85] DSEIS, Appendix E, BA § 4.3.2, at E--98 -- E-99 (concluding that the license renewal would likely affect the species, but without current monitoring data, it is impossible to gauge the extent of the impact).
[86] Colligan (NMFS) to Wrona (NRC), RE: Biological Assessment for License Renewal of the Indian Point Nuclear Generating Unit Nos. 2 and 3 (Feb. 24, 2009).

reflecting accurate estimates of impinged shortnose sturgeon, the impact assessment in the DSEIS is inadequate.[87]

The NRC Staff's inconclusive determination also rests in part on the lack of data regarding entrainment and heat shock. While the NRC Staff says that there is likely no entrainment of shortnose sturgeon occurring, this determination is based on a review of data dating back to the 1980s.[88] The NRC Staff admits that entrainment cannot be ruled out and that there is currently no monitoring program at Indian Point.[89] Similarly, in regards to potential heat shock, the NRC Staff admits that increased temperatures can have a "significant effect on the shortnose sturgeon," however, could not determine the extent to which the population would be affected because additional studies are required.[90]

The NRC Staff's ultimate "conclusion" that the range of impacts to shortnose sturgeon is "SMALL to LARGE"[91] lacks any definitiveness and is essentially meaningless, improperly flouting the requirements of NEPA.[92] While the lack of monitoring data and studies inhibits the ability to form specific conclusions, this does not excuse the NRC Staff from their obligation to accurately assess the impacts on endangered species affected by Indian Point. It is clear that the NRC Staff did not effectively or sufficiently analyze the impacts that license renewal would have on the shortnose sturgeon, and the NRC Staff cannot justify its inadequate conclusion simply by pointing to the unavailability of relevant data.

Pisces' expert report corroborates the deficiency of the NRC Staff's review.[93] Pisces points out that the data used by the NRC Staff to assess the number of shortnose and Atlantic sturgeon impinged at Indian Point is old, and that the lack of monitoring of impingement means that they do not know if current impingement rates are similar to those between the 1970s and 1990s. In addition, Pisces points out that the NRC Staff admit that they cannot assess the thermal impact on these species. The Pisces expert report concludes that, given these large uncertainties, the NRC Staff came to no conclusion on the impact of Indian Point on sturgeon, giving a range of small to large for the future impacts.[94]

The NRC Staff's analysis of the impacts to shortnose sturgeon is also wanting since it does not consider the impacts caused by IP1. If the license for Indian Point Units 2 and 3 is renewed, Entergy will use some of the systems from Indian Point Unit 1 in the continued operations of the facility.[95] Specifically, the intake structure for Unit 1 will be used to "[p]rovide support, shelter and protection for equipment credited for regulations associated with fire protection."[96] The

[87] *Id.*
[88] DSEIS, Main Report § 4.6.1. at 4-51; DSEIS, Appendix E at E-96.
[89] DSEIS, Appendix E at E-96.
[90] DSEIS, Main Report § 4.6.1. at 4-51; DSEIS, Appendix E at E-99-100.
[91] DSEIS, Main Report § 4.6.1, at 4-52.
[92] *See* 42 U.S.C. § 4332; *Marsh v. Oregon Natural Resources Counsel*, 490 U.S. 360, 374 (1989).
[93] Pisces Report at 10.
[94] *See* Pisces Report at 10.
[95] *See generally*, NRC: Indian Point Nuclear Generating Unit Nos. 2 and 3 – License Renewal Application (Apr. 30, 2007), *available at* http://www.nrc.gov/reactors/operating/licensing/renewal/applications/indian-point.html#application ("Entergy LRA").
[96] Entergy LRA § 2.4.2, at 2.4-5.

License Renewal Application states that travelling screens have been installed at the Unit 1 intake structure[97], but neither the DSEIS nor the application analyze the impingement impacts on the shortnose sturgeon. Moreover, neither of these documents cites to any reports of past shortnose impingements at the Unit 1 intake structure. By failing to analyze the effects of the continued use of the Unit 1 Intake Structure, the NRC has ignored another point of impact on the shortnose sturgeon. If Entergy is going to use the intake structure from Unit 1 in the continued operation of Indian Point, the NRC staff must take into account past and future impingement from Unit 1 in order to accurately analyze the total impacts on the species.

The NRC Staff also fails to recognize that the Indian Point nuclear facility will require an incidental take permit in order to comply with the ESA.[98] The NRC admits that future operation of the facility will likely impinge shortnose sturgeon, and this future impingement is considered a "take" under the ESA.[99] Any reliance on the fact that shortnose sturgeon appear to be rebounding in the River, is unfounded, since the fact remains that impingement is still occurring.[100] *Every* impingement of shortnose sturgeon that occurs without an incidental take permit is a violation of the ESA. Because the taking of shortnose sturgeon would be incidental to the operation of the plant, the ESA requires that the facility obtains a permit to regulate and minimize the impact on the species. Riverkeeper's concerns about future takings were echoed in a letter from Mary Colligan, Assistant Regional Administrator for Protected Resources for NMFS Northeast Region, to James Thomas at Enercon Services, a company assisting Entergy in its preparation of its Environmental Report (ER).[101] In this letter, Colligan stated that NMFS is aware that Indian Point has impinged shortnose sturgeon and that such impingement is a take under the ESA.[102] Colligan also wrote that since Indian Point has operated without a permit, such takes were violations of the ESA.[103] The DSEIS failed to note that any future impingements of shortnose sturgeon at the Indian Point nuclear facility without a permit will also be violations of the ESA. In the absence of recent data showing that impingement is not occurring, the NRC Staff and NMFS must assume that the shortnose sturgeon are continuing to be impacted by impingement, and comply with the law accordingly.

Moreover, the DSEIS is inadequate due to a complete lack of assessment of the potential effects on federally listed species caused by groundwater contamination at Indian Point. As discussed in more detail below, the IP1 and IP2 spent fuel pools are have leaked extensive amounts of highly toxic radionuclides, including strontium-90 and tritium, into the groundwater around the plant. The NRC Staff at no point in the DSEIS assesses the effects of this toxic contamination on the Hudson River's federally listed shortnose sturgeon.. Riverkeeper is highly concerned about the

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[97] *Id.* § 2.3.3.19, at 2.3-157.

[98] *See* 15 U.S.C. § 1539(a)(1)(B) (2006); *see also* 50 C.F.R. § 402.14(i) (2008) (NMFS may also include an incidental take statement in a biological opinion after formal consultation, but there is no reference to this option either).

[99] *See* 15 U.S.C. § 1532(19) (2006).

[100] *See* DSEIS, Main Report § 2.2.5.5, at 2-77 to 2-78; DSEIS, Appendix E, at E-95. In fact, the NRC Staff admits that increased population of shortnose sturgeon will likely result in increased impingement. *Id.* at E-97.

[101] *See* Entergy, Inc., License Renewal Application, Appendix E: Applicant's Environmental Report, Operating License Renewal Stage, Indian Point Energy Center (ER), Attachment A, Colligan (NMFS) to Thomas (Enercon) (Mar. 19, 2007), *available at* http://www.nrc.gov/reactors/operating/licensing/renewal/applications/indian-point/ipec-er-attachment-a2.pdf.

[102] *See id.*

[103] *See id.*

lack of analysis here, particularly because of the known dangers of exposure to radioactive substances such as strontium-90 and tritium. Strontium-90 imitates calcium by concentrating in fish bones and shells of clams and blue crab. Clams are a major part of the diet of sturgeon found in the Hudson River. Riverkeeper is therefore concerned that Hudson sturgeon are being exposed to elevated levels of this dangerous substance. Without reference to additional studies done to scrutinize the effects of such contamination on listed species and humans, the NRC Staff's DSEIS is woefully incomplete.

b. Candidate Species – Atlantic Sturgeon

The Atlantic sturgeon is currently a candidate species under the ESA, and is thus being considered for listing as threatened or endangered. As such, it does not currently receive any substantive federal protections. However, if the decision is made to list the Atlantic sturgeon the NRC may have to reinitiate Section 7 consultation with NMFS to assess the effects of relicensing on this species. The chances of re-initiation are particular strong because the listing decision will likely be released well before a final decision is made regarding the relicensing of Indian Point.

Riverkeeper is concerned with the NRC Staff's assessment of impacts on the Atlantic sturgeon. Similar to the data on shortnose sturgeon impingement, entrainment, and heat shock, the DSEIS relies on insufficient records to assess the impacts on the Atlantic sturgeon. Although the data for the impingement of Atlantic sturgeon is more complete than that for the shortnose sturgeon, there is no record of impinged fish after 1987.[104] The NRC Staff does not give a reason for why the monitoring of impingement was halted over 20 years ago and also fails to make its current impact assessments on best estimates or currently available data. Riverkeeper is also concerned that the reporting of impinged Atlantic sturgeon reflects the impingement of over 4,000 fish from 1976 to 1987.[105] If the Atlantic sturgeon is indeed listed under the Endangered Species Act, the NRC will be required to engage in the ESA Section 7 consultation process, in order to address the "taking" of Atlantic sturgeon by Indian Point's operation, and to consider mitigation measures necessary to minimize impingement and entrainment losses. The DSEIS lacks the current data that is necessary to assess potential impacts to the species and recommend mitigation strategies that could lessen the harm of those impacts. As a result, the NRC Staff has failed to provide sufficient factual support for its conclusion regarding the impacts of relicensing Indian Point to the Atlantic sturgeon.

3. Improper Analysis of Groundwater Contamination Caused by Spent Fuel Pool Leaking

Sections 4.3, 4.5, and 4.7 of the DSEIS contain the NRC Staff's evaluation of the environmental impacts of spent fuel pool leaking at Indian Point.[106] The NRC Staff discusses the status of the leaking and its investigation findings earlier in the DSEIS, in section 2.2.7, but reserves

[104] DSEIS, Main Report § 4.6.1, at 4-52.
[105] *Id.*
[106] *Id.* §§ 4.3, 4.5, 4.7.

judgment on the environmental impacts of the leaking until section 4.0.[107] These brief portions of the DSEIS, taken together totaling a paltry 4 pages at best, constitutes the NRC Staff's entire evaluation of the extensive spent fuel pool leaking that has been ongoing at the Indian Point facility for years. A review of the NRC Staff's collective assessment in the DSEIS of the spent fuel pool leaks reveals an utter failure to address any of the concerns raised in Riverkeeper's Scoping Comments or by the contention filed by Riverkeeper on this issue.

Riverkeeper's Scoping Comments urged the NRC Staff to comprehensively assess the environmental impacts of the IP1 and IP2 spent fuel pool leaks.[108] Riverkeeper explained the gross inadequacy of Entergy's Environmental Report ("ER") and, thus, urged the NRC Staff not to rely upon it to prepare its draft supplemental environmental impact statement.[109] Riverkeeper highlighted the importance of fully evaluating the ever-accumulating contamination caused by the leaks on the Hudson River ecosystem, including on fish, shellfish, and river sediments.[110] Riverkeeper's Scoping Comments also suggested assessing the feasibility of requiring Entergy to move more fuel to dry casks as a reasonable mitigation measure.[111] Riverkeeper's subsequently filed contention on spent fuel pool leaks further elaborated on the deficiencies of Entergy's analysis and the need for a thorough review of the environmental impacts resulting from the leaks.[112]

Yet, despite the reasoned and entirely valid requests articulated in Riverkeeper's Scoping Comments, the NRC Staff essentially grafted Entergy's assessment of the leaks into the DSEIS as their own.[113] This deficient analysis completely fails to comply with NEPA.

Firstly, the NRC Staff ignores the fact that Entergy has failed to definitively demonstrate that the leaking has even ceased. In fact, there is no discussion at all of whether the leaking is still active, and instead, the NRC Staff apparently accepts Entergy's current monitoring and other "remedial" activities, such as the draining of the IP1 pool, as enough.[114] Despite these actions, there is still no indication that Entergy will ever be able to definitively determine whether the IP2 pool continues to leak. Even though IP1 is no longer a possible source of leakage, IP2 still is. While Entergy identified and addressed some sources of the leakage from IP2, no one disputes that Entergy has been unable to inspect 40% of the IP2 pool liner due to the high density of the spent fuel storage racks and the minimal clearance between the bottom of the racks and the floor of the pool.[115] Indeed, Entergy has explicitly acknowledged that active leaks cannot be ruled out.[116] Moreover, as Riverkeeper has pointed out to the NRC Staff several times already, sample results

[107] *Id.* § 2.2.7, at 2-107 to 2-108. The NRC Staff references its findings relating to the significance of the spent fuel pool leaking sporadically throughout the DSEIS, but these four sections seem to represent the NRC Staff's primary analysis of this issue.
[108] Riverkeeper Scoping Comments at 12-15.
[109] *Id.*
[110] *Id.*
[111] *Id.*
[112] Riverkeeper Petition for Hearing at 74-86.
[113] DSEIS, Main report §§ 2.2.7, 4.3, 4.5, 4.7.
[114] *Id.* § 2.2.7, at 2-107 to 2-108, § 4.3, § 4.5, § 4.7.
[115] *See* Riverkeeper Scoping Comments at 13; Riverkeeper Petition for Hearing at 74, 80-81.
[116] *See* Groundwater Investigation Executive Summary (Indian Point Energy Center, Buchanan, N.Y., Jan. 2008), at 3, *available at* http://jic.semo.state.ny.us/Resources/ExecutiveSummary%20GW%20final.pdf.

clearly demonstrate that the contamination is the result of recent leaking, and not "historical" releases.[117]

Yet, Entergy has not provided any information on the feasibility of examining the remainder of the pool liner, or explained any other steps it will take to find any and all sources of leaks from IP2. In fact, Entergy has made no commitment whatsoever for augmented inspection of the spent fuel pool liners during the period of extended operation, and instead is relying on the one-time inspection of the accessible portion of the liner and groundwater testing.[118] The NRC Staff has expressed concern in its recent Safety Evaluation Report about the lack of a system at IP2 to monitor, detect and quantify potential leakage through the spent fuel pool liner, and stated that it is uncertain that the leakage problems have been permanently corrected.[119] Yet, despite these concerns, the DSEIS is devoid of discussion on the questionable status of the leaking.[120] Riverkeeper does not understand how the NRC Staff can accurately assess the environmental impacts of ongoing leaking during the 20-year extended licensing term without addressing the root of the problem.

Secondly, the NRC Staff's analysis is deficient since it relies solely on the finding that radiological doses to humans from consumption of aquatic foods, the only current exposure pathway, is within regulatory limits.[121] The NRC Staff maintains that the spent fuel pool leaks, "while new information, are within the NRC's radiation safety standards . . . and are not considered to have a significant impact on plant workers, the public, or the environment.[122] However, the NRC Staff is continuing to improperly hide behind section 4.6 of GEIS, which analyzes radiological impacts based only on dosage limits.[123] However, the GEIS only addresses radiological impacts to man from *routine operations and releases*, and does not contemplate unplanned, unmonitored releases from leaking plant systems into the environment. As such, mere calculation of dose limits is not sufficient for assessing the "significance" of the impacts of the spent fuel pool leaks.[124]

Rather, NEPA requires a broader evaluation of environmental impacts beyond mere public health concerns.[125] The CEQ regulation defining "significantly," requires consideration of the context of the action and intensity or severity of the impacts.[126] Accordingly, in order to accurately evaluate the significance of the spent fuel pool leaking, the NRC Staff's must fully assess the impacts to the natural environment of the Hudson River. However, by relying on

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[117] *See* Riverkeeper Scoping Comments at 13-14; Riverkeeper Petition for Hearing at 74, 81-82.

[118] U.S. Nuclear Regulatory Commission, Safety Evaluation Report With Open Items Related to the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286 (January 2009), at 3-123 ("SER").

[119] SER at 3-123.

[120] DSEIS, Main Report § 2.2.7, at 2-107 to 2-108, § 4.3, § 4.5, § 4.7.

[121] DSEIS, Main Report § 2.2.7, at 2-107 to 2-108; § 4.3, § 4.5, § 4.7. In addition to incorrectly relying on dose limits as a sole measurement of the impacts from the leaks, the NRC Staff's assessment of dose limits itself is fundamentally flawed since it does not take into consideration a proposed desalination plant right that is likely to result in a direct drinking water pathway. *See infra* for in-depth discussion.

[122] DSEIS, Main Report §§ 4.3, 4.5, 4.7.

[123] *Id.* §§ 2.2.7, 4.3, 4.5, 4.7.

[124] 10 C.F.R. § 51.53(c)(3)(iv); *See* 40 C.F.R. § 1508.27.

[125] *See Marsh v. Oregon Natural Resources Counsel*, 490 U.S. 360, 374 (1989).

[126] *See* 40 C.F.R. § 1508.27 (requiring analysis of ten different factors).

human dose standards, the NRC Staff completely foregoes *any* analysis of the impacts of the contamination to the Hudson River ecosystem.[127] In particular, the DSEIS fails to determine if toxic radionuclides such as strontium-90 or cesium-137 are bioaccumulating in the environment; there is no analysis of the contamination to Hudson River fish or shellfish despite sampling showing elevated levels of such radionuclides in fish;[128] there is no assessment of the effects of the contamination to the nearby ecologically critical area of Haverstraw Bay;[129] and there is no assessment of the potential effects of the leaking on the Hudson River's federally listed endangered species, such as the short-nosed sturgeon.[130]

There is also no evaluation of the cumulative long-term effects of the contaminated groundwater plumes. The NRC Staff cites Entergy's removal of spent fuel from the IP1 pool as evidence that impacts from the contamination would be minimized.[131] However, the extensive leaking from the Unit 1 pool, which contained strontium-90, one of the most toxic radionuclides, is still in the groundwater and will continue to slowly leach into the Hudson River.[132] Simply because this source of the leaking has now stopped does not change the fact that there has been no assessment of the environmental impacts of this contamination. Moreover, current and future accidental radioactive releases from the plant will only add to the existing plumes. For example, a recent underground pipe leak at the facility resulted in over 100,000 gallons of tritiated water being released directly into the plant's discharge canal, and the Hudson River.[133] The NRC Staff must sufficiently evaluate the cumulative environmental impacts of the contamination that has occurred. Likewise, any claims that the leaking has ceased from the pools altogether, which is dubious as explained above, similarly does not change the fact that there has been no analysis of the environmental impacts of the contamination to date.

Section 4.5 of the DSEIS ostensibly analyzes the environmental impacts of operation on "Groundwater Use and *Quality*."[134] It is ludicrous to think that the NRC Staff could come to a conclusion on the *quality* of groundwater by only looking at public health impacts. And yet, the end conclusion in the DSEIS explicitly states that leaks do not have a significant impact on "plant workers, the public, *or the environment*,"[135] despite absolutely no inquiry into how the leaks are affecting the natural ecosystems surrounding Indian Point.

Furthermore, by only looking at whether public health doses were within regulatory standards, the NRC Staff has failed to accurately assess the degree of the contamination caused by the spent fuel pool leaks. There is no dispute that there are at least two extensive groundwater plumes

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[127] *See* Riverkeeper Scoping Comments at 12, 14-15; Riverkeeper Petition for Hearing at 75, 84-86.
[128] *See* Riverkeeper Scoping Comments at 14; Riverkeeper Petition for Hearing at 75, 84-86.
[129] *See* Riverkeeper Scoping Comments at 14-15; Riverkeeper Petition for Hearing at 75, 84-86.
[130] *See also discussion infra.*
[131] DSEIS, Main Report § 4.3, at 4-36.
[132] In the months leading up to the completion of draining of the IP1 pool, Entergy reported it was leaking around 70 gallons per day, contributing thousands and thousands of additional gallons of polluted water into the groundwater and eventually the Hudson River. It is not clear that this additional leakage was factored into Entergy's conclusions in its Environmental Report or subsequent Investigation Report, and accordingly, it is not clear that the NRC Staff considered this either. It is, thus, apparent, that the NRC Staff has utterly failed to analyze the leaks that have occurred from IP1.
[133] *See* Annie Correal, *Indian Pt. Broken Pipe Spurs Safety Worries*, THE NEW YORK TIMES (Feb. 27, 2009).
[134] DSEIS, Main Report § 4.5 (emphasis added).
[135] *Id.* §§ 4.3, 4.5, 4.7 (emphasis added).

underlying the Indian Point site.[136] GZA GeoEnvironmental, the hydrogeological engineering firm hired by Entergy to examine the Indian Point site, had identified radionuclide contaminated plumes at depths ranging from 80 feet (below Indian Point 2) to 160 feet (near the Hudson River bank) for tritium, and from 120 feet (below Indian Point 1) to 150 feet (near the Hudson River bank) for strontium-90.[137] The geology under the Indian Point site is characterized by fractured bedrock, in particular Inwood Marble.[138] Strontium is chemically similar to calcium and prone to substitution for calcium in carbonate minerals such as marble.

A review of recent sampling results shows that the level of contamination is well in excess of EPA drinking water levels.[139] The DSEIS emphasizes the NRC Staff's investigation finding that there is currently no drinking water exposure pathway to humans.[140] As discussed at length below, this is flawed since a proposed desalination plant right across the river from Indian Point is likely to result in drinking water pathway. In any event, EPA maximum contaminant levels are a recognized, highly-conservative benchmark for comparison purposes, to assess the degree of contamination.[141] As Riverkeeper consistently points out, the NRC Staff routinely uses this method of measurement to analyze spent fuel pool leaks. Using drinking water standards is a perfect way to assess the "significance" of the leaking under NEPA, and the fact that the water at Indian Point is not used for drinking water right now is of no moment.[142] Instead, by relying solely on radiation dose calculations, the NRC Staff has failed to acknowledge the severity of the contamination.

With such glaring gaps in the NRC Staff's analysis, how can the NRC Staff possibly come to an accurate conclusion as to the "significance" of the spent fuel pool leaking? If they had taken into account that which NEPA requires, the NRC Staff should have found that the leaking is indeed "significant." The NRC Staff's opposite conclusion is entirely unwarranted, unfounded, and wrong.[143] Likewise, the NRC Staff's conclusion that "additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted" is based on a wholly incomplete analysis.[144] Thus, the NRC Staff should consider appropriate mitigation measures in light of the concerns raised herein, including, but not limited to, requiring Entergy to move more spent fuel to dry casks.[145]

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[136] *See* Riverkeeper Petition for Hearing at 82 (referencing E-mail from James Noggle, NRC, to Timothy Rice and Larry Rosenmann of the NYS DEC (Nov. 6, 2006); Groundwater Investigation Executive Summary (Indian Point Energy Center, Buchanan, N.Y., Jan. 2008), at 2-4, *available at* http://jic.semo.state.ny.us/Resources/ExecutiveSummary%20GW%20final.pdf.

[137] *See* January 7, 2008 GZA GeoEnvironmental Inc., *Hydrogeologic Site Investigation Report*, Figure 9.1 - Unit 2 Tritium Plume, Cross Section A - A', *available at* NRC ADAMS Accession No. ML0800320055; *id.* at Figure 9.2 - Unit 1 Strontium Plume, Cross Section B - B', *available at* NRC ADAMS Accession No. ML0800320056.

[138] January 7, 2008 GZA GeoEnvironmental Inc., *Hydrogeologic Site Investigation Report* at 50. The GZA report is available at NRC ADAMS Accession No. ML080320540.

[139] *See* Riverkeeper Petition for Hearing at 82-84.

[140] DSEIS, Main Report § 2.2.7, at 1-108.

[141] *See* Riverkeeper Petition for Hearing at 82-84.

[142] *See* 40 C.F.R. § 1508.27; 10 C.F.R. § 51.53(c)(3)(iv).

[143] DSEIS, Main Report § 4.3, 4.5, 4.7.

[144] *Id.* § 4.3, at 4-35.

[145] Riverkeeper Scoping Comments at 15.

The NRC Staff has the ultimate responsibility for performing the required NEPA evaluation in relicensing proceedings.[146] Since Entergy's ER was wholly deficient in regards to analyzing the impacts of the spent fuel pool leaking, it is incumbent upon the NRC Staff to pick up the slack. As such, the NRC Staff must take into account the foregoing concerns, perform the necessary analyses and assessments as indicated, and incorporate their findings into the FSEIS.[147]

4. Failure to Consider the Rockland County Desalination Project

The NRC Staff's assessment of the spent fuel pool leaks in Section 4.0 of the DSEIS is premised upon the assumption that "no drinking water exposure pathway exists"[148] and that the "only noteworthy dose pathway resulting from contaminated ground water migration to the river is through the consumption of fish and invertebrates from the Hudson River."[149] However, the facts concerning United Water New York's proposed desalination plant in Rockland County, indicate a highly foreseeable outcome to the contrary, and, as such, must be considered and incorporated into the review process in all relevant contexts and document sections.

This desalination project, which will withdraw Hudson River water, to be sited across the river and slightly downstream from Indian Point,[150] and deliver 7.5 million gallons per day of drinking water, is currently undergoing review by the NYSDEC,[151] as well as other agencies, concerning various permit applications and SEQRA. United Water New York has stated that this project is in development pursuant to the Public Service Commission Order of December 2006 ("PSC Order"), which approved a merger and rate plan, and provided for an increase in the drinking water supply to Rockland County residents.[152] According to United Water New York, as required by the PSC Order, the scheduled in-service, operational completion date for the project is 2015.[153] Plans for a pilot plant, which has been designed to evaluate water treatment methodologies for the permanent plant, are now also in the application and permitting process

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[146] *See Exelon Generation Co., LLC* (Early Site Permit for Clinton ESP Site), ASLBP No. 04-821-01-ESP, 2005 N.R.C. LEXIS 61, *5-6 (2005); 42 U.S.C. § 4332.

[147] The NRC Staff has consistently refuted the necessity of assessing the environmental impacts of the spent fuel pool leaks in the manner Riverkeeper describes, including the need to consider leaks from IP1, the effects on the Hudson River ecosystem, or the need to use any other standards aside from NRC dose limits. However, Riverkeeper's contention relating to the leaks has been admitted for a hearing, and is currently being litigated. In light of the fact that these issues are in dispute, the NRC Staff should err on the side of caution in the preparation of its FSEIS and address the concerns presented herein.

[148] *See e.g.*, DSEIS, Main Report § 2.2.7 at 2-107.

[149] *Id.*

[150] The Intake Site consists of a one-acre portion of one tax parcel in the Town of Haverstraw, 21.09-2-1, located at 710 Beach Road. As shown in Figure 2-2, annexed hereto as Exhibit __, the Intake Site is on the south side of Beach Road on a point of land that extends into the Hudson River. The Intake Site is bounded to the north by the road and to the east by the Hudson River; *see also* Google Map showing rough proximity of Indian Point to proposed desalination plant, annexed hereto as Exhibit __.

[151] *See, e.g.*, Letter from William C. Janeway (DEC Regional Director) to Rebecca Troutman (Riverkeeper), March 9, 2009, annexed to Riverkeeper's comments as Exhibit __ (Confirming DEC's lead agency status for the desalination plant project).

[152] Commission Order in Case No. 06-W-0131, Issued and Effective December 14, 2006 by the New York State Department of Public Service.

[153] Haverstraw Water Supply Project, Draft Environmental Impact Statement, September 26, 2008, at S-1. Please note that this document is currently in revision pursuant to direction from the DEC. Available at http://hudsondesal.com/home.cfm, and last viewed on March 11, 2009.

with DEC. Moreover, a Draft Environmental Impact Statement ("Desalination DEIS") on the project has already been submitted by United Water New York.[154]

Pursuant to NEPA, the NRC Staff is required to assess the impacts associated with the desalination plant in the DSEIS: An environmental impact statement must include discussion of any indirect effects of the proposed project and their significance.[155] "Indirect effects" are defined as those

> which are caused by the action and are later in time or farther removed in distance, but are still *reasonably foreseeable*. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems. Effects and impacts as used in these regulations are synonymous.[156]

Thus, an EIS must consider impacts which are "reasonably foreseeable."[157] There is no doubt that effects on Rockland County's drinking water supply due to radioactive contamination from Indian Point are "reasonably foreseeable." Due to the fact that the Hudson River flows south from IP towards the planned, closely situated intake site of the desalination plant, it is more than "reasonably foreseeable" that any current water-borne contamination, as well as potential additional contamination due to continued deterioration of plant systems, accident or terrorist event, will impact the water supply provided via the desalination plant, and in turn public health. Similarly, Entergy's own environmental documents admit that the topography of Indian Point is such that "surface drainage is toward the Hudson River."[158]

Neither Entergy nor the NRC Staff dispute that the leaking spent fuel pools have resulted in the leaching into the Hudson River of two extensive plumes of radionuclide-laden contamination.[159] Monitoring well samples at Indian Point show that the levels of contamination in the groundwater are well above EPA drinking water limits.[160] In addition to the ongoing spent fuel pool leaking, other future accidental discharges from the plant will also contribute contamination

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[154] Available at http://hudsondesal.com/home.cfm, and last viewed on March 11, 2009.
[155] 40 C.F.R. § 1502.16.
[156] 40 C.F.R. § 1508.8(b)
[157] *See* C.E.Q., Memorandum, 40 Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, 46 Fed. Reg. 12086, 18031 (March 23, 1982) ("The EIS must identify all the indirect effects that are known, and make a good faith effort to explain the effects that are not known, but are 'reasonably foreseeable.' . . . The agency has the responsibility to make an informed judgment, and to estimate future impacts on that basis, especially if trends are ascertainable. . . .The agency cannot ignore these uncertain, but probable, effects of its decisions." *See also, Swain v. Brinegar*, 542 F.2d 364, 7th Cir. 1976 ("An EIS need not review all possible environmental effects of a project. It is sufficient if it considers only those which are 'reasonably foreseeable.'"; *Carolina Environmental Study Group v. U.S.*, 510 F.2d 796, 798 DC Cir. 1975 ("Section 102(2)(C)(i) of NEPA requires a 'detailed statement' on 'the environmental impact of the proposed action.' That language requires description of reasonably foreseeable effects. A 'rule of reason' is used to ascertain those effects anticipated.").
[158] Entergy ER at 2-18.
[159] *See* Groundwater Investigation Executive Summary (Indian Point Energy Center, Buchanan, N.Y., Jan. 2008), at 2, *available at* http://jic.semo.state.ny.us/Resources/ExecutiveSummary%20GW%20final.pdf.
[160] *See* Riverkeeper Petition for Hearing at 82-83.

to the Hudson River. For example, a recent underground pipe leak at the facility resulted in over 100,000 gallons of tritiated water being released directly into the waterway.[161]

Moreover, and ominously, the Desalination DEIS *specifically considers* the presence of Indian Point and the impacts of its contaminants to the water quality:

> Due to the presence of the Indian Point nuclear power plant on the eastern shore of the Hudson River in Buchanan, NY, some have expressed concern regarding the possible radiological contamination of groundwater as well as the Hudson River close to the plant. A summary of the radiological results from United Water's sampling program is provided below. Table 2-4 summarizes the analyses performed for radionuclides in water samples collected at several locations in the Hudson River in 2007 and 2008.[162]

The Desalination DEIS states that preliminary testing showed that the water withdrawn in the vicinity of the intended site contains detectable levels of the radionuclides radium, uranium, strontium-90, and tritium.[163]

The proposed desalination plant is not merely speculative at this point given the fact that it is in the planning, environmental review, and permitting stages. It is, thus, "reasonably foreseeable," as contemplated by the regulations implementing NEPA, that impacts to drinking water quality will result due to the radiological contamination from Indian Point. The presence of an environmental impact statement for the Rockland County Desalination Project renders the foreseeability of these impacts irrefutable. Indeed, the NRC Staff does not have to rely on prognostication to consider the impacts of IP on the proposed desalination plant because there is currently ample available information for the agency to rely on. Thus, NRC Staff is required to assess the effects of Indian Point on the Rockland County desalination project.

Yet, despite the foreseeable nature of this project, the DSEIS is completely devoid of assessment of the impacts of the license renewal on drinking water quality as it relates to the use of the Hudson River as a source of drinking water via the proposed desalination plant. The NRC Staff's current analysis of radiological impacts is premised upon a hypothetical "maximally exposed individual" which does not include consumption of drinking water via the desalination plant as an exposure pathway.[164] While the NRC Staff cites to past radiological sampling data to demonstrate no detectable radiological effects on drinking water,[165] there is no mention whatsoever of what kinds of radiological effects on drinking water supply will result from having a facility in close proximity and downstream from Indian Point, withdrawing water for human consumption. Moreover, the NRC Staff's evaluation of the groundwater contamination from

[161] *See* Annie Correal, *Indian Pt. Broken Pipe Spurs Safety Worries*, THE NEW YORK TIMES (Feb. 27, 2009).
[162] Haverstraw Water Supply Project, Draft Environmental Impact Statement, September 26, 2008, at 2 – 9. Please note that this document is currently in revision pursuant to direction from the DEC.
[163] *Id.*
[164] *See* DSEIS, Main Report §§ 2.2.7, 4.3.
[165] *See id.* § 2.2.7 at 2-104, 2-105.

spent fuel pool leaks hinges on its finding that the only exposure pathway is through consumption of aquatic organisms.[166]

Thus, the DSEIS is substantially incomplete, and must be corrected prior to the conclusion of the environmental review process. The NRC Staff must comprehensively review and consider the impacts of radiological releases from the Indian Point facility, both through normal operations and from unplanned discharges, on drinking water quality in light of the Rockland County Desalination Project.

5. Failure to Properly Consider Impacts to the Communities Utilizing Hudson River Water as a Water Supply Source

Additionally, although the DSEIS acknowledges that "the Hudson River was and is used as a source of potable water,"[167] the NRC Staff fails to properly identify and evaluate potential adverse impacts to the communities which draw Hudson River water for their water needs. The DSEIS asserts that it includes "drinking water" in its evaluation of "airborne pathway," but omits this critical issue in the reference to "waterborne pathway."[168] Further, in the subsequent discussion of data from the "2006 REMP Results," the DSEIS simply refers to results of the "monthly drinking water samples" without identifying which sources (presumably those with potential airborne exposure only) were examined.[169]

Communities which use the Hudson River for their water supply needs, and are therefore vulnerable to waterborne exposure to contaminants, include, but are not limited to, the City of Poughkeepsie, the Town and Village of Rhinebeck, and New York City, which operates the emergency Chelsea pump station at New Hamburg. Due to the fact that the Hudson River is a tidal estuary (the water flows up and downstream), and dispersion and diffusion of contaminants occurs with their release into the waterway,[170] radionuclides can be transported upriver as well as downriver. Accordingly, the potential adverse impacts caused by the operation of Indian Point, under normal operation, with leaks, other accident or disaster, pertaining to the current use of the Hudson river as a source of water, must be fully assessed.

6. Improper Conclusions Regarding Cumulative Environmental Impacts of Operation

a. Cumulative Impacts on Aquatic Resources

In assessing the current and likely future stressors that contribute to cumulative impacts of aquatic resources of the Hudson River, the NRC Staff concedes that the continued operation of IP2 and IP3 has the potential to adversely affect a variety of RIS species due to the once-through

[166] *See id.* § 2.2.7 at 1-108.
[167] *Id.* § 2.2.5.2, at 2-40.
[168] *Id.* §2.2.7 at 2-104.
[169] *Id.* §2.2.7 at 2-105.
[170] *See e.g.*, Ho, D.T., P. Schlosser, & T. Caplow, Determination of longitudinal dispersion coefficient and net advection in the tidal Hudson River with a large-scale, high resolution SF6 tracer release experiment, Environ. Sci. Technol., 36, 3234-3241, 2002.; Ferdi L. Hellweger, Alan F. Blumberg, Peter Schlosser, David T. Ho, Theodore Caplow, Upmanu Lall, & Honghai Li, *Transport in the Hudson Estuary: A Modeling Study of Estuarine Circulation and Tidal Trapping*, Estuaries Vol. 27, No.3 pp.527-538 (June 2004).

cooling system.[171] (Interestingly, the staff's examination of cumulative impacts to water and sediment quality of the Hudson River does not even mention the radioactive contamination caused by spent fuel pool leaks at Indian Point[172]). When all the various factors, including the operation of Indian Point, were considered, the NRC Staff found that the overall effects on aquatic resources was "large."[173] In Pisces' expert opinion, "the Indian Point power plant must take its share of the responsibility and undertake to do as little damage a possible to an already stressed system."[174]

b. <u>Cumulative Radiological Impacts</u>

The NRC Staff concludes in Section 4.8.2 of the DSEIS that the cumulative radiological impacts are "SMALL."[175] However, in light of the issues raised above regarding the NRC Staff's flawed assessment of spent fuel pool leaks, and the failure to consider the Rockland County Desalination Project or other drinking water supplies, this conclusion is dubious. A more thorough analysis that fully addresses the above-referenced concerns must be completed before the NRC Staff can come to an accurate conclusion as to cumulative radiological impacts of continued operation of IP2 and IP3.

<u>DSEIS Section 5.0</u>

Improper Analysis of Severe Accident Mitigation Alternatives

The assessment of Severe Accident Mitigation Alternatives ("SAMAs") in Section 5.2 of the DSEIS is wholly deficient because the NRC Staff incorrectly relied upon the assessment of SAMAs in Entergy's ER.[176] Specifically, the NRC Staff found that Entergy's methodology and analyses were completely sound.[177] Unfortunately, the NRC Staff has ignored several fundamental flaws in the methods employed by Entergy, which, if considered, would greatly change the outcome of the SAMA analysis.

1. Failure to Consider the Risk of Intentional Acts of Sabotage

The NRC Staff's SAMA assessment is utterly flawed because it fails to consider the risks posed by terrorist attacks on Indian Point. Riverkeeper recognizes that the NRC refuses to consider the environmental impacts of intentional attacks in a licensing proceeding. In the instant proceeding, the NRC Staff has explicitly said that the "issue of security and risk from malevolent acts at nuclear power plants is beyond the scope of license renewal . . . the Commission's long-standing position is that NEPA does not require inquiry into the consequences of a hypothetical terrorist attack."[178] It is Riverkeeper's unwavering position that this refusal is simply unreasonable.

[171] DSEIS, Main Report § 4.8.1, at 4-56.
[172] *Id.* § 4.8.1, at 4-57.
[173] *Id.* § 4.8.1, at 4-58; Pisces Report at 10.
[174] Pisces Report at 10.
[175] DSEIS, Main Report § 4.8.3, at 4-60.
[176] *Id.* § 5.2.
[177] *Id.* § 5.2, at 5-6 to 5-10.
[178] NRC Staff Scoping Summary Report at 279-80.

Numerous reports indicate that nuclear power plants remain likely targets of terrorist attacks. The 9/11 Commission Report revealed that the mastermind of the 9/11 attacks had originally planned to hijack additional aircrafts to crash into targets, including nuclear power plants, but wrongly believed the plants were heavily defended.[179] This report indicates that the terrorists were considering attacking a specific nuclear facility in New York which one of the pilots had seen during a familiarization flight near New York.[180] This was likely Indian Point, especially given the fact that more than 17 million people live within 50 miles of the facility.[181] In the years since the 9/11 attacks, the federal government, including the NRC, has repeatedly recognized that there is a credible threat of intentional attacks on nuclear power plants.[182] Notably, existing nuclear power plants in the United States were built between the 1950s and the 1980s and were not intended to be able to withstand the impact of aircraft crashes or explosive forces.[183] Thus, given the current landscape, it is, essential that the risks of intentional attacks be considered during the relicensing process.

The U.S. Court of Appeals for the Ninth Circuit has specifically found that the NRC's consistent refusal to consider the risks of terrorism is unreasonable,[184] although, misguidedly, the NRC has explicitly chosen to limit the applicability of that judicial opinion.[185] The U.S. Environmental Protection Agency also specifically requested the NRC Staff to address the impacts of intentional attacks in the Indian Point license renewal EIS, to no avail.[186]

The Commission's rationale for precluding this important issue from review during the relicensing process is very weak. For example, the Commission has concluded that the benefits of considering the environmental impacts of attacks during a license renewal term would be marginal because those impacts are addressed in the current license term.[187] This reasoning is not supportable since the level of defense required under NRC's Atomic Energy Act-based

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[179] Nat'l Comm'n on Terrorist Attacks Upon the U.S., *The 9/11 Commission Report* (2004), at 154 ("9/11 Commission Report").
[180] *Id.* at 245.
[181] *See* Edwin Lyman, *Chernobyl on the Hudson? The Health & Economic Impacts of a Terrorist Attack at the Indian Point Nuclear Power Plant*, at 23 (2004), *available at*, http://www.riverkeeper.org/document.php/651/11302007_EL_Lym.pdf.
[182] *See, e.g.,; Wide-Ranging New Terror Alerts*, CBS News.com (May 26, 2002), *available at*, http://cbsnews.com/stories/2002/05/24/attack/main510054.shtml (discussing heightened alert of the U.S.'s nuclear power plants as a result of information gained by the intelligence community); *FBI Warns of Nuke Plant Danger*, CBS News.com (May 1, 2003), *available at*, http://www.cbsnews.com/stories/2003/09/04/attack/main571556.shtml (discussing FBI warning to nuclear plant operators to remain vigilant about suspicious activity that could signal a potential terrorist attack); General Accounting Office, *Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to be Strengthened*, GAO-03-752 (2003) (noting that U.S. nuclear power plants are possible terrorist target, and criticizing the NRC's oversight of plant security); *FBI's 4th Warning*, CBS News.com (July 2, 2004) (discussing FBI warning of recent intelligence showing Al-Qaeda interest in attacking nuclear plants).
[183] *In re All Nuclear Power Reactor Licensees*, DD-02-04 (Nov. 1, 2002), *available at* http://www.nrc.gov/reading-rm/doc-collections/petitions-2-206/directors-decision/2002/ml022890031.pdf; *NRC: Nuclear Power Plants Not Protected Against Air Crashes*, Associated Press (Mar. 28, 2002).
[184] *San Luis Obispo Mothers for Peace v. NRC*, 449 F.3d 1016 (9th Cir 2006).
[185] *Amergen Energy Co., L.L.C.* (Oyster Creek Nuclear Generating Station), CLI-07-08, 65 N.R.C. 124 (2007).
[186] Letter from Grace Musumeci, U.S. EPA, to Chief, NRC Rules and Directives Branch (Oct. 10, 2007) (ADAMS Accession No. ML07290360).
[187] *See Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-26, 56 N.R.C. 358, 365 (2002).

security regulations is lighter than the fundamental design changes that may warrant consideration under NEPA if they are cost-effective.[188] Moreover, this reasoning is inconsistent with NEPA, which imposes mandatory obligations on the NRC in considering proposals for re-licensing of nuclear plants.[189]

The Commission also rationalizes its decision to preclude risk assessment of terrorist attacks by arguing that it had already assessed the impacts of intentional attacks in the 1996 GEIS.[190] The GEIS contains the conclusion that:

> Although the threat of sabotage events cannot be accurately quantified, the commission believes that acts of sabotage are not reasonably expected. Nonetheless, if such events were to occur, the commission would expect that resultant core damage and radiological releases would be no worse than those expected from internally initiated events.[191]

In the DSEIS, the NRC Staff relies upon the conclusions in the GEIS to rationalize its exclusion of risks associated with terrorism.[192] Unfortunately, the conclusions in the GEIS been outdated by the significant change in the Commission's analysis of the potential for intentional attacks

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[188] Gordon Thompson, Risk-Related Impacts from Continued Operation of the Indian Point Nuclear Power Plants (Nov. 28, 2007), at §§ 7, 9, *available at*, http://www.riverkeeper.org/document.php/652/11302007_GT_Tho.pdf ("Thompson Report").

[189] The NRC recognized as much in a 2001 decision denying a petition for rulemaking by the Nuclear Energy Institute ("NEI") that would have eliminated the requirement to consider SAMAs, *Nuclear Energy Institute; Denial of Petition for Rulemaking,* 66 Fed. Reg. 10,834 (February 20, 2001). In response to a comment that "the costs of performing the SAMA reviews required by Part 51 are not justified when compared to the small potential safety benefits that result from the reviews," the Commission stated: "The NRC believes that it should continue to consider SAMAs for individual license renewal applications to continue to meet its responsibilities under NEPA. *That statute requires NRC to analyze the environmental impacts of its actions and consider those impacts in its decisionmaking.* In doing so, Section 102(2)(C) of NEPA implicitly requires agencies to consider measures to mitigate those impacts when preparing an impact statement. *See Robertson v. Methow Valley Citizens Council,* 490 U.S. 332 (1989). *NRC's obligation to consider mitigation exists whether mitigation is ultimately found to be cost-beneficial and whether or not mitigation ultimately will be implemented by the licensee.*" 66 Fed. Reg. at 10,836 (emphasis added). The Commission also provided a detailed rebuttal to NEI's argument that license renewal was a mere "continuation" of the current operating term and therefore should not trigger NEPA obligations: ". . . [T]o the extent that license renewal involves a continuation of impacts already experienced at the site under the current operating license, the arguments made by the petitioner would appear to call for the elimination of almost the entire environmental review of impacts from operation during the license renewal term, a position clearly at odds with the Commission's approach to the matter and also, as discussed below, inconsistent with the case law related to relicensing." 66 Fed. Reg. at 10,836-37. The Commission found that that none of the cases under NEPA excusing agencies from considering certain environmental impacts supported petitioner's argument that the NRC can ignore the impacts of its actions in the context of a license renewal. *Id.* The Commission cited to a case which squarely addressed the issue and concluded that there is a need to consider environmental impacts in the context of a relicensing. *Id.* (citing *Confederated Tribes and Bands of the Yakima Indian Nation v. Federal Energy Regulatory Commission,* 746 F.2d 466 (9th Cir. 1984). Thus, the Commission's position in *Duke Energy* is inconsistent with both NEPA and the Commission's previous interpretation of NEPA.

[190] *See Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-26, 56 N.R.C. 358, 365 n.24 (2002).

[191] GEIS at 5-18.

[192] DSEIS, Main Report § 5.1.2, at 5-3.

that has occurred since September 11, 2001.[193] It also totally overlooks the fact that mitigation measures to avoid conventional accidents may be different than those designed to avoid effects of intentional attack. The findings in the GEIS also do not take into account the fact that radiological consequences of a spent fuel pool fire are significantly different from the consequences of a core damage accident,[194] and that mitigation measures for a spent fuel pool fire would be quite different from mitigation measures for a severe core-damage accident.[195]

Moreover, in a recent denial of a petition for rulemaking, which sought reconsideration and revocation of the Category 1 designation of spent fuel pool fires, the Commission explained that it considered the probability of a successful terrorist attack to be low because licensees have implemented mitigative measures believed to lower the likelihood that fuel will ignite if the pool is attacked:

> As previously described, the NRC has required, and nuclear power plant licensees have implemented, various security and mitigation measures that, along with the robust nature of SFPs, make the probability of a successful terrorist attack (i.e., one that causes an SFP zirconium fire, which results in the release of a large amount of radioactive material into the environment) very low. As such, a successful terrorist attack is within the category of remote and speculative matters for NEPA considerations; it is not 'reasonably foreseeable.' Thus, on this basis, the NRC finds that the environmental impacts of renewing a nuclear power plant license, in regard to a terrorist attack on a SFP, are not significant.[196]

In fact, in July 2007, the NRC amended IP3's operating license to require the licensee to address large fires and explosions including those caused by planes.[197]

However, such mitigation measures contemplated by the NRC to acceptably reduce the likelihood of a successful attack on a spent fuel pool were never considered in the GEIS or in any other subsequent NEPA document.[198] This starkly demonstrates that the GEIS does not validly deal with impacts related to terrorism, and the need to assess such impacts comprehensively under NEPA as part of the license renewal process is apparent.

Despite the foregoing, the NRC Staff refused to consider the risk of intentional attacks in its SAMA assessment in the DSEIS. Accordingly, the NRC Staff's SAMA analysis is patently deficient. The Indian Point reactors and spent fuel pools are vulnerable to a range of attack scenarios for which conventional probabilistic risk assessment ("PRA") techniques can be

[193] *See San Luis Obispo Mothers for Peace v. NRC*, 449 F.3d 1016 (9th Cir 2006) ("We find it difficult to reconcile the Commission's conclusion that, as a matter of law, the possibility of a terrorist attack is 'remote and speculative,' with its stated efforts to undertake a 'top to bottom' security review against this same threat.").
[194] Thompson Report at 9 n.9
[195] *Id.* at 52.
[196] Denial of Petition for Rulemaking, 73 Fed. Reg. at 46,211 (2008).
[197] Indian Point Unit 3 Operating License, DPR-64, Condition AC, Mitigation Strategy License Condition (July 11, 2007), ML052720273, at 8.
[198] Denial of Petition for Rulemaking, 73 Fed. Reg. at 46,211 (2008).

adapted by postulating an initiating event (malicious act) and then examining the outcomes of that event.[199] This has not been done.

Moreover, in the first step of Entergy's analysis (which the NRC accepts as sound), i.e., establishing the baseline of severe accidents, Entergy, and the NRC Staff in turn, did not consider the contribution to severe accident costs made by such intentional attacks at Indian Point.[200] The present value of cost risks for an attack at an Indian Point Reactor and its pool exceeds half a billion dollars, warranting significant expenditures on SAMAs.[201] The present value of cost risks for an attack on a reactor alone are also significant -- $62 million to $73 million.[202] Relevant SAMAs with a value of this magnitude have not been considered. Additionally, Entergy's original assessment, which the NRC Staff claims is sound, fails to address National Infrastructure Protection Plan principles for increasing the inherent robustness of infrastructure facilities against attack, which could significantly reduce the radiological and regulatory risk-related impacts of continued operation of the IP2 and IP3 plants.[203]

Based on the foregoing it is clear safety risks due to intentional attacks and accident mitigation alternatives have not been adequately addressed in the DSEIS.[204] The NRC Staff must factor such risks into its SAMA analysis prior to the end of the environmental review process.

2. Failure to Consider the Risk of Spent Fuel Pool Fires

The SAMA analysis in the DSEIS does not adequately take into account the risk of spent fuel pool fires. Riverkeeper is aware that the NRC classifies the environmental impacts of pool accidents and related SAMAs as "Category 1" issues that are not subject to consideration in individual license renewal proceedings absent a waiver or change in the regulations.[205] However "new and significant" information about the risk of spent fuel pool fires warrants comprehensive review in the instant relicensing proceeding.

While initially, it was assumed that stored spent fuel generally did not pose significant risks, with the introduction of high-density, closed-form storage racks into spent fuel pools beginning in the 1970s, this understanding is no longer valid.[206] The closed-form configuration of the high density racks can create a major problem if water is lost from a spent fuel pool, including disastrous pool fires.[207] In fact, studies conducted after the issuance of the 1996 License Renewal GEIS contradict previous studies that had asserted that complete drainage of spent fuel pools was the most severe case and that aged fuel would not burn.[208] These later studies establish that if the water level in a fuel storage pool dropped to the point where the tops of the

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[199] Thompson Report at 42-45.
[200] DSEIS, Main Report § 5.2; Entergy's ER at § 4.21.
[201] *See* Thompson Report at 45-46, Table 7-7, Section 9.
[202] *Id.* at 49.
[203] *See id.* at 58-59.
[204] *See generally id.* §§ 7, 9.
[205] *Florida Power and Light*, 54 N.R.C. at 12.
[206] Thompson Report at 18-27.
[207] *Id.*
[208] *See* Waste Confidence Rule, 55 Fed. Reg. 38,474, 38,481 (Sept. 18, 1990).

fuel assemblies are uncovered, the fuel would burn regardless of its age, and resulting fires can be catastrophic.[209]

In light of this "new information," the States of Massachusetts and California recently petitioned the NRC for a rulemaking seeking reconsideration and revocation of the Category 1 designation of spent fuel pool fires.[210] The Commission issued a decision in early 2008, finding that the petitioning states had not presented "new and significant" information so as to warrant supplementation of the GEIS.[211] However, in its decision, the Commission made no attempt to defend the continuing technical validity of the studies cited in the GEIS, and in fact confirmed the conclusions of NUREG-1738 that partial drainage of a spent fuel pool is a more serious condition than complete drainage, that aged fuel can burn, and that spent fuel fires will propagate.[212]

Further the Commission discussed various mitigation measures that have been implemented by nuclear power plant licensees, asserting that such measures rendered the environmental impacts of high-density pool storage of spent fuel insignificant.[213] For example, in response to the evidence that partial draindown is a more severe situation than total draindown, the Commission discussed the fact that

> all nuclear plant SFPs have been assessed to identify additional existing cooling capability and to provide new supplemental cooling capability which could be used during such rare events. This supplemental cooling capability specifically addresses the cooling needs during partial draindown events, and would reduce the probability of a zirconium fire during those extreme events.[214]

The Commission also described other mitigation measures that have been imposed on all nuclear power plant licensees, including an "internal strategy" which implements a spent fuel pool "makeup system that can supply the required amount of makeup water and SFP spray to remove decay heat," and an "external strategy" in which an independently powered, portable SFP coolant makeup would be used to mitigate a range of scenarios that could reduce pool water levels.[215] The Commission further described "leakage control strategies" that would be considered in cases where SFP water levels can not be maintained, as well as development of timelines for dispersed and non-dispersed spent fuel storage.[216] The Commission cited to license amendments incorporating such strategies into plant licensing bases of all operating nuclear power plants in the United States.[217] Indeed, Indian Point's operating license has specifically

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[209] NUREG-1738, *Final Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants* (January 2001); 2006 NAS Study at 53-54.
[210] *See Massachusetts Attorney General; Receipt of Petition for Rulemaking*, 71 Fed. Reg. 64,169 (Nov. 1, 2006); *State of California; Receipt of Petition for Rulemaking*, 72 Fed. Reg. 27,068 (May 14, 2007).
[211] Denial of Petition for Rulemaking, 73 Fed. Reg 46,204 (2008).
[212] *Id.* at 46,208-10.
[213] *Id.* at 46,209-10.
[214] *Id.*
[215] *Id.* at 46,209.
[216] *Id.*
[217] *Id.*

been amended to incorporate such mitigation measures.[218] As discussed above, the Commission further emphasized that mitigative measures have reduced the risk of spent fuel pool fire from intentional attacks.

The Commission's discussion of spent fuel pool fires and mitigative measures is wholly contrary to their end conclusion that such fires are still a Category 1 issue. The NRC's three criteria for inclusion of an environmental impact in Category 1 are (a) the environmental impacts associated with the issue apply to all plants/plants having a specific site characteristic; (b) a single significance level has been assigned to the impacts, *and* (c) mitigation of adverse impacts associated with the issue has been considered in the analysis and it has been determined that additional plant-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation.[219]

With the Denial of Petition for Rulemaking, the Commission rendered it *impossible* for the issue of spent fuel storage to fit into the last criterion of Table B-1. As is clear from the above discussion, the Commission relied heavily on mitigative measures, which notably have been imposed at Indian Point, for its conclusion that the environmental impacts of spent fuel storage are insignificant.[220] Contrary to the criterion (c) above, not a single one of those mitigation measures was considered in the GEIS. In fact, the Denial of Petition for Rulemaking is apparently the first NEPA document in which they have been identified.[221] There are no previous NEPA documents evaluating the effectiveness of any license amendments imposed to reduce the risk of pool fires, nor any NEPA documents assessing cooling capability that were allegedly assessed for all operating spent fuel pools.[222]

Accordingly, the NRC has effectively removed spent fuel pool impacts from the realm of Category 1, and, accordingly, such impacts must be considered in the instant proceeding.

Moreover, any reliance upon 10 C.F.R. §§ 51.95(c) and 10 C.F.R. § 51.23 is misplaced based on the foregoing. Section 51.95(c) provides that at the license renewal stage, the supplemental EIS for an individual plant "need not discuss . . . any aspect of the storage of spent fuel for the facility within the scope of the generic determination in § 51.23(a) and in accordance with § 51.23(b).[223] Section 51.23(a) explains that the Commission's generic determination that spent fuel can be safely stored for at least 30 years beyond the licensed life for operation,[224] and section 51.23(b) explains that because of this generic finding of no significant impact, then "within the scope of the generic determination in paragraph (a) of this section, no discussion of

[218] Letter from John P. Boska, NRC, to Michael A. Balduzzi, Entergy (July 11, 2007), ML071920023; *see also* Indian Point Unit 3 Operating License, DPR-64, Condition AC, Mitigation Strategy License Condition (July 11, 2007), ML052720273.
[219] 10 C.F.R. Part 51, Subpart A, Appendix B, Table B-1, note 2; *see also* Denial of Petition for Rulemaking, 73 Fed. Reg. at 46,206.
[220] *See* Denial of Petition for Rulemaking, 73 Fed. Reg. 46,204.
[221] *Id.* at 46,209-10.
[222] *Id.* at 46,209-10.
[223] 10 C.F.R. § 51.95(c).
[224] *See* further discussion below about why this generic determination is no longer supportable, necessitating comprehensive review of spent fuel storage impacts generally during the instant relicensing proceeding.

any environmental impact of spent fuel storage" is required in a license renewal proceeding.[225] However, the mitigative measures the Commission now relies upon to determine that spent fuel storage poses no significant impacts, are clearly not "*within the scope of the generic determination in paragraph (a)*" of section 51.23, and therefore neither 10 C.F.R. § 51.95(c) or 10 C.F.R. § 51.23(a) applies.

Accordingly, the NRC Staff has no lawful basis to refuse to consider the environmental impacts of high-density pool storage of spent fuel in the Indian Point relicensing proceeding. However, despite all of the foregoing, the NRC Staff did not consider the risk of spent fuel pool fire in its SAMA assessment in the DSEIS. As such, the NRC Staff's SAMA is patently deficient.

Specifically, in the first step of Entergy's analysis (which the NRC accepts as sound), i.e., establishing the baseline of severe accidents, Entergy, and the NRC Staff in turn, did not consider the contribution to severe accident costs by a fire in either of the spent fuel pools at IP2 or IP3.[226] No SAMAs that would avoid or mitigate such costs have been identified.[227] If the costs of pool fires were considered, the value of SAMAs would be significant. Even using unrealistically low probability estimates in NUREG-1353, *Regulatory Analysis for the Resolution of Generic Issue 82, Beyond Design Basis Accidents in Spent Fuel Pools* (1982), the offsite cost risk of a pool fire is substantially higher than the offsite cost risk of an Early High release from a core-damage accident.[228] The present value of cost risk for a conventional pool accident at Indian Point (i.e., an accident not caused by intentional attack), using the unrealistically low probability assumptions in NUREG-1353, is $27.7 million, a significant sum.[229] If more realistic assumptions about the likelihood of a pool fire were used, the cost would be considerably higher.[230] Moreover, the present value of costs risks ("PVCR") for a spent fuel pool fire would increase substantially (i.e., from $27.7 million to $38.7 million) if the discount rate were changed from 7% to 3%, a more appropriate rate for an analysis of the benefits of measures to prevent or mitigate radiological accidents that Entergy used to test the sensitivity of its SAMA analysis.[231] If the discount rate were dropped to zero, a rate that is justified in light of the catastrophic nature of the consequences involved, the PVCR for a spent fuel pool fire would be even higher -- $51.5 million.[232]

Based on the foregoing it is clear safety risks due to spent fuel fires and accident mitigation alternatives have not been adequately addressed in the DSEIS. The NRC Staff must factor such risks into its SAMA analysis prior to the end of the environmental review process.

3. Failure to Consider the Risk of Reactor Containment Bypass

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[225] *See* 10 C.F.R. § 51.23.
[226] DSEIS, Main Report § 5.2; Entergy's ER at § 4.21.
[227] DSEIS, Main Report § 5.2
[228] Thompson Report at 28
[229] *Id.* at 49 and Table 7-7.
[230] *Id.* at 51.
[231] *Id.* at 51-52.
[232] *Id.* at 52.

The SAMA analysis in the DSEIS does not adequately take into account the risk of reactor containment bypass.[233] The SAMA analysis in the DSEIS seriously underestimates the potential for containment bypass during a core-damage accident. In light of current knowledge about severe reactor accidents, it is prudent to assume that (1) any high/dry accident sequence, (i.e., those in which the secondary side dries out due to unavailability of feedwater and the reactor coolant system ("RCS") pressure remains high while primary coolant (i.e., water) is lost and the core is uncovered), would involve induced failure of steam generator tubes, and (2) that one or more of the secondary side safety valves downstream of the affected steam generator(s) would remain open after tube failure.[234] Taking these prudent assumptions into account, the conditional probabilities of atmospheric release categories in the event of core damage increase significantly: the conditional probability of an Early High release rises from 3.6% to 51.8% for the IP2 reactor, and from 8.2% to 54.1% for IP3.[235] Correspondingly, the present value of cost risk associated with atmospheric releases increases by a factor of 5.42 for IP2 and a factor of 3.18 for IP3.[236]

However, in the first step of Entergy's analysis (which the NRC accepts as sound), i.e., establishing the baseline of severe accidents, Entergy, and the NRC Staff in turn, did not properly consider the contribution to severe accident costs made by severe accidents involving such reactor containment bypass via induced failure of steam generator tubes.[237] Because it does not account for the above-mentioned assumptions, Entergy's estimates of conditional probabilities of atmospheric release categories are incorrectly low.[238] Correspondingly, the value Entergy assigned to the cost risk associated with atmospheric releases is mistakenly low.[239] As a result, Entergy underestimated the potential value of relevant SAMAs by approximately $47.3 million for IP2 and $23.4 million for IP3.[240] If the economic benefit of averted containment bypass accidents were appropriately considered, a number of SAMAs rejected by Entergy as too costly would be cost-effective.[241]

Since induced accidents involving reactor containment bypass via induced failure of steam generator tubes have not been accounted for, the SAMA analysis in the DSEIS is flawed. The NRC Staff must factor the foregoing into its SAMA analysis prior to the end of the environmental review process.

4. Inadequate Consequence Analysis

Lastly, the SAMA analysis is flawed because the NRC Staff accepts Entergy's inadequate consequences analysis.[242] Entergy grossly miscalculated radiological consequences of severe

[233] DSEIS, Main Report § 5.2.
[234] *See* Thompson Report at 14-18, 50.
[235] *See id.*
[236] *See id.*
[237] DSEIS, Main Report § 5.2; Entergy's ER at § 4.21; *See* Thompson Report at 14-18, 50.
[238] *See* Thompson Report at 14-18, 50.
[239] *See id.*
[240] *See id.*
[241] *See id.*
[242] Riverkeeper's Contention EC-2, filed in the relicensing proceeding, but rejected by the Atomic Safety and Licensing Board raised this issue, which was supported by two expert reports: Edwin S. Lyman Expert Report, *A Critique of the Radiological Consequence Assessment Conducted in Support of the Indian Point Severe Accident Mitigation Alternative Analysis* (Nov. 2007) ("Lyman, IP SAMA Analysis Report"); Edwin S. Lyman Expert

accidents in performing its SAMA analyses for three reasons,[243] none of which the NRC Staff has taken into consideration in the DSEIS.

First, Entergy significantly underestimated off-site costs resulting from a severe accident at Indian Point by using a source term that resulted in unusually low mean off-site accident consequences in comparison to results obtained with source terms vetted by independent experts and recommended for use by the NRC.[244] The source term Entergy used to estimate consequences of the most severe accidents with early containment failure was based on radionuclide release fractions generated by the MAAP code, which are smaller for key radionuclides than the release fractions specified in NRC guidance such as NUREG-1465, *Accident Source Terms for Light-Water Nuclear Power Plants* (1995) and the NRC's recent reevaluation for high-burnup fuel, ERI/NRC 02-202, *Accident Source Terms for Light-Water Nuclear Power Plants: High Burnup and MOX Fuels* (2002).[245] The source term used by Entergy results in lower consequences than would be obtained from NUREG-1465 release fractions and release durations.[246] It has been previously observed that MAAP generates lower release fractions than those derived and used by NRC studies, such as NUREG-1150.[247] Since Entergy's use of the MAAP code yielded lower consequences than use of the NRC's source term, Entergy should be required to repeat its SAMA analysis using source terms that are based on publicly available analysis. However, a review of the NRC Staff's assessment of Entergy's SAMA analysis reveals that they have no qualms with Entergy's source term based on the MAAP code.[248]

Second, Entergy significantly underestimated off-site costs resulting from a severe accident at Indian Point because it failed to adequately consider the uncertainties in its consequence calculations resulting from meteorological variations by only using mean values for population dose and offsite economic cost estimates.[249] Entergy's uncertainty analysis for its estimate of the internal events core damage frequency ("CDF") uses an inconsistent approach and omits consideration of the uncertainties associated with other aspects of its risk calculation, including uncertainties associated with meteorological variations, which are found to be greater than the CDF uncertainties.[250] It is unreasonable to ignore such variations in the SAMA analysis.[251] However, the NRC Staff once again did not identify this as a deficiency with Entergy's SAMA analysis. In fact, the NRC Staff specifically found that the "approach taken for collecting and

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Report, *Chernobyl on the Hudson? The Health and Economic Consequences of a Terrorist Attack at the Indian Point Nuclear Plant* (Sept. 2004), *available at* http://www.riverkeeper.org/document.php/651/11302007_EL_Lym.pdf ("Lyman, Chernobyl on the Hudson"). *See* Riverkeeper Petition for Hearing at 68-74.

[243] *See* Entergy's ER § 4.21.

[244] *See* Riverkeeper Petition for Hearing at 68-70.

[245] *See* Riverkeeper Petition for Hearing at 68-70; Lyman, IP SAMA Analysis Report.

[246] *See* Riverkeeper Petition for Hearing at 68-70; Lyman, IP SAMA Analysis Report.

[247] *See* Riverkeeper Petition for Hearing at 69; J. Lehner et al., *Benefit Cost Analysis of Enhancing Combustible Gas Control Availability at Ice Condenser and Mark III Containment Plants*, at 17 (Final Letter Report, Brookhaven National Laboratory, Dec. 23, 2002) (ADAMS Accession Number ML031700011).

[248] *See* DSEIS, Exhibit G.

[249] *See* Riverkeeper Petition for Hearing at 70-71; Lyman, IP SAMA Analysis Report.

[250] *See* Riverkeeper Petition for Hearing at 70-71; Lyman, IP SAMA Analysis Report at 4.

[251] *See* Riverkeeper Petition for Hearing at 70-71; Lyman, IP SAMA Analysis Report.

applying meteorological data in the SAMA analysis is reasonable."[252] Moreover, the NRC Staff stated that it "based its assessment of offsite risk on the CDF's and offsite doses reported by Entergy."[253] Accordingly, the NRC Staff has not addressed this defect in the SAMA analysis.

Third, Entergy significantly underestimated off-site costs resulting from a severe accident at Indian Point by inappropriately using $2,000/person-rem dose conversion factor.[254] The $2,000/person-rem conversion factor is intended to represent the cost associated with the harm caused by radiation exposure with respect to the causation of "stochastic health effects, i.e., fatal cancers, nonfatal cancers, and hereditary effects.[255] The use of this conversion factor in Entergy's SAMA analysis leads to a serious underestimation of the population-dose/health related costs of a severe accident at Indian Point.[256] This is because it (i) does not take into account the significant loss of life associated with early fatalities from acute radiation exposure that could result from some of the severe accident scenarios included in Entergy's risk analysis, i.e. deterministic effects and (ii) it underestimates the total cost of latent cancer fatalities that would result from a given population dose because it fails to take into account the fact that some members of the public exposed to radiation after a severe accident will receive doses above the threshold level for application of a dose- and dose-rate reduction effectiveness factor ("DDREF").[257] Thus, the single cost conversion factor used is not appropriate when some members of an exposed population receive doses for which a DDREF would not be applied.[258] Yet, the NRC Staff had no problem with Entergy's dose conversion factor. The NRC Staff explicitly accepts Entergy's use of the $2000/person-rem factor.[259] As such, the NRC Staff has failed to address this defect in the SAMA analysis.

The above-discussed deficiencies in the SAMA consequence analysis significantly undervalues the off-site costs of severe accidents.[260] Entergy's erroneously low cost estimate has, therefore, led it to underestimate the benefits of SAMAs that would mitigate or avoid the environmental impacts of severe accidents.[261] The NRC Staff's adoption of Entergy's methodology and analysis fails to address these concerns. Based on the foregoing concerns, the NRC Staff must address these flaws in the SAMA analysis prior to the conclusion of the NEPA review process.

DSEIS Section 6.0

Inadequate Analysis of Impacts of On-Site Storage of Spent Fuel

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[252] DSEIS, Exhibit G, at G-18.
[253] DSEIS, Main Report § 5.2.2. at 5-6.
[254] *See* Riverkeeper Petition for Hearing at 68-74; Lyman, IP SAMA Analysis Report.
[255] *See* Riverkeeper Petition for Hearing at 71-74; Lyman, IP SAMA Analysis Report at 5; NUREG-1530, *Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy* (1995).
[256] *See* Riverkeeper Petition for Hearing at 73; Lyman, IP SAMA Analysis Report at 6, 10.
[257] *See* Riverkeeper Petition for Hearing at 71-74; Lyman, IP SAMA Analysis Report at 5. The DDREF is a factor that reflects the reduced potency of radiation to cause cancer at low doses or low dose rates. *See* Riverkeeper Petition for Hearing at 72, n.110.
[258] *See* Riverkeeper Petition for Hearing at 71-74; Lyman, IP SAMA Analysis Report at 5.
[259] DSEIS, Exhibit G, at G-28, G-29.
[260] *See* Riverkeeper Petition for Hearing at 68-74; Lyman, IP SAMA Analysis; Lyman, Chernobyl on the Hudson.
[261] *See* Riverkeeper Petition for Hearing at 68-74; Lyman, IP SAMA Analysis; Lyman, Chernobyl on the Hudson.

Riverkeeper's Scoping Comments explained the need for the NRC Staff to consider "new and significant" information regarding the environmental impacts of spent fuel storage, rather than relying on the outdated GEIS. Riverkeeper cited to increased security concerns due to terrorism and the failure of a long-term disposal solution as material changes affecting the baseline environment since the GEIS was written.[262] Riverkeeper, thus, urged the NRC Staff to assess the future environmental impacts of spent fuel storage in light of these material changes in the Indian Point License Renewal NEPA review process.

However, despite the serious environmental concerns associated with long-term onsite storage of spent nuclear fuel at Indian Point, the NRC Staff has chosen to avoid its responsibilities under NEPA and hide behind the wholly inadequate assessment in the GEIS which has not been updated since 1996, over 13 years ago. Specifically, the NRC Staff states in the DSEIS that it has not identified any new and significant information relating to the finding in the GEIS that "the increase in the volume of spent fuel from an additional 20 years of operation can be safely accommodated on site with small environmental effects through dry or pool storage at all plants" if a permanent disposal solution is not available.[263] This finding is completely unjustified.

The finding of small environmental effects from spent fuel storage in the GEIS, upon which the NRC Staff relies, stems from the NRC's generic "waste confidence" determination that spent fuel can be safely stored onsite for at least 30 years beyond a plant's operating life, including license renewal.[264] The NRC Staff explicitly cites to this rule, which was codified at 10 C.F.R. § 51.23(a), to evade any meaningful site-specific environmental analysis of decades of spent fuel storage at Indian Point in the DSEIS.[265]

However, given "new and significant" circumstances described herein, the NRC's generic finding of no significant impact can not be relied upon. The NRC's reasonable assurance of safe interim storage, first instituted over a quarter of a century ago and never supported by an environmental assessment or environmental impact statement under NEPA,[266] simply does not hold up given current knowledge and circumstances. Moreover, the NRC recently published a proposed update to its "Waste Confidence Decision" which, if finalized would extend the finding of no significant impact an additional 30 years.[267] A concomitant proposed rule change would omit any reference to how long spent fuel can safely be stored in "temporary" on- or off-site facilities, and simply state that such waste can be so temporarily stored without significant impact "until a disposal facility can reasonably be expected to be available."[268] If these changes are implemented, the NRC's generic finding of no significant impact will essentially be extended

[262] *See* Riverkeeper Scoping Comments at 1, 7-12.
[263] DSEIS, Main Report § 6.1 at 6-6 to 6-7.
[264] *Id.* § 6.1 at 6-2, 6-6 to 6-7; GEIS § 6.4.6.3; NRC Staff Scoping Summary Report at 222.
[265] NRC Staff Scoping Summary Report at 222; *see* 10 C.F.R. § 51.23(b) (precluding review of spent fuel storage environmental impacts in any NRC proceeding due to the generic finding of no significant impact).
[266] Final Waste Confidence Decision, 49 Fed. Reg. 34658 ("[T]he Commission finds that NEPA does not require an EIS to support the [temporary storage] finding"); *see also* 40 C.F.R. § 1508.9 (explaining that environmental assessments under NEPA should provide sufficient evidence and analysis for determining whether to prepare an EIS or a FONSI).
[267] Waste Confidence Decision Update, 73 Fed. Reg. 59,551, 59551, 59563-59569 (Oct. 9, 2008) ("WCD Update").
[268] Proposed Rule on the Consideration of Environmental Impacts of Temporary Storage of Spent Fuel After Cessation of Reactor Operation, 73 Fed. Reg. 59,547, 59551 (Oct. 9, 2008) ("Proposed Rule Change").

to some indefinable point in the future. In any event, foregoing any analysis of impacts of decades of spent nuclear waste storage because of the NRC's "waste confidence" is improper.

The NRC's "confidence" in extended safe temporary storage at reactor sites is largely the result of the NRC's expectation that a long-term repository will become available eventually.[269] However, the viability of Yucca Mountain as a long-term disposal site is becoming more tenuous by the day[270] and there is no other foreseeable long-term repository on the horizon. The NRC essentially admits this in rationalizing its proposed update to the Waste Confidence Decision.[271] Moreover, if Yucca ever does become available, it will take decades to transfer the spent fuel from Indian Point, and it will not accommodate any of the waste generated by Indian Point during the extended licensing term.[272] As such, spent fuel will continue to be stored on-site at Indian Point for the foreseeable distant future.

Yet, the NRC Staff refuses to consider the impacts of this "temporary" storage at Indian Point, pointing to the generic finding of no significant impact, despite the fact that it is completely dated and fails to consider current circumstances. Most blatantly, the NRC's generic assurance of benign spent fuel pool storage is completely undermined by the evidence of leaks at Indian Point.[273] The IP1 pool began leaking as early as the 1990s, and the leaks from IP2 were discovered in 2005.[274] With spent fuel pool degradation already an issue at Indian Point, it is patently absurd to rely on the generic no impact finding to project the long-term integrity of the pools for decades into the future. Given the site-specific situation at Indian Point, a comprehensive environmental impact review of the storage in the pools is necessary during the relicensing process. Addressing the leaks as the NRC Staff did in the DSEIS is clearly inadequate.[275]

The NRC's unbridled confidence in the safety of dry cask storage is also questionable. As Riverkeeper's Scoping Comments discussed, it is not clear what environmental impacts will result if dry casks remain loaded with spent fuel beyond their design life.[276] In light of the fact

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[269] Proposed Rule Change, 73 Fed. Reg. at 59549 (referring the WCD Update rationale) (explaining that the original 30 year timeframe for safe interim spent fuel storage was related to the NRC's expectation of when sufficient repository capacity would be available).
[270] *See* Riverkeeper Scoping Comments at 7-9; *see, e.g.*, Remarks of Chairman Klein, Feb. 25, 2008, Waste Management Symposium (explicitly stating that NRC and DOE have "inadequate funds to meet their statutory obligations" relating to Yucca); Lisa Mascaro, *Yucca Funding: Another $100 Million Cut*, Las Vegas Sun (Feb. 27, 2009), *available at*, http://www.lasvegassun.com/news/2009/feb/23/yucca-funding-another-100-million-cut/ (Obama vowing that Yucca will never open as a nuclear waste repository).
[271] Proposed Rule Change, 73 Fed. Reg. at 59549 (explaining how the Commission no longer finds the 30-year timeframe useful since an unknown amount of time will be needed to bring about the necessary societal and political acceptance for a repository site).
[272] Riverkeeper Scoping Comments at 7-9.
[273] *See Liquid Radioactive Release Lessons Learned Task Force Final Report*, U.S. Nuclear Regulatory Commission, at 5-6 (September 1, 2006), *available at* http://www.riverkeeper.org/document.php/539/NRC_Lessons_Lea.pdf (hereinafter "Radioactive Release Task Force Report").
[274] *See* Entergy's Environmental Report, at 5-4; Groundwater Investigation Executive Summary (Indian Point Energy Center, Buchanan, N.Y., Jan. 2008), *available at* http://jic.semo.state.ny.us/Resources/ExecutiveSummary%20GW%20final.pdf.
[275] See discussion above regarding inadequate discussion of leaks.
[276] *See* Riverkeeper Scoping Comments at 9-10.

that these casks will remain on the banks of the Hudson River indefinitely into the future, the NRC Staff must perform a site specific assessment of impacts of such long-term storage.

The NRC's generic finding of no significant impact also flies in the face of new information about the risks of accidents from natural forces at Indian Point. Numerous reports and studies show that fuel storage pools are potentially susceptible to fire and radiological release from natural phenomena.[277] As mentioned above, the environmental impacts of a fire in a spent fuel pool may be severe, extending over a geographic area larger than a state's legal boundaries and continuing for decades.[278] Despite such ominous potential consequences, the NRC Staff completely ignores the vulnerability of stored spent fuel at Indian Point to natural phenomenon, such as earthquakes. This is unwise given recent new information about the likelihood of earthquakes near Indian Point.

Seismologists at Columbia University's Lamont-Doherty Earth Observatory published a study in August 2008 on earthquakes in the greater New York City Area.[279] The study indicated that the Indian Point nuclear power plant sits on a previously unidentified intersection of two *active* seismic zones.[280] Indeed, several recent earthquakes in New Jersey right near the Ramapo fault, which runs directly underneath Indian Point, starkly demonstrate the active nature of the seismic areas around the facility.[281] The Columbia study further found that historic activity of earthquakes of a magnitude more than 5 has been higher in southeastern New York than in many other areas of the central and eastern United States, and that the fault lengths and stresses suggest magnitude 6 or 7 quakes (which would be 10 and 100 times bigger than magnitude 5, respectively) are "quite possible.[282]

However, despite the availability of such new seismological information, the NRC has never allowed old information, upon which nuclear plants' original licenses were based, to be contested in considering extensions of licenses.[283] There is no certainty whatsoever that the dry casks or spent fuel pools at Indian Point are designed so as to be able to withstand such natural occurrences in light of the new seismic information. Given the recent revelation about the

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[277] *See, e.g.*, NUREG-1738, Final Technical Study of 1 Spent Fuel Pool Accident Risk and Decommissioning Nuclear Power Plants (NRC: January 2001); National Academy of Sciences Committee on the Safety and Security of Commercial Spent Nuclear Fuel Storage, Safety and Security of Commercial Spent Nuclear Fuel Storage (The National Academies Press: 2006); Gordon Thompson, Risks and Risk-Reducing Options Associated with Pool Storage of Spent Nuclear Fuel at the Pilgrim and Vermont Yankee Nuclear Power Plants (May 25, 2006); Jan Beyea, Report to the Massachusetts Attorney General on the Potential Consequences of a Spent-fuel Pool Fire at the Pilgrim or Vermont Yankee Nuclear Plant (May 25, 2006).

[278] *See generally*, Gordon Thompson, Risk-Related Impacts from Continued Operation of the Indian Point Nuclear Power Plants (Nov. 28, 2007), at 18-27, *available at*, http://www.riverkeeper.org/document.php/652/11302007_GT_Tho.pdf ("Thompson Report").

[279] *See* Lynn R. Sykes, John G. Armbruster, Won-Young Kim, & Leonardo Seeber, *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, No. 4, pp. 1696-1719 (August 2008) ("2008 Columbia Earthquake Study").

[280] *Id.*

[281] *See, e.g.*, Lawrence Ragonese, *Morris County Shows Signs of Stress: Four Quakes*, The Star-Ledger (Feb. 18, 2009), *available at*, http://www.nj.com/news/index.ssf/2009/02/morris_county_shows_sign_of_st.html.

[282] 2008 Columbia Study; *see also* Robert Roy Britt, *Large Earthquakes Could Strike New York City* (Aug. 21, 2008), *available at* http://www.livescience.com/environment/080821-new-york-earthquakes.html.

[283] 2008 Columbia Earthquake Study at 1717.

specific seismology surrounding the Indian Point facility, reliance by the NRC Staff on a generic determination of environmental safety for potentially long-term on-site storage of spent fuel is totally inappropriate. The NRC Staff must assess the reasonably foreseeable impacts of continued storage of spent fuel at Indian Point in light of new information about potential accidents from natural forces.

The NRC Staff also relies upon the Commission's generic safety determination to further justify its refusal to consider the risks to spent fuel storage from intentional acts of sabotage.[284] However, the likelihood and seriousness of such risks necessitates a thorough review of the impacts of long-term storage of spent fuel at Indian Point. As discussed at length above, future terrorist attacks at Indian Point remain reasonably foreseeable, and such risks must be fully assessed in the relicensing proceeding.

Spent fuel pools are particularly at risk for intentional attacks and would pose significant environmental consequences should such attacks occur. A 2006 study by the National Academy of Sciences on security risks posed by the storage of spent fuel at nuclear plant sites ("2006 NAS Study") confirmed that attacks by civilian aircrafts remain a plausible threat.[285] The study found that attacks on spent fuel pools are attractive targets since they are less protected structurally than reactor cores and typically contain much greater inventories of medium and long-lived radionuclides than reactor cores.[286] The NAS study concluded that storage pools are susceptible to fire and radiological release from intentional attacks.[287] The environmental impacts of a fire in a spent fuel pool may be severe, extending over a geographic area larger than a state's legal boundaries and continuing for decades.[288] Moreover, as discussed above, new studies demonstrate the severe risks of spent fuel pool fires which were not known at the time the NRC issued its "waste confidence" findings.

Moreover, the 2006 NAS Study also concluded that the "potential vulnerabilities of spent fuel pools to terrorist attacks are plant-design specific. Therefore, specific vulnerabilities can be understood only by examining the characteristics of spent fuel storage at each plant."[289] At Indian Point, numerous factors demonstrate the susceptibility of the spent fuel pools to attack, including the fact that the pools are not within containment, but are housed in non-reinforced cinderblock industrial buildings. The fact that the pools are densely packed adds to the risk of catastrophic fire in the event of an attack.[290] Given the foregoing, it is essential that the NRC Staff perform a site-specific assessment of long-term spent fuel pool storage.

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[284] *See* DSEIS, Main Report § 6.1; WCD Update, 73 Fed. Reg 59,551. The NRC's overall general exclusion of issues relating to terrorism in license renewal proceedings is unwarranted, as discussed above.
[285] Nat'l Acad. of Sciences., *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report*, at 30 (2006) ("2006 NAS Study").
[286] 2006 NAS Study at 36.
[287] *Id.* at 49, 57; *see also* German Reactor Safety Org., *Protection of German Nuclear Power Plants Against the Background of the Terrorist Attacks in the U.S. on Sept. 11, 2001* (Nov. 27, 2002) (finding that large jetliners crashing into nuclear facilities under different scenarios could cause uncontrollable situations and the release of radiation). Although the NRC considers impacts of spent fuel pool fires outside the scope of license renewal review, as discussed at length above, this conclusion is no longer valid.
[288] *See generally*, Thompson Report, *supra.*
[289] 2006 NAS Study.
[290] *See* Thompson Report, *supra,* at 18-27.

The dry casks storing spent fuel at Indian Point also present security concerns. Importantly, the dry casks were designed to ensure safe storage of spent fuel, and not to resist terrorist attacks.[291] The regulations for such storage systems are designed to ensure passive heat removal and radiation shielding during normal operations, off-normal events, and accidents.[292] The 2006 NAS Study found breach of a dry cask from a terrorist attack could potentially result in releases of radioactive material from the spent fuel environment, with offsite radiological consequences.[293] Moreover, while the regulations require that dry storage facilities be located within a protected area of the plant site, the protection requirements for such installations are lower than for reactors or spent fuel pools.[294] In addition to the foregoing, at Indian Point in particular, the dry casks in the Independent Spent Fuel Storage Installation ("ISFSI") are stored on an outdoor concrete pad, lined up in rows that are easily visible from the air and the Hudson River.

Thus, as currently configured, this ISFSI is potentially vulnerable to sabotage. Given that Entergy intends to continue constructing dry casks in this manner and the fact that the spent fuel generated at Indian Point will remain stored that way for the foreseeable distant future, the NRC Staff must assess the risks associated with intentional attacks on the ISFSI. As Riverkeeper's Scoping Comments called for, the NRC Staff should consider the mitigation measures recommended by the 2006 NAS Study to reduce the risk of impacts from intentional attacks, including: additional surveillance to detect and/or thwart attacks, creating earthen berms to protect casks from aircraft strikes, placing visual barriers around storage pads to prevent targeting of individual casks, re-spacing the casks to reduce likelihood of cask-to-cask interactions in the event of aircraft attack, and implementing design changes to newly manufactured casks to improve cask resistance to attack.[295]

Based on the foregoing, a comprehensive site-specific analysis of indefinite on-site spent fuel storage at Indian Point is necessary prior to the end of the NRC Staff's environmental review process. In light of extensive "new and significant" information, the NRC Staff can not rely upon an outdated, baseless generic finding of no significant impact to avoid its obligations under NEPA.

DSEIS Section 8.0

1. Irrelevance of the NRC Staff's Assessment of Alternatives to the Existing IP2 and IP3 Cooling-Water System

As indicated above, the NRC Staff must defer to NYSDEC's determinations in the SPDES proceeding. This includes NYSDEC's assessment of alternatives to once-through cooling at Indian Point. As such, the NRC Staff's assessment in the DSEIS of alternatives to the existing IP2 and IP3 cooling-water system is totally meaningless. The NYSDEC's 2008 Ruling requires that a supplemental EIS be prepared to examine the environmental impacts that were not already

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291 *See* 2006 NAS Study; 10 C.F.R. Pt. 71.
292 *See* 2006 NAS Study; 10 C.F.R. Pt. 72.
293 *See* 2006 NAS Study.
294 *Id.*
295 Riverkeeper Scoping Comments at 11-12; 2006 NAS Study.

addressed in the SPDES FEIS for closed cycle cooling, the proposed interim measures, and any alternative technologies that Entergy may propose in order to minimize adverse environmental impact at Indian Point.[296] The NRC Staff must defer to the future determinations of NYSDEC relating to cooling-water system alternatives. Problematically, there is no indication whatsoever in the DSEIS that NRC Staff will defer to, and/or coordinate with, the NYSDEC's supplemental EIS, as required by NRC regulations and precedent.[297]

Moreover the DSEIS also includes a Restoration Alternative in Section 8.1.2 that is unlawful, as the Second Circuit ruled, in its *Riverkeeper I* and *Riverkeeper II* decisions. Pursuant to *Riverkeeper I* and *Riverkeeper II* "restoration" alternatives both at existing and new facilities are contrary to the CWA. Therefore, Section 8.1.2 should be stricken in its entirety.

2. Deficiencies in Assessment of Alternate Energy Sources

As Riverkeeper's Scoping Comments discussed, the NRC Staff is obligated fully consider the use of alternative energy sources in its analysis of alternatives for Indian Point. NEPA,[298] CEQ regulations,[299] NRC regulations,[300] and Appendix to Part 51 mandate that the full and complete environmental impacts of license renewal of IP2 and/or license renewal of IP3, be compared to the projected impacts of all reasonable alternatives. As delineated in CEQ regulations, the obligations include rigorously exploring and objectively evaluating all reasonable alternatives, devoting substantial treatment to each alternative, and including alternatives not within the jurisdiction of the lead agency.[301] Moreover, the scope of the NRC Staff's review encompasses the requirements to which the license renewal applicant is held in its Environmental Report, which includes the requirement to consider "new and significant information."[302]

A review of Sections 8.2 and 8.3 of the DSEIS reveals that the NRC Staff has utterly failed to meet this requirement.

a. Reliance on Outdated Energy Information Administration Reports

The DSEIS fails to address significant new information in reliance on outdated energy production and consumption forecasts. The Energy Information Administration of the Department of Energy ("EIA") issues annual reports and frequent updates on energy production, consumption, and prices, the Annual Energy Outlook and associated supplements and updates. The DSEIS states that "the NRC staff uses the EIA's analysis to help select reasonable alternatives to license renewal."[303] The DSEIS, released and dated December 2008, cites and

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296 NYSDEC, 2008 Ruling at 39.
297 10 C.F.R. § 51.70 (c); 40 C.F.R. § 1506.2 (b) and (c); *Seabrook*, CLI-78-1, 7 NRC at 26 (1978); *Entergy Nuclear Vt. Yankee*, CLI-07-16, 65 NRC 371, 389 (2007).
298 NEPA, 42 U.S.C. § 4321 et seq.
299 40 C.F.R. § 1502.1.
300 10 C.F.R. §§ 51.45, 51.71, 51.95.
301 40 C.F.R. 1502.14(a) – (f).
302 10 C.F.R. § 51.71(a); 10 C.F.R. § 51.53(c)(3)(iv); 10 C.F.R. Part 51, Subpart A, Appendix B; *see also* 40 C.F.R. § 1502.9(c)(1)(l) (requiring a supplemental EIS if there are "significant new circumstances or information relevant to environmental concerns and bearing on the proposed actions or its impacts."
303 DSEIS, Main Report § 8.3, at 8-33.

references "Annual Energy Outlook 2007 with Projections to 2030,"[304] "Assumptions to the Annual Energy Outlook 2006 with Projections to 2030,"[305] and "Assumptions to the Annual Energy Outlook 2007, Electricity Market Module."[306] However, the data and information contained in these annual reports have been superseded by the "Annual Energy Outlook 2009 Early Release Overview" ("2009 EIA Report").[307]

The 2009 EIA Report provides substantially changed data and information from that considered and referenced in the DSEIS concerning all of the alternative energy sources. For instance, the DSEIS relied on data from 2007 projecting coal-fired electric generation to rise to 32% of all generated capacity.[308] By contrast, the 2009 EIA Report adjusts the coal-fired electric generation projection to 24%, no significant increase from 2007, and projects reduced outlook and investment in new coal-fired generating capacity.[309] In line with this projection, the 2009 EIA Report projects much lower coal consumption by 2030 than projected even one year ago. Specifically, the 2009 EIA Report projects: (1) an even greater use of renewable energy than even one year ago, growing at 3.3% annually through 2030; (2) the largest source of growth in the electric power sector to be biomass and wind energy sources; and (3) renewable energy generation growth to 14.1% by 2030, even without a renewal of federal subsidies. Most significantly, the 2009 EIA Report projects that non-hydropower renewable power meets 33% of the total generation growth between 2007 and 2030.[310]

The DSEIS contains many assumptions about alternative energy sources derived directly from outdated data from EIA reports dating from 2006 and 2007. At a minimum, the DSEIS must select and evaluate any alternative energy source or combination of sources in light of the new and substantially different data and projections from the 2009 EIA Report. The failure of the NRC to amend the data relied upon for the analysis of alternative energy sources would violate the requirements of NEPA. Because NEPA requires an EIS in order to inform the agency of the environmental consequences of its actions, it is critical that the NRC Staff revisit their conclusions in light of the most recent data.

b. *Coal-Fired Generation Alternative*

The DSEIS devotes a majority of consideration of alternative energy sources to a single alternative that presents the arguably least feasible and least environmentally sound alternative to relicensing. This analysis sets up a "straw man" scenario that skews objective comparisons to the proposed relicensing.

The DSEIS devotes the bulk of analysis of alternative energy sources to an off-site supercritical coal-fired generation source[311] despite the fact that no New York-based utility has pending

[304] DOE/EIA-0383(2007).
[305] DOE-EIA-0554(2006).
[306] DOE-EIA-0554(2007).
[307] DOE/EIA-0383(2009) (released December 2008, full report available March 13, 2009).
[308] DSEIS, Main Report § 8.3, at 8-32.
[309] 2009 EIA Report, Table 1.
[310] AEO2009 Early Release Summary Presentation.
[311] DSEIS, Main Report § 8.3.1, at 8-33 to 8-46.

application for new coal generation in Zones H, I, J, and K.[312] In contrast, the DSEIS gives short shrift to analysis of other alternatives, in particular, renewable energy sources and conservation. This analysis and seeming preference to prove the unsuitability of a single coal-fired source comes at the expense of considering a more effective portfolio of alternative energy sources. Moreover, the analysis of the supercritical coal-fired generation source in the DSEIS fails to satisfy the requirements of NEPA.

The NRC Staff opened its analysis of this alternative by assuming that a new source would have to generate 2200 MW(e) to replace the power produced by Indian Point Units 2 and 3.[313] At the outset, this analysis ignores the fact that energy alternatives must also be considered separately.[314] The NRC Staff failed to consider the effects of this alternative in place of only one of the units at the Indian point facility. It also failed to include evidence of other, non-coal sources of power generation and conservation when completing its analysis.[315] In order to remedy these flaws, the NRC Staff must consider all of the energy alternatives in light of the fact that the license renewal is for two power generating units and with respect to other existing sources and conservation efforts. An analysis of the alternatives must occur for both units together and for each unit separately in order to comply with NEPA.[316]

c. *Natural Gas-Fired Generation Alternative*

In its analysis of natural gas-fired combined-cycle generation as an alternative to the license renewal for Indian Point Units 2 and 3, the DSEIS notes that this alternative source operates at "markedly higher thermal efficiencies" and requires less water for condensing cooling, thus requiring smaller cooling towers than the existing facility.[317] However, in its conclusion about the effects of alternative sources, the NRC Staff concludes that the license renewal would have similar impacts to alternatives.[318] Even though the analysis of the natural gas-fired alternative acknowledged significant environmental benefits, the NRC Staff ignored these factors when making a conclusion based on all of the energy alternatives. The NRC Staff cannot ignore their analysis of a natural gas-fired generation alternative when making a general conclusion on the impacts of alternatives subject to the decision not to renew the licenses for Indian Point Units 2 and 3.

Although the DSEIS addresses the fact that Indian Point Units 2 and 3 could be replaced by natural gas-fired combined-cycle generation at the Indian Point site or other locations, the analysis does not go far enough to show the development of natural gas generation in New York. The DSEIS ignores current construction of natural gas-fired facilities and other new sources that

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[312] *See* State of New York Contentions Concerning NRC Staff's Draft Supplemental Environmental Impact Statement, Docket Nos. 50-247-LR and 50-286-LR (filed February 27, 2008) at 31.
[313] DSEIS, Main Report § 8.3.1, at 8-34.
[314] Riverkeeper's Scoping Comments discussed at length the need to assess reasonable alternatives to IP2 and IP3 separately. Riverkeeper Scoping Comments at 15-17 (citing NUREG-1437 vol. 1 §§ 1.2, 1.4, 1.8 (requiring a plant, not plants, specific review and a full analysis of alternatives at *individual* license renewal reviews.)).
[315] *See* State of New York Contentions Concerning NRC Staff's Draft Supplemental Environmental Impact Statement, Docket Nos. 50-247-LR and 50-286-LR (filed February 27, 2008) at 31.
[316] *See* Riverkeeper Scoping Comments at 15-17.
[317] DSEIS, Main Report § 8.3.2, at 8-46.
[318] *Id.* § 8.4, at 8-78.

have been planned or permitted.[319] Because of this lack of consideration of the existence of and increased reliance on natural gas-fired power generation, the DSEIS is inadequate. In order to fulfill the requirements of NEPA, the NRC Staff should readdress the natural gas-fired generation alternative in order to reflect current information and trends. Currently, without this analysis, the DSEIS is incomplete.

d. Combination of Alternatives

The DSEIS suggests two options in which combinations of energy sources are used.[320] Unfortunately, these two combination alternatives are artificially narrow and arbitrary and fail to take into account additional combinations of alternatives in violation of NEPA. The NRC Staff's shoddy combination assessment in the DSEIS stems from the assumption in the GEIS that the only way to replace a large generating unit like a nuclear power plant is with another similarly large generating unit.[321] This assumption is not valid today, as utilities are meeting demand requirements with a broad combination of conservation, innovative modifications to existing plants, and renewable energy, without considering the construction of new fossil-fuel burning facilities.[322] As Riverkeeper's Scoping Comments explained, a recent study clearly demonstrates that the approximately 2000 MWe generated by Indian Point is replaceable and that if Indian Point were to close, a replacement strategy focusing on conservation, energy efficiency, renewable energy sources, and improving transmission infrastructure, would be technically feasible and achievable with no major disruptions.[323] Another study by the Nuclear Research Institute and the Institute for Energy and Environmental Research found that a reliable U.S. electricity sector is achievable without nuclear power through a combination of conservation and alternative sustainable energy sources.[324] Thus, given the feasibility of developing and implementing energy portfolios that include renewable energy sources, conservation, and energy efficiency measures, the NRC Staff should have considered a broader range of alternatives in the DSEIS. The NRC Staff's continued reliance on the GEIS ignores the significant progress made on energy issues and, in turn, ignores NEPA's mandate to fully consider "new and significant" information in the supplemental EIS.

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[319] *See* State of New York Contentions Concerning NRC Staff's Draft Supplemental Environmental Impact Statement, Docket Nos. 50-247-LR and 50-286-LR (filed February 27, 2008) at 32.
[320] DSEIS, Main Report § 8.3.5.
[321] GEIS § 8.1 ("NRC has determined that a reasonable set of alternatives should be limited to analysis of single, discrete electric generation sources"); DSEIS, Main Report § 8.3.5 (relying on NRC's recommendation in the GEIS that consideration of alternatives should "be limited to single, discrete generating options"). Riverkeeper's Scoping Comments further explained that this statement in the GEIS does not comply with NEPA's mandate to assess all reasonable alternatives to the proposed action, nor with NRC regulations mandating that *all* reasonable alternatives be identified and considered. *See* Riverkeeper's Scoping Comments at 19-20.
[322] *See* Michael Grunwald, *America's Untapped Energy Resource: Boosting Efficiency*, Time (Dec. 31, 2008), *available at* http://www.time.com/time/magazine/article/0,9171,1869224,00.html; EPRI, *Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S. (2010 – 2030)* (published Jan. 14, 2009); *see also* Riverkeeper Scoping Comments at 15-21.
[323] *See* Riverkeeper Scoping Comments at 18-19 (citing NAS, *Alternatives to the Indian Point Energy Center for Meeting New York's Electrical Power Needs*, June 2006, Chapters 1-5).
[324] *See* Riverkeeper Scoping Comments at 19 (citing IERR, "Carbon Free and Nuclear Free – A Roadmap for U.S. Energy Policy" (Oct. 2007)).

In particular, the combination assessment completely ignores the known potential of renewable energy sources. The NRC Staff's combination alternatives reflect the NRC's arbitrary belief that there are too many obstacles to implementing sufficient wind power or other renewable energy sources such that these sources could not provide anything more than 200 to 400 MW to replace either or both IP units.[325] Such beliefs are utterly misguided.[326] The NRC Staff also discounts and eliminates any contribution from hydropower or geothermal energy.[327] By limiting the consideration of energy sources in this manner, the NRC Staff's combination assessment it deficient.

The NRC Staff's combination alternatives also largely ignores the benefits of energy conservation and efficiency. The NRC Staff has failed to consider New York State's lofty plans and steps taken for reducing the state's electricity usage and increasing energy efficiency.[328] Recent information demonstrates the increasing financial, technical, and political viability of energy conservation.[329] However, by incorrectly assuming that energy conservation would only result in a savings of 800 MW, the NRC Staff arbitrarily fails to consider energy conservation as a full replacement for one or both of the units.[330]

Based on the foregoing, the NRC Staff's consideration of renewable energy sources and energy conservation and efficiency is severely wanting. Since the DSEIS does not adequately analyze the availability and environmental impacts of alternatives, the NRC Staff's assessment of the no-action alternative in section 8.2 of the DSEIS is flawed.[331] Indeed, the no-action alternative assessment does not consider and analyze much new information about various measures that would be taken if the no-action alternative were chosen, compared to the detriments that would be caused by relicensing of IP2 and IP3.[332] In contrast, the State of New York, with expert support, has laid out examples of combination alternatives using more realistic estimations, which demonstrate that the no-action alternative, i.e., not relicensing IP2 or IP3, is preferable.[333] Such combinations would use mostly renewable energy sources coupled with energy efficiency measures and are readily achievable under existing and identified New York State programs.[334]

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[325] DSEIS, Main Report § 8.3.5 at 8-65 to 8-66.
[326] *See generally See* State of New York Contentions Concerning NRC Staff's Draft Supplemental Environmental Impact Statement, Docket Nos. 50-247-LR and 50-286-LR (filed February 27, 2008) at 27-28 (citing Report by Synapse Energy Economics, Inc. demonstrating the viability of wind energy and other renewable resources).
[327] *See* DSEIS, Main Report § 8.3.4 at 8-61, 8-62, § 8.3.5, at 8-65, 8-66.
[328] *See* New York State, Public Service Commission, Energy Efficiency Portfolio Standard, http://www.dps.state.ny.us/Phase2_Case 07-M-0548.htm (last visited March 16, 2009); Energy Efficiency Fact Sheet, http://www.ny.gov/governor/press/factsheet_0107092.html; *see generally* State of New York Contentions Concerning NRC Staff's Draft Supplemental Environmental Impact Statement, Docket Nos. 50-247-LR and 50-286-LR (filed February 27, 2008) at 23-29; Riverkeeper Scoping Comments at 20.
[329] *See generally* State of New York Contentions Concerning NRC Staff's Draft Supplemental Environmental Impact Statement, Docket Nos. 50-247-LR and 50-286-LR (filed February 27, 2008) at 24-25.
[330] DSEIS, Main Report § 8.2, 8.3.5.
[331] 10 C.F.R. § 51.71; 10 C.F.R. Part 51, Subpart A, Appendix A, Section 4; 40 C.F.R. § 1502.14(a).
[332] *See generally* State of New York Contentions Concerning NRC Staff's Draft Supplemental Environmental Impact Statement, Docket Nos. 50-247-LR and 50-286-LR (filed February 27, 2008) at 22-29.
[333] *See id.* at 33-34.
[334] *See id.*

Lastly, Riverkeeper's Scoping Comments explained the necessity under NEPA to compare Indian Point's cumulative detrimental contribution to climate change and environmental degradation to safe and clean renewable energy sources.[335] The NRC Staff has not performed such an analysis in the DSEIS.

Overall, the NRC Staff's assessment of energy alternatives to Indian Point in the DSEIS is deficient, and must be fixed prior to the conclusion of the environmental review process under NEPA.

DSEIS Section 9.0

Based on the foregoing, the NRC Staff has demonstrably not performed sufficient analysis to support its preliminary recommendation "that the adverse environmental impacts of license renewal for IP2 and IP3 are not so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable."[336] In order to comply with the mandates of NEPA, the NRC Staff must consider and address the foregoing comments before issuing the FSEIS.

Thank you for your consideration.

[335] *See* Riverkeeper Scoping Comments at 20-21.
[336] DSEIS, Main Report § 9.3, at 9-8.

Sincerely,

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Exhibit A

Comments relating to the Indian Point NRC draft EIS on the Cooling System

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1 Summary

This report comments on the US NRC *'Generic Environmental Impact Statement for License Renewal of Nuclear Plants Supplement 38: Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3: Draft Report for Comment'* issued December 2008 (NUREG – 1437), Environmental Impacts of Cooling System. We are only concerned here with aquatic issues, and the impact of the plant's cooling system on fish and crustaceans in particular. The main impacts we look at in this document are entrainment, impingement and the effect of the thermal plume.

The assessment of impact undertaken on the representative important species (RIS) of (17 common fish species and the blue crab) is based on a scoring system that appears completely objective and quantitative. However, detailed examination of the method shows that it makes assumptions about the statistical properties of populations, the impact of cooling water systems on invertebrates prey species, and the relative importance of local and larger-scale changes in population number, that have not been justified and may be arbitrary.

A particular problem concerns the scoring method used to assess the strength of connection; this is a poor measure of the impact of the power plant on the species. The strength of connection is a flawed measure because it is based on rank abundance, furthermore, the lack of importance given to impacts on invertebrates makes low to moderate levels of impact for many species almost inevitable.

Another concern is that the distinction between *'Large'* and *'Small'* population impacts is hard to support from an examination of the overall population trend data.

The use of both river-wide and river segment 4 data (where Indian Point is located), and the use of population decline criteria that include a measure of the deviation from the mean of a normal distribution produce results that do not necessarily reflect the actual population trends, and have the potential to understate the importance of recent changes in abundance.

The comparison of species' proportional rank abundance in the power station kill with that living in the river results in potentially misleading conclusions. For example, the fish that contributes the highest proportion of the number of individuals killed by the power plant, and which is also the commonest in the river, only has a medium strength of connection. In our opinion, such a situation where a fish is killed in high numbers and is locally common would suggest a high degree of linkage.

A number of the RIS species have a prey score for impingement and entrainment of 1, and thus are unlikely to score highly for the strength of connection. This feature of the scoring protocol is thus central to the final outcome.

A key underlying point to note about the analysis of impingement and entrainment is the reliance on data collected between 1981 and 1990. These data are old and may not reflect current conditions.

NRC staff concludes that thermal impacts associated with the discharge are small to moderate, principally on the grounds that there is no evidence for the scale of the impact. The assertion that, because no appropriate evidence has been collected, there is therefore only a small to moderate impact, is not logical.

NRC staff state that they cannot determine the effects of climate change, particularly in relation to thermal issues. We believe they should have, at the very least, concluded that they needed more data on thermal issues before reaching a conclusion.

Although the NRC does not come to a definite conclusion about the effect of Indian Point on the sturgeon, they are concerned that they continuing operation will have adverse effects.

The cumulative effects of all the impacts on the River Hudson are assessed as large. The power plant, along with other users, must take their share of the responsibility and undertake to do as little damage a possible to an already stressed system.

2 Introduction

This report comments upon the US NRC *'Generic Environmental Impact Statement for License Renewal of Nuclear Plants Supplement 38: Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3: Draft Report for Comment'* issued December 2008. We will refer to this document below as NUREG-1437. We are only concerned here with aquatic issues, and the impact of the plant's cooling system on fish and crustaceans in particular.[1]

Fish and other species can be impacted in several ways by the operation of the power plant. They can be impinged (caught on the power station screens) as the power station withdraws water from the Hudson, entrained (smaller organisms pass thought the power station undergoing several stressors), or can be effected by the thermal plume produced by the cooling water.

The NRC method of assessing the above impact had several steps.

- Identifying the species to be examined,
- Examining what evidence there was of changes in populations and how useful it was.
- Assigning species to *Small*, *Moderate* or *Large* depending on their potential to be effected.
- Assigning a connection of *Low*, *Medium* or *High*, depending on whether the species was impinged or entrained in different numbers than they were present in the river.
- Combined the potential to be effected with the connection score to assess the impact of Indian Point.

3 Impingement and Entrainment: The scoring system

Impingement and entrainment effects are considered together by the NRC. This is an approach that has merit because the goal is the well-being of the populations as a whole, and not particular age classes.

The possible impact of the power plant is assessed using a scoring system that takes into account changes in species abundance (the trend) and strength of connection (connection), and which attempts to measure the relationship between abundance in the environment and in the power station catch. The analysis is restricted to the 18 RIS species (common fish species and the blue crab). The choice of these species is historic and was designed to represent the overall aquatic resource. They have all been studied over many years. The NRC staff note, as have many others before, that there have been notable declining

[1] NUREG-1437, Vol. 1, sections 2.2.5 Aquatic Resources, 4.1 Cooling System, 4.6 Threatened or Endangered Species, 4.8 Cumulative Impacts, 4.9 Summary of Impacts of Operations during the Renewal Term; 8.1 Alternatives to the Existing IP2 and IP3 Cooling-Water System.

trends in many RIS fish (see Population Line of Evidence column in Table shown in Figure 1). In this respect NRC staff agree with our previous analyses.[2]

Table 4-4. Impingement and Entrainment Impact Summary for Hudson River RIS

Species	Population Line of Evidence	Strength of Connection Line of Evidence	Impacts of IP2 and IP3 Cooling System on Aquatic Resources
Alewife	Large	Low to Medium	Small to Moderate
Bay Anchovy	Moderate	Low to Medium	Small to Moderate
American Shad	Large	Low to Medium	Small to Moderate
Bluefish	Large	High	Large
Hogchoker	Large	Medium to High	Moderate to Large
Atlantic Menhaden	Moderate to Large	Unknown(a)	Unknown(b)
Blueback Herring	Large	Low to Medium	Small to Moderate
Rainbow Smelt	Large	Medium	Moderate
Shortnose Sturgeon	Unknown	Unknown(a)	Unknown(b)
Spottail Shiner	Large	Low to Medium	Small to Moderate
Atlantic Sturgeon	Large	Unknown(a)	Unknown(b)
Striped Bass	Small	High	Small
Atlantic Tomcod	Large	Low to Medium	Small to Moderate
White Catfish	Large	Low to Medium	Small to Moderate
White Perch	Large	Medium to High	Moderate to Large
Weakfish	Small	Medium to High	Small
Gizzard Shad	Unknown	Unknown(a)	Unknown(b)
Blue Crab	Small	Unknown(a)	Unknown(b)

(a)Strength of connection could not be established using WOE, therefore strength of connection could range from LOW to HIGH.
(b)Conclusion of impact could not be established using WOE, therefore impacts could range from SMALL to LARGE.

Figure 1: A copy of Table 4-4 from NUREG-1437, Vol. 1.

The serious decline in abundance of many species is reflected in the number of *'Large'* classifications in column 2 of the table in Figure 1. We choose two species from Table 4-4, white catfish and weakfish, to illustrate the nature of these declines. These two species also serve to demonstrate that the distinction made in Table 4-4 between *'Large'* and *'Small'* impacts is hard to support from an examination of the overall population trend data.

3.1 *White Catfish*

The Year Class Reports for the Hudson River Estuary Monitoring Program shows that, river-wide, juvenile white catfish have been in a steep decline in abundance since 1990 (Figure 2).

[2] See "Status of Fish Populations and the Ecology of the Hudson River" and "Entrainment, Impingement and Thermal Impacts at Indian Point Power Station." Copies of these reports were are provided as Attachments 3 and 4, respectively, to the declaration of Dr. Peter Henderson, in support of Riverkeeper's request for a hearing and petition to intervene with respect to the license renewal proceeding for the Indian Point Nuclear Power Station (November 2007).

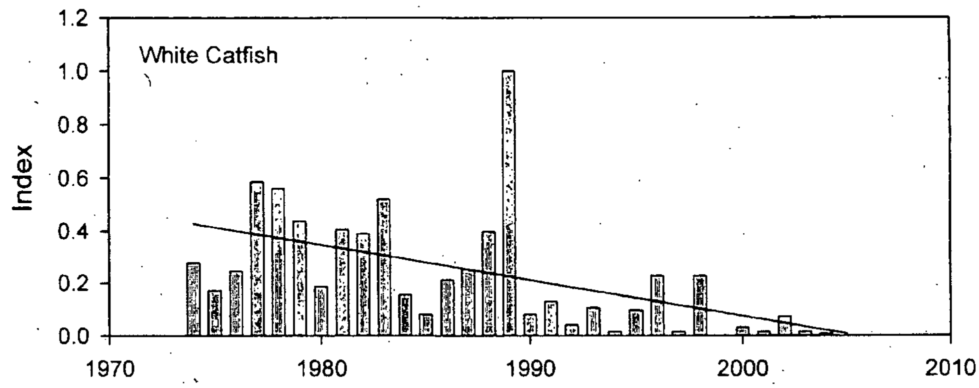


Figure 2: The standardised juvenile index for white catfish in the Hudson, showing a decreasing trend though time.
The trend is significant (a = -0.0136, b = 27.216, F = 14.0414, p = 0.0008) (Seaby and Henderson, 2007)

It is therefore unsurprising that in Table 4-4 (see Figure 1) the population line of evidence is for a 'Large' potential adverse impact. The trend shown in Figure 2, which is statistically significant, certainly seems to correspond with the definition of Large given on page H-33, NUREG-1437, Vol 2:

> *"A LARGE potential for an adverse impact to an RIS population was determined if population trends had slopes that were significantly different from zero (i.e., detectable slope) and had greater than 40 percent of annual abundance outside the defined level of noise (i.e., support for potential impact). This response was considered clearly noticeable, and an adverse environmental impact was likely."*

The fact that 40% of the observations lie outside the standardised mean abundance level observed over the first 5 years of the long-term study is also significant. To quote from page H-36, NUREG-1437, Vol. 2:

> *"Thus, observations outside the boundaries of ±1 standard deviation from the mean of the first 5 years were considered outside of the natural variability (noise). If greater than 40 percent of the standardised observations were outside this defined level of noise, then a potential for adverse impact was considered supported."*

There are two important points to note about this definition. First, it is based on the normal distribution. The abundance of natural populations is never normally distributed. This brings into question the validity of the method.

Second, the approach is based on events in the first 5 years of the time series. If during this period the population showed unusually great variability, it would make it much harder, if not impossible, to score for a Large potential impact.

3.2 *Weakfish*

Like white catfish, weakfish have also shown river-wide a steep decline in abundance since 1990 (Figure 3). However, unlike white catfish, for this species Table 4-4 classifies the population line of evidence as 'Small'.

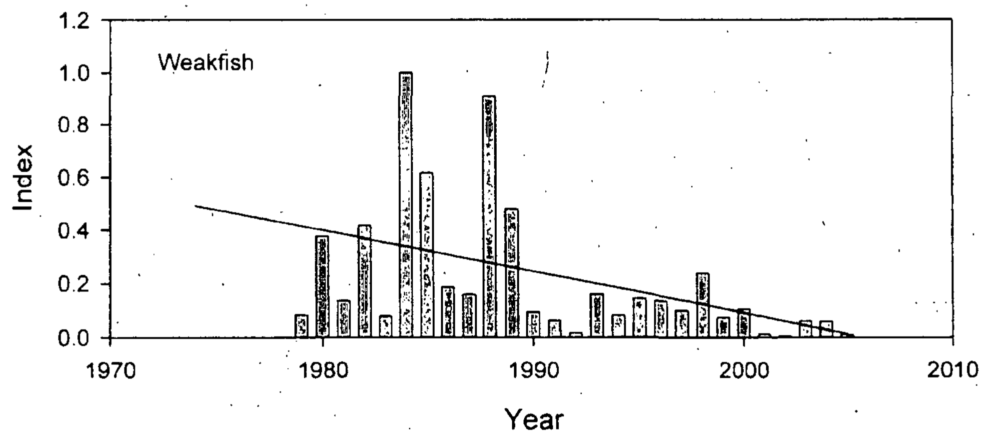


Figure 3: The standardised juvenile index for weakfish in the Hudson showing a decreasing trend though time.
The trend is significant (a = -0.0155, b = 31.0218, F = 7.0811, p = 0.0134) (Seaby and Henderson, 2007)

A 'Small' potential for adverse impact is defined on page H-32 vol 2 as:

> *"A SMALL potential for an adverse impact to an RIS population was determined if population trends had slopes that were not significantly different from zero (i.e., no detectable slope) and had ≤40 percent annual abundances falling outside a predetermined level of noise (defined here as +/-1 standard deviation from the mean of the first 5 years of data). This suggested that the RIS population had not changed detectably over time, and adverse environmental impacts were unlikely."*

The classification of the weakfish population line of evidence as Small in Table 4-4 if difficult to understand as there are clear signs that the population has shown a significant decline. If this is so, the population line of evidence should not be small, irrespective of the noise in the data set. The classification as small seems to arise because the weight of evidence (WOE) score (Table H-15, NUREG-1437, Vol. 2) assesses river-wide, river segment 4 and coastal scores for potential adverse impact. River-wide there is a moderate adverse impact assessment; see p H-42:

> *"Analysis of abundance index data suggested a large potential for adverse population impacts for three RIS (American shad, white catfish, white perch) and a **moderate** potential for adverse impacts for bay anchovy, blueback herring, Atlantic tomcod, and **weakfish**)."*

However, within river segment 4 the impact is only assessed as 'Small'. The final result is an overall 'Small' level of impact.

Weakfish are mobile, migratory predators that never complete their life cycle within river segment 4. We therefore can see no justification for including the river segment 4 analyses in an assessment of adverse population trends.

We conclude therefore that the WOE scoring system, which uses both river-wide and river segment 4 data, and uses population decline criteria that include deviation from the mean of a normal distribution, produces results that do not necessarily reflect the actual population trends, and have the potential to understate the importance of recent changes in abundance. Examination of the river-wide abundance trends for white fish and weakfish indicates that both species have, since 1990, appreciably declined in abundance. Yet while the decline in white catfish is classified as 'Large', that in weakfish is 'Small'. Such differences are more a reflection of the arbitrary nature of the statistical and quantitative approach taken, than a real difference in the state and health of the populations.

3.3 Problems with the assessment of the strength of connection line of evidence

In comparison with the evidence from the trends resulting in the population line of evidence shown in column 2 of Table 4-4 (Figure 1), the final impact assessment in the right hand column only shows a large effect for one fish, the hogchoker. There is also a moderate to large effect for a single species, white perch. The reason why so few of the large trends are translated into a large impact relates to the strength of connection measure in the third column of the table. A consideration of this measure and how it is computed is therefore of key importance.

From NUREG-1437 Vol. 2 (page H-29) we have this description of how strength of connection is measured.

> *"Impingement and/or entrainment can also remove and reintroduce RIS prey into the aquatic system in a manner that alters food web dynamics and produces indirect effects that may result in decreased recruitment, changes in predator-prey*

relationships, changes in population feeding strategies, or movements of populations closer to or farther away from the cooling system intakes or discharges. Staff based the analysis of impingement on the concordance of two ranked proportions. The first proportion was the ratio of the number of YOY and yearling fish of each species impinged in relation to the sum of all fish impinged. The second proportion was the ratio of each species abundance in the river near IP2 and IP3 relative to the total abundance of all 18 RIS. A large rank for both proportions would mean that the proportion impinged for the given RIS and the proportion abundance in the river were both large. The ratio of these two ranks would then be close to 1, suggesting that the stationary sampler was sampling proportionately to the abundance in the river (a medium strength of connection)."

The first point to note is that the analysis is undertaken by comparing a species' **proportional rank abundance** in the power station kill with that living in the river. Rather oddly, a fish that contributes the highest proportion to the number of individuals killed by the power plant, and which is also the commonest in the river, only has a medium strength of connection. In our opinion, such a situation where a fish is killed in high numbers and is locally common would suggest a high linkage. This is a point that needs consideration and critical appraisal. The effect is to reduce the assessment of the power plant's impact on abundant, commonly-caught fish.

The second point to note is that a species which is ranked less common in the power plant kill than in the river will be scored small to moderate. The key point is that the power plant kill may actually reflect the abundance in the river, however the rank could decline if other species are killed in unusually high numbers. Thus, each species is not being fairly assessed on its own merits.

We will now examine the generation of these assessments of the strength of connection line of evidence in more detail. Figure 4 shows the Weight of Evidence for the Strength of Connection table.

Table I-32 Weight of Evidence for the Strength-of-Connection Line of Evidence Based on the Result Scores of Low = 1, Medium = 2, and High = 3

Measurement	Impingement Result Score		Entrainment Result Score		WOE Score[b]	Strength of Connection
	RIS	Prey	RIS	Prey		
Use and Utility[a]	1.9	2.0	1.6	2.1		
Alewife	2	1	2	1	1.5	Low to Medium
Bay Anchovy	2	1	2	1	1.5	Low to Medium
American Shad	2	1	2	1	1.5	Low to Medium
Bluefish	4	2	2	2	2.5	High
Hogchoker	4	1	2	1	2.0	Medium to High
Atlantic Menhaden	Unknown	1	Unknown	1	Unknown	Unknown
Blueback Herring	2	1	2	1	1.5	Low to Medium
Rainbow Smelt	2	1	4	1	1.9	Medium
Shortnose Sturgeon	Unknown	1	Unknown	1	Unknown	Unknown
Spottail Shiner	1	2	1	2	1.5	Low to Medium
Atlantic Sturgeon	Unknown	1	Unknown	1	Unknown	Unknown
Striped Bass	2	4	2	2	2.5	High
Atlantic Tomcod	2	1	2	1	1.5	Low to Medium
White Catfish	2	1	2	1	1.5	Low to Medium
White Perch	2	2	2	2	2.0	Medium to High
Weakfish	2	2	2	2	2.0	Medium to High
Gizzard Shad	Unknown	1	Unknown	1	Unknown	Unknown
Blue Crab	Unknown	1	Unknown	1	Unknown	Unknown

(a) Use and Utility: Low = <1.5, Medium = ≥1.5 but ≤2.0, High = >2.0
(b) WOE Score: Small = <1.5; Small-Moderate = 1.5; Moderate = >1.5 but <2.0; Moderate-Large = 2.0; Large = >2.0

Figure 4: A copy of Table I-32 from NUREG-1437, Vol 2, page I-47.

We will illustrate weaknesses with the approach taken using, as above, a specific example from the list of RIS species.

3.4 Rainbow smelt

Juvenile rainbow smelt have disappeared from the survey since the mid 1990s (Figure 5), and it is therefore unsurprising that Table 4-4 assesses the population line of evidence as *'Large'*. However, the impact of Indian Point 2 and 3 is assessed as moderate because the strength of connection is assessed as *'Medium'*.

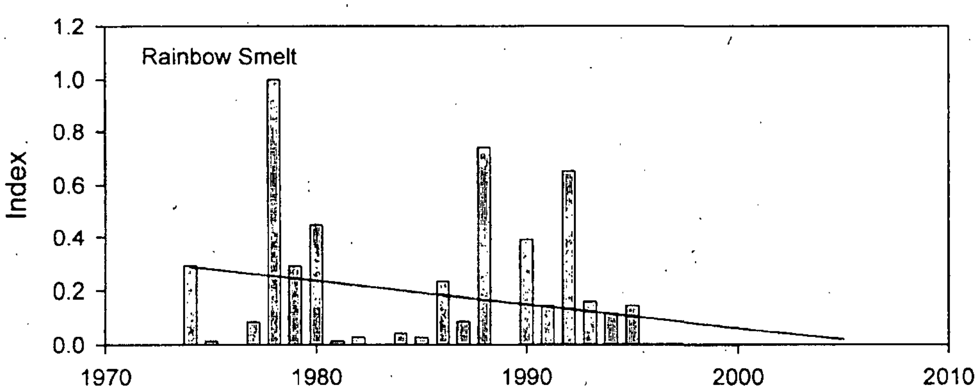


Figure 5: The standardised juvenile index for rainbow smelt in the Hudson.

Examination of Table I-32 (Figure 4) shows why the overall impact is only 'Moderate'. This table shows that both the impingement and entrainment of rainbow smelt has been appreciable, and entrainment has been given the highest score possible of 4. However, the strength of connection is only medium because both the impingement and entrainment prey scores are 1. The reason for this is stated in NUREG-1437, Vol. 2 page I-41.

> *"All remaining YOY RIS eat plankton, zooplankton, benthic invertebrates, and amphipods. These prey were assumed to be unaffected by the cooling systems, and a low strength of connection was concluded."*

This example demonstrates that an unsubstantiated and unproven assumption, that invertebrate prey species are not affected by the cooling water system, leads in turn to the conclusion that the rainbow smelt, a species which has effectively disappeared from the data in recent years and has been assessed as potentially highly impacted by entrainment, is only given a moderate impact in Table 4-4.

Before a conclusion of this nature could be justified, the assertion that the cooling water system has no impact on invertebrate prey species needs to be demonstrated. There is considerable evidence that large numbers of invertebrates are entrained and potentially killed by the cooling water system. There is therefore no reason to believe that invertebrate prey species such as amphipods are not adversely affected. This impact may extend beyond entrainment effects as the heated discharge water may also adversely affect them.

3.5 *Other species*

Examination of Table I-32 (Figure 4) shows that a number of the RIS species have a prey score for impingement and entrainment of 1, and thus are unlikely to score highly for the strength of connection. This feature of the scoring protocol is thus central to the final outcome. The Atlantic tomcod makes a telling further example. The tomcod population shows considerable year-to-year variation, but appears to be in long-term decline (Figure 6). The average standardised index from 1975 until 1995 is 0.158; in comparison the index for the last ten years of sampling (1996-2005) is only 0.0617. In the last 10 years, only 2001 produced a good recruitment, although there are signs of a recent slight improvement in tomcod numbers.

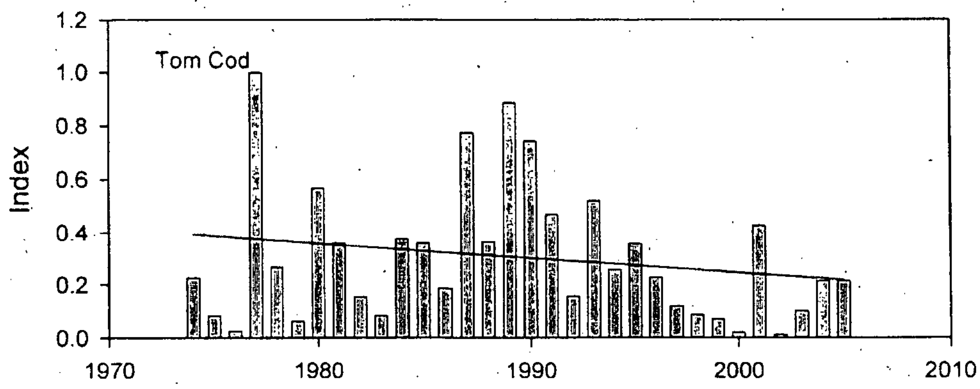


Figure 6: The standardised juvenile index for tomcod in the Hudson showing a decreasing trend though time. (Seaby and Henderson, 2007)

While the population line of evidence for a decline is large, the invertebrate prey of this species is primarily responsible for the low-to medium strength of connection and the final conclusion that the impact is small to moderate.

4 The age of the data

A key underlying point to note about the analysis of impingement and entrainment is the reliance on data collected between 1981 and 1990. These data are old, and may not reflect current conditions. Further, there are hints that the NRC staff did wonder if the data reflected present conditions. For example they noted that the data showed a declining dominance of RIS species:

> *"Until 1984, the RIS fish made up greater than or equal to 95 percent of all impinged taxa. This percentage has significantly decreased at a rate of 0.8 percent per year (linear regression; n = 16; p = 0.002) from 1985 to 1990."*

If impinged data were available for 2008 would we find that the impinged fish had changed even more? The risks inherent with the use of old data are not addressed.

It is worth noting that, although the impingement and entrainment data are over 17 years old, the population data that shows the decline in so many of these species is current. The differences in the population of fish between the 1990s and the present are great.

5 Threatened and Endangered Species

The NRC staff review the number of shortnose and Atlantic sturgeon that are impinged at Indian Point. The data used to assess the impact are old, and the lack of monitoring of impingement means that they do not know if current impingement rates are similar to those between the 1970s and 1990s. In addition, they admit that they cannot assess the thermal impact on these species (page 4-51). Given these large uncertainties the NRC staff come to no conclusion on the impact of Indian Point on theses species, giving a range of small to large for the future impacts.

6 Potential Mitigation Options and Cumulative Impacts

In section 4.1.5 the NRC staff state that they believe that the continued operation of Indian Point will have an adverse effect on the aquatic system of the lower Hudson River; we agree with this statement. However, they then go on to review some of the potential mitigation methods including many that are not viable method for this facility; we believe this review of mitigation options is meaningless. .

Finally, the cumulative adverse impacts of the many factors that affect the Hudson River are considered in section 4.8.1. The NRC staff conclude that the continued operation of Indian Point will have a large impact on some of the species examined, and could be detrimental to the shortnose sturgeon. They also consider that the effects of climate change could be substantial and are an important component of the likely adverse impact.

When all the various factors, including the operation of Indian Point, were considered (p4-58) the overall effects were considered large. Clearly, the Indian Point power plant must take its share of the responsibility and undertake to do as little damage a possible to an already stressed system.

7 Thermal impacts

In NUREG-1437, Vol. 1, page 4-27 NRC staff conclude that thermal impacts associated with the discharge are small to moderate, principally on the grounds that there is no evidence for the scale of the impact:

> *"In the absence of specific studies, and in the absence of effects sufficient to make a determination of a LARGE impacts, the NRC staff concludes that thermal impacts from IP2 and IP# could thus range from SMALL to MODERATE depending on the extent and magnitude of the thermal plume, the sensitivity of various aquatic species and lifestages likely to encounter the thermal plume, and*

the probability of an encounter occurring that could result in lethal or sublethal effects."

The assertion that, because no appropriate evidence has been collected, therefore there is only a small to moderate impact is not logical.

Linked to thermal impacts must be a consideration of climate change impacts. The following conclusion is reached in H-60:

"Thus, the NRC staff has concluded that the cumulative effects of climate change cannot be determined."

We therefore have the odd situation where they are willing to conclude that thermal effects are small to moderate and can therefore be dismissed, yet they cannot determine the effects of climate change. We believe they should have, at the very least, concluded that they needed more data on thermal issues before reaching a conclusion.

8 Conclusion

The assessment of impact on the RIS species is based on a scoring system that initially appears objective and quantitative. However, detailed examination of the method shows that it makes assumptions about the statistical properties of populations, the impact of cooling water systems on invertebrates and the relative importance of local and larger scale changes in population number, that have not been justified.

A particular problem concerns the scoring method used to assess the strength of connection; this is a poor measure of the impact of the power plant on the species. The strength of connection is a flawed measure because it is based on rank abundance, furthermore the lack of importance given to impacts on invertebrates makes low to moderate levels of impact for many species almost inevitable.

The data relied on to measure impingement and entrainment is old, and many populations have shown marked changes since that period. This brings into question the reliability of the conclusions when applied to the future.

Although the NRC does not come to a definite conclusion about the effect of Indian Point on the sturgeon, they are concerned that they continuing operation will have adverse effects.

The cumulative effects of all the impacts on the River Hudson are assed as large. The power plant, along with other users, must take their share of the responsibility and undertake to do as little damage a possible to an already stressed system.

9 References

Seaby, R M H and Henderson, P A, 2007. The status of fish populations and the ecology of the Hudson. Prepared for Riverkeeper, New York.

Exhibit B

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
55 Great Republic Drive
Gloucester, MA 01930-2276

FEB 24 2009

David J. Wrona, Branch Chief
Projects Branch 2
Division of License Renewal
Office of Nuclear Reactor Program
US Nuclear Regulatory Commission
Washington, DC 20555-0001

RE: Biological Assessment for License Renewal of the Indian Point Nuclear Generating Unit Nos. 2 and 3

Dear Mr. Wrona:

This correspondence responds to a letter dated December 22, 2008 (received January 2, 2009) regarding the initiation of formal consultation for the proposed renewal by the US Nuclear Regulatory Commission (NRC) of the Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) operating licenses for a period of an additional 20 years pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended. The current operating licenses for these units expire on September 28, 2013 (IP2) and December 12, 2015 (IP3). Consultation with NOAA's National Marine Fisheries Service (NMFS) regarding the proposed license renewal is appropriate as the action may adversely affect the federally endangered shortnose sturgeon (*Acipenser brevirostrum*). Accompanying your letter was a Biological Assessment (BA) evaluating the impact of the proposed renewal on federally endangered shortnose sturgeon (*Acipenser brevirostrum*), as well as a copy of the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 39 Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3 Draft Report*. NMFS has completed an initial review of the BA and draft EIS and has determined that we have not received all of the information necessary to initiate consultation. To complete the initiation package, we will require the information outlined below.

Section 4 of the BA contains life history and status information for shortnose sturgeon. Several corrections are necessary in this section. In the Hudson River, shortnose sturgeon spawn when water temperatures are between 8 and 15°C, which typically occurs in April. Recent information suggests that the population estimate calculated by Bain, and included in the BA, likely overestimates the number of shortnose sturgeon in the Hudson River. Dr. Katherine Hattala, a biologist with the State of New York, has examined the data used by Bain and determined that a more appropriate estimate is approximately 30,000 adult shortnose sturgeon.

Section 4.3.2 of the BA assesses the impact of impingement on shortnose sturgeon. The BA contains a summary of the available information on impingement of shortnose sturgeon (Table 2). NMFS requests that NRC staff provide the following information in regards to Table 2: (a) for each year, indicate the level of monitoring effort (e.g. weekly for six months, etc.); (b) for each year when there is no number recorded, indicate whether that was due to a lack of monitoring, or due to a lack of capture; (c) indicate the date of impingement; and, (d) indicate the size and condition (i.e., alive, injured or dead) of the impinged fish. It is our understanding that no impingement monitoring has been conducted since traveling Ristroph-type screens were installed at the facility in 1991. As noted in the BA, the lack of information makes it difficult to predict the effects of relicensing and an additional 20 years of operation on shortnose sturgeon. If the NRC is not able to require the applicant to conduct monitoring in support of relicensing, NMFS requests that the NRC provide an estimate, based on the best available scientific information, of the likely number of shortnose sturgeon impinged at the facility with the traveling Ristroph-type screens in use. NMFS expects that the NRC could use the existing impingement data in conjunction with data on the effectiveness of Ristroph-type screens to calculate this estimate. As noted in the BA, another important factor is the mortality rate of impinged sturgeons. NMFS requests that NRC provide an estimate of the mortality rate for impinged shortnose sturgeon. NMFS expects this rate could be calculated based on available mortality rate data for other similar species and/or other facilities where similar screen types have been installed.

Section 4.3.3 of the BA discusses thermal impacts. As noted in the BA, without a model of the thermal plume it is extremely difficult to predict what the level of exposure to elevated water temperatures is for shortnose sturgeon. If NRC is unable to require that the applicant conduct modeling of the thermal plume in support of relicensing, NMFS requests that the NRC use the best available scientific information to estimate the likely temporal and spatial extent to which shortnose sturgeon will be exposed to water temperatures where adverse effects are likely (i.e., greater than 28°C).

It is NMFS understanding that the proposed action is the relicensing of the facility with no modification to the existing intakes. However, in the DEIS, the NRC discusses alternatives including cooling towers. NMFS seeks clarification as to the process by which the NRC will determine whether the installation of cooling towers, or other measures, will be required of the applicant. NMFS also seeks clarification regarding the current requirements of the National Pollutant Discharge Elimination System (NPDES) Permit issued by the State of New York and the potential outcome of the adjudication process currently ongoing regarding this permit, as well as the potential for the State NPDES permit to require cooling towers.

The formal consultation process for the proposed action will not begin until we receive all of the requested information or a statement explaining why that information cannot be made available. We will notify you when we receive this additional information; our notification letter will also outline the dates within which formal consultation should be complete and the biological opinion delivered. My staff is available to discuss these information needs with NRC staff. I look forward to continuing to work with you and your staff during the consultation process. If you have any questions or concerns about this letter or about the consultation process in general, please contact Julie Crocker at (978) 282-8480.

Sincerely,

Mary A. Colligan
Assistant Regional Administrator
for Protected Resources

cc: Crocker, F/NER3 (hardcopy)
Damon-Randall, Hartley – F/NER3 (pdf)
Rusanowsky– F/NER4 (pdf)
Logan – NRC (pdf)

File Code: Sec 7 NRC Indian Point Nuclear Plant Relicensing

PCTS: F/NER/2009/00619

Exhibit C

9.15.08

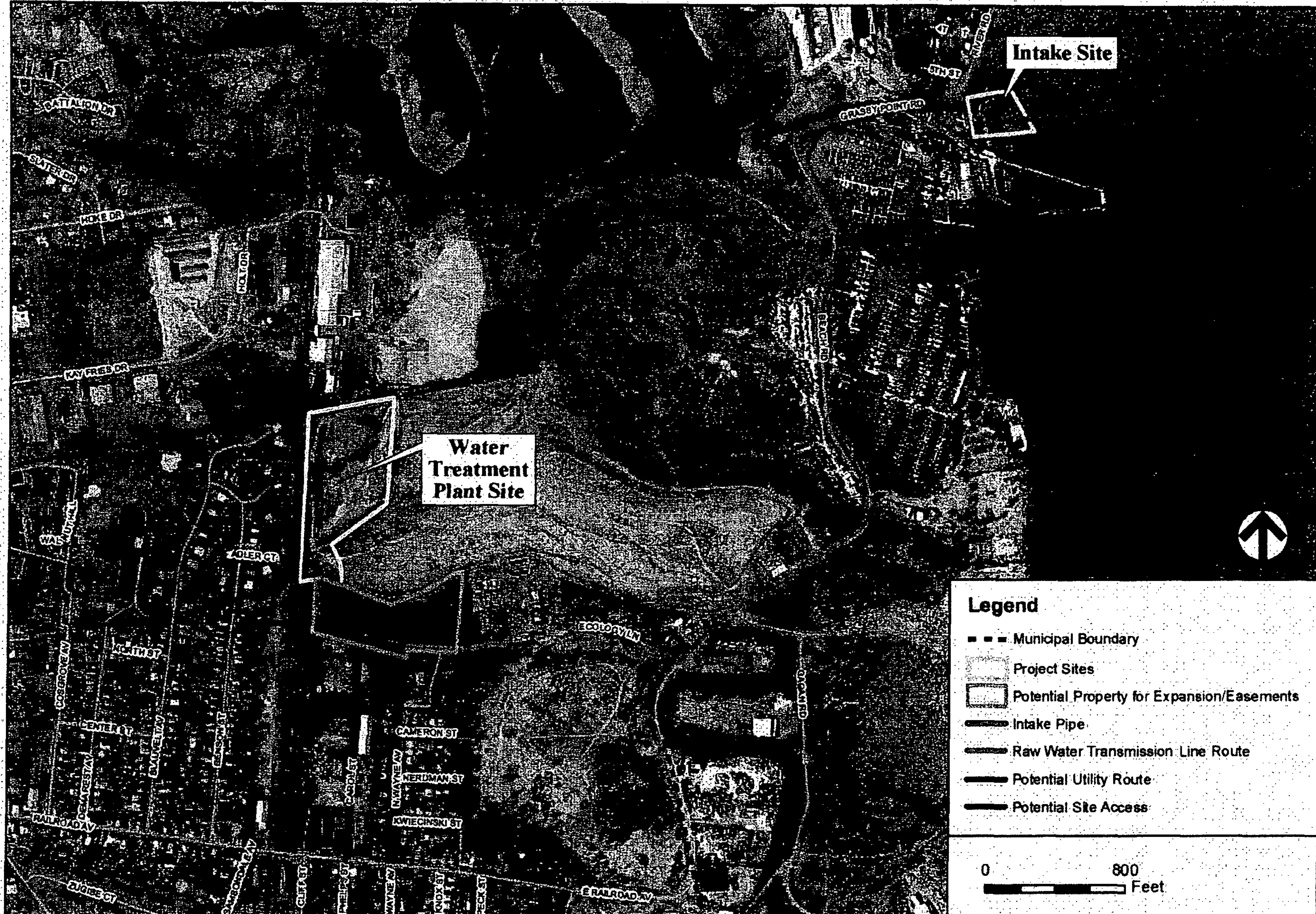
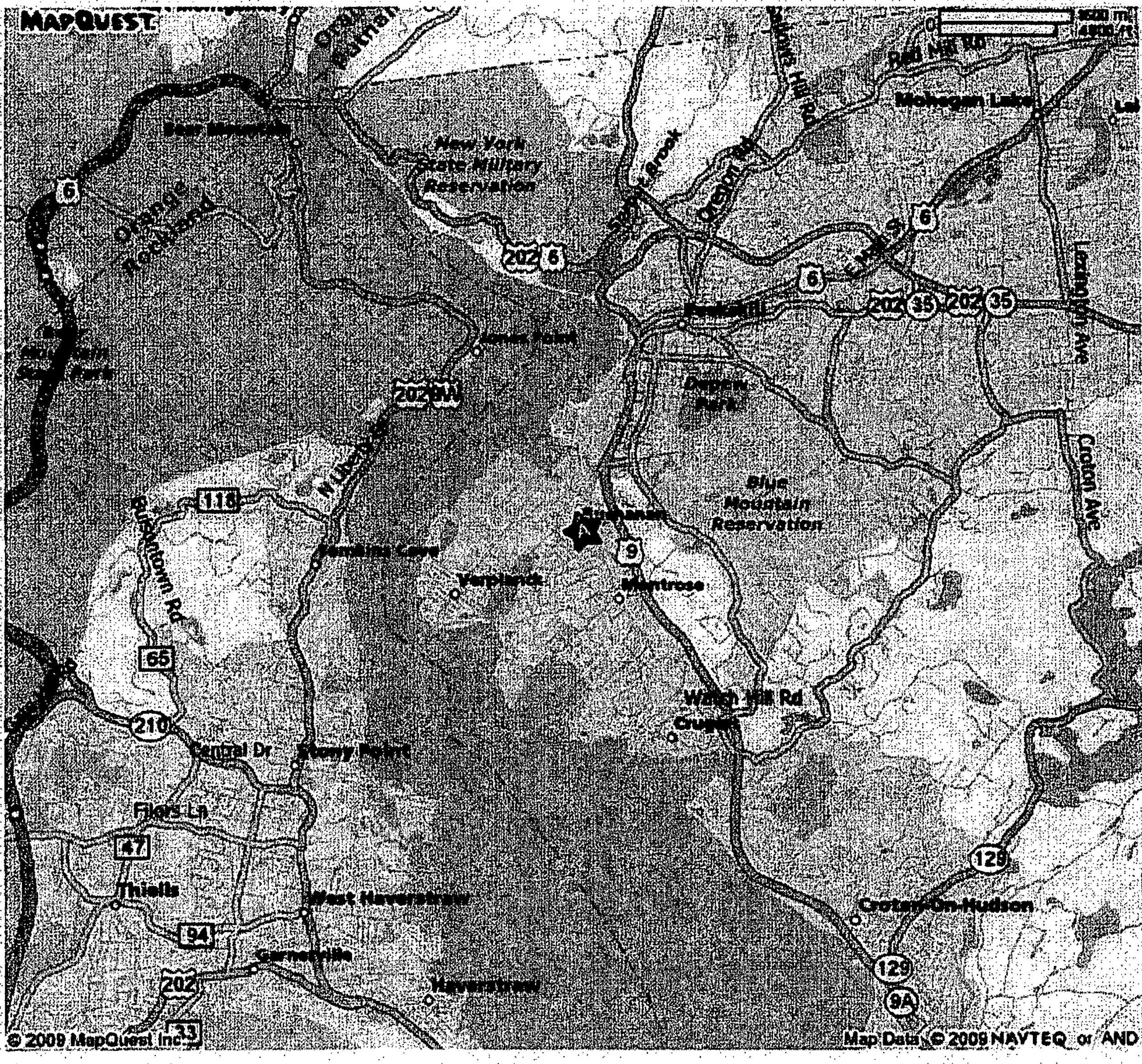


Figure 2-2
Project Site Boundaries

Exhibit D


MAPQUEST
Bear Mountain
New York
State Military
Reservation
Orange
Rockland
Mohegan Lake
Peekskill
Depew
Park
Blue
Mountain
Reservation
Buchanan
Verplanck
Montrose
Tomkins Cove
Watch Hill Rd
Crugers
Central Dr
Stony Point
Thiells
West Haverstraw
Garnerville
Haverstraw
Croton-On-Hudson
Croton Ave
Lexington Ave
202
6
35
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118
65
210
47
94
129
9A
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Exhibit E

New York State Department of Environmental Conservation
Director, Hudson Catskill Region, Region 3
21 South Putt Corners Road, New Paltz, NY 12561-1620
Phone: (845) 256-3033 • **FAX:** (845) 255-3042
Website: www.dec.ny.gov

Alexander B. Grannis
Commissioner

March 9, 2009

Ms Rebecca Troutman
Riverkeeper
828 South Broadway
Tarrytown, NY 10591

Dear Ms Troutman:

Thank you for your letter of January 12, 2008 regarding United Water New York, Inc.'s Proposal to Build a Desalination Plant in Rockland County. Your letter expressed the concern that that "every component of this Project warrants the highest scrutiny under applicable federal and state laws, and all relevant policy considerations," and urged the Department to assume Lead Agency status under the State Environmental Quality Review Act for the project.

The Department's regional staff, on February 10, 2009, forwarded to Riverkeeper staff letters addressing the environmental review of this proposal. These letters are attached for your consideration. These letters addressed the Department's intentions regarding the SEQRA review of both the pilot plant and the long-term plant associated with this proposal, and indicated the Department's intent to be the lead agency for such review.

The Department has not received any objections to our lead agency status, and no such objections being submitted as required by law, now assumes the Lead Agency role for the environmental review. In response to your letter, the Department intends to conduct a full and thorough SEQRA review as required by law, and welcomes full and open participation of the public in that process as it moves forward.

Thank you for your interest in the Department's role in the consideration of the proposed project. We look forward to your and others participation.

Sincerely,

William C. Janeway
Regional Director

Mendiola, Doris

Subject: FW: Riverkeeper Comments on Revised GEIS for NPP License Renewal, RIN3150-AI42 - E-mail 6 - Final

Attachments: 2010.01.12.Exhibit E to Riverkeeper's Comments on Revised License Renewal GEIS, RIN3150-AI42 - RK Comments on EP Rulemaking.pdf; 2010.01.12.Exhibit F to Riverkeeper's Comments on Revised License Renewal GEIS, RIN3150-AI42 - Thompson Report.pdf; 2010.01.12.Exhibit G to Riverkeeper's Comments on Revised License Renewal GEIS, RIN3150-AI42 - Lyman Report.pdf

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From: Deborah Brancato [mailto:DBrancato@riverkeeper.org]
Sent: Wednesday, January 13, 2010 12:02 AM
To: Rulemaking Comments
Subject: RE: Riverkeeper Comments on Revised GEIS for NPP License Renewal, RIN3150-AI42 - E-mail 6 - Final

Dear Secretary and Rulemakings and Adjudication Staff,

As indicated, attached please Exhibits E, F, and G to Riverkeeper, Inc.'s Comments on the NRC's "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 74 Fed. Reg. 38,117, 10 C.F.R. Part 51, RIN 3150-AI42, NRC-2008-0608 (July 31, 2009).

Deborah Brancato
Staff Attorney
Riverkeeper, Inc.
828 South Broadway
Tarrytown, NY 10591
914-478-4501 (ext. 230)
Fax: 914-478-4527
dbrancato@riverkeeper.org
www.riverkeeper.org

Riverkeeper -- Defending the Hudson. Protecting Our Communities.

EXIBIT-F

RULES AND DIRECTIVES

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5/18/09

74 FR 23219

October 19, 2009

19

Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 205555-0001
Attn: Rulemakings and Adjudications Staff
Rulemaking.Comments@nrc.gov

Re: Comments on NRC's Proposed Enhancements to Emergency Preparedness Regulations

Dear Rulemakings and Adjudications Staff:

Riverkeeper, Inc. ("Riverkeeper") hereby respectfully submits the following comments in response to the Nuclear Regulatory Commission's ("NRC") Enhancements to Emergency Preparedness Regulations, Proposed Rule, 10 C.F.R. Parts 50 and 52, RIN 3150—AI10, NRC-2008-0122, 74 Fed. Reg. 23254 (May 18, 2009) (cited hereinafter as "EP Enhancements Proposed Rule"). Riverkeeper's comments offer feedback on the proposed rule as well as the various draft documents associated with the rulemaking, including:

- Interim Staff Guidance on Emergency Planning for Nuclear Power Plants, NSIR/DPR-ISG-01 (hereinafter "Interim Staff Guidance");

- NUREG-0654/FEMA-REP-1, Supplement 4, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," Draft for Public Comment (May 18, 2009) (hereinafter "NUREG-0654/FEMA-REP-1, Supp. 4");

- NUREG/CR XXXX, "Criteria for Development of Evacuation Time Estimate Studies," Sandia National Laboratories (Predecisional Draft, April 23, 2009) (hereinafter "Draft ETE Report").

For the reasons set forth below, the proposed rule and related guidance documents fail to address numerous fundamental deficiencies with the current regulations, and should be revised as indicated.

SUNSI Review Complete
Template= ADM-013

E-RIDS = ADM-03
Add: J. Laughlin (JXL1)

828 South Broadway, Tarrytown, NY 10591 • 914.478.4527 • f: 914.478.4527 • www.riverkeeper.org

I. RIVERKEEPER'S INTEREST

Riverkeeper is a member-supported, not-for-profit organization dedicated to protecting the Hudson River and its tributaries.[1] Since its inception in 1966, Riverkeeper has used litigation, science, advocacy, and public education to raise and address concerns relating to the Indian Point nuclear power plant, located on the eastern bank of the Hudson River in Buchanan, NY. Riverkeeper is headquartered in Tarrytown, New York, approximately twenty-two (22) miles from the Indian Point facility, and has numerous members that reside within at least fifty (50) miles of the plant.[2]

Since the terrorist attacks of September 11, 2001, Riverkeeper has taken an active role in calling for improved security and emergency planning at Indian Point.[3] In 2003, New York Governor George Pataki commissioned a study of Indian Point's emergency plan by James Lee Witt & Associates ("Witt Report"),[4] which concluded that the plan would not adequately protect the public in the event of an actual emergency. In response, three of the four counties that make up Indian Point's Emergency Planning Zone ("EPZ") and the New York State Emergency Management Office ("NY SEMO") have refused to submit the Annual Certification Letter since 2003, citing serious doubts about its effectiveness. Despite Witt's findings and the utter lack of confidence in the plans by regional and state government officials, FEMA and NRC have subsequently approved the emergency plan every year since.

Riverkeeper remains convinced that the current emergency plan for Indian Point will not protect the public in an actual emergency and that comprehensive reform of the emergency planning regulations would be beneficial. Accordingly, Riverkeeper has a vested interest in the instant rulemaking proceeding, and we encourage careful consideration of the following comments.

II. THE INSTANT RULEMAKING FAILS TO ALTER THE PROCEDURAL NATURE OF CURRENT EMERGENCY PREPAREDNESS REGULATIONS

A general review of NRC's proposed regulatory changes reveals a failure to address a fundamental flaw with the current emergency preparedness regime. The existing set of sixteen emergency planning standards found in 10 C.F.R. § 50.47(b) is purely procedural, in that it does not set actual benchmarks for determining what constitutes a workable plan, sufficient to meet the "reasonable assurance" standard of §50.47(a)(1). In fact, there are no specific criteria in the regulations by which a "reasonable assurance" finding is made. This lack of any tangible regulatory framework is primarily responsible for the utter lack of public confidence in NRC's emergency planning oversight at many plants around the country, Indian Point not least among them. Residents living near Indian Point, and at other plants around the country, believe that these plans are a mere procedural formality, devoid of any connection to the daily realities of

---

[1] *See generally,* Riverkeeper.org, Our Story, http://www.riverkeeper.org/ourstory_index.php (last visited Oct. 15, 2009).

[2] *See* Riverkeeper.org, Contact Us, http://www.riverkeeper.org/contact/ (last visited Oct. 15, 2009).

[3] *See, e.g., In re Entergy Corporation (Indian Point Nuclear Power Station, Units No. 2 and 3; Facility Operating Licenses DPR-26 and DPR-64),* Section 2.206 Request for Emergency Shutdown of Indian Point Units 2 and 3 (November 8, 2001).

[4] James Lee Witt Associates, LLC, Review of Emergency Preparedness of Areas Adjacent to Indian Point and Millstone (2003) (hereinafter "Witt Report").

heavy traffic, high population density, and poor communication between licensees and surrounding communities regarding how the plan will be successfully implemented, if it is ever needed. Public confidence is built on accountability and integrity; NRC is ultimately accountable to the public when the agency approves a licensee's emergency plan. Public confidence in the NRC is especially important when it comes to emergency planning, because the effectiveness of the emergency plan ultimately depends on how well the public adheres to it.

Accordingly, Riverkeeper strongly supports the establishment of performance-based standards to be used in evaluating a licensee's emergency plan on a yearly basis. Establishing binding performance-based standards to determine whether an emergency plan provides "reasonable assurance" is essential to enlisting the support of the public and concerned stakeholders in this process. There is no accountability without a system of benchmarks by which these plans are measured and actions taken by NRC if a plan is not up to par. While there may be some areas of NRC regulation that favor regulatory flexibility, emergency planning is not one of them. This is the one area of regulatory oversight that requires a clear, easily defined baseline that can be implemented by the industry and enforced by NRC. Its success is entirely dependent on cooperation from other federal agencies, state and local first responders, and the public.

Unfortunately, the instant rulemaking proceeding fails to address the procedural nature of emergency preparedness regulations, and in fact, only appears to make further procedural amendments to the existing regime. As discussed in more detail below in relation to specifically proposed security-related and non-security related revisions, NRC should implement performance standards to ensure a more effective regulatory scheme.

III. NRC'S CONSIDERATION OF SECURITY RELATED ISSUES

NRC proposes several amendments to existing regulations in an effort to address emergency preparedness actions for hostile events.[5] Regulatory inclusion of security-based events is a logical and long overdue first step in the process of overhauling NRC's emergency planning regulations. It is essential that all licensees of currently operating plants be required to address intentional acts of sabotage to demonstrate that the onsite and offsite plans will function cohesively to protect the public in the event of a terrorist attack. However, any regulatory revisions to reflect security related issues must be founded upon accurate notions of hostile threats and radiological consequences thereof. A review of the proposed security related regulatory revisions reveals that this is not always the case.

In light of this apparent deficiency, along with several others, Riverkeeper offers the following comments in relation to specific security related revisions to the existing regulatory scheme:

A. "Challenging" Licensee Drills and Exercises

NRC's Proposed Changes

NRC recognizes that current regulations addressing drills and exercises are general in nature and do not explicitly require licensees to include hostile action event scenarios, or allow the NRC to

[5] *See* EP Enhancements Proposed Rule at 23256-60.

require specific scenario content.[6] NRC explains that while nuclear plant licensees have developed and implemented hostile action based emergency drills since the terrorist attacks of September 11, 2001 pursuant to NRC directives and industry guidance, such measures are currently only voluntary.[7] NRC further acknowledges that drill scenarios have become predictable and that "responders may be preconditioned to accident sequences that are not likely to resemble the accidents they could realistically face."[8]

As a result of their these concerns, the NRC proposes to add, *inter alia*, the following language to existing regulations related to drills and exercises:

> i. Licensees shall use drill and exercise scenarios that provide reasonable assurance that anticipatory responses will not result from preconditioning of participants. Such scenarios for nuclear power plant licensees . . . must include a wide spectrum of radiological releases and events, including hostile action events. Exercise and drill scenarios as appropriate must emphasize coordination among onsite and offsite response organizations.
>
> j. The exercises conducted . . . by nuclear power plant licensees . . . must provide the opportunity for the ERO to demonstrate proficiency in the key skills necessary to implement the principal functional areas of emergency response . . . . [and] key skills specific to emergency response duties in the control room, TSC, OSC, EOF, and joint information center. Additionally, in each six calendar year exercise planning cycle, nuclear power plant licensees . . . shall vary the content of scenarios during exercises conducted . . . to provide opportunity for ERO to demonstrate proficiency in skills necessary to respond to the following scenario elements: Hostile action directed at the plant (at an exercise frequency of at least once every 8 years), no radiological release or an unplanned minimal radiological release that does not require public protective actions, an initial classification of or rapid escalation to a Site Area Emergency or General Emergency, implementation of strategies, procedures, and guidance developed under 50.54(hh), and integration of offsite resources with onsite response . . . .[9]

The latter provision prescribes "the minimum exercise scenario elements necessary for licensees to meet NRC expectations for challenging and varied scenario content in biennial exercises."[10]

[6] *Id.* at 23259-60.
[7] *Id.*
[8] *Id.* at 23260.
[9] *Id.* at 23286.
[10] *Id.* at 23278.

In order to ensure that licensee exercise scenarios implement these new requirements, NRC further proposes to add a requirement that licensees submit full participation and onsite biennial exercise scenarios for prior NRC review and approval.[11]

Riverkeeper's Comments

While the NRC has properly identified the problematic deficiencies with current licensee drill and exercise programs, the proposed regulatory changes will not fully alleviate all relevant concerns.

i. NRC Must Provide More Specific Criteria For Determining The Appropriate Scope Of Hostile Event-Based Drills To Ensure That All Relevant Factors Are Considered

Regulatory inclusion of security-based drills is critical, however, the proposed changes are too general and vague to ensure that plant-specific hostile threat environments would be adequately reflected in future drills. More precise standards and benchmarks are, thus, necessary to ensure that drills would adequately address varying hostile threat environments and site specific concerns at particular plants.

To begin with, the frequency of hostile action event based drills, particularly full-participation exercises but also tabletop-drills, should be based on site-specific knowledge of the current threat environment at each plant. To the contrary, the NRC's proposed changes would only impose a general requirement that licensees' drills incorporate a hostile action event at least once every eight years.[12] However, this would be far too infrequent for plants operating under a higher risk of terrorist attack. In such circumstances, security-based drills should be conducted more often than the proposed regulatory change would require, such as on a biennial basis. For example, the current DHS "threat level" for New York City continues to be Orange, meaning there is a "High Risk of Terrorist Attack."[13] Thus, Indian Point, located a mere 24 miles from New York City, home to the nation's, if not the world's, largest financial center, should be required to conduct a full-participation security-based drill more frequently than once every eight years, and hopefully on a biennial basis at the very least. Given the fact that a successful terrorist attack on Indian Point (i.e., one resulting in a large radioactive release to the environment) would have grave impacts on New York City, it makes sense to require the plant to operate at a correspondingly high level of preparedness. Conversely, it may not be necessary for plants located in lightly populated areas to perform security based drills as often. Accordingly, NRC should provide for more specific standards in its proposed rulemaking to ensure that hostile action based drills are performed at a higher frequency at facilities where there is a higher level of risk of significant radioactive release.

Moreover, while the NRC now makes the vague requirement that licensees perform drills involving hostile action events, the regulation changes and associated guidance updates do not provide enough direction to ensure that varied, site-specific contingencies are considered in such

[11] *Id.* at 23277, 23285.
[12] *Id.* at 23286; Interim Staff Guidance at 27; NUREG-0654/FEMA-REP-1, Supp. 4, at 12.
[13] See NYS Office of Homeland Security website at http://www.security.state.ny.us/, last accessed October 14, 2009.

scenarios. As a result, future security-based drills may continue to be unrealistic in scope and execution.

For example, hostile action event scenarios should reflect a fast-breaking radiological release caused by an intentional attack on spent fuel storage facilities, i.e. pools and dry casks. This is imperative for several reasons. First, the likelihood for such a scenario is not insignificant given the vulnerabilities of such facilities, for example, those at Indian Point.[14] Second, the results of such an occurrence could potentially be catastrophic. For example, at Indian Point, an attack on the densely packed IP2 or IP3 spent fuel pools would result in contamination of a significant portion of the 10-mile emergency planning zone and the 50-mile ingestion pathway zone.[15] Federal government reports note that a radioactive release could begin in less than an hour. Accordingly, it is crucial that plants demonstrate that they can successfully respond to such a situation. Thirdly, inclusion of scenarios involving attacks on onsite spent fuel storage facilities is necessary to be consistent with the current status of permanent nuclear waste disposal in the United States.[16] Accordingly, consideration of an intentional attack on spent fuel is a fundamental part of a security based regulatory scheme, including licensee drill programs.

[14] The spent fuel pools at Indian Point are not housed under containment, but rather in non-reinforced cinderblock industrial buildings which are admittedly penetrable by aircraft. The dry casks in the Indian Point ISFSI are stored on an outdoor concrete pad, lined up in rows that are easily visible from the air and the Hudson River. Moreover, numerous reports indicate that nuclear power plants remain likely targets of terrorist attacks. *See, e.g.*, Nat'l Comm'n on Terrorist Attacks Upon the U.S., *The 9/11 Commission Report* (2004); *Wide-Ranging New Terror Alerts*, CBS News.com (May 26, 2002), *available at*, http://cbsnews.com/stories/2002/05/24/attack/main510054.shtml (discussing heightened alert of the U.S.'s nuclear power plants as a result of information gained by the intelligence community); *FBI Warns of Nuke Plant Danger*, CBS News.com (May 1, 2003), *available at*, http://www.cbsnews.com/stories/2003/09/04/attack/main571556.shtml (discussing FBI warning to nuclear plant operators to remain vigilant about suspicious activity that could signal a potential terrorist attack); General Accounting Office, *Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to be Strengthened*, GAO-03-752 (2003) (noting that U.S. nuclear power plants are possible terrorist targets, and criticizing the NRC's oversight of plant security); *FBI's 4th Warning*, CBS News.com (July 2, 2004) (discussing FBI warning of recent intelligence showing Al-Qaeda interest in attacking nuclear plants). A 2006 study by the National Academy of Sciences on security risks posed by the storage of spent fuel at nuclear plant sites, confirmed that attacks by civilian aircrafts remain a plausible threat. Nat'l Acad. of Sciences., *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report* (2006) (hereinafter "2006 NAS Study"). The study found that attacks on spent fuel pools are attractive targets since they are less protected structurally than reactor cores and typically contain much greater inventories of medium and long-lived radionuclides than reactor cores. *Id.*

[15] Indeed, the 2006 NAS Study concluded that storage pools are susceptible to fire and radiological release from intentional attacks. *See* 2006 NAS Study at 49, 57. The environmental impacts of a fire in a spent fuel pool may be severe, extending over a geographic area larger than a state's legal boundaries and continuing for decades. *See generally* Gordon R. Thompson, "Risk Related Impacts from Continued Operation of the Indian Point Nuclear Power Plants" (Institute for Resource and Security Studies) (November 28, 2007) (hereinafter "Thompson Report"); *see also* German Reactor Safety Org., *Protection of German Nuclear Power Plants Against the Background of the Terrorist Attacks in the U.S. on Sept. 11, 2001* (Nov. 27, 2002) (finding that large jetliners crashing into nuclear facilities under different scenarios could cause uncontrollable situations and the release of radiation).

[16] With Yucca Mountain politically dead and the NRC's "Waste Confidence Decision" wholly undermined, spent nuclear fuel is going to continue to remain onsite at nuclear power plants for the indefinite future. *See, e.g.*, Associated Press, "$13 Billion Later, Nuclear Waste Site At Dead End" (March 5, 2009), *available at* http://www.msnbc.msn.com/id/29534497/ (last visited Oct. 19, 2009) (quoting Energy Secretary Steven Chu as stating that Yucca Mountain is no longer an option for storing highly radioactive nuclear waste); *see also* Commissioner Svinicki's vote on SECY-09-0090: *Final Update of the Commission's Waste Confidence Decision* (Sept. 24, 2009), available at http://www.nrc.gov/reading-rm/doc-collections/commission/cvr/2009/2009-0090vtr-

Security-based drill scenarios should also be required to consider various possible occurrences that would result in conjunction with a hostile event. For example, hostile event based drills should encompass: significant self-evacuation, or "shadow evacuation," occurring beyond the 10-mile radius and as far away as 50 miles; simultaneous attacks resulting in a Loss of Offsite Power (LOOP); multi-pronged attacks (e.g., a drill at Indian Point would include an armed attack on the plant itself, coupled with an attack on the Tappan Zee Bridge that would render it impassable); and severely impaired critical infrastructure, such as a major traffic artery impeded due to an accident (for example, in the Fall of 2005, the Tappan Zee Bridge, a major artery between New York City, Westchester County, Rockland County, and New Jersey, was closed due to a tanker truck fire, causing delays of up to nine hours for commuters). The eventuality of such contingencies would have major implications for effective emergency response.

Unfortunately, the NRC's proposed regulatory changes do not ensure that hostile event-based drills would take into account such critical, site specific factors. The proposed rule and associated guidance merely list vague "key skills" which ERO's must demonstrate in future drill scenarios. As described in the NRC's proposed Interim Staff Guidance based on the revised regulatory changes, such skills include: "[r]esponse to hostile action, including interface with LLEAs [local law enforcement agencies]," "[e]ngineering assessment, repair plan development, and physical repair of critical equipment damaged by hostile action after the active attack but before the site is secured by LLEAs," response to a scenario which begins with or rapidly escalates to a high emergency level, ability to respond to the loss of large areas of the plant, repair of damaged equipment, "use of alternative facilities to stage the ERO for rapid activation during a hostile action event," ability to provide medical care for injured or contaminated personnel, radiological release assessment and monitoring, consideration of wind direction and persistence, consideration of a wide spectrum of radiological releases, consideration of varying equipment failure mechanisms, and the like.[17] Clearly, based on these vague directives, there is no guarantee that future hostile action based drills would take into account the relevant factors that may come into play during a hostile event, such as those discussed above. This is true, notwithstanding the NRC's new proposed obligation to pre-approve drill scenarios, since such approval would be based upon the aforementioned vague standards.

NRC's proposed regulatory changes point to reliance on an NRC sanctioned industry guidance document entitled "Conducting a Hostile Action-Based Emergency Response Drill."[18] However, a review of this document reveals broad criteria which also do not ensure that licensees will consider all relevant concerns.[19] For example, this guide discusses a hostile action event scenario structure which states rather broadly that "[t]he drill begins with the commencement of

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kls.pdf (dissenting in part on update to Waste Confidence Decision due to uncertainties of the future of long-term nuclear waste disposal). As such, spent fuel will continue to be an ever-present concern from a security standpoint.

[17] *See* Interim Staff Guidance, at 28-30.

[18] Revision 1 to Nuclear Energy Institute 06-04, "Conducting a Hostile Action-Based Emergency Response Drill" (October 30, 2007), ADAMS Accession No. ML073100460 ("NEI 06-04 Rev. 1"). This document was endorsed by the NRC in "NRC Regulatory Issue Summary 2008-08, Endorsement of Revision 1 to Nuclear Energy Institute Guidance Document NEI 06-04, 'Conducing a Hostile Action-Based Emergency Response Drill,'" (March 18, 2008), ADAMS Accession No. ML080110116.

[19] *See* NEI 06-04 Rev. 1 at 2-1 to 2-4, Appendix A (listing similarly broad capabilities licensees must demonstrate); *see also id.* at 4-1 to 4-4.

the attack (consideration in the scenario should include possible diversions and other attacks)."[20] However this open directive fails to ensure that licensees would address the appropriate site specific factors, as discussed above. The document also explains that

> [t]he scenario events are expected to present the conditions necessary for, or leading to, significant damage to irradiated fuel. Additionally, the scenario events should create a sense of urgency in assessment and the need for restoration of equipment or systems that drive the need for mobilization of resources in a controlled manner. The threat *may* be presented to fuel either in the reactor core or the spent fuel pool. In addition there must be a potential for a radiological release.[21]

Once again, this language is too general in nature to guarantee that licensees will properly take into account various contingencies that may occur during a hostile event. The permissive language relating to whether a scenario could address an attack on a spent fuel pool is unacceptable, since, as explained above, this is a credible, potentially catastrophic situation which *must* be addressed in future security based drills and exercises. Moreover, this would not require consideration of scenarios involving onsite dry cask storage facilities.

This guidance further provides that "assessment of nearby infrastructure vulnerabilities to a hostile action . . . would be a logical and expected response by OROs [offsite response organizations]" and that "developers of the off-site components of a hostile action-based drill or exercise are encouraged to consider it as an ancillary objective for hostile action-based scenarios."[22] This is clearly not explicit enough to require the necessary consideration of pertinent infrastructure concerns.

The guidance set forth in the proposed NUREG-0654/FEMA-REP-1, Supp. 4, is also too general to ensure consideration of relevant contingencies. This draft report would merely suggest that "[e]xtent of play discussions should consider varying attack scenarios (i.e., insider threat or ground, waterborne, airborne, or a combination of attacks) every exercise cycle" and that hostile action based exercise "can coincide with either a release scenario or 'no release'" scenario" but that "consecutive 'no release' HAB [hostile action-based] scenarios should not occur."[23] This draft report further provides vague directives indicating that licensees should vary radiological releases and release conditions.[24] However, without more specificity, this guidance, like the others, would not necessarily cause licensees to take all relevant release scenarios associated with a hostile event into account in future drill schemes.

Without more precise benchmarks related to the scope of hostile actions, future security-based drills at nuclear power plants may continue to be completely ineffective. A pertinent example arises out of the 2004 biennial drill at Indian Point: the scenario involved a cargo plane being

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[20] *Id.* at 4-1.
[21] *Id.* at 4-2 (emphasis added).
[22] *Id.* at 2-4.
[23] NUREG-0654/FEMA-REP-1, Supp. 4, at 10-11.
[24] *Id.* at 10.

hijacked and flown into an open area behind IP3 near the fuel storage building and the transformer yard. Only one person was presumed killed, despite extensive building damage and a jet-fuel fire. This scenario did not involve impact with actual irradiated fuel, and accordingly, no radioactive release was included, despite the fact that a General Emergency was declared just before the drill was "concluded" when the allotted time for the exercise had run out. Notably, the exercise was halted before control of the plant had been established or the General Emergency resolved. This perfectly illustrates a hostile action-based drill which did not reflect realistic assumptions that would likely accompany an actual hostile act. Under the NRC's proposed regulatory changes, scenarios like this one would remain acceptable compliance with the law, and, theoretically, licensees would never be obligated to address the credible contingencies discussed above.

Accordingly, the NRC's "enhancement" to licensee drill and exercise schemes to include hostile event-based scenarios in the instant rulemaking is not sufficient to ensure that future drills would adequately address actual hostile threat events. The NRC must provide more specific criteria for determining the appropriate scope of hostile event-based drills to ensure that all relevant factors are considered.

ii. NRC Has Not Done Enough To Ensure Increased Realism And Unpredictability In Licensee Drill Programs

Regulatory inclusion of security-based drills is one element of NRC's overall proposed measures, as cited above, intended to reduce predictability and increase realism in licensee drill programs. Riverkeeper appreciates the NRC's recognition that a higher level of unpredictability and realism must be injected into both the safety-based and security-based drills in order to improve their usefulness. As a senior NY SEMO official commented to Riverkeeper in advance of a drill at Indian Point held in November 2006, "I've been doing these drills for twenty years. They're always the same." Indeed, such changes are absolutely necessary to ensure that drills and exercises are tools which accurately test and measure facilities' capabilities to handle real emergency situations. Without a realistic underlying premise, a drill would not provide any useful function. Additionally, public confidence in a plants emergency plan can only be achieved if NRC demonstrates its willingness to test for credible scenarios.

Unfortunately, NRC's proposed changes do not go far enough to achieve the intended goals here. NRC proposes to generally require that future drill scenarios be varied so as to not result in anticipatory responses, providing only that scenario variations should include hostile action events, scenarios with no or minimal radiological release, and scenarios with an elevated initial emergency level or rapid escalation thereto.[25] NRC's draft guidance documents would likewise provide only vague direction: the Interim Staff Guidance lists general "key skills" which ERO's must demonstrate in future drill scenarios, as discussed above[26]; NUREG-0654/FEMA-REP-1, Supp. 4 memorializes the proposed regulation changes and offers some additional general guidance, including that drill scenarios "include varied release effects and environmental and meteorological conditions between exercise scenarios within a cycle (e.g., momentary or puff vs. continuous release, ground vs. elevated release, shifting wind direction and speed), as applicable

[25] EP Enhancements Proposed Rule at 23286.
[26] See Interim Staff Guidance at 28-29.

to plant design and historical site characteristics" (though these elements are not actual requirements, but rather "areas of consideration"), and "incorporate expanded causative events," taking into account "site-specific hazards (e.g., adjacent chemical plants, hazardous material storage facilities, railways, etc.), applicable regional natural events (e.g., earthquakes, hurricanes), seasonable conditions and HAB scenarios."[27] A review of all the proposed changes and guidance reveals that NRC has not provided sufficiently specific criteria to ensure that future drill scenarios will properly consider relevant, site-specific realities that may realistically come into play when accidents or hostile events ensue.

To begin with, as discussed at length above, NRC fails to provide any standards related to the substantive scope of hostile scenarios. Rather NRC's proposed regulatory changes indicate that mere inclusion of a hostile event-based scenario into a licensee's drill scheme at least once every eight years, in conjunction with other elements, is evidence of acceptable unpredictability and realism. Such a vague standard, with scant guidance, would not oblige licensees to encompass a wide variety of realistic hostile event scenarios into their drill schemes. As discussed above, it is imperative that security-based drills be based on a variety of attack scenarios, not only focused on the reactors themselves (including attack on the spent fuel pools, an aircraft attack on other critical plant buildings and systems besides the containment domes, or a waterborne attack targeting the turbine buildings or intake structures), and utilize the most current knowledge about the types of attacks that might be carried out, types of weapons used, potential target sets, and the degree of damage expected from a successful attack. Without criteria in place to ensure that accurate hostile action based events are employed in future drills, the regulatory changes will not lead to a more realistic and variable drill scheme.

Furthermore, in order to be realistic, drills should take into account various factors, which would not necessarily be encompassed under the loose proposed regulatory requirements and associated guidance. Such factors include the following: stress on limited emergency resources and personnel (for example, multiple attacks on the region including local bridges, roads, and electrical transmission lines, or a regional electrical blackout); major transportation arteries which are impassable (due to acts of terrorism or gridlock) to people evacuating[28]; radioactive plume travel beyond the 10-mile radius, which threatens to expose citizens with higher-than-acceptable doses[29]; significant shadow evacuation beyond the 10-mile radius and as far away as

[27] NUREG-0654/FEMA-REP-1, Supp. 4, at 10.

[28] In relation to the 2002 biennial drill at Indian Point, when asked how they would handle massive increases in traffic on the Tappan Zee Bridge during an evacuation, emergency officials at the Joint News Center responded that "additional toll-booth operators would be called in to handle the increased volume." Based on this response, it is evident that the involved official either did not take the issue of traffic during an emergency evacuation into account, or had an unacceptable method for handling it. Yet, this is a critical issue, especially for highly populated areas like the area around Indian Point. Indeed, numerous traffic accidents and inclement weather in the region over the past few years reveal how vulnerable the region's transportation infrastructure is to gridlock. Accordingly, such situations should be reflected in drills to ensure the plants are able to properly cope.

[29] Federal Government reports acknowledge that dangerous levels of radiation can drift well beyond the 10-mile EPZ, even beyond the 50-mile ingestion pathway (see discussion related to evacuation time estimates below). In light of this, drills should include "ingestion pathway" (i.e., the 50-mile radius around a nuclear power plant within which people could be at risk if they eat or drink contaminated food or water) exercises which require activities beyond the 10-mile radius emergency planning zone. Beyond proposed general guidance alluding to the fact that licensee's should consider varying radiological release conditions, such as varying meteorological condition or wind direction, the instant rulemaking provides no criteria that would oblige consideration of the foregoing. Indeed,

50 miles[30]; large numbers of injured and contaminated people requiring treatment and decontamination[31]; and travel of emergency officials to emergency joint news center, the hub for emergency notification operations, especially in the event of a fast breaking release scenario.[32] Without more specific criteria, licensees would continue to not be required to consider such factors. How can NRC hope to foster realistic scenarios when such critical issues are not made part of the equation?

NRC's proposed changes to enhance drill realism also falters in another respect. Under the existing regulatory scheme, safety-based drills are normally based on a gradually deteriorating safety situation that inevitably provides at least 8-12 hours for protective actions, such as evacuation, to be conducted. It has been quite problematic that accident scenarios used never seem to result in more rapid deterioration of plant conditions. NRC's new regulatory scheme does recognize this problem, and would require that licensees demonstrate ability to respond to scenarios that begin with, or escalate rapidly to (within 30 minutes), a Site Area Emergency or General Emergency.[33] However, the proposed guidance would only require that drills employ such a scenario as little as once every eight years.[34] Based on the realistic possibility that plant conditions could deteriorate quickly in an accident or hostile event, it would be wise to require drills reflecting that possibility on a more regular basis. Additionally, the new rule language and guidance leave the door open to licensees to only escalate to Site Area Emergency.[35] Not specifically requiring escalation to the highest emergency level reduces the efficacy of NRC's proposed change here.

Lastly, Riverkeeper fails to see the efficacy of mandating drill scenarios in which there is no radiological release/unplanned minimal radiological release that does not require public protective actions.[36] The importance of training and conducting exercises that consider a radiological release is paramount. This is the only way for licensees, NRC and the public to understand the consequences of release, no matter how low the perceived risk. Moreover, public confidence in an emergency plan can only be achieved if NRC demonstrates its willingness to test out worst-case scenarios. For example, at Indian Point, drills repeatedly have not included radiological releases, including the 2002 and 2004 biennial drills. Given the unique position of

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vague directives to perform "radiological assessment" are meaningless unless licensees are required to do so in the proper context. *See* Interim Staff Guidance at 28-29.

30 Academic research and the experience at Three Mile Island demonstrate there will be significant shadow evacuation outside of the 10-mile zone. The Witt report recommends consideration of shadow evacuation. *See* Witt Report at x; *see also* discussion related to evacuation time estimates below.

31 Medical personnel have expressed concerns about hospitals being overrun by citizens worried that they have been exposed to radiation and the ability to treat a large number of contaminated people. NRC's proposed guidance only identifies "ability to provide medical care for injured, contaminated *personnel*." Interim Staff Guidance at 29.

32 Exercises should not begin with all the emergency personnel already at the joint news center. As noted by county emergency officials, one of the problems presented by a fast breaking release and associated traffic congestion is that a large number of county, state, and federal emergency officials will be unable to get to the joint news center in a timely manner.

33 Interim Staff Guidance at 29.

34 *See id.* at 27; NUREG-0654/FEMA-REP-1, Supp. 4, at 9.

35 *See, e.g.*, NUREG-0654/FEMA-REP-1, Supp. 4, at 9 (indicating that classification would only need to start at or rapidly escalate to Site Area Emergency, and stating that reaching a General Emergency is not required).

36 *See* EP Enhancements Proposed Rule at 23286; Interim Staff Guidance at 27-29; NUREG-0654/FEMA-REP-1, Supp. 4, at 10.

Indian Point in a highly populated region, the value of running drills with no release is very questionable.

It is, thus, more than evident, that the proposed revisions to the licensee drill regime would not fully achieve the NRC's intended goals of less predictability and more realism. NRC's proposed changes fail to alter the existing drill regime to a sufficient degree such that predictable and ineffectual scenarios would be avoided in the future. Requiring compliance with frequent drills which reflect an *accurate* range of hostile event scenarios and give due regard to site specific considerations, would result in a far superior drill model that would accomplish the NRC's objectives here. Only if such concrete obligations are imposed to ensure realistic scenarios are employed would drills be able to accurately demonstrate licensee emergency response capabilities.

iii. NRC Should Incorporate Performance Based Standards Into Drill Requirements

In addition to the need for more precise criteria to ensure that future licensee drills and exercises address the full range of potential concerns that may arise during an emergency situation, NRC must provide a concrete method for measuring the effectiveness of future drills. Performance based standards must be inserted into the new regulatory scheme to guarantee a mechanism by which the NRC, as well as licensees and the public, can make well-informed judgments as to the effectiveness of the drill, and the actual capabilities of licensees.

While NRC's proposed regulatory changes require that future drills and exercises demonstrate various broadly termed emergency response capabilities (such as appropriate staffing, communication, implementation of protective actions, mitigation, ability to deal with hostile events and rapidly escalating emergency levels, etc),[37] the new regulatory scheme would continue to provide a vague standard for evaluating such drills. That is, the regulations provide for "formal critiques" to identify any weakness and deficiencies experienced during drills.[38] Though NRC now proposes to amend this requirement to make clear its application to drills and exercises,[39] such a vague obligation does not provide for meaningful evaluation of licensees' performance of drills. Without a mechanism to do this, drills amount to mere procedural requirements and cease to be useful tools. The proposed Interim Staff Guidance also fails to provide any concrete standards, simply reiterating that "[w]here weaknesses in performance are observed, the critique of such performance and resolution of weaknesses using corrective action programs contribute to the strength of licensee emergency preparedness through incorporation of lessons learned and training of the ERO."[40]

Instead, NRC should impose concrete standards based on actual licensee performance. In particular, NRC should require specific, measurable levels of performance be achieved during tabletop and full participation exercises, both security-based and safety-based, backed up by a strict, enforceable Corrective Action Program that allows a limited time period (less than the current 120-day period) to remedy below-standard performance problems. If a plant

[37] See Interim Staff Guidance at 28-29.
[38] 10 C.F.R. Part 50, App. E, IV.F.2.g.
[39] EP Enhancements Proposed Rule at 23278, 23286.
[40] Interim Staff Guidance at 28.

owner/operator cannot come into compliance within the prescribed time period, the licensee must shut down until compliance is achieved. For example, one such performance requirement could be for senior ERO officials to demonstrate ability to staff offsite emergency operations centers and Joint Information Centers (JIC) in a timely manner (this is currently not tested during full participation drills because staff is already present at the JIC when the drill begins).

iv. NRC Has Failed To Improve Public Participation in Licensee Drill Performance

One additional glaring flaw with the NRC's proposed regulatory changes to licensee drill and exercise programs is the failure to improve public participation in relation to licensee drill performance. Current regulatory guidance which NRC continues to endorse indicates that "scenario-related information should be treated as security sensitive."[41] Common practice involves a single public meeting several days after the exercise where the public is "debriefed" on the results of the exercise. Moreover, typically only media, elected officials' representatives and a few members of the public are allowed to observe the exercise. There is no reason for such limited involvement from the public. Thus, the NRC should take steps to ensure adequate public participation is allowed, including, but not limited to eliciting input from the public both before and after the biennial drill, requiring increased public access to Joint Information Centers during the drill, and increasing public disclosure of the results and evaluations following the biennial drills, detailing problems encountered and required changes to the plan or its implementation that must be made within a prescribed time period.

Indeed, the Governor Pataki-commissioned Witt report called for such greater public involvement in emergency planning:

> Cities, special facilities, private employers, and selected citizen groups or neighborhoods should be encouraged to participate in exercises. Elected officials should participate in exercises to make sure that the decision-making element is well represented and that they receive needed training. We further recommend that interested stakeholders be allowed to observe these exercises.[42]

Public participation in this manner is important for establishing credibility in plants' emergency plans. For example, at Indian Point, Entergy (the Indian Point Licensee) continually maintains that security and EP at Indian Point have been significantly enhanced since 9/11. However, it is impossible for the public to make an independent judgment of this claim, due to "safeguards" restrictions imposed by NRC. The opportunity to provide input on, be involved with, and hear feedback on licensees' drills would help the public to make such independent evaluations related to the effectiveness of the drills, and in turn, a licensee's emergency plan.

The NRC's proposed new requirement that licensees obtain NRC approval of future drill scenarios would provide a prime opportunity for public input to be solicited, should this requirement becomes final. Upon submittal of scenarios to the NRC, those members of the public who possess appropriate interest (such as Riverkeeper in the case of Entergy's future

[41] NEI 06-04 Rev. 1 at 4-3.
[42] Witt Report at 240-41.

proposed drills in relation to Indian Point) should be given the opportunity to offer input regarding the efficacy of the licensee's proposed drill and whether or not such drills are consistent with NRC's regulatory intent, regulations, and guidance. Additionally, the NRC's existing requirement that "[a]ll training, including exercises, shall provide for formal critiques in order to identify weak or deficient areas that need correction, " and that any deficiencies identified be corrected,[43] could provide another formal opportunity for public involvement: NRC should explicitly require that all documentation produced as a result of this obligation should be accessible for public scrutiny and comment.

Claims that scenario information must be secretive are unfounded. The realm of possible hostile event scenarios include ones already contemplated by the public at large, such as those discussed herein (such as suicide attacks on spent fuel storage facilities, jet fuel fires, disruption of offsite infrastructure, etc). Accordingly, there is no reason to classify such information as sensitive. This only serves to prevent public scrutiny related to the effectiveness of hostile action-based drill scenarios and emergency response actions. At a minimum, there must be appropriate limits on the amount of secrecy applied.

B. On-Shift Multiple Responsibilities

NRC's Proposed Changes

NRC identifies its concern that in the context of a hostile action event, on-shift Emergency Response Organization ("ERO") personnel who are assigned to emergency plan implementation functions may have multiple responsibilities that would prevent timely performance of their assigned emergency plan tasks. To address this, NRC proposes to require licensees to produce a "detailed analysis demonstrating that on-shift personnel . . . are not assigned any responsibilities that would prevent timely performance of their assigned functions."[44] NRC states that,

> [l]icensees would first need to identify the spectrum of accidents defined in their licensing basis (i.e., design basis accidents (DBAs), as well as the DBT [design basis threat], as applicable), for which there must be emergency planning. The analysis would identify all tasks which must be complete for each DBA and the DBT, as applicable, and the responders responsible for the performance of those tasks.[45]

Riverkeeper's Comments

The effectiveness of this proposed regulatory change is dependent upon consideration of an accurate range of possible accidents and hostile threats at a nuclear power plant. However, the present DBT, adopted in January 2007, is not reflective of all potential terrorist threats to a nuclear power plant. While the actual DBT is not publicly available, published descriptions

[43] EP Enhancements Proposed Rule at 23286; see 10 C.F.R. Part 50 App. E § IV.F.2.g.
[44] EP Enhancements Proposed Rule at 23284.
[45] *Id.* at 23274; *see also* Draft Interim Staff Guidance at 13 (providing specific requirements for ensuring that on-shift staff can cope with site-specific DBAs and the DBT).

reveal that NRC requires a comparatively light defense for nuclear power plants and their spent fuel.[46] Thus, it would seem that the current DBT does not reflect the level of threat which licensees may be confronted with. For example, the NRC has explicitly stated that the DBT rule "does not require protection against a deliberate hit by a large aircraft."[47]

Accordingly, requiring licensees to only address accidents defined in their licensing basis will not be broad enough to require consideration of all relevant hostile threats. Emergency response tasks will undoubtedly vary depending on the type of threat contemplated. Clearly, more severe hostile threats will cause concomitantly more severe consequences resulting in more including those discussed in above. Failing to do so will render NRC's proposed regulatory changes here largely ineffective due to resulting inaccurate analyses of on-site personnel responsibilities.

C. Licensee Coordination with Offsite Response Organizations During Hostile Action Events

NRC's Proposed Changes

NRC recognizes that offsite response organizations ("OROs") are faced with unique challenges in the context of a hostile action event which were not contemplated at the time the current regulations were developed.[48] In particular, NRC expresses concern that current regulatory scheme does not ensure adequate coordination between licensees and OROs during a hostile action event. Accordingly, NRC is proposing to specifically require that "[n]uclear power plant licensees shall ensure that offsite response organization resources (e.g., local law enforcement, firefighting, medical assistance) are available to respond to an emergency including a hostile action event at the nuclear power plant site."[49] NRC explains that licensees would have to coordinate with OROs "to ensure that licensees and OROs are able to effectively implement pre-planned actions for any contingency."[50] Moreover, this requirement would be enforced through routine inspections and observation of emergency exercises.[51]

Riverkeeper's Comments

NRC's proposed measures to address the lack of appropriate coordination with OROs will not necessarily remedy the situation. Simply requiring that licensees establish ORO availability amounts to a mere procedural requirement which does not guarantee sufficient coordination in the event of an actual emergency resulting from a hostile event.

Indeed, NRC's Interim Staff Guidance document provides only vague standards licensees are suggested to meet, which are largely procedural in nature: "review ORO resources . . . to verify that alternate resources have been identified," "address the training of the alternate personnel," maintain "additional duty rosters of qualified personnel," address timeliness of activation of the

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[46] *See* Thompson Report at 38-39 (citing NRC Press Release No. 07-012, Jan. 29, 2007).
[47] Thompson Report at 38-39.
[48] EP Enhancements Proposed Rule at 23258-59.
[49] *Id.* at 23284.
[50] *Id.* at 23274.
[51] *Id.*

alternate personnel, verify mutual aid and other agreements for alternate resources, verify updated arrangements for alternate resources, and "update license agreements with OROs."[52] Accordingly, NRC's proposed regulatory change would only appear to require that the ORO situation is in order on paper. Such ambiguity will not ensure appropriate coordination.

NRC's goal here would be much better served if more specific, enforceable, performance based standards were imposed. Such criteria should include the following:

- Demonstrated ability of offsite first responders and emergency medical personnel at trauma centers in the emergency planning zone to treat large number (to be determined) of injured or contaminated individuals.
- Demonstrated ability of local law enforcement agencies ("LLEAs") and fire departments to respond to specific types of terrorist attack, e.g. aircraft crash into the control room building, or large number of terrorists attempting to breach the fuel storage pool.
    - o Require fire departments to be trained and equipped to fight jet fuel fires.
    - o Require medical first responders to be trained and equipped to deal with burn and explosion injuries.
    - o Require OROs to have access and be trained to use heavy equipment to clear debris following an attack, so that plant personnel can reestablish control of the facility.
- Demonstrated interoperability of onsite and offsite emergency response organizations, e.g., onsite security and plant operators with LLEA, fire departments, state and federal counterterrorism organizations. For example, in a terrorist attack, is there interoperability between plant security personnel, local police departments and the FBI Hostage Rescue Team, or the U.S. Coast Guard?
- Require LLEA to be periodically trained and tested for their familiarity with the plant's physical layout and security procedures.
- Clear, enforceable guidelines specifying the role of local and state law enforcement during different security based events (i.e., support security forces versus directing traffic and emergency response personnel, etc).

Articulating more specific guidelines in this manner would be a much more effective approach towards ensuring proper coordination between licensees and OROs during hostile based events. Moreover, making such standards enforceable benchmarks which licensees must meet would make the NRC's requirement for coordination a meaningful part of the "reasonable assurance" determination.

IV. NRC'S CONSIDERATION OF NON-SECURITY RELATED ISSUES

Riverkeeper offers the following comments on NRC's proposed revisions relating to non-security related issues:

[52] Interim Staff Guidance at 19-20; see also NUREG-0654/FEMA-REP-1, Supp. 4 at 6-7 (discussing the new regulatory requirements in a similarly vague manner).

A. Backup Means for Alert and Notification Systems

NRC's Proposed Changes

NRC acknowledges that current NRC regulations do not require backup power for emergency sirens systems or other backup alert and notification system ("ANS") alerting capabilities when the primary alerting means is unavailable.[53] NRC further recognizes that if a plant's primary ANS becomes unavailable and no backup exists, the public may not be promptly alerted of an emergency event and protective actions to be taken.[54] Accordingly, NRC's revisions to the emergency preparedness regulations aim to address the necessity of backup capabilities. After considering a few different alternatives, NRC decided to add the following language to address their concerns:

> The licensee shall identify and demonstrate that the appropriate governmental authorities have both the administrative and physical means for a backup method of public alerting and notification capable of being used in the event the primary method of alerting and notification is unavailable during an emergency to alert or notify all or portions of the plume exposure pathway EPZ population. The backup method shall have the capability to alert and notify the public within the plume exposure pathway EPZ, but does not need to meet the 15-minute design objective for the primary prompt public alert and notification system.[55]

NRC's proposed Interim Staff Guidance incorporates the foregoing general changes into applicable guidance documents. Pertinently, a revision to NUREG-0654, Appendix 3, "Means for Providing Prompt Alerting and Notification of Response Organizations and the Population," (hereinafter "NUREG-0654, App. 3") would add language requiring that licensees develop a backup ANS "capable of covering essentially 100% of the population within the entire plume exposure EPZ in the event the primary method is unavailable. The backup means of alert and notification shall be conducted within a reasonable time."[56] The proposed Interim Staff Guidance further states that "[t]opography, population density, existing ORO resources, and timing will be considered in judging the acceptability of backup alerting plans," and suggests that "[a]lthough circumstances may not allow this for all facilities, OROs and utility operators should attempt to establish a backup system that will reach the population in the plume exposure EPZ within 45 minutes."[57] NUREG-0654/FEMA-REP-1, Supp. 4, also discusses the proposed changes in a similar, general manner.[58] Beyond these general, vague revisions, NRC's rulemaking indicates that guidance would be provided to assist licensees in determining the acceptability of backup methods, implementing and maintaining backup methods, performing

[53] EP Enhancements Proposed Rule at 23261.
[54] *Id.*
[55] *Id.* at 23284.
[56] Interim Staff Guidance at 46.
[57] *Id.* at 47.
[58] NUREG-0654/FEMA-REP-1, Supp. 4, at 12-17.

periodic demonstrations of backup methods, as well as to clarify design objectives and other criteria for ANS backup methods.[59]

Riverkeeper's Comments

i. NRC Must Require ANS Backup Power

Requiring a backup ANS at all operating plants is only a partial solution to an ongoing problem that is directly related to the pronounced lack of public confidence in emergency planning at many nuclear plants; it still does not address the fundamental problem of powering the ANS system if there is a loss of power to the electrical grid.

NRC specifically acknowledged this problem, and considered requiring backup power, but rejected this as an unacceptable approach since "it would address only one of several ANS failure modes (i.e., loss of AC power) for one alerting method (i.e., sirens)."[60] NRC's Interim Staff Guidance further explains that since having backup power for siren systems does not address other possible failure modes, requiring or relying on backup power for sirens is not equivalent to having an independent backup means for public alerting and notification. A proposed revision to NUREG-0654, App. 3 reflects this understanding and would state that while "[a]n independent backup means of public notification is required . . . . [b]ackup power for fixed sirens is not required unless mandated by other regulation or legislative act."[61]

However, the need for backup power is not undercut in any way by the fact that backup power would not address all ANS failure modes. Indeed, requiring a backup ANS, although very important in and of itself, is no substitute for firstly requiring backup power for primary alerting systems.

NRC recognizes that the "most common warning system used at U.S. nuclear power plants is based on sirens that are powered directly, or indirectly through batteries, by an AC power source."[62] It is, thus, imperative that the NRC ensure reliability of such systems in the reasonably foreseeable scenario of a loss of offsite power to the grid during a plant emergency. NRC should only require reliance on a secondary, fall back system after imposing requirements that increase dependability of a facility's primary ANS. This is made evident by the fact that NRC's proposed regulatory changes would not require that backup alerting systems meet the 15-minute standard for completing the initial alert and notification. Clearly, this would not guarantee the same capability as a functioning primary ANS.[63]

Furthermore, in the event of offsite power loss, relying only on a backup ANS may not prove to be a viable solution: various existing backup ANS methods, such as reverse callout systems, CAP alerts, and Internet notification via a Joint Information Center ("JIC") website, would not

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[59] EP Enhancements Proposed Rule at 23275.
[60] *Id.* at 23262.
[61] Interim Staff Guidance at 47.
[62] EP Enhancements Proposed Rule at 23262.
[63] NRC admits that "the backup method would not be required to have the same capabilities as the primary alerting system in terms of timeliness." *See* Interim Staff Guidance at 49.

have a guaranteed backup power source either in the event power to the grid is interrupted during an emergency. Even if the alerting agency, e.g. the state emergency management JIC, has backup power to send out an e-mail alert or automated phone message, most residences and businesses do not. Their computers and most home telephones that rely on AC power will not work during a power loss. Theoretically, if such methods were employed, the only people that would be notified are those using cell phones or driving in their cars with the radio on, tuned to the particular station that has an agreement to automatically transmit a CAP alert if one is initiated. In such a scenario residents would be in virtually the same position they are in at present, i.e., they would have to be notified by local law enforcement via "route alerting." In other words, the public in the 10-mile EPZ would be dependent on police driving around, announcing an emergency over their vehicle loudspeakers. This clearly would not have the same level of effectiveness as a system that could be effectively run on backup power.

Based on the foregoing, it is essential that NRC recognize and address the problems faced by alert and notification systems during power loss situations. NRC should require every operating plant to install backup power to their primary ANS so that the loss of offsite power will not affect the licensee and the local government's ability to alert the public to an emergency at the plant. Failing to do so will detract rather than enhance the protection of the public. Moreover, imposing such a requirement would be consistent with national recognition that backup power for emergency notification systems is desirable.[64]

Such a system has finally been installed at Indian Point, following a protracted effort begun by Riverkeeper and taken up by former New York Senator Hillary Rodham Clinton, in the form of legislation that became part of the Energy Policy Act of 2005. Pursuant to the legislation, Entergy replaced the trouble-plagued siren system at Indian Point with new sirens that have battery backup power. Unfortunately, the backup ANS proposed by Entergy all depend on "third-party vendors" who are not required to provide backup power capability to their systems. At a minimum, the ANS requirements approved by Congress for Indian Point should be extended to all operating plants.

ii. NRC Should Impose Requirements To Ensure Backup Alert and Notification Systems Would Operate As Effectively As Primary Alert and Notification Systems

NRC's proposed regulatory changes should ensure that backup alert and notification systems employed by licensees be as timely and effective as the functioning primary system would have been. This is especially true if NRC ignores the urgent need to require installation of backup power to ensure operation of siren systems in the event of loss of offsite power.

Unfortunately, NRC's proposed regulatory changes already indicate that backup systems would not be required to posses the same alert and notification capability as primary systems: the NRC's new rule would not require that backup systems meet the 15-minute standard for

[64] NRC even cites to U.S. House of Representatives Committee on Appropriations Report 107 – 740, which directed FEMA to update its guidance on outdoor warning and mass notification systems to be operable in the absence of an AC power supply, as well as the Energy Policy Act of 2005 which directed the NRC to require backup power for the emergency notification system for nuclear power plants where there is a permanent population in excess of 15,000,000 within a 50-mile radius of the power plant. *See* EP Enhancements Proposed Rule at 23261.

completing the initial alert and notification which the primary system is required to meet. Guidance, as discussed above, suggests that that backup alert and notification should occur "within a reasonable time," and recommends no longer than 45 minutes.[65]

Given the importance and function of a backup system in the event a primary ANS is unavailable, Riverkeeper fails to see a justifiable reason why execution of a backup system should be held to a different standard. NRC rationalizes that "some backup methods would not be capable of meeting the timeframes that are part of the primary ANS design objectives."[66] If such is the case, than those backup methods should simply not be acceptable for use by licensees. NRC further reasons that the new regulation would not require a specific timeframe related to backup systems since the existing regulation acknowledges that the events which are more likely to warrant use of alert and notification capability are those where officials would have substantial amount of time in which to make judgments regarding activation of the warning system to alert and notify the public.[67] However, this utterly ignores those events which would require urgent action.[68] Just because such situations are not as likely, does not preclude them as possibilities, and, as such, backup systems should be equipped to deal with urgent scenarios as well.

NRC does not provide much further indication as to how effectively backup systems would have to operate. Instead, NRC largely refers to future guidance that would ostensibly provide the criteria for acceptability of backup alert and notification systems. This guidance alluded to in the instant rulemaking should, of course, be made available for public review and comment so that interested members of the public can determine whether backup methodologies sanctioned by NRC would be as effective as primary alert and notification systems.

iii. NRC Should Incorporate Performance Based Standards Into ANS Requirements

In order to measure the effectiveness of primary and back up alert and notification systems, NRC should implement enforceable standards against which licensee performance must be judged. Such standards should include, at a minimum: (1) demonstrated functionality of the ANS system, (2) requirement of backup battery power to the primary ANS, and (3) at least one backup method for alerting the public.

B. Evacuation Time Estimate Updating

NRC's Proposed Changes

NRC recognizes that current regulations do not require any review or revision of Evacuation Time Estimates ("ETEs") following an initial licensing of a plant and that, although some licensees do revise ETEs, "the use of ETEs in evacuation planning is inconsistent and . . . [does] not affect the development of public protective action strategies."[69]

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[65] Interim Staff Guidance at 46-47.
[66] EP Enhancements Proposed Rule at 23275.
[67] *Id.* at 23275.
[68] 10 C.F.R. Part 50, App. E. § IV.D.3.
[69] EP Enhancements Proposed Rule at 23264.

According, NRC proposes regulatory changes in an attempt to rectify these problems. In particular, 10 C.F.R. § 50.47 would be revised to provide that ETEs "must be updated on a periodic basis," and that any updates must be submitted "to the NRC for review and approval."[70] Revisions to Appendix E to Part 50, section IV provide further details on when an update would be required:

> Within 180 days of issuance of the decennial census data . . . licensees . . . shall develop an ETE and submit it to the NRC for review and approval. . . . During the years between decennial censuses, licensees shall estimate permanent resident population changes at least annually using U.S. Census Bureau data and/or State/local government population estimates. Licensees shall maintain these estimates so that they are available for NRC inspection during the period between censuses and shall submit these estimates to the NRC with any updated ETEs. If at any time during the decennial period, the population of either the EPZ or the most populous Emergency Response Planning Area ["ERPA"] increases or decreases by more than 10 percent from the population that formed the basis for the licensee's currently approved ETE, the ETE must be updated to reflect the impact of that population change. The updated ETE must be submitted to the NRC for review and approval under § 50.4 no later than 180 days after the licensee's determination that a population change of more than 10 percent has occurred.[71]

NRC would review ETE updates "to ensure they were consistent with NRC guidance on the development of ETEs," which is out for public comment with NRC's instant rulemaking, as previously cited above.[72]

Moreover, NRC adds that ETE updates "shall be used by licensees in the formulation of protective action recommendations and must be provided to State and local governmental authorities for use in developing protective action strategies."[73] NRC explains that licensees would be expected to "identify and analyze potential enhancements to improve evacuation times and document whether implementation was appropriate."[74]

<u>*Riverkeeper's Comments*</u>

i. NRC's Proposed Trigger For Requiring ETE Updates Is Flawed

Riverkeeper agrees that ETEs must be updated regularly, however, NRC's proposed trigger of a 10% change in population density of the EPZ or most populous ERPA may not be sufficient to

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[70] *Id.* at 23282.
[71] *Id.* at 23283-84.
[72] *Id.* at 23273; *See* Draft ETE Report.
[73] EP Enhancements Proposed Rule at 23283.
[74] *Id.* at 23273.

always ensure timely updating. While variation of population density is an appropriate indicator for when an ETE update is needed, the proposed threshold would not necessarily capture population changes which may have a significant impact on ETEs.

Pertinently, of the nations commercial reactor sites, Indian Point, located just 24 miles north of New York City, (35 miles north of Times Square) tops the list as the nuclear power plant with the greatest population density within a 10-mile radius (at least 300,000) and 50-mile radius (approximately 20 million people).[75] With population ever increasing in such an already dense area, a 10% variation in only the 10-mile EPZ or most populous ERPA within the EPZ may not be sensitive enough trigger future ETE updates even though shifts in population would have an impact on evacuation estimates and associated planning.

Accordingly, NRC must require consideration of population density beyond just the EPZ and most populous ERPA. Doing so will ensure a more accurate trigger for future ETE updates for reactors like Indian Point which are located in very highly populated areas. This is especially so given substantial shadow evacuation that will occur beyond the EPZ (as discussed further below). While NRC admits that it considered requiring a review "of individual counties and States in addition to the whole EPZ," NRC decided that review of the EPZ and ERPA with the largest population "was considered to be a reasonable balance between the burden on licensees and applicants and the need to ensure that the ETE is accurate . . . ."[76] As such, it appears that NRC has failed to require consideration of relevant information for the purposes of administrative ease. However, the safety of populations surrounding nuclear power plants should trump concerns about the burden to licensees caused by mandating accurate assessments of changes in population.

Moreover, reliance upon a seemingly generic Highway Capacity Manual for the general conclusion that only increases 10% or more of vehicles on roadways would result in a decreased level of service due to traffic, and vice versa, seems highly questionable. Surely, effects on roadway service would vary depending on starting population densities (i.e., a 10% increase of vehicles in an area with millions of people would be more severe that the same increase in an area with only a couple thousand people). NRC's assessment of this highway manual forms the basis for their conclusion that population changes of less than 10 percent would not significantly impact the ETE. However, it appears far from clear that NRC's conclusions are well founded. Accordingly, NRC should perform a site-specific review of nuclear reactor sites to determine the appropriate percentage in population change particular licensees should consider. For example, at Indian Point, based on the existing high population density, a 5% change would be a more appropriate trigger.

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[75] *See, e.g.*, Witt Repot at 4, 81-82. The NRC has previously acknowledged that Indian Point has the "highest population within 10, 30 and 50 miles of any nuclear power plant in the U.S. At 50 miles, it population is more than double any other plant site." *See* U.S. Nuclear Regulatory Commission, Consolidated Edison Company of New York: Indian Point, Units 2 and 3, Memorandum and Order, January 8, 1981, at 6; *see also* Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment, Main Report (U.S. Nuclear Regulatory Commission December 2008) ("Indian Point Draft Supplemental EIS") at Table 2-1.

[76] EP Enhancements Proposed Rule at 23273.

In addition to requiring updates to ETEs based on changes to population density in accordance with the above comments, it would also be acceptable to require ETE updates based on other predetermined indicators such as traffic volume, or a preset time period. Indeed, Riverkeeper does not agree with NRC's determination that changes to infrastructure are not a suitable basis for an ETE update. Modifications to infrastructure that is critical for evacuation purposes should be an independent a basis triggering a licensee to update ETEs. NRC acknowledges that "changes in infrastructure, or addition of a large subdivision to the EPZ, could also impact the ETE," however, determined that "population is the more important factor," and, thus, only required updates based on population density changes.[77]

NRC rationalizes that infrastructure projects take years to plan, budget, and construct, whereas population changes occur over shorter periods of time, and so infrastructure changes are "an enveloped contributor."[78] NRC seems to imply that when ETE updates are performed pursuant to the prescribed changes to population density, they will encompass consideration of any infrastructure changes as well. However, it is improper to speculate or assume that population changes will occur in such a fashion as to guarantee timely consideration of any infrastructure modifications. As such, changes to infrastructure deserve independent consideration in relation to ETE updates. Furthermore, NRC's proposal would only allow consideration of changes to infrastructure once those changes were wholly complete. However, the implementation of long-term infrastructure projects, which NRC recognizes takes years, will undoubtedly have an affect upon evacuation times, and should, thus, be considered in an ETE update as well.[79] Moreover, NRC's proposed ETE update scheme consistently focuses on requiring "licensees to evaluate a population change impact on the ETE."[80] At a minimum, NRC should clarify that when an update is triggered, the update must be comprehensive, with due consideration for all appropriate factors, including planned/completed changes to infrastructure, and not just assess how the population change will affect the ETE. While the Draft ETE Report would ostensibly encompass such relevant factors, it would merely be guidance, and NRC should make its regulation changes more explicit to reflect their apparent intentions here.

Another flaw in NRC's proposed model for future ETE updates is the notable lack of an appropriate enforcement structure. NRC would merely require that licensees maintain population estimates and only submit them in the event an updated ETE is actually performed. NRC should be more proactive and require annual submittals by licensees to explain their population estimate reviews. NRC should review such submittals to ensure that licensee determinations that ETE updates are not warranted, are accurate. Having more oversight in this manner would only serve to ensure timely ETE updates.

Furthermore, to improve public participation, and foster a higher degree of public confidence in emergency preparedness regulations, NRC should explicitly require that all future ETE updates be fully disclosed for scrutiny by interested members of the public.

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[77] *Id.* at 23265; *see also* Draft ETE Report at 32 (stating that updates to ETEs are not required for planned activities such as construction or infrastructure projects).
[78] EP Enhancements Proposed Rule at 23265.
[79] For example, an ETE to assess how evacuation times would be affected during the replacement/rehabilitation of the Tappan Zee Bridge would be appropriate.
[80] EP Enhancements Proposed Rule at 23273.

ii. NRC's Proposed Guidance Document Establishing Criteria For Development Of Future Evacuation Time Estimate Studies Is Flawed

NRC's emergency preparedness rulemaking includes a proposed draft report, "Criteria for Development of Evacuation Time Estimate Studies," (hereinafter "Draft ETE Report") intended to be "a guidance template for the development of ETE studies."[81] Unfortunately, the draft report fails to address the following deficient threshold assumptions which form the basis for current ETE methodology:

a. Reliance on Keyhole Model of Evacuation

The Draft ETE Report continues to rely solely on the "keyhole model" of evacuation, that is, "[a]n evacuation of the 2 mile radius around a NPP and the downwind sectors forming a keyhole configuration."[82] However, use of this method is based upon an overly simplistic, outdated plume transport model which assumes that radiation moves in a predictable, straight-line direction (called a Gaussian plume model). Much authority indicates that such straight-line models are only appropriate for relatively flat, homogenous terrain and that where terrain is more complex, radiation dispersion will occur in a far more variable manner.[83] Many nuclear power plants are situated in areas with complex terrain. For example, Indian Point has nearby mountains and bluffs with higher elevations than the point of release from the plant would be, as well as an adjacent river located in a valley with steep sides.[84] Complex terrain features such as these have direct impacts on air flow from the site which affects how pollutants released from the plant will travel. Accordingly, assuming that radiation plumes will move in a straight-line direction, and consequent reliance upon keyhole evacuation, is not appropriate for such sites.

Without accurate assumptions about plume transport, ETEs will continue to be designed without appropriate regard for the portion of the population that will actually be affected by radiological release. In the event of an actual emergency, licensees would not have the appropriate tools to accurately assess the proper protective actions to take. Accordingly, it is imperative that NRC require licensees to develop ETEs based upon more realistic notions of plume transport.

[81] Draft ETE Report at iii.
[82] *Id.* at 7-9, 28-30, 35.
[83] *See, e.g.,* Stephen F. LaVie, Senior Emergency Preparedness Specialist, United States Nuclear Regulatory Commission, Power Point Presentation: *What's in the Black Box Known as Emergency Dose Assessment?*, prepared for the 2009 National Radiological Emergency Planning Conference Dose Assessment Workshop, Part 2, Dispersion, ADAMS Accession No. ML091050257.
[84] See, e.g., Indian Point Draft Supplemental EIS at 2-2 ("The region surrounding the Indian Point site has undulating terrain with many peaks and valleys. Dunderberg Mountain lies on the western side of the Hudson River 1 mi . . . northwest of the site. North of Dunderberg Mountain, high grounds reach an elevation of 800 feet . . . above the western bank of the Hudson River. To the east of the site lie the Spitzenberg and Blue Mountains. These peaks are about 600 ft . . . in height. There is also a weak, poorly defined series of ridges that run in a north-northeast direction east of IP2 and IP3. The Timp Mountains are west of the facility. These mountains rise to a maximum elevation of 846 ft . . . Elevations south of the site are 100 ft . . . or less and gradually slope toward the Village of Verplanck).

b. Reliance on Artificial 10-Mile Emergency Planning Zone

The Draft ETE Report continues to be based upon evacuation of the emergency planning zone ("EPZ"), defined as the "area with a radius of about 10 miles around a nuclear power plant."[85] However, ample authority suggests that radiation resulting from an accident or intentional attack at a nuclear power plant will go beyond 10 miles. For example:

- A Sandia National Laboratories report from 1982, "Calculation of Reactor Accident Consequences" (referred to as the "CRAC-2" report) indicated that a so-called "peak fatality zone" extends out to 17.5 miles and that a "peak injury zone" extends out to 50 miles;[86]
- A 1997 Brookhaven National Lab Report ("A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants") claims that a disaster from a spent fuel pool could make an area up to 2,790 square miles around the plant uninhabitable;[87]
- The Chernobyl accident demonstrates the reality that dangerously high levels of radiation can extend tens to hundreds of miles beyond the 10-mile radius and 50-mile ingestion pathway (i.e., the area within which people could be at risk if they eat or drink contaminated food or water);
- In the event of aircraft related attack resulting in radiological release, fire and smoke from burning jet fuel can carry radioactivity to higher altitudes and subsequently disperse radioactivity far beyond the 10-mile emergency zone;
- Federal legislation calling for the distribution of Potassium Tablets within a 20-mile radius of nuclear power plants suggests that the area of impact could be beyond the 10-mile EPZ;
- Recommendations made by the American Thyroid Association regarding distribution of Potassium Iodide also suggests that the area of impact could be beyond the 10-mile EPZ.

It is, thus, evident that ETEs artificially restrict the area contemplated for evacuation, resulting in unrealistic and ineffective estimates. NRC should require consideration of an expanded evacuation zone of at least 50-miles to reflect situations which are more likely to occur in the event of an actual radiological release.[88]

[85] Draft ETE Report at vii.

[86] The CRAC-2 Report stated that "increasing the evacuation distance [from 10] to 25 miles could substantially reduce the peak consequences, but the feasibility of a timely evacuation from so large an area is highly questionable."

[87] The Chernobyl accident, which rendered about a thousand square miles uninhabitable (about 100 square miles permanently), released to the environment only a fraction of the radioactive material currently stored at Indian Point. Thus, it is entirely conceivable that a significant radiological release from Indian Point could render a large portion of the New York metropolitan area uninhabitable.

[88] In the instant rulemaking, NRC deletes certain completed one-time requirements including 10 C.F.R. § 50.54(s)(1) except that portion which discusses the size of the EPZ as a 10-mile radius would be retained. *See* EP Enhancements Proposed Rule at 23267. In light of the reasons set forth herein, NRC should reconsider this determination and delete the entire provision, and compel licensees to formulate more accurate assessments of the EPZ size.

This is especially important given the new reality in the U.S. that spent nuclear fuel will continue to be kept onsite at nuclear power plant facilities for the indefinite future.[89] Releases due to accidents or attacks on vulnerable spent fuel pools or casks, such as those at Indian Point, will be far-reaching,[90] and licensees should prepare ETEs considering that possibility.

c. Unrealistic Scenario Development

The Draft ETE Report would foster unrealistic ETE scenario development. While the report contains ten different scenarios with variables including season, day, time of day, and weather conditions, none of the scenarios appear to address evacuation during rush hour in the morning or evening. Rather, the scenarios only consider "daytime," when "major work places are at typical daytime levels," and "evening," when "permanent residents are generally at home." Given the extremely high volume of commuter traffic during rush hour (especially in highly populated areas like the vicinity surrounding Indian Point), it is virtually certain that an attempted evacuation during this time would take hours longer than one occurring midday.

The failure to specifically address this contingency calls into question the usefulness of this report. Unless licensees are required to consider a realistic range of possible evacuation scenarios, ETEs will not be relevant to the NRC and Department of Homeland Security process for approving plants' emergency plans under 10 C.F.R. § 50.47.

d. Improper Consideration of Shadow Evacuation

The Draft ETE Report would not provide for proper consideration of shadow evacuation. The report conservatively recommends that "[a] shadow evacuation of 20 percent of the permanent resident population, based on US census data, should be assumed to occur in areas outside of the evacuation area being assessed for all cases extending to 15 miles from the NPP."[91]

However, ETEs should acknowledge that significant shadow evacuation will occur well beyond the 10-mile EPZ radius and as far as 50 miles. Academic research as well as Three Mile Island and Hurricane Rita demonstrate that shadow evacuations will be considerable. Given the demographics of the New York Metropolitan region, it is reasonable to assume that hundreds of thousands of people will be on the road, self-evacuating and/or trying to reach loved ones. Accordingly, consideration of 20% shadow evacuation only as far out as 15 miles would clearly not be sufficient for an accurate ETE.

Furthermore, because the draft guidance document contemplates a staged evacuation (i.e., evacuation occurring in phases), the report incorrectly assumes that an orderly shadow evacuation will occur: "For a staged evacuation, when developing the 0-2 mile ETE, it should be assumed that 20 percent of the remaining EPZ permanent resident population evacuates as a shadow evacuation. When developing the 2-5 mile ETE, it should be assumed that this shadow

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[89] *See supra* Note 16.
[90] *See supra* Note 15.
[91] Draft ETE Report at 15-16.

evacuation is complete or underway."[92] This is an unrealistic assumption for highly populated areas, such as the vicinity around Indian Point.

It is not clear from the Draft ETE Report how NRC decided its conservative recommendation relating to shadow evacuation was appropriate. Licensees should be required to consider a more accurate estimate of shadow evacuation, based on current, peer-reviewed studies of human behavior approved by both NRC and independent experts. If licensees follow the proposed suggestion, ETEs will continue to be ineffective tools for emergency planners.

Based on the foregoing, it is clear that the efficacy of NRC's proposal to require updated ETEs is severely undercut by the failure to sufficiently enhance ETE methodology such that future updates would accurately consider all relevant issues. The requirement to update ETEs becomes hollow unless licensees would be required to base their future studies on the realistic assumptions discussed above.

iii. ETEs Should Become A Performance-Based Standard

The current regulatory scheme governing ETEs, reinforced by the instant rulemaking, merely requires development of the ETE study, to be included as part of nuclear power plants' emergency plan, for use in the planning process to "help licensees recommend and offsite officials determine the most appropriate protective action."[93] As a seemingly procedural requirement, ETEs have limited effectiveness. Given the numerous deficiencies with ETE methodology, which render the estimates grossly inaccurate (as discussed above), it is hard to believe that ETEs would play any kind of actual role in any decision-making process, let alone in the NRC's "reasonable assurance" determination.

By imposing ETE standards of performance, these studies would become a meaningful component of emergency planning regulations. That is, NRC should require that licensee ETEs, using proper assumptions and methodology, demonstrate timely evacuation under varying relevant conditions. For example, a standard stating that "evacuation of 100% of the 2-mile EPZ must occur within four hours of evacuation order, during rush hour in inclement weather." Licensees should be obligated to make these kinds of demonstrations in order to receive emergency plan approval.

C. Emergency Declaration Timeliness

<u>*NRC's Proposed Changes*</u>

In response to inappropriately delayed emergency declarations, NRC proposes to add a criterion to the regulations to "ensure that licensees are aware that they are responsible for completing

[92] *Id.* at 16.
[93] EP Enhancements Proposed Rule at 23265.

emergency declarations in a timely manner in the event of a radiological emergency."[94] Specifically, licensees would be required to

> establish and maintain the capability to assess, classify, and declare an emergency condition within 15 minutes after the availability of indications to plant operators that an emergency action level has been exceeded and shall promptly declare the emergency condition as soon as possible following a determination that an emergency action has been exceeded.[95]

<u>*Riverkeeper's Comments*</u>

NRC determined that imposing a "capability criterion" was preferable over imposing "an inflexible performance criterion."[96] This is simply an explicit example of NRC's unwillingness to hold licensees to measureable standards based on actual performance. Requiring a demonstration that the 15-minute threshold could theoretically be met is clearly not as valuable as requiring demonstration that the 15 minute threshold *would* be met. Accordingly, NRC should adopt this requirement as a performance criterion in order to have a more effective tool for measuring licensee performance.

V. CONCLUSION

Based on the foregoing, Riverkeeper submits that NRC's proposed revisions to the emergency preparedness regulations do not go far enough towards remedying the currently ineffective regulatory regime. Incorporation of the suggestions articulated herein will help to develop a more useful and credible regulatory structure. Indeed, NRC must undertake a much more comprehensive review which properly considers certain fundamental assumptions identified throughout the above comments. Importantly, NRC must implement measureable, performance-based standards in order to make the existing purely procedural scheme useful.

Thank you for your consideration.

Sincerely,

s/

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94 *Id.* at 23263.
95 *Id.* at 23284.
96 *Id.* at 23263.

Exhibit-F

Thompson
Attachment 2

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Risk-Related Impacts from Continued Operation of the Indian Point Nuclear Power Plants

by
Gordon R. Thompson

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Prepared under the sponsorship of
Riverkeeper, Tarrytown, New York

Abstract

Entergy has submitted an application to the US Nuclear Regulatory Commission (NRC) for 20-year extensions of the operating licenses of the Indian Point 2 (IP2) and Indian Point 3 (IP3) nuclear power plants. This report discusses potential adverse impacts on the environment from continued operation of the IP2 and IP3 plants. Relevant impacts relate in various ways to the risk of radiological harm from unplanned releases of radioactive material to the environment. Unplanned releases of radioactive material from the IP2 or IP3 reactors or their spent fuel could arise as a result of conventional accidents – incidents caused by human error, equipment failure or natural events – or deliberate, malicious actions. Entergy and the NRC have identified some of the risk-related impacts of continued operation of the IP2 and IP3 plants. This report shows that neither party has provided a complete and accurate assessment of those impacts. Deficiencies in the risk analyses provided by Entergy and the NRC are illustrated here by examining four issues: (i) containment bypass during a core-damage accident due to induced failure of steam generator tubes; (ii) a fire in a spent-fuel pool; (iii) attack on a reactor and/or its spent fuel; and (iv) adverse impacts of the NRC's regulatory approach.

About the Institute for Resource and Security Studies

The Institute for Resource and Security Studies (IRSS) is an independent, nonprofit, Massachusetts corporation, founded in 1984. Its objective is to promote sustainable use of natural resources and global human security. In pursuit of this mission, IRSS conducts technical and policy analysis, public education, and field programs. IRSS projects always reflect a concern for practical solutions to resource and security problems.

About the Author

Gordon R. Thompson is the executive director of IRSS and a research professor at Clark University, Worcester, Massachusetts. He studied and practiced engineering in Australia, and received a doctorate in applied mathematics from Oxford University in 1973, for analyses of plasma undergoing thermonuclear fusion. Dr. Thompson has been based in the USA since 1979. His professional interests encompass a range of technical and policy issues related to international security and protection of natural resources. He has conducted numerous studies on the environmental and security impacts of nuclear facilities and options for reducing these impacts.

Acknowledgements

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Contents

List of Tables
(Tables are located at the end of the report.)

1. Introduction, Terminology and Scope

Entergy, a corporate group, has submitted an application to the US Nuclear Regulatory Commission (NRC) for 20-year extensions of the operating licenses of the Indian Point 2 (IP2) and Indian Point 3 (IP3) nuclear power plants. The current operating licenses expire in 2013 (IP2) and 2015 (IP3). Each plant features a Westinghouse pressurized-water reactor (PWR) with a dry containment. Three nuclear power plants were built at the Indian Point site, which is on the bank of the Hudson River. The Indian Point 1 plant has been shut down and is in SAFSTOR mode.

This report discusses potential adverse impacts on the environment arising from continued operation of the IP2 and IP3 plants through the periods of their current or extended operating licenses. Here, the term "environment" includes humans, human society and property, as well as other features and attributes of the biosphere. The adverse impacts that are considered here can be reasonably foreseen but will not necessarily occur.[1]

This report focuses on adverse impacts that are related to the risk of radiological harm from unplanned releases of radioactive material to the atmosphere, surface water or ground water. The radioactive material would be released from the IP2 or IP3 reactor or from the spent (i.e., no longer usable) fuel discharged from these reactors. Unplanned releases are distinct from the comparatively small, planned releases that occur during operation of a nuclear power plant. Here, the term "risk" encompasses the type and scale of potential adverse outcomes together with the probabilities of occurrence of those outcomes.[2] Two categories of risk-related impacts are addressed here. The first category consists of direct radiological harm (radiation-induced human illnesses, etc.) and the indirect social and economic impacts arising from that direct harm. The second category consists of regulatory impacts that arise from the NRC's general approach to the licensing of nuclear power plants. Both categories of impact are discussed further in Section 3, below.

Unplanned releases of radioactive material

Unplanned releases of radioactive material from the IP2 or IP3 reactors or their spent fuel could arise as a result of two types of accident. The term "conventional accidents" is

[1] An event can be reasonably foreseen even if there is no statistical basis to support a quantitative estimate of the event's probability. The NRC accepted that point when it promulgated a rule requiring protection of nuclear power plants against vehicle bombs. See: NRC, 1994.
[2] Some analysts define "risk" as the arithmetic product of two quantitative indicators: a consequence indicator; and a probability indicator. That definition is simplistic and can be misleading, and is not used in this report. That definition is especially inappropriate for risks associated with malicious actions, because there is usually no statistical basis to support quantitative estimates of the probabilities of such actions. In this report, the risk of an activity is defined as a set of quantitative and qualitative information that describes the potential adverse outcomes from the activity and the probabilities of occurrence of those outcomes.

used here to refer to incidents caused by human error, equipment failure or natural events.[3] By contrast, "malice-induced accidents" are incidents caused by deliberate, malicious actions. The parties taking those malicious actions could be national governments or sub-national groups.[4] In considering malicious actions, this report focuses on actions by sub-national groups.

Risk analyses by NRC, Entergy and IRSS

The NRC has discussed some of the risk-related impacts of operating a nuclear power plant for an extended period, in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NUREG-1437).[5] The NRC has discussed some of the risk-related impacts associated with storage of spent fuel, in documents including the *Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel* (NUREG-0575).[6] Entergy has discussed some of the risk-related impacts of continued operation of the IP2 and IP3 plants, in the Environmental Report that is provided as Appendix E of Entergy's License Renewal Application.[7] Neither the NRC nor Entergy has provided a complete and accurate assessment of the risk-related impacts of continued operation of the IP2 and IP3 plants.

This report demonstrates the deficiencies in NRC's and Entergy's analyses by examining four neglected risk issues, as discussed below. IRSS's examination does not purport to provide a comprehensive assessment of risk-related impacts for operation of the IP2 and IP3 plants. Such an assessment would require financial support at a much higher level than was available for our examination. Preparation of such an assessment is a duty of Entergy and the NRC, a duty that neither party has performed. Section 10, below, describes the assessments that Entergy and the NRC should perform. In the absence of a comprehensive assessment, this report provides illustrative analyses of selected issues. Assumptions of IRSS's analyses are stated, and the author would be pleased to engage in open technical debate regarding these analyses.

Protection of sensitive information

One of the neglected risk issues examined in this report is the potential for deliberate attack on one or more of the IP2 and IP3 reactors and the adjacent pools for storage of spent fuel. Any responsible analyst who discusses the potential for an attack on a nuclear power plant is careful about making statements in public settings. The author of this report exercises such care. The author has no access to classified information, and this

[3] The NRC's Glossary, accessed at the NRC web site (www.nrc.gov) on 25 June 2007, contains no definition of "accident". The terms "conventional accident" and "malice-induced accident" are used in this report. Both types of accident can be foreseen, and a licensee should be able to maintain control of a facility if either type of accident occurs.
[4] Relevant sub-national groups could be based in the USA or in other countries.
[5] NRC, 1996.
[6] NRC, 1979.
[7] Entergy, 2007a, Appendix E.

report contains no such information. However, a higher standard of discretion is necessary. An analyst should not publish sensitive information, defined here as detailed information that could substantially assist an attacking group to attain its objectives, even if this information is publicly available from other sources. On the other hand, if a plant's design and operation leave the plant vulnerable to attack, and the vulnerability is not being addressed appropriately, then a responsible analyst is obliged to publicly describe the vulnerability in general terms.

This report exemplifies the balance of responsibility described in the preceding paragraph. Vulnerabilities of the IP2 and IP3 plants are described here in general terms. Detailed information relating to those vulnerabilities is withheld here, although that information has been published elsewhere or could be re-created by many persons with technical education and/or military experience. For example, this report does not provide cross-section drawings of the IP2 and IP3 plants, although such drawings have been published for many years and are archived around the world.

NRC license proceedings provide potential forums at which sensitive information could be discussed without concern about disclosure to potential attackers. Rules and practices are available so that the parties to a license proceeding could discuss sensitive information in a protected setting.

Structure of this report

The remainder of this report has eleven sections. Section 2 describes selected characteristics of the IP2 and IP3 plants and their spent fuel. Section 3 outlines the categories of risk-related impacts that are relevant to continued operation of the IP2 and IP3 plants. Then, Section 4 discusses the risk assessments proffered by the NRC in NUREG-1437 and by Entergy in its License Renewal Application.

Sections 5 through 8 examine four selected risk issues that have been neglected by the NRC and Entergy. These issues are: reactor containment bypass via induced failure of steam generator tubes (Section 5); fire in a spent-fuel pool (Section 6); attack on a reactor and/or its spent fuel (Section 7); and the wider context of nuclear-facility risk (Section 8). Section 9 summarizes IRSS's findings regarding these issues, and discusses options for reducing risk. The discussion in Sections 5 through 9 identifies major deficiencies in the risk assessments proffered by the NRC and Entergy. Section 10 describes the analyses required from Entergy and the NRC to correct these deficiencies in the context of a license extension application for the IP2 and IP3 plants.

Conclusions are set forth in Section 11, and a bibliography is provided in Section 12. All documents cited in the text of this report are listed in the bibliography. Tables are provided at the end of the report.

2. Selected Characteristics of the Indian Point Nuclear Power Plants and their Spent Fuel

During operation, each of the IP2 and IP3 reactors accumulates a large inventory of radioactive material inside the fuel assemblies that make up the reactor core. Periodically, some of the fuel assemblies are discharged from the reactor because they are "spent" in the sense that they are no longer suitable for power generation. Each spent fuel assembly contains a substantial amount of radioactive material, and is stored for a period of years in a rack that sits on the floor of a water-filled pool. A pool of this type is located immediately outside the containment of each reactor. After each of these pools has received spent fuel to near its full capacity, batches of previously-discharged fuel assemblies will be periodically removed from the pool and transferred to an independent spent fuel storage installation (ISFSI) located on the Indian Point site, in order to clear space in the pool for fuel assemblies newly discharged from the adjacent reactor.[8] At the ISFSI, the spent fuel will stored dry, within air-cooled modules. The IP2 and IP3 spent-fuel pools contribute significantly to the potential for unplanned releases of radioactive material at the Indian Point site, as discussed later in this report.

The radiological risk posed by a nuclear facility is determined by two factors: the facility's inventory of radioactive material; and the potential for release of that material to the environment. At the Indian Point site, all but a small fraction of the site's inventory of radioactive material is contained within fuel assemblies at six facilities: the IP2 and IP3 reactors; the IP1, IP2 and IP3 spent-fuel pools; and the ISFSI when that facility is operational. The IP1 pool is not discussed in this report.

Active or spent fuel assemblies contain a variety of radioactive isotopes.[9] One isotope, namely cesium-137, is especially useful as an indicator of the potential for radiological harm. Cesium-137 is a radioactive isotope with a half-life of 30 years. This isotope accounts for most of the offsite radiation exposure that is attributable to the 1986 Chernobyl reactor accident, and for about half of the radiation exposure that is attributable to fallout from the testing of nuclear weapons in the atmosphere.[10] Cesium is a volatile element that would be liberally released during conventional accidents or attack scenarios that involve overheating of nuclear fuel.

Table 2-1 shows estimated amounts of cesium-137 in nuclear fuel in the IP2 and IP3 reactors and spent-fuel pools, and in one of the spent-fuel storage modules of the Indian

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[8] The Indian Point ISFSI has been established, but has not yet received spent fuel. Loading of spent fuel into storage modules at the ISFSI could commence in Spring 2008 or subsequently.

[9] In an operating reactor, an active fuel assembly contains radioactive isotopes with half-lives ranging from seconds to millennia. After the reactor is shut down or a fuel assembly becomes spent (i.e., it is discharged from the reactor), the assembly's inventory of each isotope declines at a rate determined by the isotope's half-life. Thus, an atmospheric release from an operating reactor would contain short- and longer-lived isotopes, while a release from a spent-fuel-storage facility would contain only longer-lived isotopes. That difference has implications for the emergency response that would be appropriate for each release.

[10] DOE, 1987.

Point ISFSI when that facility is operational.[11] Table 2-2 compares these amounts with atmospheric releases of cesium-137 from detonation of a 10-kilotonne fission weapon, the Chernobyl reactor accident of 1986, and atmospheric testing of nuclear weapons. These data show that release of a substantial fraction of the cesium-137 in an Indian Point nuclear facility would create comparatively large radiological consequences.

In the IP2 and IP3 spent-fuel pools, as at nuclear power plants across the USA, spent fuel is stored in high-density racks. This configuration has significant implications for risk because loss of water from such a pool would, over a wide range of scenarios, lead to spontaneous ignition of the hottest spent fuel and a fire that would spread across the pool. That fire would release to the atmosphere a substantial fraction of the pool's inventory of cesium-137, together with other radioactive isotopes. The potential for this event at Indian Point is discussed further in Section 6, below.

3. Categories of Risk-Related Impacts from Continued Operation of the IP2 and IP3 Plants

As explained in Section 1, above, two categories of risk-related impacts are addressed here. The first category consists of direct radiological harm (radiation-induced human illnesses, etc.) and the indirect social and economic impacts arising from that direct harm. The second category consists of regulatory impacts that arise from the NRC's general approach to licensing of nuclear power plants.

Direct and indirect radiological impacts

This report addresses the direct radiological harm, and the associated indirect impacts, that would result from an unplanned release of radioactive material to the environment. More specifically, the report focuses on the potential for an unplanned atmospheric release. Such a release could cause radiological consequences at the Indian Point site and at downwind, offsite locations. The released material would travel in a plume of gases and small particles. The particles would settle on the ground and other surfaces at downwind locations, and would then be re-distributed by rain, wind, etc. Humans could be irradiated through various pathways including inhalation, external exposure, and ingestion of contaminated food and water. Types of radiological consequences could include:

(i) "early" human fatalities or morbidities (illnesses) that arise during the first several weeks after the release;
(ii) "latent" fatalities or morbidities (e.g., cancers) that arise years after the release;
(iii) short- or long-term abandonment of land, buildings, etc.;
(iv) short- or long-term interruption of agriculture, water supplies, etc.; and

[11] The estimates shown in Table 2-1 employ the best information available to the author. Entergy could supply information that could be used to improve the accuracy of these estimates.

(v) social and economic impacts of the above-listed consequences.

An unplanned atmospheric release of radioactive material from the IP2 or IP3 reactors or their spent fuel could arise as a result of a conventional accident or a malice-induced accident. In this report, a conventional accident is a sequence of events initiated by human error, equipment failure, or natural forces. The potential for a conventional accident at a nuclear facility can be examined using the techniques of probabilistic risk assessment (PRA). In the PRA field, accident-initiating events are typically categorized as "internal" events (human error, equipment failure, etc.) or "external" events (earthquakes, fires, strong winds, etc.). A malice-induced accident would involve a deliberate attack at the Indian Point site. Such an attack could be mounted by a variety of actors, in a variety of ways, for various motives. The potential for an attack is discussed further in Section 7, below. That discussion shows how PRA techniques can be adapted to examine the risks of malice-induced accidents.

Regulatory impacts

The NRC's general approach to licensing of nuclear power plants creates regulatory impacts that adversely affect the environment. Granting of license extensions for the IP2 and IP3 plants would increase this burden of adverse impacts.

The potential for regulatory impacts is recognized in Executive Order 12866. That Order requires Federal agencies to "assess all costs and benefits of available regulatory alternatives". It further requires that "in choosing among alternative regulatory approaches, agencies should select those approaches that maximize net benefits".[12] The NRC argues that it is not required to comply with Executive Order 12866, but states that its regulatory analysis guidelines reflect the intent of that Order.[13] Moreover, the NRC sets forth Principles of Good Regulation in five categories: (i) independence, (ii) openness; (iii) efficiency; (iv) clarity; and (v) reliability.[14]

This report addresses two respects in which the NRC's regulatory approach does not reflect the intent of Executive Order 12866 and does not uphold the NRC's Principles of Good Regulation. First, the NRC's approach to the licensing of nuclear power plants contributes to an inappropriate, counterproductive approach by the Federal government to protection of the nation's critical infrastructure. Second, the NRC has adopted a policy of excessive secrecy that yields various adverse impacts, including suppression of clear-headed discussion of the risk posed by nuclear plants. These issues are discussed further in Section 8, below.

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[12] Clinton, 1993, Section 1.
[13] NRC, 2004, page 1.
[14] Principles of Good Regulation, accessed at the NRC web site (www.nrc.gov) on 20 November 2007.

4. Consideration of Risk by the NRC and Entergy

From the earliest years of the nuclear-technology era, analysis and experience have shown that a nuclear reactor can undergo an accident in which the reactor's fuel is damaged. This damage can lead to a release of radioactive material within the reactor and, potentially, from the reactor to the external environment. An early illustration of this accident potential occurred in the UK in 1957, when an air-cooled reactor at Windscale caught fire and released radioactive material to the atmosphere. At that time, spent fuel was not perceived as a significant hazard.

When the IP2 and IP3 plants received their construction permits in 1966 and 1969, respectively, there was limited technical understanding of the potential for severe accidents at commercial reactors. In this context, "severe" means that the reactor core is severely damaged, which typically involves melting of some fraction of the core materials. Analysts in the PRA field typically refer to such an event as a "core-damage" accident. That term is used here. Knowledge about the potential for core-damage accidents was substantially improved by completion of the Reactor Safety Study (WASH-1400) in 1975.[15] That study, although deficient in various respects, established the basic principles for a reactor PRA. More knowledge has accumulated from analysis and experience since 1975.[16]

The NRC has discussed some of the risk-related impacts of continued operation of a nuclear power plant, in its *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NUREG-1437).[17] Entergy has discussed some of the risk-related impacts of continued operation of the IP2 and IP3 plants, in the Environmental Report that is provided as Appendix E of the License Renewal Application.[18]

Chapter 5 of NUREG-1437 discusses the radiological risk of conventional accidents at various commercial reactors in the USA. In that discussion, the NRC claims that the risk attributable to earthquakes and other external initiating events is "adequately addressed by a generic consideration of internally initiated severe accidents".[19] NUREG-1437 also provides a brief discussion of the potential for a deliberate attack on a reactor, concluding:[20]

> "Although the threat of sabotage events cannot be accurately quantified, the commission believes that acts of sabotage are not reasonably expected. Nonetheless, if such events were to occur, the commission would expect that

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[15] NRC, 1975.
[16] Relevant experience includes the Three Mile Island reactor accident of 1979 and the Chernobyl reactor accident of 1986.
[17] NRC, 1996.
[18] Entergy, 2007a, Appendix E.
[19] NRC, 1996, page 5-18.
[20] NRC, 1996, page 5-18.

> resultant core damage and radiological releases would be no worse than those expected from internally initiated events."

The merit of that statement is discussed in Section 7, below. NUREG-1437 also provides a brief discussion of the potential for a fire in a spent-fuel pool, concluding:[21]

> "NRC has also found that, even under the worst probable cause of a loss of spent-fuel pool coolant (a severe seismic-generated accident causing a catastrophic failure of the pool), the likelihood of a fuel-cladding fire is highly remote (55 FR 38474)."

The merit of that statement is discussed in Section 6, below.

Entergy's Environmental Report assesses the risks of core-damage events at the IP2 and IP3 reactors. Only conventional accidents are considered. Spent-fuel-pool fires are not considered. For each reactor, risk is framed in terms of the monetized offsite and onsite costs of a set of potential atmospheric releases of radioactive material, multiplied for each release by its estimated annual probability, summed (with discounting) over the 20-year period of license extension. The resulting indicator is a "present value of cost risks" for the reactor. A variety of assumptions and approximations are used during the estimation of this indicator.

The Environmental Report examines a variety of Severe Accident Mitigation Alternatives (SAMAs) that could reduce risks. For each SAMA, a "benefit" is determined by estimating the amount by which this SAMA would, if adopted, reduce the present value of cost risks of reactor operation. The cost of implementing the SAMA is also estimated. If the benefit exceeds the cost, the SAMA is determined to be "cost effective". The Environmental Report does not reach a final verdict on the cost-effectiveness of the SAMAs that it considers. Instead, it selects, from an initial set of postulated SAMAs, a subset of SAMAs that are potentially cost-effective. Entergy states that SAMAs in that subset "have been submitted for detailed engineering cost-benefit analysis".[22]

In the 1990s, each of the IP2 and IP3 plants was subjected to an Individual Plant Examination (IPE).[23] Those studies examined the potential for a reactor core damage event initiated by internal initiating events. Each plant was subsequently subjected to an Individual Plant Examination of External Events (IPEEE), which considered external initiating events.[24] The IPEs, IPEEEs and supporting information, including independent reviews commissioned by the NRC, are publicly available through the NRC. Entergy's current knowledge of risk derives, according to the Environmental Report, from probabilistic safety assessments (PSAs) that update the IPEs and IPEEEs. The PSAs are cited in the Environmental Report but are not regarded by the NRC staff as part of the

[21] NRC, 1996, pp 6-72 to 6-75.
[22] Entergy, 2007a, Appendix E, page 4-73.
[23] Consolidated Edison, 1992; NYPA, 1994.
[24] Consolidated Edison, 1995; NYPA, 1997.

License Renewal Application, and are not available to the public.[25] Thus, the PSAs cannot be independently reviewed in a public forum. The same is true of Entergy's SAMA analyses, which are only partially published and which rest upon the PSAs. Yet, the NRC has tasked a contractor with reviewing Entergy's SAMA analyses for the IP2 and IP3 plants.[26] It is not clear how this contractor can provide a credible review.

Sections 5 through 8, below, examine four selected risk issues that have been neglected by the NRC and Entergy. In part, that examination adopts the methodology that Entergy uses to discuss SAMAs. IRSS's use of that methodology is not a general endorsement of Entergy's SAMA analyses, their methodology or their assumptions. IRSS uses the methodology to illustrate the significance of the neglected risk issues.

5. Neglected Risk Issue #1: Reactor Containment Bypass via Induced Failure of Steam Generator Tubes

During a core-damage accident at a reactor, radioactive material would be released from the damaged fuel to the reactor coolant system (RCS). A portion of that material would then travel from the RCS to the interior of the reactor containment building. Some of that portion may then travel from the interior of the containment to the external environment, through pathways that existed prior to the accident or were created during the accident. Alternatively, radioactive material may travel directly from the RCS to the external environment through pathways that bypass the containment. Core-damage scenarios involving containment bypass deserve careful consideration in a reactor risk assessment, because the release of radioactive material to the environment could be comparatively large during such a scenario. Entergy's Environmental Report does not provide an adequate examination of this issue for the IP2 and IP3 reactors. As discussed below, the Environmental Report does not properly address the potential for containment bypass via induced failure of steam generator tubes.

The IP2 and IP3 reactors have large, dry containment structures. Containments of this type have some capability to withstand destructive phenomena that accompany core-damage accidents, such as hydrogen explosions or steam explosions.[27] Thus, if containment bypass does not occur, the fraction of the radioactive material released from damaged fuel that reaches the environment might be comparatively small. Many studies have been done in the PRA field to estimate this fraction across a range of core-damage scenarios. Entergy's Environmental Report finds that the fraction is comparatively small for a majority of core-damage sequences. IRSS does not examine that finding directly. Instead, this report shows that Entergy has substantially under-estimated the potential for containment bypass. If bypass occurs, the strength of the containment is irrelevant.

[25] Communications between Diane Curran and staff of the NRC Public Document Room, August 2007.
[26] Letter (and attachments) from Joyce Fields, NRC Contracting Officer, to James Meyer, Information Systems Laboratories, Rockville, Maryland, 22 June 2007.
[27] No US commercial reactor has a containment that was specifically designed to withstand all of the destructive phenomena that could accompany a core-damage accident.

The IP2 and IP3 reactors are PWRs. This type of reactor has a potential containment-bypass pathway that requires especially careful consideration. The pathway involves failure of one or more of the tubes in one or more of the reactor's four steam generators. There are 3,200 tubes in each steam generator at the IP2 and IP3 reactors. Each tube has a diameter of 0.9 inches and a wall thickness of 0.05 inches.[28] They are, therefore, comparatively fragile. Yet, the thin walls of these tubes form part of the containment boundary. The tube walls separate the RCS from the secondary side of the steam generators, where water is boiled to generate steam that is fed to the plant's turbogenerator.[29]

A 28-inch-diameter steam pipe leaves each steam generator and passes through the containment wall. Outside the containment, each pipe is equipped with an isolation valve that can block the flow of steam. Upstream of the isolation valve, but outside the containment, each pipe is connected to five safety valves that exhaust to the atmosphere. These valves are set to open at pressures ranging from 1,065 to 1,120 psig, consistent with the steam system's design pressure of 1,085 psig. That pressure is substantially lower than the RCS design pressure of 2,485 psig.[30] Thus, if steam generator tubes fail while the RCS is at or near its design pressure, fluid from the RCS would enter the secondary side via the failed tubes, water in that fluid would flash to steam, and a pulse of pressure would occur in the steam pipes, causing one or more of the safety valves to open. Then, if a safety valve sticks open, a pathway would be created that connects the RCS to the external atmosphere. That pathway would bypass the containment, could not be blocked, and would remain open for the duration of the accident.[31] The release of radioactive material through this pathway could be substantial. In this manner, the steam generator tubes would function as an "Achilles' heel" in the containment boundary.

Tube failure during a High/Dry accident sequence

Failure of steam generator tubes could be an initiating event for a core-damage accident, or could be induced by phenomena that accompany such an accident. The scenario of greatest risk significance is one in which failure is induced by heating of the steam generator tubes while there is a high differential pressure between the RCS and the secondary side. Those conditions would be most severe during "High/Dry" core-damage scenarios (accident sequences) in which the secondary side dries out due to unavailability of feedwater and the RCS pressure remains high while primary coolant (i.e., water) is lost and the core is uncovered. During such a scenario, there would be a period when the upper portions of the RCS are occupied by steam and by hydrogen generated from steam-zirconium reaction in the core, while the lower portions of the RCS are occupied by residual water. Convective circulation of the steam-hydrogen mixture would transfer

[28] Entergy, 2007b, Table 4.1-4. This source describes the IP2 plant; the IP3 plant has a similar design.
[29] The RCS is the "primary side" of the steam generators.
[30] Entergy, 2007b, Table 4.1-4, Section 10.2.1. This source describes the IP2 plant; the IP3 plant has a similar design.
[31] At the IP2 and IP3 plants, there is no valve that can close the pathway from the core to the secondary side safety valves if steam generator tubes are ruptured.

heat to the steam generator tubes and other portions of the RCS boundary, increasing their temperature. The ability of the affected areas to withstand the high pressure inside the RCS would decrease correspondingly. The temperature of the steam generator tubes would rise comparatively quickly because the tubes have thin walls. That effect would offset the fact that convective circulation into the interior of the tubes would be comparatively weak unless a reactor coolant pump were restarted or the "loop seal" of residual water in the cold legs of the RCS were lost in other ways.

The potential for containment bypass due to induced failure of steam generator tubes has been known for two decades. During the first half of that period, NRC and licensee analysts asserted that the likelihood of this event is low.[32] The NRC adopted that position in its NUREG-1150 study.[33] However, a subsequent study at Idaho National Engineering Laboratory (INEL) determined that the NUREG-1150 position "was based on expert opinion with little supporting analysis".[34] The INEL study was followed by an NRC Staff study of the risk of induced failure of steam generator tubes.[35] The latter two studies showed the complexity of this issue and the need for further research.

The NRC has continued to support analysis on the issue. Findings from a computer modeling exercise sponsored by the NRC, using the SCAD/RELAP5 model, were released in August 2006.[36] The exercise simulated a "station blackout" event at a Westinghouse 4-loop PWR. The IP2 and IP3 reactors are in this category. A station blackout event represents many of the potential High/Dry sequences of interest here.

In the modeled event, the core is uncovered when the accident has proceeded for about 10,000 seconds (2.8 hours). Then, steam and hydrogen circulate convectively through the upper portions of the RCS, transferring heat to structures in the RCS boundary. Failure of those structures is predicted to occur during the period 13,500 to 14,600 seconds. The structures fail because they are weakened by rising temperature to the point where they can no longer sustain the high pressure inside the RCS. Modeling shows that the hottest steam generator tube fails 155 seconds prior to the next most vulnerable portion of the RCS boundary (the hot leg), even if the tube is pristine. Similar results were found in four of six sensitivity cases.[37] The hottest tube would fail earlier if that tube is degraded, and some degree of tube degradation will always be present in practice. Also, a number of tubes, typically in proximity to each other, would be in the "hottest" category, and would therefore fail at about the same time. Moreover, hot gas released from the first rupture would impinge on surrounding tubes, promoting their failure. Thus, it can reasonably be assumed that the breach in the RCS boundary would involve a number of tubes.

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[32] Thompson, 2000, Section 4.2.
[33] NRC, 1990b, Volume 2, page C-66.
[34] Ellison et al, 1996, page 7-6.
[35] NRC, 1998.
[36] Fletcher and Beaton, 2006a; Fletcher and Beaton, 2006b.
[37] Fletcher and Beaton, 2006b, Table 13.

The above-described modeling exercise assumed, based on PRA analysis, that leakage through secondary side safety valves would depressurize the secondary side of each steam generator.[38] Thus, a pathway to the atmosphere from the secondary side would be open prior to and after tube failure. Sticking open of one or more of the 20 safety valves (5 for each of the 4 steam pipes) is likely because valves could lift 50 or more times as the secondary side boils dry.[39] These valves could lift again as a result of RCS pressure pulses during the accumulator-discharge phase of the accident sequence.[40] The potential for valves to stick open at that time would be enhanced by the presence of small particles of fuel in the fluid passing through the valves.[41]

These modeling results do not provide the final word regarding the potential for induced failure of steam generator tubes. They are, however, a key source of guidance for a risk assessment conducted in 2007. In light of these results, it is currently prudent to assume that: (i) any High/Dry sequence would involve induced failure of steam generator tubes; and (ii) one or more of the secondary side safety valves downstream of the affected steam generator(s) would remain open after tube failure. In other words, any High/Dry sequence would involve a bypass of the containment and a substantial release of radioactive material to the atmosphere. Such a release would be comparable to the "Early High" release category discussed in Entergy's Environmental Report.[42] Entergy's estimates of the magnitude of an Early High release are used here, without any implication that IRSS accepts those estimates as definitive.[43]

Risk implications of induced tube failure

The next step in addressing this issue is to estimate, for the IP2 and IP3 reactors, the probability of a core-damage accident featuring induced failure of steam generator tubes. Table 4-1 shows Entergy's estimates of the core damage frequency (CDF) for these reactors. Those estimates are used here, without any implication that IRSS accepts them as definitive. Tables 5-1 and 5-2 show various estimates of the share of CDF that is attributable to accident sequences in the High/Dry category. In two instances (the first two rows of Table 5-2), that share is taken directly from a table in the cited document, by summing relevant entries in the table. In other instances, the share is inferred from the cited document in the manner described in Tables 5-1 and 5-2. All of the cited documents were prepared by Entergy or preceding licensees. From the overall picture provided by Tables 5-1 and 5-2, it is reasonable to assume that High/Dry sequences account for 50 percent of CDF for the IP2 and IP3 reactors.

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[38] Fletcher and Beaton, 2006a, Section 2.2.
[39] NRC, 1998, Section 2.3.3.
[40] NRC, 1998, Section 2.1.2.
[41] Thompson, 2000, Section 4.2.
[42] Entergy, 2007a, Appendix E, Tables E.1-10 and E.3-10.
[43] Consideration of the effects of high burnup of fuel could lead to a higher estimate for the release of radioactive material. See: Thompson, 2000, Section 4.2.

That assumption should be considered in combination with the above-stated assumption that all High/Dry sequences would lead to an atmospheric release equivalent to the Early High release described by Entergy. The combined assumptions are used here to correct Entergy's estimates of the conditional probabilities of atmospheric release categories, given the occurrence of core damage. Tables 5-3 and 5-4 show those corrections. It can be seen that the conditional probability of an Early High release rises from 3.6 percent to 51.8 percent for the IP2 reactor, and from 8.2 percent to 54.1 percent for the IP3 reactor. In Tables 5-5 and 5-6, IRSS applies the same correction to Entergy's estimates of population dose risk (PDR) and offsite economic cost risk (OECR). Table 5-7 carries the correction through to the estimation of the present value of cost risks associated with atmospheric releases from the IP2 or IP3 reactor. It can be seen that the estimated present value of cost risks rises, in comparison with Entergy's estimate, by a factor of 5.42 for the IP2 reactor and 3.18 for the IP3 reactor. Note that the estimated values shown in Table 5-7 consider only those core-damage sequences that arise from internal initiating events. Also, uncertainty is not considered in Table 5-7. Entergy's practice is to use multipliers, as shown in Table 4-1, to account for external initiating events and uncertainty.

To summarize, IRSS has shown that Entergy has substantially under-estimated (by factors of 5.42 and 3.18, respectively) the present value of cost risks for 20 years of extended operation of the IP2 and IP3 reactors. The under-estimation derives from Entergy's lack of proper consideration of the potential for containment bypass via induced failure of steam generator tubes. Deliberate, malicious acts could be relevant to that issue, but IRSS has not considered such acts in the analysis described above. A major consequence of Entergy's under-estimation of the present value of cost risks is that Entergy's SAMA analyses are incorrect and must be redone. Revised analyses would require consideration of a range of SAMAs, including SAMAs that Entergy has previously determined to be not cost effective. That matter is discussed further in Section 9, below.

6. Neglected Risk Issue #2: Fire in a Spent-Fuel Pool

6.1 Recognition of the Spent-Fuel Hazard

Until 1979 it was widely assumed that stored spent fuel did not pose risks comparable to those associated with reactors. This assumption arose because a spent fuel assembly does not contain short-lived radioactivity, and therefore produces less radioactive decay heat than does a similar fuel assembly in an operating reactor. However, that factor was counteracted by the introduction of high-density, closed-form storage racks into spent-fuel pools, beginning in the 1970s. The pools at the present generation of US nuclear plants were originally designed so that each held only a small inventory of spent fuel, with the expectation that spent fuel would be stored briefly and then taken away for reprocessing. Low-density, open-frame storage racks were used. Cooling fluid can circulate freely through such a rack. When reprocessing was abandoned in the United States, spent fuel began to accumulate in the pools. Excess spent fuel could have been offloaded to other storage facilities, allowing continued use of low-density racks. Instead, as a cost-saving measure, high-density racks were introduced, allowing much larger amounts of spent fuel to be stored in the pools.

The potential for a pool fire

Unfortunately, the closed-form configuration of the high-density racks would create a major problem if water were lost from a spent-fuel pool. The flow of air through the racks would be highly constrained, and would be almost completely cut off if residual water or debris were present in the base of the pool. As a result, removal of radioactive decay heat would be ineffective. Over a broad range of water-loss scenarios, the temperature of the zirconium fuel cladding would rise to the point (approximately 1,000 degrees C) where a self-sustaining, exothermic reaction of zirconium with air or steam would begin. Fuel discharged from the reactor for 1 month could ignite in less than 2 hours, and fuel discharged for 3 months could ignite in about 3 hours.[44] Once initiated, the fire would spread to adjacent fuel assemblies, and could ultimately involve all fuel in the pool. A large, atmospheric release of radioactive material would occur. For simplicity, this potential disaster can be described as a "pool fire".

Water could be lost from a spent-fuel pool through leakage, boiling, siphoning, pumping, displacement by objects falling into the pool, or overturning of the pool. These modes of water loss could arise from events, alone or in combination, that include: (i) acts of malice by persons within or outside the plant boundary; (ii) an accidental aircraft impact; (iii) an earthquake; (iv) dropping of a fuel cask; (v) accidental fires or explosions; and (vi) a severe accident at an adjacent reactor that, through the spread of radioactive material and other influences, precludes the ongoing provision of cooling and/or water makeup to the pool.

These events have differing probabilities of occurrence. None of them is an everyday event. Nevertheless, they are similar to events that are now routinely considered in planning and policy decisions related to commercial nuclear reactors. To date, however, such events have not been given the same attention in the context of spent-fuel pools.

Some people have found it counter-intuitive that spent fuel, given its comparatively low decay heat and its storage under water, could pose a fire hazard. This perception has slowed recognition of the hazard. In this context, a simple analogy may be helpful. We all understand that a wooden house can stand safely for many years but be turned into an inferno by a match applied in an appropriate location. A spent-fuel pool equipped with high-density racks is roughly analogous, but in this case ignition would be accomplished by draining water from the pool. In both cases, a triggering event would unleash a large amount of latent chemical energy.

[44] This sentence assumes adiabatic conditions.

The sequence of studies related to pool fires

Two studies completed in March 1979 independently identified the potential for a fire in a drained spent-fuel pool equipped with high-density racks. One study was by members of a scientific panel assembled by the German state government of Lower Saxony to review a proposal for a nuclear fuel cycle center at Gorleben.[45] After a public hearing, the Lower Saxony government ruled in May 1979, as part of a broader decision, that high-density pool storage of spent fuel would not be acceptable at Gorleben. The second study was done by Sandia Laboratories for the NRC.[46] In light of knowledge that has accumulated since 1979, the Sandia report generally stands up well, provided that one reads the report in its entirety. However, the report's introduction contains an erroneous statement that complete drainage of the pool is the most severe situation. The body of the report clearly shows that partial drainage can be a more severe case, as was recognized in the Gorleben context. Unfortunately, the NRC continued, until October 2000, to employ the erroneous assumption that complete drainage is the most severe case.

The NRC has published various documents that discuss aspects of the potential for a spent-fuel-pool fire. Several of these documents are discussed below. Only three of the various documents are products of processes that provided an opportunity for formally structured public comment and, potentially, for in-depth analysis of risks and alternatives. One such document is the August 1979 generic environmental impact statement (GEIS) on handling and storage of spent fuel (NUREG-0575).[47] The second document is the May 1996 GEIS on license renewal (NUREG-1437).[48] These two documents purported to provide systematic analysis of the risks and relative costs and benefits of alternative options. The third document is the NRC's September 1990 review (55 FR 38474) of its Waste Confidence Decision.[49] That document did not purport to provide an analysis of risks and alternatives.

NUREG-0575 addresses the potential for a spent-fuel-pool fire in a single sentence that cites the 1979 Sandia report. The sentence reads:[50]

> "Assuming that the spent fuel stored at an independent spent fuel storage installation is at least one year old, calculations have been performed to show that loss of water should not result in fuel failure due to high temperatures if proper rack design is employed."

Although this sentence refers to pool storage of spent fuel at an independent spent fuel storage installation, NUREG-0575 regards at-reactor pool storage as having the same

[45] Thompson et al, 1979.
[46] Benjamin et al, 1979.
[47] NRC, 1979.
[48] NRC, 1996.
[49] NRC, 1990a.
[50] NRC, 1979, page 4-21.

properties. This sentence misrepresents the findings of the Sandia report. The sentence does not define "proper rack design". It does not disclose Sandia's findings that high-density racks promote overheating of exposed fuel, and that overheating can cause fuel to self-ignite and burn. The NRC has never corrected this deficiency in NUREG-0575.

NUREG-1437 also addresses the potential for a spent-fuel-pool fire in a single sentence, which in this instance states:[51]

> "NRC has also found that, even, under the worst probable cause of a loss of spent-fuel pool coolant (a severe seismic-generated accident causing a catastrophic failure of the pool), the likelihood of a fuel-cladding fire is highly remote (55 FR 38474)."

The parenthetic citation is to the NRC's September 1990 review of its Waste Confidence Decision. Thus, NUREG-1437's examination of pool fires is totally dependent on the September 1990 review. In turn, that review bases its opinion about pool fires on the following four NRC documents:[52] (i) NUREG/CR-4982;[53] (ii) NUREG/CR-5176;[54] (iii) NUREG-1353;[55] and (iv) NUREG/CR-5281.[56] These documents are discussed in Section 6.2, below. That discussion reveals substantial deficiencies in the documents' analysis of the potential for a pool fire.

Thus, neither of the two GEISs (NUREG-0575 and NUREG-1437), nor the September 1990 review of the Waste Confidence Decision, provides a technically defensible examination of spent-fuel-pool fires and the associated risks and alternatives. The statements in each document regarding pool fires are inconsistent with the findings of subsequent, more credible studies discussed below.

The most recent published NRC technical study on the potential for a pool fire is an NRC Staff study, originally released in October 2000 but formally published in February 2001, that addresses the risk of a pool fire at a nuclear power plant undergoing decommissioning.[57] This author submitted comments on the study to the NRC Commissioners in February 2001.[58] The study was in several respects an improvement on previous NRC documents that addressed pool fires. It reversed the NRC's longstanding, erroneous position that total, instantaneous drainage of a pool is the most severe case of drainage. However, it did not consider acts of malice. Nor did it add significantly to the weak base of technical knowledge regarding the propagation of a fire from one fuel assembly to another. Its focus was on a plant undergoing

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[51] NRC, 1996, pp 6-72 to 6-75.
[52] NRC, 1990a, page 38481.
[53] Sailor et al, 1987.
[54] Prassinos et al, 1989.
[55] Throm, 1989.
[56] Jo et al, 1989.
[57] Collins and Hubbard, 2001
[58] Thompson, 2001a.

decommissioning. Therefore, it did not address potential interactions between pools and operating reactors, such as the interactions discussed in Section 6.3, below.

In 2003, eight authors, including the present author, published a paper on the risks of spent-fuel-pool fires and the options for reducing these risks.[59] That paper aroused vigorous comment, and its findings were disputed by NRC officials and others. Critical comment was also directed to a related report by this author.[60] In an effort to resolve this controversy, the US Congress requested the National Academy of Sciences (NAS) to conduct a study on the safety and security of spent-fuel storage. The NAS submitted a classified report to Congress in July 2004, and released an unclassified version in April 2005.[61] Press reports described considerable tension between the NAS and the NRC regarding the inclusion of material in the unclassified NAS report.[62]

Since September 2001, the NRC has not published any document that contains technical analysis related to the potential for a pool fire. The NRC has claimed that it is conducting further analysis in a classified setting. The scope of information treated as secret by the NRC is highly questionable. Much of the relevant analysis would address issues such as heat transfer and fire propagation. Calculations and experiments on such subjects should be performed and reviewed in the public domain. Classification is appropriate for other information, such as specific points of vulnerability of a spent-fuel pool to attack.

6.2 Technical Understanding of Pool Fires

Section 6.1, above, introduces the concept of a pool fire and describes the history of analysis of pool-fire risks. There is a body of technical literature on these risks, containing documents of varying degrees of completeness and accuracy. Current opinions about the risks vary widely, but the differences of opinion are more about the probabilities of pool-fire scenarios than about the physical characteristics of these scenarios. In turn, differing opinions about probabilities lead to differing support for risk-reducing options. This situation is captured in a comment by Allan Benjamin on a paper (Alvarez et al, 2003) by this author and seven colleagues.[63] Benjamin's comment is quoted in the unclassified NAS report as follows:[64]

> "In a nutshell, [Alvarez et al] correctly identify a problem that needs to be addressed, but they do not adequately demonstrate that the proposed solution is cost-effective or that it is optimal."

The "proposed solution" to which Benjamin refers is the re-equipment of spent-fuel pools with low-density, open-frame racks, transferring excess spent fuel to onsite dry storage.

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[59] Alvarez et al, 2003.
[60] Thompson, 2003.
[61] NAS, 2006.
[62] Wald, 2005.
[63] Allan Benjamin was one of the authors of: Benjamin et al, 1979.
[64] NAS, 2006, page 45.

In fact, however, the [Alvarez et al] authors had not claimed to complete the level of analysis, especially site-specific analysis, that risk-reducing options should receive in an Environmental Report or environmental impact statement (EIS). These authors stated:[65]

> "Finally, all of our proposals require further detailed analysis and some would involve risk tradeoffs that also would have to be further analyzed. Ideally, these analyses could be embedded in an open process in which both analysts and policy makers can be held accountable."

The paper by Alvarez et al is consistent with current knowledge of pool-fire phenomena, including the findings set forth in the unclassified NAS report. The same cannot be said for all of the NRC documents that were cited in the NRC's September 1990 review of its Waste Confidence Decision. As discussed in Section 6.1, above, four NRC documents were cited to support that review's finding regarding the risks of pool fires.[66] In turn, the May 1996 GEIS on license renewal (NUREG-1437) relied on the September 1990 review for its position on the risks of pool fires. The four NRC documents are discussed in the following paragraphs.

NUREG/CR-4982 was prepared at Brookhaven National Laboratory to provide "an assessment of the likelihood and consequences of a severe accident in a spent fuel storage pool".[67] The postulated accident involved complete, instantaneous loss of water from the pool, thereby excluding important phenomena from consideration. The Brookhaven authors employed a simplistic model to examine propagation of a fire from one fuel assembly to another. That model neglected important phenomena including slumping and burn-through of racks, slumping of fuel assemblies, and the accumulation of a debris bed at the base of the pool. Each of these neglected phenomena would promote fire propagation. The study ignored the potential for interactions between a pool fire and a reactor accident. It did not consider acts of malice. Overall, this study did not approach the completeness and quality needed to support consideration of a pool fire in an EIS.

NUREG/CR-5176 was prepared at Lawrence Livermore National Laboratory.[68] It examined the potential for earthquake-induced failure of the spent-fuel pool and the pool's support systems at the Vermont Yankee and Robinson Unit 2 plants. It also considered the effect of dropping a spent-fuel shipping cask on a pool wall. Overall, this study appears to have been a competent exercise within its stated assumptions. With appropriate updating, NUREG/CR-5176 could contribute to the larger body of analysis that would be needed to support consideration of a pool fire in an EIS.

NUREG-1353 was prepared by a member of the NRC Staff to support resolution of NRC Generic Issue 82.[69] It postulated a pool accident involving complete, instantaneous loss

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[65] Alvarez et al, 2003, page 35.
[66] NRC, 1990a, page 38481.
[67] Sailor et al, 1987.
[68] Prassinos et al, 1989.
[69] Throm, 1989.

of water from the pool, thereby excluding important phenomena from consideration. It relied on the fire-propagation analysis of NUREG/CR-4982. As discussed above, that analysis is inadequate. In considering heat transfer from boiling water reactor (BWR) fuel after water loss, NUREG-1353 assumed that a high-density rack configuration would involve a 5-inch open space between each row of fuel assemblies. That assumption is inappropriate and non-conservative. Modern, high-density BWR racks have a center-to-center distance of about 6 inches in both directions. Thus, NUREG-1353 under-estimated the potential for ignition of BWR fuel. Overall, NUREG-1353 did not approach the completeness and quality needed to support consideration of a pool fire in an EIS.

NUREG/CR-5281 was prepared at Brookhaven National Laboratory to evaluate options for reducing the risks of pool fires.[70] It took NUREG/CR-4982 as its starting point, and therefore shared the deficiencies of that study.

Clearly, these four NRC documents do not provide an adequate technical basis for an EIS that addresses the risks of pool fires. The knowledge that they do provide could be supplemented from other documents, including the unclassified NAS report, the paper by Alvarez et al, and the NRC Staff study (NUREG-1738) on pool-fire risk at a plant undergoing decommissioning.[71] However, this combined body of information would be inadequate to support the preparation of an EIS. For that purpose, a comprehensive, integrated study would be required, involving analysis and experiment. The depth of investigation would be similar to that involved in preparing the NRC's December 1990 study on the risks of reactor accidents (NUREG-1150).[72]

A pool-fire "source term"

The incompleteness of the present knowledge base is evident when one needs a "source term" to estimate the radiological consequences of a pool fire. The concept of a source term encompasses the magnitude, timing and other characteristics of an atmospheric release of radioactive material. Present knowledge does not allow an accurate theoretical or empirically-based prediction of the source term for a postulated pool-fire scenario. Available information indicates that, for a broad range of scenarios, the atmospheric release fraction of cesium-137 would be between 10 and 100 percent. This report assumes a cesium-137 release fraction of about 50 percent. Table 2-1 shows that the inventory of cesium-137 in the IP2 or IP3 pool during the period of license extension would be about 70 MCi. Thus, a release of 35 MCi of cesium-137 is used here to examine the consequences of a pool fire at the IP2 or IP3 plant.

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[70] Jo et al, 1989.
[71] Collins and Hubbard, 2001.
[72] NRC, 1990b.

6.3 Initiation of a Pool Fire

The initiation of a pool fire would require the loss of water from a pool, and the absence of water makeup or spray cooling of the exposed fuel during the period while it heats up to the ignition temperature. As stated above, that period would be just a few hours if fuel has been recently discharged from the reactor. After ignition, water spray would be counterproductive, because it would feed a steam-zirconium reaction.

Water could be lost from a spent-fuel pool through leakage, boiling, siphoning, pumping, displacement by objects falling into the pool, or overturning of the pool. These modes of water loss could arise from events, alone or in combination, that include: (i) acts of malice by persons within or outside the plant boundary; (ii) an accidental aircraft impact; (iii) an earthquake; (iv) dropping of a fuel cask; (v) accidental fires or explosions; and (vi) a severe accident at an adjacent reactor that, through the spread of radioactive material and other influences, precludes the ongoing provision of cooling and/or water makeup to the pool.

Given the major consequences of a pool fire, analyses should have been performed to examine pool-fire scenarios across a full range of initiating events. The NRC has devoted substantial attention and resources to the examination of reactor-core-damage scenarios, through studies such as NUREG-1150.[73] Neither the NRC nor the nuclear industry has conducted a comparable, comprehensive study of pool fires. In the absence of such a study, this report provides illustrative analysis of selected issues.

The NUREG-1353 estimate of pool-fire probability

As discussed above, the NRC document NUREG-1353 was deficient in various respects. It did, however, provide an estimate for the probability of a pool fire at a PWR plant. That estimate is 2 per million reactor-years.[74] The NRC has not issued a revised estimate for that probability. Thus, it is appropriate to examine the implications of the NUREG-1353 estimate for pool-fire risk at the IP2 or IP3 plant. IRSS performs such an examination, as described below. It does not follow that IRSS accepts the NUREG-1353 probability estimate as definitive.

A pool fire accompanied by a reactor accident

At the IP2 and IP3 plant, the pool is outside but immediately adjacent to the reactor containment, and shares some essential support systems with the reactor. Thus, it is important to consider potential interactions between the pool and the reactor in the context of accidents. There could be at least three types of interaction. First, a pool fire and a core-damage accident could occur together, with a common cause. For example, a

[73] NRC, 1990b.
[74] Throm, 1989, Table 4.7.1.

severe earthquake could cause leakage of water from the pool, while also damaging the reactor and its supporting systems to such an extent that a core-damage accident occurs. Second, the high radiation field produced by a pool fire could initiate or exacerbate an accident at the reactor by precluding the presence and functioning of operating personnel. Third, the high radiation field produced by a core-damage accident could initiate or exacerbate a pool fire, again by precluding the presence and functioning of operating personnel. Many core-damage sequences would involve the interruption of cooling to the pool, which would call for the presence of personnel to provide makeup water or spray cooling of exposed fuel.

The third type of interaction was considered in a license-amendment proceeding in regard to expansion of spent-fuel-pool capacity at the Harris nuclear power plant. There were three parties to the proceeding – the NRC Staff, Carolina Power and Light (CP&L), and Orange County. The Harris plant has one reactor and four pools. The reactor – a PWR – is in a cylindrical, domed containment building. The four pools are in a separate, adjacent building that was originally intended to serve four reactors. Only one reactor was built. Two pools were in use at high density prior to the proceeding, and the proceeding addressed the activation of the two remaining pools, also at high density.

During the proceeding, the Atomic Safety and Licensing Board (ASLB) determined that the potential for a pool fire should be considered, and ordered the three parties to analyze a single scenario for such a fire.[75] In the postulated scenario, a severe accident at the Harris reactor would contaminate the Harris site with radioactive material to an extent that would preclude actions needed to supply cooling and makeup to the Harris pools. Thereafter, the pools would boil and dry out, and fuel within the pools would burn. Following the ALSB's order, Orange County submitted a report by this author.[76] The NRC Staff submitted an affidavit by members of the Staff.[77] CP&L – the licensee – submitted a document prepared by ERIN Engineering.[78]

Orange County's analysis found that the minimum value for the best estimate of a pool fire, for the ASLB's postulated scenario, is 1.6 per 100 thousand reactor-years. That estimate did not account for acts of malice, degraded standards of plant operation, or gross errors in design, construction or operation. The NRC Staff estimated, for the same scenario, that the probability of a pool fire is on the order of 2 per 10 million reactor-years. The ASLB accepted the Staff's estimate, thereby concluding that, for the particular configuration of the Harris plant, the postulated scenario is "remote and speculative"; the ASLB then terminated the proceeding without conducting an evidentiary hearing.[79] Elsewhere, the author has described deficiencies in the ASLB's ruling.[80]

[75] ASLB, 2000.
[76] Thompson, 2000.
[77] Parry et al, 2000.
[78] ERIN, 2000.
[79] ASLB, 2001.
[80] Thompson, 2001b.

One reason for the difference in the probability estimates proffered by Orange County and the NRC Staff was their differing assessments of the spread of radioactive material from the reactor containment building to the separate, adjacent pool building. The Staff agreed with Orange County on some other matters. For example, the Staff reversed its previous, erroneous position that comparatively long-discharged fuel will not ignite in the event of water loss from a high-density pool. NRC Staff members stated that loss of water from pools containing fuel aged less than 5 years "would almost certainly result in an exothermic reaction", and also stated: "Precisely how old the fuel has to be to prevent a fire is still not resolved."[81] Moreover, the Staff assumed that a fire would be inevitable if the water level fell to the top of the racks.

Most importantly for present purposes, the technical submissions of all three parties agreed that the onset of a pool fire in two of the pools in the Harris pool building would preclude the provision of cooling and water makeup to the other two pools. This effect would arise from the spread of hot gases and radioactive material throughout the pool building, which would preclude access by operating personnel. Thus, the pools not involved in the initial fire would boil and dry out, and their fuel would burn. The parties' agreement on this point established that the radiation field created by an accident at one part of a nuclear plant could, by precluding access by personnel, cause an accident at another part of the plant. Whether or not this effect would occur in a particular scenario would depend on the specific configuration of the plant and the characteristics of the scenario.

IRSS does not, at present, offer an analysis of the potential for a conventional accident at the IP2 or IP3 reactor to initiate a fire in the adjacent pool, or vice versa. That analysis would be part of any comprehensive assessment of the risks posed by continued operation of the IP2 and IP3 plants. The analysis would need to be done specifically for the Indian Point site, and could not rely on findings for the Harris plant.

Interactions between a core-damage accident and a pool fire could be especially important in the context of an attack on the Indian Point site. Attackers could, either deliberately or inadvertently, release radioactive material from one facility (e.g., a reactor) that precludes personnel access to other facilities (e.g., a pool), thereby initiating accidents at those facilities. This matter is discussed in Section 7, below.

IRSS is aware of one instance in which the NRC published an analysis of the impacts of deliberate, malicious actions at a spent-fuel pool. Such an analysis was provided in NUREG-0575, the August 1979 GEIS on handling and storage of spent fuel. That analysis is discussed further in Section 7, below.

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[81] Parry et al, 2000, paragraph 29.

6.4 Consideration of Pool Fires in SAMA Analyses

Entergy has not considered pool fires in its SAMA analyses for the IP2 and IP3 plants. IRSS provides an illustrative analysis to show the significance of Entergy's neglect of pool fires. The results are shown in Tables 6-1 through 6-3.

Table 6-1 shows estimated offsite costs from potential atmospheric releases of radioactive material. Two categories of release are addressed. The first category consists of Early High releases from the IP2 and IP3 reactors. Entergy estimates the offsite costs of such releases to be $66 billion for the IP2 reactor and $56 billion for the IP3 reactor. The second category consists of a fire in a spent-fuel pool at the IP2 or IP3 plant. IRSS assumes that the release from such a fire would include 35 MCi of cesium-137, as discussed above. A study by Beyea et al estimates the offsite costs of a 35 MCi release of cesium-137 from the Indian Point site to be $461 billion.[82] In that study, the authors identify a number of factors that, if considered, could increase their estimate. A further increase would occur if indirect impacts of the release were considered. Indirect economic impacts would include: (i) loss of market share for products from the region and across the US, due to stigma effects; (ii) loss of tourist revenue in the region and across the US, due to stigma effects; (iii) prolonged, costly litigation that retards recovery from the event; and (iv) loss of confidence in regional and national stability and governance, causing outflow of capital and skilled labor.

Table 6-2 shows estimated offsite cost risks for the two categories of atmospheric release discussed in the preceding paragraph. For Early High releases from the IP2 and IP3 reactors, the estimates are from Entergy. For the release from a pool fire, the NUREG-1353 estimate of probability is combined with the Beyea et al estimate of offsite costs. The table shows that the offsite cost risk of a pool fire is substantially higher than the offsite cost risk of an Early High release from a core-damage accident.

Table 6-3 carries this analysis forward to provide estimates of the present value of cost risk for: (i) the full spectrum of releases from core-damage accidents at the IP2 and IP3 reactors; and (ii) a pool fire at the IP2 or IP3 plant. The table shows that the present value of cost risk is greatest for the pool fire, even without considering the onsite component of that indicator for a pool fire. The analysis is further developed in Table 7-7, which is discussed below.

Tables 6-2 and 6-3 are developed within the risk-assessment paradigm employed by Entergy and the NRC. They employ an estimate of pool-fire probability that the NRC set forth in NUREG-1353 and has not repudiated. That estimate is comparable to Entergy's estimate of the probability of an Early High release from the IP2 or IP3 reactor. The two tables show that the risk of a pool fire exceeds the risk of a core-damage accident. Yet,

[82] Beyea et al, 2004.

Entergy examines the risk of a core-damage accident but ignores the risk of a pool fire. There is no logical basis for ignoring pool-fire risk.

7. Neglected Risk Issue #3: Attack on a Reactor and/or its Spent Fuel

7.1 The General Threat Environment

The potential for a deliberate attack on a commercial nuclear facility arises within a larger context, namely the general threat environment for the US homeland. That environment reflects, in turn, a complex set of factors operating internationally.

If the IP2 and IP3 plants receive 20-year license extensions, they will operate until 2033 (IP2) and 2035 (IP3), discharging spent fuel throughout that period. The proposed Yucca Mountain repository could not accommodate more than a fraction of these reactors' cumulative discharge of spent fuel, and it is increasingly unlikely that this repository will open. No other option is currently available for removing spent fuel from the Indian Point site. At that site, as at nuclear power plant sites across the US, the most likely outcome is that spent fuel will be stored at the site for the foreseeable future, potentially for longer than a century.[83] Thus, in assessing the risks of malicious actions at the Indian Point site, one should consider the general threat environment over the next century.

The threat from sub-national groups

The US homeland has not been attacked by another nation since World War II. One factor behind this outcome has been the US deployment of military forces with a high capability for counter-attack. There have, however, been significant attacks on the US homeland and other US assets by sub-national groups since World War II. Such attacks are typically not deterred by US capability for counter-attack, because the attacking group has no identifiable territory. Indeed, sub-national groups may attack US assets with the specific purpose of prompting US counter-attacks that harm innocent persons, thereby undermining the global political position of the US.

Attacks on the homeland by sub-national groups in recent decades include vehicle bombings of the World Trade Center in New York in February 1993 and the Murrah Federal building in Oklahoma City in April 1995, and aircraft attacks on the World Trade Center and the Pentagon in September 2001. Outside the homeland, attacks on US assets by sub-national groups have included vehicle-bomb attacks on a Marine barracks in Beirut in October 1983 and embassies in Tanzania and Kenya in August 1998, and a boat-bomb attack on the USS Cole in October 2000. At present, sub-national groups routinely attack US forces in Iraq.

In many of these incidents, the attacking group has been based outside the US. An exception was the Oklahoma City bombing, where the attacking group was domestic in

[83] Thompson, 2005.

both its composition and its motives. There is concern that future attacks within the US may be made by groups that are domestically based but have linkages to, or sympathy with, interests outside the US. This phenomenon was exhibited in London in July 2005, when young men born in the UK conducted suicide bombings in underground trains and a bus.

Reducing the risks of attack by sub-national groups requires a sophisticated, multi-faceted and sustained policy. An unbalanced policy can be ineffective or counterproductive. Since September 2001, the US government has implemented a policy that is heavily weighted toward offensive military action. Evidence is accumulating that this policy has been significantly counterproductive. Table 7-1 provides a sample of the evidence. The table shows recent public-opinion data from four Muslim-majority countries (Morocco, Egypt, Pakistan, Indonesia). In each country, a majority (ranging from 53 percent of respondents in Indonesia to 86 percent in Egypt) believes that the primary goal of the US "war on terrorism" is to weaken Islam or control Middle East resources (oil and natural gas). One expression of this belief is that substantial numbers of people (ranging from 19 percent of respondents in Indonesia to 91 percent in Egypt) approve of attacks on US troops in Iraq. Smaller numbers of people (ranging from 4 to 7 percent of respondents) approve of attacks on civilians in the US.[84]

The great majority of people, in these four countries and elsewhere, will not participate in attacks on US assets. However, there are consequences when millions of people believe that the US seeks to undermine their religion and culture and control their resources. Among other consequences, this belief creates a social climate that can help sub-national groups to form and to acquire the skills, funds and equipment they need in order to mount attacks. From a US perspective, such groups are "terrorists". Within their own cultures, they may be seen as soldiers engaged in "asymmetric warfare" with a powerful enemy.

Many experts who study these issues see a substantial probability that the US homeland will, over the coming years, be subjected to an attack comparable in severity to the attack of September 2001. Table 7-2 summarizes the judgment of a selected group of experts on this matter.

The threat environment over the coming decades

As mentioned above, an assessment of the risks of malicious actions at the Indian Point site should consider the general threat environment over the next century. Forecasting trends in the threat environment over such a period is a daunting exercise, with inevitably uncertain findings. Nevertheless, a decision about extended operation of the IP2 and IP3 reactors must reflect either an implicit or an explicit forecast of trends in the general threat environment. It is preferable that the forecast be explicit, and global in scope, because the US cannot be insulated from broad trends in violent conflict and social disorder.

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[84] Kull et al, 2007.

Numerous analysts – in academia, government and business – are involved in efforts to forecast possible worldwide trends that pertain to violence. These efforts rarely attempt to look forward more than one or two decades. Two examples are illustrative. First, a group based at the University of Maryland tracks a variety of indicators for most of the countries in the world, in a data base that extends back to 1950 and earlier. Using these data, the group periodically provides country-level assessments of the potential for outbreaks of violent conflict.[85] Second, the RAND corporation has conducted a literature review and assessment of potential worldwide trends that would be adverse for US national security.[86]

Several decades ago, some analysts of potential futures began taking an integrated world view, in which social and economic trends are considered in the context of a finite planet. In this view, trends in population, resource consumption and environmental degradation can be significant, or even dominant, determinants of the options available to human societies. A well-known, early example of this genre is the *Limits to Growth* study, sponsored by the Club of Rome, which modeled world trends by using systems dynamics.[87] A more recent example is the work of the Global Scenario group, convened by the Stockholm Environment Institute (SEI).[88] This work was informed by systems-dynamics thinking, but focused on identifying the qualitative characteristics of possible future worldwide scenarios for human civilization. SEI identified three types of scenario, with two variants of each type, as shown in Table 7-3. The Conventional Worlds scenario has Market Forces and Policy Reform variants, the Barbarization scenario has Breakdown and Fortress World variants, while the Great Transitions scenario has Eco-Communalism and New Sustainability Paradigm variants.

The SEI scenarios provide a useful framework for considering the paths that human civilization could follow during the next century and beyond. Not all paths are possible. Notably, continued trends of resource depletion and irreversible degradation of ecosystems would limit the range of options available to succeeding generations. Similarly, destruction of human and industrial capital through large-scale warfare could inhibit economic and social recovery for many generations.

At present, the dominant world paradigm corresponds to the Market Forces scenario. Policy Reform is pursued at the rhetorical level, but is weakly implemented in practice. In parts of the world, notably in Africa, the Breakdown scenario is already operative. Aspects of the Fortress World scenario are also evident, and are likely to become more prominent if trends of resource depletion and ecosystem degradation continue, especially if major powers reject the dictates of sustainability and use armed force to secure resources. One sign of resource depletion is a growing body of analysis that predicts a

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[85] Marshall and Gurr, 2005.
[86] Kugler, 1995.
[87] Meadows et al, 1972.
[88] Raskin et al, 2002.

peak in world oil production within the next few decades.[89] This prediction is sobering in view of the prominent role played by oil in the origins and conduct of war in the 20th century.[90] A now-familiar sign of ecosystem degradation is anthropogenic, global climate change. Analysts are considering the potential for climate change to promote, through its adverse impacts, social disorder and violence.[91] Other manifestations of ecosystem degradation are also significant. The recent Millennium Ecosystem Assessment determined that 15 out of the 24 ecosystem services that it examined "are being degraded or used unsustainably, including fresh water, capture fisheries, air and water purification, and the regulation of regional and local climate, natural hazards, and pests".[92] According to analysts at the United Nations University in Bonn, continuation of such trends could create up to 50 million environmental refugees by the end of the decade.[93]

At present, human population and material consumption per capita are growing to a degree that visibly stresses the biosphere. Moreover, ecosystem degradation and resource depletion coexist with economic inequality, increasing availability of sophisticated weapons technology, and an immature system of global governance. Major powers are doing little to address these problems. It seems unlikely that these imbalances and sources of instability will persist at such a scale during the remainder of the 21st century without major change occurring. That change could take various forms, but two broad-brush scenarios can illustrate the range of possible outcomes. In one scenario, there would be a transition to a civilization similar to the New Sustainability Paradigm articulated by SEI. That civilization would be comparatively peaceful and technologically sophisticated. Alternatively, the world could descend into a form of barbarism such as the Fortress World scenario articulated by SEI. That society might be locally prosperous, within enclaves, but would be violent and unstable.

In assessing the likelihood of malicious actions at the Indian Point site, it would be prudent to adopt a pessimistic assumption of the potential for violent conflict in the future. Using SEI terminology, one could assume a Fortress World scenario with a high incidence of violent conflict of a type that involves sophisticated weapons and tactics. Violence might be perpetrated by national governments or by sub-national groups. A RAND corporation analyst has contemplated such a future in the following terms:[94]

> "A dangerous world may offer an insidious combination of nineteenth-century politics, twentieth-century passions, and twenty-first century technology: an explosive mixture of multipolarity, nationalism, and advanced technology."

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[89] Hirsch et al, 2005; GAO, 2007.
[90] Yergin, 1991.
[91] Gilman et al, 2007; Campbell et al, 2007; Smith and Vivekananda, 2007.
[92] MEA, 2005, page 1.
[93] Adam, 2005.
[94] Kugler, 1995, page 279.

7.2 National Policy and Practice on Homeland Security

To mount an effective response to the general threat environment for the US homeland, the nation needs a coherent homeland-security strategy that links responses to an array of specific threats, such as the potential for a deliberate attack on a commercial nuclear facility. As discussed below, there are deficiencies in the strategy that has actually been implemented. The nominal strategy was articulated by the White House in the *National Strategy for Homeland Security*, first published in July 2002 and updated in October 2007. That document sets forth four major goals:[95]

> "• Prevent and disrupt terrorist attacks;
> • Protect the American people, our critical infrastructure, and key resources;
> • Respond to and recover from incidents that do occur; and
> • Continue to strengthen the foundation to ensure our long-term success."

The document defines critical infrastructure as including "the assets, systems, and networks, whether physical or virtual, so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, public health or safety, or any combination thereof".[96] Commercial nuclear reactors and their spent fuel are identified in the document as elements of the nation's critical infrastructure and key resources.

Protecting critical infrastructure

The US Department of Homeland Security has issued the *National Infrastructure Protection Plan* (NIPP), whose purpose is to provide "the unifying structure for the integration of critical infrastructure and key resources (CI/KR) protection into a single national program".[97] Other Federal agencies, including the NRC, have confirmed their acceptance of the NIPP.

The NIPP identifies three purposes of measures to protect critical infrastructure and key resources: (i) deter the threat; (ii) mitigate vulnerabilities; and (iii) minimize consequences associated with an attack or other incident. The NIPP identifies a range of protective measures as follows:[98]

> "Protection can include a wide range of activities such as improving business protocols, hardening facilities, building resiliency and redundancy, incorporating hazard resistance into initial facility design, initiating active or passive countermeasures, installing security systems, leveraging "self-healing"

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[95] White House, 2007, page 1.
[96] White House, 2007, page 25.
[97] DHS, 2006, page iii.
[98] DHS, 2006, page 7.

> technologies, promoting workforce surety programs, or implementing cyber security measures, among various others".

Protective measures of these types could significantly reduce the probability that an attack would be successful. Such measures could, therefore, "deter" attacks by altering attackers' cost-benefit calculations. That form of deterrence is different from deterrence attributable to an attacked party's capability to counter-attack. For convenience, the two forms of deterrence are described hereafter as "protective deterrence" and "counter-attack deterrence". It should be noted that the effective functioning of both forms of deterrence requires that: (i) potential attackers are aware of the deterrence strategy; and (ii) the deterrence strategy is technically credible. That requirement means that the existence and capabilities of protective measures, such as those identified in the NIPP, should be widely advertised. The technical details of a protective measure should, however, remain confidential if disclosure of those details would allow the measure to be defeated.

From the statement quoted above, it is clear that the authors of the NIPP recognize the potential benefits of designing protective measures into a facility before it is constructed. At the design stage, attributes such as resiliency, redundancy, hardening and passive operation can often be incorporated into a facility at a comparatively low incremental cost. Capturing opportunities for low-cost enhancement of protective measures would allow decision makers to design against a more pessimistic (i.e., more prudent) threat assumption, thereby strengthening protective deterrence, reducing the costs of other security functions (e.g., guard forces), and enhancing civil liberties (e.g., by reducing the perceived need for measures such as wiretapping). Moreover, incorporation of enhanced protective measures would often reduce risks associated with conventional accidents (e.g., fires), extreme natural events (e.g., earthquakes), or other challenges not directly attributable to human malice.

Protective deterrence as part of a balanced policy for homeland security

As mentioned above, reducing the risks of attack by sub-national groups requires a sophisticated, multi-faceted and sustained policy. The policy must balance multiple factors operating within and beyond the homeland. An unbalanced policy can be ineffective or counterproductive.

A high-level task force convened by the Council on Foreign Relations (CFR) in 2002 understood the need for a balanced policy for homeland security.[99] One of the task force's major conclusions recognized the value of protective deterrence, while also recognizing that offensive military operations by the US could increase the risk of attack on the US. The conclusion was as follows:[100]

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[99] Members of the task force included two former Secretaries of State, two former chairs of the Joint Chiefs of Staff, a former Director of the CIA and the FBI, two former US Senators, and other eminent persons.
[100] Hart et al, 2002, pp 14-15.

> "*Homeland security measures have deterrence value*: US counterterrorism initiatives abroad can be reinforced by making the US homeland a less tempting target. We can transform the calculations of would-be terrorists by elevating the risk that (1) an attack on the United States will fail, and (2) the disruptive consequences of a successful attack will be minimal. It is especially critical that we bolster this deterrent now since an inevitable consequence of the US government's stepped-up military and diplomatic exertions will be to elevate the incentive to strike back before these efforts have their desired effect."

The NIPP could support a vigorous national program of protective deterrence, as recommended by the CFR task force in 2002. However, current priorities of the US government are not consistent with such a program. Resources and attention devoted to offensive military operations are much larger than those devoted to the protection of critical infrastructure.[101] The White House states, in the *National Strategy for Combating Terrorism*, issued in September 2006:[102] "We have broken old orthodoxies that once confined our counterterrorism efforts primarily to the criminal justice domain." In practice, that statement means that the US government relies overwhelmingly on military means to reduce the risks of attacks on US assets by sub-national groups. That policy continues despite mounting evidence, as illustrated by Tables 7-1 and 7-2, that it is unbalanced and counterproductive.

A well-informed analyst of homeland security summarizes current national priorities in the following statement:[103]

> "Since the White House has chosen to combat terrorism as essentially a military and intelligence activity, it treats homeland security as a decidedly second-rate priority. The job of everyday citizens is to just go about their lives, shopping and traveling, while the Pentagon, Central Intelligence Agency, and National Security Agency wage the war."

During a future Presidential administration, national priorities may shift, leading to greater emphasis on protective deterrence. Unfortunately, critical-infrastructure facilities approved or constructed prior to that policy shift may lack the protective design features that are envisioned in the NIPP. Persons responsible for the design or licensing of currently-proposed activities, such as extended operation of the IP2 and IP3 reactors, could anticipate a national policy shift and take decisions accordingly.

Section 8, below, discusses the options and issues that should be considered in developing a balanced policy for protecting US critical infrastructure from attack by sub-national groups. That discussion shows the potential benefits that could be gained by assigning a higher priority to protective deterrence.

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[101] Flynn, 2007.
[102] White House, 2006, page 1.
[103] Flynn, 2007, page 11.

7.3 Commercial Nuclear Facilities as Potential Targets of Attack

A sub-national group contemplating an attack within the US homeland would have a wide choice of targets. Also, groups in that category could vary widely in terms of their capabilities and motivations. In the context of potential attacks on nuclear facilities, the groups of concern are those that are comparatively sophisticated in their approach and comparatively well provided with funds and skills. The group that attacked New York and Washington in September 2001 met this description. A group of this type could choose to attack a US nuclear facility for one or both of two broad reasons. First, the attack could be highly symbolic. Second, the impacts of the attack could be severe.

Nuclear facilities as symbolic targets

From the symbolic perspective, commercial nuclear facilities are inevitably associated with nuclear weapons. The association further extends to the United States' large and technically sophisticated capability for offensive military operations. Application of that capability has aroused resentment in many parts of the world. Although nuclear weapons have not been used by the United States since 1945, US political leaders have repeatedly threatened, implicitly or explicitly, to use nuclear weapons again. Those threats coexist with efforts to deny nuclear weapons to other countries. The US government justified its March 2003 invasion of Iraq in large part by the possibility that the Iraqi government might eventually deploy nuclear weapons. There is speculation that the United States will attack nominally commercial nuclear facilities in Iran to forestall Iran's deployment of nuclear weapons.[104] Yet, the US government rejects the constraint of its own nuclear weapons by international agreements such as the Non-Proliferation Treaty.[105] As an approach to international security, this policy has been criticized by the director general of the International Atomic Energy Agency as "unsustainable and counterproductive".[106] It would be prudent to assume that this policy will motivate sub-national groups to respond asymmetrically to US nuclear superiority, possibly through an attack on a US commercial nuclear facility.

Radiological impacts of an attack on a nuclear facility

The impacts of an attack on a commercial nuclear facility could be severe because these facilities typically contain large amounts of radioactive material. Release of this material to the environment could create a variety of severe impacts. Also, as explained in Section 7.4, below, US nuclear facilities are provided with a defense that is "light" in a military sense. Moreover, imprudent design choices have made a number of these facilities highly vulnerable to attack. That combination of factors means that many US nuclear facilities can be regarded as potent radiological weapons that await activation by an enemy.

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[104] Hersh, 2006; Brzezinski, 2007.
[105] Deller, 2002; Scarry, 2002; Franceschini and Schaper, 2006.
[106] ElBaradei, 2004, page 9.

As explained in Section 2, above, a facility's inventory of the radioactive isotope cesium-137 provides an indicator of the facility's potency as a radiological weapon. Table 2-1 shows estimated amounts of cesium-137 in nuclear fuel in the IP2 and IP3 reactors and spent-fuel pools, and in one of the spent-fuel storage modules of the Indian Point ISFSI when that facility is operational. Table 2-2 compares these amounts with atmospheric releases of cesium-137 from detonation of a 10-kilotonne fission weapon, the Chernobyl reactor accident of 1986, and atmospheric testing of nuclear weapons. These data show that release of a substantial fraction of the cesium-137 in an Indian Point nuclear facility would create comparatively large radiological consequences.

Section 7.6, below, discusses the impacts of attack-induced atmospheric releases of radioactive material from facilities at Indian Point, in the context of SAMA analyses.

7.4 The NRC's Approach to Nuclear-Facility Security

A policy on protecting nuclear facilities from attack is laid down in NRC regulation 10 CFR 50.13. That regulation was promulgated in September 1967 by the US Atomic Energy Commission (AEC) – which preceded the NRC – and was upheld by the US Court of Appeals in August 1968. It states:[107]

> "An applicant for a license to construct and operate a production or utilization facility, or for an amendment to such license, is not required to provide for design features or other measures for the specific purpose of protection against the effects of (a) attacks and destructive acts, including sabotage, directed against the facility by an enemy of the United States, whether a foreign government or other person, or (b) use or deployment of weapons incident to US defense activities."

Some readers might interpret 10 CFR 50.13 to mean that licensees are not required to design or operate nuclear facilities to resist potential attacks by sub-national groups. The NRC has rejected that interpretation in the context of vehicle-bomb attacks, stating:[108]

> "It is simply not the case that a vehicle bomb attack on a nuclear power plant would almost certainly represent an attack by an enemy of the United States, within the meaning of that phrase in 10 CFR 50.13."

Events have obliged the NRC to progressively require greater protection against attacks by sub-national groups. A series of events, including the 1993 vehicle-bomb attack on the World Trade Center in New York, persuaded the NRC to introduce, in 1994, regulatory amendments requiring licensees to defend nuclear power plants against vehicle bombs.[109] The attacks on New York and Washington in September 2001 led the NRC to require additional protective measures.

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[107] Federal Register, Vol. 32, 26 September 1967, page 13445.
[108] NRC, 1994, page 38893.
[109] NRC, 1994.

With rare exceptions, the NRC has refused to consider potential malicious actions in the context of license proceedings or environmental impact statements. The NRC's policy on this matter is illustrated by a September 1982 ruling by the Atomic Safety and Licensing Board in the operating-license proceeding for the Harris nuclear power plant. An intervenor, Wells Eddleman, had proffered a contention alleging, in part, that the plant's safety analysis was deficient because it did not consider the "consequences of terrorists commandeering a very large airplane.....and diving it into the containment." In refusing to consider this contention, the ASLB stated:[110]

> "This part of the contention is barred by 10 CFR 50.13. This rule must be read *in pari materia* with 10 CFR 73.1(a)(1), which describes the "design basis threat" against which commercial power reactors *are* required to be protected. Under that provision, a plant's security plan must be designed to cope with a violent external assault by "several persons," equipped with light, portable weapons, such as hand-held automatic weapons, explosives, incapacitating agents, and the like. Read in the light of section 73.1, the principal thrust of section 50.13 is that military style attacks with heavier weapons are not a part of the design basis threat for commercial reactors. Reactors could not be effectively protected against such attacks without turning them into virtually impregnable fortresses at much higher cost. Thus Applicants are not required to design against such things as artillery bombardments, missiles with nuclear warheads, or kamikaze dives by large airplanes, despite the fact that such attacks would damage and may well destroy a commercial reactor."

The design basis threat

The NRC requires its licensees to defend against a design basis threat (DBT), a postulated attack that has become more severe over time. The present DBT for nuclear power plants was promulgated in January 2007. Details are not publicly available. (The NRC publishes a summary description, which is provided below.) The present DBT is similar to one ordered by the NRC in April 2003.[111] At that time, the NRC described its order as follows:[112]

> "The Order that imposes revisions to the Design Basis Threat requires power plants to implement additional protective actions to protect against sabotage by terrorists and other adversaries. The details of the design basis threat are safeguards information pursuant to Section 147 of the Atomic Energy Act and will not be released to the public. This Order builds on the changes made by the Commission's February 25, 2002 Order. The Commission believes that this DBT represents the largest reasonable threat against which a regulated private security force should be expected to defend under existing law."

[110] ASLB, 1982.
[111] NRC Press Release No. 07-012, 29 January 2007.
[112] NRC Press Release No. 03-053, 29 April 2003.

From that statement, and from other published information, it is evident that the NRC requires a comparatively "light" defense for nuclear power plants and their spent fuel. The scope of the defense does not reflect a full spectrum of threats. Instead, it reflects a consensus about the level of threat that licensees can "reasonably" be expected to resist.[113] In illustration of this approach, when the NRC adopted the currently-applicable DBT rule in January 2007, it stated that the rule "does not require protection against a deliberate hit by a large aircraft", and that "active protection [of nuclear power plants] against airborne threats is addressed by other federal organizations, including the military".[114]

The present DBT for "radiological sabotage" at a nuclear power plant has the following published attributes:[115]

> "(i) A determined violent external assault, attack by stealth, or deceptive actions, including diversionary actions, by an adversary force capable of operating in each of the following modes: A single group attacking through one entry point, multiple groups attacking through multiple entry points, a combination of one or more groups and one or more individuals attacking through multiple entry points, or individuals attacking through separate entry points, with the following attributes, assistance and equipment:
>
>> (A) Well-trained (including military training and skills) and dedicated individuals, willing to kill or be killed, with sufficient knowledge to identify specific equipment or locations necessary for a successful attack;
>> (B) Active (e.g., facilitate entrance and exit, disable alarms and communications, participate in violent attack) or passive (e.g., provide information), or both, knowledgeable inside assistance;
>> (C) Suitable weapons, including handheld automatic weapons, equipped with silencers and having effective long range accuracy;
>> (D) Hand-carried equipment, including incapacitating agents and explosives for use as tools of entry or for otherwise destroying reactor, facility, transporter, or container integrity or features of the safeguards system; and
>> (E) Land and water vehicles, which could be used for transporting personnel and their hand-carried equipment to the proximity of vital areas; and
>
> (ii) An internal threat; and
> (iii) A land vehicle bomb assault, which may be coordinated with an external assault; and

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[113] Fertel, 2006; Wells, 2006; Brian, 2006.
[114] NRC Press Release No. 07-012, 29 January 2007.
[115] 10 CFR 73.1 Purpose and scope, accessed from the NRC web site (www.nrc.gov) on 14 June 2007.

> (iv) A waterborne vehicle bomb assault, which may be coordinated with an external assault; and
> (v) A cyber attack."

That DBT seems impressive, and is more demanding than previously-published DBTs. However, the DBT cannot be highly demanding in practice, given the equipment that the NRC requires for a security force. Major items of required equipment are semiautomatic rifles, shotguns, semiautomatic pistols, bullet-resistant vests, gas masks, and flares for night vision.[116] Plausible attacks could overwhelm a security force equipped in this manner. Also, press reports state that the assumed attacking force contains no more than six persons.[117] The average US nuclear-plant site employs about 77 security personnel, covering multiple shifts.[118] Thus, comparatively few guards are on duty at any given time.[119]

Table 7-4 sets forth some potential modes and instruments of attack on a nuclear power plant, and summarizes the present defenses against these modes and instruments. That table shows that a variety of potential attack scenarios could not be effectively resisted by present defenses. Potential attacks at Indian Point are discussed in Section 7.5, below.

Protective deterrence and the NRC

A rationale for the present level of protection of nuclear facilities was articulated by the NRC chair, Richard Meserve, in 2002:[120]

> "If we allow terrorist threats to determine what we build and what we operate, we will retreat into the past – back to an era without suspension bridges, harbor tunnels, stadiums, or hydroelectric dams, let alone skyscrapers, liquid-natural-gas terminals, chemical factories, or nuclear power plants. We cannot eliminate the terrorists' targets, but instead we must eliminate the terrorists themselves. A strategy of risk avoidance – the elimination of the threat by the elimination of potential targets – does not reflect a sound response."

That statement shows no understanding of the need for a balanced policy to protect critical infrastructure, employing the principles of protective deterrence. There is considerable potential to embody those principles in the design of nuclear facilities, especially new facilities. It has been known for decades that nuclear power plants could

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[116] 10 CFR 73 Appendix B – General Criteria for Security Personnel, Section V, accessed from the NRC web site (www.nrc.gov) on 14 June 2007.
[117] Hebert, 2007.
[118] Holt and Andrews, 2006.
[119] If each member of a 77-person security force were on duty 40 hours/week for 42 weeks/year (allowing 10 weeks/year for vacation, illness, training, etc.), the average number of persons on duty at any time would be 15.
[120] Meserve, 2002, page 22.

be designed to be more robust against attack. For example, in the early 1980s the reactor vendor ASEA-Atom developed a preliminary design for an "intrinsically safe" commercial reactor known as the PIUS reactor. Passive-safety design principles were used. The design basis for the PIUS reactor included events such as equipment failures, operator errors and earthquakes, but also included: (i) takeover of the plant for one operating shift by knowledgeable saboteurs equipped with large amounts of explosives; (ii) aerial bombardment with 1,000-pound bombs; and (iii) abandonment of the plant by the operators for one week.[121]

Consideration of malicious actions in environmental impact statements

As stated above, the NRC has generally refused to consider potential malicious actions in environmental impact statements. An exception is the NRC's August 1979 GEIS on handling and storage of spent fuel (NUREG-0575), which considered potential sabotage events at a spent-fuel pool.[122] Table 7-5 describes the postulated events, which encompassed the detonation of explosive charges in the pool, breaching of the walls of the pool building and the pool floor by explosive charges or other means, and takeover of the central control room for one half-hour. Involvement of up to about 80 adversaries was implied.

NUREG-0575 did not recognize the potential for an attack with these attributes to cause a fire in the pool.[123] Technically-informed attackers operating within this envelope of attributes could cause a fire in a spent-fuel pool at the IP2 or IP3 plant or any other operating nuclear power plant in the US.[124] Informed attackers could use explosives, and their command of the control room for one half-hour, to drain water from the pool and release radioactive material from the adjacent reactor. The radiation field from the reactor release and the drained pool could preclude personnel access, thus precluding recovery actions if command of the plant were returned to the operators after one half-hour. Exposure of spent fuel to air would initiate a fire that would release to the atmosphere a large fraction of the pool's inventory of cesium-137.[125]

Pursuant to a ruling by the 9th Circuit of the US Court of Appeals, in 2007 the NRC Staff issued a Supplement to its October 2003 Environmental Assessment (EA) for a proposed ISFSI at the Diablo Canyon site. The Supplement purported to address the risks of potential malicious actions at the ISFSI. A draft version of the Supplement was issued in May 2007 and a final version was issued in August 2007.[126] IRSS prepared a detailed

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[121] Hannerz, 1983.
[122] NRC, 1979, Section 5 and Appendix J.
[123] The sabotage events postulated in NUREG-0575 yielded comparatively small estimated radioactive releases.
[124] Spent-fuel pools at the IP2 and IP3 plants and other US nuclear power plants are currently equipped with high-density racks for holding spent fuel. Loss of water from a pool equipped with high-density racks would, over a wide range of water-loss scenarios, lead to ignition and burning of spent fuel assemblies.
[125] Alvarez et al, 2003; Thompson, 2006; NAS, 2006.
[126] NRC, 2007a; NRC, 2007b.

review of the draft version and a short review of the final version.[127] There was little change from the draft to the final version. Both versions exhibited grave deficiencies. Neither version provided a credible assessment of the risks of potential malicious actions.

The NRC Staff has refused to implement the 9th Circuit ruling in regions of the US, such as New York State, that do not fall under the jurisdiction of the 9th Circuit. Nevertheless, the US Environmental Protection Agency (EPA) has requested the NRC Staff to provide, in the EIS for license extension of the IP2 and IP3 plants, "an analysis of the impacts of intentional destructive acts (e.g., terrorism)".[128] The EPA cites the 9th Circuit ruling as requiring such an analysis.

7.5 Vulnerability of the IP2 and IP3 Reactors and Pools to Attack

The IP2 and IP3 plants were not designed to withstand an attack. Nor were they designed to withstand a conventional accident involving core damage. However, they are comparatively massive structures. Thus, they have some ability to survive an attack or a conventional core-damage accident without necessarily suffering a large release of radioactive material. More precisely, a range of attack scenarios and conventional core-damage scenarios can be articulated, and an atmospheric source term can be estimated for each scenario. PRA techniques have been developed to examine conventional accident scenarios. Those techniques could be adapted to examine attack scenarios, by postulating for each scenario an initiating event (the attack) and assessing the conditional probabilities and other characteristics of the various possible outcomes of that event. The NRC employed that approach in developing its vehicle-bomb rule.[129]

PRA studies have been done for the IP2 and IP3 reactors, in the form of IPEs, IPEEEs and, more recently, PSAs. That work could be built upon to develop a broad picture of the vulnerability of these reactors to attack. The analysis could be further extended to assess the risks of pool fires arising from conventional accidents or attacks, with consideration of pool-reactor interactions. A comprehensive assessment of the risks of continued operation of the IP2 and IP3 plants would include all of these elements. Such an assessment could be performed without access to classified information, by using existing engineering knowledge and models, and by developing new models. Published professional literature provides illustrations of analytic techniques that could be used.[130]

A comprehensive assessment of the risks posed by operation of the IP2 and IP3 plants does not exist. If such an assessment did exist, parts of it would not be appropriate for publication. In the absence of that assessment, IRSS provides here some illustrative analysis of the vulnerability of the IP2 and IP3 reactors and pools to attack. The analysis is general and brief, to avoid disclosing sensitive information. IRSS could expand upon this analysis if given the opportunity to do so in a protected setting. It should be noted

[127] Thompson, 2007a; Thompson, 2007b.
[128] EPA, 2007.
[129] NRC, 1994.
[130] See, for example: Morris et al, 2006; Honnellio and Rydell, 2007; Sdouz, 2007.

that skilled attackers could readily obtain or infer a much greater depth of knowledge about the plants' vulnerability than is provided here.

Table 7-4 and the discussion in Section 7.4, above, show that US commercial nuclear plants are provided with a comparatively light defense. Thus, a sub-national group with personnel, resources and preparation time comparable to those involved in the September 2001 attacks on New York and Washington could mount an attack at the Indian Point site with a substantial probability of success.

Modes of attack

An attack might begin with actions that put the IP2 and/or IP3 plant in a compromised state and create stress for plant personnel. For example, attackers could sever the site's electricity grid connection and disable the service water system without needing to penetrate the site boundary. Due to a design deficiency at this site, lack of service water would disable the emergency diesel generators. Thus, the site would lose its primary supplies of electricity and cooling water. Additional actions, which could be accomplished by an insider, could then initiate a core-damage sequence.[131] The attackers might be satisfied to achieve core damage, recognizing that core damage would not necessarily lead to a large release of radioactive material. Alternatively, the attack plan might include actions that compromise the integrity of the reactor containment, in order to ensure a large atmospheric release.

The containment structure is a reinforced concrete vertical cylinder topped by a hemispherical dome made of the same material. The side walls are 4.5 feet thick with a 0.4 inch thick steel liner, and the dome is 3.5 feet thick with a 0.5 inch thick steel liner.[132] By some standards, this is a robust structure. It could, however, be readily breached using instruments of attack that are available to sub-national groups. For example, Table 7-6 shows the capability of shaped charges.[133] A shaped charge could be delivered by a general-aviation aircraft used as a cruise missile in remote-control or kamikaze mode. Alternatively, shaped charges could be placed by attackers who reach the target locations by parachute, ultralight aircraft, helicopter, or site penetration from land or the Hudson River. The attack might involve a standoff component in which shaped-charge warheads are delivered from an offsite location by an instrument such as the TOW (tube-launched, optically-tracked, wire-guided) missile. A shaped charge could be the first stage of a tandem device. In that configuration, the first stage penetrates a structure and is followed by a second stage that damages equipment inside the penetrated structure via fragmentation, blast, incendiary or "thermobaric" effects. An appropriately designed tandem device of this kind could be used to attack the IP2 or IP3 reactor without any other actions being taken, with a high probability of causing a large atmospheric release of radioactive material.

[131] The additional actions, which could be taken in advance of the attack, would disable equipment that is needed to maintain core cooling if the primary supplies of electricity and cooling water are unavailable.
[132] Entergy, 2007b, Section 5.1.2. This source describes the IP2 plant; the IP3 plant has a similar design.
[133] Also see: Walters, 2003.

The spent-fuel pools at the IP2 and IP3 plants are immediately outside the respective reactor containments. The floor of each pool is below the local grade level. However, the site slopes downward toward the Hudson River, so the pool floor is above river level. The pool walls are made of concrete, 3 to 6 feet thick.[134] As discussed above, a sub-national group could obtain the instruments needed to breach such a wall. Attackers might choose to breach the wall at the local grade level. That action would cause the water level in the pool to fall to near the top of the spent-fuel storage racks. Thereafter, the remaining water would boil and, if makeup water were not supplied, the pool could boil dry in about a day. As fuel assemblies became exposed, their temperature would rise. An assembly exposed for the majority of its length could heat up to ignition temperature in a few hours.[135]

In favorable circumstances, plant operators and other personnel could potentially prevent the initiation of a pool fire by the attack postulated above. To prevent a fire, the operators would have to improvise a water makeup system, or a system to spray water on exposed fuel assemblies. The operators' tasks would be greatly complicated by the radiation field from exposed fuel.[136] To prevent operators from providing makeup or spray water, the attackers could combine an attack on the pool with an attack on the adjacent reactor. The release of radioactive material from the reactor would generate a local radiation field that would, over a wide range of attack scenarios, preclude operator access for a period of days.

Aircraft as instruments of attack

Many people have suggested that an aircraft could be used as an instrument of attack on a nuclear facility. The NRC Staff considered this possibility in its Supplement to the EA for the proposed Diablo Canyon ISFSI, as discussed above.[137] The Staff made the mistaken assumption that a large, fuel-laden commercial aircraft would pose the greatest threat using this attack mode. Large, commercial aircraft caused major damage to the World Trade Center and the Pentagon in September 2001, but they would not be optimal as instruments of attack on a nuclear power plant. They are comparatively soft objects containing a few hard structures such as turbine shafts. They can be difficult to guide precisely at low speed and altitude. A well-informed group of attackers would probably prefer to use a smaller, general-aviation aircraft laden with explosive material, perhaps in a tandem configuration in which the first stage is a shaped charge. Note that the US General Accounting Office (GAO) expressed concern, in September 2003 testimony to Congress, about the potential for malicious use of general-aviation aircraft. The testimony stated:[138]

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[134] Entergy, 2007b, Table 9.5-1. This source describes the IP2 plant; the IP3 plant has a similar design.
[135] Thompson, 2000.
[136] Alvarez et al, 2003.
[137] NRC, 2007a; NRC, 2007b.
[138] Dillingham, 2003, page 14.

"Since September 2001, TSA [the Transportation Security Administration] has taken limited action to improve general aviation security, leaving it far more open and potentially vulnerable than commercial aviation. General aviation is vulnerable because general aviation pilots are not screened before takeoff and the contents of general aviation planes are not screened at any point. General aviation includes more than 200,000 privately owned airplanes, which are located in every state at more than 19,000 airports. Over 550 of these airports also provide commercial service. In the last 5 years, about 70 aircraft have been stolen from general aviation airports, indicating a potential weakness that could be exploited by terrorists."

7.6 Consideration of Potential Attacks in SAMA Analyses

In order to consider potential attacks on the IP2 and IP3 plants in SAMA analyses, it is necessary to assign a probability to each potential attack scenario. At present, there is no statistical basis to support quantitative estimates of these probabilities. However, reasonable assumptions of probability can be postulated and used in SAMA analyses to: (i) compare the risks of conventional accidents with the risks of postulated attacks; and (ii) identify and examine SAMAs that reduce these risks.

Here, IRSS provides some illustrative analyses of potential attacks that yield a large atmospheric release from a reactor and/or a pool fire. The probability of such an attack is postulated here to be 1 per 10,000 reactor-years. That number corresponds to a probability of about 1 per century across the US fleet of 104 commercial reactors, assuming that all the reactors are equally attractive as targets. In the SAMA analyses described here, the probability of 1 per 10,000 reactor-years includes a factor of uncertainty. Given the anticipated threat environment over the coming decades, and the vulnerability of the IP2 and IP3 plants, a postulated probability of 1 per 10,000 reactor-years is at the lower end of the range of assumptions that would be prudent in the context of homeland-security planning.

Table 7-7 shows the estimated present value of cost risks of an atmospheric release from the IP2 and IP3 plants. Attack-induced releases are considered, for a postulated probability of 1 per 10,000 reactor-years. Releases caused by conventional accidents are also considered, carrying forward the analyses summarized in Tables 5-7 and 6-3 to include internal and external initiating events and uncertainty. Thus, Table 7-7 provides an overall summary of the present value of cost risks as estimated by Entergy and IRSS. These estimates are discussed further in Section 9, below.

The illogic of NUREG-1437

The illustrative analysis that IRSS provides here does not purport to be comprehensive. Nevertheless, it shows that PRA techniques can be adapted to assess risks and risk-reducing options related to malice-induced accidents. IRSS's analysis also shows the illogic of the NRC's position in its GEIS on license renewal (NUREG-1437), regarding malice-induced accidents. As cited in Section 4, above, that position has two major elements.[139] First, the NRC asserts that malice-induced accidents "are not reasonably expected". That statement is contradicted by numerous events before and after the GEIS was published in May 1996. Second, the NRC asserts that, in the event of a malice-induced accident, "radiological releases would be no worse than those expected from internally initiated events". That statement ignores the opportunities available to skilled attackers to cause a very large release. One such opportunity is to cause a combined release from a reactor and the adjacent spent-fuel pool. Another opportunity is to cause core damage and a breach of containment, in order to maximize the release from a reactor.

8. Neglected Risk Issue #4: The Wider Context of Nuclear-Facility Risk

This report addresses two categories of risk-related impacts: (i) direct radiological harm and the indirect social and economic impacts arising from that direct harm; and (ii) regulatory impacts arising from the NRC's general approach to the licensing of nuclear power plants. Impacts in the second category adversely affect the environment across the United States and globally. Granting of license extensions for the IP2 and IP3 plants would add to that burden of adverse regulatory impacts. Understanding the additional burden requires one to view the risks posed by Indian Point facilities in a wider context.

Here, IRSS provides illustrative analyses of two respects in which the NRC's approach to the licensing of nuclear power plants creates adverse regulatory impacts. First, the NRC's licensing approach does not support a policy of protective deterrence. Instead, it contributes to a counterproductive approach by the Federal government to protection of the nation's critical infrastructure. Second, the NRC has adopted a policy of excessive secrecy that yields various adverse impacts, including suppression of clear-headed discussion of the risk posed by nuclear plants.

The NRC's failure to support protective deterrence

Section 7, above, describes the need for protective deterrence as part of a balanced policy for homeland security. The role of protective deterrence is illustrated by Table 8-1, which shows the strengths and weaknesses of approaches to protecting US critical infrastructure from attack by sub-national groups. That table shows the benefits that could flow from adoption of resilient design, passive defense, and other protective measures for infrastructure facilities such as the IP2 and IP3 plants. The NIPP envisions the use of such measures. Yet, the NRC does not require these measures. Instead, the NRC prefers an approach that relies on offensive military operations, surveillance of the domestic population, and related measures as the primary means of protecting nuclear facilities. That preference is evident in the NRC Staff's Supplement to the EA for the Diablo Canyon ISFSI, which states that "the broad actions taken by the Federal

[139] NRC, 1996, page 5-18.

government and the specific actions taken by the NRC since September 11, 2001, have helped to reduce the potential for terrorist attacks against NRC-regulated facilities".[140] The Staff does not recognize that many actions taken by the Federal government have been counterproductive.

The NRC's preference for secrecy instead of robust design

As an illustrative exercise, consider a proposed nuclear facility (e.g., a reactor, a spent-fuel pool, or an ISFSI) that would contain a large amount of radioactive material. There are two design options. Option A would employ a design that was developed several decades ago. It would have a comparatively low ability to resist an attack. In an effort to compensate for its vulnerability, it would be protected by a force of armed guards. Detailed information about the option's design, and about the guard force, would be secret. The public would be excluded from any effective role in the licensing of this option. The licensing and operation of this option would occur in a climate of fear. By contrast, Option B would employ a modern design using hardening, resiliency and passive protection as envisioned in the NIPP. It would have a comparatively high ability to resist an attack. As a result, a less capable guard force would be required, there would be no need for secrecy, and the public would have full access to license proceedings.

To further simplify this exercise, assume that the estimated life-cycle costs and radiological risks of Options A and B would be identical. In that case, Option A would be clearly inferior because it would increase the use of secret information and decrease the public's role in decision-making, tendencies that are antithetical to US traditions and inconsistent with long-term national prosperity. Put differently, Option A would have higher levels of social and economic impacts. Moreover, if a malicious action were to cause a release of radioactive material, the social and economic impacts would be higher if Option A had been chosen, because the public would tend to blame the government that had excluded them from the decision-making arena.

This exercise, although highly simplified, is far from theoretical. Design options have been employed that are highly vulnerable to attack, and the NRC has become much more secretive in recent years. Consider the case of spent-fuel pools equipped with high-density racks. All the spent-fuel pools at US nuclear power plants are so equipped. The NRC asserts that these pools are adequately safe and secure. Yet, since September 2001 the NRC has not published any technical analysis on the safety and security of spent-fuel pools, and has repeatedly denied requests by intervenors that spent-fuel-pool risks be addressed in evidentiary hearings. As a result, the NRC has never published any analysis on the risks of a spent-fuel-pool fire initiated by malicious action, and has never allowed an examination of these risks in a license proceeding. In this real-world case, spent-fuel pools equipped with high-density racks are Option A. An Option B is available, namely

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[140] NRC, 2007a, page 4. Also see: Meserve, 2002.

re-equipping the pools with low-density, open-frame racks, as was intended when the present generation of US nuclear power plants was designed.[141]

The costs of secrecy

As stated above, secrecy is antithetical to US traditions and inconsistent with long-term national prosperity. Thus, an EIS for a nuclear facility should consider the social and economic impacts of secrecy. That consideration would tend to favor design options involving features such as hardening, resiliency and passive protection. In some instances, secrecy-related impacts could be so high that they outweigh any benefits from operating the facility. It should be remembered that nuclear facilities exist to serve society, rather than vice versa.[142]

It should also be noted that the safety and security of nuclear facilities will be significantly and adversely affected by an entrenched culture of secrecy. Such a culture is not compatible with a clear-headed, science-based approach to the understanding of risks. Entrenched secrecy perpetuates dogma, stifles dissent, and can create a false sense of security. In illustration, the culture of secrecy in the former USSR was a major factor contributing to the occurrence of the 1986 Chernobyl reactor accident.[143]

The limited effectiveness of knowledge suppression

Within the NRC and elsewhere, factions will argue that suppression of knowledge can reduce the risks of malicious actions at nuclear facilities. Knowledge suppression is, however, a strategy with limited effectiveness. Nuclear fission power is a mature technology based on science from the mid-20th century. Detailed information about nuclear technology and individual nuclear facilities is archived at many locations around the world, and large numbers of people have worked in nuclear facilities. Similarly, information about weapons and other devices that could be used to attack nuclear facilities is widely available. Large numbers of people have been trained to use such devices in a military context. Thus, it would be prudent to assume that sophisticated sub-national groups can identify and exploit vulnerabilities in US nuclear facilities.

A balanced approach to managing sensitive information

From the preceding discussion, it is clear that managing sensitive information should be done carefully, balancing several considerations. The NRC has not achieved this balance since September 2001. Instead, the NRC has taken a crude, counterproductive approach in which it is excessively secretive while also making assertions about safety and security

[141] In this case, Option B would have a much lower radiological risk than Option A, but a higher capital cost.
[142] The NRC's Principles of Good Regulation state, in the context of openness: "Nuclear regulation is the public's business, and it must be transacted publicly and candidly". See: Principles of Good Regulation, accessed at the NRC web site (www.nrc.gov) on 20 November 2007.
[143] Thompson, 2002, Section X.

that do not withstand critical examination. To help correct this situation, the NRC should engage public stakeholders (citizen groups, academics, state and local governments, etc.) and licensees in a dialogue that seeks consensus on an effective, balanced policy for management of sensitive information. Implementation of that policy would not necessarily require changes in NRC rules.

9. An Integrated View of Risk-Related Impacts and Options for Reducing these Impacts

Sections 5 through 8, above, discuss risk issues that have been neglected by the NRC and Entergy. In Sections 5 through 7, that discussion yields quantitative findings that are expressed as variations on SAMA analyses conducted by Entergy. Those findings are summarized in Table 7-7, which shows the estimated present value of cost risks (PVCR) of an atmospheric release from the IP2 and IP3 plants for five cases. In the following discussion, PVCR is used as an indicator of risk, which does not imply that PVCR is the only or best indicator of risk.

The first case addressed in Table 7-7 encompasses conventional accidents leading to core damage. In that case, Entergy estimates the PVCR at $10.7 million for the IP2 plant and the same amount for the IP3 plant. Correction of those estimates by IRSS, to account for containment bypass during High/Dry sequences, yields a PVCR of $58.0 million for the IP2 plant and $34.1 million for the IP3 plant.

The second case encompasses conventional accidents leading to a pool fire. Assuming a probability for this event as determined in NUREG-1353, IRSS finds the PVCR to be $27.7 million. Note that IRSS does not regard the NUREG-1353 probability estimate as definitive.

The third case encompasses malice-induced accidents leading to core damage. In that case, IRSS postulates an accident probability of 1 per 10,000 reactor-years. That postulate, linked to the SAMA analyses and assumptions articulated by Entergy, yields a PVCR of $73.2 million for the IP2 plant and $62.4 million for the IP3 plant.

The fourth case encompasses malice-induced accidents leading to a pool fire, with a postulated accident probability of 1 per 10,000 reactor-years. In that case, IRSS finds the PVCR to be $498 million.

The fifth case encompasses malice-induced accidents leading to core damage at a reactor and a fire in the adjacent pool, with a postulated accident probability of 1 per 10,000 reactor-years. In that case, IRSS finds the PVCR to be $569 million for the IP2 plant and $559 million for the IP3 plant. Note that plausible attacks could lead to core damage and pool fires at both plants, yielding a higher value of PVCR than is estimated here.

SAMAs relevant to conventional accidents leading to core damage

Entergy has identified SAMAs that could reduce the PVCR of conventional accidents leading to core damage. Several of these SAMAs address, to varying extents, the potential for containment bypass due to induced failure of steam generator tubes. Entergy's neglect of that potential has resulted in under-estimation of PVCR by $47.3 (58.0 minus 10.7) million for the IP2 plant and $23.4 (34.1 minus 10.7) million for the IP3 plant. Thus, according to Entergy's methodology, any SAMA that could eliminate this type of containment bypass would be cost-effective if its cost were less than $47.3 million for the IP2 plant and $23.4 million for the IP3 plant.[144]

The potential for containment bypass due to failure of steam generator tubes, whether induced or spontaneous, is a major design weakness in the present generation of PWRs. These plants were designed decades ago. In examining SAMAs that address this bypass problem, analysts should draw lessons from recent design studies. For example, engineers working on the design of Westinghouse's IRIS reactor (a PWR undergoing pre-application licensing) were very conscious of the potential for induced failure of steam generator tubes during High/Dry core-damage sequences. Accordingly, they developed a design that seeks to eliminate this potential.[145] In the IRIS design, the steam generators are of a once-through type employing Inconel 690 tubes in a helical coil. These tubes are expected to have a high resistance to creep rupture. The primary coolant is on the exterior of the tubes, so that the tube walls are in compression rather than tension. The secondary-side piping is designed for full primary pressure, which has eliminated the need for secondary-side safety valves. These design features, taken together, are expected to dramatically reduce the potential for containment bypass via failed steam generator tubes.

The IP2 and IP3 plants cannot be modified to meet the level of safety that is expected of a new plant. Nevertheless, Entergy should redo its SAMA analyses, to properly examine options that reduce the risk arising from containment bypass due to failure of steam generator tubes. The preferred options should be those that rely on passive safety and robust design, as employed in the IRIS design. Options that employ active systems and operator actions are less reliable and more prone to degradation over a period of years. Entergy has identified an option that may have some of the needed attributes. That option is designated as Phase II SAMA Candidate Number 019 for the IP2 plant and Number 017 for the IP3 plant. It involves increasing the pressure capacity of the secondary side such that steam generator tube failure would not cause the secondary side safety valves to open. Entergy estimates the cost of this SAMA to be $13 million for the IP2 plant and the same amount for the IP3 plant.[146] That cost is substantially below the

[144] The break-even costs would actually be somewhat higher than these amounts, because Entergy's SAMA analyses already involve a contribution to PVCR from core-damage sequences involving failure of steam generator tubes.
[145] Maioli et al, 2004.
[146] Entergy, 2007a, Appendix E, Tables E.2-2 and E.4-2.

break-even costs discussed above ($47.3 million for the IP2 plant and $23.4 million for the IP3 plant) for options that eliminate the bypass potential, providing a strong indication that this SAMA would be cost-effective.[147]

SAMAs relevant to pool fires

Entergy has not identified any SAMA that could reduce the PVCR of conventional or malice-induced accidents that lead to a pool fire. Options that could achieve this outcome are described in Table 9-1. By far the most effective and reliable option would be to re-equip the pools with low-density, open-frame racks, as was intended when the IP2 and IP3 plants were designed. Table 9-2 provides a cost estimate for implementing this option by transferring spent fuel from the pool to an onsite ISFSI. The estimated cost of the option would be $43 to 86 million for the IP2 plant and $41 to 83 million for the IP3 plant.

It should be noted that an identical operation (transferring the same amount of spent fuel from the pool to an onsite ISFSI) would otherwise occur during decommissioning of the plant, if there were no offsite location (such as a repository at Yucca Mountain) to which spent fuel could be taken at that time. As stated in Section 7.1, above, it is likely that spent fuel will be stored at the Indian Point site for the foreseeable future, potentially for longer than a century. Assuming that outcome, the net present cost of the option of re-equipping each pool with low-density, open-frame racks would be, in the context of a 20-year license extension, the difference between the cost of implementing the option now and the present value of the same cost incurred 20 years in the future.[148] Assuming a discount rate of 7 percent per year, the present value would be 25 percent of the cost 20 years in the future. Thus, the net present cost of transferring spent fuel to an onsite ISFSI would be $32 to 65 million for the IP2 plant and $31 to 62 million for the IP3 plant.[149]

Table 7-7 shows two estimates for the PVCR of a pool fire at the IP2 or IP3 plant. One estimate, for a conventional accident with a probability as in NUREG-1353, is $27.7 million. That estimate of PVCR would not be sufficient to justify the estimated net present cost ($31 to 65 million) of re-equipping each pool with low-density, open-frame racks. However, a comprehensive, site-specific assessment of the risk of a pool fire caused by a conventional accident would probably yield a higher estimate of PVCR.[150]

A discount rate of 7 percent per year is generally used in this report, following Entergy's practice. That rate is not necessarily appropriate for SAMA analysis. If a rate of 3 per cent per year is used for the cost-benefit comparison described in the preceding paragraph, one finds that the PVCR of a pool fire rises from $27.7 million to $38.7

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[147] The cost of this SAMA is substantially below the break-even cost. Thus, the SAMA does not need to entirely eliminate the bypass potential in order to be cost-effective.
[148] The comparatively small cost of rack replacement is neglected here.
[149] 1.0 – 0.25 = 0.75; 0.75 x 43 to 86 = 32 to 65; 0.75 x 41 to 83 = 31 to 62.
[150] The estimated frequency and offsite costs of the event would probably be significantly higher than the values shown in Table 6-2.

million, while the net present cost of re-equipping each pool with low-density, open-frame racks falls from a range of $31 to 65 million to a range of $18 to 39 million. In that case, re-equipping each pool with low-density racks would be clearly justified. Note that Entergy uses a discount rate of 3 percent per year to test the sensitivity of its SAMA analyses. There is a strong ethical argument for using a discount rate of zero to assess the risk of radiological harm. With that rate, the PVCR of a pool fire would rise from $27.7 million to $51.5 million.

The second estimate of PVCR for a pool fire that is shown in Table 7-7, postulating a successful attack with a probability of 1 per 10,000 reactor-years, is $498 million. That value would amply justify the estimated $31 to 65 million net present cost of re-equipping each pool with low-density, open-frame racks.

SAMAs relevant to malice-induced accidents leading to core damage

Entergy has not identified any SAMA whose specific purpose would include reducing the PVCR of malice-induced accidents that lead to reactor core damage. A broad set of SAMAs should be developed for this purpose, and their respective contributions to risk reduction should be assessed by adapting PRA techniques. Some SAMAs in the set would be identical to, or closely related to, SAMAs that could reduce the PVCR of conventional accidents that lead to core damage. Other SAMAs would be useful primarily, or entirely, for decreasing the risk of attack. Identifying and assessing appropriate SAMAs is a task that should be viewed in the context of homeland-security planning. That task should be implemented as described in Section 10, below.

Section 7.5, above, provides a brief discussion of one respect in which a design deficiency at the IP2 and IP3 plants makes these plants vulnerable to attack. The particular design deficiency is the dependence of the emergency diesel generators on a supply of service water for cooling. At the Indian Point site, attackers could sever the site's electricity grid connection and disable the service water system without needing to penetrate the site boundary. Indirectly, this attack would disable the emergency diesel generators. Thus, the site would lose its primary supplies of electricity and cooling water. Additional actions, which in some attack scenarios would not require penetration of the site boundary, could then initiate a core-damage sequence and a breach of the containment, leading to a large atmospheric release. Entergy has identified two SAMAs that could potentially prevent this attack from succeeding, although Entergy does not discuss the use of these SAMAs for that purpose. The SAMAs are designated as Phase II SAMA Candidates Numbers 031 and 032 for the IP2 plant and Numbers 028 and 029 for the IP3 plant. They would provide backup sources of cooling water for the emergency diesel generators at a cost of $1.7 million (IP2 SAMA #031 or IP3 SAMA #028) or $0.5 million (IP2 SAMA #032 or IP3 SAMA #029).[151] This example shows how a SAMA could reduce risks from both conventional accidents and malice-induced accidents.

[151] Entergy, 2007a, Appendix E, Tables E.2-2 and E.4-2.

SAMAs that would be useful primarily for decreasing the risk of attack can be illustrated by options intended to prevent the impact of an aircraft on vulnerable portions of the IP2 or IP3 plant. Such an impact could occur in the context of a conventional accident (loss of power, etc.) affecting an aircraft. The probability of such an impact can be quantitatively estimated from the historical record of aircraft crashes, and is comparatively low. Alternatively, the impact could be part of a deliberate attack. In planning such an attack, a well-informed group of attackers would probably choose to employ a general-aviation aircraft laden with explosive material, as discussed in Section 7.5, above. There are at least two options at the Indian Point site for preventing deliberate impact by an aircraft. First, an active defense could be mounted using systems such as Sentinel and Phalanx.[152] Implementation of that defense would require the presence of US military personnel at the site, and would raise complex questions of command authority. Second, vulnerable portions of the site could be surrounded by one or more steel cages (made of beams, cables and nets) designed to shred an approaching aircraft and cause its explosive payload, if any, to detonate at a safe distance. A campaigning organization, Committee to Bridge the Gap, has termed this concept "Beamhenge".[153]

Options for reducing regulatory impacts

Section 8, above, discusses two respects in which the NRC's licensing approach creates adverse regulatory impacts. First, the NRC's licensing approach contributes to a counterproductive approach by the Federal government to protection of the nation's critical infrastructure. Second, the NRC has adopted a policy of excessive secrecy that yields various adverse impacts.

Options for reducing these regulatory impacts would necessarily be consistent with a policy of protective deterrence. In the context of the IP2 and IP3 plants, these impacts could be reduced by developing SAMAs that emphasize resilient design, passive defense, and related protective measures as envisioned in the NIPP. The set of SAMAs developed for the IP2 and IP3 plants should cover a full spectrum of threats, addressing conventional and malice-induced accidents, core-damage sequences, pool fires, and reactor-pool interactions.

Special attention must be given to the processes through which SAMAs related to malice-induced accidents are developed and considered in license proceedings. Stakeholder involvement in these processes should be maximized, consistent with protection of sensitive information. That subject is addressed further in Section 10, below.

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[152] Sentinel is a portable radar system that can detect and track approaching aircraft. Phalanx is an automated machine gun that is mounted on naval vessels for use against approaching aircraft, missiles, or small boats. See: Thompson, 2004.

[153] <http://www.committeetobridgethegap.org/beamhenge.html>, accessed on 18 November 2007.

10. Analyses Required From Entergy and the NRC

The NRC has determined that the risk of reactor core damage due to a conventional accident must be considered in environmental-impact analyses related to an application to extend the operating license of a nuclear power plant. Thus, the NRC has determined that core damage due to a conventional accident is a reasonably foreseeable event, and that the risk of this event is neither remote nor speculative. By contrast, the NRC does not require consideration of the risk of core damage due to a malice-induced accident, or the risk of a pool fire caused by a conventional accident or a malice-induced accident. Entergy takes the same position.

This report shows that the position taken by Entergy and the NRC lacks a logical foundation. Illustrative risk analyses by IRSS, whose findings are summarized in Table 7-7, demonstrate the illogic of Entergy and NRC's position in two respects. First, the risk of a pool fire at the IP2 or IP3 plant due to a conventional accident is greater than the risk of reactor core damage due to a conventional accident, as estimated by Entergy. Thus, a pool fire due to a conventional accident is a reasonably foreseeable event, and should be considered. Second, given a prudent assumption about the probability of attack, the risk of core damage or a pool fire at the IP2 or IP3 plant due to a malice-induced accident is greater than the risk of core damage due to a conventional accident, as estimated by Entergy. Thus, a malice-induced accident affecting the IP2 or IP3 reactor or their spent fuel is a reasonably foreseeable event, and should be considered.

In addition, IRSS shows that Entergy has substantially under-estimated the risk of reactor core damage due to a conventional accident, by failing to properly consider the potential for containment bypass.

Thus, IRSS's illustrative analyses have revealed major deficiencies in risk analyses performed by Entergy and the NRC. IRSS's analyses do not purport, however, to provide a comprehensive assessment of: (i) risk-related impacts for operation of the IP2 and IP3 plants; or (ii) deficiencies in analyses by Entergy and the NRC. Such assessments would require financial support at a much higher level than was available for our work.

Specific tasks for Entergy and the NRC

Entergy and the NRC should revise and supplement their analyses of risk-related impacts. In performing that work, Entergy and the NRC should rectify the deficiencies identified by IRSS, and should seek out and rectify other deficiencies. One source of guidance regarding other deficiencies is a November 2007 report prepared for Riverkeeper by Edwin Lyman.[154] In revising and supplementing their analyses, Entergy and the NRC should undertake at least three tasks, described in the following paragraphs.

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[154] Lyman, 2007.

First, Entergy should revise the Environmental Report in its License Renewal Application. The revised Environmental Report should address the risks of core-damage events and pool fires at the IP2 and IP3 plants due to conventional accidents and malice-induced accidents, examining each of these categories of risk in similar detail. Reactor-pool interactions should be comprehensively examined. Options for reducing the full range of risks should be considered using at least the depth of analysis that is employed for SAMAs in the present Environmental Report.

Second, the NRC should prepare a supplement that updates and corrects its August 1979 GEIS on handling and storage of spent fuel (NUREG-0575). That supplement should address the risk of pool fires to at least the depth of analysis and experiment that was conducted to prepare the NRC's December 1990 study on the risks of reactor accidents (NUREG-1150). The supplement should consider initiation of pool fires by conventional accidents and malice-induced accidents. A full range of options for reducing risk should be assessed, with explicit reference to the NIPP and the principles of protective deterrence.

Third, the NRC should prepare a supplement that updates and corrects its May 1996 GEIS on license renewal (NUREG-1437). That supplement should address the risk of reactor core damage due to malice-induced accidents, to at least the depth of analysis and experiment that was conducted to prepare NUREG-1150. The supplement should also incorporate the findings of the above-specified supplement to NUREG-0575. While incorporating those findings, the supplement to NUREG-1437 should ensure that pool-reactor interactions during conventional accidents or malice-induced accidents are thoroughly considered. A full range of options for reducing risk should be assessed, with explicit reference to the NIPP and the principles of protective deterrence.

Processes for considering risks and risk-reducing options related to malice-induced accidents

The NRC should give special attention to designing processes for considering risks and risk-reducing options related to malice-induced accidents, both generically and in the context of site-specific license proceedings. Involvement of a full range of stakeholders in these processes should be maximized, consistent with protection of sensitive information.

An important step by the NRC would be to engage public stakeholders (citizen groups, academics, state and local governments, etc.) and licensees in a dialogue that seeks consensus on an effective, balanced policy for management of sensitive information. Implementation of that policy would not necessarily require changes in NRC rules.

The generic supplements to NUREG-0575 and NUREG-1437 that are specified above should place sensitive information in classified appendices. Arrangements should be made that allow all stakeholders to contribute sensitive information to the supplements, with assurance that the information would remain protected. In site-specific licensing contexts, sensitive information should be discussed in protected settings. A balanced, consensus-based policy for management of sensitive information would facilitate productive involvement by stakeholders in generic and site-specific regulatory arenas.

11. Conclusions

11.1 Deficiencies in Risk Analyses by the NRC and Entergy, and IRSS's Examination of Selected Risk Issues

The NRC has discussed some of the risk-related impacts of continued operation of a nuclear power plant, in the GEIS for license renewal (NUREG-1437). Entergy has discussed some of the risk-related impacts of continued operation of the IP2 and IP3 plants, in the Environmental Report that is provided as Appendix E of Entergy's License Renewal Application. Neither the NRC nor Entergy has provided a complete and accurate assessment of the risk-related impacts of continued operation of the IP2 and IP3 plants. This report identifies substantial deficiencies in NRC's and Entergy's risk analyses, by examining selected risk issues. Some of the findings of our examination are expressed in terms of the methodology that Entergy uses to discuss SAMAs. IRSS's use of that methodology is not a general endorsement of Entergy's SAMA analyses, their methodology or their assumptions. Major findings of IRSS's examination of risk issues (see, especially, Table 7-7) include:

(i) Studies conducted by the NRC show that Entergy has under-estimated the extent to which the reactor containment would be bypassed during core-damage sequences arising from conventional accidents at the IP2 or IP3 reactors. IRSS's correction of that deficiency within the SAMA framework increases the present value of cost risks by a factor of 5.42 for the IP2 reactor and 3.18 for the IP3 reactor. Incorporation of this correction into Entergy's SAMA analyses would require consideration of a range of SAMAs, including SAMAs that Entergy has previously determined to be not cost effective.

(ii) Studies conducted by the NRC, the National Academy of Sciences and other entities show that loss of water from an IP2 or IP3 spent-fuel pool would, over a wide range of scenarios, lead to spontaneous ignition of the hottest spent fuel and a fire that would spread across the pool. That fire would release to the atmosphere a substantial fraction of the pool's inventory of cesium-137, together with other radioactive isotopes. Entergy has not addressed this threat in the License Renewal Application. The NRC has, in various documents, discussed the potential for a conventional accident to initiate a spent-fuel-pool fire, but none of those documents is an environmental impact statement that meets the standards of the National Environmental Policy Act.

(iii) PRA techniques could be used to assess the risk of a pool fire at the IP2 or IP3 plant, initiated by a conventional accident. In the absence of a thorough assessment of this type, IRSS has conducted illustrative analysis within the

SAMA framework. This analysis shows, given the pool-fire probability estimated in the NRC document NUREG-1353, that the present value of cost risk for a pool fire would be $27.7 million, compared to the $10.7 million estimated by Entergy for a core-damage event at the IP2 or IP3 reactor. Consideration of other factors would, with reasonable assumptions, substantially increase the present value of cost risk for a pool fire. The expected offsite costs of a pool fire at Indian Point would be at least $461 billion, and would be substantially greater if indirect costs were considered. Entergy's SAMA analyses employ a discount rate of 7 percent per year. There is a strong ethical argument for using a substantially lower discount rate to assess the risk of radiological harm. With a discount rate of 3 percent per year, the PVCR of a pool fire would rise from $27.7 million to $38.7 million, and with a rate of zero it would rise to $51.5 million.

(iv) Options are available to reduce the risk of a pool fire at the IP2 and IP3 plants. SAMA analyses should be conducted to assess the benefits and costs of these options. Notably, each pool could be re-equipped with low-density, open-frame storage racks, as was intended when the Indian Point plants were constructed. That option would dramatically reduce the risk of a pool fire. The cost-benefit findings set forth in (iii), above, and (viii), below, justify the implementation of that option at the IP2 and IP3 plants.

(v) The IP2 and IP3 reactors and their spent fuel are vulnerable to attack by sub-national groups. A successful attack could be accomplished by a group with assets similar to those of the group that attacked New York and Washington on 11 September 2001. Such a group could obtain or construct the necessary instruments of attack and employ these instruments without assistance from a government and without access to classified information. The probability of an attack at Indian Point by a well-equipped group cannot be determined by statistical analysis. Given the present threat environment and potential trends in that environment, it would be imprudent to assume a probability lower than 1 per 10,000 reactor-years during the next several decades.

(vi) PRA methodology can be adapted to assess the risk of attack on a nuclear facility. This is done by postulating a set of attacks with given characteristics, and then using PRA techniques to assess the outcomes of the postulated attacks and the conditional probabilities of those outcomes. Given the current level of defense provided at US nuclear power plants, a sophisticated and determined attack by a sub-national group would have a high conditional probability of causing a large atmospheric release of radioactive material from the IP2 or IP3 reactor or spent-fuel pool. Attackers could choose to attack a reactor and the adjacent pool, using the radioactive release from the reactor to preclude the personnel access that would be needed to perform damage control at the pool.

(vii) Neither the NRC nor Entergy has published any credible assessment of the risk of attack on a facility at Indian Point. There is no evidence that either party has conducted a thorough, credible assessment in secret. Indeed, published statements by the NRC and Entergy indicate that neither party has an accurate understanding of the risk of attack on the IP2 or IP3 reactor or their spent fuel.

(viii) In the absence of an assessment by the NRC or Entergy of the risk of attack, IRSS has conducted illustrative analysis within the SAMA framework. Assuming a probability of a successful attack of 1 per 10,000 reactor-years, this analysis finds that the present value of cost risk for an attack on a reactor would be $73.2 million for IP2 and $62.4 million for IP3, compared to the $10.7 million estimated by Entergy for a core-damage event caused by a conventional accident at the IP2 or IP3 reactor. These numbers indicate that a variety of SAMAs could be implemented to reduce the risk of attack on the IP2 or IP3 reactor. IRSS's analysis also shows that the present value of cost risk for an attack on an IP2 or IP3 spent-fuel pool would be $498 million. As a result, there would be a high benefit-cost ratio for SAMAs that substantially reduce pool risk. Notably, IRSS estimates that re-equipment of the IP2 or IP3 pool with open-frame racks, which would dramatically reduce the risk of a pool fire, could be done for a cost of $41 to 86 million. The same cost would otherwise be incurred during decommissioning of the plant, when spent fuel would be offloaded from the pool to dry storage. Thus, the net present cost of this option would be $31 to 65 million given the discount rate of 7 per cent per year that is used by Entergy, and $18 to 39 million given a discount rate of 3 percent per year.

(ix) The environment is adversely affected by regulatory impacts arising from the NRC's general approach to the licensing of nuclear power plants. Granting of license extensions for the IP2 and IP3 plants would add to the burden of adverse regulatory impacts. Two types of impact are illustrative. First, the NRC's licensing approach does not support a policy of protective deterrence. Instead, it contributes to a counterproductive approach by the Federal government to protection of the nation's critical infrastructure. Second, the NRC has adopted a policy of excessive secrecy that yields various adverse impacts.

(x) Increasing the inherent robustness of nuclear facilities against attack would reduce adverse regulatory impacts in two respects. First, enhanced robustness of these facilities would contribute to the adoption of a more effective approach to protection of the nation's critical infrastructure, through a national strategy of protective deterrence. Second, enhanced robustness of nuclear facilities would reduce the perceived need for secrecy, thereby reducing the adverse impacts that flow from excessive secrecy.

(xi) The National Infrastructure Protection Plan articulates principles for increasing the inherent robustness of infrastructure facilities against attack. There are opportunities at Indian Point to implement those principles, especially in the context of storing spent fuel. Enhanced robustness of facilities at Indian Point could significantly reduce the radiological and regulatory risk-related impacts of continued operation of the IP2 and IP3 plants. Neither Entergy nor the NRC has proffered any analysis or plan regarding implementation of the NIPP principles at Indian Point.

11.2 Analyses Required from Entergy and the NRC

The NRC has determined that the risk of reactor core damage due to a conventional accident must be considered in environmental-impact analyses related to extension of the operating license of a nuclear power plant. Thus, the NRC has determined that core damage due to a conventional accident is a reasonably foreseeable event, and that the risk of this event is neither remote nor speculative. IRSS shows that the risk of a pool fire at the IP2 or IP3 plant due to a conventional accident is greater than the risk of reactor core damage due to a conventional accident, as estimated by Entergy. Thus, a pool fire due to a conventional accident is a reasonably foreseeable event, and should be considered. Also, IRSS shows that the risk of core damage or a pool fire at the IP2 or IP3 plant due to a malice-induced accident is greater than the risk of core damage due to a conventional accident, as estimated by Entergy. Thus, a malice-induced accident affecting the IP2 or IP3 reactor or their spent fuel is a reasonably foreseeable event, and should be considered. In addition, IRSS shows that Entergy has under-estimated the risk of reactor core damage due to a conventional accident. Therefore, revision and supplementation of NRC's and Entergy's risk analyses is needed in at least the following respects:

(i) Entergy should revise the Environmental Report in its Indian Point License Renewal Application, as specified in Section 10, above.

(ii) The NRC should prepare a supplement that updates and corrects its August 1979 GEIS on handling and storage of spent fuel (NUREG-0575). The supplement should meet the specifications set forth in Section 10, above. It should explicitly address the principles of the NIPP.

(iii) The NRC should prepare a supplement that updates and corrects its May 1996 GEIS on license renewal (NUREG-1437). The supplement should meet the specifications set forth in Section 10, above. It should explicitly address the principles of the NIPP.

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Daniel Yergin, *The Prize: The Epic Quest for Oil, Money and Power* (New York: Simon and Schuster, 1991).

Table 2-1
Cesium-137 Inventories and Other Indicators for Reactors, Spent-Fuel Pools and the ISFSI at Indian Point

Indicator	Indian Point 2	Indian Point 3
Rated power of reactor	3,216 MWt	3,216 MWt
Number of fuel assemblies in reactor core	193 assemblies	193 assemblies
Mass of uranium in reactor core	87 Mg	87 Mg
Typical period of full-power exposure of a fuel assembly (assuming refueling outages of 2-month duration at 24-month intervals, discharging 72 assemblies, capacity factor of 0.9 between outages)	4.4 yrs (during 5.4 calendar years)	4.4 yrs (during 5.4 calendar years)
Typical burnup of fuel assembly at discharge	59,370 MWt-days/MgU	59,370 MWt-days/MgU
Typical Cs-137 inventory in fuel assembly at discharge (assuming steady-state fission at 0.9x22/24 power for 5.4 yrs with an energy yield of 200 MeV per fission and a Cs-137 fission fraction of 6.0 percent)	0.082 MCi	0.082 MCi
Approx. Cs-137 inventory in reactor core (assuming 193 fuel assemblies with av. burnup = 50% of discharge burnup)	7.9 MCi	7.9 MCi
Cs-137 inventory in reactor core according to License Renewal Application	11.2 MCi	11.2 MCi
Capacity of spent-fuel pool	1,376 assemblies	1,345 assemblies
Cs-137 inventory in spent-fuel pool (assuming space for full-core unloading, av. assembly age after discharge = 15 yrs	68.6 MCi	66.8 MCi
Cs-137 inventory in ISFSI module (assuming 32 fuel assemblies, av. age after discharge = 30 yrs)	1.3 MCi	

Sources:
(a) License Renewal Application, Appendix E.
(b) Consolidated Edison Company, request to NRC for license amendment to increase capacity of spent-fuel pool at Indian Point Unit 2, 20 June 1989.
(c) New York Power Authority, request to NRC for license amendment to increase capacity of spent-fuel pool at Indian Point Unit 3, 9 May 1988.

Table 2-2
Illustrative Inventories of Cesium-137

Case	Inventory of Cesium-137
Produced during detonation of a 10-kilotonne fission weapon	0.002 MCi
Released to atmosphere during Chernobyl reactor accident of 1986	2.4 MCi
Released to atmosphere during nuclear-weapon tests, primarily in the 1950s and 1960s (Fallout was non-uniformly distributed across the planet, mostly in the Northern hemisphere.)	20 MCi
In Indian Point 2 spent-fuel pool during period of license extension	68.6 MCi
In Indian Point 3 spent-fuel pool during period of license extension	66.8 MCi
In IP2 or IP3 reactor core	11.2 MCi

Notes:
(a) 1 Tbq = 1.0E+12 Bq = 27.0 Ci
(b) Inventories in the first three rows are from Table 3-2 of: Gordon Thompson, *Reasonably Foreseeable Security Events: Potential threats to options for long-term management of UK radioactive waste*, A report for the UK government's Committee on Radioactive Waste Management, IRSS, 2 November 2005.
(c) Inventories in the fourth and fifth rows are author's estimates set forth in this report.
(d) Inventory in the sixth row is from Appendix E of the License Renewal Application.

Table 4-1
Estimated Core Damage Frequencies for Conventional Accidents at the IP2 and IP3 Reactors

Source of Estimate	Factors Included in Estimate	Estimated Core Damage Frequency (per reactor-year)	
		Indian Point 2	**Indian Point 3**
License Renewal Application, Appendix E, Section 4.21	Internal initiating events	1.79E-05	1.15E-05
	Internal + external initiating events	6.80E-05 (multiplier of 3.80)	6.35E-05 (multiplier of 5.52)
	Internal + external initiating events, plus uncertainty	1.43E-04 (multiplier of 8)	9.20E-05 (multiplier of 8)

Notes:
(a) Initiating events involving acts of malice are not considered in these estimates.
(b) The multipliers shown in the second and third rows are applied to the frequency estimates in the first row.

Table 5-1
Predicted Core-Damage Sequences at the IP2 Reactor in the High/Dry Category

Source of Estimate	Types of Core-Damage Sequence in the High/Dry Category	Share of Estimated Total CDF (percent)
Indian Point 2 IPE, August 1992, Section 3.4.1.1 (See also Section 3.1.6.3.6.)	Sequences 1, 3, 4, 9, 13, 17, 19, 22 and 39 of the 42 most probable core-damage sequences Comments: The 42 most probable core-damage sequences account for 80% of the estimated total CDF. Thus, the aggregate frequency of the above-listed sequences is adjusted here by a factor 1/0.8. Most of the listed sequences involve failure of primary bleed, leading to RCS pressure in the range of the pressurizer relief valve setpoints (pressure > 2350 psia).	43 (% of internal CDF)
License Renewal Application, Appendix E, Attachment E.1, Table E.1-6	Plant damage states with high RCS pressure (pressure > 2350 psia) and no secondary-side cooling prior to onset of core damage	47 (% of internal CDF)
License Renewal Application, Appendix E, Attachment E.1, Table E.1-6	Plant damage states with high RCS pressure (pressure > 2350 psia) or medium RCS pressure (2350 psia > pressure > 675 psia) and no secondary-side cooling prior to onset of core damage	71 (% of internal CDF)
Indian Point 2 IPEEE, December 1995, Section 3.1.6.4 and Table 3.1-8 (corrected version of February 1998)	Seismic damage states 35, 36, 37 and 47 Comments: Some sequences could exhibit medium RCS pressure. In some sequences, the turbine-driven AFW pump might operate, which would reduce the High/Dry share of total seismic CDF.	59 (% of seismic CDF)
Indian Point 2 IPEEE, December 1995, Section 4.6.3	Relevant sequences are not fully identified Comments: Fire scenario A3-10 is the most probable fire-initiated sequence, accounting for 9% of fire CDF. This High/Dry sequence would involve loss of all AFW and primary bleed, leading to core damage at high RCS pressure. Other fire scenarios would contribute to a substantial High/Dry share of fire CDF.	Not available (% of fire CDF)

Table 5-2
Predicted Core-Damage Sequences at the IP3 Reactor in the High/Dry Category

Source of Estimate	Types of Core-Damage Sequence in the High/Dry Category	Share of Estimated Total CDF (percent)
Indian Point 3 IPE, June 1994, Tables 3.1.5.2 and 4.4.1.1	Plant damage states with RCS pressure status RX1 (pressure > 2350 psia) and auxiliary feedwater status F1 or F3	47 (% of internal CDF)
Indian Point 3 IPE, June 1994, Tables 3.1.5.2 and 4.4.1.1	Plant damage states with RCS pressure status RX1 (pressure > 2350 psia) or RX2 (2350 psia > pressure > 675 psia) and auxiliary feedwater status F1 or F3	53 (% of internal CDF)
License Renewal Application, Appendix E, Attachment E.3, Table E.3-6	Plant damage states with high RCS pressure (pressure > 2350 psia) and no secondary-side cooling prior to onset of core damage	27 (% of internal CDF)
License Renewal Application, Appendix E, Attachment E.3, Table E.3-6	Plant damage states with high RCS pressure (pressure > 2350 psia) or medium RCS pressure (2350 psia > pressure > 675 psia) and no secondary-side cooling prior to onset of core damage	56 (% of internal CDF)
Indian Point 3 IPEEE, September 1997, Section 3.1.5.5	Seismic accident sequences 1, 4, 6 and 8 Comments: Some sequences could exhibit medium RCS pressure. In some sequences, the turbine-driven AFW pump might operate, which would reduce the High/Dry share of total seismic CDF.	56 (% of seismic CDF)
Indian Point 3 IPEEE, September 1997, Section 4.7.5	Fires in 480 V switchgear room Comments: Some sequences could exhibit medium RCS pressure. In some sequences, the turbine-driven AFW pump could operate, which would reduce the High/Dry share of total fire CDF. Conversely, other fire-initiated sequences could increase the High/Dry share.	62 (% of fire CDF)

Table 5-3
Estimated Conditional Probabilities of Categories of Atmospheric Release from a Core-Damage Event at the IP2 Reactor

Source of Estimate	Category of Radioactive Release	Conditional Probability of Release Category, Given Core Damage (percent)
License Renewal Application, Appendix E, Attachment E.1, Table E.1-9	Early High	3.6
	Other	96.4
	Total	100
Above-stated estimate corrected by accounting for containment bypass during High/Dry sequences	Early High	51.8
	Other	48.2
	Total	100

Notes:
(a) The corrected estimate in this table assumes that 50 percent of core-damage sequences are High/Dry sequences that lead to containment bypass via induced failure of steam generator tubes, leading to an Early High release.
(b) The correction is applied by re-allocating 50 percent of core-damage sequences across release categories in proportion to the previously-estimated conditional probability of each category.
(c) This table considers only those core-damage sequences that arise from "internal" initiating events.

Table 5-4
Estimated Conditional Probabilities of Categories of Atmospheric Release from a Core-Damage Event at the IP3 Reactor

Source of Estimate	Category of Radioactive Release	Conditional Probability of Release Category, Given Core Damage (percent)
License Renewal Application, Appendix E, Attachment E.3, Table E.3-9	Early High	8.2
	Other	91.8
	Total	100
Above-stated estimate corrected by accounting for containment bypass during High/Dry sequences	Early High	54.1
	Other	45.9
	Total	100

Notes:
(a) The corrected estimate in this table assumes that 50 percent of core-damage sequences are High/Dry sequences that lead to containment bypass via induced failure of steam generator tubes, leading to an Early High release.
(b) The correction is applied by re-allocating 50 percent of core-damage sequences across release categories in proportion to the previously-estimated conditional probability of each category.
(c) This table considers only those core-damage sequences that arise from "internal" initiating events.

Table 5-5
Estimated Population Dose Risk (PDR) and Offsite Economic Cost Risk (OECR) Associated with Atmospheric Release from a Core-Damage Event at the IP2 Reactor

Source of Estimate	Category Of Radioactive Release	Conditional Probability of Release Category, Given Core Damage (percent)	Population Dose Risk (person-rem/yr)	Offsite Economic Cost Risk ($/yr)
License Renewal Application, Appendix E, Attach. E.1, Table E.1-14	Early High	3.6	1.03E+01	2.22E+04
	Other	96.4	1.17E+01	2.27E+04
	Total	100	2.20E+01	4.49E+04
Above-stated estimate corrected by accounting for containment bypass during High/Dry sequences	Early High	51.8	1.48E+02	3.19E+05
	Other	48.2	5.85E+00	1.14E+04
	Total	100	1.54E+02	3.30E+05

Notes:
(a) The corrected estimate in this table assumes that 50 percent of core-damage sequences are High/Dry sequences that lead to containment bypass via induced failure of steam generator tubes, leading to an Early High release.
(b) The correction is applied by re-allocating 50 percent of core-damage sequences across release categories in proportion to the previously-estimated conditional probability of each category.
(c) This table considers only those core-damage sequences that arise from "internal" initiating events.

Table 5-6
Estimated Population Dose Risk (PDR) and Offsite Economic Cost Risk (OECR) Associated with Atmospheric Release from a Core-Damage Event at the IP3 Reactor

Source of Estimate	Category Of Radioactive Release	Conditional Probability of Release Category, Given Core Damage (percent)	Population Dose Risk (person-rem/yr)	Offsite Economic Cost Risk ($/yr)
License Renewal Application, Appendix E, Attach. E.3, Table E.3-14	Early High	8.2	1.24E+01	2.81E+04
	Other	91.8	1.21E+01	2.47E+04
	Total	100	2.45E+01	5.28E+04
Above-stated estimate corrected by accounting for containment bypass during High/Dry sequences	Early High	54.1	8.18E+01	1.85E+05
	Other	45.9	6.05E+00	1.24E+04
	Total	100	8.79E+01	1.97E+05

Notes:
(a) The corrected estimate in this table assumes that 50 percent of core-damage sequences are High/Dry sequences that lead to containment bypass via induced failure of steam generator tubes, leading to an Early High release.
(b) The correction is applied by re-allocating 50 percent of core-damage sequences across release categories in proportion to the previously-estimated conditional probability of each category.
(c) This table considers only those core-damage sequences that arise from "internal" initiating events.

Table 5-7
Estimated Present Value of Cost Risks Associated with Atmospheric Release from a Core-Damage Event at the IP2 or IP3 Reactor

Source of Estimate	Type of Cost Risk	Present Value for Indian Point 2 ($)	Present Value for Indian Point 3 ($)
License Renewal Application, Appendix E, Table 4-3	Offsite population dose	473,568	527,382
	Offsite economic costs	483,254	568,281
	Onsite dose	6,814	4,377
	Onsite economic costs	374,303	240,475
	Total	1,337,939	1,340,515
Above-stated estimate corrected by accounting for containment bypass during High/Dry sequences	Offsite population dose	3,314,973	1,892,118
	Offsite economic costs	3,551,757	2,120,291
	Onsite dose	6,814	4,377
	Onsite economic costs	374,303	240,475
	Total	7,247,847	4,257,261

Notes:
(a) Corrected estimates for population dose risk and offsite economic cost risk are drawn from Tables 5-5 and 5-6 of this report.
(b) Dose is valued at $2,000 per person-rem.
(c) Present value is determined by accumulating annual value over 20 years with a discount rate of 7 percent per year.
(d) This table considers only those core-damage sequences that arise from "internal" initiating events.
(e) The License Renewal Application (Appendix E, Section 4.21) estimates that a core-damage event at the IP2 or IP3 reactor would yield onsite dose costs of $35.4 million (M$ 6.60 for immediate doses and M$ 28.8 for long-term doses) and onsite economic costs of $1.94 billion (G$ 1.08 for cleanup/decontamination and G$ 0.86 for replacement power).
(f) The correction applied in the lower half of this table increases the estimated present value of cost risks by a factor of 5.42 for the IP2 reactor and 3.18 for the IP3 reactor.

Table 6-1
Estimated Offsite Costs Resulting from Potential Atmospheric Releases: Early High Release from a Core-Damage Event at the IP2 or IP3 Reactor; Fire in the IP2 or IP3 Spent-Fuel Pool

Source of Estimate	Type of Release	Source Term	Offsite Costs (billion $)
License Renewal Application, Appendix E, Attachment E.1, Tables E.1-10, E.1-13 & E.1-14	Early High Release from IP2 reactor	• 2.6 MCi of Cs-137 (23% of core inventory) • Various amounts of other radioactive isotopes	• Population dose: 32 • Economic costs: 34 • Total costs: 66
License Renewal Application, Appendix E, Attachment E.3, Tables E.3-10, E.3-13 & E.3-14	Early High Release from IP3 reactor	• 1.7 MCi of Cs-137 (15% of core inventory) • Various amounts of other radioactive isotopes	• Population dose: 26 • Economic costs: 30 • Total costs: 56
Study by Beyea et al	Fire in a spent-fuel pool at the IP2 or IP3 plant	• 35 MCi of Cs-137	• Total costs: 461

Notes:
(a) The License Renewal Application assigns a cost of $2,000 per person-rem of population dose.
(b) The citation for the study by Beyea et al is: Jan Beyea, Ed Lyman, Frank von Hippel, "Damages from a Major Release of Cs-137 into the Atmosphere of the United States", *Science and Global Security*, Volume 12, 2004, pp 125-136.

Table 6-2
Estimated Offsite Cost Risks Associated with Atmospheric Releases: Early High Release from a Core-Damage Event at the IP2 or IP3 Reactor; Fire in the IP2 or IP3 Spent-Fuel Pool

Indicator	Affected Facility		
	Indian Point 2 Reactor	**Indian Point 3 Reactor**	**Spent-Fuel Pool at the IP2 or IP3 Plant**
Type of radioactive release	Early High release from core damage	Early High release from core damage	Fire in the pool, following water loss
Estimated frequency of release, for internal + external initiating events	2.47E-06 per RY (as in License Renewal Application)	5.21E-06 per RY (as in License Renewal Application)	2.00E-06 per RY (as estimated in NUREG-1353)
Estimated total offsite costs	$66 billion (as in License Renewal Application)	$56 billion (as in License Renewal Application)	$461 billion (from study by Beyea et al)
Estimated offsite cost risk	$163,000 per yr	$292,000 per yr	$922,000 per yr

Notes:
(a) The citation for NUREG-1353 is: E. D. Throm, *Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools", NUREG-1353*, NRC, April 1989.
(b) In the second row, the Early High release frequencies for the IP reactors are from Appendix E of the License Renewal Application as follows: Attachment E.1, Table E.1-14, adjusted by a multiplier of 3.80 (for IP2); and Attachment E.3, Table E.3-14, adjusted by a multiplier of 5.52 (for IP3). The License Renewal Application employs these multipliers to account for internal and external initiating events. (See Table 4-1.)
(c) The estimated total offsite costs in the third row are from Table 6-1.

Table 6-3
Estimated Present Value of Cost Risks Associated with Atmospheric Releases: Full Spectrum of Releases from a Core-Damage Event at the IP2 or IP3 Reactor; Fire in the IP2 or IP3 Spent-Fuel Pool

Indicator	Affected Facility		
	Indian Point 2 Reactor	**Indian Point 3 Reactor**	**Spent-Fuel Pool at the IP2 or IP3 Plant**
Type of radioactive release	Full spectrum of releases from core damage	Full spectrum of releases from core damage	Fire in the pool, following water loss
Present value of offsite cost risk, for internal + external initiating events	$3,635,924 (as in License Renewal Application)	$6,048,060 (as in License Renewal Application)	$9,923,394 (probability from NUREG-1353, offsite cost from study by Beyea et al)
Present value of onsite cost risk, for internal + external initiating events	$1,448,245 (as in License Renewal Application)	$1,351,583 (as in License Renewal Application)	Not estimated in this table
Total present value of cost risk, for internal + external initiating events	$5,084,168	$7,399,643	$9,923,394

Notes:
(a) The full spectrum of releases from each of the two reactors includes accident sequences in which the containment does not fail.
(b) For the two reactors, the estimated present values shown in Table 5-7 (not corrected for containment bypass during High/Dry sequences) are adjusted here by multipliers of 3.80 (for IP2) and 5.52 (for IP3) to account for both internal and external initiating events. Uncertainty multipliers are not used in this table.
(c) For the affected spent-fuel pool, the estimate shown in Table 6-2 for offsite cost risk ($922,000 per year) is converted to a present value by accumulating the annual value over 20 years with a discount rate of 7 percent per year.

Table 7-1
Public Opinion in Four Muslim Countries Regarding the US "War on Terrorism"

Country	Percentage of Respondents Who Think that the Primary Goal of What the US Calls "the War on Terrorism" is to:		
	Weaken and Divide the Islamic Religion and its People	Achieve Political and Military Domination to Control Middle East Resources	Protect Itself from Terrorist Attacks
Morocco	33	39	19
Egypt	31	55	9
Pakistan	42	26	12
Indonesia	29	24	23

Notes:
(a) Data are from: Steven Kull et al, *Muslim Public Opinion on US Policy, Attacks on Civilians and al Qaeda*, Program on International Policy Attitudes, University of Maryland, 24 April 2007.
(b) Percentages not shown in each row are "do not know" or "no response".

Table 7-2
Opinions of Selected Experts Regarding the Probability of Another 9/11-Type Attack in the United States

Time Horizon for Potential Attack	Fraction of Interviewed Experts Holding Position (percent)	
	Attack has No Chance or is Unlikely	Attack is Likely or Certain
Within 6 months	80	20
Within 5 years	30	70
Within 10 years	17	83

Notes:
(a) These and other survey data are discussed in: "The Terrorism Index", *Foreign Policy*, September/October 2007, pp 60-67. The underlying data are from: "Terrorism Survey III", June 2007, accessed from the website of the Center for American Progress <www.americanprogress.org> on 21 August 2007.
(b) The following question was posed to 108 US-based experts in international security: "What is the likelihood of a terrorist attack on the scale of the 9/11 attacks occurring again in the United States in the following time frames?"

Table 7-3
Future World Scenarios Identified by the Stockholm Environment Institute

Scenario	Characteristics
Conventional Worlds	
Market Forces	Competitive, open and integrated global markets drive world development. Social and environmental concerns are secondary.
Policy Reform	Comprehensive and coordinated government action is initiated for poverty reduction and environmental sustainability.
Barbarization	
Breakdown	Conflict and crises spiral out of control and institutions collapse.
Fortress World	This scenario features an authoritarian response to the threat of breakdown, as the world divides into a kind of global apartheid with the elite in interconnected, protected enclaves and an impoverished majority outside.
Great Transitions	
Eco-Communalism	This is a vision of bio-regionalism, localism, face-to-face democracy and economic autarky. While this scenario is popular among some environmental and anarchistic subcultures, it is difficult to visualize a plausible path, from the globalizing trends of today to eco-communalism, that does not pass through some form of barbarization.
New Sustainability Paradigm	This scenario changes the character of global civilization rather than retreating into localism. It validates global solidarity, cultural cross-fertilization and economic connectedness while seeking a liberatory, humanistic and ecological transition.

Source:
Paul Raskin et al, *Great Transition: The Promise and Lure of the Times Ahead*, Stockholm Environment Institute, 2002.

Table 7-4
Some Potential Modes and Instruments of Attack on a Nuclear Power Plant

Attack Mode/Instrument	Characteristics	Present Defense
Commando-style attack	• Could involve heavy weapons and sophisticated tactics • Successful attack would require substantial planning and resources	Alarms, fences and lightly-armed guards, with offsite backup
Land-vehicle bomb	• Readily obtainable • Highly destructive if detonated at target	Vehicle barriers at entry points to Protected Area
Anti-tank missile	• Readily obtainable • Highly destructive at point of impact	None if missile launched from offsite
Commercial aircraft	• More difficult to obtain than pre-9/11 • Can destroy larger, softer targets	None
Explosive-laden smaller aircraft	• Readily obtainable • Can destroy smaller, harder targets	None
10-kilotonne nuclear weapon	• Difficult to obtain • Assured destruction if detonated at target	None

Notes:
This table is adapted from a table, supported by analysis and citations, in: Gordon Thompson, *Robust Storage of Spent Nuclear Fuel: A Neglected Issue of Homeland Security*, IRSS, January 2003. Later sources confirming this table include:
(a) Gordon Thompson, testimony before the California Public Utilities Commission regarding Application No. 04-02-026, 13 December 2004.
(b) Jim Wells, US Government Accountability Office, testimony before the Subcommittee on National Security, Emerging Threats and International Relations, US House Committee on Government Reform, 4 April 2006.
(c) Marvin Fertel, Nuclear Energy Institute, testimony before the Subcommittee on National Security, Emerging Threats and International Relations, US House Committee on Government Reform, 4 April 2006.
(d) Danielle Brian, Project on Government Oversight, letter to NRC chair Nils J. Diaz, 22 February 2006.
(e) National Research Council, *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report*, National Academies Press, 2006.

Table 7-5
Potential Sabotage Events at a Spent-Fuel-Storage Pool, as Postulated in the NRC's August 1979 GEIS on Handling and Storage of Spent LWR Fuel

Event Designator	General Description of Event	Additional Details
Mode 1	• Between 1 and 1,000 fuel assemblies undergo extensive damage by high-explosive charges detonated under water • Adversaries commandeer the central control room and hold it for approx. 0.5 hr to prevent the ventilation fans from being turned off	• One adversary can carry 3 charges, each of which can damage 4 fuel assemblies • Damage to 1,000 assemblies (i.e., by 83 adversaries) is a "worst-case bounding estimate"
Mode 2	• Identical to Mode 1 except that, in addition, an adversary enters the ventilation building and removes or ruptures the HEPA filters	
Mode 3	• Identical to Mode 1 within the pool building except that, in addition, adversaries breach two opposite walls of the building by explosives or other means	• Adversaries enter the central control room or ventilation building and turn off or disable the ventilation fans
Mode 4	• Identical to Mode 1 except that, in addition, adversaries use an additional explosive charge or other means to breach the pool liner and 5-ft-thick concrete floor of the pool	

Notes:
(a) Information in this table is from Appendix J of: USNRC, *Generic EIS on Handling and Storage of Spent Light Water Power Reactor Fuel, NUREG-0575*, August 1979.
(b) The postulated fuel damage ruptures the cladding of each rod in an affected fuel assembly, releasing "contained gases" (gap activity) to the pool water, whereupon the released gases bubble to the water surface and enter the air volume above that surface.

Table 7-6
The Shaped Charge as a Potential Instrument of Attack

Category of Information	Selected Information in Category
General information	• Shaped charges have many civilian and military applications, and have been used for decades • Applications include human-carried demolition charges or warheads for anti-tank missiles • Construction and use does not require assistance from a government or access to classified information
Use in World War II	• The German MISTEL, designed to be carried in the nose of an un-manned bomber aircraft, is the largest known shaped charge • Japan used a smaller version of this device, the SAKURA bomb, for kamikaze attacks against US warships
A large, contemporary device	• Developed by a US government laboratory for mounting in the nose of a cruise missile • Described in an unclassified, published report (citation is voluntarily withheld here) • Purpose is to penetrate large thicknesses of rock or concrete as the first stage of a "tandem" warhead • Configuration is a cylinder with a diameter of 71 cm and a length of 72 cm • When tested in November 2002, created a hole of 25 cm diameter in tuff rock to a depth of 5.9 m • Device has a mass of 410 kg; would be within the payload capacity of many general-aviation aircraft
A potential delivery vehicle	• A Beechcraft King Air 90 general-aviation aircraft will carry a payload of up to 990 kg at a speed of up to 460 km/hr • A used King Air 90 can be purchased in the US for $0.4-1.0 million

Source:
Gordon Thompson, Institute for Resource and Security Studies, testimony before the Public Utilities Commission of the State of California regarding Application No. 04-02-026, 13 December 2004.

Table 7-7
Estimated Present Value of Cost Risks of a Potential Atmospheric Release from a Reactor or Spent-Fuel Pool at Indian Point, Including a Release Caused by an Attack

Type of Event	Estimated Present Value of Cost Risks for Affected Facility		
	Indian Point 2 Reactor	**Spent-Fuel Pool at the IP2 or IP3 Plant**	**Indian Point 3 Reactor**
Full spectrum of releases from reactor core damage, for internal + external initiating events (excluding attack) plus uncertainty	$10.7 million (as in License Renewal Application)	Not applicable	$10.7 million (as in License Renewal Application)
Above-stated estimate corrected by accounting for containment bypass during High/Dry sequences	$58.0 million	Not applicable	$34.1 million
Fire in pool, for internal + external initiating events (excluding attack) plus uncertainty	Not applicable	$27.7 million (assuming probability as in NUREG-1353)	Not applicable
Attack on reactor assuming probability of 1 per 10,000 reactor-years	$73.2 million	Not applicable	$62.4 million
Attack on pool assuming probability of 1 per 10,000 reactor-years	Not applicable	$498 million	Not applicable
Attack on IP2 reactor and pool assuming probability of 1 per 10,000 reactor-years	$569 million		Not applicable
Attack on IP3 reactor and pool assuming probability of 1 per 10,000 reactor-years	Not applicable	$559 million	

(Notes for this table are on the following page.)

Notes for Table 7-7:

(a) Estimated present values in the first two rows are from Table 5-7, adjusted by a multiplier of 8 to account for external initiating events and uncertainty.

(b) In the third row, the probability of a pool fire is assumed, following NUREG-1353, to be 2.0E-06 per reactor-year adjusted by an uncertainty multiplier (the ratio of 95th percentile to mean probability) of 2.78. That multiplier is taken from Table 4.6.8 of NUREG-1353, for a 99% cutoff value. The fire is assumed to yield an atmospheric release of 35 MCi of Cs-137, with accompanying offsite costs of $461 billion as estimated by Beyea et al. (See Tables 6-1 and 6-2.)

(c) An attack on a reactor is assumed here to yield an atmospheric release and accompanying offsite costs as estimated in the License Renewal Application for an Early High release. (See Table 6-1.)

(d) An attack on a spent-fuel pool is assumed here to initiate a fire that yields an atmospheric release of 35 MCi of Cs-137, with accompanying offsite costs of $461 billion as estimated by Beyea et al. (See Table 6-1.)

(e) A core-damage event and/or a spent-fuel-pool fire at each unit is assumed here to yield onsite costs of $2 billion, as estimated in the License Renewal Application for a core-damage event at IP2 or IP3. (See Table 5-7.)

(f) Present value is determined by accumulating annual value over 20 years with a discount rate of 7 percent per year.

Table 8-1
Selected Approaches to Protecting US Critical Infrastructure From Attack by Sub-National Groups, and Some of the Strengths and Weaknesses of these Approaches

Approach	Strengths	Weaknesses
Offensive military operations internationally	• Can deter or prevent governments from supporting sub-national groups hostile to the US	• Can promote growth of sub-national groups hostile to the US, and build sympathy for these groups in foreign populations • Can be costly in terms of lives, money and national reputation
International police cooperation within a legal framework	• Can identify and intercept potential attackers	• Implementation can be slow and/or incomplete • Requires ongoing international cooperation
Surveillance and control of the domestic population	• Can identify and intercept potential attackers	• Can destroy civil liberties, leading to political, social and economic decline of the nation
Active defense of infrastructure facilities (by use of guards, guns, gates, etc.)	• Can stop attackers before they reach the target	• Can involve higher operating costs • Requires ongoing vigilance • May require military involvement
Resilient design, passive defense, and related protective measures for infrastructure facilities (as envisioned in the NIPP)	• Can allow target to survive attack without damage, thereby enhancing protective deterrence • Can substitute for other protective approaches, avoiding their costs and adverse impacts • Can reduce risks from accidents, natural hazards, etc.	• Can involve higher capital costs

Table 9-1
Selected Options to Reduce the Risk of a Spent-Fuel-Pool Fire at the Indian Point Nuclear Power Plants

Option	Passive or Active?	Does Option Address Fire Scenarios Arising From:		Comments
		Malice?	Other Events?	
Re-equip pool with low-density, open-frame racks	Passive	Yes	Yes	• Will substantially reduce pool inventory of radioactive material • Will prevent auto-ignition of fuel in almost all cases
Install emergency water sprays above pool	Active	Yes	Yes	• Spray system must be highly robust • Spraying water on overheated fuel can feed Zr-steam reaction
Mix hotter (younger) and colder (older) fuel in pool	Passive	Yes	Yes	• Can delay or prevent auto-ignition in some cases • Will be ineffective if debris or residual water block air flow • Can promote fire propagation to older fuel
Minimize movement of spent-fuel cask over pool	Active	No (Most cases)	Yes	• Can conflict with adoption of low-density, open-frame racks
Deploy air-defense system (e.g., Sentinel and Phalanx) at plant	Active	Yes	No	• Implementation requires presence of US military at plant
Develop enhanced onsite capability for damage control	Active	Yes	Yes	• Requires new equipment, staff and training • Personnel must function in extreme environments

Table 9-2
Estimation of Cost to Offload Spent Fuel from Pools at the IP2 and IP3 Plants After 5 Years of Decay

Estimation Step	Indian Point 2	Indian Point 3
Present licensed capacity of pool	1,376 fuel assemblies	1,345 fuel assemblies
Pool capacity needed for full-core discharge	193 fuel assemblies	193 fuel assemblies
Anticipated av. pool inventory of spent fuel during period of license extension	1,376 – 193 – 32 = 1,151 fuel assemblies (assuming periodic offload of 64 assemblies to ISFSI)	1,345 – 193 – 32 = 1,120 fuel assemblies (assuming periodic offload of 64 assemblies to ISFSI)
Av. annual discharge of fuel from reactor	36 fuel assemblies	36 fuel assemblies
Pool capacity needed to store fuel for 5-yr decay, incl. 10% buffer	36x5x1.1 = 198 fuel assemblies	36x5x1.1 = 198 fuel assemblies
Total pool capacity needed for full-core discharge and 5-yr decay	193 + 198 = 391 fuel assemblies	193 + 198 = 391 fuel assemblies
Fuel requiring offload if pool storage is limited to fuel undergoing 5-yr decay	1,151 – 198 = 953 fuel assemblies	1,120 – 198 = 922 fuel assemblies
Capital cost to offload fuel, assuming 450 kgU per assembly and capital cost of $100 to 200 per kgU for dry storage	$43 to 86 million	$41 to 83 million

Notes:
(a) Data, except capital cost per kgU, are from Table 2-1.
(b) A capital cost of $100 to 200 per kgU for dry storage of spent fuel is used by Robert Alvarez et al in their paper in *Science and Global Security*, Volume 11, 2003, pp 1-51.

Exhibit 15

CHERNOBYL ON THE HUDSON?

THE HEALTH AND ECONOMIC IMPACTS OF A TERRORIST ATTACK AT THE INDIAN POINT NUCLEAR PLANT

Edwin S. Lyman, PhD
Union of Concerned Scientists
September 2004

Commissioned by Riverkeeper, Inc.

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EXECUTIVE SUMMARY

Since 9/11, the specter of a terrorist attack at the Indian Point nuclear power plant, thirty-five miles upwind from midtown Manhattan, has caused great concern for residents of the New York metropolitan area. Although the Nuclear Regulatory Commission (NRC) ordered modest security upgrades at Indian Point and other nuclear power plants in response to the 9/11 attacks, the plants remain vulnerable, both to air attacks and to ground assaults by large terrorist teams with paramilitary training and advanced weaponry. Many question whether the NRC's security and emergency planning requirements at Indian Point are adequate, given its attractiveness as a terrorist target and the grave consequences for the region of a successful attack.

This report presents the results of an independent analysis of the health and economic impacts of a terrorist attack at Indian Point that results in a core meltdown and a large radiological release to the environment. We find that, depending on the weather conditions, an attack could result in as many as 44,000 near-term deaths from acute radiation syndrome or as many as 518,000 long-term deaths from cancer among individuals within fifty miles of the plant. These findings confirm that Indian Point poses a severe threat to the entire New York metropolitan area. The scope of emergency planning measures should be promptly expanded to provide some protection from the fallout from an attack at Indian Point to those New York area residents who currently have none. Security at Indian Point should also be upgraded to a level commensurate with the threat it poses to the region.

A 1982 study by Sandia National Laboratories found that a core meltdown and radiological release at one of the two operating Indian Point reactors could cause 50,000 near-term deaths from acute radiation syndrome and 14,000 long-term deaths from cancer. When these results were originally disclosed to the press, an NRC official tried to reassure the public by saying that the kind of accident the study considered would be less likely than "a jumbo jet crashing into a football stadium during the Superbowl."

In the post-9/11 era, the possibility of a jumbo jet crashing into the Superbowl --- or even a nuclear power plant --- no longer seems as remote as it did in 1982. Nonetheless, NRC continues to argue that the 1982 Sandia report is unrealistic because it focused on "worst-case" accidents involving the simultaneous failure of multiple safety systems, which are highly unlikely to occur by chance. But when the potential for terrorist attacks is considered, this argument no longer applies. "Worst-case" scenarios are precisely the ones that terrorists have in mind when planning attacks.

Both NRC and Entergy, the owner of Indian Point, assert that even for the most severe terrorist attack, current emergency plans will be adequate to protect residents who live in the evacuation zone within 10 miles of the plant. They also say that there will be no significant radiological impact on New York City or any other location outside of the 10-mile zone. Accordingly, NRC has opposed proposals made after 9/11 to extend the emergency planning zone around Indian Point. However, NRC and Entergy have not provided the public with any documentation of the assumptions and calculations underlying these claims.

In view of the lack of public information available on these controversial issues, we carried out an independent technical analysis to help inform the debate. Our calculations were performed with the same state-of-the-art computer code that NRC uses to assess accident consequences. We used the NRC's guidance on the radiological release from a core meltdown, current estimates of radiation risk, population data from the 2000 census, and the most recent evacuation time estimate for the 10-mile Indian Point emergency planning zone. Following the format of the 1982 Sandia report, we calculated the numbers of near-term deaths from acute radiation syndrome, the numbers of long-term deaths from cancer, and the maximum distance at which near-term deaths can occur. We evaluated the impact of both evacuation and sheltering on these outcomes. We also estimated the economic damages due to the long-term relocation of individuals from contaminated areas, and the cost of cleanup or condemnation of those areas.

The health and environmental impacts of a large radiological release at Indian Point depend strongly on the weather conditions. We have carried out calculations for over 140,000 combinations of weather conditions for the New York area and wind directions for the Indian Point site, based on a year's worth of weather data. For this data set, we have determined the average consequences, the peak consequences, and the consequences for "95th percentile" weather conditions (in other words, only 5% of the weather sequences analyzed resulted in greater consequences).

We believe that the 95th percentile results, rather than the average values, represent a reasonable assessment of the likely outcome of a successful terrorist attack, since such attacks would most likely not occur at random, but would be timed to coincide with weather conditions that favor greater casualties. Attacks capable of causing the peak consequences that we calculate would be difficult to achieve because of inaccuracies in weather forecasts, restricted windows of opportunity and other factors, but remain within the realm of possibility.

For a successful attack at one of the two operating Indian Point reactors, we find that

- The number of near-term deaths within 50 miles, due to lethal radiation exposures received within 7 days after the attack, is approximately 3,500 for 95th percentile weather conditions, and approximately 44,000 for the worst case evaluated. Although we assumed that the 10-mile emergency planning zone was entirely evacuated in these cases, this effort was inadequate because (according to Entergy's own estimate) it would take nearly 9.5 hours to fully evacuate the 10-mile zone, whereas in our model the first radiological release occurs about two hours after the attack.

- Near-term deaths can occur among individuals living as far as 18 miles from Indian Point for the 95th percentile case, and as far as 60 miles away in the worst case evaluated. Timely sheltering could be effective in reducing the number of near-term deaths among people residing outside of the 10-mile emergency planning zone, but currently no formal emergency plan is required for these individuals.

- The number of long-term cancer deaths within 50 miles, due to non-acutely lethal radiation exposures within 7 days after the attack, is almost 100,000 for 95th percentile weather conditions and more than 500,000 for the worst weather case evaluated. The peak value corresponds to an attack timed to coincide with weather conditions that maximize radioactive fallout over New York City.

- Based on the 95th percentile case, Food and Drug Administration guidance would recommend that many New York City residents under 40, and children in particular, take potassium iodide (KI) to block absorption for radioactive iodine in the thyroid. However, there is no requirement that KI be stockpiled for use in New York City.

- The economic damages within 100 miles would exceed $1.1 trillion for the 95th percentile case, and could be as great as $2.1 trillion for the worst case evaluated, based on Environmental Protection Agency guidance for population relocation and cleanup. Millions of people would require permanent relocation.

We hope that this information will be useful to Federal, State and local homeland security officials as they continue to develop plans to protect all those at risk from terrorist attacks in the post-9/11 world.

INTRODUCTION

(a) The terrorist threat to nuclear power plants

Public concern about the vulnerability of nuclear power plants to catastrophic acts of sabotage soared in the aftermath of the September 11 terrorist attacks. There is ample justification for this concern.

Soon after the 9/11 attacks, the Nuclear Regulatory Commission conceded that U.S. nuclear power plants were not designed to withstand the high-speed impact of a fully fueled, modern passenger jet. The report of the 9/11 Commission has revealed that al Qaeda considered attacks on nuclear plants as part of their original plan, but declined to do so primarily because of their mistaken belief that the airspace around nuclear power plants in the U.S. was "restricted," and that planes that violated this airspace would likely be shot down before impact.[1]

But al Qaeda is surely now aware that no such restrictions were in place on 9/11. And it is clear from press reports that even today, no-fly zones around nuclear plants are imposed only at times of elevated threat level, and are limited in scope to minimize their economic impact on the aviation industry. This policy reflects a confidence in the ability of the intelligence community to provide timely advance warning of a surprise attack that --- given the 9/11 example --- is not entirely warranted. Moreover, even when no-fly zones are in place around nuclear plants, they are not likely to be effectively enforced. For instance, the U.S. government does not require that surface-to-air anti-aircraft protection be provided at nuclear plants, although such defenses have been routinely employed in Washington, D.C. since the 9/11 attacks.

In addition to the aircraft threat, many have begun to question the adequacy of physical security at nuclear plants to protect against ground-based, paramilitary assaults, in view of revelations that thousands of individuals received sophisticated training in military tactics at al Qaeda camps in Afghanistan. Press reports have documented many security failures at nuclear plants around the country, and have called attention to the troubling statistic that during a series of security performance tests in the 1990s, guard forces at nearly 50% of US plants failed to prevent mock terrorist teams from simulating damage that would have caused meltdowns had they been real attacks. This information, which was widely available but largely ignored before 9/11, suddenly became far more alarming in the new threat environment.

Today, the danger of a terrorist attack at a nuclear power plant in the United States --- either from the air or from the ground --- is apparently as great as ever. According to a January 14, 2004 speech by Robert L. Hutchings, Chairman of the National Intelligence Council (NIC),[2]

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[1] *The 9/11 Commission Report, Authorized Edition*, W.W. Norton, New York, 2004, p. 245.
[2] Robert L. Hutchings, "Terrorism and Economic Security," speech to the International Security Management Organization, Scottsdale, AZ, January 14, 2004.

"targets such as nuclear power plants ... are high on al Qa'ida's targeting list as a way to sow panic and hurt our economy ... The group has continued to hone its use of transportation assets as weapons ... although we have disrupted several airline plots, we have not eliminated the threat to airplanes. There are still al Qa'ida operatives who we believe have been deployed to hijack planes and fly them into key targets ... Al Qa'ida's intent is clear. Its capabilities are circumscribed but still substantial. And our vulnerabilities are still great."

More recently, the 9/11 Commission concluded that "major vulnerabilities still exist in cargo and general aviation security. These, together with inadequate screening and access controls, continue to present aviation security challenges."[3]

(b) The Nuclear Regulatory Commission: an agency in denial

Since 9/11, members of the public, non-profit groups and lawmakers across the United States have been calling for major security upgrades at nuclear power plants, including consideration of measures such as military protection against ground assault and anti-aircraft defenses against jet attack. Yet the response of the Nuclear Regulatory Commission (NRC), the agency that regulates both the safety and security of US nuclear reactors, has not been commensurate with the magnitude of the threat.[4] And the Department of Homeland Security, the agency charged with coordinating the defense of the entire US critical infrastructure against terrorist attacks, appears to be merely following NRC's lead.[5]

Notwithstanding a steady stream of FBI warnings citing nuclear power plants as potential terrorist targets, NRC continues to maintain that there is no need to consider measures that could reduce the vulnerability of nuclear plants to air attack. NRC's position is that "the best approach to dealing with threats from aircraft is through strengthening airport and airline security measures."[6]

As it became clear that NRC was not going to require the nuclear industry to protect nuclear plants from attacks on the scale of September 11, some groups began calling for plants to be shut permanently. Because many of the most dangerous fission products in a nuclear reactor core decay rapidly after shutdown, the health consequences of a terrorist attack on a shutdown nuclear reactor would be significantly lower than those of an attack on an operating reactor.[7]

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[3] *9/11 Commission Report* (2004), op cit., p. 391.
[4] D. Hirsch, D. Lochbaum and E. Lyman, "NRC's Dirty Little Secret," *Bulletin of the Atomic Scientists*, May/June 2003.
[5] E. Lyman, "Nuclear Plant Protection and the Homeland Security Mandate," Proceedings of the 44th Annual Meeting of the Institute of Nuclear Materials Management, Phoenix, Arizona, July 2003.
[6] US Nuclear Regulatory Commission, "Frequently Asked Questions About NRC's Response to the 9/11/01 Events," revised March 15, 2004. On the NRC web site: http://www.nrc.gov/what-we-do/safeguards/911/faq.html#3.
[7] Calculations by the author, using the computer code MACCS2, indicate that for an attack occurring at twenty days after reactor shutdown and resulting in core melt and loss of containment, the number of early fatalities from acute radiation sickness would be reduced by 80% and the number of latent cancer fatalities

Public concern has been greatest for those plants seen as prime terrorist targets because of their symbolic importance or location near large population and commercial centers, such as the Indian Point nuclear power plant in Westchester County, New York, whose two operating reactors are situated only 24 miles from the New York City limits, 35 miles from midtown Manhattan and in close proximity to the reservoir system that supplies drinking water to nine million people. The post-9/11 movement to shut down Indian Point has attracted a level of support from the public and elected officials not seen since the early 1980s, including calls for shutdown by over 400 elected officials and over 50 municipalities.

In response to this challenge, NRC, Entergy (the owner of Indian Point), other nuclear utilities, and their trade group in Washington, the Nuclear Energy Institute (NEI), have undertaken a massive public relations campaign to assuage public fears about the risk of terrorism at Indian Point. First, they assert that a combination of robust nuclear plant design, physical security and redundant safety measures would be able to stop any terrorist attack from causing significant damage to the reactor core. Second, they argue that even if terrorists were to successfully attack Indian Point and cause a large radiological release, the public health consequences could be successfully mitigated by execution of the emergency plans already in place for residents within the 10-mile-radius "emergency planning zone" (EPZ). And third, they claim that outside of the 10-mile EPZ, exposures would be so low that no special precautions would be necessary to adequately protect the public from radiation, other than possible interdiction of contaminated produce and water.[8]

A typical example of the third argument can be found in a recent letter the NRC sent to Alex Matthiessen, Executive Director of Riverkeeper:[9]

> "Outside of 10 miles, direct exposure is expected to be sufficiently low that evacuation or sheltering would not be necessary. Exposure to a radioactive plume would not likely result in immediate or serious long-term health effects. Consideration of public sheltering and evacuation in emergency plans is very conservative and recommended at very low dose levels, well below the levels where health effects would be expected to occur."

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resulting from lower exposures would be reduced by 50%, compared to an attack when the reactor is operating at full power. This calculation does not consider an attack on the storage pools for the highly radioactive spent fuel, which could result in significant long-term radiological contamination over a wide area and enormous economic consequences. For an extensive discussion of this threat, as well as an analysis of approaches for mitigating it, see R. Alvarez et al., "Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States," *Science and Global Security* **11** (2003) 1-51.

[8] The NRC defines two "emergency planning zones," or EPZs. The 10-mile "plume exposure" EPZ is the region where evacuation or other actions could be ordered to protect the public from coming into contact with an atmospheric release of radioactivity. The 50-mile "ingestion" EPZ is the region where interdiction of agricultural products and water supplies could be ordered to prevent the consumption of contaminated produce. No evacuation planning is required for individuals residing within the ingestion EPZ but outside of the plume exposure EPZ.

[9] Letter from Cornelius F. Holden, Jr., Office of Nuclear Reactor Regulation, US NRC, to Alex Matthiessen, Riverkeeper, September 30, 2003.

The purpose of this report is to address these three claims, with an emphasis on the second and third, by conducting a quantitative assessment of the potential consequences of a terrorist-induced radiological release at Indian Point for individuals both within and without the 10-mile EPZ, including residents of New York City.

There is a considerable need today for an independent study of these questions. At a time when the importance of rigorous emergency planning for catastrophic terrorist attacks is obvious, it is essential that responsible officials be fully apprised of the facts, especially if they contradict long-held assumptions and biases. The lives of many people could be put at jeopardy if emergency plans are not designed with the most accurate information at hand.

This means, in particular, that the emergency planning process should be designed to account for the full spectrum of potential consequences, including so-called "fast-breaking" release scenarios in which radioactive releases to the environment would begin within about thirty minutes after an attack. This was one of the major conclusions of the report carried out for the government of New York State by James Lee Witt Associates.[10] Certain terrorist attack scenarios could be capable of causing such rapid releases.

But NRC and the Federal Emergency Management Agency (FEMA) continue to be reluctant to require testing of fast-breaking radiological releases in emergency planning exercises, asserting that such events are highly unlikely to occur.[11] However, this argument is no longer relevant in an age when terrorists have acquired unprecedented levels of technical expertise, and are actively targeting critical infrastructure facilities with the intent to maximize casualties and economic damages. If current emergency plans cannot successfully cope with all credible terrorist-induced events, they should be upgraded. If upgrading to a sufficiently protective level is so cumbersome as to be practically impossible, then other options, including plant shutdown, should not be ruled out.

Members of the public deserve to be fully informed of the potential consequences for their health and property of a successful terrorist attack at Indian Point, so that they can prepare for an attack in accordance with their own judgment and willingness to accept risk. This principle is consistent with the guidance of the Department of Homeland Security, whose Web site www.ready.gov advises that "all Americans should begin a process of learning about potential threats so we are better prepared to react during an attack." Sources of technical information other than NRC and the nuclear industry are

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[10] James Lee Witt Associates, *Review of Emergency Preparedness of Areas Adjacent to Indian Point and Millstone*, March 2003, Executive Summary, pg. x.

[11] Although it was anticipated that the widely publicized June 8, 2004 emergency planning exercise at Indian Point would involve a "fast-breaking" release, NRC in fact chose a scenario in which no release at all occurred. It was assumed that terrorists attacked the plant with a jet aircraft but missed the reactor and only managed to crash into the switchyard, causing a loss of off-site power but not enough damage to result in a radiological release. Thus the exercise provided no information as to the effectiveness of the Indian Point emergency plan in protecting residents of the EPZ from injury had the plane actually hit its target and initiated the damage scenario that is assessed in this report.

also essential to facilitate a factually accurate and honest discussion of the risks and benefits of continued operation of Indian Point in the post-9/11 era.

Some observers may criticize the public release of this report as irresponsible because they believe it (1) could assist terrorists in planning attacks, or (2) could interfere with the successful execution of emergency plans by unnecessarily frightening members of the public who the authorities claim are not at risk.

We are acutely aware of such concerns and, after careful consideration, have concluded that they do not have merit. We have reviewed this report carefully and omitted any information specific enough to be useful to terrorists seeking to attack Indian Point. Unfortunately, far more detailed information about nuclear plant design, operation and vulnerabilities than this report contains has already been --- and continues to be --- widely disseminated. For example, a paper written by staff of the Oak Ridge National Laboratory (ORNL) and the Defense Threat Reduction Agency (DTRA), published in 2004 in a technical journal and available on the Internet, contains a diagram of a generic nuclear power plant indicating where truck bombs of various sizes could be detonated in order to stage an attack with a 100% probability of core damage.

There can be little doubt that al Qaeda and other terrorist organizations are already well aware of the severity of the consequences that could result from an attack at Indian Point. It is NRC and FEMA that seem not to appreciate this risk, and it is to them above all that we direct this study. We also believe that there is a considerable cost, but no apparent benefit, to withholding information that could help people to protect themselves in the event of a terrorist attack at Indian Point. Better information will enable better coordination of all populations at risk and help to avoid situations where some individuals take inappropriate actions that endanger others.

This report would not have been necessary had we seen any indication that NRC and other government authorities fully appreciate the seriousness of the risk to the public from radiological sabotage, or if certain members of the Nuclear Regulatory Commission had not made statements regarding severe accident consequences and risks that contradicted the results of quantitative analyses developed and refined over several decades by NRC's own technical staff and contractors.

For instance, at a recent briefing on NRC's emergency preparedness program, NRC Commissioner Edward McGaffigan, comparing the radiological exposure from a reactor accident to air travel, radon and other sources of exposure to natural radioactivity, said that[12]

> "...the order of magnitude of the release is similar to all of these other things in people's lives and they should not panic over a few hundred millirem or even a couple of rem ... but it's this radiation phobia, absolutely inflamed by these anti-

[12] US NRC, *Briefing on Emergency Preparedness Program Status*, Public Meeting, September 24, 2003, transcript, p. 73.

> nuclear groups putting out their misinformation that actually hurts emergency planning …"

Commissioner McGaffigan's statement is misleading on at least three counts:

(1) Current emergency planning guidance is already based on the principle that exposures of "a couple of rem" would be acceptable following a large radiological release;

(2) The potential doses from a large radiological release can greatly exceed "a few hundred millirem or even a couple of rem" far downwind of the release site, and for many individuals could result in a significant increase in their lifetime risk of cancer (10% or greater) or even pose a risk of severe injury or death from acute radiation exposure;

(3) Even if the average dose resulting from a large release were on the order of "a couple of rem," the total collective detriment (latent cancer fatalities and economic damages) could be very high if a large number of people in a densely populated area were so affected.

We believe that misinformation originating within NRC itself is the biggest obstacle to development of the robust radiological emergency planning strategies needed to cope with today's heightened threat. Statements like those cited above raise the concern that those responsible for regulating the nuclear industry and protecting it from terrorist attack are either in a chronic state of denial or actually believe the propaganda generated by the nuclear industry for public consumption. If this is indeed the case, then one cannot have confidence that emergency planning officials are basing their decisions on accurate and unbiased information. Since the departure of NRC Commissioner Greta Dicus a few years ago, the current Commission does not have any members with backgrounds in radiation protection and health issues. One wonders whether the NRC Commissioners truly understand and appreciate the full extent of the dangers posed by the facilities that they regulate.

(c) The CRAC2 Report

Given the lack of credible information from public officials on the potential consequences of a terrorist attack at Indian Point, concerned neighbors of the plant turned to one of the few sources on this subject in the public domain --- the so-called "CRAC2 Report," carried out by Sandia National Laboratories (SNL) under contract for NRC in 1981. This study, formally entitled "Technical Guidance for Siting Criteria Development," used a computer code developed by SNL known as CRAC2 ("Calculation of Reactor Accident Consequences") to analyze the consequences of severe nuclear plant accidents and to study their dependence on population density, meteorological conditions and other characteristics. The version of the CRAC2 Report that had been submitted to NRC for eventual public release only contained average values of consequence results, but the "peak" values for worst-case weather conditions were obtained by Congressman Edward Markey in 1982 and provided to the Washington Post.[13]

At many reactor sites, the CRAC2 Report predicted that for unfavorable weather conditions, a severe nuclear reactor accident could cause tens of thousands of early fatalities as a result of severe radiation exposure, and comparable numbers of latent cancer fatalities from smaller exposures. For Indian Point 3 (which at the time operated at a significantly lower power than it now does), CRAC2 predicted peak values of 50,000 early fatalities and 14,000 latent cancer fatalities, with early fatalities occurring as far as 17.5 miles downwind of the site.

The CRAC2 Report only considered accidents affecting operating nuclear reactors, and did not evaluate the consequences of accidents also involving spent fuel storage pools. Spent fuel pool loss-of-coolant accidents could themselves result in large numbers of latent cancer fatalities, widespread radiological contamination and huge cleanup bills, even if only a fraction of the fuel in the pool were damaged.

The release of the CRAC2 figures caused a great deal of consternation, but NRC was able to defuse the controversy by claiming that the peak results corresponded to accidents with extremely low probabilities (said to be one in a billion), and hence were not a cause for concern. In fact, Robert Bernero, director of the NRC's risk analysis division at the time, said (in a moment of unfortunate prescience) that such severe accidents would be less likely than "a jumbo jet crashing into a football stadium during the Superbowl."[14]

When Riverkeeper and other groups dusted off and called attention to the CRAC2 Report following the September 11 attacks, the NRC appeared unable to appreciate the new relevance of the study in a world where the possibility of a jumbo jet crashing into the Superbowl was no longer so remote. For example, in rejecting a 2001 petition filed by Riverkeeper to shut down the Indian Point plant until Entergy implemented a number of prudent security-related measures, the NRC merely repeated its old probability-based arguments, saying that[15]

> "...the reactor siting studies in the CRAC2 Report ... used generic postulated releases of radioactivity from a spectrum of severe (core melt) accidents, independent of the probabilities of the event occurring or the impact of the mitigation mechanisms. The studies were never intended to be realistic assessments of accident consequences. The estimated deaths and injuries resulted from assuming the most adverse condition for each parameter in the analytical code. In the cited studies, the number of resulting deaths and injuries also reflected the assumption that no protective actions were taken for the first 24

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[13] Subcommittee on Oversight & Investigations, Committee on Interior and Insular Affairs, U.S. House of Representatives, "Calculation of Reactor Accident Consequences (CRAC2) For U.S. Nuclear Power Plants Conditional on an 'SST1' Release," November 1, 1982.
[14] Robert J. McCloskey, "The Odds of the Worst Case," *Washington Post*, November 17, 1982.
[15] US Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Notice of Director's Decision Under 10 CFR 2.206, November 18, 2002.

hours. The studies did not, and were never intended to, reflect reality or serve as a basis for emergency planning. The CRAC2 Report analyses used more simplistic models than current technologies."

Earlier in 2002, in a letter to the New York City Council, the NRC also said that[16]

> "The Sandia study does not factor in the numerous probabilistic risk studies that have been performed since 1982. More realistic, current inputs, assumptions, and modeling techniques would be expected to result in much smaller health consequences."

In a more recent "point paper" on homeland protection and preparedness, NRC continued to repeat these themes, although its conclusions were somewhat more equivocal: [17]

> "The Sandia Siting Study ["CRAC2"] ... was performed to develop technical guidance to support the formulation of new regulations for siting nuclear power reactors. A very large radiation release and delayed evacuation, among other factors, accounts for the more severe consequences ... As an overall conclusion, that report does not present an up-to-date picture of risk at nuclear plants and does not reflect current knowledge in probabilistic or phenomenological modeling.
>
> "Since September 11, 2001, the NRC has been performing assessments of the consequences of a terrorist attack on a nuclear power plant. These assessments are much more detailed than past analyses and reflect our improved understanding of severe accident phenomena. The more recent analyses have involved a more realistic assessment of the radiation release, emergency planning capabilities, radiation spreading, and health effects. More recent analysis indicates a general finding that public health effects from terrorist attacks at most sites are likely to be relatively small."

Although NRC continues to harshly criticize the CRAC2 Report and anyone who cites its results, it has not publicly identified the "more realistic, current inputs, assumptions and modeling techniques that would be expected to result in much smaller health consequences," much less demonstrated the validity of these results by providing the public with its calculations for independent review. In fact, NRC now considers that these analyses are too sensitive for public release, making it impossible for the public to verify its claims.

NRC's unwillingness to share this kind of information with the public is not unexpected. NRC (like its predecessor, the Atomic Energy Commission) has worked over its history to shield the public from estimates of the consequences of severe accidents without simultaneous consideration of the low probabilities of such accidents. By multiplying

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[16] Hubert Miller, Region I Administrator, US NRC, letter to Donna De Constanzo, Legislative Attorney, New York City Council, July 24, 2002.

[17] US Nuclear Regulatory Commission, "Point Paper on Current Homeland Protection and Preparedness Issues," November 2003, on the NRC Web site, www.nrc.gov.

high consequence values with very low probability numbers, the consequence figures appear less startling to the layman but are obscured in meaning. For instance, a release that could cause 100,000 cancer fatalities would only appear to cause 1 cancer fatality per year if the associated probability of the release were 1/100,000 per year.

This issue was central to the so-called Indian Point Special Proceeding, a 1983 review conducted by a panel of NRC administrative judges that examined whether Indian Point posed unusually high risks because of its location in the densely populated New York metropolitan area. Before this proceeding, the NRC ruled that all testimony on accident consequences must also contain a discussion of accident probabilities. However, in its decision, the three-judge Atomic Safety and Licensing Board panel concluded that "the Commission should not ignore the potential consequences of severe-consequence accidents by always multiplying those consequences by low probability values."[18] One of the judges dissented from this majority opinion, insisting that singling out Indian Point "to the exclusion of many other sites similarly situated in effect raises again the question of considering consequences without their associated probabilities. This we have been restricted from doing by the Commission."[19] Today, it appears that this minority opinion ultimately prevailed at NRC.

The results of the CRAC2 Report are indeed of questionable applicability today. But the reasons for this are not the ones that NRC has identified, but include, for example, the fact that the CRAC2 Report

- used census data from 1970, at a time before rampant suburban sprawl greatly increased the population densities in formerly rural areas close to some nuclear reactor sites;

- assumed that the entire 10-mile emergency planning zone would be completely evacuated within at most six hours after issuance of a warning (contrary to NRC's assertion that the CRAC2 peak results reflect the assumption that "no protective actions were taken for the first 24 hours"), whereas the current evacuation time estimate for the Indian Point EPZ, based on updated assessments of likely road congestion, is nearly ten hours;

- assumed aggressive medical treatment for all victims of acute radiation exposure in developing estimates of the number of early fatalities, and employed a now-obsolete correlation between radiation dose and cancer risk that underestimated the risk by a factor of 4 relative to current models;

- sampled only 100 weather sequences out of 8760 (an entire year's worth), a method which we find underestimates the peak value occurring over the course of a year by 30%.

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[18] US Nuclear Regulatory Commission, Atomic Safety and Licensing Board, Indian Point Special Proceeding, Recommendations to the Commission, October 24, 1983, p. 107.
[19] Ibid, "Dissenting Views of Judge Gleason," p. 433.

In 1990, the CRAC2 code was retired in favor of a new code known as MACCS ("MELCOR Accident Consequence Code System"), which was updated to MACCS2 in 1997. The MACCS2 code, also developed by Sandia National Laboratories, is the state-of-the-art consequence code employed by both NRC and DOE in conducting dose assessments of radiological releases to the atmosphere. It includes numerous improvements over the CRAC2 code.[20]

However, the fundamental physics models that form the basis for both the CRAC2 and MACCS2 codes have not changed in the past two decades. Nor has evidence arisen since the CRAC2 Report was issued that would suggest that the CRAC2 "source term" --- that is, the fraction of the radioactive contents of the reactor core assumed to be released to the environment during a severe accident --- significantly overestimated potential releases. On the contrary, the Chernobyl disaster in 1986 demonstrated that such large releases were possible.[21] The state-of-the art revised source term developed by NRC, as defined in the NRC report NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants," is little different from the source terms used in the CRAC2 Report.[22] Recent experimental work, including the Phébus tests in France, have provided further confirmation of the NUREG-1465 source term.[23] Other tests, such as the VERCORS experiments in France, have found that NUREG-1465 actually underestimates the releases of some significant radionuclides.

The NRC continues to stress the absence of consideration of accident probabilities in dismissing the results of the CRAC2 Report. However, this criticism is invalid in the post-9/11 era. Accident probabilities are not relevant for scenarios that are intentionally caused by sabotage. Severe releases resulting from the simultaneous failure of multiple safety systems, while very unlikely if left up to chance, are precisely the outcomes sought by terrorists seeking to maximize the impact of their attack. Thus the most unlikely accident sequences may well be the most likely sabotage sequences.

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[20] D.I. Chanin and M.L. Young, *Code Manual for MACCS2: Volume 1, User's Guide*, SAND97-0594, Sandia National Laboratories, March 1997.

[21] The nuclear industry often argues that a Chernobyl-type accident could not happen in the United States because the reactor was of a different and inferior type to US plants and lacked a robust containment structure. While it is true that the specific accident sequence that led to the destruction of the Chernobyl-4 reactor and the resulting radiological release was characteristic of graphite-moderated reactors like Chernobyl and would not likely occur at a US light-water reactor (LWR), it is simply false to claim that there are no possible accident sequences that could result in consequences similar to those of Chernobyl --- namely, core melt, loss or bypass of containment, and large radiological release to the environment. In fact, because such an event is not as likely to be as energetic as the Chernobyl explosion, and the plume is not likely to be as hot as the Chernobyl plume (which was fed by the burning of a large mass of graphite), the radiological release from a severe accident at a US LWR will not rise as high or disperse as far. Therefore, radiological exposure to the public near a US LWR could be far greater than was the case at Chernobyl, because the plume would be more concentrated closer to the plant.

[22] L. Soffer, et al., *Accident Source Terms for Light-Water Nuclear Power Plants, Final Report,* NUREG-1465, US NRC, February 1995.

[23] US NRC, Memorandum from Ashok Thadani to Samuel J. Collins, "Use of Results from Phébus-FP Tests to Validate Severe Accident Codes and the NRC's Revised Accident Source Term (NUREG-1465)," Research Information Letter RIL-0004, August 21, 2000.

Other aspects that add an element of randomness to accident scenarios, such as meteorological conditions, can also be controlled through the advance planning and timing of a terrorist attack. Therefore, even if NRC were correct in claiming that the CRAC2 Report assumes the "most adverse condition" for each accident-related parameter, such an approach would still be appropriate for analyzing the potential maximum consequences of a sophisticated terrorist attack.

<u>We have not been able to identify any issues that would suggest the consequence estimates provided in the CRAC2 Report were significantly overstated.</u> But in light of the problems with the CRAC2 Report discussed earlier, we have conducted our own analysis of the consequences of a sophisticated terrorist attack at the Indian Point plant, using the MACCS2 code and the most up-to-date information available. This included the NUREG-1465 revised source term, the most current dose conversion and cancer risk coefficients recommended by the International Commission on Radiological Protection (ICRP), and the most recent evacuation time estimate (ETE) for Indian Point developed by consultants for Entergy Nuclear, the plant operator. We used the SECPOP2000 code, developed for NRC by Sandia National Laboratories, to generate a high-resolution MACCS2 site data file that includes a regional population distribution based on 2000 Census data and an economic data distribution based on 1997 government statistics.

<u>For Indian Point, we find that the MACCS2 results for peak early fatalities are generally consistent with the CRAC2 Report, but that the CRAC2 Report significantly underestimates the peak number of latent cancer fatalities that could occur.</u>

Moreover, the consequence estimates in this report are based on a number of optimistic assumptions, or "conservatisms," that tend to underestimate the true consequences of a terrorist attack at Indian Point. For example:

1. We use an evacuation time estimate that assumes the attack takes place in the summer in good weather, and does not take into account the possibility that terrorists may time their attack when evacuation is more difficult or actively interfere with the evacuation.

2. We only consider the permanent resident population of the 10-mile plume exposure EPZ, and not the daily transient population, which would increase the total population of the EPZ by about 25%.

3. We use values for the rated power of the Indian Point reactors from 2002 that are about 5% lower than the current values.

4. The only health consequences we consider are early fatalities from acute radiation syndrome and latent fatalities from cancer. We do not assess the excess mortality associated with the occurrence of other well-documented health effects of radiation such as cardiovascular disease. We also do not consider non-fatal effects of radiation, such as the reduction in intelligence quotient (IQ) of children irradiated in utero or other birth defects.

5. The NUREG-1465 source term does not represent the maximum possible radiological release from a core melt. Also, the assumed delay time between the attack and the start of the radiological release is nearly two hours, which is not nearly as short as the minimum of 30 minutes that is contemplated in NRC's emergency planning regulations.

6. The calculations assume only that the reactors itself are attacked and that the large quantity of spent fuel in the wet storage pools remains undamaged.

In the following sections, we discuss some technical issues related to severe accident and sabotage phenomena. Then we describe the methodology, tools and input parameters used to carry out the calculation. Finally, we present our results and conclusions.

ACCIDENTS: DESIGN-BASIS, BEYOND-DESIGN-BASIS, AND DELIBERATE

The NRC has traditionally grouped nuclear reactor accidents into two main categories: "design-basis" accidents, and "beyond-design-basis" or "severe" accidents.

(a) Design-basis accidents

Design-basis accidents are accidents that nuclear plants must be able to withstand without experiencing unacceptable damage or resulting in radiological releases that exceed the regulatory limits known as "Part 100" releases (because of where they can be found in the NRC regulations).

One of the more challenging design-basis accidents for pressurized-water reactors (PWRs) like those at Indian Point is a loss-of-coolant accident (LOCA). In the "primary" system of a PWR, the reactor core, which is contained in a steel vessel, is directly cooled by the flow of high-pressure water forced through pipes. In a LOCA, a pipe break or other breach of the primary system results in a loss of the water essential for removing heat from the reactor fuel elements. Even if the nuclear reactor is immediately shut down or "scrammed," an enormous quantity of heat is still present in the fuel, and cooling water must be restored before a significant number of fuel elements reach temperatures above a critical limit. If heated beyond this limit, the fuel element cladding can become brittle and shatter upon contact with cooling water. Eventually, the core geometry can become "uncoolable" and the fuel pellets themselves will reach temperatures at which they start to melt.

In a design-basis LOCA, it is assumed that the emergency core cooling system (ECCS) works as designed to provide makeup coolant water to the nuclear fuel, terminating the event before it becomes impossible to control. Even in this case, however, a significant fraction of the radioactive inventory in the core could be released into the coolant and transported out of the primary system through the pipe break. The primary system therefore must be enclosed in a leak-tight containment building to ensure that Part 100 limits are not exceeded in the event of a design-basis LOCA. To demonstrate compliance with Part 100, dose calculations at the site boundary are carried out by specifying a so-called "source term" --- the radioactive contents of the gases within the containment following the LOCA --- and assuming that the containment building leaks at its maximum design leak rate, typically about 0.1% per day. Such an event was historically considered a "maximum credible accident."

(b) Beyond-design-basis accidents

In contrast to design-basis accidents, "beyond-design-basis" accidents (also known as "severe" accidents) are those in which multiple failures occur, backup safety systems do not work as designed, the core experiences a total "meltdown" and radiological releases far greater than the Part 100 limits become possible. For example, if the ECCS does not work properly after a LOCA, the core will continue to overheat, eventually forming a molten mass that will breach the bottom of the steel reactor vessel and drop onto the containment floor. It will then react violently with any water that is present and with concrete and other materials in the containment. At this point, there is little hope that the event can be terminated before much of the radioactive material within the fuel is released in the form of gases and aerosols into the containment building.

Even worse is the potential for mechanisms such as steam or hydrogen explosions to rupture the containment building, releasing its radioactive contents into the environment. Although not the only distinguishing feature, a major distinction between design-basis and severe accidents is whether containment integrity is maintained. Even a small rupture in the containment building --- no more than a foot in diameter --- would be sufficient to depressurize it and to vent the gases and aerosols it contains into the environment in less than half an hour.[24] This would result in a catastrophic release of radioactivity on the scale of Chernobyl, and Part 100 radiation exposure limits would be greatly exceeded.

The containment building can also be "bypassed" if there is a rupture in one of the interfaces between the primary coolant system and other systems that are outside of containment, such as the "secondary" coolant system (the fluid that drives the turbine generators) or the low-pressure safety injection system. For instance, the rupture in the steam generator that occurred at Indian Point 2 in February 2000 created a pathway in which radioactive steam from the primary system was able to pass into the secondary system, which is not enclosed in a leak-tight boundary. If that event had coincided with significant fuel damage, the radiological release to the environment could have been far greater.

NRC has always had an uncomfortable relationship with beyond-design-basis accidents. By their very definition, they are accidents that were not considered in the original design basis for the plant. In fact, according to NRC, "the technical basis for containment design was intended to ensure very low leakage under postulated loss-of-coolant accidents. No explicit consideration was given to performance under severe accidents."[25] Indeed, NRC has never instituted a formal regulatory requirement that severe accidents be prevented. In 1985, the Commission ruled by fiat in its Severe Accident Policy Statement that "existing plants pose no undue risk to health and safety" and that no regulatory changes were required to reduce severe accident risk. NRC's basic assumption is that if a plant meets design basis requirements, then it will have sufficient resistance against severe accidents, and it has devoted considerable resources to the task of "confirmatory research" to justify this assumption. NRC believes that this approach provides "adequate protection" of public health and safety because the probability of a

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[24] US Nuclear Regulatory Commission, *Preliminary Assessment of Core Melt Accidents at the Zion and Indian Point Nuclear Power Plants and Strategies for Mitigating Their Effects, Analysis of Containment Building Failure Modes, Preliminary Report*, NUREG-0850, Vol. 1, November 1981, p. 3-2.
[25] US Nuclear Regulatory Commission, *Reactor Risk Reference Document (Appendices J-O)*, NUREG-1150, Draft for Comment, February 1987, p. J.10-1.

severe accident capable of rupturing or bypassing the containment prior to effective evacuation of the EPZ is so low in most cases as to be below regulatory concern.[26]

(c) "Deliberate accidents"

It is true that a spontaneous occurrence of the multiple system failures necessary to cause a severe accident and large radiological release is typically a very improbable event. However, if one considers the possibility of sabotage or "deliberate" accidents, the low-probability argument that NRC uses to justify the continued operation of nuclear plants completely breaks down. Terrorists with basic and readily available knowledge of how nuclear plants operate can design their attack to maximize the chance of achieving a core melt and large radiological release. With modest inside assistance, as contemplated by NRC in its regulations and practices, saboteurs would be able to identify a plant-specific set of components known as a "target set." If all elements of a target set are disabled or destroyed, significant core damage would result. Thus, by deliberately disrupting all redundant safety systems, saboteurs can cause a severe event that would have had only a very low probability of occurrence if left to chance.

The likelihood of a successful attack is enhanced for plants with "common-cause" failure modes. A common-cause failure is a single event that can lead to the failure of multiple redundant systems. For example, if the diesel fuel supplied to a nuclear plant with two independent emergency diesel generators from the same distributor is impure, then both generators may fail to start for the same reason if off-site power is lost and emergency power is needed. This would result in a station blackout, one of the most serious challenges to pressurized-water reactors like Indian Point. While some common-cause failure modes can be corrected, others are intrinsic to the design of currently operating nuclear plants. Common-cause failure modes make the saboteurs' job easier, as fewer targets would have to be disabled to achieve the desired goal.

In addition to causing a core meltdown, terrorists also have the means to ensure that the radioactive materials released from the melting fuel can escape into the environment by breaching, severely weakening or bypassing the containment.[27] Finally, saboteurs can maximize the harm caused by a radiological release by staging their attack when the meteorological conditions favor a significant dispersal over densely populated areas, and even interfering with the execution of emergency plans.

NRC has formally maintained for at least two decades that it does not make sense to assign probabilities to terrorist attacks. In a 2002 memorandum, NRC stated that[28]

> "the horrors of September 11 notwithstanding, it remains true that the likelihood of a terrorist attack being directed at a particular nuclear facility is not

[26] There have been situations where NRC concluded that "adequate protection" was not met at certain nuclear plants and required additional safety measures. However, such instances are rare.
[27] We have decided not to describe such means in greater detail, although we have little doubt that terrorists are already familiar with them.
[28] US NRC, Memorandum and Order, CLI-02-025, December 18, 2002, p. 17.

quantifiable. Any attempt at quantification or even qualitative assessment would be highly speculative. In fact, the likelihood of attack cannot be ascertained with confidence by any state-of-the-art methodology ... we have no way to calculate the probability portion of the [risk] equation, except in such general terms as to be nearly meaningless."

Yet at other times, NRC does not hesitate to invoke probabilities when arguing that the public has nothing to fear from terrorist attacks on nuclear plants. For example, here is what NRC has to say about the CRAC2 study in its recent "point paper" on homeland protection and preparedness:[29]

> "Over the years, the NRC has performed a number of consequence evaluations to address regulatory issues ... We have considered the extent to which past analyses, often the subject of public statements by advocacy groups and the media, can be superceded [sic] by more recent analysis ... Past studies usually have considered ... a number of scenarios, which resulted in only minor consequences. The most limiting severe scenarios, which comprise a minority of the calculations and represent *very low probability events* [emphasis added], are the predictions typically cited in press accounts. These scenarios have assumed ... very large radiation releases, bounding emergency response assumptions or bounding conditions (including weather) for the spread of the radiation. The combination of these factors produces large and highly unlikely results."

These two excerpts are inconsistent. If it is meaningless to quantify the likelihood of a terrorist attack, then one cannot dismiss the possibility of terrorist attacks causing the most severe consequences by claiming they are "highly unlikely." Therefore, in order to base emergency planning on the best possible information, NRC must accept the fact that the growing threat of domestic terrorism has forever altered the delicate risk calculus that underlies its approach to safety regulation. NRC can no longer shy away from confronting the worst-case consequences of terrorist attacks on nuclear power plants. And perhaps the most attractive target in the country, where the consequences are likely to be the greatest, is Indian Point.

[29] US NRC, "Point Paper on Current Homeland Protection and Preparedness Issues" (2003), op cit.

THE HEALTH CONSEQUENCES OF A RADIOLOGICAL RELEASE FROM INDIAN POINT

The Indian Point power plant is located on 239 acres on the Hudson River in the village of Buchanan in Westchester County, New York. There are two operating pressurized-water reactors (PWRs) on site, Indian Point 2, rated at 971 MWe, and Indian Point 3, rated at 984 MWe. Both reactors are operated by Entergy Nuclear.

Indian Point is located in one of the most densely populated metropolitan areas in the United States, situated about 24 miles from the New York City limits and 35 miles from midtown Manhattan. Extrapolating from 2000 Census data, in 2003 over 305,000 persons resided within the roughly ten-mile radius plume exposure emergency planning zone for Indian Point, and over 17 million lived within 50 miles of the site.[30]

The types of injury that may occur following a catastrophic release of radioactive material resulting from a terrorist attack at Indian Point fall into two broad categories. The first category, "early" injuries and fatalities, are those that are caused by short-term whole-body exposures to doses of radiation high enough to cause cell death. Early injuries include the constellation of symptoms known as **acute radiation syndrome** that should be familiar to anyone who has read *Hiroshima* by John Hersey --- gastrointestinal disturbance, epilation (hair loss) and bone marrow damage. Other early injuries include severe skin damage, cataracts and sterility. For sufficiently high doses, early fatalities --- death within days or weeks --- can occur. These so-called "deterministic" effects are induced only when levels of radiation exposure exceed certain thresholds.

Another class of injury caused by ionizing radiation exposure is genetic damage that is insufficient to cause cell death. At doses below the thresholds for deterministic effects, radiation may cause damage to DNA that interferes with the normal process of cell reproduction. This damage can eventually lead to cancer, which may not appear for years or even decades, depending on the type. Because a single radiation-induced DNA lesion is believed to be capable of progressing to cancer, there is no threshold for these so-called "stochastic" effects.[31]

The clinical response of individuals to ionizing radiation exposure is highly variable from person to person. Some individuals have a lower capability of DNA repair and thus are more susceptible to the carcinogenic effects of radiation --- a condition that is most severe in people with certain genetic diseases like ataxia telangiectasia. Children are particularly vulnerable to radiation exposure. For the same degree of exposure to a

[30] A figure of 20 million people within 50 miles of Indian Point has often been quoted. This value may have been obtained by summing the populations of all counties that are either totally or partially within the 50-mile zone.

[31] A small but vocal group of pro-nuclear activists continue to maintain, in the face of overwhelming scientific evidence to the contrary, that a threshold dose exists below which ionizing radiation may have no effect or even may provide health benefits. However, there is a growing body of experimental data that indicates that low-dose radiation may actually be a more potent carcinogen than high-dose radiation because of low-dose "bystander effects."

radioactive plume, children will receive a greater absorbed dose than adults because of their lower body weight and higher respiration rate, even though their lung capacity is smaller. And because children and fetuses have much higher growth rates than adults, the same radiation dose has a greater chance of causing cancer in children and fetuses than in adults.

Exposure to low-dose ionizing radiation has also been associated with excess mortality from diseases other than cancer, such as cardiovascular disease, possibly as a result of radiation-induced inflammation. There is growing evidence that the effect of low-dose radiation exposure on mortality from diseases other than cancer may be as great as its effect on mortality from cancer, implying that current, cancer-based risk estimates may be too low by a factor of two.[32]

A radiological release from a nuclear plant accident would consist of many different types of radioactive materials. Some isotopes, such as cesium-137, emit penetrating gamma rays and can cause radiation injury from outside of the body. Other isotopes do not emit radiation that can penetrate skin but are most dangerous when inhaled or ingested, where they can concentrate in internal organs and deliver high doses to surrounding tissue. Iodine-131, which concentrates in the thyroid gland, and strontium-90, which concentrates in teeth and bones, are in this category. Some isotopes have short half-lives and do not persist in the environment, while others are long-lived and can result in long-term contamination.

NRC requires that evacuation planning in the event of a radiological emergency take place only within the so-called "plume exposure" emergency planning zone (EPZ), a roughly circular area with a radius of approximately ten miles. The choice of this distance was based in part on NRC analyses indicating that in the event of a severe accident, dose rates high enough to cause early fatalities from acute radiation syndrome would be confined to a region within about ten miles of the release point. However, dose rates outside of this region, although on average not high enough to cause early fatalities, could be high enough to result in a significant risk of cancer unless effective protective measures are taken. NRC's emergency planning regulations were never designed to limit such exposures in the event of the "worst core melt sequences," for which the protection goal is that "immediate life threatening doses would generally not occur outside the zone."[33]

Thus the current emergency planning basis is not now, and never was, intended to protect the public from significant but not immediately lethal exposures in the event of the "worst core melt sequences," such as those that could result from a well-planned terrorist attack. It should therefore be no surprise that NRC's emergency planning procedures

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[32] A. MacLachlan, "UNSCEAR Probes Low-Dose Radiation Link to Non-Cancer Death Rate," *Nucleonics Week*, June 17, 2004.
[33] US NRC, *Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Plants*, NUREG-0654, 1980, p. 12.

would not protect individuals either inside or outside the EPZ from such exposures in the event of an attack.

The proximity of Indian Point to New York City, its populous suburbs and its watershed, given the potential hazard it represents, has long been an issue of concern and controversy. Following the Three Mile Island accident in March 1979, the Union of Concerned Scientists (UCS) unsuccessfully petitioned the NRC to suspend operations at Indian Point, in part because of its location in a densely populated area. At the same time, the NRC formed two task forces to examine the risks posed by Indian Point and the Zion plant near Chicago "because of the high population densities surrounding those units" and initiated a formal adjudication, the Indian Point Special Proceeding, to review the issues raised in the UCS petition and others.[34]

During the Special Proceeding, three NRC administrative judges heard testimony regarding the potential impacts of a severe accident at Indian Point on New York City residents. For instance, the director of New York City's Bureau of Radiation Control testified that potassium iodide (KI), which can block the uptake of radioactive iodine by the thyroid if taken near the time of exposure, should be stockpiled for "possible immediate use in New York City," at a time when NRC did not recommend that KI be provided even for residents of the 10-mile EPZ.

The administrative judges reached some disturbing conclusions in the proceeding. They stated that "under certain meteorological conditions, delayed fatalities from cancer appear to be possible almost anywhere in the city" and that "a severe release at Indian Point could have more serious consequences than that same release at virtually any other site licensed by the Commission." And they urged the Commission "to give serious consideration to the potential costs to society of dangerous, low probability accidents. Such accidents could, as Staff testimony has shown, result in fatalities that number in the hundreds or thousands."

The Commission appears to have essentially forgotten these conclusions. Many of the technical issues resolved during the course of the Special Proceeding are being debated all over again today.

[34] US NRC, Indian Point Special Proceeding, 1983, p. 5.

THE MACCS2 CODE

MACCS2 is a computer code that was developed by Sandia National Laboratories under NRC sponsorship as a successor to CRAC2.[35] It is designed to estimate the health, environmental and economic consequences of radiation dispersal accidents, and is widely used by NRC and DOE for various safety applications. It utilizes a standard straight-line Gaussian plume model to estimate the atmospheric dispersion of a point release of radionuclides, consisting of up to four distinct plumes, and well-established models to predict the deposition of radioactive particles on the ground from both gravitational settling ("dry deposition") and precipitation ("wet deposition").[36] From the dispersion and deposition patterns, the code can then estimate the radiation doses to individuals as a result of external and inhalation exposures to the radioactive plume and to external radiation from radionuclides deposited on the ground ("groundshine"). The code also has the capability to model long-term exposures resulting from groundshine, food contamination, water contamination and inhalation of resuspended radioactive dust.

The code also can evaluate the impact of various protective actions on the health and environmental consequences of the release, including evacuation, sheltering and, in the long term, remediation or condemnation of contaminated areas. Most parameters, such as the average evacuation speed, decontamination costs, and the dose criteria for temporary relocation and long-term habitation, can be specified by the user.

MACCS2 requires a large number of user-specified input parameters. A given release is characterized by a "source term," which is defined by its radionuclide content, duration and heat content, among other factors. The shape of the Gaussian plume is determined by the wind speed, the release duration, the atmospheric stability (Pasquill) class and the height of the mixing layer at the time of the release.

MACCS2 requires the user to supply population and meteorological data, which can range from a uniform population density to a site-specific population distribution on a high-resolution polar grid. The meteorological data can range from constant weather conditions to a 120-hour weather sequence. The code can process up to 8760 weather sequences --- a year's worth --- and generate a frequency distribution of the results.

The code allows the user to define the dose-response models for early fatalities (EFs) and latent cancer fatalities (LCFs). We use the MACCS2 default models. For EFs, MACCS2 uses a 2-parameter hazard function, with a default LD_{50} dose (the dose associated with a 50% chance of death) of 380 rem. LCFs, MACCS2 uses the standard linear, no-threshold model, with a dose-response coefficient of 0.1 LCF/person-Sievert and a dose-dependent reduction factor of 2, per the 1991 recommendations of the International Committee on

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[35] Chanin and Young (1997), op cit.

[36] Much of the following section is based on a recent comprehensive review of MACCS2 by the Department of Energy, which we would recommend to readers interested in a more in-depth discussion of the capabilities and limitations of the code. See Office of Environment, Safety and Health, U.S. Department of Energy, *MACCS2 Computer Code Application Guidance for Documented Safety Analysis: Interim Report*, DOE-EH-4.2.1.4-Interim-MACCS2, September 2003.

Radiological Protection (ICRP) in ICRP 60.[37] The corresponding coefficients used in the CRAC2 model, based on now-antiquated estimates, were lower by a factor of 4.

For the calculation of the committed effective dose equivalent (CEDE) resulting from inhalation and ingestion of radionuclides, we have replaced the default MACCS2 input file with one based on the more recent dose conversion factors in ICRP 72.[38] We have shown previously that this substitution reduces the projected number of latent cancer fatalities from a severe nuclear reactor accident by about one-third.[39] (The default MACCS2 file incorporates EPA guidance based on ICRP 30, which although out of date continues to be the basis for regulatory analyses in the United States.)

When using MACCS2 several years ago, we discovered an error that resulted in an overcounting of latent cancer fatalities in the case of very large releases. After pointing this out to the code manager, SNL sent us a revised version of the code with the error corrected, which we have used for the analysis in this report.

Like most radiological consequence codes in common use, MACCS2 has a number of limitations. First of all, because it incorporates a Gaussian plume model, the speed and direction of the plume are determined by the initial wind speed and direction at the time of release, and cannot change in response to changing atmospheric conditions (either in time or in space). Consequently, the code becomes less reliable when predicting dispersion patterns over long distances and long time periods, given the increasing likelihood of wind shifts. Also, the Gaussian plume model does not take into account terrain effects, which can have a highly complex impact on wind field patterns and plume dispersion. And finally, MACCS2 cannot be used for estimating dispersion less than 100 meters from the source.

However, MACCS2 is adequate for the purpose of this report, which is to develop order-of-magnitude estimates of the radiological consequences of a catastrophic attack at Indian Point for residents of New York City and the entire New York metropolitan area, and to assess the impact of different protective actions on these consequences. We restrict our evaluations to a circular area with a radius of 50 miles centered on Indian Point, except for the calculation of long-term doses and economic impacts, which we assess out to 100 miles.

In the next section, we discuss the basis for the MACCS2 input parameters that we use in our evaluation.

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[37] MACCS2 does not allow the user to specify different dose-response models for different radionuclides. We use a model with a dose-dependent reduction factor of 2, even though this assumption likely underestimates the carcinogenic potential of alpha-emitters, which is not reduced in effectiveness at low doses or dose rates.

[38] International Commission on Radiological Protection (ICRP), *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5, Compilation of Ingestion and Inhalation Dose Coefficients*, ICRP Publication 72, Pergamon Press, Oxford, 1996.

[39] E. Lyman, "Public Health Risks of Substituting Mixed-Oxide for Uranium Fuel in Pressurized-Water Reactors," *Science and Global Security* **9** (2001), pgs. 33-79. See Footnote 48.

THE SABOTAGE SCENARIO

The scenario that we analyze is based on the so-called "revised source term" that NRC defined in 1995 in NUREG-1465. The revised source term was developed as a more realistic characterization of the magnitude and timing of radionuclide releases during a core-melt accident than the source term originally specified for use in Part 100 siting analyses. In its entirety, the PWR revised source term presented in NUREG-1465 corresponds to a severe accident in which the primary coolant system is depressurized early in the accident sequence. An example is a "large break loss-of-coolant accident" (LBLOCA), in which primary coolant is rapidly lost and the low-pressure safety injection system fails to operate properly, resulting in core melt and vessel failure. This scenario is one of the most severe events that can occur at PWRs like Indian Point, and could result in a relatively rapid release of radioactivity.

(a) The source term

A severe accident of this type would progress through four distinct phases. As the water level in the core decreases and the fuel becomes uncovered, the zirconium cladding tubes encasing the fuel rods overheat, swell, oxidize and rupture. When that occurs, radionuclides that have accumulated in the "gap" between the fuel and the cladding will be released into the reactor coolant system. If there is a break in the reactor coolant system (as would be the case in a LBLOCA), then these radionuclides would be released into the atmosphere of the containment building. These so-called "gap" releases consist of the more volatile radionuclides contained in irradiated fuel, such as isotopes of krypton, xenon, iodine and cesium. This period is known as the "gap release" phase, and is predicted to last about 30 minutes. The oxidation of the zirconium cladding by water also generates hydrogen, which is a flammable gas.

As the core continues to heat up, the ceramic fuel pellets themselves begin to melt, releasing greater quantities of radionuclides into the reactor vessel and through the breach in the reactor coolant system into the containment building atmosphere. The molten fuel mass then collapses and drops to the bottom of the reactor vessel, where it aggressively attacks the steel, melts through the bottom and spills onto the floor of the containment building.[40] The period between the start of fuel melting and breach of the reactor vessel is known as the "early in-vessel" phase, and typically would last about an hour.

When the molten fuel breaches the reactor vessel and drops to the containment building floor, it violently reacts with any water that has accumulated in the cavity and with the concrete floor itself. This "core-concrete interaction" causes further releases of radionuclides from the molten fuel into the containment building. This period is known as the "ex-vessel" phase, and would last for several hours.

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[40] This scenario is not theoretical. During the 1979 accident at Three Mile Island Unit 2, part of the melted core relocated to the bottom of the reactor vessel where it began melting through the steel. The re-introduction of forced cooling water flow terminated this sequence before vessel failure.

At the same time, some portion of the molten core may remain in the reactor vessel, where it would continue to degrade in the presence of air and release radionuclides. Also, radionuclides released during the in-vessel phase that deposit on structures within the primary coolant system may be re-released into the containment building. These releases take place during the "late in-vessel" phase and could continue for many hours.

At the time when the molten core falls to the floor of the reactor vessel, steam explosions may occur that could blow apart the reactor vessel, creating high-velocity "missiles" that could rupture the containment building and violently expel the radioactive gases and aerosols it contains into the environment. This would result in a shorter in-vessel phase. If the vessel remains intact until melt-through, hydrogen or steam explosions are also possible when the molten fuel spills onto the concrete below the vessel, providing another opportunity for containment failure.

The complete revised source term (all four phases) is a general characterization of a low-pressure severe accident sequence, such as a large-break loss of coolant accident with failure of emergency core cooling systems. According to the timing of the accident phases in the revised source term, the "gap release" phase would begin within a few minutes after the initiation of the event and lasts for 30 minutes. At that time, the early in-vessel phase begins as the fuel pellets start to melt. This phase is assumed to last for 1.3 hours, and ends when the vessel is breached.

In our scenario, we assume that the attackers have weakened but not fully breached the containment, so that there is a high probability that the containment building will be ruptured by a steam or hydrogen explosion at the time of vessel breach. This results in a rapid purge of the radionuclide content of the containment building atmosphere into the environment, followed by a longer-duration release due to core-concrete interactions and late in-vessel releases.

We do not wish to discuss in detail how saboteurs could initiate this type of accident sequence. However, since NRC asserts that even in a terrorist attack these events are unlikely to occur, we need to present some evidence of the plausibility of these scenarios. One such scenario would involve a 9/11-type jet aircraft attack on the containment building, possibly accompanied by a ground attack on the on-site emergency power supplies. (One must also assume that interruption of off-site power takes place during an attack, given that off-site power lines are not under the control of the licensee and are not protected.)

The Nuclear Energy Institute (NEI) issued a press release in 2002 describing some of the conclusions of a study conducted by the Electric Power Research Institute (EPRI) that purported to show that penetration of a PWR containment by a jet aircraft attack was impossible. A study participant later acknowledged that (1) the justification for limiting the impact speed to 350 mph was based on pilot interviews and not on the results of simulator testing, and (2) even at 350 mph, their analysis actually found that the 42-inch thick reinforced concrete containment dome of a PWR suffered "substantial damage" and the steel liner was deformed.[41]

However, even if penetration of the containment does not occur, the vibrations induced by the impact could well disrupt the supports of the coolant pumps or the steam generators, causing a LBLOCA. The emergency core cooling system pumps, which require electrical power, would not be available under blackout conditions caused by the disabling of both off-site and on-site power supplies. Thus makeup coolant would not be provided, the core would rapidly become uncovered and the NUREG-1465 sequence would begin. Other engineered safety features such as containment sprays and recirculation cooling would not be available in the absence of electrical power. The damaged containment building would then be far less resistant to the pressure pulse caused by a steam spike or hydrogen explosion, and would have a much higher probability of rupture at vessel breach. We note that the steel liner of a reinforced concrete containment structure like that at Indian Point only carries 10 to 20% of the internal pressure load, and therefore may fail well before the design containment failure pressure is reached if the concrete shell is damaged.

Because the emergency diesel generators are themselves quite sensitive to vibration, a ground assault may not even be necessary to disable them, since the aircraft impact itself, followed by a fuel-air explosion, could cause them to fail.

One can find support for the credibility of this scenario in the recently leaked summary of a report prepared for the German Environment Ministry by the nuclear safety consultant GRS on the vulnerability of German nuclear reactors to aircraft attacks.[42] In the summary, GRS defined a series of credible damage scenarios and then determined whether or not the resulting accident sequence would be controllable The report considered an attack on the Biblis B PWR by a small jet (Airbus A320) or medium-sized jet (Airbus A300) travelling at speeds from 225 to 394 miles per hour, where the peak speed of 394 mph was determined through the use of simulators. GRS concluded that for an event in which the jet did not penetrate the containment, but the resulting vibrations caused a primary coolant leak, and the control room was destroyed by debris and fire (a condition similar to a station blackout), then control of the sequence of events would be "uncertain."[43] Biblis B was designed for protection against the crash of a 1960s-era Starfighter jet and as a result is equipped, like most German reactors, with a double containment. In contrast, Indian Point 2 and 3, while of the same 1970s vintage as Biblis B, were not designed to be resistant to airplane crashes, and do not have double containments.

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[41] R. Nickell, "Nuclear Plant Structures: Resistance to Aircraft Impact," 44th Annual Meeting of the Institute of Nuclear Materials Management, Phoenix, AZ, July 13-17, 2003.
[42] Mark Hibbs, "Utilities Expect Showdown with Trittin over Air Terror Threat," *Nucleonics Week* **45**, February 12, 2004.
[43] Gesellschaft für Anlagen und Reaktorsicherheit, *Schutz der deutschen Kernkraftwerke vor dem Hintergrund der terroristischen Anschläge in den USA vom 11. September 2001*, (*Protection of German Nuclear Power Plants in the Context of the September 11, 2001 Terrorist Attacks in the US*), November 27, 2002.

The NUREG-1465 revised source term is shown in Table 1. The source term is characterized by grouping together fission products with similar chemical properties and for each group specifying a "release fraction"; that is, the fraction of the core radionuclide inventory released from the damaged fuel into the containment building atmosphere. Noble gases include krypton (Kr); halogens include iodine (I); alkali metals include cesium (Cs); noble metals include ruthenium (Ru); the cerium (Ce) group includes actinides such as plutonium (Pu) and the lanthanide (La) group includes actinides such as curium (Cm).

TABLE 1: NUREG-1465 radionuclide releases into containment for PWRs

	Gap	Early In-Vessel	Ex-Vessel	Late In-Vessel
Duration (hrs)	0.5	1.3	2.0	10.0
Release fractions (%):				
Noble Gases (Kr)	0.05	0.95	0	0
Halogens (I)	0.05	0.35	0.25	0.1
Alkali Metals (Cs)	0.05	0.25	0.35	0.1
Tellurium group (Te)	0	0.05	0.25	0.005
Barium, Strontium (Ba, Sr)	0	0.02	0.1	0
Noble Metals (Ru)	0	0.0025	0.0025	0
Cerium group (Ce)	0	0.0005	0.005	0
Lanthanides (La)	0	0.0002	0.005	0

It is important to note that NUREG-1465 is not intended to be a "worst-case" source term. The accompanying guidance specifically states that "it is emphasized that the release fractions for the source terms presented in this report are intended to be representative or typical, rather than conservative or bounding values..."[44] In fact, the release fractions for tellurium, the cerium group and the lanthanides were significantly lowered in response to industry comments. Upper-bound estimates, which are provided in a table in the back of NUREG-1465, indicate that "virtually all the iodine and cesium could enter the containment."[45] And experimental evidence obtained since NUREG-1465 was published in 1995 suggests that the tellurium, ruthenium, cerium and lanthanide release fractions in the revised source term may significantly underestimate actual releases of these radionuclide groups.[46] Thus our use of the NUREG-1465 source term is far from the worst possible case and may underestimate the impacts of credible scenarios.

[44] NUREG-1465, p. 13.
[45] NUREG-1465, p. 17.
[46] Energy Research, Inc., Expert Panel Report on Source Terms for High-Burnup and MOX Fuels, 2002.

We model this scenario in MACCS2 as a two-plume release. The first release begins at the time of vessel breach and containment failure, 1.8 hours after initiation of the accident, and continues over a period of 200 seconds as the containment atmosphere is rapidly vented. The second plume lasts for two hours as core-concrete interactions occur. For simplicity, only the first two hours of the late in-vessel release are included; the last eight hours are omitted, although this late release would likely make a significant contribution to public exposures, given the nearly ten-hour evacuation time estimate for the 10-mile EPZ.

We further assume that the entire radionuclide inventory released from the damaged fuel into the containment atmosphere escapes into the environment through the rupture in the containment. There is little information in the literature about realistic values for the fraction of the containment inventory that is released to the environment. In NUREG-1150, NRC states that "in some early failure cases, the [containment to environment] transmission fraction is quite high for the entire range of uncertainty. In an early containment failure case for the Sequoyah plant ... the fractional release of radioactive material ranges from 25 percent to 90 percent of the material released from the reactor coolant system."[47] A review of the default values of this fraction for the Sequoyah and Surry plants used in supporting analyses for NUREG-1150 indicates that environmental releases ranging from 80 to 98% of the radionuclides in the containment atmosphere were typically assumed. The only case in which significant retention within the containment building occurs is when there is a delay of several hours between the initiation of core degradation and the time of containment failure, which is not the case for the scenario we are considering. Given that we are using only the first three phases of the NUREG-1465 source term, which may underestimate the maximum release of radionuclides like iodine and cesium by 35%, we believe it is reasonable to neglect the retention within the containment building of at most 20% of the radionuclide inventory.

Another plume characteristic that is very important for determining the distribution and magnitude of consequences is the heat energy that it contains. The oxidation of zirconium cladding during core degradation generates a large amount of heat in a short period of time, which can cause the plume to become buoyant and rise. Greater initial plume heights result in lower radionuclide concentrations close to the plant, but wider dispersal of the plume.

It is unlikely that a radiological release at any US PWR would produce a plume as high as the one released during the Chernobyl disaster. Because of the large mass of graphite moderator in the Chernobyl-4 reactor, a hot and long-duration graphite fire caused a very high plume that was responsible for dispersing radionuclides over vast distances. However, at the same time, the exposure and contamination within 50 miles of the Chernobyl site was much lower than it would have been if the plume had not risen so high. This means that the cooler plume that would be characteristic of a core meltdown at Indian Point could actually be a greater threat to the New York metropolitan area than the contamination pattern resulting from the Chernobyl accident might suggest.

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[47] US NRC, *Severe Accident Risks: An Assessment for Five Nuclear Power Plants*, NUREG-1150, Volume 2, December 1990, p. C-108.

Table 2 shows the two-plume source term for input into MACCS2, adapted from the NUREG-1465 source term in Table 1. The first plume consists of the containment radionuclide inventory at the time of vessel breach (the sum of the first and second columns in Table 1). The second plume consists of the releases generated by core-concrete interactions and a fraction of the late-in-vessel releases (the sum of the third column and one-fifth of the fourth column in Table 1).

TABLE 2: Source term used in MACCS2 model

Plume	Release time (hrs)	Duration(hrs)	Energy release (MW)	Kr	I	Cs	Te	Ba	Ru	Ce	La
1	1.8	0.06	2.8	1	0.4	0.3	0.05	0.02	0.0025	0.0005	0.0002
2	1.86	2	1.6	0	0.27	0.37	0.25	0.1	0.0025	0.005	0.005

The reactor core inventory used was calculated for a representative 3565 MWt PWR at the end of an equilibrium 18-month cycle using the SCALE code, and was then scaled to the Indian Point 2 power rating of 3071 MWt.[48] Since Indian Point 2 operates on a 24-month cycle, the inventory we use here does not represent the peak inventory of the reactor core, which occurs just before refueling.

(b) Meteorology

The calculation of radiological consequences from a severe accident is strongly dependent on the meteorological conditions at the time of the release and for several days afterward. Relevant factors include the wind speed, the wind direction, the atmospheric stability, the height of the mixing layer and the occurrence of precipitation.

The MACCS2 code can utilize a weather sequence of hourly data for a 120-hour period following the initial release. The user has the option to supply a file with an entire year's worth of hourly meteorological data (8760 entries), consisting of wind speed, atmospheric stability class, and precipitation. The program can then calculate up to 8760 results, each corresponding to a release beginning at a different hour of the year. For each set of weather data, MACCS2 can also generate sixteen results by rotating the plume direction into each sector of the compass, repeating the calculation for each plume direction, and then weighting the results with the fraction of the time that the wind blows in that direction (as specified by the user-supplied "wind rose," or set of probabilities that the wind will be blowing in a certain direction at the site). Finally, the code can tabulate the results in a frequency distribution.

48 Lyman (2001), op cit., pp. 64-66.

The MACCS2 code, like the CRAC2 code before it, has the option to sample a reduced number of weather sequences, based on a semi-random sampling method. The reason for employing a sampling scheme in the past was no doubt the length of computing time needed for each calculation; however, the program runs quickly on modern machines, so there is no need to employ the MACCS2 sampling scheme. In fact, a comparison of the results obtained from sampling, which utilizes about 100 weather sequences, and the results obtained from an entire year's worth of sequences, finds that the peak consequence values in the sampling distribution are 30% or more below the peak consequences over the entire year, if the plume rotation option is not utilized. Thus there is a significant sampling error for peak values associated with the MACCS2 sampling scheme (and presumably the CRAC2 sampling scheme as well).

We were unable to obtain the meteorological data for the Indian Point site needed for input into MACCS2. Instead, we used a meteorological data file for New York City, the location of the nearest National Weather Service weather monitoring station, that was supplied with the original CRAC2 code. This is the same approach that was taken in the CRAC2 Report, which was ostensibly a site-specific study of the 91 sites where nuclear reactors were located or planned, but did not use meteorological data files specific to those sites. Instead, the study used data derived from 29 National Weather Service stations that were "chosen as a representative set of the nation's meteorological conditions."[49] NRC later had to adopt the same approach, using the New York City meteorological data file as a surrogate for Indian Point-specific data in a CRAC2 benchmark exercise, because it was unable to obtain the Indian Point data.[50]

Use of the New York City meteorological data file in lieu of Indian Point site data is a reasonable approximation for the purposes of this report. Two of the most important factors in determining the radiological consequences of a terrorist attack at Indian Point are the wind direction and the precipitation. With regard to the first factor, we use the Indian Point site wind rose to take into account the effect of the variation in wind direction.[51] With regard to precipitation data, since the MACCS2 code only allows for uniform precipitation over the entire evaluation area, the precipitation data set from New York City is just as relevant as data from the Indian Point site for determining the consequences for the New York metropolitan area.

One phenomenon that we cannot fully account for without access to meteorological data specific to the Indian Point site is the coupling between wind direction and wind speed that results from the plant's location in the Hudson River Valley. Wind speeds below a threshold of below 4 meters per second tend to result in plumes that follow the course of the river valley, whereas greater wind speeds produce plumes that are free to travel in any direction and are better approximated by the straight-line Gaussian model. Our use of the

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[49] R. Davis, A. Hanson, V. Mubayi and H. Nourbakhsh, *Reassessment of Selected Factors Affecting Siting of Nuclear Power Plants*, NUREG/CR-6295, US Nuclear Regulatory Commission, 1997, p. 3-30.
[50] US Nuclear Regulatory Commission, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437, Vol. 1, Sec. 5.3.3.2.3.
[51] James Lee Witt Associates, *Review of Emergency Preparedness of Areas Adjacent to Indian Point and Millstone*, March 2003, Figure 3-1, p. 21.

Indian Point wind rose accounts for this effect, but to the extent that the distribution of wind speeds in the meteorological data file that we use differs from that at the Indian Point site, the calculations may include some cases that involve unrealistic wind patterns. However, any errors in the distribution resulting from this approximation are not likely to be significant in comparison to the uncertainties associated with use of the straight-line Gaussian model in MACCS2. In any event, it is likely that properly accounting for this effect would result in the channeling of a greater number of slow-moving, concentrated plumes directly downriver toward densely populated Manhattan, thereby increasing the overall radiological impact.

We have also run the calculations using the meteorological data file for the Surry site in Virginia to compare the maximum consequences obtained. We find that the values for peak early fatalities differ by less than 1% and the value for peak latent cancer fatalities differs by less than 5%. We interpret this result as an indication that the peak consequences we found for Indian Point are not due to weather conditions unique to the meteorological data file for New York City.

If Entergy were willing to provide us with data from the Indian Point meteorological monitoring station, we would be pleased to use it to assess whether it would have a significant impact on our results. However, we would expect any impact to be minor.

(c) Protective actions

Another crucial factor in determining the consequences associated with a terrorist attack at Indian Point is the effectiveness of the actions taken to protect individuals within the 10-mile emergency planning zone (EPZ).

The MACCS2 emergency planning model requires the user to input the time when notification is given to emergency response officials to initiate protective actions for the surrounding population; the time at which evacuation begins after notification is received; and the effective evacuation speed. Once evacuation begins, each individual then proceeds in a direction radially outward from the release point at a rate given by the effective evacuation speed.

We have assumed that the time at which the off-site alarm is sounded is coincident with the initiation of core melting; that is, 30 minutes after the attack. It is unlikely that the decision to evacuate could be made in much less time. This choice still provides an interval of 78 minutes between the sounding of the alarm and the initiation of the radiological release, consistent with earlier studies such as the CRAC2 Report.

We have assumed that the delay time between receipt of notification by the public within the EPZ and initiation of evacuation is two hours. This is the default parameter in the MACCS2 code, and is consistent both with earlier estimates of the "mobilization time" and with the most recent ones for the Indian Point site, which found that 100% of the public within the EPZ would be mobilized to evacuate by two hours after notification.[52]

[52] James Lee Witt Associates (2003), op cit., Figure 5-6, p. 96.

The effective evacuation speed was obtained from the mobilization time estimate of two hours and the most recent Indian Point evacuation time estimate (ETE) for good summer weather of 9 hours 25 minutes.[53] Subtracting the two-hour mobilization time leaves a maximum time of 7.42 hours for the actual evacuation. Since the maximum travel distance to leave the EPZ is approximately ten miles, this corresponds to an effective evacuation speed of 1.35 miles per hour, or 0.6 meters per second. The high value for the ETE and the correspondingly low effective evacuation speed reflect the severe traffic congestion within the EPZ that is projected to occur in the event that a crisis occurs at Indian Point requiring evacuation.

Outside of the 10-mile EPZ, the baseline dose calculations assume that individuals will take no protective actions.[54] Although this may not be realistic, we believe that it would be inappropriate to assume otherwise. Since NRC and FEMA do not require that any preparation for an emergency be undertaken outside of the 10-mile EPZ, it would not be conservative to assume that individuals outside of the EPZ would receive prompt notification of the event or would know what to do even if they did receive notification. However, to examine the impact of this assumption on the results, we consider a case where the emergency evacuation zone is extended to 25 miles, and the average evacuation speed remains the same as in the 10-mile EPZ case.

(d) Population distribution

In order to accurately calculate the consequences of a terrorist attack at Indian Point, it is necessary to have the correct spatial distribution of population in the vicinity of the site. MACCS2 has the option to use a site population data file, in which the site-specific population is provided on a grid divided into sixteen angular sectors. The user can specify the lengths of sectors in the radial direction.

Most of our analysis is focused on a circular region centered on the Indian Point site with a radius of fifty miles. The ten-mile EPZ is divided into eleven regions, with divisions at the site exclusion zone (about 0.5 miles), at the one-mile point, and nine successive mile-wide intervals. The region between the EPZ and the fifty-mile limit is subdivided into ten intervals (see Figure 1, below).

Permanent resident population data for the ten-mile EPZ was obtained from the estimates for 2003 generated by KLD Associates for the Evacuation Time Estimate study that it prepared for Entergy.[55] The total number of permanent residents within a ten-mile circular zone around Indian Point in 2003, according to KLD, was 267,099. We have not included the transient population in the region in our calculations, even though it would add another 25% to the permanent population estimate, according to KLD data.

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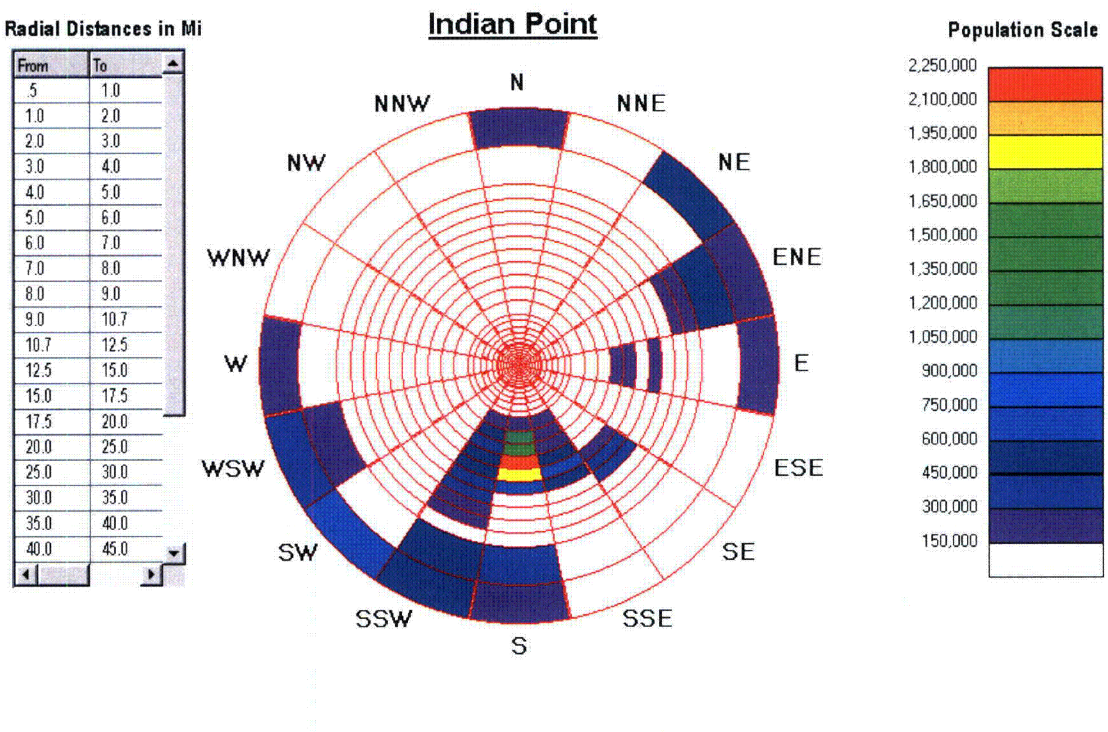
[53] KLD Associates, Inc., *Indian Point Energy Center Evacuation Time Estimate*, Rev. 0 (2003), p. 7-8.
[54] However, the calculation of doses within the EPZ does reflect the impact of "shadow evacuation" of individuals outside of the EPZ, since it uses the KLD Associates evacuation time estimate for the EPZ, which assumes that shadow evacuation occurs.
[55] KLD Associates, Inc. (2003), op cit., p. 3-7.

For the region from 10 to 100 miles from Indian Point, the MACCS2 site data file was generated with the SECPOP2000 code, which is the most recent version of the SECPOP code originally developed by the Environmental Protection Agency and later adopted by NRC for use in regulatory applications.[56] SECPOP2000 utilizes 2000 US Census data to estimate population distributions on a user-specified grid surrounding any location in the United States, drawing on a high-resolution database of over eight million census-blocks. By utilizing the 2000 Census data in SECPOP2000, we have slightly underestimated the population in this region, which appears to have increased by about 1% between 2000 and 2003.

The Indian Point plume exposure EPZ is not in the shape of a perfect circle of ten-mile radius, but includes some regions that are beyond ten miles from the plant. To account for the 38,177 individuals that reside within the EPZ but outside of the 10-mile circular zone (according to KLD estimates for 2003), we used the SECPOP2000 code to determine that an "effective" circular EPZ boundary of 10.68 miles would include the appropriate additional number of permanent residents, and adjusted the MACCS2 grid accordingly.

Figure 1 displays the population rosette generated by SECPOP2000 for Indian Point, out to a distance of 100 miles. The location of New York City is plainly visible on the grid.

FIGURE 1



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[56] N. Bixler et al., *SECPOP2000: Sector Population, Land Fraction, and Economic Estimation Program*, NUREG/CR-6525, Rev. 1, Sandia National Laboratories, August 2003.

RESULTS

In this section, we present the results of the MACCS2 simulation of a terrorist attack at IP2, as previously described.

MACCS2 generates results for two distinct periods following a radiological release. First, it calculates the doses to individuals received during the "emergency" phase of the event, defined as the period extending up to the first week following the release. The doses received during this period result from direct exposure to and inhalation of the plume, as well as exposure to plume particles deposited on the ground ("groundshine"). Second, it separately calculates doses received beyond the first week after the release as a result of groundshine, inhalation of resuspended particles, and consumption of contaminated food and water. The first sets of results provided below refer only to the consequences of exposures received during a one-week emergency phase. The economic and long-term health consequences are calculated based on the evaluation of chronic exposures for a period of fifty years following the release, which are dominated by groundshine.

Following the format of the CRAC2 Report summary, our calculation considers several public health and environmental endpoints, including early fatalities, latent cancer fatalities, maximum distance for early fatalities, and total economic costs. The calculations were carried out for each of the 8760 weather sequences in the New York City meteorological data file by rotating the plume direction into each of the 16 sectors of the compass, and then generating a weighted average of the results according to the Indian Point site wind rose. For each endpoint, in addition to the mean of the distribution and the peak value corresponding to the worst-case meteorological conditions encountered during the year, we present the 95th and 99.5th percentile values of the distribution.

The results of the MACCS2 frequency distribution are based on the assumption that the radiological release would occur at random during the year, even though the timing of a terrorist attack most likely would be far from random. As we have previously discussed, one must assume that a terrorist attack intended to cause the maximum number of casualties would be timed to coincide as closely as possible with the most favorable weather conditions. In the case of Indian Point, an attack at night --- the time when a terrorist attack is most likely to be successful --- also happens to be the time when the prevailing winds are blowing toward New York City. Consequently, the mean and other statistical parameters derived from a random distribution are not characteristics of the actual distribution of consequences resulting from a terrorist attack, which would be restricted to a much more limited set of potential release times. A meteorological data set confined to the evening hours would skew the distribution in the direction of increased consequences.

In our judgment, the 95th percentile values of these distributions, rather than the mean values, are reasonable representations of the likely outcome of a well-planned terrorist attack. This choice reflects the fact that the attack time will be largely of the terrorists' choosing, but that some factors will necessarily remain out of their control --- for instance, the ability to accurately predict precipitation patterns, and the ability to launch an attack exactly as planned.

In the following tables, it is important to note that the peak results in each category do not correspond in general to the same weather sequence. For example, the weather conditions that lead to the maximum number of early fatalities are typically those that involve rainout and substantial deposition of the plume close to the plant, and thus are not the same conditions that lead to peak latent cancer fatalities, which involve rainout of the plume over New York City.

(a) Consequences of radiological exposures during "emergency phase"

Here we consider the consequences of exposures received during the 7-day "emergency phase." We calculate the number of "early fatalities" (EFs) resulting from acute radiation syndrome, both for the residents of the 10-mile EPZ, who are assumed to evacuate according to the scheme described previously, and for the entire population within 50 miles of the plant. Following the CRAC2 Report, we also provide the "early fatality distance," that is, the greatest distance from the Indian Point site at which early fatalities may occur. Finally, we provide an estimate of the number of latent cancer fatalities (LCFs) that will occur over the lifetimes of those who are exposed to doses that are not immediately life-threatening, both for residents of the EPZ and for residents of the 50-mile region.

It is important to note that these estimates are based on dose conversion factors (the radiation doses resulting from internal exposure to unit quantities of radioactive isotopes) appropriate for a uniform population of adults, and do not account for population variations such as age-specific differences. A calculation fully accounting for individual variability of response to radiation exposure is beyond the capability of the MACCS2 code and the scope of this report.

In Table 3, these results are provided for the case in which 100% evacuation of the EPZ occurs, based on the KLD evacuation time estimate and 2-hour mobilization time discussed earlier. Table 4 presents the same information for the case where the EPZ population is sheltered for 24 hours prior to evacuation. Finally, Table 5 presents the results for the extreme case where no special precautions are taken in the EPZ.

In interpreting the results of these tables, one should keep in mind that the MACCS2 code uses different radiation shielding factors for individuals that are evacuating, sheltering or engaged in normal activity. The default MACCS2 parameters (which we adopt in this study) assume that evacuees are not shielded from the radioactive plume by structures, since they are mostly outdoors or in non-airtight vehicles during the evacuation. Individuals who shelter themselves instead of evacuating are shielded to a considerable extent by structures, but may be exposed to higher levels of radiation overall because they remain in areas closer to the site of plume release. The MACCS2 default shielding parameters assume that sheltering reduces doses from direct plume exposure by 40% and doses from plume inhalation by 67%. The relative benefits of sheltering versus evacuation are obviously quite sensitive to the values of the shielding parameters. Finally, the level of shielding for individuals engaged in "normal activity" falls in between the levels for evacuation and for sheltering, with reductions in doses from direct plume exposure and plume inhalation relative to evacuees of 25% and 59%, respectively.

TABLE 3: Terrorist attack at IP 2, MACCS2 estimates of early fatalities (EFs), latent cancer fatalities (LCFs) and the EF distance resulting from emergency phase exposures, 100% evacuation of EPZ

	Mean	95th percentile	99.5th percentile	Peak
Consequence:				
EFs, within EPZ	527	2,440	11,500	26,200
EFs, 0-50 mi.	696	3,460	16,600	43,700
EF distance (mi.)	5.3	18	24	60
LCFs, within EPZ	9,200	31,600	59,000	89,500
LCFs, 0-50 mi.	28,100	99,400	208,000	518,000

TABLE 4: Terrorist attack at IP 2, MACCS2 estimates of early fatalities (EFs), latent cancer fatalities (LCFs) and the EF distance resulting from emergency phase exposures, 24-hour sheltering in EPZ

	Mean	95th percentile	99.5th percentile	Peak
Consequence:				
EFs, within EPZ	626	2,550	6,370	13,000
EFs, 0-50 mi.	795	3,250	10,200	38,700
EF distance (mi.)	6.2	18	24	60
LCFs, within EPZ	3,770	9,920	12,100	19,400
LCFs, 0-50 mi.	22,700	81,000	192,000	512,000

TABLE 5: Terrorist attack at IP 2, MACCS2 estimates of early fatalities (EFs), latent cancer fatalities (LCFs) and the EF distance resulting from emergency phase exposures, normal activity in EPZ

	Mean	95th percentile	99.5th percentile	Peak
Consequence:				
EFs, within EPZ	4,050	12,600	22,300	38,500
EFs, 0-50 mi.	4,220	13,500	27,300	71,300
EF distance (mi.)	9	18	24	60
LCFs, within EPZ	4,480	10,400	12,500	20,300
LCFs, 0-50 mi.	23,400	82,600	193,000	516,000

A comparison of Tables 3 and 4 indicates that sheltering instead of evacuation results in slightly higher mean early fatalities, but substantially lower 99.5th percentile and peak values. A possible interpretation of this counterintuitive result is that the higher percentile early fatality results for the evacuation case correspond to rare situations in which people evacuate in such a manner as to maximize their radiation exposure (for instance, if they are unfortunate enough to be traveling directly underneath the radioactive plume at the same speed and in the same direction). These situations cannot occur for the sheltering case. Overall, sheltering does appear to substantially reduce the projected number of latent cancer fatalities within the EPZ relative to evacuation, for the default MACCS2 shielding parameters.

A comparison of Table 5 to Tables 3 and 4 indicates that either evacuation or sheltering would substantially reduce the number of early fatalities within the EPZ relative to a case where no protective actions are taken. Also, by comparing Tables 3 and 5, one sees that the number of latent cancer fatalities in the EPZ is considerably lower for the normal activity case than for the evacuation case. There are two reasons for this. First, many evacuees will receive doses that are not high enough to cause early fatalities, yet will contribute to their lifetime cancer risk. In the normal activity case, some of these individuals will receive higher doses and succumb to acute radiation syndrome instead. Second, the MACCS2 default shielding factors give considerable protection to individuals engaged in normal activity compared to evacuees, and may not be realistic.[57]

The peak numbers of latent cancer fatalities for all three cases in the 50-mile zone are disturbingly high, and are more than double the number in the 99.5th percentile. But an examination of the particular weather sequence corresponding to this result indicates that

[57] The protection due to shielding has a bigger impact on the number of latent cancer fatalities, which is a linear function of population dose, than on the number of early fatalities, which is a non-linear function of dose. Shielding would only prevent early fatalities for those individuals whose acute radiation doses would be lowered by sheltering from above to below the early fatality threshold.

the rarity of the event is an artifact of the meteorological data file that we have used, and not a consequence of very extreme or unusual weather conditions for the New York City region. We are not disclosing the details of this weather sequence.

The reader may also notice that the values for the "early fatality distance" for the 95th percentile and above are the same in Tables 3-5, but the mean values are not. This is because the distances for the 95th percentile and above are all greater than 10 miles, so that they are not affected by differences in protective actions that apply only within the 10-mile EPZ.

(b) Doses received by individuals outside of the 10-mile EPZ

It is clear from the previous section that direct exposure to the radioactive plume resulting from a terrorist attack at Indian Point could have severe consequences well beyond the 10-mile EPZ, yet there is no regulatory requirement that local authorities educate residents outside of the EPZ about these risks, or undertake emergency planning to protect these individuals from plume exposures. Therefore, individuals who are now at risk do not have the information that they may need to protect themselves. This is a shortsighted policy, and in fact is inconsistent with government guidelines for protective actions in the event of a radiological emergency.

In this section, we calculate the plume centerline thyroid doses to adults and five-year-old children, and the plume centerline whole-body doses to adults, both at the EPZ boundary and in midtown New York City. (For a given distance downwind of a release, the maximum dose is found at the plume centerline.) We then compare these values to the appropriate protective action recommendations. Thyroid doses are compared to the dose thresholds in the most recent FDA recommendations for potassium iodide administration and whole-body doses are compared to the EPA protective action guides (PAGs) for emergency-phase evacuation. In both cases, the plume centerline doses received to individuals in New York City are well in excess of the projected dose thresholds that would trigger protective actions.

(i) Thyroid doses to children, their consequences, and the need for KI distribution

The statistically significant increase in the incidence of thyroid cancer observed among children exposed to fallout from the Chernobyl disaster leaves little doubt of the causal relationship between the occurrence of these cancers and the massive release of radioactive iodine to the environment resulting from the accident.[58] The effectiveness of widespread distribution of stable iodine in the form of potassium iodide (KI) to block uptake of radioactive iodine in the thyroid was also confirmed in western areas of Poland, where the timely administration of KI was estimated to have reduced peak doses from radioactive iodine by 30%.[59]

[58] D. Williams, "Cancer After Nuclear Fallout: Lessons from The Chernobyl Accident," *Nature Reviews Cancer* **2** (2002), p. 543-549.
[59] Board on Radiation Effects Research, National Research Council, *Distribution and Administration of Potassium Iodide in the Event of a Nuclear Incident*, National Academies Press, 2003, p. 58.

In the United States, after resisting public demands for many years, the Nuclear Regulatory Commission finally agreed in January 2001 to amend its emergency planning regulations to explicitly consider the use of KI, and to fund the purchase of KI for distribution within the 10-mile plume exposure EPZs of nuclear plants in states that requested it. This effort accelerated after the September 11 attacks, as more states requested the drug, but even today only fewer than two-thirds of the 34 states and tribal governments that qualify for the KI purchase program have actually stockpiled it. New York State is one of the participants.

Despite a few attempts in Congress after September 11 to require the distribution of KI in areas outside of the plume exposure EPZs, the 10-mile limit remains in effect today, and NRC continues to defend it. In a recent Commission meeting on emergency planning, NRC employee Trish Milligan said that[60]

> "...the [NRC] staff has concluded that recommending consideration of potassium iodide distribution out to 10 miles was adequate for protection of the public health and safety."

Earlier in this briefing, Ms. Milligan provided evidence of the NRC staff's thinking that led to this conclusion:[61]

> "When the population is evacuated out of the [10-mile] area and potentially contaminated foodstuffs are interdicted, the risk from further radioactive iodine exposure to the thyroid gland is essentially eliminated."

These statements again show that NRC continues to use design-basis accidents, in which the containment remains intact, as the model for its protective action recommendations. Although NRC claims that its emergency planning requirements take into account all potential releases, including those resulting from terrorist acts, it clearly is not taking into account catastrophic events such as the scenario being analyzed in this report.

These statements also suggest that NRC is committing the fallacy of using the pattern of radioactive iodine exposure that occurred after the Chernobyl accident as the model for the pattern that could occur here. In the Chernobyl event, the majority of the thyroid dose to children occurred through ingestion of contaminated milk and other foodstuffs that were not interdicted due to the failure of the Soviet authorities to act in a timely manner. However, the food pathway dominated in that case primarily because of the extremely high elevation of the Chernobyl plume, which reduced the concentration of radioactive iodine in the plume and therefore the doses received through direct inhalation.
But as pointed out earlier, the plume from a severe accident at a water-moderated PWR like Indian Point would probably not rise as high as the Chernobyl plume, and the associated collective thyroid dose would have a greater contribution from direct plume inhalation and a lower contribution from milk consumption. In this case, the importance

[60] US NRC, "Briefing on Emergency Preparedness Program Status" (2003), transcript, p. 21.
[61] Ibid, p.19.

of KI prophylaxis would increase relative to that of milk interdiction for controlling overall population exposure to radioactive iodine.

Our calculations clearly indicate that a severe threat to children from exposure to radioactive iodine is present far beyond the 10-mile EPZ where KI is now being made available. In Table 6, we present some results of the distribution for plume centerline thyroid dose to both adults and to five-year-old children at the EPZ boundary and in midtown Manhattan (32.5 miles downwind). In the last column, we provide the projected dose thresholds from the most recent guidelines issued by the FDA for KI prophylaxis.

The thyroid dose to five-year-olds due to I-131 internal exposure was calculated by using the age-dependent coefficients for dose per unit intake provided in ICRP 72, which are approximately a factor of five greater than those for adults. The calculation must also take into account the difference in the rate of intake of air for children and for adults. Children have lower lung capacities than adults, but they have higher metabolic rates and therefore breath more rapidly. The higher breathing rate of children tends to partially offset their lower lung capacity. Data collected by the California Environmental Protection Agency indicates that on average, children consume air at a rate about 75% of that of adults.[62] We have used this figure in our calculation.

TABLE 6: Terrorist attack at IP 2, MACCS2 estimates of centerline thyroid doses to 5-year-olds resulting from emergency phase exposures (all doses in rem)

Location	Age	Mean	95^{th} percentile	99.5^{th} percentile	Peak	FDA KI threshold
Outside EPZ (11.6 mi)	Adult	1,120	3,400	5,850	9,560	10 (ages 18-40) 500 (over 40)
	5 years	3,620	10,900	18,000	32,100	5
Midtown Manhattan (32.5 mi)	Adult	164	429	761	1,270	10 (ages 18-40) 500 (over 40)
	5 years	530	1,310	2,500	4,240	5

The results in Table 6 show that the thyroid doses to 5-year-olds are approximately three times greater than those for adults. This tracks well with information in the World Health Organization's 1999 guidelines for iodine prophylaxis, which states that thyroid doses from inhalation in children around three years old will be increased up to threefold relative to adults.[63]

[62] Air Resources Board, California Environmental Protection Agency, "How Much Air Do We Breathe?", Research Note #94-11, August 1994. On the Web at www.arb.ca.gov/research/resnotes/notes/94-11.htm.
[63] World Health Organization, *Guidelines for Iodine Prophylaxis Following Nuclear Accidents*, WHO, Geneva, 1999, Sec. 3.3.

These results make clear that both 95th percentile and mean projected thyroid doses can greatly exceed the FDA-recommended threshold for KI prophylaxis administration at locations well outside the 10-mile EPZ, for 5-year-old children and for adults of all ages. In Manhattan, KI would be recommended for children and adults under 40, based on the 95th percentile projection.

The health consequences of doses of this magnitude to the thyroid would be considerable. As the 99.5th percentile is approached, the 5-year-old doses are high enough to cause death of thyroid tissue. In fact, they are on the order of the doses that are applied therapeutically to treat hyperthyroidism and other diseases by destroying the thyroid gland. Children with this condition would require thyroid hormone replacement therapy for their entire lives. At lower doses, in which cells are not killed but DNA is damaged, the risk of thyroid cancer to children would be appreciable. According to estimates obtained from Chernobyl studies, a 95th percentile thyroid dose of 1,310 rem to a 5-year-old child in Manhattan would result in an excess risk of about 0.3% per year of contracting thyroid cancer.[64] Given that the average worldwide rate of incidence of childhood thyroid cancer is about 0.0001% per year, this would represent an impressive increase.

These results directly contradict the reassuring statements by NRC quoted earlier. But it is no secret to NRC that such severe thyroid exposures can occur as the result of a catastrophic release. Results very similar to these were issued by NRC staff in 1998 in the first version of a draft report on the use of KI, NUREG-1633.[65] This draft included a Section VII entitled "Sample Calculations," in which the NRC staff estimated the centerline thyroid doses at the 10-mile EPZ boundary from severe accidents using the RASCAL computer code. Table 5 of the draft report shows that the NRC's calculated dose to the adult thyroid at the 10-mile limit ranged from 1500 to 19,000 rem for severe accidents with iodine release fractions ranging from 6 to 35%, for a single weather sequence.[66] In the introductory section, the report states that "doses in the range of 25,000 rad are used to ablate thyroids as part of a therapeutic procedure. Such thyroid doses are possible during severe accidents."[67] NRC's results are even more severe than ours, which were obtained using the NRC revised source term, with a higher iodine release fraction of 67%.

Given NRC's reluctance to provide information of this type to the public, it is no surprise that the Commission withdrew the draft NUREG-1633 and purged it from its web site, ordering the issuance of a "substantially revised document" taking into account "the many useful public comments" that it received.[68] Lo and behold, the second draft of

[64] The average excess absolute risk per unit thyroid dose for children exposed to Chernobyl fallout has been estimated 2.1 per million children per rad. D. Williams, op cit., p. 544.
[65] F.J. Congel et al., *Assessment of the Use of Potassium Iodide (KI) As A Public Protective Action During Severe Reactor Accidents*, Draft Report for Comment, NUREG-1633, US Nuclear Regulatory Commission, July 1998.
[66] Ibid, p. 26.
[67] Ibid, p. 6.
[68] US NRC, "Staff Requirements --- Federal Register Notice on Potassium Iodide," SRM-COMSECY-98-016, September 30, 1998.

NUREG-1633, which was rewritten by Trish Milligan and reissued four years later, mysteriously failed to include Section VII, "Sample Calculations," as well as all information related to those calculations (such as the clear statement cited earlier that thyroid doses in the range of 25,000 rad are possible during severe accidents).[69] This took place even though the Commission's public direction to the NRC staff on changes to be incorporated into the revision made no explicit reference to this section.[70] However, it is clear that the expurgated information would be inconsistent with NRC's previous rulemaking restricting consideration of KI distribution only to the 10-mile zone. Even after this exercise in censorship, the Commission still voted in 2002 to block release of the revised draft NUREG-1633 as a final document.

Some insight into the level of understanding of the health impacts of a catastrophic release of radioactive iodine of the current Commission can be found in the statement of Commissioner McGaffigan in voting to delay release of the revised NUREG-1633 for public comment. In his comments, McGaffigan wrote[71]

> "Both WHO [the World Health Organization] and FDA set the intervention level on KI prophylaxis for those over 40 at 5 gray (500 rem) to the thyroid ... Since we do not expect, *even in the worst circumstances*, any member of the public to receive 500 rem to the thyroid, it would be useful for FDA to clarify whether we should plan for KI prophylaxis for those over 40." [Emphasis added.]

This statement is not consistent with what is known about the potential consequences of a severe nuclear accident. Few experts would claim that such high doses cannot occur "even in the worst circumstances," and the NRC's own emergency planning guidance is not intended to prevent such doses in *all* accidents, but only in *most* accidents. Given that the Commissioner presumably read the first draft of NUREG-1633, he would have seen the results of the staff's thyroid dose calculations and other supporting material. There is no discussion in the public record that provides a rationale for Commissioner McGaffigan's rejection of the informed judgment and quantitative analysis of his technical staff.

In 2003, at the request of Congress a National Research Council committee released a report addressing the issue of distribution and administration of KI in the event of a nuclear incident.[72] Most notably, the committee concluded that[73]

> "1. KI should be available to everyone at risk of significant health consequences from accumulation of radioiodine in the thyroid in the event of a radiological incident...

[69] US NRC, "Status of Potassium Iodide Activities, SECY-01-0069, Attachment 1 (NUREG-1633, draft for comment; prepared by P.A. Milligan, April 11, 2001).
[70] US NRC, SRM-COMSECY-98-016.
[71] US NRC, Commission Voting Record on SECY-01-0069, "Status of Potassium Iodide Activities," June 29, 2001.
[72] National Research Council (2003), op cit.
[73] Ibid, p. 5.

2. KI distribution programs should consider … local stockpiling outside the emergency planning zone …"

While the committee did not itself take on the politically sensitive question of how to determine the universe of individuals who would be "at risk of significant health consequences," it did recommend that "the decision regarding the geographical area to be covered in a KI distribution program should be based on risk estimates derived from calculations of site-specific averted thyroid doses for the most vulnerable populations."[74] This is the type of information that we provide in Table 6 (and the type that NRC struck from draft NUREG-1633). We hope that the information in our report provides a starting point for state and local municipalities to determine the true extent of areas that could be significantly affected by terrorist attacks at nuclear plants in their jurisdiction and to make provisions for availability of KI in those regions. Our calculations show that New York City should be considered part of such an area.

However, even timely administration of KI to all those at risk can only reduce, but cannot fully mitigate, the consequences of a release of radioactive iodine resulting from a terrorist attack at Indian Point. The projected dose to individuals who undergo timely KI prophylaxis can be reduced by about a factor of 10. A review of the results of Table 6 shows that doses and cancer risks to many children in the affected areas will still be high even after a ten-fold reduction in received dose. And KI can only protect people from exposure to radioactive iodine, and not from exposure to the dozens of other radioactive elements that would be released to the environment in the event of a successful attack.

(ii) Whole-body doses and the need for evacuation or sheltering

In addition to KI distribution, the other major protective action that will be relied on to reduce exposures following a terrorist attack at Indian Point is evacuation of the population at risk. In Table 7, we present the results of our calculation for the projected centerline whole-body "total effective dose equivalents" (TEDEs) just outside the EPZ boundary and in downtown Manhattan, and compare those with the EPA recommended dose threshold for evacuation during the emergency phase following a radiological incident. As in the discussion of projected thyroid doses and KI prophylaxis, we find that projected centerline TEDEs would exceed the EPA Protective Action Guide (PAG) for evacuation of 1-5 rem at distances well outside of the 10-mile plume exposure EPZ within which NRC requires evacuation planning.

[74] Ibid, p. 162.

TABLE 7: Terrorist attack at IP 2, MACCS2 estimates of adult centerline whole-body total effective dose equivalents (TEDEs) resulting from emergency phase exposures (all doses in rem)

	Mean	95^{th} percentile	99.5^{th} percentile	Peak	EPA PAG
Location					
EPZ boundary (11.6 mi)	198	549	926	1,490	1-5
Midtown Manhattan (32.5 mi)	30	77	131	307	1-5

From the results in Table 7, it is clear that according to the EPA early phase PAG for evacuation of 1-5 rem, evacuation would be recommended for individuals in the path of the plume centerline not only outside of the EPZ boundary, but in New York City and beyond. An individual in Manhattan receiving the 95^{th} percentile TEDE of 77 rem during the emergency phase period would have an excess absolute lifetime cancer fatality risk of approximately 8%, which corresponds to a 40% increase in the lifetime individual risk of developing a fatal cancer (which is about one in five in the United States).

We now examine the potential reduction in health consequences that could result from evacuation of a larger region than the current 10-mile EPZ by considering a case in which the boundary of the plume exposure EPZ is expanded from 10.7 to 25 miles. We calculate the impact of different protective actions in this region on the numbers of early fatalities and latent cancer fatalities among the population within the expanded EPZ but outside of the original 10-mile EPZ. The residents of the expanded EPZ are assumed either (1) to evacuate with the same mobilization time and at the same average speed as the residents of the original EPZ, or (2) to shelter in place for 24 hours and then evacuate. The results are provided in Table 8.

TABLE 8: Terrorist attack at IP 2, MACCS2 95^{th} percentile estimates of early fatalities (EFs) and latent cancer fatalities (LCFs) resulting from emergency phase exposures; 25-mile EPZ

	Normal activity	Evacuation	Sheltering for 24 hrs
Consequence:			
EFs, 10.7-25 mi	664	0	0
LCFs, 10.7-25 mi	19,800	45,700	9,020

These results indicate that evacuation and sheltering are equally effective in eliminating the risk of early fatalities among residents of the 10.7-25 mile region for the 95th percentile case. On the other hand, one sees that evacuation also tends to increase the number of latent cancer fatalities relative to normal activity, while sheltering reduces the number. Thus for this scenario, it appears that sheltering of individuals in the 10.7-25 mile region would be preferable to evacuation of this region for the MACCS2 evacuation and sheltering models we use here. This is consistent with the results we obtained earlier when considering the comparative impacts of evacuation and sheltering of residents of the 10-mile EPZ, again indicating that evacuation tends to increase population doses by placing more people in direct contact with the radioactive plume. However, other models and other shielding parameter choices may lead to different conclusions. We would urge emergency planning officials to evaluate an exhaustive set of scenarios, and to conduct a realistic and site-specific assessment of the degrees of shielding that structures in the region may provide, to determine what types of actions would provide the greatest protection for residents of regions outside of the 10-mile EPZ.

(c) Long-term economic and health consequences

In this section we provide MACCS2 order-of-magnitude estimates of the economic costs of the terrorist attack scenario, the numbers of latent cancer fatalities resulting from long-term radiation exposures (primarily as a result of land contamination), and the number of people who will require permanent relocation. NRC has used MACCS2 to estimate the economic damages of reactor accidents for various regulatory applications.[75]

There is no unique definition of the economic damages resulting from a radiological contamination event. In the MACCS2 model, which is a descendant of the CRAC2 model, the total economic costs include the cost of decontamination to a user-specified cleanup standard, the cost of condemnation of property that cannot be cost-effectively decontaminated to the specified standard, and a simple lump-sum compensation payment to all members of the public who are forced to relocate either temporarily or permanently as a result of the attack. Although simplistic, this model does provide a reasonable estimate of the order of magnitude of the direct economic impact of a successful terrorist attack at Indian Point.

(i) EPA Protective Action Guide cleanup standard

We first employ the long-term habitability cleanup standards provided by the EPA protective action guide (PAG) for the "intermediate phase," which is the period that begins after the emergency phase ends, when releases have been brought under control and accurate radiation surveys have been taken of contaminated areas. The EPA intermediate phase PAG recommends temporary relocation of individuals and decontamination if the projected whole-body total effective dose equivalent (TEDE) (not taking into account any shielding from structures) over the first year after a radiological

[75] US NRC, Office of Nuclear Regulatory Research, *Regulatory Analysis Technical Evaluation Handbook*, NUREG/BR-0184, January 1997, p. 5.37.

release would exceed 2 rem. The EPA chose this value with the expectation that if met, then the projected (shielded) TEDE in the second (and any subsequent year) would be below 0.5 rem, and the cumulative TEDE over a fifty-year period would not exceed 5 rem.

The MACCS2 economic consequence model evaluates the cost of restoring contaminated areas to habitability (which we define as reducing the unshielded TEDE during the first year of reoccupancy to below 2 rem), and compares that cost to the cost of condemning the property. All cost parameters, including the costs of decontamination, condemnation and compensation, can be specified by the user. We employ an economic model partly based on parameters developed for a recent study on the consequences of spent fuel pool accidents.[76] The model utilizes the results of a 1996 Sandia National Laboratories report that estimates radiological decontamination costs for mixed-use urban areas.[77] We refer interested readers to these two references for information on the limitations and assumptions of the model.

The SECPOP2000 code, executed for the Indian Point site, provides the required site-specific inputs for this calculation, including the average values of farm and non-farm wealth for each region of the MACCS2 grid, based on 1997 economic data. These values are used to assess the cost-effectiveness of decontaminating a specific element versus simply condemning it.

Table 9 presents the long-term health and economic consequences calculated by MACCS2 for a region 100 miles downwind of the release, considering only costs related to residential and small business relocation, decontamination and compensation. Since the calculation was performed using values from a 1996 study and from 1997 economic data, we have converted the results to 2003 dollars using an inflation adjustment factor of 1.10. Because of significant uncertainties in the assignments of parameters for this calculation, the results in Table 9 should only be regarded as order-of-magnitude estimates. The reader should note that the latent cancer fatality figures in Table 9 result from doses incurred after the one-week emergency phase is over, and therefore are additional to the numbers of latent cancer fatalities resulting from emergency-phase exposures reported previously in Tables 3 to 5.

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[76] J. Beyea, E. Lyman and F. von Hippel, "Damages from a Major Release of ^{137}Cs into the Atmosphere of the United States," *Science and Global Security* 12 (2004) 1-12.

[77] D. Chanin and W. Murfin, *Site Restoration: Estimates of Attributable Costs From Plutonium Dispersal Accidents*, SND96-0057, Sandia National Laboratories, 1996.

TABLE 9: Terrorist attack at IP 2, MACCS2 estimates of long-term economic and health consequences, EPA intermediate phase PAG (< 2 rem in first year; approx. 5 rem in 50 yrs)

Consequence	Mean	95th percentile	99.5th percentile	Peak
Total cost, 0-100 mi (2003 $)	$371 billion	$1.17 trillion	$1.39 trillion	$2.12 trillion
People permanently relocated	684,000	3.19 million	7.91 million	11.1 million
LCFs, 0-100 mi	12,000	41,200	57,900	84,900
Plume Centerline 50-year TEDE (rem)	4.57	7.04	7.18	7.42

One can see from Table 9 that imposition of the EPA intermediate phase PAG does result in restricting the mean 50-year cumulative TEDE to below 5 rem, but that this limit is exceeded for the higher percentiles of the distribution. Thus for a terrorist attack at the 95th percentile, the subsidiary goal of the EPA intermediate phase PAG is not met.

(ii) Relaxed cleanup standard

In the recent NRC meeting on emergency planning described earlier, NRC staff and Commissioners questioned claims by activists that a severe nuclear accident would render large areas "permanently uninhabitable," arguing that the radiation protection standard underlying that determination is too stringent compared to levels of natural background radiation to which people are already exposed.

For instance, Trish Milligan said that[78]

> "There's been a concern that a radioactive release as a result of a nuclear power plant accident will render thousands of square miles uninhabitable around a plant. It is true that radioactive materials can travel long distances. But it is simply not true that the mere presence of radioactive materials are [sic] harmful... the standard applied to this particular claim has been a whole body dose of 10 rem over 30 years, or approximately 330 millirem per year. This dose is almost the average background radiation dose in the United States which is about 360 millirem per year. Some parts of the country have a background radiation dose two or more times higher than the national average. So in effect this additional 330 millirem dose is an additional year background dose or the difference in dose

[78] US NRC, Briefing on Emergency Preparedness (2003), op cit., transcript, p. 22.

between someone living in a sandy coastal area or someone living in the Rocky Mountains."

Ms. Milligan does not note that her opinion of an acceptable level of radiation is not consistent with national standards, such as the EPA PAGs. The EPA long-term goal of limiting chronic exposures after a radiological release to 5 rem in 50 years corresponds to an average annual exposure of 100 millirem above background, while she implies that even a standard of 330 millirem per year, which would double the background dose on average, is unnecessarily stringent.

However, we can evaluate the impact of weakening the EPA PAGs for long-term exposure on costs and risks. In Table 10, we assess the impact of adopting a long-term protective action guide of 25 rem in 50 years, or an average annual dose of 500 millirem per year. By comparing the 95th percentile columns in Table 10 and Table 9, one can see that relaxing the standard would modestly reduce the post-release cleanup costs by about 25% and drastically reduce the number of relocated individuals by 90%. However, weakening the standard would nearly triple the number of long-term cancer deaths among residents of the contaminated area. Cost-benefit analyses of proposals to weaken long-term exposure standards should take this consequence into account.

TABLE 10: Long-term economic and health consequences of a terrorist attack at IP 2, relaxed cleanup standard (25 rem in 50 years)

	Mean	95th percentile	99.5th percentile	Peak
Consequence:				
Total cost, 0-100 mi (2003 $)	$249 billion	$886 billion	$1.14 trillion	$1.50 trillion
People permanently relocated	118,000	334,000	1.86 million	7.98 million
LCFs, 0-100 mi	36,300	115,000	169,000	279,000

(d) An even worse case

The previous results were based on the analysis of a terrorist attack that resulted in a catastrophic radiological release from only one of the two operating reactors at the Indian Point site. However, it is plausible that both reactors could be attacked, or that an attack on one could result in the development of an unrecoverable condition at the other. Here we present the results of a scenario in which Indian Point 3 undergoes a similar accident sequence to Indian Point 2 after a time delay of just over two hours. This could occur, for example, if Indian Point 3 experienced a failure of its backup power supplies at the time that Indian Point 2 was attacked. Given the loss of off-site power at the same time, Indian Point 3 could experience a small-break LOCA and eventually a core melt, commencing about two hours after accident initiation. We assume that the attackers weaken the IP3 containment so that it ruptures at the time of vessel failure. In Table 11, we present the results of this scenario for the case of full evacuation of the EPZ.

As bad as this scenario is, it still does not represent the worst case. If any or all of the three spent fuel pools at the Indian Point site were also damaged during the attack, the impacts would be far greater, especially with regard to long-term health and economic consequences.

TABLE 11: Terrorist attack at IP 2 and 3, MACCS2 estimates of early fatalities (EFs) and latent cancer fatalities (LCFs) resulting from emergency phase exposures, 100% evacuation of EPZ

	Mean	95^{th} percentile	99.5^{th} percentile	Peak
Consequence:				
EFs, within EPZ	925	4,660	18,400	34,100
EFs, 0-50 mi.	1,620	8,580	30,900	78,400
EF, distance (mi.)	9.1	21	29	60
LCFs, within EPZ	14,800	42,900	75,100	122,000
LCFs, 0-50 mi.	53,400	180,000	342,000	701,000

CONCLUSIONS

In conclusion, we make the following observations.

1) The current emergency planning basis for Indian Point provides insufficient protection for the public within the 10-mile emergency planning zone in the event of a successful terrorist attack. Even in the case of a complete evacuation, up to 44,000 early fatalities are possible.

2) The radiological exposure of the population and corresponding long-term health consequences of a successful terrorist attack at Indian Point could be extremely severe, even for individuals well outside of the 10-mile emergency planning zone. We calculate that over 500,000 latent cancer fatalities could occur under certain meteorological conditions. A well-developed emergency plan for these individuals, including comprehensive distribution of potassium iodide throughout the entire area at risk, could significantly mitigate some of the health impacts if promptly and effectively carried out. However, even in the case of 100% evacuation within the 10-mile EPZ and 100% sheltering between 10 and 25 miles, the consequences could be catastrophic for residents of New York City and the entire metropolitan area.

3) The economic impact and disruption for New York City residents resulting from a terrorist attack on Indian Point could be immense, involving damages from hundreds of billions to trillions of dollars, and the permanent displacement of millions of individuals. This would dwarf the impacts of the September 11 attacks.

4) The potential harm from a successful terrorist attack at Indian Point is significant even when only the mean results are considered, and is astonishing when the results for 95^{th} and 99.5^{th} meteorological conditions are considered. Given the immense public policy implications, a public dialogue should immediately be initiated to identify the protective measures desired by the entire affected population to prevent such an attack or effectively mitigate its consequences should prevention fail. As this study makes abundantly clear, this population extends far beyond the 10-mile zone that is the focus of emergency planning efforts today.

We hope that this information will be useful for officials in the Department of Homeland Security as it carries out its statutory requirement to conduct a comprehensive assessment of the terrorist threat to the US critical infrastructure, as well as for health and emergency planning officials in New York City and other areas that are not now currently engaged in emergency preparedness activities related to a terrorist attack at Indian Point.

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